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Differential Range Expansion and Habitat Use Among the Naturalized *Anolis* Lizards of Bermuda

Until the 20th Century, the Bermuda archipelago hosted a single endemic species of lizard: the Bermuda Rock Skink, *Plestiodon longirostris* (formerly *Eumeces longirostris*; Brandley et al. 2005; Wingate 1965). Beginning in the early 1900s, however, both purposeful and apparently accidental introductions of *Anolis* lizards have resulted in three species becoming permanently established ("naturalized") on Bermuda. These three species—*Anolis grahami*, *Anolis leachii*, and *Anolis extremus* (Fig. 1)—are native to different Caribbean islands and belong to distantly related *Anolis* clades (Poe 2004, Nicholson et al. 2012; Gamble et al. 2014; Helmus et al. 2014).

Anolis grahami was introduced in 1905 (26 males and 45 females) from Kingston, Jamaica to the Botanical Gardens in Paget Parish, and achieved a virtually archipelago-wide distribution at some point between 1935 and 1945 (Wingate 1965). In contrast, *A. leachii* from Antigua and Barbuda, and *A. extremus* from Barbados (all islands in the Lesser Antilles) appear to have been small, unintentional introductions occurring in the 1940s (Wingate 1965; Losos 1996; Macedonia and Clark 2003). *Anolis leachii* first was discovered around 1940 on the north (harbor) shore of Warwick Parish. *Anolis extremus* is thought to have arrived in the Royal Naval Dockyard at the tip of Ireland Island (Sandys Parish) sometime before 1945, although it was not formally documented until 1953 (Wingate 1965). By 1956, *A. extremus* was abundant on Ireland and Boaz Islands, and exhibited a "patchwork distribution" on Somerset Island (Wingate 1965; Losos 1996).

Although *A. grahami* and *A. extremus* are similar in size (SVL: adult males ~65–70 mm, adult females ~50 mm; Macedonia and Clark, 2003 and unpubl. data) and have been reported to exhibit similar structural habitat use, they differ in insolation preference: whereas *A. grahami* is heliophilic, *A. extremus* prefers shade (Wingate 1965; Schoener 1970; Losos 1996). Losos (1996) found that although males of the substantially larger *A. leachii* (SVL: adult males ~ 95–100 mm, adult females ~ 70 mm; Macedonia and Clark, 2003 and unpubl. data) preferred larger perch diameters than did male *A. grahami*, the two species did not differ in use of sun versus shade. In addition, Wingate (1965) noted that despite the introduction of *A. leachii* into habitat already occupied by *A. grahami*, the former's preference for broader perches and thicker vegetation, as well as spending very little time foraging on the ground, probably reduced competition between these two species.

Unlike the rapid range expansion documented for *A. grahami*, the distributions of *A. leachii* and *A. extremus* were still (virtually) limited to a single parish each in 1963—roughly two decades after they first appeared on Bermuda (Wingate 1965). By the early 1990s, however, *A. leachii* had enlarged its range to encompass the western three-quarters of the archipelago (Losos 1996). In contrast, *A. extremus* extended its range very little (< 2 km) between the early 1960s and early 1990s (Losos 1996). Wingate (1965) suggested that competition arising from similar body size and structural habitat could have resulted in the inability of *A. grahami* to colonize Boaz and Ireland Islands, and the inability of *A. extremus* to expand its range eastward beyond Somerset Island. It was this apparent case of competitive exclusion (e.g., Hardin 1960) that motivated Losos (1996) to conduct his follow-up study of the Bermudian anoles nearly three decades after Wingate's (1965) original research.

In the present study we replicate and extend the work of these earlier authors on the distribution and ecology of *Anolis* lizards naturalized on Bermuda. First, we update the distributions of each species using data from GPS-tagging cameras. These cameras allowed us to link the geographic position of each lizard with a photographic record for later verification of species identity and age/sex class. Second, we compare perch heights and perch diameters among our study species and between sexes with data accurately gathered using measuring tapes. Last, we follow previous authors in comparing insolation preferences among study species and between sexes, but in addition we compare body surface temperatures using data obtained with laser-sighted thermometer "guns."

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MATERIALS AND METHODS

Sites and Sampling.—We conducted our study during the first two weeks of May 2012. The 40 km-long Bermuda archipelago is arrayed in the shape of a "fishhook" lying in a northeast–southwest orientation, and is divided into nine parishes (Fig. 2).

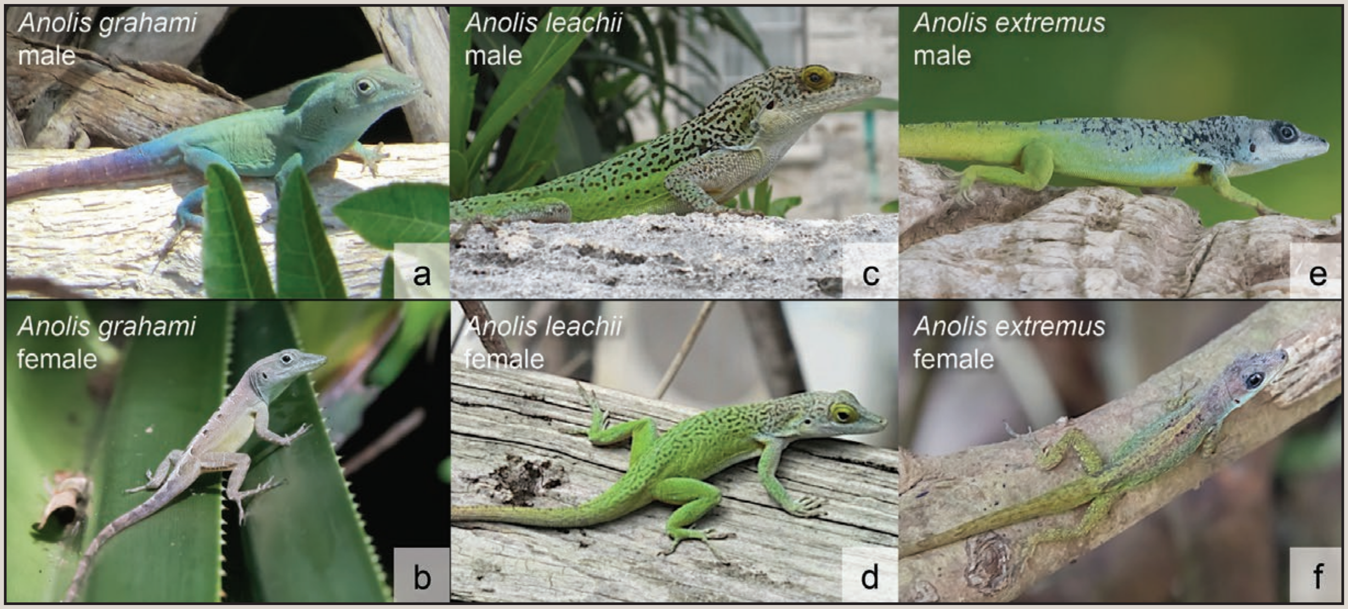

Fig. 1. Representative adult males and females of the three study species on Bermuda. Images not to scale.

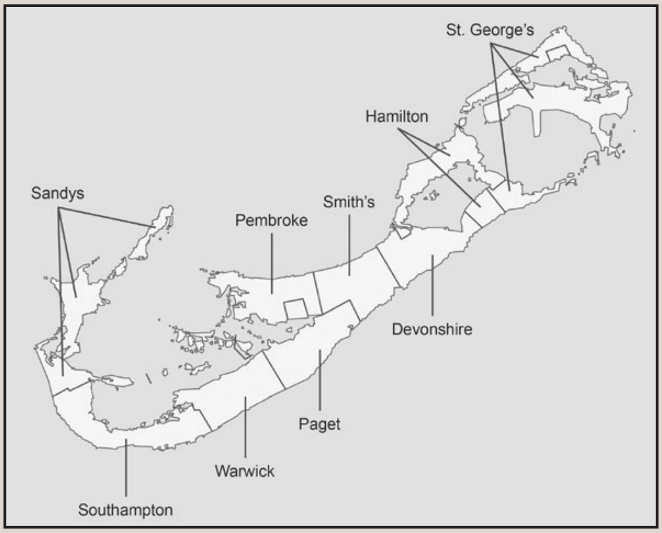

Fig. 2. Map of Bermuda parishes. The three-sided squares in Pembroke and St. George's parishes delineate the City of Hamilton and Town of St. George's, respectively.

We traveled to different parishes by bus and ferry, and walked predetermined routes while scanning surfaces on which lizards might perch. When a lizard was sighted, it was approached slowly and photographed using a Casio Exilim-H20G camera, which attached a GPS tag to each photo. The GPS longitude/latitude coordinates later were exported as Microsoft Excel files, which were uploaded to Earth Point (Earth Point Corporation, Kuna, Idaho) to create the KML files that plotted each subject's location in Google Earth.

As we did not capture lizards for this study, we distinguished two adult age/sex classes of subjects from our photos: adult males and adult female-sized lizards. The adult female-sized age/sex class explicitly acknowledges that some small (non-adult) males cannot be distinguished at a distance from adult females (Schoener 1970); we refer to such individuals herein simply as females. Hatchlings and juvenile-sized females were not included in our survey. Subjects' perch heights and perch diameters were quantified precisely using commercial fabric tape measures. Upon discovering a subject, we noted whether the lizard was located in (1) full sun, i.e., direct, unfiltered sunlight, (2) full shade, or (3) partial shade. We assigned the category of partial shade to a subject if its trunk (i.e., midsection from neck to hind limbs) was (a) entirely in light shade, (b) was in dappled sunlight, or (c) if part of the trunk was in sun and another part in shade. Subjects' body surface temperatures were obtained at a distance (typically 1.5–3 m) by aiming the infrared laser spot of a thermometer "gun" (Etekcity Lasergrip 774 ETC 8380 Temperature Gun Non-contact Digital Laser Infrared IR Thermometer, Etekcity.com) at the subject's trunk. If the trunk was divided unequally by sun and shade, we took our thermal reading within the larger of the two areas (i.e., sun or shade). In cases where a subject's trunk was divided equally by sun and shade, we focused the laser spot at the sun/shade interface. Body surface temperatures were not gathered for all subjects, as some individuals fled before these data could be acquired. Last, we supplemented our small 2012 sample size for *A. extremus* females (N = 4) with data from 28 females gathered by James Stroud in 2014 and 2015, as well as with our own additional data from 22 females gathered on 4–5 July 2016.

Statistical analysis.—Statistical tests were conducted in SPSS (v21.0, IBM Inc., Armonk, New York) and VassarStats (Lowry 2014). Prior to analysis, measurement variables were tested for normality with the Shapiro-Wilk test (http://scistatcalc.blogspot.com/2013/10/shapiro-wilk-test-calculator.html). Body surface temperature distributions were examined separately for each sex of each species and were found to be normal in all cases. Raw values for perch height and perch diameter were not normally distributed, but conformed to a normal distribution after log transformation. All analyses of perch height and perch diameter used these transformed values. Subjects on the ground were not included in our perch height analyses and were analyzed separately.

For comparisons of measures (e.g., above-ground perch height, perch diameter, and body surface temperature) we used two-way ANOVAs with species and sex as fixed factors. Bonferroni correction was used for post hoc pairwise tests. We conducted between-sex comparisons of proportions of subjects

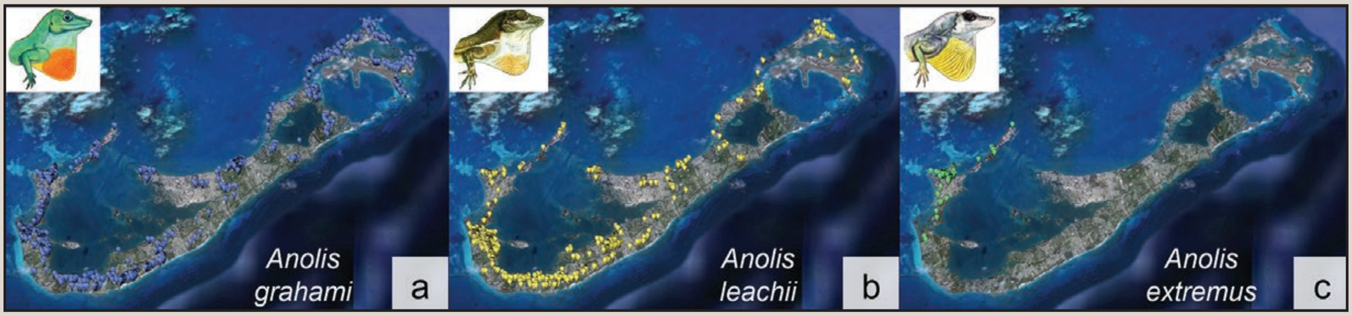

FIG. 3. Distribution maps indicating GPS coordinates for individual adult lizards of both sexes. (a) blue markers: *A. grahami*, (b) yellow markers: *A. leachii*, (c) green markers: *A. extremus*. Inset illustrations of males of the study species are from Schwartz and Henderson (1985).

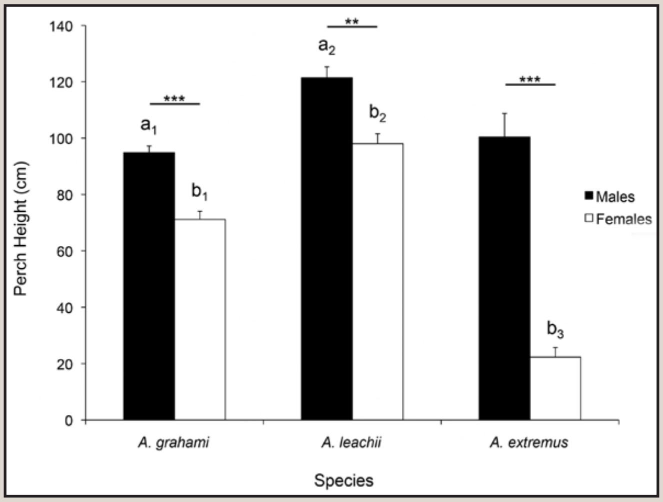

FIG. 4. Comparison of perch heights by sex and study species. Bars represent means ± 1 SEM. Horizontal bars with asterisks indicate significant between-sex, intraspecific comparisons: ** = $P \leq 0.01$, *** = $P \leq 0.001$. Same letters with different numerical subscripts indicate significant ($P \leq 0.0001$) same-sex, interspecific comparisons.

observed on the ground versus above the ground using the z-ratio test for the difference between two independent proportions. For each sex within each species we then compared numbers of subjects occupying different insolation categories using the chi-square goodness-of-fit test. Last, we used the z-ratio test to determine if the proportion of male or female subjects in a given insolation category differed between pairs of species. As Bonferroni correction was not available in SPSS or VassarStats for multiple tests of frequencies or proportions, we used a sequential Bonferroni correction calculator to adjust *P*-values in such tests (Gaetano 2013). Although significant results of many comparisons in this study exhibited exceedingly small *P*-values (e.g., $P = 1.0 \times 10^{-10}$), for simplicity we report such values in the text only to $P < 0.0001$, and use the standard convention of asterisks in our figures of * $P < 0.05$, ** $P < 0.01$, and *** $P < 001$.

RESULTS

Species Distributions.—As anticipated from Losos' (1996) findings, we observed *A. grahami* in all areas that we sampled across Bermuda (Fig. 3a). We also discovered that since Losos' (1996) study, *A. leachii* had extended its range 4.5 km northward from Mangrove Bay to the tip of Ireland Island at the western end of Sandys Parish, and had extended the eastern edge of its range an additional 9 km to the easternmost points of St. George's Parish (Fig. 3b). Thus, *A. leachii* is now the second naturalized anole on Bermuda to achieve an archipelago-wide distribution. Surprisingly, we found no change in the distribution of *A. extremus* (Fig. 3c) from that documented by Losos (1996).

Perch Height.—Results of a two-way ANOVA on perch height revealed a significant main effect of species ($F_{2,1963} = 64.82$, $P < 0.0001$) and sex ($F_{1,1963} = 138.87$, $P < 0.0001$), as well as a significant species * sex interaction ($F_{2,1963} = 34.96$, $P < 0.0001$) that arose from differences between the sexes in the among-species relationships of perch heights (see Fig. 4). Between-sex post hoc comparisons showed that males perched significantly higher than females in all three species: *A. grahami* ($N_M = 784$, $N_F = 451$; $P < 0.0001$), *A. leachi* ($N_M = 346$, $N_F = 293$; $P < 0.01$), and *A. extremus* ($N_M = 51$, $N_F = 43$; $P < 0.0001$; Fig. 4). Interspecific comparisons showed that male *A. leachii* perched significantly higher than male *A. grahami* ($P < 0.0001$); no other comparisons among males were significant. Among females, *A. leachii* perched significantly higher than *A. grahami* ($P < 0.0001$) and *A. extremus* ($P < 0.0001$), with female *A. grahami* also perching higher than female *A. extremus* ($P < 0.0001$; Fig. 4).

Between sexes, proportionately more females than males were found on the ground in all three species: *A. grahami* ($z = 7.82$, $P < 0.001$), *A. leachii* ($z = 3.88$, $P < 0.001$), and *A. extremus* ($z = 2.27$, $P < 0.05$; Fig. 5). Between species, proportionately more male *A. grahami* than male *A. leachii* were located on the ground ($z = 3.03$, $P < 0.01$), as were proportionately more female *A. grahami* than female *A. leachii* ($z = 5.20$, $P < 0.001$); no other same-sex interspecific comparisons were significant (Fig. 5).

Perch Diameter.—Results from a two-way ANOVA on perch diameters showed a significant main effect of species ($F_{2,1352} = 21.67$, $P < 0.0001$) and sex ($F_{1,1352} = 54.29$, $P < 0.0001$), as well as a significant species * sex interaction ($F_{1,1352} = 3.31$, $P < 0.05$). This interaction stemmed from a nearly threefold difference in perch diameters between the sexes in *A. extremus,* as compared to less than a twofold difference between the sexes in *A. grahami* and *A. leachii* (Fig. 6). Between-sex post hoc comparisons showed that male perches were significantly greater in diameter than were those of females in all three species: *A. grahami* ($N_M = 525$, $N_F = 286$; $P < 0.0001$), *A. leachii* ($N_M = 259$, $N_F = 214$, $P < 0.0001$), and *A. extremus* ($N_M = 36$, $N_F = 38$; $P < 0.0001$; Fig. 6). Male *A. grahami* perch diameters did not differ significantly from those of the much larger male *A. leachii* ($P > 0.05$), but were greater than those of the similar-sized male *A. extremus* ($P < 0.05$; Fig. 6). Perch diameters of male *A. leachii* also were greater than those of male *A. extremus* ($P < 0.05$; Fig. 6). Although perch diameters did not differ between female *A. grahami* and *A. leachi* ($P > 0.05$), these species exhibited significantly larger

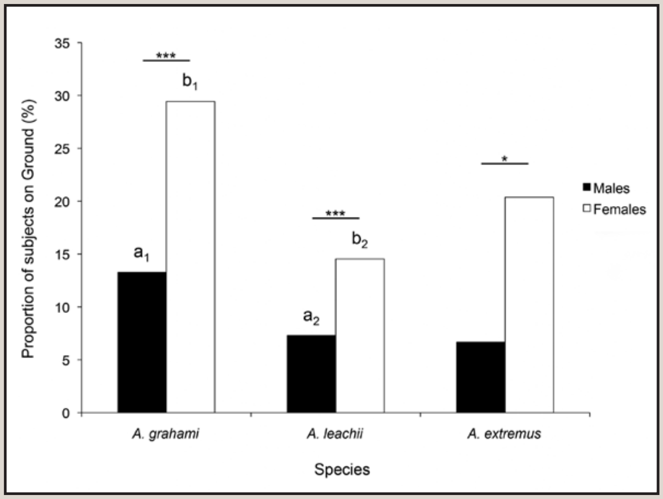

Fig. 5. Comparison of proportions of subjects located on the ground by sex and study species. Horizontal bars with asterisks indicate significant between-sex, intraspecific comparisons: * = $P \leq 0.05$, *** = $P \leq 0.001$. Same letters with different numerical subscripts indicate significant same-sex, interspecific comparisons ($P \leq 0.01$ for males and $P \leq 0.001$ for females).

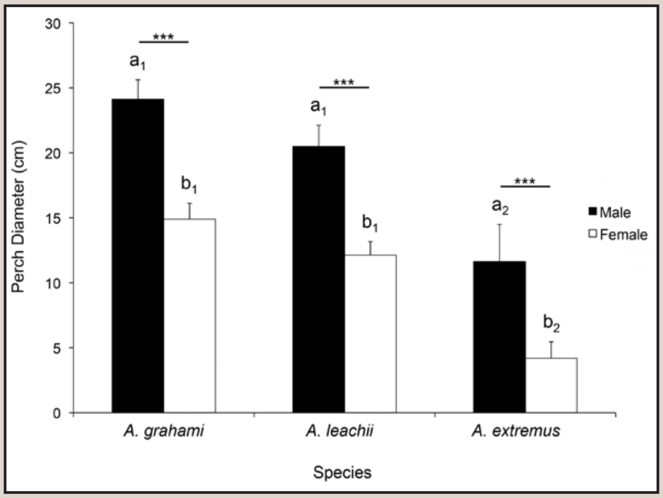

Fig. 6. Comparison of perch diameters by sex and study species. Bars represent means ± 1 SEM. Horizontal bars with asterisks indicate significant between-sex, intraspecific comparisons: *** = $P \leq 0.001$. Same letters with different numerical subscripts indicate significant same-sex, interspecific comparisons ($P \leq 0.05$ for males and $P \leq 0.0001$ for females).

perch diameters than did female *A. extremus* ($P < 0.0001$ in both comparisons; Fig. 6).

Body Surface Temperature.—Results of a two-way ANOVA on body surface temperatures revealed a significant main effect of species ($F_{2,1437} = 9.45$, $P < 0.0001$) but not sex ($F_{1,1437} = 0.03$, $P > 0.05$). The species * sex interaction was non-significant ($F_{2,1452} = 0.72$, $P > 0.05$). Posthoc interspecific comparisons showed that *A. grahami* (N = 947) body surface temperatures were significantly higher than those of *A. leachii* (N = 453, $P < 0.001$) and *A. extremus* (N = 43, $P < 0.0001$), and that *A. leachii* body surface temperatures also were significantly higher than those of *A. extremus* ($P < 0.01$; Fig. 7).

Insolation Preference: Intraspecific Comparisons.—Intraspecific within-sex comparisons of the number of subjects observed in each insolation category differed significantly from expected frequencies in all cases (χ^2 goodness-of-fit value range: 20.81–42.78, df = 2, $P < 0.0001$ in all tests). Pairwise comparisons (df = 1) showed that more *A. grahami* males (N = 1014) were observed in full sun than in full shade ($\chi^2 = 14.88$, $P < 0.001$), and that more were located in partial shade than in full shade ($\chi^2 = 20.02$, $P < 0.001$), but the number of *A. grahami* males seen in full sun did not differ from the number in partial shade ($\chi^2 = 0.34$, $P > 0.05$; Fig. 8a). Unlike male *A. grahami*, more male *A. leachii* (N = 430) were observed in partial shade than in full sun ($\chi^2 = 28.36$, $P < 0.001$) and in full shade than in full sun ($\chi^2 = 5.76$, $P < 0.05$). In addition, more male *A. leachii* were observed in partial shade than in full shade ($\chi^2 = 8.52$, $P < 0.01$; Fig. 8a). In contrast to *A. grahami* and *A. leachii*, far more male *A. extremus* (N = 56) were located in full shade than in partial shade ($\chi^2 = 14.58$, $P < 0.001$) or full sun ($\chi^2 = 22.76$, $P < 0.001$; Fig. 8a). The number of *A. extremus* males observed in partial shade did not differ from those in full sun ($\chi^2 = 0.94$, $P > 0.05$).

Female *A. grahami* and *A. leachii* were more similar in their insolation preferences than were males. Female *A. grahami* (N = 691) were found more often in partial shade than in full sun ($\chi^2 = 12.26$, $P < 0.001$) and in full shade than in full sun ($\chi^2 = 19.1$, $P < 0.0001$), but the number of females observed in partial shade did not differ from those in full shade: $\chi^2 = 0.7$, $P > 0.05$; Fig. 8b). Similarly, female *A. leachii* (N = 397) were detected more often in partial shade than in full sun ($\chi^2 = 33.52$, $P < 0.001$) and in full shade than in full sun ($\chi^2 = 37.28$, $P < 0.001$), but the number of females observed in partial shade and in full shade did not differ: $\chi^2 = 0.08$, $P > 0.05$; Fig. 8b). Like males, female *A. extremus* (N = 26) exhibited a strong preference for full shade: more females were detected in full shade than in partial shade ($\chi^2 = 8.66$, $P < 0.01$) or in full sun ($\chi^2 = 19.04$, $P < 0.001$); in fact, we failed to observe a single female in full sun (Fig. 8b). A test between female *A. extremus* found in partial shade versus full sun could not be conducted due to expected values < 5 in both cells.

Insolation Preference: Interspecific Comparisons.—Results revealed that proportionally more male *A. grahami* were located in full sun than were male *A. leachii* (z = 3.0, $P < 0.001$) or male *A. extremus* (z = 3.87, $P < 0.001$), and that proportionally more male *A. leachii* were observed in full sun than were male *A. extremus* (z = 2.14, $P < 0.05$; Fig. 8a). Next, proportionately more male *A. leachii* were observed in partial shade than were male *A. grahami* (z = 2.48, $P < 0.05$) or male *A. extremus* (z = 3.57, $P < 0.001$), and proportionally more male *A. grahami* were observed in partial shade than were male *A. extremus* (z = 2.75, $P < 0.01$; Fig. 8a). Last, proportionally more male *A. extremus* were located in full shade than were male *A. grahami* (z = 6.98, $P < 0.001$) or male *A. leachii* (z = 5.49, $P < 0.001$), and proportionally more male *A. leachii* were found in full shade than were male *A. grahami* (z = 2.23, $P < 0.05$; Fig. 8a).

Results of interspecific pairwise comparisons for females showed that proportionately more female *A. grahami* were observed in full sun than were female *A. leachii* (z = 2.83, $P < 0.01$; Fig. 8b). The proportion of *A. extremus* females in full sun could not be tested against *A. grahami* due to the requirement that each cell contain at least 5 observations. Although the proportions of female *A. grahami* and *A. leachii* located in partial shade both were greater than the proportion of female *A. extremus* in partial shade, neither test was significant following sequential Bonferroni correction (Fig. 8b). Finally, the proportion of female *A. extremus* found in full shade was greater than that for female *A. grahami* (z = 4.64, $P < 0.001$) as well as *A. leachi* (z = 3.88, $P < 0.001$), and

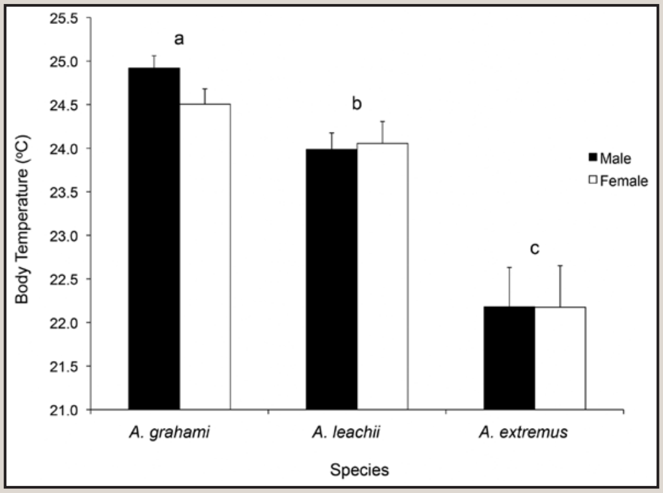

Fig. 7. Comparison of body surface temperatures by sex and study species measured between May 2 and May 12, 2012. Bars represent means ± 1 SEM. As sexes within a species did not differ in body surface temperature, sexes were pooled for this analysis. Different letters above bars indicate significant (P ≤ 0.01) between-species comparisons.

the difference between *A. grahami* and *A. leachii* females closely approached significance (z = 1.94, *P* = 0.0527; Fig. 8b).

Discussion

Our aim in this study was to replicate and extend Losos' (1996) report on the range expansion, structural habitat use, and thermal ecology of the naturalized anoles of Bermuda. Below we discuss each of these topics in turn, and then focus on the matter of why, in contrast to its congeners, *A. extremus* has increased its range so little over the past half century.

Species Distributions.—Wingate (1965) reported in his 1963 survey that between 30 and 40 years following its introduction in 1905, *A. grahami* could be found everywhere on Bermuda (including several offshore islands) except for the 2.5 km distance between "The Lagoon" on South Ireland Island and the far end of North Ireland Island. By the time Losos (1996) conducted his study in 1991, *A. grahami* had achieved complete coverage of the Bermuda archipelago. We found no differences in the distribution of *A. grahami* from that documented by Losos (1996). Excluding a single observation that Losos (1996) considered to be an outlier, he determined that *A. leachii* had extended its range ~8 km westward and ~13 km eastward from the range limits reported by Wingate (1965). Our results show that *A. leachii* has continued to expand its range both eastward and westward and has achieved an archipelago-wide distribution.

In contrast to dramatic range expansions of *A. grahami* and *A. leachii*, Losos (1996) reported that *A. extremus* had increased its range only ~1.25 km in Sandys Parish since Wingate's (1965) study. In fact, we found no difference in the range limits of *A. extremus* from that reported by Losos (1996). We can rule out the possibilities that abrupt environmental change or unsuitable intervening habitat (e.g., Glor and Warren 2011) are barriers to *A. extremus* dispersal, as the easternmost location in which we found this species (Woodlawn Road in Hog Bay, Sandys Parish) was no different than much of Bermuda: highly developed (e.g., suburbs).

Perch Height.—We found that males perched higher than females, and were found less frequently on the ground than were females (Figs. 4, 5). These results are consistent with those of Schoener (1970), in which he found that male *A. grahami* and *A. extremus* perched higher than females of their respective species (he did not report on *A. leachii*). We also found for males as well as females that *A. leachii* perched higher than *A. grahami*. In contrast, Losos (1996) did not find interspecific differences in male perch heights (he did not report results for females).

Perch Diameter.—Schoener (1970) reported that, within species, male *A. grahami* and *A. extremus* used significantly larger-diameter perches than did females (he did not report results for *A. leachii*). We found the same outcome for *A. grahami*, *A. extremus*, and *A. leachii*. Previous interspecific comparisons have shown that *A. extremus* (Schoener 1970) and *A. leachii* (Losos 1996) used larger-diameter perches than *A. grahami*. In contrast, we found that diameters of male *A. grahami* perches were larger (though not significantly so) than those of male *A. leachii*, and perches used by male *A. extremus* were significantly smaller than those of *A. grahami* and *A. leachii* (Fig. 6). Our results could reflect, at least in part, a relatively greater use of broad tree trunks as perches by male *A. grahami* than by male *A. leachii* or *A. extremus*.

Body Surface Temperature and Insolation.—Although we found no significant differences in body surface temperature between the sexes, these temperatures differed significantly among species: *A. grahami* exhibited the highest body surface temperatures, *A. extremus* the lowest, and *A. leachii* was intermediate (Fig. 7). Unsurprisingly, insolation preferences among our study species mirrored results for body surface temperatures: *A. grahami* males preferred full sun more than males of the other two species, *A. extremus* males strongly preferred full shade, and *A. leachii* males were found most often in partial shade (Fig. 8). Consistent with our findings, both Schoener (1970) and Losos (1996) found male *A. grahami* in the sun more often than the other study species, and found male *A. extremus* most commonly in the shade.

Differential Range Expansion Among Bermudian Anoles.—From the point of their release at the Bermuda Botanical Gardens in Paget Parish in 1905, *A. grahami* achieved a virtually archipelago-wide distribution in 30 to 40 years (Wingate 1965). With no native arboreal lizards to exert competition, apparently little stood in the way of *A. grahami* range expansion. By comparison, roughly 20–25 years post-introduction, *A. leachii* remained restricted almost solely to Warwick Parish (Wingate 1965). Although a dramatic difference must have existed between the known large number of *A. grahami* introduced to Bermuda and the likely small number of *A. leachii* colonists, it also is worth considering that *A. grahami* was well established in Warwick Parish in the 1940s when *A. leachii* first arrived (Wingate 1965). Differences in arthropod prey size preferences and structural habitat probably reduce within-sex interspecific competition between *A. leachii* and *A. grahami* (e.g., Wingate 1965; Schoener 1967), but similar body sizes (SVLs) of female *A. leachii* and male *A. grahami* may increase inter-sexual competition for food, which in turn may have contributed to the initially slow range expansion of *A. leachii*.

Other factors, including reduction in tree cover and low tolerance for cold temperatures, also may have played a role in the marginal range expansion of *A. leachii* during its first few decades on Bermuda (Wingate 1965; Losos 1996). For example, Wingate (1965) reported that numerous *A. leachii* would be found dead following severe winter storms (which never was the case for *A. grahami*). Nevertheless, in the 28 years between the

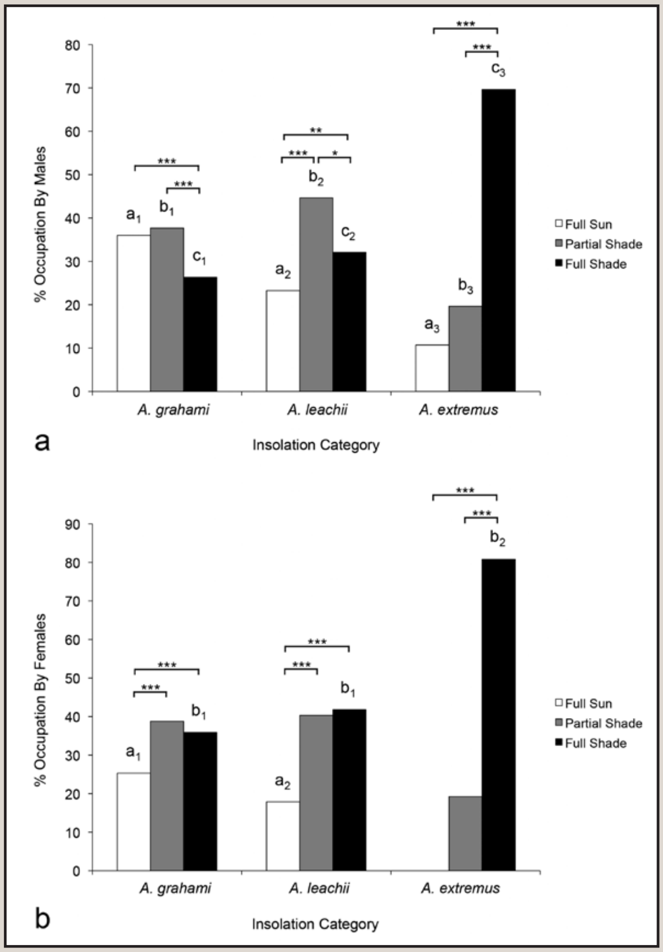

FIG. 8. Comparison of insolation by study species: (a) males, (b) females. Horizontal bars with asterisks denote significant between-sex intraspecific comparisons: * = $P \leq 0.05$, ** = $P \leq 0.01$, *** $P \leq 0.001$. Same letters with different numerical subscripts indicate significant same-sex, interspecific comparisons at $P \leq 0.05$ or smaller.

data gathered in 1963 by Wingate (1965) and in 1991 by Losos (1996), *A. leachii* had expanded its range to include all parishes except St. George's and St. David's in northeastern Bermuda. By the time we conducted our study in 2012, *A. leachii* was present throughout the archipelago. Losos (1996) pointed out that increased vehicle traffic, the ornamental plant industry (i.e., transportation of lizards and their eggs), and purposeful (undocumented) translocations of *A. leachii* by humans beyond Warwick Parish might explain the escalated range expansion in this species over the past several decades. Although these variables may have contributed to the slow-then-rapid range expansion of *A. leachii*, it remains perplexing why *A. extremus* has not experienced a similar sudden accelerated rate of dispersal.

One factor that may have contributed to the arrested dispersal of *A. extremus* on Bermuda is ecological niche incumbency (Algar et al. 2013). Niche incumbency is a form of competitive exclusion (e.g., Hardin 1960) in which a species is prevented from expanding its range into an area already occupied by a species to which it is ecologically very similar (e.g., Algar et al. 2013; Williams 1965). Several authors (Wingate 1965; Schoener 1970; Losos 1996) have argued that, aside from thermal preference, *A. grahami* and *A. extremus* differ very little in prey size choice or structural habitat use. For example, both Schoener (1970) and Losos (1996) reported that *A. grahami* and *A. extremus* tend to occupy the same perches at different times of the day: sunny when occupied by *A. grahami* and shady when occupied by *A. extremus*.

It therefore seems relevant that a recent phylogenetically-focused study of ecological interactions among members of three Cuban *Anolis* clades showed, within clades, that similarly sized species (i.e., same structural niche) with differing thermal preferences were more likely to coexist in local assemblages, as were species with the same thermal niche but different structural niches (Cádiz et al. 2013). Likewise, using phylogenetic comparative methods Hertz et al. (2013) showed that recently diverged *Anolis* species differed more often in climatic niche (i.e., thermal and insolation preferences) than in structural niche, and that divergence in thermal niche has often followed diversification in structural niche. Results of these studies suggest not only that thermal preferences may be more plastic in anole evolution than morphological divergence, but also that differences in thermal niche facilitate coexistence via reduced competition.

It therefore is curious that, despite *A. grahami* having achieved nearly complete coverage of Bermuda over three to four decades in the absence of congeners, this species still was unable to invade much of the *A. extremus* stronghold of the Ireland Islands as late as 1963 (Wingate 1965; Losos 1996). The incumbency of *A. extremus* in this location is consistent with the prospect that its presence prevented invasion of the Ireland Islands by *A. grahami* for at least 20 years after the two species came into contact. Yet, given that *A. grahami* eventually colonized the Ireland Islands, and that *A. leachii* eventually expanded its range beyond Warwick Parish, niche incumbency seems unlikely to be responsible for *A. extremus* extending its distribution less than two kilometers over the past half century.

Currently we do not know if subtle attributes of vegetation structure or microclimate that might be unique to Sandys Parish have made it difficult for *A. extremus* to expand its range eastward. Alternatively or in addition, genetic constraints may be limiting the dispersal of *A. extremus*. Gorman et al. (1976) estimated heterozygosity for 24 allozymes of *A. extremus* on Bermuda to be only 16% of that present in this species on its native island of Barbados—a quantity considerably lower than the 56% heterozygosity in *A. leachii* and 82% in *A. grahami* on Bermuda, as compared to their source populations. We therefore cannot discount the possibility that the genetic bottleneck experienced during colonization of Bermuda has compromised this species' ability to disperse in the presence of competition from congeners. Moreover, new mutations that are correlated with phenotypic or life history variation can have an impact on range expansion (e.g., Burton et al. 2010). Hypothetically, such mutations could have contributed to the ability of *A. leachii* to expand its range after the early 1960s, or could have facilitated invasion of the Ireland Islands by *A. grahami* following an apparent standoff with *A. extremus* there for at least two decades.

Future Directions.—Insight into the limited dispersal of *A. extremus* might be gained through a quantitative study of habitat structure and microclimate properties and/or detailed investigations into species-specific biotic interactions (e.g. agonistic relationships) that may have influenced dispersal patterns. Moreover, an experimental removal/introduction study (e.g., Schoener and Schoener 1983; Kalmath et al. 2013; Stuart et al. 2014) is imaginable, in which species introduction order and timing is controlled. Bermuda harbors a number of very small islands (e.g., in Harrington Sound and the Great Sound) where such an experiment might be carried out.

Finally, it has been over a half century since dietary studies of Bermudian anoles were conducted (Simmons 1958; Wingate 1965), at which time there was no area on Bermuda where all three species were sympatric, and where sympatry between species pairs was limited to Warwick and Sandys Parishes. Such data might provide further clarification of the mechanisms permitting species coexistence, and could be instructive with regard to the recent discovery of the highly invasive *Anolis sagrei* on Bermuda. The presence of *A. sagrei* was first noted by Macedonia (Losos 2012), and since has been studied in the context of ecological and geographical overlap with the critically endangered *Plestiodon longirostris* (Stroud et al., *in press*). In conclusion, we hope that future studies will utilize a range of observational, experimental, and genetic techniques to better understand the dynamics of colonization and range expansion in the naturalized (and newly invasive) *Anolis* lizards of Bermuda.

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Morphological Variation and Natural History in the Enigmatic Lizard Clade *Scopaeabronia* (Squamata: Anguidae: *Abronia*)

Numerous species of Mexican squamates are known to science from meager comparative material (Campbell and Frost 1993; Bezy and Camarillo R. 2002; Wilson and Townsend 2007; Bryson and Graham 2010; Wilson and Mata-Silva 2015). Such species typically have a restricted geographic range, a secretive life history, and occupy inaccessible habitat. These attributes combine to produce few encounters by scientists. This, in turn, often leads to uncertainty regarding a species' taxonomic validity, accurate diagnosis, and conservation risk. For such species, when additional specimens do come to light, an opportunity arises to elaborate on infraspecific variation, revise identification traits, update conservation assessments, and report on natural history (Lemos-Espinal and Smith 2005; Luría-Manzano et al. 2014; Pavón-Vázquez et al. 2014; Scarpetta et al. 2015). Such an opportunity recently presented itself to us involving two enigmatic species in the poorly-studied genus *Abronia* (Squamata: Anguidae).

The arboreal alligator lizards in the genus *Abronia* comprise a largely allopatric radiation of 29 described species of montane forest specialists, scattered across the highlands of Mexico and nuclear Central America from eastern Mexico to western Honduras (Campbell and Frost 1993; Campbell 1994; Campbell and Brodie 1999; Campbell et al. 1998; Campbell et al. 2016; Flores-Villela and Sánchez-H 2003). Members of this genus are considered among the most poorly known squamates in Central America—due primarily to their limited geographic range, elusive arboreal behavior, and remote habitats. Within the genus, six clades (originally designated as subgenera) have been identified that are morphologically and genetically diagnosable (Campbell and Frost 1993; Chippindale et al. 1998).

One of these clades is *Scopaeabronia*, also known in some older literature as the *Abronia bogerti* group. Species in this clade are easily recognized on the basis of over a half-dozen morphological synapomorphies (Campbell and Frost 1993). Species of *Scopaeabronia* are also ecologically unusual among the genus, because they inhabit forest at comparatively low elevations from 1540 m down to at least 660 m. The clade includes three species: *Abronia bogerti* Tihen, 1954; *Abronia chiszari* Smith and Smith, 1981; and *Abronia ramirezi* Campbell, 1994. Each species was described solely from the holotype, and cumulatively only four additional *Scopaeabronia* individuals have since become available for scientific study (Flores-Villela and Vogt 1992; Bille 2001; Pérez-Higareda et al. 2002). DNA sequence data is available only for *A. chiszari*.

The first described member of this clade, *Abronia bogerti*, is known from two specimens found in the Chimalapas highlands. The holotype (AMNH 68887) was collected on an unspecified date in 1948 from "north of Niltepec, between Cerro Atravesado and Sierra Madre, Oaxaca, Mexico, probably between 2,500 and 4,500 feet" (Tihen 1954). The second specimen was photographed and released on 7 July 2000, from Cerro Baúl on land that is politically contested by the Mexican states of Oaxaca and Chiapas (Bille 2001). *Abronia chiszari* is found only in the isolated Sierra de Los Tuxtlas, and is known from three specimens plus three others that were observed but not described. The holotype (UTA R-3195) was collected on 18 August 1962, and a second individual (CNAR 19750, formerly UNAM-LT 3151) was collected on 4 June or 4 July 1986 (Smith and Smith 1981; Flores-Villela and Vogt 1992). Both were found in the western foothills of Volcán Santa Marta. A third specimen of *A. chiszari* (CNAR 19749, formerly UNAM-LT 4057) was taken from Cerro Amayaga on 23 September 1994 (Pérez-Higareda et al. 2002). The most recently described *Scopaeabronia* is *A. ramirezi*, of which only the holotype (IHN 1294, formerly IHN 1177) is available, collected on 20 July 1990 from Cerro la Vela, Municipio de Jiquipilas, Chiapas (Campbell 1994). We provide a map illustrating these localities, along with new localities reported herein (Fig. 1).

During surveys in 2014 and 2015, we observed five additional specimens of *A. bogerti* on the slopes of Cerro Baúl. We also had an opportunity to closely study three *A. chiszari* from the Sierra de Los Tuxtlas. Here, we describe the morphology and color pattern of these new specimens, and present supplemental natural history data when available. We then compare our specimens against existing *Scopaeabronia* material, and find it necessary to revise the diagnostic features of this group. We conclude by discussing potential taxonomic and conservation implications of our findings, and provide an updated diagnosis and key to the clade.

Materials and methods.—We surveyed for reptiles and amphibians on foot, targeting *Abronia*, from 23–25 September 2014 and 29–30 August 2015 on the southwest slopes of Cerro Baúl, a peak in the southeastern part of the Chimalapas highlands. This mountainous region has also been referred to in the literature as the Sierra Atravesada (Bille 2001) and as the southeastern Oaxacan highlands (Campbell 1984). Recent publications place Cerro Baúl in the Municipio de San Miguel Chimalapa, Oaxaca (Bille 2001; Johnson et al. 2015), although these and other sources (e.g., Lamoreux et al. 2015) note that the territory is also claimed by Chiapas. The authorities and residents of the nearest inhabited

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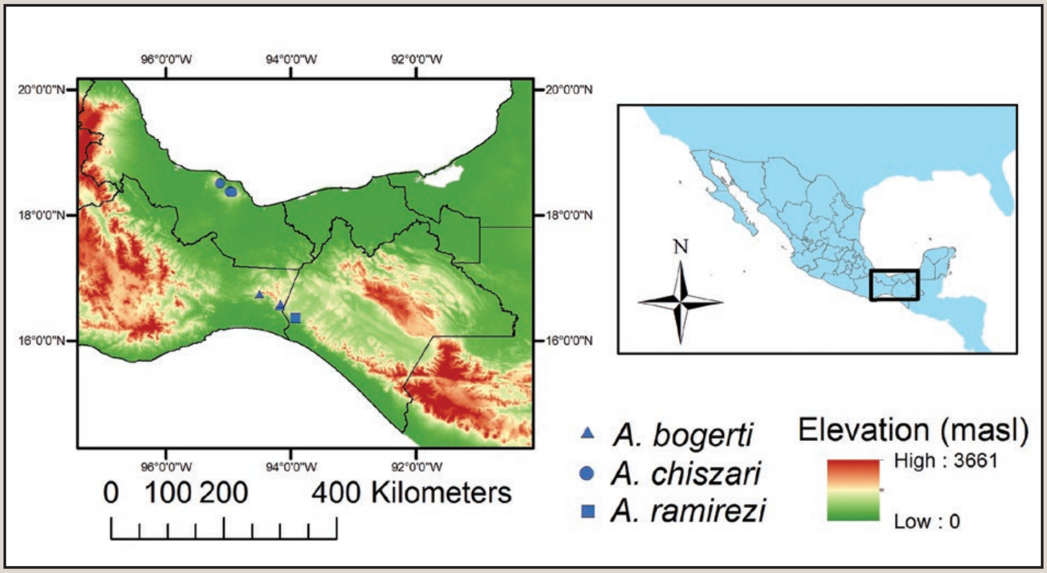

FIG. 1. Map of known localities for the three described species of *Scopaeabronia*.

town of Colonia Rodulfo Figueroa, for instance, are vehement that the entire mountain lies in the Municipio de Belisario Domínguez, Chiapas. Vegetation on Cerro Baúl is a complex matrix of mesic forest variously dominated by *Quercus* spp., *Pinus* spp., and *Liquidambar styraciflua* on the lower slopes, transitioning to mixed tropical cloud forest on the upper slopes and *Cupressus* sp. forest with palms along the summit ridgeline (Fig. 2). Many areas are still regenerating after extensive forest fires in 1998 (Lamoreux et al. 2015), and pastures and maize fields form a patchwork on the mountain's lower slopes.

We supplemented our field work with searches of public museum collections and private live and digital collections, which revealed additional *Scopaeabronia* material.

We fixed one *A. bogerti* specimen in 10% buffered formalin, preserved it in 70% ethanol, and deposited it in the Museo de Zoología "Alfonso L. Herrera," Facultad de Ciencias, Universidad Nacional Autónoma de México (MZFC-HE, formerly MZFC). We are maintaining two additional *A. bogerti* specimens (as yet assigned only field collector numbers) alive in naturalistic enclosures in México, Distrito Federal, for continued behavioral observation until their natural death, whereupon they also will be fixed, preserved, and deposited in the MZFC-HE collection. For animals available only from digital images, we deposited photo vouchers at the Natural History Museum of Los Angeles County (LACM PC; the PC indicates Photo Collection).

We recorded measurements using dial calipers (to the nearest mm). Scale terminology follows Bogert and Porter (1967), and scale count protocols follow Campbell (1982). For bilateral head scales, we recorded counts on both sides, expressed herein as "right/left." Our protocol for counting dorsal body bands is modified from Stebbins (1958): we consider isolated partial bands as 0.5 bands, partly divided "Y-shaped" bands as 1.5 bands, and count all bands that lie fully or ≥ halfway anterior to the posterior border of the thighs. For animals with divergent counts of complete transverse dorsal scale rows on either side of the dorsal midline (due to aberrant fission/fusion), we express this count as a range. We determined sex by manual eversion of hemipenes in life.

Results.—On 24 and 25 September 2014, we observed two live *A. bogerti* and a shed skin of a third individual at two localities separated by 0.8 km (by air) on the southwestern slopes of Cerro Baúl, just to the northwest of the animal captured by Bille (2001). These localities are at 1490 and 1540 m elevation, respectively, with approximate coordinates 16.55°N, 94.17°W (WGS 84). We failed to capture or photograph either live lizard, yet identification was unquestionable. Then on 29 August 2015, at the upper-elevation site within 50 m of where we observed one lizard the previous year, we collected three male *A. bogerti* from separate trees in the span of 40 min.

FIG. 2. View of Cerro Baúl, Mexico, looking east-northeast.

Following these discoveries, we had occasion to examine a subadult male specimen of *A. chiszari* (CNAR 19749, formerly UNAM-LT 4057). The color pattern of this specimen is described elsewhere, but its lepidosis has never been studied (Pérez-Higareda et al. 2002). Furthermore, we took the opportunity to examine photographs of two new adult *A. chiszari* previously held in captivity and collected from vague localities within the Sierra de Los Tuxtlas. One lizard (LACM PC 2016–17) originated from an unknown site in that mountain range, while the other (LACM PC 2013–15) was collected in the year 2000 on the southern or southeastern slopes of Volcán San Martín, at an estimated elevation of 1000 m. The latter animal had been

Fig. 3. *Abronia* (*Scopaeabronia*) *bogerti* specimens from Cerro Baúl, Mexico, illustrating color in life within 24 h of capture. From top to bottom: AGC 926, WSB 1099, MZFC-HE 30037.

previously mentioned in the literature (Heimes 2002; Zaldívar Riverón et al. 2002), but the data we provide here is novel.

From this new material, we assessed all physical features that have been proposed or identified by past workers as diagnostic for *Scopaeabronia* or the clade's represented species. We also include data for all previously known *Scopaeabronia* exemplars. Characters traditionally used for diagnosing *Scopaeabronia* from other clades within *Abronia* are given in Table 1. Characters traditionally used for distinguishing among the three species are given in Table 2.

The three captured *A. bogerti* were variable in coloration (Fig. 3), but with generalizable pattern features as described herein. The dorsal region of the head is mostly gray, becoming tan anterior to the orbits, and hairline black margins are present on some scales. The upper temporals, and postparietals, are predominantly black. The lower temporals are white or cream-colored, with wide to narrow black borders along the anterior and/or ventral margins. Fine black vermiculations adorn many

Table 1. Summary of traits traditionally considered diagnostic of the clade *Scopaeabronia*.

Character	*A. ramirezi* IHN 1294 (IHN 1177) Holotype	*A. chiszari* UTA R-3195 Holotype	*A. chiszari* CNAR 19750 (UNAM-LT 3151)	*A. chiszari* CNAR 19749 (UNAM-LT 4057)	*A. chiszari* LACM-PC 2013–15A	*A. chiszari* LACM-PC 2016–17A	*A. bogerti* AMNH 6887 Holotype	*A. bogerti* (Bille 2001)	*A. bogerti* MZFC-HE 30037	*A. bogerti* AGC 926	*A. bogerti* WSB 1099
lower primary temporals expanded	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	–/Yes	Yes/Yes	Yes/Yes	Yes/Yes
longitudinal rows of nuchals	8	7–8*	8	8	8	8	8	8	8	7–8°	8
transverse dorsal scale rows	39	40–41†	46	45	44–45	46–47	39–40	38	39–40	39–41	42–43
transverse dorsal body bands	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
attenuate body morphology	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
prefrontal-anterior superciliary contact	No/Yes	No/Yes	Yes/Yes	No/No	–/Yes	No/No	No/No(barely)	No/No	No/No(barely)	No/No	No/No
cantholoreal-frontonasal contact	No/No	No/No	No/No	No/No	–/No	No/No	Yes/Yes	No/No	No/No	No/No	No/No
primary temporals contacting postoculars	1/1	1/1	1/1	1/1	1/1	1/1	1/1	–/1	1/1	1/1	2/1
tertiary temporals	4/3	3/3	3/3	3/3	2/3	3/3	2/2	–/4	2/3	3/2	4/4

* = Full fusion (in one row) or partial fusion (in two rows) of two paravertebral nuchal scales leads to a minimum number of seven. All other transverse rows of nuchals number eight scales.

° = Full fusion (in one row) of two paravertebral nuchal scales leads to minimum number of seven. All other transverse rows of nuchals number eight scales.

† = Reported by Campbell (1984) as 39.

TABLE 2. Summary of traits separating the three described species of *Scopaeabronia*.

Character	*A. ramirezi* IHN 1294 (IHN 1177) Holotype	*A. chiszari* UTA R-3195 Holotype	*A. chiszari* CNAR 19750 (UNAM-LT 3151)	*A. chiszari* CNAR 19749 (UNAM-LT 4057)	*A. chiszari* LACM PC 2013–15	*A. chiszari* LACM PC 2016–17	*A. bogerti* AMNH 6887 Holotype	*A. bogerti* (Bille 2001)	*A. bogerti* MZFC-HE 30037	*A. bogerti* AGC 926	*A. bogerti* WSB 1099
anterior internasals	3	2	2	2	–	4	4	4	2	2	2
frontonasal-frontal contact	Yes	No	No	No	Yes (barely)	No	No	Yes	Yes (barely)	Yes	No
lateral supraoculars	2/2	3/3	3/3	3/3	3/3	3/3	4/3	3/3	2/2	2/2	2/2
anterior temporals	3/2	3	3/3	3/3	–/3	3/3	2/2	3/3*	2/2	3/3	3/3
dark body band count	9.5°	11	11	–	11.5	11.5	10–11	8.5[a]	8.5	8	9
dorsal scale keeling	Smooth	Smooth or weakly keeled	Smooth or weakly keeled	Smooth or weakly keeled	Smooth or weakly keeled	Smooth or weakly keeled	Moderately to weakly keeled	Moderately to weakly keeled	Moderately to weakly keeled	Moderately to weakly keeled	Moderately to weakly keeled
longitudinal dorsal scale rows	12	16	15–16	14–15	–	–	14	14	14	14–15	14–15
longitudinal ventral scale rows	10	12	12	12	–	–	10–12†	–	12	10–12‡	12
subdigital lamellae on fourth toe	16/17	18–20	19/19	21/19	–	–	18–19	–	20/20	18/–	18/18
age/sex/SVL	female, adult 93 mm	male, juvenile 41 mm	male, subadult 74 mm	male, subadult 75 mm	female, adult 91 mm	female, adult 105 mm	male, subadult 64 mm	female, adult 87 mm	male, subadult 77 mm	male, adult 94 mm	male, adult 91 mm

* = Reported by Bille (2001) as 2/2.

° = Reported by Campbell (1994) as 10.

[a] = Reported by Bille (2001) as 9.

† = Only one row with 10, near the forelimbs.

‡ = Only one row with 10, and most of the remaining rows alternate 11–12. We exclude from our counts a row of tiny ventral scales on the left side, at the margin of the lateral fold.

Fig. 4. Forest microhabitat occupied by *Abronia (Scopaeabronia) bogerti* on Cerro Baúl, Mexico, illustrating diversity and abundance of epiphytic growth.

scales of the head, particularly the lower temporals. The chin, throat, infralabials, and supralabials are white (sometimes lightly marked with darker flecks), forming a distinct pale lip stripe (sometimes faint) posterior to the orbit. The snout tip is yellow or yellow-green. The body and tail are dull to bright yellow-green, becoming dusky along the dorsal midline and fading to whitish along the posterior flanks. Both body and tail show distinct dark transverse bands, which vary from jet black to medium gray. These bands may be irregular in outline or even divided, are typically expanded dorsally, and rarely extend to the lateral fold. The limbs are colored like the body, but with indistinct dark blotching forming a somewhat reticulated pattern, and never with transverse dark bands. The dorsal finger and toe scales are dark with pale margins, creating a finely banded appearance.

We encountered the five live *A. bogerti* between 1300 and 1645 h, under sunny or partly cloudy skies. All were perched exposed at a height of 3.5–8.0 m on the trunks of oaks, *Quercus* spp., in full shade, partial shade, or full sun. Species-level identification of the two *Quercus* taxa was precluded by the unavailability of fruits. Occupied oaks were ca. 8–17 m tall, with diameter-at-breast-height of 0.10–0.75 m. All lizards were on or near ridgelines, in patches of pure *Quercus* spp. forest nested in a matrix of forest dominated by *Pinus* spp. Epiphytic growth was limited, on both occupied and unoccupied trees. Bromeliads (Bromeliaceae) dominated the epiphytic assemblage, with *Tillandsia juncea* and *T. seleriana* most abundant but with some *T. tricolor* and *T. usneoides* also observed (Fig. 4). Epiphytic tank bromeliads were absent. We also noted unidentified species of epiphytic ferns and orchids, but in far lower abundance than any of the *Tillandsia* spp.

We collected the recently shed skin of an *A. bogerti* ca. 10 m high in the canopy of a large *Quercus* sp. tree, among outer leaves and twigs. Earlier that afternoon, we had observed an adult conspecific on the same tree.

The *A. bogerti* were generally wary in disposition. Three crawled slowly or rapidly up the oak trunk when sighted. Although reported here for the first time in *Abronia*, their movement was reminiscent of many arboreal lizards such as *Corucia zebrata*, *Laemanctus* spp., and chameleons, with the body and head rocking rhythmically at an oblique angle with each step. The remaining two lizards moved little or sat motionless until captured, although they watched us intently. We secured all three captured lizards with a noose. In the hand, the lizards regularly bit, death rolled, and defecated defensively. Observations from two captive individuals, assembled over a period of several months, confirmed the lizards to be strongly arboreal—as expected based on all other *Abronia* species for which data exists (Campbell and Frost 1993). They regularly used their prehensile tail when climbing. Locomotion, both when climbing and on flat surfaces, was highly sinuous. A rapid slithering motion with the limbs appressed to the body was also employed. As reported for *A. ramirezi* (Campbell 1994), the lizards often leapt short distances, particularly when climbing. Both lizards seemed remarkably aware of their surroundings, with a nervous demeanor. When approached, they usually attempted to hide or escape—in contrast to the "relative tameness" in captivity that has been reported for other congeners (Campbell and Frost 1993). When placed together less than a week post-capture, two males became agonistic within minutes, simultaneously biting and holding each other's bodies and tails until we manually separated them. This aggressive behavior is consistent with the findings of controlled male-male encounter trials in the congener *Abronia* (*Abronia*) *vasconcelosii* (Formanowicz et al. 1990).

Discussion.—All of the new material we report here is clearly attributable to *Scopaeabronia*. We base this determination on the presence of seven diagnostic features: 1) expansion of the lower primary temporal scale, such that it is the only primary temporal in contact with the postocular scale series (a second primary temporal is narrowly in contact with the postoculars on specimen WSB 1099 from Cerro Baúl); 2) posterolateral head scales not knoblike; 3) supra-auriculars not protuberant or spinelike; 4) presence of eight longitudinal nuchal scale rows (seven in one row on specimen AGC 926 from Cerro Baúl, the result of a single instance of paravertebral scale fusion); 5) presence of 38 or more transverse dorsal scale rows; 6) presence of distinct transverse dorsal body bands in adults of both sexes; and 7) attenuate body morphology. However, based on this same material, we demonstrate that three traits of lepidosis that were suspected or considered diagnostic by past workers (Tihen 1954; Smith and Smith 1981; Good 1988; Flores-Villela and Vogt 1992; Campbell and Frost 1993; Campbell 1994; Bille 2001) are sufficiently variable to warrant their abandonment as diagnostic aids for the *Scopaeabronia* clade. These diagnostically uninformative traits are: 1) prefrontal-anterior superciliary contact; 2) cantholoreal-frontonasal contact; and 3) number of tertiary temporal scales.

Our series of three *Scopaeabronia* specimens from Cerro Baúl, plus the fourth syntopic individual documented by Bille (2001) show remarkable variability in lepidosis traits considered diagnostic for species-level identification within the clade (Fig. 1, Table 2). Similar variability is expressed in the three *A. chiszari* specimens whose lepidosis we report here for the first time (Table 2). Although sample sizes are small, there is no obvious signal of sex or ontogeny in explaining the variability of either series. Importantly, none of the four Cerro Baúl specimens possesses all traits of the *A. bogerti* holotype previously deemed diagnostic. The same is true for two of the three Sierra de Los Tuxtlas specimens relative to the *A. chiszari* holotype. However, the preponderance of traits displayed by the specimens, both when examined separately and as series, best match *A. bogerti* and *A. chiszari*, respectively (Table 2).

We show that only five morphological traits (a subset of those originally listed by Campbell and Frost [1993]) are now reliable for distinguishing among *A. bogerti*, *A. chiszari*, and *A. ramirezi*. These useful traits are: 1) number of transverse dorsal scale rows; 2) number of longitudinal dorsal scale rows; 3) number of longitudinal ventral scale rows; 4) degree of dorsal scale keeling; and 5) number of subdigital lamellae on the fourth toe. In addition, geography can be used as a supplemental identifier because the three species are allopatric. However, we further demonstrate that four lepidosis traits, which past workers have suspected or considered diagnostic, are sufficiently variable to warrant their abandonment as species-level identifiers within the *Scopaeabronia* clade. These diagnostically uninformative traits are: 1) number of anterior internasal scales; 2) frontonasal-frontal scale contact; 3) number of lateral supraocular scales; and 4) number of anterior temporal scales.

We suspect that once additional comparative *Scopaeabronia* material is secured, some or all of the five remaining morphological traits separating these three species may also prove diagnostically uninformative. Moreover, we note that a continuous arc of forested or historically forested highlands above 800 m elevation (presumably suitable for *Scopaeabronia*) connects Cerro Baúl to Cerro la Vela. It is therefore plausible that *A. bogerti* and *A. ramirezi* might, in fact, represent clinal extremes of a single variable species. Barring improved geographic sampling, and pending the availability of a genetic sample of *A. ramirezi*, however, we refrain from recommending any taxonomic changes at this time.

The adult male *A. bogerti* specimen (AGC 926) is the largest and heaviest wild *Scopaeabronia* on record at 94 mm SVL and 12.7 g. One of the *A. chiszari* (LACM PC 2016–17) is even larger and heavier at 105 mm SVL and 20 g—but its mass was likely artificially influenced by captive conditions. Previously, the largest known *Scopaeabronia* was the adult female holotype of *A. ramirezi* (IHN 1177) at 93 mm SVL. This finding suggests that *Scopaeabronia* likely are not as miniaturized relative to other *Abronia* as previously thought. However, their body form is still consistently more elongate and slender relative to all other *Abronia* species.

Our documentation of *A. bogerti* from 1540 m elevation is marginally the highest ever recorded for *Scopaeabronia*, exceeding the previous record of ca. 1500 m (Bille 2001). The congener *Abronia (Abaculabronia) ornelasi* is known from 1500–1600 m elevation on Cerro Baúl (Campbell 1984). This finding indicates that *A. bogerti* is effectively sympatric with *A. ornelasi*, as suggested by Bille (2001). However, ecological niche divergence within the complex forest matrix on Cerro Baúl may preclude syntopic occurrence of these two species, as indicated by Campbell and Frost (1993). Only two prior cases of sympatry in *Abronia* have been documented, both of them from Guatemala (Campbell and Frost 1993; Peterson and Nieto-Montes de Oca 1996; Torres et al. 2013).

The isolated Sierra de Los Tuxtlas consists of two major peaks: Volcán San Martín to the west and Volcán Santa Marta to the east. A series of much smaller volcanic cones stretches between them, and just to the east lies a third, mid-sized peak (Volcán San Martín Pajapan). Smith and Smith (1981) indicated that *A. chiszari* might occur only on the slopes of Volcán Santa Marta, and Flores-Villela and Vogt (1992) confidently predicted the species' absence elsewhere in the Sierra de Los Tuxtlas. The later discovery of *A. chiszari* from Cerro Amayaga, midway between the two major peaks, cast that assertion into question (Pérez-Higareda et al. 2002). The additional *A. chiszari* individual we report here (LACM PC 2013–15), from an imprecise locality somewhere on the lower slopes of Volcán San Martín, strongly suggests that the species is distributed throughout the Sierra de Los Tuxtlas.

The conservation status of the *A. bogerti* population on Cerro Baúl is worrisome. Although extensive tracts of largely undisturbed forest remain on this and nearby peaks, clear cuts for pastures and agriculture approach within 100 m of both sites where we documented *A. bogerti*. Charcoal production, focusing on the very oaks that appear to be preferred habitat for *A. bogerti*, is also an active and growing industry in the nearby town of Colonia Rodulfo Figueroa. No government-protected area exists anywhere in the Chimalapas highlands. We strongly recommend the establishment of a formal forest reserve on Cerro Baúl, in close consultation with local residents. Creation of such a protected area would help safeguard the only known extant populations of *Abronia ornelasi*, *A. bogerti*, and the plethodontid salamander genus *Ixalotriton*, along with the northernmost populations of the birds *Pharomachrus mocinno* and *Oreophasus derbianus*, and a globally important population of *Tapirus bairdii* (Lamoreux et al. 2015). We recognize, however, that the volatile political situation in the region must be resolved before creation of a reserve will be tenable.

Due to their rarity and attractive appearance, *Abronia* have been commercialized by hobbyists in Mexico and abroad. We encourage those who maintain captive *Abronia*, and especially *Scopaeabronia*, to make their animals available for scientific study—in keeping with standards proposed for zoological parks (Reid 2013; Spindler and Wisziewski 2013). In this report, we illustrate the significant value of even a few additional specimens for improving knowledge of basic biology and morphology in this enigmatic genus. An accurate understanding of truly diagnostic features is particularly relevant for conservation, given the protected legal status of most *Abronia* in Mexico and officials' need to accurately identify animals in the pet trade.

We conclude by presenting an updated dichotomous key to the three species of *Scopaeabronia*. This revised key is intended to replace couplets 19 and 20 in the key to the genus *Abronia* available in Campbell and Frost (1993). We preface our key with a diagnosis of the clade, again modified from Campbell and Frost (1993).

Diagnosis: *Scopaeabronia* is distinguished from all other members of the genus *Abronia* by four synapomorphies: 1) presence of eight longitudinal nuchal scale rows of similar size (a few paravertebral nuchal scales may be aberrantly fused to produce seven rows); 2) presence of 38 or more transverse dorsal scale rows; 3) presence of distinct transverse dorsal body bands on adults of both sexes; and 4) attenuate body morphology. The clade is further diagnosed by the possession of three additional features, which individually may be shared with certain other congeners: 1) posterolateral head scales not strongly convex or knoblike; 2) supra-auricular scales not protuberant or spinelike; 3) lower primary temporal greatly enlarged relative to upper primary temporal scales, and only the lower primary temporal in contact with the postocular scales.

1(a). Longitudinal dorsal scale rows 12, longitudinal ventral scale rows 10, dorsal scales smooth, subdigital lamellae on fourth toe 17 or fewer..*Abronia ramirezi*

1(b). Not with above combination of characters. Generally with higher longitudinal scale row counts and more subdigital lamellae. Dorsal scales may be weakly or moderately keeled ……………………………......…………………………….......2

2(a). Dorsal scales mostly smooth (vertebral and paravertebral scales sometimes weakly keeled), dorsal transverse scale rows 40–47. Known only from the Sierra de Los Tuxtlas, Veracruz, Mexico ....*Abronia chiszari*

2(b). Dorsal scales mostly keeled (vertebral and paravertebral scales moderately so), dorsal transverse scale rows 38–43. Known only from the Chimalapas highlands of Oaxaca and Chiapas, Mexico..*Abronia bogerti*

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Vocal Repertoire and Calling Activity of a Dwarf Clawed Frog (*Hymenochirus boettgeri*)

Most anurans (frogs and toads) are highly vocal, and rely on acoustic communication to mediate social interactions and mate choice (Ryan 2001; Gerhardt and Huber 2002; Wells 2007). Many species have vocal repertoires consisting of several different types of calls produced in different behavioral contexts (reviewed in Wells 2007). The most commonly uttered vocalization is the advertisement call, whose primary function is to attract conspecific females from a distance. In some species, males and females produce close-range courtship calls that can further influence mating decisions. Many species also have release calls; these are vocalizations given by either other males or unreceptive females when clasped by a male, and function to facilitate release from unwanted amplexus (Tobias et al. 2014). Vocalizations are also involved in mediating male-male interactions. The advertisement call, and frequently also special aggressive or encounter calls, may function in determining inter-male distances within the chorus or settle disputes over calling sites and territories (reviewed in Wells 2007). Thus, vocalizations play important roles in sexual selection by both female choice and male-male competition. Despite the obvious importance of vocalizations for the behavioral ecology of frogs and toads, detailed descriptions of the vocal repertoire and patterns of calling activity are available for only a relatively small subset of species (Bee et al. 2013). Yet, such descriptions can give a better idea about the richness of social interaction found in anurans, and guide further research on topics ranging from mate choice to call evolution and systematics to community ecology.

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There is considerable diversity of calls and larynx morphologies among frogs, but the vast majority of species produce airborne vocalizations; here, a call is produced by moving air from the lungs through the glottis and call production is associated with the conspicuous inflation of the male's vocal sac (Duellman and Trueb 1994). A notable exception from this general pattern occurs in frogs of the family Pipidae, which includes the South American Surinam toads (genus *Pipa*) and the African clawed frogs (genera *Hymenochirus, Silurana, Xenopus*, and *Pseudhymenochirus*). Pipids are fully aquatic frogs, with unique biology, morphology, and call production mechanism (Cannatella and Trueb 1988; Yager 1992). As a consequence of their unique call production mechanism, which relies on bony rods in the larynx to produce clicking sounds (Yager 1992), vocalization occurs largely without externally visible movements of the flanks or throat (Rabb 1960; Österdahl and Olsson 1963; Rabb and Rabb 1963; Weygoldt 1976; but see Irisarri et al. 2011). This motionless calling is performed underwater making it next to impossible to ascertain which individual is producing the vocalization, thus hindering observations of behavioral interactions. Despite these difficulties, advertisement calls have been described for 22 species of *Silurana* and *Xenopus* frogs (Tobias et al. 2011), and the data suggests a rich and varied vocal repertoire. The temporal structure of their calls varies from simple single clicks to complex calls with two temporal patterns, and some species have vocal repertoires consisting of multiple call types (Tobias et al. 1998; Tobias et al. 2011; Tobias et al. 2014). For example, in *Xenopus laevis,* the most well-studied species of the clade, females produce two types of calls (ticking and rapping calls), and males produce six types of calls (advertisement call, amplectant call, answer call, chirps, tick,s and growls). Chirps are given during male-male interactions, and growling accompanies male-male clasping and may function as a release call (Tobias et al. 2004; Tobias et al. 2014).


FIG. 1. Male *Hymenochirus boettgeri*.

The objective of this study was to provide a quantitative description of the vocal repertoire of the Dwarf Clawed Frog *Hymenochirus boettgeri*, and to ascertain the social contexts in which each vocalization is produced. Previous studies on the reproductive behavior of this species have focused on their use of chemical communication (Pearl et al. 2000), yet males do call and the function of these calls is largely unknown (but see Österdahl and Olsson 1963; Rabb and Rabb 1963). We staged different social contexts (solitary, single sex groups, mixed sex groups), and collected automated recordings using a hydrophone to sample patterns of calling activity and types of vocalizations to decipher the communicative significance of acoustic signals in the social behavior of this species.

METHODS

Study animals and recording setup.—We conducted the study between 14 February and 6 April 2011 with *H. boettgeri* frogs (Fig. 1; N = 5 females and 15 males) obtained from a local pet store (Hoffer's Tropical Life Pets, Milwaukee, Wisconsin, USA). All 20 frogs were obtained at the same time, making it likely that they came from the same supplier and were related. We housed animals in same sex groups in four 57-L aquariums with gravel, live plants, and PVC pipes as hiding places. Each of these maintenance tanks contained a small filter and a heater

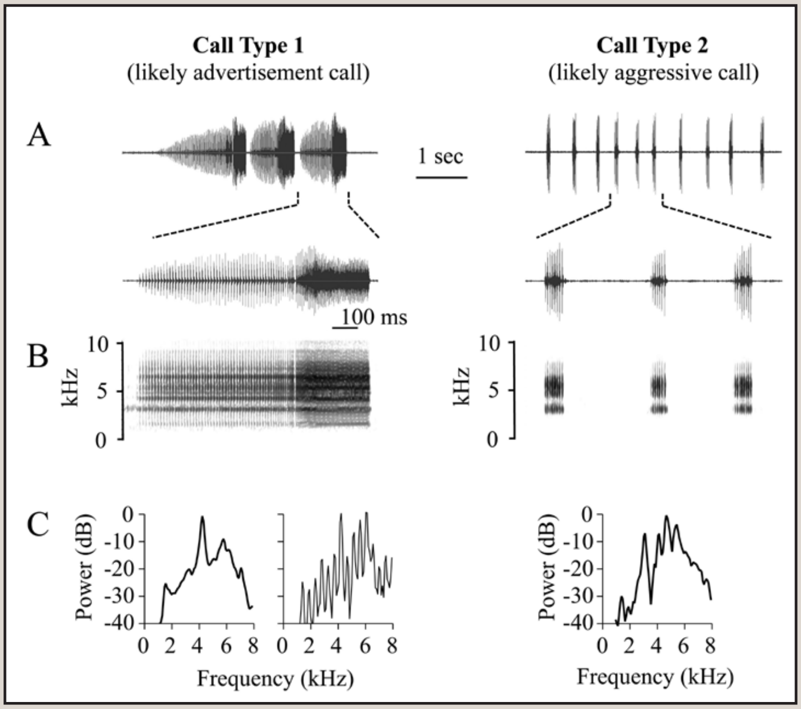

FIG. 2. Calls of *Hymenochirus boettgeri.* A) Waveforms of a call sequence of Type 1 calls (left, top trace: three calls of one male; bottom trace: zoomed in view of one call) and of Type 2 calls (right, top trace: 11 calls of one male; bottom trace: zoomed in view of three calls). B) Spectrograms of a Type 1 call (left) and three Type 2 calls (right). C). Powerspectra of the two elements of a Type 1 call (left), and of a Type 2 call (right).

that maintained the water temperature at 25°C. Tanks were illuminated by strip lights with a 12 h/12 h light/dark cycle, set to switch on at 0800 and off at 2000 hrs.

We recorded frog calls with a Song Meter MS2 hydrophone connected to a Song Meter SM2+ automated recorder (Wildlife Acoustics, Inc., Massachusetts, USA). The recorder was programmed to record for 10 minutes every hour at the hour. The recording tank was housed in the same room as the maintenance tanks. The maintenance tanks and the recording tank were similar in setup, except that the filter was switched off during recording sessions to improve recording quality.

Experimental design.—We examined the importance of sex and social context on calling activity and call type production by comparing recordings that were obtained when the recording tank contained (i) only one female (N = 3; each recorded for 24 h); (ii) only one male (N = 3; each recorded for 24 h); (iii) a group of two males (N = 3 groups, comprised of different combinations of individuals; each group recorded for 24 h); or (iv) a mixed sex group of two males and one female (N = 4 groups; different combinations of individuals; recorded for 1 d, 2 d, 5 d, and 11 d, respectively). In general, we did not re-use frogs across treatments, except for two females that participated in both the female only and the mixed sex groups, and two males that participated in the two-male treatment and then, after adding a female, were also recorded in the mixed sex treatment. In total we obtained 660 10-min recordings, 43% of which contained at least one vocalization.

We first conducted a qualitative analysis of the vocal repertoire by grouping vocalizations into categories based on auditory and visual (spectrograms) comparison (Fig. 2). To obtain a quantitative description of the calls in the vocal repertoire, we subsequently selected 10 calls of each call type from 10 different males for detailed analysis (i.e., we analyzed a total of 100 Type 1 and 100 Type 2 calls). We selected calls for detailed analysis based on optimal signal-to-noise ratio. Although we did not mark frogs for individual identification, the sequential nature of the recording sessions, and the fact that we did not re-use males in subsequent trials, allowed us to assign recordings to different males. For recordings from treatments that had more than one male calling at the same time in the recording tank, we used relative amplitude to assign calls to different males. Although this did not allow us to assign calls to individual males, it still meant we analyzed calls from different individuals (which is adequate for our purpose of describing a species' call repertoire). We analyzed calls with Raven Pro v.1.3 (Cornell Lab of Ornithology), and measured the following call properties: (i) number of calls per bout (calls were generally given in bouts of several calls), (ii) call duration (time from onset of call to offset of call), (iii) call period (time from onset of call to onset of following call), (iv) pulse period (time from onset of pulse to onset of following pulse; Nota Bene: this call trait is referred to as "pulse" in the general frog call literature, but often called a "click" in descriptions of pipid frog calls), and (v) dominant frequency (measured separately for each call element in the Type 1 calls; see below). General descriptions of the call types and their variability are based on the raw data (N = 100 calls / type). We then calculated averages for the calls of each male (N = 10), and used those average values to compare traits between call types. Because we would not have been able to attribute a call on our automated recordings to a specific caller's identity (except in the three single male trials), we did not measure male size, and can therefore not test whether certain call properties are correlated with body size.

We further analyzed the pattern of calling activity. For this we scored each of the 660 recordings for the presence or absence of calls (scored as 1 or 0, respectively); if vocalizations were detected, we further scored them for the call type that was given. We only scored presence/absence of call type, not number of calls per recording.

Statistical analysis.—We compared the different elements of the Type 1 call, as well as the two call types overall. Type 1 calls are complex calls. To test whether the two elements comprising a Type 1 call are different, we used a mixed model (Standard Least Squares; EMS), with an α of 0.05. We entered different call parameters as response variables, and call element and male ID as fixed factors (we entered male ID to account for the fact that each male contributed data for both the first and second call element). Although some comparisons showed unequal variances, we did not correct for that because mixed models are robust to violations of statistical assumptions.

When comparing different call types, we visually inspected histograms to verify normal distribution, and used Levene's test to check for equal variances. We then compared data showing equal variances using ANOVA, and those showing unequal variances using Welch ANOVA. We compared overall call duration, pulse period and dominant frequency between Type 1 and Type 2 calls, using an α of 0.05. Because Type 1 calls are complex calls whose two call elements differ in pulse period, we ran this comparison with the Type 2 call twice, once comparing the first, and once the second element of the call. For this comparison we adjusted the α to 0.025. All statistical analyses were computed in JMP Version 8.0 (SAS Institute, Inc., Cary, North Carolina, USA).

Results

Call repertoire.—Solitary males, and males in groups (e.g., two-male and mixed sex treatments) called spontaneously, and we identified two call types (Table 1, Fig. 2) with putatively discrete communicative significance. Recordings from solitary females never registered any vocalizations. Recordings of mixed sex groups did not contain additional vocalizations that had not also occurred in recordings from the two-male treatment, suggesting that females also did not vocalize in social settings.

A representative Type 1 call is shown in Fig. 2 (left) (see also Table 1). Type 1 calls can occur singly, but are generally given in a few calls per bout. These calls are characterized by having a complex call structure (two elements). The first element has a longer call duration and pulse period than the second element (Fig. 3A, B). The dominant frequency of the two call elements is not significantly different (Fig. 3C), but the second element can have a slight upward frequency sweep, and generally shows visible harmonics (see Fig. 2C). Acoustically this call resembles the sound made by repeatedly twisting the cork of a wine bottle.

A representative Type 2 call is shown in Fig. 2 (right). Type 2 calls are given in more calls per bout, and are characterized by having a simple call structure (one element). Acoustically these calls resemble a repeated "kreek" sound. Type 2 calls have a higher number of calls per bout, shorter call duration, and shorter call period (Table 1, Fig. 4A, B, C). The dominant frequency does not differ between call types (Fig. 4D), but note the frequency composition (i.e., density of harmonics) is quite different between the calls (see Fig. 2C). The pulse period of Type 2 calls is similar to that in the first call element of Type 1 calls, but longer than the pulse period in the second element of Type 1 calls (Fig. 4E). Overall, Type 1 calls are given more frequently than Type 2

Table 1. Parameters of the two call types recorded from *Hymenochirus boettgeri* males; presented are mean ± SD and the range (in parenthesis).

Call Parameter	Call Type I	Call Type II
# Calls /Bout	5.6 ± 3.3 (1–14)	29 ± 21 (14–84)
Call Duration	908 ± 371 ms (168–2542 ms)	73 ± 27 ms (22–277 ms)
Call Period	1024 ± 399 ms (223–2576 ms)	413 ± 167 ms (110–1186 ms)
# Call Components	2	1
Duration		
1st Component	605 ± 357 ms (168–2100 ms)	
2nd Component	305 ± 78 ms (168–578 ms)	
Rel. Duration 1st Component (%)	57 ± 14 % (35–89)	
Pulse Period		
1st Component	8.5 ± 1.4 ms (5.3–12.8 ms)	8.0 ± 1.1 ms (6.2–13.6 ms)
2nd Component	3.6 ± 1.4 ms (1.9–6.7 ms)	
Dom Frequency		
1st Component	5169 ± 813 Hz (3989–6288 Hz)	5081 ± 603 Hz (3101–6424 Hz)
2nd Component	5091 ± 745 Hz (4048–6289 Hz)	
Relative Amplitude (Ampl. 2nd – 1st Component)	3.1 ± 6.1 dB (-15.2–13.2 dB)	

calls (Fig. 5). While either call type can be heard in isolation, Type 2 calls are generally associated with Type 1 calls: 91.4 % of times we observed Type 2 calls, they occurred on the same recordings that also contained Type 1 calls ($r = 0.67$, $P = 0.0004$). No call type was specific to the mixed-sex group social context, i.e., whenever two males were together both call types could be heard, and the presence of a female did not result in additional call types. Sometimes males produce intermediate calls that started as Type 1 calls, but ended as Type 2 calls; the reverse (starting as Type 2 and ending as Type 1) was never observed.

Calling activity.—In both solitary males (Fig. 5A) and groups of males (Fig. 5B, C), calling activity peaked during the early nighttime hours. For solitary males, only Type 1 calls were registered (Fig. 5A), while both call types were registered for groups of two males, and mixed-sex groups (Fig. 5B, C). Calling activity of Type 1 calls increased and peaked earlier than Type 2 calls (Fig. 5), and this pattern was particularly prevalent in mixed-sex groups (Fig. 5C). In trials where no female was present, calling activity of Type 1 calls (Fig. 5A,B) showed a narrower peak (3–5 h/night), while high calling activity persisted over a longer period of time when females were present (about 9 h/night, Fig. 5C).

Discussion

In anurans, vocal repertoires can be complex and comprise several distinct call types (Höbel 2000; Narins et al. 2000; Christensen-Dalsgaard et al. 2002; Feng et al. 2002; Tobias et al. 2004). Nevertheless, most species seem to have only two or three call types in their repertoire (Rand and Ryan 1981; Wells and Greer 1981; Kanamadi et al. 2001; Bee et al. 2013). We found that the vocal repertoire of male *H. boettgeri* contains at least two call types, with probably different communicative significance. However, because we never observed mating / amplexus during our trials, it is possible that we did not capture the entire vocal repertoire of this species. Although we currently do not know the different functions (if any) of the two described call types of *H. boettgeri* with certainty, comparison with other frogs allows us to speculate about their putative functions.

Advertisement calls serve the dual function of attracting females and advertising male position to other males (Gerhardt and Huber 2002; Wells 2007), and, in *Xenopus*, they also serve to suppress calling in conspecific males (Tobias et al. 2010). Four observations suggest that the Type 1 call of *H. boettgeri* is the species' advertisement call. First, Type 1 calls are the most frequently given call type. Second, this call type was registered in all social contexts suggesting that it is geared towards both males and females. Third, in the absence of competition (i.e., solitary males), only Type 1 calls occurred; this rules out an encounter or aggressive function of this call type. Fourth, in trials where a female was present, high calling activity of Type 1 calls persisted over a longer period of time than in trials that did not include a female, suggesting that the presence of females motivated males to call.

Generally, the dual-purpose function of advertisement calls (mate attraction / male position advert) is achieved with a "simple call," i.e., a call consisting of one uniform acoustical element (Gerhardt and Huber 2002; Wells 2007). In some species, however, such as the Puerto Rican Coqui (*Eleutherodactylus coqui*) or the Túngara Frog (*Physalaemus pulstulosus*), males produce "complex calls" comprised of two acoustically distinct elements. Here, one element is geared more towards males, and the other more towards females (Narins and Capranica 1976, 1978; Rand and Ryan 1981). The Type 1 calls of *H. boettgeri* consist of two acoustically different call elements, i.e., they are complex calls, and the different call elements may have different intended receivers and serve different communicative purposes. Because the first call element of the Type 1 call is more similar to the Type 2 call, spectrally and in its fine pulse structure, we speculate that the first element is directed towards males, and the second is directed towards females. Playback experiments are needed to verify this hypothesis.

Type 2 calls were not observed in recordings of solitary males, suggesting that it is not another type of advertisement or courtship call. Rather, because Type 2 calls were only observed in situations where two males could interact with each other both vocally and physically, this vocalization could be a release call or an aggressive call. Since we did not conduct visual observations concurrent with the acoustic sampling, we do not know whether the Type 2 call was given only in response to clasping attempts between males, i.e., whether this call type is a release call. Additional experiments, either via visual surveys or by having males in the same tank, but physically separated by chemically and acoustically transparent dividers, would be needed to confidently exclude the possibility that this call type is a release

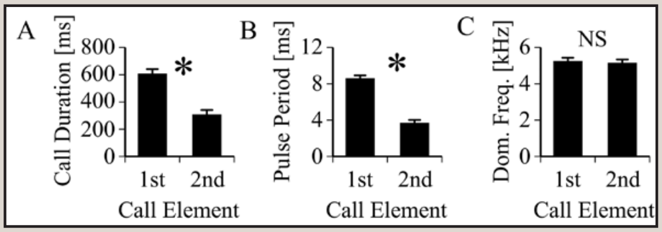

Fig. 3. Differences between the first and second element of Type 1 calls. A) Duration ($F_{1,19}$ = 28.97, $P < 0.0001$) and (B) pulse period ($F_{1,19}$ = 67.77, $P < 0.0001$) were significantly different between the two elements of the Type 1 call, but (C) dominant frequency was not ($F_{1,19}$ = 0.09, $P = 0.77$). Shown are least square mean + SE. Significant differences indicated by asterisk. Male ID was never significant (data not shown).

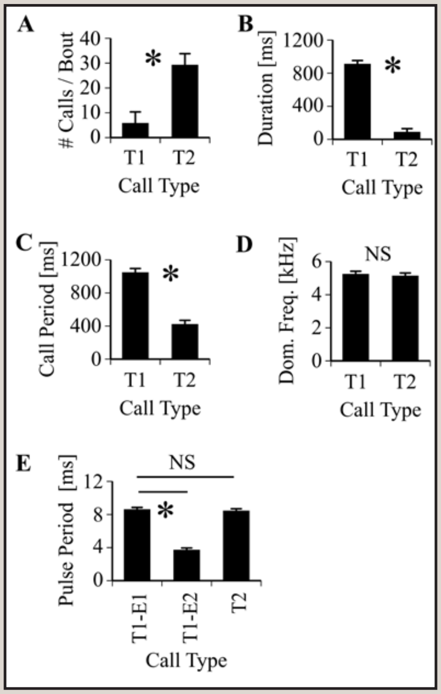

Fig. 4. Differences between the two call types. A) The number of calls per bout (Welch ANOVA: $F_{1,9.44}$ = 11.82, $P = 0.007$), (B) call duration (Welch ANOVA: $F_{1,9.47}$ = 136.5, $P < 0.0001$), and (C) call period (Welch ANOVA: $F_{1,9.94}$ = 62.6, $P < 0.0001$) were significantly different between call types. D) Pulse period of the Type 2 call was not different from the first element of the Type 1 call (ANOVA: $F_{1,19}$ = 0.12, $P = 0.74$), but significantly different from the second element of the Type 1 call (Welch ANOVA: $F_{1,13.33}$ = 111.3, $P < 0.0001$). E) Dominant frequency also did not differ between call types (ANOVA: $F_{1,19}$ = 0.13, $P = 0.73$), but note the difference in frequency composition between the calls (see Fig. 2C). Shown are mean ± SE. Significant differences indicated by asterisk.

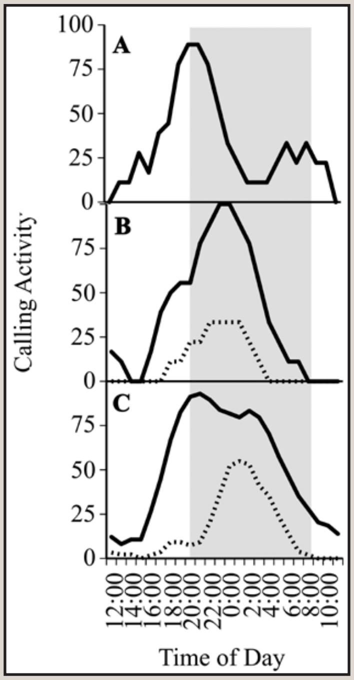

Fig. 5. Calling activity of single males (A), groups of two males (B) and mixed-sex groups (C). Calling activity of Type 1 calls is shown as solid black line, that of Type 2 calls in dashed line. The shaded area indicates periods of darkness (i.e., lights out).

call. However, since only the clasped male should produce a release call, yet we have several recordings where both males were giving this call simultaneously, we think it is more likely that the Type 2 call is the species' aggressive call.

Aggressive calls can be distinct or graded. In graded aggressive calls, an increase in aggressive intent is reflected by the addition of more calls or call notes (Wagner 1989; Wells 1989). For example, male Blanchard's Cricket Frogs, *Acris creptians blanchardi*, respond to increased sound pressure level of rival male calls (i.e., to increased rival proximity) by producing progressively longer call bouts, longer calls with more pulses, and more pulse bouts per call (Wagner 1989). The call bouts of *H. boettgeri* Type 2 calls can range in size from 14–84 calls/bout, suggesting the presence of a similarly graded aggressive call display.

Although we suggest that Type 2 calls are involved in antagonistic interactions between males, the particular behavioral context is less clear. Since Type 2 calls increase in prevalence only after the activity of Type 1 calls is already increased or peaked, these calls probably do not function in regulating inter-male distances during nightly chorus establishment, as is the case with aggressive calls during chorus formation in many species of frogs (Wells 2007). There, aggressive calls occur more frequently during the initial portion of nightly chorus formation, and diminish in prevalence once calling sites are established and males switch to giving predominantly advertisement calls (Dyson and Passmore 1992). The concurrent nature of both call types in *H. boettgeri* also suggest that Type 2 calls are not involved in call suppression behavior similar to the one described for another pipid frog, *Xenopus laevis*, where after initial chorus formation males induce rivals to fall silent until only the dominant male remains calling (Tobias et al. 2010).

Multimodal communication in anuran amphibians.—In contrast to the large number of studies on chemical communication in caudate amphibians (reviewed in Houck 2009), there are few documented examples of the use of chemical communication in adult anurans (review: Belanger and Corkum 2009). Nevertheless, some adult anurans use chemical cues for sex recognition and mate attraction (Wabnitz et al. 2000; Waldman and Bishop 2004; Asay et al. 2005; Byrne and Keogh 2007), and *Hymenochirus* frogs are among the few species for which chemical mate attraction has been experimentally documented (Pearl et al. 2000). *Hymenochirus* mate attraction chemicals are produced by the postaxillary breeding glands of adult males (Pearl et al. 2000), which develop during sexual maturation and enlarge during the breeding season (Rabb and Rabb 1963). In a y-maze, female *Hymenochirus* showed positive chemotaxis to water housing males with intact breeding glands, but females showed no reaction to water housing breeding gland-ablated males. Further, males showed no response to water housing either females or other males, indicating that the chemical cues are a female attractant, and not a signal geared towards males (i.e., neither a male repellent nor a species aggregation signal that attracts other male to a breeding site) (Pearl et al. 2000).

The presence of a mate-attraction chemical (Pearl et al. 2000), along with acoustic advertisement calls (Österdahl and Olsson 1963; Rabb and Rabb 1963; this study) suggests that *Hymenochirus* frogs use multiple sensory modalities in their reproductive behavior. To date the relative importance of chemical and acoustic signals is unclear, and we do not know whether either signal by itself, or a combination of both, is necessary for successful mate attraction and pair formation. It is possible that the chemical signal attracts the female to the breeding site, but that acoustic signals are subsequently used to localize males at the breeding site, or to choose among several males in the chorus. Conversely, calls could attract females to the chorus, and once there, females could use the chemical signal to choose among males.

The mate attraction efficacy of chemical and acoustic signals depends on water movement, microhabitat structure, and environmental background noise, as well as on the proximity of mate searching females. Variation in these environmental conditions may have played a role in the evolution of this multimodal communication system, and may still be important in determining the relative role each modality plays for mate choice. Although studies on multimodal communication in anurans have focused mainly on visual signals (Taylor et al. 2008; Starnberger et al. 2014), there are some examples of the use of vibrational (Lewis et al. 2001; Caldwell et al. 2010) and water-surface waves (Walkowiak and Münz 1985; Seidel et al. 2001; Höbel and Kolodziej 2013) to signal conspecifics. The uncommon (for anurans) use of chemical signals, combined with the small, yet complex vocal repertoire (complex call structure of the putative advertisement call, and probably graded aggressive call) suggest *Hymenochirus* frogs may be fruitful study subjects for examining the evolution of multimodal communication in anurans.

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Diet Composition of Southeast Asian Fanged Frogs of the *Limnonectes kuhlii* Species Complex

Post-metamorphic anurans are generally considered carnivorous, though some cases of frugivory and herbivory have been documented (Pertel et al. 2010). Various feeding strategies exist among anurans including sit-and-wait predation, active foraging, and opportunistic feeding (Duellman and Trueb 1986). Fanged frogs (Anura, Dicroglossidae) allied to the *Limnonectes kuhlii* (Tschudi 1838) complex are distributed throughout Southeast Asia and little is known about their feeding behavior and diet. Recent systematic work on this species complex has revealed that what was considered a single, widely distributed species for the past two centuries is actually a non-monophyletic group comprising more than 24 distinct evolutionary lineages (McLeod 2010). Several lineages occur in syntopy, and questions regarding niche partitioning are of particular interest in these cases.

Generally, frogs of the *L. kuhlii* complex are known to occur primarily in riparian habitats and seem to be tied closely to these aquatic environments. Based on field studies of multiple species in Thailand, Malaysia, and Brunei, specimens are most frequently collected and observed sitting on the banks of streams, in shallow water at the edge of streams, in the shelter of boulders in high-flow stream conditions, or in lotic pond-like habitats associated with nearby streams. Rarely are individuals encountered in the forest habitat surrounding these aquatic environments. Unpublished data (DSM) suggests that these frogs are never more than 30 m away from water. Limited available information (McLeod 2009) and opportunistic observations (DSM) suggest that species of this complex may be sit-and-wait predators. One species, *Limnonectes megastomias* (McLeod 2008), was found to prey upon invertebrates, mollusks and even larger prey such as birds (McLeod 2009). The purpose of this work is to provide an initial assessment of the diet of different species of the *Limnonectes kuhlii* complex. Herein we document the diets (by way of gut content analyses) of 19 individuals representing nine species within the *L. kuhlii* complex.

Materials and Methods.—We analyzed gut contents from 19 specimens that were eviscerated for the purpose of producing osteological materials for use in another study. Specimens were collected in the field by a variety of people utilizing different methods of euthanasia, fixation, and preservation. In some cases individual animals were kept for only a few hours prior to euthanasia whereas in others individual animals may have remained in captivity without feeding for 12–24 h. Specimen data is presented in Table 1. Identified stomach contents are presented in Table 2. Lineage names follow those of McLeod (2010). Specimens examined and their respective gut contents

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Table 1. Specimens examined of the *Limnonectes kuhlii* complex. Lineage names and numbers correspond to those of McLeod (2010). Materials were loaned from California Academy of Sciences (CAS), Field Museum of Natural History (FMNH), Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology (IEBR), University of Kansas Biodiversity Institute (KU), Louisiana State University (LSU), and Vietnam National Museum of Nature (VNMN).

Species	Voucher Number	Sex	SVL (mm)	Location
L. kuhlii (1)	LSU 81895	F	62.6	West Java Prov., Indonesia
Lineage 4	FMNH 262723	M	55.8	Ratanakiri Prov., Cambodia
	FMNH 262730	F	61.7	Stung Treng Prov., Cambodia
Lineage 5	FMNH 258507	F	54.4	Xe Kong Prov., Lao PDR
	FMNH 258508	M	53.6	Xe Kong Prov., Lao PDR
L. bannaensis (8)	IEBR A.2014.33	M	67.6	Ha Giang Dist., Vietnam
	KU 292029	M	80.5	Guangxi Prov., China
	VNMN A.2015.44	F	51.4	Ha Giang Dist., Vietnam
	VNMN A.2015.47	F	57.1	Ha Giang Dist., Vietnam
L. longchuanensis (9)	CAS 210195	F	72.1	Sagaing Div., Myanmar
	CAS 221808	M	69.7	Shan State, Myanmar
L. megastomias (10)	KU 307774	M	104.8	Nakhon Ratchasima, Thailand
	KU 307775	F	71.4	Nakhon Ratchasima, Thailand
	KU 307776	F	80.1	Nakhon Ratchasima, Thailand
L. isanensis (11)	FMNH 266212	F	56.3	Loei Prov., Thailand
	FMNH 266218	M	86.4	Loei Prov., Thailand
L. taylori (12)	CAS 230949	M	46.1	Shan State, Myanmar
L. nguyenorum (13)	VNMN A.2015.3	F	36.5	Ha Giang Dist., Vietnam
	IEBR A.2015.3	M	43.5	Ha Giang Dist., Vietnam

Table 2. Stomach contents of the *Limnonectes kuhlii* complex. The total number of prey items is followed by the number of stomachs containing each taxon in parentheses. Lineage names and numbers follow McLeod (2010), and are abbreviated as follows: LIK = *L. kuhlii*, L4 = Lineage 4, L5 = Lineage 5, LBA = *L. bannaensis*, LLO = *L. longchuanensis*, LME = *L. megastomias*, LIS = *L. isaneasis*, LTA = *L. taylori*, LNG = *L. nguyenorum*.

Species/lineage	LIK	L4	L5	LBA	LLO	LME	LIS	LTA	LNG
Sample size	1	2	2	4	2	3	2	1	2
Food Type									
PHYLLUM ARTHROPODA									
Coleoptera	0 (0)	0 (0)	1 (1)	7 (2)	4 (1)	0 (0)	2 (2)	0 (0)	1 (1)
Lepidoptera	2 (1)	0 (0)	0 (0)	1 (1)	2 (1)	0 (0)	23 (1)	0 (0)	0 (0)
Odonata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	0 (0)	1 (1)
Hymenoptera	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	2 (1)	0	0 (0)	0 (0)
Formicidae	0 (0)	2 (1)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	2 (1)
Isoptera	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	221 (2)	0	0 (0)	0 (0)
Orthoptera	0 (0)	0 (0)	0 (0)	4 (3)	2 (2)	1 (1)	2 (2)	0 (0)	0 (0)
Hemiptera	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0	0 (0)	0 (0)
Reduviidae	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0	0 (0)	0 (0)
Cicadellidae	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0	0 (0)	0 (0)
Dermaptera	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0	0 (0)	0 (0)
Diplopoda	0 (0)	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Decapoda	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)
PHYLLUM MOLLUSCA									
Gastropoda	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Plant Material	2 (1)	1 (1)	0 (0)	1 (1)	1 (1)	2 (1)	0 (0)	1 (1)	1 (1)
Sediment	6 (1)	1 (1)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	4 (1)
Unidentified	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)

Fig. 1. Field observation of an adult male *Limnonectes megastomias* recently having consumed an adult male *Limnonectes gyldenstolpei* at the type locality of *L. megastomias* at Sakaerat Environmental Research station (Nakhon Ratchasima, Thailand).

are deposited in the following institutions: California Academy of Sciences (CAS), Field Museum of Natural History (FMNH), Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology (IEBR), University of Kansas Biodiversity Institute (KU), Louisiana State University (LSU), and Vietnam National Museum of Nature (VNMN).

Results.—Excluding sediment and plant matter, 14 different types of food items were identified to the lowest taxonomic level possible (i.e., order or family). Orthopterans and coleopterans were the most prevalent prey items, with orthopterans identified in eight (42.1%) of the frog stomachs, and coleopterans in seven (36.8%) of the stomachs. Plant matter was the most common material found, appearing in the stomachs of eight (88.9%) of the nine lineages. Coleoptera was the most prevalent of the food items, found in five (55.5%) of the lineages, followed closely by Lepidoptera and Formicidae (Hymenoptera), both of which were found in four (44.4%) of the lineages. *Limnonectes bannaensis* Ye, Fei, Xie & Jiang, 2007 showed the greatest range of diet with 12 of the 14 (85.7%) food items identified, including five food items that were unique to this species.

Discussion.— Small sample sizes limit the ability to draw conclusions about species-specific dietary preferences. Also, the amount of time some specimens spent in captivity is likely to have influenced the contents of their gut and the state of digestion of food items. For example, partial or full digestion of some food types may have occurred to a point where identification was no longer possible. Nevertheless, our data provide a starting point for understanding dietary patterns and resource partitioning in this group of frogs. We present all results with the caveat that additional sampling will likely confirm some of our observations of species-specific diets and will show other patterns to be generalizations across the *L. kuhlii* complex.

Overall, frogs in the *L. kuhlii* complex seem to feed primarily upon arthropods, particularly insects. With the exception of a gastropod (Phylum Mollusca), all identified animal taxa in the gut contents were arthropods consisting primarily of insects (11 taxa), but also included a crustacean and a millipede (Table 2). Insects are among the most diverse organisms on earth (Grimaldi and Engel 2005), particularly in tropical areas, and that could explain their high abundance among the analyzed samples. The abundance of coleopterans and orthopterans, the two orders of insects found most frequently, is not unexpected. Insects from these orders are common in the diets of anurans due to their relatively abundance (Coleoptera) or large body size (Orthoptera), which provide a large amount of food and energy (Boquimpani-Feitas et al. 2002; Klaion et al. 2011).

Among the insects consumed, the orders Coleopteran, Lepidoptera, Hymenoptera (especially ants), and Orthoptera were eaten by most species in the *L. kuhlii* complex. Coincidentally, the first three orders are among the most diverse and abundant insects worldwide (Grimaldi and Engel 2005). Two species of *Limnonectes* had unique prey items in their diet: *Limnonectes nguyenorum* McLeod, Kurlbaum & Hoang, 2015 consumed an adult dragonfly (Odonata), and one individual of *L. isanensis* McLeod, Kelly & Barley, 2012 ate a freshwater crab. Individuals of some species consumed larger numbers of specific prey than others; in particular, one specimen of *L. megastomias* had 220 termites (Order Isoptera) in its stomach. This species is known to consume other frogs, birds, insects and other invertebrates (McLeod 2009). These data, in combination with the presence of a large number of Isopteran prey supports the observation that *L. megastomias* is an opportunistic predator with a sit-and-wait feeding strategy.

The greatest richness of prey items (11 of 14 taxa) was associated with specimens of *L. bannaensis* but this surely reflects the number of samples examined (N = 4), almost double the number of specimens analyzed for most species. Comparatively, *L. isaneasis* (N = 2) showed the second greatest richness with five of the prey taxa. *Limnonectes bannaensis, L. isaneasis* and a member from *L. longchuanensis* were among the largest (snout-vent length) of the frogs sampled and thus, body size could be correlated with richness. *Limnonectes megastomias* is also a large species of frog, similar to the size of *L. bannaensis* and *L. isaneasis*, and it does appear that size plays a role in the abundance of prey consumed, as indicated by the number of termites found inside their guts (220 termites). The *L. megastomias* individuals sampled did not display the wide range of prey items expected in individuals of other large species, however we only examined the content from two specimens of this species.

Plant materials were found in the stomachs sampled, occurring in 7 of 19 individuals and representing 7 of 9 clades investigated. It is important to note that the presence of plant material in 7 of the stomachs does not make it the most common type of food consumed by these frogs. Compared to the amount of animal material, which is found in 18 of the 19 frogs analyzed as well as in greater amounts, plant material is a minor part of the frog's diet. The presence of plant materials, especially leaf remains, found in the stomachs of these frogs suggests one of two possibilities: either these frogs are intentionally ingesting the leaves, or they are incidentally ingested while trying to catch animal prey among leaf litter. Accidental ingestion of leaf material has been reported in a number of other studies (e.g., Marra et al. 2004; Siqueira et al. 2006; Martins et al. 2010; Almeida-Santos et al. 2011). We are aware of only one case of a frog (the South American hylid *Xenohyla truncata*) ingesting plant matter intentionally (Silva and Brito-Pereira 2006).

It is almost certain that our results do not reflect the complete dietary patterns of the species represented in this study. Whereas we did not record any vertebrate prey in our samples, McLeod (2009) reported that *L. megastomias* consumed birds and its congener, *L. gyldenstolpei* (Andersson, 1916) (Fig. 1). Focused studies on diet in these frogs will more clearly delineate the use of food resources and any species-specific patterns of prey preference. Moreover, future studies of sympatric and syntopic populations will be able to address questions of food resource partitioning and will elucidate the mechanisms that allow closely related and ecologically similar and species to co-exist in the same physical space.

Acknowledgments.—We are grateful to the institutions and individuals that provided specimens and allowed DSM to dissect them for another study. The subsequent ability to investigate stomach contents from these specimens only adds to their value as research materials and has provided an opportunity to engage students in the research process. We thank the anonymous reviewers for their comments and suggestions that improved the manuscript.

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Distribution and Habitat Partitioning of Two Skink Species on the Nevada National Security Site in South-central Nevada

Two skink species are known to occur on the Nevada National Security Site (NNSS) in south-central Nevada, USA. The Western Red-tailed Skink (*Plestiodon gilberti rubricaudatus*) is on the Nevada Natural Heritage Program's "Animal and Plant At-Risk Tracking List" while the Great Basin Skink (*Plestiodon skiltonianus utahensis*) is not. Information about both species is lacking, especially for Nevada. *Plestiodon g. rubricaudatus* occurs at the northern edge and *P. s. utahensis* occurs at the southern edge of their respective ranges on the NNSS. Historically (i.e., prior to 2006) on the NNSS, *P. g. rubricaudatus* was known from five locations (Medica et al. 1990; Boone and Sowell 1999; unpublished data) and *P. s. utahensis* was known from seven locations (Tanner and Jorgensen 1963; Woodward 1993; unpublished data) (Fig. 1). The main objective of this study is to determine the distribution, abundance, and habitat use of *P. g. rubricaudatus* and *P. s. utahensis* on the NNSS.

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Methods

The NNSS is located in south-central Nevada, approximately 105 km northwest of Las Vegas, and encompasses approximately 3561 km^2 (Fig. 1). It is located in an area of southern Nevada that lies between the Great Basin Desert and the Mojave Desert as defined by Jaeger (1957). Transitional areas between the two deserts are also present having been created by gradients in precipitation, elevation, temperature, and soils. Unique combinations of physical site conditions have resulted in several different vegetation communities including 10 vegetation alliances and 20 vegetation associations (Ostler et al. 2000). Elevation ranges from less than 1000 m to 2340 m above sea level. Average annual precipitation ranges from 12 cm at the lower elevations to 33 cm at the higher elevations (Soule 2006).

We conducted literature reviews and internet searches (i.e. VertNet.org) to locate all records of *P. g. rubricaudatus* and *P. s. utahensis* from the NNSS, and consulted with Phil Medica, a former NNSS biologist, to locate additional records. We conducted

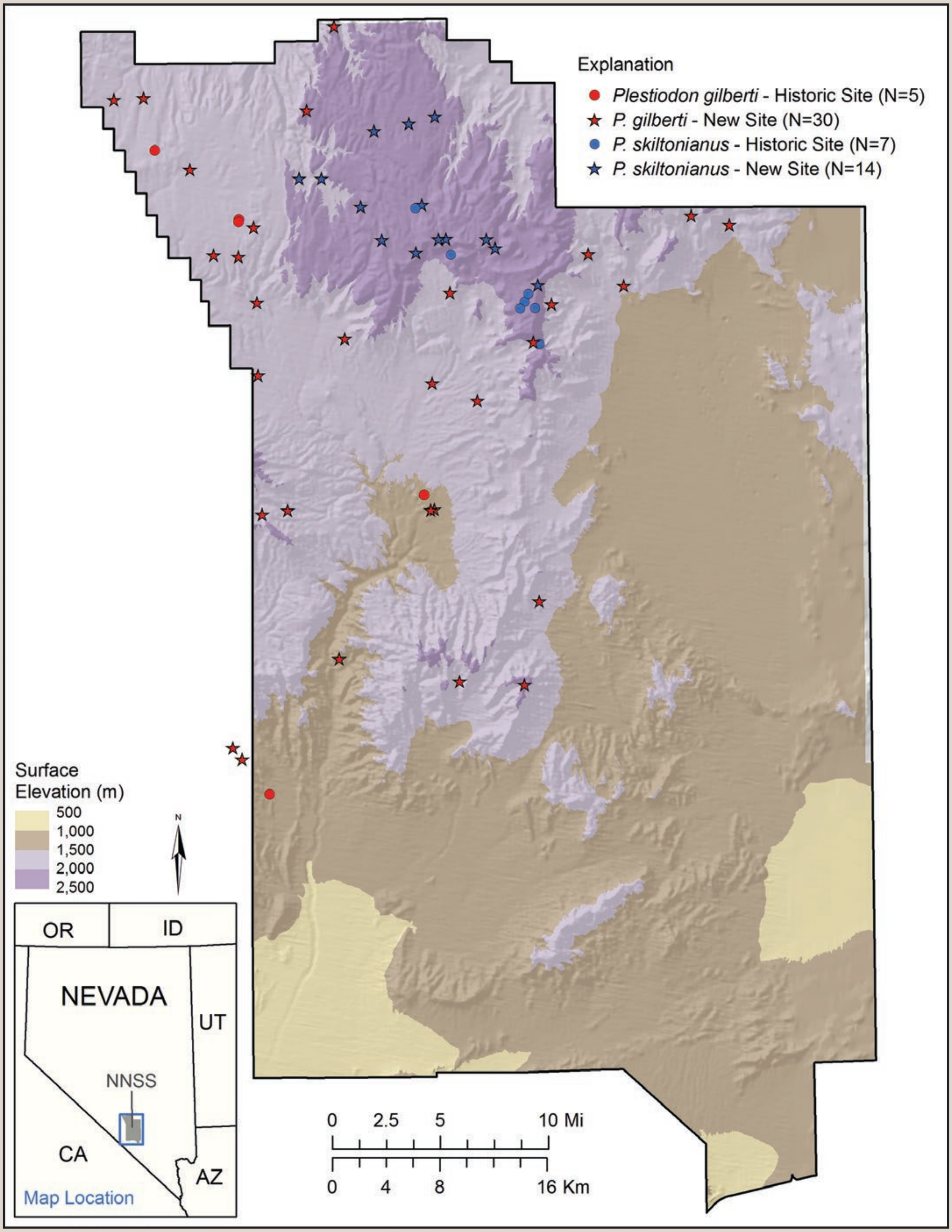

Fig. 1. Current and historic (pre-2006) distribution of Western Red-tailed and Great Basin skinks on or near the Nevada National Security Site by elevation. Each symbol marks a site where at least one skink was captured. Note the two western red-tailed skink locations on the western boundary at 1494 and 1555 m. Elevation coverage ends at NNSS boundary.

an intensive trapping study at 129 sites from 2006–2011 with additional sporadic trapping during 2012 and 2013. Trapping protocol generally entailed setting 30 stand-alone, box-type funnel traps (61 cm long x 21 cm wide x 21 cm tall) at a site for two weeks. We set traps along vegetation or rocks to act as natural drift fences to funnel skinks into the traps similar to the technique described in Fitch (1987), and sampled three to four sites concurrently per two-week session. We set traps on Monday, checked them every one to three days (Enge 2001) and closed them on Thursday of the first week. We repeated this process the second week and then moved traps to new sites. Based on the habitat preferences found in the literature, we selected sites in rocky areas near ephemeral washes or at springs (Macey and Papenfuss 1991; Stebbins 2003) or in open, rocky areas with scattered vegetative cover (Rodgers and Fitch 1947). We also recorded *P. s. utahensis* observations opportunistically during other wildlife monitoring activities. For each site Universal Transverse Mercator coordinates (North American Datum 1983) were taken using a hand-held GPS unit or estimated by plotting site locations from written descriptions using ArcGIS version 10.2. We estimated elevation (m) for each site from USGS 7.5 minute topographic maps or ArcGIS version 10.2. When a skink was captured, it was weighed, measured, and marked by clipping one to two toes in a unique pattern so individual skinks could be identified.

Results

We documented a total of 54 *P. g. rubricaudatus* records at 35 sites (5 historic, 30 new) between 1130–2095 m elevation (mean = 1735 ± 214 m). This included 42 individuals with 7 recaptures during the trapping portion of the study and 5 individuals from historic records (Fig. 1). Additionally, we documented a total of 101 *P. s. utahensis* records at 21 sites (7 historic, 14 new) between 1963–2299 m elevation (mean = 2141 ± 99 m). This included 57 individuals with 8 recaptures by Brigham Young University (BYU) researchers at two sites (captured in 1961–1971), 10 individuals by Alex Johnson at five sites (1975) (MVZ 140895–140903, 140907), five individuals at one of the BYU sites (1993), and 21 individuals at 14 new sites during the trapping portion of the study (Fig. 1). The most *P. g. rubricaudatus* documented at a site was four individuals. At the northernmost BYU plot, BYU researchers captured and marked 34 individual *P. s. utahensis* with 8 recaptures over an unspecified time period during the 1960s and 1970s. They calculated a minimum density of 5.6 adult *P. s. utahensis* /ha (14 adults on a 2.5-ha plot) (unpublished BYU data).

Discussion

High elevation habitat on the NNSS is considered to be typically above 2000 m in the *Pinus monophylla/Artemisia nova* (Pinyon Pine/Black Sagebrush) and *Pinus monophylla/Artemisia tridentata* (Pinyon Pine/Big Sagebrush) woodland vegetation associations These areas, on average, receive more precipitation (≥ 27 cm) than the other parts of the NNSS (≤ 25 cm) (Ostler et al. 2000).

Findings from our study that *P. g. rubricaudatus* typically inhabit lower elevation, more arid sites corroborate other studies (Rodgers and Fitch 1947; Tanner 1957; Macey and Papenfuss 1991; Morrison et al. 1999; Morrison and Hall 1999) although elevation ranges differ slightly depending on location. Macey and Papenfuss (1991) found *P. g. rubricaudatus* associated with water in the Inyo-White Mountains of California and Nevada at elevations between 1220 and 1440 m and away from water between 1830 and 2440 m (range 1220–2440 m). They describe *P. s. utahensis* as a high-elevation species thought to be found between 2130 and 3050 m based on only a few records. Morrison et al. (1999) caught both *P. g. rubricaudatus* and *P. s. utahensis* at three sites between 1900 and 2200 m and Morrison and Hall (1999) captured both species at a spring at 2157 m also in the Inyo-White Mountains. *Plestiodon g. rubricaudatus* on the NNSS occurred mostly within the same elevation range as that documented in the Inyo-White Mountains except for one individual caught at 1130 m in Creosote Bush (*Larrea tridentata*) habitat away from water. This is the only skink that has been caught in Creosote Bush habitat on the NNSS and may have dispersed downslope from a source population on the upper slopes of Yucca Mountain during the extremely wet winter and spring of 1994–1995. *Plestiodon s. utahensis* on the NNSS occurred within the elevation range of *P. s. utahensis* found in the Inyo-White Mountains.

Although there is some elevational overlap between *P. g. rubricaudatus* and *P. s. utahensis* (1963–2095 m), we found no areas of sympatry on the NNSS. This may be due to imperfect detection or habitat selection differences. Morrison and Hall (1999) noted areas of sympatry in their study at four sites occurring at 1900 m (Westgard), 2100 m (Pinyon), 2157 m (Montenegro Spring), and 2200 m (Cedar). In their study, *P. s. utahensis* were more numerous at the higher elevation, more mesic sites whereas *P. g. rubricaudatus* were more numerous on the lower elevation, more arid Westgard site, similar to the patterns we detected for the NNSS.

High elevation habitat occupied by *P. s. utahensis* is limited on the NNSS with little possibility of increasing in the future. This habitat may be at risk as the climate gets hotter and drier which could result in the extirpation of *P. s. utahensis* and possible range expansion of the *P. g. rubricaudatus* on the NNSS. Permanent plots are being established in these habitats to monitor changes in the vegetation (Hall et al. 2016). Gambel Oak (*Quercus gambelii*) in particular is a good indicator species for the health of these communities and provides good habitat for *P. s. utahensis* (Tanner 1957). Periodic monitoring of these plots should continue in addition to monitoring the skink populations in these areas.

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Prey Availability and Foraging Events of the Northern Mexican Gartersnake (*Thamnophis eques megalops*) in North-central Arizona

The Northern Mexican Gartersnake (*Thamnophis eques megalops*) is a generalist mesopredator and wetland and riparian obligate distributed in Arizona, New Mexico, and northern Mexico (Degenhardt et al. 1996; Rossman et al. 1996; Brennan and Holycross 2006). Extensive population declines have been documented throughout the range of the species in the United States with potential drivers including the introduction of nonnative predatory species, loss of native prey, and habitat loss. Based on these declines, the U.S. Fish and Wildlife Service (USFWS) listed *T. e. megalops* as federally threatened under the Endangered Species Act on July 8, 2014 (USFWS 2014) with viable populations occurring in north-central, western, and southern Arizona.

The USFWS identified "harmful nonnative species" including the American Bullfrog (*Lithobates catesbeianus*), spiny-rayed predatory fish in the families Centrarchidae and Ictaluridae, and the crayfish *Orconectes virilis* and *Procambarus clarkii* as the leading threat to the survival of *T. e. megalops* throughout its range in the United States (USFWS 2014). Confirmed depredation events on neonates and adults by *L. catesbeianus* and Largemouth Bass (*Micropterus salmoides*) have been documented in previous studies (Rosen and Schwalbe 1995; Young and Boyarski 2013). In addition, potential negative interactions with nonnative species include competition for native prey species (Rosen and Schwalbe 2002; Holycross et al. 2006) and injury or mortality when snakes prey on centrarchid and ictalurid fish and swallow spines (USFWS 2014; Boyarski et al. 2015). Based on these perceived threats, two of the primary constituent elements (PCEs) deemed essential to the conservation of *T. e. megalops* in the proposed rule for designation of critical habitat are: 1) a prey base consisting of viable populations of native amphibian and native fish species; and 2) the absence or occurrence of nonnative aquatic predatory species at "low enough levels such that recruitment of northern Mexican gartersnakes and maintenance of viable native fish or soft-rayed, nonnative fish populations (prey) is still occurring" (USFWS 2013).

While an appropriate aquatic prey base is considered a significant factor in *T. e. megalops* recovery and long-term survival, dietary descriptions are limited to relatively few studies and records in Arizona and northern Mexico (García and Drummond 1988; d'Orgeix et al. 2013; T. Cotten, T. Sprague, pers. comm.). The species is thought to rely primarily on native, small-bodied prey including annelids, leopard frog (*Lithobates* sp.) adults and tadpoles, Mexican Spadefoot (*Spea multiplicata*) adults, Woodhouse's Toad (*Anaxyrus woodhousii*) juveniles and tadpoles, and Western Tiger Salamander (*Ambystoma mavortium*) larvae (USFWS 2014). However, nonnative aquatic vertebrates have also been identified as potential food sources, including *L. catesbeianus* juveniles and tadpoles, soft-rayed fish including the Western Mosquitofish (*Gambusia affinis*) and the Red Shiner (*Cyprinella lutrensis*) (S. Lashway, T. Sprague, pers. comm.), and Goldfish (*Carassius auratus*), a nonnative spiny-rayed cyprinid fish (García and Drummond 1988).

Building on previous dietary accounts, we investigated potential prey availability and confirmed prey use for *T. e. megalops*, as part of a larger study to determine population demography, habitat use, and spatial behavior for the species along the upper-middle Verde River in north-central Arizona (Emmons and Nowak 2016). Here, we present additional prey records that provide a greater understanding of *T. e. megalops* diets, with implications for critical habitat elements deemed

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essential for the survival of this federally threatened species in the United States.

Methods.— Study sites were located along the upper-middle Verde River (Yavapai County, Arizona) and featured relatively wild, undeveloped riparian corridors along the perennial Verde River, which is listed as one of five remaining United States localities that contain potentially viable populations of the species in question (USFWS 2014). One of the sites also contained artificial lagoons fed by diversions from the main stem river. Due to the vulnerable status of *T. e. megalops* we have withheld specific site name information to protect snakes at the study locations. We pooled data from sites because there is potential genetic and reproductive connectivity between subpopulations of gartersnakes (D. Wood, pers. comm.), they share a similar assemblage of potential aquatic prey species, and they are included in the same sub-basin unit as described in the designation of critical habitat proposed rule (USFWS 2013).

We recorded total numbers of potential prey captured in self-baiting Gee™ minnow traps (e.g., Nowak and Santana-Bendix 2002; Holycross et al. 2006). We defined potential prey as invertebrates and vertebrates identified in previous diet studies for *T. e. megalops* and similar aquatic gartersnake species, including spiny-rayed fish. Furthermore, we categorized all *L. catesbeianus* and *A. woodhousii* (the two potential anuran species present at the study sites) by age class to maintain consistency with the USFWS final listing rule, where juveniles and tadpoles, but not subadults or adults, of both species were identified as potential prey (USFWS 2014). We used the following categories: adult (≥ 135 mm), subadult (< 135 mm and ≥ 80 mm), juvenile (< 80 mm), and tadpole for *L. catesbeianus*; and adult (≥ 60 mm), juvenile (< 60 mm), and tadpole for *A. woodhousii*, based on previous studies conducted in Arizona (Sullivan 1983; T. Jones, pers. comm.). Survey effort was measured in trap-hours (the number of traps multiplied by the number of hours traps were open) and calculated for each sampling trip from the median time of the first day when traps were set and opened to the last day when traps were closed and removed. We determined relative prey availability by calculating the mean number (± 1 SE) of each species captured per trap-hour per sampling trip, to standardize survey effort and account for differences in duration and intensity between trips. Minnow traps were checked and emptied at least once per day in 2012–2013, and two times per day in 2014. All potential prey were removed on a daily basis (2012 and May–August 2013–2014) or every other day (September–November 2013–2014) to prevent mortality during trapping sessions.

We recorded prey to species when possible that were in the process of being consumed or regurgitated by *T. e. megalops* captured in Gee™ minnow traps and through opportunistic encounters, including while tracking radio-telemetered snakes (Nowak 2006; Boyarski et al. 2015; Emmons and Nowak 2016). We did not induce regurgitation through palpation, as previous studies suggest the method results in short-term negative impacts on snakes through increased hormonal stress levels, and potential long-term impacts via injury or mortality through hemorrhaging (Schuett et al. 2002; Fauvel et al. 2012). This precaution seemed particularly prudent given the conservation status of *T. e. megalops*, and the possibility for spiny-rayed fish as prey items.

Gartersnakes were uniquely marked using heat cautery brands and passive integrated transponder (PIT) tags (Fagerstone and Johns 1987; Jemison et al. 1995; Winne et al. 2006) to identify the number of individual snakes with respect to the number of prey use events observed. We recorded measurements for captured *T. e. megalops* and confirmed prey, including gartersnake snout–vent (SVL) length, mass, and sex, total length (snout to tail tip) for fish and tadpoles, snout–urostyle length (SUL) for metamorphosed frogs and toads, and mass for snakes and prey species when possible. Anurans were identified to age class using the same categories as used in trap surveys. We also calculated prey-snake ratios for length and mass and calculated ratios (mean ± 1 SE) for length and mass, when measurements were available for prey items. Telemetered snakes in the process of consuming prey items contained surgically implanted internal radio transmitters; surgical procedures and care followed those of Hardy and Greene (1999), as modified in Nowak (2006) and Boyarski et al. (2015).

Results.—We conducted 22 minnow trap trips at the study sites for an estimated 122,738 trap-hours from May 2012 through November 2014 and detected 15,519 total of 12 different potential prey species, all aquatic vertebrates, including 10 nonnative species and two native species (Table 1). *Gambusia affinis* was the most frequently encountered nonnative potential prey species in minnow traps, comprising 37% (N = 5780) of the total captures with an availability rate of 0.046 ± 0.012 individuals/trap-hour (mean ± 1 SE), and Common Carp (*Cyprinus carpio*) was the least frequently encountered nonnative potential prey item, comprising < 0.1% (N = 2) of the total captures with an availability rate of 0.001 ± 0.001 individuals/trap-hour (mean ± 1 SE). *Anaxyrus woodhousii* tadpoles were the most frequently encountered native potential prey item, comprising 5% (N = 804) of the total captures with an availability rate of 0.004 ± 0.002 individuals/trap-hour (mean ± 1 SE), and *A. woodhousii* juveniles were the least frequently encountered native potential prey item, comprising < 0.1% (N = 3) of the total captures with an availability rate of 0.001 ± 0.001 individuals/trap-hour (mean ± 1 SE). No native fish species were represented in our samples, and no adult *L. catesbeianus* were captured in minnow traps. We documented > 94% nonnative aquatic vertebrates throughout our sampling efforts, including > 56% that were considered “harmful” as described in the USFWS final listing rule (USFWS 2014).

We observed 23 foraging events from 22 individual snakes consisting of 16 detections in minnow traps and seven opportunistic encounters during telemetry (Table 2). Prey consisted of four nonnative species and one native species with *L. catesbeianus* being the most frequently documented prey species consumed by *T. e. megalops* (16 of 23 events or 70%), including one adult, one subadult, five juveniles, and nine tadpoles. We documented 87% nonnative aquatic vertebrates used as prey, and > 83% that were considered “harmful” as described in the USFWS final listing rule (USFWS 2014). We collected mass measurements for 15 of the 23 prey, and they represented 1.6–32.4% of the respective gartersnake mass measurements, with a mean prey-snake mass ratio of 12.4% (± 2.6 SE). We collected length measurements for 19 of the 23 prey, and they represented 4.6–30.3% of the respective gartersnake SVL measurements, with a mean prey-snake SVL ratio of 14.9% (± 1.2 SE) (Table 3).

We encountered two telemetered snakes in the process of consuming adult anurans > 100 mm, including one female on 16 July 2014 that subdued and swallowed a relatively large (SUL = 147 mm) *L. catesbeianus* (Fig. 1). The same female on 21 April 2015 regurgitated an adult *A. woodhousii* (SUL = 106 mm; mass was not obtained due to the partially digested state of the prey item) on a subsequent date when the snake was recaptured for transmitter removal; the snake had a mass of 169.5 g and an SVL of 702 mm. A second female on 11 September 2014 was found consuming an adult *A. woodhousii* with an SUL of 122 mm (Fig. 2).

FIG. 1. *Thamnophis eques megalops* consuming adult *Lithobates catesbeianus* at the upper-middle Verde River, Yavapai County, Arizona.

FIG. 2. *Thamnophis eques megalops* consuming adult *Anaxyrus woodhousii* at the upper-middle Verde River, Yavapai County, Arizona.

FIG. 3. *Thamnophis eques megalops* with protruding fish spine from suspected *Ameiurus* sp. at the upper-middle Verde River, Yavapai County, Arizona.

FIG. 4. *Thamnophis eques megalops* with regurgitated *Ameiurus melas* and additional suspected *A. melas* as prey bolus mid-body with protruding spine at the upper-middle Verde River, Yavapai County, Arizona.

We recorded three events where nonnative, spiny-rayed fish were preyed upon by *T. e. megalops*, including *M. salmoides* and Black Bullhead (*Ameiurus melas*), and a suspected *Ameiurus* species. On 27 July 2013 one female snake regurgitated two juvenile *M. salmoides* after removal from a minnow trap. On 28 September 2013 we captured a male gartersnake with a spine from a suspected *Ameiurus* sp. protruding through the skin posterior to the head; the spine was safely removed and appeared to be the only remaining part of a prey item that was swallowed and successfully digested (Fig. 3). A male found opportunistically on 17 June 2014 was in the process of consuming one *A. melas* with a second prey bolus suspected to be the same species, with a pectoral spine protruding through the snake's midbody wall (Fig. 4).

Discussion.—Based on our survey efforts, nonnative species comprised the majority (> 94%) of potential aquatic vertebrate prey available to *T. e. megalops* at our study sites in north-central Arizona, and native fish species were absent or in such low numbers that they escaped detection. The potential prey availability and confirmed prey use records from minnow traps could be interpreted as biased due to artificial conditions that can concentrate and limit escape of species that snakes may not normally associate with food sources, and underestimation of larger-bodied prey items that were unlikely to access traps due to their terrestrial nature or the confining size of the funnel entrances. However, even when these possible biases are taken into account, our trap sampling efforts still suggest that potential aquatic prey availability is dominated by nonnative aquatic species in the upper-middle Verde River, a locality recognized by the USFWS to contain one of five remaining likely viable populations for *T. e. megalops* in the United States (USFWS 2014). Given that the snake populations at our study sites appear to

Table 1. *Thamnophis eques megalops* potential aquatic prey captured during minnow trap surveys in the upper-middle Verde River, Arizona, 2012–2014. Potential prey species are listed by their standard and scientific names, and anurans are categorized by age class. "Number" refers to total captures per potential prey species throughout the duration of the study, "%" refers to relative proportion of each potential prey species, and "Prey availability" refers to the mean number (± SE) of potential prey species captured per trap-hours per trap survey trip.

Potential Prey Species	Number	%	Prey availability
Nonnative			
Western Mosquitofish, *Gambusia affinis*	5780	37.3	0.046 ± 0.012
Red Shiner, *Cyprinella lutrensis*	121	0.8	0.001 ± 0.001
Green Sunfish, *Lepomis cyanellus*	4072	26.3	0.029 ± 0.011
Bluegill, *Lepomis macrochirus*	248	1.6	0.002 ± 0.001
Smallmouth Bass, *Micropterus dolomieu*	149	1.0	0.001 ± 0.001
Largemouth Bass, *Micropterus salmoides*	630	4.1	0.004 ± 0.002
Yellow Bullhead, *Ameiurus natalis*	7	< 0.1	0.001 ± 0.001
Black Bullhead, *Ameiurus melas*	13	< 0.1	0.001 ± 0.001
Common Carp, *Cyprinus carpio*	2	< 0.1	0.001 ± 0.001
American Bullfrog, *Lithobates catesbeianus* (subad.)	101	< 0.1	0.001 ± 0.001
American Bullfrog, *Lithobates catesbeianus* (juv.)	239	1.5	0.002 ± 0.001
American Bullfrog, *Lithobates catesbeianus* (tad.)	3324	21.4	0.020 ± 0.011
Native			
Woodhouse's Toad, *Anaxyrus woodhousii* (ad.)	20	0.1	0.001 ± 0.001
Woodhouse's Toad, *Anaxyrus woodhousii* (juv.)	3	< 0.1	0.001 ± 0.001
Woodhouse's Toad, *Anaxyrus woodhousii* (tad.)	804	5.2	0.004 ± 0.003
Sonora Mud Turtle, *Kinosternon sonoriense* (hatchling)	6	< 0.1	0.001 ± 0.001
Total	15519		

be persisting, it seems likely that our prey use observations are broadly representative of potential *T. e. megalops* diets within the watershed.

Our study builds on previous dietary accounts that nonnative species are used as prey, including at least three species listed as "harmful" in the final listing rule for *T. e. megalops* (USFWS 2014). To our knowledge, we present the first confirmed records of *T. e. megalops* eating large-bodied (SUL > 100 mm) native and nonnative anurans, and spiny-rayed centrarchid and ictalurid fish. We also present the first species record of an individual that survived after apparently consuming a spiny-rayed fish and a spine punctured the snake's body wall, similar to accounts for other aquatic snake species (Mills 2002; Šukalo 2014; J. Placyk pers. comm.). Diet studies of similar aquatic gartersnake species have also documented prey use of nonnative spiny-rayed fish and anurans, including the Black-necked Gartersnake (*T. cyrtopsis*) eating *L. catesbeianus* (Fleharty 1967); the Two-striped Gartersnake (*T. hammondii*) consuming Redbelly Tilapia (*Tilapia zillii*) and *Xenopus laevus* (Ervin and Fisher 2001; Rodríguez-Robles and Galina-Tessaro 2006); the Eastern Ribbonsnake (*T. saurita*) consuming spiny-rayed cyprinid fish (Bell et al. 2007); the Mexican Black-bellied Gartersnake (*T. melanogaster*) eating *Carassius auratus* (Manjarrez et al. 2013); and the Giant Gartersnake (*T. gigas*) eating *L. catesbeianus* and spiny-rayed centrarchid and ictalurid fish (Ersan 2015). Conversely, previous studies with the Aquatic Gartersnake (*T. atratus*) and the Mountain Gartersnake (*T. elegans elegans*) suggest a reliance on native amphibians as a food source, and negative repercussions on snake populations when native prey sources are removed by introduced predators (Matthews et al. 2002; Preston and Johnson 2012). It is possible that the response to the loss of native prey and the capacity to utilize novel food sources is site-based or intraspecific for different gartersnake species.

For *T. e. megalops*, trapping surveys indicate nonnative species dominate prey availability at two of the other locations that have potentially viable *T. e. megalops* populations in the United States: Page Springs and Bubbling Ponds State Fish Hatcheries associated with Oak Creek in north-central Arizona, and the upper Santa Cruz River in the San Rafael Valley in southern Arizona (S. Lashway, T. Sprague, pers. comm.). There are confirmed observations of snakes regurgitating *G. affinis* and *L. catesbeianus* tadpoles and juveniles during minnow trap surveys and opportunistic encounters at both sites (S. Lashway, T. Sprague, pers. comm.), and one record of a large adult snake captured from a minnow trap with a suspected subadult or adult *L. catesbeianus* as a prey bolus from the Santa Cruz River (S. Lashway, pers. comm.). Additionally, a large adult snake was observed consuming an adult *A. woodhousii* from Bubbling Ponds during an opportunistic encounter, although no measurements were recorded for the snake or prey item (V. Boyarski, pers. comm.). Given the ontogenetic shifts in diet observed by García and Drummond (1988), Lind and Welsh (1994), De Queiroz et al. (2001), and Manjarrez et al. (2013), where *T. e. megalops* and similar aquatic gartersnake species utilize increasingly larger prey as they grow, it is likely that both subadult and adult *L. catesbeianus* and adult *A. woodhousii* may represent seasonally important food sources for larger individuals that inhabit sites populated by native and nonnative larger-bodied anuran species.

These records conflict with the perceptions that the species relies primarily on small-bodied prey, and requires a high abundance of native prey sources and the absence or low abundance of predatory nonnative species to survive (USFWS 2013, 2014). Instead, our prey use records, combined with previous dietary accounts for *T. e. megalops* and other snake species, suggest plasticity in foraging behavior, enabling the use of novel, seasonably available (Ervin and Fisher 2001; Rodríguez-

Table 2. *Thamnophis eques megalops* confirmed prey based on field observations from minnow traps and opportunistic encounters in the upper-middle Verde River, Arizona, 2012–2015. Prey species are listed by their standard and scientific names, and anurans are categorized by age class. "Number" refers to total prey use events observed per prey species, "%" refers to the relative proportion of each prey species, and "Method" refers to the type of observation ("minnow trap" or "opportunistic encounter") used for each prey use event.

Prey Species	Number	%	Method
Nonnative			
Western Mosquitofish, *Gambusia affinis*	1	4.4	minnow trap
Largemouth Bass, *Micropterus salmoides*	1	4.4	minnow trap
Black Bullhead, *Ameiurus melas*	1	4.4	opportunistic
Ameiurus sp. (spine)	1	4.4	opportunistic
American Bullfrog, *Lithobates catesbeianus* (ad.)	1	4.4	opportunistic
American Bullfrog, *Lithobates catesbeianus* (subad.)	1	4.4	opportunistic
American Bullfrog, *Lithobates catesbeianus* (juv.)	5	21.6	minnow trap
American Bullfrog, *Lithobates catesbeianus* (tad.)	9	39.0	minnow trap
Native			
Woodhouse's Toad, *Anaxyrus woodhousii* (ad.)	3	13.0	opportunistic
Total	23		

Table 3. Confirmed prey use event measurements for prey and *Thamnophis eques megalops* in the upper-middle Verde River, Arizona, 2012–2015. Prey species are listed by their scientific names, and anurans are categorized by age class. "Prey mass" and "Snake mass" are measured in grams (when available), and "Prey-snake mass ratio" refers to the percentage of snake mass represented by the prey item. "Prey length" and "Snake SVL" are measured in millimeters (when available), and TL = total length, SUL = snout–urostyle length, and SVL = snout–vent length. "Prey-snake length ratio" refers to the percentage of snake length represented by the prey item.

Prey Species	Prey mass (g)	Snake mass (g)	Prey-snake mass ratio (%)	Prey length (mm)	Snake SVL (mm)	Prey-snake length ratio (%)
Nonnative						
Gambusia affinis	1.3	82.0	1.6	25 (TL)	540	4.6
Micropterus salmoides	1.5	67.0	2.2	64 (TL)	512	12.5
Ameiurus melas	7.4	58.7	12.6	90 (TL)	484	18.6
Ameiurus sp. (spine)	unknown	43.1	unknown	unknown	463	unknown
Lithobates catesbeianus (tad.)	1.3	28.5	4.6	60 (TL)	369	16.3
	0.5	23.1	2.2	40 (TL)	385	10.4
	0.8	29.5	2.7	53 (TL)	381	13.9
	1.2	28.3	4.2	65 (TL)	355	18.3
	4.4	26.0	16.9	86 (TL)	376	22.9
	13.6	42.0	32.4	135 (TL)	445	30.3
	unknown	6.0	unknown	unknown	229	unknown
	unknown	38.0	unknown	unknown	470	unknown
	2.3	79.0	2.9	60 (TL)	540	11.1
Lithobates catesbeianus (juv.)	8.3	55.5	15.0	49 (SUL)	455	10.8
	13.5	69.0	19.6	56 (SUL)	506	11.1
	18.1	76.5	23.7	74 (SUL)	535	13.8
	22.8	92.5	24.6	75 (SUL)	584	12.8
	unknown	46.0	unknown	75 (SUL)	520	14.4
Lithobates catesbeianus (subad.)	45.1	217.0	20.8	94 (SUL)	697	13.5
Lithobates catesbeianus (ad.)	unknown	169.5	unknown	147 (SUL)	702	20.9
Native						
Anaxyrus woodhousii (ad.)	unknown	185.0	unknown	71 (SUL)	705	10.1
	unknown	262.0	unknown	106 (SUL)	727	14.6
	unknown	236.0	unknown	122 (SUL)	725	16.8
Mean prey-snake ratios			12.4 ± 2.6			14.9 ± 1.2

Robles and Galina-Tessaro 2006; d'Orgeix et al. 2013), and in some cases, nonnative prey. Indeed, nonnative prey have allowed population-level benefits including increased size of adults and number of offspring of Lake Erie Watersnakes (*Nerodia sipedon insularum*; King et al. 2006, 2008), and the continued abundance of introduced Brown Treesnakes (*Boiga irregularis*) in Guam following the decline or extirpation of native vertebrate prey (Rodda and Savidge 2007; Siers 2015). Our findings suggest that adult *T. e. megalops* will utilize relatively large-bodied native and nonnative prey items, and in certain watersheds where native aquatic prey species are much-reduced or even extirpated, the species may be able to maintain viable populations by shifting to a diet comprised primarily of nonnative prey, even those considered "harmful" in USFWS listing documents. We encourage continued investigations into prey use, including ontogenetic dietary shifts, prey use in ephemeral watersheds, and the potential impacts on gartersnakes swallowing spiny-rayed fish, to inform management and recovery efforts for this threatened species. We also recommend a revision of the primary constituent elements for the USFWS critical habitat designation final rule to reflect a wider variety of native and nonnative prey sources that contribute to the long-term survival of *T. e. megalops* populations in the United States.

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Rare Color-Pattern Misfits in Indigenous Arrays of Parthenogenetic *Aspidoscelis neotesselata* (Colorado Checkered Whiptail)

A recent assessment of the northern distribution of parthenogenetic *Aspidoscelis neotesselata* added two counties to the four counties previously defining its natural range in southeastern Colorado (Taylor et al. 2015b). Even so, a fragmented distribution in limited areas of only six counties represents a relatively small range (Walker et al. 1997a, 2012; Walker 2012; Taylor et al. 2015a,b). This supports a hypothesis, based on low levels of postorigin genetic variation, that *A. neotesselata* had a relatively recent origin (Parker and Selander 1976; Densmore et al. 1989; Taylor et al. 2015a). Nevertheless, genetically based morphological divergence in *Aspidoscelis neotesselata* is illustrated by four basic color-pattern classes designated by capital letters: A and B (Zweifel 1965), C (Walker et al. 1997a), and D (Walker et al. 2012b). Histocompatibility between individuals of different pattern classes indicates that *A. neotesselata* originated from a single F_1 hybrid of *A. tesselata* × *A. sexlineata viridis* (Walker et al. 2012b). Because pattern-class B is the only pattern class of *A. neotesselata* presently in syntopic contact with both progenitor species (e.g., "B1 and tess C" sites shown in Taylor et al. (2015a: fig. 3), it is thought to represent the ancestral pattern class (Walker et al. 1997b).

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We follow Frost and Hillis (1990) in emphasizing a basic difference between gonochoristic (sexually reproducing) and parthenogenetic species. In gonochoristic species of *Aspidoscelis*, evolutionary patterns reside in "population lineages," whereas these patterns take the form of mother-and-daughter "arrays" in parthenogenetic species. For *Aspidoscelis neotesselata*, we use the term "indigenous array" to denote a local group of individuals of the same color-pattern class. Although allopatric arrays typically comprise individuals of only one pattern

Table 1. Descriptive statistics for color-pattern misfits found in arrays of a different color-pattern class and reference samples used to assess their multivariate morphological affinities. LJ = La Junta; FCNC = Fountain Creek Nature Center (pooled sample including samples of A2 from Fremont and Teller counties); PNC = Pueblo Nature Center; CP = Crystal Pond; Lime = historic mine site. Color pattern designations (D, A2, A1, B1, and C) follow site abbreviations. Shown are means ± SE and range limits. For CV1 and CV2, group means that are not significantly different (α = 0.05) are identified by the same capital letter. See Appendix 2 for character definitions.

Characters	Reference groups					Color-pattern misfits		
	LJ D N = 35	FCNC A2 N = 39	PNC A1 N = 26	CP B1 N = 12	Lime C N = 37	UADZ 8872 CP ?	HLT 0398 FCNC D	HLT 0210 Lime A1
CV1	-2.4 ± 0.12 -4.9 to -1.3 A	-0.7 ± 0.15 -2.1 to 2.0 B	-0.3 ± 0.25 -2.3 to 2.4 B	1.1 ± 0.27 0.3 to 3.8 C	2.9 ± 0.18 0.6 to 4.8 D	1.0	-1.8	0.3
CV2	-1.1 ± 0.16 -3.8 to 0.1 A	1.6 ± 0.15 -1.1 to 3.6 B	-0.6 ± 0.21 -2.5 to 1.5 A	1.7 ± 0.37 -0.5 to 3.7 B	-0.8 ± 0.17 -3.4 to 1.5 A	0.4	-0.4	-3.3
L-breaks	1.1 ± 0.16 0–3	1.6 ± 0.33 0–10	4.4 ± 1.04 0–20	5.8 ± 1.06 3–15	10.6 ± 0.99 2–26	5	0	7
GAB	76.4 ± 0.40 72–81	80.5 ± 0.53 73–87	82.5 ± 0.77 74–90	83.8 ± 0.83 77–88	85.4 ± 0.51 80–96	81	72	87
SPV	6.0 ± 0.16 3–7	7.2 ± 0.13 6–9	6.4 ± 0.23 4–9	9.5 ± 0.34 8–12	9.2 ± 0.14 8–11	7	6	6
LSG	17.4 ± 0.32 13–21	23.9 ± 0.40 18–28	22.4 ± 0.58 17–27	21.1 ± 0.73 16–24	22.1 ± 0.50 13–29	18	23	17
SDL	33.5 ± 0.18 32–36	35.2 ± 0.17 33–38	33.2 ± 0.25 30–35	35.9 ± 0.51 34–38	33.6 ± 0.23 30–36	36	33	32
COS	12.5 ± 0.19 11–17	12.3 ± 0.20 9–15	11.8 ± 0.28 10–16	13.2 ± 0.42 11–16	15.8 ± 0.37 11–21	12	14	12
FP	39.3 ± 0.23 37–42	39.9 ± 0.25 36–43	38.4 ± 0.28 36–41	39.2 ± 0.56 36–41	37.8 ± 0.20 35–41	38	39	36

Table 2. Correlations between univariate characters and canonical variates generated from a canonical variate analysis of five reference samples of pattern classes A1, A2, B1, C, and D of *Aspidoscelis neotesselata* from southeastern Colorado.

	Correlations			
Characters	CV1	CV2	CV3	CV4
SPV	0.670	0.249	-0.515	-0.236
GAB	0.523	0.098	0.259	-0.376
L-breaks	0.470	-0.218	-0.041	-0.101
SDL	-0.005	0.604	-0.259	-0.067
FP	-0.224	0.294	-0.117	0.246
LSG	0.235	0.497	0.543	0.541
COS	0.433	-0.244	-0.394	0.713
Eigenvalues	3.792	1.479	0.828	0.131
% of variance	60.9	23.7	13.3	2.1

class, allopatric arrays of the same pattern class can differ in morphological meristic characters. For example, Taylor et al. (2015a) subdivided allopatric arrays within pattern classes A and B into A1, A2, B1, and B2 groups by multivariate analyses of meristic characters. Herein, we use this level of resolution to investigate a new problem—the presence of rare individuals of one pattern class (color-pattern misfits) in arrays of a different pattern class (indigenous arrays). Based on the relative quantitative morphological resemblance of misfits to reference samples, we made a choice from among three hypotheses that would best explain the presence of each color-pattern misfit in its indigenous array: 1) it hatched from an egg produced by an indigenous individual; 2) it arrived by natural dispersal; 3) it represents a product of human introduction.

Materials and methods.—We found misfits in indigenous arrays at three locations: Fountain Creek Nature Center (El Paso County), Lime (Pueblo County), and Crystal Pond (Otero County). We compared these three misfits to samples of the respective indigenous arrays and samples of arrays with color patterns most closely resembled by the misfits (Appendix 1). For one indigenous array, the two specimens of pattern

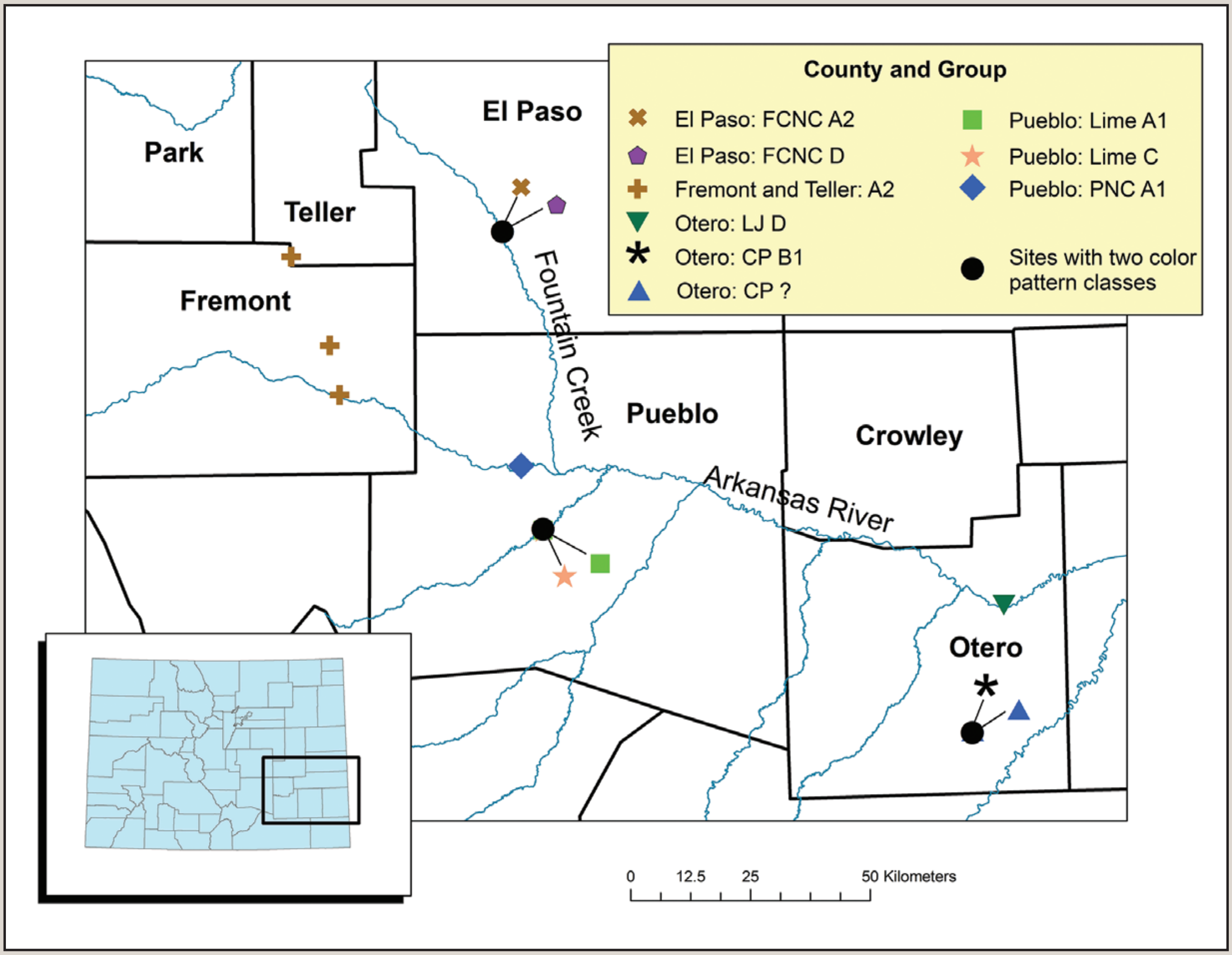

Fig. 1. Colorado localities with color-pattern misfits in indigenous arrays of a different pattern class and sampling sites of reference samples: FCNC = Fountain Creek Nature Center; LJ = La Junta; CP = Crystal Pond; PNC = Pueblo Nature Center; Lime = a historic mine site. Lines connect each site to symbols identifying the two color-pattern classes found there (CP ? = an individual with an ambiguous color pattern from the Crystal Pond site).

class A from Fountain Creek Nature Center were identified as members of group A2 (Taylor et al. 2015b). Our sample, designated as FCNC A2, is a pooled sample of these two specimens and 37 others from Fremont and Teller counties identified as members of the A2 group (Taylor et al. 2015a).

We used seven univariate morphological characters that have demonstrated value in discriminating among groups of *Aspidoscelis* as the foundation of this study (Appendix 2). Of these, the L-breaks character is subject to ontogenetic development (Taylor et al. 2015a). Therefore, we used linear regression to check each sample for a relationship between L-breaks and snout–vent length (SVL). We found this relationship only in reference sample A1 from Pueblo Nature Center and removed the relationship by excluding specimens < 72 mm SVL from that sample for the definitive analyses.

We also checked the relative merits of conducting a canonical variate analysis (CVA) using original univariate characters versus using principal component intermediaries (Jombart et al. 2010). We chose the univariate-character model because it was more direct, and both methods gave the same classification success (91.9%). We included each misfit in the CVA as unassigned for classification to the sample (a priori group) that it most closely resembled. Assignments were made by relative Mahalanobis D^2 distances from each misfit to the centroids of the five reference samples (smaller D^2 values = greater resemblance). Because Mahalanobis D^2 distances are sensitive to multivariate outliers (Tabachnick and Fidell 2013), we checked each a priori group by evaluating D^2 distances from each specimen to the centroid of the remaining cases in that group. Specimens with D^2 values exceeding a critical chi-square value at $P = 0.001$ and degrees of freedom defined by the number of characters included in the CVA model would be identified as outliers and removed from the definitive analyses (Tabachnick and Fidell 2013). Multivariate outliers were not present in our samples. We used software from SPSS 17.0, IBM and NCSS 10, NCSS, LLC, Kaysville, Utah, for statistical routines, tests, and graph construction.

Results.—Reference samples of groups D, (A1 and A2), B1, and C were distinguished from one another by CV1 (Table 1), a canonical variate that primarily summarized intergroup variation in SPV, GAB, L-breaks, and COS characters (Table 2). Groups A1 and A2 were separated on the CV2 axis that primarily summarized intergroup variation in SDL, FP, and LSG characters (Table 2). The CVA model

TABLE 3. Classification of 149 specimens in five a priori groups of *Aspidoscelis neotesselata* from southeastern Colorado based on a canonical variate analysis of seven morphological meristic characters.

	Predicted group membership				
A priori groups	LJ D	CP B1	PNC A1	FCNC A2	Lime C
La Junta D	35	0	0	0	0
Crystal Pond B1	0	11	0	0	1
Pueblo Nature Center A1	0	0	22	2	2
Fountain Creek Nature Center A2	1	2	1	35	0
Lime C	0	0	3	0	34

FIG. 2. Looking south across habitat of *Aspidoscelis neotesselata* at Crystal Pond (dam identified by arrow), Otero County, Colorado. An individual with an ambiguous color pattern (UADZ 8872) was collected from the dam on 9 August 2009 along with representatives of indigenous pattern class B1. Yucca plants, assorted shrubs, and juniper trees were scarce, critical components of this habitat.

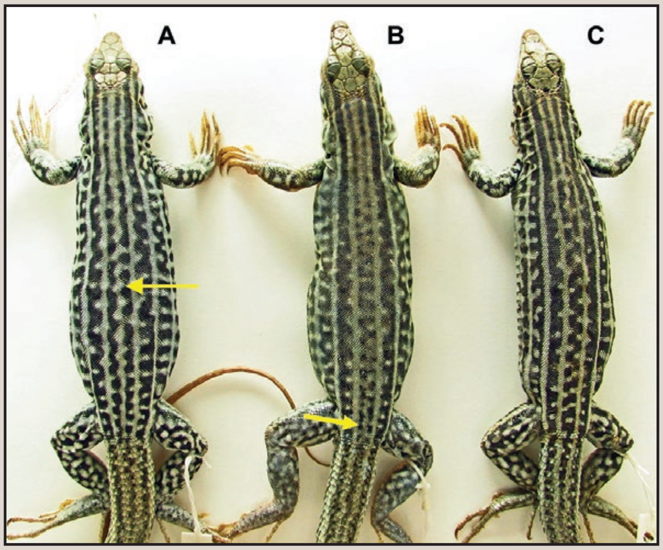

FIG. 3. Representatives of *Aspidoscelis neotesselata* from southeastern Colorado: A) indigenous pattern class B1 from Crystal Pond, Otero County (HLT 0393, 94 mm SVL); B) color-pattern misfit from Crystal Pond (UADZ 8872, 93 mm SVL); C) pattern class D from La Junta, Otero County (HLT 0339, 94 mm SVL). Pattern class B (A) differs from the misfit (B) and pattern class D (C) by a pale line (usually intact, occasionally disrupted) in the vertebral dark field (arrow). The color-pattern misfit (B) resembles pattern classes D and A in the absence of a vertebral line at midbody, but the low number of pale spots in the dorsolateral dark fields is a characteristic of pattern class D and the short pale line at the posterior end of the vertebral field (arrow) is a characteristic of pattern class A.

provided an overall classification success of 91.9%, with only 12 misclassified specimens (Table 3).

An individual of ambiguous pattern class in an indigenous array of pattern class B1 at Crystal Pond.—Aspidoscelis neotesselata was discovered at the Crystal Pond site (Otero: CP in Fig. 1) on 9 June 1997 during a herpetological survey of the Comanche National Grassland by a team that included CEM (Mackessy 1998). LJL independently discovered *A. neotesselata* at this site on 25 May 2007; a photograph of this individual of pattern class B appears in Livo (2009). LJL also coined the name "Crystal Pond" based on abundant calcite crystals in rocks at this site. Crystal Pond is a small stock pond constructed as a supplemental water source for free-ranging cattle, and individuals of *A. neotesselata* utilize the dam and nearby slopes as habitat (Fig. 2).

Together, AJW and LKG collected misfit UADZ 8872 (University of Arkansas Department of Zoology) and two specimens of indigenous pattern class B1 at Crystal Pond on 9 August 2009. UADZ 8872, a color pattern and meristic enigma, was the only unusual specimen among 13 individuals collected from the Crystal Pond site in 2000, 2001, 2008, 2009, and 2014 (Appendix 1). The vertebral dark field of UADZ 8872 lacks an organized vertebral line at midbody, thus resembling both pattern classes D and A. However, UADZ 8872 resembles pattern class D in having a small number of pale spots in the dorsolateral dark fields, and it resembles pattern class A in the vertebral-line remnant at the posterior end of the vertebral field (Fig.3). The multivariate assignment of UADZ 8872 to a priori group was also ambiguous. The CVA classified UADZ 8872 as most closely resembling group A2, but the assignment probability was weak ($D^2 = 4.138$; $P = 0.551$). The resemblance of UADZ 8872 to La Junta D was even weaker ($D^2 = 5.478$; $P = 0.262$). This asymmetrical morphological resemblance is shown by the position of UADZ 8872 relative to the centroids of A2 and D clusters (Fig. 4).

An individual of pattern class D in an indigenous array of pattern class A2 at Fountain Creek Nature Center.— Don Erickson discovered *Aspidoscelis neotesselata* at this site (Fig. 1) in 2012 (Taylor et al. 2015b). Fountain Creek Nature Center and Fountain Creek Regional Park, located approximately 13 straight-line km south of Colorado Springs, are popular destinations for outdoor

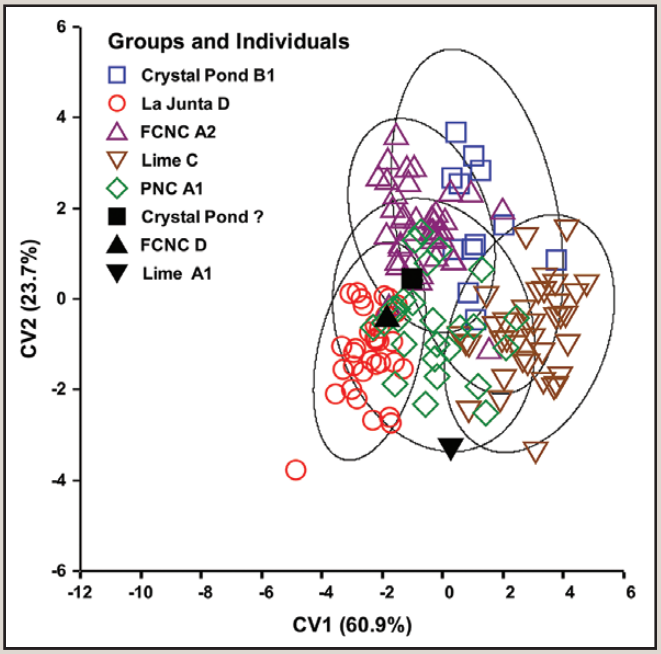

Fig. 4. Scatterplot of canonical variate scores derived from a canonical variate analysis using seven univariate morphological characters and five reference samples (a priori groups) of *Aspidoscelis neotesselata* from southeastern Colorado. Crystal Pond B1 = 12 specimens from Crystal Pond, Otero County; La Junta D = 35 specimens from La Junta, Otero County; FCNC A2 = 39 specimens from Fountain Creek Nature Center, El Paso County and sites in Fremont and Teller counties; Lime C = 37 specimens from Lime, Pueblo County; PNC A1 = 26 specimens from Pueblo Nature Center, Pueblo County. Solid symbols denote color-pattern misfits; Crystal Pond ? = individual with an ambiguous color pattern. Axis percentages represent proportions of variation accounted for by canonical variates CV1 and CV2, and ellipses enclose the 95% confidence limits of score distributions.

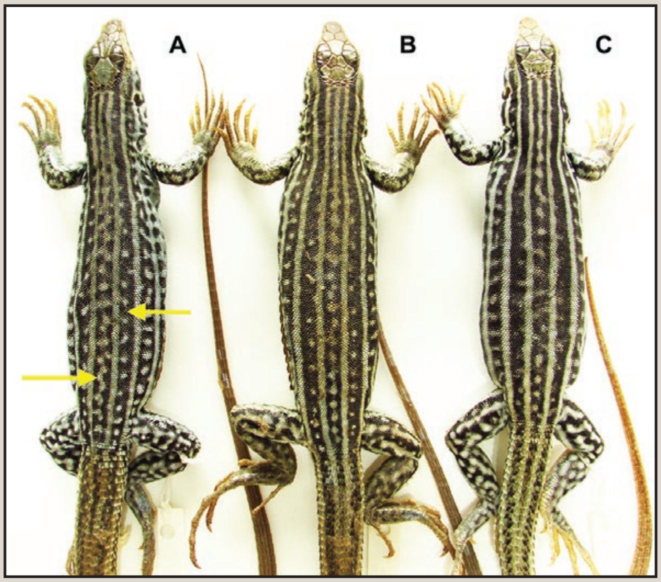

Fig. 5. Representatives of *Aspidoscelis neotesselata* from southeastern Colorado: A) pattern class A2 from Fountain Creek Nature Center (FCNC), El Paso County (HLT 0397, 88 mm SVL); B) misfit of pattern class D from FCNC (HLT 0398, 88 mm SVL); C) pattern class D from La Junta, Otero County (HLT 0333, 84 mm SVL). Pattern class A (A) differs from pattern class D (B and C) by a short, pale, zigzag line at the posterior end of the vertebral dark field (arrow) and more pale spots in the dorsolateral dark fields (arrow).

recreation and education activities. The habitat of *A. neotesselata* comprised hiking trails, bordering vegetation, and low slopes east of Fountain Creek.

LJL, HLT, and Steve Wilcox collected one specimen of pattern class A2 from FCNC on 18 July 2014 and the misfit of pattern class D (HLT 0398) and another individual of A2 on 15 August 2014 (Taylor et al. 2015b). We consider pattern class A2 to be the indigenous array based on the CVA classification of the two collected specimens to group A2 and photographs of additional individuals of pattern class A at FCNC (Taylor et al., 2015b). Individuals of pattern class D can be distinguished from those of pattern class A by two features: (1) a series of pale spots, rather than a short zigzag line, at the posterior end of the vertebral dark field and (2) a sparse distribution of pale spots in the dorsolateral dark fields (Fig. 5). The CVA identified HLT 0398 as most closely resembling pattern class D from La Junta ($D^2 = 4.883$; $P = 0.853$), a resemblance also shown by the location of HLT 0398 embedded in the cluster of specimens of La Junta D (Fig. 4). Misfit HLT 0398 resembled group A2 to a lesser degree ($D^2 = 8.671$; $P = 0.128$).

An individual of pattern class A1 in an indigenous array of pattern class C at Lime.—This site (Fig. 1) is part of a historic lime-mining operation and, since the 1960s (Walker et al. 1997a), pattern class C has been found only at this locality. HLT collected the misfit of pattern class A1 (HLT 0210) and four individuals of indigenous pattern class C (HLT 0211–0214) on 26 June 2006 from a stand of greasewood (*Sarcobatus* sp.) on an anthropogenically modified landscape (Fig. 6). Figures 2 and 6 provide a partial perspective of the breadth of habitat types used by *A. neotesselata* in its natural range. HLT 0210 was the only individual of pattern class A that we found among 91 specimens of pattern class C collected at Lime in 1963, 1990, 1999, 2002, 2003, 2004, and 2006 (Walker et al. 1997a; Taylor et al. 2015a).

Individuals of pattern class C can be distinguished from those of pattern class A by (1) the presence of a prominent zigzagged line in the vertebral field that usually makes several lateral contacts with the paravertebral stripes and (2) white bars in the dorsolateral dark fields. Although some individuals of pattern class A have pale elements in the vertebral field, these elements do not have a distinctly linear organization at midbody (Fig. 7). The CVA classified HLT 0210 to the reference sample of pattern class A1 from the Pueblo Nature Center with a robust probability ($D^2 = 9.867$; $P = 0.996$), and its meristic resemblance to Lime C was negligible ($D^2 = 22.120$; $P = 0.002$). The position of HLT 0210 on CV1 and its location in the PNC A1 cluster depicts the strong morphological resemblance to group A1 (Fig. 4).

Discussion.—None of the three color-pattern misfits had a close morphological resemblance to its syntopic indigenous array. However, although our evidence does not provide absolute certainty in explaining their presence, it does give greater weight to a particular explanation for each case.

The misfit of pattern class A at Lime (HLT 0210) is a close multivariate fit to the array of pattern class A1 from PNC. Because this array is only ca.14 straight-line km north of the indigenous array of pattern class C at Lime, this raises the possibility that the range of A1 has expanded southward. We hypothesize that this color-pattern misfit arrived at Lime by natural dispersal that involved a number of successive generations of ancestors. We rejected the possibility that HLT 0210 originated from a contemporary hybridization event between *A. tesselata* C and

Fig. 6. Habitat component of *A. neotesselata* at Lime, Pueblo County, Colorado. View is looking northeast through a local stand of greasewood (*Sarcobatus* sp.) from which the misfit of pattern class A1 (HLT 0210) was collected with four representatives of indigenous pattern class C (HLT 0211–0214) on 26 June 2006. Stands of greasewood are one aspect of a complex habitat occupied by *A. neotesselata* at this locality.

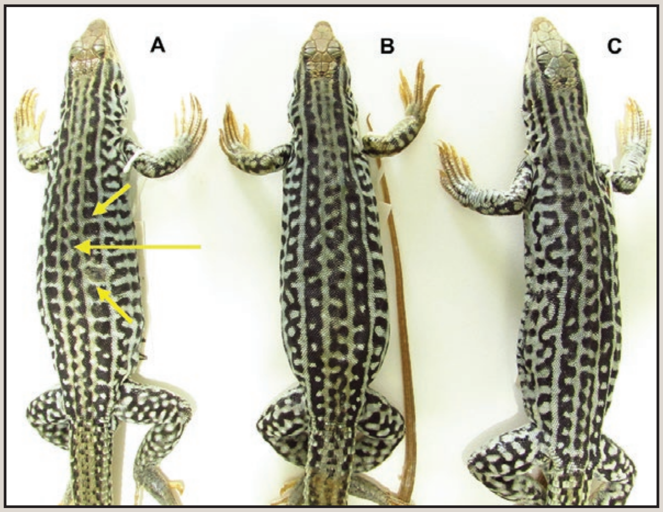

Fig. 7. Representatives of *Aspidoscelis neotesselata* from southeastern Colorado: A) indigenous pattern class C from Lime, Pueblo County (HLT 0214, 93 mm SVL); B) misfit of pattern class A1 collected from the array of Lime C (HLT 0210, 91 mm SVL); C) pattern class A1 from Juniper Breaks Campground, Pueblo Lake State Park, Pueblo County (HLT 0215, 104 mm SVL). Pattern class C differs from pattern class A in a prominent pale line (or line of pale elements) in the vertebral dark field at midbody (arrow) and white bars in the dorsolateral dark fields (arrows).

A. sexlineata viridis because the nearest array of *A. tesselata* C is approximately 107 straight-line km ESE of the Lime site.

The color pattern of the misfit of pattern class D at FCNC (HLT 0398) is a close match to the array of pattern class D from La Junta, but its pale stripes were tan rather than gray. The probability that HLT 0398 is a representative of the La Junta array did decrease from 0.963 with A1, A2 and D references (Taylor et al. 2015b) to 0.853 when B1 and C references were included with A1, A2, D references in the CVA of the present study. This is still a robust classification considering the overlapping variation among a priori groups. However, the array of pattern class D at La Junta is approximately 125 straight-line km southeast of FCNC. Because the known geographic distribution of pattern class D is restricted to the city limits of La Junta (Walker et al. 2012b; Taylor et al. 2015b), its presence at FCNC best fits a hypothesis of human introduction.

There are parallel, high-traffic railway and highway connectors between La Junta and FCNC, so the misfit might represent either an accidental stowaway or its descendant. However, despite its low resemblance to A2 ($P = 0.128$), we cannot positively reject the possibility that HLT 0398 originated, as a pattern class D, by anomalous development of an egg produced by an individual of group A2 at FCNC. We rejected the possibility that HLT 0398 originated from a contemporary hybridization event between *A. tesselata* C and *A. sexlineata viridis* because the nearest array of *A. tesselata* C is approximately 154 straight-line km SE of the FCNC site. The possibility of a self-sustaining array of pattern class D at FCNC is presently under study (Taylor et al. 2015b).

The presence of UADZ 8872 at Crystal Pond might represent an in situ origin. UADZ 8872 has color-pattern elements of two pattern classes (D and A), and its multivariate assignment to group A2, located 127 linear km to the west, was based on a relatively low probability of 0.551. The probability of membership in the array of La Junta D, approximately 27 straight-line km north of Crystal Pond, was even less convincing ($P = 0.262$). Because neither natural dispersal nor human introductions explain these incongruities, we hypothesize that misfit UADZ 8872 originated at Crystal Pond by anomalous development of an egg produced by an individual of group B1. We discounted the possibility that misfit UADZ 8872 was the product of a contemporary hybridization event between individuals of *A. tesselata* C and *A. sexlineata viridis* because it is unlikely that these two species coexisted at Crystal Pond prior to 9 August 2009 when UADZ 8872 was collected. For example, we encountered individuals of *A. neotesselata* B1, but not *A. tesselata*, at Crystal Pond during extensive searches on 3 July 2000, 6 June 2001, 25 May 2007, and 2 July 2008. Because the habitat at Crystal Pond has an open structure, we would have readily noticed the presence of representatives of *A. tesselata* if they had been present on those dates.

Low levels of postorigin genetic variation discovered in *A. neotesselata* (Taylor et al. 2015a) are counterbalanced by an inherited fixed heterozygosity of 71% as determined from 31 nuclear gene loci (Parker and Selander 1976; Taylor et al. 2015a). Dessauer and Cole (1984) demonstrated that alleles expressed themselves in proportion to their dosage in 2n, 3n, and 4n representatives of *Aspidoscelis*, and that genetically modified subunits were randomly involved in the assembly of isozymes at all three ploidy levels. Dessauer and Cole (1984) also proposed that parthenogenetic *Aspidoscelis* might benefit from subunit variation, and that the selective advantage of parthenogenesis and clonal reproduction might be the perpetuation of heterotic gene combinations. Therefore, because triploid *A. neotesselata* inherited genomes of *A. marmorata* and *A. gularis septemvittata* from parthenogenetic *A. tesselata* (its maternal progenitor) and a haploid genome from *Aspidoscelis sexlineata* (Neaves 1969; Parker and Selander 1976; Dessauer and Cole 1989), *A. neotesselata* might have inherited a "general purpose genotype," as defined by Lynch (1984). That is, its high level of heterozygosity might have enhanced the ecological potential of *A. neotesselata* as suggested by its success in colonizing a diversity of habitats in Colorado (Walker et al. 1997a, 2012b; Taylor et al. 2006, 2015b) and an extralimital habitat following introduction into Grant

County, Washington state (Weaver et al. 2011). Taylor et al. (2006) and Walker et al. (2012b) viewed the current allopatric distributions of pattern classes in *A. neotesselata* as reflecting adaptations to mutually exclusive habitats. However, a “general purpose genotype” and the involvement of chance in the successful establishment of different clones at new locations could also have generated this pattern of allopatric distributions. The discovery of coexisting arrays of different pattern classes, rather than single color-pattern misfits in established arrays, would provide support for this alternative hypothesis.

Acknowledgments.—We thank N. S. Bernard, Supervisor of Fountain Creek Nature Center and T. Wolken, Community Services Director, for permission to collect voucher specimens and Colorado Parks and Wildlife, Department of Natural Resources, for providing Scientific Collecting license HP 772 to HLT and HP 950 to CEM. The Thorsen family graciously permitted collecting on Indian Springs Ranch, Fremont County, Colorado. We thank J. Newby and T. Kroeger for field assistance at Crystal Pond and three anonymous reviewers for suggestions that significantly improved our manuscript.

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Appendix 1

Specimens used.—HLT numbers = Regis University (RU) numbers; UADZ = University of Arkansas Department of Zoology. UTM coordinates based on GPS datum WGS84. **Colorado, Otero County**: Pattern class D. La Junta (UTM 13S 628661E, 4206010N): UADZ 6009, 6011, 6015, 6273–6276. 6283–6285, 6289, 6290, 6294, 6321, 6331, 6541, 7769, RU 02090, 98083, 98084, HLT 0333, 0335–0348; N = 35. Crystal Pond (13S 621974E, 4179791N): Ambiguous specimen UADZ 8872; N = 1. Pattern class B1: HLT 0327–0331, 0392, 0393, 0395, UADZ 8044, UADZ 6895, 8873, 8874; N = 12. **Colorado, Pueblo County**: Pattern class A1: Pueblo Nature Center (UTM 13S 528035E, 4235693N). HLT 0053–0074, 0102, 0104, 0180–0184; N = 29; Pueblo Lake State Park, Juniper Breaks Campground (UTM 13S 521837E, 4236735N). HLT 0215 (topotypic); N = 1; Historic cultural site of Lime (UTM 13S 532585E, 4222266N). Misfit of pattern class A: HLT 0210; N = 1; Pattern class C: RU 02091–02093. HLT 0025–0032, 0039–0051, 0103, 0185–0189, 0211–0214, AMNH 146593–146595 (RU 99013–99015); N = 37. **Colorado, Fremont County**: Pattern class A2. Several sites north of Florence including (UTM 13S 490238E, 4250759N: southernmost site) and (UTM 13S 490785E, 4251693N: northernmost site): HLT 0085–0093, 0096, 0098–0101, 0105, 0106, 0108–0115, 0190–0192; Sixmile Park, Indian Springs Ranch (UTM 13S 488250E, 4261108N): HLT 0094, 0095, 0193–0197; N = 34. **Colorado, El Paso County**: Pattern class A2. Fountain Creek Nature Center (UTM 13S 524576 E, 4284921 N): HLT 0396, 0397; N = 2. Misfit of pattern class D. HLT 0398; N = 1. **Colorado, Teller County**: Pattern class A2. Edge of Shelf Road next to Fourmile Creek (UTM 13S 524573E, 42184926N): HLT 0399–0401; N = 3.

APPENDIX 2

Morphological meristic characters.—**COS**: bilateral total of circumorbital scales (Wright and Lowe 1967). **FP**: sum of femoral pores on both thighs. **GAB**: number of granular dorsal scales in a single row around midbody (Wright and Lowe 1967). The third ventral row of enlarged ventral scales, lateral to the midsagittal line, terminates anteriorly in the axillary region. The 15th ventral scale posterior to this terminus established the point for beginning the GAB count. **L-breaks**: bilateral count of number of dark disruptions (breaks) in the pale lateral stripe. Pale scales in the stripe may accumulate melanin during ontogeny to form localized transverse bridges between dark fields (Taylor et al. 2015a). **LSG**: bilateral total of number of lateral supraocular granules, i.e., granular scales located between the supraoculars and superciliary scales (Walker et al. 1966). The count includes all scales anterior to a line extended from the suture line between the third and fourth supraoculars. **SDL**: number of subdigital lamellae on the fourth toe (right was chosen unless damaged) of one foot (Cole et al. 1988). **SPV**: number of scales separating medial margins of paravertebral stripes at a position, as close as possible, to the counting position for GAB (Wright and Lowe 1967).

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Aspidoscelis marmorata (Marbled Whiptail) in Monahans Sandhills State Park of Texas: Extraordinary Variation in Color Patterns

On 12 August 2011, MWL distributed a digital image seeking identification of a whiptail lizard (Fig. 1A) with an unusual color pattern. It was taken in situ in Monahans Sandhills State Park (MSSP) which comprises ~1550 ha of a much larger area of sandhills and dunes in Ward and Winkler counties in western Texas, USA. Initially, JMW hypothesized that the image represented a new color pattern class of diploid parthenogenetic *Aspidoscelis tesselata* (Common Checkered Whiptail), which occurs in bordering counties to the east (e.g., Crane) and west (e.g., Reeves). However, subsequent Texas Parks and Wildlife Department-sanctioned investigations of lizards in the park by JEC, MWL, and H. L. Taylor revealed the presence of only one teiid lizard species, namely gonochoristic *Aspidoscelis marmorata* (Marbled Whiptail). The landscape there comprises both barren dunes up to 21 m high with perpetually shifting wind-blown sand, and sandhills and dunes stabilized by a variety of plant species, the most notable being the low-growing climax shrub, *Quercus havardii* (Shinoak). Collecting results by JEC indicated that *A. marmorata* existed in lower densities in MSSP than at many other sites in Texas (also see Hendricks and Dixon 1986). Phenotypic variation and ecology of *A. marmorata* have not been studied in the sandhills of western Texas. The purpose of this report is to document the extraordinary range of variation observed in dorsal color patterns (Figs. 1–3), variation in morphological characters (Table 1), and other details pertaining to each specimen (Tables 2–3) in the sample of *A. marmorata* from MSSP which make this population of exceptional systematic, evolutionary, ecological, and conservation interest.

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MATERIALS AND METHODS

Stimulated by the images provided by MWL (Fig. 1A), M. R. J. Forstner (Fig. 1B), and a specimen collected by MWL and an associate and then photographed by H. L. Taylor in 2011 (Fig. 1C), JEC visited MSSP once in 2014, eight days in 2015, and 10 days in 2016 to collect and observe whiptail lizards (only the 11 days on which specimens were collected are noted in Table 2). He obtained 19 specimens of *A. marmorata* from MSSP, all cataloged into the University of Arkansas Department of Zoology (UADZ) herpetology collection for use in this study (Tables 1–3; Figs. 2–3). About 40% of whiptails observed were collected, averaging only 1.0 lizards per trip (range 0–4, N = 19 days), results that reflect both scarcity and extreme wariness of these lizards. All *A. marmorata* observed in MSSP were in sandhill formations with open-structured stabilizing vegetation or near day-use picnic areas. Historical and contemporary information pertaining to MSSP (e.g., geology, climatology, hydrology, geographical extent, history of human usage) was included in reports by Machenberg (1982, 1984).

Aspidoscelis tigris and *A. marmorata*, derived from a common ancestor, hybridize in the three known zones of contact, all in the northwestern Animas Valley in Hidalgo County in extreme southwestern New Mexico (Dessauer et al. 2000, fig. 1). Although opinions have differed on whether the names *tigris* and *marmorata* should be applied to either different species (e.g., Hendricks and Dixon 1986) or subspecies (e.g., Dessauer et al. 2000), we followed the latest SSAR Checklist which treats them as species (de Queiroz and Reeder 2012). East (i.e., *A. marmorata marmorata*) and west (i.e., *A. tigris punctilinealis*) of the hybrid zones, these taxa are characterized by different dorsal color patterns, shifts in allele frequencies at five protein loci, and sharp step-clines for all morphological characters studied to date (Dessauer and Cole 1991; Dessauer et al. 2000)

In two recent studies we assessed color pattern variation in *A. tigris punctilinealis* from Gila County, Arizona (Walker and

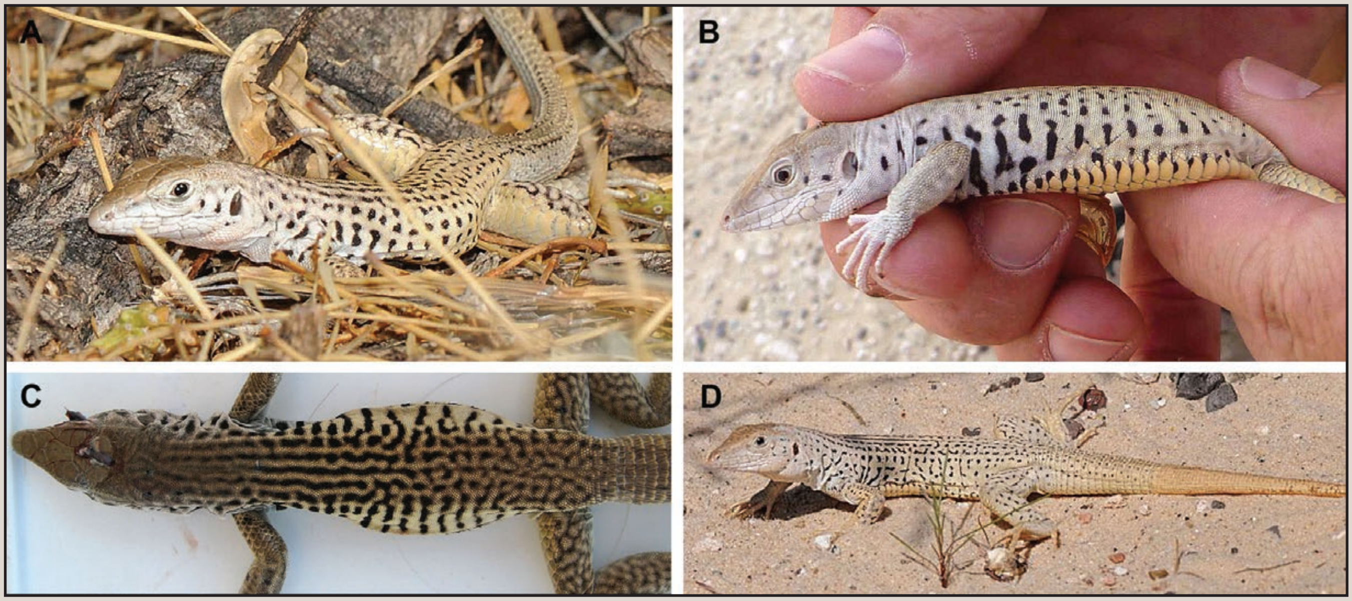

Fig. 1. A) *Aspidoscelis marmorata reticuloriens* (with large areas of dorsal black ground color) in situ in 2011 in Monahans Sandhills State Park (MSSP), Ward County, Texas, that provided the impetus for this study. Photo by M. W. Lockwood. B) Captive of this subspecies from MSSP in 2011. Photo by M. R. J. Forstner. C) Preserved individual of this subspecies from MSSP in 2011. Photo by H. L. Taylor. D) Example of this subspecies (with small areas of dorsal black ground color) in situ in 2013 also showing substrate blending. Photo by M. W. Lockwood.

Table 1. Comparisons of meristic data for eight characters based on samples of *Aspidoscelis tigris punctilinealis* from Gila County, Arizona (complete collection data in Walker and Sullivan 2014), *A. tigris septentrionalis* from San Juan County, New Mexico (complete collection data in Walker et al. 2015), and *A. marmorata reticuloriens* from Ward County, Texas (see Tables 2 and 3 herein). Only means and SE with all different superscripted letters are significantly different ($P = 0.05$).

Character abbreviation: description	*A. t. punctilinealis* Gila Co., AZ	*A. t. septentrionalis* San Juan Co., NM	*A. m. reticuloriens* Ward Co., TX	F Statistics JMP
GAB: granular scales around midbody from one lateral row of ventral scales to opposite row of lateral scales	86.3 ± 1.13^{B} 72–101 (28)	81.0 ± 1.19^{C} 68–89 (25)	95.6 ± 1.37^{A} 88–109 (19)	$F_{2,69} = 32.93, P = <.0001$
GOR: granular scales between occipital scales and first row of caudal scales		163.9 ± 1.67^{B} 148–175 (25)	191.3 ± 1.89^{A} 180–213 (19)	$F_{1,42} = 119.28, P = <.0001$
PV: granular scales between paravertebral stripes at Midbody	7.6 ± 0.22^{A} 5–12 (28)	6.1 ± 0.24^{B} 5–8 (25)		$F_{1,51} = 21.19, P = <.0001$
FP: femoral pores summed from thighs of both hind limbs	40.4 ± 0.48^{B} 36–46 (28)	38.8 ± 0.51^{B} 35–41 (25)	46.8 ± 0.58^{A} 43–52 (19)	$F_{2,69} = 58.98, P = <.0001$
SDL: subdigital lamellae from the fourth toe of the left pes	31.8 ± 0.32^{B} 29–35 (28)	31.5 ± 0.33^{B} 30–34 (25)	34.8 ± 0.38^{A} 32–38 (19)	$F_{2,69} = 18.77, P = <.0001$
COS: circumorbital scales summed from between supraocular and median head scales from both sides	14.8 ± 0.55^{B} 10–20 (28)	16.5 ± 0.58^{B} 12–24 (25)	20.4 ± 0.70^{A} 12–28 (19)	$F_{2,69} = 19.25, P = <.0001$
LSG: lateral supraocular granules summed from anterior to third supraocular sutures from both sides	29.1 ± 1.27^{B} 20–46 (28)	28.8 ± 1.34^{B} 18–43 (25)	37.8 ± 1.54^{A} 26–54 (19)	$F_{2,69} = 12.07, P = <.0001$
ILS: interlabial scales, summed from between infralabial and chin shields from both sides of head	47.5 ± 1.70^{B} 34–73 (28)	50.6 ± 1.80^{AB} 37–72 (25)	55.2 ± 2.06^{A} 39–71 (19)	$F_{2,69} = 4.15, P = 0.1995$

Sullivan 2014), and *A. tigris septentrionalis* from Mohave County, Arizona, and San Juan County, New Mexico (Walker et al. 2015). Herein, we qualitatively compared certain of these samples of *A. tigris* with the sample of *A. marmorata reticuloriens* from MSSP, with reference to size of postantebrachial scales on the posterior aspect of each of the forearms and size of mesoptychial scales bordering the edge of the gular fold. We also assessed patterns of variation in the univariate meristic characters listed and defined in Table 1 to obtain results on the relationship of color pattern and morphology.

Prior to preservation, each lizard from MSSP was weighed to 0.1 g (Table 2), measured for SVL to mm (Table 2), and a tail

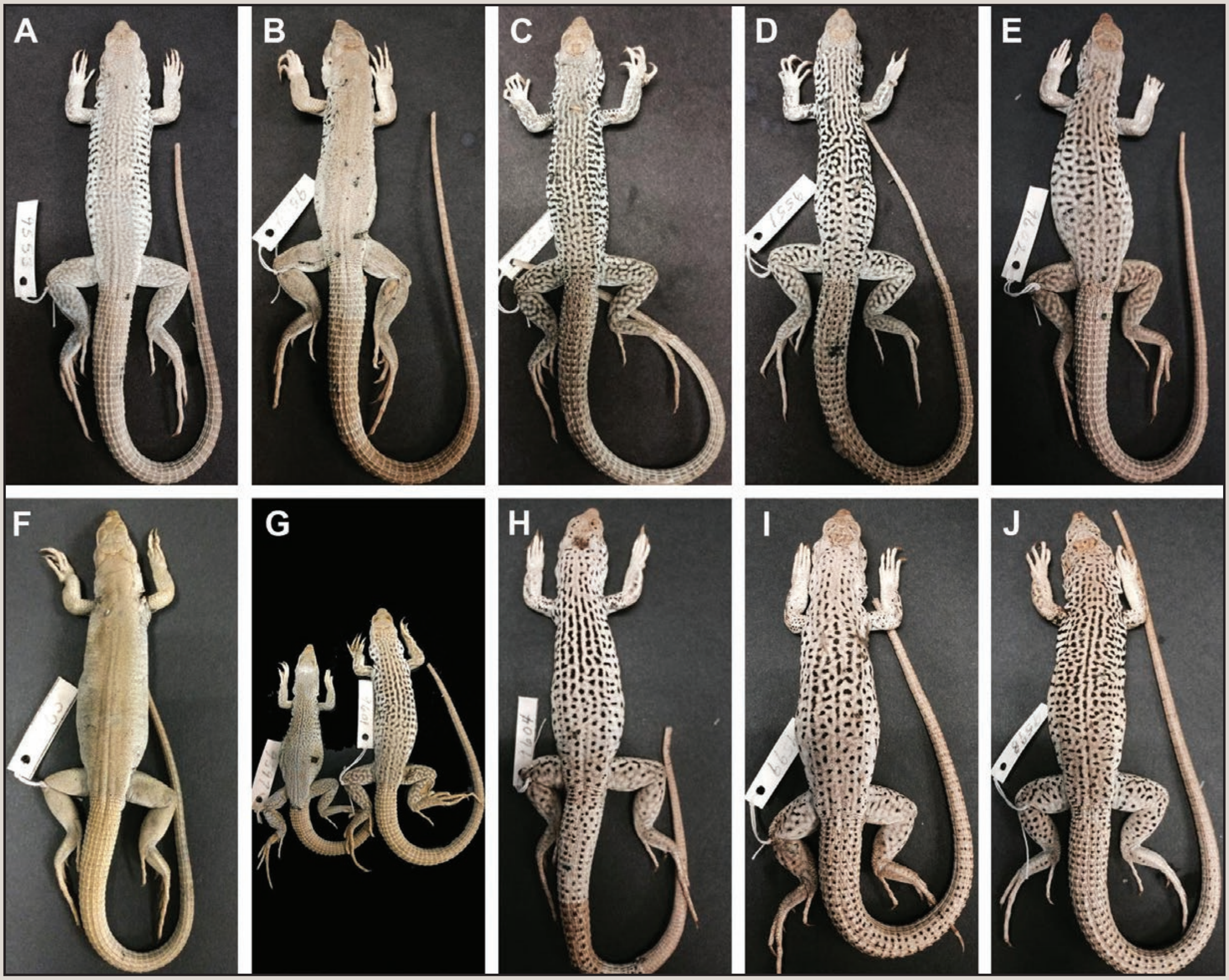

Fig. 2. Variation in dorsal color patterns in specimens of *Aspidoscelis marmorata reticuloriens* collected by JEC in 2014 and 2015 in Monahans Sandhills State Park, Ward County, Texas. A) UADZ 9553 ♂ of 82 mm SVL; B) UADZ 9554 ♂ of 82 mm SVL; C) UADZ 9552 ♂ of 82 mm SVL; D) UADZ 9551 ♂ of 87 mm SVL; E) UADZ 9602 ♀ of 85 mm SVL; F) UADZ 9603 ♀ of 77 mm SVL; G) UADZ 9597 ♂ of 62 mm SVL (left) and UADZ 9601 ♂ of 70 mm SVL (right); H) UADZ 9604 ♂ of 90 mm SVL; I) UADZ 9599 ♂ of 93 mm SVL; J) UADZ 9598 ♂ of 93 mm SVL.

clip of several mm was placed in 95% ethanol and coded for genetic analysis (results deferred to a subsequent report). In the laboratory, the SVL of each specimen was again measured as analyses of color patterns were conducted. For each specimen, the measurements obtained before (unpreserved snout vent length, USVL) and after preservation (preserved snout vent length, PSVL = SVL) were included in Table 2; however, only the latter (SVL) and unpreserved mass (UM) were used in descriptive accounts of color pattern, figure legends, and to estimate the summer of life of a lizard. Our data suggested that hatchlings appear in late July and early August (e.g., observed 3 August 2016), grow to about 60 mm SVL the first summer, to about 75 mm the second summer, to about 85 mm the third summer, and as large as 95 mm the fourth summer.

In the two recent studies of *A. tigris* (Walker and Sullivan 2014; Walker et al. 2015), we standardized terminology to compare lizards from different populations in Arizona and New Mexico because phenotypic diversity was largely based on ontogenetic, sexual, and/or geographic modifications of basically similar dorsal color patterns (e.g., consisting of rounded spots, vertical bars, named longitudinal pale stripes and intervening dark fields, and extent of contrast between these and the surrounding darker ground color). However, extensive variation in the dorsal color patterns among individuals of *A. marmorata* from MSSP did not consist of modifications of the basically similar components noted which precluded use of the standardized terminology of Walker and Sullivan (2014) and Walker et al. (2015). Instead, the dorsal pattern of each live (Fig. 1) and preserved (Tables 2–3; Figs. 2–3) individual of *A. marmorata* from MSSP, excluding entirely blanched lizards, comprised one or more ensembles (i.e., areas) consisting of either similar or different combinations of pale-colored pattern elements and darker ground colors. Typically, the longitudinal middle ~40% of the dorsal color pattern from head to tail differed from the longitudinal ~30% of the pattern on each side. Moreover, we also observed that different ensembles characterized the anterior and posterior aspects of the longitudinal dorsal and lateral components of the color pattern (e.g., Lineate/

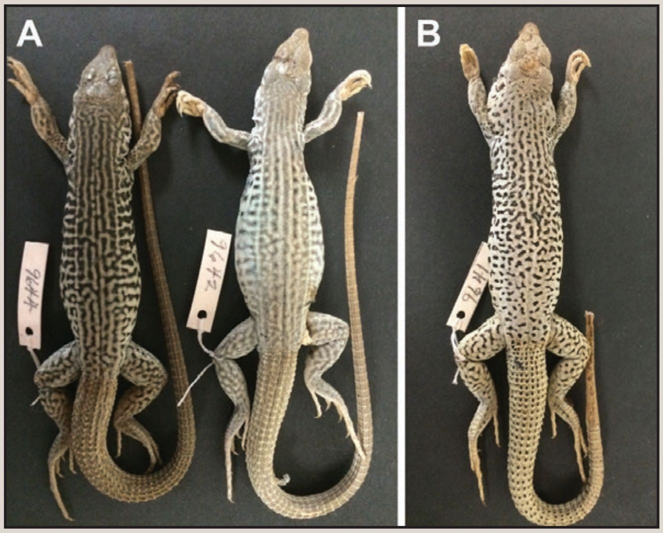

Fig. 3. Images made by JMW showing marked differences between the much darker overall dorsal pattern of a typical individual of *Aspidoscelis marmorata reticuloriens* (A-left, UADZ 9644 ♂ of 80 mm SVL) from the Crane County site beyond the Texas sandhills (see Specimens Examined) and two individuals (A-right., UADZ 9642 ♀ of 85 mm SVL and [B], UADZ 9641 ♂ of 96 mm SVL) from Monahans Sandhills State Park, Ward County, Texas, all collected by JEC in June 2016.

Rectangular-Barred/Rectangular). Remarkably, each of the first four specimens (UADZ 9551–9554; Fig. 2A–D) collected by JEC in MSSP in 2014 was characterized by a different arrangement of pattern ensembles. In all, we used nine designations (= combinations) to represent patterns of dorsal variation in the four (21.1%) females and 15 (78.9%) males listed in Tables 2–3. These designations involved combinations of the following pattern ensembles: 1) blanched (sensu Rosenblum et al. 2004) = contrast between ground color and pattern elements either much reduced or lacking; 2) lineate = mainly irregular pale colored lines and intervening darker ground color; 3) barred = mainly alternating pale and dark vertical bars along the sides; and 4) rectangular = predominantly rectangular to polygonal areas of dark ground color surrounded by gray-white pattern elements. The following accounts feature individuals from the pattern types recognized among lizards from MSSP (Tables 2–3; Figs. 2–3). The preserved specimen collected by MWL (Fig. 1C), variation in the live lizards photographed by him in (Figs. 1A, D), and by M. R. J. Forstner (Fig. 1B) were not included in Tables 2–3.

Results

Samples of *A. tigris* from Gila County, Arizona, and San Juan County, New Mexico, were indistinguishable from each other and from the sample of *A. marmorata* from Ward County, Texas, in two characters of scutellation that are diagnostic for the *A. tigris* species group; all specimens of each species possessed granular postantebrachial scales on the posterior aspect of each of the forelimbs and small mesoptychial scales bordering the gular fold. Data for eight meristic characters were statistically compared in Table 1. Of particular interest were results obtained from comparisons of *A. tigris* from San Juan County and *A. marmorata* from Ward County as both geographically distantly separated samples contained individuals with blanched dorsal color patterns, although details of patterns differed by group. Statistically significant differences were apparent in all characters except PV, for which no data were possible because of the nature of the dorsal pattern in *A. marmorata*, and means for the ILS character.

The two lizards photographed in situ by MWL in MSSP (Figs. 1A, D) did not have obvious anterior to posterior differentiation of pattern ensembles on either the previously defined dorsal or lateral aspects of the body. Their entire dorsal patterns consisted of maximally contrasted longitudinal gray-white lines cross-connected by bars of the same color that isolated rectangular to polygonal/patches of black ground color, though the extent of ground color in their patterns was markedly different. The black ground color of the limbs in both lizards was much reduced by extensive gray-white markings of various shapes. Dorsally, they differed from all of 49 specimens from Ward and neighboring counties deposited in the Texas Cooperative Wildlife Collection and featured in two composite images provided by J. R. Dixon.

Initially, we sorted the dorsal color pattern variants among the 19 preserved specimens of *A. marmorata* from MSSP into two basic groups. We designated three of four lizards (75%) in the first group as Blanched/Blanched-Blanched/Blanched (Tables 2–3; Fig. 2B and F–G-left). They were the most extreme dorsal pattern variants from MSSP, representing the ultimate in substrate matching phenotypes. The smallest of these was a juvenile male (UADZ 9597 of 62 mm SVL and 6.9 g UM) estimated to be in the second summer of life. It had gray-white ventral surfaces, and a dorsal pattern of faint gray-white worm-like vermiculations set within an only slightly darker gray ground color together with a lateral distribution of gray-white isolating minute inconspicuous bar-like or rectangular areas of dusky black ground color (Fig. 2G-left). A gravid female (UADZ 9603 of 77 mm SVL and 13.8 g UM) was estimated to be in the third summer of life. It had pale gray to gray-white ventral surfaces, and it was uniformly gray dorsally and had inconspicuous (i.e., very faint) medium gray bars laterally (Fig. 2F). An adult male (UADZ 9554 of 82 mm SVL and 23.3 g UM) was estimated to be in the third summer of life. It was similar to the preceding gravid female except for having a few scales in the outer row of ventral scales on each side with narrow black posterior edges, and a uniformly medium gray dorsum except for a distribution of inconspicuous rectangular areas of dusky black on each side immediately posterior to the forelimbs (Fig. 2B). Viewed from perspectives either directly above these specimens in the laboratory or from a distance of a few feet in the field, each one had the appearance of being uniformly gray (also see Fig. 1D).

We designated one of four lizards (25%) from group one, with a mostly weakly contrasted dorsal pattern, as Blanched/Blanched-Barred/Rectangular (Fig. 2A). This adult male (UADZ 9553 of 82 mm SVL and 16.0 g UM) was estimated to be in the third summer of life. It had gray-white ventral surfaces, and inconspicuous gray-white worm-like vermiculations set within a slightly darker gray ground color dorsally and a checkered distribution of mostly gray-white isolating minute bar-like or rectangular areas of dusky black ground color laterally.

We identified seven basic dorsal color patterns consisting of one to three ensembles (i.e., lineate, rectangular, and barred) among the second group of 15 lizards characterized by strongly contrasted dorsal color patterns. We designated two of 15 (13.3%) specimens as Lineate/Lineate-Barred/Barred. One of the two (Fig. 2C) was an adult male (UADZ 9552 of 82 mm SVL and 19.1 g UM) estimated to be in the third summer of life. It exhibited the strongest possible contrast between the black ground color and the gray-white pattern elements arrayed in a lineate pattern from

Table 2. Column headings: UADZ = museum number (Figs. = 2–3); DCPE-LCPE = Dorsal Color Pattern Ensembles-Lateral Color Pattern Ensembles; GPS = Global Positioning System WGS84; ELEV = Elevation; S = Sex; USVL = Unpreserved Snout Vent Length in mm/PSVL = Preserved Snout Vent Length in mm; UM = Unpreserved Mass in g; DATE = Date of Collection for Each of 19 specimens of *Aspidoscelis marmorata reticuloriens* obtained by JEC in 2014 (N = 4), 2015 (N = 11), and 2016 (N = 4) in Monahans Sandhills State Park, Ward County, Texas.

UADZ (FIGS.)	DCPE-LCPE	GPS	ELEV	S	USVL/PSVL	UM	DATE
9551 (Fig. 2D)	Lineate/Rectangular-Barred/Rectangular	31.63788°N, 102.82701°W	837 m	♂	91/87 mm	20.1 g	21 July 2014
9552 (Fig. 2C)	Lineate/Lineate-Barred/Barred	31.63788°N, 102.82701°W	837 m	♂	88/82 mm	19.1 g	21 July 2014
9553 (Fig. 2A)	Blanched/Blanched-Barred/Rectangular	31.63788°N, 102.82701°W	837 m	♂	86/82 mm	16.0 g	21 July 2014
9554 (Fig. 2B)	Blanched/Blanched-Blanched/Blanched	31.63992°N, 102.81895°W	841 m	♂	89/82 mm	23.3 g	21 July 2014
9596 (NONE)	Lineate/Lineate-Barred/Rectangular	31.63816°N, 102.82569°W	844 m	♀	71/70 mm	8.2 g	9 June 2015
9597 (Fig. 2G-l.)	Blanched/Blanched-Blanched/Blanched	31.64293°N, 102.82727°W	846 m	♂	65/62 mm	6.9 g	9 June 2015
9598 (Fig. 2J)	Lineate/Rectangular-Barred/Rectangular	31.63919°N, 102.82193°W	837 m	♂	98/93 mm	31.8 g	9 June 2015
9599 (Fig. 2I)	Rectangular/Rectangular-Rectangular/Rectangular	31.63869°N, 102.82413°W	839 m	♂	98/93 mm	27.1 g	11 June 2015
9600 (NONE)	Lineate/Lineate-Barred/Rectangular	31.63753°N, 102.82851°W	836 m	♂	96/92 mm	30.5 g	11 June 2015
9601 (Fig. 2G-r.)	Lineate/Rectangular-Rectangular/Rectangular	31.64358°N, 102.82665°W	842 m	♂	75/70 mm	10.3 g	12 June 2015
9602 (Fig. 2E)	Lineate/Lineate-Barred/Barred	31.63797°N, 102.82679°W	842 m	♀	87/85 mm	20.3 g	13 June 2015
9603 (Fig. 2F)	Blanched/Blanched-Blanched/Blanched	31.63994°N, 102.81895°W	834 m	♀	77/77 mm	13.8 g	8 July 2015
9604 (Fig. 2H)	Lineate/Lineate-Rectangular/Rectangular	31.63919°N, 102.82065°W	843 m	♂	94/90 mm	25.2 g	8 July 2015
9605 (NONE)	Lineate/Lineate-Barred/Rectangular	31.63781°N, 102.82635°W	841 m	♂	85/83 mm	16.3 g	9 July 2015
9606 (NONE)	Lineate/Rectangular-Rectangular/Rectangular	31.63853°N, 102.82343°W	842 m	♂	88/84 mm	25.5 g	10 July 2015
9641 (Fig. 3B)	Lineate/Rectangular-Barred/Rectangular	31.63910°N, 102.82220°W	838 m	♂	98/96 mm	27.8 g	8 June 2016
9642 (Fig. 3A-r.)	Lineate/Lineate-Rectangular/Barred	31.63926°N, 102.82179°W	836 m	♀	89/85 mm	21.2 g	8 June 2016
9660 (NONE)	Lineate/Rectangular-Barred/Rectangular	31.64565°N, 102.83026°W	834 m	♂	90/87 mm	23.6 g	3August 2016
9663 (NONE)	Lineate/Rectangular-Barred/Rectangular	31.63892°N, 102.82273°W	838 m	♂	96/92 mm	28.9 g	8 August 2016

Table 3. Explanation of pattern ensembles in the dorsal and ventral patterns among 19 preserved specimens of *Aspidoscelis marmorata reticuloriens* from Monahans Sandhills State Park, Ward County, Texas. Abbreviations: UADZ/S/PSVL/FIGS. = Museum Number/Sex/Preserved Snout Vent Length/Figures 2–3; ADPE = Anterior Dorsal Pattern Ensemble: PDPE = Posterior Dorsal Pattern Ensemble; ALPE = Anterior Lateral Pattern Ensemble; PLPE = Posterior Lateral Ensemble; ST = Spots on Throat; DBECS = Distribution of Black Edged Chest Scales; and DPT = Dorsal Pattern of Tail.

UADZ/S/PSVL/FIGS.	ADPE	PDPE	ALPE	PLPE	ST	DBECS	DPT
9551 ♂ 87 mm (Fig. 2D)	Lineate	Rectangular	Barred	Rectangular	Few laterally	Laterals narrowly edged	Spotted/banded
9552 ♂ 82 mm (Fig. 2C)	Lineate	Lineate	Barred	Barred	None	Laterals narrowly edged	Spotted/banded
9553 ♂ 82 mm (Fig. 2A)	Blanched	Blanched	Barred	Rectangular	None	Laterals narrowly edged	Pale gray banded
9554 ♂ 82 mm (Fig. 2B)	Blanched	Blanched	Blanched	Blanched	None	Laterals narrowly edged	Pale gray banded
9596 ♀ 70 mm (NONE)	Lineate	Lineate	Barred	Rectangular	None	Laterals narrowly edged	Pale gray banded
9597 ♂ 62 mm (Fig. 2G-l.)	Blanched	Blanched	Blanched	Blanched	None	None	Gray
9598 ♂ 93 mm (Fig. 2J)	Lineate	Rectangular	Barred	Rectangular	Few scattered	Laterals narrowly edged	Spotted in bands
9599 ♂ 93 mm (Fig. 2 I)	Rectangular	Rectangular	Rectangular	Rectangular	Few scattered	Most edged	Spotted
9600 ♂ 92 mm (NONE)	Lineate	Lineate	Barred	Rectangular	Many scattered	Most edged	Spotted in bands

(*continued on next page*)

Table 3. Continued.

UADZ/S/PSVL/FIGS.	ADPE	PDPE	ALPE	PLPE	ST	DBECS	DPT
9601 ♂ 70 mm (Fig. 2G-r.)	Lineate	Rectangular	Rectangular	Rectangular	None	Laterals narrowly edged	Pale gray banded
9602 ♀ 85 mm (Fig. 2E)	Lineate	Lineate	Barred	Barred	None	Laterals narrowly edged	Gray
9603 ♀ 77 mm (Fig. 2F)	Blanched	Blanched	Blanched	Blanched	None	None edged	Gray
9604 ♂ 90 mm (Fig. 2H)	Lineate	Lineate	Rectangular	Rectangular	Few scattered	Most edged	Spotted
9605 ♂ 83 mm (NONE)	Lineate	Lineate	Barred	Rectangular	None	Laterals narrowly edged	Pale gray banded
9606 ♂ 84 mm (NONE)	Lineate	Rectangular	Rectangular	Rectangular	Few scattered	Most edged	Spotted in bands
9641 ♂ 96 mm (Fig. 3B}	Lineate	Rectangular	Barred	Rectangular	Few scattered	Most edged	Spotted in bands
9642 ♀ 85 mm (Fig. 3A-l.)	Lineate	Lineate	Rectangular	Barred	None	None	Pale gray banded
9660 ♂ 87 mm (NONE)	Lineate	Rectangular	Barred	Rectangular	None	Laterals narrowly edged	Spotted in bands
9663 ♂ 92 mm (NONE)	Lineate	Rectangular	Barred	Rectangular	None	Laterals narrowly edged	Spotted in bands

head to base of tail, whereas both sides of the body had patterns of alternating vertical bars anteriorly and posteriorly. These ensembles were also present in another estimated third summer adult (Fig. 2E), a female (UADZ 9602 of 85 mm SVL and 20.3 g UM) that exhibited a striking resemblance to some individuals of diploid parthenogenetic *Aspidoscelis dixoni* pattern class A from the Chinati Mountains in Presidio County, Texas. We designated five of 15 specimens (33.3%) as Lineate/Rectangular-Barred/Rectangular. The adult male in Fig. 2D (UADZ 9551 of 87 mm SVL and 20.1 g UM) was estimated to be in the third summer of life. It had gray-white ventral surfaces, dorsum with a contrasted anterior lineate ensemble and a checkered (i.e., rectangular) posterior ensemble coupled with sides with anterior barred and posterior rectangular ensembles. Similarly patterned were four adult males, one being in the third summer of life (UADZ 9660 of 87 mm SVL and 23.6 g UM) and three estimated to be in the fourth summer of life (i.e., Fig. 2J, UADZ 9598 of 93 mm SVL and 31.8 g UM; Fig. 3B, UADZ 9641of 96 mm SVL and 27.8 g UM; UADZ 9663 of 92 mm SVL and 28.9 g UM). We designated three of 15 (20.0%) strongly contrasted specimens as Lineate/Lineate-Barred/Rectangular, which included a second-year female (UADZ 9596 of 70 mm SVL and 8.2 g. UM), a third-year male (UADZ 9605 of 83 mm SVL and 16.3 g UM), and a fourth-year male (UADZ 9600 of 92 mm SVL and 30.5 g UM). We designated two of 15 specimens (13.3%) as Lineate/Rectangular-Rectangular/Rectangular (Table 2; Fig. 2G-right), which included a second-year male (UADZ 9601 of 70 mm SVL and 10.3 g UM) and a third-year male (UADZ 9606 of 84 mm SVL and 25.5 g UM). We designated one of 15 specimens (6.7%) as Rectangular/Rectangular-Rectangular/Rectangular (Table 2; Fig. 2I), a fourth-year male (UADZ 9599 of 93 mm SVL and 27.1 g UM). We designated one of 15 specimens (6.7%) as Lineate/Lineate-Rectangular/Rectangular (Table 2; Fig. 2H), a fourth-year male (UADZ 9604 of 90 mm SVL and 25.2 g UM). Finally, we designated one of 15 (6.7%), a third-year gravid female (Table 2; Fig. 3A-right). as Lineate/Lineate Rectangular/Barred (UADZ 9642 of 85 mm SVL and 21.2 UM).

Discussion

The smaller of the two major groups recognized among the MSSP sample of 19 preserved specimens of *A. marmorata reticuloriens* included one essentially unicolored lizard and three with only the slightest contrast between pale pattern components and slightly darker gray ground colors (e.g., equivalent to unicolored [*A. inornata*, Walker et al. 2009]; blanched [*A. inornata*, Walker et al. 1996; Rosenblum et al. 2004]; faded [*A. tigris*, Walker et al. 2015]; pale [*A. tigris*, Taylor and Buschman 1993]). The larger group comprised 15 lizards with seven different combinations of contrasted dorsal pattern ensembles of pale components and dusky black to black ground colors (e.g., similar to dark [*A. tigris*, Taylor and Buschman 1993]; strongly contrasted [*A. tigris*, Walker et al. 2015]). The revisionary study of *A. marmorata* (= *Cnemidophorus marmoratus*) by Hendricks and Dixon (1986) did not clarify variation in the MSSP population per se. Although our UADZ preserved sample of *A. marmorata reticuloriens* from MSSP comprised only four females and 15 males, the range of dorsal color pattern variation exhibited by these specimens greatly exceeded that observed in dozens of other samples representative of both the *A. tigris* complex (i.e., from USA, Baja California, islands east and west of the peninsula, and continental Mexico) and the *A. marmorata* complex (i.e., from USA and continental Mexico).

We did not find evidence that the variation in these lizards could be attributed either to ontogenetic variation (i.e., both blanched and strongly contrasted patterns were observed in a juvenile and in adults) or sexual variation (i.e., both pattern grouping were observed in both sexes).

As pertains to ecology, we identified three Blanched/Blanched-Blanched/Blanched individuals and one Blanched/Blanched-Barred/Rectangular individual of *A. marmorata reticuloriens* from MSSP that exhibited substrate matching dorsal color patterns as might have been expected from sandhills/dunes formations based on the study of *A. inornata* in White Sands National Monument, New Mexico (Rosenblum et al. 2004). Although such blanched patterns would appear to make lizards less visible as they moved over open sand between the vegetated areas on the dunes, natural selection has not resulted in most lizards of this species having such extreme patterns in MSSP. However, an image obtained by MWL in MSSP (Fig. 1D) with a contrasted pattern blended strikingly with the substrate indicating that a fully blanched pattern perhaps has no advantage in substrate matching over all contrasted phenotypes.

Fifteen preserved specimens exhibited seven combinations of three previously described dorsal pattern ensembles indicating that stability of details of pattern is less important in this population than maintenance of a degree of strong contrast between pale and dark components thereof. Although the essentially unicolored blanched pattern could represent crypsis on open ground, we surmised that the contrasted ensembles would make predators less aware of lizards hiding, foraging, and/or digging burrows in the dappled sunlight in vegetation, activities that would consume much of their daily activity periods. Away from MSSP and surrounding sandhill formations the dorsal patterns of individuals of both males and females of *A. marmorata* are much darker than those within the sandhills (e.g., Fig. 3A-left.).

Acknowledgments.—All UADZ voucher specimens of *Aspidoscelis marmorata reticuloriens* used in this study were collected in accordance with the provisions of Texas Parks and Wildlife Department (TPWD) permits SPO61 and SPR-1090-298 issued to JEC. We thank D. Riskind of TPWD for assistance in the permitting process, Superintendent M. Smith and A. Tavarez of MSSP for numerous courtesies, H. L. Taylor for assistance in the field, M. R. J. Forstner for an image, J. R. Dixon for two images showing many individuals of *A. marmorata*, and B. K. Sullivan and G. Koehler for much needed assistance in constructing Figs. 1–3. The specimens of *A. tigris punctilinealis* were loaned to us by B. K. Sullivan.

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SPECIMENS EXAMINED

Aspidoscelis marmorata reticuloriens (Eastern Marbled Whiptail). Texas: Ward County: Monahans Sandhills State Park: UADZ 9551–9554, 9596–9606, 9641–9642, 9660, 9663 (N = 19). For collection details see Tables 2–3 herein.

Specimen of the subspecies not included in Tables 2–3. Texas: Crane County: 1.12 km E of junction of US Hwy 385 and Ma Barker Road near the latter road at 31.32904ºN, 102.33614ºW and elev. 838 m (UADZ 9644, N = 1).

Aspidoscelis tigris punctilinealis (Sonoran Tiger Whiptail). Arizona: Gila County: Brian K. Sullivan (BKS) 1799–1805, 1809–1822, 1835–1841 (N = 28). For collection details see Walker and Sullivan 2014.

Aspidoscelis tigris septentrionalis (Plateau Tiger Whiptail). New Mexico: San Juan County: 9478–9488, 9494–9495, 9503, 9509–9513, 9572–9274, 9576, 9584–9585 (N = 25). For collection details see Walker et al. 2015.

TECHNIQUES

Herpetological Review, 2016, 47(4), 575–578.

A Review of Common Mudpuppy (*Necturus maculosus*) Capture Methods and Description of a Revised Trap Design

Necturus maculosus is a widespread, aquatic salamander native to both lentic and lotic systems in eastern North America (Petranka 1998). These salamanders typically occur under cover such as large flat rocks or logs, especially in areas with layers of mud substrate and debris (Petranka 1998; Matson 2005). Adults often exhibit high site fidelity (Shoop and Gunning 1967; Matson 1998). *Necturus maculosus* has a long lifespan (~30 years; Bonin et al. 1995), and plays an integral role in its environment as a predator, feeding on fish, crayfish, and mollusks (VanDeValk and Coleman 2010). Breeding occurs in the fall; females store sperm in spermatheca over the winter with ovulation and fertilization delayed until spring (Petranka 1998; Matson 2005). Egg deposition occurs under large flat rocks in the spring and summer (Petranka 1998; Matson 2005). Larvae hatch in early summer, and there is evidence that adult *N. maculosus* attend and guard clutches of eggs (Hime et al. 2014). Additionally, *N. maculosus* is the only known host for the Salamander Mussel (*Simpsonaias ambigua*), a regionally imperiled freshwater mussel.

Although thought to be common throughout its range (Barbour 1971; Petranka 1998), much of the life history of *N. maculosus* is unknown. For example, habitat preferences, seasonal movements, population structure, gene flow, and dispersal are poorly understood (but see McDaniel et al. 2009). The lack of information is due, in part, to its cryptic nature and capture difficulty (Matson 1990). Here we review various capture methods for *N. maculosus*, as well as illustrate and highlight a new trap design for their efficient capture.

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Review of Capture Methods

A number of methods are commonly used for *N. maculosus* sampling, including electroshocking, manual surveys, seining, and trapping using minnow traps (Table 1).

Electroshocking.—Electroshocking uses a mild electric current to stun aquatic vertebrates for easy capture with nets. Although electroshocking has been used to successfully capture *N. maculosus* (Shoop and Gunning 1967; Schmidt et al. 2004; VanDeValk and Coleman 2010), it has numerous drawbacks, and may be ineffective (Matson 1990). Backpack electroshocking is limited by navigability and depth of the water, and is typically feasible in water where the sampler is able to wear waders (< 1 m deep). Boat-mounted electroshocking enables the sampling of larger systems, but limits smaller stream sampling and is cost prohibitive. Drawbacks of both electroshocking methods include dependency on adequate water conductivity to deliver the shock, known as a limited shock radius. Furthermore, *N. maculosus* tend to stay under large flat rocks, reducing the chance of netting a shocked *N. maculosus*, as the rock prevents the mudpuppy from rising to the surface (Matson 1990). Nickerson et al. (2002) and Nickerson and Krysko (2003) discourage the usage of electroshocking, given the possible non-target and negative effects on Hellbender (*Cryptobranchus alleganiensis*) larvae. These concerns may apply to *N. maculosus* larvae as well.

Manual surveying.—Manual surveying, by wading or skin diving, is also commonly used to sample for *N. maculosus*, especially in shallow water (Nickerson et al. 2002). This method involves walking or floating upstream while flipping large flat rocks typically used by *N. maculosus* for refuge. Benefits of this method include the opportunity to directly observe mudpuppies in their habitat, as well as a relatively high level of capture efficiency (Matson 1990). Drawbacks to this method include a dependency on low, clear water conditions, wadeable study sites, and an inability to sample deep water pools. Furthermore, when utilizing this method, skill is needed to hand capture or net each *N. maculosus*. Given the wide range of *N. maculosus* habitats, this method has had variable results, with better results in smaller lotic areas and shallow lentic areas (Gibbons and Nelson 1968; Matson 1990; Trauth et al. 2007).

Seining.—Seining typically involves dragging a seine net through a river or stream, with at least one person disturbing debris and rock piles ahead of the seine, in order to remove mudpuppies from their habitat on the bottom of streams. Cagle (1954) found little success capturing adult *N. maculosus* using

Table 1. Summary of previous Common Mudpuppy capture events. 0 indicates that method was tried, but with no capture success. – indicates a method was used, but was largely ineffective and/or not recommended. + indicates that a method was used and was successful and/or recommended. ** Indicates mudpuppies were caught using fishing poles rather than traditional set lines.

Author	Year	Location	Time of year	Electro-shocking	Manual surveys	Minnow traps	Seines	Trapnets	Set lines
Cagle	1954	Big Creek, LA	Jan–Feb				0	0	+
Shoop and Gunning	1967	Big Creek, LA	Year-round	+		0	+		–
Gibbons and Nelson Jr	1968	Gull Lake, MI	Apr-May		+				
Matson	1990	Grand River, OH	Mar–July	0	–	–	+		
Bonin et al.	1995	St. Lawrence River, Can.	Winter			+			+**
Gendron et al.	1997	ON & QC, Can.	Jan–Mar			+			
Nickerson et al.	2002	Little Pigeon River, TN	Aug–Oct		+				
Schmidt et al.	2004	Hudson River, NY	Summer	+					
Harper et al.	2006	West-Central MN	May, Jun, Sep	+			+		
Trauth et al.	2007	Spring River, AR	Year-round		+	0			
McDaniel et al.	2009	Sydenham River, ON	Nov–Mar			+			
Chellman and Parrish	2010	Lamoille River, VT	Year-round			+			
VanDeValk and Coleman	2010	Northern NY	Oct–Nov, Apr	+				–	
Palis	2010	Lusk Creek, IL	Sep–Oct, May–Jun		–	0			

seines, however Matson (1990) found seining to be the most successful of four techniques tried. Seining seems to work best for capturing larval and immature *N. maculosus*, especially in streams where primary refuge sites are in leaf litter, rather than beneath large flat rocks (Cagle 1954; Matson 1990).

Modified minnow traps.—Modified minnow traps have been the most-utilized form of *N. maculosus* trapping in the last 50 years (McDaniel et al. 2009; Chellman and Parrish 2010). This method uses a standard minnow trap that has enlarged openings to allow for *N. maculosus* entry. These traps are typically baited with chicken liver, cat food, or raw fish (Gendron et al. 1997; Trauth et al. 2007), and are placed near perceived *N. maculosus* refugia in streams. Benefits of these traps include the ability to sample in deep and turbid water, as well as the ability to sample in freezing conditions without undue risk for hypothermia. Disadvantages to this capture method include low trap success at zero to 0.02 *N. maculosus* per trap night (Matson 1990; Trauth et al. 2007; McDaniel et al. 2009; Chellman and Parrish 2010; Palis 2010). Given low trap rates associated with this method, the use of modified minnow traps is best executed when a large number of trap nights can be implemented, as few trap nights may result in no *N. maculosus* captures (Trauth et al. 2007; Palis 2010).

Other methods.—Other less commonly used methods include fish trapnets and set lines (Shoop and Gunning 1967; Bonin et al. 1995; VanDeValk and Coleman 2010). Trapnets have not been frequently used in the last 50 years, but were used with minimal success in capturing *N. maculosus louisianensis* in Louisiana in the 1950s, though recently VanDeValk and Coleman (2010) obtained *N. maculosus* captured incidentally in trap nets for their analyses. While baited trot lines had a similarly poor success rate (Cagle 1954), the use of set lines has been more successful (Cagle 1954; Shoop and Gunning 1967). These two methods are characterized by baited hooks tied to trees or the shoreline, and are either floated (trot line) or not floated (set line). These methods have seen less use primarily due to a bias toward large juveniles and adults, as well as increased mortality rates from hook swallowing (Cagle 1954; Shoop and Gunning 1967; Matson 1990). Similar to the use of set lines, Bonin et al. (1995) were able to acquire a few samples from fisherman for use in their analyses; however, this method is not commonly used.

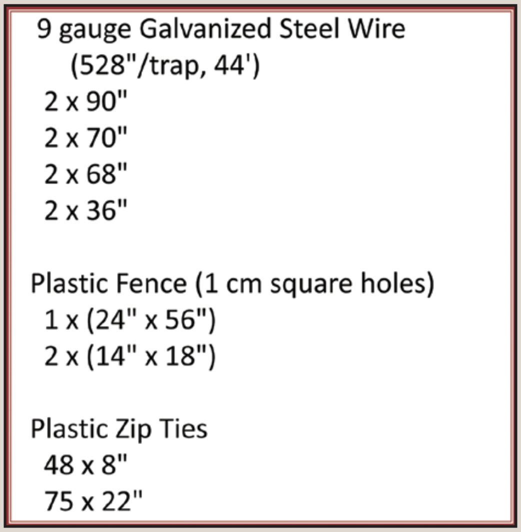
New trap design.—Our trap design is derived from hellbender traps created by Briggler et al. (2013), which they modified from traps designed by Foster et al. (2008). Briggler et al. (2013) observed a few capture events of mudpuppies during tests of their traps; here we focused our efforts on the use of traps modified specifically for *N. maculosus*. The “Briggler traps” were constructed of aluminum wire and plastic mesh, with six panels bound together with zip ties to form a box. These traps were collapsible, with only 3–4 zip ties binding each panel together. Our traps are constructed from 9-gauge aluminum wire, plastic net mesh, and zip ties. See Fig. 1 for a list of materials per trap. Our traps have dimensions of 61 cm long × 46 cm wide × 22 cm tall, with a funnel diameter of 10 cm (Fig. 2). Key modifications were made to improve ease of use, durability, and trap success. One modification was winding zip ties around the edges of the panels to bind them together. While this eliminated the collapsibility of the traps, it increased the durability. Because traps were no longer collapsible, we further modified the trap and added trap doors on the top of the trap to allow for the addition of bait and weight, as well as for the extraction of animals. Given that mudpuppies tend to keep their limbs om the substrate, we used a thicker, more durable plastic mesh, with 1-cm holes, which potentially allows for a sturdier surface for a sturdier footing.

Our modified Briggler traps sat flush on the benthic substrate, enabling a mudpuppy to walk up into the trap, rather than swim, potentially increasing the chance of capture relative to modified minnow traps. Time needed for construction of these traps was approximately 5–8 person hours per trap, though this process can be accelerated by forming a multi-person assembly line. Materials for these traps came to approximately US $15 per trap, and materials can be purchased at most hardware stores.

To deploy, each trap was baited with raw fish scraps contained in a mesh bag (we used zip-tied plastic sleeves designed to pad wine bottles). Each trap was weighted by placing rocks found

Table 2. Summary of Common Mudpuppy sampling from present study for both manual surveys and trapping surveys using modified Briggler traps. Absence of a number indicates no sampling took place in that watershed during that month.

Watershed	Sampling method	Total person-hrs	Total *Necturus*	Jan	Feb	——	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kentucky	Manual	353	12					0	0	12		0		
	Trapping	120	4		0			0	0		0	3		1
Kinniconick	Manual	41	1								1			
	Trapping	8	4									4		
Licking	Manual	621	36				4	2	3	3	17	7		
	Trapping	104	16	2	6			0				6	2	



9 gauge Galvanized Steel Wire
(528"/trap, 44')
2 x 90"
2 x 70"
2 x 68"
2 x 36"

Plastic Fence (1 cm square holes)
1 x (24" x 56")
2 x (14" x 18")

Plastic Zip Ties
48 x 8"
75 x 22"

Fig. 1. Materials needed per trap.

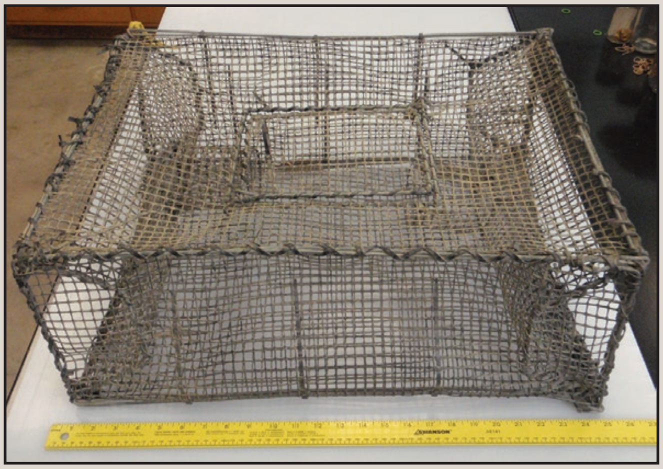


Fig. 2. Modified Briggler trap. Note the trap door on top for accessing trap compartment, as well as funneled ends, which allow for mudpuppies to walk into the trap while positioned on stream floor.

Fig. 3. Mudpuppy captured in trap near Cynthiana, Kentucky, USA

on the bank inside the trap, the trap door was zip-tied closed, and then the trap was placed on a flat part of the stream bed, preferentially in deep pools or next to large flat rocks. Traps were secured to the bank using 6-mm polypropylene rope tied to a tree or other stable structure. Each trap was left in the river for 1–2 nights. Manual surveys were also conducted, in which 2–4 surveyors walked/snorkeled upstream in rivers, lifting large flat rocks and other potential refugia, and then capturing observed individuals by hand or with a mesh bag.

Trapping was conducted for 528 trap-nights by deploying 9–10 traps at a time on a semi-regular basis from February 2014 to February 2015 (except for the months of April, May and August). We captured 24 *N. maculosus* (Fig. 3), with a trap success of 0.045 *N. maculosus* per trap night. No *N. maculosus* were caught from June to September. All *N. maculosus* were caught between October and February 2015. Eliminating summer trapping hours results in 441 trap nights and a success rate of 0.054. This success rate was comparable to some studies using modified minnow traps (McDaniel et al. 2009), and better than other trapping methods described above (Matson 1990; Trauth et al. 2007; Chellman and Parrish 2010; Palis 2010). Deploying and removing 10 traps required two people and approximately two hours per visit. Converting trap nights to person-hours equates to approximately 8 person-hours per trapping event, 4 person-hours for deployment, and 4 person-hours for collection. Our modified Briggler trapping took place over 232 person-hours and resulted in capture at a rate of 0.10 *N. maculosus* per person-hour (Table 2). Our modified Briggler trap method was more efficient than our manual surveys, which resulted in 49 *N. maculosus* over 1225 person-hours from May–September 2014 and October 2015, for 0.040 *N. maculosus* per person-hour. However, excluding a single highly productive site, at which we caught 33 *N. maculosus*, our manual survey success rate dropped to 16 *N. maculosus* over 924 person-hours, resulting in a capture rate of only 0.017 *N. maculosus* per person-hour.

Conclusions

Overall, sampling *N. maculosus* using any trapping method results in low capture rates, however trapping seems to work best from late fall through early spring (Cagle 1954; Matson 1990; Bonin et al. 1995; Gendron et al. 1997; Nickerson et al. 2002; VanDeValk and Coleman 2010). Late summer and fall seem to be ideal times for manual surveys, as *N. maculosus* are relatively easily accessed due to larval guarding by females and the occurrence of breeding pairs under flat rocks and other cover objects, as well as generally low water levels (Petranka 1998; Hime et al. 2014). Winter through mid spring is a primary foraging period for *N. maculosus* (Shoop and Gunning 1967), potentially explaining the higher trapping success rate during this time (McDaniel et al. 2010). Regardless of sampling method, researchers and managers need to be aware of the varying success rates based on time of year, and schedule their sampling dates accordingly.

Necturus maculosus can occupy a wide range of habitats, from small streams to large rivers, and from small ponds to the Great Lakes (Bishop 1926; Petranka 1998; Matson 2005). This calls for flexibility in sampling methods depending on habitat type; manual surveys are most successful in clear and shallow water, seining works best in more debris-laden stream systems that are absent of large flat rocks, electroshocking works well in areas with few rocks and high conductivity, and trapping is ideal in deep and murky water, especially during the winter and early spring.

In conclusion, there is not a single, universally successful method for capturing *N. maculosus* at all times of the year or in all habitats. It is vital that researchers and managers be flexible with *N. maculosus* capture methods, and are prepared to utilize different methods for different habitat types and seasons. Although not to be used as a single, paramount method, we suggest the addition of modified Briggler traps to the *N. maculosus* capture arsenal, based on cost, time, and capture efficiency. Optimizing capture methodology will lead to the best chance for high capture rates, and will enable the further study of these understudied creatures.

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Employing Camera Traps for Studying Habitat Use by Crocodiles in a Mangrove Forest in Sarawak, Borneo

Effective wildlife monitoring for conservation relies on census methods that deliver cost effective and logistically efficient data. Camera trapping has become a common tool in contemporary wildlife science, helping researchers collect images of uncommon or rarely seen and often threatened species as evidence. The development of camera trapping technique has led to significant advancement of the understanding of the diversity of animals and has helped detect secretive species that survive in low densities (e.g., Mohd-Azlan 2003; Mohd-Azlan et al. 2003). However, relatively few studies of crocodilians have employed the technique (Thorbjarnarson et al. 2000; Channa et al. 2010; Charruau and Hénaut 2012; Platt et al. 2014a), and one recent survey reported a lack of success (Platt et al. 2014b), possibly due to lack of technical modification of motion-sensitive infrared cameras (Merchant et al. 2012).

Camera traps are designed purposely to detect wild animals by using a passive infrared sensor (Mohd-Azlan and Engkamat 2006). The camera incorporates a mechanism to trigger a photograph by the movement and differential heat of the main subject in front of the camera and that of its surroundings. Additionally, the use of camera traps can reduce bias in data, such as in wildlife surveys, which can have an adverse effect on the results (Mohd-Azlan 2009). Another advantage of the technique is that it is non-invasive, not involving handling of target species (Ancrenaz et al. 2012; Ariefiandy et al. 2013; Sunarto et al. 2013).

Although primarily aquatic, crocodilians typically require terrestrial substrate, such as mud flats and water-edge environments for activities, including nesting, foraging (for terrestrial animals, such as pigs, primates, and otters), or thermoregulatory purposes. They can move considerable distances both overland (Pooley and Gans 1976) and along waterways (Walsh and Whitehead 1993).

In this study, we analyze crocodile activity and terrestrial habitat use in the vicinity of river banks with the use of camera traps, in order to increase understanding of crocodile behavior. These objectives are relevant given the escalating levels of human-crocodile conflicts in Sarawak (Das 2002). Thus, by setting up camera traps at selected areas where Saltwater Crocodiles are believed to habitually land, more information on their activity patterns can be obtained. The general objectives of the current study were to test whether camera traps can be used to record timing of activities and habitat use of crocodiles.

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METHODS

We conducted this study at Pulau Liak in Kuching Wetland National Park (KWNP; Fig. 1), located ca. 8 km SW of Kuching City, the capital of Sarawak State, in East Malaysia (Borneo) where the Saltwater Crocodile (*Crocodylus porosus*) is listed under Part II of the First Schedule of the Sarawak Wild Life Protection Ordinance 1998. KWNP consists of coastal, marine, and freshwater ecosystems, and was gazetted as a National Park in 2002. The 6610-ha area is dominated by saline and deltaic mangrove systems, including marine waterways and tidal creeks, such as connecting rivers of Sungei Sibu-Laut, Batang Salak, and Sungei Santubong. The study area was selected to set camera traps centered around Pulau Liak (1.624°N, 110.25876°E; WGS84), and Sungei Sibu (1.676611°N, 110.23666°E), based on previous frequent sightings of *C. porosus* and the presence of crocodile wallows on river banks. Within the KWNP area, the common mangroves are *Rhizophora apiculata*, *Avicennia alba*, *A. marina*, *Bruguiera cylindrica*, *B. sexangula*, *B. gymnorhiza*, and *Ceriops tagal*.

We deployed three units of commercially made passive infrared Bushnell® Trophy Cam Camo-119445 cameras, with sensor resolution of 5MP, which captured images when triggered by movement and/or differences in temperature in the area immediately in front of the camera sensors. Each of these were established at a subsite within the study area (referred to as CT1, CT2, and CT3). Cameras were set with a delay mechanism of three minutes between photographs to reduce repeat photographs of the same individual crocodile. The study period was June 2013 to April 2014, a period of 11 months.

Time periods were analyzed to determine presence of crocodiles and temporal and spatial aspects of activity. To estimate the number of individuals recorded at the same locality, individuals were identified on the basis of both characteristic marks (such as scar tissue on head and body) and an estimation of body size. The activity pattern in terms of landing and functions of terrestrial habitat was also examined. The levels of activity were determined from the date and time recorded on the photograph.

RESULTS

A total of 55 wildlife photographs of four species were recorded from 207 camera days. This includes a total of 43 images of *C. porosus*, including two of hatchlings that suggest the presence of a nest in the study area during the time of survey (November). Additionally, the cameras captured eight images of the Long-tailed Macaque (*Macaca fascicularis*), three images of Oriental Small-clawed Otter (*Aonyx cinerea*), and a single image of an unidentified species of squirrel (Table 1).

TABLE 1. Photo trap index of animals recorded by camera traps at Kuching Wetland National Park, Sarawak, Malaysia. Abbreviations: IUCN, International Union for Conservation of Nature 2016; LC, Least Concern; VU, Vulnerable; SWLPO, Sarawak Wildlife Protection Ordinance 1998; WCA, Wildlife Conservation Act 2010; CITES, Convention on International Trade in Endangered Species of Wild Flora and Fauna 2013 (listing for Sarawak population); NL, Not Listed.

Order/ Family	Species	Common name	Total images	IUCN	SWLPO	WCA	CITES
Crocodylia							
Crocodylidae	*Crocodylus porosus*	Saltwater Crocodile	43	LC	Part II	Schedule I; Part 2	II
Primate							
Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque	8	LC	Part II	Schedule I; Part 2	NL
Carnivora							
Mustelidae	*Aonyx cinerea*	Oriental Small-clawed Otter	3	VU	Part II	Schedule I; Part 2	NL
Rodentia							
Sciuridae	unknown	Squirrel	1	–	–	–	–
Total			55				

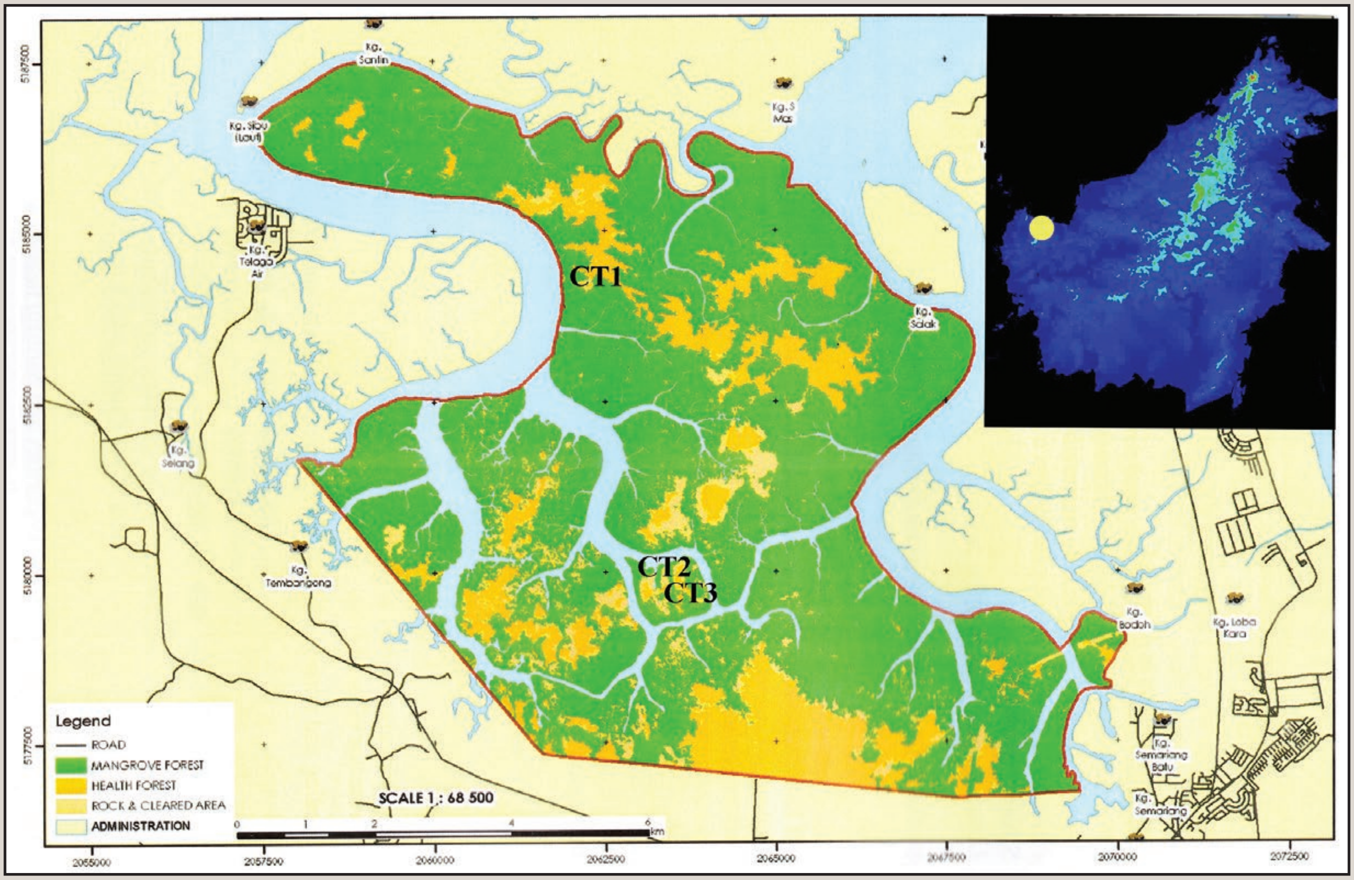

FIG. 1. Map of Kuching Wetland National Park, dominated by mangrove habitats, with islands of secondary forests. Three camera trapping sites are indicated (CT 1–3). Locator map of Borneo on top right, showing location of study site (yellow dot).

Of the total images captured, 91% were taken after dark (1800–0800 h) and four (9%) recorded during daylight hours (Fig. 2). The terrestrial activity pattern of *C. porosus* shows that their presence near riverbanks peaked during 0400–0500 h (N = 8), and they tend to be present around specific sites for 30–60 mins. This suggests that peak activity occurs just before dawn, at ca. 0630 h. No photographs were captured between 0500–0600 h, 0800–1100 h, 1300–1400 h, and 1600–1800 h, suggesting that the heavy human activities in the area, such as the operation of fishing boats near the banks, might reduce landing activities of crocodiles. Although a greater number of crocodiles were recorded during high tide than other tidal conditions (Fig. 3), our data are insufficient to correlate crocodile emergence with tidal conditions. Images of eight individuals were captured during incoming high tide and two during low tide, between 1900–2000 h and 0600–0700 h, respectively.

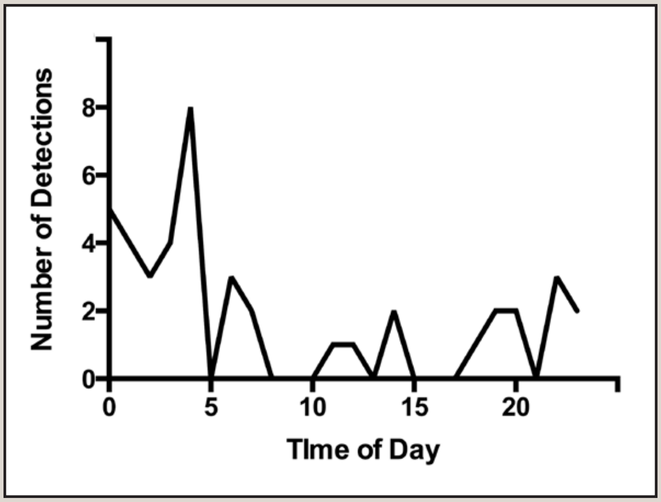

Fig. 2. Activity levels of *Crocodylus porosus*, showing peak activity during dawn and dusk, with sporadic activities during daylight, based on camera trapping data. Time of day: 0000 h to 2400 h.

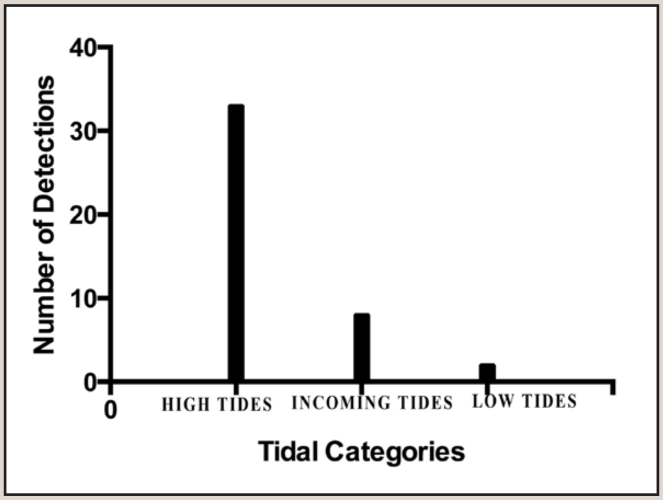

Fig. 3. Number of images of *Crocodylus porosus* captured related to tidal condition, showing approximately 77% of images coincided with high tide.

Fig. 4A–B. Photos captured of two individuals of *Crocodylus porosus* at CT2.

From the image analysis, at least four individual crocodiles were confirmed as residents (Fig. 4). Four images captured only the eyes of the crocodiles, whereas eight images were of tail only. However, based on estimates of size of the crocodiles, these images are believed to represent the only two individuals.

Discussion

Numerous studies have demonstrated the efficacy of camera traps in the study of medium to large-sized mammals and birds (Rovero et al. 2010 ; O'Connell et al. 2011; Meek and Pittet 2012), small mammals (Oliveira-Santos et al. 2008), large mammals (Mohd Azlan and Sharma 2006), crocodilians (Chowfin and Leslie 2014), large lizards (Ariefiandy et al. 2013), and amphibians (Pagnucco et al. 2011). Camera traps have also been successfully deployed for studying critical life history events, including aggregation around mineral licks (Matsubayashi et al. 2007), predation (Campos and Mourão 2014), and nest care (Charruau and Hénaut 2012).

The present study corroborates Huchzermeyer's (2003) classification of crocodiles as nocturnal, with active foraging done at night, while opportunistically feeding by day. *Crocodylus porosus* was mostly recorded in the vicinity of the riverbanks, during dusk, night, or dawn. By this time, water temperature is warmer than the land on account of the absence of radiation. Ectothermic animals tend to move from a relatively cool to a warm environment and increase their heart rate to raise heat convection and cooling rates (Franklin and Seebacher 2003). In addition, crocodile activities in terrestrial habitats may be correlated with local tidal conditions. Most images captured were during high tide (≥ 3.0 m). In spite of the fact that crocodiles prefer to stay near riverbanks during high tides or incoming tides, macaques and otters (both potential prey of crocodiles) are active during low tide, probably to use mangroves as an extension of their terrestrial habitats and to forage for food on the mud flats during low tide. Mud crabs are among the favorite food of the Long-tailed Macaques, and perhaps also of otters.

At least four individual crocodiles are confirmed to be residents within the area where the CT1 camera was set, based on size and cephalic markings observed. *Crocodylus porosus* is known to maintain territories or home ranges (Pope 1955). Three photos of adult crocodiles demonstrated reaction to the red flash, by opening their mouths, which may be a common reaction to threat. The reaction by wild crocodiles towards light from camera traps has apparently never been documented in previous studies.

The occurrence of hatchlings in November suggests that the breeding season for the species within the area is likely around August. The species is known to nest between November and April (Webb and Manolis 2009; Webb et al. 2010), and September through February is the wet season for East Malaysia due to passage of the Northeast Monsoons. The images of hatchlings provide evidence that the nests are not far, as hatchlings can travel only ca. 50 m from their nesting sites (Webb and Manolis 2009). Pulau Liak (also known as Pulau Buaya, in Malay, "Crocodile Island") can be categorized or identified as one of the nesting sites of the species within the park due to presence of hatchlings and yearlings around that area (Tuen et al. 2010).

Several limitations were encountered in the use of passive infrared sensor traps to study crocodiles. Most cameras have a differential temperature between the target and ambient temperature greater than 2.7°C. Therefore, the passive infrared sensor fails to trigger if the subject in front of the camera has either a low differential temperature or is within the ambient temperature range. Additionally, the passive infrared sensor is case sensitive, and can also be triggered by the movement of hot air or by movement of vegetation within the detection zone (Rovero et al. 2013). Finally, camera locations were restricted to areas that are not inundated, and within the context of this study within a mangrove / tidal region, was dependent on tide levels.

Nonetheless, camera traps show encouraging results. Refinements are required for incorporating the use of cameras in studies of wild crocodilian populations, including: 1) choice of cameras and sampling rate (e.g., brand and specification, that potentially influence detection success rate and memory capacity); 2) placement of cameras (e.g., height, angle, attachment site, and distance from river banks and other potential crocodile habitats, for which experience of field personnel is important); 3) density of cameras in the field; and 4) data collection protocols and analyses.

This study reiterates that camera traps can be used to study wild crocodiles by recording their activity patterns and habitat use at crocodile landing areas without the use of bait. We also show that crocodiles can usually be observed at their landing areas mostly during the night. Both physiology and tides could be factors that affect the presence and movement of crocodiles in the vicinity of riverbanks. Individual recognition can also enhance accuracy of population estimation, using the capture-recapture method.

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Repeatability of Locomotor Endurance in the Small-mouthed Salamander, *Ambystoma texanum*

Amphibian population declines have been linked to a variety of factors, including climate change and habitat destruction (Kiesecker et al. 2001), making assessment of the viability of habitat corridors and assisted dispersal a priority for conservation research (Milanovich et al. 2010). To quantify and evaluate dispersal ability, researchers commonly conduct physiological experiments involving multiple trials on wild-caught specimens. The performance of individuals during these experiments is assumed to be consistent and repeatable, but a direct assessment of whether or not this is the case is lacking. Assessing the value of laboratory experiments for describing performance in nature and for quantifying physiological measures for individuals requires knowledge of the impacts of experimental conditions on these measures (Bennett 1987).

Dispersal in *Ambystoma* salamanders is one case where repeatability of lab-based measurements of locomotor endurance is important because such experiments are used to infer how salamanders move across landscapes. Endurance measures can be combined with a measure of vagility to predict the genetic framework of amphibian metapopulations, as increased endurance and vagility have been shown to decrease genetic heterogeneity between populations (Johnson et al. 2010; Hillman et al. 2014). However, information pertaining to the repeatability of endurance is scarce. One of the very few studies to investigate this matter found that locomotor endurance of the endangered California Tiger Salamander (*Ambystoma californiense*) is repeatable over a period of a few days but not over a longer period of fifteen months (Austin and Shaffer 1992).

However, this estimation of repeatability may not be generalizable to other salamander species for several reasons. First, *A. californiense* is an endangered habitat specialist found only in Pacific coastal grasslands and is also one of the largest *Ambystoma* species (Trenham et al. 2000). Because surface area plays a major role in the regulation of body temperature and respiration of amphibians, it is difficult to scale the physiology of salamanders of vastly different sizes (Pincheira-Donoso et al. 2008). Second, multiple trial experiments on wild-caught and lab-raised salamanders may occur over a period that falls between just a few days and 15 months in order to measure average performance at a given time point or life-stage, but data on the repeatability of endurance in these time spans is currently lacking.

Common factors associated with the basic housing and care of animals, such as the frequency of feeding prior to trials, might also influence performance. The effects of food quantity on locomotor performance are unclear and other research has rarely taken into account unique aspects of the physiology of the species being studied, such as the remarkably slow metabolisms of salamanders compared to other vertebrates (Feder 1976). For example, feeding can decrease the burst speed of Garter Snakes (*Thamnophis elegans*; Garland and Arnold 1983) or not affect performance at all (Ford and Shuttlesworth 1986). In Trinket Snakes (*Elaphe helena*), large meals limit both burst speed and endurance (Mehta 2006). While an optimal meal size that maximizes endurance and antipredator behavior has been identified in these wild snakes, an optimal meal size or feeding schedule for captive amphibians participating in physiological trials has not been investigated (Sih and Christensen 2001). If we wish to maximize consistency in future experiments involving amphibians that will likely require feeding, we must determine how feeding affects amphibian performance and optimize our research protocol accordingly.

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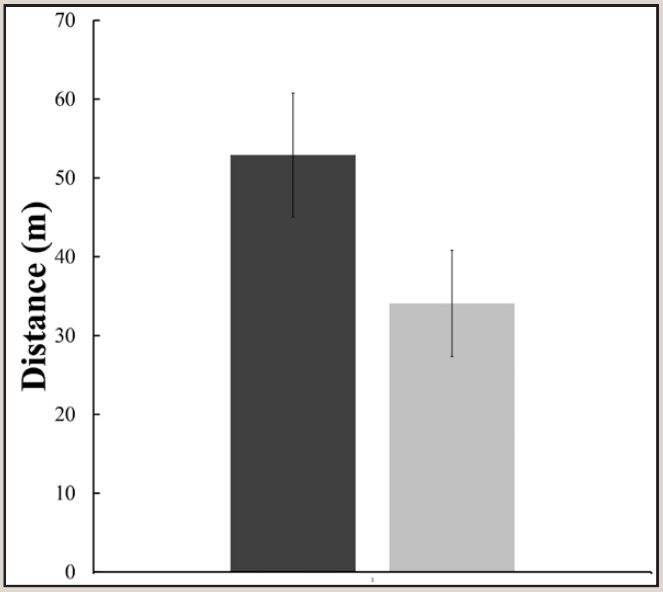

Fig.1. The average distance *Ambystoma texanum* were able to run in meters during their first (dark gray) and second (light gray) trials. Bars show mean ± SE. Individuals ran a significantly shorter distance during their second trial (*P* = 0.02).

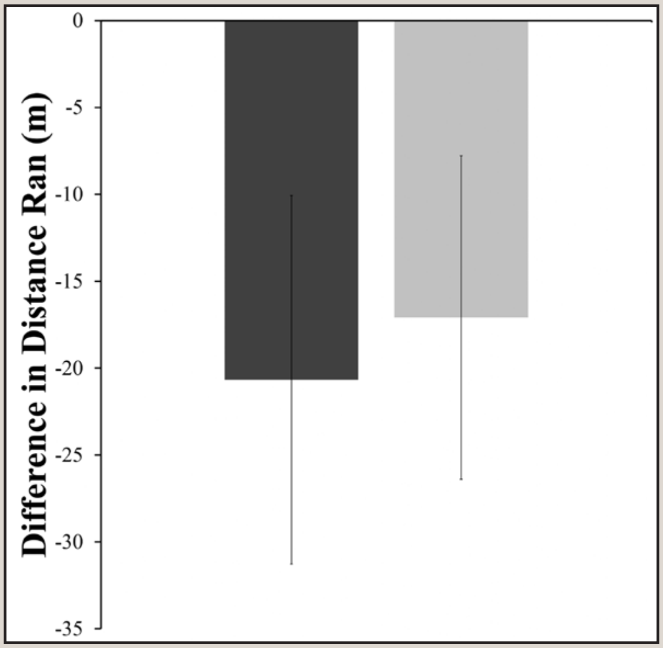

Fig. 2. The average difference in distance *Ambystoma texanum* in the Fed (dark gray) and Unfed (light gray) groups were able to run between Trial 1 and Trial 2. Bars show mean ± SE. There was not a significant difference in endurance between the Fed and Unfed groups (*P* = 0.49)

Here, we fill these gaps in knowledge by studying the repeatability of locomotor endurance in lab-raised, juvenile Small-mouthed Salamanders (*Ambystoma texanum*) that were maintained on two different feeding schedules. We conducted two treadmill trials with each individual to assess whether the number of trials would affect the distance they were able to travel. In addition, we selected feeding schedules that we predicted would safely warrant a change in performance and replicate natural patterns of feeding frequency in salamanders (J. Bogart, personal communication). We chose *A. texanum* as a generalizable species in the genus *Ambystoma* because of their generalist habitat requirements and widespread range across central North America (Petranka 2010).

Methods

We collected six *A. texanum* egg masses from two wetlands (N = 3 per site) in Crawford County, Ohio, USA, in April 2014 and allowed embryos to develop in a 14°C cold room. We separated larvae and fed them Brine Shrimp and *Daphnia magna* depending on size. After metamorphosis, we fed metamorphs three appropriately sized crickets (measured as less than the distance between the salamander's eyes) once a week. Individuals were housed under a 12 h light/dark photoperiod in 33 x 19 x 10.8 cm clear plastic shoeboxes that included two sheets of wet, non-bleached paper towel as substrate.

All locomotor endurance trials were conducted in the same room where animals were housed to maintain a consistent environment with as little disruption to photoperiod or temperature as possible. Temperature was recorded daily and never deviated from 14°C throughout the experiment. In July 2015, the surviving 28 juvenile *A. texanum* were divided into two groups of 14 with two different feeding schedules: Fed and Unfed. Both groups were fed two appropriately sized crickets before their first trial. Individuals in the Fed group were fed two appropriately sized crickets two weeks later before their second trial while those in the Unfed group were not fed before their second trial. In other words, salamanders from both groups were fed on Day 0 and then participated in their first endurance trial on Day 3. Salamanders from the Fed group were then fed on Day 14 and participated in their second trial on Day 17, while salamanders from the Unfed group were not fed any time after Day 0 and participated in their second trial on Day 17. Because we could locate no information regarding feeding frequency in wild *Ambystoma*, we chose the two week fasting period based on doubling the current feeding schedule of captive salamanders as recommended by Bogart (pers. comm.). Animals are currently fed weekly and demonstrate consistent weights for adults (unpubl. data), and we chose to double this duration. We recorded weight (g) with a scale accurate to 0.01 g and snout–vent length (mm) with a Salamander Stick (Walston and Mullin 2005) for all animals prior to each endurance trial, on Days 3 and 17. Because immediate digestion can affect locomotor endurance, individuals were fasted three days prior to every endurance trial (Garland and Arnold 1983).

Endurance trials were conducted on the custom treadmill from Johnson et al. (2010) and followed the same protocol. Briefly, we encouraged salamanders to walk on the belt by swiping their tail from side to side with a metal ruler. We measured endurance as the amount of time an individual could keep moving at a constant speed of 0.035 m/s and then transformed into distance ran. We rehydrated all *A. texanum* every three minutes and then checked for exhaustion as measured by righting response; if an individual was unable to right itself after we flipped it onto its back, we immediately ended the trial. We used a repeated-measures ANOVA in SPSS (version 22; IBM Corporation, 2013) with the averages of both SVL and weight measurements as covariates to compare the distance ran between Fed and Unfed groups. We predicted that salamanders in the Fed group would run significantly farther than those in the Unfed group because they would have more available energy for locomotion.

Results

Fed salamanders, on average, weighed 2.73 g (± 0.11 standard error [SE]) and were 41.29 mm (± 0.70 SE) in SVL. Unfed salamanders, on average, weighed 3.00 g (± 0.15 SE) and were 41.15 mm (± 0.60 SE) in SVL. The Unfed group did lose more mass over time than the Fed group, as expected. Between trials, the Fed group lost an average of 0.05 g (± 0.06 SE), while the Unfed group lost an average of 0.95 g (± 0.25 SE). The measurement variable met all assumptions of repeated measures ANOVA, including sphericity. Salamander weight and SVL were highly correlated; therefore, we used only weight as a covariate in the repeated measures ANOVA because we felt like this measurement was more accurate due to the difficulties of measuring small animals' SVL.

We found that the number of trials a juvenile *A. texanum* was subjected to did significantly reduce the distance it was able to run: movement distance on the second trial was 35.7% shorter than the first trial, independent of feeding group (repeated measures ANOVA, $P = 0.02$, $F[1,26] = 6.78$, Fig. 1). However, we could not detect any effect of feeding schedule on endurance, as there was no significant difference in endurance between the Fed and Unfed groups (repeated measures ANOVA, $P = 0.49$, $F[1,26] = 0.47$, Fig. 1). Fed animals traveled an average of 40.24 m (± 9.37 SE) compared to an average of 49.33 m (± 9.35 SE) for Unfed animals. There was no significant interaction between feeding schedule and the number of times *A. texanum* were run on the treadmill ($P = 0.82$, $F[1,26] = 0.05$, Fig. 2), and there was no significant interaction between endurance and weight for either group ($P = 0.211$, $F[1,26] = 1.62$).

Discussion

Because multiple endurance trials significantly reduced a salamander's endurance over time, ensuring that study organisms are given enough time to recover between trials may be important for making accurate endurance estimates. In fact, similar results were found in a study of the speed and endurance of Green Snakes (*Oepheodrys aestivus*), in which the crawl speed of female Green Snakes was dependent on trial number and some females would sometimes refuse to move in later trials (Plummer 1997). Even more similar results were found in a study of the terrestrial movement capability of Greater Sirens (*Siren lacertina*) and Two-toed Amphiumas (*Amphiuma means*). It was found that these two species of aquatic salamander presented, on average, a 27.8% decline in endurance between trials across multiple simulated environmental conditions when given an hour to rest (Schalk and Luhring 2010). Many papers evaluating endurance or speed, however, do not consider the effect of their repeat trials and have no standard recovery time: some trials are conducted in rapid succession while other study organisms are given anywhere from a few minutes to a day to recover (Else and Bennett 1987; Bennett et al. 1989; Plummer 1997; Adams et al. 1999). Other papers do not mention a recovery time at all (Finkler et al. 2003). It would be very useful to conduct experiments similar to ours on frequently studied organisms in order to avoid biased estimates resulting from an overtired organism that cannot perform consistently. The significant decline in our salamander's endurance as well as anecdotal observations of their stubbornness or struggle to get moving in the second trial indicate that a tired salamander will not yield repeatable results.

Contrary to our predictions, the two different feeding schedules we designed did not affect the locomotor performance of *A. texanum*, as locomotor endurance decreased between the first and second trials regardless of feeding group. These results provide insight into how salamanders and other animals being subjected to physiological experiments should be cared for. Because how much an individual was fed did not play a significant role in its performance, perhaps a dedicated and meticulously recorded feeding regimen is not critical to obtaining accurate results. Alternatively, there may be an optimal feeding schedule (nutritional content, intermediate frequency) for captive amphibians that would prevent the stark drop in endurance from trial to trial we encountered in our experiment. Research pertaining to the natural feeding frequencies of adult *Ambystoma* salamanders is lacking, but would be helpful in this pursuit.

Our results may also inform our understanding of dispersal in *Ambystoma*. Salamanders like the Small-mouthed Salamander migrate to their breeding ponds during a short, rainy period in early spring (Husting 1965; Semlitsch 1998). The movement period of *A. texanum* is likely the time period of lowest prey abundance, and they are most likely fueled by stored fat built up while living underground the rest of the year (Lindquist and Bachmann 1980; Whiteman et al. 1994). This may explain why our juvenile *A. texanum* seemed to require more time than expected to rebuild energy after exhaustion, because wild *Ambystoma* likely only take part in a maximum of two movement periods during a year that are greater than two weeks apart from one another.

As amphibians are a taxonomic group of high conservation priority and particular spatial demands for reproduction, a better understanding of their movement is critical. Reliable measurements of locomotor endurance can be valuable for inferring movement capability in wild populations, which is crucial when designing migration corridors, minimizing habitat fragmentation, and studying metapopulation mechanics (Milanovich et al. 2010; Hillman et al. 2014). However, a standardized methodology for these endurance investigations is currently lacking.

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Theory and Practice of the Hydrodynamic Redesign of Artificial Hellbender Habitat

The Hellbender (*Cryptobranchus alleganiensis*) is a cryptic, large-bodied amphibian endemic to cool Appalachian and Ozark mountain streams (Nickerson and Mays 1973; Petranka 1998). As is the case with many salamanders, a long lifespan, reliance on aquatic habitat and sensitivity to environmental change make *C. alleganiensis* an excellent indicator of ecosystem health (Olson et al. 2012; Welsh and Ollivier 1998). Unfortunately, these same qualities have led to drastic declines in populations of these amphibians nearly ubiquitously across their range (Nickerson and Mays 1973; Wheeler et al. 2003). As a result, the Ozark subspieces, *C. a. bishopi*, was listed under the U.S. Endangered Species Act as Endangered in 2011 (Federal Register 2011), and has been deemed Imperiled (N2) by NatureServe (2015). The eastern subspecies, *C. a. alleganiensis*, has been listed due to varying degrees of risk in 13 of the 16 states in which it occurs (Mayasich et al. 2003; KDFWR 2013), and has been assigned a national NatureServe (2015) status of Vulnerable to Apparently Secure (N3/N4). As a species, *C. alleganiensis* is considered Near Threatened by the International Union for Conservation of Nature (IUCN; Hammerson and Phillips 2004).

Habitat loss due to increased sedimentation from development within inhabited watersheds is suspected as a leading cause of declines among *C. alleganiensis* populations (Wheeler et al. 2003). Large loads of particulate matter entering streams deplete dissolved oxygen levels and fill the concave undersides of the large, flat rocks that serve as shelter and nesting sites for *C. alleganiensis*. In combination, these effects can reduce animal fitness and lead to breeding failure (Ringler and Hall 1975; Harlan and Wilkinson 1981; Briggler and Ackerson 2012; Browne et al. 2012). To combat this landscape-level threat to *C. alleganiensis*, Briggler and Ackerson (2012) developed artificial nesting structures to increase Hellbender habitat while

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reducing sediment accumulation. Wild *C. alleganiensis* adults have inhabited and successfully bred in these boot-shaped nest boxes within Missouri streams.

The success of nest boxes in Missouri led researchers to test whether similar management tools could increase *C. a. alleganiensis* populations in the streams of western North Carolina, where these salamanders are listed as a Species of Special Concern (Messerman 2014). Fifty-four nest boxes were constructed following the boot-shaped design of Briggler and Ackerson (2012) in May 2013, and were installed across five known *C. alleganiensis* stream sites between late June and early August 2013. Messerman (2014) then monitored each nest box every three to four weeks through November 2013, and the boxes were revisited in August 2014 and July 2015 to observe structural condition and occupancy (Messerman, pers. obs.). Of the 54 nest boxes, only two structures at a single site were confirmed as inhabited in 2014 and 2015, and no breeding events were detected (Messerman, pers. obs.). Moreover, many of these ~50 lb concrete boxes moved in flood events or accumulated sediment at the downstream tunnel entrance (Messerman 2014). The low success of the boot-shaped nest box design in North Carolina may be attributed to the sites generally being narrower and shallower than those in Missouri, with much of the substrate consisting of bedrock slabs covered by relatively thin layers of rock, gravel and silt. Here we address the observed shortcomings of the original North Carolina design through the lens of engineering, and present a new and easily implemented nest box model for use in streams like those found in western North Carolina.

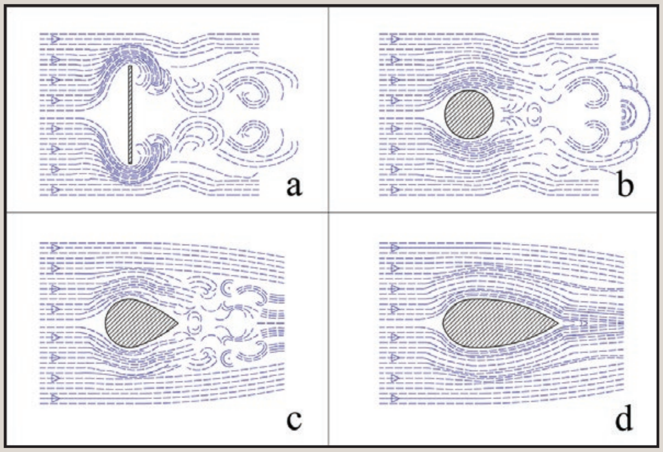
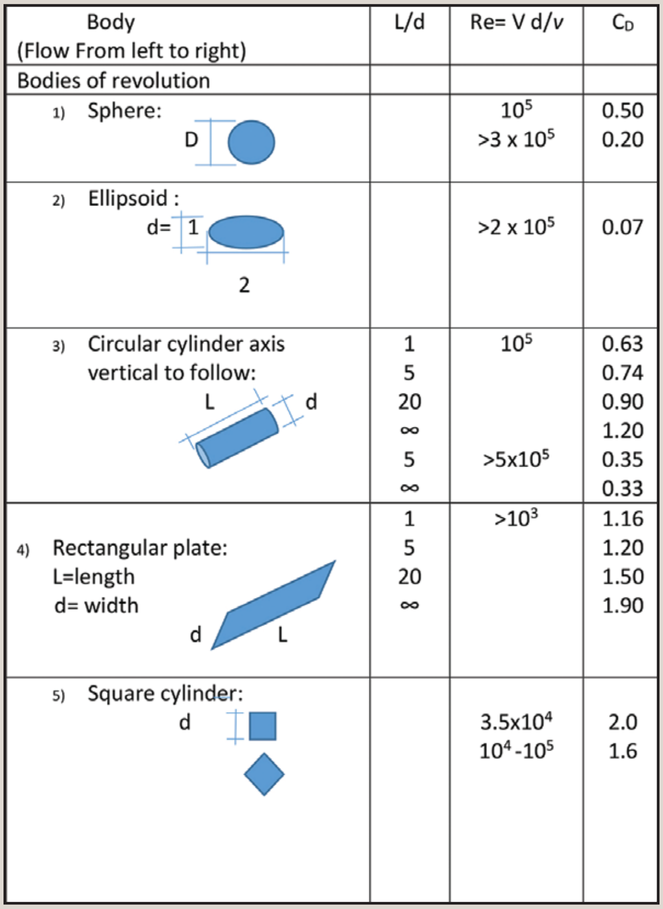


Fig. 1. The impact of object shape on the production of eddy currents downstream of an object (based on Richter and Nikrityuk [2012]).



Body (Flow From left to right)	L/d	Re= V d/v	C_D
Bodies of revolution			
1) Sphere: D		10^5 $>3 \times 10^5$	0.50 0.20
2) Ellipsoid : d= 1, 2		$>2 \times 10^5$	0.07
3) Circular cylinder axis vertical to follow: L d	1	10^5	0.63
	5		0.74
	20		0.90
	∞		1.20
	5	$>5\times10^5$	0.35
	∞		0.33
4) Rectangular plate: L=length d= width d L	1	$>10^3$	1.16
	5		1.20
	20		1.50
	∞		1.90
5) Square cylinder: d		3.5×10^4 10^4-10^5	2.0 1.6

Fig. 2. Drag coefficients for different shapes and dimensions (based on Prasuhn [1980]).

Flow Considerations

The two issues of sedimentation and disturbance/movement of the nest boxes can be addressed by a consideration of flow in the vicinity of a solid object. Such an object can cause changes in the flow velocity and pressure. These changes can be described using several equations. The first equation of interest is the continuity equation that represents the conservation of mass between a point 1 and a point 2 which are two cross sections along a stream:

$$Q = \rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

where Q is the flow or discharge (volume per time), ρ is the density of the fluid (mass per volume), A is the cross-sectional area of flow (length squared) and V is the velocity of flow (length per time). Continuity states that the mass flowing into a designated volume must equal the mass flowing out of the volume. For a fluid of essentially constant density (e.g., water), where $\rho_1 = \rho_2$, the equation reduces to the product of area and velocity being constant. Thus, if the cross-sectional area is increased, the velocity will decrease, and vice versa.

Flow is also governed by the Bernoulli equation, where the total energy of flow, H (length), has components of pressure, P (force per area), depth, y (length) and velocity. The difference in energy states between a point 1 and a point 2 can thus be represented by:

$$H_1 = \frac{P_1}{\gamma} + y_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + y_2 + \frac{V_2^2}{2g} + h_L = H_2$$

where γ is the specific weight of the fluid (force per volume), g is the gravitational constant (length per time squared) and h_L represents the energy lost in the flow between the two points. As a fluid flows from point 1 to point 2, the distribution of energy between the components may change. As an example, water flowing in a water main may sometimes have more of its energy in terms of velocity, and at other times may have more of its energy in terms of water pressure. For ease of conversion between the components, the energy terms are all expressed in units of length.

Another useful concept to consider is that of streamlines. Streamlines depict velocity vectors (magnitude and direction), and their orientation is always parallel to the direction of flow. With localized disruptions to flow, as with the placement of a

TABLE 1. Standard coefficients of friction for materials in contact with concrete.

Contacting Surfaces	Friction Coefficient (µf)
Concrete on soil/rock	0.30
Concrete on steel	0.45
Cement Blocks on cement blocks	0.65
Cement Concrete on dry clay	0.40
Cement Concrete on wet clay	0.20
Cement Concrete on wet sand	0.40
Cement Concrete on dry sand	0.50–0.60
Cement Concrete on dry gravel	0.50–0.60
Cement Concrete on dry rock	0.60–0.70
Cement Concrete on wet rock	0.50

Note: Friction is greater on dry surfaces than wet surfaces.

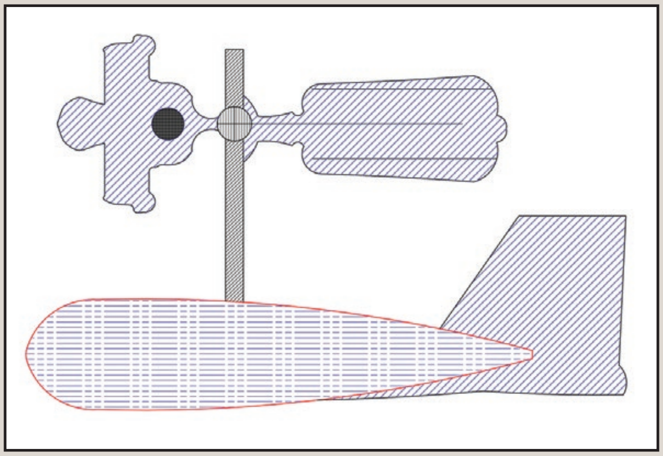


FIG. 3. Streamlined shape of a current meter (based on Prasuhn [1980]).

solid object in the flow, the streamlines are disrupted. Streamlines in the flow as a whole (e.g., a river) may be undisturbed and remain constant, but streamlines immediately surrounding the object will be compressed (Fig. 1). What appears as a dark area in Fig. 1 is the result of the streamlines being compressed. The compression of the streamlines can be seen as decreasing the cross-sectional area of flow associated with each streamline. By continuity, and because the amount of flow is not decreasing just because an object has been placed in the stream, a decrease in the cross-sectional area of flow will be associated with an increase in the velocity. By Bernoulli's equation, an increase in velocity will be associated with a decrease in the pressure of the flow in the vicinity of the solid object.

The low-pressure area is located near the rear portion (i.e., downstream region) of the hydraulic structure, and this difference in pressures gives rise to what is called form drag, where drag is used to indicate a resistance to flow as represented by a force. The shape and relative dimensions of the object will impact the form drag that results from flow. Drag can also be thought of as the impact of flowing water on a solid body. Flow may thus exert a force on a solid body as represented by:

$$F_D = C_D A \frac{\rho V_0^2}{2}$$

where F_D is the drag force, C_D is the drag coefficient associated with the shape and dimensions of the solid object, A is the cross-sectional area that is projected upstream by the object (length squared), ρ is the density of the fluid and V_0 is the flow velocity upstream of the solid object. Over time, experiments measuring the impact of flow around solid bodies have resulted in an accepted set of drag coefficients associated with different shapes and relative dimensions (Fig. 2). As can be seen, drag coefficients can vary from 0.07 to 2.00, thus greatly impacting the drag force that flowing water will exert on a solid body. Drag coefficients may also be impacted based upon the values of the dimensionless Reynolds number (**Re**) (Fig. 2), where larger **Re** are associated with decreased drag based upon achieving a fully rough condition. The value for the **Re** is calculated as:

$$Re = \frac{Vd}{\nu}$$

where V is the velocity of the flow, d is the diameter of a pipe or can be considered as a depth of flow and ν is the kinematic viscosity of the fluid (length squared per time). The **Re** will be large if the velocity and/or diameter are large or if the kinematic viscosity is small.

The movement of fluid around the solid object means that ordered streamlines are absent from the area immediately downstream of the object, producing an area of disordered flow. In this disordered flow, the velocity vectors occur in all directions and may be circular in motion, where they are called eddies (Fig. 1a, b, and c). Parcels of water moving in opposite directions and impacting each other result in water with reduced velocities. These reduced velocities have less energy and are thus unable to transport the existing sediment load. Sedimentation may thus occur downstream of a solid object.

In order for an object (that is not buoyant) lying flat on a surface to be moved by the water flowing around it, the drag force must be greater than the resisting force, that is, the force required to initiate sliding motion. The resistance to the initiation of sliding motion is based on friction, where a friction force, F_f can be calculated as:

$$F_f = \mu W$$

where µ is the coefficient of friction based upon the two materials coming in contact with each other (Table 1) and W is the weight of the object that may be moved.

ENGINEERING ISSUES WITH RECTANGULAR NEST BOX

Knowing from the above discussion that object shape and relative dimensions impact flow parameters, it is possible to assign at least partial causes to the problems reported with the operation of rectangular nest boxes. Sedimentation of suspended materials along the downstream face of the rectangular nest boxes could be attributed to disordered flow where velocity vectors are oriented in all directions, including some that are in opposite directions that negate each other, resulting in low velocities. Reduced velocities allow suspended sediment to drop out. The movement of the nest boxes from their original locations could be attributed to drag forces that are initiated on the upstream side of the nest box as the flow must be redirected around it. Drag forces are greater from larger, faster, storm flows, and it may be during these times that the disturbance occurs. Thus, there are design issues with both the upstream and downstream

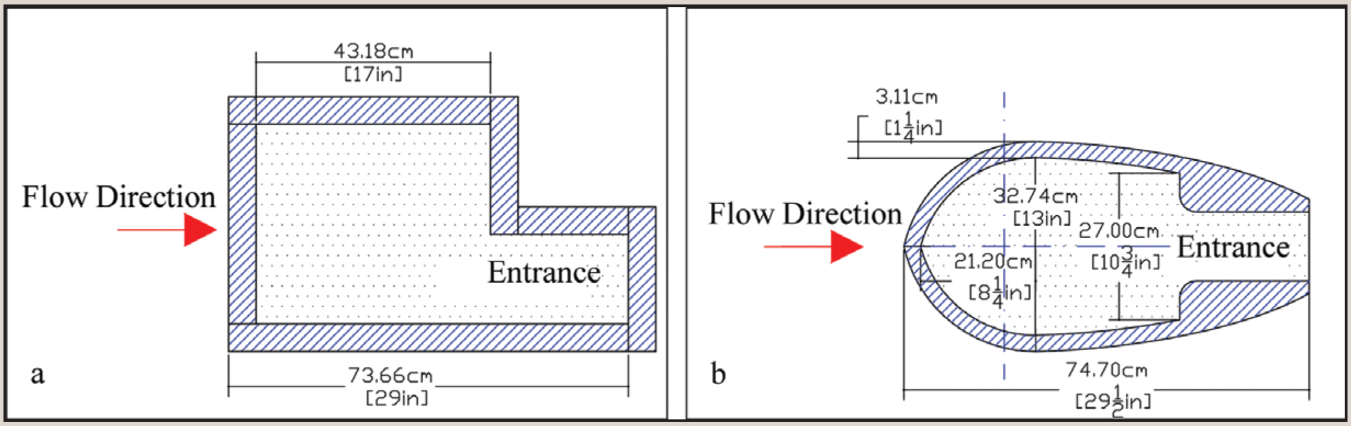


Fig. 4. a. Top view of existing nest box shape (rectangular); b. Top view of redesigned nest box shape (streamlined).

faces of the nest box that must be addressed simultaneously. An alternative nest box design is proposed that is evaluated based upon the fluid mechanics principles discussed above.

Engineering Constraints with Nest Box Redesign

There are a number of constraints that are imposed on the redesign process based on the fact that the nest boxes are being utilized as breeding locations for Hellbenders in their natural habitat.

1. There must be an internal cavity that is large enough for the male Hellbender to move in along with any egg masses present.
2. While the eggs are developing, the male needs to be able to defend them from predators, so a tunnel (length greater than width) entrance is desired that provides only limited access to the internal cavity.
3. Consistent with natural habitat, the entrance to the internal cavity must be located on the downstream side of the nest box (Pfingsten and Downs 1989).
4. To reduce the effects of human disturbance on Hellbenders, the nest boxes must be placed far away from roads and other easy access points. Thus, the structures must be light enough to be carried to more remote locations in the field by researchers.
5. The bottom of the nest box must be essentially flat in order to be stable in its placement on the bottom of a stream bed.
6. Any new nest boxes must be able to be constructed from an inexpensive material and with a design that limits constructability and durability issues.

Modifications to Nest Box Design

Given the above constraints, the design challenge was to develop a nest box to meet the required characteristics for biological functionality while improving hydrodynamic performance. Hydrodynamics can provide examples of solid objects designed to be placed in flowing water with the intention of causing the least disturbance. Once such example consists of the weights that are used with current meters (Fig. 3), devices utilized to measure the velocity of flow at different depths within a stream, based upon the rate of rotation of a set of vanes. Weights are used to orient the flow measuring device in a vertical position to reduce reading errors caused from velocity vectors that are not perpendicular to the axis holding the rotating vanes. The shape of the weight is established both to minimize the drag on the weight that would cause it to move away from the vertical and to minimize the disordered downstream flow that could produce velocity vectors in multiple directions.

Computer-aided design software (AutoCAD, Autodesk, Inc., 2015) was utilized to produce the redesigned Hellbender nest box. Relative dimensions were identified from a drawing of a current meter weight and manipulated to incorporate all of the nest box design constraints. The streamlined nest box has a different external shape and interior space in comparison to the original rectangular design (Fig. 4).

The upstream projection of the current meter weight is a rounded point, approximating a parabolic curve. Producing forms for a pointed projection can be difficult and may not allow for sufficient concrete thickness or wire reinforcement. Additionally, points can be problematic as they may be subject to breakage from the impact of transported rocks/cobbles. The current meter weight is three-dimensional and is considered to be a rotational body, meaning that if the direction of flow is considered as the x-axis, then the body has the same curvature in the y–z plane. The fact that the nest box must be flat on the bottom means that the rotational body must be truncated on the bottom. Thus, for the redesigned nest box, the upstream parabolic projection was flattened for constructability and durability, and the shape of the nest box mimics only the upper half of the current meter weight shape.

The rear portion of the current meter weight decreases dramatically and finishes with the addition of fins that help to properly orient the weight with respect to the oncoming flow. Fins are not necessary for the performance of the nest box and were never considered. The significant decrease in the rear projected area had to be modified in order to accommodate the placement of the access tunnel, which was then subsumed into the body of the nest box. Thus, the decreasing portion of the rear projection was truncated and has relative dimensions that are more consistent with the middle portion of the current meter weight. The streamlined shape of the current meter weight helps to direct the streamlines around the body so that they may rejoin together downstream of the body, in order that any eddies of disordered flow that might induce sedimentation occur downstream of the body. Without disordered flow, velocities are maintained to keep sediment in suspension.

Table 2. Initiation of motion calculations for rectangular and streamlined nest boxes.

Flow velocity	Rectangular Nest Box					Streamlined Nest Box				
V (m/s)	C_{D1}	A_1 (m^2)	F_{D1} (N)	F_{F1} (N)	Sliding Force = F_{D1} - F_{F1}	C_{D2}	A_2 (m^2)	F^{D2} (N)	FF2 (N)	Sliding Force = F_{D2} - F_{F2}
0.1	2	0.06	0.56	86.66	-86.10	0.10	0.07	0.03	118.81	-118.77
0.5	2	0.06	14.00	86.66	-72.66	0.10	0.07	0.86	118.81	-117.95
1	2	0.06	56.00	86.66	-30.66	0.10	0.07	3.45	118.81	-115.36
1.25	2	0.06	87.50	86.66	0.84	0.10	0.07	5.39	118.81	-113.42
1.86	2	0.06	193.74	86.66	107.08	0.10	0.07	11.94	118.81	-106.87
3	2	0.06	504.00	86.66	417.34	0.10	0.07	31.05	118.81	-87.76
5	2	0.06	1400.00	86.66	1313.34	0.10	0.07	86.25	118.81	-32.56
5.87	2	0.06	1931.81	86.66	1845.15	0.10	0.07	119.01	118.81	0.204

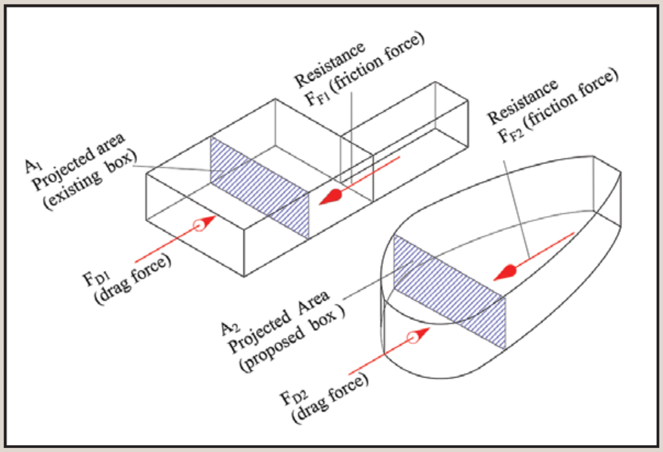


Fig. 5. Projected area and orientation of the drag and friction forces for the rectangular and streamlined shapes.

Fig. 6. Photographs of the streamlined nest box prototype.

The elongation of the nest box for both the upstream and downstream issues means that the weight of the box has increased beyond the approximately 50 lb of the nest boxes used previously in North Carolina. Because of the use of reinforcing wire mesh, the thickness of the walls was decreased to 1” to attempt to limit the increase in the weight. Additionally, the top was designed as a lid that could be carried into the field separately and would provide access to the nest box for visual inspection to verify usage/habitation.

Reduction in Drag Force for the Proposed Nest Box

To determine the potential impact of a redesigned streamlined nest box, a series of calculations were performed (not an actual test of motion) between the existing, rectangular nest box design and the hydrodynamically redesigned, streamlined nest box (Table 2). The calculations (for water with ρ = 1000 kg/m^3) are based on velocities that might be expected during periods of low flow and high flow (during storm events). The characteristics that would produce any given velocity are a function of the contributing watershed area, the design precipitation event, as well as the stream cross-section, surface roughness and slope. A drag coefficient for the projection of the rectangular nest box can safely be assumed to be 2.0 (Fig. 2). The shape of the redesigned nest box has no direct analog, so an approximation is made. The drag coefficient of 0.07 for a 2:1 ellipsoid may be too low, so a value of 0.10 was used for general comparison purposes. The area used in the drag calculations is the projected area (Fig. 5) that is larger for the hydrodynamic box (0.069 m^2) than for the rectangular box (0.056 m^2). A coefficient of friction of 0.3 was used as corresponding to a concrete box positioned on a soil/rock channel bottom. A weight of 222.4 N (50 lb) was used for the rectangular box, while a weight of 395.9 N (89 lb) was calculated from the design drawings for the streamlined box. Rocks placed on a nest box for camouflage would have a similar effect on stability for either a rectangular or a streamlined box, and were thus not incorporated into the calculations.

Motion begins once a drag force is greater than a resisting friction force. Given the assumptions above, the predictive calculations indicate that motion would be initiated for the rectangular box at a flow velocity of 1.25 m/s (4.10 ft/s), while motion would be predicted to be initiated for the streamlined box at a flow velocity of 5.87 m/s (19.25 ft/s). This is a more than a four-fold increase in the calculated velocity predicted to destabilize a nest box.

Construction Considerations

Once the design was completed, the form for pouring the streamlined nest box had to itself be designed. In order that the constructed prototype maintains a shape with specific hydrodynamic properties, the scale drawings from AutoCAD were transferred to multiple panels of plywood for cutting. Once cut, the plywood sheets that create the outside of the nest box were glued and screwed together to form a solid, durable and reusable outer mold. The interior surface was sanded and covered with a putty to ensure easy release of the nest box from the mold. As indicated earlier, the prototype needed a separate lid for easier transport. The lid mold includes an inner lip to allow the lid to sit smoothly and snugly upon placement in the field.

The requirement for an internal cavity necessitated a removable wooden piece that would establish the shape and size of the cavity. An interior mold was also created for the access tunnel. It was divided into three parts with the center being a wedge shape to facilitate tapping out and removal of the outer two sections.

Hardware cloth was utilized to reinforce the concrete, which for this initial prototype was simply the thinnest mortar commonly used for bonding ceramic tiles (QUIKRETE ®). All walls of the nest box were reinforced, with particular attention being given to the wrapping in the vicinity of the access tunnel. It is important to use a concrete containing sand, as a larger aggregate would make it difficult to adequately pour the thin walls of the structure and ensure complete contact between the cement and the aggregate. A constant moisture content between the several batches of concrete that were required to pour the entire nest box ensures a consistent strength between the batches. During the pour, a plastic hammer and a thin wooden shim were used to remove the air from the poured concrete, especially the walls, to improve strength. The molded concrete was wetted at least two times each day during curing, especially for the first seven days, to prevent cracking and facilitate the chemical reactions of the setting concrete. The concrete was allowed to set for 24 hours before removal from the mold, and continued to develop strength over time with continued wetting. Photographs show multiple views of the constructed nest box (Fig. 6).

Conclusions

Collaboration between a biologist and several engineers resulted in the redesign of a previously employed rectangular Hellbender nest box to meet biological requirements and improve field performance. Analyzing the functioning of the nest box from the perspective of hydrodynamics identified at least partial reasons for observed instability and sedimentation around the downstream access tunnel. The analysis further suggested how the redesign should be undertaken: producing modifications to the upstream face in order to reduce drag caused by flowing water and to the downstream face to complete the redirection of streamlines around the nest box to limit sedimentation. The more than four-fold increase in the predicted velocity of flow required to destabilize the streamlined nest box as compared to the rectangular nest box (as produced by demonstration calculations), suggests that it is a tool with a greater likelihood of success in augmenting Hellbender populations in North Carolina stream sites. At this time, researchers in North Carolina are in the process of building, installing and testing the efficacy of the redesigned nest box in the field. Results from the field testing will be incorporated into future refinement of the design.

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AMPHIBIAN AND REPTILE DISEASES

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Snake Fungal Disease, *Ophidiomyces ophiodiicola*, in Ohio, USA

Snake Fungal Disease (SFD) is a recently described disease of free-ranging snake populations resulting from infection by *Ophidiomyces ophiodiicola* (Allender et al. 2015a). Typically presenting as skin lesions near the head and neck, SFD consistently results in morbidity or mortality and may cause severe localized population declines (*Sistrurus catenatus*, Allender et al. 2013; *Crotalus horridus*, Clark et al. 2011; *Thamnophis radix*, Dolinski et al. 2014). SFD has been reported in free-ranging snake populations in 15 Eastern and Midwestern US states (Allender et al. 2015b) and at least 11 species to date (Cheatwood et al. 2003; Rajeev et al. 2009; Allender et al. 2013; Dolinski et al. 2014; McBride et al. 2015; Guthrie et al. 2016). In Ohio, SFD was first reported from retroactive testing of five Lake Erie Watersnakes (*Nerodia sipedon insularum*), an Ohio state-listed species (collected from Ottawa County in 2009, Lorch et al. 2016). Although yet to be detected in most species in Ohio, SFD has been detected in surrounding states in six genera or species that are Ohio state endangered, threatened, or species of concern (*C. horridus*, Clark et al. 2011; *N. sipedon insularis*, Lorch et al. 2016; *S. catenatus*, Allender et al. 2013; *T. radix*, Dolinski et al. 2014). Due to potential high pathogenicity of SFD and associated conservation concerns, the goal of this study was to further document the occurrence of SFD in additional free-ranging snake populations in Ohio.

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As a part of annual monitoring of snake populations in Ashtabula County, located in northeastern Ohio, we collected swab samples for monitoring SFD in free-ranging snake populations. From 6 to 21 May 2015, we collected a total of 16 swabs of the nasolabial pits and any lesions from 15 Massasaugas (*Sistrurus catenatus*) captured during visual encounter and artificial cover surveys at five field sites (Table 1). We also noted the presence of lesions or other abnormalities consistent with SFD infection. In order to collect disease samples, we restrained Massasaugas using clear plastic tubes and both the naso-labial pits and any visible lesions were swabbed using rayon tipped Fisherfinest™ transport swabs (Fisher Scientific, Pittsburg, Pennsylvania, USA). In addition, a single Eastern Hog-nosed Snake (*Heterodon platirhinos*) captured in Scioto County in southern Ohio on 22 May 2015 presented with multiple visible lesions was swabbed for SFD on 27 June 2015. In order to minimize cross-contamination among individuals and inadvertent disease spread among individuals and populations, all processing equipment, such as scales and meter tapes, were either used only once or sanitized using Clorox bleach spray between individual snakes. Field equipment, such as tongs and coolers, were sanitized using Clorox bleach spray between sites to prevent the potential spread of SFD among sites.

Although the presence of lesions near the head and neck has been found to be a good indicator of potential infection, biopsies and cultures do not always corroborate such conclusions (Guthrie et al. 2016). Therefore, in addition to noting any obvious lesions, we collected swabs from both lesions and nasolabial pits. Samples were stored on wet ice in the field, stored at -20°C until overnight shipment to the Wildlife Epidemiology Lab (University of Illinois Urbana-Champaign, Urbana, Illinois, USA). We extracted DNA using manufacturer's recommendation for swabs (DNA blood and swab mini kit, Qiagen, Valencia, California, USA) and tissue samples (DNEasy kit, Qiagen). The DNA concentration and purity was determined using a spectrophotometer (Nanodrop, Thermo Scientific, Waltham, Massachusetts, USA). A TaqMan assay was performed using primers targeting a 68 base pair segment of internal transcribed spacer, between 18S and 5.8S rRNA genes of *Ophidiomyces* (Allender et al. 2015b). Quantitative PCR assays were conducted using a real-time PCR thermocycler and data analyzed using the associated software (7500 ABI real-time PCR System, Sequence Detection Software v2.05, Applied Biosystems, Carlsbad, California, USA).

We observed a single healed lesion approximately mid-body on the ventral side of a single Massasauga and did not observe indications of lesions on any additional Massasaugas. We did not detect SFD in any of the 15 Massasauga specimens tested using qPCR (Table 1). In all instances, Massasauga samples resulted in a mean Ct of greater than 40 with 0 fungal copies. The Eastern Hog-nosed Snake tested positive for SFD with a mean Ct of 23.7 and 16,600 fungal copies (Table 1).

We did not detect SFD in any of the 16 samples from Massasaugas in northeastern Ohio. The negative result was somewhat surprising given the presence of SFD in Massasauga populations from both Illinois (Allender et al. 2011; Allender et al. 2015b) and Michigan (Allender et al. 2015c; Tetzlaff et al. 2015). If there was a relatively low prevalence of 5% in Ohio, similar to results from Michigan (Allender et al. 2015c), one would need to sample 60 snakes in order to have 95% confidence that SFD is absent from a population (Skerratt et al. 2008). Due to our relatively low sample size (N = 15) and the difficulties associated with detecting SFD in asymptomatic individuals, we cannot conclude that SFD is not present in Massasauga populations of northeastern Ohio; however, we can say with relative certainty that none of the snakes we sampled were positive for *Ophidiomyces* (Allender et al. 2015b). Screening efforts such as ours where individuals without lesions are swabbed may be ineffective for monitoring the presence of SFD and other methods such as eDNA detection methods may be warranted in situations where symptomatic individuals are absent from a population.

To our knowledge, we report the first confirmed detection of SFD in the Eastern Hog-nosed Snake. This particular snake was collected as a part of a multispecies public education program focused on native southern Ohio snake communities. This program allowed the public to handle and interact with multiple species collected from multiple locations in southern Ohio with the intent to release specimens after the event. Although the SFD-positive Eastern Hog-nosed Snake in question died prior to release, this case exposes potential issues with disease spread and transmission among species and populations related to such educational programs. Although the mechanism for transmission of SFD is suspected to be environmental, there is reason to believe that transmission among individuals through direct (i.e., individuals housed together) or indirect means (i.e., transfer via human mediation) is probable given our understanding of other fungal pathogens of wildlife such as *Batrachochytrium dendrobatidis* and *B. salamandrivorans* (which cause chytridiomycosis) in amphibians (Rachowicz et al. 2004; Mendez et al. 2008; Martel et al. 2014) and *Geomyces destructans* (white-nose syndrome) in bats (Langwig et al. 2012). Therefore, to prevent an inadvertent human-mediated spread of SFD in free-ranging snake communities, it may be sensible to instead use long-term captives for public outreach events, use biosecure methods to forestall disease transmission with the public, or deposit wild-caught animals from such events in museum collections.

TABLE 1. Summary of 15 Massasaugas (*Sistrurus catenatus*) and one Eastern Hog-nosed Snake (*Heterodon platirhinos*) evaluated for snake fungal disease in Ohio, USA from 6 to 22 May 2015. Asterisk (*) indicates that both a lesion and nasolabial pit swab were collected from the same individual on different dates.

Species	Capture date	County	Site	Sex	Age	Length (cm)	Mass (g)	Swab type	Mean Ct Value value	Mean *Ophidiomyces* quantity	qPCR results
S. catenatus	19 May 2015	Ashtabula	GR	female	adult	33.0	37.0	pits	> 40	0	–
S. catenatus	14 May 2015	Ashtabula	ML	female	adult	51.0	56.0	pits	> 40	0	–
S. catenatus	12 May 2015	Ashtabula	RM	female	adult	57.0	62.0	pits	> 40	0	–
S. catenatus	12 May 2015	Ashtabula	RM	male	adult	52.0	58.0	pits	> 40	0	–
S. catenatus	12 May 2015	Ashtabula	RM	male	juvenile	43.0	48.0	pits	> 40	0	–
S. catenatus	12 May 2015	Ashtabula	RM	female	adult	58.0	64.0	pits	> 40	0	–
S. catenatus	14 May 2015	Ashtabula	RM	male	adult	60.0	67.5	pits	> 40	0	–
S. catenatus	21 May 2015	Ashtabula	RM	male	adult	61.0	68.0	pits	> 40	0	–
S. catenatus	21 May 2015	Ashtabula	RM	female	adult	54.0	58.0	pits	> 40	0	–
S. catenatus	21 May 2015	Ashtabula	RM	male	adult	44.0	49.0	pits	> 40	0	–
S. catenatus	12 May 2015	Ashtabula	RM	female	adult	59.5	64.5	pits	> 40	0	–
S. catenatus	21 May 2015	Ashtabula	RM	female	adult	49.0	52.5	pits	> 40	0	–
*S. catenatus**	6 May 2015	Ashtabula	ST	male	adult	55.0	61.0	pits	> 40	0	–
*S. catenatus**	12 May 2015	Ashtabula	ST	male	adult	—	—	lesion	> 40	0	–
S. catenatus	19 May 2015	Ashtabula	ST	female	adult	55.0	60.0	pits	> 40	0	–
S. catenatus	14 May 2015	Ashtabula	YW	female	adult	55.0	59.5	pits	> 40	0	–
H. platirhinos	22 May 2015	Scioto	—	NR	juvenile	NR	NR	lesion	23.7	16600	+

Our results confirm the presence SFD in Ohio nine years after it was first detected from a Lake Erie Watersnake collected in 2006 in extreme northern Ohio. Additionally, the detection of SFD in extreme southern Ohio indicates at least the potential for *O. ophiodiicola* to be widespread throughout the state. Furthermore, SFD is now known to be present in multiple snake species in Ohio. The ability of *O. ophiodiicola* to persist and infect snake communities across such a broad geographic range relates to its likely presence in the environment as a saprobe and capacity to thrive under varying environmental conditions (Allender et al. 2015a). Given the potential range of *O. ophiodiicola* in Ohio and the confirmed infection in surrounding states of six genera or species that are Ohio state endangered, threatened, or species of concern, continued monitoring for SFD in free-ranging snake populations, particularly in regions harboring sensitive species is merited. Further research to determine optimal sampling times, methods, and sample sizes, as well as investigations of the feasibility of eDNA detection of *O. ophiodiicola* also is needed. Preventative measures such as consistent decontamination methods similar to those recommended for *B. dendrobatidis* and *B. salamandrivorans* should be employed by researchers, managers, and other individuals who interact with snakes to prevent the spread of SFD within and among free-ranging snake communities.

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Detection of an FV3-like Ranavirus in Wood Frogs (*Lithobates sylvaticus*) and Green Frogs (*Lithobates clamitans*) in a Constructed Vernal Pool Network in Central New York State

Ranavirus, an emerging and often lethal pathogen of amphibians, reptiles, and fish, has been detected across the continental United States (Duffus et al. 2015). FV3-like ranaviruses have been reported at several locations in New York State in larval Spotted Salamanders (*Ambystoma maculatum*), Jefferson Salamanders (*Ambystoma jeffersonianum*), Wood Frogs (*Lithobates sylvaticus*), Green Frogs (*Lithobates clamitans*), Tiger Salamanders (*Ambystoma tigrinum*; Brunner et al. 2011; Titus and Green 2013; Crespi et al. 2015), and Eastern Box Turtles (*Terrapene carolina carolina*; Johnson et al. 2008). To determine baseline prevalence and patterns of a disease in the environment, systematic surveillance over multi-year periods is necessary. Here, we report ranavirus prevalence for two species across four years in a vernal pool array. We screened *L. sylvaticus* and *L. clamitans* for ranavirus in both natural and constructed woodland vernal pools to determine baseline prevalence estimates. *Lithobates sylvaticus* are commonly occurring at this study site and highly susceptible to ranavirus (Hoverman et al. 2011). *Lithobates clamitans*, however, are less susceptible to ranavirus infection, and exhibit lower mortality rates in a laboratory setting (Hoverman et al. 2011).

In 2010, the Upper Susquehanna Coalition in collaboration with the State University of New York College of Environmental Science and Forestry (SUNY-ESF) constructed 71 vernal pools in Svend O. Heiberg Memorial Forest, Onondaga County, New York State (42.77165°N, 76.08636°W; Fig. 1). These pools were designed in clusters of 1, 3, or 9 pools, contained within numbered landscape hexagons, with an additional cluster—the "microarray"—as shown in Fig. 1. From 2011–2014, all pools containing water were each sampled approximately every four weeks during wood frog tadpole development, for a total of three sampling events per pool, beginning from late May to early June, with the exception of 2013. Due to financial and logistical constraints, sampling in 2013 only occurred in one round in July. For all other years, earliest sampling began six to eight weeks after wood frog egg masses were observed in pools, allowing tadpoles to develop to at least Gosner stage 25 (Gosner 1960). A maximum of 42 pools contained either wood frog or green frog larvae in any given year.

Larval sampling at each interval described above was performed according to pipe sampling protocols as described in Werner et al. (2007), with samples spaced 1–2 m apart in pools greater than 5 m diameter. One sample per ca. 2 m^2 of surface area were taken in smaller pools. Captured tadpoles were stored in buckets containing water from their pool. In 2011 and 2012, buckets were combined and 30 tadpoles randomly sampled from the total sample population of each pool. In 2013 and 2014, an equal number of tadpoles were randomly sampled from each bucket until 10 (year 2013) or 30 (year 2014) individuals were reached. If less than the target number of individuals were sampled, all were used for further processing. All other individuals were immediately returned to their pool of origin, and those selected for further processing were humanely euthanized by immersion in 70% ethanol. Proper care was taken during sampling in all years to prevent contamination between sites by disinfecting all equipment with 10% bleach solution. Ponds were also visually monitored once weekly from May-August each year with the exception of 2013, in which ponds were visited once monthly.

Specimens were preserved in 95% ethanol and stored at 4°C for further processing. Samples from years 2011–2012 were stored together in jars per pool, as these were originally collected simply for Gosner staging as part of a separate study on population recovery at restored vernal pool sites (unpubl. data). Samples from 2013–2014 were stored individually. Ranavirus testing for 2011 was originally intended as preliminary screening, to justify further specimen collection and screening in subsequent years; thus, samples of only five individuals per pool were tested. In 2012–2013, ten individuals per pool where at least ten were captured were randomly selected for testing, to at minimum detect ranavirus outbreaks during these years (Gray et al. 2015). In 2014, all 30 individuals where at least 30 were captured were used. For 2011–2013 samples, liver tissue (up to 25 mg) was extracted, immersed in cell lysis buffer and digested with 10 µL Proteinase K. DNA was extracted and purified using a salt extraction method (Sambrook and Russell 2001). Ranavirus DNA was amplified by PCR using major capsid protein primers 4 and 5 in Mao et al. (1997), following thermocycling conditions for routine PCR described in the Quick-Load® Taq 2X Master Mix handbook (New England BioLabs® Inc.). Products were separated via 1% agarose gel electrophoresis and visualized with ethidium bromide. Negative and ambiguous results were re-amplified using PCR methods as described above.

For 2014 samples, ≤ 20 mg liver tissue was extracted, and DNA was purified using Qiagen DNeasy® Blood and Tissue kit according to manufacturer's protocols for animal tissue. Ranavirus DNA was amplified by conventional PCR using methods described above, and negative or ambiguous results were analyzed by quantitative PCR assay developed by Pallister et al. (2007). Twenty-three percent of conventional PCR negatives were declared positive by quantitative PCR. Quantitative PCR was conducted at Cornell University Animal Health Diagnostic Center using Applied Biosystems StepOne™ real-time PCR system and analyzed with StepOne software v2.3. DNA extractions and cPCR were completed at SUNY ESF. PCR products from four *L. sylvaticus* from 2011 were purified

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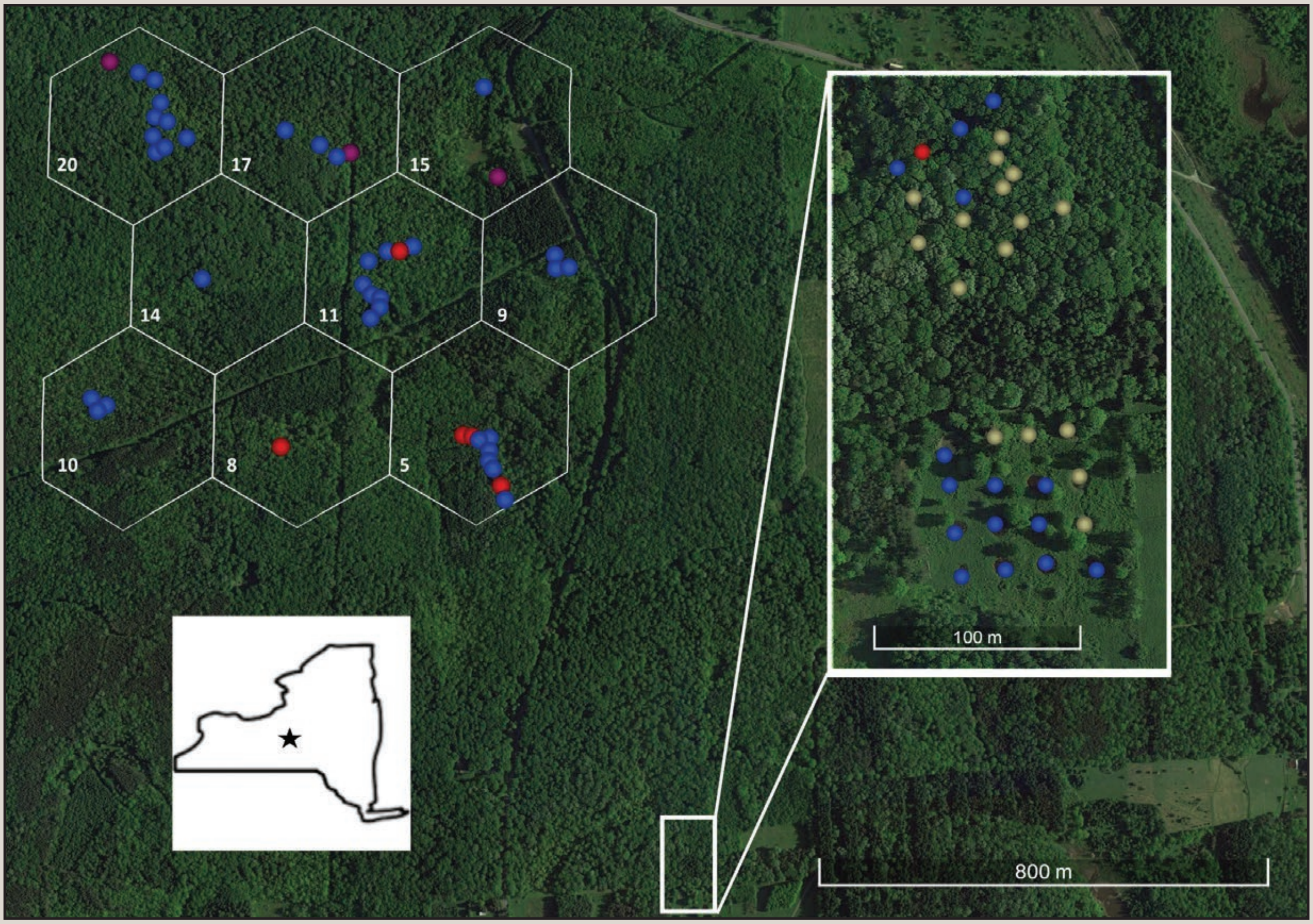

FIG. 1. Aerial view of Heiberg Forest, showing location within New York State (star, map inset). Landscape was divided into 9.3-ha hexagons, and clusters of either 1, 3, or 9 pools (blue dots) were constructed within selected hexagons. Microarray cluster (enlarged section) contained pools with hydroperiods shorter than one month post-spring thaw (beige dots); these pools remained dry during entire summer season each year and were not sampled. Purple dots indicate natural pool sites. Red dots indicate observed die-offs.

using Omega E.Z.N.A.® Cycle Pure Kit, and sequenced at Yale University DNA Analysis Facility. Samples were aligned using BioEdit v 7.2.5, and BLAST® analysis revealed 100% identity with Frog Virus 3 isolate D1 major capsid protein gene, GenBank accession #JQ771299.

Ranavirus prevalence, reported as total ranavirus-positive specimens/total specimens tested during each year, per species, ranged from 0.13–0.51 for *L. sylvaticus*, and 0.0–0.33 for *L. clamitans* (Table 1). Recurring die-offs (visual observation of dead tadpoles) of *L. sylvaticus* were observed during sampling in one hexagon 5 pool in June 2011, July 2013, and July 2014 (of eight total hexagon 5 pools containing water) (Fig. 1). A *L. sylvaticus* die-off occurred in a second hexagon 5 pool in July 2013. Other observed *L. sylvaticus* die-offs occurred in hexagon 11 in June 2011 (one pool of nine containing water), and the microarray in June 2012 (one pool of 16 containing water). Subcutaneous hemorrhaging was observed in *L. sylvaticus* tadpoles from one hexagon 9 pool in July 2014 (of three containing water). No die-offs were observed in hexagon 9 during weekly visits. Moribund *L. clamitans* (erratic swimming, lethargy, skin sloughing) and decomposing carcasses were seen in pool 5B in August 2014 (of eight hexagon 5 pools containing water). Die-offs of *L. clamitans* were observed in hexagon 8 (containing a single pool) in August 2012, and August 2013. In addition, three *A. maculatum* larvae captured during sampling in July 2014 from hexagon 5 exhibited subcutaneous hemorrhaging and extreme lethargy, and tested positive for ranavirus via qPCR.

Lithobates clamitans has been considered as a possible reservoir host for ranavirus (Hoverman et al. 2012), due to their lower rates of infection and mortality (Hoverman et al. 2011) and multi-year larval development periods. Many other species of pool-breeding amphibians are also present in Heiberg Forest (in order of highest to lowest observed abundance): Spring Peepers (*Pseudacris crucifer*), Spotted Salamanders (*A. maculatum*), American Toads (*Anaxyrus americanus*), Eastern Spotted Newts (*Notophthalmus viridescens*), and American Bullfrogs (*L. catesbeianus*). Each of these species is susceptible, in varying degrees, to ranavirus (Green et al. 2002; Hoverman et al. 2011; Forzán and Wood 2013; Richter et al. 2013), and further study of infection status in these species would provide more insight into transmission within the Heiberg system. However, other than *L. sylvaticus*, *L. clamitans*, and *A. maculatum*, no dead or moribund individuals of the Heiberg amphibian species were observed.

With baseline prevalence greater than zero throughout the spring and summer seasons, proper decontamination protocols should be adhered to by both researchers and recreational users of these forest properties. Our recommendations for continued

Table 1. Prevalence estimates for Wood Frog (*Lithobates sylvaticus*) and Green Frog (*L. clamitans*) populations by year. Sample sizes are indicated. *Sampling in 2011 did not include *L. clamitans*. **Sampling only occurred in July. †Values are as follows: (# ponds with observed die-offs of this species/# ponds with ≥ 1 ranavirus-positive specimen of this species/# ponds sampled containing this species). ‡Ponds were not sampled during these die-offs.

		Year			
		2011*	2012	2013**	2014
Lithobates sylvaticus	Prevalence	0.36 (N = 275)	0.13 (N = 436)	0.13 (N = 101)	0.51 (N = 817)
	Ponds†	2/20/34	1/9/22	2/7/11	1/29/32
Lithobates clamitans	Prevalence	NA	0.13 (N = 60)	0 (N = 12)	0.33 (N = 204)
	Ponds†	NA	1‡/2/14	1‡/0/3	1/15/18

surveillance include standardized screening methods and long-term population monitoring. Other studies have suggested that four years is not sufficient to determine population impacts of recurrent outbreaks (Petranka et al. 2003; Earl and Gray 2014). Adult amphibians should also be included in screening processes, as sub-lethally infected adults returning to breeding ponds could be sources of contamination (Brunner et al. 2004). *Lithobates sylvaticus* exhibits a source-sink metapopulation structure (Peterman et al. 2013) and may remain stable or decline at slower rates in hexagon clusters of 3 or 9 pools despite recurrent outbreaks; therefore examining ranavirus effects on populations in Heiberg forest could be useful for guiding future vernal pool construction efforts.

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Presence of *Ranavirus* in a Created Temporary Pool Complex in Southeastern New York, USA

Amphibian population declines have been attributed to habitat loss, fragmentation, and degradation prompting the protection and even creation of amphibian habitats, such as breeding pools (Lichko and Calhoun 2003; Calhoun et al. 2014). If well-constructed, these habitats should support the full suite of ecological interactions (Kolozsvary and Holgerson 2016), including parasitism. Viruses in the genus *Ranavirus* (family Iridoviridae), for instance, are common pathogens of pond-breeding amphibians, often leading to mass mortality events and sometimes long-term population declines (Green et al. 2002; Gray et al. 2009; Miller et al. 2011; Price et al. 2014; Duffus et al. 2015). Petranka et al. (2007) and Youker-Smith et al. (2016) have both reported that *Ranavirus* infections and die-offs occur in amphibian larvae from constructed ponds, especially in Wood Frogs (*Lithobates sylvaticus*) and Spotted Salamanders (*Ambystoma maculatum*), suggesting that amphibian populations in constructed ponds are at least epidemiologically similar to natural ponds. But such studies remain rare. Here we document *Ranavirus* infections in three amphibian species inhabiting a newly created temporary pool in southeastern New York, USA.

Dip-net surveys for amphibian larvae were conducted every other week in seven created temporary pools from early May through July (or until a pool was dry) in 2013 and 2014, as part of a larger study (pools created in 2006; see Kolozsvary and Holgerson 2016). The ponds were embedded in a mixed-deciduous forest intermixed with several large wetlands and other water bodies, adjacent to the Stewart International Airport in the towns of Newburgh and New Windsor, New York, USA (Fig. 1). On 19 June 2013, during regular sampling for water chemistry measurements, dozens of dead or moribund amphibian larvae were found scattered throughout created temporary pool B2 (41.494011°N, 74.122403°W; area = 275.19 m^2; maximum depth = 62 cm) in addition to dozens of actively swimming Wood Frog tadpoles. Pool B2 had substrate dominated by leaf litter, downed logs, with minimal vegetation—except for a small patch of submerged vegetation—and clear water, and thus visibility in the water column was high. Ten live Wood Frog larvae (Gosner stages 31–36) with varying degrees of petechial lesions and edema were collected with a dipnet. These and subsequent specimens were euthanized with tricaine methanesulfonate (MS-222), immediately placed on dry ice in the field, and transported to the laboratory where they were frozen. The specimens were then shipped to Washington State University on dry ice for virus screening.

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On 22 June 2013, we returned to pool B2 to conduct the regular dip-net survey. We again observed dozens of Wood Frog larvae carcasses scattered throughout the pool, but saw substantially fewer Wood Frog larvae swimming in the pool than we had three days earlier. During the dip-net survey (20 person minutes), we captured only seven live Wood Frog larvae, all of which showed varying degrees of lesions and edema. We did not conduct a dip-net survey at the pool on 19 June, so we do not have a quantitative comparison of relative numbers of Wood Frog larvae between the two dates, but the difference was qualitatively striking. We did not intend to submit additional Wood Frog larvae for testing, so these seven larvae were released after the survey, but we did collect two Spotted Salamander (*Ambystoma maculatum*) larvae, one Spring Peeper (*Pseudacris crucifer*) larva, and an adult Red-spotted Newt (*Notophthalmus v. viridescens*). Petechial lesions were visible on the Spotted Salamander larvae, which were close to metamorphosis, but not on the Spring Peeper, which was a recent hatchling (Gosner stage < 27; note: the Spring Peeper was not tested for ranavirus.) The newt had red, swollen hind legs, especially proximally, where they join with the body, and thin, red, spidery veins visible on the ventral surface of its main body. An adult Red-spotted Newt had been seen consistently in the pool during previous sampling occasions, although it may or may not have been the newt we collected.

No other amphibian larvae were found in pool B2 during the next bi-weekly sampling event (5 July 2013), which was the last sampling event for this pool before the pool dried completely on 18 July 2013. No dead or visibly sick amphibians were observed in any of the other six created temporary pools in the complex throughout the sampling season.

In 2014, the same set of seven created temporary pools was sampled and no amphibian die-offs were observed in pool B2. However, on 25 May 2014, Wood Frog larvae with visible petechial lesions and edema were observed in pool C1 (41.496168°N, 74.1222207°W; area = 153.78 m^2; maximum depth = 37 cm). Visibility in the water of pool C1 was obscured by dark water color and areas of thick vegetation (primarily *Phragmites australis*), so the extent of the die-off was difficult to assess. Although five live Wood Frog larvae with visible signs of disease were collected, the larvae were not properly preserved on ice and

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Fig. 1. Map showing the locations of the study sites: seven created pools adjacent to Stewart International Airport, Towns of Newburgh and New Windsor, New York, USA.

Table 1. Summary of ranavirus infection documented in pooled samples of *Lithobates sylvaticus* and *Ambystoma maculatum* larvae, and one *Notophthalmus v. viridescens* adult from a created temporary pool (B2) in southeastern New York, USA in 2013.

Species	Common Name	Date collected	Stage	No. collected	Ranavirus isolated?
Lithobates sylvaticus	Wood Frog	19 June 2013	Larvae	10	Yes
Ambystoma maculatum	Spotted Salamander	22 June 2013	Larvae	2	Yes
Notophthalmus v. viridescens	Red-spotted Newt	22 June 2013	Adult	1	Yes

the specimens were thus not tested. Wood Frog larvae were not observed in pool C1 on subsequent bi-weekly sampling trips in 2014, but apparently healthy Spotted Salamander, Spring Peeper, and Gray Treefrog (*Hyla versicolor*) larvae were captured in June and healthy Gray Treefrog, Green Frog (*Lithobates clamitans*), and Red-spotted Newt larvae were found there in July. In 2014, C1 held water until approximately 20 August. No additional amphibian die-offs were observed in any of the other created temporary pools throughout the rest of the sampling season (end of July 2014).

Liver and gastrointestinal tracts were dissected from the Wood Frog larvae, salamander larvae, and adult newt, placed in 2-mL screw cap tubes with 1.0-mm diameter silicon-carbide sharp particles and 2% fetal bovine serum (FBS) in minimum essential medium with Hanks salts (HMEM; HyClone, Ottawa, Ontario, Canada), and homogenized for 60s using a Mini-BeadBeater-16 (BioSpec Products, Bartlesville, Oklahoma, USA). All 10 Wood Frog larvae were screened in one batch, as were the two Spotted Salamander larvae. The homogenates were then filtered through 0.45-µm syringe filters and inoculated onto FHM cells in T-75 flasks (Corning, Corning, New York, USA) with 10% FBS-HMEM. When full cytopathic effects were observed in each flask under a 100x inverted light microscope, indicating the presence of replicating virus, the cells and media were harvested and frozen. DNA was then extracted from the three virus isolates using Qiagen DNeasy Blood and Tissue kit following the manufacturer's instructions (QIAGEN Inc, Valencia, California, USA) and then *Ranavirus* DNA was amplified in triplicate 20-uL

Taqman realtime polymerase chain reactions targeting a 70-bp region within the major capsid protein gene (Picco and Collins 2008) to verify that the isolated virus was a ranavirus. DNA from all three virus isolates showed clear amplification in each of the three wells on which they were run, confirming that the isolated viruses were ranaviruses (Table 1).

Collectively, our data suggest that a *Ranavirus* was responsible for an amphibian die-off involving at least three species in pool B2 in June of 2013. This is the second report of ranavirus-related die-offs associated with created temporary pools in New York State (Youker-Smith et al. 2016). The other created pool complex is located in Heiberg Memorial Forest in central New York, approximately 215 km from our study pools, where ranavirus was detected in 13–51% of ponds and die-offs occurred in 3–18% of ponds, depending on the year (Youker-Smith et al. 2016). Our finding of ranavirus-related mortality in just one (~14%) of the seven constructed pools is thus broadly consistent with their results. Our observations suggest an additional die-off occurred in Wood Frog larvae, but not other amphibian species in pool C1 in 2014, but this was not confirmed.

Although no statewide surveys of ranaviruses in New York have been conducted, *Ranavirus* appears to occur throughout the state. In addition to our study and that of Youker-Smith et al. (2016), *Ranavirus* has been documented in several temporary pool complexes in northern and eastern New York (Brunner et al. 2011), and in adult Wood Frogs returning to ponds to breed in six areas in central and eastern New York (Crespi et al. 2015). *Ranavirus* was also found in a die-off of Wood Frog larvae in James Baird State Park, Dutchess County, New York, in 2007, and in a 2013 die-off of American Bullfrog larvae (*Lithobates catesbeianus*) in a permanent fire prevention pond in Peebles Island State Park, Albany County, New York (L. Bogan, pers. comm.).

It is not known how *Ranavirus* colonizes created pools, but unlike in natural pools, the pathogen could have been introduced during the initial pool construction. *Ranavirus* might also be introduced by researchers or monitoring personnel moving between created pools as they traverse the property, if they do not adhere to adequate decontamination protocols, or from the movement of reservoir faunal species into created pools from adjacent habitats. For example, Red-spotted Newts, which inhabit and move between semi-permanent and permanent wetlands, were documented at both pools B2 and C1 during this study. While newts are generally thought to be resistant to *Ranavirus* infection (Hoverman et al. 2011), they can be, and indeed were infected with *Ranavirus* in our study. Wood Frog adults are also known to harbor sublethal *Ranavirus* infections (Crespi et al. 2015). Regardless of how *Ranavirus* moved into the created pool complex, our observations highlight that just as in natural pools, created amphibian-breeding pools are subject to colonization by emerging infectious diseases and efforts to document and monitor movement of diseases into novel environments are warranted.

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Prevalence of *Batrachochytrium dendrobatidis* in Two Sympatric Treefrog Species, *Hyla cinerea* and *Hyla versicolor*

In the past decade *Batrachochytrium dendrobatidis* (*Bd*) has been detected in a variety of amphibian species in North America (e.g., Bradley et al. 2002; Schlaepfer et al. 2007; Woodhams et al. 2008; Pearl et al. 2009; Chatfield et al. 2012), which can be devastating when a species is susceptible to the disease caused by *Bd*, chytridiomycosis (Rachowicz et al. 2006; Murray et al. 2009; Pilliod et al. 2010). The disease disrupts cutaneous function in amphibians and negatively affects electrolyte transport through the skin, causing mortality in some taxa (Voyles et al. 2009).

In the US, common and widespread anuran species, such as American Bullfrogs (*Lithobates catesbeianus*) are often positive for *Bd*, although some species usually do not exhibit clinical signs of the disease (Garner et al. 2006; Steiner and Lehtinen 2008; Pearl et al. 2009). *Bd*-reservoir species, in this regard, may lead to patterns of higher *Bd* occurrences at sites with increasing species richness (Olson et al. 2013), and recurrent infections in other species. High *Bd* prevalence in common, reservoir species can pose a danger if they co-occur with disease-susceptible species. Two common North American treefrogs, the Green Treefrog (*Hyla cinerea*) and Gray Treefrog (*H. versicolor*) are widely distributed, yet published assessments of *Bd* in these species remain scarce. We argue that these two species should be of particular interest given their wide distribution across the eastern half of the United States and co-occurrence with other species. This scenario is similar to the western US hylid, Pacific Treefrog (*Pseudacris regilla*), which also is hypothesized to be a *Bd*-carrier species potentially transmitting the pathogen to new ponds and other amphibian species (Reeder et al. 2012). However, the eastern US hylids are popular in the pet trade, which could potentially accelerate the spread of the disease if these commonly traded species are *Bd* carriers (Fisher and Garner 2007; Schloegel et al. 2009).

The occurrence of *Bd* within North American hylids appears to be relatively low, although *Bd* has been detected in several species. For example, Rizkalla (2010) found no *Bd* among three *Hyla* species in Florida, and studies conducted in Wisconsin, Minnesota, East Texas, Louisiana, and Georgia found that all *Hyla* samples were negative for *Bd* (Timpe et al. 2008; Rodriguez et al. 2009; Sadinski et al. 2010; Saenz et al. 2010; Brannelly et al. 2012). However, *Bd*-positive individuals have been detected in the Canyon Treefrog (*H. arenicolor*), Gray Treefrog, Cope's Gray Treefrog (*H. chrysoscelis*), and Pacific Treefrog (*P. regilla*) (Bradley et al. 2002; Fellers et al. 2011; Muelleman and Montgomery 2013). The majority of *Bd* prevalence assessments in treefrogs has been conducted as part of assessments of larger amphibian communities in a particular geographic area; only one study in the eastern US has focused specifically on treefrogs (Brannelly et al. 2012). Consequently, sample size per study normally has been

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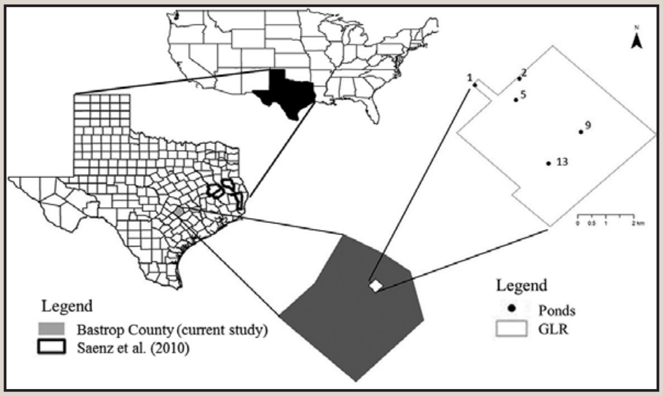

FIG. 1. Map showing USA with Texas highlighted in black (top) and more specifically the map of Texas with outlined counties (bottom left). Current study was conducted at Griffith League Ranch (GLR) in Bastrop County (highlighted in gray) and four additional counties outlined in bold represent counties surveyed by Saenz et al. (2010), the only other study that assessed *Batrachochytrium dendrobatidis* (*Bd*) in treefrogs in Texas. Out of 19 ponds at GLR, we assessed ponds 1, 2, 5, 9, and 13 where Green and Gray Treefrogs (*Hyla cinerea* and *H. versicolor*, respectively) occur.

TABLE 1. Green and Gray Treefrogs (*Hyla cinerea* and *H. versicolor*, respectively), sampled for *Batrachochytrium dendrobatidis* (*Bd*) during 2014 and 2015 field seasons in Bastrop County, Texas, USA.

Site	Species	No. *Bd*-positive/ No. sampled		Prevalence (%)
		2014	2015	
Pond 1	*H. cinerea*	0/8	0/27	0
	H. versicolor	2/7	0/2	22
Pond 2	*H. cinerea*	0/9	0/0	0
	H. versicolor	1/6	0/0	17
Pond 5	*H. cinerea*	0/1	0/55	0
	H. versicolor	0/4	1/7	9
Pond 9	*H. cinerea*	0/18	0/0	0
	H. versicolor	0/0	0/0	0
Pond 13	*H. cinerea*	0/0	0/5	0
	H. versicolor	0/0	0/1	0
Total	*H. cinerea*	0/36	0/87	0
	H. versicolor	3/17	1/10	15

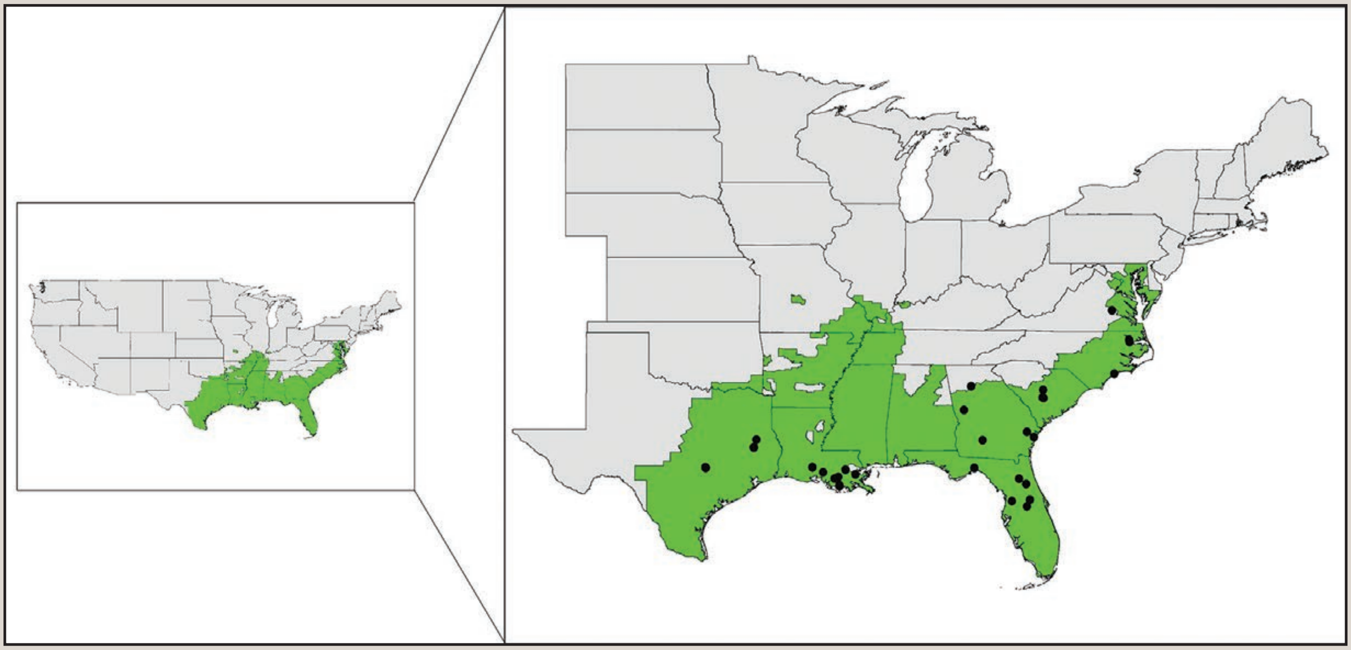

Fig. 2. United States map outlining the Green Treefrog (*Hyla cinerea*) distribution (green). Circles represent the regions where treefrogs were surveyed for *Batrachochytrium dendrobatidis* (*Bd*) and found to be *Bd*-negative. To date, no Green Treefrogs have been found to be *Bd*-positive.

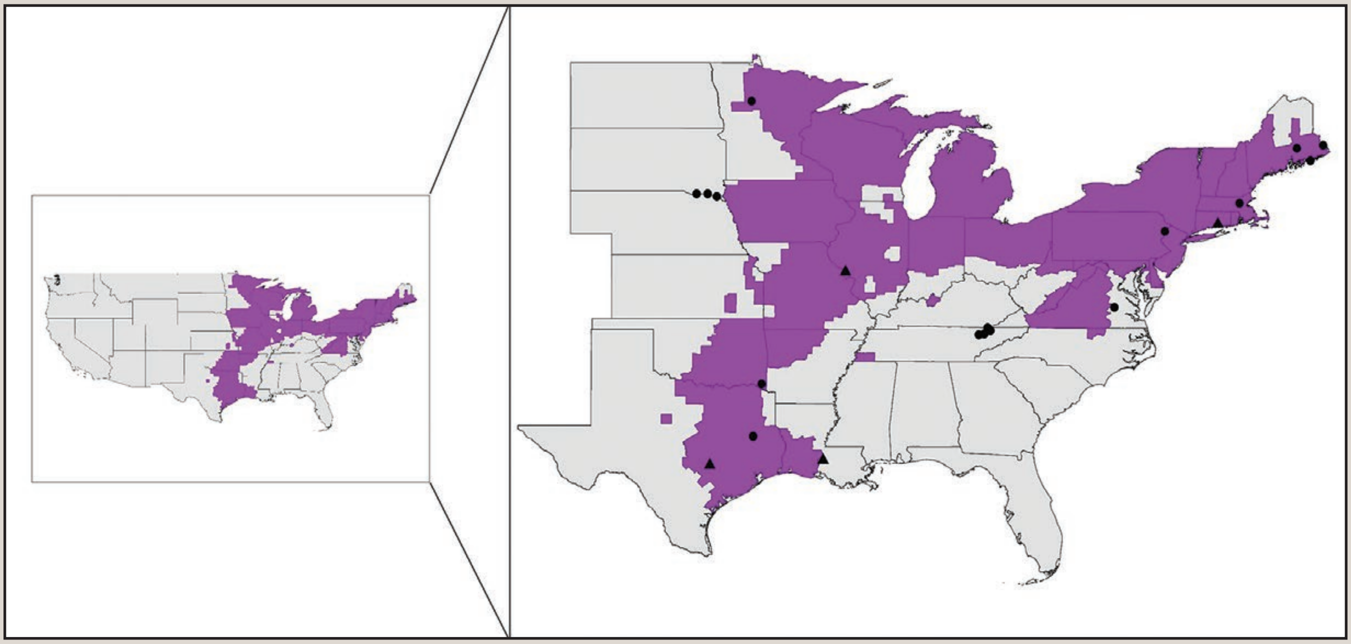

Fig. 3. United States map outlining the Gray Treefrogs (*Hyla versicolor*) distribution (purple). Circles represent the regions where treefrogs were surveyed for *Batrachochytrium dendrobatidis* (*Bd*) and found to be *Bd*-negative. Triangles represent the regions in which the frogs were found to be *Bd*-positive.

small, ranging from 1 to 42 (mean = ~18), with the exception of Brannelly et al. (2012; N = 258). With a small sample size, *Bd* may not be detected if it occurs at low prevalence (Skerratt et al. 2007).

Texas is home to ~70 amphibian species but *Bd* occurrence has not been widely studied, with the exception of studies in east and central Texas (Gaertner et al. 2009; Saenz et al. 2010). Thus far, *Bd* has not been assessed in treefrogs of central Texas, but Saenz et al. (2010) tested treefrogs for *Bd* in east Texas and found no positive samples. Central Texas is of a particular interest since several endemic and endangered amphibian species inhabit this region, such as several species of the salamander genus *Eurycea*, and the Houston Toad (*Anaxyrus houstonensis*; Dixon 2013). Previous *Bd* research showed 17% of Houston Toads and 83% of the sympatric Gulf Coast Toads (*Incilius nebulifer*) sampled were *Bd*-positive (Gaertner et al. 2010). Gaertner et al. (2012) studied Blanchard's Cricket Frog (*Acris crepitans blanchardi*) and found 89% *Bd* occurrence whereas Villamizar-Gomez (2013) tested the Houston Toad, Gulf Coast Toad, Blanchard's Cricket

TABLE 2. Studies that assessed *Batrachochytrium dendrobatidis* (*Bd*) prevalence in Green and Gray Treefrogs (*Hyla cinerea* and *H. versicolor*, respectively) across US states. "+" represents *Bd*-positive detections and "-" represents *Bd*-negative detections.

State	Species	+/-	Citation
Florida	*H. cinerea*	-	Rizkalla et al. (2009, 2010); Rothermel et al. (2008)
Georgia	*H. cinerea*	-	Green and Dodd (2007); Rothermel et al. (2008); Timpe et al. (2008)
Louisiana	*H. cinerea*	-	Brannelly et al. (2012)
North Carolina	*H. cinerea*	-	Bd-maps.net (accessed 25 May, 2016); Rothermel et al. (2008)
South Carolina	*H. cinerea*	-	Daszak et al. (2005); www.Bd-maps.net (accessed 25 May, 2016); Rothermel et al. (2008)
Texas	*H. cinerea*	-	Current study; Saenz et al. (2010)
Virginia	*H. cinerea*	-	Pullen et al. (2010)
Connecticut	*H. versicolor*	+	Richards-Hrdlicka et al. (2013)
Louisiana	*H. versicolor*	+	Rothermel et al. (2008)
Illinois	*H. versicolor*	+	Mulleman and Montgomery (2013)
Massachusetts	*H. versicolor*	-	Longcore et al. (2007)
Maine	*H. versicolor*	-	Longcore et al. (2007)
Minnesota	*H. versicolor*	-	Rodriguez et al. (2009)
Oklahoma	*H. versicolor*	-	Bd-maps.net (accessed 25 May, 2016)
Pennsylvania	*H. versicolor*	-	Glenney et al. (2010)
South Dakota	*H. versicolor*	-	Brown and Kerby (2013)
Tennessee	*H. versicolor*	-	Rollins et al. (2013)
Texas	*H. versicolor*	+/-	Current study; Saenz et al. (2010), respectively
Virginia	*H. versicolor*	-	Pullen et al. (2010)

Frog, and Hurter's Spadefoot (*Scaphiopus hurteri*) in the same region, and found 3% overall *Bd* occurrence and only cricket frogs were infected. To date, there have been no clinical signs of pathology from the disease nor mass mortalities recorded in any of the infected species in this region.

In this study, our goals were twofold. First, we assessed *Bd* occurrence in Green and Gray Treefrogs within a pond system in central Texas. Our study site overlaps an area where bufonids and cricket frogs previously tested positive for *Bd* (Gaertner et al. 2009, 2012; Villamizar-Gomez 2013). Therefore, it is important to assess other amphibians that inhabit the area in order to determine which other species might be affected by the pathogen. Second, we conducted a literature review for studies that tested for *Bd* in Green and Gray Treefrogs within the US to examine where the species distribution overlapped with positive and negative *Bd* detections and identify US states that have not been surveyed, to inform future studies of the influence of potential *Bd*-carrier species.

Our study was conducted in Bastrop County, Texas, at Griffith League Ranch owned by Boy Scouts of America (Fig. 1). The ranch lies within the Lost Pines Ecoregion, dominated by Loblolly Pine (*Pinus taeda*), Post Oak (*Quercus stellata*), Blackjack Oak (*Quercus marilandica*), and Eastern Red Cedar (*Juniperus virginiana*; Brown et al. 2011). Twelve amphibian species occur here, including the endangered Houston Toad (Brown et al. 2011). We surveyed ponds 1, 2, 5, and 9 from March to July 2014 and ponds 1, 5, and 13 from May to October 2015 (Fig. 1). Ponds 9 and 13 were within the burned area caused by the 2011 Bastrop wildfire. *Bd* was previously detected at two ponds in association with Blanchard's Cricket Frog (1 and 5; Gaertner et al. 2012).

As a part of an ongoing survey of Green and Gray Treefrogs, we opportunistically sampled the ponds during night surveys. In 2015, additional frogs were caught by traditional PVC pipes (Glorioso and Waddle 2014). All frogs were captured by hand; surveyors wore disposable vinyl gloves, changing them between captures. Adult frogs were individually marked by toe clips and tissue samples were placed in individual vials with 95% ethanol for future analyses. Toe clips were stored at -80°C and used for laboratory testing.

We extracted DNA using a DNeasy Qiagen Kit (Qiagen, USA) and the *Bd* detection was assessed using a real time Taqman qPCR assay (Boyle et al. 2004). The probe ChytrMGB2 was used with two species-specific primers ITS1-3 Chytr and 5.8S Chytr summarized in Boyle et al. (2004) and Garland et al. (2010). We ran each sample in triplicate and compared them to a regression line based on a consecutive 10-fold dilution of five standards to determine any positive detections.

For the literature review portion of this study, we used the Google Scholar search engine to identify any study that involved testing *Bd* in Green and Gray Treefrogs. Key words included broad terms such as "*Batrachochytrium dendrobatidis*" and "Anura," to more specific "Hyla" and "tree frogs." We also specifically reviewed the Amphibian Disease section of *Herpetological Review* in the last 15 years and searched www.*Bd*-Maps.net, an online database that includes geographic data of published and unpublished *Bd* assessments with the goal of providing an available resource for temporal and geographical epidemiologic analyses (Olson et al. 2013). To visually present the data we used ArcMap 10.2.2. We downloaded spatial data layers of species distribution available through International Union for Conservation of Nature (IUCN) and overlaid positive and negative *Bd* detections.

Across our five study ponds we collected 36 Green Treefrogs and 17 Gray Treefrogs in 2014, and 87 Green Treefrogs and 10 Gray Treefrogs in 2015 (Table 1). The majority of samples were collected during the highest activity months for Green Treefrogs, June and July (57 and 59, respectively). Zero of 123 Green Treefrog samples were *Bd*-positive. However, 4 of 27 Gray Treefrogs tested *Bd*-positive. *Bd* occurrence in Gray Treefrogs varied from zero to 22% among ponds, averaging 15% overall (Table 1). Positive samples were found in ponds 1, 2, and 5 (Fig. 1). Our literature review (Table 2) demonstrated that *Bd* was not detected in Green Treefrogs in any of the seven states that were sampled within that species' range (Fig. 2), but was detected in 4 of 12 states (Fig. 3; Connecticut, Louisiana, Illinois, and Texas [current study]) where Gray Treefrogs samples were analyzed.

Assessing *Bd* in common, widely distributed, and often traded species is important because such species can accelerate spread of the pathogen and pose a greater risk to more vulnerable species. In this study, we showed with a relatively large sample size (N = 123), that Green Treefrogs tested negative for *Bd*, which is consistent with previous studies. At the same localities, we were able to detect *Bd* in Gray Treefrogs with a much smaller sample size (N = 27). What is particularly intriguing is that the Houston Toad and Gulf Coast Toad in 2006, Blanchard's Cricket Frogs in 2009 and 2012, and Gray Treefrogs in 2014/2015 tested *Bd*-positive at the same localities where Green Treefrogs tested *Bd*-negative (Gaertner et al. 2009, 2010, 2012). Similarly, Brannelly et al. (2012) did not find infected Green Treefrogs among 258 samples collected from the wild in Louisiana but were able to infect Green Treefrogs in the laboratory, although they did not subsequently show any clinical signs of the disease.

Research has shown that seasonality, temperatures, and precipitation can have a great influence on *Bd* occurrence among Anurans (Retallick et al. 2004; Pullen et al. 2010; Sapsford et al. 2013; Xie et al. 2016). In general, prevalence is negatively associated with high air temperatures. For example, Kriger and Hero (2007) showed that individual frogs are capable of acquiring *Bd* and clearing their infections, which was closely tied to changes in climatic conditions. More relevant to our study, Gaertner et al. (2009) found no infection in the month of July. In our study, 116 of 150 (77%) samples were collected in June and July, usually the hottest months in central Texas. While those are the months when Green Treefrogs are most active, the high air temperatures could be responsible for no *Bd* detections in Green Treefrogs in our study, and testing Green Treefrogs during the predicted high-prevalence months in this region is of future interest. However, Brannelly et al. (2012) collected samples year-round and Saenz et al. (2010) collected samples from January through May and still failed to detect *Bd* in this species.

In comparison, the four *Bd*-positive detections in Gray Treefrogs were found in March (N = 2), May (N = 1), and June (N = 1), and a high occurrence of ~89% for these ponds in late spring was also found by Gaertner et al. (2009). The Gray Treefrog breeding season usually starts earlier in the year than the Green Treefrogs (Saenz et al. 2006) which would then correspond with lower air temperatures. It is also worth noting that the only ponds with no *Bd* infections were pond 9 and 13, the uplands of which catastrophically burned in a wildfire. Surveying these ponds for *Bd* throughout the year is warranted in order to address the hypothesis that the changes wrought by wildfire might be contributing to the lack of *Bd* occurrence. Since the *Bd* life cycle is closely tied to water, highly aquatic species might be the most vulnerable (Berger et al. 2005). Given that treefrogs spend the majority of the breeding season calling in the surrounding vegetation and not at the pond edge, this might provide less exposure to *Bd,* which could explain the generally low occurrence.

Overall, there is no apparent pattern in the *Bd* distribution across the Gray Treefrog geographic range (Fig. 3). Southern, central, and eastern regions detected positive individuals in recent years, but at the same time northern, eastern, and central regions also failed to detect *Bd*. Filling in these gaps and conducting research that increases the sampling effort will help understand not only the *Bd* distribution in these frogs but other factors that may influence the patterns in prevalence, such as seasonality, latitude/longitude, elevation, as well as biotic factors and prevalence in co-occurring species. With the fungus being potentially transmitted among populations inhabiting the same aquatic habitat, it is important to continue to address *Bd* prevalence in different taxa and across various geographic regions in order to identify both vector and susceptible species.

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No Occurrence of Ranaviruses in Reptiles from Wapanocca National Wildlife Refuge in Arkansas, USA

TABLE 1. Life history and morphological characteristics of sampled turtles (mass and length are averages).

Species	N	Sex	Mass (kg)	SE	Length (cm)	SE
Kinosternon subrubrum	1	F	1.00	NA	70.00	NA
Chrysemys picta	5	M	0.90	0.08	124.20	12.21
Trachemys scripta	25	F	0.97	0.09	109.76	3.50
	20	M	0.31	0.05	93.5	13.94
Pseudemys conccina	8	M	0.90	0.09	116.00	2.20
Apalone spinifera	1	F	1.30	NA	160.00	NA
	1	M	0.40	NA	85.00	NA

Ranaviruses have been identified in reptiles and amphibians across the United States, often leading to mass mortality events (Gray et al. 2009; Duffus et al. 2015), but in other cases causing persistent infections in the absence of die-offs (e.g., Johnson et al. 2008; Greer et al. 2009). While ranavirus infections have been documented in the Southeast, Midwest, and numerous areas across the United States (Allender et al. 2011; Gray et al. 2012; Goodman et al. 2013; Duffus et al. 2015), infections have not been detected in Arkansas.

Our goal was to determine the background prevalence of ranavirus in turtles in the Wapanocca National Wildlife Refuge (WNWR) in eastern Arkansas. We deployed five baited hoop nets (diameter 1 m, mesh 2.5 cm) on 10 October 2015 at a single site in WNWR (Fig. 1) and checked them the following day. Upon capture, we determined the species, sex, mass, and length of each individual, and checked for any clinical signs of ranavirus infection such as ocular discharge, dermatitis, or necrotic oral tissue (Allender et al. 2013). In order to assess ranavirus prevalence and species specificity, we collected a tail clip (~1.0 cm) from each turtle with a sterile razor blade, placed it in a snap-top tube (Fisherbrand®, Cat. # 02-681-272), immediately placed the tube on ice, and returned it to the lab within four hours of harvesting where it was stored at 4°C (Gray et al. 2012, Goodman et al. 2013). We used a new blade and gloves for each sample.

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To extract DNA from the tail clips, we used a DNeasy Blood and Tissue Kit (Qiagen Inc., Valencia, CA, USA) according to the manufacturer's protocols. After extraction, we used real time quantitative polymerase chain reaction (qPCR) to detect ranavirus DNA following protocols described previously by Whitfield et al. (2013). Briefly, we ran each sample in triplicate 20uL reactions for 40 cycles of 95°C (20 s), 54°C (20 s), and 72°C (30 s) using a StepOne Plus qPCR machine (Applied Biosystems). Each plate included gBlock standards as a positive control and water as negative controls.

We did not detect any clinical signs of ranavirus infections nor was ranavirus DNA detected in any of the 61 turtles captured, representing five species (Table 1). Assuming a perfect diagnostic test, the upper 95% CI for prevalence was 5.9% across all species. (Note that tail clips may have false negative rates of ~20% in bullfrog tadpoles, although tail clips are preferred over swabs; Gray et al. 2012; Goodman et al. 2013). Within *Trachemys scripta*, the most abundant species we captured and one that is known to be susceptible to ranavirus infection (Brenes et al. 2014), we are 95% confident that ranavirus prevalence was ≤7.9%. While the turtles at WNWR were likely not infected with ranavirus, we cannot rule out a low prevalence of infection, which has been found in other studies of turtles (e.g., Allender et al. 2011, 2013;

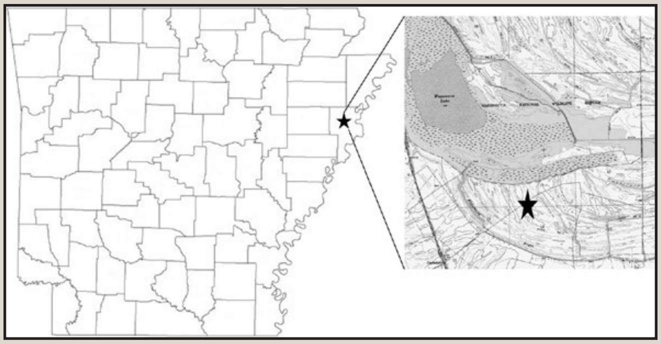

FIG 1. The location of the study site (star) in the Wapanocca National Wildlife Refuge (inset on the right) in the town of Turrell, Arkansas (map of counties on the left).

Goodman et a. 2013), nor extend these conclusions to other turtle populations within WNWR and the state of Arkansas. Future surveys must be conducted to determine if ranavirus is present in other parts of the state.

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Art in Herpetology

As space and available material permit, we will occasionally publish examples of historical as well as contemporary herpetological art. We welcome the submission of historical material under the following conditions:

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- Accompanying text should provide information on the subject matter, artist/illustrator, and publication source. Include references as needed to appropriately attribute information from other sources.

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- Artist will retain copyright of all submitted material.
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HERPETOCULTURE

Herpetological Review, 2016, 47(4), 608–611.

Reproduction of the South American Bushmaster, *Lachesis muta* (Serpentes: Viperidae), in Captivity

The genus *Lachesis* contains four species: *L. acrochorda, L. melanocephala, L. muta*, and *L. stenophrys*. The penultimate taxon is sometimes subdivided into *L. m. muta* and *L. m. rhombeata*, but recognition of these subspecies may be questionable (Vial and Porras-Jimenez 1967; Ripa 2001; Campbell and Lamar 2004; Fernandes et al. 2004). Species belonging to this genus, commonly known as bushmasters, are the largest venomous snakes in the Americas. They are found mostly in primary forest (Campbell and Lamar 2004), and are specialized and selective nocturnal predators, preferring small to medium-sized rodent prey (Greene and Santana 1983; Ripa 2000, 2001; Turner et al. 2008). Moreover, they are the only vipers in the New World that lay eggs instead of giving live birth (Vial and Porras-Jimenez 1967; Ripa 1994; Campbell and Lamar 2004).

Lachesis muta is probably the longest of all vipers, with adults commonly exceeding 300 cm in total length. This snake ranges in South America east of the Andes, and its elevational distribution ranges from sea level to about 1000 m elev. (Campbell and Lamar 2004), although Lancini (1986) reported that in Venezuela this species may range up to 1800 m elev. In the wild, the bushmaster`s diet is generally composed of small rodents such as the little brown rice rat (*Oryzomys* sp.) and spiny rats (*Proechimys* sp.) (Greene 1997; Campbell and Lamar 2004). Moreover, bushmasters employ a sit-and-wait hunting strategy, usually along small mammal pathways (Greene and Santana 1983; Ripa 1999; Campbell and Lamar 2004; Turner et al. 2008).

Regarding its reproduction, *L. muta* appears to be sexually stimulated by cold fronts and storms that trigger reproductive behavior rather than a specific period of fertility (Boyer et al. 1989; Souza 2007; Turner et al. 2008). This species has been reported guarding its eggs within subterranean cavities or burrows made by Pacas (*Agouti paca*) and armadillos (family Dasypodidae), leading to speculation that parental care throughout the entire incubation period in this species is an important response against predators and active mammal burrowers (Mole 1924; Ripa 1994; Souza 2007; Turner et al. 2008; Henao Duque and Corrales 2015).

There is a general scarcity of information available on the breeding of *Lachesis muta* in captivity (Boyer et al. 1989; Souza 2007; Eisele 2009; Alves et al. 2014), and various factors may be affecting successful captive reproduction in the species including stress, poor body condition (i.e., dehydration, emaciation), parasitism, and inappropriate housing, humidity levels and substrates (Turner et al. 2008). Here we report on the successful reproduction of *L. muta* in captivity, and discuss *in-situ* field observations that may be relevant to its captive breeding and management.

METHODS

This study was conducted on an adult sexual pair of 9-year-old captive-bred *L. muta* maintained separately indoors at The World of Snakes exhibit, breeding, and research center in Alajuela, Costa Rica. The male measured 217 cm in snout–vent length (SVL), 238 cm in total length (TL), and 4875 g, whereas the female measured 199 cm SVL, 214 cm TL, and 3920 g.

The enclosure used in this study was constructed with a metal frame which provided support for the asbestos sheeting material used for the floor and ceiling, a concrete rear wall, glass front, and galvanized dividers on the sides. The enclosure had multiple compartments, offering the ability to house the animals separately and in total measured 3.4 × 1.2 × 0.9 m (L × W × H). Two plastic shelters measuring 90 × 50 × 30 cm each provided refuge for the snakes, and several logs and rocks were provided to facilitate ecdysis; water was supplied ad libitum. A bottom layer of gravel allowed for drainage. Above the gravel was a thin layer of river sand and soil to help maintain the humidity in the terrarium; this layer was then covered by dry leaves to help with nesting. The gravel substrate provided a barrier to the moist underlying soil of the ground that may promote fungi, parasites and ventral skin infections in the snakes (Corrales et al. 2014).

A temperature gradient of 21–28°C was created inside the enclosure with a 75-W incandescent bulb that was turned on each morning for three hours as well as a heat-pad in one corner of the enclosure. The relative humidity inside the enclosure ranged from 55 to 96% depending on natural environmental fluctuations and the frequency of misting in the terrarium. Each snake was offered a dead 90-g rat each week.

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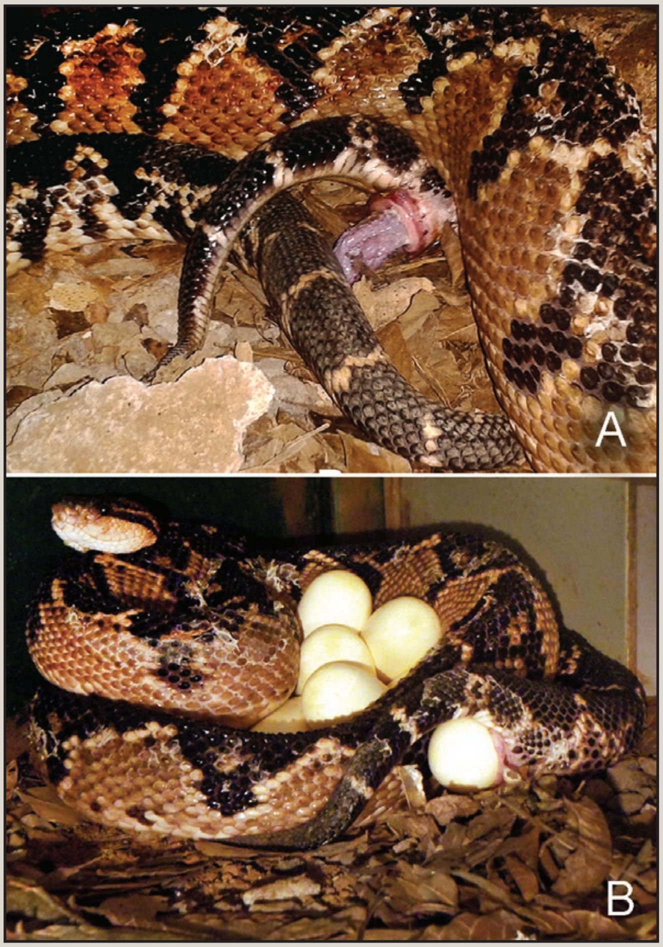

Fig. 1. Captive reproduction of the South American Bushmaster (*Lachesis muta*). A) Close-up of intromission. B) Oviposition, detailing nest construction and maternal care.

Fig. 2. Newly hatched *Lachesis muta* in captivity.

Fig. 3. *Lachesis muta* neonate (L.5; see Table 2) found in Municipio Caripe, Monagas State, Venezuela.

Results

The pair of *L. muta* reproduced four times between 2009 and 2014. The first oviposition occurred in 2009 when the adults were five-years-old, resulting in a clutch of 11 eggs. In 2010, the pair was bred again and produced a clutch of seven eggs. After a two year span without reproduction, the pair mated again in 2013 and 2014, yielding clutches of 10 and 8 eggs, respectively (Table 1). Reproductive and incubation data were collected only in 2013 due to changes in staffing.

In early November 2012, both animals were placed together following the simulation of a cold front in the enclosure, lowering the temperature by removing the heater and misting twice per week to raise the humidity. Although food was still offered weekly, the male did not accept food during this time, resuming feeding in February 2013; the female failed to eat on a consistent basis.

Over the first few weeks following these environmental changes, the male's activity increased, roaming about the enclosure with constant tongue flicking movements; the female remained inactive and coiled within the shelter.

On 23 November 2012, food was offered at around 1330 h but neither snake was interested; the male defensively struck the rat but did not consume it. One hour later (1430 h), the senior author found the pair copulating (Fig. 1A), and the male was seen rubbing its head on the posterior third of the female's outstretched body. After approximately 50 minutes of copulation, the female began crawling around the cage, seemingly in an effort to end copulation, and at 1548 h, they separated from each other. No further instances of copulation were observed. While gravid, the female did drink water, but did not show interest in food and remained relatively inactive until two weeks prior to oviposition, when she began searching for a suitable nest spot.

After 95 days of gestation, 10 eggs were deposited inside the shelter on 26 February 2013 (Fig. 1B). The shelter was removed and the eggs were collected and transferred to a glass incubation chamber measuring 45 × 60 × 45 cm. This chamber held 5 cm of water at the bottom and a featured a solid platform in the center for an elevated foam-covered tray on which the eggs were placed. A glass lid at a 45° inclination angle facilitated condensation buildup to drip to one end of the chamber, and a 30 × 5 cm air vent was located on the other side. A submersible aquarium heater inside the chamber and a heater inside the room helped maintain an appropriate range of conditions inside the chamber, with temperature varying between 26 and 30°C and relative humidity ranging from 77 to 88%.

TABLE 1. Captive reproduction data for *Lachesis muta* at The World of Snakes, Alajuela, Costa Rica.

Clutch	Oviposition date	Clutch size	Number hatched	Incubation (days)
1	5 May 2009	11	11	No data
2	7 May2010	7	6	No data
3	26 February 2013	10	6	75
4	15 March 2014	8	Unfertile eggs	No data

TABLE 2. Summary of *Lachesis muta* neonates collected in Municipio Caripe, Monagas State, Venezuela, from April 2011 to April 2013.

Neonate	Sex	Total length (cm)	Date	Microhabitat	Umbilical mark
L.1	1.0	79	26-02-2011	Dry log	Scar
L.2	0.1	43	19-03-2011	Dry leaves layer	Fresh with blood
L.3	0.1	54	12-06-2011	Clear understory	Present and clear
L.4	1.0	47	13-06-2011	Buttresses	Fresh with blood
L.5	0.1	40	01-02-2012	Rock formations	Fresh with blood
L.6	1.0	47	04-02-2012	Buttresses	Present and clear
L.7	1.0	49	15-08-2013	Rock formations	Present and clear
L.8	0.1	43	20-12-2013	Rock formations	Fresh with blood

On 12 May 2013, the eggs started to hatch, resulting in six live neonates that ranged in weight from 60 to 80 g, with an average of 74 ± 8 g (Fig. 2); length measurements were not recorded. The remaining four eggs proved to be infertile.

DISCUSSION

During each reproductive season, female *L. muta* in captivity may fast up to six months during courtship, gestation, and nest guarding, which can lead to a loss of approximately 30% of their overall body mass after oviposition (Ripa 1994; Ripa 1999). In 2011 and 2012, the female in the present study did not gain back weight that had been lost during the previous consecutive breeding years and failed to produce eggs. This lack of egg production may have been due to low levels of fat storage, or an insufficient amount of mature follicles to undergo reproduction (Rossi 2006).

A marked decrease in clutch size was observed over consecutive breeding years (2009–2010 and 2013–2014), and in 2014, all eggs proved to be infertile. Corrales et al. (2014) reported that clutch size in captive *L. stenophrys* also decreased over consecutive years of reproduction, and even though Eisele (2009) did not observe such a decrease over consecutive years in *L. muta*, it was determined that a non-reproductive year was appropriate after the two clutches. Taking this potential trend into account, it may be best to use multiple females in captive breeding programs and alternate the females every other year to potentially avoid declines in fecundity and egg viability.

Ripa (1994) reported a gestation period of 101 days in *L. melanocephala* and *L. stenophrys*, which is similar to the period reported here for *L. muta*. Eisele (2009) reported a mean clutch size of 15 eggs from two clutches of *L. muta* eggs and a gravid female weight of 5.4 kg; in the present study, mean clutch size was nine eggs from four clutches, and the gravid female had a weight of 3.92 kg in September 2013. Alves et al. (2014) reported an average clutch size of 5.83 eggs for *L. muta*, and did not observe a correlation between female SVL and clutch size.

Boyer et al. (1989) utilized an incubation temperature of 30–31°C for *L. muta* and reported an incubation period of 61 days. At cooler temperatures, Souza (2007) reported an incubation period of 74–79 days at 25°C, and Eisele (2009) reported incubation periods of 71 and 76 days for two clutches of *L. muta* eggs incubated at 25.5–27°C. The 75-day incubation period recorded in the present study is consistent with these latter two reports, but not that of Boyer et al. (1989), whose higher temperatures likely contributed to a shorter incubation period. Neonates in the present study were larger than those reported by Eisele (2009) which averaged 67.5 and 66.7 g from two clutches, and Boyer et al. (1989) which averaged 50 g.

Field data were opportunistically collected on a pair of wild *L. muta* (male: 2.54 m TL; female: 2.32 m TL) that were observed mating at a high elevation (up to 2100 m) by the tertiary author in Municipio Caripe of the Monagas State, Venezuela (10.20193°N, 63.36491°W) on 10 November 2012 (Flores, unpubl. data). Relatively low nighttime temperatures of 14–20°C and an absence of rain for two weeks were recorded prior to the observed mating. Eight hatchlings were also found in this area during various months between 2011 and 2013 (Table 2, Fig. 3). In contrast to Alves et al. (2014), who reported seasonality in the reproductive cycle of *L. muta* based on examination of preserved museum specimens, these field data might suggest a non-seasonal reproductive pattern where mating takes place throughout the year and is influenced by weather conditions (i.e., low temperatures), and hatching occurs during both the dry (December to May) and rainy (June to November) seasons (Sánchez 2000; Sánchez et al. 2004). From observations of captive specimens, it seems likely that cold fronts are a potential trigger for reproduction in this species (Boyer et al. 1989; Ripa 1994; Souza 2007; Turner et al. 2008; this study).

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HERPETOCULTURE NOTES

TESTUDINES — TURTLES

***CARRETOCHELYS INSCULPTA* (Fly River Turtle). CLEANING MUTUALISM.** Cleaning mutualism is a well-known symbiotic relationship frequently observed in the wild. This interaction involves a cleaner, a host, and often times may take place at a cleaning station. A cleaning event typically involves the cleaner species removing ectoparasites from a client species (Losey et al. 1994. Copeia. 1994:684–690). The cleaner may also feed on the skin of the host to remove mucus or diseased skin (Floeter et al. 2007. J. Anim. Ecol. 76[1]:105–111). Cleaner species often linger around an area known as the cleaning station, while clients approach such a place specifically to be cleaned. Cleaners may range from specialized fish to birds (Losey 1972. Copeia. 1972:820–833; Poulin and Grutter 1996. Bioscience. 46[7]:512–517). Meanwhile clients can include any species in need of ectoparasite removal, typically a species larger than the cleaner. Cleaning mutualisms occur among various species; however, most documented instances occur in marine environments (Floeter et al. 2007, *op. cit.*).

Carettochelys insculpta is an omnivorous turtle found in freshwater streams and rivers in the Northern Territory of Australia and the southern part of Papua New Guinea. They have a carapace covered with soft skin that lacks keratinized scutes. The carapace can range from olive to black in coloration and is counter shaded by a cream colored plastron. *Carettochelys insculpta* are fully aquatic and have four flipper-like limbs resembling the limbs of a sea turtle. They can also be identified by their long, snorkel-like snout (Cann 1998. Australian Freshwater Turtles. Beaumont Publishing, Singapore. 292 pp.)

A single male *C. insculpta* was observed over a period of four non-consecutive days in its enclosure at the Smithsonian National Zoo in Washington, District of Columbia, USA. The *C. insculpta* was housed with a *Pterygoplichthys gibbiceps* (Leopard Pleco) during the observations. *Carettochelys insculpta* and *P. gibbiceps* do not occur naturally together in the wild; *C. insculpta* is endemic to parts of Australia and New Guinea, while *P. gibbiceps* naturally occurs in South America. Nonetheless, a presumably symbiotic cleaning mutualism was regularly observed among these individuals.

The *C. insculpta* was often seen posing during a cleaning event (Fig. 1A). Posing is a behavior common to clients in cleaning mutualisms. During posing, the client species assumes a position in anticipation of a cleaning. This position is only assumed during a cleaning interaction (Losey 1972, *op.*

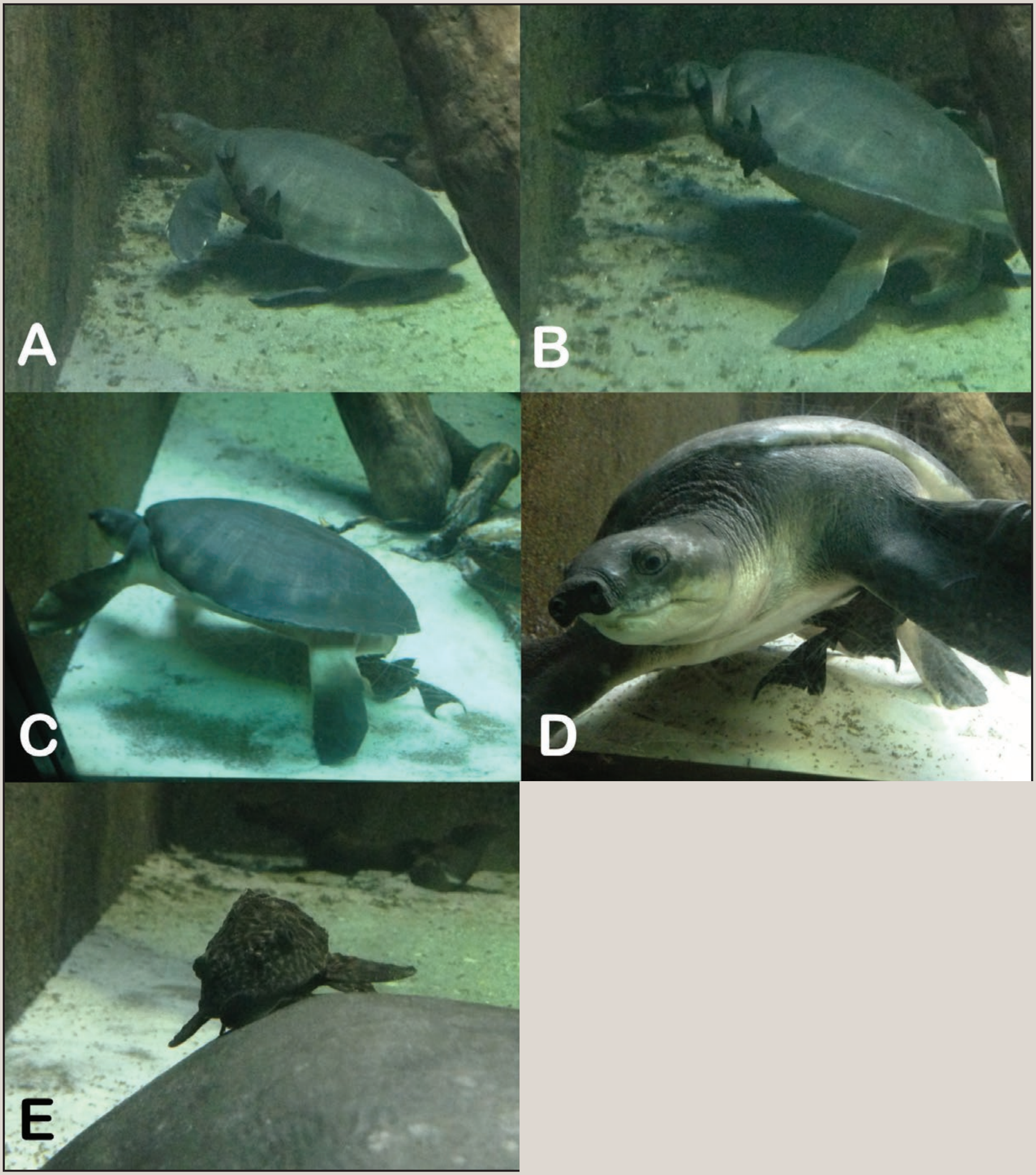

Fig. 1. A) The *Carettochelys insculpta* seen posing during a cleaning event. B) The *C. insculpta* is seen with limbs stretched out and head lifted upward. C & D) The *C. insculpta* can be observed lifting a portion of its plastron from the substrate as *Pterygoplichthys gibbiceps* moved in to clean the area exposed underneath. E) The *P. gibbiceps* was observed resting on the carapace of the turtle.

cit.). The *C. insculpta* was observed posing for the fish five times out of seven cleaning events. As seen in Fig. 1B, the limbs of the *C. insculpta* were stretched out and the head lifted upward, a pose that has been previously observed among clients. Similarly, clients often remain motionless during a cleaning event (Poulin and Grutter 1996, *op. cit.*), which was observed multiple times. Additionally, a possible cleaning station was identified in the enclosure. A single branch was frequented by both individuals a large percentage of the observation time. Cleaning events were often observed at this site, indicating that this branch may very well be a cleaning station in the enclosure. The use of this cleaning station was noted approximately seventy five times during the observations.

A majority of the cleanings were instigated by the *C. insculpta* by nudging the fish to indicate the desire for a cleaning. The *C. insculpta* was also observed shifting the direction of its body, moving limbs, or corralling the fish towards different parts of its body. When the turtle would shift positions or move its limbs this resulted in the fish cleaning those areas that were adjusted. In Fig. 1C and Fig. 1D, the turtle can be observed lifting a portion of its plastron from the substrate and *P. gibbiceps* having moved in to clean the area exposed underneath the turtle. The *P. gibbiceps* was observed cleaning the carapace, plastron, limbs, neck, chin, head, and around the cloaca during most cleaning events.

Interestingly, the *P. gibbiceps* was observed on several occasions simply resting on the turtle, either on a limb or the shell (Fig. 1E). This resting behavior was observed a total of ten times throughout the observational periods; both during a cleaning event and when no cleaning event was in progress. The reason for this behavior is unclear; this likely does not constitute cleaning behavior, but it is an interesting aspect of the possible symbiotic relationship between these individuals.

The observation period ended when the *P. gibbiceps* was found dead in the enclosure. It is unknown whether the *C. insculpta* decided to consume the *P. gibbiceps* or whether it died of another cause. It is well known that cheating clients exist in seemingly symbiotic relationships. A cheating client will take advantage of the cleaner by consuming it (Poulin and Grutter 1996, *op. cit.*). The *C. insculpta* was not observed killing the *P. gibbiceps*, however the turtle was observed consuming parts of the fish after it had died. The *P. gibbiceps* may have already died before consumption by the turtle. It is unclear what occurred.

It is necessary to speculate why this cleaning mutualism occurred since *C. insculpta* and *P. gibbiceps* do not live together in the wild. There are several species of fish that may fill the same niche as *P. gibbiceps* would that inhabit the Fly-Strickland river system in New Guinea where *C. insculpta* is found (Roberts 1978. Smithsonian Contrib. to Zoo. 281). However, there has not yet been a documented cleaning mutualism between fish and *C. inscuplta* in the wild.

An alternate or additional explanation for this cleaning mutualism is simply the desire of this *C. insculpta* to be cleaned. It is well known that *C. insculpta* is a host to ectoparasites found on its skin (Saumure and Doody 2000. Herpetol. Rev. 31[4]:237–238). It is possible that the turtle's need to be cleaned stems from this natural tendency to get rid of these ectoparasites. This may explain why the turtle initiated the majority of the cleaning events.

Because cleaning mutualisms have been known to occur among different species in captivity (Poulin and Grutter 1996, *op. cit.*), it is possible that a cleaning mutualism will also occur with another individual of *P. gibbiceps*. Further study will be needed to determine if the relationship observed between these two individuals is specific to them or if the same relationship will result with a different fish. In the future *P. gibbiceps* or another cleaner fish from within the same range of *C. insculpta* should be placed in the enclosure. The individuals should be observed in the same manner as above. Initial interactions and characteristics such as presence of a cleaning station and client posing should be noted in the observations.

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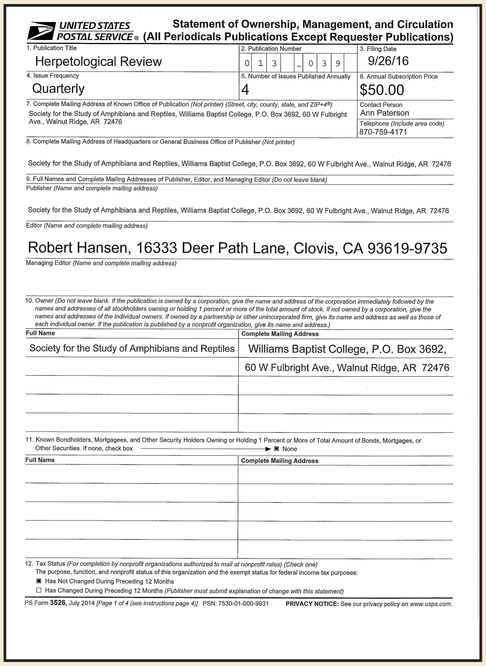

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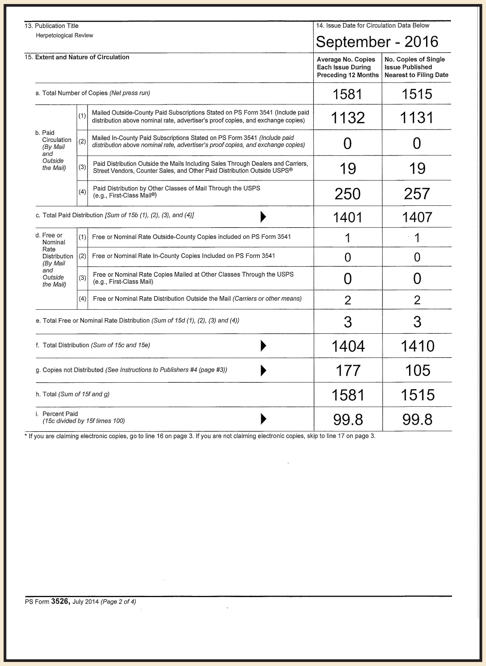

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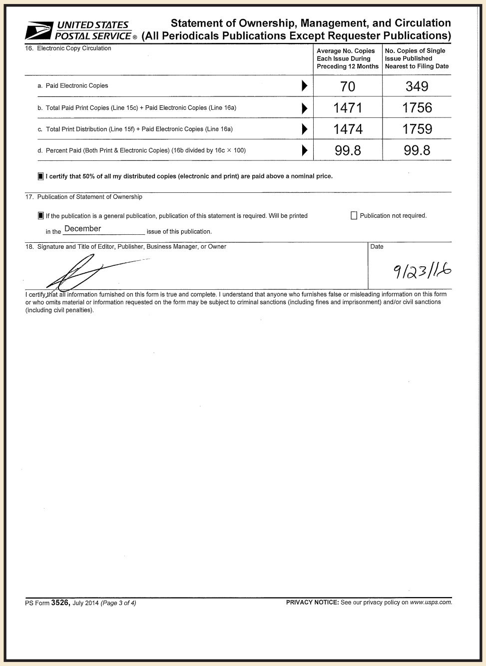

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CONSERVATION

Herpetological Review, 2016, 47(4), 614–617.

Restoring and Enhancing Eastern Hellbender (*Cryptobranchus alleganiensis*) Habitat through the Placement of Flagstone Cover Rocks

The Eastern Hellbender (*Cryptobranchus alleganiensis*) is recognized as a High Priority Species of Greatest Conservation Need by the New York State Department of Environmental Conservation (DEC) (NYSDEC 2015) due to declining population sizes in the only two watersheds where it occurs (Foster et al. 2009; NYSDEC 2015). In addition, Eastern Hellbenders have been listed as a Species of Special Concern in New York since 1983 and hellbenders are widely believed to be declining throughout much of their range (Nickerson and Mays 1973; Trauth et al. 1992; Wheeler et al. 2003; Briggler et al. 2007; NYSDEC 2015). In New York's Allegheny River Watershed (ARW), a 2004–2005 re-survey of previously studied sites indicated an average of 40% reduction of adult hellbenders over all of the sites surveyed during 1983–1985 and 1988 (Foster et al. 2009). In addition, hellbenders were no longer found within two previously inhabited sites. These surveys also showed that hellbender populations were largely comprised of older adult animals and that the lack of recruitment of juveniles to the adult stage may be a reason for the decline.

Degradation and loss of habitat are suspected as a cause of hellbender population declines that may affect juvenile survival and recruitment (NYSDEC 2015). Most stream substrates in the Allegheny River Watershed (ARW) in New York are developed from glacial outwash gravels or lacustrine silt and clay deposits (NYSDEC 2007 and NRCS 2016). Where large rocks are present, streambeds are eroding valley walls and depositing new, large, clean rocks into the system. However, armoring of stream and river shorelines as well as stream relocation has removed habitat and prevented erosion and natural deposition of rocks into streams at many locations. Streambeds with numerous large, flat rocks present in the substrate are uncommon and existing streambed rocks can become embedded over time by gravel and silt deposition.

To address hellbender population decline, two New York State agencies, the New York State Department of Transportation (DOT) and DEC began a joint project to restore and enhance hellbender habitat and its continuity in the Allegheny River Watershed in 2010. The project involved placing large, flat cover rocks, or "flagstone," at several selected sites throughout the ARW. This action complemented a hellbender captive-rearing and release effort started in 2009 by DEC and the Buffalo Zoo with the collection of hellbender eggs from the ARW. The sites where rocks were placed would be used as future release locations for a portion of the captive-reared hellbenders. Placed rocks would also be available to wild hellbenders in the ARW, especially if rocks were placed to enhance habitat at sites where wild hellbenders were present. We proposed that the placement of additional rocks would provide shelter for captive-reared and wild hellbenders and the number of hellbenders at rock placement sites would increase over time. We examined the effectiveness of this restoration effort by comparing the number of captures of hellbenders before and after supplemental rock

Fig. 1. Skid steer hauling flagstone cover rocks down to enhancement site where they were hand placed.

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FIG. 2: Recently placed flagstone cover rocks.

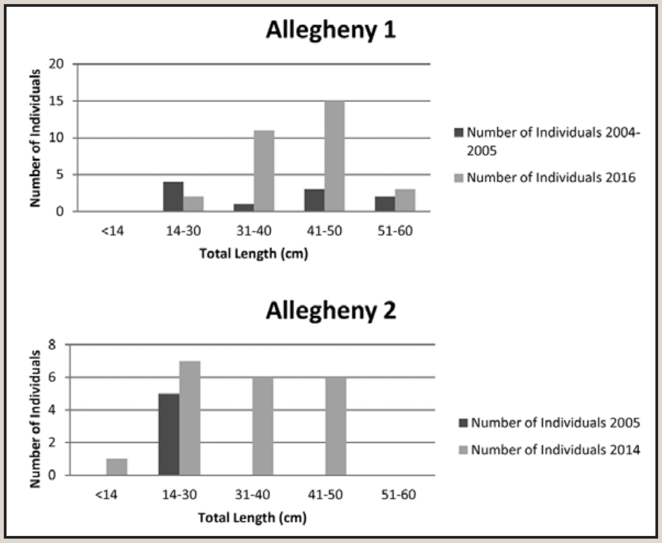

FIG. 3. Size class distribution for hellbenders captured at two surveyed sites before and after rock placement.

placement at two sites where hellbender surveys had been previously completed.

METHODS

Flat quarried flagstone rocks, with a minimum dimension of 51 cm × 51 cm and a thickness of 5–10 cm were placed at 12 sites within four hellbender-inhabited streams. Half of these rocks were greater than or equal to 91 × 91 cm. In total, 31 pallets of flagstone, or 62 tons, were placed.

Rocks were delivered to streams by a small skid steer loader with tracks to haul pallets to installation stations (Fig. 1). Rocks were then carefully unloaded and placed by hand. In a few instances, large rocks broke during transport and the smaller pieces were also placed in the streams. A depression to provide space for future hellbender use was first created in the streambed by kicking gravel and substrate aside before final positioning of each rock over the depression. Approximately 353 m^2 of flagstone was placed in the ARW. Rocks were placed in or as close to the thalweg (deepest part of channel, where water flow is fastest) as possible to reduce future embedding by sedimentation. Flagstone was installed in the summer and fall of 2010 through 2013 (Fig. 2).

Beginning with the collection of wild hellbender eggs in October 2009, Eastern Hellbenders were captive-reared from eggs at the Buffalo Zoo and several assisting zoos for later release throughout the ARW. All captive-raised hellbenders were implanted with a passive integrated transponder (PIT) (Gibbons and Andrews 2004), which identified individual hellbenders as well as made a distinction between wild-hatched and those that were raised in captivity from eggs. Rock-lifting surveys and capture techniques (Taber et.al 1975; Peterson 1987; Nickerson and Krysko 2003) were previously conducted in 2004 and 2005 to estimate hellbender numbers within the ARW (Foster et al. 2009). These surveys included two of our rock placement sites. We conducted rock-lifting surveys in 2014 and 2016 to measure hellbender use of these two sites after our rock placement treatment, using the same survey and capture methods as Foster et al. (2009). Demographic data (snout–vent length, total length, weight and sex) were collected from all individuals captured and each was implanted with a PIT tag.

For two survey sites (Allegheny 1 and Allegheny 2), a t-test for two independent samples with equal variance (Lowry 2016) was used to compare the total numbers of individual hellbenders captured pre-rock placement during three surveys in 2005, to the total number of individuals captured post-rock placement during three surveys in 2014 and 2016. The sites were paired based on surveys completed.

RESULTS

In total, 12 sites received placed rock and captive-reared hellbenders, but thorough rock-lifting surveys have not been completed at all of these sites. Lifting of placed rock during monitoring of captive-reared hellbenders revealed that they used these rocks for at least one year at four of the 12 enhanced rock sites. Wild hellbenders were observed under placed rocks at four enhanced rock sites. In addition to hellbenders, Mudpuppies (*Necturus maculosus*) and fish such as darters (Percidae) and minnows (Cyprinidae) were also frequently observed under placed rocks. We report here the results of thorough surveys we conducted at two sites where rock-lifting surveys had been done by Foster et al. (2009) prior to our rock placement. Post rock placement, Allegheny 1 contained 77 additional large cover rocks, ≥ 60 cm in diameter, within its 112-m length and Allegheny 2 contained 38 additional large cover rocks within 105 m of stream.

A total of 55 captive-reared hellbenders were released at the Allegheny 1 site and a total of 31 were released at the Allegheny 2 site in 2011, 2012, and 2013. However, no captive-reared hellbenders were encountered at these two sites during any of our post-rock placement surveys conducted in 2014 and 2016. Yet, wild hellbenders were found to occupy the sites with many being encountered under placed rock (Table 1). We observed an increase in the number of wild hellbenders captured at both of these sites during our surveys in 2014 and 2016 compared to the 2005 surveys. A t-test for two independent samples with equal variance shows a significant difference ($P \leq 0.05$), where $P = 0.05$ for comparison of number of hellbenders captured before and after rock placement.

We used total length measurements to provide a measure of size class distribution of hellbenders captured during our 2014 and 2016 surveys (Foster et al. 2009). We compared size class distributions observed at both sites during pre- (2004, 2005) and post-rock placement (2014, 2016) surveys (Fig. 3). We observed

Table 1. Number of wild hellbenders caught during rock lifting surveys at two Allegheny River watershed sites pre-rock and post-rock placement.

Rock placement site	Survey # (year) survey	# of individuals caught pre-placement	Year rock placement	# of individuals caught post-placement
Allegheny 1	1 (2004)	2	2010, 2011	
Allegheny 1	2 (2005)	5		
Allegheny 1	3 (2005)	5*		
Allegheny 1	4 (2016)			31*
Allegheny 2	1 (2004)	0	2010, 2013	
Allegheny 2	2 (2004)	0		
Allegheny 2	3 (2005)	0*		
Allegheny 2	4 (2005)	5*		
Allegheny 2	5 (2014)			13*
Allegheny2	6 (2014)			10*

*Indicated data used in t-test for two independent samples with equal variance analysis.

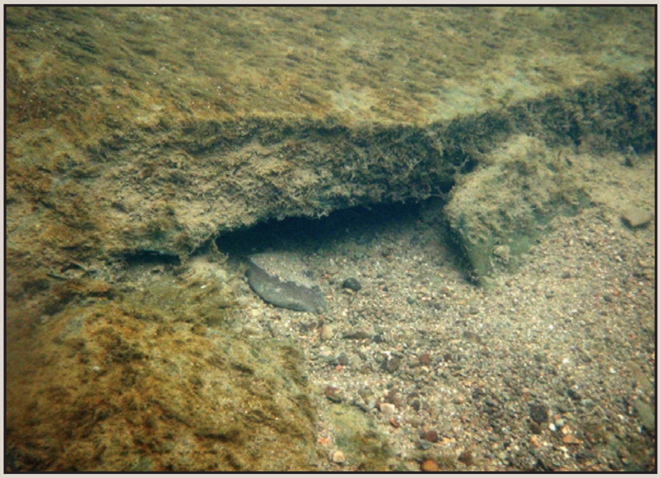

Fig. 4. Underwater entrance to active hellbender nest established beneath imported flagstone cover rock.

several size classes during our surveys including larvae and many young individuals. During 2014 rock-lifting surveys, one hellbender nest was found under a rock placed in 2011 (Fig. 4).

Discussion

Placed flagstone rocks provide suitable habitat for both captive-reared and wild-born hellbenders. We recognized, however, that placed rocks needed to remain physically available for use by hellbenders. We observed some burial of placed rock; especially if it was located at the inside bend of stream sites, where some placed rocks were buried by newly deposited sediment. We relocated some of the nearly buried rock into the thalweg of the stream and this alleviated the problem. We also observed that many of the depressions we had created under newly placed rock filled in with fine silt if they were not occupied by a hellbender, but when hellbenders were using the man-made depressions they were relatively clear of silt.

Captive-reared hellbenders were observed using the placed flagstone after release and have become established at four enhanced and previously unoccupied sites. We were disappointed by the unexpectedly low success rate of captive-reared hellbenders establishing at only four of 12 rock placement sites. However, a subsequent monitoring study of caged hellbenders at the Allegheny 2 site revealed that all captive-reared and caged hellbenders (N = 5) placed there died within several weeks. Pre- and post-mortem examination of these individuals revealed evidence of chytridiomychosis from infection with *Batrachochytrium dendrobatidis* (*Bd*) (NYSDEC 2014). We believe that at both the Allegheny 1 and Allegheny 2 sites, our captive-reared hellbenders failed to establish because of their susceptibility to *Bd* and subsequent mortality, and not because of deficient habitat quality of the placed rocks.

Although the rock placement effort targeted release sites for captive-reared hellbenders, resident wild hellbenders used the placed flagstones to a greater extent. Our data show a significant increase in the number of wild hellbenders at each of the two sites after rock placement. We believe this represents an increase in hellbender numbers in these locations due to recruitment and/or migration and not due to any change in survey method or detection bias. Our search methods were the same as those used in the 2005 surveys and all surveys, including those in 2005, were completed during periods of low stream flows, which maximize detection of hellbenders.

Additionally, careful examination of the size class information from pre- and post-rock placement surveys (Fig. 3) suggests that some of the larger hellbenders are migrants from other sites. During the 2016 survey of the Allegheny 1 site, we did not capture any hellbenders of the larger size classes (> 30 cm) pit-tagged by Foster et al. (2009) in their 2004 and 2005 surveys. Tag loss could account for non-detection of previously tagged hellbenders but should be negligible. Tag retention in our captive-reared hellbenders (N = 421) observed during periods ranging from 71 days to 3.5 years prior to release has been 99.3%. We did, however, capture 29 untagged hellbenders in three size classes > 30 cm in total length. This is 25 more than the four juveniles (< 30 cm) Foster et al. (2009) encountered and did not tag. We believe that at least some of these additional larger hellbenders are migrants. It is unlikely that larval or small juvenile hellbenders could have reached the two largest size classes (> 40 cm) in the

11-year interval between surveys due to described slower growth rates for hellbenders approaching these larger size classes (Taber et al. 1975; Peterson et al. 1988; Horchler 2010).

At the Allegheny 2 site, we captured 12 hellbenders in two size classes > 30 cm in total length. This is 7 more than the 5 juveniles captured by Foster et al. (2009) and could have been present as mature individuals during the 2016 survey. Here, also, we do not believe that onsite reproduction produced the hellbenders we observed in at least the largest size class during the nine-year interval between surveys.

Both the Allegheny 1 and Allegheny 2 sites are located downstream of additional known hellbender population sites, 0.92 km and 2 km (measured along the stream course), respectively, which could have provided a source of migrant hellbenders. We believe that the placement of cover rocks at these two sites facilitated the establishment of migrating hellbenders. Prior to our rock placement treatments the substrate at these sites was mostly gravel with occasional flat cover rocks ranging in diameter from 30 to 60 cm, but with few (29 at Allegheny 1 and 16 at Allegheny 2) large cover rocks 60 cm or larger in diameter. Post rock placement, Allegheny 1 contained 106 total large cover rocks and Allegheny 2 contained 54. This represents an increase of just over three times as many cover rocks available for resident and migrating hellbenders.

We interpret the increase in numbers of hellbenders using rocks at our study sites as a true measure of population growth at these sites and not the result of improved ease of hellbender detection during surveys. The study sites lacked inaccessible areas such as deep pools, bank holes, or dense submergent vegetation where hellbenders could potentially avoid detection during surveys. Robin Foster (pers. comm.) indicated she did not feel she missed detecting hellbenders there during the 2004 and 2005 surveys. We have also seen an increase in hellbender populations at placed rock sites that did not previously support hellbenders. At a different rock placement site not part of this study, ten wild hellbenders < 30 cm were recently captured. Pre-rock placement, this site did not have suitable cover habitat for hellbenders.

In conclusion, placement of flagstone rocks is an effective tool for enhancing hellbender habitat where suitable cover rocks are scarce or absent. Adding suitable rocks can create, restore, and enhance habitat, improve habitat continuity, provide nest sites to facilitate future recruitment, and increase the local distribution of hellbenders. Additionally, placed rocks provided habitat for Mudpuppies and fish such as darters and minnows. Placing flagstone rocks for habitat enhancement was shown to increase hellbender populations at the locations in this study.

Acknowledgments.—We thank the following individuals and institutions. Buffalo Zoo: Gerald Aquilina, Penelope Felski, Kurt Volle; Buffalo State College: Amy McMillan, Robin Foster; Region 9 DEC Wildlife Staff: Greg Ecker, Gary Klock, Michael Koch, Joline Bruckman, Peter Iacono, Mark Kandel; Region 5 NYSDOT Staff: David Tackley Jr., Michael Thompson, Bill Moll, Heather Horth, Sylvia Jones, Kimberly Lorenz, and Shelah LaDuc. Funding for the captive-reared headstarted hellbenders and part of the purchased flagstone was provided by a State Wildlife Grant to New York from the U.S. Fish & Wildlife Service.

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HERPETOLOGICAL HISTORY

Herpetological Review, 2016, 47(4), 618–620.

Right Snake, Wrong Lake: Louis Agassiz's 1848 Eastern Massasauga (*Sistrurus catenatus*) Specimen

In 2009 during a visit to Cornell University's Archives, Kraig Adler showed me a reference to Louis Agassiz collecting a rattlesnake specimen in 1848 while on an expedition to the Lake Superior region in the Upper Midwest of the U.S. Later, I became aware of the collecting location error transmitted through the scientific literature for 166 years. A discussion follows detailing how the locational error probably occurred and how Agassiz's voucher specimen (MCZ R-388) has now been validated against his description in the 1850 report, therefore allowing for a corrected collection location.

Expedition

Swiss-born Louis Agassiz came to the United States from Europe in 1846 and accepted a professorship at Harvard University where he taught until his death in 1873. The Museum of Comparative Zoology (MCZ), which he promoted, was established in 1859.

Two years after being at Harvard, he mounted an expedition to Lake Superior from 15 June to the end of August, 1848. The results of this trip were subsequently published (Agassiz 1850). On the northbound leg of the trip, Agassiz collected an Eastern Massasauga (*Sistrurus catenatus*) on 22 June 1848 and made a two-page detailed description accompanied with a lithographed illustration of the specimen done by Antonine Sonrel (Fig. 1). Agassiz (1850:382) stated: "The specimen was caught on the southern extremity of Lake Huron." Agassiz (1850:22) reported: "June 22. We entered Lake Huron about breakfast time. . . Land in sight on the left all day, except in crossing Saginaw Bay. On entering Lake Huron, we began to feel that we were getting into another region. Canoes of Indians about; the weather cool morning and evening, and the vegetation northerly, the pine family having a decided preponderance in the landscape."

Most Likely Collecting Scenario

The most likely scenario involving the collecting event was that the ship anchored offshore and the party canoed into the beach. There they made a fire and had breakfast. This new landscape of conifers gave the party a chance to whet their scientific curiosity. At some point they encountered the massasauga probably at the edge of the treeline and swales.

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Reports of Massasaugas in St. Clair County

Agassiz's location as the "southern extremity of Lake Huron" places it in St. Clair County, Michigan, north of Port Huron. For this county there are two historical references from newspapers: 1) *Kalamazoo Daily Telegraph* June 16, 1886: "A massasauga was one of the recent sights on Main street, Marine City." 2) *Jackson Citizen Patriot* Aug 12, 1896: "Mrs. Stephen Hart, of Berville [Berlin Twp], was bitten by a rattlesnake while hunting eggs. She is not expected to live."

Massasauga Habitat in St. Clair County

Albert and Comer (2008) show pre-settlement wetlands along the Lake Huron shore north of present-day Port Huron. Two areas of cedar swamp can be seen with an area of tamarack swamp. The former cedar swamp areas are currently shown by low depressions behind the shoreline beach ridges along with several drains (US Geological Lakeport Sheet 1961). These wetlands were massasauga habitat.

No Rattlesnakes in Michigan's Upper Peninsula Proper

In 25 years of compiling a dataset on the historical occurrences of the Eastern Massasauga in the Great Lakes area and in the Midwest, I have found no reports or evidence of the snake's presence from newspapers, county and township histories, element occurrence reports, and institutional voucher specimens. Likewise, there is no discussion of the snake's presence in the Upper Peninsula proper in the scientific literature and in popular field guides for amphibians and reptiles.

Mackinac County is considered part of the Upper Peninsula and has massasauga records, although none in the Upper Peninsula north of the Straits of Mackinac. The county's massasauga records are from Bois Blanc Island, south of the straits and offshore from the Lower Peninsula's Cheboygan County. The Ironwood newspaper from the Upper Peninsula has historically reported rattlesnake occurrences but all of those reports are for Michigan's Lower Peninsula. If there had been rattlesnakes in the Upper Peninsula, the lumberjacks, miners, railroad crews, conservation crews, fisheries biologists, botanists, hikers, and campers would have encountered them at some point and these observations would have been documented.

General Location

Agassiz (1850: 380, 382) reported on frogs "caught in various localities along the northern shores of Lake Superior," and snakes and frogs "occurring about Lake Superior." The terms "northern shores" and "about" are general locality descriptions whereas "southern extremity" is more restricted.

Restricted Location

Agassiz referred to the "southern extremity of Lake Huron." In Merriam-Webster's Collegiate Dictionary 11th ed. (Mish et al. 2008) the first definition of "extremity" is "the farthest or most remote part, section, or point (the island's westernmost)." Therefore, the "southern extremity" of Lake Huron would be in St. Clair County. Because it is not known precisely where they landed in St. Clair County, a reasonable georeference point on the Lake Huron shore would be at the midpoint between the very southern edge of the lake, just north of the Bluewater Bridge at Port Huron and the northern boundary of St. Clair County. This would be near Lakeport at 43.083597°N, 82.469508°W (NAD 83; 179 m elev.), ca. 10 km (6.2 mi.) north of Port Huron.

Chain of Confusion Listing Lake Superior as Collecting Location

The Museum of Comparative Zoology online catalog shows an image of page 16 of the original accession ledger with specimen R-388: "*Crotalophorus tergeminus*, Holbr., collected by Prof. L. Agassiz with the locality of Lake Superior." The problem starts here, for Agassiz collected only one massasauga specimen and there is only one specimen in the accession ledger with the location as "Lake Superior," and the collector as "Prof. L. Agassiz."

Agassiz's report (1850) contains several references to Lake Superior which may have confused readers: 1) the report title "Lake Superior Its Physical Character, Vegetation, and Animals...;" 2) the content listing on p. ix for Chapter VII is titled, "Description of Some New Species of Reptiles From the Region of Lake Superior," and this title also appears at the top of p. 378, the beginning of Chapter VII; 3) the top of each verso-facing page reads "Lake Superior;" 4) the top of each recto-facing page from pp. 379–382 reads "Reptiles of Lake Superior;" 5) at the top of pages where Agassiz describes the specimen caught "on the southern extremity of Lake Huron," p. 381 reads "Reptiles of Lake Superior," and p. 382 reads "Lake Superior." Given all these references to Lake Superior, the person filling out the entry on p. 16 of the accession ledger may not have noticed the sentence on line eight of p. 382: "The specimen was caught on the southern extremity of Lake Huron."

The following is a chronological listing of the misleading citations from the herpetological literature.

1) Baird and Girard (1853:14) "*Crotalophorus*. . . AGASS. Lake Sup. 1850."

2) Garman (1883:176) "*Crotalophorus* sp. Agassiz, 1850, Lake Superior."

3) Stejneger (1895:412) "1850 *Crotaphorus*, sp., AGASSIZ, Lake Superior."

4) Cope (1900:1144) "*Crotalophorus tergeminus*...AGASSIZ, Lake Superior, 1850." Cope then lists the erroneous Lake

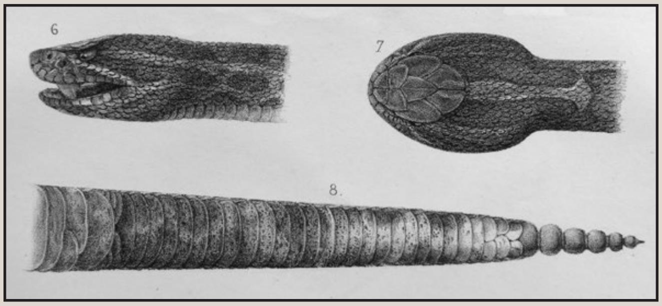

Fig. 1. Plate VI, Agassiz (1850) Lithograph by Antoine Sonrel.

Fig. 2. MCZ R-388 Ventral view showing three divided posterior sub-caudal scales and rattle segments.

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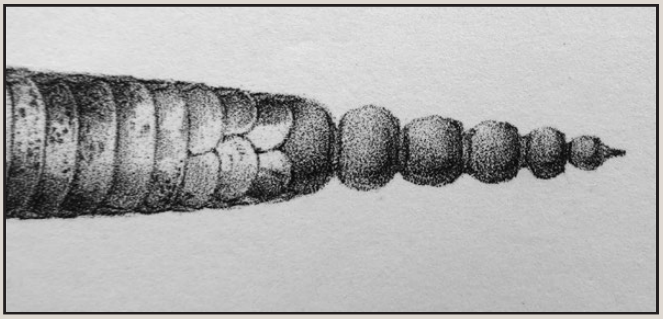

Fig. 3. Plate 6 (Agassiz 1850) Lithograph ventral view showing three divided posterior sub-caudal scales and rattle segments.

Fig. 4. MCZ R-388 showing dorsal surface.

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Superior location again on p. 1146 under *Sistrurus catenatus catenatus* Rafinesque as: "*Crotalophorus* AGASSIZ, Lake Superior, p. 176." Clearly this is in error given that p. 176 contains a listing of botanical species. Cope must have confused this with p. 176 in Garman (1883).

5) Gloyd (1940:45) "1850 *Crotophorus* sp. AGASSIZ, Lake Superior." Later, under locality records, Gloyd (1940:51) makes a contradictory statement by lumping Lake Superior and Lake Huron: "No definite locality: 'Lake Superior' [southern extremity of Lake Huron] MCZ 5468." Gloyd cites MCZ 5468 as a referred specimen but the MCZ accession logbook lists only the general locality of "Northern Michigan" and there is no mention of "Lake Superior." Currently, MCZ R-5468 is listed on the MCZ database as *Sistrurus catenatus catenatus* and the location as "Northern Michigan" with a georeference from Berkeley Mapper making a centroidal dot in the middle of the Upper Peninsula.

Although Ruthven et al. (1928:129) cited Baird and Girard (1853: Grosse Isle), Cope (New Buffalo: 1900), and Stejneger (1895: the state) for Michigan occurrence, they did not include the above referenced "Agassiz" and "Lake Superior" citations. The absence of these citations from Ruthven's definitive treatment of Michigan's herpetofauna is puzzling. Yet, Ruthven et al. (1928:129) placed a centroidal closed circle in the Upper Peninsula proper for Mackinac County to indicate the occurrence of *Sistrurus catenatus*. Apparently, that circle was intended for Creaser's (1928:369) Bois Blanc island specimen,which, although technically in Mackinac County, was on an island offshore from nearby Cheboygan County in the lower peninsula. Thus, a general readership, unaware of the Creaser specimen and viewing the map, would conclude that rattlesnakes were present in the Upper Peninsula proper.

There is only one specimen listed in the MCZ accession logbook from "Lake Superior," and collected by "Prof. L. Agassiz." Therefore, MCZ R-388 is the strongest candidate to match the specimen described by Agassiz. If this specimen was indeed the one Agassiz collected and described in detail and accompanied by a lithograh (Fig. 1), then the location would have been St. Clair County, Michigan ("southern extremity of Lake Huron"), with a collection date of 22 June 1848.

Morphological Analysis of Harvard's MCZ R-388 Specimen

Gregory Schneider and I examined MCZ R-388, and determined that this specimen was indeed a complete match for the snake described in detail by Agassiz. We based this on the following: rattle segments (five rattles, no button) (Figs. 2, 3), 30 dorsal blotches, five tail bands (Fig. 4), 28 sub-caudal scales (three of which were bilobed) (Figs. 2, 3), 132 ventrals (vs. 130 reported by Agassiz), head length 1 1/4 in., tail length 3 5/8 in., the "overall" 26 in. (snout–vent) length. Independent of Agassiz's description, sex was determined by a previous tail dissection to be a male 2–3 years old based on the complete rattle string of five segments. Thus, the specimen was determined to be the one described in Agassiz's report, and from the location stated: "southern extremity of Lake Huron" placing it in St. Clair County.

Based on a dataset of 1036 institutional voucher specimens and 100 other specimens (private collections and donations to high schools), MCZ R-388 is the oldest Eastern Massasauga museum specimen from Michigan and the third oldest from east of the Mississippi river.

This is a new county record for St. Clair County and extends the range of the Eastern Massasauga in Michigan from the present record in Macomb Co. (UMMZ 125427: 42.776860°N, 83.067410°W), 36.45 miles to the east.

Acknowledgments.—I thank José Rosado (Museum of Comparative Zoology) for specimen loan, Gregory Schneider (University of Michigan Museum of Zoology) for assistance in the morphological analysis of the specimen, and Kraig Adler for bringing Louis Agassiz's 1850 report to my attention. All original photography is © President and Fellows of Harvard College.

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GEOGRAPHIC DISTRIBUTION

CAUDATA — SALAMANDERS

***NOTOPHTHALMUS VIRIDESCENS* (Eastern Newt).** USA: WISCONSIN: Marathon Co.: Plover River Woods State Natural Area, Town of Plover; T29N, R10E, S22 (44.97329°N, 89.27814°W; WGS 84). 15 May 2016. N. G. Schiltz and J. M. Lorch. Verified by Josh Kapfer and Erik Wild. Milwaukee Public Museum (MPM VZP844a, b; photo voucher). New county record. Fills the gap in the known range of this species in Wisconsin (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.; Casper 1997. Herpetol. Rev. 28:214–216; Casper 1999. Herpetol. Rev. 30:181–182). Specimen was found within a rotting log on the southside of the river. One additional eft was found at the site (not photographed). Surrounding habitat was primarily northern mesic forest with rich soils (associated plant species observed include *Dicentra* sp. and *Podophyllum* sp.) with an adjacent White Cedar (*Thuja occidentalis*) stand along stream.

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***PLETHODON CINEREUS* (Eastern Red-backed Salamander).** USA: WISCONSIN: Pepin Co.: Maiden Rock Bluff State Natural Area; E of Hwy 35, ca. 1.6 mi N of jct with County Road J (44.49847°N, 92.28464°W; WGS 84). 3 May 2016. Erik R. Wild. Verified by Joshua M. Kapfer. Milwaukee Public Museum (MPM VZP 849a, 849b; photo voucher). New county record extending known distribution westward deep into the driftless area to ca. 100 m from the Mississippi River (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.).

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***PLETHODON GLUTINOSUS* (Northern Slimy Salamander).** USA: OHIO: Delaware Co.: 360 m W of Harlem Rd in Galena, Ohio; 9.0 km NE of Westerville, Ohio (40.17841°N, 82.84786°W; WGS 84). 24 May 2016. William E. Peterman. Verified by Christopher A. Phillips. Illinois Natural History Survey (INHS 23830). The observed individual was a mature female with ova visible, found under a 50 cm x 60 cm rock at the base of a steep, rock-covered, south-facing slope, ca. 9 m from a stream. A photo was taken and has been accessioned with INHS (INHS 2016e). This was confirmed as a new county record based on township-level distribution records reported by Pfingsten (2013. *In* Pfingsten et al. [eds.], Amphibians of Ohio, pp. 369–377. Ohio Biological Survey, Columbus, Ohio). This observation occurred during research activities approved under Ohio Scientific Collector's Permit 19-077 issued to WEP.

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***PLETHODON GLUTINOSUS* (Northern Slimy Salamander).** USA: OHIO: Franklin Co.: Blendon Woods Metro Park: (40.07421°N, 82.87534°W; WGS 84). 23 May 2016. William E. Peterman and Andrew Wilk. Verified by Christopher A. Phillips. Illinois Natural History Survey (INHS 23830). The observed individual was a mature male with a prominent mental glad, found under a 30 cm x 30 cm rock midway up a north-facing slope, ca. 15 meters from a stream. A photo was taken and has been accessioned with INHS (INHS 2016d). This was confirmed as a new county record based on township-level distribution records reported by Pfingsten (2013. *In* Pfingsten et al. [eds.], Amphibians of Ohio, pp. 369–377. Ohio Biological Survey, Columbus, Ohio). This observation occurred during research activities approved under Ohio Scientific Collector's Permit 19-077 issued to William E. Peterman.

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***PSEUDOTRITON RUBER* (Red Salamander).** USA: PENNSYLVANIA: Sullivan Co.: East Branch Fishing Creek, Pennsylvania State Game Lands Number 13, 1.5 km NE Jamison City (41.315072°N, 76.34761°W; WGS 84). 11 September 2016. Sean M. Hartzell. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178634; photo voucher). Updates the sole previous historic record for *Pseudotriton ruber* in Sullivan County (CM 37923) by 55 years. The collection location of CM 37923, collected in 1961 at "Beaver Lake" cannot be located on maps (McCoy 1982. Amphibians and Reptiles in Pennsylvania: Checklist, Bibliography, and Atlas of Distribution. Carnegie Mus. Nat. Hist. Spec. Publ. 6:1–91). As a result, no record was plotted for *P. ruber* in Sullivan County within published atlases on the distribution of amphibians and reptiles in Pennsylvania (e.g., McCoy 1982, *op. cit.*; Hulse et al. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York. 419 pp.). Thus, in addition to updating the historic record, this note provides this first record for *P. ruber* in Sullivan County with complete locality information. This species is known from adjacent Columbia, Lycoming, and Wyoming counties (Hulse et al. 2001, *op. cit.*). Young adult collected, photographed, and released along the bank of a headwater stream under a Pennsylvania Fish and Boat Commission license (051-252-328).

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***TRITURUS KARELINII* (Southern Crested Newt).** IRAN: GOLESTAN PROVINCE: Ramian County: Sefid Cheshmeh Village (36.993083°N, 55.062138°E), 119 m elev. 8 April 2016. M. Nekuea and P. Beyhaghi. Verified by H. G. Kami. Zoological Museum of Golestan University (ZMGU 3547). This is the easternmost record for this species. An adult was collected at 0500 h in a small pond filled with spring water that was located between orchards and a forest. A larva was found at 1230 h at 1-m depth in the pond among aquatic plants. Some sympatric species of amphibians and reptiles include *Bufo eichwaldi*, *Hyla orientalis*, *Pelophylax ridibundus*, *Rana pseudodalmatina*, *Darevskia kamii*, *Mauremys caspica*, and *Natrix tessellata*. The nearest reported locality for *T. karelinii* is 60 km SW from the locality reported here (Kami 1997. Zool. Middle East 15:37–40).

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ANURA — FROGS

***ANAXYRUS FOWLERI* (Fowler's Toad)**. USA: PENNSYLVANIA: Clinton Co.: Lamar (41.002534°N, 77.534857°W; WGS 84). 4 June 2016. Sean M. Hartzell and Cody R. Pavlick. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 177967; photo voucher). Updates previous records from Clinton County by 108 years (Carnegie Museum of Natural History [CM] 2095, 2148) and represents a range extension within central Pennsylvania by ca. 16 km SW from these historic records (Hulse et al. 200l. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York. 419 pp.).

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***ANAXYRUS FOWLERI* (Fowler's Toad)**. USA: PENNSLYVANIA: Columbia Co.: Lime Ridge, along the North Branch of the Susquehanna River (41.028371°N, 76.330722°W; WGS 84). 21 June 2016. S. Hartzell. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178567; photo voucher). First vouchered county record (Hulse et al. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York. 419 pp.; Hartzell 2016. J. Pennsylvania Acad. Sci. 90:7–12).

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***DENDROBATES AURATUS* (Green-and-black Poison Dart Frog)**. NICARAGUA: REGIÓN AUTÓNOMA DEL CARIBE SUR: Reserva Natural Punta Gorda in Reserva Sureste, 7 km SW from the community of Punta Roc (11.367339°N, 83.917631°W; WGS 84), 12 m elev. 7 February 2011. Christopher A. Jordan. Verified by James Harding. La Universidad Centroamericana (UNAN 782; photo voucher). First record from Departamento de Región Autónoma del Caribe Sur and northernmost record for this species in Central America, representing a 45-km range extension north from the closest previously known locality at San Miguelito, Departamento de Río San Juan (Savage 1968. Copeia 1968:745–776). The frog was found in a seasonally flooded *Raphia taedigera* swamp.

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ELACHISTOCLEIS MAGNUS. BRAZIL: RONDÔNIA: Porto Velho: open rain forest along bank of the upper Madeira River, ca. 150 km southwest of the city of Porto Velho (9.725576°S, 64.917121°W; SAD 69), 132 m elev. 28 September 2014. Nilton B. dos Santos. Verified by Pedro L. V. Peloso. Coleção de Referência da Herpetofauna do Estado de Rondônia, Município de Porto Velho, Estado de Rondônia (UFRO HEP 3526). *Elachistocleis magnus* is an endemic species from Brazil, being reported from the states of Pará, Mato Grosso and Rondônia (Strüssmann et al. 2012. Check List 8:317–320). This is the first record of this species from the upper Madeira River and extends the range of the species in Rondônia ca. 400 km SW of a previous record at Manicoré Municipality, Amazonas, Brazil (Strüssmann et al. 2012, *op. cit.*). Additionally, this specimen is ca. 308 km N of a previous record at Costa Marques Municipality, Rondônia, Brazil (Caramaschi 2010. Bol. Mus. Nac. N. S., Zool., Rio de Janeiro 527:1–30) and ca. 472 km NW from the type locality: Espigão D'Oeste Municipality, Rondônia, Brazil (Strüssmann et al. 2012, *op. cit.*). Specimen collected under an approved permit IBAMA (#400/2014).

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***ELEUTHERODACTYLUS CYSTIGNATHOIDES* (= *SYRROPHUS CYSTIGNATHOIDES*) (Rio Grande Chirping Frog)**. USA: TEXAS: Bandera Co.: Enchanted River Estates, Bandera (29.72371°N, 99.05441°W; WGS 84). 10 September 2016. Christopher Mock and Mayra Oyervides. Verified by Carl Franklin. Amphibian and Reptile Diversity Research Center, University of Texas at Arlington (UTADC 8722; audio recording). At approximately 2139 h, several *Eleutherodactylus cystignathoides* were heard calling within the Enchanted River Estates subdivision in the town of Bandera. In addition, two adult *E. cystignathoides* were then found under plastic and wood debris. Both were caught and released on site to further substantiate this record and the identification. The closest known record of the species is from Bexar County (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.), which is adjacent to the northeast boundary of Bandera County. This new record extends the species' known distribution 64.3 km NW of the Bexar County specimen (Biodiversity Research and Teaching Collections [TCWC] 48106; 29.4830556°N, 98.6016667°W, WGS 84) collected in 1973. Specimens were captured and released on site as appropriate under SPR-0913-130 issued to MO.

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***ELEUTHERODACTYLUS CYSTIGNATHOIDES* (Rio Grande Chirping Frog).** USA: TEXAS: Caldwell Co.: FM 20 right-of-way adjacent to the Clear Fork Creek Bridge, ca. 0.5 km SW of the Lockhart State Park entrance (29.85484°N, 97.70222°W; WGS 84). 13 October 2013. J. Eric Lee and Romey L. Swanson. Verified by Travis LaDuc. Biodiversity Collections (formerly Texas Natural History Collections), University of Texas at Austin (TNHC 89683). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). A single individual was collected by hand. Several individuals were observed calling along Clear Fork Creek and within Lockhart State Park following heavy rains. These observations verify that *E. cystignathoides* is established within Caldwell County and possibly abundant within the vicinity of Lockhart, Texas. This observation fills a regional gap along the southeastern segment of the Balcones Escarpment within Central Texas. Specimen collected under an approved Texas Parks and Wildlife Department Scientific Collecting Permit (SPR-0993-638) issued to TRS.

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***ELEUTHERODACTYLUS CYSTIGNATHOIDES* (Rio Grande Chirping Frog).** USA: TEXAS: Kendall Co.: Cibolo Nature Center (CNC) in Boerne, Texas (29.78130°N, 98.70892°W; WGS 84). 8 October 2015. Romey L. Swanson and J. Eric Lee. Verified by Travis J. LaDuc. Biodiversity Collections, University of Texas at Austin (TNHC 96349). A single *E. cystignathoides* was collected at 2130 h by hand from beneath a tarp at Cibolo Nature Center along banks of Cibolo Creek in southern Kendall County, Texas. New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). Previous *Eleutherodactylus* records have been reported from CNC and all refer to the native *E. marnockii* (Cliff Chirping Frog), however, we suspect that these records could represent misidentified *E. cystignathoides.* Further survey efforts will be needed to discern the status of these two sympatric species within southern Kendall County. This record establishes *E. cystignathoides* within Kendall County and represents the first vouchered specimen from the southern Edwards Plateau ecoregion. Capture followed scattered light rains during the preceding day. Overnight lows ranged between 13–18°C. Specimen collected under an approved Texas Parks and Wildlife Department Scientific Collecting Permit (SPR-10978-912) issued to Travis J. LaDuc.

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***GASTROPHRYNE CAROLINENSIS* (Eastern Narrow-mouthed Toad).** USA: ARKANSAS: Carroll Co.: 13 km NE Berryville (36.478233°N, 93.524728°W; WGS 84). 15 May 2016. M. B. Connior and K. Roberts. Verified by S. E. Trauth. Arkansas State University Museum of Zoology (ASUMZ 33572). Single adult captured by hand represents a new county record partially filling a distributional hiatus between previous records in Benton and Marion counties in northern Arkansas (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.). Specimen collected under an Arkansas Game & Fish Commission Scientific Collecting Permit (#081820151) issued to MBC.

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***INCILIUS NEBULIFER* (Gulf Coast Toad)** USA: MISSISSIPPI: Forrest Co.: 0.6 km E of the intersection of Interstate 59 and MS Hwy 49 (31.355284°N, 89.340243°W; WGS 84). 17 September 2016. Grover J. Brown, Christopher Pellecchia, Rebecca Pellecchia, and Jennifer Y. Lamb. Verified by Carl P. Qualls. Mississippi Museum of Natural Science (MMNS 19460). New county record (Mendelson III 2005. *In* Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 424–427. University of California Press, Berkeley, California; Robert L. Jones, pers. comm.). Two adult toads were found over two nights in an area also supporting *Anaxyrus terrestris* and *A. fowleri* populations. At 2015 h, 16 September 2016, one adult toad was found sitting on Lakeview Rd. The second toad (82.5 mm SVL; 52.9 g) was found and collected (MMNS 19460) at 2140 h, 17 September 2016, on a concrete sidewalk at the Hattiesburg Convention Center. The closest previously known record is 3.0 km SW from Lamar County, Mississippi (MMNS 19380, 19381; Lamb 2013. Herpetol. Rev. 44:621). Whether these are introduced or relict populations is unknown, but if the former, it appears that *I. nebulifer* could be dispersing and colonizing nearby counties. Specimen collected under MMNS permit #0512161.

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***LITHOBATES SEPTENTRIONALIS* (Mink Frog).** USA: WISCONSIN: Polk Co.: Twenty-ninth Lake (45.48°N, 92.49°W; WGS 84). 28 May 2016 and 4 June 2016. Brian Michael Collins. Verified by Joshua M. Kapfer. Milwaukee Public Museum (MPM VZP846; audio recording). New county record that extends the species' documented range in northwest Wisconsin (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.). Numerous *Lithobates septentrionalis* vocalizations were heard and recorded near active and inactive beaver lodges in the shallow margins of Twenty-ninth Lake.

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***NYCTIBATES CORRUGATUS*.** GABON: ESTUAIRE PROVINCE: Noya Department: SEEF logging zone south of Monts de Cristal National Park (0.694444°N, 10.300387°E; WGS 84). 28 May 2016. Emily Neil and Arnold Dounga. Verified by David Blackburn. Museum of Vertebrate Zoology, University of California, Berkeley (MVZObs: Herp: 22; photo voucher). Despite two previous inventories in and around the Mont Cristal National Park (Lötters et al. 2000. Elaphe 8:63–66; Bell et al. 2011.

Ecohealth 8:116–120) and several inventories across Gabon (for summary see Frétey et al. 2011. Amphibiens d'Afrique centrale et d'Angola. Biotope, Muséum national d'Histoire naturelle, Paris. 232 pp.), this is the first known record of *N. corrugatus* for Gabon. It has previously been recorded in Cameroon, Equatorial Guinea, and Nigeria (Amiet 1971. Ann. Fac. Sci. Cameroun 6:85–98; Boulenger 1904, Ann. Mag. Nat. Hist., Ser. 7, 13:261; De la Riva 1994. Rev. Esp. Herpetología 8:123–139). This record extends the known distribution of *N. corrugatus* ca. 106 km S of the nearest known record in Moka, Equatorial Guinea (Lasso et al. 2002. Graellsia 58:21–34). We thank ANPN for issuing permits (N: AE15018 /PR/ANPN/SE/CS/AEPN) and for providing logistical support.

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***PSEUDACRIS CRUCIFER* (Spring Peeper)**. USA: IOWA: Ringgold Co.: Ringgold Wildlife Management Area (40.59823°N, 94.14711°W; WGS 84), 331 m elev. 3 June 2016. Timothy M. Swartz. Verified by Christopher A. Phillips. Illinois Natural History Survey (INHS 2016f; photo voucher). A total of 31 individuals (28 larvae and 3 recently metamorphosed individuals) were captured by hand or dipnet in a shallow, partially-vegetated wetland. Individuals were photographed and released at the point of capture. New county record (LeClere 2013. A Field Guide to the Amphibians and Reptiles of Iowa. ECO Herpetological Publishing and Distribution, Rodeo, New Mexico. 349 pp.; Green et al. 2014. North American Amphibians: Distribution and Diversity. University of California Press, Berkley, California. 352 pp.), extending the range of this species ca. 11.6 km NW of closest vouchered record (Hatfield, Missouri; Biodiversity Institute, University of Kansas [KU] 222314, 222315) and ca. 36.1 km SW of the closest Iowa record (J. LeClere, pers. comm.). This work was conducted under Scientific Collector's Permit SC1184 awarded by the Iowa Department of Natural Resources.

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***PSEUDACRIS MACULATA* (Boreal Chorus Frog)**. USA: WISCONSIN: Trempealeau Co.: Trempealeau National Wildlife Refuge (44.047045°N, 91.521138°W; WGS 84). April 1995. Allen Blake Sheldon. Verified by Joshua M. Kapfer. Milwaukee Public Museum (MPM VZP826; photo voucher). New county record that fills a gap in the species' documented range (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.). An adult was photographed in a small, shallow wetland ca. 0.75 mi. E of the visitors' center, north of the wildlife drive. Numerous individuals have been seen here, including a calling male as recent as April 2002.

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***SCINAX EXIGUUS* (Gran Sabana Snouted Treefrog)**. BRAZIL: RORAIMA: Municipality of Boa Vista: Estação Ecológica Maracá: Lateral aterro trail (3.3698°N, 61.4418°W, WGS 84). 21 June 2011. Miguel T. Rodrigues, M. Teixeira Jr., R. Recoder, A. Camacho, S. M. Sousa, J. Cassimiro, A. Fouquet, and C. M. Carvalho. Verified by Julián Faivovich. Herpetological collection of Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP 157407). Adult male specimen.

Municipality of Paracaíma: Área BV8 (4.4846°N, 61.1545°W; WGS 84). 30 May 2011. Miguel T. Rodrigues, M. Teixeira Jr., R. Recoder, A. Camacho, S. M. Sousa, J. Cassimiro, A. Fouquet, and C. M. Carvalho. Verified by Julián Faivovich. MZUSP 157397–157403. All adult male specimens.

Municipality of Tepequém: Avião caído trail (3.766283°N, 61.699083°W; WGS 84). 1 June 2011. Miguel T. Rodrigues, M. Teixeira Jr., R. Recoder, A. Camacho, S. M. Sousa, J. Cassimiro, A. Fouquet, and C. M. Carvalho. Verified by Julián Faivovich. MZUSP 157404, 157405. Two adult males. An additional specimen (MZUSP 157406; adult male) was collected on 2 June 2011 ca. 2.7 km WNW from the Avião caído collection site.

This species is previously known from Northern part of the Gran Sabana (drainage of the Río Caroní), Estado de Bolívar, Venezuela, at elev. of 1210–1350 m (Duellman 1986. Copeia 1986:864–870; Gorzula and Señaris 1999. Scient. Guaianae 8:41). First country records, the northernmost locality at municipality of Paracaíma is ca. 159 km SSE from the type locality: Km 144 on the El Dorado-Santa Elena de Uairén Road in the Gran Sabana (5.88333°N, 61.38333°W), Estado de Bolívar, Venezuela (Duellman 1986, *op. cit.*), and 48 km SSW from the southernmost record for the species for Estado de Bolívar, Venezuela: Mapaurí, savannas (Gorzula and Señaris 1999, *op. cit.*). The locality at municipality Boa Vista is the southernmost known record for the species in Brazil, extending known range ca. 280 km S from the type locality in the Gran Sabana, Estado de Bolívar, Venezuela (Duellman 1986, *op. cit.*).

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TESTUDINES — TURTLES

***APALONE MUTICA MUTICA* (Midland Smooth Softshell)**. USA: ARKANSAS: Perry Co.: large backwater of the Arkansas River, ca. 0.97 km from the confluence and 67 meters west of the Perry–Conway county line (35.085517°N, 92.643481°W; WGS 84), 81 m elev. 5 May 2014. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012470–012472; photo voucher). One specimen was captured in a baited three-ring hoop net on sandy substrate. Individual had a large growth on the left forelimb between the first and second claws. This record fills a distribution gap between Pulaski County (ca. 50 river km SE) and Pope County (ca. 50 river km W). First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***APALONE SPINIFERA* (Spiny Softshell).** USA: NORTH CAROLINA: Henderson Co.: Laurel Green Park, Town of Laurel Park (35.314086°N, 82.483437°W; WGS 84). 10 June 2016. Christopher R. Wilson and Willow J. Wilson. Verified by Jeffrey C. Beane. North Carolina Museum of Natural Sciences (NCSM CRW-16-1; photo voucher). First county record (Carolina Herp Atlas: www.carolinaherpatlas.org; 17 Oct 2016; Jeffrey C. Beane and John Finnegan, pers. comm.). Individual was found basking in small pond along small tributary to Wash Creek. Specimen appears to be *A. s. spinifera* (Eastern Spiny Softshell) based on the shell and head patterns (Jefferey Beane, pers. comm.).

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***GRAPTEMYS GEOGRAPHICA* (Northern Map Turtle).** USA: ARKANSAS: Washington Co.: shoreline of Lake Sequoyah in Lake Sequoyah Park, 8 km east of Fayetteville (36.054175°N, 94.063728°W; WGS 84), 362 m elev. 6 June 2016. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012468, 012469; photo voucher). One juvenile (ca. 5 cm carapace length) was photographed basking on the rocky shoreline, filling a distribution gap between Benton and Crawford counties. Two more individuals spotted basking, but were not photographed. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***GRAPTEMYS GEOGRAPHICA* (Northern Map Turtle).** USA: GEORGIA: Bartow Co.: 2.41 km east of the town of Kingston (34.244833°N, 84.916439°W; WGS 84). 13 March 2016. Grover Brown. Verified by Peter V. Lindeman and Kenneth Krysko. Florida Museum of Natural History (UF 177361; photo voucher). New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). A subadult female was seen and photographed basking on dead wood in Two Run Creek off Hwy 293. This record is the first record of *Graptemys* from within the Etowah River Drainage (Lindeman 2013. The Map Turtle and Sawback Atlas: Ecology, Evolution, Distribution, and Conservation. University of Oklahoma Press, Norman, Oklahoma. 460 pp.), which is significant as their status in the state is listed as “Rare.” The Etowah drainage is fairly extensive throughout North Georgia, so the potential for additional populations in smaller tributaries is of particular conservation interest. This record is ca. 68 river km upstream of the next closest record from the Coosa River in Floyd County, Georgia (Brown and Kinney 2011. Herpetol. Rev. 42:565).

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***GRAPTEMYS OUACHITENSIS* (Ouachita Map Turtle).** USA: ARKANSAS: Montgomery Co.: backwaters near the confluence of the Ouachita River and Lake Ouachita, ca. 777 m W of Hwy 27 bridge (34.628422°N, 93.555603°W; WGS 84), 175 m elev. 25 April 2016. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Natural Digital Archives (KUDA 012473–012476; photo voucher). One juvenile hand-captured while basking on woody debris and two adult individuals photographed while basking, with multiple others not photographed. This record fills a distribution gap among Polk, Scott, Yell, Garland, Hot Spring, and Clark counties. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***GRAPTEMYS OUACHITENSIS* (Ouachita Map Turtle).** USA: ARKANSAS: Perry Co.: backwater of the Arkansas River, consisting of woody debris and emergent snags (35.082106°N, 92.647783°W; WGS 84), 81 m elev. 28 September 2013. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012477). From September 2013 to November 2014, over 200 individuals were captured using baited three-ring hoop nets and lead lines, including adult males, females, and hatchlings. This record fills a distribution gap between Yell, Conway, Faulkner, Pulaski, Saline, and Garland counties. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at:http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***GRAPTEMYS PEARLENSIS* (Pearl Map Turtle).** USA: MISSISSIPPI: Hancock Co.: East Pearl River, ca. 9.6 river km upstream of the East Pearl River and Interstate 10 junction (30.356833°N, 89.655607°W; WGS 84). 18 June 2008. Will Selman. Verified by Peter Lindeman. Florida Museum of Natural History (UF 177353; photo voucher). An additional specimen (UF 177354; photo voucher) was observed in the East Pearl River, ca. 13.7 rkm upstream of the East Pearl River and Interstate 10 junction (30.378656°N, 89.664454°W) on 7 July 2008. New county record (Lindeman 2013. The Map Turtle and Sawback Atlas: Ecology, Evolution, Distribution, and Conservation. University of Oklahoma Press, Norman, Oklahoma. 460 pp.). Both observations were of juvenile females. Additionally, two males and one juvenile were captured between 12.6–17.9 rkm upstream of the East Pearl and Interstate 10 junction (no photographs of individuals). This is the farthest downstream record for *G. pearlensis* within the East Pearl River, and the latitude is similar to the downstream distribution of the species in the West Pearl River (Porter River, near Pearl River, St. Tammany Parish; Louisiana Museum of Natural History [LSUMZ] 7611, 7613–7615, 7956, 9560). During trapping efforts on the East Pearl River, basking *G. pearlensis* were observed as far south as the Napoleon boat ramp (30.329000°N, 89.632051°W), ca. 5.5 river km downstream of our southernmost capture.

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***GRAPTEMYS PSEUDOGEOGRAPHICA KOHNII* (Mississippi Map Turtle)**. USA: ARKANSAS: Perry Co.: northeast shoreline of Harris Brake Lake (34.983667°N, 92.76465°W; WGS 84) 86 m elev. 20 August 2014. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012467). One juvenile was hand-caught in riprap on the shoreline near the boat ramp, and multiple adult individuals were spotted basking in the area. This record fills a distribution gap among Faulkner, Pulaski, Saline, Garland, and Yell counties. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***KINOSTERNON BAURII* (Striped Mud Turtle)**. USA: GEORGIA: Fayette Co.: Whitewater Creek (33.484686°N, 84.508338°W; WGS 84). 12 August 2016. Grover J. Brown and Greg Brashear. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178590; photo voucher). New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). An adult male (88.9 mm SCL) was found foraging in Whitewater Creek near the town of Fayetteville at 2000 h. The closest previously known record was found 11.3 km E in Clayton County, Georgia. Only a handful of records exist for this species in the Piedmont of Georgia, but this may be due to the similarity in appearance to *Kinosternon subrubrum* (Eastern Mud Turtle). Additional trapping in the floodplains of headwater streams in the Flint and Ocmulgee drainages may indicate this species is more abundant in middle Georgia than previously thought.

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***PSEUDEMYS CONCINNA* (River Cooter)**. USA: GEORGIA: Harris Co.: Chattahoochee River adjacent to Johnson Island (32.78148°N, 85.13029°W; NAD 83). 20 September 2016. J. Jensen, B. Folt, and J. Roberts. Verified by Nikki Castleberry. Georgia Museum of Natural History (GMNH 51171; photo voucher). Juvenile captured in a baited hoop-net trap. New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). Numerous other individuals of all size classes were also observed basking on logs in the vicinity.

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***PSEUDEMYS CONCINNA* (River Cooter)**. USA: SOUTH CAROLINA: Pickens Co.: Little Eastatoee Road (34.918972°N, 82.830389°W; WGS 84). 1 June 2016. C. Sabin, B. Bagwell, J. Mota, J. Newman, and K. Barrett. Verified by David Laurencio. Auburn University Museum of Natural History (AUM AHAP-D 1240; photo voucher). New county record (www.vertnet.org, 1 June 2016; Carolina Herp Atlas: www.carolinaherpatlas.org, 1 June 2016). This record fills a distributional gap between Oconee and Greenville counties in South Carolina. Ariello et. al. (2013. J. Morphol. 274:1060–1069) conducted a morphological study of *Pseudemys concinna* in Pickens County, however, no voucher specimens were accessioned. This record represents the first known physical evidence of the species in the county. Funding for this research was provided by F11AF00666 to KB.

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***PSEUDEMYS CONCINNA CONCINNA* (Eastern River Cooter)**. USA: ARKANSAS: Hempstead Co.: road-side ditch containing large woody debris which drains into Grassy Lake (33.704458°N, 93.888539°W; WGS 84), 81 m elev. 5 April 2014. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012455). Two specimens were captured in three-ring hoop nets (one juvenile, one female), filling a distribution gap among Sevier, Little River, Miller, Lafayette, and Pike counties. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***PSEUDEMYS GORZUGI* (Rio Grande Cooter)**. USA: NEW MEXICO: Chaves Co.: Bitter Lake National Wildlife Refuge (northern section), ca. 12.5 km ENE of Roswell, New Mexico (33.4397°N, 104.3989°W; WGS 84), 1061 m elev. August 2008. U.S. Fish & Wildlife Service staff. Verified by James N. Stuart. Museum of Southwestern Biology, University of New Mexico (MSB 96593). First specimen of the species for Chaves Co. (Degenhardt et al. 1996. Amphibians and Reptiles of New Mexico. University of New Mexico Press, Albuquerque, New Mexico. 431 pp.). The carcass of this specimen was found on a grassy bank of a pond by USFWS refuge staff but subsequent surveys have failed to detect this species on Bitter Lake National Wildlife Refuge (C.W. Painter, pers. comm.). An earlier account of this species from the refuge was listed by Bundy (1951. Copeia 1951:314) but no specimen is associated with that record. The nearest specimens have been collected ca. 100 km directly south, in the lower reaches of Brantley Lake, 21 km northwest of Carlsbad, Eddy Co., New Mexico. Specimen collected under an approved New Mexico Department of Game and Fish permit (#3328) issued to Howard L. Snell.

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***STERNOTHERUS ODORATUS* (Eastern Musk Turtle)**. USA: ARKANSAS: Perry Co.: large backwater of the Arkansas River, ca. 0.69 km from the confluence and 300 m W of the county line (35.08351°N, 92.64722°W; WGS 84), 81 m elev. 21 March 2014. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012462–012465). Two specimens were captured in baited three-ring hoop nets (one male, one female), filling a distribution gap among Yell, Conway, Faulkner, Pulaski, Saline, and Garland counties. First county record(Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at: http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***TRACHEMYS SCRIPTA TROOSTII* (Cumberland Slider).** USA: VIRGINIA: Smyth Co.: North Fork Holston River, 0.39 km SW of State Road 91 & Kent Street, (36.90138°N, 81.74607°W; NAD 83). 21 July 2016. J. D. Kleopfer. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178642; photo voucher). Washington Co.: North Fork Holston River, 0.08 km W of Smyth County (36.87967°N, 81.78894°W; NAD 83). 20 July 2016. J. D. Kleopfer. Verified by Kenneth L. Krysko. UF 178641 (photo voucher).

First county records and range extension of 81 air km northeast. Previously, only two observations of this species had been recorded from Virginia and both were from the North Fork Holston River in Scott County (Mitchell 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, D.C. 352 pp.; Virginia Fish and Wildlife Information Service, Species Observations (SppObs) Database. 4 Aug 2016). Unvouchered observations were made at these same locations by William Hopkins (Virginia Tech) in 2007 and were included in Kleopfer et al. (2014. A Guide to the Turtle of Virginia. Bureau of Wildlife Resources Special Publication Number 4, Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 44 pp.).

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SQUAMATA — LIZARDS

***ANOLIS SAGREI* (Brown Anole).** USA: TEXAS: Lavaca Co.: 4.8 km E of Shiner (29.428700°N, 97.126158°W; WGS 84). 20 November 2015. Jasmine A. Hernandez, Andrea Villamizar-Gomez, and Michael R. J. Forstner. Verified by Toby J. Hibbitts. Biodiversity Research and Teaching Collections (TCWC 102259). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). This record fills a distributional gap among the adjacent counties Guadalupe, Bexar, Matagorda, Brazoria, Galveston, Fort Bend, and Harris counties. One juvenile specimen (32.6 mm SVL, 39.0 mm TL, 1.3 g) captured approximately 0.08 km N of U.S. Highway 90 Alternate where multiple *Anolis sagrei* individuals were observed across the site. Specimen collected under a Scientific Permit for Research (SPR-0102-191) issued to MRJF by Texas Parks and Wildlife Department.

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***ANOLIS SAGREI* (Brown Anole).** USA: TEXAS: Montgomery Co.: Acacia Park, ca. 0.8 air km S FM 1488 and 2.3 km W of Hwy 242 (30.218996°N, 95.529147°W; WGS 84), ca. 54 m elev. 2 August 2016. David C. McMartin. Verified by Travis J. LaDuc. Biodiversity Collections (formerly Texas Natural History Collections), University of Texas at Austin (TNHC 99819). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). *Anolis sagrei* is established in multiple counties south of this observation in the Houston, Texas area. Between 9 June and 3 August 2016, approximately 150 individuals including males, females, juveniles, and hatchlings were observed in numerous neighborhoods in The Woodlands, Texas, with 140 photo vouchers obtained. In several instances this species was observed within 10 m of native *Anolis carolinensis.* Specimen collected under a Texas Parks and Wildlife Department hunting license (#737560036908).

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***CORYTOPHANES CRISTATUS* (Smooth-headed Helmeted Basilisk).** MEXICO: TABASCO: Municipality of Teapa: Cerro del Madrigal, near Zunu, ca. 60.49 km S of Villahermosa, Tabasco (17.484478°N, 92.838592°W; WGS 84), 643 m elev. 3 August 2014. Marco Antonio Torrez-Pérez, Diana Ivette Triana-Ramírez, and Liliana Ríos-Rodas. Verified by Jerry D. Johnson. Colección de Anfibios y Reptiles de Tabasco, Universidad Juárez Autónoma de Tabasco (CART 00749). Another individual (CART 00823) was found near by on 4 August 2014 at 602 m elev. First records for Tabasco, extending known range ca. 84 km W from near Palenque, Chiapas (Lee 1996. The Amphibians and Reptiles of the Yucatán Peninsula. Cornell University Press, Ithaca, New York. 500 pp.). Reynoso-Rosales et al. (2007. *In* Bueno et al. [eds.], Biodiversidad del Estado de Tabasco, pp. 241–260. Instit. Biol., UNAM, CONABIO, México, D.F.), cited Lee's (1996, *op. cit.*) map for listing *C. cristatus* as occurring in Tabasco, but the latter did not identify any vouchered specimen, only speculation depicted on his map that showed Tabasco within the species range.An unvouchered lizard believed to be *C. cristatus* was observed by J. M. Koller-González on 25 August 2014 near Ejido Corregidora, Sierra de Tenosique, Tenosique Municipality, which is located ca. 55.22 km SW of the Zona Arqueológica Piedras Negras, Petén, Guatemala (Smith and Taylor 1950. Bull. U.S. Natl. Mus. 199:1–253). All lizards were found in tropical evergreen forest. Fieldwork was supported by Universidad Juárez Autónoma de Tabasco through the project Programa de Fomento a la Investigación UJAT-2013-IB-30. Fieldwork was supported and endorsed by the Universidad Juarez Autonoma de Tabasco through the project "Programa de Fomento a la Investigación" under the assigned number: UJAT-2013-IB-30.

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***CTENOSAURA SIMILIS* (Gray's Spiny-Tailed Iguana)**. USA: FLORIDA: Lee Co.: Cayo Costa, State Park visitor cabins (26.68774°N, 82.25701°W; WGS 84), 3 m elev. 17 May 2016. Joseph R. Mendelson III and Alison M. Kelly. Verified by Kenneth Krysko. Florida Museum of Natural History (UF 178254; photo voucher). First record for this species on this barrier island (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. 524 pp.; K. Krysko pers. comm.). Informal surveys and conversations with park staff indicate the species is established, but not yet abundant.

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***DACTYLOA TRANSVERSALIS* (Banded Tree Anole)**. BRAZIL: MATO GROSSO: Municipality of Vila Bela da Santíssima Trindade: Fazenda Santa Helena (14.83263°S, 59.97540°W; WGS 84), 202 m elev. 10 September 2015. Paulo R. Machado-Filho and Guilherme M. Moya. Verified by Marco A. de Sena. Coleção Zoológica da Universidade Federal de Goiás, Municipality of Goiânia, Goiás State, (ZUFG 1209). *Dactyloa transversalis* was previously knownfrom Colombia, Ecuador, Peru, and Brazil (Ribeiro-Junior 2015. Zootaxa 3983:1–110). In Brazil, this species was reported in the states of Amazonas, Acre, and Rondônia (Langstroth 2005. Kempffiana 1:101–128). First state record, extending the range 375 km SE from the Municipality of Pimenta Bueno, Rondônia, the nearest locality to the new record (Ribeiro-Junior 2015, *op. cit.*). Specimen collected as part of a fauna monitoring program (Process: IBAMA 02001.000328/2009-98, Authorization: N° 617/2015).

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***HEMIDACTYLUS MABOUIA* (Tropical House Gecko)**. USA: FLORIDA: Levy Co.: Manatee Springs State Park, NW 115 Street & Hickory Camp Loop, 0.16 km N (29.488031°N, 82.975515°W; WGS 84). 30 July 2016. Eric C. Munscher and J. S. Munscher. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178574; photo voucher). New county record (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. 524 pp.). A group of four geckos was observed preying on insects near a light on a building wall. This record extends this species' known range in Florida ca. 65 km SW from the nearest reported locality of Gainesville, Florida (Krysko et al. 2011, *op. cit.*).

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***HEMIDACTYLUS TURCICUS* (Mediterranean Gecko)**. USA: MISSISSIPPI: Oktibbeha Co.: Mississippi State, 295 Lee Boulevard, Mississippi State University (MSU), Harned Hall (33.455643°N, 88.788086°W; WGS 84), 116 m elev. 5 October 2016. Ronald Altig. Verified by Neftali Camacho. Natural History Museum of Los Angeles County (LACM PC 2121). Juvenile collected on the wall of Harned Hall (Department of Biological Sciences building). New county record (Lee 2008. J. Mississippi Acad. Sci. 53:184–188). Fills a gap in the range between the closest vouchered locality, ca. 91 km W in Winona, Montgomery County (Mississippi Museum of Natural Science [MMNS] 15802–15807; Lee 2008, *op. cit.*) and a record 93 km E in Tuscaloosa County, Alabama (Thawley 2010. Herpetol. Rev. 41:378). These geckos have been living on the MSU campus at least since fall 1968 (R. Altig, pers. observ.).

RONALD ALTIG, Department of Biological Sciences, Mississippi State University, Mississippi State, Mississippi 39762, USA (e-mail: raltig@biology.msstate.edu); **GREGORY B. PAULY**, Section of Herpetology, Natural History Museum of Los Angeles County, Los Angeles, California 90007, USA (e-mail: gpauly@nhm.org); **ROBERT E. ESPINOZA**, Department of Biology, California State University, Northridge, Northridge, California 91330-8303, USA (e-mail: robert.e.espinoza@csun.edu).

***HEMIDACTYLUS TURCICUS* (Mediterranean Gecko)**. USA: TEXAS: Hill Co.: ca. 1 km E of Hillsboro (32.014391°N, 97.074868°W; WGS 84), 241 m elev. 17 March 2016. Morgan E. Whitworth, Zachary C. Adcock, Shawn F. McCracken, and Michael R. J. Forstner. Verified by Toby J. Hibbitts. Biodiversity Research and Teaching Collections, Texas A&M University (TCWC 102278). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). This record fills a distributional gap within the surrounding Johnson, Ellis, McLennan, and Navarro counties. The nearest record is 47 km NW (TCWC 95592). Adult specimen (48 mm SVL, 114 mm TL) collected on the side of a private residence. Property owner states that this species has been observed on the property for approximately 10 years. Specimen collected under Scientific Permit SPR-0102-191 issued to MRJF by Texas Parks and Wildlife Department.

MORGAN E. WHITWORTH (e-mail: mew111@txstate.edu), **ZACHARY C. ADCOCK**, **SHAWN F. McCRACKEN**, and **MICHAEL R. J. FORSTNER**, Department of Biology, Texas State University, 601 University Drive, San Marcos, Texas 78666, USA.

***HEMIDACTYLUS TURCICUS* (Mediterranean Gecko)**. USA: TEXAS: Zavala Co.: Batesville (28.961868°N, 99.618282°W; WGS 84), 218 m elev. 22 March 2016. Peter A. Johns, Zachary C. Adcock, Shawn F. McCracken, and Michael R. J. Forstner. Verified by Toby J. Hibbitts. Biodiversity Research and Teaching Collections, Texas A&M University (TCWC 102279, 102280). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). This record fills a distributional gap within the surrounding Kinney, Uvalde, Medina, Frio, Lasalle, Dimmit, and Maverick counties. The nearest previously documented record is ca. 59 km ESE in Frio County (Biodiversity Institute, University of Kansas [KU] 315663). Two juvenile specimens (37 mm SVL, 76 mm TL; 34 mm SVL, 55 mm TL) captured on a wall of a metal building in a residential neighborhood. Specimens collected under Scientific Permit SPR-0102-191 issued to MRJF by Texas Parks and Wildlife Department.

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***IGUANA IGUANA* (Green Iguana)**. USA: FLORIDA: Monroe Co.: Pigeon Key (24.70418°N, 81.15518°W; WGS 84). 15 September 2016. Kelly A. McKinnon. Verified by Kenneth Krysko. Florida Museum of Natural History (UF 178565; photo voucher). New island record (Krysko et al. 2007. Iguana 14:142–151; Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. 524 pp.). Over the last few years the Pigeon Key *I. iguana* population has increased and the species is now common. Reproduction has been noted, and juvenile individuals have also been observed.

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MICROGECKO LATIFI. IRAN: MARKAZI PROVINCE: Saveh County: ca. 3 km E of Jalayer Valligae near Saveh City (34.885292°N, 50.065848°E; WGS 84), 1300–1400 m elev. 8 May 2013. Bahman Zangi. Verified by Steven C. Anderson. Museum of Vertebrate Zoology, University of California, Berkeley (MVZObs:Herp:22). First confirmed record for Markazi Province, and ca. 70 km from the nearest known record, 2 km S of Qom City (Mirghazanfari 2013. Herpetol. Rev. 44:274). This is the northernmost latitude recorded for the species. It was found during a somewhat cloudy day beneath a piece of rock on a hillside with gravel and small sized rocks, sandy-loam soil and limestone substrate. Associated flora includes *Artemisia* spp., *Astragalus* spp., *Amygdalus scoparia*, *Aeluropus littoralis*, *Scariola orientalis*, *Limonium meyeri*, *Papaver rhoeas*, and *Atraphaxis* sp. There are no serious threats to this species, but in some areas, livestock moving over hillsides (the natural habitat for this species) might adversely impact local populations.

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***OPHISAURUS ATTENUATUS* (Slender Glass Lizard)**. USA: ARKANSAS: Benton Co.: 5 km NE Maysville (36.436304°N, 94.558736°W; WGS 84). 10 May 2016. M. B. Connior. Verified by S. E. Trauth. Arkansas State University Museum of Zoology (ASUMZ 33571). Single adult male (168 mm SVL) collected by hand represents a new county record partially filling a distributional gap in extreme northwestern Arkansas between previous records in Carroll and Washington counties in Arkansas (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.). Specimen collected under an Arkansas Game & Fish Commission Scientific Collecting Permit (#081820151).

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***XENOSAURUS TZACUALTIPANTECUS* (Zacualtipan Knob-scaled Lizard)**. MÉXICO: PUEBLA: Municipality of Tlatlauquitepec: Tepehican, 2 km N of Tlatlauquitepec (19.085216°N, 97.506833°W; WGS 84), 1930 m elev. 21 February 2016. Adán Alvarado Hernández. Verified by Juan Carlos López-Vidal. Museo de Zoología, Instituto Tecnológico Superior de Zacapoaxtla (MZITSZ 00038). First record for Puebla and a range extension of ca. 75 km WSW of the type locality located 7.5 km SSW of Zacualtipan, Hidalgo (Woolrich-Piña and Smith. 2012. Herpetologica 68:551–559). The adult female was found in an oak forest at 1143 h with its head sticking out of a limestone crevice. Fieldwork was supported by the ITSZ project No. PI.LB-16-05 and PI.LB-16-12 to GAWP.

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SQUAMATA — SNAKES

***COLUBER FLAGELLUM FLAGELLUM* (Eastern Coachwhip)**. USA: ARKANSAS: Carroll Co.: 13 km NE Berryville (36.478233°N, 93.524728°W; WGS 84). 1 August 2015. M.B. Connior and K. Roberts. Verified by S. E. Trauth. Arkansas State University Museum of Zoology (ASUMZ 33427; photo voucher). Adult individual collected by hand represents a new county record partially filling a distributional gap among previous records in Benton, Madison, and Boone counties in northern Arkansas (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.).

MATTHEW B. CONNIOR, Life Sciences, Northwest Arkansas Community College, One College Drive, Bentonville, Arkansas 72712, USA (e-mail: mconnior@nwacc.edu); **KORY G. ROBERTS**, Rogers High School, 2300 S. Dixieland Road, Rogers, Arkansas 72758, USA (e-mail: webmaster@herpsofarkansas.com).

***DIADOPHIS PUNCTATUS* (Ring-necked Snake)**. USA: TENNESSEE: Lewis Co.: along Walker Road at Green Pond vernal pool (35.4964°N, 87.3149°W; WGS 84). 27 May 2015. Cynthia Rohrbach. Verified by A. Floyd Scott. David H. Snyder Museum of Zoology, Austin Peay State University (APSU 19649; photo voucher). New county record (Scott and Redmond 1996. Atlas of Reptiles in Tennessee. Austin Peay State University, Clarksville, Tennessee. www.apsu.edu/reptatlas; 2 May 2016). The snake was found under a 61 × 61-cm cover board at 1433 h at Green Pond, an upland vernal pool in pin oak flatwoods, which is located on Big Swan Headwaters Preserve, owned by Swan Conservation Trust. The venter of the snake had a median row of half-moons, such as is characteristic of *D. p. punctatus* (Southern Ring-necked Snake). The snake was found in southeastern Lewis County, approximately equidistant from the three nearest known localities in Perry (APSU 12336–12338, 12340, 12343), Wayne (KU 97831), and Maury (APSU 19231) counties.

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***DIADOPHIS PUNCTATUS EDWARDSII* (Northern Ring-necked Snake)**. USA: WISCONSIN: Monroe Co.: northern Monroe County (44.15°N, 90.57°W; WGS 84). 26 August 2016.

Rori A. Paloski and Stacy A. Rowe. Verified by Joshua M. Kapfer. Milwaukee Public Museum (MPM VZP851a,b; photo voucher). Locality has been generalized due to the sensitive nature of this species in Wisconsin. New county record that completes a gap in the subspecies' documented range in Wisconsin (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.). One adult *Diadophis punctatus edwardsii* was found underneath a discarded railroad tie at the base of a railroad embankment. This specimen was found within sand prairie and oak barrens habitat. Adjacent habitat consisted of northern sedge meadow, White Pine-Red Maple swamp with pockets of open meadow dominated by broad-leaved sedges and shrub-carr, cranberry beds, and margins of open bog around lakes and flowages transitioning to closed canopy northern wet forest/Black Spruce swamp. Furthermore, this specimen provides important historical context for the overlapping subspecies distribution of the *D. p. edwardsii* and *D. p. arnyi* in Wisconsin.

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***FARANCIA ABACURA* (Red-bellied Mudsnake)**. USA: TENNESSEE: McNairy Co.: Finger, on Center Hill Road near Bushel Branch (35.354008°N, 88.592277°W; WGS 84). 24 August 2016. Brian P. Butterfield. Verified by A. F. Scott. David H. Snyder Museum of Zoology, Austin Peay State University (APSU 19759; photo voucher). New county record (Scott and Redmond 1996. Atlas of Reptiles in Tennessee. Austin Peay State University, Clarksville, Tennessee. www.apsu.edu/reptatlas; 24 Aug 2016). An individual male was found DOR. Specimen collected under a Tennessee Wildlife Resources Agency Scientific Collection Permit (#1494) issued to BPB.

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***INDOTYPHLOPS BRAMINUS* (Brahminy Blindsnake)**. MÉXICO: YUCATÁN: Municipality of Mérida: Sol Campestre (21.021709°N, 89.597115°W; WGS 84). 8 October 2009. Maximilian Paradiz-Dominguez. Verified by Van Wallach. Museum of Comparative Zoology, Harvard University (MCZ Herpetology Observations 27; photo voucher). First record for Yucatán and a 335-airline km range extension northwest of Chetumal, Quintana Roo (Cedeño-Vázquez et al. 2003. Herpetol. Rev. 34:394), and a 355-airline km range extension northeast of Ciudad del Carmen, Campeche (Solano-Zavaleta et al. 2006. Herpetol. Rev. 37:500). This snake was found under a rock in an area where new houses were being built and non-native plants (e.g., *Cycas revoluta, Heliconia wagneriana*) were being imported for landscaping. Two other individuals were discovered in Mérida on 15 September 2009 under a rock after a thunderstorm.

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***LAMPROPELTIS GETULA NIGRA* (Eastern Black Kingsnake)**. USA: INDIANA: Putnam Co.: Deer Creek Fish and Wildlife Area (39.59117ºN, 86.88913ºW; WGS 84). 1 September 2015. Sarabeth Klueh-Mundy and Jason Mirtl. Verified by Alan Resetar. Field Museum of Natural History (FMNH 286716–286719). This capture provides a new county record for Indiana Minton 2001. Amphibians and Reptiles of Indiana. Indiana Academy of Science, Indianapolis, Indiana. 404 pp.).

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***LAMPROPELTIS TRIANGULUM TRIANGULUM* (Eastern Milksnake)**. USA: ILLINOIS: Carroll Co.: Thomson Causeway Recreation Area (41.95024°N, 90.11576°W; WGS 84). 11 June 2016. Morgan R. Muell, Nathan J. Kutok, and Isaiah S. Lieberenz. Verified by Fredric J. Janzen. Illinois Natural History Survey (INHS 26941) and Iowa State University Research Collection (ISUA 201601; photo voucher). First vouchered county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Natural History Survey Manual 8, Champaign, Illinois. 282 pp.). One adult female (685 mm SVL, 107 mm TL, 92.86 g) was found fatally injured on the side of a gravel road going through the Thomson Causeway Recreation Area. Field research on reptiles at the site has been ongoing for nearly 30 years with no previous captures of *L. t. triangulum.* The species is documented from adjacent Jo Daviess County to the north and Ogle County to the east (Philips et al. 1999, *op. cit.*). Funding for this work was provided by a grant from the National Science Foundation to F. J. Janzen. Permission to conduct this research was granted by the Illinois DNR, U.S. Army Corp of Engineers, and U.S. Fish & Wildlife Service.

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***LIODYTES PYGAEA PYGAEA* (Northern Florida Swampsnake)**. USA: FLORIDA: Jefferson Co.: Greenville, Livingston Road, Dixie Plantation (30.621103°N, 83.695771°W; WGS 84). 27 April 2014. Jonathan D. Mays. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 178568; photo voucher). Adult observed crossing road at dusk. First record for the county. (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. 524 pp.).

JONATHAN D. MAYS (e-mail: jonathan.mays@myfwc.com), **KEVIN M. ENGE**, and **PAUL E. MOLER**, Florida Fish and Wildlife Conservation Commission, 1105 S.W. Williston Road, Gainesville, Florida 32601, USA.

***MICRUROIDES EURYXANTHUS* (Sonoran Coralsnake)**. USA: ARIZONA: Yuma Co.: Tinajas Altas Mountains, unnamed canyon on Barry M. Goldwater Range West (32.386847°N, 114.116525°W; WGS 84), 351 m elev. 29 March 2016. Chip Cochran. Verified by Charlotte Johnson. Arizona State University (ASU 36012). New county record and extends the known range ca. 93 km SSE of the Chocolate Mountains (University of Arizona, Museum of Natural History [UAZ] 45840) and ca. 96 km WNW of the Agua Dulce Mountains (University of Michigan Museum of Zoology [UMMZ] 75625). The adult female (500 mm SVL, 532 TL, 16.63 g) was found on the crawl at the bottom of a wash surrounded by Lower Colorado River Desertscrub and Sonoran Desert Scrub (Brown 1994. Biotic Communities of the Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City, Utah. 342 pp.) at 1218 h. Ambient 1.5 m temperature was 23.0°C, humidity at 1.5 m was 39.3%, substrate temperature was 45.6°C, cloud cover was exceedingly thin and covered 60% of the sky. An additional specimen (ASU HP00079; photo voucher; verified by

Andrew T. Holycross), previously discovered, from this mountain range was chanced upon during the writing of this note. It was located just up a side canyon off Guzzler Canyon (32.365558°N, 114.103944°W; WGS 84), on 24 August 2014 by Doug Duerre. Both snakes had an abnormal amount of black banding dorsally, the result being stretches where the snake's pattern appeared yellow-black-yellow-black-yellow when viewed dorsally as opposed to the traditional yellow-black-yellow-red-yellow color scheme. Specimen was collected under Arizona Game and Fish Department Scientific Collecting Permit, Richard C. Cochran III (#SP743315).

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***NERODIA CYCLOPION* (Mississippi Green Watersnake)**. USA: TENNESSEE: Shelby Co.: Shelby Farms Greenline in Memphis (35.148981°N, 89.806629°W; WGS 84). 31 July 2016. Åsa Karlström. Verified by A. Floyd Scott. Auburn University Natural History Museum (AHAP-D 1246; photo voucher). *Nerodia cyclopion* is considered extremely rare and critically imperiled by the Tennessee Department of Environment and Conservation; the species is known in Tennessee from only a handful of records in the extreme western portion of the state. All vouchered records with precise locality information were collected in northwestern Tennessee (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Austin Peay State University, Clarksville, Tennessee. www.apsu.edu/amatlas; 2 Aug 2016); one record of the species (APSU 13375) exists for Shelby County in southwestern Tennessee but the observation occurred in 1935 and only approximate locality information is given (i.e., "near Memphis;" A. Floyd Scott, pers. comm.). Thus, the current observation is the first vouchered record from the area with complete collection information and also confirms that the rare species is still present in the region.

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***OPHEODRYS VERNALIS* (Smooth Greensnake)**. USA: WISCONSIN: Crawford Co.: 1.6 km SW of the center of Mount Sterling (43.309106°N, 90.947461°W; WGS 84). 12 July 2013 and 23 May 2015. Erik Thomsen. Verified by Joshua Kapfer. Milwaukee Public Museum (MPM VZP824, VZP825; photo voucher). New county record extending the known range of this species in Wisconsin (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 87 pp.). Adults were observed on a mowed firebreak trail on July 12 2013 and May 23 2015 respectively and photographed by ET. The habitat was gently sloping tall-grass prairie remnant surrounded by matrix of oak woodland and active agricultural fields.

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***RENA DULCIS DULCIS* (Plains Blind Snake)**. USA: TEXAS: Terrell Co.: ca. 127 km S of Sheffield at the Independence Creek Preserve (30.447219°N, 101.801359°W; WGS 84), 615.4 m elev. 23 April 2016. Jacquelyn M. Tleimat, Charles J. Bintliff, Andrew R. MacLaren, Michael R. J. Forstner and Shawn F. McCracken. Verified by Toby J. Hibbitts. Biodiversity Research and Teaching Collections, Texas A&M University (TCWC 102281). New county record (Dixon 2013. Amphibians and Reptiles of Texas: with Keys, Taxonomic Synopses, Bibliography, and Distribution Maps. Texas A&M University Press, College Station, Texas. 447 pp.). This record fills a distributional gap within the surrounding Crockett and Val Verde counties. Unpublished records of *Rena dulcis* from Terrell Co. exist at the Biodiversity Collections, University of Texas at Austin (TNHC), but our specimen represents the first confirmed and published *Rena d. dulcis* record from the county. The nearest (previously unreported) record for *R. dulcis* is from 4.5 km to the northeast (TNHC 77332). The adult specimen (155 mm SVL, 162 mm TL, 1.1 g) was collected during a visual encounter survey, hiding under a large rock. Specimen collected under Scientific Permit SPR-0102-191 issued to MRJF by Texas Parks and Wildlife Department. Access to the Independence Creek Preserve was provided by The Nature Conservancy of Texas.

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***STORERIA OCCIPITOMACULATA OCCIPITOMACULATA* (Northern Red-bellied Snake)**. USA: INDIANA: Porter Co.: T36, R6W, S26 (coordinates not disclosed due to rarity of the species in this part of the state). 20 May 2016. Kelly M. Carey and Tom L. Estrem. Verified by Alan Resetar. Field Museum of Natural History (FMNH AR IMG 015; photo voucher). New county record (Minton 2001. Amphibians and Reptiles of Indiana. Indiana Academy of Science, Indianapolis, Indiana. 404 pp.). Single individual observed partially concealed in vegetation in an open field. *Storeria occipitomaculata* is considered uncommon in Indiana and northern records evidently represent relic populations (Minton 2001, *op. cit.*). This record fills a gap between Lake and LaPorte counties in the Lake Michigan border region of northwest Indiana (Minton 2001, *op. cit.*).

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***THAMNOPHIS MARCIANUS* (Checkered Gartersnake)**. USA: ARIZONA: La Paz Co.: Colorado River, 4 km SSW of Cibola on the Cibola National Wildlife Refuge (33.28090°N, 114.68487°W; NAD 27). 26 May 2016. R. Munes. Verified by Travis J. LaDuc. Arizona State University (ASU 36014).

Yuma Co.: Colorado River, 1.5 km SE of Imperial Dam (32.872516°N, 114.453171°W; NAD 27). 17 May 2016. R. N. Reed. Verified by Travis J. LaDuc. ASU 36013. Specimen collected from a funnel trap. Seven additional *T. marcianus* were trapped and released at or near this site from 17–31 May 2016 and colleagues report unvouchered observation of six individuals between 2011–2016 (T. Cotten and L. Piest, pers. comm.).

Prior to the extensive water diversions and impoundments associated with the development of agriculture along the Gila and Colorado rivers, *T. marcianus* distribution probably followed the course of the Gila River westward through the extremely arid desert of southwestern Arizona to its confluence with the Colorado River near Yuma, Arizona (Brennan and Holycross 2006. A Field Guide to Amphibians and Reptiles in Arizona. Arizona Game and Fish Department, Phoenix, Arizona. 150 pp.). However, there are no vouchers (historical or modern) along the Gila River between Yuma and Painted Rock Reservoir (ATH, unpubl. data), the course of which is now a perennially dry riverbed. At the advent of the 20th century, *T. marcianus* appears to have been distributed along the Colorado River from near its mouth upstream to just below Parker, Arizona. A 1905 specimen (USNM 37514) from the east base of the Cocopah Mountains, Mexico, places them in the Rio Hardy near the mouth of the Colorado River. Three Arizona specimens (USNM 21820, 21821, CAS 6468), collected between 1894–1899, document them between the Mexican Border up to the vicinity of Yuma, Arizona (two of these were collected by E.A. Mearns during the U.S.–Mexico Boundary Surveys). Finally, a 1910 specimen (MVZ 1821) from "Riverside Mtn" documents *T. marcianus* up the Colorado River to within 27 river km of Parker, Arizona, and a series of specimens (collected in the 1910s and 1930s) on the California side of the border document a continuous *T. marcianus* population between the Riverside Mountains specimen and the Arizona specimens south of Yuma. Although the extremely arid landscape surrounding these rivers was entirely inhospitable to aquatic snakes, by the early 1930s *T. marcianus* had invaded the canals and sloughs associated with agricultural development of the Imperial Valley (Imperial County, California) and was abundant enough to have been collected off roads throughout this region (SDSNH 2421, 13755, 22652, 23410, 23426, 29214, 29267). Adjacent agricultural lands south of Mexicali, Mexico, yielded a few specimens (SDSNH 18935, 18936 and LACM 21016) in the early 1950s. Likewise, three specimens (SDSNH 23409, 25489, 34201) were collected between 1935 and 1941 off roads in agricultural areas in the vicinity of Yuma, Arizona. However, in the intervening decades since these early records, very few specimens have been collected from either the Colorado River or adjacent agricultural lands in either Arizona or California. To our knowledge, the most recent records from the entire region include a gravid female collected from 1.4 mi. N of Imperial Dam on Imperial Dam Road in 1974 (ASU 15976) and a specimen (LACM 178035) collected from Mecca, California, in 2009, which documents range expansion north of the Salton Sea into the Coachella Valley.

Despite a dearth of recent specimens from the Colorado River, our observations establish that *T. marcianus* is extant in the region, despite recent invasion of these habitats by introduced *Nerodia fasciata*. We trapped both *N. fasciata* and *T. marcianus* in the same trap arrays in the same habitats during May 2016, suggesting significant niche overlap between the species and raising the possibility that *N. fasciata* may expand its distribution to mirror that of *T. marcianus* in this region. The specimen we report from Cibola National Wildlife Refuge is the first *T. marcianus* specimen from La Paz County. All specimens were collected under an Arizona Game & Fish Department Scientific Collecting Permit (#SP750617) issued to RNR.

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***THAMNOPHIS PROXIMUS PROXIMUS* (Orange-striped Ribbon Snake)**. USA: ARKANSAS: Perry Co.: large backwater of the Arkansas River, ca. 0.83 km from the confluence and 219 m from the county line (35.085478°N, 92.645294°W; WGS 84), 81 m elev. 20 April 2014. Luke S. Pearson. Verified by William E. Duellman. University of Kansas Digital Archives (KUDA 012788, 012789; photo voucher). One specimen was captured while swimming across the backwater channel, filling a distribution gap among Yell, Conway, Faulkner, Pulaski, Saline, and Garland counties. First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.; Roberts and Irwin 2012. Arkansas Herpetological Atlas 2012, Distributions of Amphibians and Reptiles. Available online at:http://herpsofarkansas.com/wiki/uploads/Herp/Atlas/arherpatlas2012.pdf).

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***THAMNOPHIS RADIX* (Plains Gartersnake)**. USA: IOWA: Ringgold Co.: Ringgold Wildlife Management Area (40.690828°N, 94.094544°W; WGS 84), 361 m elev. 30 July 2016. Timothy M. Swartz. Verified by Christopher A. Phillips. Illinois Natural History Survey (INHS 2016g; photo voucher). One adult individual was captured by hand in vegetation along the edge of a stock pond. The individual was photographed and the released at the point of capture. New county record (LeClere 2013. A Field Guide to the Amphibians and Reptiles of Iowa. ECO Herpetological Publishing and Distribution, Rodeo, New Mexico. 349 pp.). Prior to this record, this species had been documented in adjacent Iowa counties to the north and east and is common throughout the state.

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Erratum

Three county records reported by Munscher et al. (2016. Herpetol. Rev. 47: 251, 254, 255) for *Apalone ferox*, *Pseudemys nelsoni*, and *Sternotherus minor* in Hernando County, Florida, USA, are not new county records or range extensions, but instead represent additional records from that county (Jackson 2006. *In* P. A. Meylan [ed.], Biology and Conservation of Florida Turtles. Chelon. Res. Monogr. No. 3:313–324; Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final Report, Florida Fish and Wildlife Conservation Commission, Tallahassee. 524 pp).

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Two Additions to the Herpetofauna of Kasos (Aegean Sea, Greece) and the Role of Human-mediated Dispersals

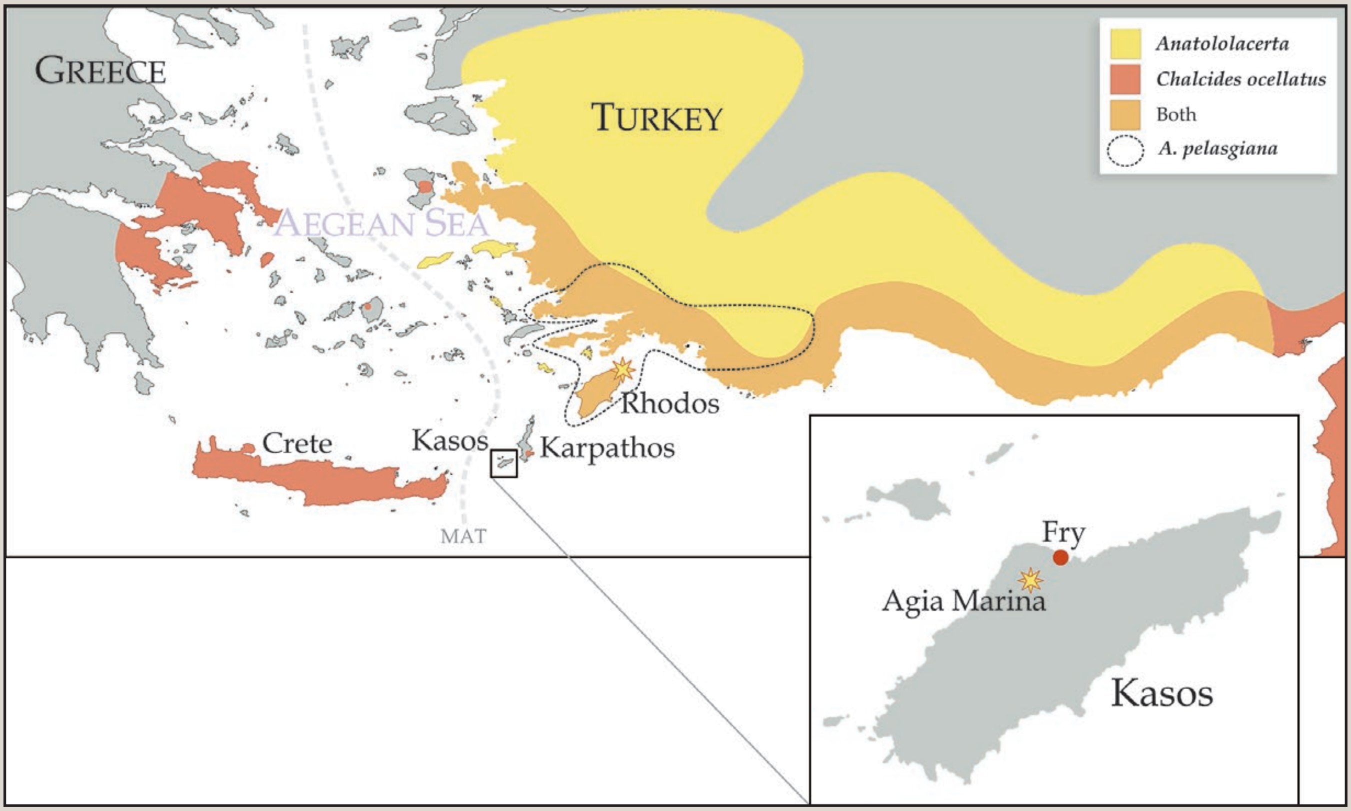

FIG. 1. The location of Kasos island in the Aegean Sea and the distributions of the genus *Anatololacerta*, *A. pelasgiana*, and *Chalcides ocellatus* in this region. Dot shows the locality where *C. ocellatus* was recorded in Kasos and stars indicate the localities of *A. pelasgiana* that share the same mtDNA haplotypes on Kasos and Rhodos.

The Aegean archipelago lies in the eastern Mediterranean Sea, between the southern Balkan Peninsula (Greece) and Anatolia (Turkey) (Fig. 1). It is a biodiversity-rich area, due to (1) its position at the crossroads among Europe, Asia, and Africa; (2) its geomorphology that includes more than 9000 islands and islets (Blondel et al. 2010); and (3) its active geological history (e.g., Creutzburg 1963; Dermitzakis 1990). Humans have also contributed importantly to forming the Mediterranean and Aegean fauna since civilizations have continuously occupied this area for at least 9000 years. Some human activities, such as agriculture and stock-breeding, have actively modified the landscape, while others, such as the development of commercial routes in land and sea, have led to the accidental transport of terrestrial animals, altering species' distributions (Gippoliti and Amori 2006).

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Among the Aegean islands, the Kasos-Karpathos island group is of particular interest. It is located at the southernmost Aegean region, situated between the island of Crete in the west, and the island of Rhodos and the southwestern edge of Anatolia in the east (Fig. 1). Kasos and Karpathos, separated by a narrow and shallow sea strait (approx. 6 km wide and 60 m deep), have played an important role in the palaeogeographic history of the Aegean region: the first formation of the early Aegean Sea, known as the mid-Aegean trench (MAT; Fig. 1) occurred between today's Kasos and Crete some 12 Mya (Creutzburg 1963; Dermitzakis 1990), leading to the biogeographical separation between the west and east Aegean biotas. The geological separation between Karpathos and Rhodos occurred some 3.5 Mya (Barrier 1979; Daams and De Weerd 1980). In this sense, the Kasos-Karpathos fauna (and flora) is part of the east Aegean assemblage but has remained isolated for a long time, which has led to significant biodiversity and the protection of parts of both islands under the Natura 2000 network.

The island of Karpathos has received considerable attention from researchers and field enthusiasts because of its larger size, habitat variety, easier accessibility, and high number of visitors during the tourist season. Kasos, on the other hand, is a small

FIG. 2. A) *Anatololacerta pelasgiana* from Kasos and (B) its habitat on the island.

FIG. 3. A) *Chalcides ocellatus* from Kasos and (B) its habitat on the island.

island (49 km^2) characterized by arid limestone hills, with low shrub vegetation and no trees, except for the olive and fig trees cultivated in few and restricted valleys. The island can be considered as a typical example of environmental downgrading due to intensive grazing, which has resulted in extensive areas covered exclusively with phrygana (*Sarcopoterium spinosum*, *Thymus capitatus*, and *Genista acanthothamnos*). Moreover, there are no permanent superficial water bodies on the island. Its position, antiquity, small size, and extreme aridity lead to a poor herpetofauna including only five species—one amphibian and four reptiles. These five species are the Karpathos-Kasos endemic Lycian Salamander *Lyciasalamandra helverseni* (Pieper 1963), the geckos *Mediodactylus kotschyi oertzeni* (Boettger 1888) and *Hemidactylus turcicus* (Linnaeus 1758), the skink *Ablepharus kitaibelii fabichi* (Štepánek 1938), and the colubrid snake *Telescopus fallax rhodicus* Wettstein 1952 (Cattaneo 2010). Three of these species (*L. helverseni*, *M. kotschyi*, and *A. kitaibelii*) are probably old inhabitants of Kasos (Kasapidis et al. 2005; Eleftherakos et al. 2007; Skourtanioti et al. 2016), while *H. turcicus* was first reported by Cattaneo (2010) and probably represents a recent human-mediated arrival.

We conducted two herpetological field surveys in 2016 during 27–29 May and 10–14 July. During the first visit, a local farmer who was familiar with the fauna of the island described all species mentioned above plus an "exotic foreign" lizard that he had observed for the past 2–3 years. We visited the location where he had seen these animals (35.413690°N, 26.915261°E; WGS84) and discovered a population of the lacertid *Anatololacerta* (Fig. 2a), the Anatolian lizard that is endemic to Turkey and very few Aegean islands and islets (Fig. 1) (Bellati et al. 2015; Candan et al. 2016). At least six individuals were observed in a small uncultivated area southeast of the village of Agia Marina. This is an arid region with sparse *Pistacia* shrubs and traditional stone walls among sheep and goat enclosures (Fig. 2b). During our second visit in July, locals also reported having seen this species within the village.

One female individual was collected for identification and the specimen was deposited in the herpetological collection of the Zoological Museum of the University of Patras, Greece (voucher number ZMUP 438). The genus-level identification was verified by Ç. Ilgaz and Y. Kumlutaş (Dokuz Eylül University, Buca, Izmir, Turkey) through photographs, but identification to species was not possible, especially since *Anatololacerta* is a taxonomically problematic group (Bellati et al. 2015). To identify this species and assess the phylogenetic position and origin of the Kasos population, we used DNA analysis.

The mitochondrial markers cytochrome b (cytb) and 12s rRNA (12s) were PCR-amplified and sequenced as in Bellati et al. (2015). The resulted sequences, along with all available *Anatololacerta* cytb and 12s sequences from GenBank, were aligned and compared to each other. Our cytb sequence was identical to LN611220–2, while the 12s sequences was identical to LN611172–4 (Bellati et al. 2015). These sequences correspond to three individuals of *Anatololacerta pelasgiana* (Mertens, 1959) from Rhodos.This identification and sharing of the same mtDNA haplotype with the Rhodos population (Fig. 1) implies that the population of *Anatololacerta pelasgiana* found in Kasos is probably the result of a recent human-induced dispersal. This is supported by the fact that these lizards were not observed by locals previous to three years ago and that other researchers did not report this species from Kasos, although it is the only lacertid, i.e., true lizard, on the island (Cattaneo et al. 2010). The ongoing transportation of products such as livestock fodder from Rhodos may facilitate the unintended dispersal of this Anatolian lizard.

During our second visit, a dead Ocellated Skink *Chalcides ocellatus* (Forskål, 1775) was collected in Fry village (35.416340°N, 26.923086°E; ZMUP 488), the capital and home to the island's harbor. Within a distance of 200 m, three more individuals (one adult and two juveniles; Fig. 3a) were observed in the village and hiding in stone-walls (Fig. 3b). The Ocellated Skink, a North African species, has a long history of human-mediated colonizations throughout Europe and even America (e.g., Caputo et al. 1997; Kornilios et al. 2010; Gunn et al. 2012). Its entire distribution in the eastern Mediterranean is thought to be a result of many anthropogenically assisted dispersal events (Kornilios et al. 2010). As a result, its distribution in the Aegean is scattered and it occurs on a few islands that include Crete and Karpathos, west and east of Kasos, respectively (Fig. 1). Interestingly, in Karpathos it has only been recorded in the island's capital and harbor (Pigadia) by three researchers during the past 80 years (Cattaneo 2010). The fact that Cattaneo did not record this species from Kasos when he visited the island in 2009 may be because of the species' restricted distribution and probably small population on the island, or the species might have been transferred to Kasos more recently.

These two new herpetological reports from Kasos update our knowledge on the distribution of *A. pelasgiana* and *C. ocellatus* in the Aegean and increase the number of reptiles on the island from four to six. More importantly, these records highlight the continued impact of human activities in shaping the herpetofauna of Mediterranean and Aegean islands.

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Historic Amphibian and Reptile County Records from the A. Jewell Schock Museum of Natural History at Wayne State College

The A. Jewell Schock Museum of Natural History (AJSM) at Wayne State College is located in Wayne, Nebraska, USA, and maintains a small collection of approximately 400 specimens of amphibians and reptiles as part of its overall collection. These specimens are primarily from Nebraska, California, Texas, and Louisiana, and represent collection efforts primarily by A. Jewell Shock, Kurt Edwards, Bill S. Birkhead, and from Wayne State College class trips to regional locations. Here, we report seven new county records from Nebraska, Texas, and Oklahoma. These new distributional records were discovered when updating jars and fluids and cataloging the herpetology collection at the AJSM from May–July 2016. County records were determined by examining Baldwin (1965), Ballinger et al. (2010), Black and Sievert (1989), Fogell (2010), Davis et al. (2014), Dixon (2013), Hubbs (2013, 2016), Hudson (1942), Lynch (1985), Sievert and Sievert (2011), individual records published in *Herpetological Review* since 2000, and through examination of museum holdings (i.e., VertNet). All specimen identifications were verified by Travis J. LaDuc (Biodiversity Collections, University of Texas at Austin) and were georeferenced with GEOLocate (WGS 84 datum; www.museum.tulane.edu/geolocate). Uncertainty values (in m) associated with georeferencing are presented following the georeferenced coordinates. All nomenclature follows that of Crother (2012), and all specimens were weighed and measured in September 2016 by DRD. No collecting permit information is on file at AJSM concerning these specimens, but most were collected prior to the permit requirements issued by state agencies. The closest known localities to individuals are from specimens at the Sam Noble Oklahoma Museum of Natural History (OMNH), the Biodiversity Collections at the University of Texas at Austin (TNHC), the Museum of Zoology at the University of Michigan (UMMZ), and the University of Nebraska State Museum (UNSM).

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ANURA — FROGS

***HYLA CINEREA* (Green Treefrog)**. USA: OKLAHOMA: Payne Co.: Holiday Inn, Stillwater (36.11605°N, 97.05137°W; error = 8,699 m). 24 May 1976. Mike Pelc. AJSM 0309. This specimen (9.3 g; 51 mm SVL) may represent a new population of *H. cinerea* in the northwestern edge of their distribution in Oklahoma (Black and Sievert 1989; Sievert and Sievert 2011). The nearest known specimen is from ca. 33.2 km to the northeast from Pawnee, Pawnee County, Oklahoma (UMMZ 138066). It is unclear if this specimen (AJSM 0309), and the individual from Pawnee County (UMMZ 138066), are from native or introduced populations given representation in museum collections of only a single specimen. It is known that *H. cinerea* have been spread outside their native range through the commercial plant trade and the accidental and intentional release of individuals kept as pets and this may be the source of these individuals. Further sampling should be conducted to determine if these populations remain extant, if they were the introduction of single individuals, or if populations on this northwestern edge are continuous or disjunct with nearby populations.

***PSEUDACRIS MACULATA* (Boreal Chorus Frog)**. USA: NEBRASKA: Wayne Co.: Ikes Lake (42.29805°N, 97.05485°W; error = 233 m). 14 September 1995. Chris Bye. AJSM 0325. This specimen (0.6 g; 23 mm SVL) fills a gap in the distribution of *P. maculata* in northeastern Nebraska and is known from all surrounding counties (Ballinger et al. 2010; Fogell 2010; Davis 2016). The nearest known specimens are from ca. 31.0 km to the southeast from near Pender, Thurston County, Nebraska (OMNH 444881, 44882; Davis 2016).

TESTUDINES — TURTLES

***APALONE MUTICA* (Smooth Softshell)**. USA: TEXAS: Travis Co.: Lake Travis (30.44034°N, 98.06464°W; error = 24,402 m). 5 July 1966. A. Jewell Schock. AJSM 0248. This specimen (sub-adult female; 87.8 g; 108 mm carapace length; 80 mm plastron length) fills a gap in the patchy distribution of *A. mutica* in central Texas (Dixon 2013). The nearest known specimen is from ca. 42.5 km to the northwest from Lake Lyndon B. Johnson, Llano County, Texas (TNHC 84897).

SQUAMATA — LIZARDS

***SCELOPORUS CONSOBRINUS* (Prairie Lizard)**. USA: NEBRASKA: Rock Co.: Southeastern Rock County (42.18045°N, 99.36926°W; error = 10,429 m). 20 September 1985. Scott Anderson. AJSM 0031. This specimen (adult female; 8.0 g; 57 mm SVL; 57 mm tail length) fills a gap in the distribution of *S. consobrinus* in northern Nebraska and is known from all surrounding counties (Ballinger et al. 2010; Fogell 2010; Johannsen et al. 2016). The nearest known specimens are from ca. 33.0 km to the southeast from northern Garfield County, Nebraska (UNSM 3542–3544).

SQUAMATA — SNAKES

***LAMPROPELTIS TRIANGULUM* (Milksnake)**. USA: NEBRASKA: Burt Co.: Craig (41.78555°N, 96.36391°W; error = 815 m). 11 June 1945. Gladis Friis. AJSM 0092. This specimen (adult male; 71.7 g; 542 mm SVL; 89 mm tail length) fills part of a large gap in the distribution of *L. triangulum* in northeastern Nebraska and is known from Washington County, Nebraska to the south (Ballinger et al. 2010; Fogell 2010) and Harrison and Monona counties, Iowa to the east (LeClere 2013). The nearest known specimen is from ca. 36.7 km to the south from Arlington, Washington County, Nebraska (UMMZ 74044).

Stanton Co.: Stanton, Robert Freiberg Farm (41.95028°N, 97.22393°W; error = 2,101 m). 18 October 1979. Robert Freiberg. AJSM 0094. This specimen (juvenile; 4.3 g; 223 mm SVL; 36 mm tail length) fills part of a large gap in the distribution of *L. triangulum* in northeastern Nebraska and is known from no surrounding counties (Ballinger et al. 2010; Fogell 2010). The nearest known specimen is from ca. 73.7 km to the east-southeast from Craig, Burt County, Nebraska (AJSM 0092; see above).

***NERODIA SIPEDON* (Common Watersnake)**. USA: NEBRASKA: Dodge Co.: Scribner (41.66667°N, 96.66586°W; error = 1,104 m). July 1966. Wyberg. AJSM 0112. This specimen (adult male; 512.7 g; 898 mm SVL; 233 mm tail length) fills part of a gap in the distribution of *N. sipedon* in eastern Nebraska and is known from Cuming County to the north and Saunders County to the south (Ballinger et al. 2010; Fogell 2010). The nearest known specimens are from ca. 19.8 km to the north from West Point, Cuming County, Nebraska (UNSM 2315, 2316).

Acknowledgments.—We thank the Wayne State College School of Natural and Social Sciences for funding to update these collections, B. Heitz for printing specimen tags, R. Johannsen for specimen measurement assistance, and students and faculty who have participated in specimen collection throughout the years. We also thank T. LaDuc (TNHC) for verifying all specimens and providing museum specimen information. Additional museum specimen information was provided by C. Siler and J. Watters (OMNH), G. Schneider (UMMZ), and T. Labedz (UNSM). Helpful comments on this manuscript were provided by J. Farkas, B. Hayford, and the University of South Dakota GrEBE Discussion Group.

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Herpetological Review, 2016, 47(4), 637–638.

New County Records of Reptiles and Amphibians from Livingston and Ford Counties in East-Central Illinois, USA

As part of ongoing field studies for our 7th grade science classes, we sampled locations in Livingston and Ford counties, Illinois, USA, for the presence of amphibians and reptiles. Herein we report six captures that represent new county records in the state of Illinois. All vouchered specimens listed are housed at the Illinois Natural History Survey (INHS), while unvouchered specimens are represented by digital images in the Non-INHS Unvouchered Illinois Herps Database (INHS Unvouch). Tissues, if collected, were given INHS a freezer location number (INHS FLN). County records were confirmed using the Illinois Herpetological Database at the INHS, which contains records of Illinois amphibians and reptiles from 30 museum collections as well as a collection of digital images of unvouchered specimens, and by examining volumes of *Herpetological Review* published since Phillips et al. (1999). Coordinates are presented in decimal degrees using map datum WGS 84. Scientific and common names follow Crother (2012).

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CAUDATA — SALAMANDERS

***AMBYSTOMA TIGRINUM* (Eastern Tiger Salamander)**. Livingston Co.: 17930 East County Road 1100 North, Fairbury, Illinois (40.786625°N, 88.591021°W). 6 October 2013. Chase Leman, Allie Zimmerman, and R. Scott Saffer. Verified by A. R. Kuhns. INHS 23631; tissue: INHS FLN 3898. This specimen was found in a window well and is the first of two collected in the area.

***AMBYSTOMA TEXANUM* (Small-mouthed Salamander)**. Ford Co.: Gardner Prairie pond at 210 Gardner St, Kempton, Illinois (40.933533°N, 88.234417°W). 15 June 2016. Matthew Huisman and R. Scott Saffer. Verified by A. R. Kuhns. INHS 25854. This larva was caught by hand from a pond in a prairie restoration.

ANURA — FROGS

***LITHOBATES PIPIENS* (Northern Leopard Frog)**. Ford Co.: Gardner Prairie pond at 210 Gardner St, Kempton, Illinois (40.933533°N, 88.234417°W). 30 September 2011. Palvee Singh, Nick Thorson, Jacki Weller, Ashton Roach, Don Gardner, and R. Scott Saffer. Verified by C. A. Phillips. INHS Unvouch 42685 (photo voucher). Caught by hand in a small drainage at prairie restoration site, photographed, and released.

Livingston Co.: 2.4 km W of Kempton on County Road 3700 North (40.936418°N, 88.254472°W). 15 June 2016. Matthew Huisman, R. Scott Saffer, and Akiko Thorson-Saffer. Verified by A. R. Kuhns. INHS 25850. First of three specimen (including INHS 25851 and INHS 25852) caught by hand on the road.

TESTUDINES — TURTLES

***APALONE SPINIFERA* (Spiny Softshell)**. Livingston Co.: under the First Street bridge on the south side of Fairbury, Illinois (40.735167°N, 88.515183°W). 14 October 2013. William Burkett, Vivian Walter, Liam Barnes, and R. Scott Saffer. Verified by M. J. Dreslik. INHS 23980. Adult skeleton found on riverbank.

***CHELYDRA SERPENTINA* (Snapping Turtle)**. Livingston Co.: Forrest Village Park, Forrest, Illinois (40.742467°N, 88.407917°W). 14 October 2013. Nathan Dotterer, Summer Huber, Alyssa Schaffer, and R. Scott Saffer. Verified by A. R. Kuhns. INHS Unvouch 42991 (photo voucher). Juvenile turtle caught by hand, photographed, and released.

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Herpetological Review, 2016, 47(4), 638.

New Amphibian and Reptile Records from Illinois, USA

The following records represent species presumed to occur but are undocumented by photos or voucher specimens, and/or fill distribution gaps in the currently recognized ranges of these species (Smith 1961; Phillips et al. 1999; TGA, unpublished database). All identifications were verified by Chris Phillips and vouchers were deposited at the Illinois Natural History Survey (INHS). Specimens collected under an Illinois Department of Natural Resources Scientific Collecting Permit (#A16.0132) issued to TGA.

ANURA — FROGS

***LITHOBATES CLAMITANS* (Green Frog)**. USA: ILLINOIS: Mercer Co.: Keithsburg, floodplain of Pope Creek and Mississippi River (41.10424°N, 90.94154°W; WGS 84). 26 April 2015. T. G. Anton. INHS 24271. Metamorph found under log in floodplain.

TESTUDINES — TURTLES

***APALONE SPINIFERA* (Spiny Softshell)**. USA: ILLINOIS: Mercer Co.: Keithsburg, floodplain of Pope Creek and Mississippi River (41.10321°N, 90.94263°W; WGS 84). 26 April 2015. T. G. Anton. INHS 24245. Dried carcass of adult male found on floodplain shoreline.

***CHRYSEMYS PICTA* (Painted Turtle)**. USA: ILLINOIS: Mercer Co.: Keithsburg, floodplain of Pope Creek and Mississippi River (41.10424°N, 90.94154°W; WGS 84). 26 April 2015. J. T. Cavataio. INHS 24246. Carapace and plastron of juvenile killed by undetermined predator found on floodplain shoreline.

***CHELYDRA SERPENTINA* (Snapping Turtle)**. USA: ILLINOIS: Putnam Co.: Hennepin, Dixon Waterfowl Refuge (41.230791°N, 89.347132°W; WGS 84). 15 April 2010. Gary Sullivan. INHS Photo 43275 (photo voucher). Adult photographed on mudflat.

***GRAPTEMYS GEOGRAPHICA* (Northern Map Turtle)**: USA: ILLINOIS: Mercer Co.: Keithsburg, floodplain of Pope Creek and Mississippi River (41.106667°N, 90.947419°W; WGS 84). 2 May 2015. D. Mills. INHS Photo 43278 (photo voucher). Adult female photographed basking on log in Pope Creek near confluence with Mississippi River.

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NATURAL HISTORY NOTES

CAUDATA — SALAMANDERS

***CRYPTOBRANCHUS ALLEGANIENSIS ALLEGANIENSIS* (Eastern Hellbender). UNUSUAL MORTALITY.** On 29 June 2016, an adult female *Cryptobranchus alleganiensis alleganiensis* (SVL = 275 mm; total length = 420 mm; 472 g) was found dead in a stream near a bridge and campsite in a tributary of the French Broad River, Transylvania Co., North Carolina, USA (site information is on file with the North Carolina Wildlife Resources Commission and is withheld to protect the specific location). The hellbender was found ventral side up with sediment covering the body (Fig. 1A) and rigor mortis had yet to set in, indicating the mortality had likely occurred within approx. 2 days. A cut fishing line (40.8 cm) was found protruding from the mouth (Fig. 1B) indicating the possibility of death due to internal injury to the stomach and esophagus, as the specimen was not emaciated based on mass and length. The carcass head was palpitated, and no external injuries or trauma were observed outside of a slight reddening at the gill slits. Further examination of the hellbender revealed the hyoid bone was fractured at the center line of the lower jaw. While the exact cause of death is uncertain, one possible explanation for this unusual mortality is that internal injury was sustained to the hellbender's hyoid bone and digestive tract during an encounter with a 2-cm long fisherman's hook (embedded approx. 57 mm deep past the throat in the stomach) and subsequent struggle, as hellbenders are capable of rapidly rotating their bodies when capturing prey (Beck 1965. Field & Stream 69:65–66). We examined the specimen for external wounds and palpable injuries, but did not detect any external injuries besides the embedded hook. This observation provides support that anthropogenic mortality is occurring (possibly due to hooking and subsequent internal injury following ingestion of hook and associated behavioral prey capture movements) in a salamander of special concern in North Carolina. Ingestion of hooks has been documented for other herpetofauna experiencing fishing pressure, including freshwater turtles, where up to 33% sampled contained hooks (Steen et al. 2014. PLoS ONE 9:e91368). The salamander is deposited in the collections of the North Carolina Museum of Natural Sciences (NCSM 90049).

Fig. 1. A) *Cryptobranchus alleganiensis alleganiensis* adult mortality as found in the stream; B) same specimen showing fishing line protruding from mouth.

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***NOTOPHTHALMUS VIRIDESCENS* (Eastern Newt). TERRESTRIAL AGGREGATION.** At 1348 h on 14 September 2016, nine *Notophthalmus viridescens* were observed under one small piece of bark (ca. 30 × 14 cm) at Mendon Ponds Park, Mendon, Monroe County, New York, USA (43.02472°N, 77.57277°W, WGS 84; 171 m elev.). Eight of the nine were huddled together (Fig. 1). The aggregation contained five individuals of the juvenile terrestrial eft stage and four adults, which are typically aquatic. It is not clear whether the adults had recently undergone the second metamorphosis to adults, as this typically happens in late August and September (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington DC. 587 pp.), or were existing adults that were forced to move to terrestrial habitat due to drought. Adults are typically aquatic (Petranka 1998, *op. cit.*) but can be forced to become terrestrial during drought years such as 2016. The aggregation was probably related to the unusually dry conditions in the area in July and August 2016. Rohr and Madison (2003. Oecologia 135:657–664) demonstrated that newts in the laboratory would huddle to conserve water during times of potential dehydration. The area where the aggregation was

FIG. 1. Nine *Notophthalmus viridescens* aggregated under a piece of bark in Mendon Ponds Park, Mendon, New York, USA.

found contains vernal pools that often contain water year around but contained no standing water at the time of the observation. I visited the site again five days later (19 September 2016) after two consecutive days with rain but there was still no water in the pools and there were no newts under the bark.

Pitkin and Tilley (1982. Copeia 1982:185–186) described an aggregation of approximately 600 adult *N. viridescens* under the ice in Massachusetts, USA during March but this is the largest terrestrial aggregation that I could find in the literature. Healy (1975. Am. Midl. Nat. 93:131–138) described finding "as many as seven efts" feeding on insects "near one mushroom" during September in Massachusetts, USA. This description, however, sounds like the newts were observed on the surface and not under a cover object. Several other newts were observed on 14 September 2016 but the only other instance of multiple newts under the same cover object was that of two small efts that were approximately 18 cm apart under a small log.

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SIREN INTERMEDIA NETTINGII **(Western Lesser Siren). OVIPOSITION.** Very little is known about the reproduction of all species of sirens (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.). For *Siren intermedia*, egg-laying has been reported to occur primarily in February to March, as noted from Arkansas (Noble and Marshall 1932. Am. Mus. Novit. 532:1–17) and South Carolina (Sever et al. 1996. J. Morphol. 227:335–348), but can occur as early as December in southern Florida (Godley 1983. Am. Midl. Nat. 110:215–219) and January in Louisiana (Raymond 1991. Southwest. Nat. 36:144–147). Here, we report the egg-laying of a wild-caught *S. i. nettingii* in the laboratory in western Kentucky, USA. To our knowledge, our account is the most northerly population with any estimate of egg-laying date. The female was captured using a minnow trap on 12 March 2007 from Murphy's Pond, Hickman Co., Kentucky, USA (36.74050°N, 88.85730°W; WGS 84). The female was transported to the laboratory at Murray State University, placed in a plastic box containing several cm water, and measured (anesthetized) 223 mm SVL and 330 mm total length (70.8 g). The siren laid eggs on 14 March 2007. The eggs were deposited in two clumps, one containing four eggs and one containing three eggs. The eggs were attached to the bottom of the container with the gelatinous matrix, such that the eggs maintained their position when the container was tilted. We implanted a Passive Integrated Transponder into the female, at which point she laid ten more eggs. We returned the siren to the site of capture to allow her to lay the remainder of her eggs in the wild, as *S. intermedia* clutch sizes are thought be around 200–500 eggs (Leja 2005. *In* Lannoo [ed.], Amphibian Declines: the Status of United States Species, pp. 910–912. University of California Press, Berkeley). The eggs laid in the laboratory were maintained in the laboratory for developmental observation. The eggs never appeared to develop and showed signs of fungus after approximately two weeks. This is consistent with recent evidence that fertilization is external (Reinhard et al. 2013. Zool. Anz. 253:1–5). This account suggests that egg-laying dates in Kentucky likely overlap considerably with more southerly areas in their geographic distribution.

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ANURA — FROGS

ATELOPUS HOOGMOEDI **(Hoogmoed Harlequin Toad). MULTIPLE AMPLEXUS.** Several species of tropical frogs, particularly those from the families Hylidae and Bufonidae, can exhibit different reproductive strategies as a way to obtain breeding pairs. During mating events, multiple amplexus, amplexus between males, interspecific amplexus, amplexus between living males and dead females (necrogamy), functional necrophilia (Izzo et al. 2012. J. Nat. Hist. 46:2961–2967) and even amplexus with inanimate objects (Mollov et al. 2010. Biharean Biol. 4:121–125) has been reported in anurans. *Atelopus hoogmoedi* is a terrestrial and diurnal species, and is most commonly found at small streams in primary forest (Ouboter and Jairam 2012. Amphibians of Suriname. Leiden, Boston. 376 pp.). Herein, w*e report for the first time multiple amplexus in A. hoogmoedi.* The event was observed at ca. 1600 h on 8 June 2016, at the margin of a stream near the company Beadell Brazil LTDA, Serra do Navio, Amapá, Brazil (0.8776°N, 51.9369°W, WGS 84; 112 m elev.). Two male *A. hoogmoedi* were observed engaging in amplexus simultaneously with the female in non-flooded forest floor. One male was in

PHOTO BY W. ALMEIDA-SANTOS

FIG. 1. Multiple amplexus in *Atelopus hoogmoedi* where two males are amplexing one female.

axillary amplexus, while a second male was in inguinal amplexus (Fig. 1). In this observation both males and female remained absolutely motionless. Individuals were not collected due to the easy identification of species. The photographic images are deposited in the herpetology laboratory of Universidade Federal do Amapá, Brazil.

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***CERATOPHRYS AURITA* (Sapo-de-chifre; Brazilian Horned Frog). MORTALITY.** *Ceratophrys aurita* is a secretive species of the Ceratophryidae that occurs across the coast of Brazil from Bahia to Rio Grande do Sul states (Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0, accessed 13 March 2016. Electronic database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York). It is a large predator of anurans (Solé et al. 2010. Salamandra 46:101–103; Schalk et al. 2014. South Am. J. Herpetol. 9:90–105). *Rhinella schneideri* is a common and toxic bufonid widely distributed from the Brazilian Amazon to northern Argentina (Frost 2016, *op. cit.*). The predation of *R. schneideri* by *C. aurita* has been reported in the literature (Toledo et al. 2007. J. Zool. 271:170–177).

About 1130 h on 15 December 2015, an adult male *C. aurita* (SVL = 12.3 cm; mouth width = 7.7 cm) was observed preying upon a subadult male *R. schneideri* (SVL = 9.4 cm; body width = 6.5 cm; Fig. 1A) in a banana plantation at Fazenda Aliança, Jacupemba, Aracruz, Espírito Santo, southeastern Brazil (19.5615°S, 40.2000°W; WGS 84). *Ceratophrys aurita* ingested the *R. schneideri* despite the fact that the prey displayed body inflation after subjugation. The predator was held captive for nearly one and a half days in an open cage, moistened and shaded. However, it was found dead; its stomach contained only the *R. schneideri* specimen (Fig. 1B). The predator death is likely due to the ingestion of a highly toxic prey. Species of the genus *Rhinella* produce toxic skin secretions which usually afford protection from predators (Clarke 1997. Biol. Rev. 72:365–379). It is noteworthy that the width ratio between predator's mouth and prey body (Fig. 1B) is remarkably low (1.18). The predator and its prey (MBML 8305) are housed at the Zoological Collection of Museu de Biologia Prof. Mello Leitão, Instituto Nacional da Mata Atlântica, Espírito Santo, Brazil.

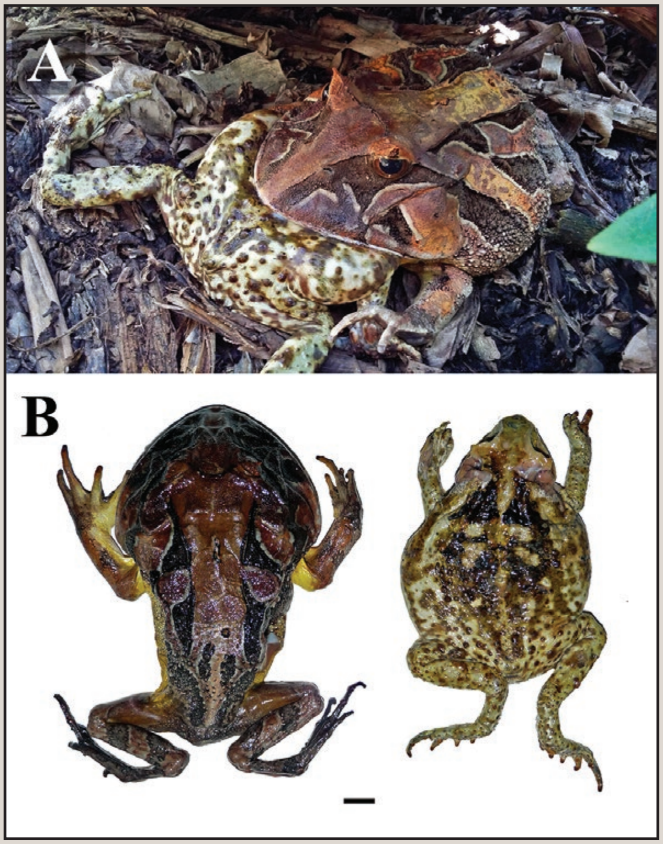

PHOTO BY RUBENS A. RIBEIRO

FIG. 1. A) *Ceratophrys aurita* preying upon *Rhinella schneideri* and (B) predator and prey after stomach content analyses (scale bar = 1 cm).

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***HYLA EXIMIA* (Mountain Tree Frog). PREDATION.** *Hyla eximia* is a small treefrog of wide distribution and high elevations from the mountains of Arizona and New Mexico, USA to south of the Sierra Madre Occidental and Guerrero, Mexico (Degenhardt et al. 2005. Amphibians and Reptiles of New Mexico. University of New

FIG. 1. Nest of a female Black Widow (*Latrodectus mactans*) with dead prey (*Hyla eximia*).

Mexico Press, Albuquerque. 431 pp.). Here, we report the first record of predation on an adult *Hyla eximia* by a *Latrodectus mactans* (Southern Black Widow).

At 1132 h on 9 May 2016, during field work at the municipality of Ichaqueo, Michoacán, Mexico (19.56998°N, 101.13258°W, WGS 84; 2407 m elev.), we observed an adult female Black Widow spider feeding on an adult *H. eximia* in a nest located beneath a rock measuring 30 x 20 cm (Fig. 1). The frog was dead within the spider's nest and covered with little branches, leaves, invertebrate pieces, dust, and web (Fig. 1). The predator and prey were not collected and the rock was returned to its original position. Arachnids are well known predators of amphibians (Toledo 2005. Herpetol. Rev. 36:395–400); however, to our knowledge there are no reports identifying widow spiders as predators of amphibians. Other prey items include invertebrates and a variety of reptile prey such as European lizards (*Podarcis melisellensis*; Schwammer and Baurecht 1988. Herpetozoa 1:73–76), North American lizards (*Aspidoscelis gularis;* Carbajal-Márquez et al. 2013. Herpetol. Rev. 44:505), and several North American snakes, e.g., *Hypsiglena chlorophaea* (Ervin and Carroll 2007. Herpetol. Rev. 38:468), *Opheodrys aestivus* and *Storeria dekayi* (Neill 1948. Herpetologica 4:158), and *Contia tenuis* (Beaman and Tucker 2014. Herpetol. Rev. 45:514).

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***LEPTODACTYLUS LATRANS* (Criolla Frog). DIET.** Many amphibians have a broad diet that depends upon prey availability in the environment (Duellman and Trueb 1994. Biology of Amphibians. Johns Hopkins University Press, Baltimore, Maryland. 670 pp.). Additionally, frog diets respond to physiological factors, such as energy demand (Grayson et al. 2005. Comp. Biochem. Physiol. 141:298–304), and are influenced by morphological traits such as body size and skull shape (Emerson 1985. Herpetologica 41:177–188; Biavati et al. 2004. Herpetol. J. 38:510–518). These features enable large anurans to feed on large prey such as small mammals, birds, turtles, snakes, and other anurans (Duellman and Trueb 1994, *op. cit.*). *Leptodactylus latrans* is a large, nocturnal anuran with a generalist diet. It occurs in tropical South America east of the Andes (Maneyro et al. 2004. Iheringia Ser. Zool. 94:57–61; Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0, accessed 1 June 2016. Electronic database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York) and can be found in lentic and lotic environments of natural and anthropic areas (Solé et al. 2009. Herpetol. Notes 2:9–15). The diet of this species is composed of arachnids, crustaceans, insects, mollusks, and small vertebrates such as fishes, rodents, and anurans (Maneyro et al., *op. cit.*; Solé 2010. *In* Dodd [ed.], Amphibian Ecology and Conservation: a Handbook of Techniques, pp.167–184. Oxford University Press, Oxford).

On 23 January 2016, a male *L. latrans* (SVL = 96.26 mm; 90 g) was collected (SISBIO license 49876-1) in Campo Belo do Sul, Santa Catarina, Brazil (27.893970°S, 50.769922°W, WGS 84; 939 m elev.). During a dietary analysis, we found a partially digested corpse of the snake *Atractus* sp. comprising 100% of the stomach content of *L. latrans*. Unfortunately, the snake could not be identified to species level because of its advanced state of digestion that prevented examination of key head characters. The *L. latrans* specimen and the ingested *Atractus* sp. were both deposited in the Zoological Collection of the Universidade Federal de Santa Maria (ZUFSM 9985).

The consumption of snakes by anurans has been recorded for other large anuran species; e.g., there are reports of *Pyxicephalus adspersus* eating newly born *Hemachatus haemachatus* (Branch 1976. J. Herpetol. 10:266–268), *Lithobates catesbeianus* preying on snakes in Brazil, Canada, and China (Silva et al. 2007. Herpetol. Rev. 38:443; Jancowski 2013. NeoBiota 16:17–37; Liu et al. 2015. Asian Herpetol. Res. 6:34–44), and species of the genus *Ceratophrys* preying on a wide variety of species, including snakes (Duellman 1994. Herpetologica 50:51–64). This is the first record of a snake in the diet of *L. latrans*.

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***LEPTODACTYLUS VASTUS* (Northeastern Pepper Frog). ENDOPARASITES.** *Leptodactylus vastus* is a large terrestrial, nocturnal leptodactylid found in northeastern Brazil (Roberto et al. 2012. Biota Neotrop. 13:320–330); it belongs to the *Leptodactylus pentadactylus* group and was recently split from *L. labyrinthicus* (Heyer 2005. Arq. Zool. 37:269–348). Here, we report on nematode infections in the digestive tracts of *L. vastus* in an area of Caatinga vegetation in Aiuaba, Ceará, northeastern Brazil. Five specimens of *L. vastus* (all males; mean SVL = 10.8 cm ± SD 1.3 cm; range = 9.1–12.6 cm) were collected in the municipality Aiuaba at the Ecological Station of Aiuaba, Brazil (6.573476°S, 40.123564°W, datum SAD69; 466 m elev.) on 27 March 2011 and examined for endoparasites. Voucher specimens were deposited in the herpetological collection of the Universidade Regional do Cariri – URCA-H (LZ 1310). Parasites were preserved in 70% alcohol and subsequently mounted on temporary slides using Hoyer's medium, and identified beneath a microscope. Each specimen was dissected by a longitudinal incision and digestive tracts were removed and analyzed separately (stomach, small intestine, and large intestine). Of the five frogs examined, one was infected with five nematodes in the small intestine. The nematodes were identified (according to Vicente et al. 1991. Rev. Bras. Zool. 7:549–626) as *Oswaldocruzia mazzai* Travassos, 1935. The parasite genus *Oswaldocruzia* parasitizes mainly amphibians and, less frequently, reptiles (Ben Slimane et al. 1996. Mem. Inst. Oswaldo Cruz 91:317–328). Species of *Oswaldocruzia* are distinguished on the basis of the relative disposition of bursal rays and the shape of the spicule tips (see Vicente et al. 1991, *op. cit.;* Ben-Slimane and Durette-Desset 1996. Misc. Zool. 19:55–66). In South America there are 13 species of *Oswaldocruzia* infecting amphibians (Campião et al. 2014. Zootaxa 3843:1–93). There are records of *O. mazzai* infecting Leptodactylidae, Bufonidae, and Craugastoridae frogs in Brazil, Ecuador, and Guyana (Campião et al. 2014, *op. cit.*). To our knowledge, *L. vastus* is a new host for *O. mazzai*.

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LITHODYTES LINEATUS **(Painted Antnest Frog). ASSOCIATION WITH *ATTA* ANTS.** The first report showing the association between *Lithodytes lineatus* and leaf-cutting ants of the genus *Atta* was described by Schlüter (1980. Salamandra 164:227–247) who heard individuals vocalizing inside the galleries of these ants. Later, other observations involving the association between these genera were published and, until now, involved *L. lineatus* using active nests of *Atta cephalotes* to vocalize and also as breeding sites (Schlüter and Rëgos 1981. Amphibia-Reptilia 2:117–121; Lamar and Wild 1995. Herpetol. Nat. Hist. 32:135–142; Schlüter et al. 2009. Herpetol. Notes 2:101–105). However, the taxonomic identities of other species of *Atta* that *L. lineatus* associates with have not yet been described.

We conducted active searches to find *L. lineatus* in Rondônia, Brazil. At ca. 1800 h on 9 March 2015 in the left bank of the Jaci Paraná river (9.4116°S, 64.4441°W, WGS 84) we saw one individual vocalizing at the entrance to the ant nest of *A. laevigata* (Fig. 1), and heard six other individuals. In the bank of the Madeira river (9.1467°S, 64.5095°W, WGS 84) between 1800 and 2000 h on 12 March 2015, we found four juveniles and one newly metamorphosed froglet (with the remnants of a tail) of *L. lineatus* emerging from entrances of the anthill of *A. sexdens*.

Besides the two species of *Atta* found in this study, *A. cephalotes* also occurs in the region (Della Lucia 2011. Formigas cortadeiras: da Bioecologia ao Manejo. UFV, Viçosa, Minas Gerais. 421 pp.), however, nests of this species were not detected. The taxonomic identity of *Atta* is an important contribution to understand details of the natural history of *L. lineatus* and these are the first records of the use of active nests of ants *A. laevigata* and *A. sexdens* by *L. lineatus*.

We are grateful to Santo Antônio Energia who provided logistical support during fieldwork in Rondônia, to Fabricio Baccaro who helped identify the ants, and to Albertina Lima who indicated the localities.

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Fig. 1. An adult male *Lithodytes lineatus* inside an active nest of the leaf cutting ant *Atta laevigata.*

MICROHYLA BUTLERI **(Tubercled Pygmy Frog). PREDATION.** At 2112 h on 15 August 2008, at the Xishuangbanna Tropical Botanic Garden (21.92906°N, 101.25269°E, WGS 84), Yunnan Province, China, we observed the female (bottom member) of a breeding

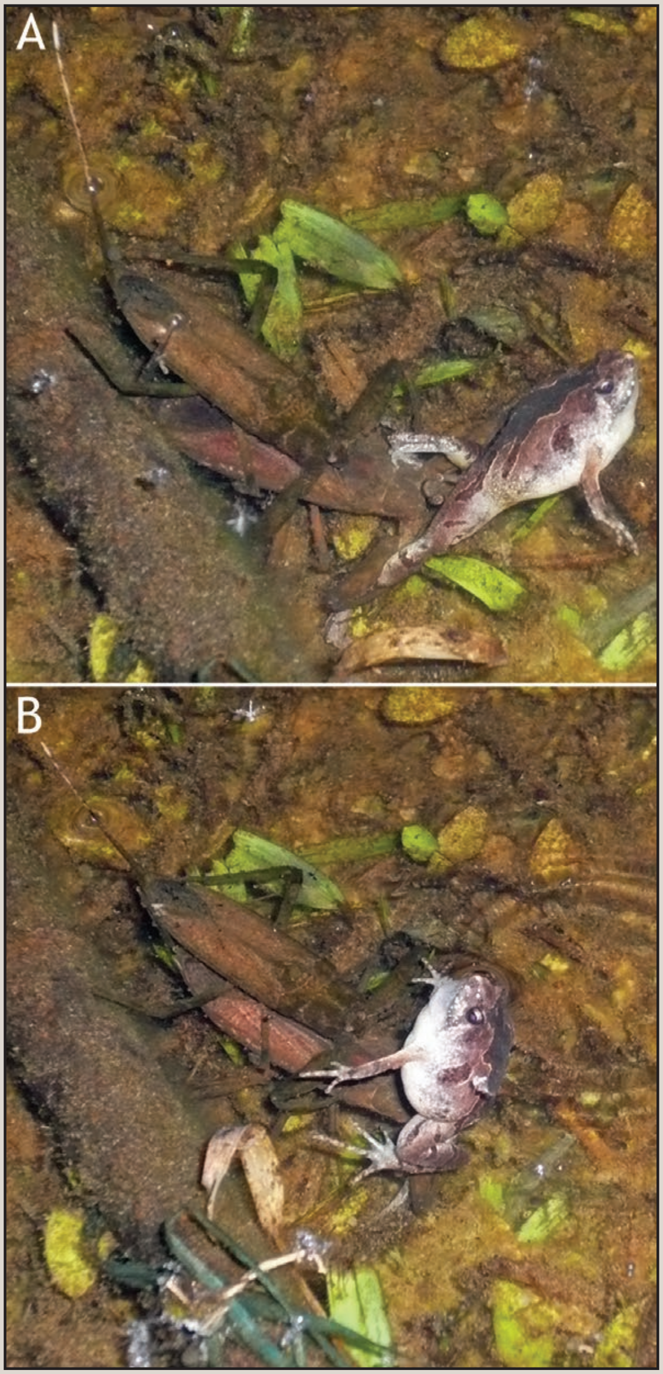

PHOTO BY M. R. HELMUS

Fig. 1. Female water scorpion preying on an adult *Microhyla butleri.* A) The initial stages of predation; the female nepid (bottom member of breeding pair) grabbed the rear leg of the *M. butleri* and pierced the frog with her rostrum. B) Minutes later, the frog was subdued and immobilized.

pair of Nepidae (water scorpion) prey upon an adult *Microhyla butleri* (Fig. 1). The female grabbed the frog with her forelimbs and pierced it with her rostrum (Fig. 1). Nepids inject their prey with digestive enzymes from their rostra and we presume this is what occurred here. The frog was quickly immobilized and the female began to feed on the frog (Fig. 1). The male nepid remained attached to the top of the female for the duration of the feeding but did not participate in the consumption of the *M. butleri*. *Microhyla butleri* are small (SVL ca. 21 mm) frogs and this one was easily handled by the nepid female. We have tentatively identified the insects as being from the genus *Laccotrephes* (subfamily Nepinae), however, species determination within this group can be difficult for Southeast Asian species (Polhemus and Polhemus 2013. Raffles Bull. Zool. 61:25–45). We observed this behavior in a shallow, still, ephemeral pool with emergent vegetation, the preferred habitat of nepids (Menke 1979. Bull. California Insect Surv. 21:70–75). Although nepids frequently consume aquatic prey including insects, gastropods, and tadpoles, to our knowledge, this is the first report of predation on an adult microhylid.

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MYERSIELLA MICROPS **(Rãzinha-assobiadora-da-mata; Elongated Frog). ANTIPREDATOR MECHANISMS.** *Myersiella microps* (Microhylidae) is a small (20–40 mm) globular frog with a very small head and tapered snout. It is an elusive inhabitant of forest leaf-litter across the Brazilian Atlantic Forest (Izecksohn and Carvalho-e-Silva. 2001. Anfíbios do Município do Rio de Janeiro. Editora UFRJ, Rio de Janeiro. 148 pp.). Here, we report on antipredator mechanisms of two individuals of *M. microps* hand-captured from the leaf litter during nocturnal surveys. On 15 February 2015, we captured an individual at Parque Nacional Serra dos Órgãos, Teresópolis, Rio de Janeiro, southeastern Brazil (22.4899°S, 43.0699°W, WGS 84; 1187 m elev.). First, the individual remained motionless but then it fled and hid. After recapture, it fought (i.e., kicked the limbs vigorously) to avoid subjugation. When released back on the ground, it fled away, hid, and remained motionless. After being recaptured again, it simultaneously displayed fighting (i.e., vigorous kicking), body inflation, and release of odoriferous and adhesive secretions. It also emitted a distress call and displayed thanatosis with legs slightly stretched.

On 19 November 2015, we captured another individual at Pedra do Garrafão, Santa Maria de Jetibá, Espírito Santo, Brazil (20.1671°S, 40.9284°W, WGS 84; 1300 m elev.). This individual was a male that stopped calling when we approached it. When we visualized it under the leaf litter, it remained motionless until we hand-captured it. When we released it in a plastic bucket, it displayed stiff-legged behavior (Fig. 1A). It also displayed body-raising with legs vertically stretched when disturbed by a stick (Fig. 1B, C). During both postures, the individual displayed body inflation. The individual tried to flee several times. It is deposited in the Zoological Collection of Museu de Biologia Mello Leitão, Brazil (MBML 8816). We report for the first time a detailed repertoire of antipredator mechanisms of *M. microps*, contributing to the knowledge of behavioral ecology of this species.

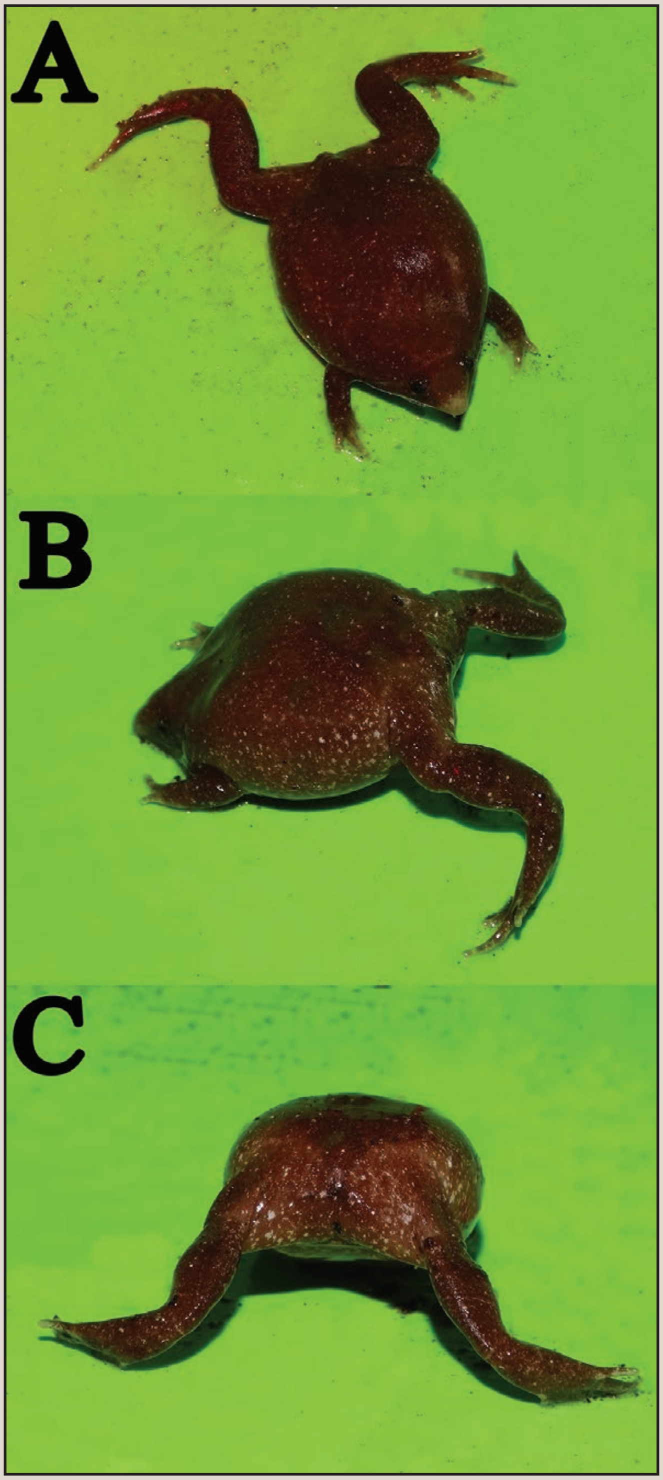

Fig. 1. Antipredator postures of *Myersiella microps* (MBML 8816): A) stiff-legged behavior; B) and C) body raising with legs vertically stretched.

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***ODORRANA AMAMIENSIS* (Amami Tip-nosed Frog). MORPHOLOGICAL DIFFERENCES IN BREEDING INDIVIDUALS.** We report on morphological differences in breeding (versus non-breeding) individuals of both sexes of *Odorrana amamiensis*. *Odorrana amamiensis* is endemic to Amami-Oshima Island and Tokunoshima Island, southern Japan (Matsui 1994. Zool. J. Linn. Soc. 111:385–415). This frog is listed as Endangered by the IUCN Red List (Kaneko and Matsui 2004. http://www.iucnredlist.org/details/58541/0; accessed 23 Aug 2016), but their natural history, including breeding ecology, has not been described except by Maeda and Matsui (1999. Frogs and Toads of Japan, revised edition. Bun-ichi Sogo Shuppan, Tokyo) who reported that this frog bred at mountain streams between October and May, and only males had vocal sacs to produce mating calls.

We observed morphological differences between breeding and non-breeding individuals on Amami-Oshima Island. We sexed individuals by gently opening their mouths with forceps and inspecting the vocal sac area; vocal sacs were present in males and absent in females. We sampled 39 breeding individuals (13 females and 26 males) at a breeding site (28.20956°N, 129.26982°E, WGS 84; 306 m elev.) in the breeding season (October–December 2015), and 39 non-breeding individuals (32 females and 7 males) at the forest near the breeding site in the non-breeding season (June–September 2015 and May 2016). We could not find frogs precisely at the breeding site in the non-breeding season because the frogs dispersed to the forest in the non-breeding season.

We found all of the breeding individuals of both sexes developed tiny spines throughout the side of their jaw and knees (Fig. 1A, Fig. 2A), while the spines were not observed in non-breeding individuals (Fig. 1B, Fig. 2B). We also found that the ventral body color of breeding individuals (Fig. 1A, Fig. 2A) were dark compared to non-breeding individuals (Fig. 1B, Fig. 2B).

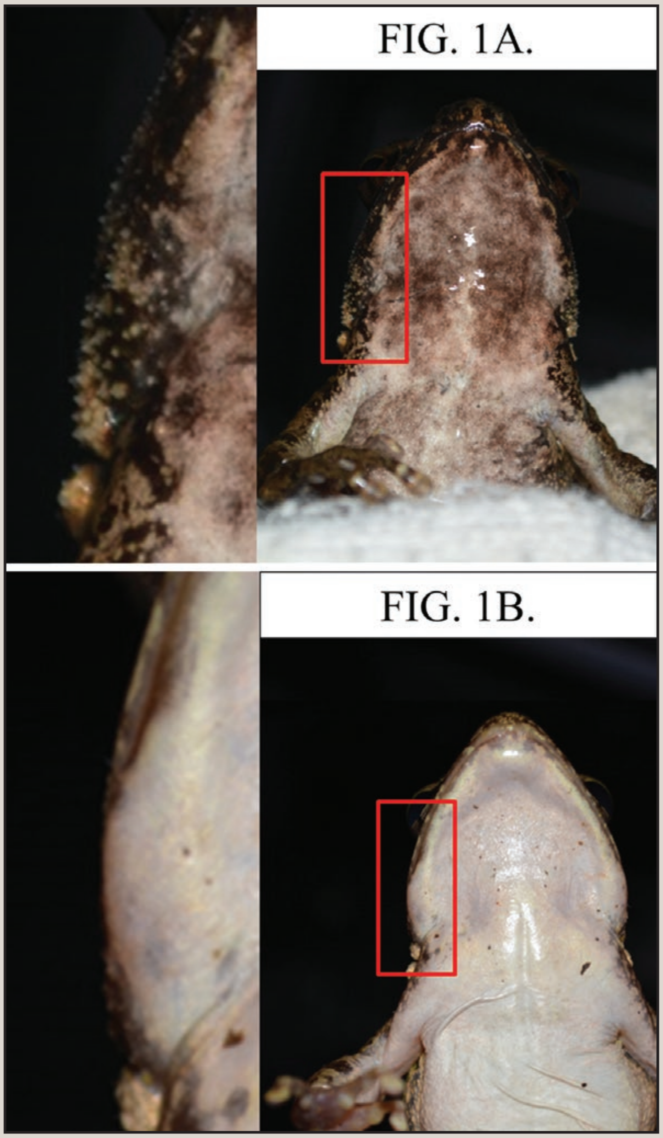

PHOTO: H. KOMINE.

Fig. 1. Ventral view of a female *Odorrana amamiensis* in the A) breeding season, and B) non-breeding season.

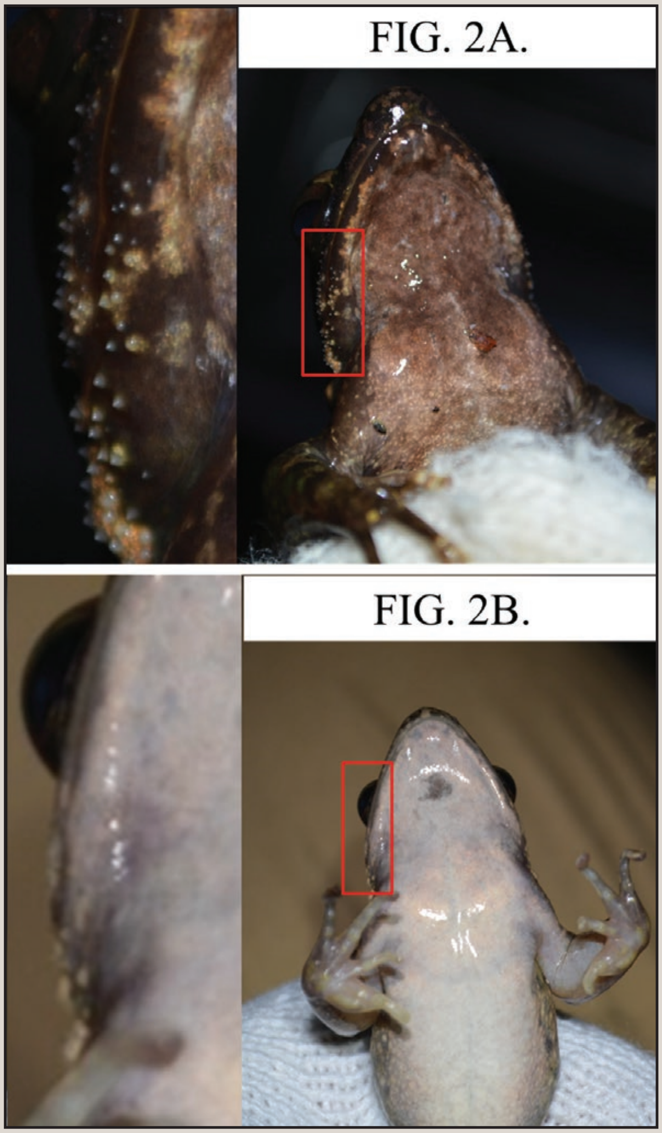

PHOTO: H. KOMINE.

Fig. 2. Ventral view of a male *Odorrana amamiensis* in the A) breeding season, and B) non-breeding season.

We did not confirm whether these morphological differences occurred in non-breeding individuals in the breeding season. It is well known that morphological changes occur in one sex (often in males) in breeding individuals (e.g., the development of nuptial pads to hold females). However, morphological changes that occur in both sexes are not common. Previous studies reporting on the functions of spines in frogs found that they are associated with sexual dimorphism (Cadle 1995. Zool. J. Linn. Soc. 115:313–345) or anti-predator strategies (e.g., camouflage; Guayasamin et al. 2015. Zool. J. Linn. Soc. 173:913–928, weapons with venom; Jared et al. 2015. Curr. Biol. 25:2166–2170). In this report, the function of the tiny spines of *O. amamiensis* is not clear, however morphological changes in both sexes may mean that the trait is favored by natural selection rather than sexual selection. Further research is required on the duration and function of the morphological change and whether such traits exist throughout the lineage of *Odorrana.*

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***PIPA ARRABALI* (Arrabal's Amazonian Toad). PREDATION.** Amphibians comprise part of the diet of a wide variety of animals including insects, such as water bugs. Water bugs prey on a diversity of aquatic animals, for example insects, cladocerans, amphibians, and small fish (Cullen 1969. Proc. R. Entomol. Soc. A. 44:123–137; Smith 1980. Nat. Hist. 89:56–63; Eterovick and Sazim. 2000. Amphibia-Reptilia 21:439–461; Hirai and Hidaka 2002. Ecol. Res. 17:655–661; Toledo 2003. Phyllomedusa 2:105–108; Toledo 2005. Herpetol. Rev. 36:395–400; Toledo et al. 2005. Herpetol. Bull. 90:29–31). The Pipidae comprises aquatic frogs widely distributed in the Neotropical region, including Amazonian South America, occurring in temporary ponds and swamps (Trueb and Cannatella 1986. Herpetologica 42:412–449; Lima et al. 2008. Guide to the Frogs of Reserva Adolpho Ducke, Central Amazonia. Áttema Design Editorial, Manaus. 168 pp.). Owing to its aquatic habits, these frogs may be predated by large aquatic insects that occur in the same environment, such as those of the Belostomatidae.

Fig. 1. *Pipa arrabali* being preyed upon by *Lethocerus maximus.*

We report the first record of a water bug (*Lethocerus maximus*) preying on an adult *Pipa arrabali* (Fig. 1). At 1833 h on 22 November 2005 we observed the predation in a temporary pond on the reserve ZF-2 (2.6588°S, 60.0660°W; WGS84), located 14 km N of Manaus, Amazonas on Hwy BR-174, Brazil. The *L. maximus* was holding the frog ventrally with all pairs of legs wrapped around the frog's body to immobilize it (Fig. 1B). The frog was immobilized in the ventral region and died likely due to action of enzymes and toxins. Water bugs inject toxins causing paralysis and digestive enzymes producing necrosis (Swart and Felgenhauer 2003. Ann. Entomol. Soc. Am. 96:870–882). The *L. maximus* had a length of 68 mm, and began to ingest the frog through the same location of the initial bite. The frog (SVL = 54 mm) showed no other injury, which might indicate that the insect does not remove the proboscis from the prey's body before beginning ingestion.

This study increases the list of invertebrates that can prey on adult frogs. Furthermore, we highlight the ability of *L. maximus* to prey on frogs of robust size such as *P. arrabali.*

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***PRISTIMANTIS BACCHUS* (Wine Robber Frog). PARENTAL CARE AND CLUTCH SIZE.** *Pristimantis* is an anuran genus represented by 495 species with a distribution that includes the southern Caribbean, and Central America, and South America. 218 species of *Pristimantis* are known from Colombia (Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0 (accessed 21 July 2016). Electronic Database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York). As with all terraranan frogs, *Pristimantis* exhibits direct development (Duellman and Lehr 2009. Terrestrial-Breeding Frogs (Strabomantidae) in Peru. NTV Natur Und Tier-Verlag, Berlin. 382 pp.). To date, published information on clutch size, nest type, and parental care exist for only ca. 17 species of *Pristimantis.* The aim of this note is to provide these valuable natural history data for an endangered frog located on the western slopes of the Cordillera Oriental in Colombia. *Pristimantis bacchus* is restricted to oak forests in the Department of Santander, Colombia (Lynch 1984. Milwaukee Public Mus. Contrib. Biol. Geol. 60:1–19). This species is listed as Endangered by the IUCN due to habitat loss caused by agricultural practices (Castro et al. 2004. http://www.iucnredlist.org/details/56447/0; accessed 21 Jul 2016).

On 14 May 2015, we found an adult female of *P. bacchus* (SVL = 38.15 mm), sitting on a clutch of 57 eggs (Fig. 1A) at El Diviso, Vereda La Colorada, municipality San Vicente de Chucurí, Department of Santander, Colombia (6.7924°N, 73.4798°W, WGS 84; 1373 m elev.). We determined the frog was a female based on her body size (SVL is < 30 mm in males). The female and her egg mass were on a superficial root next to small and medium-sized rocks. At the time we found the clutch, the female was completely covering the egg mass with her head and body, allowing us to deduce the presence of parental care by the female. We temporarily removed the female from the clutch to examine the eggs. The eggs were spherical with a cream coloration and the mass of eggs was roughly conical-shaped, reminiscent of a bunch of grapes. The clutch size of *P. bacchus* is the largest on record for *Pristimantis* in Colombia, and the second largest reported for the genus so far, after the Ecuadorian species *P. vertebralis* with 67 eggs (Lynch and Duellman 1997. Spec. Publ. Nat. Hist. Mus. Univ. Kansas 23:1–236).

Additionally, at 2315 h on 15 May 2015, during a nocturnal visual encounter transect at the same site, we found a pair in axillary amplexus on a leaf ca. 1 m above the ground (Fig. 1B).

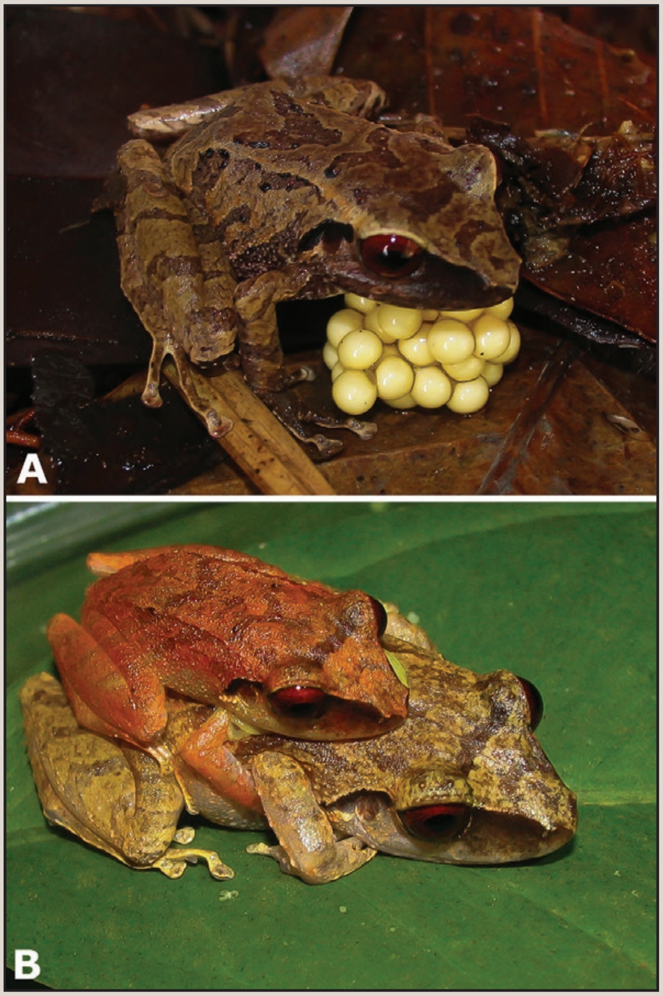

Fig. 1. A) *In situ* photograph of female *Pristimantis bacchus* as discovered attending her eggs in Diviso, San Vicente de Chucurí, Santander, Colombia. B) Axillary amplexus in *Pristimantis bacchus.*

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***RANA AURORA* (Northern Red-legged Frog). PREDATION.** Like most ranids, the American Bullfrog (*Lithobates catesbeianus* = *Rana catesbeiana*) is an opportunistic predator which will eat most prey it can swallow (Dodd 2013. Frogs of the United States and Canada. Johns Hopkins University Press, Baltimore, Maryland. 982 pp.). *Lithobates catesbeianus* was first introduced to Oregon in 1914 by the Oregon Department of Fish and Wildlife (Hazeltine 1915. Oregon Sportsman 3:170–171) and has since become established in many parts of the state (Jones et al. 2005. Amphibians of the Pacific Northwest. Seattle Audubon Society, Seattle, Washington. 227 pp.). *Lithobates catesbeianus* is often cited as a predator of *Rana aurora*, a smaller ranid native to the Pacific Northwest (Corkran and Thoms 1996. Amphibians of Oregon, Washington, and British Columbia. Lone Pine Press, Renton, Washington. 176 pp.; Jones et al. 2005, *op. cit.*), and has been implicated in the decline of the latter species (Nussbaum et al. 1983. Amphibians and Reptiles of the Pacific Northwest. University of Idaho Press, Moscow, Idaho. 332 pp.). To date, however, only a single field observation of such predation has been

Fig. 1. Radiograph of *Lithobates catesbeianus* with tagged *Rana aurora* in stomach (left side of photo). Note long bones and PIT tag (length = 12.5 mm) of the *R. aurora.*

published: Twedt (1993. M.A. Thesis, Humboldt State University, Arcata, California. 66 pp.) reported finding four "juvenile" *R. aurora* in a sample of *L. catesbeianus* stomachs (N = 22), but did not note the size of either species, nor how many stomachs in which the four consumed frogs were found. To address the deficiency of published field observations, we here report the consumption of *R. aurora* by *L. catesbeianus* under field conditions.

The following observation was made at a small (17 × 11 m) spring-fed pond located in the floodplain of the Yamhill River near McMinnville, Washington County, Oregon, USA (45.2117°N, 123.1972°W, WGS 84; 45 m elev.). The pond is permanent, heavily shaded, and is used by *R. aurora* year-round. *L. catesbeianus* adults and larvae are occasionally observed in the pond. At 1430 h on 23 May 2016, we captured an adult female *L. catesbeianus* (SVL = 145 mm; 365.8 g with prey). This frog contained an adult female *R. aurora* that had previously been marked with a PIT tag (Fig. 1). When last captured (on 25 March 2016), the *R. aurora* had measured 67.0 mm SVL and weighed 21.7 g, a size which would make it nearly half (46%) of the length of the *L. catesbeianus*, but less than one tenth (0.06%) of its mass.

We are interested in additional observations of such predation and request correspondence on the subject.

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***RANA AURORA* (Northern Red-legged frog). TRANSPORT.** *Rana aurora* is native to extreme northwestern coastal California, coastal Oregon, and Washington west of the Cascade Range, and southwestern British Columbia (Pearl 2005. *In* Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 528–529. University of California Press, Berkeley, California). On 9 December 2010, we were contacted by a South Pasadena, California, USA resident who reported that she had discovered a frog in the holiday tree she had purchased from the lot at a local drugstore the week before. A photo identification by SSS determined that it was a subadult *R. aurora.* Inquiry to the source of the trees at the drugstore confirmed that they had been sourced in Oregon, USA.

Records of amphibians dispersing to areas outside of their native range via holiday trees are increasing. *Pseudacris regilla* has been observed hitching a ride on holiday trees outside of its native range from Oregon to Arizona (Rorabaugh et al. 2004. Southwest. Nat. 49:94–99) and from the Pacific Northwest (USA) to Guam (Christy et al. 2007. Divers. Distrib. 13:598–607). The phenomenon is not restricted to frogs—an *Ambystoma gracile*, native to the Pacific Northwest, USA, was discovered in a holiday tree in Fort Lauderdale, Florida, USA, and three others were discovered via similar routes in southern California, USA—in San Diego, Fresno, and Santa Barbara counties (Rochford et al. 2015. IRCF Rept. Amphib. 22:126–127).

The spread of non-native amphibians can result in invasion and establishment in novel habitats through transport via the horticultural trade, with potential for negative ecological and conservation consequences (Kraus et al. 1999. Herpetol. Rev. 30:21–25; Kraus and Campbell 2002. Biol. Invasions 4:327–332). Trade and transport of amphibians provides unique potential for novel pathogens, such as the amphibian chytrid fungi *Batrachochytrium dendrobatidis* and *B. salamandrivorans*, to spread and invade naïve populations (Fisher and Garner 2007. Fungal Biol. 21:2–9; Martel et al. 2014. Science 346:630–631).

We notice that in recent years holiday trees are being sheathed in tighter cylinders of plastic webbing, which may be making the interior of the trees either more attractive as a refuge when stored lying on the ground, or more difficult to escape from until the tree is cut loose.

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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***RANA BLAIRI* (Plains Leopard Frog). REPRODUCTION.** *Rana blairi* is distributed across most of the southern Great Plains, from the High Plains of Texas and New Mexico north to the Western Corn Belt Plains of eastern Nebraska, reaching its northernmost extent in southeastern South Dakota (Dodd 2013. Frogs of the United States and Canada, Volume 2. The Johns Hopkins University Press, Baltimore, Maryland. 982 pp.). Due to the wide range of latitudes that *R. blairi* occupies, breeding seasons typically begin earlier in lower latitudes. For example, the breeding season is reported as early as February in Oklahoma (Bragg 1950. *In* Bragg et al. [eds.], Researches on the Amphibia of Oklahoma, pp. 35–38. University of Oklahoma Press, Norman, Oklahoma), Texas (Tipton et al. 2012. Texas Amphibians: A Field Guide. University of Texas Press, Austin, Texas. 309 pp.), and New Mexico (Scott and Jennings 1985. Occas. Pap. Mus. Southwest. Biol. 3:1–21). However, *R. blairi* reproduction typically begins in March in southern Nebraska and April in northern Nebraska (Lynch 1985. Trans. Nebraska Acad. Sci. 13:33–57), while breeding seasons are reported to occur from late March through May in Iowa (LeClere 2013. A Field Guide to the Amphibians and Reptiles of Iowa. ECO Herpetological Publishing & Distribution, Rodeo, New Mexico. 349 pp.) and March–June in South Dakota (Kiesow 2006. Field Guide to the Amphibians and Reptiles of South Dakota. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota. 178 pp.). Recent data suggest that some anurans in South Dakota might continue to breed much later than previously expected (Blais et al. 2015. Herpetol. Rev. 46:416–417). Here, we report an observation of a late season breeding event by L. blairi in South Dakota.

On 2 September 2015, a large *R. blairi* egg mass was found in a riparian wetland along the Missouri River ca. 13.1 km SSE of Elk Point, Union Co., South Dakota, USA (42.56766°N, 96.65469°W; WGS 84). These eggs were attached to vegetation along the shoreline (Gosner Stage 17) and were likely laid the preceding night. A portion of the egg mass was brought to the University of South Dakota and allowed to hatch, develop, and complete metamorphosis to confirm species identification. Eggs, tadpoles, and post-metamorphic juveniles were vouchered from this clutch and deposited at the Biodiversity Collections at the University of Texas at Austin (eggs: TNHC 97894 [DRD 2256]; tadpoles: TNHC 97895 [DRD 2382]; juveniles: 97891 [DRD 2371], 97892 [DRD 2380], 97893 [DRD 2381]). Specimens were collected under a South Dakota Department of Game, Fish and Parks Scientific Collector's Permit (#11) issued to DRD.

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***RHACOPHORUS BIPUNCTATUS* (Twin-spotted Tree Frog). ENDOPARASITE.** *Rhacophorus bipunctatus* occurs in northeastern India, northern Bangladesh, eastern Tibet, southern China, Laos, Vietnam, southwestern Cambodia, Myanmar, Thailand, and Perak, Peninsular Malaysia (Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0, accessed 16 April 2016. Electronic database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York). Previous helminth records for *R. bipunctatus* are the monogenean *Polystoma indicum*, cestode *Cylindrotaenia baeri*, plerocercoid cestode larvae, and the nematode *Rhabdias ranae* from India (Imkongwapang et al. 2014. J. Parasitol. Dis. 38:85–100). In this note we add to the helminth list for *R. bipunctatus*.

We examined six *R. bipunctatus* (mean SVL = 30.33 mm ± 1.2 SD, range = 29–32 mm) from Peninsular Malaysia, Perak state, Bukit Larut (4.324758°N, 101.324758°E; WGS 84) collected in June 2012 by LLG and deposited in the herpetology collection of La Sierra University, Riverside County, USA as LSUHC 10635-10637, 10670, 10687, 10932.

The digestive tract was removed and the esophagus, stomach, small and large intestine were opened and their contents examined for parasites utilizing a dissecting microscope. One female nematode was found in the small intestine of LSUHC 10637. Prevalence (number infected hosts/number examined hosts × 100) = 17%. The nematode was placed in a drop of lactophenol on a glass microscope slide, cover slipped, studied under a compound microscope, compared with the original description, and identified as *Falcaustra purchoni*. The helminth was deposited in the Harold W. Manter Laboratory (HWML), University of Nebraska, Lincoln, USA as HWML 98398.

Falcaustra purchoni was described from *Phrynoidis asper* (as *Bufo asper*) from Pahang state, Peninsular Malaysia by Yuen (1963. J. Helminthol. 37:241–250). *Rhacophorus bipunctatus* is the second host reported for *F. purchoni* and is a new host record.

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***RHINELLA SCHNEIDERI* (Cururu Toad). COPROPHAGY.** Coprophagy is common in herbivorous animals (Parra 1978. *In* Montgomery [ed.], The Ecology of Arboreal Folivores, pp. 205–229. Smithsonian Institution Press, Washington, D.C.) and insects (Nalepa et al. 2001. Insectes Soc. 48:194–201; Rodrigues 2010. Biota Neotrop. 10:123–127; Luçardo 2014. Cienc. Rural 44:652–659). However, few records of coprophagy by amphibian larvae are known (Duellman and Trueb, 1994. Biology of Amphibians. 2nd ed. Johns Hopkins University Press, London. 613 pp.). Pryor and Bjorndal (2005. Physiol. Biochem. Zool. 78:201–215; 2005. J. Exp. Zool. 303A:704–712) observed that tadpoles of *Lithobates catesbeianus* chose to feed on feces even when other food sources were available. Steinwascher (1978. Copeia 1978:130–134) showed that tadpoles of *L. catesbeianus* decreased their metabolism when feces were denied, which slowed their growth rate. Gromko et al. (1973. J. Exp. Zool. 186A:63–72) showed that the tadpoles of *L. pipiens* benefited from coprophagy by making them grow larger.

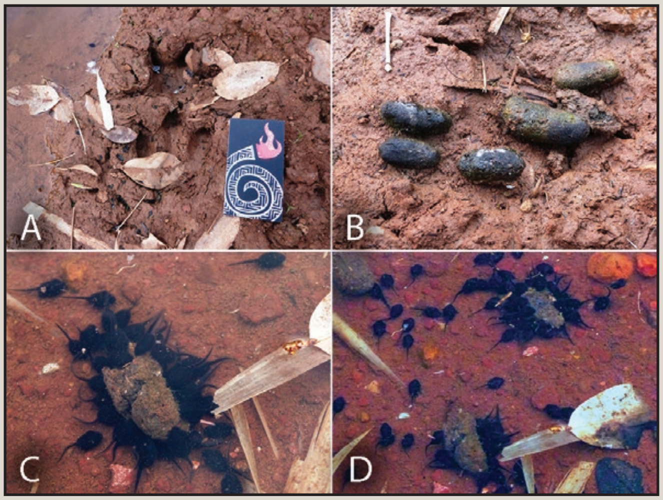

Fig. 1. Tracks (A) and scats (B) of *Hydrochoerus hydrochaeris* (Capybara) and the observed coprophagy by tadpoles of *Rhinella schneideri* (C, D) at Jardim Botânico, Goiânia municipality, Goiás state, Brazil.

Rhinella schneideri is a large toad, distributed widely in South America, from open areas of the Cerrado biome (Bastos and Araújo 2002. *In* Nascimento and Oliveira [eds.], Herpetologia no Brasil II, pp. 87–100. Sociedade Brasileira de Herpetologia, Belo Horizonte). Adults feed mainly on insect larvae, beetles and ants (Batista et al. 2011. Herpetol. Notes 4:17–21). At about 1000 h on 22 August 2015 at Jardim Botânico, a Municipal Conservation Unit of Goiânia municipality, Goiás, Brazil (16.7220°S, 49.2503°W, WGS 84) we observed the first record of coprophagy by larval *R. schneideri*. This occurred at an artificial lake connected to a stream at the edge of a gallery forest edge. Traces and feces of capybara (*Hydrochoerus hydrochaeris*) were found on the shore (Figs. 1A, B). At the time, the tadpoles fed intensively on the feces (Figs. 1C, D). We observed the event for approximately five minutes until the tadpoles ingested all the stools. Capybaras are large rodents that feed on plant matter and defecate in terrestrial or aquatic environment (Emmons and Ferr 1997. Neotropical Rainforest Mammals: A Field Guide. University of Chicago Press, Chicago, Illinois. 281 pp.). Capybaras excrete two types of stools: the first, visualized in the present event, have oval shape and green color and holds less protein than the second, called cecotrofe (Mendes et al. 2000. Appl. Anim. Behav. Sci. 66:161–167). Feces of herbivores generally have large amounts of vitamins and microbial proteins and may therefore provide *R. schneideri* a nutritious food source. Tadpole vouchers were collected and deposited in Coleção Zoológica da Universidade Federal de Goiás (ZUFG 2736).

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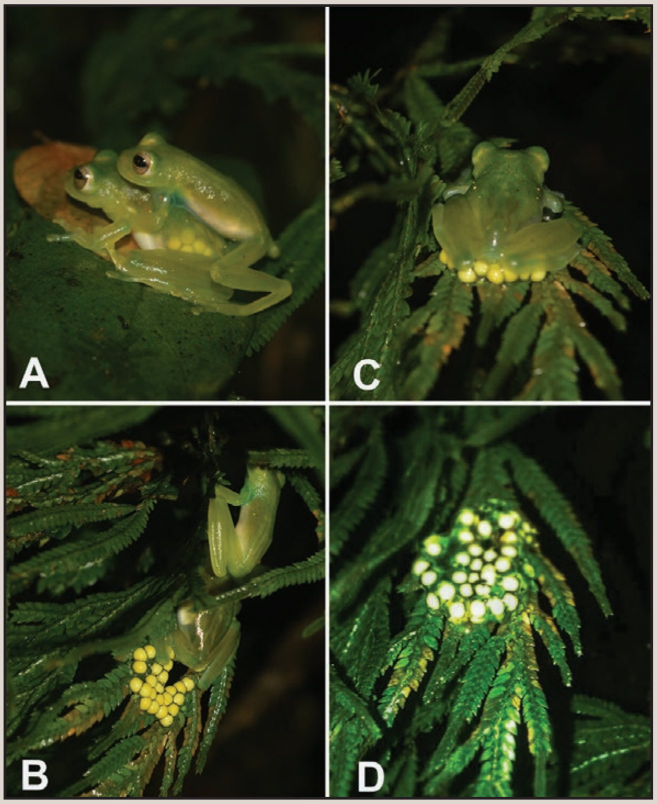
***TERATOHYLA MIDAS* (Santa Cecilia Cochran Frog). REPRODUCTIVE BEHAVIOR.** The family Centrolenidae (glassfrogs) includes 151 species of nocturnal neotropical frogs, which are associated with vegetation along streams (Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0, accessed 28 June 2016. Electronic database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York). Females lay their eggs on rocky substrates or vegetation overhanging water; after hatching, tadpoles fall into the water to complete metamorphosis (Cisneros-Heredia and McDiarmid 2007. Zootaxa 1572:1–82). Aspects of natural history of many members of this family are poorly documented, *Teratohyla midas* included (Lynch and Duellman 1973. Occ. Pap. Mus. Nat. Hist. Univ. Kansas 16:1–66; Crump 1974. Occ. Pap. Mus. Nat. Hist. Univ. Kansas 61:1–68; Toft and Duellman 1979. Herpetologica 35:71–77). Actually, there is no detailed study on the ecology or natural history of this species. Here, we provide data about amplexus and oviposition behavior of *T. midas*. We found a population of *T. midas* in the Reserva Natural y Comunitaria El Manantial in the municipality of Florencia, department of Caquetá, Colombia (1.6366°N, 74.5855°W, WGS 84; 392 m elev.). The habitat is characterized by a rocky tributary that has a width of 15–20 m and is crossed by large caverns. Along the stream there are large rocks mostly covered by vegetation where the species is found. Here, we have found other species of frogs: *Hyalinobatrachium* sp. (Centrolenidae), *Hyloxalus bocagei* (Aromobatidae), *Pristimantis* sp. (Craugastoridae), *Rhinella margaritifera* (Bufonidae), Hylidae *Hypsiboas lanciformis* (Hylidae), and *Lithodytes lineatus* (Leptodactylidae).



PHOTOS BY JUAN C. DÍAZ-RICAURTE

Fig. 1. Amplexus and oviposition behavior in the glassfrog *Teratohyla midas* in the Reserva Natural y Comunitaria El Manantial in the municipality of Florencia, department of Caquetá, Colombia. A) Male and female *T. midas* in axillary position amplexus. B) Once the female laid the eggs the male moved forward on the back of the female, leaving his ventral area in contact with the female's head for 15 min. C) Afterwards the female raised her belly moving backwards and covering the egg clutch with her body for 57 min. D) Finally, the female leaves the eggs. (Photograph D was taken with a different camera relative to A–C, therefore differences in coloration and exposure exist).

At 2320 h on 8 April 2016 in the new moon phase, we observed a male and female *T. midas* in amplexus. Also, we observed five vocalizing individuals 8 m from the amplectant pair. We observed the reproductive behavior of the amplectant pair with a red light at a distance of 1.5 m to minimize disturbance to the pair. The amplexus was observed on the upper side of a leaf (*Selaginella* sp.), 3.4 m above the water surface (Fig.1A). Over 162 min of constant observation, we observed that the female moved, jumped and sometimes crawled short distances with the male on her dorsum, five times from leaf to leaf (leaves of *Lycophyta* sp., *Selaginella* sp., or *Trychomanes elegans*) until stopping on another leaf. This behavior implied that the female was looking for a suitable place for oviposition (Guevara-Molina and Vargas-Salinas 2014. Herpetol. Bull. 128:29–30). Sometimes the male exhibited circular movements with his hind legs, usually when the female was moving, but always maintained amplexus in the nuchal and axillary position. At 0043 h oviposition began on a leaf of *Selaginella* sp. the egg-laying process lasted five seconds. The female laid 27 eggs and 3 seconds later the male moved forward on the back of the female, leaving his ventral area in contact with the head of the female for 15 min (Fig. 1B). At 0101 h the male left the female. During this period the female did not move. At 0103 h the female raised her belly moving backwards and covering the egg clutch with her body for 57 min at which time the egg clutch appeared more hydrated (see Fig. 1C). Once the female left the eggs, the male and female were captured and measured: SVL male = 21 mm, SVL female = 22 mm). The clutch consisted of 27 pale yellow eggs (mean length = 34 mm, mean width = 6 mm; Fig 1D).

The attendance of eggs by females has been recorded in other species of glass frogs such as *Espadarana prosoblepon* (Jacobson 1985. Herpetologica 41:396–404), *Nymphargus grandisonae* (Guevara-Molina and Vargas-Salinas 2014, *op. cit.*) and *Ikakogi tayrona* (M. Rada, pers. comm. cited by Cisneros-Heredia and McDiarmid 2007, *op. cit.*). Attendance of eggs by the female *I. tayrona* has been experimentally proven to prevent dehydration of the egg masses and protect them from predators and other causes of mortality (Valencia-Bravo and Delia 2015. Behav. Ecol. Sociobiol 70:41–48). We observed that when the female covered her eggs, they appeared more hydrated. However, as yet, we do not know if the attendance of eggs by the female *T. midas* keeps them hydrated and/or protects them from predators or other causes of mortality. However, our observations provide basic information on the reproductive behavior of *T. midas*. We suggest further observations of this behavior, experimentally testing whether egg care directly benefits the development of embryos.

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***VITREORANA URANOSCOPA*. PREDATION BY *ATTILA RUFUS*.** *Vitreorana uranoscopa* is a glassfrog that occurs along the Atlantic Forest domain, north of the Brazilian states of Minas Gerais and Espírito Santo and south of Rio Grande do Sul, also occurring in Misiones, Argentina (Machado et al. 2014. Herpetol. Notes 7:443–446). *Attila rufus* (Grey-headed Attila) is an endemic bird of the subtropical and tropical forests of Brazil and occupies the forest strata from the canopy through to the ground. At 1300 h on 01 November 2015 in PRNP Reserve Guaiamum, São Luiz do Paraitinga, São Paulo, Brazil (23.3167°S, 45.1667°W; WGS 84) we observed an *A. rufus* perched in woody vegetation ca. 2 m above the ground, holding a *V. uranoscopa* in its beak (Fig. 1). The *V. uranoscopa* was emitting a distress call. With the prey item in its beak, the *A. rufus* started hitting it against the branch, until after multiple hits the vocalization of the frog ceased and the bird swallowed the frog whole. This is the first report of *V. uranoscopa* being preyed upon by *A. rufus*.

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PHOTO BY RODRIGO DELA ROSA DE SOUZA

FIG. 1. *Attila rufus* preying on a *Vitreorana uranoscopa* in PRNP Reserve Guaiamum, São Luiz do Paraitinga, São Paulo, Brazil.

TESTUDINES — TURTLES

***CHELONOIDIS CARBONARIUS* (Red-footed Tortoise). ANTIPREDATOR BEHAVIOR.** Although terrestrial mammals are the primary prey of Jaguars (*Panthera onca*), large armored reptiles such as caimans, river turtles, and tortoises are a major component of their diets (Emmons 1987. Behav. Ecol. Sociobiol. 20:271–283; Emmons 1989. J. Herpetol. 23:311–314; Garla et al. 2001. Biotropica 33:691–696; Guilder et al. 2015. Mammal. Biol. 80:65–72). However, although forest tortoises figure among the main prey for *P. onca*, their strategies to alleviate predation have received little attention. Forest tortoises are diurnal, terrestrial, primary frugivores that also commonly feed on flowers, fungi, leaves, insects, and carrion (Moskovits 1985. PhD. Dissertation, University of Chicago, Illinois; Moskovits and Bjorndal 1990. Herpetologica 46:207–218). Here, I reported on opportunistic observations on shelter use by *Chelonoidis carbonarius* that could be interpreted as an antipredator strategy.

The data were recorded in an undisturbed forest at Maracá Ecological Station (MES). MES is a 1013 km^2 riverine island located in the Uraricoera River, in the state of Roraima, northern Brazilian Amazonia (3.3622°N, 61.4336°W; SAD 69), positioned on the ecotone between the Amazonian forest and Roraima-Rupununi savannas of the Guyana Shield (Moskovits 1985, *op. cit.*; Mourthé 2014. Braz. J. Biol. 74:720–727). Large felids attain relatively low densities at MES (Mendes Pontes 2004. Mammal. Biol. 69:319–336; Mourthé and Barnett 2014. Folia Primatol. 85:379–398). *Chelonoidis carbonarius* and *C. denticulata* (Yellow-footed Tortoise) occur sympatrically at MES, with *C. carbonarius* being generally restricted to the savanna habitats and adjacent forests, and attaining densities five-fold higher (~1 ind./ha) than *C. denticulata* (Moskovits 1985, *op. cit.*). All observations were recorded in the eastern part of the island, an area predominantly covered by *terra firme* forest interspersed with small non-forest enclaves.

On 24 May 2008, I witnessed an adult *C. carbonarius* lodged below a tangle of lianas at the ground level. It was 1638 h and the tortoise appeared to be sleeping. On 9 May 2009 at 0835 h I recorded another *C. carbonarius* moving within a hollow log. It was probably leaving its nocturnal shelter when I observed it. On 12 May 2009 I recorded a *C. carbonarius* entering this same hollow log at 1606 h. Unfortunately, it was not possible to determine if it was the same individual recorded on 9 May 2009. On 17 July 2009 another *C. carbonarius* was recorded eating something that appeared to be a foamy leptodactylid egg clutch within another hollow log at 1534 h.

Because of their slow movements and relatively high densities, forest tortoises are easy and predictable prey for jaguars at MES and predation should be an important aspect influencing their behavior. Although well-protected shelters such as ground holes and hollow logs may also satisfy aspects of thermoregulation and humidity requirements (Moskovits 1985, *op. cit.*), they may also be used by *C. carbonarius* as night shelters for safety. Less protected shelters like a tangle of lianas are rarely used (Moskovits 1985, *op. cit.*) but even when partly open, this kind of shelter can provide a relatively safe refuge when other well-protected shelters are not available. The use of such shelters could obscure a jaguar's view or offer a tortoise a refuge that cannot be easily approached by the jaguar (Moskovits 1985, *opt. cit.*; Emmons 1989, *op. cit.*), thus diminishing the chances of predation.

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***GLYPTEMYS INSCUPLTA* (Wood Turtle). BASKING HABITAT.** The invasive grass *Phragmites australis* is generally considered an inhibitor to freshwater turtle reproductive success (Bolton and Brooks 2010. Chelon. Conserv. Biol. 9:238–243). At 1315 h on 24 May 2016 (partly cloudy, 16.0°C) we observed and documented (Fig. 1) the use of a *Phragmites australis* stand as a basking site by a female *Glyptemys insculpta.* As part of an 11-year telemetry study at the Great Swamp in Dutchess County New York, USA, this specific female, as well as several other specimens, have been observed basking in and around *Phragmites* on multiple occasions at this site during the course of the study. We observed the female basking on a sunny hummock covered with and surrounded by *Phragmites.* This specific stand of *Phragmites australis*, which we estimate at 2600 m^2, is set in and is adjacent to an area of 1.68 km^2 which is considered more typical *G. insculpta* habitat. The water depth at the site of capture was 17.8 cm. This location was in the very center of the stand. Just before capture the turtle remained cryptically basking. Upon release the turtle easily negotiated the vegetative debris and scrambled over the hummock, moving further into the thicket. The overall impacts invasive *Phragmites* might have on *G. insculpta* behavior and survival is unclear, however no previous study has documented this turtle's use of this impacted habitat for basking.

Fig. 1. Female *Glyptemys insculpta* basking on a hummock surrounded by *Phragmites australis.*

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***GOPHERUS AGASSIZII* (Mohave Desert Tortoise). PROBABLE RATTLESNAKE ENVENOMATION.** At 1340 h PST on 25 April 2008, a young, large adult male *Gopherus agassizii* (No. 4417; 241 mm in carapace length at the midline), was discovered in the shade of a Creosote Bush (*Larrea tridentata*) with head lolling downward, apparently in distress, with caked, drying blood extending from the left ocular area to the maxillary rhamphotheca (beak) (Fig. 1). The periocular region appeared swollen and the cervical integument was turgid and swollen on the left ventral aspect. The tortoise occasionally gaped, revealing a very pale tongue and associated tissues. Four spines of Silver Cholla (*Cylindropuntia echinocarpa*) protruded from the

Fig. 1. Translocated wild *Gopherus agassizii* (No. 4417) after probable envenomation from a rattlesnake and about 3 h prior to death, central Mojave Desert, California USA.

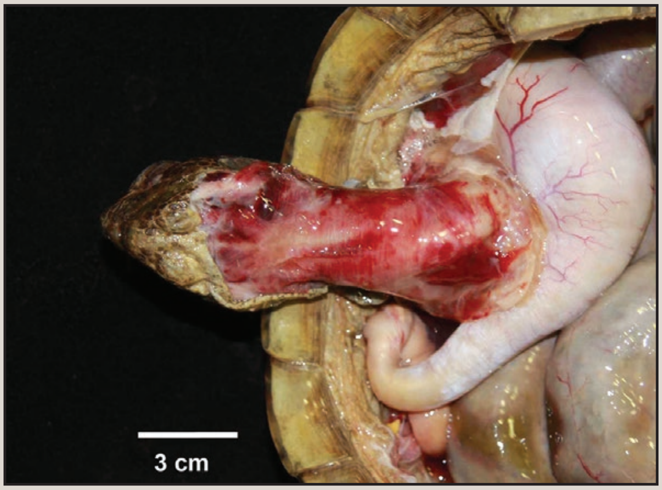

Fig. 2. *Gopherus agassizii* (No. 4417) at the time of necropsy and showing subcutaneous hemorrhage extending from the left periorbital area to the base of the cervical subcutaneous connective tissue.

left foreleg. Initial observations suggested that the tortoise had received a severe traumatic injury to the left side of the head. The tortoise expired at 1700 h, was placed on ice, and sent to one of us (ERJ) for necropsy. The necropsy revealed "hemorrhage around the inner margins of the orbit with subcutaneous hemorrhage extending from the left periorbital area to the base of the cervical subcutaneous connective tissue." Tissue damage was compatible with rattlesnake envenomation (Jacobson and Berry 2012. J. Wildl. Dis. 48:1063–1068). Three species of rattlesnakes have been observed in the area: *Crotalus cerastes* (Sidewinder Rattlesnake), *C. scutulatus* (Mohave Rattlesnake), and *C. mitchellii pyrrhus* (Speckled Rattlesnake) or *C. stephensi* (Panamint Rattlesnake) (Douglas et al. 2007. Copeia 2007:920–932). Based on our observations, *C. cerastes* and *C. scutulatus* were more common than *C. stephensi*, and *C. scutulatus* was more aggressive than the other two species. However, the appearance of the tissue at gross necropsy (Fig. 2) was compatible with venom from a rattlesnake in the *C. mitchellii pyrrus*/*C. stephensi* group, because this group produces an extremely hemorrhagic venom and is more likely to bite than *C. cerastes* (Stephen P. Mackessy, pers. comm.).

The tortoise had been fitted with a radio transmitter and was part of a major translocation project designed to move several hundred tortoises off of the National Training Center, Fort Irwin, in the central Mojave Desert, California (Heaton et al. 2008. Biodivers. Conserv. 17:575–590), and to study health and diseases of tortoises prior to and after translocation (Berry et al. 2015. J. Wildl. Manage. 79:122–136). On 8 April, 17 days earlier, the tortoise had been translocated 17.75 km to the WSW from its home site and released on a plot on the alluvial fan of the Paradise Range, San Bernardino County, California. Initially the tortoise was tracked daily and then every few days for a total of 11 different observations between release and the day of death. The tortoise moved about 807.2 m/day (based on point-to-point locations) for the first six days; over 17 days, it traveled at an average rate of 467 m/day. On the day of death, the tortoise had travelled a minimum of 7.9 km in footpath distance (total, point-to-point observations) and was approximately 2 km W of the release site. We hypothesize that the tortoise probably encountered the rattlesnake on the same day it was found dying, possibly by inadvertently stepping on it or coming too close to it. Less likely is an encounter in a burrow, because a nearby burrow could not be found on the day of death, even with careful searching. However, the tortoise was observed on the mound of a burrow on 10 April and digging a pallet on 14 April. We have frequently observed *G. agassizii* in burrows with rattlesnakes in the western Mojave Desert (usually *C. scutulatus*), as have other scientists (Walde et al. 2014. Herpetol. Rev. 45:688). Strikes at and deaths of *G. agassizii* from rattlesnake envenomation may occur and not be observed, because death results in a few hours or days and the cause of death may be obscured by retreat to shelters, putrefaction, or scavenging. Funding for the translocation project was from the National Training Center, Fort Irwin, California, and the U.S. Geological Survey. We thank R. Murphy for the review.

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***GOPHERUS POLYPHEMUS* (Gopher Tortoise). DIET.** *Gopherus polyphemus* is known to eat the scat of heterospecifics including foxes (*Vulpes vulpes* or *Urocyon cinereoargenteus*), Raccoon (*Procyon lotor*), rabbit (*Sylvilagus* spp.), and White-tailed Deer (*Odocoileus virginianus*) (Radzio et al. 2010. Herpetol. Rev. 41:485, and references therein). It has been hypothesized that tortoises derive nutritional benefits and symbiotic gut microbes from eating the scat of conspecifics and other animals (Garner and Landers 1981. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agencies 35:120–134; Anderson and Herrington 1992. Herpetol. Rev. 23:59).

On 3 June 2014 at 1204 h while conducting *G. polyphemus* nest searches on firing point 505 at the Camp Shelby Joint Forces Training Center (CSJFTC), Perry Co., Mississippi, USA, we observed an adult female Gopher Tortoise foraging. The tortoise was observed near *Sus scrofa* (feral hog) scat and upon capture it was noted to have the scat in and around its mouth. Feral hogs were first observed on Camp Shelby on 31 January 2005 (JRL, pers. obs.) and at present appear to be throughout the installation. A feral hog eradication program was initiated on base in 2012. The open mowed field in which the Gopher Tortoise was found had recently (within 24 h) been dug up by a feral hog/hogs but without any *G. polyphemus* nests excavated. To our knowledge this is the first occurrence recorded of *G. polyphemus* eating feral hog scat.

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***INDOTESTUDO ELONGATA* (Elongated Tortoise). CARAPACIAL SCARRING.** *Indotestudo elongata* is a wide-ranging, mid-sized tortoise species found throughout much of Southeast Asia. Weighing up to 4 kg with carapace lengths up to 360 mm long, *I. elongata* is a potential prey item for many carnivorous species (Ihlow 2016. Chelon. Res. Monogr. 5[9]:096.1–14). We have studied this species at the Sakaerat Environmental Research Station (SERS), in Nakhon Ratchasima Province, Thailand. Through radio telemetry-assisted field observations, we have discovered 48 individual tortoises resting in open environments and leaf litter, with 55 further observations of tracked individuals in the open. We have also observed 11 juveniles (< 200 g) resting in the open in in dry dipterocarp forest. When approached by humans *I. elongata* often remain exposed, only retreating into their shell upon being handled (Sriprateep et al. 2013. Trop. Nat. Hist. 131:21–37). The lack of defensive response may suggest relatively light predation pressure within the study area.

On 1 May 2016 we captured an adult male *I. elongata* in the Sakaerat Environmental Research Station in dry evergreen forest, 250 m from a large dam in the reserve (14.50983°E, 101.92024°N). The individual had carapace scars across its left and right costal scutes through to the vertebral scutes (Fig. 1). During processing we determined the individual was an adult male, with a straight-line carapace length of 215 mm, a carapace width of 139 mm, and mass of 1.286 kg. The scars were deep enough to remove the outer layer of the carapace scutes and there was new growth of scute material around the wound sites. The scars were vertically and symmetrically arrayed along both sides of the mid-carapace, however they did not connect across the vertebral scutes. Each scar was approximately 0.5 mm in depth and varied from 50 mm to 20 mm in length (Fig. 1C). The affected area was 75 mm wide on both sides of the carapace with the deepest and longest scars in the center of the area. The initial injury caused severe lacerations through the keratinous layer of the carapace but not the underlying

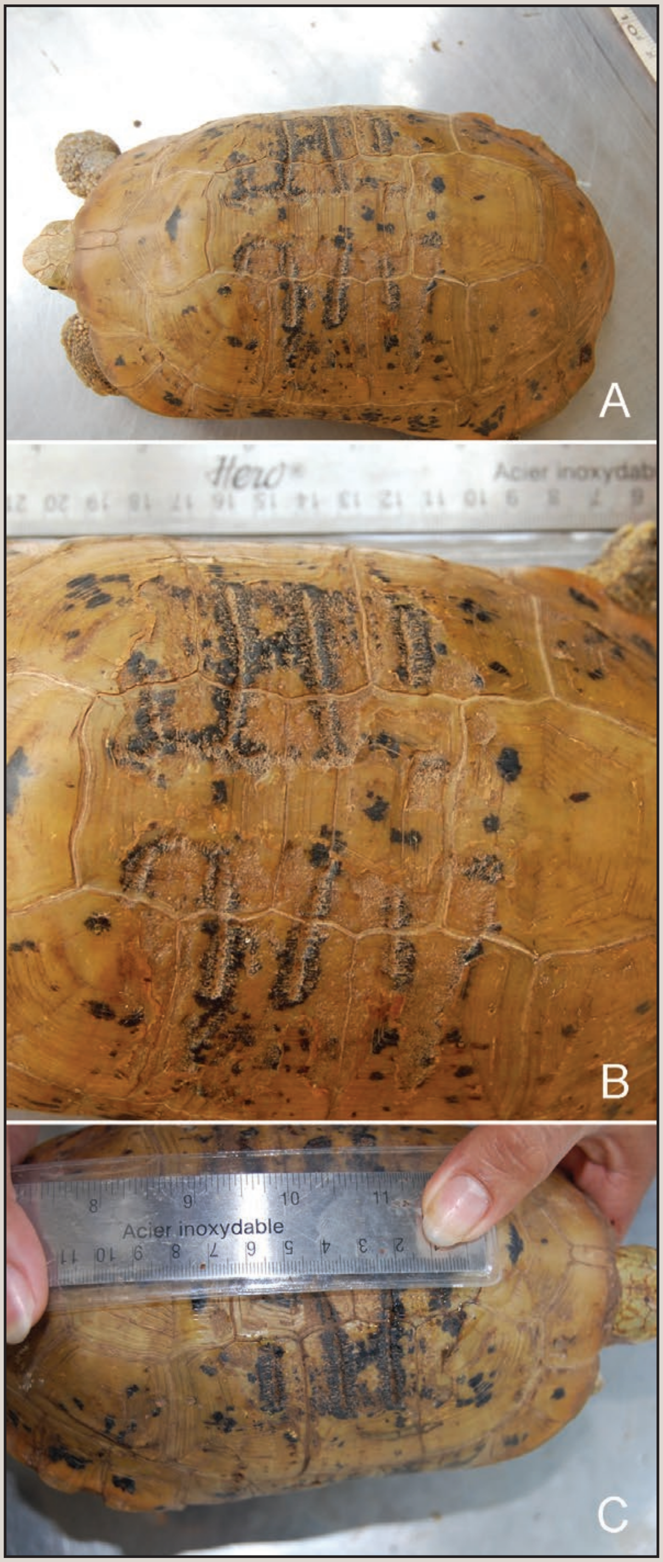

Fig. 1. Carapacial scars in *Indotestudo elongata*: A) dorsal view; B) right lateral view; C) dorsal view with measurement.

skeletal structures or soft tissues. Over time the injury has healed, with the necrotic layers replaced by a layer of new scute growth.

We recaptured the animal on 20 July 2016, 600 m southeast of its previous location, with no fresh injuries. The tortoise was in good condition with clear eyes and nasal passages.

There would appear to be three possible causes for the carapacial scarring noted here. One possibility is that the scars were inflicted by a carnivore attempting to bite the top of the carapace, either to puncture or lift the animal. The SERS area is inhabited by several large carnivore species including Tiger (*Panthera tigris*), Leopard (*Panthera pardus delacouri*), and Dhole (*Cuon alpinus*). A number of other opportunistic predators and small carnivores such as Asiatic Black Bear (*Ursus tibethanus*), Wild Boar (*Sus scrofa*), Jackal (*Canis aureus*), monitor lizards (*Varanus* spp.), and small cats are also present (Francis 2008. Mammals of Thailand and Southeast Asia. Asia Books, Bangkok; Das 2010. Reptiles of Thailand and Southeast Asia. Asia Books, Bangkok). Only the larger carnivore species would appear to have the capability to capitalize upon adult *I. elongata* as prey items. In this case the canines would be 42 mm apart and two separate bite attempts would have had to occur. The limbs, plastron and marginal scutes had no damage on either capture, indicating that a potential predator only targeted the central carapace. Recorded predation events on adult *I. elongata* are rare with most events recorded only through incomplete evidence based on remnant transmitters (van Dijk 1998. Ph.D. Dissertation. Department of Zoology, Faculty of Science, National University of Ireland).

Black stains surround the marks on the carapace and do not match the usual evidence for tooth or claw lacerations. The black stains could be necrotic tissue from a predation event (Ihlow, pers. comm.). However, an alternative hypothesis suggests that the damage could have resulted from extreme heat (Cairos, pers. comm.), perhaps as the animal was caught under debris or fencing during a wild fire (Homer 1998 J. Wildl. Dis. 343:508–523; Sanz-Aguilar 2011. Biol. Conserv. 144:1040–1049). If the black marks are burns, then the marks would outline the area that a particular item had rested on the carapace and burned through the top strata. However, we feel that the marks are unlikely to be the result of a burn, as this type of excessive heat (capable of creating deep gouges in the carapace) would probably damage the underlying bone, causing the scutes to loosen and fall off. We have observed loose scutes as a result of burns in other individuals. In addition, we would expect evidence of burns elsewhere on the animal (Homer, *op. cit.*). There is no sign of damage in the center of the vertebral scutes, which should be evident if there was an extreme heat pressure on top of the animal for a period long enough to cause deep scarring.

An additional alternative suggestion for the cause of these injuries would be from human action. Humans sometimes inscribe turtle and tortoise carapaces with initials or coded letter-number sequences for individual identification purposes. This could be done using an etching tool or knife to cut into the keratinous layer. In this region, Buddhist blessings are regularly made on chelonians, which are then released back into the wild in the belief that this will bring fortune and positive karma to the person; typically these are water blessings or are written on the animal with dissolvable paints. We have not seen evidence of actual carved inscription on chelonians in this region, but the scars on this tortoise's carapace were arrayed in a symmetrical pattern and at least suggestive of human writing. Our local Thai colleagues did not recognize any obvious meaning in these marks, assuming it was written in the local language.

The causes for this animal's injuries are presently unknown. Until we can obtain measurements of predator jaws in the region we will be incapable of identifying a species potentially capable of producing the carapacial scars. Questioning of local people might provide positive or negative evidence that the scars were inscribed by a human. In any case, the described injury does not appear to be negatively affecting the behaviour or feeding patterns of this tortoise.

This discovery was part of the Sakaerat Tortoise Telemetry Project and is supported by the Sakaerat Environmental Research Station. We acknowledge the National Research Council of Thailand for providing permits and assistance in establishing the research project, and Suranaree University of Technology for academic and research support. The British Chelonia Group and National Geographic Conservation Fund provided funding for this project. Mike Hogan is also acknowledged for his original discovery of the subject tortoise on 1 May 2016.

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PHRYNOPS GEOFFROANUS **(Geoffroy's Side-necked Turtle). ENDOPARASITES.** *Phrynops geoffroanus* is a freshwater chelid that occurs in South America from Colombian Amazonia to the Brazilian state of Rio Grande do Sul, and from Uruguay to northern Argentina (Lema and Ferreira 1990. Acta Biol. Leopoldensia 12:125–164; McCord et al. 2001. Rev. Biol. Trop. 49:715–764). It inhabits the shallow areas of both lakes and rivers, including polluted urban waters (Ernst and Barbour 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C. 313 pp.). Despite the wide geographic distribution of *P. geoffroanus* and its abundance in many Brazilian rivers, some aspects of its natural history remain poorly studied, including the incidence of endoparasites (Lisboa et al. 2004 Arq. Inst. Biol. 71:392–393). Here we report nematode parasites of Brazilian *P. geoffroanus.*

In 2015 a specimen of *P. geoffroanus* that was already deposited in the Coleção Herpetológica da Universidade Federal de Juiz de Fora - Répteis (CHUFJF-Répteis 770) was necropsied. The specimen was from the municipality of Juiz de Fora, Minas Gerais state, Brazil (21.68888°S, 43.34444°W). Nematodes were collected from the small intestine of this speciemen. The parasites were fixed in 4% formalin solution for 10 days, and preserved in 70°GL ethanol. For identification, the nematodes were clarified in Amann's lactofenol for examination as whole mounts. Voucher specimens (CHIOC - 38320) were deposited in the Instituto Oswaldo Cruz Helminthological Collection (CHIOC), Rio de Janeiro, RJ, Brazil.

Nematodes parasites were identified as *Camallanus* sp. (Camallanoidea, Camallanidae) according to Anderson et al. (2009. Keys to the Nematode Parasites of Vertebrates. CAB International, Wallingford, UK. 463 pp.). Species of *Camallanus* are usually recorded in fish and amphibians (Moravec 1998 Nematodes of Freshwater Fishes of the Neotropical Region. Academia, Praha, Czech Republic. 464 pp.; Anderson et al. 2009, *op. cit.*), and there are few reports of this genus of nematode in Brazilian freshwater turtles; however Mascarenhas et al. (2013 Parasitol. Res. 112: 3365–3368) reported *Camallanus* sp. parasitizing specimens of *Acanthochelys spixii* and *Hydromedusa tectifera* from southern Brazil, and Bernadon et al. (2013 Pan-Am. J. Aquat. Sci. 8:55–57) reported this parasite in *Phrynops hilarii* also from southern Brazil. Previous studies on helminth parasites of *P. geoffroanus* in Brazil note the nematode *Serpinema monospiculatus* (Camallanoidea, Camallanidae) in hosts from Pernambuco, northeast region (Freitas and Dobbin Jr. 1962. Atas Soc. Biol. Rio de Janeiro 6:5–7); the monogenea *Polystomoides brasiliensis* (Polystomatidea, Polystomatidae) in specimens from Minas Gerais, southeast region, Brazil (Vieira et al. 2008 J. Parasitol. 94:626–630); the trematodes *Cheloniodiplostomum* sp. (Digenea, Proterodiplostomidae) in turtles from Minas Gerais (Novelli et al. 2013 Herpetol. Rev. 44:308); and *Nematophila grandis* (Digenea, Diplodiscidae) parasitizing *P. geoffroanus* of unspecified locality (Dujardin 1845 Histoire Naturelle des Helminthes ou vers Intestinaux. Librairie encyclopedique de Roret, Paris, France. 449 pp.; Travassos et al. 1969 Mem. Inst. Oswaldo Cruz 67:1–886). The present study is apparently the first record of the nematode *Camallanus* sp. as a parasite of *Phrynops geoffroanus.*

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PODOCNEMIS SEXTUBERCULATA **(Six-tubercled Amazon River Turtle). REPRODUCTION.** *Podocnemis sextuberculata* inhabits the Amazon Basin in Brazil, Peru, and Colombia (Rueda-Almonacid et al. 2007. Las Tortugas y Cocodrilianos de los Países Andinos del Trópico. Conservation International, Bogotá, D.C., Colombia. 467 pp.). This species is abundant in white and clear water river systems in Brazil (Vogt 2008. Amazon Turtles. Biblos, Lima, Peru. 104 pp.). Only rarely does it occur in black water systems. Recently it was reported to coexist with three other species of *Podocnemis* in the Rio Uatuma, a black water river, which is a northern tributary of the Amazon River Basin. (Da Cunha et al. 2014. Herpetol. Rev 45:319).

Information on *P. sextuberculata* reproduction generally reports female reproductive size, clutch size, and hatchlings (e.g., Pezzutti and Vogt 1999. Chelon. Conserv. Biol. 3:419–424; Haller and Rodrigues 2006. Chelon. Conserv. Biol. 5:280–284). However, published data on reproductive morphology in *P. sextuberculata* and other *Podocnemis* spp. are largely lacking.

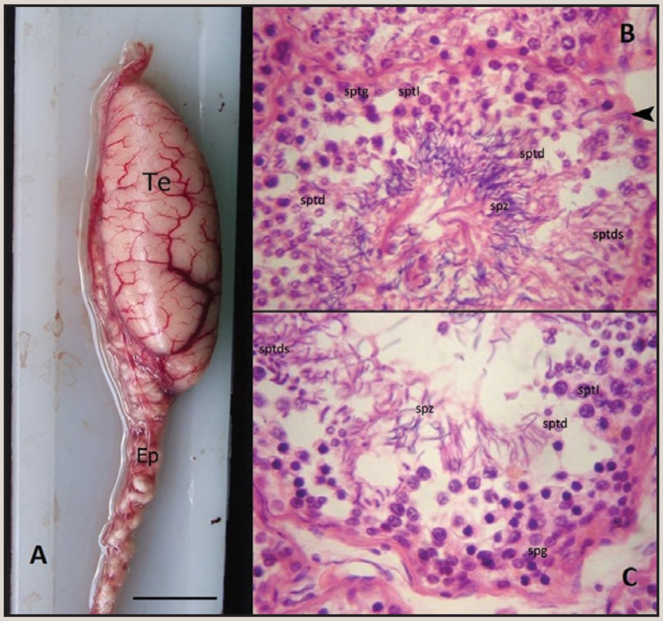

Fig. 1. Gonadal structures of an adult male *Podocnemis sextuberculata*. A) Testis external morphology: Te = testis; Ep = epididymis. Line = 1 cm. Testis exhibiting seminiferous tubules actively producing sperm. B) Testis in July: spz = spermatozoa; spg = spermatogonia; sptI = spermatocyte I; sptds = spermatids in spermiogenesis; arrow head = Sertoli cell. C) Testis in August: spz = spermatozoa; spg = spermatogonia; sptI = spermatocyte I.

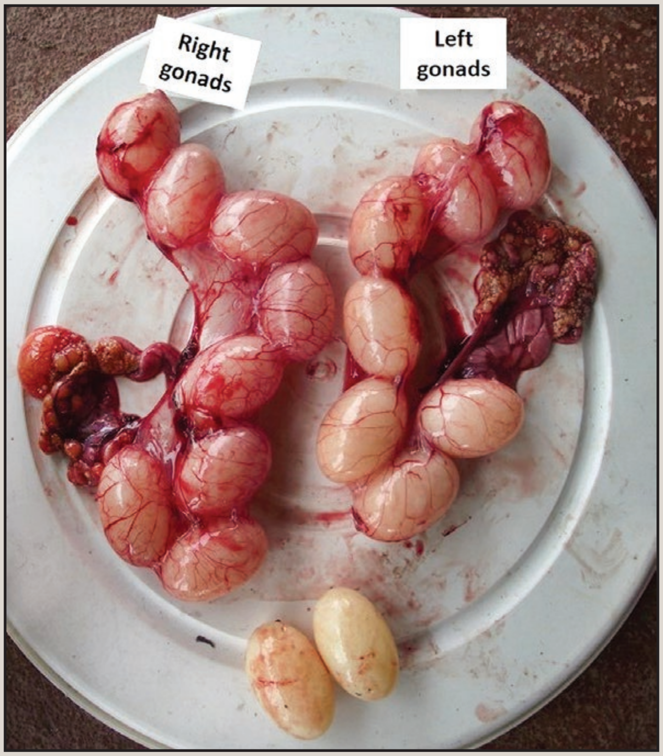

Fig. 2. Right and left gonads of the largest *Podocnemis sextuberculata* with enlarged vitellogenic follicles in ovaries and shelled eggs in the oviducts.

The purpose of this note is to provide additional data from gross anatomy and histological examination of the gonads.

We used the gonads of seventeen (twelve males and five females) *P. sextuberculata* for morphological analysis. All specimens were collected from the Trombetas River Biological Reserve (1.34333°S, 56.82833°W; WGS 84), in Oriximiná, Pará State, Brazil. Range in carapace length was 157–296 mm (N = 17; mean = 213.05; SD = 34.93) and mass 440–2600 g (N = 17; mean = 1086.47; SD = 587.4).

We studied the testes of males and ovaries and oviducts of females, as well as the ducts that function in the transport of gametes (Miller and Dinkelacker 2008. *In* Wyneken et al. [eds.], Biology of Turtles, pp.207–259. CRC Press, Boca Raton, Florida). External sexually dimorphic characters were evaluated for each specimen. We noted the size and number of follicles and corpora lutea in the ovaries, as well as eggs in the oviducts of females (Vogt 2001. *In* Chao et al. [eds.], Conservation and Management of Ornamental Fish Resources of the Rio Negro Basin, Amazonia, Brazil: Project Piaba, pp. 245–262. Universidade do Amazonas). We evaluated the degree of vascularization of the testes and the folding of the seminal ducts (efferent ducts, epididymis, and vas deferens).

The reproductive organs (ovaries and testes) were removed and embedded in paraffin; sections were cut at 5µm and mounted on glass slides, and stained with hematoxylin followed by eosin counterstain. The sections were examined under a light microscope to describe morphological aspects. Adult males were characterized by the presence of spermatogenic lineage cells (spermatogonia, spermatocytes, spermatids, and spermatozoa). Adult specimens were classified in resting conditions if the testes exhibited discontinuation of the sperm production.

The 12 males were determined to be sexually mature by both maturity criteria: inspection of the external morphology of the gonads and subsequent histological analysis (Fig. 1A). Carapace length of these males was 156–230 mm (N = 12; mean = 199.25; SD = 20.3).

The gonads of the males captured in July (N = 2) and August (N = 3) were in full spermatogenic activity. Males collected in October (N = 2) (Fig. 1B) and December (N = 5) (Fig. 1C) had degenerating sperm in seminiferous tubules with some disaggregating sperm remaining in the central portion of the lumen, which indicate low testis activity.

Female carapace length ranged 181–296 mm (N = 5; mean = 244.6; SD = 44.8). The largest immature female analyzed was CL = 235 mm, where no enlarged vitellogenic follicles and no corpora lutea were observed in the ovary. The smallest mature female was CL = 278 mm, where the ovary had seventeen corpora lutea and enlarged ovarian follicles with shelled eggs in the oviducts. As some females exhibited sexually mature ovaries (e.g., enlarged vitellogenic follicles and corpora lutea) as well as shelled eggs in the oviducts (CL = 278 mm; October, 2010; CL = 296 mm, September, 2012, Fig. 2), it is possible that they may be laying at least two, perhaps three, clutches per nesting season, consistent with the nesting season of this species in the Trombetas River (September and October).

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***STERNOTHERUS CARINATUS* (Razor-backed Musk Turtle). PARASITISM.** On 22 May 2016, a male *Sternotherus carinatus* was hand captured on the Comite River in southeastern Louisiana, USA (30.70090°N, 91.05153°W). Upon further inspection, two leeches were discovered near the tail and rear legs. The leeches were removed and stored in 95% ethanol. The leeches were later identified as *Placobdella parasitica.* This species of leech is fairly common among North American freshwater turtles and has been recorded in 22 additional turtle species (Moser 1995. Texas J. Sci. 47:71–74; Watermolen 1996. J. Fresh. Ecol. 11:211–217). This record stands as the first documentation of *P. parasitica* using *S. carinatus* as its host and increases the number of known aquatic turtle hosts.

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***TERRAPENE CAROLINA* (Eastern Box Turtle). DIET.** *Terrapene carolina* are opportunistic omnivores, consuming a large variety of plants and animals (Dodd 2001. North American Box Turtles: A Natural History. University of Oklahoma Press, Norman. 231 pp.; Ernst and Lovich 2009. Turtles of the United States and Canada, 2nd ed. Johns Hopkins University Press, Baltimore, Maryland. 827 pp.). Invertebrates, in particular, can comprise a significant portion of the diet (Surface 1908. Zool. Bull. Div. Zool. Pennsylvania Dept. Agric. 6:106–196; Klimstra and Newsome 1960. Ecology 41:639–647). Here, we report two novel invertebrate prey items in the diet of *T. carolina.*

FIG. 1. *Terrapene carolina* consuming a leech, Johnson County, Illinois.

At 1012 h, 29 April 2016, JGP observed an adult male *T. carolina* feeding on a leech (Annelida: Hirudinea: *Erpobdella* sp.) in a muddy floodplain forest adjacent to a *Nyssa tupelo-Taxodium distichum* swamp in Johnson County, Illinois, USA (Fig. 1). On 10 June 2007, JCM encountered an adult male *T. carolina* consuming a black leech in a wooded creek floodplain with shallow water in Deep Run Park, Henrico County, Virginia, USA. Given the propensity of *T. carolina* to eat terrestrial annelids (i.e., earthworms; Dodd 2002, *op. cit.*; Ernst and Lovich 2009, *op. cit.*) the consumption of leeches is not unexpected.

At 0720 h, 28 June 2016, JAS observed one adult male and two adult female *T. carolina* feeding on dying honeybees (Insecta: Hymenoptera: *Apis mellifera*) on a gravel driveway. A honeycomb, queen bee, and most worker bees were removed alive from an adjacent house soffit the previous evening by a beekeeper. The turtles consumed the moribund bees, but ignored dead ones. The turtles were not observed at this specific location prior to hive removal, nor thereafter. The smell of honey was prevalent at the time of observation and we suspect the turtles located this transient food source by olfaction (Wachowiak et al. 2002. J. Neurophysiol. 87:1035–1045). Attraction to honey and/or bees has been observed in Ornate Box Turtles (*Terrapene ornata*; Metcalf and Metcalf 1970. Trans. Kansas Acad. Sci. 73:96–117).

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***TRACHEMYS SCRIPTA ELEGANS* (Red-Eared Slider) and *GRAPTEMYS GEOGRAPHICA* (Northern Map Turtle). HYBRIDIZATION.** Intergeneric hybridization occurs more commonly than once thought in turtles (Galgon and Fritz 2002. Herpetozoa 15:137–148; Blank 2006. *In* Vetter and van Dijk [eds.], Terralog, Turtles of the World Vol. 4: East and South Asia, pp. 148–149. Edition Chimaira, Frankfurt am Main, Germany), although most examples have occurred in captivity (Fritz 1995. Herpetofauna 17:19–34) where species are confined together artificially. Hybrids between *Trachemys* and *Graptemys* are occasionally produced in captivity for the pet trade and display a variable mix of phenotypic characteristics from both parent species, however natural occurrences of such hybrids have not been reported. Herein we report occurrences of hybridization between *G. geographica* and *T. scripta elegans* in the wild.

In September 2013 during a turtle survey, two hybrids were captured in hoop net traps baited with pieces of silver carp (*Hypophthalmichthys molitrix*) on the North Fork Saline River, Gallatin County, Illinois, USA, by R. Bluett and D. Woolard. After discovering that reports of these species hybridizing was lacking in the literature, A. Gooley and R. Bluett retrapped the same stretch of river in August 2014 to obtain photographs and measurements of any hybrids. One female (Fig. 1; 37.76471°N, 88.32310°W; WGS 84) and two male (Fig. 2; 37.77127°N, 88.31359°W, and 37.77216°N, 88.30926°W; WGS 84) hybrids, as well as 9 *T. s. elegans* and 8 *G. geographica* were captured as a result. The hybrids were identified as such because they possessed a combination of *T. s. elegans* and *G. geographica* phenotypic characteristics similar to captive hybrids. Adult *T. s.*

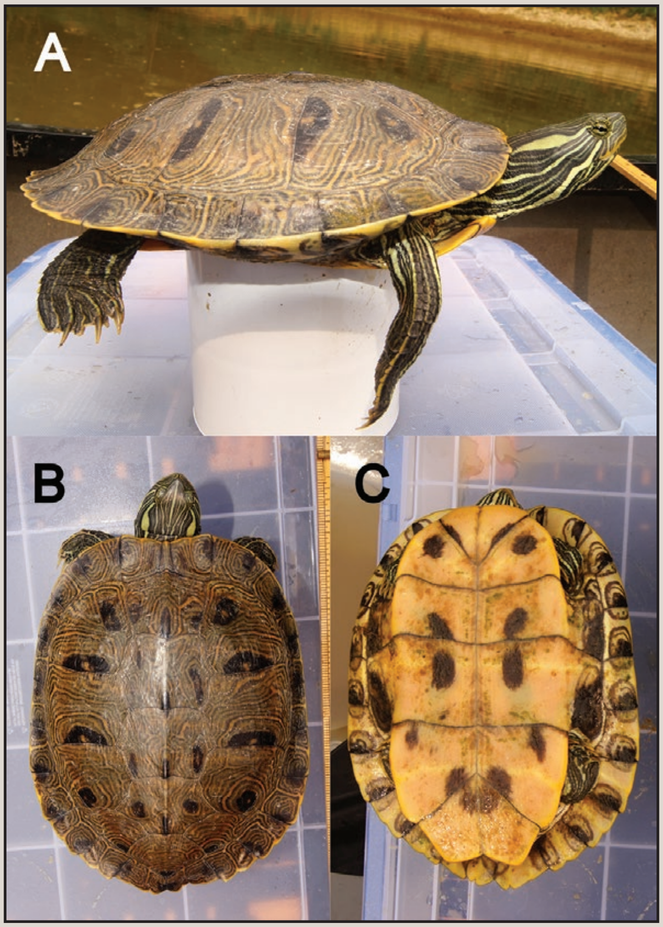

Fig. 1. Lateral (A), dorsal (B), and ventral (C) views of a female hybrid between *Graptemys geographica* and *Trachemys scripta elegans* (North Fork Saline River, Gallatin County, Illinois) captured August 2014. Note the pale-yellow postorbital stripe, carapace patterning, and dark blotches on the plastron.

elegans are characterized by yellow-striped green to olive brown skin, wide red postorbital stripes, green to olive carapaces with yellow striping across each pleural, and yellow plastrons with a large dark blotch on each scute (Ernst and Lovich 2009. Turtles of the United States and Canada, 2nd ed. John Hopkins University Press, Baltimore, Maryland. 827 pp.; Powell et al. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America, 4th ed. Houghton Mifflin Harcourt Publishing Company, New York. 494 pp.). Adult *G. geographica* are characterized by yellow-striped olive to brown-black skin, small triangular post orbital marks, olive green carapaces covered in yellowish-orange reticulations bordered in black, small to absent vertebral spines, pale yellow plastrons, and megacephalic females (Ernst and Lovich, *op. cit.*; Lindeman 2013. The Map Turtle and Sawback Atlas: Ecology, Evolution, Distribution, and Conservation, University of Oklahoma Press, Norman. 460 pp.). Each hybrid possessed prominent orange patterning bordered in black on the carapace that appeared intermediate between *G. geographica* reticulations and *T. scripta elegans* striping, small vertebral spines, a pale yellow plastron with large dark blotches or oculi on each plastral scute, and yellow striping bordered by thick black lines on the head, neck, and limbs. The female's carapace was light olive with a dark blotch on each scute while the males' carapaces were olive to dark olive-green. Small vertebral spines were present on the female and one male but nearly absent on the other male. Both males possessed large yellow postorbital blotches while the female possessed a prominent pale-yellow postorbital stripe. The female (midline carapace length [MLCL] = 18.6 cm; width = 14.8 cm; mass = 624 g) was larger than the males (MLCL = 14.3 cm; width = 11.1 cm; mass = 283 g; and MLCL = 11.9 cm; width = 10.0; mass = 227 g respectively) but did not display megacephaly; the head was not noticeably wider than similarly sized male *T. s. elegans* captured at the location.

Fig. 2. Lateral views of two male hybrids between *Graptemys geographica* and *Trachemys scripta elegans* (North Fork Saline River, Gallatin County, Illinois) captured August 2014. Note the large postorbital blotches and carapace patterning.

The capture location was rural and surrounded by agricultural land, leading us to believe the hybrid individuals were not of captive origin. We speculate this hybridization was facilitated by periodic low streamflow that confined *T. s. elegans* and *G. geographica* together in close proximity in shallow pools, leading to reduced habitat partitioning and an inability of females to retreat from mating advances of heterospecific males. Resulting conditions would be similar to that of captive environments where pre-zygotic isolating mechanisms more readily break down. Intergeneric turtle hybrids are potentially fertile (Galgon and Fritz, *op. cit.*), thus the frequency and effects of gene flow events between sympatric wild turtle populations of differing genera needs further investigation.

Our activities were authorized by state law (515 Illinois Compiled Statutes 5/20-100) and complied with standards for animal welfare adopted by the American Society of Ichthyologists and Herpetologists.

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CROCODYLIA — CROCODILIANS

***ALLIGATOR MISSISSIPPIENSIS* (American Alligator). INCIDENTAL CAPTURE AND ESCAPE FROM WATERFOWL TRAP.** Several studies have documented the use of “walk in” box traps to capture crocodilians, including *Alligator mississippiensis* (Elsey and Trosclair 2004. Herpetol. Rev. 35:253–255; Ryberg and Cathey 2004. Wildl. Soc. Bull. 32:183–187). Recently, we documented *A. mississippiensis* (hereafter alligators) possibly consuming corn at an automated deer feeder (Platt and Elsey 2011. Croc. Spec. Grp. Newsl. 30:27–28). It is uncertain if the alligators were attracted to the corn present at the feeders, the audible noise made by the feeder dispensing corn, or the presence of potential prey species such as *Odocoileus virginianus* (White-tailed Deer), *Sus scrofa* (Feral Pigs), or *Procyon lotor* (Raccoons) that might be present at the feeders (Platt and Elsey 2011, *op. cit.*). Although alligators are generally considered to be carnivores and early research suggested they may not be able to digest plant-based proteins (Coulson and Hernandez 1983. Alligator Metabolism. Studies on Chemical Reactions *in vivo*. Pergamon Press, New York. 182 pp.), recent work has documented that alligators are able to utilize plant proteins (Reigh and Williams 2013. Aquaculture 412–413:81–87). Indeed, a recent review suggested numerous crocodilian species exhibit frugivory and may serve as seed-dispersers (Platt et al. 2013. J. Zool. 291:87–99).

We initiated a study in 2015 to band *Dendrocygna autumnalis* (Black-bellied Whistling Ducks, hereafter BBWD) in southwestern Louisiana, USA. Round walk-in corral style traps (9.14 m diameter and 1.22 m high) were constructed and baited with cracked corn. One trapping site was on a levee with adjacent marsh wetlands on privately owned property in Grand Chenier, Louisiana. The site is located ~9 km W of Rockefeller Wildlife Refuge headquarters. The site was first baited on 16 February 2016, and the trap was set up on 22 February; fresh bait was placed approximately 5–7 days/week. Game camera traps (Moultrie A5 low glow) were deployed to monitor BBWD consumption of bait within the traps to guide in scheduling banding efforts and times.

Fig. 1. Adult American Alligator (*Alligator mississippiensis*) inside waterfowl trap, Grand Chenier, Louisiana.

Review of images captured revealed an image of an adult alligator within the trap at 2045 h on 11 March 2016 (Fig. 1). The next image was captured 4 hours and 8 minutes later, by which time the alligator was absent and the trap was damaged, almost certainly by the large alligator climbing out to escape. The alligator may have escaped much sooner without the camera being activated; a raccoon in foreground may have caused the photo to be taken. Of note, the trap was designed as a light-weight temporary waterfowl trap, and was not of overly sturdy design for containing large predatory species. Based on the known height of the pen (1.22 m) we estimate the alligator’s total length to be ca. 2.13–2.44 m, clearly an adult. The opening to allow access of waterfowl to the trap is only ~25 cm wide; thus it seems the alligator would have not easily fit through this relatively small opening.

The camera trap image caught prior to the appearance of the alligator was taken at 1840 h, which documented a bird (presumably *Fulica americana*, an American Coot,) in the trap and at least ten BBWD flying above the trap. This suggests the alligator may have been attracted to (1) the coot if it was still present; (2) BBWD that may have been resting/roosting nearby; (3) the bait corn within the trap; (4) other species attracted to the corn such as raccoons or (5) somehow entered the trap inadvertently. Also, it is noteworthy that the trap was situated on dry land, thus the normally aquatic alligator (Elsey and Woodward 2010. *In* Manolis and Stevenson [eds.], Crocodiles. Status Survey and Conservation Action Plan. 3rd ed., pp 1–4. Crocodilian Specialist Group, Darwin) would have left its typical wetlands habitat to investigate the baited waterfowl trap on the adjacent levee. However the wetlands were only ~6 m away from the trap, and alligators are known to sometimes exhibit terrestrial hunting (Dinets 2010. Herpetol. Bull. 114:15–18). During the day on 11 March, camera trap images showed numerous waterbirds (BBWD, *F. americana*, *Quiscalus major* [Boat-tailed Grackles], *Agelaius phoeniceus* [Red-winged Blackbirds], and *Anas discors* or *Anas crecca* [Teal]) visiting the bait site; all are potential prey for *A. mississippiensis.*

Additionally, in the 2015 trapping season, one of us (JW) made several observations of an adult alligator (ca. 213 cm total length) near a similarly designed waterfowl trap at a site some 48 km E of the site discussed above. Indirect evidence suggested the alligator appeared attracted to waterfowl near and within the trap, and may have even have deterred waterfowl entering the trap. An adult alligator was observed nearly each time (N = 5 or 6) the trap was baited/visited by JW, and the alligator was observed lunging at BBWDs on several occasions. Another biologist observed similar behavior at a duck banding site some 32 km further east.

One of us (RME) has previously captured a juvenile alligator (ca. 122 cm total length) in a walk-in turtle trap placed in a local freshwater pond; and co-workers have caught adult alligators in Fyke nets (Selman et al. 2014. Chelon. Conserv. Biol. 13:131–139) used to trap *Malaclemys terrapin* (Diamondback Terrapins) in brackish-saline habitats. In a multi-year study in southwestern Louisiana, nine alligators (ca. 91–244 cm total length) were caught in 504 trap days; in one instance two alligators were caught in the same Fyke net on the same day (W. Selman, pers. comm.). The nets were initially unbaited, however by-catch (fish) or movements of terrapins within the net may have attracted alligators, which are sensitive to even minor disturbances in the water due to complex integumentary sensory organs (Soares 2002. Nature 417:241–242; Leitch and Cantania 2012. J. Exp. Biol. 215:4217–4230).

This note documents several observations of interest, including the remarkable agility of *A. mississippiensis* needed to gain entrance to and climb out of the waterfowl trap, the possible attraction to and/or consumption of corn by the alligator, and the potential opportunity to feed upon trapped waterbirds by the alligator. Alligators have been documented to feed upon numerous avian species (Wolfe et al. 1987. Northeast Gulf Sci. 9:1–8) but in general birds are not a major component of their diet, relative to fish and mammals (McNease and Joanen 1977. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 31:36–40). It is also of interest that opportunistic alligators seem to very rapidly associate the waterfowl trap with a potential food source; indeed crocodilians have a remarkable capability for learning (Grigg and Kirschner 2015. Biology and Evolution of Crocodylians. Cornell University Press, Ithaca, New York. 649 pp). Also, this study illustrates how the presence of crocodilian species (some of which are imperiled) might be documented by use of camera traps during studies targeting the critically endangered crocodilian (Platt et al. 2002. Nat. Hist. Bull. Siam. Soc. 50:7–14), or while attempting to record images of unrelated fauna in the same region.

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***ALLIGATOR MISSISSIPPIENSIS* (American Alligator). DIET.** American Alligators are opportunistic predators and their diet has been studied extensively (Elsey et al. 1992. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 46:57–66, and references therein and below). Composition of *Alligator mississippiensis* diet often varies due to geographic variation in prey availability (Neill 1971. The Last of the Ruling Reptiles. Alligators, Crocodiles, and their Kin. Columbia University Press, New York. 486 pp.; Gabrey 2010. Herpetol. Conserv. Biol. 5:241–250). Additionally, differential digestion rates can lead to under-representation of soft-bodied prey items or over-representation of materials resistant to digestion (Jackson et al. 1974. J. Herpetol. 8:378–381; Garnett 1985. J. Herpetol. 19:303–304; Delany and Abercrombie 1986. J. Wildl. Manage. 50:348–353; Platt et al. 1990. Northeast Gulf Sci. 11:123–130). We herein report on a prey item for *A. mississippiensis* which to our knowledge has not previously been reported.

As part of an unpublished investigation on cannibalism in *A. mississippiensis*, we examined stomachs from 685 hunter-harvested *A. mississippiensis* from two sites in coastal Louisiana. Most specimens were adults. The site in southeast Louisiana was the state-owned Salvador Wildlife Management Area in St. Charles Parish (ca. 12,140 ha fresh marsh habitat), from which 400 stomachs were examined from *A. mississippiensis* harvested in July 1994, with total lengths of 1.22–3.05 m. The southwest Louisiana site was privately owned wetlands in Cameron Parish (ca. 9320 ha of intermediate/brackish salinity marsh), from which 285 stomachs were collected in September 1994, with total lengths of 1.50–3.53 m).

Two stomachs from *A. mississippiensis* of unknown sex from the Cameron Parish site contained parts of *Plestiodon fasciatus* (Common Five-lined Skinks). The smaller *A. mississippiensis* (1.73 m) had parts of at least one *P. fasciatus* in its stomach, as well as vegetation, five roundworms, and a shotgun shell hull. The stomach contents of the larger *A. mississippiensis* (2.16 m) included remains of at least two *P. fasciatus*, *Callinectes sapidus* (Blue Crab), vegetation, a few roundworms, two shotgun shell hulls, and a bullet. To our knowledge, *P. fasciatus* has not been reported as prey for *A. mississippiensis* despite numerous studies examining hundreds of stomachs in Louisiana (Giles and Childs 1949. J. Wildl. Mgmt. 13:16–28, N = 318 stomachs; Valentine et al. 1972. J. Wildl. Mgmt. 36:809–815, N = 413 specimens; McNease and Joanen 1977. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 31:36–40, N = 314 stomachs; Sloan 1987. A food habit study of adult alligators from Marsh Island Wildlife Refuge, Louisiana, unpublished report, 321 samples; Gabrey 2010, *op. cit.*, N = 553 specimens) and Florida (Delany and Abercrombie 1986, *op. cit.*, 350 specimens; Barr 1997. PhD Dissertation, Univeristy of Miami, Florida; N = 635 specimens; and Delany et al. 1999. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 53:375–389 N = 219 samples). For additional studies see review by Wolfe et al. 1987 (Northeast Gulf Sci. 9:1–8).

Kellogg (1929, U.S. Dept. Agric. Tech. Bull. 147:1–36) noted one "little ground lizard" (then *Leiolopisma laterale*, now Little Brown Skink *Scincella lateralis*) in one of 157 *A. mississippiensis* stomachs evaluated, all but twelve of which were obtained in Cameron and Vermilion parishes in southwest Louisiana. Two subadult *Crocodylus porosus* (Salt-water Crocodile) contained "Scinicidae" in their stomach contents (Taylor 1979. Aust. Wildl. Res. 6:347–359). Neill (1971, *op. cit.*) noted that lizard species found within the range of *A. mississippiensis* are not aquatic and enter the water only accidentally or in predator avoidance, and thus suggested that little significance can be attached to the few records of lizards in *A. mississippiensis* stomachs. Alternatively, skinks are small, soft-bodied, and likely rapidly digested, and could be less detectable and easily overlooked in *A. mississippiensis* food habit analyses. It is of interest that to our knowledge this prey species has not previously been reported for *A. mississippiensis* considering how well studied this topic is within the species, and we recovered two instances of *A. mississippiensis* having consumed at least three *P. fasciatus* from the same wetlands. It has also recently been reported that *S. lateralis* exhibits commensal nesting in *A. mississippiensis* nests (Elsey et al. 2013. Herpetol. Rev. 44:659–660), which may provide opportunity for this species to fall prey to *A. mississippiensis*. However, most small bodied skinks are likely not energetically advantageous as a prey item, perhaps leading this taxa to be rarely (and possibly only opportunistically) consumed by *A. mississippiensis* and other large adult crocodilians.

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***PALEOSUCHUS* SPP. (Dwarf Caiman) and *OSTEOLAEMUS* SPP. (Dwarf Crocodile). DEFENSE MECHANISMS.** Collectively, the 27 extant species (reviewed in Grigg and Kirshner 2015. The Crocodylian Family Tree. *In* Biology and Evolution of Crocodylians, pp 43–79. CSIRO Publishing, Victoria, Australia) of the order Crocodylia are members of nine genera and, despite this diversity, are characterized as being generally aquatic and having a relatively conserved body plan (Brochu 2003. Annu. Rev.

Earth Plan. Sci. 31:357–397). Defense mechanisms traditionally associated with this group include aggression (biting and tail thrashing), running or sliding away, swimming, submergence, and threat displays like gaping, lunging, jaw-clapping, head slaps, hissing and other vocalizations. The relatively large adult size of most crocodilians also serves as a deterrent for many potential predators (Webb and Messel 1977. Aust. Wildl. Res. 4:311–319). For the most part, these defensive strategies rely on either large body size or close proximity to water for refuge. Two crocodilian genera—the New World *Paleosuchus* (Dwarf Caiman) and the Old World *Osteolaemus* (Dwarf Crocodiles)—include the smallest, most terrestrial species in the order Crocodylia.

Paleosuchus spp. are native to the northern countries of South America, and as far south as northern Paraguay where they are found in or near forested streams, although often they inhabit densely forested areas where very little standing water is permanently available (Magnusson 1989. *In* Hall and Bryant [eds.], Crocodiles: Their Ecology, Management, and Conservation, pp. 101–109. IUCN Publications, Gland, Switzerland). *Osteolaemus* spp. are distributed throughout West and Central Africa where they inhabit a wide variety of wetland habitats including terra firma, seasonally inundated and mangrove forests, emergent grass and papyrus swamps, and even gallery forests in wooded savannah zones (Waitkuwait 1989. *In* Hall and Bryant [eds.], Crocodiles: Their Ecology, Management, and Conservation, pp. 260–275. IUCN Publications, Gland, Switzerland; Luiselli, et al. 1999. J. Zool. 247:127–131; Riley and Huchzermeyer 1999. Copeia 1999:313–320; Eaton et al. 2009. Mol. Phylogen. Evol. 50:496–506).

We had the opportunity to observe, interact with, and handle hundreds of wild *Paleosuchus* spp. and *Osteolaemus* spp., during which time we observed that, while these species exhibit the same suite of defense mechanisms as other crocodilians, in many cases they employed alternative defense strategies that have not been formally described in crocodilians. Here, we describe two unique behaviors employed by adults of these species and discuss hypotheses to be tested for the adaptive advantage of each.

When encountered in the wild, *P. trigonatus* often remained completely motionless allowing close approach and were relatively easy to capture both in shallow streambeds and on land. When seized by the back of the neck, captured individuals, both in the wild and in captivity, typically forcefully lifted their heads up and back pinching one's hand between the nuchal scutes. This also appears to link the scutes forming a continuous, less penetrable nuchal shield. *Paleosuchus palpebrosus*, which is smaller and may be less terrestrial than *P. trigonatus*, exhibited a similar cryptic motionless behavior. However, while also exhibiting the neck-clasping behavior once molested (MM and CW, pers. obs.), they often made themselves very rigid followed by sudden and violent torsion or writhing movements (R. Botero-Arias, pers. comm.). We observed these behavioral phenomena in wild *Paleosuchus* spp. near the Rio Orosa in Madre Selva, Peru (March 2003), in the Rio Volta area, Province of São Paulo in central Brazil (November 2014), and in captive specimens at the St. Augustine Alligator Farm (St. Augustine, Florida, USA), Ellen Trout Zoo (Lufkin, Texas, USA), Dallas Zoo (Dallas, Texas, USA), and in the private collection of M. Merchant.

Perhaps more pronounced than in *Paleosuchus* spp., *Osteolaemus* spp. encountered in the wild most often remained completely motionless allowing close approach and were also relatively easy to capture. Exceptions to this were individuals at sites where crocodiles are heavily hunted, and individuals still at the entrance of their burrows, which typically retreated back into the burrow more rapidly at sign of danger. Captured individuals, either upon being seized by the back of the neck or after a locking cable snare is tightened around their neck, typically remained quiet and still, exhibiting virtually no response until, and sometimes even after, being dragged or lifted off the ground. Their reactions included writhing or torsion maneuvers and becoming rigid which, when the animal was lifted off the ground, resulted in them curling their bodies laterally into rigid semi-circles. We observed these mechanisms in wild *Osteolaemus* spp. from sites throughout the entire natural range of the genus, including in Democratic Republic of Congo, Congo, Gabon, Ghana, Cote d¹Ivoire, Senegal and Gambia, during multiple years of fieldwork (2004–2014) and during all seasons of the year (MHS, pers. obs. and M. J. Eaton, pers. comm.). No *Osteolaemus* individuals have, as yet, been observed performing the neck clasping behavior described above for *Paleosuchus*.

Although the genera *Paleosuchus* and *Osteolaemus* are in different families (Alligatoridae vs. Crocodylidae, respectively) and are distributed on two different continents (South America and Africa, respectively), they exhibit a remarkable amount of anatomical, ecological, and behavioral similarity. Dwarf caiman (*Paleosuchus* spp.) and dwarf crocodiles (*Osteolaemus* spp.) are the smallest extant members of the Crocodylia (Medem 1981. *In* Los Crocodylia de Sur América. Vol I. Colciencias, Bogotá, Colombia; Riley and Huchzermeyer 1999. Copeia 1999:313–320). They are seemingly more terrestrial year round than other crocodilians, perhaps reflecting terrestrial food abundance and/or seasonal availability of inundated habitats in these forested wetlands (Magnusson 1989, *op. cit.*) Both are markedly nocturnal and semi-fossorial, making extensive use of excavated dens or burrows during the day and as defensive retreats at night. They have large, more dorsally positioned eyes with bony palpebral coverings and have heavily armored skin, including substantial dorsal scutes, significantly ossified ventral surfaces, high, pointed nuchal scutes with very sharp central keels, enlarged and pointed post-occipital scales, and abundant accessory keeled scales on the neck (Brazaitis 1974. Zoologica 58:59–101; Brazaitis 1989. *In* Hall and Bryant [eds.], Crocodiles: Their Ecology, Management, and Conservation, pp. 17–43. IUCN Publications, Gland, Switzerland). The keeled scales, unlike in

Fig. 1. The dark coloration of an adult *Osteolaemus tetraspis* allows for camouflage against the forest floor.

FIG. 2. Enlarged nuchal scutes of *Paleosuchus trigonatus*, proposed to be used for a pinch response to discourage predation.

other crocodilian genera, can be abrasive to human hands during capture. These traits might reflect adaptations to their forested habitat preference, terrestrial activity, nocturnal lifestyles, and diminutive statures.

The principal defensive mechanism for both genera seems to be morphological, including color/pattern crypsis and their heavily ossified skins. Adults in both species groups are typically dark in coloration, matching the low-light conditions beneath the forest canopy and blending well with the leaf litter that covers the floor of both the aquatic and terrestrial portions of their habitat, while juveniles typically display more disruptive color patterns (Fig. 1). However, the small body sizes of *Paleosuchus* and *Osteolaemus* correlate with weaker bite forces than other crocodilians (Erickson et al. 2012. PLoS ONE 7:e31781) and they are typically slower when fleeing, often relying on short hops when on land, and swimming only short distances when in the water (MHS, pers. obs.). These relative deficiencies may result in reduced abilities to protect themselves against predators using conventional crocodilian defense mechanisms, and may have favored the evolution of alternate strategies.

The terrestrial nature and small body size of these crocodilians increase their exposure to a set of terrestrial predators that other (adult) crocodilians might not encounter frequently. Somaweera et al. (2013. Herpetol. Monog. 27:23–51) provided a comprehensive review of predation events on crocodilians. Published predation records on adult *Paleosuchus* included Yellow and Green Anacondas (*Eunectes notaeus* and *E. murinus*), and Jaguars (*Panthera onca*), and for adult *Osteolaemus* included the African Rock Python (*Python sebae*, L. Makaga and C. Orbell, pers. comm) and the Leopard (*Panthera pardus*, Henschel et al. 2005. Afr. J. Ecol. 43:21–28). Several other ecological equivalents of these predators, e.g., constricting snakes (*Boa constrictor*), cats (*Puma concolor*, *Panthera leo*, *Leopardus pardalis*, *Caracal aurata*), hyenas (*Crocuta* spp. and *Hyaena* spp.), and otters (*Aonyx* spp., *Lontra* spp., *Pteronura* spp., and *Lutra* spp.) were recorded preying upon other crocodilian species within the distribution of *Paleosuchus* and *Osteolaemus* (e.g., *Caiman* spp., *Crocodylus* spp., and *Mecistops* spp.; Ribas et al. 2012. Stud. Neotrop. Fauna Environ. 47:19–23; Somaweera et al., *op. cit.*), and we consider it likely these same species are potential predators of dwarf caiman and dwarf crocodiles where they are sympatric.

We postulate that the several convergent behaviors exhibited by these crocodilians suggest that large snakes of the genera *Eunectes*, *Boa*, and *Python* are among the more important predators of adult *Paleosuchus* and *Osteolaemus*. For example, immobility may decrease the probability of encounters with these large snake predators, which are also largely stationary ambush hunters. Although not yet quantified, our experience suggests that these dwarf crocodilians have a much more impressive capacity for becoming rigid than similarly-sized individuals of other crocodilian species (MM and MHS, pers. obs.). It may be that this enhanced capacity to become rigid, in combination with their impressive dorsal armor, helps them resist the pressure of constriction. Or, for individuals encountered by snakes in their burrows, their ability to make themselves rigid and inflexible may enable them to lock themselves against burrow walls preventing the snakes from coiling or pulling them out of the burrows for constriction—a behavior commonly employed by heavily armored and crevice-dwelling lizards (Cooper et al. 1999. Ethology 105:687–700; Cooper et al. 2000. Herpetologica 56:394–401; Broeckhoven et al. 2015. J. Anim. Ecol. 84:1213–1221).

The more interesting comparison, however, is not the behavioral and anatomical convergence, but rather potential drivers of the divergent defensive behaviors displayed when crypsis fails. For example, jaguars seize their caiman prey by the neck, and the unique defensive behavior described above for *Paleosuchus* spp. may be a method of pinching the heavy, interlocking nuchal scutes (Fig. 2) together. This might startle the jaguar, causing it to release its bite long enough for the caiman to escape and/or to protect the spinal column against damage from the bite. Jaguars have the most robust canine teeth relative to size among felids, an adaptation that allows them to pierce hard prey substances like tortoise shells and cranial casings (Meachen-Samuels and van Valkenburgh 2009. Biol. J. Linn. Soc. 96:784–799). Although caiman (*Caiman* spp. and *Melanosuchus niger*) make up significant portions of jaguar diet in some places (Cavalcanti and Gese 2010. J. Mammal. 91:722–736; Da Silveira et al. 2010. J. Herpetol. 44:418–424), these larger caiman are most often taken by pouncing from tree perches or steep banks directly in deep water of flooded forests (e.g., Mamirua, Brazil; P. Henschel, pers. comm.) or as they are found in mass concentrations during the dry season (e.g., Pantanal of Brazil, Bolivia, and Paraguay, and the Llanos of Venezuela and Colombia). In these instances, simply being aquatic and protection in numbers are seemingly adequate defenses, perhaps explaining why *Caiman* spp. and *M. niger* have not evolved a similar defense mechanism as *Paleosuchus*. In contrast, jaguars would almost exclusively encounter *Paleosuchus* spp. on land or in very shallow flooded/aquatic habitats and a lack of defense mechanisms would leave dwarf caiman more vulnerable. Smaller cats in these ecosystems (e.g., *Puma yagouaroundi*, *Leopardus wiedii*, and *L. pardalis*) are highly specialized feeders on small mammals, birds, and small reptiles, and have never been recorded predating adult crocodilians, or other prey of similar size, and are likely not capable.

Presumably, leopards would attack *Osteolaemus* in a similar manner, begging the question why dwarf crocodiles do not react similarly given that they have similar nuchal and dorsal armor and are similarly exposed. There are very few confirmed records of leopards preying on dwarf crocodiles, or other crocodilian species, and crocodiles are likely not important prey items (P. Henschel, pers. comm.). For example, only two crocodile remains, both *Osteolaemus*, were found in 850 leopard scats analyzed across five sites in the Congo forest landscape (Hart et al. 1996. Afr. J. Ecol. 34:364–379; Ososky 1998. Masters Thesis, Northern Illinois University, DeKalb. 56 pp.; Ray and Sunquist 2001. Oecologia 127:395–408; Henschel et al. 2005. Afr. J. Ecol. 43:21–28; Henschel et al. 2011. J. Zool. 285:11–20). These studies reported fewer than five other occurrences of leopard predation on reptiles and it may simply be that leopard dentition and cranial musculature are not equipped for reptilian prey (Meachen-Samuels and van Valkenburgh, *op. cit.*). The only other forest-dwelling cat in this system, the African Golden Cat, is a highly specialized forager on small mammals, birds, and small reptiles, and is not known to predate adult crocodilians, or prey of similar size, and is likely not capable.

Direct observation of predation events on *Paleosuchus* and *Osteolaemus* is difficult, as evidenced by the paucity of observations both in the literature and as anecdotes from field researchers. As a result, the data do not yet exist to evaluate the relative importance of specific predators in driving behavioral development. Although the difference in felid predation pressure acting on these ecologically convergent genera seems clear, the degree to which this specific force is driving divergent behavioral adaptations is yet to be empirically tested. That being said, teasing apart the defensive, energetic, and reproductive benefits of these morphological and behavioral characters to evaluate their independent impacts on the evolution of these species will also undoubtedly present a challenge—if these traits even confer such an advantage (e.g., Gould and Lewontin 1979. Proc. Roy. Soc. Lond. B 205:581–598). For example, pronounced head raising is often a submissive behavior seen in intraspecific interactions in crocodilians (Senter 2008. J. Herpetol. 42:354–360) and *Paleosuchus* may just be applying it as an anti-predatory response. Alhough we believe our speculations on convergence and divergence in dwarf crocodilian defensive behavior have merit, these remain to be tested.

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SQUAMATA — LIZARDS

***AMEIVA AMEIVA* (Giant Ameiva). PREDATION.** Lizards are a food source for many bird species in neotropical forests. *Ameiva ameiva* is a diurnal lizard occurring in most of tropical and subtropical South America, east of the Andes extending north to Panamá. In Brazil, it is one of the most conspicuous members of lizard assemblages (Sales et al. 2011. Phyllomedusa 10:165–176), inhabiting several ecosystems from semi-arid regions to wet lowland forests, and even habitats that are disturbed by human activity. *Trigisoma lineatum* (Rufescent Tiger Heron) inhabits the banks of rivers, feeding on fish, amphibians and reptiles (Beltzer 1990. Stud. Neotrop. Fauna E 25:93–96; Briso et al. 2014. Herpetol. Notes 7:731–732). During an avifaunal survey conducted on 17 January 2013, we observed an adult *T. lineatum* preying upon an adult *A. ameiva* (Fig. 1). The observation took place in the Araras Pantanal Eco Lodge in the municipality of Poconé, Mato Grosso state, Central Brazil (16.287041°S, 56.636676°W; WGS 84). For approximately fifteen minutes the bird pecked and pressed on the lizard while it was on the ground, during which time the lizard apparently died. The bird then swallowed the lizard entirely, head first. The individuals were not collected. To our knowledge, this is the first report of predation on *A. ameiva* by *T. lineatum.*

We thank Fernão Prado for providing the photograph and details of the predation event. ATM thanks Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES) for the scholarships.

Fig. 1. A Rufescent Tiger-heron (*Trigisoma lineatum*) holding an *Ameiva ameiva* in its beak in the municipality of Poconé, Mato Grosso state, central Brazil.

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***AMEIVULA NATIVO* (Linhare's Lizard) and *TROPIDURUS TORQUATUS* (Amazon Lava Lizard). PREDATION.** *Ameivula nativo* is an endemic lizard that occurs only in the *restingas* of Espírito Santo and Bahia States in Brazil (Menezes and Rocha 2013. North-western J. Zool. 9:337–344). *Tropidurus torquatus* is distributed throughout Brazil, eastern Bolívia and northern Argentina (Concistré 2012. Masters Dissertation. Universidade de São Paulo, São Paulo). The Guira Cuckoo, *Guira guira* (Fig. 1A; Cuculidae), occurs from central Brazil through Bolivia, Paraguay, Uruguray and Argentina, where it feeds mainly on small arthropods but also consumes small reptiles (Sick 1997. Ornitologia Brasileira. Editora Nova Fronteira, Rio de Janeiro, Rio de Janeiro. 862 pp.). Here we report the first observations of predation on *A. nativo* and *T. torquatus* by *G. guira*.

In June 2009, at the Rodovia do Sol (ES-060), a road-killed individual of *G. guira* (Fig. 1D) was collected at kilometer 54 (20.65ºS, 40.55ºW, WGS 84; 36 m elev.), in a *restinga* area (coastal sand plains) of Guarapari Municipality, Espírito Santo state, in southeastern Brazil. Five partially digested subadult to adult lizards were found within its stomach: three *A. nativo* and two *T. torquatus* (Figs. 1B–E). The bird specimen (MBML 7679) and its stomach contents were deposited at the Bird Collection of the Prof. Mello Leitão Biology Museum.

This was the first record of predation on *A. nativo* by *G. guira*. *Ameivula nativo*, although abundant in the area, is an endangered species in Brazil (Almeida et al. 2007. *In* Passamani and Mendes [eds.], Livro de Espécies Ameaçadas de Extinção no Espírito Santo, pp. 65–75. IPEMA, Vitória, Espírito Santo). The presence of three *A. nativo* individuals inside the stomach of a single *G. guira* individual may indicate that the impact of these birds on the *A. nativo* populations could be relevant to its conservation. *Tropidurus torquatus* is a common prey item of medium-sized birds (Rocha and Vrcibradic 1998. Ciências y Cultura 50:364–368), and thus may be a regular prey item of *G. guira*, as suggested by Koski and Merçon (2015. Herpetol. Notes 8:35–37).

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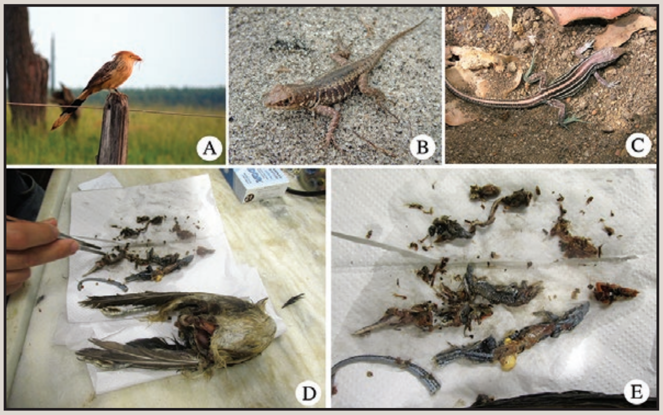

PHOTOS BY J. N. SILVA AND T. S. SOARES

Fig. 1. A) Guira Cuckoo (*Guira guira*) and the lizards (B) *Tropidurus torquatus* and (C) *Ameivula nativo* from the Restingas area of Paulo Cesar Vinha State Park. D–E) Stomach contents of the collected *G. guira*.

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***ANOLIS CAROLINENSIS* (Green Anole). DIET and PERCH SITE.** Green Anoles prefer dense vegetation in open areas (Dundee and Rossman 1989. The Amphibians and Reptiles of Louisiana. Louisiana State University Press, Baton Rouge, Louisiana. 300 pp.). Schaefer et al. 2009 (Southeast. Nat. 8:63–76) found that greater shrub density corresponded with higher anole populations by providing more perch sites, increased food resources, and greater concealment from predators. In this note, we report *Anolis carolinensis* preying upon an indigenous *Repipta taurus* (Horned Assassin Bug) in East Texas within the body of the leaf of the carnivorous plant, *Sarracenia alata* (Yellow Trumpets).

At 1130 h on 1 April 2016, we observed an adult female *A. carolinensis* in an East Texas hillside bog (31.071403°N, 94.275728°W, WGS 84; 76 m elev.). The trumpet-shaped leaf of the pitcher plant (*S. alta*) was destructively peeled back to reveal the anole (Fig. 1). This anole was ca. 20 cm above the ground inside the leaf of the yellow trumpet, facing up, snout facing towards the opening of the leaf, with the tail downward into the narrow part of the pitcher. The lizard had already captured the *R. taurus*. In earlier work on the contents of pitcher plant prey items, two different pitchers contained the skeletal remains of *A. carolinensis*, oriented in an identical manner in the leaf. The significance of both the skeletal and live *A. carolinensis* is not clear. It may be that the pitcher plant leaf provides concealment from predators and the anole takes advantage of the insect-attracting nectar glands, found on the interior portion of the leaf, to lure prey. The presence of both a live prey capturing adult and skeletonized *A. carolinensis* warrants further investigation on how anoles utilize the leaves of pitcher plants. We thank Daniel Bennett for kindly identifying the species of *Repipta*.

Fig. 1. *Anolis carolinensis* consuming *Repipta taurus* while perched inside of a *Sarracenia alta* leaf.

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***ANOLIS NEBULOSUS* (Clouded Anole). LIFE EXPECTANCY.** Mortality and body size in lizards of the genus *Anolis* have been well-studied (Losos 2009. Lizards in an Evolutionary Tree. Ecology and Adaptive Radiation of Anoles. University of California Press, Berkeley. 527 pp.). A study on the coast of Jalisco, Mexico suggested that female *A. nebulosus* do not survive to the second reproductive season, based on capture-recapture data, although data on males was not available (Ramírez-Bautista and Vitt 1997. Herpetologica 53:423–431). The study also suggested that males reached sexual maturity at 7 months of age (at snout–vent length [SVL] = 32 mm) and females at 9 months of age (SVL = 35 mm). It follows that females would die before the age of 21 months (9 months at the first reproductive season + 12 months to the next one). Here we report survivorship data for *A. nebulosus* at two sites in Mexico, shedding some doubt on the idea that females are annual species.

We studied *A. nebulosus* at the Chamela Biological Station in Jalisco, Mexico (19.4966°N, 105.0405°W, WGS 84; elev. 78 m); and on San Agustin Island (19.5347°N, 105.0883°W, WGS 84; elev. 15 m), situated 5 km from Chamela Biological Station. We measured mortality rate in both anole populations every two months, from October 2010 to September 2012 (ten samples in total per site). For this we established three quadrants (20 × 20 m), and we marked individuals by toe clipping. We calculated the mortality rate for each site by using the software Mark®.

We marked 60 males and 40 females on the mainland, of which only 15% and 7.5% were recaptured, respectively. On average, the monthly rate of recapture for continental males and females was 0.048 and 0.022, respectively. We recaptured two males (3.3% of all males marked) on four occasions over 9 months (October 2010 to June 2011). The body sizes (SVL) for these two lizards during the first capture were 25.5 mm and 29 mm, respectively, whereas their size at last capture was 35 mm and 38 mm respectively, meaning that the first lizard grew 9.5 mm and the second lizard grew 9 mm. The largest body size recorded in males was 41.2 mm. One female grew 8 mm from February 2010 (first capture, SVL = 25 mm) to September 2011 (SVL = 33 mm); she had not reached maturity based on size. The largest body size registered in females was 40.4 mm.

We marked 157 males and 159 females on the island, but we recaptured only 33.8% and 26.1% individuals, respectively. On average, the monthly recapture rate for insular males and females was 0.098 and 0.094, respectively. In contrast with the mainland, 8.2% and 4.4% of insular males and females were recaptured on more than four occasions (over a 9-month period). We recorded two males (1.2% of males marked), which were recaptured on 10 occasions (over 21 months; October 2010 to June 2012). In both cases, their body size at first capture was 37 mm (at reproductive stage), whereas at their SVLs were 50.5 mm and 53.2 mm at their last capture. The largest body size recorded in males was 55.4 mm SVL. We also recaptured two females (1.2% of females marked) on 10 occasions over a 21-month period (December 2010 to August 2012). Both females were at reproductive stage (37.6 mm and 37 mm SVL) during their first capture, whereas during their last capture they were 47.1 mm and 49 mm, respectively. The highest body size recorded for insular females was 51.1 mm SVL. We found no significant differences in mortality rate between sites (unpubl. data). However, a detailed analysis of our data shows some differences between sites in lifespan and maximum body size reached by the individuals. Growth rate was higher in males (0.066 mm/d) than females (0.049) from the island and from the mainland (males = 0.036, females = 0.022) (unpubl. data), and body sizes were higher on the island.

Our findings suggest that at least some lizards in both the island and the mainland populations can live for > 1 yr, and can have more than one reproductive event during their lifetime. In particular, our results from the island indicated that *A. nebulosus* might not be an annual species and might live > 20 months, allowing at least two reproductive events.

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***ANOLIS ROQUET* (Martinique's Anole). COLORATION.** *Anolis roquet* specimens from coastal habitats along the northeast of Martinique are classically referred to as *A. roquet majoigris* (Lazell 1972. Bull. Mus. Comp. Zool. Harvard 143:1–115) and in more recent work considered to represent an eastern littoral ecotype of *A. roquet* (Thorpe et al. 2012. Mol. Ecol. 21:5299–5308). Lazell (1972, *op. cit.*) reported that this form tends to exhibit a grey-green to brown base coloration with males being noted to occasionally exhibit whitish blotches on the head and anterior trunk (Fig. 1A), while females are said to lack white patches altogether (Fig. 1B).

On 5 December 2015, on the coast between Sainte-Marie and Le Marigot, Martinique, an adult female *A. roquet* with aberrant

FIG. 1. Images of (A) male and (B) female *Anolis roquet majoigris* with typical coloration.

Fig. 2. Images of aberrantly colored female *Anolis roquet majoigris* photographed (A) *in situ* and (B, C) showing normal scale formation.

coloration was captured (Fig. 2A). The individual had a mottled brown base coloration, with white patches concentrated toward the anterior. These white patches predominated the surface of the head, neck and anterior trunk, and contained scales of normal appearance, although devoid of any pigmentation (Figs. 2B, C). Over the course of photographing this individual, her base coloration darkened from that when she was first observed, however no color change was observed in the white areas. Although limited amounts of whitish blotches on the head have been noted in males of this form, it was previously unknown in females. Further, to the best of our knowledge, the extent of hypopigmentation, or partial leucism, observed in this individual does not appear to be documented previously in *A. roquet*.

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***ASPIDOSCELIS GULARIS* (Texas Spotted Whiptail/Common Spotted Whiptail). SCAVENGING.** Like the rest of the *Aspidoscelis* genus, the diet of *A. gularis* consists primarily of small arthropods, including insects such as termites, grasshoppers, crickets, moth larvae, beetles and ants, and arachnids such as spiders and scorpions (Leavitt and Leavitt 2009. *In* Jones and Lovich [eds.], Lizards of the American Southwest, pp. 346–349. Rio Nuevo Publishers, Tucson, Arizona). As it grows, *A. gularis* consumes a wider variety of arthropod prey, but eats more grasshoppers when this prey item is in abundance (Lemos-Espinal and Smith 2008. Anfibios y Reptiles del Estado de Coahuila, Mexico. UNAM. Mexico D.F.). Here we record an observation of scavenging behavior of *A. gularis* on a dead ant, *Atta mexicana*.

At 1242 h on 11 June 2016, we observed an *A. gularis* foraging 2.15 km NE of the junction of Mexican Highway 57, at the slopes of Cerro Gordo in the locality of La Esperanza in the municipality of Villa de Zaragoza, San Luis Potosí, Mexico (21.97811°N, 100.79841°W, WGS 84; 1877 m elev.). The lizard, which was 2 m from us, noticed our presence but continued foraging while maintaining a safe distance. The locality was dominated by patches of Bilberry Cactus (*Myrtillocactus geometrizans*); the substrate was humid due to recent rains but held a temperature of 36°C. While foraging, the lizard discovered the carcass of a reproductive male ant, *Atta mexicana*, which was part of the nocturnal reproductive swarm that we observed the night before, in response to the rainy season. The lizard began picking up, shaking and biting pieces off the corpse. However, it became aware of our presence and abandoned the carcass, quickly fleeing to nearby bushes.

This opportunistic behavior is relevant due to the nature of the lizard and the season it was recorded in. Whiptail lizards are active foragers, consuming live prey including the rapid pursuit of fast-moving species. June is part of the rainy season at this locality, a time of great abundance of arthropods. Although many insect prey present a challenge for *A. gularis* to capture (e.g., grasshoppers, moths, and some small wasps), many others like beetles and ants are fairly easy to capture for this remarkably fast lizard. It is possible that dead or dying reproductive ants, appearing in the morning after their nocturnal swarm, provide an important source of energy for *A. gularis*.

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***ASPIDOSCELIS SEXLINEATA* (Six-lined Racerunner). SYMBIOSIS.** On 14 July 2014, in Okaloosa County, Florida, USA, a leaf-cutting bee (Megachilidae) was observed entering a sandy burrow that had been constructed and actively used by an adult *Aspidoscelis sexlineata* as recently as 10 July. Prior to this observation, leaf-cutting bees were observed actively cutting leaves and constructing nest cells in other cavities nearby, but this was the first cavity used by the bees that was created by another animal. After recognizing this, we continued to watch the bee return six additional times with curled leaf cuttings. The bee only remained in the burrow for a few seconds before exiting and flying out of the burrow without pausing at the entrance. It was difficult to track exactly where the bee was going for the cuttings, but we did locate a Common Persimmon (*Diospyros virginiana*) in the general direction of travel that had many freshly cut leaves. We continued to monitor the burrow following these observations but never documented the return of the lizard. The opening of the burrow eventually closed, presumably due to lack of maintenance following rain events. We made no attempt to determine if adult bees successfully emerged the following spring.

The use of burrows excavated by other species by *A. sexlineata*, including the Gopher Tortoise (*Gopherus polyphemus*) (Alexy et al. 2003. Wildl. Soc. Bull. 31:1240–1243) and small mammals (Gentry and Smith 1968. J. Mammal. 49:562–565; Funderburg and Lee 1968. J. Herpetol. 1:99–100) has been documented, as has use of racerunner burrows by several groups of insects, including members of Carabidae, Gryllidae, and Reduviidae (Hardy 1962. Univ. Kansas Sci. Bull. 43:1–74). However, to our knowledge this is the first documentation of use by Megachilidae. Our observation suggests that use of the lizard burrow as a leaf-cutting bee nest may not have been compatible with continued use by a racerunner; however, we cannot be sure of this. Activity burrows are typically made by racerunners in the warmer months and tend to be shallow and quickly constructed (Etheridge et al. 1983. Copeia 1983:206–214). These burrows are likely temporary refugia, and therefore may not represent a significant energy investment by the lizard, so abandoned burrows may be regularly available during the nesting season of leaf-cutting bees. Additional observations would be required to determine if this is a commensal or parasitic use of burrows by Megachilidae, or if leaf-cutting bee larvae, pupae, or adults using *A. sexlineata* burrows are at risk of becoming food for racerunners, which are known to feed on hymenopterans (Warner 2000. Trans Illinois Acad. Sci. 93:239–248; Fitch 1958. Univ. Kansas Publ. Mus. Nat. Hist. 11:11–62).

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CERCOSAURA SCHREIBERSII **(Schreiber's Many-fingered Teiid). PREDATION.** *Cercosaura schreibersii* is a terrestrial lizard ranging from Peru to Uruguay, including Bolivia, Paraguay, Argentina, and southern Brazil (Ruibal 1952. Bull. Mus. Comp. Zool. 106:477–529; Balestrin et al. 2010. Biota Neotrop. 10: 131–139). It has a greatly reduced body size, reaching slightly more than 40 mm snout–vent length, with a long tail nearly three times this size, that is easily autotomized (Borges-Martins et al. 2007. *In* Becker et al. [eds.], Biodiversidade: Regiões da Lagoa do Casamento e dos Butiazais de Tapes, Planície Costeira do Rio Grande do Sul, pp. 292–315. Ministério do Meio Ambiente, Brasília). This species forages on invertebrates during the day (Achaval 1984. Bol. Soc. Zool. Uruguay Seg. Epoca 2:59–62). In this note, we report the predation of an adult specimen of *C. schreibersii* by the spider *Plesiopelma* sp. in the Uruguayan pampas region.

The event took place at 1200 h on 20 February 2015 in a prairie environment. The area belongs to the Aeropuerto Internacional de Carrasco (34.8369°S, 56.0300°W; WGS 84), near Montevideo city, in extreme southern Uruguay. At the time of the event, the spider had caught the small lizard, which was still alive and was trying to escape from the chelicerae; however, the lizard was already seriously injured on the anterior body region (Fig. 1). The observation lasted 10 minutes, ending when the spider entered its refuge with the dead lizard.


Fig. 1. *Plesiopelma* sp. preying upon the lizard *Cercosaura schreibersii.*

Small reptiles are potential prey for a wide range of animals, including invertebrates, and within this group, spiders (Bauer 1990. Herpetol. Rev. 21:83–87; Armas 2000. Rev. Ib. Arac. 3:87–88). This record is the first involving predation between these two species. Although the genus *Plesiopelma* belongs to the family Theraphosidae, it is not a large spider within the group, and the presence of reptiles in its diet is probably unusual.

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CNEMIDOPHORUS LEMNISCATUS **(Rainbow Whiptail). DIET: ACTIVE PLANT COMSUMPTION.** Plant consumption in insectivorous lizards is usually considered incidental, or sometimes complementary, as occurs in *Cnemidophorus* species, where diet studies are restricted to few taxa, registering only two species with an exclusively herbivorous diet (Deraring and Shall 1991. Ecology 73:845–858; Schall and Ressel 1991. Copeia 1991:111–119). On 25 June 2016, we observed and filmed two adult individuals of *C. lemniscatus* actively foraging on small shrubs (Fabaceae, genus *Stylosanthes*) during field work at Tauremena in the Llanos region of Colombia (4.95751°N, 72.73984° W, WGS 84; 311 m elev.). These individuals fed on the small flowers (of approximately 10 mm from the sepals to the border of the petals) of this plant; the flowers apparently did not contain insects. One of the individuals consumed six flowers and the second larger individual consumed eight flowers, both during a period of 21 and 26 seconds, respectively. The arrival of the larger individual to the shrub chased away the smaller one. We also collected one young female (ICN-R 12521, Colección de Reptiles, Instituto de Ciencias Naturales, Universidad Nacional de Colombia) from the same population and examined its stomach contents; a large proportion (60% of the total stomach contents), were flowers of the same plant (*Stylosanthes*), 28% were the elytra of coleopterans, 8% caterpillars, and 4% spider fragments. We thus provide evidence that individuals of this species include a significant proportion of plant material in their diet, and that they actively search for plants during their foraging activities. The diet of *C. lemniscatus* has been studied in some populations from South America (Vitt et al. 1997. Copeia 1997:745–757) and has been considered insectivorous, with incidental consumption of plant material. However, we suggest that plant material could represent an important energy source for lizard populations occurring in the eastern lowland region of Columbia, an aspect that deserves further research.

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CYRTODACTYLUS QUADRIVIRGATUS **(Four-striped Forest Gecko). REPRODUCTION.** *Cyrtodactylus quadrivirgatus* ranges from southern Thailand, through Peninsular Malaysia to Sumatra (Manthey and Grossmann 1997. Amphibien & Reptilien Südostasiens. Natur und Tier - Verlag, Berlin, Germany. 512 pp.). In Peninsular Malaysia, *C. quadrivirgatus* is generally ubiquitous (Grismer 2011. Lizards of Peninsular Malaysia, Singapore and their Adjacent Archipelagos. Edition Chimaira, Franfurt am Main. 728 pp.). Das reported *C. quadrivirgatus* produced clutches consisting of two eggs (2010. A Field Guide to the Reptiles of South-east Asia, Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, Bali. New Holland Publishers, Ltd., London, UK. 376 pp.). Herein we report additional information on *C. quadrivirgatus* reproduction.

We examined 89 *C. quadrivirgatus* deposited in the herpetology collection of La Sierra University (LSUHC), Riverside, California, USA, collected in Peninsular Malaysia from 2002–2015, consisting of 41 adult males (mean SVL = 58.0 mm ± 5.4 SD, range = 47–68 mm), 39 adult females (mean SVL = 63.3 mm ± 5.1 SD, range = 54–73 mm), and nine subadults (mean SVL = 40.9 mm ± 24.35 SD, range = 36–48 mm). Lizards were captured by hand and were sacrificed with an overdose of pentobarbital.

Cyrtodactylus quadrivirgatus collected by Peninsular Malaysian states were: Johor (LSUHC) 8969–8972; Kedah (LSUHC) 6863–6865, 6870, 7102, 9438, 9445, 9446, 9620, 9622, 9623, 9625, 9837, 10577, 10649, 11549, 11814; Kelantan (LSUHC) 12166, 12167; Pahang (LSUHC) 4813, 4980, 5017, 5173, 5517, 5582, 6136, 6146, 6461, 6478, 6479, 6484, 6778, 8081, 9083–9089, 9924, 11021,11030, 11031, 12135; Penang (LSUHC) 6737, 6738, 6756, 9702, 9724, 10072, 10073, 10611, 11029, 11120; Perak (LSUHC) 5633, 5634, 5640, 8859, 8860, 9011, 9012, 9014–9016, 9191, 9864–9872, 9909; Selangor (LSUHC) 6503, 6607, 6608, 6617, 6618; Terengganu (LSUHC) 9057, 9058, 10853, 10968.

A cut was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut into 5-µm sections and stained with Harris hematoxylin followed by eosin counterstain. Enlarged follicles (> 4 mm) or oviductal eggs were counted. Histology slides were deposited in LSUHC.

The only stage present in the testicular cycle was spermiogenesis in which the lumina of the seminiferous tubules were lined by sperm or clusters of metamorphosing spermatids. The smallest reproductively active male measured 47 mm SVL and was collected in June (LSUHC 9087). Monthly distribution of spermiogenic males was: March (N = 10), June (N = 9), July (N = 5), August (N = 7), September (N = 10).

Four stages were present in the monthly ovarian cycle (Table 1): 1) quiescent, no yolk deposition; 2) early yolk deposition, basophilic yolk granules in the ooplasm; 3) enlarged follicles > 4 mm; 4) oviductal eggs. Mean clutch size (N = 17) was 1.9 ± 0.33 SD, range 1–2. The smallest reproductively active female (2 follicles > 4 mm) measured 56 mm SVL (LSUHC 5633) and was collected in August. There was no indication that females produce multiple clutches, as no female with oviductal eggs and concurrent yolk deposition was found. All subadults (N = 9) had tiny gonads and were judged to be reproductively inactive.

Table 1. Monthly stages in the ovarian cycle of 39 adult female *Cyrtodactylus quadrivirgatus* from West Malaysia.

Month	N	Quiescent	Early yolk deposition	Enlarged follicles > 4 mm	Oviductal eggs
March	7	2	1	3	1
June	17	9	3	1	4
July	1	1	0	0	0
August	7	1	0	5	1
September	7	4	1	1	1

The presence of reproductive activity in all months sampled indicates *C. quadrivirgatus* has an extended reproductive cycle, which was also reported for *C. seribuatensis* from Peninsular Malaysia (Goldberg and Grismer 2015. Herpetol. Rev 46:89–90). Whether reproduction occurs throughout the year as postulated by Grismer (*op. cit.*) will require examination of samples from additional months.

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CYRTODACTYLUS TIOMANENSIS **(Tioman Island Bent–toed Gecko). REPRODUCTION.** *Cyrtodactylus tiomanensis* is known only from Tioman Island, Pahang State, Peninsular Malaysia (Grismer 2011. Lizards of Peninsular Malaysia, Singapore and their Adjacent Archipelagos. Edition Chimaira, Frankfurt am Main, Germany. 728 pp.). Grismer (*op. cit.*) reported gravid females carrying two eggs from July and hatchlings during June, July and August.

We examined a sample of 16 *C. tiomanensis* consisting of six adult males, (mean SVL = 81.3 mm ± 5.0 SD, range = 73–87 mm), two adult females (mean SVL = 85.5 mm ± 2.1 SD, range = 84–87 mm), two females of uncertain maturity (mean SVL = 75.5 mm ± 3.5 SD, range = 73–78 mm) and six subadults (mean SVL = 40.8 mm ± 6.1 SD, range = 37–53 mm). These were collected in June and July 2001 to 2004 at Pulau Tioman (2.8167°N 104.1833°E), Pahang State, West Malaysia, and deposited in the herpetology collection of La Sierra University (LSUHC), Riverside, California, USA, as LSUHC 3771, 3793, 3794, 4581–4584, 4587, 4590, 4597, 5411, 5512, 5520, 6250, 6251, 6268. Lizards were sacrificed by an overdose of pentobarbital.

A cut was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut into 5-µm sections, and stained with Harris hematoxylin followed by eosin counterstain. Enlarged follicles (> 5 mm) were counted. Histology slides were deposited at LSUHC.

The smallest reproductively active male (spermiogenesis) measured 78 mm SVL (LSUHC 6251) and was collected in June. One slightly smaller male (LSUHC 6268) collected in July, which measured 73 mm SVL was in late recrudescence (just prior to spermiogenesis). Spermatids were the predominant cell, with only an occasional spermatozoon noted. It is likely spermiogenesis would have commenced shortly. This male may have represented the minimum size at maturity for *C. tiomanensis* males.

One female from July (LSUHC 3794) which measured 87 mm SVL contained two enlarged follicles (> 5 mm) representing a clutch of two eggs. Another female from July which measured 84 mm SVL (LSUHC 4590) had commenced yolk deposition. Basophilic vitellogenic granules were in the ooplasm. We are unable to ascertain if two females with quiescent ovaries (no yolk deposition) which measured 78 (LSUHC 5512) and 73 mm SVL (LSUHC 3793) had reached the minimum size for maturity. Six subadults all contained tiny ovaries and could not be sexed. Examination of *C. tiomanensis* from additional months is needed before the duration of the reproductive cycle can be ascertained.

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***DRACO TAENIOPTERUS* (Barred Gliding Lizard). REPRODUCTION.** *Draco taeniopterus* is known from parts of Myanmar, Thailand, Thailand, Cambodia, and northern Peninsular Malaysia (Das 2010. A Field Guide to the Reptiles of South-east Asia, Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, Bali. New Holland Publishers, London. 376 pp.). Information on reproduction of *D. taeniopterus* is in Goldberg and Grismer (2015. Hamadryad 37:117–121). The purpose of this note is to provide information on a new maximum clutch size for *D. taeniopterus*.

One female *D. taneiopterus* (SVL = 90 mm) was examined from Terengganu State, Gunung Tebu (5.5913°N, 102.6122°E; 580–800 m elev.), Peninsular Malaysia, deposited in the herpetology collection of La Sierra University (LSUHC), Riverside, California as LSUHC 10908.

A cut was made in the lower abdominal cavity and the ovaries were exposed. Five oviductal eggs were present (3 left oviduct, 2 right oviduct). Goldberg and Grismer (*op. cit.*) previously reported a range of 1–4 for *D. taneiopterus* clutches. Five is a new maximum clutch size for *D. taneiopterus*.

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***EMOIA CYANURA* (Brown-tailed Copper-striped Skink). NOCTURNAL FORAGING AND FORAGING ON BUILDINGS.** *Emoia cyanura* is an abundant and widespread skink occurring on many islands of the Pacific Ocean (Ineich and Zug 1991. Copeia 1991:1132–1136; Zug 2013. Reptiles and Amphibians of the Pacific Islands: A Comprehensive Guide. University of California Press, Berkeley. 306 pp.). On Fiji it occurs primarily in moderate to closed canopy forest but can occasionally be found at forest edges and in human disturbed areas (Morrison 2003. A Field Guide to the Herpetofauna of Fiji. University of the South Pacific, Suva. 121 pp.). It is considered to be primarily terrestrial but occasionally forages low on the base and lower branches of trees or axils of palms and pandanus (Morrison 2003, *op. cit.*; Zug 2013, *op. cit.*). It is also considered to be a diurnal species, active from just after sunrise to shortly before sunset (Zug 1991. Bishop Mus. Bull. Zool. 2:1–136; Morrison 2003, *op. cit.*). On Fiji, the species has been recorded in lowland rainforest, coastal stand vegetation, small island vegetation, agricultural land (including gardens), but not on human made structures (Morrison 2005. Pac. Sci. 59: 481–489).

At 1930 h on 6 June 2011 and again at 1918 h on 9 June 2011, a single *E. cyanura* was observed foraging on the upper beam of an outside wooden deck of a building near Welangi, Taveuni, Fiji (16.7364°S, 179.9356°W; WGS 84), among LED fairy lights. The beam was approximately 2.5 m above the deck floor and approximately 6 m above the ground. Numerous *Lepidodactylus lugubris* (Mourning Geckos) were also observed foraging on beams nearby. We did not observe *E. cyanura* to capture any prey and the skink was warier than the geckos when approached, quickly retreating into a crevice. In both instances the skink was observed approximately two hours after sunset during complete darkness (except for the artificial lighting).

Presumably, the attraction of invertebrates to artificial lights attracts lizards because of the greater quantity of food and the increased predictability of finding prey (Perry et al. 2008. *In* Mitchell et al. [eds.], Urban Herpetology, pp. 239–256. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah). Although more anecdotal information about the effects of night lighting on lizards is available than for any other group, few of these observations are of skinks (Perry and Fisher 2006. *In* Rich and Longcore [eds.], Ecological Consequences of Artificial Night Lighting, pp. 169–191. Island Press, Washington, DC; Perry et al. 2008, *op. cit.*). These observations of *E. cyanura* appear to be the first documented record of nocturnal foraging and foraging on human structures by this species.

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***GONATODES ALBOGULARIS* (Yellow-headed Gecko). PREDATION.** *Gonatodes albogularis* is found below 1900 m elev. in tropical and dry forest from northwestern South America through Central America. Microhabitats include mainly tree trunks but also it can be found in rocky environments and on buildings (Rodríguez-Mahecha et al. 2008. Guía Ilustrada de Fauna del Santuario de Vida Silvestre Los Besotes, Valledupar, Cesar, Colombia. Editorial Panamericana, Formas e Impresos, Bogotá, Colombia. 574 pp). Known predators of *Gonatodes* are mostly diurnal vertebrates such as birds (Woodcreeper: Kupriyanov et al. 2012. J. Nat. Hist. 46:2985–2997; House Sparrow: Powell and Henderson 2008. Iguana 15:9–11; Spotted Puffbird: Okada and Costa-Campos 2014. Herpetol. Rev. 45:498–499) and snakes (Parrot Snake: Vitt and Vangilder 1983. Amphibia-Reptilia 4:273–296; Brown Vinesnake: pers. obs., El Agrado, Huila, Colombia). Nocturnal predators are less well-known (Blunt-headed Tree Snakes: de Sousa et al. 2014. Zoologia 31:8–19). Here I present an observation of predation of a *G. albogularis* by a Whip Scorpion (Amblipigidae: *Phrynus* sp.), a common nocturnal predator in tropical forests.

In November 2014, I performed a herpetological inventory in dry forests of Guane in the municipality of Barichara, Santander state, Colombia (6.68399°N, 73.23983°W, WGS 84; 1040 m elev.). During a night spotlight at 0210 h on 24 November 2014, I detected a *G. albogularis* sleeping on a boulder, and a Whip Scorpion (*Phrynus* sp.) about 20 cm from the gecko. When one

FIG. 1. A Whip Scorpion (*Phrynus* sp.) preying on an adult male *Gonatodes albogularis* in a dry forest from Guane (Santander, Colombia).

of its sensory legs gently touched the gecko, almost instantly, the whip scorpion lunged and captured the gecko with its pedipalps. The whip scorpion bit the gecko's throat, and after the gecko was dead, the whip scorpion took the gecko back to the boulder. Although whip scorpions can prey upon small lizards (anoles: Reagan and Waide 1996. The Food Web of a Tropical Rainforest. University of Chicago Press. Chicago. Illinois. 623 pp; Kok 1998. Herpetol. Rev. 291:41; de Armas 2001. Rev. Iber. Arac. 3:87–88), this observation represents the first account of a whip scorpion preying upon *G. albogularis*.

This observation was made during a research project about Functional Diversity of Dry Forests, leaded by Fundación Natura Colombia and funded by Ecopetrol.

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HEMIDACTYLUS PARVIMACULATUS **(Small-spotted Half-toed Gecko). PREDATION.** *Hemidactylus parvimaculatus* was recently elevated to species status (Bauer et al. 2010. Herpetol. J. 20:129–138), a decision supported by Bauer et al. (2010. Mol. Phylogenet. Evol. 57:343–352) and Lajmi et al. (2016. Org. Divers. Evol. 16:659–677). Its known natural distribution covers Sri Lanka and southern and eastern India (Lajmi et al., *op. cit.*). Although it lives in highly urbanized areas, surprisingly little information on its natural history is available. Karunarathna and Amarasinghe (2011. Taprobanica 2:104) observed an adult *H. parvimaculatus* eating a microhylid frog, a young *Uperodon variegatus*, and Somaweera and Somaweera (2009. Lizards of Sri Lanka – A Colour Guide with Field Keys. Chimaira, Frankfurt am Main. 303 pp.) mention that cannibalism is commonly observed among these geckos. Here we report predation on *H. parvimaculatus* by a Yellow-billed Babbler (*Turdoides affinis*).

At 0645–0655 h on 20 February 2014 (i.e., approx. half an hour after sunrise) we watched a flock of Yellow-billed Babblers foraging in the garden of the hotel Puttalam Rest House in the center of the large town Puttalam, western Sri Lanka (8.028906°N, 79.831923°E; 7 m elev.). At 0650 h one individual was observed having captured a *H. parvimaculatus* (Fig. 1) and the gecko was quickly swallowed. The irregular dark brown spots on dorsum are essential for differentiating the gecko from *H. frenatus* (cf. Das and de Silva 2005. A Photographic Guide to Snakes and other Reptiles of Sri Lanka. New Holland Publishers, London, 144 pp.; Somaweera and Somaweera, *op. cit.*).

Fig. 1. *Hemidactylus parvimaculatus* being preyed upon by a *Turdoides affinis* (Yellow-billed Babbler).

This is the first record of predation on *H. parvimaculatus* by *T. affnis*, or indeed by any animal. It is an omnivorous bird that feeds mainly on animals, especially invertebrates (Johnsingh et al. 1982. J. Bombay Nat. Hist. Soc. 79:503–514; Collar and Robson 2007. *In* del Hoyo et al. [eds.], Handbook of the Birds of the World, vol. 12. Picathartes to Tits and Chickadees, pp. 70–291. Lynx Edicions, Barcelona). *Turdoides affinis* has also been recorded preying upon two reptile species, *Calotes versicolor* and *Cylindrophis maculata* (Ali and Ripley 1996. Handbook of the Birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka, vol. 6. Cuckoo-Shrikes to Babaxes. 2nd ed. Oxford University Press, Delhi, xiii + 247 pp.; Karunarathna and Amarasinghe. 2005. Sri Lanka Naturalist 7:27).

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IGUANA IGUANA **(Green Iguana). PREDATION.** The diurnal, arboreal, and folivorous *Iguana iguana* is a large lizard widely distributed in Central and South America. The anti-predator tactics of Green Iguanas include camouflage, flight, and active defensive behavior (Greene et al. 1978. J. Herpetol. 12:169–176). Nevertheless, individuals of all ages are preyed upon by many vertebrates, including reptiles, mammals, and birds (Greene et al. 1978, *op. cit.*). Herein, we report a new predator of *I. iguana, Oxybelis fulgidus* (Green Vine Snake).

At 1147 h on 26 April 2011 we found a roadkill adult male *O. fulgidus* (total length ca. 130 cm) on a road in Rurópolis municipality, Pará state, Brazil (4.123583°S, 54.98329°W, WGS 84; 134 m elev.). The impact of the car wheels probably exposed the stomach contents of the snake: a juvenile *I. iguana* (total length ca. 25.0 cm; Fig. 1). The specimens were not vouchered due to their condition.

Although adult *I. iguana* are likely to be hunted only by top predators such as crocodiles, large hawks, and wild cats, juveniles

Fig. 1. A juvenile *I. iguana* exposed from the stomach of a roadkill adult male *Oxybelis fulgidis*.

are vulnerable to small birds and snakes (Greene et al. 1978, *op. cit.*). A large individual *Oxybelis aeneus* was recorded preying on a juvenile *I. iguana* in Barro Colorado Island, Panama (Greene et al. 1978, *op. cit.*).

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***LEPOSOMA PARIETALE* (Common Root Lizard). MATING.** *Leposoma parietale* is widely distributed across Colombia, Ecuador, Peru, and Venezuela. It is a diurnal lizard found in tropical forest and inhabits the forest floor (leaf litter). It is mainly observed in primary forest although individuals have been found near forest edge and gaps in secondary forests (Vitt and Zani 1996. Can. J. Zool. 74:1313–1335). It is sympatric and shares the strata with several species that belong to Gymnophtalmidae, Dactyloinae, Sphaerodactylidae, and Teiidae. *Leposoma parietale* is oviparous and reproduce cyclically through a long breeding season between March and August. Multiple and successive clutches produced by individual females have been reported; the only ecological information on this species comes from two localities in Ecuador, and there is no information regarding copulation behavior (Duellman 1978. The Biology of an Equatorial Herpetofauna in Amazonian Ecuador. Univ. Kansas Misc. Publ. No. 65, 352 pp.; Vitt and De La Torre 1996. Guía para la Investigación de las Lagartijas de Cuyabeno [= A Research Guide to the Lizards of Cuyabeno, Quito, Ecuador]. Museo de Zoología, Centro de Biodiversidad y Ambiente, Pontificia Universidad Católica del Ecuador). Here we add information about the habitat of *L. parietale* and provide for the first time insights on its mating behavior.

A pair of *L. parietale* was observed at 1318 h on 21 November 2014 in a mating position (Fig. 1) in Jatun Sacha Biological Reserve, located in Napo Province, Ecuador (1.072255°S, 77.614489°W; 431 m elev.). The area is evergreen tropical forest. The pair was observed at ground level in a small gap in primary forest (Terra firme) (Fig. 1). At the beginning of the observation, both individuals were rapidly walking together on muddy forest floor covered by leaf litter. After they stopped, the remained immobile side by side for the duration of the observation (5 minutes); the male held the female by grasping (biting) the female's neck in his jaws. At the same time, one of his hemipenes remained in her cloaca. A close up of the genitals section shows an ornamented hemipenal spine (Fig. 1); this structure possibly reinforces couple-anchoring. The male curved his tail under the female's in a cross position similar to other lizard species, where females remain passive to ensure successful copulation (Ribeiro et al. 2011. Biota Neotrop. 11:363–368). The male had a bright red-orange ventral color extending from the head to the tail. The duration of the full mating process was not recorded as the couple was already mating when found.

Fig. 1. *Leposoma parietale in copulo*, including a close-up (inset) of the genitals showing the ornamented hemipenis.

Mating of lizards is mainly stereotyped, but there is variation in specific behaviors among groups. Our finding adds to the scarce information on reproductive behavior in lizards in the region (Ribeiro et al, *op. cit.*; Gogliath et al. 2010. Biota Neotrop. 10:347–350). Advances in the knowledge of reproductive behavior in *Leposoma* species may prove a key factor in understanding the origin of parthenogenesis and behavioral evolution of the group. *Leposoma percarinatus* is one of the 17 described species of *Leposoma* and unlike the others it is parthenogenetic (Uzzell and Barry 1971. Peabody Mus. Nat. Hist. 154:1–39). The origin of this species is hypothesized as a hybridization between the closely related *L. guianense* and *L. parietale* (Pellegrino et al. 2011. Mol. Phylogenet. Evol. 61:446–459; Souza et al. 2015. South Amer. J. Herpetol. 10:121–131). Furthermore, in some unisexual species, courtship, copulation, or pseudo-copulation behaviors have been observed. The function of these behaviors has been interpreted as ovulate stimulation or to establish dominance or territoriality in parthenogenetic species (Cole and Townsend 1983. Anim. Behav. 31:724–728). Our observation is the first record of *L. parietale* sexual behavior and provides a possible starting point to contrast their behavioral repertoire with that of *L. percarinatus.*

Finally, although *L. parietale* is considered an abundant species, the destruction of natural areas constitutes a threat to the species, which occurs mainly occur in natural forest, areas that are highly impacted by landscape fragmentation. Our observations were in a private reserve managed by the Jatun Sacha Foundation (22,000 ha with 70% of primary forest). We believe that complete information on habitat selection and its importance for species survival will provide the basis for the establishment of strong conservation polices in natural reserves such as Jatun Sacha. Nicole Butter and Sarah Papworth provided helpful comments to the manuscript.

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***PHRYNOSOMA MCALLII* (Flat-tailed Horned Lizard). ULTRAVIOLET (UVB) EXPOSURE.** *Phrynosoma mcallii* is a medium-sized horned lizard found in the extreme southwestern corner of Arizona, the southeastern corner of California, and adjoining portions of Sonora and Baja California, Mexico in some of the hottest and most barren examples of the Sonoran Desert (Sherbrook 2003. Introduction to Horned Lizards of North America. University of California Press, Berkeley. 177 pp.; Rorabaugh and Young 2009. *In* Jones and Lovich [eds.], Lizards of the American Southwest: A Photographic Field Guide, pp. 182–185. Rio Nuevo Publishers, Tucson, Arizona). Thermal environment, activity, and regulation have been investigated in this species (Norris 1949. Copeia 1949:176–180; Mayhew 1968. *In*

G. W. Brown Jr. [ed.], Biology of Desert Amphibians and Reptiles, pp. 195–356. Academic Press, New York; Wone and Beauchamp 2003. J. Herpetol. 37:679–686). However, its exposure to solar ultraviolet-B (UVB) remains unreported. Because UVB exposure has both detrimental and beneficial effects on lizards, knowledge of the natural UVB environment while basking is important from the point of view of conservation and captive management of amphibians and reptiles (Ferguson et al. 2010. Zoo Biol. 29:317–334).

Field surveys of *P. mcallii* were conducted at the East Mesa Flat-tailed Horned Lizard Management Area in the summer of 2014 (Flat-tailed Horned Lizard Interagency Coordinating Committee 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 78 pp. plus appendices. U.S. Bureau of Land Management, Palm Springs, California). During field training sessions to teach field assistants how to track and locate this species, field crews recorded UVB exposure and environmental temperatures at locations where horned lizards were first discovered. Approximately 10–15 observers per day recorded data between 0630 and 1100 h on 21, 22, 23 May 2014. We recorded data for 17 *P. mcallii*. According to the survey protocol, each lizard discovered by a trainee or trainer was undisturbed until every member of the group had an opportunity to visually locate it. Once everyone had the opportunity to observe the animal, it was captured and data were collected, including UVB irradiance (Solarmeter 6.5 which displays ultraviolet index [UVI], Solartech, Inc. Harrison Township, Michigan) as well as air and ground temperature (Ryobi Non-Contact InfraRed Thermometer IR001 One World Technologies, Inc. Anderson, South Carolina). UVB readings were taken by placing the base of the Solarmeter on the substrate and orienting the sensor towards the sun. We also measured air temperatures with the sensor of the thermometer shaded, and measured ground temperature by pointing the laser next to the location of the lizard prior to its capture.

Table 1. Temperatures and UV-index (UVI) recorded for *Phrynosoma mcallii* during field surveys at East Mesa Flat-tailed Horned Lizard Management Area in May 2014.

Date	Local time (h)	Air temp °C	Ground temp °C	UVI	Sex M.F
20 May 2014	0713	21.3	20.5	0.2	0.1
	0729	23.6	29.4	0.4	0.1
	0750	23.9	23.3	1.0	0.1
	0800	22.8	32.2	1.0	1.0
	0822	25	25.5	1.6	1.0
	0955	28.7	38.7	4.0	-
	1016	31.9	43.3	4.8	-
21 May 2014	0820	23.9	28.3	1.1	-
	0840	23.3	27.22	1.6	-
	0900	25	32.2	2.4	-
	0935	25.5	36.1	3.4	-
	1042	29.4	50.5	5.0	-
22 May 2014	0700	20	18.3	0.2	1.0
	0745	22.5	27.5	0.6	1.0
	0815	23.9	31.9	1.2	0.1
	0902	28.6	40.3	2.3	0.1
	0934	30.8	43.9	2.7	1.0

The mean UV index of exposure during the morning was 1.97 with a median of 1.6 (Table 1). These values would qualify it as occupying UVB zone 3 during its morning activity period (see Ferguson et al. 2010, *op. cit.* for definition of the four UVB zones), zone 3 being the second highest UVI exposure zone. The only other *Phrynosoma* species for which morning UVB zone has been recorded is *P. cornutum* (Texas Horned Lizard) (Ferguson et al. 2015. Southwest. Nat. 60:231–239). *P. cornutum* occupies zone 4 (highest UVI zone) during its morning activity. The difference in average morning UVI exposure recorded for the two species is likely due to the earlier time of exposure of *P. mcallii* compared to *P. cornutum*. Higher ambient temperatures as midday approached likely constrained activity of *P. mcallii* to earlier times of day when solar altitude and corresponding solar radiation was lower (Wone and Beauchamp 2003, *op. cit.*). Whether or not UVB dose (irradiation X exposure duration) differs between the two species for its entire daily activity period requires further documentation.

I thank the U.S. Fish and Wildlife Service (USFWS) and Bureau of Land Management (BLM) for the opportunity to collect these data. All data were collected during training sessions that were co-sponsored by the USFWS and BLM, with staff from both agencies present. Gary W Ferguson, William Gehrmann, and Mike Maez provided assistance in preparing the manuscript. I also thank fellow trainers Brian Aucone, Danny Martin, David Wojnowski, Megan E. Lahti, Kevin Young, Jack Crayon, and various other trainers who have helped on the project as well as the trainees who made finding many more lizards possible. I thank the Dallas Zoo for continued support.

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***PHYLLOPEZUS PERIOSUS* (Paraiba Gecko). TREE SAP FORAGING.** The use of tree sap has been described for a diurnal gecko in Brazil (Teixeira et al. 2013 Herpetol. Notes 6:545–547); however, there are no records of the use of this resource by nocturnal lizards. This paper reports tree sap foraging by *Phyllopezus periosus*, a nocturnal species that occurs in the Caatinga Region (Andrade et al. 2013. Biota Neotrop. 13:199–209).

During an expedition to Serra de Santana, a shruby arboreal Caatinga area located in the municipality of Lagoa Nova, Rio Grande do Norte, Brazil (6.124938°S, 36.563979°W; WGS 84), three observations of *P. periosus* feeding on tree sap were made. Only one specimen was captured, and it was deposited in the Herpetological Collection of Universidade Federal do Rio Grande do Norte (UFRN 5960).

At 2035 h on 10 March 2015, an adult male (SVL = 122.5 mm) was observed perched approximately 1 m above the ground feeding on the sap of *Schinopsis brasiliensis* (Baraúna), a native tree; this individual was observed for five minutes and then collected. During the observation time, the lizard remained stationary, moving its tongue slowly in order to obtain the sap released by a natural crack in the tree bark. At 2340 h on 17 March 2015 a specimen was observed feeding on sap at the same tree of the previous observation; however, upon noticing the observer, the lizard quickly moved away from the foraging site. At 2350 h on 19 March 2015 a specimen was also foraging on the trunk of a *S. brasiliensis*. This observation lasted 15 min, including 7 min of the lizard moving only its tongue while consuming the sap, 7 min remaining motionless, and 1 min lunging to capture winged insects that entered its field of vision.

The recurrent cases of sap foraging recorded in this population allow us to infer that this resource is an important dietary supplement for this species. Our observation is the first record of sap foraging by *P. periosus* and the first report of the use of native plants as a food resource by a nocturnal Caatinga lizard species.

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***PODARCIS MURALIS* (Common Wall Lizard). PARASITE LOAD.** Herein we present the first record of the tapeworm *Mesocestoides litteratus* in *Podarcis muralis* in its native range in Western Europe. The life cycle of this parasite comprises presumably two intermediate hosts and one definite host, although details remain unresolved. Most likely, the first intermediate host is a coprophagous arthropod that transmits the tapeworm parasite to its predators, usually a rodent, amphibian, lizard, or bird. The development into the characteristic tetrathyridium larvae occurs in the second intermediate host. Upon ingestion of the intermediate host by a large mammal, the definitive host, the tapeworm reaches its adult stage in the intestinal tract, reproduces and the life cycle is completed. In the second intermediate host (e.g., a lizard), peritoneal infection occurs through active penetration of the intestinal wall by ingested tapeworm larvae. Here, the worms reproduce asexually by longitudinal fission which leads to the high parasite load typically observed (Bonfanti 2004. J. Vet. Med. A Physiol. Pathol. Clin. Med. 51:435–438).

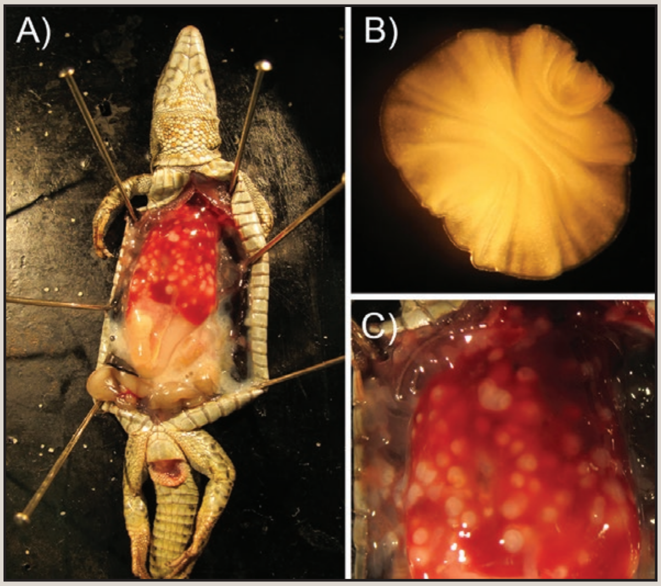

Fig. 1. A) Dissected female of *Podarcis muralis* with heavy infestation by *Mesocoithes litteratus* (tetrathyridia). B) Single tetrathyridia that was found in the peritoneal cavity. C) Magnification of the liver of the infested female with encapsulated tetrathyridia.

A number of lizards have been described as intermediate hosts, including several species belonging to the family Lacertidae: the Anatolian lizard *Anatololacerta danfordi*, in Turkey (Gürelli et al. 2007. North-West J. Zool. 3:96–104), the Green Lizard, *Lacerta viridis*, in Bulgaria (Biserkov and Kostadinova 1998. J. Helminthol. 72:267–271), the Balkan Green Lizard, *Lacerta trilineata*, from Turkey (Yildirimhan et al. 2011. Turk. J. Zool. 35:519–535), and the Sand Lizard, *Lacerta agilis*, from the Czech Republic (Literak et al. 2004. Folia Parasitol. 51:45–49). Within the genus *Podarcis*, only *P. muralis* has been previously described as host of *Mesocestoides lineatus* (cited in Literak et al., *op. cit.*). A low (1 out of 43 animals) level of infection in *P. muralis* by an unidentified *Mesocestoides* was described in a non-native population in Ohio (Burke et al. 2007. J. Herpetol. 41:755–757), originally introduced from Italy.

As part of an ongoing research project we collected 16 adults (3 males and 13 females) from a *P. muralis* population in the French Pyrenees in April 2015 (Cole de la Core; 42.8586°N, 1.1050°E; 1395 m elev.). The animals were dissected and their parasite load investigated. Two of the animals were infected with larval cestodes. We found 21 tetrathyridia in the peritoneal cavity of one female, and a high load of tetrathyridia in a second female (Fig. 1). In addition, the second female had a large number of encapsulated cestodes in the liver (Fig. 1C). Prevalence of infestation in lizards is usually around 10% (McAllister 1988. J. Wildl. Dis. 24:160–163), which is consistent with our observation (13%).

Species identification based on morphological traits of tetrathyridia is unreliable due to a general lack of diagnostic features. Therefore, we referred to the use of the 18S rRNA gene as a molecular marker. We extracted genomic DNA from three individual larvae using the Qiagen DNeasy Blood & Tissue kit. We PCR amplified part of the 18S rRNA gene with the previously published primers TimA and TimB (Norén and Jondelius 1999. Cladistics 15:103–112). Comparison of the obtained sequences with the NCBI nucleotide database revealed 100% identity to 18S rRNA sequences of *Mesocoithes litteratus* (e.g., JN088189). We therefore conclude that this is the first report of the *Podarcis muralis* as an intermediate host of *Mesocoithes litteratus*.

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***PTYCHOGLOSSUS PLICATUS* (Taylor's Large-scaled Lizard). NESTING.** *Ptychoglossus* is a lizard genus with 15 described species distributed in wet tropical forest from Costa Rica to Brazil and Perú. Knowledge of many of the species in this genus is limited to information about geographic distribution, habitat, and diet (Savage 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna between two Continents, between Two Seas. University of Chicago Press, Chicago, Illinois, 934 pp.). Three *Ptychoglossus* species are known to occur in Panamá, including the diurnal *P. plicatus* (Savage 2002, *op.cit.*). Here, we document the first observation of *P. plicatus* laying eggs in the nests of *Cyphomyrmex* sp., a fungus-growing ant.

FIG. 1A) Two Ptychoglossus *plicatus* eggs in a *Cyphomyrmex* nest. B) Lateral view of head and (C) dorsal view of *P. plicatus* neonate six days old.

Nineteen *Cyphomyrmex* nests were collected in cloud forest at the Parque Nacional Omar Torrijos Herrera in El Cope, Coclé Province, Panamá (8.40348°N, 80.40348°W), one of which contained two oval eggs embedded in the fungus garden (Fig. 1A). The eggs were cream colored (5.2 × 12.5 mm, 4.5 × 11.9 mm). This undescribed *Cyphomyrmex* species (unpubl. data) is related to *Cyphomyrmex cf. longiscapus n. sp.* 2 (Mehdiabadi et al. 2012. Nat. Commun. 3:840).

The ant nests were transferred to laboratory conditions that included 8:16 light:dark hours and room temperature of ~25°C. The nests were fed and cleaned twice weekly. Seventy-three days after the nests were collected, the two eggs hatched. The two neonate lizards were identified as *P. plicatus*, and their sizes were 40.0 and 40.5 mm, total length (Figs. 1B–C). The lizards lived on the nest two and fourteen days after hatching.

We conducted limited behavioral observations on interactions between worker ants and the eggs and neonates (a total period of 24 h from 30 April to 1 May 2016). Our limited observations revealed that ants conducted the grooming and fungal planting behavior over the eggs, similar to that observed in *Apterostigma gonoides* ants with eggs from the snake *Liothyphlops albirostris* (Bruner et al. 2012. Psyche, vol. 2012, Article ID 532314, 5 pp.). The ants neither attacked nor avoided the neonate lizards. To our knowledge, the lizards did not consume adult or juvenile ants. The lizard´s gastrointestinal systems were dissected, and no evidence of ants or ant tissues was observed.

This is the first report of oviposition by a microteiid lizard (Gymnophthalmidae) in an ant nest. It is of interest because it increases the number of Squamata that are documented to lay eggs in fungus-growing ant nests. Moreover, our observations support previous findings that *P. plicatus* lays two eggs per clutch (Goldberg 2008. Bull. Maryland Herpetol. Soc. 44:42–45). However, our observations do not support the idea that ant nests could represent a guaranteed food source to the lizard, as suggested for *Leposoma rugiceps* (Telford 1971. Copeia 1971:670–675). It is very likely that the fungus-growing ant nests are linked to the oviposition behavior of reptiles because they provide a warm, moist, and safe habitat which increases egg and neonate survival, warranting further study (see summary in Bruner et al. 2012, *op. cit.*).

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***SCELOPORUS UNIFORMIS* (Yellow-backed Spiny Lizard). BIFURCATED TAIL.** Bifurcated tails have been noted previously among lizards with autotomous tails (see Conzendey et al. 2013. Herpetol. Rev. 44:145–146, and references therein), but the prevalence of this phenomenon in wild lizards is unknown. Although a bifurcated tail was reported in one species of the the genus *Sceloporus* (*S. occidentalis*, Clark 1973. HISS News-J. 1:158), and two regeneration events in a single tail were reported in *S. uniformis* (Bateman et al. 2015. Herpetol. Rev. 46:95), to our knowledge bifurcation has not been reported in *S. uniformis*. Herein we report the first occurrence of tail bifurcation in the species.

At 2000 h on 17 December 2015, a relative of the second author located a sub-adult *S. uniformis* (SVL = 78 mm; mass = 13.7 g) wedged between a concrete driveway and a stucco wall in Santa Clara, Washington Co., Utah (37.13817°N, 113.65127°W, WGS 84; 875 m elev.). The lizard was near death, presumably due to sub-freezing temperatures (-4°C was the low temperature for 17 December) and the unsuitable hibernation location. Upon closer examination, the lizard was found to possess a bifurcated tail and WHH was contacted. Following collection, the lizard was held indoors overnight for photographing, but by the following morning the animal had succumbed.

Similar to other reports of tail bifurcation in lizards (see Mata-Silva et al. 2010. Herpetol. Rev. 41:352–353), this animal presumably suffered tail injury, possibly due to an attempted predation event, but the tail was not completely lost. Subsequently, the original tail maintained circulatory connectivity, thus keeping the tissues alive, while a second tail regenerated. The breakage occurred 62 mm post vent. The length of the original tail (post-break point) was 12 mm and was located on the right side, while the length of the regenerated tail was 20 mm and was on the left. The regenerated tail also possessed the reduced scale size and lack of scale patterning, typical of regrown tails. Interestingly, it was the regenerated tail which aligned with the anteroposterior axis of the animal's body, with the original tail adjoining this axis at an angle of approximately 70 degrees. The original tail appeared to have been broken a second time (timing relative to the bifurcation is unknown) as the tail tip is missing, leaving a healed, blunt end. The specimen will be deposited in the herpetology collection at the Monte L. Bean Life Science Museum (BYU/MLBM) at Brigham Young University and was collected under Utah DWR permit COR 4SAL8984m.

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***SPHENOMORPHUS PRAESIGNIS* (Blotched Forest Skink). REPRODUCTION.** *Sphenomorphus praesignis* is an elusive, upland species of skink that ranges from southern Thailand southward through the three major mountain ranges of

Peninsular Malaysia (Grismer 2011. Lizards of Peninsular Malaysia, Singapore and their Adjacent Archipelagos. Edition Chimaira, Frankfurt am Main. 728 pp.). Gravid females from Fraser's Hill, Pahang have been observed in June (Grismer, *op. cit.*) and more recently, there was a report of seven and eight oviductal eggs in two adult females (LSUHC 9095 and 10593, respectively) collected from Fraser's Hill and Bukit Larut, Perak, respectively (Goldberg and Grismer 2014. Herpetol. Rev. 45:135). Here we add the first record of viviparity in this species as well as additional information about oviductal eggs in a specimen from Bukit Larut, Perak State (LSUHC 9095).

A gravid female (LSUHC 12510; SVL = 120 mm) was collected from beneath debris at approximately 1500 h at Bukit Larut (4.85743°N, 100.80758°E) on 8 July 2013 and taken into captivity at a residence on Penang Island. Seven days later on 15 July 2013, she gave birth to a brood of six individuals (SVL = 40–41 mm, tail length [TL] = 50 mm) that retained small, external yolk sacs (5 mm diam). The oviductal eggs of another gravid female (LSUHC 9095, SVL = 121 mm, TL = 86 mm) collected form Bukit Larut on 26 June 2010 were removed by making a cut at the anterior portion of the infundibulum and the caudalmost portion of the uterus. The oviducts filled most of the body cavity displacing the digestive organs medially. The left and right oviducts measured 40 mm and 46 mm and contained four and three eggs, respectively. Embryos were at approximately stage 17/18 when compared to *Anolis* (Sanger et al. 2008. J. Morphol 269:129–137) in that each had distinct scales and chromatophores. Another gravid female (LSUHC 10593, SVL = 109 mm, TL = 134 mm [regenerated]) with eight oviductal eggs was collected on 10 April 2010 from Bukit Larut. These data suggest that the reproductive season of *S. praesignus* at Bukit Larut may begin as early as January, with births commencing during July.

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***XANTUSIA RIVERSIANA* (Island Night Lizard). AMELANISM.** Observations of amelanism in wild-caught lizards are rarely reported in the literature, with the best known example being adaptive coloration within the White Sands ecotone associated with a single Mc1r mutation (Rosenblum et al. 2010. Proc. Natl. Acad. Sci. USA 107:2113–2117). *Xantusia riversiana* is the only reptile endemic to three California Channel Islands: Santa Barbara, San Clemente, and San Nicolas. It is characterized by a long life span, low reproductive rate, low dispersal distance, and high site fidelity (reviewed in United States Fish and Wildlife Service 2014. FWS-R8-ES-2012-0099-0006). Amelanism has not been reported for *X. riversiana* or any other member of the Xantusiidae, nor have other researchers with long-term projects focused on *X. riversiana* observed this aberrant coloration (Charles Drost, William Mautz, pers. comm.). Here we report the first case of amelanism in *X. riversiana*.

Fig. 1. Dorsal photograph of amelanistic *Xantusia riversiana*.

At 1701 h on 29 June 2015 an amelanistic juvenile male island night lizard (Fig. 1) was captured at the base of a California Boxthorn assemblage (*Lycium californicum*) using a Sherman trap. The behavior and morphology of the lizard was normal with no other aberrant conditions noted (SVL = 59 mm, tail length = 50 mm with 16 mm regrowth; mass = 5 g); lizards with the normal coloration phenotype were captured within the same assemblage < 1m from the trapping location. Photographs of the lizard were taken in the field and the lizard was released at the site of capture. In total, we captured 312 individuals from the sampled island, suggesting a low frequency of occurrence of amelanism (0.321%). The geographic information and island name of the observation have been omitted due to concerns over the sensitivity and status of the species.

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SQUAMATA — SNAKES

***ATRACTUS TORQUATUS* (Neck-banded Groundsnake) and *ATRACTUS MAJOR* (Large Groundsnake). REPRODUCTION.** The fossorial dipsadinae genus *Atractus* contains about 130 species that are widely distributed in the Neotropics (Schargel et al. 2013. Zootaxa 3721:455–474; Uetz et al. 2016. The Reptile Database. http://www.reptile-database.org, accessed 5 May 2016). *Atractus major* and *A. torquatus* are distributed through the eastern portion of the Amazon Basin and the distribution of *A. torquatus* extends to the Guiana Shield (Passos and Prudente 2012. Zootaxa 3407:1–21; Schargel et al., *op. cit.*). The ecology of both species is poorly known and data about their reproduction is especially scarce. Herein, we report new data on reproduction for both species. Specimens examined are housed in the herpetological collection of the Centro de Ornitología y Biodiversidad (CORBIDI), Lima, Peru.

Atractus major presents a variable clutch size, from three to twelve eggs (Valencia et al. 2008. Guía de Campo Reptiles del Ecuador. Fundación Herpetológica Gustavo Orcés, Quito, Ecuador. 236 pp.; Esqueda and La Marca 2005. Herpetropicos 2:1–32; Duellman 1978. Misc. Publ. Univ. Kansas. 65:1–352); laying in the Manaos region occurs from August to November (Martins and Oliveira 1993. Zool. Meded. 67:21–40). A female *A. major* (CORBIDI 8351; SVL = 656 mm) collected on 28 November 2010 from Native Community Poyentimari (12.1885°S, 73.0009°W, WGS 84; 725 m elev.), La Convención province, Cusco department, Peru, contained 11 ovarian follicles (six in the left oviduct and five in the right oviduct); average length = 18.27 mm (range = 17.05–20.69 mm), width = 8.35 mm (7.35–9.06 mm), and volume = 675 mm^3 (486–818 m^3). Another female *A. major* (CORBIDI 17226; SVL = 53.3 cm) was collected on 8 February 2016 from the Mapuya River (10.7405°S, 73.0512°W, WGS 84; 332 m elev.), Atalaya province, Ucayali department, Peru, contained five large oviductal eggs (3 in the left oviduct and 2 in the right oviduct); average length = 18.92 mm (16.47–21.05 mm), width = 7.54 mm (7–8.3 mm), and volume = 556 mm^3 (484– 594 mm^3).

For *A. torquatus*, there are reports of three to eight eggs per clutch. Oviposition period is unknown, although hatchlings and small juveniles have been found in January, February, August, and November in Brazil (Martins and Oliveira 1998. Herpetol. Nat. Hist. 6:78–150). On 29 October 2012, a female *A. torquatus* (CORBIDI 12647; SVL = 57.5 cm) was collected in the forests of Medio Campuya locality, Maynas province, Loreto department, Peru (1.5176°S, 73.8161°W, WGS 84; 135 m elev.) that contained nine oviductal eggs with well-developed shells (three in the left oviduct and six in the right oviduct); average length = 24.8 mm (22.95–26.72 mm), width = 13.2 mm (11.73–14.85 mm), and volume = 2275 mm^3 (1925–2716 mm^3).

The months when these three specimens were collected represent the early and/or full rainy season in the Peruvian Amazon rainforest and are the first reproductive data for *A. major* and *A. torquatus* from Peru.

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***ATRACTUS TRIHEDRURUS* (South Brazilian Spindle Snake). DIET.** *Atractus trihedrurus* is a dipsadid snake endemic to the Atlantic Forest of southeastern and southern Brazil. The diet of species within the genus *Atractus* is often associated with their semi-fossorial habits, and studies based on gut contents have revealed that some species feed mainly on earthworms, although acari and insects can also be consumed (reviewed in Martins and Oliveira 1998. Herpetol. Nat. Hist. 6:78–150). However, to our knowledge there is no diet information for *A. trihedrurus.*

On 08 January 2014 at 0810 h, an adult *A. trihedrurus* was observed eating a giant earthworm (Fig. 1) at Carlos Botelho State Park, in the state of São Paulo, Brazil (24.06628°S, 47.99772°W, WGS 84; 740 m elev.). This park comprises one of the most significant Atlantic Forest remnants in southeast Brazil, where the vegetation is classified as submontane rainforest (Oliveira-Filho and Fontes 2000. Biotropica 32:793–810). The snake and the earthworm were partially covered by leaf litter and the earthworm was partially eaten but still alive when we found it. Indeed, the earthworm was compressing its body, apparently as an anti-predatory strategy. The specimens was photographed, but not collected.

We are especially grateful to Cybele S. Lisboa for the help in identification of snake.

Fig. 1. Adult *Atractus trihedrurus* swallowing a giant earthworm in Carlos Botelho State Park, southeast Brazil.

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***BOA CONSTRICTOR* (Common Boa; Jibóia). DIET.** On 20 February 2016, at ca. 1723 h, in a pasture area near a coffee plantation, municipality of Cachoeiro de Itapemirim, Espírito Santo state, Brazil (20.680778°S, 41.094083°W, WGS 84; 151 m elev.), we observed the capture of a bird by a *Boa constrictor.* The bird, belong to the genus *Furnarius* (João-de-barro), was on a fence and flew to the ground to forage. We witnessed the *B. constrictor* (SVL ca. 1 m TL) approach in the grass and lunge at the bird. The boa captured, constricted, and ingested the prey headfirst over ca. 30 min (Fig. 1A, B). There were other birds of various species resting on the fence (Fig. 1C), however no reactions among the birds were observed. Birds are the primary prey of immature *B. constrictor* and are also frequently eaten by adults (Pizzatto et al. 2009. Amphib- Reptil. 30:533–544). This is the first record of *B. constrictor* predation on birds belonging to genus *Furnarius.* Our predation observation supports the idea that *B. constrictor* exhibits both active search and ambush foraging strategies (Rodríguez-Robles et al. 1999. J. Zool. 248:49–58).

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Fig. 1. A, B) *Boa constrictor* ingesting a bird of the genus *Furnarius.* C) Birds resting on the fence near coffee trees.

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***BOA CONSTRICTOR* (Common Boa). REPRODUCTION / COURTSHIP.** Despite being one of the most commonly kept pet snakes and having an extremely wide distribution, little is know about the courtship behavior of *Boa constrictor* in the wild (Burger and Ford 2009. *In* Henderson and Powell [eds.], Biology of the Boas and Pythons, pp. 215– 226. Eagle Mountain Publishing, Eagle Mountain, Utah). Here we report the courtship behavior of this species recorded in San Rafael de Escazú, Costa Rica (9.936028°N, 84.143987°W, WGS 84; 1008 m elev.) in October 2006. A pair was observed daily for nine days, exposed on top of a pile of plastic roofing. The site was monitored for an additional two weeks without success. While exposed and basking, the female would be completely entangled with the male, sometimes for more than four hours. From a series of photos, we recorded that the male coiled around the middle of the body of the female (she was substantially thicker and darker than male), with their tails in contact (Fig. 1), but intromission was not directly observed. The male attempted to touch the anterior region of the female with his head, but the female continually hid her head under their bodies or the plastic roofing (Fig. 1). This observation provides rare insight into mating behavior of *B. constrictor* in the wild.

FIG. 1. *Boa constrictor* courtship in San Rafael de Escazú, Costa Rica.

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***BOIGA DENDROPHILA* (Mangrove Cat Snake). DIET.** *Boiga dendrophila* is a large (to 250 cm total length) rear-fanged snake, known from pristine as well as disturbed lowland forests and mangrove swamps of Southeast Asia (David and Vogel 1996. The Snakes of Sumatra: An Annotated Checklist and Key with Natural History Notes. Edition Chimaira, Frankfurt am Main. 260 pp.; Das 2006. A Photographic Guide to the Snakes and Other Reptiles of Borneo. New Holland Publishers, Ltd., London. 144 pp.). Its known diet includes vertebrates such as frogs, lizards, birds, and rodents; one colubrid snake, *Ahaetulla prasina* (Stuebing and Inger 1999. A Field Guide to the Snakes of Borneo, Natural History Publications, Sdn. Bhd. Kota Kinabalu. 235 pp.), and a viper, *Parias sumatranus* (Pui and Das 2011. Herpetol. Rev. 42:281–282) have been noted in its diet.

FIG. 1. A.) *Boiga dendrophila* encountered within a private garden in Kuching, East Malaysia. B) *Dendrelaphis pictus* recovered from the *B. dendrophila.*

On 13 December 2015, at ca. 2100 h, an adult *B. dendrophila* (total length ca. 1 m; Fig. 1A) was encountered within the compound of a private garden at Tabuan Jaya (01.51763°N, 110.38692°E, WGS 84; elev. 25 m), abutting the Sama Jaya Nature Reserve, Kuching, Sarawak, East Malaysia (Borneo). It was observed ca. 1.5 m above ground on a tree, captured and retained overnight for observations (it showed a distinct abdominal bulge) and photography. It regurgitated a *Dendrelaphis pictus* (Fig. 1B; total length ca. 0.80 m) the next evening. The prey was folded in half, suggesting a midbody capture and ingestion. *Dendrelaphis pictus* is a diurnal, arboreal snake, whereas *B. dendrophila* is nocturnal and arboreal; both species are known from lowland forests across Sundaland. The protected area is a relatively small (38 ha) forest fragment supporting *Kerangas* (Bornean heath) vegetation.

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***BOTHROPS JARARACA* (Jararaca). DIET.** *Bothrops jararaca* is an abundant viperid associated with forested areas from central and southeastern Brazil to northern Argentina. Juvenile *B. jararaca* often perch on vegetation and feed mainly on anurans, while adults are predominantly terrestrial and feed mainly on small rodents (Sazima and Haddad 1992. *In* Morellato [ed.], História Natural da Serra do Japi—Ecologia e Preservação de uma Área Florestal no Sudeste do Brasil, pp. 212–237. FAPESP, Campinas). *Haddadus binotatus* is an endemic anuran of the Brazilian Atlantic Forest. It is abundant in leaf litter, but during reproduction may be found perched on vegetation up to 1 m high.

During a nocturnal survey on 26 February 2016, a juvenile male *B. jararaca* (total length = 51.0 cm) was observed on the ground preying upon an adult female *H. binotatus* (SVL = 5.5 cm; Fig. 1A) at the Reserva Biológica Augusto Ruschi, municipality of Santa Teresa, Espírito Santo state, southeastern Brazil (19.904690°S, 40.540929°W; WGS 84; elev. 620 m). The snake swallowed the frog head first. In laboratory, the *B. jararaca* was dissected and the anuran extracted in order to confirm identification (Fig. 1B) and both specimens (MBML 3506) are deposited at the Zoological Collection of Museu de Biologia Prof. Mello Leitão, Instituto Nacional da Mata Atlântica, Santa Teresa municipality, Espírito Santo state, southeastern Brazil. To our knowledge, this is the first report on predation of *H. binotatus* by *B. jararaca*.

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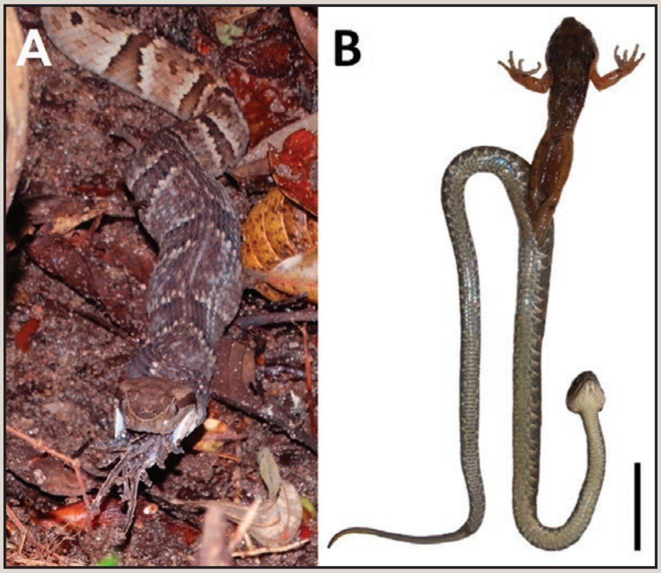

Fig. 1. Juvenile *Bothrops jararaca* preying upon an adult *Haddadus binotatus*, Atlantic forest, Espírito Santo state, southeastern Brazil. A) Anuran swallowed headfirst; B) anuran extracted from the snake's stomach. Scale bar = 5 cm.

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***COLUBER CONSTRICTOR* (North American Racer). REPRODUCTION / ARBOREAL MATING.** Although *Coluber constrictor* is primarily terrestrial, it is well known for its arboreal foraging, basking, and avoidance of danger (Mulaik and Mulaik 1942. Copeia 1942:13–15; Fitch 1963. Univ. Kansas Publ. Mus. Nat. Hist. 15[8]:351–468; Plummer and Congdon 1994. Copeia 1994:20–26; Ernst and Ernst 2003:81. Snakes of the United States and Canada. Smithsonian Inst. Press, Washington, D.C. 680 pp.). *Coluber constrictor* has been observed in vegetation to heights of "12 feet" (Fitch, *op. cit.*), "3 m" (Fitch and Shirer 1971. Copeia 1971:118–128), and "10 m" (Ernst and Ernst, *op. cit.*). However, there has been only one previous mention of arboreality in mating racers (Lillywhite 1985. J. Herpetol. 19:306–308). In that case (25 June in Kansas) courtship occurred on the ground, but after 2 min of intromission, the male dragged the intromittent female into a tree to a height of 5 m where copulation continued. However, the male may have been seeking the safety of the tree due to the presence of the observer and the location of the initial courtship in an exposed residential yard.

Fig. 1. Adult (presumably male) Indiana *Coluber constrictor* descending from 4.7 m above ground (top center) to tangle of Oriental Bittersweet (circled, at 4.1 m) where courtship and presumed copulation were later observed.

Fig. 2. Adult (presumably male and female) Indiana *Coluber constrictor* in a tangle of Oriental Bittersweet 4.1 m above ground. Note the head of the presumed male above that of the presumed female, and the partially everted left hemipenis of the male in the upper left.

On 6 May 2016, at 0940 h (air temp ca. 15°C, sunny, calm winds), in a middle-growth woodlot located 3.7 km SE of Centerville, Wayne County, Indiana, USA, I observed two racers moving along tree branches (*Liriodendron tulipifera*) among Oriental Bittersweet (*Celastrus orbiculatus*) vines at heights of 4.1 and 4.7 m above ground (Fig. 1). I immediately left the site so as not to further disturb them. I returned briefly at 0957 h and the higher snake (presumably male) had descended to the level (4.1 m) of the lower (presumably female) snake in a thick tangle of Bittersweet, and appeared to be courting her (bodies aligned, male rubbing/writhing against the female, head above hers, but no biting observed). When I returned at 1123 h they were in the same approximate location and positions, and appeared to be copulating (Fig. 2), but by ca. 1230 h, when I again returned, they were not in the area. This date is well within the normal reported mating season of the species (e.g., Fitch, *op. cit.*), but this is the first record of arboreal courtship and copulation for *C. constrictor*.

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Fig 1. Coiled posture of rattleless *Crotalus oreganus helleri* prior to radiographs.

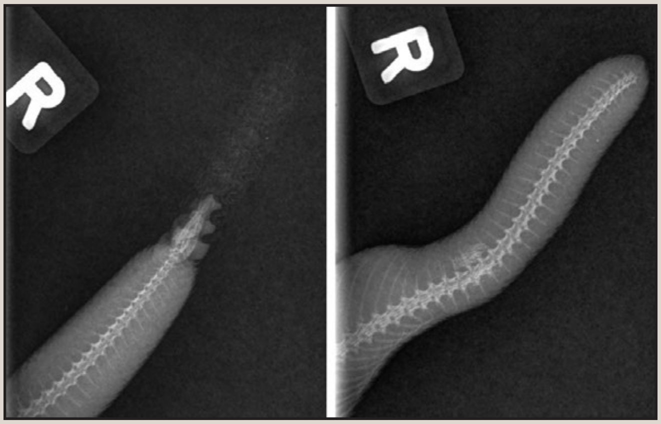

Fig 2. Radiographs of rattled (left) and rattleless (right) adult male *Crotaus oreganus helleri.*

***CROTALUS OREGANUS HELLERI* (Southern Pacific Rattlesnake). LOSS OF RATTLE STYLE AND MATRIX.** The loss of the rattle and style/matrix has been previously reported for *Crotalus atrox* (Western Diamond-backed Rattlesnake) and *C. ruber* (Red Diamond Rattlesnake) (Schuett et al. 2012 Herpetol. Rev. 341–342). Here we report apparent rattle loss in a wild-caught *C. o. helleri* from within the same field site (Rancho Jamul Ecological Reserve, California, USA) as the *C. ruber* reported by Schuett et al. (*op. cit.*).

On 04 Oct 2014 an adult male *C. o. helleri* (SVL = 902 mm, tail length = 68 mm; 540 g) was captured coiled at the base of a large rock outcrop (32.68613°N, 116.85632°W, WGS 84). No rattle was noted (Fig. 1), nor was any injury or scarring that would indicate the loss of rattle due to trauma; upon handling defensive responses included posturing and attempted rattling (i.e., tail shaking). Radiographs were taken to compare morphology of the rattleless *C. o. helleri* to a rattled adult male *C. o. helleri* (Fig. 2). Radiographs were taken by Thomas Boyer, DVM, that confirmed the lack of an underlying rattle matrix.

Since 2011, we have captured 26 *C. o. helleri* from within Rancho Jamul Ecological Reserve and 19 *C. o. helleri* from the neighboring protected area of Hollenbeck Wildlife Canyon, suggesting the occurrence of rattlelessness is rare within this population. The loss of the rattle from injury as a neonate cannot be eliminated; however, the absence the style and matrix as indicated by radiographs suggests a congenital loss of rattle style and matrix. As Schuett et al. (*op. cit.*), we favor a non-injury hypothesis that this phenotypic change is genetic in nature either as direct mutation to structural (e.g., Hox) genes or through the action of transposable elements.

Although rare, rattleless individuals appear able to survive to adulthood without the use of the rattle as a defensive mechanism. Additional research into phenotype frequency, heritability, and fitness effects would contribute to understanding the evolutionary and ecological aspects of rattle loss and a deeper understanding of the genetic mechanisms involved.

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***CROTALUS OREGANUS LUTOSUS* (*C. VIRIDIS LUTOSUS*) (Great Basin Rattlesnake). BEHAVIOR**. Water is at a premium in the desert, and the species living there have adapted means of procuring it whenever possible. Here I provide the first report of "rain harvesting" behavior by wild *Crotalus oreganus lutosus*.

The following observations were made on 9 July 2014, at the northern end of the Great Basin (Harney Co., Oregon, USA; 43.2658ºN, 118.8442ºW, WGS 84; 1256 m elev.). This area is high desert; annual precipitation averages 16.5 cm. Where observations were made, the habitat consisted of basalt outcrops surrounded by dry, alkaline playas and sandy dunes dominated by sagebrush (*Artemisia tridentata*) and greasewood (*Sarcobatus vermiculatus*). At 0900 h, it started to rain lightly. At 0915 h, I found an adult *C. o. lutosus* coiled among boulders near a low rock ledge. The snake was out in the open, fully exposed to the rain. It had formed a tight coil, with its tail in the center and its head at the outside of the coil (Fig. 1). The snake had flattened its body and was holding the outer edge of the coil above the ground, forming a shallow dish. After watching the snake drink for a few minutes, I disturbed it by moving. In response, it immediately relaxed its ribs, assumed the typical round body shape, and uncoiled, in preparation to move away. I remained still and did not disturb it further. In less than a minute it had re-coiled the posterior 2/3 of its body, flattened again, and resumed drinking rain off its coils. At this point, I backed up and watched it quietly until 0935, at which point the rain began to cease, and the snake quietly uncoiled and crawled away. A patch of dry soil marked the spot where the snake had been sitting, illustrating the tightness of the coil and its efficacy as a rain collector.

At 0945, it began raining again. At 0948, a short distance away, I watched two more adult *C. o. lutosus* of similar size performing the exact same behavior; both were coiled next to cover (a rock ledge), but were out in the rain, tightly coiled, and forming a dish in the same manner as the first. In this position, one drank continuously from its coils for >10 min, and was still drinking when I left. I watched another drink for several minutes; when it crawled away, it left a dry spot in the same manner as the first snake.

Possibly the most interesting part of this behavior is the extreme flattening of the snake's body, a posture common to rain-harvesting snakes (Aird and Aird 1990. Bull. Chicago Herpetol. Soc. 25:217; Cardwell 2006. Herpetol. Rev. 37:142–144). This appears to increase the efficiency of the collecting dish, as well the dish's size. An indication of this is given by the fact that the first snake immediately resumed the posture after being disturbed. Since its original description in captive *C. o. lutosus* (Aird and Aird 1990, *op. cit.*), rain harvesting has been reported in seven other species of rattlesnakes, all native to desert regions of the southwestern United States and northern Mexico: *Crotalus atrox* (Repp and Schuett 2008. Southwest. Nat. 53:108–114), *C. cerastes* (Rorabaugh 2007. Son. Herpetol. 20:128–129), *C. lepidus* (Mata-Silva et al. 2014. Southwest. Nat. 59:303–304), *C. mitchellii* (Glaudas 2009. Southwest. Nat. 54:518–521), *C. molossus* (Mata-Silva et al. 2012. Herpetol. Rev. 43:145–146), *C. scutulatus* (Cardwell 2006, *op. cit.*), and *C. viridis concolor* (Ashton and Johnson 1998. Herpetol. Rev. 29:170). It is surprising that this is the first report of the behavior in wild *C. o. lutosus*, given the relatively large range and abundance of this species.


FIG. 1. *Crotalus oreganus lutosus* in "rain-harvesting" posture.

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***CUBOPHIS CAYMANUS* (Cayman Racer). DIET.** *Cubophis caymanus* (previously *Alsophis cantherigerus caymanus*) is a diurnal snake endemic to the island of Grand Cayman, Cayman Islands. The documented diet of *C. caymanus* includes *Anolis* spp., *Iguana iguana* (Green Iguana), and *Eleutherodactylus planirostris* (Greenhouse Frog; Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. University Press of Florida, Gainesville, Florida. 495 pp.).

Shortly after dark on 28 November 2008 I encountered a *C. caymanus* preying upon a large adult *Osteopilus septentrionalis* (Cuban Treefrog) in the grounds of the Queen Elizabeth II

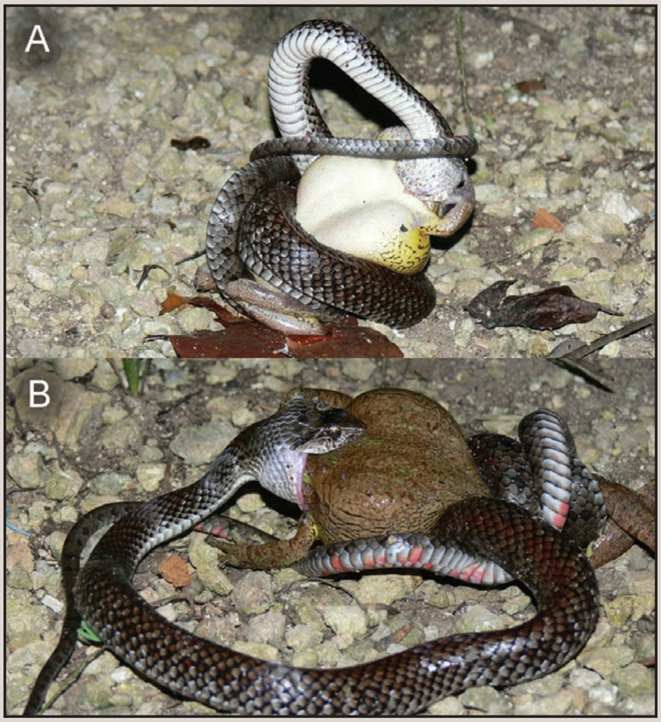

FIG. 1. *Cubophis caymanus* (Cayman Racer) preying on *Osteopilus septentrionalis* (Cuban Treefrog) on Grand Cayman, Cayman Islands. A) *Cubophis caymanus* biting the head of *O. septentrionalis.* B) *Cubophis caymanus* constraining the legs of *O. septentrionalis* and attempting to swallow it.

Botanical Park, Grand Cayman, Cayman Islands (19.31807°N, 81.16840°W, WGS 84). I was alerted to the scene by the sound of the *O. septentrionalis* making a loud distress call. When I discovered the pair, the snake had the frog's head in its mouth and its body contained within coils (Fig. 1A). After 1 min, the snake constrained the frog's legs within its coils (Fig. 1B). The frog was very inflated and continued to emit a loud distress call while pushing at the snake's head with its hands (Fig. 1). The snake continued attempting to swallow the frog for the next 40 min, after which I ceased observations. By this point the frog was subdued and no longer emitting a distress call. At the completion of my observations, the frog's head and part of its body had been ingested.

Osteopilus septentrionalis has been widely introduced throughout Florida and the Caribbean islands, but the population in the Cayman Islands may in fact be native (Henderson and Powell 2009, *op. cit.*; Kraus 2009. Alien Reptiles and Amphibians: a Scientific Compendium and Analysis. Springer Science + Business Media B.V., Dordrecht, Netherlands. 564 pp.). Besides *O. septentrionalis*, only two other anuran species occur on Grand Cayman: *E. planirostris* and *Gastrophryne carolinensis* (Eastern Narrow-mouthed Toad; Henderson and Powell 2009, *op. cit.*). Although I have heard verbal accounts of *C. caymanus* preying on *O. septentrionalis*, to my knowledge, this is the first published account of the interaction (Henderson and Powell 2009, *op. cit.*). Both *C. caymanus* and *O. septentrionalis* are abundant on Grand Cayman and considering the rather depauperate anuran fauna, this frog is likely an essential prey species for this snake.

I thank Frederick Burton, the Blue Iguana Recovery Program, and the staff of the Queen Elizabeth II Botanical Park for logistical support and land access.

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***DIADOPHIS PUNCTATUS EDWARDSII* (Northern Ring-necked Snake). DIET.** *Diadophis punctatus edwardsii* is a semi-fossorial snake species which has little formal research on its diet. Published information on the diet of *D. p. edwardsii* has found the major prey items to include the salamanders *Plethodon cinereus, P. glutinosus, Desmognathus fuscus, Eurycea bislineata*, and earthworms (Barbour 1950. Copeia 1950:100–107; Bush 1959. Herpetologica 15:73–77; Brown 1979. Am. Midl. Nat. 102:200–203) However, these publications are limited to small sample sizes. All Pennsylvania, USA, origin *D. punctatus* were dissected and examined from the herpetological collection of *Diadophis* at the State Museum of Pennsylvania (N = 22). Museum specimens originated from seven counties: Chester (N = 1), Cumberland (N = 1), Dauphin (N = 4), Franklin (N = 5), Northumberland (N = 1), and Westmoreland (N = 10). Only one of the 22 specimens had any stomach contents and it contained a *P. cinereus.*

An additional 36 living *D. punctatus* were captured in Cumberland (N = 25), Franklin (N = 1), Perry (N = 1), and York (N = 9) counties Pennsylvania, USA. Individuals were always located under rocks or logs, and commonly near forest edge habitat. Stomach contents were retrieved by stomach flushing (Legler 1977. Herpetologica 33:281–284) or gentle external palpation (Cruz 2013. Unpublished Master's Thesis, Marshall University, Huntington,West Virginia. 36 pp.). All of the stomach contents retrieved in this portion of the study contained plethodontid species—five *P. cinereus* and one unidentifiable *Plethodon.* Thus, in total, 58 *D. punctatus* were examined: 88% (N = 51) contained no stomach contents, 12% (N = 7) contained a plethodontid salamander. Stomach contents were only found in specimens during the months of May, June, and July; never during April, August, September, or October. This regional study represents the most thorough analysis of the diet of *D. p. edwardsii* to date and suggests that they primarily depredate plethodontid salamanders.

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***ERYTHROLAMPRUS AESCULAPII* (False Coral Snake). DIET.** *Erythrolamprus aesculapii* (Dipsadidae) is a terrestrial and diurnal species (Marques et al. 2001. Serpentes da Mata Atlântica: Guia Ilustrado para Serra do Mar. Holos Editora, Ribeirão Preto. 184 pp.) widely distributed in the Neotropics (Peters and Orejas-Miranda 1970. Bull. U.S. Nat. Mus. 297:1–347). Ophiophagy has been documented in *E. aesculapii* through analysis of preserved specimens and occasional field observations (Santos and Vaz-Silva 2012. Herpetol. Notes 5:495–496). Here we report predation on *Atractus badius* (Dipsadidae) by *E. aesculapii.*

On 27 November 2015, at ca. 1510 h, one of us (GDS) observed and photographed an adult *E. aesculapii* feeding on an *A. badius* (Fig. 1) in the Centro Rústico de Vivência, Tumucumaque Mountains National Park, Amapá, Brazil (1.1873°N, 52.3708°W, WGS 84; elev. 99 m). The *E. aesculapii* bit the prey approximately 5 cm above the tail and swallowed it in approximately 50 min. Our observation reinforces the idea that *E. aesculapii* preys on a wide range of snakes species (Marques and Puorto 1994. Rev. Bras. Biol. 54:253–259).

Special thanks to André L. S. Nunes for identifying the *Erythrolamprus aesculapii* and *Atractus badius.*

Fig. 1. *Erythrolamprus aesculapii* preying upon *Atractus badius* in Tumucumaque Mountains National Park, Eastern Amazon, Brazil.

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***ERYTHROLAMPRUS MILIARIS* (Cobra D'água; Military Ground Snake). DIET.** *Erythrolamprus miliaris* is a diurnal-nocturnal snake associated with permanent water bodies across South America. *Hypsiboas albomarginatus* is a medium-sized treefrog that breeds in permanent or temporary ponds and is often found in bushes and low vegetation nearby (Izecksohn and Carvalho-e-Silva 2001. Anfíbios do Município do Rio de Janeiro. Editora da UFRJ, Rio de Janeiro. 148 pp.). It occurs in the Atlantic forests of eastern Brazil from the State of Pernambuco in the northeast to the state of Santa Catarina in the south, and in the Caribbean lowlands of Colombia to Guianas, lower Amazon Basin (Frost 2016. Amphibian Species of the World: an Online Reference. Version 6.0, accessed 15 August 2016. Electronic database accessible at http://research.amnh.org. American Museum of Natural History, New York). During a diurnal survey on 01 November 2015, ROM observed an adult *E. miliaris* preying upon an adult *H. albomarginatus* beside a lake (Fig. 1) in the municipality of Santa Teresa, Espírito Santo state, southeastern Brazil (40.60645°W, 19.95423°S; WGS 84; elev. 621 m). The *H. albomarginatus* was in the marginal vegetation, near a breeding location when it was preyed upon by the *E. miliaris*. To our knowledge, this is the first report of predation on *H. albomarginatus* by *E. miliaris*. ATM thanks Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES) for scholarships.

Fig. 1. *Erythrolamprus miliaris* preying upon *Hypsiboas albomarginatus* next to a lake in the municipality of Santa Teresa, Espírito Santo state, southeastern Brazil.

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***ERYTHROLAMPRUS TAENIOGASTER*. DIET.** *Erythrolamprus taeniogaster* (Dipsadidae) is a diurnal and nocturnal species, occurring in the Atlantic Forest, Caatinga, Cerrado, Pantanal and Amazon basin (Nogueira et al. 2010. *In* Diniz et al. (eds.), Diversidade de Répteis Squamata e Evolução do Conhecimento Faunístico no Cerrado, pp. 333–375. Editora UNB, Brasília), that feeds on a wide variety of taxa, including frogs (Marques et al. 2005. Serpentes do Pantanal: Guia Ilustrado. Holos Editora, Ribeirão Preto. 184 pp.). Herein, we report predation on the frog *Leptodactylus macrosternum* by *E. taeniogaster* on 17 June 2015, at 2015 h, in a wetland in the munipality of Santana, Amapa State, Brazil (0.036311°N, 51.162481°W, WGS 84; 26 m elev.). While conducting a herpetological survey in the area, one of us (JCS) found an adult *E. taeniogaster* slowly approaching a adult male *L. macrosternum*. The snake attacked the frog with a bite in the inguinal region, however, the frog escaped and was quickly recaptured by the right flank and subsequently ingested headfirst (Fig. 1). The predation event took 20 min, and the snake took 15 min swallowing its prey. This snake is known to be more active during the rainy season (Dec–June) when they are flooded out of refugia and are out foraging. This observation suggests that the snakes forage opportunistically at frog breeding sites.

Special thanks to André L. S. Nunes for identifying the *Erythrolamprus taeniogaster*.

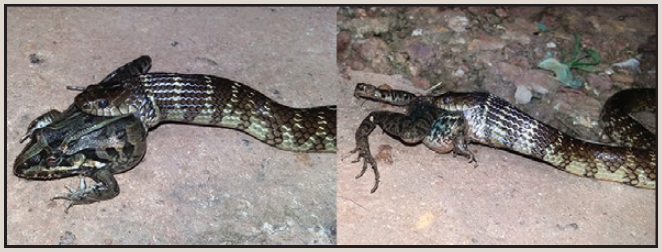

Fig. 1. *Erythrolamprus taeniogaster* preying on an adult male *Leptodactylus macrosternum* at a wetland in the munipality of Santana, Amapa State, Brazil.

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***FARANCIA ERYTROGRAMMA* (Rainbow Snake). SEASONAL ACTIVITY.** *Farancia erytrogramma* is a relatively large bodied (> 1 m), secretive, semi-aquatic species found in the southeast Coastal Plain from Maryland south to north-central Florida and west to Louisiana, USA. Due to its secretive behavior and use of difficult to sample habitats, such as swamps, rivers, and marshes, the life history of *F. erytrogramma* is poorly understood. Much of what is known about *F. erytrogramma* seasonal activity is based on opportunistic observations. Throughout its range *F. erytrogramma* has been documented active in every month (Richmond 1945. Copeia 1945:28–30; Neill 1964. Am. Midl. Nat. 71:257–295; Palmer and Braswell 1995. Reptiles of North Carolina. University of North Carolina Press, Chapel Hill. 412 pp.), with activity peaks occurring in March, April, June, and October (Richmond, *op. cit.*; Neill, *op. cit.*; Gibbons et al. 1977. Herpetologica 33:276–281). Observations of active *F. erytrogramma* north of Florida between late November and the end of February could be considered unusual, because this species would presumably need to hibernate to escape cold temperatures, but Palmer and Braswell (*op. cit.*) note several cases of winter terrestrial activity in North Carolina. Here we report several additional instances of winter activity of *F. erytrogramma* in Virginia and South Carolina, USA.

On 1 February 2016, a road-killed adult female *F. erytrogramma* (SVL = 102.2 cm; tail length = 16.1 cm) was found approximately 1.95 km SSE of Providence Forge, Virginia, on Route 155 south where it crosses the Chickahominy River (37.429°N, 77.038°W, WGS 84) on the New Kent and Charles City county line. Following several days of snow and rain, flows in the Chickahominy River were above normal, possibly flooding this snake's hibernaculum. Above average air temperatures the day before and the day of the observation may have provided opportunity for this snake to find another hibernaculum.

Aquatic trapping and drift fence sampling on the U.S. Department of Energy's Savannah River Site (SRS) in west-central South Carolina revealed that *F. erytrogramma* can be relatively common in a variety of freshwater habitats (Gibbons et al., *op. cit.*; Gibbons and Semlitsch 1991. Guide to the Amphibians and Reptiles of the Savannah River Site. University of Georgia Press, Athens. 131 pp.), but this species is rarely found moving overland (Steen et al. 2013. Herpetol. Rev. 44:208–213). Of 45 *F. erytrogramma* captured on or near the SRS between 2002 and 2014, only 6 (2 alive, 4 dead) were captured on roads. Of those six, two were captured in the winter. The first was a road-killed individual (not measured) found by Tony Mills at a creek overpass just north of the SRS (33.343°N, 81.822°W, WGS 84) on 24 Jan 2002. The second was a live subadult female (SVL = 54.5 cm; tail length = 7.6 cm) found crossing Hwy 125 at the overpass of Upper Three Runs Creek (33.239°N, 81.744°W, WGS 84) on 15 Feb 2003 (light rain, air temp ca. 13°C) by Cameron Young. The winter/spring of 2002–2003 marked the cessation of a prolonged drought in the region, and substantial snake movement was observed in early spring 2003 as aquatic snakes returned to water bodies that had been dry during the drought (Willson et al. 2006. Wetlands 26:1071–1078). However, movement of other species peaked in March, with few snakes found returning to wetlands in February (Willson et al., *op. cit.*). Taken together, these observations suggest that *F. erytrogramma* may be more prone to winter activity than other snake species in the southeastern USA. This overland movement might be driven by the need to shift habitats in response to changing water levels within their aquatic habitat. Clearly, further research is needed to understand the ecology and behavior of this enigmatic species.

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HETERODON PLATIRHINOS (Eastern Hog-nosed Snake). REPRODUCTION / MINIMUM SIZE AT SEXUAL MATURITY.

Heterodon platirhinos is a medium-sized dipsadid reaching maximum lengths of SVL = 105 cm (Carlile et al. 2011. Herpetol. Rev. 42:291–292). Some authors suggest male *H. platirhinos* mature at lengths as short as SVL = 40 cm and females at SVL = 45 cm, but offer no corroborating evidence (Wright and Wright 1957. Handbook of the Snakes of the United States and Canada. Comstock Publishing Associates, Ithaca, New York. 1164 pp.; Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America, 3rd ed. Houghton Mifflin, New York. 616 pp.). Platt (1969. Univ. Kans. Publ. Mus. Nat. Hist. 18:253–420) thought females reach sexual maturity at SVL = 50 cm, based on the smallest female observed ovipositing, as reported by Meyer (1958. Herpetologica. 14:128). Platt (*op. cit.*) also concluded that males reach sexual maturity at SVL = 45.1 cm, based on samples of active spermatozoa he found in cloacal smears.

To the best of my knowledge, I report the minimum size at sexual maturity of a male *H. platirhinos* based on an individual found during a survey on a barrier island off the coast of New York State. At 1446 h on 18 April 2014, I observed a breeding aggregation of *H. platirhinos* consisting of two males and one female (Fig. 1). Only one of the males was actively copulating with the female (SVL = 55.2 cm; 153 g; Fig. 2), while the other was coiled around them. After copulation ended, the copulating male was measured and found to be 3 cm shorter (SVL = 370 mm; 65 g) than the minimum size of sexual maturity suggested by Wright and Wright (*op. cit.*) and Conant and Collins (*op. cit.*), and nearly 8 cm shorter than the minimum size suggested by Platt (*op. cit.*). In addition, at 1530 h on 17 Jun 2015, I observed a gravid female (SVL = 46.3 cm; 151 g) staging near a communal nesting area. This female approached the minimum size suggested by Wright

Fig 1. Breeding aggregation of *Heterodon platirhinos* consisting of two males and one female.

Fig 2. Copulation between a male (SVL = 37 cm) and female (SVL = 55.2 cm) *Heterodon platirhinos.*

and Wright (*op. cit.*) and Conant and Collins (*op. cit.*), but was 3.7 cm shorter than the smallest reported sexually mature female reported by Meyer (*op. cit.*). It should be noted that *H. platirhinos* on the island are geographically isolated, and may be subject to island effects (Vanek and Burke, unpubl. data).

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***LAMPROPELTIS CALIFORNIAE* (California Kingsnake). DIET / OOPHAGY.** The diet of *Lampropeltis californiae* has been rarely reported, but is assumed to be similar to other members of the *L. getula* complex. Across the *L. getula* complex, prey items include snakes, lizards, turtles, rodents, and birds (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution, Washington, D.C. 668 pp.). Egg-eating has also been documented and records include the eggs of other snakes (Lewke 1982. Herpetol. Rev. 13:18), turtles (Brauman and Fiorillo 1995. Herpetol. Rev. 26:101–102), and birds. In California, *L. californiae* has been reported to eat the eggs of *Aimophila ruficeps* (Rufous-crowned Sparrow; Morrison and Bolger 2002. Ecol. Appl. 12:398–411), *Callipepla californica* (California Quail; Compton 1933. Condor 35:71–72), and *Vireo bellii* (Least Bell's Vireo; Pemberton and Carriger 1916. Condor 18:233). *L. californiae* is also known for nest robbing and eating the nestlings of *Pipilo maculatus* (Spotted Towhee; Davis 1960. Condor 62:434–456), *A. ruficeps* (Morrison and Bolger, *op. cit.*), and *V. bellii* (Clark 2009. Southwest. Nat. 54:352–353). Here we report the first case of predation on *Zenaida macroura* (Mourning Dove) eggs by *L. californiae.*

On 21 April 2016, at 1245 h, one of us (LLW) observed an adult striped-phase *L. californiae* in the nest of a *Z. macroura* in the backyard of the home of LLW (32.75794°N, 117.01923°W, WGS 84; 190 m elev) in La Mesa, San Diego Co., California, USA. Located 1.5 m above the ground in a fig tree (*Ficus carica*), the nest was under observation the day before and had contained an adult *Z. macroura* brooding two eggs. When the nest was checked a second time, the *L. californiae* was loosely coiled around the edge of the nest and was in the process of eating the first egg (Fig. 1). No signs of the adult doves were seen. Over the course of 4 min, the snake ingested the first egg intact; the second egg fell out of the nest but was held next to the nest by the body of the snake. As the snake attempted to bite the second egg, it fell to the ground and cracked. During the whole episode, a *Troglodytes aedon* (House Wren) could be heard scolding the snake, since it had an occupied nest box within the same tree. Images are available through the RASCals project in iNaturalist (inaturalist.org) or the Amphibian and Reptile Atlas of Peninsular California (herpatlas.sdnhm.org) and both the photos and videos are archived in the San Diego Natural History Museum's herpetology photographic collection (SDNHM-HerpPC 5330–5336).


FIG. 1. An adult striped-phase *Lampropeltis californiae* consuming the eggs of a *Zenaida macroura* (Mourning Dove) in San Diego County, California, USA.

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***LAMPROPELTIS TRIANGULUM SYSPILA* (Red Milksnake). PIEBALDISM.** Piebaldism (or "partial leucism") is a form of hypopigmentation that differs from albinism (the absence of melanin pigment) or complete leucism in that the total absence of pigments is localized, manifesting as patches of white coloration on an otherwise normally colored and patterned individual (Acevedo et al. 2009. Polar Biol. 32:41–45). Here, we describe the first instance of piebaldism in a wild *Lampropeltis triangulum syspila.*

On 14 May 2014, an adult male *L. t. syspila* (Fig. 1; total length = 92 cm) with aberrant piebald patterning was captured in William B. Bankhead National Forest (Lawrence Co.) of northwest Alabama, USA. The snake was captured in a box-trap array as part of a survey of herpetofaunal community responses to forest management (Sutton et al. 2013. Forest Ecol. Manag. 295:213–227). The major piebald areas were localized to the snake's dorsum, not dropping ventrally more than 6 scale rows from the dorsal midline (Fig. 1). In general, the unpigmented areas were poorly defined and often fragmented by scales with natural coloration. The disjunct and smeared appearance of the piebaldism and the surrounding area was unlike any color aberration we have observed. The snake appeared to be in good physical condition and was released after morphometric processing.

Albinistic or leucistic organisms suffer from high mortality and other complications in nature (Krecsák 2008. Russ. J. Herpetol. 15:97–102), but the fossorial natural history of *Lampropeltis*


FIG. 1. Piebaldism (i.e., "partial leucism") observed in *Lampropeltis triangulum syspila* from northwest Alabama, USA.

spp. might preclude them from some of these issues. A potential alternative explanation for this coloration is the *L. t. syspila* suffered a burn injury during a prescribed dormant-season fire. Thermal burns can permanently damage skin chromatophores and produce a skin condition (leukoderma) that closely resembles an inherited piebald condition (Mader 1996. Reptile Medicine and Surgery. W. B. Saunders Company, Philadelphia, Pennsylvania. 512 pp.). However, closer examination of the snake revealed no scarring, puckering, or scalation asymmetries, which would be expected following such an extensive injury.

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***LIASIS OLIVACEUS BARRONI* (Pilbara Olive Python). DIET.** The diet and ecology of *Liasis olivaceus barroni* remains poorly known despite its "Vulnerable" status under the Australian federal Environment Protection and Biodiversity Conservation Act 1999. A diet study undertaken by Shine and Slip (1990. Herpetologica 46:283–290) did not include any *L. o. barroni* specimens; however, it did provide a detailed analysis of the diet of the northern nominal subspecies *L. o. olivaceus* which has been considered comparable due to the highly opportunistic predatory behavior displayed by both subspecies (Barker and Barker 1995. Pythons of the World. Vol 1. Australia. Advanced Vivarium Systems, Lakeside, California. 171 pp.). Shine and Slip (*op. cit.*) characterized the diet of *L. olivaceus* as approximately 26% reptilian, 26% avian, and 48% mammalian prey. The diet of *L. o. barroni* is known from few records and observations that include "waterbird species" including "ducks," White-faced Heron (*Egretta novaehollandiae*) and Australian Wood Duck (*Chenonetta jubata*), "pigeons" including the Spinifex Pigeon (*Geophaps plumifera*), Rothschild's Rock-wallaby (*Petrogale rothschildi*), and small Common Wallaroo (*Macropus robustus*) as well as some captive birds such as Budgerigar (*Melopsittacus undulatus*) and finch species (Barker and Barker, o*p. cit.*; Pearson 2006. Giant Pythons of the Pilbara. Landscope 19:32–39; Pearson 2007. *In* Swan [ed.], Keeping and Breeding Australian Pythons, pp. 174–181. Mike Swan Herp Books, Australia; Ellis 2013. Herpetol. Rev. 44:693).

On 21 October 2014, a *L. o. barroni* scat was collected from a permanent waterbody approximately 140 km SE of Karratha, Western Australia (21.581344°S, 117.881475°E; WGS 84). The scat was collected on a rock ledge just above the water level next to a large permanent spring. The scat (220 × 38 mm) was broken into four pieces, which were deposited over an area of approximately 0.25 m^2. The scat was identified as belonging to *L. o. barroni* and not a dog or dingo (*Canis familiaris* or *C. dingo*) due to its size, the presence of urates and the location, which was inaccessible to the latter species. Analysis of scat contents revealed a number of feathers of *Threskiornis moluccus* (Australian White Ibis), a medium-sized waterbird frequently observed near waterbodies in the Pilbara region.

A further observation of waterbird predation was made in August 1980 in dense rush beds near Crossing Pool on Millstream National Park, Western Australia (21.580796°S, 117.092223°E; WGS 84). A two-meter long *L. o. barroni* was observed consuming an adult *Anas gracilis* (Grey Teal). The duck was still alive when first located and the python took approximately 30 min to consume it entirely. A photograph of the python following consumption of the Grey Teal was published in Storr et al. (1986. Snakes of Western Australia. Western Australian Museum, Perth, Australia. 176 pp.; pl. 5, fig. 2, p. 123).

Our records support previous suggestions that birds, particularly waterbirds, are likely to make up a large portion of the diet of adult *L. o. barroni* due to its frequent association with water bodies (Ellis, *op. cit.*).

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***LYCODON FLAVOZONATUS* (Yellow Banded Big Tooth Snake). DIET.** *Lycodon flavozonatus* (= *Dinodon flavozonatum*) is a common and widespread species found throughout central and southern Asia, but its diet is poorly documented. Das (2010. Reptiles of South-east Asia. New Holland Publishers, Cape Town, South Africa. 376 pp.) lists the diet as "unstudied." Zhao (2006. Snakes of China. Anhui Science and Technology Publishing House, Hefei, Anhui. 372 pp.) lists the diet as "birds, lizards perhaps snakes." There is no documentation of specific prey items below class or order level (e.g., birds, mammals, snakes, etc.). At 2207 h on 24 June 2015, while surveying at the Wuyishan National Nature Reserve in northwestern Fujian Province, China (27.733610°N 117.641150°E, WGS 84; 1196 m elev.), we encountered a *L. flavozonatus* (total length ca. 75 cm) with an obvious bolus in its stomach. We palpated the individual until it regurgitated its meal, which consisted of a gravid female *Sibynophis chinensis* (Chinese Mountain Snake) and an unidentified skink species. The skink was too digested to positively identify, but it was likely either *Scincella modesta* or *Sphenomorphus indicus*/*incognitus*. The anterior portion of the *S. chinensis* was completely digested, but the remaining portion measured ca. 24 cm. The *S. chinensis* specimen was found to contain three well-developed eggs (34.8 mm, 34.0 mm, and 27.8 mm, by 8.0 mm, 7.0 mm, and 7.7 mm, respectively). This observation represents both an official documentation of ophiophagy in *L. flavozonatus*, predation of Scincidae, and a reproductive observation for *S. chinensis,* which at the 27th latitude, on 24 June, had yet to oviposit. Photographic vouchers (*L. flavozonatus*: HM 131694; *S. chinensis*: HM 131695) were deposited with HerpMapper.org (HM).

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***NERODIA ERYTHROGASTER* (Plain-bellied Watersnake). REPRODUCTION.** During March 2016, a concentration of watersnakes was observed near a boardwalk at the Sam D. Hamilton Noxubee National Wildlife Refuge, Noxubee County, Mississippi, USA. This boardwalk passes approximately 400 m through a stand of seasonally-flooded Bald Cypress (*Taxodium distichum*) leading to an overlook on Bluff Lake facing a heron rookery. After water had receded from around the boardwalk in late March, a pair of mating *N. erythrogaster* was seen and photographed by VM on 28 March, completely out in the open such that the two snakes could be seen in their entirety (Fig. 1). These snakes remained in this presumably mated position as they were photographed several times from different angles. Such clear exposure of the body positions of a mated pair was unusual compared to a complex mating aggregation of seven snakes seen by WP in Clay County, Mississippi in late April 2001 (Parker 2003. Herpeteol. Rev. 34:151–152). Gibbons and

Fig. 1. Mating pair of *Nerodia erythrogaster* observed on 28 March 2016 in Mississippi, USA.

Dorcas (2004. North American Watersnakes: A Natural History. University of Oklahoma Press, Norman. 238 pp.) described mating of *N. erythrogaster* in late April in Ohio and Oklahoma and early May in Ohio. Thus, VM's observation is about a month earlier than other such observations.

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***OXYRHOPUS PETOLARIUS DIGITALIS* (Banded Calico Snake). DIET.** *Oxyrhopus petolarius* is a medium-sized snake belonging to the tribe Pseudoboini. This species occurs from Mexico through Central America to Bolivia and Brazil (Peters and Orejas-Miranda 1970. Bull. U.S. Natl. Mus. 297:1–347). It is nocturnal and terrestrial, with occasional records of diurnal and arboreal activity (Costa et al. 2010. Biota Neotrop. 10:353–377). Its generalist diet includes small mammals, lizards, birds, snakes, and bird eggs (Vrcibradic et al. 2011. Herpetol. Rev. 42:299–300; Costa et al. 2014. Herpetol. Notes 7:115–118). *Volatinia jacarina* is a small granivorous thraupid bird, usually found in open areas (Carvalho et al. 2007. Braz. J. Biol. 67:275-281) throughout Central and South America (Sick 1997. Ornitologia Brasileira. 2nd ed. Nova Fronteira, Rio de Janeiro. 912 pp.).

Here we report the stomach contents of an *O. p. digitalis* (total length = 77 cm), captured near an Atlantic Forest fragment, in Municipality of Cataguases (21.2436°S, 42.7257°W; WGS 84), Minas Gerais, Brazil. A male *V. jacarina* (total length = 114 mm) was found in the snake's stomach (Fig. 1), and had been swallowed headfirst. The snake is housed in the herpetological collection of the Universidade Federal de Viçosa, Minas Gerais, Brazil (MZUFV 2414).

Fig. 1. A) *Oxyrhopus petolarius digitalis* (MZUFV 2414; SVL = 77 mm) from the municipality of Cataguases, state of Minas Gerais, Brazil ,and (B) its prey, *Volatinia jacarina*.

Birds have also been reported as prey of several Pseudoboini species (Sazima and Abe 1991. Stud. Neotrop. Fauna E 26:159–1640). Bernarde and Machado (2000. Herpetol. Rev. 31:247–248) recorded predation by *O. p. digitalis* on *Columbina talpacoti*; thus this observation represents the second species of bird known as prey of this snake. Because *O. petolarius* is predominantly nocturnal (Costa et al., *op. cit.*) the *V. jacarina* may have been captured as it was sleeping at night.

We thank Diego J. Santana and Carla S. Guimarães for a critical reading and helpful comments, and the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) for collection permit (ICMBio permit number 26008-5).

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***PHILODRYAS NATTERERI* (Paraguay Green Racer). DIET.** *Philodryas nattereri* is a dipsadid snake native to the arid and semi-arid regions of Brazil, Paraguay, and Colombia (Uetz et al. 2016. The Reptile Database, http://www.reptile-database.org; accessed 3 Jun 2016). It is a terrestrial and semi-arboreal active forager known to eat eggs, lizards, other snakes, mammals, amphibians, and one unknown species of passeriform bird (Vitt and Vangilder 1983. Amphibia-Reptilia 4:273–296; Mesquita et al. 2011. Herpetol. J. 21:193–198).

On 26 May 2016 we observed a *P. nattereri* (SVL ca. 90 cm) preying on hatchling *Eupsittula cactorum* (Cactus Conure or "Maracanã"; Fig. 1A) in caatinga habitat in the city of Caicó, Rio Grande do Norte, Brazil (6.441750°S, 37.034639°W; WGS 84). The predation occurred during the day in a tree (*Sideroxylon obtusifolium*) nearly 2 m above the ground. The snake caught one of the hatchlings inside a hole in a termite nest of *Nasutitermes* sp. (Fig. 1B) and tried to swallow it for ca. 15 min. After this time, the snake climbed to the top of the tree with the bird in its mouth and complete ingestion was not observed. The following morning, we found two dead hatchling *E. cactorum* with apparent bite marks, beneath the tree (Fig. 1C). We suspect that the snake was unable to swallow the first bird, dropped it

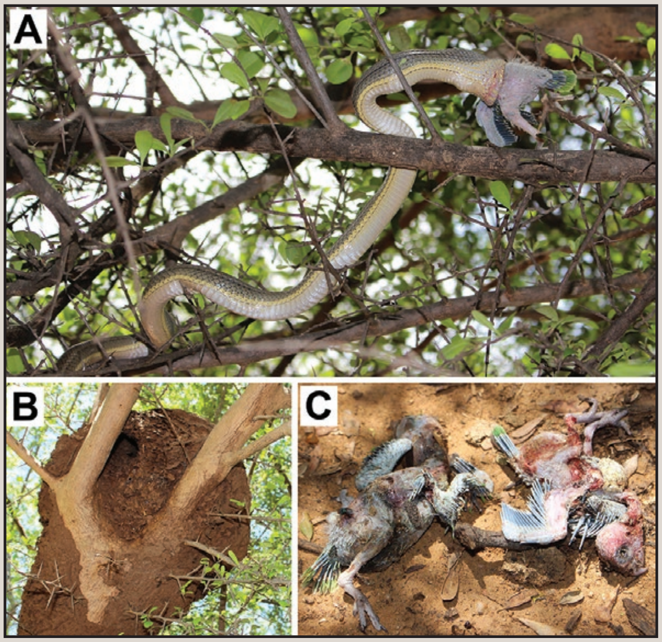

Fig. 1. A) *Philodryas nattereri* preying on a hatchling *Eupsittula cactorum* in the city of Caicó, Rio Grande do Norte, Brazil. B) Termite nest of *Nasutitermes* sp. C) Two dead hatchling *E. cactorum.*

to the ground, and returned to the same nest and repeated the attempted predation on a second hatchling.

We are grateful to Gibson Machado Alves, father of the first author, who took the photo and made behavioral observations reported in this note.

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PHILODRYAS OLFERSII **(Cobra-cipó; Lichtenstein's Green Racer). DIET.** *Philodryas olfersii* is a medium-sized, semiarboreal, and diurnal species (Hartmann and Marques 2005. Amphibia-Reptilia 26:25–31), widely distributed throughout South America, living in forests and neighboring areas. This snake is a dietary generalist, feeding on small vertebrates, such as mammals, frogs, birds, and lizards (Hartmann and Marques, *op. cit.*). *Ameiva ameiva* is a diurnal lizard, occurring in most of tropical and subtropical South America east of the Andes, extending north to Panamá. In Brazil, it inhabits several different ecosystems and is one of the most conspicuous members of lizard assemblages (Sales et al. 2011. Phyllomedusa 10:165–176). During a diurnal survey on 18 October 2015, a *P. olfersii* was observed preying upon a juvenile *A. ameiva* (Fig. 1) in the Mosteiro Zen Morro da Vargem, municipality of Ibiraçu, Espírito Santo state, southeastern Brazil (40.378415°W, 19.842013°S; WGS 84; elev. 115 m). The *P. olfersii* was found constricting the *A. ameiva* and subsequently began ingesting it headfirst. The observation lasted for 10 min, and once disturbed by our presence, the snake fled with the lizard in its mouth. To our knowledge, this is the first report of predation on *A. ameiva* by *P. olfersii.*

We thank the photographer Jonas Alves, for providing the photo and details of the predation event. ATM thanks Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES) for the scholarship.

Fig. 1. *Philodryas olfersii* preying on a juvenile *Ameiva ameiva* in the municipality of Ibiraçu, Espírito Santo, southeastern Brazil.

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PHILODRYAS PATAGONIENSIS **(Patagonia Green Racer). DIET / OPHIDIOPHAGY.** *Philodryas patagoniensis* has a widespread distribution, ranging from Argentina to Brazil, Bolivia, and Uruguay (Abegg and Neto 2012. Serpentes do Rio Grande do Sul. LEW, Tapera, Rio Grande do Sul. 152 pp.). It is a dietary generalist, consuming invertebrates, mammals, birds, frogs, lizards, and other snakes (Lopez and Giraudo 2008. J. Herpetol. 3:474–480). Ophidiophagy is thought to be uncommon in *P. patagoniensis* with records of *Erythrolamprus jaegeri*, *Lygophis dileps*, and *Philodryas olfersii* (Lopez and Giraudo, *op. cit.*; Marques et al. 2012. Herpetol. Notes 5:315–317).

On 3 October 2015, in the municipality of Chui, state of Rio Grande do Sul, Brazil (33.678447°S, 53.513633°W, WGS 84; 9 m elev.), we collected an adult female *P. patagoniensis* (SVL = 103 cm, tail length = 25 cm) under a tile plate in a field. While being transported, it regurgitated the remains of an *Erythrolamprus semiaureus*, which included the entire tail (tail length = 17 cm). The total length of the regurgitated specimen was estimated at 92 cm, based on reference specimens. This represents the first record of *E. semiaureus* predation by *P. patagoniensis* under natural conditions (see Lema et al. 1983. Comun. Mus. Ciênc. PUCRS, Sér. Zool., Porto Alegre 26:41–121 for a captive record). Both specimens are deposited at the Coleção Herpetológica da FURG, Rio Grande, Rio Grande do Sul, Brazil (CHFURG 4526 and 4527; *P. patagoniensis* and *E. semiaureus*, respectively). Collection permit was authorized by Instituto Chico Mendes de Conservação à Biodiversidade (ICMBio 43658-1).

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***PHILODRYAS SIMONSII* (Schmidt's Racer) and *PHILODRYAS TACHYMENOIDES* (Schmidt's Green Racer). REPRODUCTION and DIET.** The neotropical opistoglyphus snake genus *Philodryas* contains 22 species distributed through the Andes, Amazon Basin, Pampas, and Patagonia, reaching elevations up to 3000 m (Uetz et al. The Reptile Database, http://www.reptile-database.org; accessed 15 Apr 2016; Zaher et al. 2014. Zootaxa 3785:469–480). Some species (e.g., *P. olfersii* and *P. patagoniensis*) have abundant information on their natural history, while others, especially Andean species, remain poorly known. Herein, we report the first data on reproduction and diet for *P. simonsii* and *P. tachymenoides*, respectively. The voucher specimens are deposited in the herpetological collection of Centro de Ornitología y Biodiversidad (CORBIDI), Lima, Peru.

One gravid female *P. simonsii* (CORBIDI 5008; SVL = 565 mm) was collected on 24 March 2010, in Santa Eulalia (11.8090°S, 76.6292°W, WGS 84; 1800 m elev.), Huarochiri province, Lima department, Peru. The specimen was dissected and four well-developed eggs (1 in the left oviduct and 3 in the right oviduct) were found. Measurements were: average length = 27.5 mm (range 25.7–29.5 mm), width = 10.6 mm (10.4–11.1 mm), and volume = 1640.2 mm³ (1483.6–1903.1 mm³).

On 4 March 2012, an adult female *P. tachymenoides* (CORBIDI 11238; SVL = 533 mm; total length = 719 mm; head width = 11.1 mm) was collected in Corire Conservation Concession, Castilla province, Arequipa department, Peru (16.0621°S, 72.1799°W, WGS 84; 2625 m elev.). Its stomach contained an adult *Phyllotis limatus* (SVL = 103 mm; total length = 20.3 mm; cranial width = 16 mm), which was ingested head first. On 22 March 2016 at 1502 h, an adult *P. tachymenoides* (SVL ca. 500 mm) was observed feeding on a juvenile toad, *Rhinella limensis* (Fig. 1), near Churin village (10.9117°S, 77.0018°W, WGS 84; 1600 m elev.), Oyón province, Lima department, Peru. The snake swallowed the toad headfirst. The present information represents the first record of reproduction for *P. simonsii* and the first prey items recorded for *P. tachymenoides*.

FIG. 1. *Philodryas tachymenoides* preying on *Rhinella limensis* near Churin Village, Lima, Peru.

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***REGINA RIGIDA* (Glossy Crayfish Snake). PREDATION.** On 23 September 2015 an *Amia calva* (Bowfin fish; total length = 47.0 cm) was collected from the Combahee River (Colleton County, South Carolina, USA; 32.68295°N, 80.77792°W, WGS 84), during a fisheries survey (water temperature = 25.4°C, salinity = 1.0 ppt). It was dissected on 24 September 2015, and was found to have a partially digested *Regina rigida rigida* (total length = 55.3 cm) in its stomach (Fig. 1). Despite some discoloration and damage, it was identifiable by the stripes on the ventral side formed by the paired dark triangles on each ventral scale (Powell et al. 1998. A Key to Amphibians and Reptiles of the Continental United States and Canada. University Press of Kansas. Lawrence, Kansas. 131 pp.).

Amia calva have a broad diet, consisting of crustaceans like crayfish and grass shrimp, insects, and fishes, including *Anguilla rostrata* (American Eel) (Ashley and Rachels 1999. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 53:50–60; Lagler and Applegate 1942. Copeia 1942:190–191). There are also two reports of predation on a related snake (*Regina alleni*, Striped Crayfish Snake) by *A. calva* (Jordan and Arrington 2001. Wetlands 21:155–159), but clearly these occurrences are uncommon and we are not aware of any reports of *R. rigida* being ingested by any fish species.

FIG. 1. Lengths of *Amia calva* (Bowfin) and *Regina rigida* it had consumed.

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***RENA DISSECTUS* (New Mexico Threadsnake). PREDATION.** *Rena dissectus* is a subterranean species that commences nocturnal aboveground activity around sunset for a few hours during active periods from March to October (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 680 pp.). This small snake is likely preyed upon by many animals when on the surface, but a limited number of predation events have been reported. Known predators include large centipedes, snakes, birds, and mammals (Ernst and Ernst, *op. cit.*). To our knowledge, there are no published observations of this species being predated by an amphibian.

On 9 June 2015, we observed an *Anaxyrus woodhousii* (Woodhouse's Toad) consuming a *R. dissectus* in the flood plain of the Gila River, Grant County, New Mexico, USA (32.9449°N, 108.6093°W, WGS 84; elev. 1370 m). The adult-sized toad was located on a roadway at dusk after a heavy rain with the snake in its mouth. The locality was situated at an ecotone between the river floodplain to the east and upland desert grasslands to the west. Riparian habitats were dominated by Fremont Cottonwoods (*Populus fremontii*). We deposited the snake into herpetological collections at the Sternberg Museum of Natural History (FHSM 16809), Fort Hays State University, Hays, Kansas, USA. This observation represents the northern edge of the distribution for *R. dissectus* in the region as our observation and an individual collected in 1964 from "along Gila River near Cliff" (Western New Mexico University 9089) are known from the immediate area (Degenhardt et al. 1996. Amphibians and Reptiles of New Mexico. University of New Mexico Press, Albuquerque. 431 pp.). *Anaxyrus woodhousii* are known to consume a variety of prey items, including small arthropods such as Coleoptera, Hymenoptera, Lepidoptera, Isopoda, and arachnids (Gehlbach and Collette 1959. Herpetologica 15:141–143). This is the first observation of an *A. woodhousii* predating a *R. dissectus*.

This project was funded in part by the Share with Wildlife program of the New Mexico Department of Game and Fish while one of us (KG) was researching mammals in the region. We thank Tom Giermakowski at the Museum of Southwestern Biology, University of New Mexico, and Jim Stuart, New Mexico Department of Game and Fish for assistance in tracking down locality data for the prior records of occurrence in the area.

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***STORERIA DEKAYI* (Dekay's Brownsnake). DEFENSIVE BEHAVIOR.** *Storeria dekayi* exhibit a diverse array of defensive behaviors, including cryptic concealment, death-feigning, flattening, fleeing, gaping, head-hiding, inflation, immobility, lip-curling, musking, posturing, striking, and thrashing (reviewed by Gray 2014. Collinsorum 3:20–27). Gray (2015. J. N. Am. Herpetol. 2015:43–52) studied defensive behaviors of *S. dekayi* in the field and noted that before contact occurs (i.e., touching the snake in order to elicit a defensive behavioral response), *S. dekayi* will either remain immobile, attempt to flee, or occasionally engage in head-hiding behavior. Gray (2015, *op. cit.*) noted in his study that open-mouthed striking behavior in *S. dekayi* occurred only after contact.

In two of approximately 20 encounters with *S. dekayi* since 2008, I have observed open-mouthed striking behavior in *S. dekayi* in which the snake struck immediately upon detection without contact. Both observations occurred during summer 2008 while overturning debris (wooden paneling) in Scott Township, Columbia Co, Pennsylvania, USA (41.0058°N, 76.4150°W; WGS 84). On the first occasion, immediately after lifting cover, a small *S. dekayi* (total length ca. 18–20 cm) assumed a strike posture and subsequently preformed one open-mouthed strike before fleeing. On the second occasion, a *S. dekayi* (total length ca. 25 cm) immediately assumed a defensive posture upon removal of cover and preformed 3–4 open-mouthed strikes before fleeing, while a similar sized conspecific immediately fled. Although *S. dekayi* more typically displays inoffensive behaviors such as immobility or fleeing during the initial phase of encounter by a predator, as reported by (Gray 2015, *op. cit.*), the observations reported herein suggest that *S. dekayi* may also occasionally respond aggressively to predators before contact.

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***TANTILLA MELANOCEPHALA* (Crowned Snake). REPRODUCTION.** *Tantilla melanocephala* is a small and semifossorial snake distributed from Guatemala to Argentina and Uruguay (Uetz et al. 2016. The Reptile Database, http://www.reptile-database.org; accessed 17 May 2016). In Argentina, there are few records of the species (Giraudo et al. 2012. Cuad. Herpetol. 26:303–326) and reproductive data are scarce. Here, we present the first detailed reproductive data for *T. melanocephala* in Argentina. At 1522 h on 7 December 2014 a gravid female *T. melanocephala* (SVL= 26.9 cm; tail length = 7.9 cm; mass = 10.61 g) was found under a *Eucalyptus* sp. log in "Estancia Don Antonio" (28.925961°S, 56.407581°W, WGS 84; 72 m elev.) in General Alvear Department, Corrientes Province, Argentina. On 11 December 2014 in the laboratory, the female laid one egg, and on 12 December laid two more eggs. The eggs measured 21.10 × 7.76, 24.09 × 7.99, and 23.40 × 7.80 mm; weighed 1.22, 1.23, and 1.20 g; and the volume was 663.28, 801.16, and 743.18 mm^3, respectively. The total fresh clutch mass was 3.65 g and post-oviposition female body mass was 6.96 g. The Relative Clutch Mass (total clutch mass/body mass of mother after oviposition; Shine 1980. Oecología 46:92–100) was 0.52. The specimens were fixed and deposited at the Herpetological Collection of the Universidad Nacional del Nordeste as a voucher specimen (UNNEC 13012). At oviposition, the development embryo stage was 22 (Zehr 1962. Copeia 1962:322–329), similar to that reported for other snakes species (Blackburn 1995. J. Theor. Biol. 174:199–216). The reproductive data reported here are similar to those registered for *T. melanocephala* from Brazil (Marques and Puorto 1998. Amphibia-Reptilia 19:311–318; Do Santos Costa et al. 2006. J. Herpetol. 40:556–559) and other species of the genus (Easterla 1975. Herpetologica 31:234–236).

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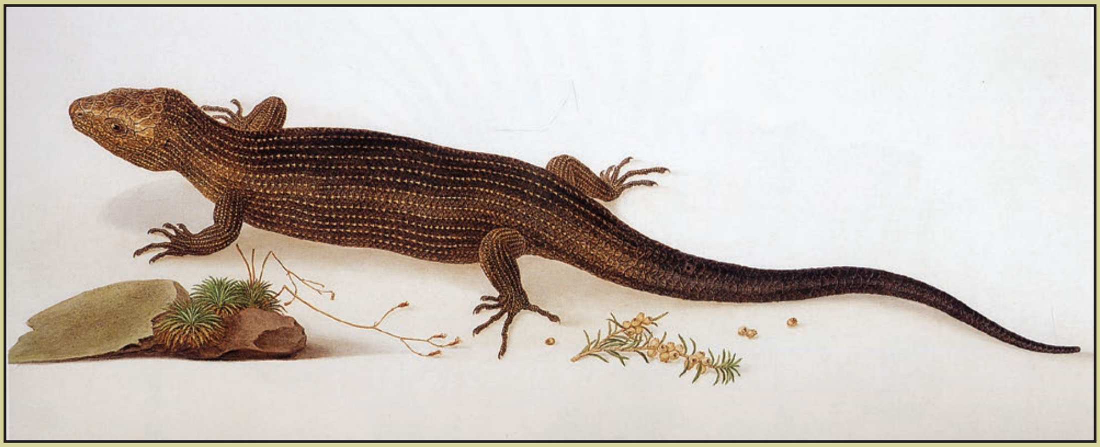
Fig. 1



Art in Herpetology: Four Historical Views of a Large Australian Skink (Genus *Egernia*)

> Amongst the reptiles was a variety of lizards; one of which, of the larger size, was met with by [Captain William] Dampier on the West Coast, and described by him "as sort of guano [lizard]. But differing from others in three remarkable particulars: for these had a larger and more uglier head, and had no tail: And at the rump, instead of the tail there, they had a stump of a tail, which appeared like another head; but not really such, being without mouth or eyes. Yet this creature seemed by this means to have a head at each end; and, which may be reckoned a fourth difference, the legs, also, seemed all four of them to be forelegs, being all alike in shape and length, and seeming by the joints and bendings to be made as if they were to go indifferently either head or tail foremost [This description likely identifies the Shingleback Skink *Tiliqua rugosa* = *Trachydosaurus rugosus*]…The guano's I have observed to be very good meat; and I have often eaten of them with pleasure; but though I have eaten of snakes, crocodiles, and alligators and many creatures that look frightfully enough, and there are but few I should have been afraid to eat of, if pressed by hunger, yet I think my stomach would scarce have served to venture upon these New Holland guano's, both the looks and the smell of them being so offensive.
>
> Matthew Flinders, 1814.
> *A voyage to Terra Australis*… volume 1:64–65.

King's Skink (now *Egernia kingii*) was described as *Tiliqua kingii* by John Edward Gray from the British Museum in 1838. The lizard was named after Captain and Admiral Philip Parker King (1791–1856), Australian-born British marine surveyor and collector. This saurian is found on offshore islands, coastal dunes, and rocky outcrops of south-western Western Australia. On the islands it is common, lives in seabird burrows, and preys on their eggs and young. Obervations over a ten-year period by Masters and Shine (2002. Australian Zoologist 32:377–380) revealed a very stable adult pair-bond within this species based on a single family of lizards (a pair of adults plus six successive litters of their offspring) near Perth. Synonymy follows Cogger (1983. Zoological Catalogue of Australia. Vol. 1. Amphibia and Reptilia. Australian Government Publishing Service, Canberra, ACT. 313 pp.; 2014. Reptiles and Amphibians of Australia, 7th ed. CSIRO Publishing, Collingwood, Victoria. 1064 pp.) and Uetz et al. (2016. The Reptile Database. http://www.reptile-database.org/ accessed March 2016).

The colored image of the King's Skink shown here (Fig. 1) is actually a reproduction of a watercolor drawing by Ferdinand Bauer from an expedition in Australia by Matthew Flinders, and was based on a specimen killed at King Island, King George Sound in Western Australia on 22 Dec 1801. Flinders' *A Voyage to Terra Australis* was published in 1814 (G. and W. Nicol, London. 2 vols and atlas). The drawing is in the collection of the Natural History Museum, London and is reproduced here through the courtesy of Judith Magee at the Museum (Bauer Zoological Number 29).

In 1839, the taxon was listed in Duméril and Bibron's *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles* as *Tropidolopisma Dumerilii* (Le Tropidolopisme de Duméril) in the synonymy in volume 5 on p. 745 (part). The image is plate # 50 from the Atlas in *Erpétologie Générale,* listed under the name *Scincus Dumerilii* (Fig. 2). Tracing a Duméril and Bibron scientific name can sometimes be difficult—*Scincus aterrimus* Duméril and Bibron 1839: 745 (nomen nudum); *Scincus nuittensis* Duméril and Bibron 1839: 745 (nomen nudum); *Scincus trifasciatus* Duméril and Bibron 1839: 745 (nomen nudum).

These black-and-white drawings are from *The Lizards of Australia and New Zealand* by John E. Gray published in 1845 (Catalogue of the Specimens of Lizards in the Collection of the British Museum. Trustees of the British Museum/Edward Newman, London. xxvii + 289 pp.). In his *Catalogue*, Gray listed two species of large skinks. The first was called *Topidolepisma Kingii* and he listed it as *Tiliqua Kingii* in his synonymy (Fig. 3). The second was The Shining Tropidolepisma (*T. nitida*), now considered *Egernia kingii* (Fig. 4). Included here are both plates from Gray (1867. The Lizards of Australia and New Zealand in the Collection of the British Museum / reprinted by SSAR 1995). The famous artist George Henry Ford (1809–1876) produced all but perhaps one (# 20) of the extraordinary plates in this work.

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Fig. 2

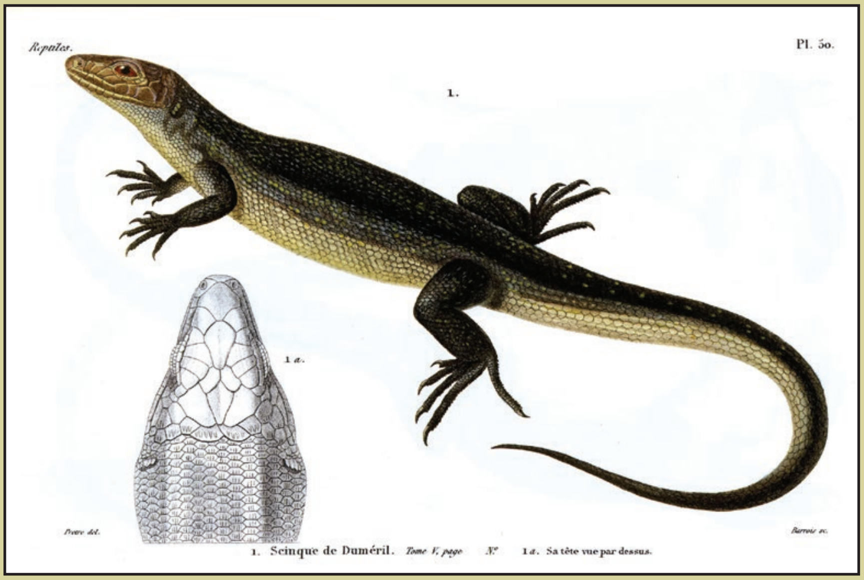


Fig. 3

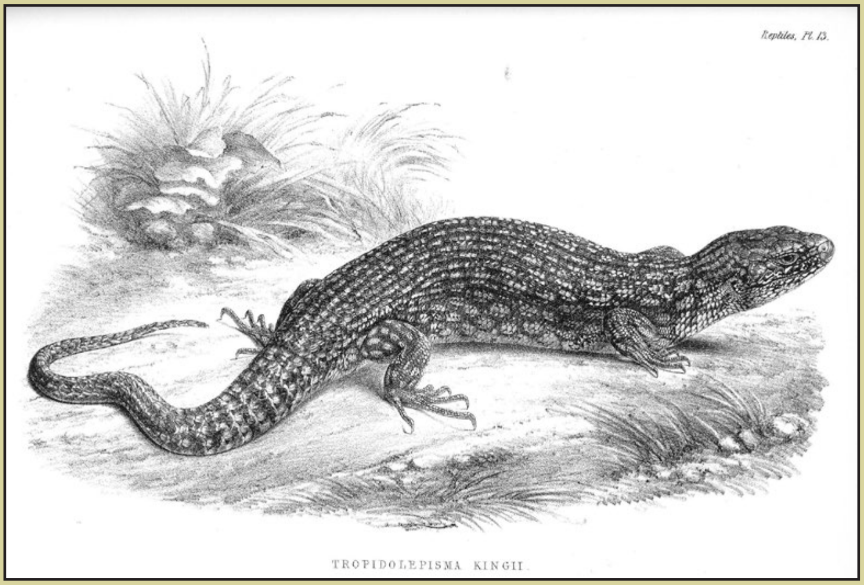
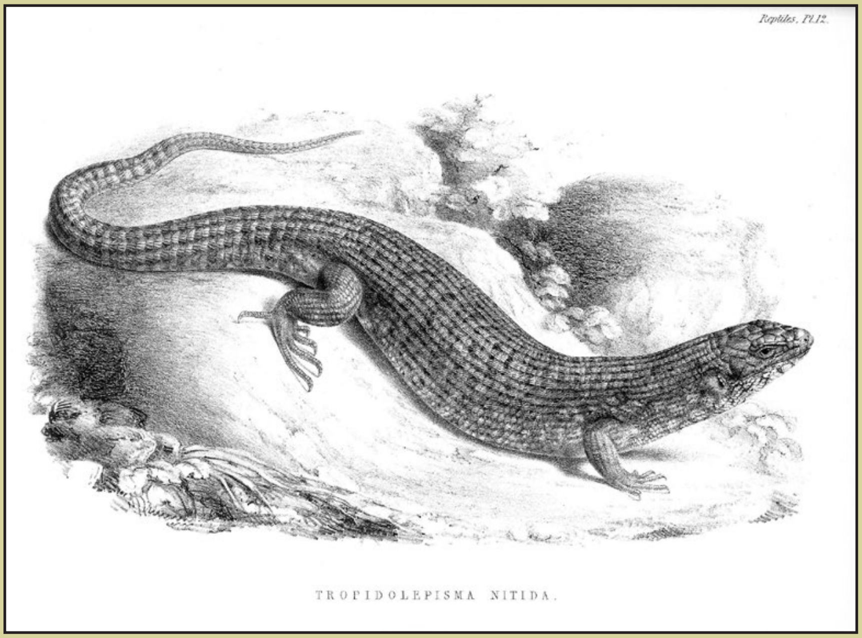


Fig. 4

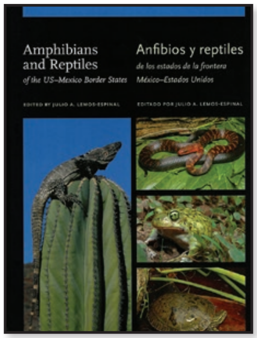


BOOK REVIEWS

Herpetological Review, 2016, 47(4), 692–694.

Amphibians and Reptiles of the US – Mexico Border States / Anfibios y Reptiles de los Estados de la Frontera México – Estados Unidos

Edited by Julio A. Lemos-Espinal. 2015. W. L. Moody Jr. Natural History Series, No. 52, Texas A&M University Press, College Station, Texas. x + 614 pp. Hardcover. US $90.00. ISBN 978-1-62349-306-6.



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Julio Lemos-Espinal has been prolific over the past 20 years with efforts to enhance our understanding of the amphibians and reptiles of Mexico. Lemos-Espinal's efforts typically are the results of collaborations with herpetologists north and south of the US–Mexico border; his collaborators include, but certainly are not limited to, Royce Ballinger, David Chiszar, James Dixon, Raymundo Montoya-Ayala, Luis Oliver-Lopez, Geoffrey Smith, Hobart Smith, and Guillermo Woolrich-Piña. Several of his previous contributions have included checklists, keys, and distribution maps of the amphibians and reptiles from various Mexican states including some of those along the US–Mexico border (Lemos-Espinal et al. 2004; Lemos-Espinal and Smith 2007; Lemos-Espinal and Dixon 2013; Lemos-Espinal et al. 2014). These characteristics make Lemos-Espinal uniquely qualified to undertake the daunting task of synthesizing an annotated checklist of the 648 species (as of this publication) of amphibians and reptiles from the 10 states (six in Mexico: Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas; four in the US: California, Arizona, New Mexico, and Texas). Those 648 species include 85 salamanders, 101 frogs, 2 crocodilians, 50 turtles, 213 lizards, and 196 snakes (including non-native species).

This book is bilingual with English text in the first half of the book, Spanish in the second. I reviewed the English portions only. The two sets of text are separated by 78 color plates (containing 600 pictures) that depict much of the borderland's herpetofauna. The book is well organized. Chapter 1 is an introduction that lets the reader know what information is included in the book, the contents of each chapter, and how each of the state-specific chapters is organized. Chapter 2 justifies the scientific and common names used in the book. Chapters 3–12 are state-specific chapters going from west to east, first south, and then north of the US–Mexico border. The last, Chapter 13, is a discussion of diversity of the herpetofauna of the Border States using cluster diagrams generated from Jaccard's Similarity indices. Following the last chapter (Chapter 13) on diversity in the Spanish section, there is a large appendix, references by chapter, and, finally, indices in English then Spanish.

Chapter 1 indicates clearly that the book "*… summarizes what is known about the distributions of amphibians and reptiles in each of the 10 states along the United States–Mexico border; provides a current list of amphibians and reptiles that have been recorded in each of these states; and analyzes which of those species are shared between the two countries…*" This book does not contain identification keys or distribution maps for species. If you are looking for that information, you need to find state-specific treatments that exist for most of the states (Texas, New Mexico, Arizona, California, Baja California, Chihuahua, and Coahuila). Lemos-Espinal et al. (2015) have just published a book that includes distribution maps and keys for species in Sonora, Chihuahua, and Coahuila.

Chapter 2 reviews the scientific and common names used in the book. With many authors preparing state-specific chapters, this not only helps the reader, it helps maintain consistency across state chapters. Lemos-Espinal includes introduced as well as native species. Nomenclatural decisions affect the species richness of state herpetofaunas. For example, *Lampropeltis splendida*, *L. holbrooki*, and *L. californiae* are not used (contained within *L. getula*) due to inadequate assessment of taxa in Mexico. In this case, nomenclatural decisions reduced species richness in Texas, New Mexico, and Arizona. Most nomenclatural issues are straightforward and stated for the record. Many of the Spanish common named used by Lemos-Espinal differ from those designated by Liner and Casas-Andreu (2008) because of taxonomic changes or otherwise misleading common names. The one common name change that deviated from Liner and Casas-Andreu (2008) and Crother (2008) and seemed to be unnecessary was referring to the "Massasauga" as "Massasauga Rattlesnake."

State-specific chapters, 3–12, shared a common organization: general introduction, summary of previous herpetological work in the state, list (in table form) of type specimens from the state, discussion of major physiographic characteristics of the state including hydrology, limited geology, climate, biotic zones, and how amphibians and reptiles were distributed across those physiographic regions or biotic zones. Most state-specific introductions summarize the geographical boundaries of the state and the numbers of amphibians and reptiles (broken into traditional orders) found in the state. Some state authors include discussions of shared and endemic taxa (Baja California and California), while the remaining states include that information later in the chapter. The state-specific chapters include thorough histories of herpetology in each state, but as these chapters were written to stand alone, there is much overlap. Authors for each state include their version of the impact that the US and Mexican boundary surveys of the 1850s had on the understanding of amphibians and reptiles in that state. Most addressed the important roles of Spencer, Girard, Cope, Kennicott, and others had in naming species, all associated with a thorough table of the type specimens from that state. The history of herpetology in this part of the world is great reading.

Authors for state-specific chapters dealt with the association of amphibians and reptiles with different physiographic regions or biotic communities in different ways. Authors of the Baja California chapter focused on "assemblages" of species that were restricted (found only in that biotic zone or physiographic region) to that region within the state. For example, in Baja California, 41 species of amphibians and reptiles were documented in the Coniferous Forest Region, but the assemblage for that region included only four species: *Rana boylii*, *Sceloporus vandenburgianus*, *Lampropeltis multifasciata*, and *Thamnophis elegans*. In Baja California, these were the only species found only in the Coniferous Forest Region. However, all four species are found outside the political boundaries of Baja California. *Sceloporus vandenburgianus* and *L. multifasciata* are also found in California. Unfortunately, there is not a Coniferous Forest Region in the California chapter. *Rana boylii* is also found in California and Oregon. *Thamnophis elegans* is one of the most widespread snakes in western North America. Other regions have inherently different types of assemblages. In the Central Gulf Coast Region of Baja California, the assemblage included nine species: *Crotaphytus insularis*, *Phyllodactylus partidus*, *Sauromalus hispidus*, *Callisaurus splendidus*, *Petrosaurus slevini*, *Uta antigua*, *Aspidoscelis cana*, *Crotalus angelensis*, and *C. lorenzoensis*. As in the former example, all are found only in this region within Baja California. But in this example, all are endemic to this region and are found nowhere else in the world. Assemblages from these two regions of Baja California represent two very different groups of species. If the point of delimiting assemblages is to identify unique components of the herpetofauna associated with different habitat types within states, this strategy seemed to miss the point. Perhaps more emphasis on the entire community of amphibians and reptiles found in a particular habitat type would have better captured herpetofaunal characteristics. Authors of other state-specific chapters seemed to have taken this approach and did not rely on discussions of habitat specific assemblages.

In general, state-specific chapters identified major habitat types found within the state and then listed species found there. Several state-specific chapters identified physiographic regions, but then went on to identify more and different biotic zones or provinces. For example, authors for the Arizona chapter identified three physiographic regions, Basin and Range, Transition, and Colorado Plateau. They then identified 14 biotic communities (following Brown and Lowe 1980). State chapters might have benefitted from common and consistent designations of biotic zones across states (in a similar manner to nomenclature). Biotic communities of Brown and Lowe (1980) might have been a good starting point, but the coverage of that map does not extend far enough to the north in California or to the east in Texas, Nuevo León, and Tamaulipas. State-specific chapters would have benefitted greatly from maps of each state depicting major mountain ranges, major rivers, and standardized biotic communities or zones. I realize that such maps are much easier to wish for than they are to produce.

Chapter 13 is entitled "Herpetofaunal Diversity of the United States–Mexico Border States." This is a stimulating chapter. It includes land surface areas, latitudinal and longitudinal limits, numbers of species by taxonomic group, numbers of endemics, and numbers of introduced species for each state. Authors then subjected species richness data (648 spp.) to Jaccard's Similarity and cluster analyses. Jaccard's Similarity values are generated in a pair-wise fashion for all combinations of states. Similarity coefficients are then subjected to cluster analyses. Cluster trees depict state-level assessments of herpetological community similarity. Authors conducted these analyses independently for major taxonomic groups, and, in turn, with introduced species and marine species removed. Eighteen species were introduced across states and seven species were marine (six sea turtles and one sea snake). The overall cluster tree depicted greatest similarity between four pairs of states, Arizona and New Mexico, Sonora and Chihuahua, Nuevo León and Coahuila, and California and Baja California. The California/Baja California cluster occupied a basal position (most different) on the tree. The remaining states formed two main clusters. One cluster was comprised of the Arizona/New Mexico and Sonora/Chihuahua pairs. The second cluster included the Nuevo León/Coahuila pair joined by Tamaulipas, and then Texas. Trees for all amphibians and reptiles generated with introduced and marine species removed produced the same patterns of herpetofaunal similarity. With introduced and marine species removed, cluster trees represent and stimulate a number of zoogeographic hypotheses that help to explain the patterns of herpetofaunal diversity in the US–Mexico border states. For example, salamanders exhibit a different pattern of community similarity compared to frogs or all amphibians or all reptiles. Such differences might be understood based on the Holarctic origins of salamanders compared to the greater affinity to the tropics of other groups. The chapter concludes with a pitch for greater collaborative conservation efforts due to the large number of shared species across the US–Mexico border. Authors add a cautionary note regarding the construction of the border fence, and the potential for more extensive border fencing. Fencing could adversely affect conservation of the border region herpetofauna.

A list of all border region species, with indications of which species can be found in which state and their conservation status, can be found in the excellent appendix. This appendix summarizes much of the book in table form. I detected a single error in that *Lithobates berlandieri* is listed as native in Arizona although it is an introduced species.

This book is a good introduction to the herpetofauna of a large geographical area that is the US–Mexico border states region. Lists of species with habitat affinities found in each state represent a valuable starting point for future herpetological research. The bibliography provides entry to the literature relevant to that region. Anyone working in the region or hoping to in the future will recognize the value of this book.

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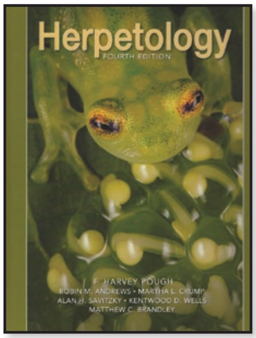
Herpetology, Fourth Edition

F. Harvey Pough, Robin M. Andrews, Martha L. Crump, Alan H. Savitzky, Kentwood D. Wells, and Matthew C. Brandley. 2016. Sinauer Associates, Inc., Sunderland, Massachusetts. xv + 591 pp. (+ 128 pp. Glossary, Literature Cited and indices), 549 illustrations. Hardcover. US $99.95. ISBN 978-1-60535-233-6.



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This latest update of Pough et al.'s "Herpetology" should be a most welcomed addition to any herpetologist's bookshelf. For decades now, there have been two competing textbooks on herpetology available at any particular time, in two distinct lineages. The older lineage, let's call it Lineage "G," began with Goin and Goin's (1962) "Introduction to Herpetology," which has proceeded through a total of seven editions, several changes in authorship, two variations of the title, and one change of publisher, all the while retaining "introduction" or "introductory" someplace on the front cover. The latest avatar of Lineage G is Vitt and Caldwell (2014) "Herpetology, an Introductory Biology of Amphibians and Reptiles" (Fourth Edition). The second lineage of textbooks, Lineage "P," can be thought to have begun with Porter's (1972) "Herpetology." Porter's book, which had no subsequent editions, eventually slid further and further out of date until it was superseded by the first edition of "Herpetology" by Pough et al. in 1998. The Fourth Edition of "Herpetology" clearly shows its direct descent from its immediate ancestors, though with one change in authorship: John Cadle has been replaced by Matthew Brandley.

I have long thought that Lineages G and P were somewhat complementary as textbooks of herpetology. Although both explore the same overall knowledge landscape, certain topics have tended to be discussed in more detail and lucidity by one, and other topics better by the other. A particular strength of Pough et al. relative to the competition, for example, has long been in functional morphology and physiology (in the current book's "How do they work?" section) and this remains true in the new edition. In general, though, the coverage in the latest versions of both of these books is now comprehensively broad, even if not particularly deep in some areas. As such, their value for learning about herpetology is that they can provide students with the basics that a professor can expand upon, and or that the students can delve into more completely on their own using primary sources. They are not really books that would invite anyone to read cover-to-cover; they are references, and perform very well in that role. As all textbooks tend to do, they have grown larger, edition by edition, with the addition of new knowledge on top of the old, more illustrations, and assorted fresh elements of design. Thus the current editions are now near equal in breadth, and in heft: Vitt and Caldwell (2014) has 757 pages and is 42.2 mm thick, while Pough et al. (2016) is a bit slimmer but still runs to 719 pages, if you count them all up, and is 28.4 mm thick. You can weigh them if you want to.

In aid of introducing students to the basics, Pough et al. has two excellent chapters on the systematics and diversity of extant amphibians and reptiles (Chapters 3 and 4). They are well laid out, profusely illustrated, and have lots of maps. And they are big, together taking up 161 pages. I like them as a supplementary means of introducing students to the diversity of the animals so that when they later learn about particular aspects of the animals' biology, they may at least have heard of the animals before and might better place the information in context. Only a rare few herpetology students are natural-born herp nuts who come to class already knowing how to pronounce *Ptychoglossus* and *Bothriechis*, and can rhyme off the names of all 52 families of frogs. For most everybody else, taxonomy is a formidable quagmire of incomprehensible, italicized, Latinate polysyllables, dauntingly impossible to memorize. Yet they do need to know which animals we're talking about. A particularly sadistic professor might demand that students actually intently study these chapters but exposure and context, together, will cement at least some of these names, and the diversity they represent, into students' brains. These chapters, then, are a good place to start from and refer back to.

Not quite so successful is the opening chapter "Why Study Herpetology," which is really mostly an abstract of material presented in more depth later on in the book. Why, really, do herpetologists study herpetology? Certainly there is an illustrious history of significant contributions to knowledge based on studies of amphibians and/or reptiles and, as we invariably need to say on job applications and grant proposals, the animals can be excellent study systems for testing the predictions of theories about whatever subject it is that you want to test the theories of. This is the prosaic approach that this chapter takes, pointing out that this is a diverse bunch of animals, that it's interesting to consider ectotherms, that amphibians and reptiles are important components of ecosystems, and that a lot of them are in trouble for anthropogenic reasons. But, really, ask any bunch of herpetologists candidly why they study amphibians or reptiles and their answers are going to be, more or less, because they've loved them since they were toddlers and that the joy of having figured out something about them that they didn't know before is the enthralling delight of doing science. Can't a textbook say that? Or at least allude to it?

I am also not that fond of Chapter 2, which is an uneasy marriage between the principles of phylogenetic systematics and the fossil history of amphibians and reptiles. I suppose there are those who think that a discourse on cladistic methodology in general is essential in a herpetology book, but I see this part of Chapter 2 as largely a holdover from earlier editions written when cladistics was fresh and exciting, and not yet in freshman biology curricula or even (gasp) high school. Besides, you would be hard pressed to find worse examples of the power of cladistic analysis than the origins of the Lissamphibia and the relationship of turtles to other amniotes. Phylogenies from fossils are problematic enough without contemplating the huge gaps in the fossil record that make the phylogenetic resolution of these particular problems so difficult. And then, rather amusingly and despite its overtly cladistical tone, the chapter still presents the configuration of temporal fenestrae as the defining character states of the Amniota despite recent evidence that, aside from the Synapsids, these states may have been more labile than classically thought. Personally, I think the paleontology would fit rather well into Chapters 3 and 4.

Chapter 5, on the biogeography of amphibians and reptiles does an excellent job of introducing the complementary principles of dispersal and vicariance in relation to the distribution of modern taxa. It explains very well the large-scale distribution patterns resulting from the breakup of Pangaea, the subsequent drifting apart of the continents, and the occasional collisions between those drifting continents. Although its discussion of the effects of the Pleistocene glaciations is a bit too brief, at least in the opinion of a northerner like me, it does satisfactorily introduce the process of post-glacial dispersal and range expansion in response to long-term climate change. The final part of the chapter, on island biogeography, is very good, especially with the Antillean *Anolis* as the star examples of adaptive radiation on islands.

As I have already mentioned, Chapters 6–11 (Part II, How do they work?") are the real strengths of the book. The coverage is excellent, the explanations are lucid and the examples are right on target. I especially appreciate the chapters on ectotherm physiology (Chapters 6 and 7) since this is the one aspect of their biology that really unifies them in contrast to mammals (including us) and birds. A major hurdle, I think, for students of herpetology to truly understand the animals, is to think like an ectotherm, for which heat is a resource rather than a metabolic product. These chapters make this exceptionally clear. I also highly recommend Chapters 10 and 11 on locomotion and feeding, respectively, and Chapters 8 and 9 offer very thorough coverage of reproduction and life history in these animals. It is somewhat surprising, though, in a book that very carefully balances its emphasis on amphibians versus reptiles, that these topics are discussed separately for each order in different chapters. True, there are deep differences in the reproductive biology of amphibians compared to reptiles but, by dividing them, the book misses the chance to broadly compare, for example, mechanisms of sex determination or modes of parental care. Although all sexually-reproducing species require the presence of both males and females, it is remarkable the variety of ways they manage to go about ensuring that. Among amphibians and reptiles, as a whole, there are female heterogametic genetic sex determination systems, male heterogametic genetic sex determination systems, and temperature-dependent sex determination systems (not to mention an assortment of truly crazy unisexual systems). Yet, at heart, the underlying genetic pathways leading to the expression of maleness or femaleness remain largely the same, according to recent work. It's such a great topic that it's a shame it isn't all brought together. Similarly, in discussing the incidence of parental care, the book introduces the explanatory principle of cost (to the parent) vs. benefit (to the offspring) twice, separately for amphibians and for reptiles. This means that when it offers examples for reptiles, it can only contrast crocodilians, for which the costs and benefits of parental care are both rather low, with the one turtle that also has parental care, rather than to the oodles of terrestrial breeding amphibians for which both the costs and benefits of parental care are very high, all the while without fully linking the examples to the major principle.

Chapters 12–16 (Part III, What do they do?"), while still remarkably good, pose some organizational problems for the book. These chapters are about aspects of behavior and ecology, but many of the topics within them have strong conceptual links with topics discussed elsewhere. For example, dispersal is discussed in Chapter 5 in the context of biogeography but migration and dispersal strategies, i.e., what the animals actually do that results in this biogeography are way back in Chapter 12. Similarly, reproduction is treated at length in Chapters 8 and 9, whereas reproductive behavior and mating systems are far away in Chapters 13 and 14, respectively. Feeding is in Chapter 11, diets are in Chapter 15. I appreciate that these organizational issues are not easily resolved.

The book ends, naturally enough, with a discourse on conservation and the future prospects for amphibians and reptiles (Chapter 17). This chapter is superb. It is timely, balanced, and even guardedly optimistic. It presents the expected horror stories of decline and destruction but then, quite remarkably, it weaves in the complex realities of the human presence on the lives and habitats of these animals. It explores these for both amphibians and reptiles systematically, cogently, and succinctly. It presents options, current hot-button issues, and uplifting bits of good news. Above all, and unlike many new books and news items about amphibians and/or reptiles, with conservation placed in context, the book makes it clear that the most interesting thing about these animals is not that there are progressively fewer of them.

The artwork in the book is of very high quality throughout and the book, overall, has an appealing look to it. The book's diagrams and figures are mostly all redrawn from the published originals, which is a key element in maintaining this consistently high visual appeal. Often, this leads to greatly improved clarity and presentation. For instance, Tyrone Hayes' busy diagram showing the interconnectivities of factors affecting population decline (Hayes et al. 2010) gets a beautiful do-over that shows even better how everything imaginable is related to everything else. But sometimes, the redrawing of figures has resulted in mistakes. The illustration of sea turtle swimming (fig. 10.17), for instance, shows a sequence of drawings representing non-sequential video frames of a single locomotor cycle and indicates that the whole sequence takes 16 s. In the original paper by Davenport et al. (1984), the 18 individual video frames of the sequence were 0.087 s apart, the whole cycle lasting 1.48 s. Also incorrectly, fig 10.17 depicts the turtle's flipper as moving in a symmetrical figure-8 motion, whereas Davenport et al. clearly showed that it does not. With regard to the sense of hearing in frogs, fig. 13.15, redrawn from Wilczynski et al. (1984), is thoroughly confusing since the right side of the x-axis scale of the lower graph goes from 20 to 100 kHz (far beyond the range of hearing). In fact, the scale should read 2.0 to 10.0 kHz, which makes much more sense. In looking up these references, I found I had to contend with the book's chapter-by-chapter Literature Cited section that requires that you know not only the name(s) of the authors to find something, but also the book chapter it's mentioned in first. I found this cumbersome.

When I started teaching herpetology years ago, the "-ology" courses (mammalogy, ornithology, ichthyology, etc.) were decidedly out of vogue. I was allowed to teach herpetology provided it didn't cost much. So I set out to teach a course that set the curriculum of the day on its head. Rather that teach principles of one aspect of biology using examples drawn from all over the animal and plant kingdoms, I began to teach principles of many aspects of biology, with all my examples being amphibians and reptiles so that students could see how all these various principles come together at one point of focus: the organism. The book provides plenty of examples for almost everything it deals with. To some extent, these examples can be simply "cool things about herps," but I value them as the means to illustrate biological principles in an organismal context. In this, and in many other ways, this is a very good book. It can be used as a course book for a mid-level course, or as background knowledge for an advanced course, or as a reference at any level. The writing is very good, the text is largely error-free, and it shines a spotlight on the animals, who deserve it.

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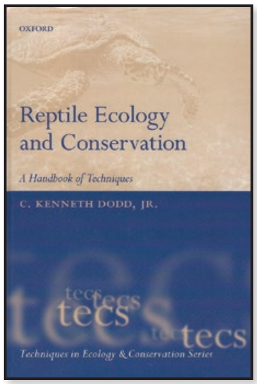
Reptile Ecology and Conservation: a Handbook of Techniques

C. Kenneth Dodd, Jr. (ed.) 2016. Oxford University Press, Oxford, United Kingdom. xxviii + 462 pp., 62 figures (including 28 black and white photograph composites), 19 tables. Softcover. US $59.95. ISBN 978-0-19-872614-2. Hardcover. US $125.00. ISBN 978-0-19-872613-5.



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> "*The primary objectives of management should always focus on the species or community of concern, and not…political motivations.*"
> —D. A. Pike (p. 419, chapter 29)

The quote above, from the penultimate chapter of this book, is an ideal that often goes unrealized. In the arid Southwest, political motivations are commonly primary in conservation and management of reptiles—especially given the move toward empowerment of local stakeholders, whether they farm grazing ungulates or solar panels. The complexity of merging science and conservation policy aside, this useful book summarizes methods to help insure sound science in this contentious political climate. It is a compilation edited by C. K. Dodd, Jr., representing the 14th contribution to Oxford techniques in ecology and conservation series (series editor, W. J. Sutherland).

This collection of 30 short contributions comprises six parts: introduction, individuals, sampling, communities, experiments, and conservation, independent of a short preface of two pages. The last provides hints as to the intended audience and purpose of the book: "…an urgent need for field research on reptile species and their community interactions" (p. vii), and "…to delineate important new developments…what the techniques tell or do not tell a researcher" (p. vii). The 30 chapters, unlike those of many multi-authored volumes, are all 10–15 pages in length, with 25–55 citations, though the genetics contribution has 129 citations. A short index, 13 pages in length, closes this relatively small book—over 450 pages are confined to a rectangle 155 mm × 235 mm (24 mm thick). Given the absence of a compelling rationale for economy of space, a larger format (200 mm × 300 mm) allows rapid assimilation of information in figures (especially for photograph composites) and tables. The editor did an excellent job of confining authors to a uniform space limit, but the authors might have been more uniform in clearly stating their chapter level goals.

The introductory section, Part I, consists of three chapters (diversity and life history, planning field studies, data collection) and a total of 40 pages. The phylogenetic and ecological diversity of reptiles is admirably introduced in Chapter 1 which is followed by an outline of experimental design in Chapter 2. Sampling scale and independence are both considered in Chapter 2 (and subsequent chapters), but I was surprised the issue of pseudo-replication was not stressed to a greater degree. The ease of application of programs like PRESENCE (discussed in detail in a subsequent chapter) has led to instances in which users subdivide sites into a large number of small plots rather than more biologically relevant population units. The last of the introductory chapters addresses data collection, an increasingly unappreciated art. I would put even more "field" in the "fieldnotes" advice section of Chapter 3 while simultaneously stressing that information retrieval is facilitated by moving away from exclusively hard-copy approaches to fieldnotes.

The second section of the book comprises six "individual level" chapters in 75 pages (Part II: marking, digital identification, preserving specimens, reproduction, diet, movement and telemetry). These are relatively standard contributions, covering well-worn ground, but nonetheless required reading. Two novel chapters, titled simply "diet" (chapter 8) and "reproduction" (Chapter 7), both fill long-standing gaps—how does one become familiar with these issues (e.g., dissections, stomach flushing, statistical analyses) and learn the ropes? I must note that many of these topics, as well as those in parts III and IV, are covered in McDiarmid et al. (2012).

The central core of ecology, and by extension, conservation, is sampling. Beginning with a chapter (10) on sampling of "surface dwellers," Part III devotes 100 pages to this topic. This first chapter has sections on visual encounter surveys (VES), pit fall trap arrays, drift fences, funnel traps, road riding—all the usual methods. This same chapter addresses a number of statistical concerns, and surprisingly, it does so in the usual number (11) of pages. I was happy to see repeatability, or comparability of sampling events, addressed in some detail. Results from road riding studies, for all their limitations, can be highly repeatable, especially in the arid Southwest (Jones et al. 2011; Sullivan 2012), although these recent reviews were not cited.

Six more chapters on sampling methodology complete Part III: arboreal and fossorial forms, sea snakes, freshwater turtles, terrestrial turtles and tortoises, sea turtles, crocodilians. The first three chapters of this section (10–12) overlap one another with topics such as noosing and coverboards (10, 11) or stomach contents and blood samples (10–12) covered more than once. So many forms are threatened or endangered, it is perhaps no surprise that freshwater turtles (Chapter 13), and terrestrial turtles and tortoises (Chapter 14), warrant separate chapters even though similar methods are addressed for both groups (statistical issues, mark-recapture, VES). My own bias would have been to expand the section in chapter 14 on indirect sampling: that is, surveys for sign of organisms such as refuges, tracks, nests, fecal pellets (recently reviewed in McDiarmid et al. 2012). In light of their increasing use with tortoises, sea turtles, and lizards, comparison of indirect and direct survey methods would repay the effort. Indirect surveys are used to document presence (e.g., Sullivan et al. 2014a) and even as a crude index of abundance in some especially well-studied systems (Sullivan and Sullivan 2008).

Following sampling methodology, the next level, "community" (Part IV), consists of six chapters across 90 pages (plots and transects, rapid diversity assessments, measuring microhabitats, water quality, diversity measures, landscape ecology and GIS). These chapter headings reveal that there is continued overlap between Part III (sampling) and Part IV (community): Chapter 17, plot and transect censuses, covers much ground addressed in the prior sampling contributions (e.g., VES, transects, plots, effort tradeoffs). There is additional (and valuable) discussion of statistical issues, including a refreshing evaluation of independence (in practice and in principle). Figure 17.3, a flow chart, does the reader a service by integrating contributions from other chapters—this volume could have benefited from additional efforts along these lines.

The relative absence of citations to work from arid environments, such as the Southwest deserts (e.g., Germaine and Wakeling 2001; Sullivan 2012), was notable in the chapters on survey methods in parts III and IV. Consider the suggestion that "8 × 8 m plots are common" (plot size for reptiles, Chapter 17); my arid-land bias causes me to view this as far too small. In open deserts (rather than rain forests) 100-m^2 plots are used for many lizards, including *Phrynosoma* and *Sauromalus* (Barrows et al. 2008; Sullivan and Sullivan 2008). Chapter 18 covers "rapid diversity estimates," but given this is simply a rapid application of previously described methods (especially chapters 10 and 17), it might have been more efficient to combine this with a similar sampling chapter. Chapter 19 takes up microhabitats, although it is placed in the community section; there is considerable discussion of non-desert environments in which thermoregulation is paramount. The discussion of frequently measured habitat variables had few examples from the arid landscapes, nor of organisms like *Sauromalus, Sceloporus,* or *Aspidoscelis* for which anti-predatory rather than thermoregulatory concerns might be critical to habitat preferences (Sullivan and Sullivan 2008; Rosenblum and Harmon 2011).

Diversity measures are reviewed in Chapter 21; a number of useful tables assist the reader in sorting through these contentious and oft-debated metrics. Deserts as reptile diversity hotspots, including allusions to Pianka's fabled "40 species of lizards at a site" in Australia, are explicitly acknowledged. As one increasingly impressed by the plethora of modeling efforts attempting to predict how any number of reptiles will respond to changes in habitats over the coming decades, I eagerly anticipated a critical assessment of these efforts in Chapter 22 (landscape ecology and GIS methods). The absence of attention to the source of data for these analyses is striking—often the data on distribution of various forms are taken uncritically from museum collections, acknowledged but largely accepted "as is." The degree to which these models are biased by such data distributions (e.g., huge numbers of road-killed snakes, absence of collections reflecting abundance, regional bias near museums) is an ongoing concern, taken up briefly in this chapter.

Three chapters, a total of 40 pages, make up Part V, but they cover some of the most important methods used in reptile ecology and conservation today. Chapter 23 covers experimental populations—what was once termed the "University of Michigan approach." The explicit discussion (including subheading) of "selecting a species," indicates that contributors varied in their position as to organism or question-oriented research programs. Regardless, the mesocosm approach is vital to both experimental ecology and conservation translocation (supplementation, reintroduction) programs. Physiological ecology (Chapter 24) is an exhaustive review of the field, and includes the easily assimilated graphs—if still a bit small—for which the field is rightly famous. Chapter 25 on genetic issues was perhaps the most exhaustive, with three times as many citations as other contributions. Nonetheless, I was struck by the absence of any consideration of species boundaries or evolutionarily significant units, or recent moves toward ecosystem level management efforts instead of individual taxa (Sullivan et al. 2014b).

The final chapters, five covering 75 pages, occupy Part VI and they concern more sampling (occupancy, abundance, disease samples), and philosophical issues (management, education). The chapter (26) on occupancy models reads as something of a defense of PRESENCE, a reply to the many criticisms of this useful modeling approach. This program is widely used by agency personnel, and lauded because so many aspects of sampling can be assessed—researchers can evaluate the degree to which different observers impact surveys. It does suffer when sampling units are limited (e.g., ten preserves are too few, perhaps accounting for the over-subdivision of plots alluded to above). Given that it is intimately related to chapters 10 and 17, as all three concern sampling individuals of populations, it might have been conjoined with other contributions. Chapter 29, covering conservation and management broadly, touches on many topics all too briefly, including urban environments and translocation (see below); some of these topics easily could have warranted chapter-level coverage.

I have only two concerns with this book. First, coverage of one of the most important issues facing conservation biologists today: translocation. I am sympathetic to the authors of the present volume. Like me, they desire a return to past definitions, but continued use of RRT (relocation, repatriation, translocation; pp. 431–432) is counter-productive. As currently defined by the IUCN, the over-arching term for all animal relocations and introductions is translocation (see review in Sullivan et al. 2015). Mere semantics? Of course—but it continues to confuse and confound workers when different terms are used for similar actions, especially in review articles (see citations in Sullivan et al. 2015). Historically, translocations (= relocation of old, mitigation translocation of the current IUCN) involved the movement of a single individual (often an adult) to a nearby area with an unknown (but assumed) resident population, to mitigate some human-animal conflict. Thus, mitigation translocation concerns assimilation of an individual not the establishment of a population. By contrast, introductions (repatriations, supplementations) typically involve the release of many individuals, often including juveniles (or eggs) to an area devoid of a resident population. Hence, herpetologists working in these two distinct domains of conservation biology pursue dramatically different goals; this is why we must maintain clarity in terminology. Confusion has led to inaccurate estimations of "success," which continue to this day to confound and compromise any number of conservation efforts with reptiles (Sullivan et al. 2015).

My other concern, as alluded to above, is overlap. For any techniques book, organization is key; many readers will open this volume with a specific question about a method, hoping to find a chapter that addresses the issue from start to finish (making the index important, too). My preference: reduce redundancy by avoiding taxonomic chapters (e.g., "sea snakes" and "sea turtles"), but regardless, adopt a theme and stick to it. Taxonomic groupings, although expedient, lead to repeated instances of overlap as exemplified by the fact that VES are covered as a major chapter section (i.e., by a subheading, and from 1–3 pages of text) in four different chapters (p. 128, Ch 10; p. 185, Ch. 14; p. 232, Ch 17; p. 245, Ch. 18), and are not dramatically divergent (i.e., tailored to the taxon at hand). Readers benefit when they can read accounts of a method, such as VES, fully described at the outset, and then qualified by example via the unique applications as they vary taxon by taxon. On the other hand, the approach taken here allows the reader to quickly locate methods used with their study organism, and avoid wading through what they might view as extraneous material.

Overall, l think that most will find little to quibble about with this volume, save for the obvious overlap with the collection of McDiarmid et al. (2012)—in fact, a number of authors contributed to both works. Given the enormous effort currently underway with investigations of ecology and conservation of reptiles around the world, I think the field can support two edited volumes on these methods. I close by noting that the present book not only contains a wealth of information, but is extremely well produced. I was hard pressed to find any issues aside from the small size of some figures described above; a trivial error includes: "*Helodermia*" for "*Heloderma*" (p. 130). This is an important collection of methods for all students of reptile ecology and conservation.

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Reptile Life in the Land of Israel

Yehudah Werner. 2016. Edition Chimaira, Frankfurt am Main (www.chimaira.de). Available in North America from ECO Publishing (www.ecouniverse.com). 494 pp., 844 figures. Hardcover. US $150.00. ISBN 978-3-389973-104-0

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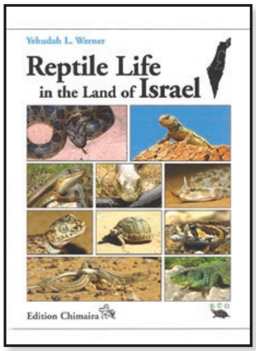

I have followed Prof. Werner's work for roughly 50 years. Even if he doesn't consider this book the capstone of his career, it certainly serves as such. It is unarguably the most complete coverage of the natural history of Israeli reptiles imaginable. Considering that the book was first published in Hebrew and written again in English, it is easy to imagine the devotion given to this project. It is the culmination of a lifetime of personal experience and gathering of pertinent literature. Werner is not only a museum curator, although he is that, but an active field biologist, as I can attest, having accompanied him in the field years ago in Turkmenistan. He is also a keen observer of captive animals in the lab.

This could be regarded as two books, as the first lengthy section is essentially a general herpetology, using Israeli reptiles as examples when possible, but extending beyond Israel in its global coverage. Thus, it could serve as a textbook for zoology students or for naturalists not completely familiar with reptiles. The real meat of the book (or the "second" book) is the complete coverage of the natural history of each Order, Family, Genus, and Species of reptile occurring within the borders of Israel/Palestine. Although I don't find this specifically stated, the coverage of this book includes the Sinai Peninsula (now Egypt).

Although it contains all the necessary components of a field guide in addition to everything else, that is, keys, illustrations, range maps, etc., it is far too bulky to carry in the field, and far too precious to submit to the hazards of the outdoor environment.

The author has tried to include every fact known about every species that occurs in Israel, so most accounts cover at least two pages. Each species account contains a line drawing illustrating dorsal, lateral and ventral aspects of the head; each of these illustrations represents an actual specimen and includes the museum registry number. He even devotes three pages to the Nile Crocodile, *Crocodylus niloticus*, which has been extinct in Israel for more than a century. Each account is accompanied by at least one photograph, usually in color, always of live animals, and often showing some aspect of the natural history, mating, feeding, shedding, and so on. Some of the photos of captive animals have been taken on a mirror, thus showing both dorsum and venter. This is a technique adopted by Werner and used extensively in his publications. As the title indicates, this is a book on the life history of reptiles, not specifically on taxonomy, although this is covered necessarily. As a consequence, the species accounts do not include synonymies, although alternative generic names are sometimes mentioned. This might be seen as a shortcoming, as access to the literature may require searching for older names, some of which have been changed only recently, and many were of long standing. Such information is particularly important to students and newcomers to the region.

Topics included in the species accounts cover all aspects so far known of life history, development, behavior, sexual dimorphism, color variation and changes in color as adjustment to temperature, nuptial coloration and the like. Where any topics are missing, opportunity for future research is indicated, at least by implication. A particular strength of the coverage is that information is drawn from the entire range of distribution of the species and is not restricted to Israel. As this is not a work devoted to taxonomy, the ever-popular cladograms of such recent works are not included.

The text ends with a discussion of biogeography. This discussion is limited to a descriptive and ecological geography, with no real discussion of historical biogeography or phylogeography. These latter two approaches are in any case hypothetical and phylogeography is based almost entirely on molecular phylogenetics, expressed cladistically. The Levant in general is an interesting region in phytogeography as well as zoogeography. Its climate and topography are varied enough that it supports Mediterranean, Irano-Turanian, Saharo-Arabian, and Anatolian influences. A number of taxa of African predominance find their northern limits in Israel, and several of northern affinities find their southern limits here.

There is little mention of molecular systematics in this book, which is fair enough, considering that morphology offers the best explanations of the biological adaptations that are the real subjects of this book. Although it is becoming possible to identify the genes that produce some of this morphology, that in itself tells us nothing of the adaptations, which are identified by their morphological functioning.

Several appendixes follow the discussion of biogeography. These consist of the history of reptile research in Israel, research objectives and methods in herpetology, the profession of herpetology, literature and journals, the relationship between people and reptiles, snakebite, nature conservation, and Hebrew names of the reptiles (including transliteration into Roman script). It is not clear why most of these topics are in appendixes rather than in the introductory text on herpetology.

A final appendix was added by the publisher. It consists of color photographs of all or most of the species discussed in the text. Because the text itself is so well illustrated, these photographs add little to the utility of the book, and must have raised the production costs considerably, as presumably the photographers were compensated. Necessarily, these costs must be reflected in the price of the book. There are multiple photographs of most of the species. I suppose this was thought to enhance the attractiveness of the book to potential buyers who purchase any pretty book on herpetology. Having said that, on the positive side, most of the photographs are excellent. They were taken in Israel, as indicated by the localities given in the captions, or from Jordan or Syria, and they serve to illustrate the variation in color and pattern of the species shown.

Any reviewer can come up with some sort of negative criticism; indeed, some consider it an obligation. It is difficult to know whether any shortcomings in this book are attributable to the author or to the publisher's policies. I suspect the latter in most cases. What I find are sins of omission rather than errors of fact. There is an index of Latin names, but no subject index, although the detailed contents help to compensate for this. Professional zoologists are used to having citations in the format of the authors' names and dates in parentheses, rather than the format used here, which is by numbered reference to the alphabetically arranged bibliography. My copy has several bookmarks and sticky notes in the list of references as a consequence. An extensive glossary would have been very useful, especially for the introductory part of the book.

In an apologia, Werner compares his book unfavorably in contrast with John Anderson's herpetological volume in the Zoology of Egypt. I absolutely disagree with this apology. John Anderson's book was a model for its time, but its time was the 19th century and Anderson had not spent his entire life in Egypt. Werner's book is a synopsis of the 20th century. In saying that, I do not mean to imply that the coverage ends with 1999. Indeed the references and personal observations continue until the time of publication. I know of no other regional herpetological book that comes close to this one in its quality and scope.

Reptile Life in the Land of Israel belongs in the library of every museum that maintains a herpetological collection international in scope and every personal library of those concerned with the Western Palearctic. I know that my copy will be a continuing source of reference. The extensive bibliography alone (1702 references) is a valuable treasure. Unfortunately, the price will keep it out of the hands of all but the most serious researcher.

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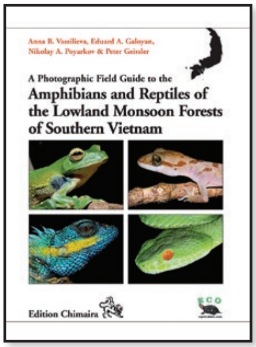
A Photographic Field Guide to the Amphibians and Reptiles of the Lowland Monsoon Forests of Southern Vietnam

Anna B. Vassilieva, Eduard A. Galoyan, Nikolay A. Poyarkov, and Peter Geissler. 2016. Edition Chimaira, Frankfurt am Main. 324 pp. Hardcover. 49.80 Euros (approximately US $56.50). ISBN 978-3-89973-465-2.



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This superb new book has been co-authored by a team of Russian and German herpetologists. Its solid binding and hard cover, with good quality glossy paper, make it easy to bring in the field. It covers 142 species (41 amphibians and 101 reptiles). Eight of the amphibian species and ten of the reptile species (respectively 19.5 and 9.9 %) covered by the guide were described in the 21st Century. Four of the amphibian species and three reptile species have even been co-described in previous contributions by the authors, who have an extensive field experience within the area. The guide includes a foreword by the Vietnamese herpetologist Nguyen Van Sang; an introduction (pp. 14–28) with information on herpetological history and geography of the region covered; a chapter on the reintroduction of the Siamese crocodile (pp. 29–31) that would have been more logically placed within the crocodile section; a chapter on how to use the guide (pp. 32–41) that provides clear and extremely useful illustrations of the diagnostic characters for each taxonomic group; the amphibian (pp. 43–127) and the reptile (pp. 129–308) species accounts; a checklist of the reptiles and amphibians of Cat Tien National Park and their conservation status (Vietnam Red List, IUCN Red List, CITES); a glossary; and a reference section. At the end are 11 pages of ads for other books published by the same publishing house, which thus represent more than 3 % of the total number of pages.

Besides the four beautiful reptile and amphibian photographs on the front cover and the authors' photographs on the back cover, the guide presents three maps, 14 biotope photographs, and 378 photographs of individuals, eggs or tadpoles (137 for amphibians, 241 for reptiles), all in color. All photographs, without any exception, are of remarkable quality. The authors have mostly presented whole-body photographs, which are most useful for species identification, and they were generally taken *in situ*. Some photographs deserve special mention, like the ones illustrating predator-prey interactions, such as on page 216, showing an *Ahaetulla prasina* (Boie, 1827) preying on a *Hemidactylus frenatus* Duméril & Bibron, 1836 (not "Schlegel, 1836" as indicated in the guide) (unfortunately the latter was erroneously identified as a "flat-tailed house gecko", i.e., *H. platyurus* [Schneider, 1797]). A photograph shows the recently described pitviper *Trimeresurus rubeus* preying on an unidentified tree frog, which is actually *Polypedates megacephalus* (Poyarkov, pers. comm.). Eleven amphibian species are shown in amplexus. All photographs are accompanied by a mention of the Vietnamese province in which they were taken, which greatly increases their value, even if it would have been much better to have precise localities. The vast majority of the photographs were taken in Vietnam, which decreases the risk of illustrating populations that might be later shown to belong to a different taxon than the one found in the area covered by the guide. There are just a few exceptions: a *Varanus salvator* from "Indonesia," captive *Python bivittatus* without locality, a *Gonyosoma oxycephalum* from "Thailand," a *Ptyas mucosa* from Hainan, and *Heosemys annandalii* from "Cambodia". The Indonesian monitor was more precisely photographed in Ujung Kulon National Park, western Java (A. Vassilieva, pers. comm.). Some photographs show species never illustrated alive before, such as *Oligodon saintgironsi*, which had been described in 2008 based on long-preserved museum specimens. All species were illustrated by at least one photograph, often several.

The "guide structure" section of the book explains that it "includes the illustrated accounts of 142 common or reliably documented species of amphibians and reptiles inhabiting the forests of Cat Tien National Park and adjacent lowland and hilly areas of southern Vietnam." Given this explanation, the absence of accounts for many species is surprising. Among them, numerous species recorded from lowland or hilly forested localities directly adjacent to the park or in neighboring provinces, such as *Cyrtodactylus dati* Ngo, 2013, *C. huynhi* Ngo & Bauer, 2008, *C. takouensis* Ngo & Bauer, 2008, *Gekko russelltraini* Ngo, Bauer, Wood & Grismer, 2009, *Takydromus madaensis* Bobrov, 2013 (still known only by its holotype but regarded as a valid species in the guide, although the authors couldn't find any additional specimens at the type locality; Poyarkov, pers. comm.). The list of species would have been greater if it included all species living in southern Vietnam, especially the offshore islands, i.e., the entire geographic area shown in the guide's map (fig. 2) extending from Dak Lak Province in the north to the southern tip of Ca Mau Province and all the associated islands in Rach Gia Bay. The herpetofauna of this region is diverse and contains a number of endemic species (Grismer and Ngo 2007; Grismer et al. 2008, 2011, 2015; Ngo et al. 2008). The inclusion of the Phu Quoc Island and the Con Dao Archipelago hundreds of kilometers from each other and hundreds of kilometers south of any of their other study sites emphasizes the absence of coverage throughout the entire Lower Mekong basin. Only some of these species are listed in the "confusing species" section of each species account. In this respect, the title of the guide is misleading, as it should have stated that it covers mostly Cat Tien National Park, not all the lowland monsoon forests of southern Vietnam. The global distribution indicated for each species is generally correct, rarely incomplete, like in the case of *Ptychozoon trinotaterra*, said to occur in "Thailand, Vietnam, possibly Cambodia," although it has been documented from Cambodia (Hartmann et al. 2014) and Laos (Teynié et al. 2014).

According to a taxonomic revision published after the guide (Yuan et al. 2016) and co-authored by one of the guide's authors, the population of *Microhyla fissipes* in southern Vietnam is actually referable to the recently described *M. mukhlesuri* (Hasan et al. 2014).

The appendix providing a list of the amphibian and reptile species known thus far from Cat Tien National Park shows an asterisk near the species that were recorded in literature sources but whose "presence in Cat Tien was not confirmed during the long-term survey by the authors." These 21 species marked with an asterisk are not included in the species accounts, except for five (*Glyphoglossus molossus*, *Hylarana macrodactyla*, *Lygosoma bowringii*, *Python bivittatus* and *Oligodon fasciolatus*). On the other hand, *Rhacophorus helenae*, *Dixonius vietnamensis*, *Hypsiscopus plumbea*, *Ahaetulla nasuta*, *Dendrelaphis subocularis*, *Rhynchophis prasinus*, and *Amphiesma stolatum*, not listed for Cat Tien National Park, are included in the species accounts. The decision to include or exclude species from the species accounts is thus a bit arbitrary and forces the reader to be equipped with more general reptile or amphibian guides to make sure that all the species present in the area are envisaged before attempting identification.

The text for each species account includes the English and Vietnamese common names (the latter written without the Vietnamese accents), and sections on size, identification, global distribution, morphological and color description, ecology and habitat, activity, reproduction, confusing species, references, and for some species additional notes.

We note that the proper taxon authorship of *Boiga siamensis* is "Nootpand, 1971," not "Nutaphand, 1971" (Pauwels et al. 2005). There is no indication why the Red-tailed Ground Skink has been referred to as "*Scincella* cf. *rufocaudata*" and the Buonloi Forest Skink as "*Sphenomorphus* cf. *buenloicus*."

The maximum total length of *Xenochrophis flavipunctatus* is indicated as 1100 mm. The largest documented specimens are 1275 mm in total length, and extrapolations based on individuals with broken tail indicate a possible total length of 1368 mm (Chanhome et al. 2001). Following the recent description of *Malayemys isan* by Sumontha et al. (2016), we confirm the identification of the individual shown on pages 296–297 as *M. subtrijuga* based on its possession of six nasal stripes and the contact between the infra- and the supraorbital stripes. A few more words could have been added to the glossary, in particular paravertebral, pentadactyl, postoccipital, presubocular, and subocular that are used in various species accounts.

We have only two regrets for the guide. First, the absence of identification keys, even to family level, especially given the extensive herpetofaunal knowledge of the authors and the relatively limited number of species treated. Second, the non-exhaustive literature cited. We would have preferred that the literature provide an extensive list of works published on the reptiles and amphibians of the area covered by the guide, including those in Vietnamese and Russian. In our opinion, the literature cited (146 references) includes too many general works that are not bringing specific information on the region covered.

These few shortcomings should not obscure the fact that this new book is a remarkable piece of work, resulting from extensive field survey, an extensive knowledge of the local species, and great photographic skills. It is a most useful tool for field workers in the area and a beautiful book to consult for all naturalists. We strongly encourage our colleagues and natural history libraries to purchase it.

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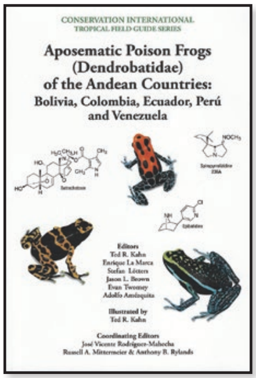
Aposematic Poison Frogs (Dendrobatidae) of the Andean Countries: Bolivia, Colombia, Ecuador, Perú and Venezuela

Edited by Ted R. Kahn, Enrique La Marca, Stefan Lötters, Jason L. Brown, Evan Twomey, and Adolfo Amézquita. 2016. Conservation International, Arlington, Virginia (Available through Natural History Book Service at http://www.nhbs.com/series/40786/conservation-international-tropical-field-guides). xxii + 588 pp., 123 color photos, 164 color illustrations, 74 color distribution maps. Softcover. £34.99 (ca. US $46.00). ISBN 978-1-934151-27-3.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TROPICAL FIELD GUIDE SERIES

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(Dendrobatidae)
of the Andean Countries:
Bolivia, Colombia, Ecuador, Perú
and Venezuela

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Poison frogs (Dendrobatidae) truly are living jewels of the forest. Hopping about in daylight as though to taunt predators, these frogs sporting stripes, spots, and reticulations of red, orange, yellow, blue, and green go about life with abandon. So, too, *Aposematic Poison Frogs* (*Dendrobatidae*) *of the Andean Countries: Bolivia, Colombia, Ecuador, Perú and Venezuela* is a gem.

Aposematic Poison Frogs (*Dendrobatidae*) *of the Andean Countries* is the most recent book in the Tropical Field Guide series published by Conservation International (CI). The stated goal of this series is "the consolidation of existing knowledge on target groups of organisms, especially flagship species, as a stimulus to promote ecotourism." In 1994, when the first field guide in the series (*Lemurs of Madagascar*) was published, CI regarded ecotourism as "one of the best economic-based solutions to the biodiversity crisis." Two decades later, CI remains steadfast in this belief.

Poison frogs of the family Dendrobatidae are regarded as "mini-flagship" species already popular with ecotourists who walk forest trails by day and frequently encounter these dazzling frogs. This comprehensive volume will inform and delight readers; serve as an authoritative summary of dendrobatid biology; stimulate further interest among biologists and non-biologists alike in these amazing amphibians; and contribute to the survival of dendrobatids and protection of their habitats. Much has been written about poison frogs, including scientific reviews (e.g., Weygoldt 1987; Santos et al. 2003; Vences et al. 2003), articles for the general reader (e.g., Myers and Daly 1983; Walls 1994), and husbandry advice for hobbyists (e.g., Lötters et al. 2007; Sihler and Sihler 2007), but until now there has never been a field guide focused on these frogs.

This volume represents the experience and knowledge of more than 100 researchers worldwide. It reflects a massive amount of work and took the authors nearly 10 years to compile. The book is dedicated to John W. Daly (1933–2008), who spent much of his life studying dendrobatids and their alkaloids and the potential medicinal applications of those compounds. In his foreword, John D. Lynch writes that the authors are experts and students "effectively bridging the gap between 'pioneers' in the field, and the next generation of up and coming students that soon will replace them." Lynch commends the authors for communicating technical scientific studies in a way that will engage anyone interested in nature and for accurately conveying the life history, conservation, and diversity of these frogs. I wholeheartedly agree.

The layout of the book is attractive and user-friendly, and the organization is impeccable. A useful "How to Use This Field Guide" briefly describes the subsections of the accounts (10 chapters): genus description, species accounts, authors, names, taxonomic comments, identification and description of the adults, identification and description of larvae and froglets, similar species, alkaloid profile, natural history and ecology, calls and vocalizations, reproduction, distribution, threats, and conservation status. Throughout the book, subheadings and spaces between paragraphs allow for easy reading. The multi-colored maps of biomes and species distributions and black & white line drawings are functional and esthetically pleasing. Unfortunately, many of the color photographs of frogs and habitats are dark. Ted Kahn's paintings of frogs based on photographs are stunning. The editors did an outstanding job of transforming more than 100 authors into a uniform voice.

Chapter 1, "Recent Progress in the Systematics of Poison Frogs and Their Relatives (Dendrobatoidea)," written by Taran Grant and Darrel R. Frost, begins with a clear discussion of the tasks of systematics and the reason for flux in species' scientific names. Over the past several decades, the number of known species of dendrobatids has increased from about 70 (in one family, Dendrobatidae) to 306 (Frost 2016). Currently, two families within the Dendrobatoidea are recognized: Aromobatidae (122 species, all of which are non-toxic, as far as we know) and Dendrobatidae (184 species, including all of the toxic species of poison frogs, plus some that are non-toxic). This field guide focuses on the family Dendrobatidae. Tables and diagrams enhance the chapter. It ends with a caveat that the new taxonomy of dendrobatoids "is based on the analysis of an unprecedented amount of evidence but is far from the last word on the systematics of this group." Never mind, for now we have an outstanding discussion of the current state of dendrobatoid taxonomy.

Chapter 2, "Amphibian Conservation in the Tropical Andes and Amazon Basin," written by Adolfo Amézquita, Ted R. Kahn, Kristopher Kraus, Enrique La Marca, Ricardo A. Medina-Rengifo, and Giovanni Alberto Cháves-Portilla, provides a comprehensive synthesis. The Tropical Andes Hotspot (Colombia, Ecuador, Perú, Venezuela, and Bolivia) is considered the most important and most endangered of the world's Hotspots (Mittermeier et al. 2004). Only a small fraction of the region is protected, and no functional biological corridors connect protected areas. After a brief summary of amphibian declines and the threats facing that group, the authors focus on why poison frogs are vulnerable to these threats. The chapter includes discussion of *in situ* and *ex situ* conservation and highlights several reserves that protect dendrobatids. The authors cover a lot of information, but it is all presented clearly and concisely.

Chapter 3, "Reproduction and Larvae of Aposematic Andean Poison Frogs," written by Ted R. Kahn, is a short overview of dendrobatid life histories and tadpoles. Four tables summarize information on amplexus, egg and clutch size, parental care, and larval characteristics at the generic level. The black and white illustrations of tadpole mouthparts and body plan will be helpful for readers attempting to identify larvae (best accomplished with a microscope). Unfortunately (from my perspective), the chapter is missing discussion of some of the fascinating aspects of dendrobatid reproduction (e.g., evolution of parental care; environmental correlates of biparental care, male versus female care, and tadpole deposition sites).

Chapter 4, “Discovery of Bioactive Alkaloids in Dendrobatid Frogs: Traditional and Medicinal Uses,” was written by John W. Daly shortly before he passed away in 2008. I wish I could tell Daly how much I enjoyed his chapter, written as the story of how we know what we know about dendrobatid toxins. Daly discusses indigenous use of three species of poison frogs for poisoning blowgun darts, arthropod sources for batrachotoxins, medicinal and research use of alkaloids, and the fact that regulatory difficulties related to “bio-prospecting” may prevent us from fully benefitting from alkaloids before the frogs and their habitats are gone. A table categorizes dendrobatid alkaloids into the various classes of these compounds. Daly’s lifetime collaborators compiled a 13-page appendix of alkaloids identified from Andean poison frogs and the dietary sources of those alkaloids (when known). The appendix lists every species of Andean poison frog (all the species included in this volume) and includes not only published information, but also Daly’s hand-written notes, transcribed and reviewed. The appendix lists virtually everything known to date concerning dendrobatid alkaloids and will be indispensible to those working with dendrobatid skin toxins.

The last 10 chapters, comprising 72% of the book, are species accounts organized by genus: *Adelphobates*, *Ameereega*, *Andinobates*, *Dendrobates*, *Epipedobates*, *Excidobates*, *Minyobates*, *Oophaga*, *Phyllobates*, and *Ranitomeya*. These accounts were written by many dozens of authors, including many non-native-English speakers, yet the text reads as though one native English-speaking person (a skilled writer, well versed in grammar) penned them. Ted Kahn is a common denominator on many of the accounts, so I assume we have him to thank for a job extremely well done. The accounts are engaging and informative, although I found it odd that the volume contains no dichotomous keys to the species, as readers might find them useful. The reasoning may have been that the combination of distribution maps, color photographs and paintings of the frogs, and the entries under “Similar Species,” allows readers to identify species easily.

A seven-page glossary, two pages of useful websites, an extensive bibliography, and an index round out the volume. The book ends with six lined pages for field notes and a page with a 220-mm ruler. The page states, “Place Frog Here and Photograph for Scale Using Margin Ruler. The frog should be in a clean transparent plastic bag to prevent possible disease spread.” This sums up the spirit of the book. Readers are encouraged to take an active role in their own learning experience, but not at the expense of the frogs.

This book truly is a gift to biologists, ecotourists, nature-lovers, and to the frogs themselves. The authors, editors, and Conservation International deserve kudos for a beautifully written and produced volume. The book is definitely worth the price, but be forewarned: It is printed on high-quality paper and is 588+ pages, so it is heavy. I encourage all herpetologists, especially those interested in dendrobatids, and all ecotourists exploring the Andean countries of Bolivia, Colombia, Ecuador, Perú, and Venezuela to give this book a prominent place on your nature bookshelf—except when you carry it in your backpack in hopes of watching these colorful jewels boldly go about their business in the open, protected by a diverse pharmacopeia of alkaloids.

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The Leatherback Turtle: Biology and Conservation

James R. Spotila and Pilar Santidrian Tomillo (eds.). 2015. Johns Hopkins University Press, Baltimore, Maryland. xii + 219 pp. Hardcover. 9 black & white photographs, 70 line drawings, 16 color plates. US $70.00. ISBN: 978-1-4214-1708-0.

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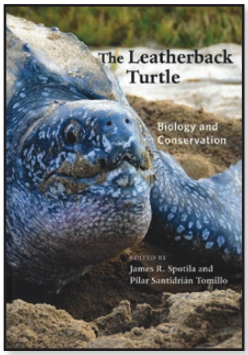

In their preface, Spotila and Santidrian Tomillo describe the impetus for this book as the timely filling of a need to compile the collective knowledge on this unique species of sea turtle for science, conservation, and general education. As two of the premier researchers on leatherbacks, they’ve capitalized on their access to the top levels of the sea turtle research and conservation community and solicited equally qualified colleagues for treatises on all aspects of the biology and ecology of *Dermochelys coriacea*. The resulting volume consists of 18 chapters, which are distributed among five theme-based “Parts.” Part I- *Biology*, Part II- *Life History and Reproduction*, Part III- *Population Status and Trends*, Part IV- *From Egg to Adulthood*, and Part V- *The Future of the Leatherback Turtle* each consist of three to four relevant chapters.

The *Biology* section of the book opens with a succinct review of the phylogeny and evolutionary history of leatherbacks by well-known turtle biologist Peter Pritchard. He provides a history of the family Dermocheylidae and summarizes the morphological, physiological, and behavioral adaptations that distinguish the single extant genus from all other modern sea turtles (Cheloniidae), and offers brief comments on leatherback distribution and population trends in face of current threats. Chapter 2 follows with a synopsis of current phylogenetic and phylogeographic knowledge of leatherbacks, and describes ongoing projects to further elucidate population structure and vital rates using genetic techniques. Characterization of their extreme diving behaviors and the physiological adaptations that provide these capabilities are the subject of Chapter 3. The *Biology* section closes with a very comprehensive chapter on leatherback anatomy. Of particular utility here are the comments that distinguish specific anatomical features of *Dermochelys* from those of the hard-shell sea turtles.

The next section of the volume, entitled *Life History and Reproduction*, covers adult reproductive inputs and some of the factors influencing hatchling production and contributions to the population. Chapter 5 reviews endocrinology and the gonadal cycle, again providing and contrasting information from other species where relevant. The following chapter describes nest site selection, nesting behavior and clutch frequency, and joins the previous chapter in noting the relative paucity of knowledge on leatherback mating behavior. Chapter 7 briefly presents the environmental factors that affect clutches on the beach and summarizes the stages of incubation and hatchling emergence, and known geographic patterns of leatherback. Pivotal temperatures and the transitional range of temperatures for sex determination are communicated in Chapter 8. The two latter chapters provide a more complete view of climate change outcomes by citing both temperature and precipitation effects. Authors in this section noted the greater plasticity in site fidelity of leatherbacks along with the possible impacts of climate change on sex ratios. This is one of the places in the book where it would have been interesting to see a synthetic closing statement, perhaps discussing the effects of population-level integration of these two factors.

The *Population Status and Trends* section comprises three chapters that cover the Atlantic and Pacific Basins and the Indian Ocean. The authors provide population data from literature reviews, current studies, and their own work, covering in-water and nesting beach information, seasonality, genetic relationships, biometry, threats and trends. The section could have benefitted from some standardization in presentation, as some of the information categories are not given for all three oceans. This is likely the combined result of the chapters originating as three independent manuscripts, and a lack of collecting effort and/or published reports on those data. All three chapters do well in populating the global threat radar for leatherback populations, and the section ends with eight pages of very nice color photographs of leatherbacks.

The editors made an interesting choice in their placing of the next four chapters into a separate section entitled *From Eggs to Adulthood*. At first glance it appears that much of the material covered would have folded neatly into the chapters of the *Biology* or *Life History and Reproduction* sections. However, as one reads further into each of these particular chapters, it is evident that the scope, depth, and number of concepts being discussed benefit from the clarity afforded by their separation. Chapter 12 alone expands from a review of egg structure and composition, through effects of clutch structure and the role of shelled albumin gobs (erroneously known as "yolkless eggs"), and on to intrinsic and extrinsic factors affecting embryonic development and hatching success. Extrinsic factors, particularly temperature, hydric regimes, and respiratory gas concentrations are given even more detailed treatment in the second half of the chapter. Chapter 13, leading with a section appropriately sub-titled "How leatherbacks work," takes a similar approach and provides succinct reviews of all the animal's major homeostatic and growth functions. These build toward the concept of energy budgets and the role of physiological constraints in setting life history parameters. A compelling call is made to utilize the toolbox of "conservation physiology" to guide critical thought in efforts to sustain leatherback populations.

Dermochelys coriacea is the most wide-ranging of sea turtles, and Chapter 14 presents information on the possible orientation mechanisms used to navigate on their long nesting and foraging migrations. Satellite telemetry tracks are provided, illustrating general movement patterns within ocean basins, and examples of finer scaled foraging and internesting movements are cited. The limited knowledge we have of leatherback hatchling movement and dispersal is discussed using information from particle drift modeling, dispersal simulations, and genetic data. The last chapter in this section outlines the role of marine productivity and climatic oscillation in determining not only the distribution of foraging leatherbacks but growth and fecundity as well. The authors provide some interesting insights on how and why highly productive areas may be bypassed for regions with lower productivity, and how this affects survival.

The book's final section, *The Future of the Leatherback Turtle*, directly addresses what are commonly considered two overarching threats to leatherback populations: suboptimal and lost aquatic and terrestrial habitat, exacerbated by climatic cycles and change and fisheries interactions. The *Warming Climate* chapter gives a summary of the possible physiological outcomes of water temperature increases for leatherbacks, then goes on to complement the preceding chapter's discussion on the effects of climatic cycles on marine productivity by detailing the observed and predicted ENSO effects on the reproductive ecology (output and migration) of the important leatherback nesting aggregation at Playa Grande, Costa Rica. Moving to the nesting beach, the authors provide a synopsis of the consequences of warmer beaches for sex ratios and persistence of populations. It is important to note their suggestions for use of caution and a measured approach in employing interventions such as relocation and hatcheries. A brief mention of the sea level rise associated with global climate change includes the interesting observation that its effect of eliminating nesting habitat may be integrated as a mechanism to shift turtles to higher latitude, cooler beaches. Chapter 17 carefully explains the types of data needed to effectively evaluate fisheries impacts on leatherbacks, then presents striking numbers for reported leatherback bycatch in longline, net, and trawl fisheries over a 21-year period. The efficacy of technological solutions such gear modifications is discussed, and techniques such as telemetry of non-target species and partnership-building among stakeholders are suggested as means of addressing the bycatch issue at a scale required to preserve leatherback populations. By way of closing, the editors focus the final chapter broadly yet accurately on our vastly improved yet still deficient current knowledge, and rally the reader to accept the challenges posed by existing and expanding data gaps.

Spotila and Santidrian Tomillo have done a very commendable job of initiating and shepherding the tremendous effort required to produce this book. As might be expected from a compilation of topical manuscripts, there is some overlap of subject matter between the chapters and the sections—this despite the fact that one or both editors contributed to seven of the 18 chapters. In most cases, however, these instances provide further explication and detail rather than redundancy. The literature cited for each chapter is comprehensive, referencing current work at the time of publication as well as seminal papers. *The Leatherback Turtle* provides a global reference for a globally distributed species and fills any number of data gaps for biologists, managers and citizen-scientists, especially in places such as the southeastern United States that are documenting an increasing trend in leatherback nesting. While doing so, the book clearly points the way towards much needed research and conservation efforts for this unique animal.

Note: Any use of trade, firm or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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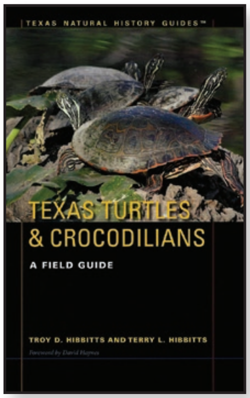
Texas Turtles & Crocodilians: a Field Guide

Troy D. Hibbitts and Terry L. Hibbitts. 2016. Texas Natural History Guides. University of Texas Press, Austin, Texas (http://utpress.utexas.edu). xvi + 276 pp., 117 photos, 36 maps. Softcover. US $24.95. ISBN 978-1477307779.



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Many of us recollect our field guide as the trusted companion to many adventures. Yet many kids now have more digital experiences rather than muddy ones, keeping a digital tether of constant access to information and people. This makes a quality field book into a critical tool, often the only reference on hand for review when users are outdoors having the encounters the book seeks to inspire. The new field guide for Texas turtles and the American Alligator delivers the right content to its users the majority of the time, has a couple of things that might have been better alternatives, and has at least one area that is factually misleading. Overall, this is a useful guide to the turtles of Texas and completes the herpetological field guide series for the state.

Texas has a remarkable diversity of reptiles, including more than 30 species of turtles, representing a bit more than half of the total turtle species diversity found in the United States. This field guide seeks to enable identification and provides brief information on each of the native species and established non-native (*Pseudemys nelsoni*) species, while noting several exotic taxa that are often found across the state (e.g., *Centrochelys sulcata* or *Caiman* sp.). The authors of this volume are life-long herpetologists with an enviable amount of time spent in active field herpetological pursuits. I examined the hardcopy and e-book version of this contribution for its use as a practical field guide by having it along during our own fieldwork in early 2016.

While there is a previously published identification pamphlet (Franklin 2015) and a more comprehensive volume that addresses both reptiles and amphibians (Dixon 2013), there are no other books that are designed to enable a person to identify and learn something about the turtles observed while in the field in Texas. The new volume completes a series of herpetological field guides that addresses the amphibians (Tipton et al. 2012), lizards (Hibbits and Hibbits 2015), and snakes (Dixon and Werler 2005) of Texas. While each is generally in the same format, the current volume introduces a broad array of material before proceeding to the taxon-specific accounts. The accounts themselves are fairly standard fare among modern guides and across the herpetological series for Texas.

I consider field guides to be as critical a piece of fieldwork machinery as hoop nets, especially given the nature of my employment and mentoring goals. Working with students in the field and watching them use and learn from field guides can be very insightful to how well the machine (i.e., field guide) functions in its everyday tasks. I am not embarrassed to report that talking about a field guide as a muted smart phone seems to strike a useful bridge from their world to my own. Here the physical book is well constructed and quite usefully printed on somewhat water tolerant paper (i.e., most of our Texas species are aquatic) in a solid binding. Its overall size format is the sweet spot for portability but with the attendant sacrifices to viewability (e.g., maps). The book withstood truck camping, the bottom of a dry bag, beaches, the edges of resacas, and just being used for the months up to this review. It is happily scuffed and a little crumpled, but has held up well to cautious field use.

The introductory materials are suitable to a general audience and cover a fairly broad array of topics. The authors begin the book with the broad context of turtle and crocodilian origins, evolution, and diversity. The introduction to the Crocodylia begins with coverage for the American Alligator and enables it to be integrated and consistently addressed within the volume. The natural history sections group the two clades and seek to broadly address aspects of ecology, reproduction, and behavior for both groups. I found these sections to provide a suitable middle ground for conveying information broadly but with sufficient detail to engage the reader, yet I think keeping the turtles and alligator information in discrete sections may have been preferable.

The next two sections introduce the reader to the physical environments inhabited by these animals in Texas and the potential anthropogenic impacts to habitats and species. The approach enables a watershed level introduction to the state with relevant species noted for each of these regional areas. Representative images depict features of the watersheds, and descriptions enable the reader to match the differing physical aspects of these to the types of turtles present. The impact sections include the normal litany of impacts (e.g., habitat loss, pollution, introduced species and so on), but also some turtle specific aspects such as predator control against nest predation and the consequences of turtle bycatch from recreational and commercial fishing. These sections conclude with a pragmatic review of the successful recovery of the American Alligator from a historically endangered species to a modern sport hunting novelty. The authors address the declines of aquatic turtles caused by the meat trade, but appear to diminish the potential impacts of pet trade collections on wild populations. The basis of the argument for minimal impacts appears to be derived from the magnitude difference between the meat trade and pet trade animal shipment volumes, which is understandable. However, it is far less clear from the available data exactly what represents the actual pet trade volume. Further, the impacts of pet trade collection have not been clearly analyzed, despite calls to correct the regulatory reporting issues (Schlaepfer et al. 2005; Mali et al. 2014).

The final introductory sections address aspects of field herpetology for the new practitioner, but also includes a useful series of reminders for all of us. These include tips on finding and observing these animals, photographing them, and then the practical and legal aspects of physically collecting and retaining individuals. This is all appropriately prohibitive for discussions with regard to the alligator, but also cautionary with regard to maintaining private collections of turtles, living or preserved. There is a brief section on capture, handling, and the potential hazards this can mean to the unskilled. Unfortunately, this section also includes a discussion that is factually wrong regarding reptile zoonoses, restricted here to infections from the bacteria, *Salmonella* sp. The authors mistakenly convey that human infections require mouth contact with a turtle, and further, that concerns over this zoonotic are "overblown." This is a very misleading section for the book and is badly misinformed. I suggest that errata be sent with the book that point to the Centers for Disease Control (CDC) website links for relevant modern cases, and that the authors review the relevant literature before a comprehensive revision of these paragraphs is completed. Succinctly, salmonellosis is seldom a serious issue, but it can be life threatening and does not require oral contact with a turtle. Like all zoonotics, it can be deadly serious and should not be minimized (nor exaggerated). Here it would have been appropriate to note the suitable precautions (e.g., gloves, hand-washing, decontamination of surfaces) that are easy and are not appreciably different than handling raw chicken from the supermarket.

The remainder of the book is the core of the field guide as a tool. The authors introduce taxonomy, note its fragility in an era of too many DNA sequencers and not enough systematists (my words, not theirs), and then proceed through the individual species accounts. It would benefit the printed volume to maximize the font used in the illustration figures of turtle shell morphology, and I would similarly suggest that an illustration or skeletons demonstrating the differences in morphology for Cryptodira and Pleurodira would better serve than photographs of a representative from each group. The authors include a dichotomous key and full glossary to cover the majority of terms that novice users questioned. I would note that the maps themselves are difficult simply by nature of the distributions for many taxa and the relative size of the maps in the printed volume. All of the maps for animals with disjunct distribution segments (e.g., p. 103; *Chelydra serpentina*), limited distributions (e.g., p. 145; *Chrysemys picta*), or coastal occurrences (i.e., p. 127; *Malaclemys terrapin* and all sea turtle maps) are not functional for fieldwork in the printed volume. Those maps are useable in the electronic version where the maps have excellent enlargement by zooming. The decision to keep the maps monochromatic rather than making the distributions colored in blue has exacerbated the problem significantly in both versions of the book.

Overall, the species accounts are complete and engage the reader with quality images both in hand and in habitat. Many of the accounts specifically link information back to the introductory sections on conservation or regulatory issues. I consider many of the images to be high quality as evidenced by the cover image and that of many of the accounts. There are images that should be revised or replaced to better depict the organism (i.e., p. 112; male *Graptemys caglei* much tighter cropped to the animal), be less visually confusing (e.g., p. 134; *Pseudemys gorzugi*), or simply have the legend revised to note two taxa are present in the photo (i.e., p. 152; *Trachemys gaigeae* basking with *Apalone*). These are critiques, but are not intended to be critical as the vast majority of images by the authors clearly depict the species and multiple images of each are provided. Use in the field of both the paper and electronic versions proved these images to be accessible, and where confusion arose, the account was often able to resolve the characters between taxa. I would note that the majority of those characters likely require the animals in hand rather than at spotting scope or camera distances. Unfortunately, unlike the maps, these images do not zoom in the e-book edition, which seems another place for improvement. I found the supporting bibliography to be very brief for the curious, especially as a third of the volume is dedicated to wide ranging topics briefly addressed and without clear source information. I did find the inclusion of herpetological societies (names but no contact information), professional societies, and online resources to be quite valuable to the users of the book.

The new book on Texas turtles and the alligator was designed to help both experienced and novice individuals to understand what they have seen, what they have found in their yards, or what they have found dead-on-road (DOR). It is constructed in print as a durable book for use outside and also works for us on tablets and smart phones as a tool for both amateurs and professionals. I conclude that some changes to the volume would be needed before I would recommend the printed version to my students, but I believe that the most critical improvements could be quickly and easily completed for the e-book version and those revisions pushed out to the electronic platforms. This book completes the herpetological field guides for Texas with an appropriate focus on clearly depicting animals, providing brief data for each species, and allowing the next generation to start planning trips to find these animals in the big backyard that is Texas.

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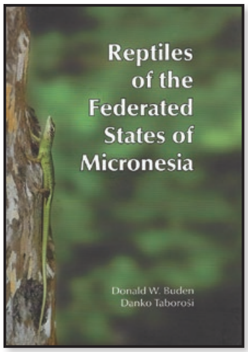
Herpetological Review, 2016, 47(4), 707.

Reptiles of the Federated States of Micronesia

Donald W. Buden and Danko Taboroši. 2016. Island Research and Education Initiative (http://www.islandresearch.org). 312 pp., > 300 photos, 35 maps. Hardcover. US $25.00. ISBN 978-982-9123-94-7.



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Encompassing one-third of the earth's surface, the Pacific Ocean is the largest geographic feature of our planet. The thousands of oceanic islands scattered across this great ocean are so far distant from each other that these far-flung islands were the last part of the globe to be colonized by humans. The vastness of the Pacific acts as an organic filter for terrestrial species, and this biological sieve has produced fantastic simple natural evolutionary experiments that have provided some of the greatest early insights into evolutionary biology. The remoteness of Pacific islands makes travel and scientific collections difficult and this combined with the numerous governing, and sometimes warring, nations has long hindered a comprehensive coverage of the reptile diversity. The first real attempt to describe the reptile fauna of the Pacific did not occur until after World War II with Loveridge's excellent *Reptiles of the Pacific World* (1946). Since then, there has been a slow trickle of outstanding books including *Herpetofauna of New Caledonia* by Aaron Bauer and Ross Sadlier, *Snakes of Papua New Guinea* by Mark O'Shea, *Reptiles and Amphibians of the Solomon Islands* by Mike McCoy, *Herpetofauna of Fiji* by Clare Morrison, and recently, the most comprehensive volume to date, *Reptiles and Amphibians of the Pacific* by George Zug.

Finally there is a book that covers in detail the lizards, snakes, and turtles from the Federated States of Micronesia (FSM). Scattered northeast of Australia and New Guinea lie more than 600 islands (from west to east) of the archipelagos of Yap, Chuuk, Pohnpei, and Kosrae. The isolation of these islands in the western Pacific has led to a wonderfully endemic and isolated reptile fauna. Donald Buden and Danko Taboroši have produced an outstanding 312-page book, *Reptiles of the Federated States of Micronesia*, that covers the diverse aquatic and terrestrial reptile fauna of the FSM. The book provides details on the classification, ecology, and natural history of 41 endemic species, as well as established and non-established invasive species. The book includes >300 photographs, 35 distribution maps, and numerous keys and very useful distribution tables at the end of the text. The printing quality is excellent, with vibrant color photographs, maps, and tables. Buden and Taboroši have extensive experience in the FSM. Buden, as a Professor of Biology at the College of Micronesia-FSM, has dedicated a large component of his career to understanding the distribution, ecology, and natural history of Pacific reptiles. Taboroši, an excellent photographer and director of the Island Research and Education Initiative based in Pohnpei, has extensive experience across the widespread islands of the FSM.

The book begins with a very informative and important introduction to Micronesia, including sections on geography, geology, climate, place names, and details of the 10 different habitat types found across Micronesian archipelagos. The individual species accounts provide an excellent overview and include sections on distribution, status, description, habits and habitat, and for some species accounts, an additional remarks section that addresses aspects of phylogenetic relationships and morphology. The inclusion of primary literature references greatly enriches the use of the book for professional herpetologists. A fantastic aspect of this book, atypical for most guides, is that there are multiple photographs for each species allowing the reader to get a good feeling for intraspecific color pattern and morphology. The authors have more personal experience in this part of the world than any other living vertebrate biologists, and as such their insights into the ecology and natural history of this fauna is terribly important for current and future generations of biologists and Micronesians. The book ends with a section on non-established exotics (established invasive species are included in the main species accounts), and a resource and reference section with very useful distribution tables.

In summary, the collaborative effort by Buden and Taboroši shines through with clear writing, beautiful photographs, and in-depth details on the ecology and natural history of all species. The guide allows easy species identification by professional and amateur biologists, and the physical book itself is of excellent quality and should withstand the rigors of being carried around in a backpack in the steamy tropical Pacific. This reasonably priced guide will be useful to scientists and eco-travelers, as well as conservation managers, and is a pleasing addition to the literature of the Pacific.

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Metamorphosis: Ontario's Amphibians at all Stages of Development

Peter B. Mills. 2016. Privately published, printed and bound by SLG Group, Brampton, Ontario (http://www.peterbmills.com/metamorphosis.html). 104 pp. Softcover, US $21.80. ISBN 978-0-9950603-0-2.

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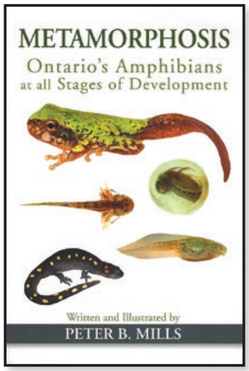

Three field guides cover the Province of Ontario's amphibians (Johnson 1989; MacCulloch 2002; Gillingwater and MacKenzie 2015). Each of these was well received, but like most field guides they tended to focus mostly on adult stages. Johnson (1989) did provide some text descriptions of eggs and larvae. MacCulloch (2002) and Gillingwater and MacKenzie (2015) also provided limited descriptions, but the former provided photographs of larvae for most species. These books, like the herpetological literature in general, simply reflected the unbalanced knowledge among life stages—it's much easier to identify and study adults. With only 27 species of amphibians known to have occurred in Ontario, and 23 extant species, it is not too difficult to learn to distinguish among adults of species as it is in most regions. However, Ontario is bigger than any state and many countries with habitats ranging from tallgrass prairie to Carolinian and boreal forests, and ultimately tundra. Consequently, considerable variation among populations or developmental plasticity (Relyea 2001) can make species identification challenging among adults and more difficult, or even a "nightmare," among larvae if one works in more than one region. The extent of this problem became evident decades ago on a conference field trip when three eminent herpetologists from different regions of North America were arguing over the identification of a captured tadpole. Fortunately, a young local herpetologist managed to solve the dispute. Earlier in my career when surveying among multiple regions in Ontario, I often had to raise larvae in the lab for accurate identification.

Mills' book takes up the challenge and makes its contribution by giving more balanced coverage to the "first half" of the dual life of amphibians. Mills takes the traditional approach for figures, arguing that illustrations are far superior to photographs and quotes Roger Tory Peterson who noted that a "composite of your experience" can be captured in an illustration. Mills used "hand-done, but rendered digitally" painted images. The images of both adults and larvae in each species account are definitely of better quality than the small black and white photographs in Altig and McDiarmid's (2015) book, but they are not quite as sharp or contrasting as traditional painted images. However, the overall quality of the images and restricted regional coverage addresses two of the criticisms of Altig and McDiamid's exhaustive book on amphibian larvae (see Wassersug 2015). The images largely succeed in capturing key distinguishing features of the species. Based on my experience working with amphibians in multiple regions of Ontario, the book works well, especially for larvae.

The book is organized well by first briefly going through the basics in the Introduction using short sections under the headings: Things to Know, Breeding and Metamorphosis, Eat and Be Eaten, How to Identify Amphibians and Their Larvae, Plasticity, How to Find Amphibians and their Larvae, Rearing Amphibian Larvae, and Ethical Considerations. A short section on Ontario follows with a simplified map showing only part of central and southern Ontario. This is of course where most people live in Ontario, but most of the province's land area is in the north. Next is a simple introduction to salamanders and anurans, each of these being followed by individual species accounts. The species accounts are usually four pages long covering some of the basics for each species. These sections could be a bit more detailed benefiting individuals first learning the amphibians. For example, there is discussion about using the vent characteristics to distinguish male from female Spotted Salamanders, but no mention of using the vent in Mudpuppies or tympanum size for sex determination in Green Frogs or American Bullfrogs. Some species such as Boreal and Western Chorus Frogs are lumped together because the author considers that they look identical. My own experience indicates that the dorsal stripes are much more broken up and the limbs are relatively shorter in Boreal compared to Western Chorus Frogs in Ontario. There are also differences in behavior, habitat selection, and activity patterns not discussed. It is stated that chorus frogs call loudly for only a brief period in the spring. This is true for Western Chorus Frogs in southern Ontario; however, Boreal Chorus Frogs often call for a prolonged period in northern Ontario. I was also surprised that when Mills discussed symbiotic algae associated with Spotted Salamander eggs, he did not mention their greenish color. Likewise, Eastern Newt efts were described as being bright orange or orange-brown, but there is no mention of red individuals. Habitat descriptions could also have been better. Perhaps the most contentious statement was "Eastern Red-backed Salamanders can be found in the same habitat (and may indeed live in streams where Two-lined are absent and there is no competition)". Although I have found redbacks in some seepage areas, I am not aware of any accounts of this terrestrial salamander living in streams.

Three short sections end the book providing additional information under the headings: Frogs and Toads – Extensions, Extirpated and Questionable Species, Further Reading, and Keywords. As in most field guides, the font size of the text is a bit small, but the images of eggs, several larval stages, and adults are of a good size. The overall dimensions of 15 x 23 cm and thick glossy pages suggest that the book will be both portable and durable in the field.

The information covered is kept simple and limited to some basic characteristics of each species and features for identification. The author uses few technical terms and uses early, mid, and late stages instead of Gosner's (1960) or Harrison's (1969) developmental stages for anuran or caudate larvae respectively. Accounts are listed under standard common names. Current scientific names are also given but not listing the former taxonomy will not help inexperienced users connect with reference sources. Experienced herpetologists may like to see a bit more detail than is given, but as written, the book will be easy to use by novices and it can still be used by more seasoned herpetologists.

While I like most of the "paintings" of larvae and the more balanced attention among life stages, I thought that the book could have been better. A more clear writing style may help future revisions (fewer dangling participles). There were a few typos, for example, "compliment" instead of "complement," and "parotid" instead of "parotoid" glands. There were also a few words that appear "coined" if the reader is an Oxford or Webster user, but they appear in trendy online dictionaries. Examples include "girthier" hind limbs where "thicker" works, and "mouldering" logs where "decayed" would do fine. The fact that the author is quite young and primarily a naturalist/artist comes across when reading the book. While the book largely succeeds in its goal of providing a more balanced regional field guide, it would have clearly benefited from being edited by an experienced herpetologist and proofread by others.

Being restricted to just Ontario's species will limit the book's audience, but considering the wide overlapping ranges of northern temperate amphibian species, it should also be of some use in adjacent jurisdictions such as Manitoba, Michigan, Minnesota, Ohio, Pennsylvania, New York, and Québec. For more thorough accounts of biology and ecology one can consult three excellent reference books (Petranka 1998 for salamanders, Dodd 2013 for anurans, or Wells 2007 for amphibian ecology and behavior). For in-depth accounts describing and keying out amphibian eggs, embryos, and larvae for all species in the United States and Canada, one can seek out the recently published *Handbook of Larval Amphibians* (Altig and McDiarmid 2015) or the earlier thorough volume dealing with tadpoles (McDiarmid and Altig 1999). Although several improvements could be made, Mills' small book may find use as a field guide for professional biologists, herpetologists, and naturalists in and near Ontario. It will likely inspire others to write future improved guides to other regions of North America.

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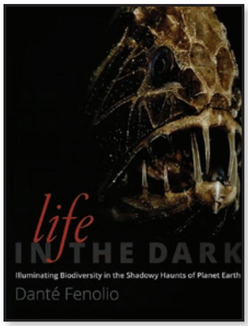
PUBLICATIONS RECEIVED

Life in the Dark. Illuminating Biodiversity in the Shadowy Haunts of Planet Earth

Danté Fenolio. 2016. Johns Hopkins University Press, Baltimore, Maryland (www.press.jhu.edu). 312 pp. Hardcover. US $39.95. ISBN-978-1-4214-1863-6.



Life in the Dark is a richly illustrated compendium of animal life in the dark reaches of the Earth, whether in the abyssal regions of the ocean, in the perpetual darkness of caves, or in deep freshwater habitats; the book even discusses fossorial species that rarely if ever venture above ground or into the sunlight, such as certain frogs, caecilians, and amphisbaenians (pp. 32–35, 42–43, 153–170). Fenolio also includes chapters providing an introduction to life in darkness, a section on parasites of species dwelling in the dark, and a plea for the conservation of a biodiversity that is mostly never seen, especially by non- biologists. Not surprisingly, much of the book features invertebrates and fishes, but it embraces both amphibians and reptiles in a number of chapters (especially pp. 199–209), particularly cave salamanders. Of specific interest to herpetologists are the outstanding photographs of eggs and adults of rare salamanders, including a photo of the only known specimen of *Eurycea robusta* and an artist's rendition of how the animal may have appeared in life (p. 182), a discussion of the potential importance of amphibian skin secretions in human medicine (pp. 255–262), and a short bibliography of papers on such species (pp. 275–276). The book is intended for naturalists, but the more than 200 dazzling photographs of little-seen animals should excite both a professional and general audience. Danté Fenolio is Vice President for Conservation and Research at the San Antonio Zoo.

LETTERS TO THE EDITOR

Herpetological Review, 2016, 47(4), 710–711.

Venezuelan Crisis Takes Toll on Natural History Museum

The current political and economic crisis in Venezuela has created unprecedented shortages of food and medicine besides alarming levels of crime. Academia is suffering massive brain drain and severe resource restrictions that are destroying decades of progress (Fraser 2016; Requena 2016). Natural history collections are also in dire straits and particularly troubling is the negligence bedeviling the *Museo de la Estación Biológica de Rancho Grande*.

This significant zoological museum houses more than 127,000 specimens of mostly vertebrates, including 50 holotypes (44 of which are reptiles or amphibians). Many specimens are an irreplaceable representation of the country's biodiversity from extremely remote sites now either destroyed or inaccessible due to crime.

Just ten years ago the museum had six research staff and five technicians whose work guaranteed specimen preservation and availability. Today stewardship and maintenance of the museum depends upon just two employees as the ministry in charge ("*Ministerio del Poder Popular para Ecosocialismo y Aguas*") has failed to replace personnel that have retired, relocated or passed away. Research has stopped, availability of specimens for study is practically impossible, and the welfare of all specimens and associated data are under grave danger. The size, complexity, and importance of the museum's holdings demand a team of scientists with curatorial experience to prevent loss of the collections, a very real threat given their location in a valley with elevated humidity, sporadic flooding, and frequent electrical blackouts followed by surges that fry A/C and dehumidifiers. The Venezuelan government must take immediate action to hire qualified personnel and provide them with resources to adequately maintain the material housed in these collections before irreversible damage commences. Initiatives by the global community to call for such action are welcome and might include communications by professional societies and individual colleagues directed to the "*Dirección General de Diversidad Biológica*" (see contact information below) as well as wide dissemination of this letter describing the emergency facing the museum.

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The aforementioned situation is an extreme example of the global phenomenon of the abandonment of natural history collections by governmental agencies (Kemp 2015). Natural history museums are critical assets for biodiversity studies and research with high impact on public health, food availability, and the effects of climate change on these areas (Suarez and Tsutsui 2004). This is especially important for Venezuela given the collapse of the country's agriculture, the dramatic rise in vector transmitted diseases, and the recent approval of a large series of mining projects in pristine environments with no regard to their environmental impact. Intergovernmental and non-governmental organizations must work with the global scientific community to prevent the loss of biological material key for our species to surmount the challenges of the Anthropocene.

Natural history collections are at risk from any number of dangers and curators generally try to keep these possibilities in mind when designing conservation plans and protocols. Humidity, theft, pests, chemical reagents, and other environmental hazards are readily identifiable and provisions may be formulated. Even some natural catastrophes such as floods, earthquakes, and storms may be accounted for in procedural manuals, but unfortunately countless collections have been destroyed as collateral damage from social, economic, and political upheavals. These occur at irregular intervals and affect not just the institutions but also their staff at all levels. Such calamities are rarely, if ever accounted for in planning, and their occurrence may be so intertwined with institutional and external complications that rescue of the collections can become unviable. Stemming from events that range from acts of war to political extremism or economic disasters that make life unbearable, the demise of a collection may be instantaneous or prolong itself during a variable length of time as material and human resources evaporate. Salvaging specimens may or may not be possible depending upon the circumstances. In some cases legal, political, and even ideological barriers may prevent any action from being taken, thus assuring the deterioration of collections ironically considered national patrimonies. Clearly where governance and institutionalism is weakest, and general levels of education are substandard, natural history collections generally are at greatest risk. Unfortunately such conditions all too frequently coincide with countries richest in biodiversity but with few resources dedicated to their study and conservation. The incurred and potential losses are mind-boggling and must deserve some time to sort out and consider how to mitigate or avoid damage and salvage collections when possible. Which are most at risk? Which are the most valuable? What can be done? What cannot be done? When cranking up the A/C or replenishing formaldehyde just isn't enough.

In this case at least let us raise our voices in polite, but firm expressions of concern.

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APPENDIX

Contact information for the Dirección General de Diversidad Biológica:
Lic. Edis Solorzano, Directora General de Diversidad Biológica, Ministerio del Poder Popular para el Ambiente. Av. Oeste 8, Torre Sur, Centro Simón Bolívar, El Silencio 1010. Piso 9, Dirección General de Diversidad Biológica. Teléfono: +58 (212) 4084757; e-mail address: diversidadbiologicaven.dg@gmail.com [send copy to edissolorzano@hotmail.com]

ZOO VIEW

Herpetological Review, 2016, 47(4), 711–718.

Amphibian Conservation Efforts at the Smithsonian's National Zoological Park and Conservation Biology Institute

In response to the global extinction crisis, the Smithsonian's National Zoological Park (NZP) and Conservation Biology Institute (SCBI) launched a major new amphibian conservation effort in 2008, to coincide with the American Association of Zoos and Aquarium (AZA) "Year of the Frog" campaign (Mendelson et al. 2006). A full-time interdisciplinary research position was created (and filled by BG) to focus exclusively on amphibian conservation, with a mandate from NZP to leverage existing internal Smithsonian resources to help implement the global amphibian conservation action plan (Gascon et al. 2007). We reviewed our existing global research capacity and identified two key areas of overlap with amphibian biodiversity hotspots. Specifically, the SCBI headquarters (Front Royal, Virginia) includes a 3200-acre research facility in the heart of Appalachia, a region with more than 70 salamander species, mostly endemic to the region (Stuart et al. 2008), and the Smithsonian Tropical Research Institute (Panama City, Panama) where an exceptionally diverse group of anurans has declined precipitously due to the pathogenic fungus *Batrachochytrium dendrobatidis* (*Bd*), the causative agent of chytridiomycosis (Lips et al. 2006). In addition to field conservation work, the Smithsonian's National Zoological Park is a tremendous resource for disseminating amphibian science and conservation messages, with more than 2 million people each year visiting our herpetological exhibits. JBM served as the curator of herpetology from 2009–2014 and worked to shift the management paradigm from traditional animal exhibitions to herpetological conservation by focusing limited space and keeper resources on species of conservation concern, encouraging staff to participate in field research efforts, and becoming more engaged in conservation breeding programs (see Murphy and Xanten 2007 for a detailed account of the history of the department). This paper outlines the contributions of these centers (SCBI, STRI, and NZP) to amphibian conservation from 2008–2016. Our goals are to promote a culture of amphibian conservation within the AZA and to acknowledge the tireless contributions of our conservation colleagues to these important efforts.

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PANAMANIAN FROGS

Building Capacity in Panama.—Despite volumes of research, few effective conservation actions have been effectively implemented to mitigate threats to amphibians. Between 2005–2015, over 12,000 papers were published on amphibian conservation, of which about 1000 focused specifically on

FIG. 1. Biologist Jorge Guerrel tends to a captive assurance colony of *Atelopus* inside a modified shipping container at the Smithsonian Tropical Research Institute's new Gamboa Amphibian Research and Conservation Center in Panama.

Fig. 2. The 5000 sq. ft. Gamboa Amphibian Research and Conservation Center has office space, telecommunications, laboratory space for visiting STRI researchers, a quarantine room, seven modified shipping containers, backup power, and waste-water treatment plant.

chytridiomycosis (Thompson Reuters 2016). While this research greatly advanced our understanding of the threats to amphibian survival, a lack of funding and capacity for applied conservation seriously limit our ability to save these species from extinction (Gratwicke et al. 2012). We found that a lack of facilities and full-time dedicated professionals focused on amphibian conservation in Panama was a major limiting factor. As such, the primary goal of our work in Panama has been to build a team of talented herpetologists and adequate facilities at STRI to implement conservation actions at a meaningful scale.

Panama is home to 214 amphibians, and about 36 species are thought to be highly susceptible to the amphibian chytrid fungus, of which, nine have disappeared completely (Gratwicke et al. 2015). About 100 species continue to persist—even in *Bd* positive situations and the remainder were too rare to evaluate (Gratwicke et al. 2015). To counter the loss of amphibians due to chytridiomycosis, we launched the Panama Amphibian Rescue and Conservation Project in 2009. The project is a consortium of zoos and aquariums whose founders included Africam Safari (Mexico), Cheyenne Mountain Zoo (Colorado), Defenders of Wildlife (DC), Houston Zoo (Texas), Summit Municipal Park (Panama), Zoo New England (Massachusetts), NZP (Washington, D.C), and STRI (Panama). Our project is directed by prominent Panamanian herpetologist Roberto Ibáñez with a primary goal to build additional facilities in Panama to house and grow captive populations of endangered amphibians threatened by *Bd*. Our new 5000-square-foot Gamboa Amphibian Research and Conservation Center opened in 2015 (Figs. 1, 2). It is a major new resource for on-the-ground conservation that complements the Houston Zoo's El Valle Amphibian Conservation Center (EVACC) (Gagliardo et al. 2008). Prior to opening the Gamboa center to the public, we conducted expeditions to collect priority species, treated *Bd*-infected frogs gathered in the field, and worked to resolve veterinary issues associated with the captive collection (Baitchman and Pessier 2013; Pessier et al. 2014). The combined facilities currently employ 12 people and house 12 species of priority frogs (Fig. 3), six of which were successfully bred in captivity for the first time as part of this effort (PARC 2015). One of our primary focal species for research and conservation has been the Panamanian Golden Frog (*Atelopus zeteki*) that was named for STRI's first director, James Zetek, who collected the type specimen in 1929 (Dunn 1933). The captive population of Golden Frogs in the US is managed by the American Zoo and Aquarium Association's Golden Frog Species Survival Plan (SSP) at the Maryland Zoo in Baltimore, which has greatly facilitated research on this species in captivity. In 2013 we worked with the IUCN Species Survival Commission to develop a stakeholder-based conservation plan aimed at the restoration of wild Panamanian Golden Frog populations (Estrada et al. 2013).

Searching for a Cure.—Multiple approaches have been proposed for mitigating the effects of chytridiomycosis in nature (Woodhams et al. 2011) and promising advances have been made in the area of climate refuges (Puschendorf et al. 2011), application of antifungal agents to habitat (Bosch et al. 2015), and vaccines (McMahon et al. 2014). Our research has focused on the use of probiotics—beneficial bacteria that produce antifungal agents when applied to frog skin. Harris et al. (2009) demonstrated that probiotic bacteria could protect Mountain Yellow-legged Frogs (*Rana muscosa*) from *Bd* mortality, highlighting the potential of this strategy for applied conservation efforts. We attempted to apply this strategy to *Bd*-infected *Atelopus* (using surplus frogs), but the beneficial bacteria failed to persist on the frogs, which succumbed to chytridiomycosis (Becker et al. 2011; Becker et al. 2015). In the process of this research, we discovered a great deal about the microbiome of Golden Frogs both in the wild and in captivity (Becker et al. 2014), and found that the ability to clear a *Bd* infection was associated both with unique skin microbes and differential gene expression (Ellison et al. 2014; Becker et al. 2015) (Fig. 5).

Understanding the mechanisms of natural resistance to *Bd* is another strategy to developing a cure for chytridiomycosis in *Atelopus* and other susceptible species. In partnership with the Smithsonian's Center for Conservation Genetics, we studied the relationship between gene expression (i.e., transcriptomics) and disease outcomes in the Lowland Leopard Frog, *Lithobates yavapaiensis*. This frog is from the southwestern U.S., where populations naturally differ in their susceptibility to chytridiomycosis (Savage and Zamudio 2011). In recent studies, we determined that frogs with lower levels of immune proteins in the blood are more susceptible to *Bd* (Savage et al. 2016). However, specific genes could not be associated with a particular disease outcome, instead, an overactive immune response was associated with chytridiomycosis susceptibility (Anna Savage, pers. comm). These studies highlight the complexity of *Bd* pathology and the need for further research to inform potential solutions.

Sustaining Captive Populations in the U.S. and Panama.—Sustaining and managing captive collections of amphibians over the longer term can be greatly facilitated by active genome resource banking and assisted reproduction. These tools can preserve genetic diversity, enhance reproductive success, and reduce overall numbers of live animals required to meet population goals (Wildt et al. 1997). We developed a comprehensive biobanking protocol and in 2015 and began systematically cryopreserving tissues and living amphibian sperm using methods developed by Gina DellaTogna as part of her PhD studying a population of male captive Panamanian Golden Frogs (DellaTogna 2015). DellaTogna is the first Panamanian student to earn her PhD studying this emblematic animal, and is continuing this research in partnership with Maryland Zoo, with the goal of producing *Atelopus* tadpoles from in-vitro fertilization of eggs using cryopreserved spermatozoa samples, and applying the methods to other priority species (Fig. 4).

Fig. 3. At our two facilities in Panama we have successfully bred all five extant harlequin frogs *Atelopus zeteki, A. limosus, A. varius, A. certus,* and *A. glyphus.* Two dart frogs (*Andinobates geminisae* and *Oophaga vicentei*), two treefrogs (*Hylomantis lemur* and *Anotheca spinosa*), and two hemiphractids (*Hemiphractus fasciatus* and *Gastrotheca cornuta*) have also been bred.

In addition to developing these tools we have used the scientific method to address other problems associated with captive management issues. Spindly leg syndrome is an issue associated with captive care of amphibians. We have characterized the problem in Golden Mantellas (*Mantella aurantiaca*) from Madagascar but its causes remain unclear (Claunch and Augustine 2015). Our initial experiments on *Atelopus* in Panama showed that prevalence of spindly leg syndrome was not related to tadpole dietary protein and we will continue to design experiments that systematically evaluate

Fig. 4. Gina DellaTogna and Roberto Ibáñez working on collecting spermic urine from *Atelopus* for cryopreservation in the lab at the Gamboa Amphibian Research and Conservation Center.

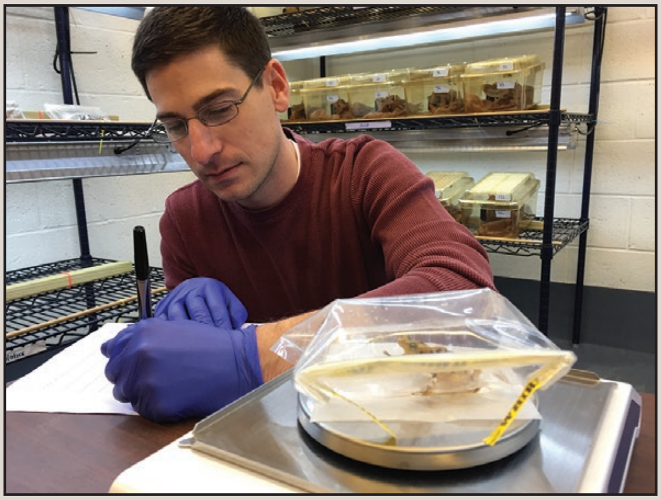

Fig. 5. Matthew Becker conducting probiotics research on an experimental colony of *Atelopus zeteki* at National Zoo. These surplus-bred frogs were generously provided by the Golden Frog SSP managed by the Maryland Zoo in Baltimore.

other potential causes (J. Guerrel, pers. comm.). Lack of space is another factor limiting captive amphibian collections so we studied the physiological and behavioral consequences of housing *Atelopus* in groups of 2–8 individuals. Group housing improves space efficiency and expands conservation capacity, but may cause increased disease susceptibility related to physiological stress. In our study of co-housed *Atelopus* males, we found that they fought vigorously in the first two weeks of being placed together, as measured by aggressive interactions and elevated stress hormones in their feces. However, after the third week, both the aggressive interactions and fecal glucocorticoids subsided to baseline levels in small and large groups, and we concluded that we could safely co-house larger groups of males over the longer term (Cikanek et al. 2014).

Building a Constituency.—Given the central role of human values in conservation, our approach to amphibian outreach has focused on engaging people with nature to foster inspiration and a desire to protect the natural world (Gratwicke et al. 2016). The products of our Panamanian amphibian outreach program include numerous news articles and television segments, a bilingual website, a feature-length documentary, and a total of five frog-themed exhibitions at Smithsonian's facilities in Panama and the National Zoo. The El Valle Amphibian Conservation Center is the only place in Panama where the public can see the endemic Golden Frog, and the exhibit is visited by about 100,000 people each year. In 2014, we opened a new bilingual "Fabulous Frogs of Panama" exhibition at the Punta Culebra Nature Center in Panama City. It is visited by about 60,000 people per year, about 15,000 of whom are Panamanian students on school field trips. The "Fabulous Frogs of Panama" exhibit features the diversity of common frogs in Panama and species of conservation concern, while interpreters share the cultural significance of frogs in Panama and tell the story of the chytrid threat to amphibians (Fig. 6). At the National Zoo, we tell our amphibian conservation story to our 2 million annual visitors primarily at the "Amphibian Alert!" exhibit in the Amazonia Science Gallery. This exhibit explains amphibian diversity, the chytrid fungus, and amphibian arks, connecting the visitor to our Panama field work and research efforts though a looping documentary entitled "Mission Critical: Amphibian Rescue," produced and aired by Smithsonian Networks. A second smaller display at the Reptile Discovery Center specifically showcases the Panama Amphibian Rescue and Conservation Project and our participation in the Golden Frog SSP program (Evans et al. 2012).

We do not have a full time amphibian conservation education staff member, but all of our staff pull together to help volunteers with educational activities for the Golden Frog Festival which takes place in Panama during the week of August 14, which is officially legislated as "Dia de la Rana Dorada." The festival has grown in popularity since its first incarnation in 2010. Now, thousands of people participate in multiple events around the country, including the Golden Frog Day parade coordinated by the Ministry of the Environment where hundreds of school children dress up like Golden Frogs and march in the streets of El Valle de Anton (PARC 2015). For teachers, we developed an informal curriculum with age-appropriate student activities that align with the national curriculum, to be used in association with one of the exhibits or educational posters (PARC 2014). Each curriculum topic incorporates a conservation action for students to help achieve our conservation goals such as fundraising, volunteering or participating in the Global Amphibian Bioblitz citizen-science survey of wildlife (Loarie et al. 2011). In the US, we participate in the AZA Frogwatch program to engage and train zoogoers to observe and listen to frog calls in their own back yards. While it is challenging to evaluate the effects of any outreach program, we feel that the significant efforts by AZA members, scientists, and the popular press since the 2008 Year of the Frog has led to a shift in public discourse about amphibian conservation. The tone has changed from a more defensive position on "Why frogs matter," to one where amphibians are a more central part of the conversation about biodiversity and environmental stewardship both in Panama and the US.

Appalachian Salamanders

Almost half of all salamander species are listed as threatened or endangered (Stuart et al. 2008). The Appalachian region is home to more salamander species than anywhere else in the world, making it a true hotspot for salamander biodiversity (Stuart et al. 2008). Several populations of Appalachian salamanders

FIG. 6. The bilingual "Fabulous Frogs of Panama!" exhibit at the Punta Culebra Nature Center in Panama City. This exhibit indirectly communicates that amphibians are diverse, delicate, beautiful creatures to be valued and protected.

FIG. 7. Kim Terrell conducting her work on the effects of climate change on Hellbenders in the Appalachian Salamander Research Lab. This work is conducted in the public eye and Kim directly communicated her findings to zoogoers in the Reptile Discovery Center.

living in apparently pristine habitat have experienced enigmatic declines (Highton 2005; Caruso and Lips 2013). We convened an Appalachian salamander workshop in 2008 at SCBI in Front Royal, Virginia to evaluate conservation threats to salamanders using IUCN threat categories. Attendees ranked 1) climate change, 2) pollution, 3) residential development, 4) energy production and mining, and 5) invasive species and disease as the top potential threats to salamanders, but acknowledged that much more systematic research was needed to understand the scope and nature of the problems (Gratwicke 2008).

Evaluating the Threat of Climate Change.—As a result of this prioritization, our focus at the Smithsonian Conservation Biology Institute has been working to develop a better understanding how climate change might affect salamanders. Mountaintop endemic species such as the Shenandoah Salamander (*Plethodon Shenandoah*) have been a primary concern. We evaluated climate risks to *P. shenandoah* by developing systematic baseline occupancy survey methods (Sevin 2014) and manipulating climate in an experimental mesocosm approach with US Geological Survey colleagues. We found that under future climate scenarios, *P. shenandoah* was able to compete favorably with Red-backed Salamanders (*P. cinereus*; Dallalio 2013). One recent study suggested that warmer, drier climatic conditions were responsible for observed reductions of adult *Plethodon* salamander body size (Caruso et al. 2014). However, we examined museum collections and found the opposite relationship in *P. cinereus*. Specifically, body size in museum specimens increased slightly in association with warmer, drier conditions (McCarthy et al., *in prep.*).

In addition to potential effects on terrestrial salamanders, changing rainfall patterns will likely lead to more extreme variation in stream flow and temperatures. This is likely to affect aquatic species like Hellbenders (*Cryptobranchus alleganiensis*) and exacerbate existing threats to wild populations (Wheeler et al. 2002; Burgmeier et al. 2011). To gain a better understanding of this species' current distribution, we have been collaborating with a larger regional citizen-science initiative to detect Hellbenders using environmental DNA from 180 sites in the Northeast region (K. Terrell, pers. comm). We are conducting experimental research at the National Zoo's Appalachian Salamander Lab to better understand how naturalistic patterns of temperature change influence various indicators of in *C. alleganiensis* (Fig. 7). We were surprised to find that Hellbenders were quite resilient to these fluctuations and even had improved immune function (Terrell et al. 2013).

Emerging Diseases in US Salamanders.—At the time of our 2008 salamander workshop it was unclear whether *Bd* may have been responsible for unexplained plethodontid salamander declines. Subsequent surveys in the wild and of museum specimens only detected *Bd* on wild plethodontids at very low frequencies, along with low zoospore loads indicating that *Bd* is unlikely to be playing a major role in shaping contemporary or historical salamander populations (Gratwicke et al. 2011; Caruso and Lips 2013; Muletz et al. 2014). The disease has higher prevalence rates in aquatic salamanders like Hellbenders, but it is unclear to what extent it has affected their wild populations (Bales et al. 2015).

A recent cause for concern is the new salamander-specific species of chytrid fungus *Batrachochytrium salamandrivorans* (*Bsal*) that was discovered recently in Europe but has not been detected on US salamanders (Martel et al. 2014; Bales et al. 2015). Just as the international trade in amphibians for pets and food may have been a vector for *Bd* (Gratwicke et al. 2010), more than 100,000 potential carriers of *Bsal* are imported into the US as pets each year, which is a substantial risk for the accidental introduction of *Bsal* to the United States (Gray et al. 2015). The legal trade in these species has been temporarily halted with a salamander trade moratorium issued by the U.S. Fish and Wildlife Service (USFWS 2016), but it is unclear whether the pathogen is already in the country. We partnered with the Amphibian Survival Alliance to engage hobbyists to screen their pets for *Bsal* and obtained more than 600 citizen-science-collected swabs from pet salamanders that will be tested for *Bsal* at the SCBI genetics lab.

Appalachian Salamander Lab Exhibit.—One of the top-level conservation actions identified at the 2008 Salamander Workshop was educating local residents of Appalachia about the importance and uniqueness of salamanders. Andy Odum had already been leading a successful effort to exhibit and breed native salamanders at the Toledo Zoo, but the National Zoo was

Fig. 8. Alan Peters, curator of the Reptile Discovery Center, helps zoo visitors search for Green, Eastern Red-backed, and Long-tailed salamanders on the Appalachian salamander wall.

not exhibiting any native salamander species at the time. We agreed at that meeting that even though native salamanders are challenging to exhibit, we needed to showcase some of our nation's incredible salamander diversity to the National Zoo's 2 million annual visitors. We conceived a "salamander hall" in the Reptile Discovery Center that would have a custom-built multi-species *Plethodon* salamander wall on one side, and an active Appalachian salamander research lab on the other, where researchers and docents could engage visitors and promote our conservation message (Fig. 8). Using this space, we have conducted studies related to climate change (Terrell et al. 2013), olfaction (Kuppert 2013), and captive nutrition (Augustine et al. 2016).

The Appalachian salamander exhibit provides visitors with interesting context for the diversity of US salamanders by displaying our native Hellbenders in a salamander hallway alongside a Japanese Giant Salamander (*Andrias japonicas* exhibit. This genus represents the largest amphibian species in the world (Fig. 9). Our goal is to inspire our zoo visitors with this superlative amphibian and to foster a sense of wonder about our local salamander biodiversity.

Conclusion

With interdisciplinary coordination and support from the highest levels of leadership, the Smithsonian's amphibian conservation program has leveraged significant in-kind resources to support amphibian conservation. These resources include physical space and expertise from multiple departments, specifically, animal husbandry, research, veterinary science, public affairs, exhibits, and advancement. We currently employ 12 full-time conservation staff in Panama and have been assisted by a host of volunteers, interns, five PhD students, a DVM student, and four post-doctoral fellows. The active conservation research program is complimented by the captive collection which has shifted from one composed primarily of exotic least concern species, to one that is more focused on native species and species of conservation concern. Our conservation programs give us an engaging story to tell and our new amphibian exhibits all highlight the connections between the captive collections and active research and field conservation. Our future goals are to optimize breeding and husbandry protocols for understudied amphibian species and to continue to facilitate research and education efforts. Our programs provide the next generation of frog conservationists with opportunities to gain skills and inspiration, while contributing to the global efforts to protect and understand threatened amphibians.

Fig. 9. Three large Japanese Giant Salamander tanks are maintained in a closed system with interconnected transfer tubes and dens. Water temperatures are maintained by a chiller system and cycled annually to replicate stream temperatures at the Asa Zoo, where these salamanders are regularly bred in semi-natural systems. Our hope is to breed these cryptobranchids in a completely closed system and use them as a flagship species to help cultivate an appreciation for our native Hellbenders.

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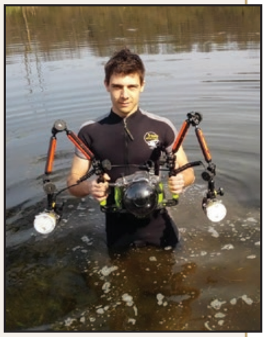
ABOUT OUR COVER: *Vipera walser*

Vipera walser is the most recent addition to viperid taxonomy, having been "discovered" via molecular genetic analysis as distinct from nearby populations of the ecologically and morphologically similar *V. berus* (Ghielmi et al. 2016. Journal of Zoological Systematics and Evolutiionary Research 54:161–173). It might seem surprising that new vertebrates—especially something like a viperid snake—continue to be found in relatively well explored areas of Europe. In this case of *V. walser*, although specimens were present in museum collections dating from > 85 yrs ago, these were catalogued as range-margin *V. berus*. It was only until genetic sequencing was undertaken was this cryptic diversity brought to light. And indeed, not only are these allopatric species deeply differentiated and show no evidence of introgression, they are not even sister taxa. *Vipera walser* appears to be nested within a Caucasian clade rather than affiliated with the geographically proximate *V. berus* complex.

Vipera walser is a relict species that occurs in a small, high-elevation, high-rainfall region in the western Italian Alps. The new species appears to be quite common within its restricted range, occupying open, rock-strewn landscapes. Interestingly, it exhibits nearly the same range of pattern variation seen in populations of the widely distributed *V. berus*—a zigzag pattern on various ground colors, and including even a melanistic form. The species is named for the Walser people, who migrated from the north in the 12th and 13th centuries to settle in mountain valleys of the Alps.

The small and likely fragmented range of this species in alpine valleys potentially makes it vulnerable to extinction. Although loss of forest cover worldwide has strongly impacted the conservation of numerous amphibian and reptile species, one of the threats facing *V. walser* is the potential for return of forests to their currently open habitats. This is likely given the decline in agricultural practices that have historically maintained the open nature of alpine valleys in the Alps. An additional threat, based on experiences with other recently described viperids (e.g., *V. kaznakovi*), is collection for the pet trade.

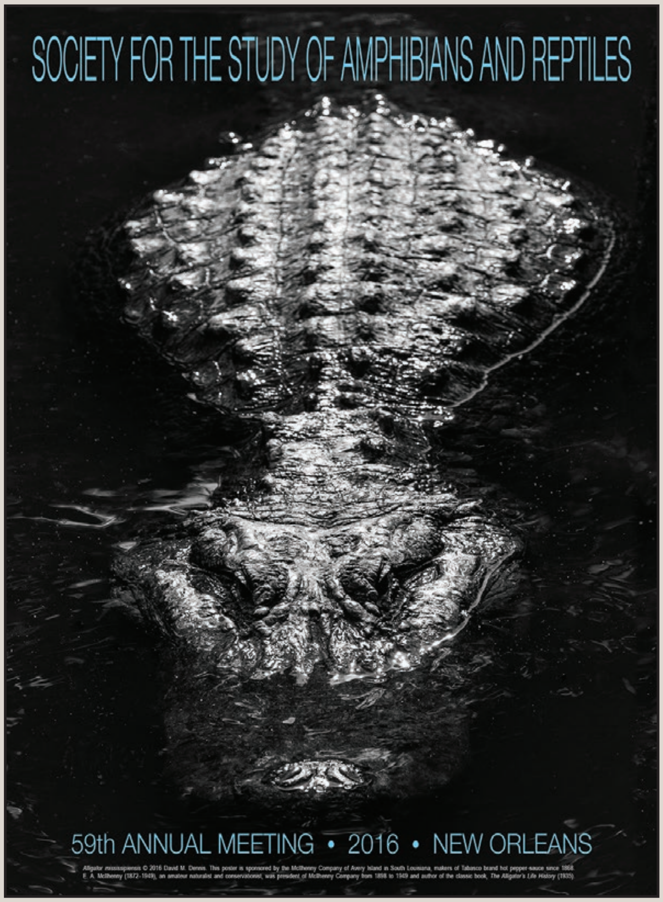
The adult Walser Viper on our cover was photographed by **Matteo Di Nicola**. This "wide-angle macro" image was recorded using a Nikon D750 camera and a Tokina 10–17mm lens (f/25, ISO 320, 1/60 sec shutter speed, focal length 16mm), with fill flash provided by a Nikon R1 wireless dual flash system. Additional images by Di Nicola may be viewed at <www.matteodinicola.com>.



SSAR BUSINESS

2016 Annual Meeting, New Orleans, Louisiana

The 59th Annual Meeting of SSAR took place 6–10 July 2016 in the Marriott Hotel in New Orleans, Louisiana (Fig. 1). The last time JMIH met in this location was 2006. Ichthyologists and herpetologists are always happy to return to New Orleans! Organizing societies were the Society for the Study of Amphibians and Reptiles (in conjunction with the International Society for the History and Bibliography of Herpetology), American Elasmobranch Society (celebrating its 32nd annual meeting), American Society of Ichthyologists and Herpetologists (celebrating its 96th and centennial annual meeting—ASIH did not meet 1943–1945), and The Herpetologists' League (celebrating its 74th annual meeting). The hosting institutions were Tulane University, Southeastern Louisiana University, Louisiana State University, Loyola University New Orleans, and University of Louisiana Lafayette. The local hosts were Kyle Piller (Chair), Brian Crother, Mary White, Chris Beachy (all from Southeastern Louisiana University), and Hank Bart (Tulane University). They were assisted by the following volunteers: Josh Cahal, Cody Godwin, Kory Evans-Jackson, Mallory Hirschler, Melanie Partin, Ariana Rupp, and AJ Turner (from Southeastern Louisiana University, University of Louisiana Lafayette, and Loyola University New Orleans). We thank them, and the folks from KState, for all of their hard work and another highly enjoyable JMIH.



NIGHTIME PHOTOGRAPH BY DAVID M. DENNIS

Fig. 1. SSAR Welcome poster that was provided in registrant's bags.

The meeting included 84 oral sessions (including several "lightning talks" sessions), 369 poster presentations, seven workshops (including two highly popular workshops on using "R"), and five symposia. SSAR co-sponsored a symposium with HL and ASIH entitled "Eco-Evolutionary Dynamics Across Taxa: Fishes, Amphibians, and Reptiles." Thanks to David Green and Andrew Hendry for organizing this symposium that included nine presentations. Other symposia were "Social Behavior in Reptiles: Secretive does not Mean Asocial," "ASIH at 100: Setting the Stage for the Next 100 Years," "Lessons From, and Visions For, Long-Term Studies of Freshwater Fish Communities," and "Biology and Ecology of Sawfishes." Once again SSAR ran a successful mentoring program for both herpetologists and ichthyologists. Thanks to the work of Joe Mendelson, III and Kris Kaiser, we paired six mentors with six mentees.

Social and Professional Events

The meeting kicked off on July 6th with a six-hour SSAR Board meeting. This was followed in the evening by the Presidential Travelogue. President Aaron Bauer introduced this year's speaker, José Padial (Carnegie Museum of Natural History), noting that José was an obvious choice when he considered where we hadn't had a travelogue speaker talk about for a while (Fig. 2). The title of José's presentation was "Searching for the Unknown: Herpetological Explorations in the Amazon and the Sahara." José began by saying that he doesn't have the opportunity often to highlight the best parts of his job, that is, travelling to interesting parts of the world and that he was looking forward to giving a talk that doesn't involve complicated figures and taxonomies, i.e., things he can be criticized for! José said that he had wanted to explore from a young age and it was eye-opening when he was an undergraduate student in Spain to realize that in four hours he could drive from Granada to Northern Africa. He and his brother were the first herpetologists to sample from a large area in Mauritania. As his career developed, José wanted to go to new places and discover new species. Over a three-week period, he sampled

Fig. 2. The 2016 President's Travelogue Speaker Jose Padial (center), flanked by President Bauer (L) and Kraig Adler (R).

along an altitudinal transect in the Peruvian Andes hoping to get to 15,000 ft. Although he and his team didn't get that high, they did reach 2700 m and along the way discovered 14 new species. José said that when he is doing fieldwork, he sees broad-scale patterns unfolding in front of him that are a rich source of both data and hypotheses. For example in Mauritania, he sees species adapted to a sand-dwelling lifestyle as well as species adapted to rock pools (which he described as "islands" in a sand desert). Over the years José said that he slowly became involved in conservation issues. In the last three years, he has been surveying one of the less well-known areas of the Amazon in Peru—a bamboo-dominated park that contains a large population of uncontacted human tribes. His discovery of new herp species has led to increased support for the park. José remarked that while carrying out fieldwork, he listens to the local people who have their own concerns and ideas about conservation issues. José ended his travelogue with a photograph of himself with friends at age 17 exploring areas around his home looking for herps. Decades later, he says he's lucky enough to still be doing it.

The Plenary Session opened up the first official day of the meeting for most. Kyle Piller, one of the local hosts, welcomed us to JMIH and reported that 1278 people had registered for the meeting, including 622 professionals, 619 students, and 337 SSAR members. Attendees hailed from 46 US states and 30 countries. Kyle reminded us that the last time we met in New Orleans was one year after Hurricane Katrina. Many things have changed since then. Kyle said that in the past 10 years some neighborhoods had been completely or partly rebuilt, but that there were others that would probably never be rebuilt. Levees have been rebuilt to withstand a Category 3 hurricane and a more complex water pumping system is in place. One thing that hasn't changed a great deal unfortunately is the area of wetlands, which remain small and very fragmented. While in New Orleans, we were encouraged to indulge in the food and enjoy the culture, music, history, and architecture, as well as the fish, amphibians, and reptiles.

Following Kyle's welcome, a number of awards were presented. The Robert H. Gibbs Award for Excellence in Systematic Ichthyology was presented to Melanie Stiassny. The Henry S. Fitch Award for Excellence in Herpetology was presented to George R. Zug. The Robert K. Johnson Award for Excellence in Service to ASIH was presented to long-time treasurer, Margaret Neighbors. The SSAR/HL/ASIH Meritorious Teaching Award in Herpetology was presented to Emily Taylor from Cal Poly San Luis Obispo, who was described as an exemplary teacher and whose herpetology course is referred to as "legendary." In receiving her award, Emily remarked, "this is probably the coolest award I have ever received!" The ASIH/AES Meritorious Teaching Award in Ichthyology was presented to Don Buth. PARC presented its Alison Haskell Award for Excellence in Herpetofaunal Conservation to Linda Weir. The Joseph Nelson Award for Lifetime Achievement in Ichthyology was presented to Gerald Allen. Finally, HL announced the inaugural winner of the Raymond D. Semlitsch Research Award for Early Career Herpetologists—Kristen Cecala.

The JMIH Plenary Speaker, Sylvia Earle (Founder of Deep Sea Ocean Exploration and Research Inc, Founder of Mission Blue and SEAlliance), spoke about "Exploring the Deep Frontier." She noted how humans have changed the "nature of nature" in a relatively brief period of time and advised us to be thinking about the next 100 years. In a recap of her remarkable career she commented on the difficulties of being a female scientist in the late 1960s and early 1970s. She spoke about the importance of democratizing access to the sea and warned that if we fail to take care of the natural world, nothing else matters.


Fig. 3. Attendees at the SSAR/HL Student Reception.

R. Dean Grubbs was the AES Plenary Speaker and spoke on the "Conservation Biology of Sawfishes: Is there Hope for the Most Imperiled Elasmobranchs?" He was followed by the HL Distinguished Herpetologist, Jonathon Losos, who spoke on "Known Knowns and Unknown Unknowns: Herpetological Progress in Fits and Starts." Jonathan said that when he was invited to speak he visited the HL website to look at the list of past speakers. He noted that the first speaker was Ernest Williams who spoke on "The Anoline Radiation: Unity and Variation" in which he talked about what little we know about this group of lizards and what we have yet to understand. Jonathan noted that, despite much work in the past three decades, there are still "lots of things we don't know that we don't know" (and that he never thought he would quote Donald Rumsfeld!). He then spoke about possible causes of the deep mitochondrial subdivision in the *Anolis* phylogeny, recent challenges to our understanding of territorial behavior in this group, and some anoline "oddities"—a species in which males have a moveable horn and another with a decided interest in the color orange. Jonathan finished by saying that natural history information is key to understanding this group and that there are plenty of interesting anoline questions still to be answered. Larry Allen then gave the ASIH Past Presidential Address. He was followed by Lynne Parenti and then Jay Savage who were both ASIH 100th Anniversary Speakers.

The annual SSAR/HL Student Reception, held later the same day as the Plenary Session, was, as usual, well attended. Invited professionals mingled with graduate students on the 41st floor of the Marriott in the aptly-named Riverview Room with a stunning view of the Mississippi River and the city (Fig. 3). The student reception was followed by the JMIH Opening Reception held offsite at Mardi Gras World, a warehouse where floats are made (Fig. 4). As we entered, we walked past some of the amazing floats created for Mardi Gras and other parades. Live music and food was available by the river as well as indoors where a French Quarter neighborhood was created.

A workshop on Grant Writing for Students that was organized by Jeremy Feinberg, Cat Hendry, and Greg Watkins-Colwell was held on July 8th. Approximately 35 students attended. We thank the panelists Brad Shaffer, Erin Muths, Chris Austin, Alex Pyron, Tim Colston, and Evan Eskew.

The SSAR/HL Live Auction was held in the evening on the last day of the meeting. The auctioneers were Sean Graham, Sara Ruane, and Frank Burbrink. Cat Hendry helped immensely with set up and organization. Organization was complicated this year

Fig. 4. The JMIH Welcome Reception took place at Mardi Gras World along the Mississippi River.

because we needed to keep the Ernie Liner material separate from the other donated items because of differences in the way the profits are shared with the other societies. We raised over $6,500 (including $3,460 from the auctioning of material from the Ernie Liner donation). We also had a number of other student volunteers who had a great time and worked hard. Auction co-chair Samantha Kahl says that she hopes to have them volunteer at future meetings.

Vinny Farallo (Chair, Student Travel Awards Committee) oversaw the silent auction again. Recipients of the $400 SSAR Student Travel Awards took turns to work the silent auction table for 2–3 hrs throughout the course of the meetings. The Silent Auction raised just over $780.

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Board and Business Meetings Summaries

SSAR Board Meeting

President Aaron Bauer called the Board Meeting to order at 0806 h on 6 July 2016 in the Marriott Hotel, New Orleans, Louisiana. In attendance were the following Board Members, Editors, and Committee Chairs: Kraig Adler (Editor, *Contributions to Herpetology*), Robin Andrews (Board Member, Reg. 2018), Paul Bartelt (co-Editor *Journal of Herpetology*), Aaron Bauer (President; Editor, *Facsimile Reprints in Herpetology*), Brian Crother (Chair, Scientific and English Names Committee), Tiffany Doan (co-Editor *Journal of Herpetology*), Robert Espinoza (Chair, Nominations Committee), Vincent Farallo (Chair, Student Travel Award Committee; Member, Website Subcommittee), Tony Gamble (Board Member, Reg. 2018), Lisa Hazard (Board Member, Reg. 2016), Cat Hendry, (co-Chair, Student Participation Committee), Michelle Koo (Member, Website Subcommittee), Kim Lovich (Board Member, Conserv. 2018), Joe Mendelson, III (co-Chair, Conservation Committee), Joe Mitchell (Editor, *Herpetological Conservation*), Ann Paterson (Treasurer), Marion Preest (Secretary), Al Savitzky (SSAR Representative to AIBS and BioOne), Rick Shine (President-Elect), Dustin Siegel (SSAR Rep, Meeting Management and Planning Committee), Lynnette Sievert (Chair, Kennedy Student Award Committee), Carol Spencer (Chair, Website Subcommittee), and Greg Watkins-Colwell (Board Member, Reg, 2016; Organizer, SSAR/HL Live Auction). Additional society members present included Cari Ann Hickerson and Erin Muths. Apologies were received from Alison Cree (non-US Board Member, 2016).

Introductions were made and minutes of the 2015 Board of Directors Meeting (Lawrence, Kansas) were approved. President Aaron Bauer acknowledged the hard work of Rafe Brown, Rich Glor, Kraig Adler, and others that made the 2015 Annual Meeting held on the University of Kansas such a success. Reports of officers and committee chairs were then presented and discussed.

Officers' Reports

President Aaron Bauer reported that his initial tasks during the reporting period were associated with the 2015 meeting in Lawrence, Kansas. He expressed his personal thanks, as well as that of the society as a whole, to local hosts Rafe Brown and Rich Glor and their local team, as well as to Kraig Adler (meeting liaison), and the many others who contributed to a memorable conference. At the conference itself President Bauer was engaged in the usual functions and appreciated the opportunity to speak in the plenary session about the value of SSAR membership. He indicated that during and following the meeting he was approached by many members, especially students, who were interested in taking a more active role in SSAR. Aaron voiced his opinion that the meeting in Kansas demonstrated that SSAR is capable of holding successful stand-alone meetings (i.e., not part of JMIH). Currently there are plans to hold SSAR meetings at the University of Michigan in 2020 and University of Florida in 2025.

In preparation for the 2016 New Orleans JMIH meeting President Bauer invited José Padial (Carnegie Museum) to give the President's Travelogue on his field research in the Sahara and the Amazon.

President Bauer appointed Dustin Siegel as the SSAR representative on the Meeting Management and Planning Committee. With Treasurer Ann Paterson and others, he worked to find solutions to our need to fill the Publications Secretary's office, to redefine its responsibilities, and to find a replacement for the services of ZenScientist.com. Formal bids were requested and following several rounds of feedback from the Board and editors, Christy Classi was chosen to take over membership management and at least some of the former activities performed by the Publications Secretary's office and/or by ZenScientist.com. Specifics were negotiated chiefly by Ann Paterson because of the degree of integration needed between the membership management office and the Treasurer's office. In April 2016, President Bauer signed the contract on behalf of SSAR and the transfer will take effect in Fall 2016. Other functions previously performed by Breck Bartholomew still need to be delegated. Aaron confirmed Jeremy Feinberg's appointment as chair of the Student Participation Committee and also appointed Cat Hendry to this committee. Raul Diaz was appointed chair of the Long Range Planning Committee and Greg Watkins-Colwell was appointed to chair the Membership Committee. Aaron introduced Cari Ann Hickerson, the incoming Publications Secretary. The Board approved the granting of a Presidential Award to Breck Bartholomew for his many years of service to herpetology and SSAR.

Aaron has also been working on finding a replacement for Treasurer Ann Paterson. Thankfully Ann has agreed to continue to serve until a suitable replacement has been found and she will work with that person to ensure a smooth transition. President Bauer expressed his sincere thanks to Ann for her tireless efforts as Treasurer and her many innovations to improve the operation of the Treasurer's office and of the Society as a whole. Robert Espinoza suggested that we consider having a Treasurer-Elect (as we have a President-Elect). That person would be trained by the Treasurer and gradually assume some of the duties of the Treasurer. This model (which would necessitate a change in by-laws) will be considered in the future. Treasurer Paterson remarked that the Treasurer's job will be made easier, as some of the current duties will be assumed by Christy Classi.

In preparation for the World Congress of Herpetology in Hangzhou, China in August 2016, Aaron has been in touch with the local hosts and Secretary General Elect, Xiang Ji. SSAR has been listed as a sponsoring society affiliated with the Congress and through the efforts of Kraig Adler, SSAR will be providing a free facsimile reprint and a color informational sheet in the registration materials of all delegates, as well as screening "Amphibians of the Appalachians." President Bauer also responded to and approved requests for the support of the Andalusian Reptile and Amphibian Workshop in Spain, and the Mexican Herpetological Society Meeting in Tepic, Nayarit in the form of donations of SSAR publications.

President Bauer responded to comments about the *Herpetology at Kansas* book published by SSAR and released at the KU meeting, wrote letters to the governor and state legislature of Illinois on behalf of SSAR in support of maintaining funding to the Illinois State Museum, signed an AIBS-spearheaded letter to Congress about the future of NSF on behalf of SSAR, signed the new 10-year MOU regarding SSAR's participation in the JMIH, and designated SSAR representatives (Marc Behrendt and Samantha Kahl) to an *ad hoc* JMIH committee to investigate the options for childcare at future meetings. In association with the work of the Conservation Committee President Bauer wrote and/or signed letters to the Federal Attorney General for Environmental Protection of Mexico regarding the discharge of pollutants, to the Secretary of the Interior regarding the threat of *Bsal*, to USFWS about the resultant *Bsal* regulations, and to North Carolina wildlife authorities protesting a planned alligator hunt beginning in 2016. All letters were acknowledged and the North Carolina alligator hunt was called off, in part due to letters received from SSAR and other concerned groups.

In early April 2016, President Bauer hosted a meeting with ASIH President Maureen Donnelly and The Herpetologists' League President David Green to discuss ways in which the herpetological societies could work together for the benefit of all.

Finally, he carried out routine correspondence with chairs and members of many standing committees, with officers and editors in conjunction with matters arising, and with numerous SSAR members, as well as members of the public.

Treasurer Ann Paterson reported that SSAR had a mixed financial year in 2015. However, our investments (like the market overall) were flat and membership income was still low. In her report, Treasurer Paterson summarized some key points:

1. Money was taken from restricted fund accounts and moved to the general operating account so that the funds would be available without restrictions. Previously, we have not moved these funds. This helps to show in a transparent way that funds are being used as specified, but will make the funds appear to have lost money due to the transfers.

2. Money was transferred into investment accounts in August as needed to move donations into the correct funds.

3. The budget has been overhauled to more accurately reflect our expenditures and income. The lump sum for investment income has been removed because that lumped restricted and unrestricted funds together. The investment income line in the general operating budget now represents unrestricted income only while the restricted funds are listed separately.

We had budgeted for income of $330,500 and expenses of $330,260 for 2015. In reality, our income was approximately $276,559 and our expenses were approximately $276,923, for a loss of $364. This is oversimplified, as our basic budget outline does not include directed donations and other specialized transfers. We are working to find a better way to represent funds carried from one year to another. We are not spending everything budgeted and need to evaluate how we can make our budget more accurate.

Below are summarized changes made in 2015–2016 and proposed future changes.

1. We began a system of transferring funds to and from investment accounts in August after JMIH. This will allow us to more transparently use restricted funds for their intended purpose while freeing up funds for general operating expenses as needed. While we would all like to see the restricted funds grow by leaving extra money in them, this leaves us with limited investment resources that are unrestricted in the event of budget shortfalls. Treasurer Paterson recommended that we transfer funds to our unrestricted investments at least for a while to build up our unrestricted reserves.

2. Treasurer Paterson has modified the budget so that it does not show all investment income as available for general budget expenses. In reality, much of the income is restricted and cannot be used this way. In future years, we can look at the amount of investment income in each fund compared with the amount needed to pay out awards. Ann has added a line to the general budget for restricted fund shortfalls because we will sometimes have insufficient investment income to cover all expenses (as happened this year due to lower investment returns). That line is currently low, but we can also use investment reserves to make up these shortfalls.

3. We have a new credit card processing system that has higher security and some new features, such as Apple Pay. This will be available for use in New Orleans. Christy Classi, our new membership manager, will be using the same credit card processing system as the treasurer.

4. Our relationship with the Truman Heartland Community Foundation allows contributions to be made on the foundation website, www.thcf.org, for any funds housed there. Individuals can make a one-time donation or set up a recurring donation. We need to promote donation options available through THCF, including annuities and other options for those wishing to make large gifts.

5. We now have an Amazon Smile account, so it is possible to make small donations to SSAR by shopping through Amazon Smile and choosing SSAR as the charity. However, we have only been receiving very small amounts and need to promote this more.

6. We continue to need ways to increase oversight of SSAR finances. This is something that Beverly Powell, our accountant, and Treasurer Paterson will discuss with the incoming treasurer and president.

7. We now have general liability insurance as well as director's and officer's insurance.

8. The profit and loss report and budget have been modified to more closely follow our QuickBooksPro reports. Ann hopes to set up our new QuickBooksPro 2016 to include budgets and to more easily allow tracking from one year to the next.

9. We have been sending more international wire transfers, which adds to the cost of sending funds. These are not currently included in the budget, but we may need to consider increasing the amount allocated for awards to cover these additional costs.

10. We need to carefully consider our budget, which was in the red this year. We budgeted based upon expecting higher investment returns to consider, but the market was less favorable this year. Ann regularly receives requests for additional funds and it is very difficult to turn these down because they are important to the mission of the society. However, we can't realistically continue to have unexpectedly higher expenses in multiple areas without increases in income. Ann strongly encourages all committees to carefully evaluate their budget to consider whether they really need everything that they are requesting and whether they are likely to have unexpectedly higher expenses. We need to add in all items to the budget for the board to consider so that unexpected expenses are as small as possible. We have been fortunate in being able to cover these expenses and we have substantial reserve funds in investments. However, we need to carefully think about these issues for the long-term financial health of the society. It is very easy to add expenses, but there will be substantial consequences if we continue on this pattern without increasing income.

Profit and Loss: The approved 2015 budget was balanced and despite some expenses going over budget, most of our expenses were under budget. We received a profit on the KU meeting but have not yet received the funds, so that income is missing from the profit and loss report until we receive it.

Investments: The Society's investments were stable with some decrease during 2015, in keeping with the trends in the global market. The overall numbers were higher due to the addition of funds, not due to market growth. The total market value as of 31 December 2015 was $769,318 (compared with $737,166.49 at the end of 2014). The value has been relatively stable in 2016. The funds have gained $3,738 so far this year (investment gains minus administrative fees). However, we had to withdraw funds from the reserve to pay for publication printing at the beginning of 2016. Additionally, funds were deposited for the Metallinou Fund. This gives a total balance of $751,974.52 as of April 2016.

Secretary Marion Preest provided Officers, Editors, and Committee Chairs with minutes of the 2015 Board Meeting and summarized the 2015 Annual Meeting for publication in *Herp. Review*. She compiled the 2016 Annual Report, prepared agendas for the Board and Business Meetings for the 2016 JMIH, and was again involved in organizing a reception for student members of SSAR and HL to be held at the Annual Meeting. Marion called for input and votes from the Board on various issues, e.g., membership management options, matters relating to the upcoming resignation of the Publications Secretary and the Treasurer, etc. She circulated conflict-of-interest documents for Board member signatures. She confirmed eligibility for participation in various student activities, e.g., Travel Awards, Seibert Awards, etc. Marion regularly updated the SSAR letterhead to reflect changes in personnel. She also informed the Editors of *Journal of Herpetology* and *Herp. Review* of these changes and provided various updates for the Web Oversight Committee. She wrote letters to student winners of various awards and prepared announcements for publication in *Herp. Review*. She also dealt with many emails and phone calls from SSAR members and the general public and served on the Long Range Planning Committee, Nominations Committee, and the Mentorship Committee.

Publications Secretary Breck Bartholomew reported that during 2015 there was a push to sell off as much of the SSAR book inventory as possible. Many books were offered at greatly reduced prices and several books were remaindered. This effort resulted in much better sales than we have seen in recent years. However, although books remain on sale, the total sales for 2016 (through May 12) have been relatively stagnant. None of the books published in the last five years were offered to remainder book dealers. Some of these books were included in the sale. These titles make up the bulk of the remaining inventory, along with some of the foreign language Facsimiles. In addition, multiple copies of several circulars remain in inventory.

The Publications Secretary then discussed various issues that need to be dealt with before he steps down effective at the end of 2016. Most of the duties previously performed on behalf of *Herp. Review* have been taken care of. Ruthe Smith is working as a subcontractor to email pdfs to authors and index each issue of *Herp. Review*. The only remaining duty is billing advertisers for ads in *Herp. Review*. Currently the Publications office is billing page charges for the *Journal of Herpetology*. Previously the Treasurer was doing this, but it was switched to the Publications office a few years ago. Breck suggests that the Treasurer or Christy Classi picks up this duty.

Back issues of both journals need to be housed and mailed to members who join late in the year, or who receive damaged copies. Breck suggests this would best function as part of Christy Classi's duties since she will have the membership list and will be managing memberships. Another option would be for the society to change the membership period from the calendar year (January through December) as it currently stands, to an annual membership beginning on the date paid (e.g., May 12, 2016 to May 11, 2017). This latter type of membership would never require back issues to be mailed, since no membership would be "late." Lost or damaged copies would still need to be replaced.

Finally, the publications office has been submitting the print quantities for both journals. This has normally been based on the previous year's final membership numbers. Breck has tried to print 50–75 extra copies for replacement copies and back orders. Generally this number is more than enough, but occasionally we have run out of individual issues. Print quantity obligates the society financially, so Breck recommends that someone in a long-standing position within the society (Treasurer, Secretary, or Editor of one of the journals) take on this responsibility. Aaron recommended that these extra copies be kept at Allen Press for one year and then be sent to the Publications Secretary.

Breck considers that perhaps the most important website issue concerns the pdfs of *Herp. Review*. Currently the articles published in *Herp. Review* are member-access only. This allows SSAR to sell online-only *HR* subscriptions. These *Herp. Review* articles are also available to all other online memberships. It would be possible to move all of the contents of *Herp. Review* to open access.

In addition to the member access pdfs, the society has several open access pdfs which have been stored on the ZenScientist website. These include *Herp. Review* (complete older issues, and current sections other than the articles) and *Catalogue of American Amphibians and Reptiles* (open access with all accounts and indexes available on the ZenScientist website). All of these files need to be moved to the SSAR website before the end of the year. The Website Committee will work with Breck's office to make the transition from ZenScientist to the SSAR website. Providing a moving window for five-year access to *Herp. Review* online for members is problematic. A question was raised as to whether our membership numbers might decline if open access was provided. Google analytics might allow us to track numbers of members and non-members who access *Herp. Review* online.

The ZenScientist website has some other items that might be of interest for the SSAR website. These include some group photos of past meetings, satirical journals (*Journal of Tautology, Herpervertological Review*, etc.) issued at past meetings. Of perhaps less interest are photos and historical letters.

Currently, SSAR publications are advertised on SSARbooks.com. This website costs about $40 per month and is designed specifically for bookstores. If SSAR continues to maintain a publications office, Breck recommends maintaining this website.

Items donated to SSAR (Hutchison Library, Conant Library, and other small collections) as well as the Liner Collection—donated to SSAR, HL, and ASIH—need to be dealt with. Previous discussions have concluded that it is highly unlikely that anyone will be found who is willing to sell off these collections on behalf of the societies. It is also questionable how much value these donations have in today's market. Prior to 2008, books maintained a solid and increasing value. Since that time the market has changed substantially and it is difficult to sell most books. The sale of journals and reprints is even more difficult. Kraig Adler mentioned that the sale of the first three libraries donated to SSAR did not involve the Publications Secretary and that perhaps we return to this model. Aaron expressed hope that it will not be necessary to move donated items to the location of the new Publications Secretary. Further, he indicated that he has asked Breck to contact authors of books published more than five years ago and for which we have more than 250 copies on hand, and inform them that, for the cost of postage, they are welcome to purchase all but a few copies of their books. We must make every effort to reduce our stock of books. Kraig Adler reported that he and Breck are working on a plan to send SSAR publications to regional and national herp societies (for the cost of postage) as a way of reducing stock and raising the profile of SSAR.

George Pisani reported that he again filed SSAR's annual corporate report with the Office of the Kansas Secretary of State.

Editors' Reports

No report was submitted for *Catalogue of American Amphibians and Reptiles*.

Kraig Adler, Editor of *Contributions to Herpetology*, reported that "Herpetology at Kansas: A Centennial History," by William E. Duellman was published in 2015 and softbound copies were presented to all registrants at the SSAR meeting in Lawrence. Expected to be published in 2017 is "Salamanders of Japan," by Ikio Sato (1943), a translation into English. This classic work covering Imperial Japan (Japan, Taiwan, Korea, and part of Sakhalin Island [Russia]) was written in an old form of Japanese that uses now-obsolete Chinese characters and is not intelligible to most Japanese today. As a result, it contains a great deal of natural history that has not been accessible to scholars. A grant for US $55,000 was obtained from the Seidell Program at Smithsonian to cover the costs of translation by Richard Goris. Goris is an American who has lived in Japan since the early 1950s, and is the author not only of several herpetological books but also of the best-selling Japanese-English dictionary.

Kraig reported that the following are anticipated in 2018 and beyond: "A Guide to the Snakes of the Philippines" by Rafe Brown, Alan Leviton, Maren Gaulke, and Arvin Diesmos, "Contributions to the History of Herpetology, Bibliographic Appendix," edited by Kraig Adler, and "Field Guide to Amphibians and Reptiles of the West Indies" by S. Blair Hedges.

Aaron Bauer, Editor of *Facsimile Reprints in Herpetology*, reported that activity this year has again been associated with progress on the production of "The Collected Herpetological Works of Giorgio Jan" with an introduction, annotated bibliography, and extensive systematic comments by Roy McDiarmid and Jay Savage. The work includes a near full-sized facsimile of the *Iconographie Generale des Ophidiens* and Jan's other herpetological works. Aaron plans to advertise the book in Fall 2016 with a late 2016 publication.

Aaron reported that Cantor's *Zoology of Chusan* (1842) and his *General Features of Chusan* (1842) will be prepared as a facsimile give-away for the World Congress of Herpetology, to be held in Hangzhou, China in 2016. Kraig Adler as guest editor has completed the preparation of the facsimile and provided an informative introductory text.

Planned for 2017 is *The Collected Herpetological Works of J. V. Barboza du Bocage (1823–1907)* with an introduction, annotated bibliography, and data on types by Luis Ceríaco. The facsimile will include approximately 150 manuscript pages of new material dealing with Bocage's life and works, his complete bibliography, and short accounts for each of the 104 species of amphibians and reptiles he described.

Beyond 2017, *The Herpetological Contributions of John Edward Gray* is expected. Although SSAR has reprinted a number of Gray's larger works, many shorter papers, including many from *Annals and Magazine of Natural History* and *Proceedings of the Zoological Society of London*, as well as extremely rare herpetological sections of numerous voyages, remain difficult to access. In all, approximately 200 individual papers will be included. Papers are currently being collected for this work and a previously published bibliography is being updated and corrected.

Other titles that are under consideration for future facsimiles are *The Herpetological Contributions of Lönnberg and Andersson* and *Zur Entwicklungsgeschichte und Anatomie der ceylonesischen Blindwuehle Ichthyophis glutinosus* by Sarasin and Sarasin (the former chiefly in English, Swedish, and German). An English translation of J. G. Schneider's *Historia Amphibiorum* (1799, 1801) is also currently in preparation as a potential facsimile reprint. A new proposal has been received to reprint the 19th century German language herpetological works of Heinrich Rathke, dealing chiefly with the development of reptiles. This project may be feasible if funding from German sources can be obtained.

John Moriarty, Editor of *Herpetological Circulars*, reported that in 2016, five previously published Circulars were converted into e-books. The titles are: #35: A Review of Marking and Individual Recognition Techniques for Amphibians and Reptiles; #39: Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico; #40: Standard French Names of Amphibians and Reptiles of North America North of Mexico; #41: Collecting and Preserving Genetic Material for Herpetological Research; #42: Herpetological Collecting and Collections Management

The Chair of the Standard English and Scientific Names Committee, Brian Crother, indicated that he hopes for a hard copy of the names list in 2017 and will contact Moriarty. John plans to convert older, out-of-print *Herp. Circulars*, which have not already been digitized, into PDFs and make them available on the SSAR website.

Editor of *Herpetological Conservation*, Joe Mitchell, reported that there was no movement on this series during the past year. However, he is aware of a book-length manuscript in the final stages that would be suitable. It might be possible to convince the authors to consider publishing under *Herp. Conservation*.

Robert Hansen, Editor of *Herpetological Review*, reported that Volume 46 (2015) was similar in length to publications in the previous two years. Volume 47 (2016) is projected to consist of roughly the same number of pages. *Herpetological Review* continues to publish in full color at no charge to authors. Bob reports that he has moved all of the smaller contributions (geographic distribution notes, natural history notes, book reviews, etc.) to Open Access. Full issues outside of the most recent five-year window are also Open Access via the ZenScientist web site.

As is typical, the *HR* staff experienced some turnover during the last year. New personnel includes William Lamar (Section Editor, Glimpses of the Past), Jen Stabile (Section Editor, Conservation), Ken Dodd (Book Review Editor), Matt Allender (Associate Editor for Diseases), Sean Doody (Section Editor, Natural History Notes), and Chan Kin Onn (Copy Editor). Bob thanked Elizabeth Timpe (Copy Editor), Priya Nanjappa (Section Editor, Conservation), Alan Richmond (Section Editor, Geographic Distribution), Charles Linkem (Section Editor, Natural History Notes), and Aaron Bauer (Book Review Editor) for their excellent service. In particular, Bob wants to acknowledge Aaron Bauer's long and excellent tenure as our Book Review Editor. Aaron took on this position in 1991 at the same time Bob became Editor. Aaron's obvious passion for books and his impressive network of international connections made for an outstanding book review section. Bob considers himself very fortunate in working with Aaron during this period.

Tiffany Doan and Paul Bartelt remain as Co-Editors of the *Journal of Herpetology* (*JHerp* hereafter) Erin Muths and Gad Perry are winding down their roles as outgoing co-editors, and they continue to handle papers submitted in 2013 and before. Erin Muths is now an associate editor for special invited perspective papers. The editorial office remains at Waldorf College.

The Associate Editor roster at the end of 2015 through the first few months of 2016 contained 13 continuing AEs: Neil Bernstein (US), Phil Bishop (New Zealand), Xavier Bonnet (France), Rafe Brown (US), Russell Burke (US), Jennifer Gillette (New Zealand), Evan Grant (US), Nancy Karraker (US), Edgar Lehr (US), Marc Mazerolle (Canada), R. Graham Reynolds (US), John Rowe (US), and Reid Tingley (Australia); both co-editors also function as AEs. Brian Greene (US), James Harris (Portugal), Hinrich Kaiser (US), Frank Mazzotti (US), and Stephen Tilley (US) resigned. David Chapple (Australia), Steve Corn (US), Rocky Parker (US), Christopher Salice (US), James Watling (US), and Erik Wild (Brazil) have resigned but are continuing to finish revised manuscripts. Jake Brashears (US), Rafael de Sa (US), Matthew Heinicke (US), Blake Hossack (US), Russell Ligon (US), and Timothy Lewis (US) came on as new AEs during 2015 and the first half of 2016. Juan D. Daza (US) is currently serving as a guest AE for a special section on Gondwanan lepidosaurs. Paul Andreadis remains the Index Editor for the Journal. The Editorial Board continues to be composed of Brian Crother, David Cundall, William Dunson, David Green, Diana Hews, Joe Mendelson III, James Petranka, Rick Shine, Brian Sullivan, Gregory Watkins-Colwell, John Wiens, and Dawn Wilson.

The addition of six new AEs was critical to maintaining the AE pool. Tiffany and Paul would still like to add one or two more AEs, especially those who specialize in reptile ecology or systematics. They are especially interested in expanding representation of AEs from countries other than the United States.

During 2015 there was a higher submission rate to *JHerp*. than 2014, but lower than all of the other years for which Tiffany and Paul have data. Submissions so far for 2016 (69 as of the middle of May) are much lower than the number submitted during the same period in 2015 (110). The overall reduction in submissions is a source of concern. This low rate of submission has caused them to make the issues of the current volume smaller and has also reduced the wait time from acceptance to publication. Rejection rates have risen from last year to a more typical level. Tiffany and Paul are happy to report that the amount of time needed to reach initial decisions decreased in 2015 to its lowest level since implementing online submission; days from receipt to final decision also declined to about four months. The number of colleagues who are contacted before the needed number of willing reviewers remains high. The turnover in AEs has produced more efficient manuscript processing in general.

In Volume 50 the wait between acceptance of a paper and publication ranges from 4–13 months, with the average less than 9 months. However, thanks to "Online First," readers have access to a near-final pre-print within weeks of acceptance.

Tiffany and Paul reported that they are planning continuous publication of manuscripts accepted by *JHerp* starting in March 2017. Kraig Adler indicated that he thought this could provide a good opportunity to advertise the journal and the society.

During 2015 Tiffany and Paul received submissions from 29 countries, which is higher than last year but lower than all of the years from 2009–2013, which had 33–48 countries represented. The leading countries from which manuscripts originate remain the US and Brazil (ranks both countries have held since data became available in 2006). According to the AP "Member Submissions" report, 36% of all submissions in 2015 had one or more authors who are SSAR members, with 64% having none. This remains virtually unchanged since 2010, despite the 2013 decision that members do not need to pay page charges.

The quality of *JHerp.*, as reflected by the ISI Impact Factor and total citations reported for 2014 (reported in June 2015, the latest data available), ranks 100th out of 153 in the Zoology category, with an Impact Factor of 0.832, falling further behind Copeia (1.034), Herpetologica (1.140), and Herpetological Monographs (1.727).

Over the past few years the co-Editors have implemented a number of new features. They report:

Volume 50 special features.—2016 marks the 50th volume of *Journal of Herpetology*. To commemorate this milestone we have implemented many changes to the look of the journal and special features for each of the four issues. Thanks to input from Kraig Adler, in Volume 50 we have a gold cover with changing artwork for each issue, which features a copy of a historical cover of the journal juxtaposed with a beautiful photograph. We also solicited special content for each issue including a history of the journal by Kraig Adler, an invited perspective by Pat Gregory, an editorial about herpetological ethics by Gad Perry, and an essay about the future of the journal by Richard Seigel.

Open Access.—After the 2015 board meeting we worked with BioOne and Allen Press to institute an open access option. Authors may purchase open access for $150 per article. We have also designated Kraig Adler's history article as open access and will be designating Gad Perry's ethics editorial as open access in the September issue.

Twitter Account.—In March 2015, we started a twitter account for the Journal, @JofHerp, where we tweet about new journal issues, special sections, and other herpetology news. We reached over 1,000 followers in May 2016.

Standing Committee Chair Reports

Incoming chair of the Conservation Committee, Joe Mendelson III, reported that he had worked closely with co-chair Betsie Rothermel, to accomplish two objectives in the past year. They submitted a letter of opposition to North Carolina Wildlife Resources Commission regarding a proposition to allow a sport-hunting season for American Alligator. All biological evidence indicated that the marginal populations there would not support such sustained pressure. The NCWRC did not approve the proposed hunts. Working with a particularly broad set of informal collaborators and PARC, HL, ASIH, Canadian Herpetological Society, Amphibian Survival Alliance, and Amphibian Ark, Joe participated in lobbying efforts with USFWS to support implementation of the Lacey Act to restrict importation and interstate transport of many salamander species. This extraordinary measure was deemed necessary in light of the impending threat of the newly discovered pathogen *Batrachochytrium salamandrivorans*, in Europe. While somewhat controversial among stakeholders in the pet trade and zoos, the measure was ultimately passed. In the future, the Committee anticipates focusing on the few remaining rattlesnake roundups in the southeastern United States. Kraig Adler commented that he thought this was one of the most eventful years yet for this committee and commended them for their work.

Joe Beatty, Chair of the Dean Metter Award Committee, received 8 applications this year for the Dean E. Metter Memorial Award. All applications were of high quality and choosing an awardee proved to be challenging. That said, the committee was unanimous in recommending Matthew McTernan for this year's award to President Aaron Bauer. Matt is a master's student with Roger Anderson at Western Washington University in Bellingham, Washington. He has requested funds from SSAR to be used to complete his final season of field work in Washington State, where he is comparing the behavior and physiology of a single subspecies of the lizard, *Sceloporus occidentalis*, in three different climatic zones in Washington. His research incorporates both a field component as well as laboratory work on behavioral and physiological differences across the three populations.

The 24th annual Seibert Awards Competition (Rafe Brown, Chair) was run at the 58th Annual Meeting of SSAR in Lawrence. There were 69 eligible presentations. The Seibert Award winners for 2015 were: Systematics/Evolution: **Carl Hutter** et al. (University of Kansas), "Molecular systematics of Malagasy bright-eyed tree frogs (Mantellidae: *Boophis*), with discussion of the evolutionary history of breeding strategies." Ecology: **Nick Huron** et al. (University of Oklahoma), "Community assembly of a morphologically diverse skink genus (*Brachymeles*)." Conservation: **Tyler Hoskins** (Miami University), "Tracking the legacy of larval atrazine exposure throughout the lifecycle of Blanchard's cricket frogs (*Acris blanchardi*)." Physiology/Morphology: **David Penning** et al. (University of Louisiana at Lafayette), "The ontogeny of constriction in the ball python (*Python regius*): performance, experience, and growth." All winners received a check for US $200 and a book from CRC Press.

Honorable mentions were: Systematics/Evolution: (1) **Jesse Grismer** (University of Kansas) "The great exchange: dispersal, vicariance, and biogeography of the Draconinae", "Phylogenetic relationships of South African geckos in *Pachydactylus geitje* species complex (Squamata: Gekkonidae)," (2) **Pascal Title** (University of Michigan) "Spatial macroevolutionary patterns in Australian squamates," (3) **Alexa Warwick** (Florida State University) "Natural replication for testing the influence of landscape processes on genetic structure in the Pine Barrens tree frog," and (special undergraduate honorable mention) "**Matt Buehler** (University of Kansas) "The phylogenetic placement of *Ogmodon* (Elapidae) and a discussion of colonization patterns of Fijian squamates." Ecology: **Alex Rohtla** and Aaron Bauer (Villanova) " The call of the gecko: an acoustic and morphological examination of gecko vocalizations." Conservation: **Daniel Quinn** et al. (Truman State University) "Site fidelity and survivorship of headstarted gopher tortoises (*Gopherus polyphemus*) used to augment depleted populations in managed areas." Physiology/Morphology: (1) **Melissa Van Kleeck** et al. (University of Hawaii at Manoa) "Prey-associated head-size variation in an invasive lizard in the Hawaiian Islands," and (2) Anil Zacharia, **Robin Abraham**, Sandeep Das Jayan and Ronald Altig (University of Kansas) "Reproductive strategy of *Nasikabatrachus sahyadrensis* (Anura: Nasikabatrachidae), the only extant member of an archaic frog lineage."

Scott Boback (Chair, Herpetological Education Committee, HEC) reported that the other members on the HEC this year were Dora Pinou, Lynn Haugen, Alan Richmond, and Brad Shaffer. Brad was the recipient of the 2015 Meritorious Teaching Award in Herpetology (MTAH) and was asked to serve on the committee as has been our policy. Scott has suggested to the committee that we modify this policy in future years. He suggested the previous awardee be invited, but should not be expected to participate on the committee.

In 2014–15, the previous chair (Craig Guyer) diligently created documents describing operating procedures for the chair and committee members. These have been posted online for the committee via OneDrive and have been quite helpful with this year's activities. These will be updated and modified as the committee evolves.

The largest project by the HEC this year was the MTAH sponsored by The Herpetologists' League, the Society for the Study of Amphibians and Reptiles, and the American Society of Ichthyologists and Herpetologists. This year the committee solicited nominees for the 2016 MTAH in the society journals although it was unclear which journals actually printed the solicitation. The call was also posted on all three of the societies' websites. The committee received three new nominations this year. In April, Scott provided the committee with materials from six candidates (three were holdovers from previous year's submissions). The winner of the 2016 MTAH will be recognized during the Plenary Session at the JMIH in New Orleans and will be presented with both a plaque and a check for $500.

The HEC has discussed a number of ways of improving the selection process for the MTAH. Some of the issues discussed include considering diversity among our candidates as well as number of years of eligibility remaining. Both of these were used in considering candidates this year. Another issue was raised as to how nominators may sometimes be unaware of the status of their submission. The HEC has plans for improving this communication so that the nominators are aware of the status of their submission.

During this past year, the status of the Herpetology Hotline was brought to the attention of the HEC chair. Currently, the Hotline is operated by Greg Watkins-Colwell. The number of Hotline submissions has increased slightly (averaging 10 per week) and managing the Hotline has become challenging. In May 2016, the chair of the HEC called a Skype meeting with previous members of the committee (Greg Watkins-Colwell, Joe Mendelson) and President Bauer to discuss ways to improve the Hotline. During this meeting we also discussed a mechanism for replacing individuals on the committee. It was decided that each year one of the presidents of the three societies will nominate a new committee member. This will rotate among the societies. Each year, the chair of the committee will rotate off the following year. Therefore, regardless of whether former recipients elect to serve on the HEC, we should be able to maintain committee membership with this rotation mechanism. During the 2016 JMIH, the HEC will meet to discuss a number of issues. Scott has invited other herpetologists who maintain web blogs to discuss additional ways to improve the Herpetology Hotline.

The Kennedy Award Committee (Lynnette Sievert, Chair) has completed its work for Volume 49 of the *Journal of Herpetology*. The Committee has selected "Niche partitioning at local and regional scale in the North African Salamandridae" by Daniel Escoriza and Jihene Ben Hassine, Vol. 49:276–283. The Kennedy Award carries with it a cash prize of US $200 or the winner's selection of any SSAR publications valued at twice that amount. The committee invites all student members of the Society to submit their work to the *Journal*, and encourages regular members who supervise the work of students to draw this award to the attention of those students.

Dustin Seigel (SSAR Rep, Meeting Management and Planning Committee, MMPC) reported that the committee met 30 March 2016 to 2 April 2016 in New Orleans, Louisiana, at the New Orleans Marriott to schedule and observe venues for various events. The MMPC discussed whether JMIH should offer childcare services during the meeting. Subsequently, KState was asked to solicit bids. Reserving a service would cost JMIH approximately $6,400. The service would then charge $55 for half-day care per child. The MMPC thought that this was too much of a financial burden and potential liability to the societies and consequently chose not to provide childcare services in New Orleans. The SSAR Board discussed providing childcare at meetings. The Board recognized the importance of childcare for many of our members and was in favor of continuing to investigate the matter. There was some discussion of having the JMIH Welcome Reception off site, i.e., necessitating a bus trip. These are costly, and lines to board the buses are often very long. Additionally, the SSAR/HL Student Reception often precedes the Reception and wanting to be on one of the first few buses means leaving the Student Reception early. It was suggested that we could push back the time of the Welcome Reception or consider issuing tickets for buses so you would know to which bus you are assigned and when you would need to begin lining up.

Austin, Texas is the location for the 2017 JMIH. Two sites were discussed for the 2018 JMIH meeting: Rochester, New York and Hartford, Connecticut. Rochester was the cheaper bid and the committee seemed to lean more toward the Rochester location. The decision was delayed pending more information on meeting space and finding a local host for the meeting.

One symposium, sponsored by HL/SSAR/ASIH, is scheduled for the 2017 JMIH: "The Science, Management, and Policy of Amphibian Conservation: Extending the Legacy of Ray Semlitsch." The MMPC discussed the lack of symposia being offered and the procedures for soliciting symposia. There is a need for a common symposium submission form for JMIH.

In November 2015, President Bauer appointed Greg Watkins-Colwell as Chair of the Membership Committee and charged the committee to work with the Student Participation Committee. In the intervening months some progress has been made. Kingsnake.com agreed to give SSAR banner ads on the site for free. Four different ads (which vary by size) are now in rotation on the site. Kraig Adler made membership flyers to be shared at various events. He also shared a PowerPoint presentation on SSAR that could be used by members who give talks at regional meetings or as add-ons to any public presentation. Additionally, the chair is seeking new individuals willing to serve on the Membership Committee, especially individuals from outside North America. The Board had its perennial discussion of why membership is important, especially for students and what can be done to encourage students to become and remain members.

No report was received from the Mentorship Committee. Robert Espinoza, Nominations Committee Chair, reported that a full slate of nominees is available for the 2016 election. The following individuals have agreed to run:

President-Elect: Martha Crump, Stanley Fox, C. Richard Tracy
Treasurer: Kim Lovich
Secretary: Marion Preest
Board (Regular): Raul Diaz, Chris Gienger, Ann Paterson, Melissa Pilgrim, Dustin Seigel, Greg Watkins-Colwell
Board (Conservation): Lee Fitzgerald, Toby Hibbits,
Board (non-US): Jacqueline Litzgus, Hidetoshi Ota

Espinoza suggested that candidates (especially candidates for President-Elect) be asked to submit a statement outlining why they wish to run for a particular position. The Board approved this recommendation. (See election results, p. 731.)

Resolutions were presented at the SSAR Business Meeting in Lawrence in 2015, and these have been published in *Herpetological Review*.

Josh Kapfer (Chair, Roger Conant Grants-in-Herpetology Committee) received 47 proposals (substantially fewer than in the past three years). Most applications were in the "Travel" category. No awards were made in the "Undergraduate" category.

The winners each received $500 and they are:

Conservation:

- Andrew Gygli (University of Wyoming): "Comparing efficacy of eDNA vs. visual surveys for amphibian monitoring"
- Zachary Adcock (Texas State University): "Evaluating environmental DNA (eDNA) as a survey technique for federally listed Central Texas *Eurycea* salamanders"

Education:

- Natalia A. Maruscak: "Education and outreach program for conserving amphibians in agroecosystems of the Pampean Region (Argentina)"

Field Research in Herpetology

- Joseph Baecher (Eastern Kentucky University): "Fine-scale microhabitat factors influencing terrestrial amphibian diversity in a low-elevation old growth forest in Central Appalachia"
- Mark Sandfoss (University of Florida): "Rates of water flux in a unique insular population of pitviper"

International Research in Herpetology

- Samantha Garza (Seoul National University, Korea): "Natural history of an evolutionarily distinct Asian plethodontid salamander."
- Lee Raye (Cardiff University, United Kingdom): "The pre-industrial evidence for pool frogs in Britain".

Laboratory Research in Herpetology

- Gillian Larson (California State University, Northridge): "Climatic adaptation of an invasive gecko: rapid adaptive evolution or developmental plasticity?"
- Miranda Strasburg (Miami University): "Effects of pesticides on parasitic infections in amphibians through alteration in behavior"

Travel

- Maggie Hantak (Ohio University): “Color polymorphism and ecological divergence in the red-backed salamander, *Plethodon cinereus*”
- Alexander Shepack (Southern Illinois University): “Back from the brink? Rebounding amphibian populations with an enzootic pathogen”

In light of the resignation of Publications Secretary, Breck Bartholomew, the website committee (Chair, Carol Spencer) strategized ways of replacing the functions of Breck’s office in a web-friendly manner, such as e-commerce and online orders. They assisted by contacting other vertebrate organizations (e.g., AOU, ASM) to find out how they are handling membership services. They put Treasurer Paterson and President Bauer in contact with Christy Classi, who runs membership for ASM as a contractor. Due to satisfactory reviews and the comprehensive services she can provide, Christy will take over membership services for SSAR. The website committee also started migrating the digital assets like journal PDFs and other materials from Breck’s ZenScientist site to the SSAR website. All freely available PDFs will be moved by 31 December 2016. The Committee aims for convenient online access to membership updates and activities, and downloads of PDFs and publications. Future plans by the website committee for 2016 include planning and beginning to implement a file management system linked or hosted on the SSAR website to allow download of the materials (e.g., PDFs) that are freely available, and to develop or plan for, a membership-only section for PDFs, publications, and material downloads. The website committee is still in the process of evaluating file management systems.

Other tasks that were completed in 2015 were final updates to the SSAR website, including setting up automated backups of the site to Dropbox and final implementation of the CNDB (North American Species Names Database). Most of these SSAR website and CNDB database features were written about extensively in the previous report submitted in June 2015. CNDB can be viewed at http://ssarherps.org/cndb/. Tasks completed from June–December of 2015 include finishing CNDB editing features and addition of image links to CalPhotos for each species.

The Website committee would like to emphasize that the SSAR website is a community resource that allows members and committee chairs to edit and update content. Likewise, the North American Species Names database (Common Names Database- CNDB) can be edited easily by section editors and SSAR committee members. The committee can make specific logins for these pages so that committee members can have access and update their committee-specific SSAR web pages and even add Latest News and Events. Currently, Website committee members usually make these edits (with a few exceptions), but it would be easier and faster for all concerned if SSAR committee members updated their own pages regularly. Contact Carol Spencer or Michelle Koo to obtain a WordPress or CNDB login.

Vincent Farallo was the “Herp Hipster” (aka website coordinator) from July 2015 until June 2016. His activities included regularly checking the SSAR Gmail account and forwarding these messages to people capable of addressing questions and issues, or answering questions himself. On average, he dealt with approximately five emails per week, in addition to responding to requests for making posts or changes/edits to the website from the co-chairs or other SSAR committee chairs. Having a sole point of contact for these requests, often of a timely nature, allowed for immediate response. Vinny also recruited, and trained when needed, other student members to write blog posts and maintain social networking through Facebook and Twitter. Vinny developed a Googledoc set of instructions on how to write blog posts for SSAR. Nicole Angelli contributed regular posts to the website detailing natural history notes from the upcoming issues of *Herp Review*. Dan Paluh contributed posts to Facebook as well as posts to the website. Sarah Manka and Abbigail Nicholson helped post herpetology related content to the SSAR Twitter account. Elyse Freitas has been helping to gather information from the *Herp. Review* Facebook page so that we can ultimately merge it with the SSAR Facebook page to help centralize our social media presence. Todd Pierson is taking over as Herp Hipster for the Website committee starting 1 July 2016.

SSAR’s Facebook page is “Liked” by 9,169 people who are 59% male and 40% female. 3,854 Facebook friends reside in the U.S., followed by 521 and 513 from the U.K. and Mexico; 931 people were added since 15 July 2015. The Website Committee posts on average four times per month, and the posts were viewed more than 30,000 times. The top four posts for the year were: 1) Copperhead Institute video, (2) Meritorious Teaching Award announcement, 3) Predation by Bass on Five-lined Skink, 4) US Salamander ban and information for owners/scientists

Brian Crother, Chair of the Standard English and Scientific Names Committee, reported that there has been no activity this past year. However, with the approval of the board, the committee feels a new paper edition (8th) is due. The 5th was published in 2000 with an update in 2003. The 6th came out in 2008 and the 7th in 2012. The Committee will begin work Fall 2016 with an expected publication date in 2017.

Jeremy Feinberg (co-Chair) provided a report on the activities of the Student Participation Committee (SPC). 2015 was a transitional year following several years of reduced activity within the committee. To help reinvigorate the SPC and bolster its future success, efforts were made to clearly define its goals and streamline the transition process for new chairs. Unlike other committees that are typically chaired by more experienced members of the Society, the SPC tends to draw upon students to fill the position. Given this, a “manual” was developed to aid new SPC chairs. This guide is intended to help incumbents hit the ground running and maximize their impact especially as tenures may be shortened due to turnover as students graduate and move on.

Other work in 2015 included developing ideas for student retention and also keeping an eye towards the future by focusing on one of the most important goals of the SPC—organizing and running an event to help engage students and encourage their increased participation. To this end, and with much help from Cat Hendry (Committee co-Chair) and Greg Watkins-Colwell, a new student workshop was proposed for the 2016 JMIH in New Orleans. This workshop will be titled Grant Writing for Students and will feature panelists from a variety of successful grant-writing backgrounds, including a few graduate students as well as several career-level panelists with expertise ranging from NSF funding to other federal and/or state sources and even private foundation grants. This will be a lunchtime event and will include pizza for those students in attendance. Cat Hendry will take over as Committee Chair in 2017.

Tffany Doan (Chair) announced that the fifth annual student poster awards, now named the Victor Hutchison Student Poster Awards, were presented at the 58th Annual Meeting of the SSAR in Lawrence. There were 37 eligible posters. The Victor Hutchison Award winners each received a check for US $200 and a book from CRC Press. The winners were: Evolution, Genetics, & Systematics: **Aaron Griffing** (Villanova University) "Postnatal ontogeny of parafrontal bones in the Sphaerodactylidae." Conservation & Management: **Peter Delgado** (University of Puerto Rico-Rio Piedras) "Is climate warming responsible for the elevation range shift of the tropical tree frog, *Eleutherodactylus portoricensis*." Ecology, Natural History, Distribution, & Behavior: **Ellee Cook** (University of Missouri) "Is bigger always better? Evaluating individual differences in territorial behavior in female *Anolis gundlachi* lizards."

Vincent Farallo (Chair, Student Travel Awards Committee) reported that only ten applications were received for the 12 available awards of $500 to help fund student travel to the 2015 SSAR meeting in Lawrence Kansas. After an announcement was sent out to students who had already registered, an additional 24 applications were received. This was during the infancy of the new website which is why Vinny believes we received so few applications by the first deadline. At the time of this report the deadline for the 2016 award had already passed and 32 applications were received. The 32 applicants were the most received (by the initial deadline) since the World Congress of Herpetology in 2012. Vinny attributes the increase in applications this year to the new website and the ability to easily post news directly to Facebook and Twitter.

The main role of the Student Travel Awards Committee continues to be to accept applications for the award and coordinate with the awardees to supervise the silent auction table at the annual meeting. Details of the travel award are presented on the SSAR website and are regularly updated to ensure students have current information.

As there was not an election held in 2015, there was no report from the Election Officer, Dan Noble.

Greg Watkins-Colwell, Chair of the Live Auction Committee, reported that in 2015 the SSAR Live Auction was held in the Oread Hotel in Lawrence, Kansas. SSAR split neither proceeds nor responsibilities with any other society, thus all proceeds went to fund SSAR student travel awards. Auctioneers for 2015 were Joe Mendelson III, Frank Burbrink, John Moriarty, Richard Glor, and Greg Watkins-Colwell. Students assisting the live auction were Krista Mougey, Megan Smith, Catriona Hendry, John Phillips, Elyse Freitas, Kai Wang, and Stuart Neilsen. Efforts were made to include as many different auctioneers (with different auctioning styles) as possible. Humor and "unique" items were also part of the night's festivities adding to the levity. The auction maintained a large audience late into the evening.

Vinny Farallo remains as chair of the Silent Auction Subcommittee. Mike Jorgensen has stepped down. The auction items were set up in the same room as the Live Auction viewing room. This facilitated increased security of live auction items, while also providing for personnel to answer questions about either set of auctions. Once again, each of the ten recipients of the $500 SSAR Student Travel Award took turns to work the silent auction tables for 2–3 hours. The Silent Auction raised $1,023.00 and the Live Auction made $8,057.50.

Greg confirmed that he stepped down from the Live Auction Committee at the end of the 2015 Live Auction. Samantha Kahl will assume that role with Sean Graham, and Vinny Farallo will remain chair of the Silent Auction sub-committee.

Al Savitzky, representative to BioOne and AIBS, reported that this year BioOne elected not to convene its annual Publishers and Partners Meeting. However, as a member of the BioOne Board of Directors he has attended two meetings of the Board since last summer, and he draws on information from those meetings to provide this report.

BioOne continues to provide an outstanding level of service and income for its member publishers. As of the end of 2015, BioOne has published 1.2 million pages and has generated a total of 15 million hits by readers. BioOne has returned over $35 million to its member publishers. Net sales of the BioOne collection increased by 2% over 2014, reaching $6,520,427. After operating costs are paid, the remaining funds are returned in the form of both royalties and profit-sharing, and are based on an algorithm that reflects relative use of the journal within the collection. BioOne Complete (the total collection of titles, formerly two separate collections known as BioOne.1 and BioOne.2) now includes 184 publications from 140 society and other nonprofit publishers. Subscription costs are graduated according to the size of the subscribing institution or consortium. Importantly, even at the highest subscription rate the per-title cost to libraries is only $205. That is ***93% less*** than the average biology journal cost in 2015, which was $2,977. Needless to say, this represents a very high value to subscribing libraries, and the renewal rate for the BioOne collection remains well above 90%. Furthermore, BioOne continues to provide free access to its content for over 2,500 libraries in developing countries. Additional information concerning BioOne can be found at http://www.bioone.org/. Al thinks it worth reaching out to BioOne again and asking if they are interested in *Herp. Review*.

According to Al, AIBS has continued to concentrate on restructuring and sharpening its mission. That mission involves a strong commitment to the AIBS Public Policy Office, which provides direct communication between our societies and legislators and other lawmakers. AIBS continues to provide direct access to legislators on behalf of its professional society constituents. Society members are again encouraged to consider signing up with the AIBS Legislative Action Center (LAC; http://policy.aibs.org/), which provides immediate alerts regarding relevant legislation and simplifies contacting individual legislators to express an opinion on those issues. Many of the issues that emerge through the LAC involve conservation or the federal funding of science. Al rotated off the Board of Directors of AIBS at the end of 2015. Accordingly, he says that the society may wish to consider appointing a new representative to this organization.

Dick Durtsche, Symposium Proposal Coordinator, reported that this year one symposium proposal was submitted for SSAR sponsorship at the 2017 JMIH meetings in Austin, Texas. The proposal entitled "*The Science, Management, and Policy of Amphibian Conservation: Extending the Legacy of Ray Semlitsch*" was submitted by **Julia Earl** as lead organizer with co-organizers **Michelle Boone, Katie O'Donnell, Freya Rowland**. The symposium will focus on the impact and legacy of Raymond D. Semlitsch's research on amphibian conservation biology. The organizers have assembled a diverse list of potential speakers and poster presenters that span the fields explored by Dr. Semlitsch. The symposium proposal was sent out for external review, and reviewers' comments and the proposal were submitted to the SSAR Board for consideration of sponsorship. The Board agreed to sponsor the symposium.

New Business

SSAR received a request from Kraig Adler and Aaron Bauer to provide a grant of up to $5,000 to the Reptile Database in 2017 to assist in development of a website in the USA that mirrors the

Fig. 5. Winners of Student Travel Awards, along with winners and Honorable Mention recipients of the Seibert Student Awards and the Victor Hutchison Student Poster Awards. From L to R: Patrick Moldowan, Jake Pruett, Nicole Angeli, Katie Mercier, Corey Dale Cates, Rob Denton, Arianna Kuhn, Aaron Griffing, President Aaron Bauer, Scott Buchanan, Phil Pearson, Brendan Pinto, and Tiffany Doan (Chair, Victor Hutchison Student Poster Awards).

website in Europe. The Reptile Database, founded by Peter Uetz in 1995, is regularly consulted by professional and amateur herpetologists, conservation organizations, and the general public, and has become an essential resource for biodiversity research, taxonomy, conservation, and digitization of systematics. It has also become a repository for color images of reptiles, with more than 4500 species already on the site. The website is currently on a private server in the Czech Republic and its future is uncertain. The Board discussed this request. Questions were raised about whether SSAR would have editorial control, whether there would be a competing "names list," and concerns about the "SSAR brand." There was also discussion about long-term maintenance of the database, which would be a very large project. The Board then voted on whether to grant the request. The vote was in favor (8 in support, 1 opposed) contingent upon funds being available in the 2017 budget.

The Board considered a proposal from Rayna Bell and Kraig Adler to establish a permanent endowment that would support postdoctoral researchers at SSAR meetings. This endowment would honor Margarita Metallinou, a highly promising Greek herpetologist who was killed in a wildlife accident in southern Africa in 2015. Two fund-raising efforts have already been used: (1) the traditional method of a notice in *Herp Review*, and (2) on-line crowd sourcing. These efforts have raised $28,560. The Carl Gans Collections and Charitable Fund has donated $5,000. As a true endowment, there will be no payout from this endowment until late in 2017, thus no funds to support a postdoc at the JMIH in Austin, Texas in 2017. Rayna and Kraig requested a one-time award of $1,000 from SSAR to kick-start the postdoctoral travel awards in time for their use in Austin (see ad, p. 745). This was approved by the Board. Joe Mendelson indicated that he would attempt to gain a pledge from Zoo Atlanta. SSAR will continue to solicit donations for the Metallinou Endowment. Given the success of crowd-funding, SSAR may wish to consider its use further.

Discussion then turned to the issue of whether SSAR should continue to offer meetings that break away from the JMIH model on a regular basis, e.g., once every five years. There are 14 voting members of the Board. All nine voting members present at the Board meeting when this was discussed were in support.

Fig. 6. The customary passing of the gavel from outgoing President Aaron Bauer to President-Elect Rick Shine.

The Board then turned to the 2017 budget. A balanced budget of $301,850 for 2017 was approved by the Board.

The meeting then adjourned.

Long-Range Planning Committee Open Meeting

An open meeting led by the Long-Range Planning Committee (LRPC) for all SSAR members was held on the afternoon of July 9th. In attendance were: Raul Diaz (via telephone) who led the meeting, Kraig Adler, Paul Bartelt, Tiffany Doan, Vinny Farallo, Michelle Koo, Joe Mendelson III, Ann Paterson, Marion Preest, Rick Shine, Carol Spencer, and Greg Watkins-Colwell. The main focus of the meeting was the SSAR website and raising SSAR's profile on the web. A desire was expressed to make the website more of a website for herpetologists in general rather than "SSAR's website." There was discussion of the possibility of an "SSAR YouTube channel" on which we could post material from the annual meetings, e.g., award-winning student talks, the Presidential Travelogue, plenary talks, etc. Also discussed were various ways of bridging the divide between SSAR and the herpetocultural community.

SSAR Business Meeting

The Annual SSAR Business Meeting was called to order by President Bauer (1803 hrs, July 9th). Nearly 100 members of SSAR were present. Officers, Editors, and Committee Chairs who were at the Business Meeting introduced themselves to the other attendees and gave brief summaries of their annual reports and relevant information from the Board Meeting. President Bauer then noted a number of herpetologists who have passed away in the last year: Andrey Stoyanov, Nikolay Tzankov, Dobrin Dobrev, Donald Broadley, Benedetto Lanza, Monique Halloy, Ralph Axtell, David Hardy, Itzchak Gilboa, Eduard Brygoo, Georges Pasteur, Ronald Gutberlet, Douglas Rossman, Ted Case, Charles Carpenter, and Louis Guillette.

Rob Denton read the following resolutions: "SSAR wishes to thank a large number of individuals for service to the Society. First and foremost, thanks to the local hosts, the members of the local committee, and the many students who assisted. New Orleans is always a fun place for a meeting and 2016 has been no exception! We're grateful to KState for another smoothly run meeting. Thanks to this year's President's Travelogue speaker, José Padial for his excellent talk "Searching for the Unknown: Herpetological Explorations in the Amazon and the Sahara." We are grateful to everyone who has been involved over the past year in ensuring a smooth transition following Publications Secretary Breck Bartholomew's resignation. There has been a lot of creative thinking and attention to detail by many people. Breck's resignation will be effective at the end of this year and we will acknowledge Breck appropriately in the 2017 resolutions. We are particularly thankful that Cari Ann Hickerson has agreed to become Publications Secretary. Editor of *Herp Review*, Bob Hansen wishes to acknowledge Aaron Bauer for 25 years as Book Review Editor. Bob notes the role that Aaron's obvious passion for books and his impressive network of international connections played in his service as an outstanding book review editor. Bob also thanks Elizabeth Timpe, Priya Nanjappa, Alan Richmond, and Charles Linkem who are stepping down from various roles with Herp Review. Editors of JHerp, Tiffany Doan and Paul Bartelt wish to thank Brian Greene, James Harris, Hinrich Kaiser, Frank Mazzotti, Stephen Tilley, David Chapple, Steve Corn, Rocky Parker, Christopher Salice, James Watling, and Erik Wild who have served as Associate Editors. SSAR acknowledges John Sulzycki of CRC Press for his continued support of the Henri Seibert Student Awards and the Victor Hutchison Student Poster Awards. Congratulations to the seventh winner of the SSAR/HL/ASIH Meritorious Teaching Award in Herpetology, Dr. Emily Taylor. Thanks to Scott Boback who chaired the Herpetology Education Committee. Thanks again to those who were part of the Mentorship Program and served as mentors for students attending this meeting. Thanks to Robert Espinoza, Chair of the Nominations Committee, for pulling together a strong slate of nominees to run for a variety of positions in the society. Finally, thanks to SSAR's "Herp Hipster," Vinny Farallo, who has served as the website coordinator for the past year, and Greg Watkins-Colwell who, after many, many years, is stepping down from the Auction Committee."

Henri Seibert Best Paper and Victor Hutchison Student Poster Awards were presented by Tiffany Doan and Student Travel Awards were presented by Vinny Farallo (Fig. 5).

President Bauer presented a "SSAR Presidential Award for Lifetime Achievement in Herpetology" to Breck Bartholomew (*in absentia*). Breck was acknowledged and thanked for his long and loyal service to SSAR as well as outstanding service to the herpetological community globally through Bibliomania and ZenScientist.com. Finally, as is custom, outgoing President Bauer (who will end his term on Dec 31, 2016) presented the SSAR gavel to President-Elect Rick Shine (Fig. 6).

—Respectfully submitted by **MARION PREEST**, *SSAR Secretary*

List of Abbreviations Used
AIBS - American Institute of Biological Sciences
ASIH - American Society of Ichthyologists and Herpetologists
HL - The Herpetologists' League
JMIH - Joint Meeting of Ichthyologists and Herpetologists
KU - University of Kansas
LRPC - Long-Range Planning Committee
MTAH - Meritorious Teaching Award in Herpetology
PARC - Partners in Amphibian and Reptile Conservation

SSAR Election Results

Results of the 2016 SSAR election are as follows:

President-Elect: Martha Crump
Treasurer: Kim Lovich
Secretary: Marion Preest
Board Members (Regular): Ann Paterson, Melissa Pilgrim, Greg Watkins-Colwell
Board Member (Conservation): Lee Fitzgerald
Board Member (non-US): Jacqueline Litzgus

Thank you to all of the nominees who agreed to stand for positions, Robert Espinoza (Chair) and other members of the Nominations Committee, and Dan Noble (Election Officer).

Support SSAR through Amazon Smile

If you use Amazon.com you can give back to the society with every purchase. Through the Amazon Smile program, you are able to designate an organization to receive a small contribution with each purchase. For instructions, go directly to <smile.amazon.com> and type "Society for the Study of Amphibians and Reptiles" in the search bar at the top of the screen. Once SSAR is selected, that will remain your default organization for future purchases.

NEWSNOTES

Incoming SSAR President Wins Major Research Award

Australian herpetologist (and incoming SSAR President) Rick Shine, of The University of Sydney, has been awarded the 2016 Prime Minister's Prize for Science ($250,000). The award was based on his work using evolutionary principles to address conservation challenges, and was presented by the Prime Minister, the Hon. Malcolm Turnbull, at a dinner held 19 October 2016 in the Great Hall of Parliament House, Canberra.

Rick joins his brother John in receiving this honor. John Shine received the 2010 Prime Minister's Prize for Science for his leadership in biomedical research. John also helped Rick in his early exploration of reptiles. "I was the kid who brought bluetongue lizards to school," Rick says. "When my big brother learnt to drive, he took me out into the bush where I could capture snakes and bring them home."

"The Prime Minister's Prize for Science is an incredible recognition of the value of basic, simple science, it's the kind of thing that Charles Darwin did when he wandered around the world. You go out into the bush and you see what the animals are doing, there's nothing more sophisticated than a notebook involved," Rick says. Following in the footsteps of Darwin, Rick loves lizards and snakes. "Some people love model trains, some people love Picasso; for me, it's snakes." In addition to the Prime Minister's Prize, Shine also was named the New South Wales Scientist of the year, which carries a cash award of $60,000.

SSAR congratulates Rick for an exemplary scientific career and well-deserved recognition.

Reptiles Database Update

We just released a new version of the Reptile Database, this time with the following **key figures**:

Total number of reptile species: 10,450 (previous release, April 2016: 10,391)
New species added since last release: 54
New species described in 2016: 108 (by Aug 11, our latest deadline)
New species records: 59 (including 12 revalidations and elevations from subspecies)
Changed names: 68 (including synonymizations, revalidations, new genus assignments)
See the species checklist for details and a list of new and changed names.

References: 39,888 (previous release, April 2016: 38,902)
New references added to this release: 986
References published in 2016: 1,023

New photos: Over the past 4 months we have added more than 300 photos from 55 photographers, namely (sorted by first name) Adavanne Shivaprakash, Alejandro Solorzano, Alexander Haas, Ali Gholamifard, Andrea Molyneaux, Arlindo de Figueiredo Béda, Aurélien Miralles, Bill Love, Bruno Gattolin, Carlos Cintra, David Andrés Velásquez, Diederik van der Molen, Diego Santana (via Henrique Costa), Elyas T (Iran), Graham Reynolds, Guido F Medina-Rangel, Gustavo Campillo, Herbert Rösler, Hermann Seufer, Igor Doronin, Ivan Ineich, Jaime Troncoso, Jean-Claude Jamoulle, John Philipps, John Philipps, John Regan, Jordi Janssen, Jorge Alberto Zuniga-Baos, José Luis Pérez Gonzalez, Josh Rich, Ke Jiang, Ken Krysko, Lee Grismer (via Anthony Cobos), Libio Roy Santa Cruz Farfán, MA Muin, Michael, Neang Thy, Nguyen Ngoc Sang, Orlando Mercado, Paddy Ryan, Parag Dandge (via Norbert Kissler), Parham Beyhaghi, Peggy Faucher, Peter Schulze Niehoff, Porag Jyoti Phukan, Rob Bryson, Roberto García-Roa, Samuel Lalronunga, Sven Mecke, Tiffany Doan, Tomas Mazuch, Vincenzo Rizzo Pinna, Vishal Santra, Zeeshan Mirza. **Thanks to all of you!** Note that your photos will only go online in a week or two as we upload them separately.

Photo submissions: in order to facilitate photo submissions we have set up a special email address: photos@reptile-database.org. Please submit photos (or questions about photos) to this address. Obviously we are primarily interested in species which have no photos in the database yet (still about ~4000). We can also send you wish-lists for certain geographic areas or taxonomic groups. Please check the species entries for photos / species needed.

Literature Editor wanted: We are looking for one or more literature editors who are willing to collect new literature records and convert them into our database format. This will take you up to 10–15 min a day. You will primarily follow the table of content alerts that journals send out as well as a few other sources such as Google alerts, tweets, etc. In return, we will give you access to up to 10 articles per week, including our large digital library and papers behind paywalls. Please contact us for further details.

Biological editors wanted: If you are interested in certain biological questions, we may want you as specialist biological editor. For instance, we have started to add data on reptile **reproduction**, but this information needs to be curated and updated. While we have basic reproduction data (mostly parity states, i.e., oviparous / viviparous) we would be happy to add others as well, e.g. litter size, mating seasons, etc. However, please don't send us data on individual species ("Species X is oviparous"); instead, a "reproduction editor" would collect data for whole genera or larger groups, as a table, so we can import that information more easily and in a more consistent format. Please contact us for details.

Filemaker developer wanted: We are looking for a Filemaker database developer who can help us with runtime development, mobile app development, and general scripting.

US Mirror site. In collaboration with the Society for the Study of Amphibians and Reptiles (SSAR), we are planning to set up a mirror site of the Reptile Database in the US. Remember that the database is currently hosted by Reptarium in the Czech Republic. Please let us know if you have the infrastructure to host such a site. We have a small amount of money to spend on that so we do not completely rely on your goodwill. Please contact us for details.

Web site redesign. In the same vein, we are looking for help with the redesign of the database site. Let us know if you are knowledgeable about web design and if you are interested in volunteering. We do actually have a bit of money to spend on both the hosting and the web design but it's not a whole lot, but the herp community would certainly be grateful!

The Reptile Database as book on demand? We wonder whether there would be interest in the Reptile Database (or parts of it) published on paper (or as eBook). If you are interested in working on a book publishing on demand project, please let us know. Obviously, this would be a semi-commercial project to support the rest of the database, so you would be paid for that. We will keep the rest of you posted on where this is going.

MEETINGS

8th World Congress of Herpetology, Tonglu, China

The 8th World Congress of Herpetology was held in China over the period 15–21 August 2016. Originally planned for the city of Hangzhou, actions taken by the central government of China in preparation for the G20 meetings, which were held shortly after the World Congress, necessitated a last-minute change of the venue to Tonglu, some 75 km (100 km by car) west of Hangzhou on the Fuchun River. Despite a matter of only days to make the switch of venue, the local organizers managed to transfer the meeting to the five-star high-rise Legend Hotel with a minimum of confusion and inconvenience to attendees. Approximately 680 delegates (plus 42 accompanying persons and 30 student volunteers) from 50 countries gathered for the meeting (Fig. 1). In addition to the host country of China, there were large delegations from the United States, Japan, Australia, Germany, Brazil, and the United Kingdom. A healthy 38% of attendees were students.

SSAR was in evidence at the meetings in a number of ways. As a major sponsoring society, the SSAR logo appeared on the screen during the introductory remarks and in between plenary lectures in the large hotel ballroom and a two-page color insert "SSAR Salutes the China Congress" appeared in the meeting program book (Fig. 2). SSAR continued its tradition of producing a publication in honor of the World Congress as a gift to all attending. This year the publication was a facsimile reprint of Theodore Cantor's *Zoology of Chusan*, which presented descriptions of the fauna of the Chusan (Zhoushan) Islands, Zhejiang Province, not far from Hangzhou. This book is now available for purchase through SSAR for those who were unable to attend the Congress. I addition, SSAR's audio-visual presentation "Amphibians of the Appalachians," completely updated with new photographs by David Dennis and Eric Juterbock was screened as a prelude to the World Congress silent auction.

The Congress kicked-off with a welcome cocktail party in the Dragon Palace inside the Legend Hotel on August 15th. The official program opening took place in the Grand Imperial Ballroom and featured welcomes from the local organizer and incoming Secretary General, Prof. Xiang Ji, the Congress Chair, Academician Prof. Ya-ping Zhang, the presidents of the local hosting institutions (Nanjing Normal University, Hangzhou University, and Lishui University), as well as outgoing Secretary General of the World Congress, Prof. Jean-Marc Hero. In addition, plenary speakers, academicians, and other honored guests were

Fig. 1. Group photo from the 8th World Congress of Herpetology.

Fig. 2. SSAR was prominently acknowledged as a major sponsor of the World Congress of Herpetology.

Fig. 3. Winners of the Chinese Herpetological Society International Cooperation Awards with dignitaries at the opening ceremony of the 8th World Congress of Herpetology (Awardee Kraig Adler was unable to attend but his plaque and trophy were hand delivered to him at his home).

Fig. 4. Winners of the student paper awards for best presentation by taxonomic group. Secretary General Jean-Marc Hero is fourth from right.

Fig. 5. Herpetologists Masafumi Matsui, Gordon Burghardt, David Hillis, and Hidetoshi Ota enjoy the closing banquet in the Legend Hotel.

Fig. 6. David Blackburn (Florida Museum of Natural History) flanked by expatriate Americans Scott Keogh (Australian National University) and Krystal Tolley (South African National Biodiversity Institute) at the World Congress banquet.

introduced, and awards were announced and distributed. International Cooperation Awards from the Chinese Herpetological Society were presented to Profs. Natalia Ananjeva (Russian Academy of Sciences), Masafumi Matsui (Kyoto University), Robert Murphy (Royal Ontario Museum), Richard Shine (University of Sydney), and Kraig Adler (Cornell University), all of whom have had long histories of research collaboration with Chinese colleagues (Fig. 3). Student winners of World Congress Travel Awards were also announced. Support for attendance was provided via funding from the local congress organization as well as the World Congress of Herpetology itself. In addition, other students from around the world were supported via the Carl Gans Collections and Charitable Fund.

The opening plenary lecture, by Prof. Barry Sinervo (University of California, Santa Cruz), was a sobering and highly personal presentation, "The Sixth Mass Extinction is Underway." This was followed by plenaries by Kate Sanders (Rapid Radiation and Speciation of Sea Snakes) and Yi-ming Li (Dynamics of Species Range). Subsequent mornings each began with two plenary presentations: August 17th — Krystal Tolley (Ever Since Gondwana

… Biogeography of African Reptiles), Indraneil Das (Ethnoherpetology: Perspectives and Conservation), August 19th — Paula Cabral Eterovick (A Challenging World for Frogs), Hidetoshi Ota (Systematics and Biogeography of the East Asian Herpetofauna), August 20th — Corinne Richards-Zawacki (Selection and the Evolution of Warning Color Diversity in the Stawberry Poison Frog), Francesco Ficetola (What Determines Biogeographical Patterns of Amphibians and Reptiles).

Paper sessions were held in six rooms concurrently and covered the gamut of herpetological topics in nearly 30 symposia as well as contributed paper sessions. In all, there were 471 oral presentations. Taxon specific sessions included those on caecilians, invasive *Xenopus laevis*, and Chinese Giant Salamanders, whereas other symposia focused on genomics, ontogeny, physiology, morphology, behavior, ethnoherpetology, island evolution, phylogeny, paleontology, ecology, and of course many aspects of conservation. “From Canterbury to Hangzhou: Lessons Learned on the Threat of Emergent Infectious Diseases to Herpetofauna,” one of the conservation-oriented symposia, provided a link to the First World Congress of Herpetology, when amphibian decline was a nascent topic. One hundred and eighty posters likewise covered the diversity of possible topics in herpetology, with a strong representation of Chinese and other students and strong representation of contributions on faunistics, variation, parasitology, and morphology among other subjects.

The WCH8 also provided opportunities for socializing and sightseeing. A local excursion to see the stage play “A Moonlit Night on the Spring River” took place on August 16th at the Tonglu Theatre and was free to all delegates. Thursday, August 18th was reserved for an optional mid-conference excursion to a number of sites of interest in the Tonglu area, including places if historical, archaeological, and scenic interest, although many delegates explored on their own, looking for local amphibians and reptiles, or took the opportunity to spend the day interacting with friends and colleagues from around the world.

The silent auction on Friday, August 19th included books and other herpetological items from around the world, but with a distinctive Chinese emphasis. It was followed by the presentation of bids for the 9th World Congress of Herpetology, to be held in 2020. Spirited presentations were given, featuring the scientific, financial, and social benefits of each of four possible venues, as well as the merits of their local herpetofaunas. All four sites—Budapest (Hungary), Nairobi (Kenya), Gold Coast (Australia), and Dunedin (New Zealand —had vociferous backers, but in the end, the World Congress Executive Committee, weighing not only crowd support, but the details of the bids, selected New Zealand. This decision was announced at the closing banquet, held in the Imperial Ballroom on the night of August 20th. The banquet featured, in addition to course after course of excellent food, the awarding of student prizes for the best papers in each of several taxonomic categories (Fig. 4), as well as formal acknowledgement of the many people who made the 8th World Congress of Herpetology the spectacular success it was (Figs. 5, 6).

—Submitted by Aaron M. Bauer

Meetings Calendar

Meeting announcement information should be sent directly to the Editor (herpreview@gmail.com) well in advance of the event. We also welcome brief reports of meetings; please consult the Editor for details.

12–13 January 2017— California-Nevada Amphibian Populations Task Force, Santa Barbara, California, USA. Information: https://www.regonline.com/registration/Checkin.aspx?EventID=1898787

16–19 February 2017—Southeastern Partners in Amphibian and Reptile Conservation (SE PARC) annual meeting (“Aligning Conservation Goals”), Little Rock, Arkansas, USA. Information: http://separc.org/meetings/

24–26 February 2017—Desert Tortoise Council Symposium, Las Vegas, Nevada, USA. Information: http://www.deserttortoise.org/symposia.html

27 February–3 March 2017—Northwest Partners in Amphibian and Reptile Conservation (NW PARC) annual meeting, Arcata, California, in conjunction with Society for Northwestern Vertebrate Biology (SNVB) and the North Coast Chapter of The Wildlife Society. Information: www.nwparc.org

12–16 July 2017—Joint Meeting of Ichthyologists and Herpetologists, Austin, Texas, USA.

19–22 July 2017—40th Annual International Herpetological Symposium, Rodeo, New Mexico, USA. Information: www.internationalherpetologicalsymposium.com

24–27 July 2017—Biology of the Snakes, Rodeo, New Mexico, USA. Information: biologyofsnakes.com

24–28 July 2017—XI Congreso Latinoamericano de Herpetología, Quito, Ecuador. Information: http://www.latinherps.ec/index.php/congresoHerpetologia/index

CURRENT RESEARCH

The purpose of Current Research is to present brief summaries and citations for selected papers from journals other than those published by the American Society of Ichthyologists and Herpetologists, The Herpetologists' League, and the Society for the Study of Amphibians and Reptiles. Limited space prohibits comprehensive coverage of the literature, but an effort will be made to cover a variety of taxa and topics. To ensure that the coverage is as broad and current as possible, authors are invited to send reprints to the Current Research section editors, Ben Lowe or Chava Weitzman; e-mail addresses may be found on the inside front cover.

Painted Turtles: They Can Survive the Extreme, but They Don't Get Better at It

The Painted Turtle, *Chrysemys picta*, can recover from prolonged periods of anoxia, though such conditions result in periods of anhomeostasis before the animal can return to normal functions. Previous studies have demonstrated that some species may alter their anaerobic capacities in response to repeated or prolonged bouts of anoxia, indicating some level of plasticity. The authors of this paper wanted to determine whether Painted Turtles are also able to alter their physiological response to repeated anoxic bouts. They included 64 turtles in two experiments (32 each control and treatment). In Experiment 1, treatment turtles were subjected to 10 bouts of submergence over 19 days, while control turtles were not. For Experiment 2, turtles were cannulated and then submerged for two hours, with repeated blood samples collected during submergence for half of each experimental group. After Experiment 2 submergence, turtles were allowed to recover, with blood samples collected throughout recovery. Eight turtles from each of the experimental and control groups were euthanized at the following timepoints: post-experiment 1 treatment, post cannulation/pre-experiment 2 treatment, post-experiment 2 submergence, and post-experiment 2 recovery. Tissue samples (ventricle, liver, pectoralis, carapace) were collected from all euthanized turtles. Blood and tissue samples were analyzed for multiple chemistry variables, and the authors used ANOVAs and t-tests to compare values between the groups. Turtles that experienced repeated bouts of anoxia in Experiment 1 had increased citrate synthase and cytochrome C oxidase levels and decreased glycogen content in the liver when compared to control animals, though no other tissue sampled had altered chemistry levels. When exposed to an additional period of anoxia in Experiment 2, the control and treatment groups did not exhibit different tissue chemistry levels, indicating that previous bouts of anoxia did not enable individuals to produce an altered response due to plasticity. Using repeated sampling, the authors describe the pattern of blood and tissue chemistry throughout the period of submergence and recovery. The authors discuss potential physiological reasons for the changes observed in liver tissue in this study. While it is possible that the length of time submerged may not have been long enough to induce a plastic response, the authors argue that the fact that the turtles had physiological responses to the anoxia does not support this. The lack of improved tolerance to anoxic stress, thus, may indicate that the responses to such a stress are not plastic.

Warren, D. E., and D. C. Jackson. 2017. The metabolic consequences of repeated anoxic stress in the western painted turtle, *Chrysemys picta bellii*. Comparative Chemistry and Physiology, Part A 203:1-8. doi:10.1016/j.cbpa.2016.07.012

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The Current Status and Future of Herpetofaunal Invasions

There is a sizeable threat posed by many alien species, and some ecosystems may be more at risk to invasions than others. Research on potential invasions by a species frequently uses species distribution models (SDMs) based solely on climate variables, ignoring other factors such as vegetation, human activity, etc., which could result in underestimated predictions. Areas where biodiversity hotspots and areas with high invasibility overlap could help identify regions of conservation priority. The aim of this paper is to determine potential invasion hotspots for herpetofauna, compare SDMs with and without habitat variables, and then determine where predicted invasion regions overlap with biodiversity hotspots. The authors of this paper used a global database of introductions to calculate predicted regions of high invasibility for 279 herpetofaunal species (98 amphibian, 181 reptile). Models used eight climatic variables, predictions for two time frames (2050s and 2080s), and three habitat variables (human footprint, normalized difference vegetation index (NDVI) as a vegetation proxy, and availability of open water). Five SDM algorithms were implemented and from these models, the authors designated the grid cells in the top 25% of alien species richness as potential invasion hotspots. The authors then determined where invasion hotspots overlapped with biodiversity hotspots. The results of SDMs with and without habitat variables were similar. These data revealed Europe, North America, and the Caribbean currently lead the planet in numbers of herpetofaunal invasions. Non-native herpetofaunal species richness was calculated to be slightly higher for biodiversity hotspots than for non-hotspots. Compared to the invasion risks calculated for our current climate, some regions of the world are predicted to expand spatially in invasion risk (e.g., northern Europe), while other regions are predicted to decrease in risk (e.g., southern Africa). Under current conditions, biodiversity hotspots are more at-risk than non-hotspots, and this difference is predicted to increase in future climates. The models suggest that approximately 40% of invasion hotspots overlap with biodiversity hotspots, under current and predicted future climates, covering approximately 60% of biodiversity hotspot area. Changes in human activity can influence the future path of human-mediated introductions.

The authors argue that this, as well as factors that affect species establishment, are two of the next logical additions to SDMs. While tropical biodiversity hotspots seem to be at great risk of invasions, current introduced species are found mostly in the temperate regions of North America and Europe, as their spread depends on human activity. Because they are still relatively isolated and invasion-free, the authors stress the need to make biodiversity hotspots most at risk a priority for biosecurity efforts.

Li, X., X. Liu, F. Kraus, R. Tingley, and Y. Li. 2016. Risk of biological invasions is concentrated in biodiversity hotspots. Frontiers in Ecology and the Environment 14:411–417.

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Dragon Color Variation: Autosomal with Heritable Expression

The presence of multiple color morphs can be regulated by few genes under simple Mendelian segregation. Morphs may represent separate peaks in a fitness landscape, with associated fitness benefits resulting from behavioral differentiation. The Tawny Dragon, *Ctenophorus decresii*, is an agamid lizard in Australia with four distinct throat color morphs: orange, yellow, orange + yellow, and grey. Males of different morphs display different levels of aggression and boldness. While morphs are only differentiated in males, coloration can be triggered in females with testosterone. Here, the authors investigate Tawny Dragon throat coloration to establish how the presence of morphs in this species fit into models of Mendelian inheritance, and to determine the level of genetic basis of variation in yellow and orange colors within and between morphs. The competing models were as follows: Model 1) One locus, four alleles; Model 2) One locus, three alleles with co-dominant expression; Model 3) Two loci, each with two alleles. To address these aims, wild dragons were collected and mated in the lab, resulting in 58 offspring. Paternity of all offspring was determined with microsatellites. Digital photographs were used to determine number of pixels in each color category and to assign each individual, adults and offspring, into one of the four color morphs. To test the likelihood of the three models, the authors compared observed phenotypes with predicted phenotypes based on known parental phenotypes for each model separately. The results ruled out Model 1 as well as Models 2 and 3 by sex-linked inheritance. When allele frequencies were not assumed to be under Hardy-Weinberg equilibrium, Model 3 by autosomal inheritance best described the data, Model 2 under autosomal inheritance was the second most likely. The authors also determined heritability of the expression of orange and yellow, and found that expression of both colors was heritable from both fathers and mothers, though the magnitude of heritability from both parents was similar for orange, but not yellow. These experiments support that throat coloration of Tawny Dragons is likely controlled by few autosomal loci with few alleles, though the authors state that more complex models that were not tested here may alternatively be better supported. While many lizard species have distinct color morphs, mode of inheritance and heritability have only been investigated for few species. Further research to determine likelihood of similar mechanisms across taxa resulting in these morphs would thus be an interesting future direction. The authors further discuss the underlying biochemistry resulting in these pigments.

Rankin, K. J., C. A. McLean, D. J. Kemp, and D. Stuart-Fox. 2016. The genetic basis of discrete and quantitative colour variation in the polymorphic lizard, *Ctenophorus decresii*. BMC Evolutionary Biology 16:179.

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Translocation Success of Crypsis-Dependent Species Affected by Substrate Matching

A critical factor in translocation for conservation purposes is habitat suitability. This variable includes the usual considerations of climate, substrate, food availability, etc. However, in instances where individuals of a species must adequately camouflage themselves, other factors such as background color and additional specific habitat characteristics may also need to be included in habitat suitability estimates. For translocations, the genetic variation of the focal species and the complexity of the habitat could affect survival of a translocated population, and consideration of these factors would help to avoid a population bottleneck. This paper presents results on how a translocated population changed in its color patterning over a short period of time. In New Zealand, a population of Shore Skinks (*Oligosoma smithi*), which inhabits diverse coastal regions, was translocated from the mainland to the Tiritiri Matangi Island Scientific Reserve (Tiri) in 1996. A total of 40 skinks were translocated, nine of which were gravid females (to produce approximately 36 offspring within a few months). After translocation, both Tiri and the mainland site of origin were surveyed every three months for a year using pitfall trap arrays. The founder population and skinks caught during surveys were photographed against the nearby background. Photos were used to categorize skinks into four pattern groups and to quantify color values, saturation, and brightness. The authors analyzed these data for the degree of background-matching and changes in the translocated population over time. The proportion of skinks within each of the four pattern types changed in the translocated population from the founders. In particular, the plain-colored phenotype disappeared on the island, while the darker and more complex phenotype, which was represented in the majority of the founders, grew in proportion. The authors note that factors such as a lack of bare sand could have affected the success of the plain phenotype. They additionally discuss how the complex-patterned phenotype matched or mismatched with available habitat backgrounds, and how interspecific competitors may have affected success in relation to exploiting available habitat heterogeneity. If heritability of the plain phenotype is assumed, then the results of this translocation indicate a decrease in genetic diversity. Other island populations of the Shore Skink also exhibit reduced diversity in color pattern, so the decrease seen here is not necessarily surprising. However, this effect from a translocation indicates that there are factors to account for in order to maximize success of a translocated population of a cryptic species. For example, having data on the translocation site allows scientists to actively choose individuals more likely to survive in those sites. Alternatively, if maintaining diversity is of concern, as for conservation translocations, then choosing an environment that allows for each phenotype to thrive is an important consideration.

Baling, M., D. Stuart-Fox, D. H. Brunton, and J. Dale. 2016. Habitat suitability for conservation translocation: The importance of considering camouflage in cryptic species. Biological Conservation 203:298–305.

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Evolution of Tail Vibrations Likely Supported Evolution of the Rattle

One controversial hypothesis in evolution is that changes in phenotype induced by the environment could also induce the evolution of new traits. This hypothesis is particularly relevant to explain the evolution of communication signals incorporating both morphological and behavioral traits. In this paper, the authors investigate this hypothesis in the context of the rattle and tail vibrations in rattlesnakes. This is an ideal system as the rattle, which is used as a predator deterrent, evolved only once. To address the hypothesis, the authors stimulated tail vibrations in 155 captive snakes representing 56 species (38 viperids, 18 colubrids). Vibrations were recorded to measure vibration duration (up to one minute), rate of tail vibration, and probability of tail vibration within a species. These data were then plotted onto a known phylogeny, ancestral states were estimated, and trial results were compared against phylogenetic distance to rattlesnakes. Analyses were conducted with and without New World colubrids, as results indicated that they seem to mimic rattlesnakes. This study found a phylogenetic signal in both duration and rate of tail vibration, both of which were also correlated with phylogenetic distance from rattlesnakes. Thus, species more closely related to rattlesnakes displayed tail vibration phenotypes more similar to those found among rattlesnakes. The presence of tail vibration in snakes without rattles and the patterns observed by this experiment support the hypothesis that tail vibrating may have been a precursor to rattling behavior in rattlesnakes. The authors discuss current alternative hypotheses for how the rattle evolved, noting that the use of it as a predator deterrent would have allowed for directional selection toward its current form to increase signal efficiency. This experiment adds to a growing body of literature supporting behavior as a precursor to novel morphological features.

Allf, B. C., P. A. P. Durst, and D. W. Pfennig. 2016. Behavioral plasticity and the origins of novelty: The evolution of the rattlesnake rattle. American Naturalist 188:475–483.

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Evolution of Hindlimb Loss Caused by Few Mutations in a Developmental Pathway

Extant basal snake lineages, though limbless, retain structures associated with hind limbs such as pelvic girdles and diminutive femurs. These structures are lost in advanced snakes, though an extinct alethinophidian clade may have regained these limbs. The authors of this paper use a series of experiments and sequence comparisons to determine the likely cause of limb loss in the python/boa clade. Previous work found that pythons produced the Sonic hedgehog (SHH) protein, an important developmental protein, in early developmental stages at limb buds, but not for long after oviposition. The change in SHH over developmental time indicated that factors affecting its expression have been altered. Experiments in this paper, comparing development of pythons with that of anoles, found that SHH mRNA expression decreased over time in pythons when it was maintained in anoles. Further investigation suggested that while SHH expression occurred early in development, a feedback loop required for its maintenance was disrupted in the snakes. From sequence comparisons among snake lineages, the authors found three mutations in the enhancer region of this pathway, and discovered that each of these mutations separately reduce transcription, and emergence of them over time likely had a cumulative effect on the reduction of limb development. Recent phylogenies indicate that the three limb-reducing mutations were all present in the most recent common ancestor of pythons and boas, which dates back to the late Upper Cretaceous, a time when snake lineages greatly diversified. In addition to these three mutations, one binding site in the pathway has also been lost. Beyond these few changes, snakes retain the remainder of the hindlimb formation developmental pathway, as pythons develop limb buds that are later lost, indicating that the ability to regain hindlimbs in extinct lineages would not have required re-evolution of structures.

Leal, F., and M. J. Cohn. 2016. Loss and re-emergence of legs in snakes by modular evolution of *sonic hedgehog* and *HOXD* enhancers. Current Biology 26:1–8.

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Skin-Protective Compounds Protect *Lithodytes* Frogs Against Leaf-Cutter Ant Attack

Mimicry of chemical cues allows for individuals of one species to go unnoticed among those of another, protecting against attack. The frog species *Lithodytes lineatus* breeds and seeks shelter in nests of *Atta* leaf-cutter ants in the Amazon rainforest. In such locales where amphibian diversity is high, nesting outside of water could allow for protection against strong predation pressures. However, *Atta* ants use chemical cues to identify conspecifics, attacking intruders. Thus, in order for *L. lineatus* to coexist with *Atta*, they must deceive the ants, likely by producing similar chemical cues. The authors of this paper use a series of two experiments to test this hypothesis. They tested this hypothesis with two experiments. First, they collected individuals of *L. lineatus* (N = 10), two species of the sister genus *Adenomera* (N = 10), and two additional, less-related species (*Allobates femoralis* and *Ameerega picta*; N = 10 total). Each frog was presented at the opening of an *Atta* colony to measure response time to attack and the number of ants attached to the frog at the end of the 10 minutes. From these trials, zero of the *L. lineatus* individuals were attacked, while all of the other 20 individuals from two experimental groups were attacked with 9 to 52 ants attaching. The sister genus, *Adenomera*, and the two unrelated frog species had similar attack pressures. Latency to attack ranged from 0.36 minutes on average for *Ameerega picta* to 3.78 minutes on average for *Allobates femoralis*. These results demonstrate that while *L. lineatus* produce a product in their skin to enable them to coexist with *Atta* spp., close relatives of *Lithodytes* and other frogs phenotypically similar to *Lithodytes* do not have similar protective abilities. In a second experiment, the authors aimed to display that chemicals in the skin allow *L. lineatus* to be tolerated in ant nests. To accomplish this, they placed skin extracts from euthanized *L. lineatus* on toads (*Rhinella major*) (10 mg extract from a single individual in ultrapure water; N = 10); ultra-pure water was applied to other toads as a control (N = 10). These individuals were then individually placed at *Atta* nest openings, with data collected as in the first experiment. As expected, frogs with skin-extracts were not attacked, while all control frogs were attacked by an average of 14.3 ants. From this experiment, both sexes of *L. lineatus* were seen to produce equal protectants against ant attacks. The authors discuss possible reasons why these frogs use ant nests, as well as the possible interactions that may occur between the frog and ant species, as it is not currently known if this is a facilitative or negative interaction. The authors state that the next step in understanding this interaction is to determine the specific compounds produced by the frogs that allow coexistence with leaf-cutter ants.

de Lima Barros, A., J. L. López-Lozano, and A. P. Lima. 2016. The frog *Lithodytes lineatus* (Anura: Leptodactylidae) uses chemical recognition to live in colonies of leaf-cutting ants of the genus *Atta* (Hymenoptera: Formicidae). Behavioral Ecology and Sociobiology, doi:10.1007/s00265-016-2223-y

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European Amphibian Distributions Spread from Glacial Refugia

The size of a species' distribution impacts the likelihood of extinction, and some taxa, such as amphibians, may be particularly susceptible to decreasing distributions from climatic changes. In Europe, amphibian distributions that are more northerly tend to also be larger than those more southerly, and research has found that historical climate is a better predictor of these distributions than current climate. Additionally, distribution size may be particularly associated with traits tied to dispersal ability in amphibians. In this paper, the authors use structural equation models to determine the importance of body size, fecundity, maximum life span, and habitat specialization on species distribution size for all European amphibians (excluding non-native and island species). To measure habitat specialization, species were categorized as opportunistic or specialists. Frogs (N = 28) and salamanders (N = 24) were modeled separately, and models were kept simple because of the small sample sizes. The northern and southern latitudes of species distributions were also compared with the approximate latitude of the 0°C isotherm from the last glacial maximum, at 45°N. A histogram of distribution size generated by the authors was right-skewed for both frogs and salamanders, though frog distributions were larger on average than those of salamanders. Smaller range sizes also tended to be distributed closer to 45°N, and tended to include that latitude when distributions were larger, supporting an hypothesis that current amphibian species spread from areas of refugia from the last glacial maximum. An increase in fecundity and life span, and body size in frogs, correlated with an increase in range size, as did more generalist habitat associations. For frog species, life span had the largest effect on size of species distribution, while fecundity had the largest effect for salamanders. Structural equation models explained up to 61% of the variation in the data. These results indicate that species traits that impact dispersal ability also have important effects on distribution. The results further support the hypothesis that historical climate may be more important than recent climate in explaining current species distributions. Interestingly, the order of importance of species traits differed between frogs and salamanders. While variation could be stochastic in this small sample size, it also could have occurred from factors such as site fidelity or the presence of paedomorphs in some salamander species, allowing for species to better survive in more heterogeneous environments. The authors note that though they have not addressed other popular hypotheses, the work in this paper provides a parsimonious explanation to describe current range sizes.

Trakimas, G., R. J. Whittaker, and M. K. Borregaard. 2016. Do biological traits drive geographical patterns in European amphibians? Global Ecology and Biogeography 25:1228–1238.

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Is Inbreeding All That Bad? Some Skinks Prefer It

To avoid inbreeding depression, most organisms preferentially breed with non-relatives. However, the assumption that inbreeding should be completely avoided ignores the fact that not breeding with a relative may mean not breeding at all. Additionally, the effects of inbreeding depression are not experienced by those that are breeding. Inbreeding also increases inclusive fitness, which provides a benefit to the parents. The authors of this paper thus state that preferential inbreeding should be expected, though empirical searches for inbreeding preference are lacking. *Liopholis whitii* is a skink species that lives in family groups of a mating pair and their offspring. Previous work has determined that the relatedness of mating pairs in this species is closer than expected, though it is unclear whether this inbreeding is due to preference or population structure. Extra-pair copulations in this system take off some of the stress of inbreeding depression. The authors conducted a Y-maze choice experiment with olfactory cues in the breeding season to determine if individuals prefer closely related conspecifics over those less related. Degree of relatedness was determined using microsatellite data for each individual. For each sex, 21 trials were conducted, during which individuals showed more interest in the less-related conspecific in the form of tongue flicks, though they ultimately spent more time in the arm of the maze with the more-related option. These results indicate that individuals can detect and discriminate between conspecifics based on their scents, and that when given an option between conspecifics of the other sex, they preferentially associate with closely related individuals. Ten of the skinks were allowed to interact after the trials to ensure that these behaviors lead to other mating behaviors such as chasing and mating. In this skink mating system, there seems to be a preference for inbreeding, and the long-term effects and heritability of this preference should be further studied, as should the role of extra-pair copulations in such a system. Lastly, the authors discuss the benefits that would be gained from studying the mating systems of the entire *Egernia* group, which includes *L. whitii*, to investigate avoidance, tolerance, and preference for inbreeding across diverse mating strategies among closely related species.

Bordogna, G., G. Cunningham, L. J. Fitzpatrick, B. Halliwell, H. E. A. MacGregor, K. L. Munch, E. Wapstra, and G. M. While. 2016. An experimental test of relatedness-based mate discrimination in a social lizard. Behavioral Ecology and Sociobiology doi: 10.1007/s00265-016-2217-9

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Helminth Communities Diverge Between Sympatric Host Species

Helminth parasites of amphibians are frequently generalists, able to invade multiple host species at a single location. The distribution of these generalists may depend on their ability to move among sites. Additionally, however, co-evolutionary factors could still affect which host species are more or less susceptible to those parasites, and thus one may expect to find similar parasite types within a species, rather than between species. The authors of this paper wanted to determine which has more similar macroparasite communities: sympatric species or allopatric conspecifics. *Leptodactylus chaquensis* and *L. podicipinus* are allopatric frog species in Brazil, with similar ecological niches, though they differ in body size. The authors collected individuals of both species from two sites, which were 78 km apart and differed in water availability. Parasite species prevalence, abundance, and mean infection intensity were determined for each taxon. Permutational multivariate analysis of variance determined the contribution of host body size, host species, and site on parasite community composition, while cluster analyses were employed to determine similarities of allopatric versus sympatric communities between host species. Individual frogs had up to five helminth species, and of the nearly 20 helminth taxa identified, there was much overlap between sympatric frog species as well as within species allopatrically. Host habitat had a lower influence on parasite communities than host size and host species, and parasite communities were more similar within species than between species at a site. These results align with other studies on patterns of frog skin microbiomes, and suggest that co-evolutionary history tying to specific host traits plays an important role in parasite infectivity. The authors argue that the increased parasite richness found in *L. chaquensis* was likely due to this species' larger body size. Its larger surface area could allow for more types of parasites to infect. It is also likely that this species can ingest larger prey items, unavailable to *L. podicipinus*, exposing it to additional parasitic taxa. Where differences in communities occurred between the two sites, the authors state that these differences were likely due to environmental conditions, as wetter or drier regions may support parasites with different life history strategies. Lastly, these two closely related frog species may experience host shifts from their parasites, allowing the host species to harbor some of the same parasite taxa. Additional studies to better account for environmental factors and the effects of phylogenetic relatedness of hosts would help to close the gaps in understanding in amphibian host-parasite interactions.

Campião, K. M., O. T. Dias, R. J. Silva, V. L. Ferreira, and L. E. R. Tavares. 2016. Living apart and having similar trouble: frog helminth parasites determined by the host or by the habitat? Canadian Journal of Zoology, doi: 10.1139/cjz-2016-0066.

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OBITUARIES

Herpetological Review, 2016, 47(4), 741.

June-Shian Lai (1970–2016): Specialist on the Salamanders of Taiwan

PHOTO BY KOJI IIZUKA

Fig. 1. June-Shiang Lai, in the Otemachi-no-mori forest near Tokyo, August 2015.

June-Shiang Lai (Fig. 1), an expert on hynobiid salamanders, died tragically on 27 June 2016, from a fall suffered during a field trip to the slopes of Mt. Chirai in Taiwan. He had developed a fine reputation for his broad-ranging research on Taiwanese salamanders, including an extensive study on the developmental biology of *Hynobius formosanus*. In 2016, together with an international team of collaborators, he published an integrative analysis of the stream-living subgroup of *Hynobius* salamanders based on cytogenetics, limb structure and development, and life-history parameters. Earlier, Lai had discovered two new Taiwanese species (*H. fuscus* and *H. glacialis*), which he described and named in 2008.

Lai was born in Hualien, Taiwan, on 19 October 1970. He received his master's degree from Taiwan Normal University in Taipei and in 2008 earned a PhD from the same institution. At the time of his death, he was an assistant professor at the university. The accident occurred on the northern peak of Mt. Chirai, at an elevation of about 3200 m, where he fell from a 300-m cliff along a very steep slope. He was an experienced field naturalist and climber and it is not known what actually triggered his accident. His death at such an early age is a terrible loss to his colleagues and to all herpetologists.

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Herpetology Loses a Class Act: Rodolfo Ruibal, 1927–2016

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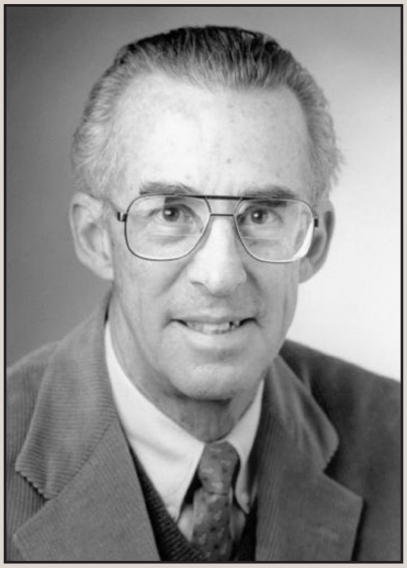

Fig. 1. Rodolfo Ruibal at UC Riverside, 1980s.

Rodolfo "Rudy" Ruibal, one of herpetology's finest gentlemen, died at his home in Riverside, California on 30 August 2016. His death followed that of Irene, his wife of 68 years, who passed away just six months earlier. He was 88 years old, and during those many years he lived a passionate, productive and interesting life (Fig. 1).

Rudy was born in Havana, Cuba on 27 October 1927. He was an only child and attended the same Jesuit school as Fidel Castro, Belen Jesuit Preparatory School. Rudy developed an early fascination for animals, and he spent a lot of his time chasing lizards in his yard. His attraction to these reptiles no doubt nurtured his becoming a budding natural historian who would investigate tropical lizards more seriously as a scientist years later. Another important part of Rudy's fascination with wildlife was that of watching fishes while swimming over a tropical reef in the coastal waters of Cuba. His ashes will be spread in the area where he spent much time swimming during his youth.

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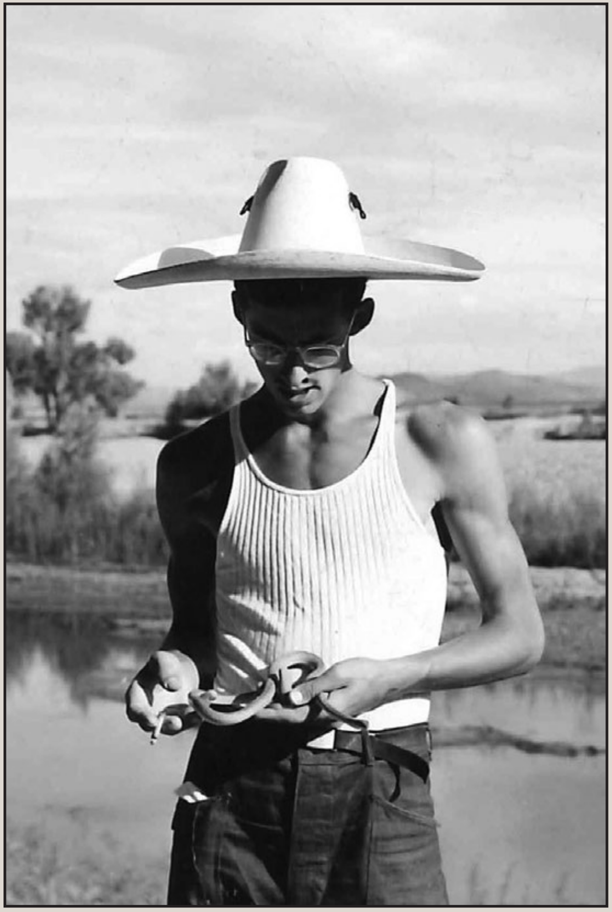

PHOTO BY CHARLES BOGERT, COURTESY OF KRAIG ADLER

FIG. 2. Young Rodolfo Ruibal at Río Nazas, Mexico, 1946.

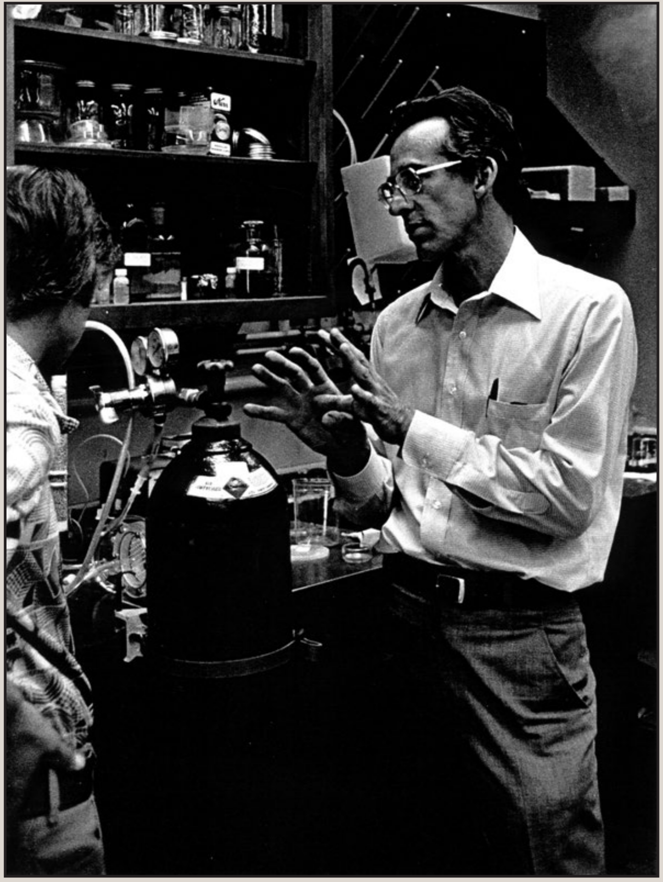

PHOTO COURTESY OF IRENE RUIBAL

FIG. 3. Rodolfo Ruibal instructing a student in his laboratory at UC Riverside.

Rudy's parents immigrated to New York City in 1936 when their son was about eight years of age. His father had worked for a sugar company in Cuba, and his new job was to be in charge of an office for the same company on Wall Street. Rudy's mother had previously worked as a secretary in the United States, but had returned to Cuba prior to the immigration to New York City. Rudy began his education in the U.S. by again attending a Jesuit school, but soon he went on to enter the Horace Mann Elementary School. It was a progressive school in the sense that students could leave after they completed their class work, which was mixed with individual projects. Very early Rudy was ambitious and, together with a classmate, undertook a project to produce an encyclopedia of the snakes of the world. The family soon moved to Flushing, a neighborhood in the northeastern part of the borough of Queens where Rudy attended public school. Subsequently he attended high school at McBurney School in Manhattan, which operated much like a New England prep school.

Rudy distinguished himself very early as someone having serious interest in reptiles and science. He was the first member of his immediate family to have graduated from high school, and the connection with McBurney gave Rudy the opportunity to attend Harvard University beginning in 1944 when he was just 16 years of age. He specialized as a biology major, and he worked at the Museum of Comparative Zoology. Rudy also interned at the American Museum of Natural History where he met and became friends with Charles Bogert (Fig. 2). There he also first met his wife Irene, who was Bogert's secretary in the Department of Herpetology, around the end of his freshman year. Rudy courted Irene for about two years. They were married in 1947 and enjoyed a strong and enduring marriage until Irene's death in 2016.

Very near the end of World War II Rudy entered the military, and he broke from his studies at the university during 1946–1948 when he served in the Army Medical Corps. He learned a lot of biology while in the Medical Corps, and he was in charge of a clinical laboratory at the end of his service. In February 1948 Rudy left the military after a year and a half, and he worked as a clinical laboratory technician at a hospital for about six months. Eventually he returned to Harvard and completed his B.A. degree in 1950. He also earned a varsity letter playing soccer during these college years.

After completing his studies at Harvard, Rudy enrolled in the graduate program in biology at Columbia University where John Moore was his advisor and mentor. During the graduate years at Columbia, part of Rudy's expenses were paid by the GI bill. He also worked as a teaching assistant at City College. He completed his M.A. degree in 1953 and his Ph.D. in 1954. Very soon thereafter he accepted a position at the University of California at Riverside (UCR), which first opened for classes in 1954. Herman Spieth was then the head of the new Biology Department. He already knew Rudy from prior years when he was a professor at City College and also taught a graduate course at Columbia. Rudy was one of the founding faculty at the fledging UCR, and he began teaching as an Acting Instructor during the fall quarter of 1954. When Rudy and Irene first arrived in Riverside, they lived in what he described as a "cheap motel" in nearby Arlington. The environment was new to these New Yorkers, and they were very

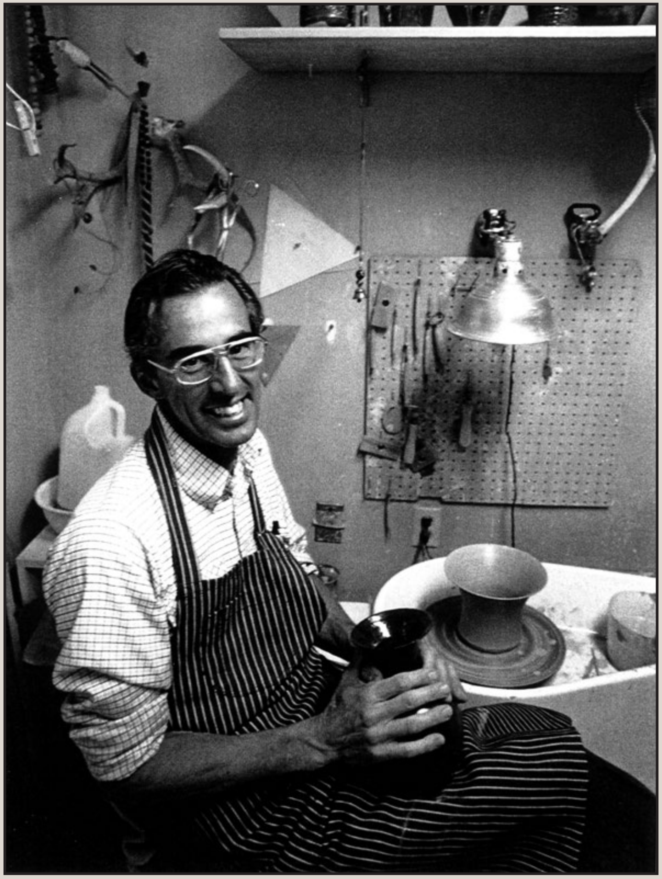

PHOTO COURTESY OF IRENE RUIBAL

Fig. 4. Rodolfo Ruibal working pottery at his home in Riverside, California.

impressed by all the orange trees. While living in Arlington, Rudy enjoyed driving to campus on a route that passed along Victoria Avenue, which he thought looked "simply grand." Also during the early years at UCR he enjoyed an office that was in a greenhouse near the campus botanical garden, as well as another in one of the buildings closer to the campus center. Students had many instructive meetings with Rudy in the greenhouse, and various research adventures took place there. Once I set up a large Red Diamond Rattlesnake in a locked cage overnight, intended for extraction of venom for a class project in Vaughan Shoemaker's physiology class. The next morning I discovered the wrath of Rudy, for he had posted a sign on the cage with very large, black letters instructing me "Get This Out!"

Rudy and Irene's son and only child, Claude, was born in January 1955, soon after settling in California. Claude was raised in Riverside where he became interested in sports and helped to set up the LA Olympics. He has always worked in sports, most recently founding a Sports TV network, Universal Sports that was acquired by Comcast/NBC Universal. He ran sports content and search-related initiatives at Google/YouTube and is now Executive Director of a TV production and digital media unit of the Wanda Group, based in Switzerland. Rudy is also survived by his daughter-in-law Maria Ruibal and two grandchildren, Stefania Ruibal, a 19-year old sophomore at Trinity College in Hartford, Connecticut, and Maximilian Ruibal, a 16-year old sophomore at Zurich International School in Switzerland. Rudy was a dedicated father whose philosophy allowed children to explore and develop independence and to enter any profession of their own choosing. He loved children, and after greeting adults who might be visiting with their offspring in tow, he immediately gravitated to the kids and gave them special attention.

Both Rudy and Irene enjoyed a rich social life, and they had many ties to the community of Riverside as well as UCR. Partly because the campus was small and partly because of Rudy's interests and personality, they entertained friends that included faculty in the arts and humanities as well as sciences. I remember when I was an undergraduate at UCR, the professor of a course I took in English literature told me how much he liked Dr. Ruibal for being "a fine person" and for being much, much broader than many other scientists that he knew. Irene was known for being a marvelous chef, and people enjoyed many wonderful meals at the Ruibal home.

Rodolfo Ruibal was the quintessential scientist and faculty member when he was at UCR. He steadfastly rose through academic ranks beginning with Instructor in 1954 and achieving the status of Professor in 1967. He devoted a lot of time to teaching, and he was a positive influence for many students (Fig. 3). I remember many anatomy and embryology lectures where beforehand he had drawn amazingly perfect and artful diagrams using colored chalks on blackboard. Every lecture was important to Rudy, and each imparted not only important and useful information but also the very best of professional example. He strode into the classroom with head held high, and he had perfect posture and clarity of language while he interacted with the class. I think in the judgement of many persons, Rudy simply had *style* in every sense of the word. He earned a Distinguished Teaching Award in 1978.

Rudy also excelled in research, and he was always musing about some new interesting question that drove his inquiring mind and a determination to investigate. In the 1950s Rudy worked in Cuba, chasing lizards as he did when he was a child. But this time it was serious research, and he published influential papers on the ecology and evolution of Caribbean lizards. His initial work was in taxonomy of Cuban lizards, but his insightful curiosity led him to become interested in how lizards were adapted to their environment. Thus, he became a successful practitioner of the emerging field of physiological ecology. Ray Huey acknowledged recently that Rudy had a "huge impact" on his career, citing especially his 1961 paper in *Evolution* that he said "is full of great ideas that are still relevant" (Ruibal 1961). Many other persons, including myself, were similarly influenced by the thoughtful research and writing of Rodolfo Ruibal, and indeed the influence of his research endures today. On a more personal level beyond the black and white print of his scientific publications, many of us remember the spirited twinkling of his eyes when he discussed new ideas that interested him. Rudy was awarded a Guggenheim Fellowship during 1967–1968, and he was a Fellow of the California Academy of Sciences.

Rudy traveled a lot in Cuba, the West Indies, Mexico, Ecuador, Chile, Argentina, and Paraguay, always using the keen eyes of a curious biologist. He developed a particular fascination with skin, and he was one of the first scientists to investigate the structural and functional properties of digital appendages that enable anoles and geckos to cling and move up smooth vertical surfaces without falling (Ruibal and Ernst 1965). Although the physical mechanism enabling adhesion of these lizards to flat surfaces would be worked out in detail later by Kellar Autumn and others, Rudy essentially got it right when he posited the adhesion related strictly to the area and physical nature of dry contact.

Later Rudy's interests shifted to amphibians, especially the physiological adaptations that enabled various species to survive in dry and harsh environments (e.g., Ruibal 1962; Ruibal et al. 1969). Vaughan Shoemaker was hired as a comparative physiologist by UCR in 1965, and he, Rudy and Lon McClanahan (Rudy's first graduate student) bonded close friendships that took them to South America and led to many amazing discoveries as well as adventures in the field. During their first year together the trio made trips to Arizona where they examined the blood chemistry of aestivating spadefoot toads and the properties and moisture levels of soils in which they buried themselves (Shoemaker et al. 1969). Later Rudy spent a sabbatical year in Argentina where he became fascinated with the adaptations of frogs as well as many other features of arid environments. Eventually, grant funding from the NSF (1971–76) allowed the trio to continue what became a synergistic, multifaceted series of research projects focused on the physiological adaptations of amphibians. During the 1980s Rudy's field work shifted to Paraguay, partly because the political situation posed dangers to continuing scientific field work in Argentina, but mostly because he thought the phyllomedusine frogs that were so interesting would be more abundant there. Rudy's work—in collaboration with the "trio"—brought to light some of the very important adaptations of xerophilous anurans including properties of the cocoon in aestivating species (Ruibal and Hillman 1981; McClanahan et al. 1983) and the novel wiping behaviors of arboreal tree frogs that smear cutaneous lipids over their skin surfaces and thereby greatly increase the resistance to evaporative water loss when they become temporarily quiescent in hot, dry weather (e.g., Shoemaker et al. 1972; Blaylock et al. 1976). Eventually, Rudy established a breeding colony of the Waxy Monkey Treefrog, *Phyllomedusa sauvagii*, to eliminate the need for collecting them from the field. He also reared *Lepidobatrachus llanensis* in his laboratory where he perfected hormonal treatments that induced females to produce eggs and stimulated amplexus in the males. He also elucidated the role of carnivory in the development of the tadpoles.

Rudy selflessly gave much service to his profession. He was the Editor of *Copeia*, published by the American Association of Ichthyologists and Herpetologists (ASIH), from 1971–1975. Following on from this service, he became one of the more influential editors of the *Journal of Herpetology*, published by the Society for the Study of Amphibians and Reptiles (SSAR), which he managed as the chief Editor from 1979 to 1988. During the first few years of his service, he transformed the journal to a more professional level in terms of content and appearance, coincident with his influence and that of Kraig Adler to move the printing of the journal to Allen Press (Adler 2016). Rudy was very sensitive to the importance and influence of an editor, and he believed that an editor had no right to focus a journal unless it represented the will of the membership and governing board of the society that produced it. He streamlined the review process and transformed the journal to a more international status. He was especially sensitive to the fact there were perhaps some 10,000 potential herpetologists and members of the SSAR in Latin American countries to the south. Non-English speaking authors who submitted manuscripts to other journals were often insulted in dealing with the editors. Rudy abhorred such practice, and he would not have it this way at *JH*. Samuel Sweet, who succeeded Ruibal as Editor, recalls Rudy saying "We don't do that here; you can help them rewrite their manuscripts." He welcomed papers from Latin America or elsewhere overseas, and he paid special attention to obtaining prompt, quality reviews and handling manuscripts with courtesy. He invested much personal time improving the writing of non-English speaking authors who submitted interesting papers, and he raised the bar for scientific work in Latin America. In the process, the *Journal of Herpetology* became elevated to the status of a quality journal. Rudy often bucked conventions, and he spent long hours with file cabinets and a typewriter during days before the emerging dominance of computers. Kraig Adler recently commented "It was my great privilege to know Rudy and to work with him on SSAR matters."

Rudy made important administrative contributions to the University of California system and to the faculty at UCR. He was Chairman of the College of Letters and Science from 1961–1964, and he chaired the Department of Biology from 1979–1982. He became friends with Phil Boyd and helped to establish the Philip Boyd Deep Canyon Desert Research Center, located on the northeastern flank of the Santa Rosa Mountains near the western edge of the Colorado Desert. Philip Boyd was a regent of the University of California, and he donated land for the research center in 1958. This research center is one of the original 7 of the total of 39 sites in the University of California Natural Reserve System, and it thrives today as an important field station for faculty and students. Rudy served as the Chairman of the Boyd Desert Research Center from 1962–1972. For about one year Rudy flew to Berkeley almost weekly and was an advisor to Clark Kerr, who was then the President of the UC system and a person for whom Rudy had strong admiration. He advised President Kerr on various faculty matters, and he helped draft letters to resolve issues that arose and required the President's attention. Rudy was also the Acting Director of UC Mexus for about one year (1992–1993). This organization had many connections with universities throughout Mexico and promoted teaching and research between Mexico and the University of California.

While Rudy had a passion for herpetology, and this was a central part of his personality, he also had broader interests that extended to the arts and humanities. Rudy's *modus operandi* as an educator was eclectic, and he was a superb mentor for anyone interested in a solid liberal arts education. While he was in New York City he had attended art classes and was sketching with charcoal and pencil. He later associated with the Art Museum in Riverside soon after he moved to UCR. Rudy met influential people at the Art Museum who added color and breadth to his new life in California. He connected with a very good potter, whose name was Dean Strawn, and he learned how to make pottery which he enjoyed for many years. He had a kiln and crafted pottery at his home, where he also began to make beads for necklaces (Fig. 4). He then became skillful in using brass and silver to make various kinds of jewelry. He learned these techniques at the Art Museum which had offered evening classes during the summer. Rudy's jewelry became well known, and he sold it through many places such as the Art Museum, Riverside's historic Mission Inn, and the Brandon gallery in Fallbrook.

Rodolfo Ruibal retired and became Emeritus Professor in June of 1994. During his career he made outstanding contributions to science, education, his family, Latin America, and society. His life touched many persons, and the world is much better because of his influence. He will be missed by many, but his spirit and passion for life lives on in the collective memories, knowledge, and inspiration that was passed forward. Rudy endures as a true paragon in herpetology.

Acknowledgments.— I am grateful to numerous persons with whom I have shared stories and thoughts about Rudy over many years. These persons include Lon McClanahan, Stanley Hillman, Stanley Hillyard, Stanley Yokota, Roger Seymour, and Don Janes. I also owe special thanks to persons who have provided information and fact-checking during the genesis of this manuscript: Claude Ruibal, Kraig Adler, Sam Sweet, Lon McClanahan, Stanley Hillman, and Estella Dávalos. Photographs of Rudy were provided earlier by Irene Ruibal and more recently by Kraig Adler and Kris Lovekin. Finally, I thank Robert Hansen for inviting me to write this obituary, knowing my deep admiration and affection for Rudy Ruibal.

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SSAR Announces New Endowment

The Dr. Margarita Metallinou
POSTDOCTORAL TRAVEL AWARDS

SSAR is very pleased to announce the establishment of a new endowment in support of postdoctoral fellows. These awards will assist successful applicants to attend and present their research at SSAR's annual meetings and meet and interact with leaders in the field, which comes at a key time in their careers when they are seeking permanent positions. *Awards are open to postdocs from all countries.* The first awards will be made to attend the **Society's 2017 meeting** as part of the JMIH event at the Renaissance Austin Hotel, Austin, Texas, USA (July 12–16, 2017).

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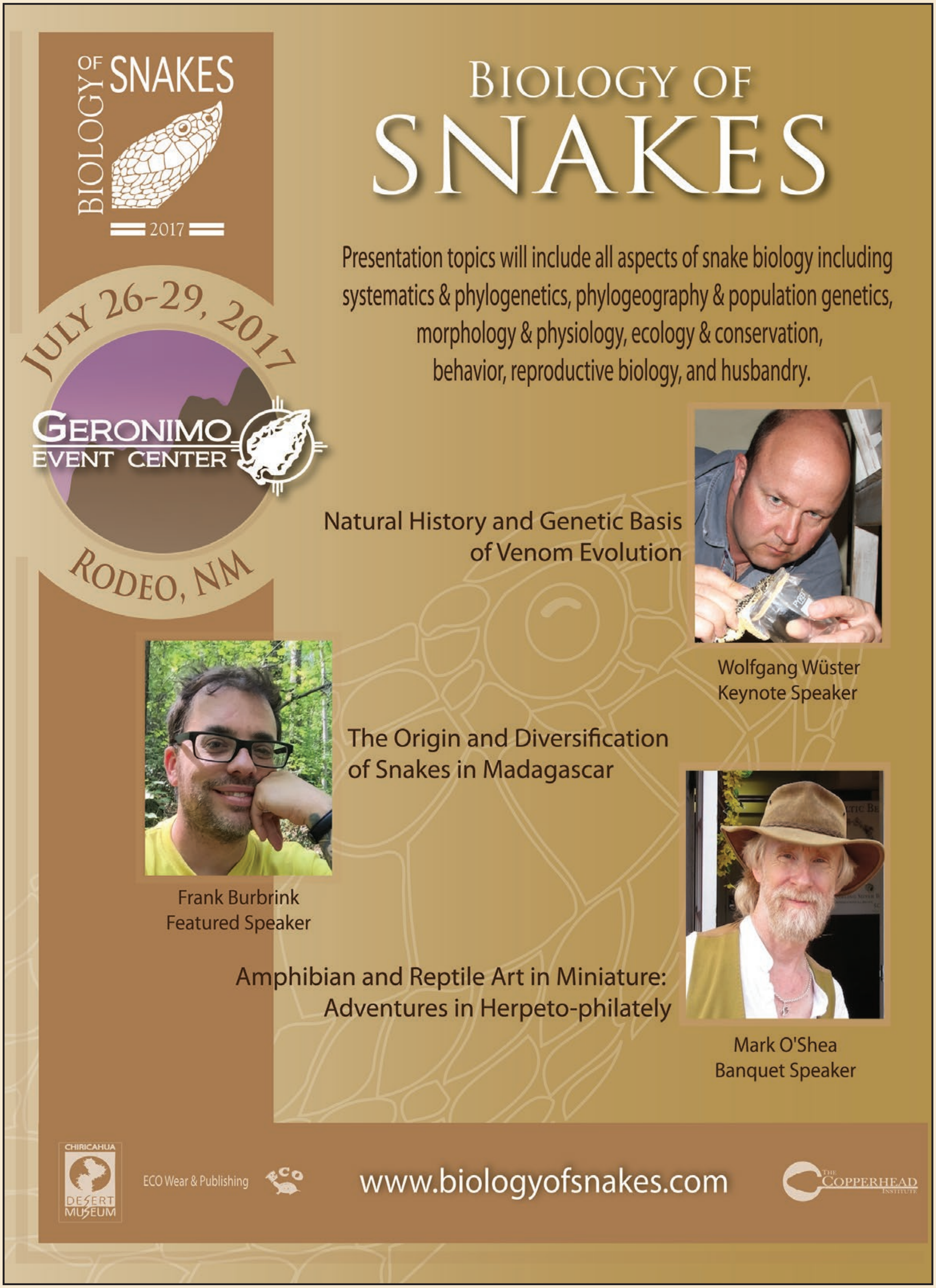
1. Applicants must be officially employed as a postdoctoral fellow at the times of both the application *and* the meeting.
2. **Application deadline is: March 1, 2017.**
3. Applicants must be members of SSAR (http://ssarherps.org/) and be presenting a paper or poster at JMIH 2017.
4. **Applications must be sent electronically to Dr. Bell, committee chair, at bellrc@si.edu** and be submitted as a *single* PDF with the file name "LastNameFirstName_Metallinou2017" These must include the applicant's CV, a one-paragraph summary of the research to be presented (ideally, the abstract for the meeting presentation), and a short description of the applicant's career goals and how attending the meeting will help achieve them.
5. One or more awards up to US$1000 will be made. State the amount requested in the application. Award funds will be made available at the meeting.

Dr. Margarita Metallinou, a talented Greek evolutionary biologist, received her doctorate in Spain and was on a postdoc in the USA when, in July 2015, she died in a wildlife accident while conducting fieldwork in Zambia, southern Africa. She had been scheduled to present her work at the Society's meeting later that summer at the University of Kansas. SSAR, together with the Metallinou family, decided that the most fitting and lasting memorial would be to support other postdocs to attend meetings of the Society. We thank members of the Metallinou family and Margarita's many friends for their most generous support, as well as dozens of other persons who have contributed to the endowment. We especially thank the Trustees of the Carl Gans Fund for their major support and Zoo Atlanta for its special funding for year 1.

We wish to grow the Metallinou Postdoctoral Endowment to help a larger number of postdocs in future years. Please inquire with the SSAR Treasurer, Dr. Ann Paterson (*email*: distichus@hotmail.com *or by post*: Department of Natural Science, Williams Baptist College, Walnut Ridge, AR 72476), to make a donation. These are tax-deductible in the USA.

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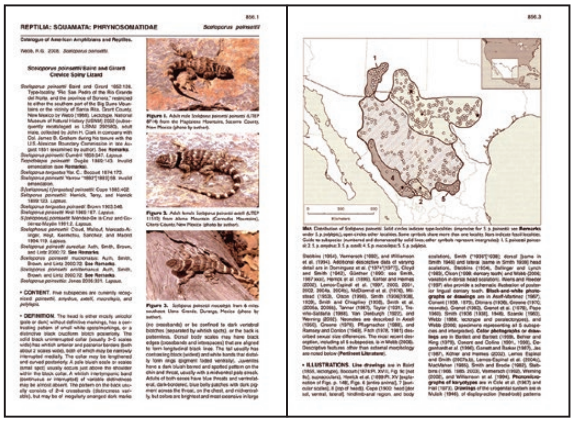

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