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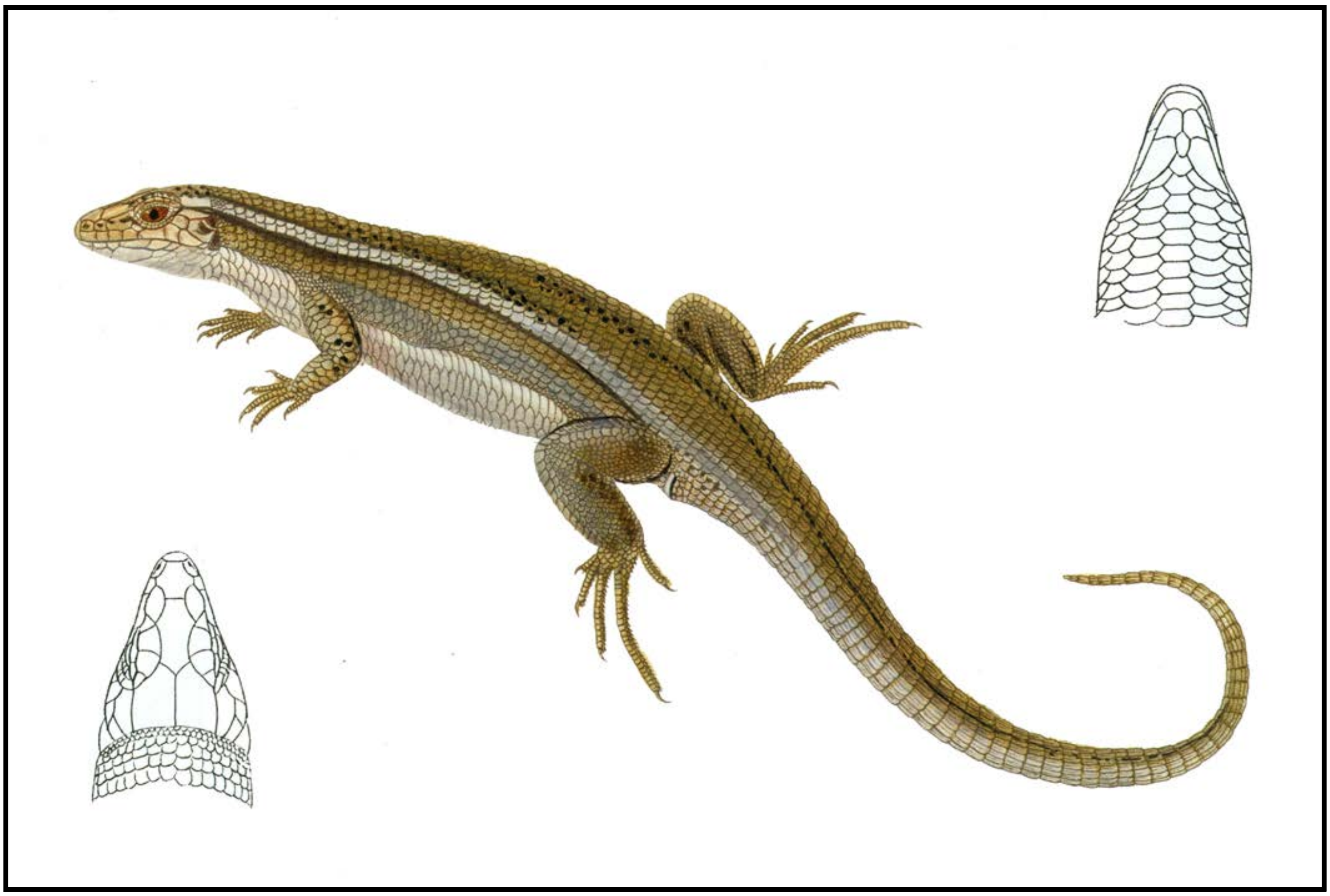

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Cover: Madagascar girdled lizard, *Zonosaurus madagascariensis*. Drawing (as *Gherrosaurus bifasciatus*) from *Erpétologie Générale on Histoire Naturelle Complète des Reptiles—Atlas* by A. M. C. Duméril, G. Bibron and A. Duméril, 1854.

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Notes on the Herpetofauna of Mexico 42: An Incident of Hail Killing a *Crotalus viridis* in Chihuahua, Mexico

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Abstract

Here we document the death of a prairie rattlesnake (*Crotalus viridis*) in the municipality of Juarez, Chihuahua, during a rain/hail storm on 18 September 2022.

Resumen

Aquí documentamos la muerte de una serpiente cascabel de pradera (*Crotalus viridis*) en el municipio de Juárez, Chihuahua, durante una tormenta de lluvia/granizo el 18 de septiembre de 2022.

On 18 September 2022, while surveying the condition of the mushroom communities in an area where there are many assembly factories near the city of Juárez, we found a dead *Crotalus viridis* close to one of the assembly factories (31°45′59.6905″N, 106°41′16.0652″W, elevation 1249 masl), near State Road 2. The strange death of the rattlesnake occurred because that day there was a strong rainstorm between 1600 and 1900 h, with an accumulation of 9.8 mm of rain; from 1700 to 1715 h, the rain turned into a heavy hailstorm. These data were stored by the meteorological station at the Universidad Autónoma de Ciudad Juarez (UACJ).

Unfortunately, no data were taken on the snake that was killed during this atmospheric phenomenon, due to fact that the initial observers who were botanists (mycologists) had no experience in collecting information on vertebrates.

Prairie rattlesnake (*Crotalus viridus*) killed by hail in Chihuahua, Mexico, 18 September 2022. Photograph by Karina Peña-Avilés.

Background on the affected species, *Crotalus viridis*

Distribution: The prairie rattlesnake (*Crotalus viridis*) is one of 46 rattlesnake species documented to occur in Mexico (Alvarado-Diaz and Campbell, 2004; Campbell and Lamar, 2004; Campbell and Flores-Villela, 2008; Bryson et al., 2014; Heimes, 2016; Meik et al., 2018; Carbajal-Márquez et al., 2020; Carbajal-Márquez et al., 2022). The distribution of this rattlesnake extends from a northern extreme in southern Canada (in the provinces of Alberta and Saskatchewan), and throughout the Great Plains of the United States. The distribution includes much of New Mexico, Colorado, Wyoming, and Montana, as well as northeastern Texas, and the eastern borders of Nebraska, Arizona, the Dakotas, and a small portion of northern Mexico (Campbell and Lamar, 2004; Latella and Snell, 2015; SEMARNAT, 2018). According to Ashton (2001), the *viridis* group consists of two distinct phylogenetic clades: the western clade, *C. oreganus*, and the eastern clade, *C. viridis*. In Mexico *C. viridis* is known only in the states of Coahuila and Chihuahua (Saviola et al., 2015), but was reported from extreme northeastern "Sonora" by Smith

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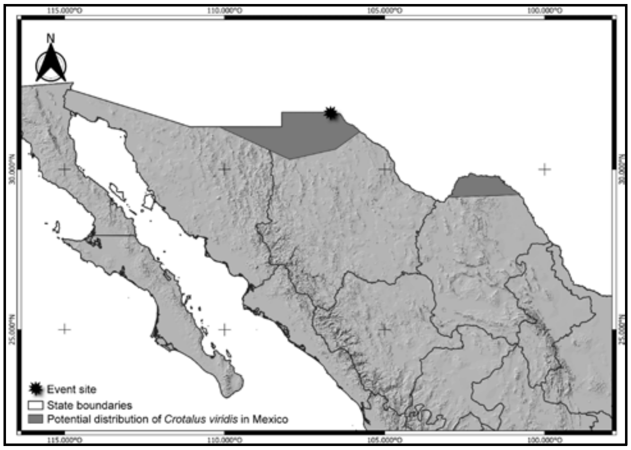

Potential distribution of *Crotalus viridis* in northern Mexico. Map created by Edgar Emmanuel Hernández-Juárez.

and Taylor (1945). Lemos-Espinal and Smith (2007a) recorded *C. viridis* in the municipalities of Ascension, Janos, and Juárez, Chihuahua. In Coahuila, *C. viridis* is documented in the municipality of Allende (Lemos-Espinal and Smith, 2007b). *Crotalus viridis* is found in only one of the seven natural regions in the Chihuahuan Desert (Lavín-Murcio and Lazcano, 2010).

Diet: The main items in the diet of *C. viridis* are small mammals, but adults and especially juveniles also feed on lizards, frogs, toads, insects, birds, eggs, and carrion (Lemos-Espinal and Smith, 2007a, b; Davis and Douglas, 2016).

Reproduction: Synchronization between males and females appears to be modulated by temperature rather than photoperiod (Davis and Douglas, 2016). With regard to their reproduction, Lemos-Espinal and Smith (2007a) commented that copulation may take place at different times according to environmental conditions—in some areas when they emerge from hibernation in the spring, in others in the fall. In the southern part of the species' distribution, where the season of activity is longer, copulation can occur in spring and extend to the end of the season (August–October). Litter size can range from 3 to 21; newborns are 216–279 mm in total length (Lemos-Espinal and Smith, 2007b). Macías-Rodríguez et al. (2013) documented two combat events between males of *C. viridis*, one in early autumn and one in spring in northern Chihuahua, Mexico. Male combat in rattlesnakes is indicative of the approach of the breeding season.

Parasites: Parasites have been documented for the species, including one example of *Porocephalus crotali*, a pentastomid worm (Klauber, 1956), and also *Mesocestoides* sp. (Bolette, 1998). Gatica-Colima et al. (2014) reported the presence of two mites of the family Argasidae in a wild individual of *C. viridis* photographed in Janos, Chihuahua, which represents the first record of this mite family associated with *C. viridis* and the second argasid found in a snake in Mexico.

Conservation status: We used the same systems (i.e., IUCN, SEMARNAT and EVS) as Alvarado-Diaz et al. (2013) and Mata-Silva et al. (2015) to assess the conservation status of the herpetofauna of Chihuahua. For a detailed description of the three systems see Mata-Silva et al. (2015). *Crotalus viridis* is not an endemic species in Mexico and is listed by the IUCN as an LC (Least Concern) species. This snake has an EVS score of 12 (a medium vulnerability species) and the Mexican NOM-059 status Is Special Protection (Pr). The physiographic distribution in Mexico is the Northern Plateau basins and ranges and Sonoran Desert basins and ranges, according to Wilson and Johnson (2010). Lemos-Espinal and Smith (2007a) commented that the activity patterns of this species have not been studied in Mexican populations and are likely to be very different from those in the northern populations found in United States of America. Friggens et al. (2013) indicated that this species could be subject to mortality due to events such as heat waves.

Human impact on the species: Fitzgerald et al. (2004) documented reptile trade in the Chihuahuan Desert Ecoregion, in the locality known as Platero's, Zacatecas, which is an important magical-religious center, where in 1997 more than 100 skins of rattlesnakes, including *C. viridis*, as well as snake oil and a dental balm were secured. The rattlesnake *C. viridis* is also trafficked in local markets for meat consumption and traditional medicine. The greatest anthropogenic threats facing *C. viridis* in northern Mexico are habitat destruction, its use as traditional medicine and food, and the trade in live animals or their skins (Lavín-Murcio and Lazcano, 2010). Many populations of herpetofaunal species are suffering from anthropogenic activities that have altered their habitats, including deforestation for ranching purposes, mining, road kills, provoked forest fires, and many more (SEMARNAT, 2018; Lazcano et al., 2019).

Background on the study site

There are various plant communities in the area, including *Izotal* (yucca woodlands made up of *Yucca elata* and *Y. torreyi*, as well as bullhorn acacia, *Vachellia cornigera*). There is also a scrub community dominated mostly by shrubby and herbaceous plants without thorns. Among the species found are *Larrea tridentata* (creosote bush / *gobernadora*), *Flourencia cernua* (American tarwort / *hojeasen*), *Atriplex canescens*, (four-wing saltbush / *chamizo*), *Solanum elaeagnifolium*, (silverleaf nightshade / *trompillo*), *Echinochloa crus-galli* (barnyard grass), *Bahia absinthifolia* (hairyseed bahia / *margarita del desierto*), *Parthenium incanum* (New Mexico rubber plant / *copalillo medicinal*), *Hilaria mutica* (tobosa grass / *toboso*), and *Ambrosia dumosa* (burrobush / *hierba del burro*), among others. Another scrub community is also present, with different proportions of vegetation, made up of a mixture of shrubby plants with and without thorns. The characteristic species are *Neltuma glandulosa* (mesquite), *Atriplex canescens*, *Larrea tridentata*, *Opuntia macrocentra*, *O. engelmanii*, *O. violacea*, *Cylindro-*


One of the various plant communities in the area. Photograph by Karina Peña-Avilés.

puntia sp. (cane cholla / *choya*), *Koeberlinia spinosa* (crucifixion thorn / *corona de cristo*), *Ephedra trifurca* (longleaf jointfir, ephedra), among others. Finally, sandy desert vegetation is characterized by patches of vegetation from surrounding areas that are gradually turning into dunes. The characteristic species of the area are *Neltuma glandulosa*, *Atriplex canescens*, *Dasylirion* spp. (sotoles), *Artemisia filifolia* (sand sagebrush / *estafiate*) and *Ephedra trifurca* (COTECOCA, 1978; García-Estarrón, 2008; Granados-Sánchez et al., 2011; Quiñónez-Martínez et al., 2018).

The climate of the study site is very dry or dry desert, with rainfall in summer. Temperatures are extreme, with an average annual maximum of 25.4 °C and an average annual minimum of 18.9 °C. The annual relative humidity is 48% with minimum of 35% and maximum of 60% (SEMARNAT, 2016).

Methods

Monitoring flora and fauna is one of the activities regularly carried out by the staff of our Laboratorio de Biodiversidad, Instituto de Ciencias Biomédicas, of the Universidad Autonóma de Juarez in the municipality of Juárez, Chihuahua.

Discussion and Conclusions

Extremes of precipitation will continue to damage property and wildlife wherever they occur (Narwade et al., 2014). We don't know if climate change will increase the number of hailstorms in the future. But we must be aware of how to protect our property and wildlife from these events. Climate change will no doubt enhance the chances for large hailstones, as warmer air containing more water vapor will enter the atmosphere. Powerful storms, with powerful updrafts, will occur more frequently. In 2021 scientists from Universität Bern, the University of New South Wales, and the Karlsruhe Institute of Technology investigated the impact of climate change on hailstorms (Niall and Walsh, 2005; Brimelow et al., 2017; Raupach et al., 2021; Fan et al., 2022). There is a great need for more field work dealing with this matter in the near future.

Acknowledgments

We thank the students of Laboratorio de Biodiversidad, Instituto de Ciencias Biomédicas, Universidad Autónoma de Juárez, for their participation in many of our surveys that were conducted in the municipality of Juárez and the northern portion of Chihuahua.

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Mexican Geographical Distribution Notes 1: First Record of *Tropidodipsas repleta* from the State of Sinaloa

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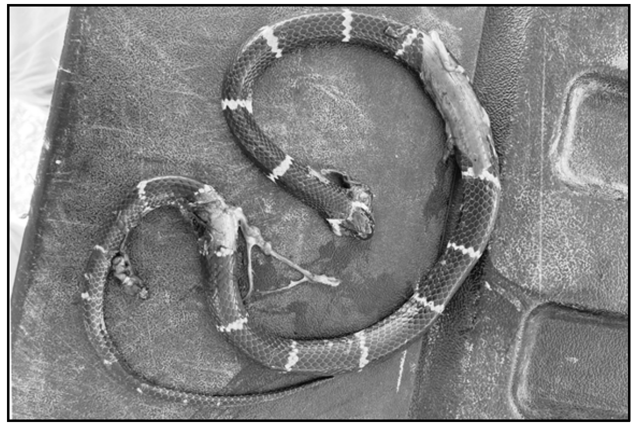
Keywords: Squamata, Serpentes, Colubridae, Dipsadinae

Introduction

Tropidodipsas repleta was described by Smith et al. (2005), based on a single specimen from Sonora. Later, Smith and Lemos-Espinal (2006) reported on a second specimen from Chihuahua. This snake species remains extremely rare, with occasional photos appearing online on various websites and social media sites such as Facebook (C. Grünwald, personal observation). Maynard et al. (2019) summarized the eight records of which they were aware that were verifiable by either a museum specimen or a photo voucher. Seven of those were from the state of Sonora, and one from Chihuahua. Herein, we report on the first record of the species from nearby Sinaloa, and we extend the known distribution of the species significantly to the south.



Tropidodipsas repleta from Sinaloa reported herein. Photograph by Ricardo Ramírez-Chaparro.

Distribution Record

MEXICO: SINALOA: Municipio de Badiraguato: 8.3 km S of Surutato (25.7467, -107,5592; WGS 84; 1560 m elev). 03 September 2022. Ricardo Ramírez. Verified by Jacobo Reyes-Velasco. A photo voucher of the individual was deposited in the University of Texas Arlington, Digital Collection (UTADC 9828). This snake was DOR at night in tropical deciduous forest / oak woodland ecotone. This record was submitted to iNaturalist under the link: https://www.inaturalist.org/observations/161609650.

Discussion

This represents the ninth record of this rare species and the first time that it is recorded from the state of Sinaloa. This record expands the known range 230 km to the south of the Chihuahua record, and 320–330 km south of the seven Sonora records along Highway 16. The elevation and habitat are consistent with where this species has been collected in Sonora and Chihuahua.

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Why the Striking Diversity of Conspicuous Color Patterns in a Poison Frog from Central America?

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Abstract

This brief review applies classical theory in animal evolution and behavior to ask why the best-studied poison frog species *Oophaga pumilio* (Dendrobatidae) displays dramatic color variation among island populations of the Bocas del Toro archipelago, situated off the north-western coast of Panama. The aims of the paper are to: (1) simplify a vast literature by narrowing down myriad explanations for color evolution in *O. pumilio* to an organized synthesis of evolutionary processes (neutral evolution, natural selection, and sexual selection) that integrates proximate (mechanistic) and ultimate (concerned with the broad fitness consequences) phenomena; and (2) to explore recent work on *O. pumilio* that may supply insight into several important questions about the evolution of aposematism. Aposematism is the use of conspicuous signals paired with some form of unprofitability or unpalatability to ward off predators. These questions concern the extent to which the three aforementioned evolutionary processes drive diversity in aposematic signals; how the selective regime expected to be at play in aposematic species may, contrary to expectation, allow for diversity in aposematic color; and whether aposematic signals are expected to be reliable indicators of unpalatability.

Introduction

We have marveled at conspicuous color in animals for millennia (Rojas et al., 2015). The prevalence of conspicuous animal color begs a question: would prey conspicuousness not facilitate detectability and capture, assuming predators have visual systems even remotely resembling ours? In the last century, we have made enormous strides towards understanding how conspicuous color evolves and is maintained (Endler, 1983). Indeed, the hypothesis that bright coloration is often a compromise between sexual selection and natural selection, which dates back to correspondence between Charles Darwin and Alfred R. Wallace in late February of 1867, has become the consensus view among biologists (Darwin, 1871; Endler, 1983; Noonan and Comeault, 2009). While natural selection favors phenotypes with greater survival ability, sexual selection favors phenotypes with greater reproductive success due to greater mate acquisition ability.

Aposematism, whereby prey use conspicuous signals to warn predators of unprofitability, is an ingenious predator avoidance strategy that can evolve under both natural and sexual selection (Rojas and Endler, 2013). Aposematic theory predicts that predators should learn to associate conspicuous signals with bad taste (Rojas et al., 2015). Aposematic colors in particular act as warning and sexual signals in diverse taxa, from butterflies to frogs (Ruxton et al., 2018). A color may quickly become fixed in a population not only because it effectively signals unpalatability to predators (natural selection), but also because it provides substantial sensory stimulation to opposite-sex conspecifics through high signal quantity (brightness, hue) (Maan and Cummings, 2009; Ruxton et al., 2018), or exploits pre-existing sensory biases like the color of a common food source (sensory exploitation hypothesis), both sexually selected causes (Ryan et al., 1990). Because a color pattern can evolve under natural and sexual selection in this way, a challenge is to determine the sequence in which an aposematic population was subjected to the two forces as well as the relative strengths of in the establishment of an aposematic phenotype (Rojas et al., 2015).

Another major question in aposematic evolution—besides the contributions of natural and sexual selection—regards violations of a key theoretical prediction. Aposematic organisms rely on detection by predators and subsequent predator education; otherwise, why possess such an energetically costly (i.e., requiring sequestration or production of color pigments [Crothers et al., 2016]) and visually obvious trait? Therefore, positive, frequency-dependent selection, whereby the fitness of a phenotype increases with its frequency, is expected in aposematic organisms. Positive, frequency-dependent selection minimizes polymorphism (within-population variation) and polytypism (between-population variation) in aposematic signals, which hastens learning and maximizes avoidance by predators (Ruxton et al., 2018). Nonaposematic organisms, on the other hand, must rely on concealment to avoid detection by predators. Thus, nonaposematic organisms are expected to evolve under negative, frequency-dependent selection, whereby the fitness of a phenotype decreases with its frequency, maximizing polymorphism and polytypism; overloading predators with visual information (Rand, 1967; Ricklefs and O'Rourke, 1975); and reducing predator ability to memorize a "search image" (Dukas, 2002). The predator search image hypothesis posits that predators should select prey that are abundant and with which they have had success. Thus, it is useful for nonaposematic species, populations, and individuals to be rare and morphologically distinct from each other (Dukas, 2002). A question then, is why polytypism and polymorphism appear in many aposematic organisms, including many beetles, butterflies, and poison frogs, wherein positive, frequency-dependent selection should be the dominant form of natural selection (O'Donald and Majerus, 1987; Rojas and Endler, 2013).

A final important question regarding aposematism is whether aposematic signals reliably indicate unpalatability. There is dissent over whether warning signals should be quantitatively honest, with a relatively tight correlation between conspicuousness and toxicity, or qualitatively honest, where the presence rather than magnitude of the aposematic signal advertises secondary defenses (Ruxton et al., 2018). Theoretical studies have predicted both negative and positive relationships between unpalatability and conspicuousness, and empirical studies are also conflicting, both intra- and interspecifically (Crothers et al., 2016; Ruxton et al., 2018).

Neotropical poison frogs (Dendrobatidae) are ideal for studies of how aposematism evolves, because the trait has arisen at least five times independently in the family (Santos et al., 2003; Tarvin et al., 2017). In the past 25 years, the best-studied dendrobatid species, *Oophaga pumilio*, has become a focus of research investigating how highly variable color patterns can arise and be maintained in animals (Summers et al., 1997), with many questions remaining to be answered (Yang et al., 2019). *Oophaga pumilio* is red throughout its ancient mainland distribution in Costa Rica and Panama. However, while the species has colonized the Bocas del Toro archipelago off the coast of Panama only within the last ~10,000 years, these populations display remarkable color polytypism (Summers et al., 1997) and polymorphism (Yang et al., 2019). *Oophaga pumilio* provides an excellent opportunity to understand the interactions of the broad evolutionary processes that control the variation—neutral evolution, natural selection, and sexual selection.

Unfortunately, readers uninitiated in the *O. pumilio* system may easily be overwhelmed by the literature: a perfunctory skimming suggests seemingly unending causes of polytypism—maternal imprinting, parental care, assortative mating, limited gene flow, sexual selection, natural selection, and more. Here, I attempt to formulate a clearer picture of aposematic evolution in *O. pumilio*. I integrate fundamental theory in evolutionary biology and animal behavior to explore, why, contrary to theoretical expectations, polytypism and polymorphism are maintained. Resolving this is of particular interest to evolutionary biologists, because color polymorphism is likely a precursor to color polytypism (between-population variation) and speciation (Lawrence et al., 2019).

I consider ultimate evolutionary causes of polytypism and polymorphism individually: (1) sexual selection; (2) natural selection; and (3) drift, and tie in discussion of the proximate mechanisms, which are often the workhorses of the ultimate drivers. For example, natural selection (e.g., frequency-dependent, weak purifying) (Lawrence et al., 2019); sexual selection (via uniparental care, intrasexual competition, and mate choice for example) (Summers et al., 1997; Rojas and Endler, 2013); and neutral evolution (drift) (Tazzyman and Iwasa, 2010) are ultimate explanations. Sexual selection can exert itself through non-random (assortative) female preferences governed by maternal imprinting, a proximate behavioral mechanism (Yang et al., 2019). Traits can evolve neutrally in a population, becoming through stochastic processes explained by limited gene flow between populations, a proximate genetic mechanism (Tazzyman and Iwasa, 2010). Finally, I ask whether signaling is reliable in this species and caution readers not to generalize the conclusions regarding signal reliability in *O. pumilio* to other dendrobatids, an evolutionarily complex group.

Sexual Selection

Work by Summers et al. (1997) may have spurred the intensive research program on *O. pumilio*. The study is one of few to frame questions in an macroevolutionary context to ask what makes *O. pumilio* unique among dendrobatids. The authors found that three island populations of aposematic dendrobatids—*Phyllobates lugubris*, *Minyobates* sp., and *O. pumilio*—are about the same age (they have similar levels of mitochondrial sequence divergence) (Summers et al., 1997), even though *O. pumilio* is the only species of the three with inter-island color variation. Although the authors lacked direct evidence for female mate choice in explaining the polytypic patterns, they assumed a role of sexual selection based on life history information for the species and theoretical predictions. The authors posited that color differences among species could be explained by female investment in *O. pumilio* (the other two species have male parental care).

Predictions of sexual selection theory link parental care to female choice, which merits brief discussion. Female choice for male ornaments should be high in taxa with greater female compared to male investment in offspring (Williams, 1966; Trivers, 1972). In species with substantial male parental care, female preferences are under direct selection due to benefits provided to the female (energy saving from avoiding caregiving, resources contributed to the female and offspring [Trivers, 1972]). Therefore, female choice is constrained (Kirkpatrick, 1985). In species in which males provide little to no parental investment, constraints are relaxed. Thus, sexually selected traits can diverge rapidly, because females may vary in preferences across populations (Darwin, 1871; West-Eberhard, 1983).

Work following up on the role of sexual selection in driving color variation in *O. pumilio* in a cross-species context is lacking. However, granular, intraspecific work on sexual selection in Bocas del Toro populations of *O. pumilio* has yielded insights. Significantly, sexual selection is hypothesized to be the primary driver of color diversification in *O. pumilio*, partly explaining inter-island polytypism and polymorphism (Crothers et al., 2011).

Findings continue to support the idea that assortative preferences of females are likely important targets of sexual selection in *O. pumilio*. Females in three island populations show assortative preferences mediated by male dorsal coloration (Maan and Cummings, 2008) and in two populations by male brightness (Maan and Cummings, 2009). Hypotheses for female choice of brighter males include indirect benefits, because brightness is associated with offspring fitness in terms of predator deterrence, foraging efficiency and/or alkaloid sequestration; direct benefits, i.e., that reliable signaling of physical condition is a result of metabolic tradeoffs and thus the ability to confer the females with resources (Maan and Cummings, 2009); and confounding effects of male behavior; more brightly colored *O. pumilio* males call from higher, more visible perching sites compared to duller ones on Isla Solarte (Crothers et al., 2016), a pattern that also holds across populations too (Rudh et al., 2011, 2013). Females prefer perch-calling males. An explanation is higher signal efficacy and salience: evolution is expected to favor mate preferences for signals that stand out relative to the background (salient), because these signals take less energy to identify (efficacious). Perch calling as a more obvious and visible signal than calling from concealed location is salient and efficacious, and thus preferred (Rudh et al., 2011, 2013; Crothers et al., 2016).

Intrasexual conflict also matters. Warning coloration has likely been co-opted as an agonistic indicator trait in *O. pumilio*, at least in the Isla Solarte population. Here, there is polymorphism in brightness: males are significantly brighter than females (Maan and Cummings, 2009). Fascinatingly, the presumed major predator (birds) cannot perceive the male brightness variation in this population, suggesting limited ability for natural selection to influence the trait. Brighter Isla Solarte males exhibit shorter latencies to call (Crothers and Cummings, 2015), call more often, and approach other bright same-sex conspecifics faster than duller males. Males, regardless of brightness, more frequently call to and approach brighter males (Crothers et al., 2011). Finally, differences in brightness predict the probability of the brighter male in an experimental pair being the sole aggressor (initiating agonistic calling). Where differences are smaller, both males are more likely to engage in agonistic calling (Crothers and Cummings, 2015). Because changes in signal brightness can drive changes in hue, brightness variation mediated by intrasexual conflict-driven sexual selection possibly contributes to polytypism among the island populations (Crothers and Cummings, 2013), consistent with the finding that males on islands are brighter than those on the mainland (Maan and Cummings, 2009).

Excitingly, a proximate mechanism through which sexual selection may act in *O. pumilio* has been recently identified: maternal imprinting. Maternal imprinting affects male-male competition and female preferences. There were two major takeaways from an experiment using three geographically isolated populations of *O. pumilio*: (1) Cross-fostered *O. pumilio* females prefer males that share the color of their foster mother (an example of an assortative female preference); (2) Cross-fostered males are also more aggressive towards rivals that share the color of the foster mother. Furthermore, population genetic modeling demonstrates that sexual selection alone can stabilize co-existence of different morphotypes in a population and strengthen the trait-preference association, which may lead to behavioral reproductive isolation and speciation (Yang et al., 2019).

Drift

Theoretical workers proposed a process called "coupled drift", which relies on both sexually selected trait-preference evolution and drift, to explain polytypism in *O. pumilio* (Tazzyman and Iwasa, 2010; Yang et al., 2019). Drift is likely an important factor explaining polytypism among *O. pumilio* populations; these populations are small and geographically isolated (Summers et al., 1997). In "coupled drift", one trait (the "follower trait") tracks the evolution of the other (the "leader trait"). According to the mathematical predictions, female preference is required to be the "leader trait" and color the "follower trait" for polytypism to have evolved in *O. pumilio*. Essentially, the evolution of color is determined mainly by drift in female preference, because color is coupled to female preference by sexual selection. Mathematical modeling predicts that coupled drift will cause more color variation than neutral drift if (1) additive genetic variance in preference is higher than that in color, and; (2) preference is more strongly affected by drift when sexual selection is present than is color when sexual selection is absent. Thus, the model suggests that sexually selecting species should vary more than nonsexually selecting ones, like the two dendrobatids in sympatry with *O. pumilio* (Tazzyman and Iwasa, 2010).

Natural Selection

Natural selection likely plays a partial role in explaining polytypism among island populations of *O. pumilio* and possibly a small role in explaining polymorphism (Yang et al., 2019). As discussed, aposematic theory predicts monomorphism in color signal. Monomorphism should be favored not only due to assortative female preferences but also natural selection, specifically purifying selection from predators. Purifying selection should select against any new color forms that arise via mutation while the forms are rare, and only fix color forms that are common (positive frequency-dependent selection). The idea here is that predators have not learned to avoid new forms and thus should preferentially prey on them.

However, the opposite may be true in *O. pumilio*: avian predators may display neophobia, avoiding red and yellow patterns, including ones on which they have not been educated. In fact, predator avoidance of bright red and yellow colors might be stronger than avoidance of the local frog coloration on which predators have learned, especially given that some island populations of *O. pumilio* are not highly unpalatable. In this way, predator selection may exacerbate sexually selected brightness (Hegna et al., 2013).

Consistent with the hypothesis, attack rates on Isla Colón are lower on clay models of foreign red than on local green frogs (Hegna et al., 2013). Furthermore, other workers found, using mark-recapture and clay models, equal predator avoidance of yellow and red frogs where the two types are sympatric (on Bastimentos Island), even though red frogs are more common and widespread, suggesting red might be more aversive than yellow (Richards-Zawacki et al., 2013). Results of a third clay model study are conflicting: frogs with highly conspicuous colors were found to be more susceptible to avian attacks. The interpretation was that bird predation selects for a bright, conspicuous coloration in local prey because the conspicuousness itself facilitates the education of birds for predator avoidance. Despite the inconsistency, this study does corroborate the idea that local frogs are not necessarily more susceptible to avian attacks, though the study also did not find strong support for avian neophobia (Dreher et al., 2015).

Findings from all three clay model studies support the hypothesis that natural selection plays a role in polytypism evolution in *O. pumilio*. Another major takeaway is that neophobia may be more predictive than predator learning of local color in shaping polytypic patterns (Richards-Zawacki et al., 2013). Finally, it should be noted that overall predator attack rate on red (mainland), green (Isla Colón of the Bocas del Toro archipelago), and brown (control) clay models was lower in Isla Colón compared to that on the mainland, suggesting lower predation pressure on the islands. Likely, reduced pressure from birds compared to the mainland has relaxed stabilizing selection across the archipelago, perhaps facilitating color diversification under sexual selection and/or drift (Maan and Cummings, 2009). In particular, liberation from predation pressure on islands may facilitate evolution of boldness and brightness via sexual selection (Maan and Cummings, 2009), particularly within populations, which hearkens back to the previously discussed results on sexual selection (that lower predation may explain the diversification in male brightness outside the avian perceptual limits and male brightness as a predictor of perch calling).

Concluding Remarks on the Reliability of Aposematic Signals in *O. pumilio*

Theory suggests that aposematic conspicuousness can function as a reliable indicator of unpalatability (Ruxton et al., 2018). The establishment of a reliable signaling system might be facilitated if the signal has evolved to be directed towards the sensory system of a dominant (i.e., making most of the attacks) predator group—birds in *O. pumilio*. Signaling in *O. pumilio* may be a reliable quantitative signal of unpalatability, and perhaps in some cases, mate quality. Data suggest that aposematic signaling in *O. pumilio* predicts level of unpalatability between and within Bocas del Toro populations. Across 10 populations, unpalatability is strongly correlated with frog brightness as well as conspicuousness to *in silico* bird-specific perceptual models (Maan and Cummings, 2012). Reliable signaling may also be sexually selected within populations. On Isla Solarte, brighter frogs exhibit lower advertising call pulse rates (Crothers et al., 2011), a possibly fitness-related trait negatively correlated with mating—and possibly reproductive—success (Pröhl, 2003).

If various predator groups are involved, alternative strategies to reliable signaling might be favored. Optimal strategies may be contingent on tradeoffs between conspicuousness and unpalatability in particular ecosystems (Maan and Cummings, 2009). One alternative strategy is mimicry. Two types have been identified in dendrobatids—Batesian (wherein a palatable species mimics an unpalatable species to gain protection, i.e., two *Allobates* species that mimic unpalatable *Ameerega* [Darst and Cummings, 2006; Darst et al., 2006]), and Müllerian (wherein an unpalatable species mimics the color of another unpalatable model to hasten predator learning, i.e., Peruvian dendrobatid *Ranitomeya imitator* [Symula et al., 2001]).

Thus, while studies of ultimate and proximate causes of color variation in *O. pumilio* may provide deep insights about aposematic evolution, we should be careful not to generalize our findings, even to other dendrobatids. Dendrobatidae is an evolutionarily intricate group whose members have unique histories of selective regimes. Furthermore, dendrobatids continue to evolve in the context of myriad predator-prey assemblages and taxon-specific ecological interactions and tradeoffs, implying diverse strategies for aposematic signaling may exist. While *O. pumilio* is an exceptionally powerful species model given its color diversity, studies are needed across aposematic dendrobatids to determine how generally evolutionary patterns from *O. pumilio* hold.

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Book Review: *The Conservation and Biogeography of Amphibians in the Caribbean* edited by Neftalí Ríos-López and Harold Heatwole

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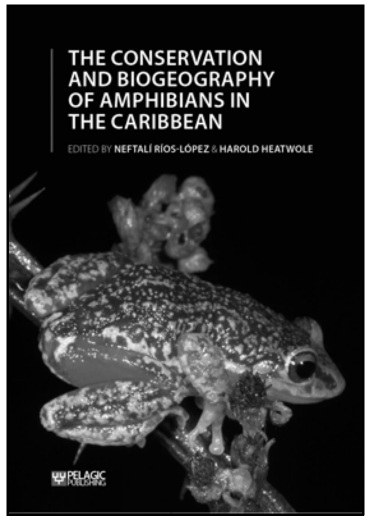


Island ecosystems are treasure troves for biologists — most famously Charles Darwin himself, whose theory of evolution by natural selection was partially inspired by a visit to the Galápagos. Because of their isolation, islands slowly accumulate species from nearby landmasses, and then embark with them on distinctive evolutionary voyages, (largely) free of outside influence. Birds, mammals and reptiles tend to be the most numerous and iconic island vertebrates—see the kâkâpô, the lemur, the Galápagos tortoise — but what of amphibians? Because they never evolved waterproofing, and are usually dependent on fresh water for development, amphibians are less likely to colonize islands than other terrestrial vertebrates. Those island amphibians that do exist are thus yet more precious—and vulnerable. Nowhere is this more apparent than in the Caribbean islands, which boast a unique and highly endemic amphibian fauna, while experiencing some of the most dire habitat destruction and climate change effects in the world. Enter *The Conservation and Biogeography of Amphibians in the Caribbean,* a new volume edited by Neftalí Ríos-López and Harold Heatwole, which seeks to collect the total knowledge of Caribbean amphibians and offer guidance toward their conservation before more of them disappear. With its comprehensive scope and in-depth, island-by-island approach, this book should satisfy those with serious interest in the topic.

The stated purpose of this book is to serve as a "time capsule, providing a perspective by present-day experts on the conservation of amphibians and the challenges faced by each taxon in the region" (p. xiii). For each island or island-group in the Caribbean, starting with the Bahamas and ending with the Bocas del Toro Archipelago of Panama, the editors and a suite of qualified guest authors offer a comprehensive overview of its amphibian fauna, a realistic assessment of the threats it faces, and suggestions for future study and conservation priorities. In this the book is undoubtedly successful. For academics in the field and interested, knowledgeable parties, it will be an invaluable resource; more casual audiences should approach with caution.

The two editors are current leaders in the biology of Caribbean amphibians. Neftalí Ríos-López is a professor of biology at the University of Puerto Rico, and has studied Caribbean amphibians for over 30 years, including the management of important captive breeding programs and the description of new species. Harold Heatwole, one of the most prolific and accomplished living herpetologists, is a professor emeritus at North Carolina State University. Heatwole's interests and experience are too extensive to summarize in a single paragraph—he holds three PhDs (biology, botany, and geography), has written seven books and ~350 scientific papers, and has survived sea snake envenomation. The editors also contributed to several of the book's chapters as authors; the list of guest authors includes a variety of other prominent names in Caribbean herpetology.

The first chapter of the book is a general review of the theory of island biogeography by the editors. This chapter's inclusion undoubtedly enriches the book by providing context for the importance of island ecosystems in eco-evolutionary and conservation biology. Taken in isolation, it would work quite well as a general introduction to island biogeography, sweeping from pre-MacArthur-Wilson literature to cutting-edge tests of the theory's predictions published in the last few years. In fact I almost wish the chapter were published separately as it could be exceedingly useful to much more than the relatively niche audience of the book itself.

The remaining 12 chapters focus on specific islands or island-groups within the Caribbean. The book's greatest strength is its comprehensive scope here. Each of these chapters generally contains the following sections in one form or another:

- A general introduction to the island system. The most poignant of these comes from Ríos-López's chapter on the amphibians of Haiti, which ties together Haiti's unique history of slavery, colonialism, revolution, and poverty with the extraordinary rate of habitat destruction resulting from it (pp. 219–222). With this context, the fact that 90% (27/30) of Haiti's endemic frog species are critically endangered, provided later (p. 249), is that much more sobering, and a reminder of the interconnectedness between humans and the rest of the animal world.
- Geography and geology. This information is often of the highest necessity for understanding biogeography and the relations of species to their environments. This section from the chapter on Cuba by Díaz et al. is particularly rich, with numerous full-color maps (pp. 65–69).
- Native amphibians. Often accompanied by color photographs, this section will be of highest interest to more casual audiences. Habits, habitat, reproduction, and conservation status are generally covered in detail for each species. Particularly memorable is the section from the chapter on

the Lesser Antilles by Powell and Henderson ("*Eleutherodactylus johnstonei* is the anuran version of a weed," was the quote-of-the-book; p. 484), featuring a harrowing and detailed account of the fall of the "mountain chicken," *Leptodactylus fallax.* This large frog was a delicacy and tourist attraction on Dominica and Montserrat until the early 2000s, when chytridiomycosis caused catastrophic population declines from thousands to just a few individuals (pp. 487–491). The species only survives today via intensive monitoring and captive breeding.

- Nonnative amphibians. This topic ranges from frogs that immigrated from neighboring islands without human intervention hundreds or thousands of years ago, to frogs deliberately introduced to control pests before becoming pests themselves. The same cast of actors appears from island to island: the cane toad *Rhinella marina;* the Cuban treefrog *Osteopilus septentrionalis*, etc. One amusing account was of a fire salamander (*Salamandra salamandra*) that in 2012 was mistakenly shipped from France to St. Barthélemy in a box of salad (p. 506).
- Threats to amphibians. This section details threats to Caribbean amphibians ranging from deforestation, to over-collection by scientists, to mongoose predation. Of these sections, the one by Ríos-López et al. on Puerto Rico is most comprehensive. Especially interesting is the discussion of the effects of Hurricane Maria on amphibians and their habitats from 2017 to the present (pp. 408–411).
- Conservation priorities. This section outlines conservation actions already in place, such as captive breeding programs and the establishment of protected areas, and offers suggestions on actions to take in the future. Far too often, existing conservation actions for Caribbean amphibians are few and far between. For example, Auguste et al. discuss in detail the timeline of wildlife conservation legislation in Trinidad, and how it has become enmired in bureaucracy and changes in government (pp. 564–565).

As with any anthology or edited volume, overall chapter quality in this book is inconsistent. My personal favorite, striking an excellent combination of depth and breadth alongside a plethora of full-color images, was the chapter on Cuba by Díaz et al. The chapter by Ríos-López et al. on Puerto Rico and the Virgin Islands was also impressive, but perhaps overly long and detailed—at 170 pages it is almost an entire book in itself. On the other hand, Stephenson and Wilson's 16-page chapter on Jamaica was underwhelming, with cursory species accounts and a noticeable lack of images. Though the overall curation, writing, and contribution by editors Ríos-López and Heatwole is excellent, I cannot help but think that a sterner editorial hand, and a more ambitious vision for the "perfect chapter," could have enforced greater consistency from one chapter to the next.

This volume is written for an academic audience, and should not be mistaken for a field guide, popular science book, or coffee table book. It will be most enjoyed by researchers of Caribbean reptiles and amphibians, and others with serious interest in the topic, but herpetologists who work elsewhere (such as myself) will also find much of value in it. Overall this is a strong volume and a landmark publication for Caribbean herpetology. Owing to their unique ecologies, amphibians are less common in the Caribbean (and island ecosystems in general) than reptiles, which with some exceptions has perhaps resulted in comparatively less attention from herpetologists and conservationists. Hopefully, *The Conservation and Biogeography of Amphibians in the Caribbean* will inspire a new generation of research and preservation in this fascinating group.

Minutes of the CHS Board Meeting, April 11, 2023

A meeting of the CHS board of directors was called to order via Zoom at 7:36 P.M. Board members Kyle Houlihan and Margaret Ann Paauw were absent. Caitlin Monesmith John Webb and Lucy Webb also attended. Minutes of the March 14 board meeting were read and accepted with changes.

Officers' reports

Treasurer: Rich Crowley reviewed the March financial reports.

Media secretary: Gabrielle Evans says that Instagram is still our best online site. Twitter and Tumblr are basically inactive. John Webb will experiment with streaming meetings and report back.

Membership secretary: Mike Dloogatch read through the list of recent nonrenewals.

Sergeant-at-arms: Tom Mikosz reported 22 in-person attendees at the March meeting.

Committee reports

Junior Herpers: Caitlin Monesmith will reinstitute meetings of the Junior Herpers at the Notebaert, 1:00 P.M., Sunday May 21, with a short reintroduction, and touring of the museum reptile collection. She hopes to advertise with a flyer at the Association of American Educators, and post on all CHS media sites.

Shows: Gail Oomens plans to resume live animal shows soon. She will be sending out emails to members who have worked the shows previously.

Old business

We are still in need of someone to take charge of the library.

New business

Rich reported thatAnna Payton, formerly at DuPage County Care & Control, is now Director of Animal Care & Control in Will County. We may see rescues coming in from them.

Amelia Pollock reported we will have a table to display materials/ native reptiles at the International Herpetological Symposium.

The meeting adjourned at 8:36 P.M.

Respectfully submitted by recording secretary Gail Oomens

Herpetological Art in the Chattanooga, Tennessee, Zoo — June 7, 2022

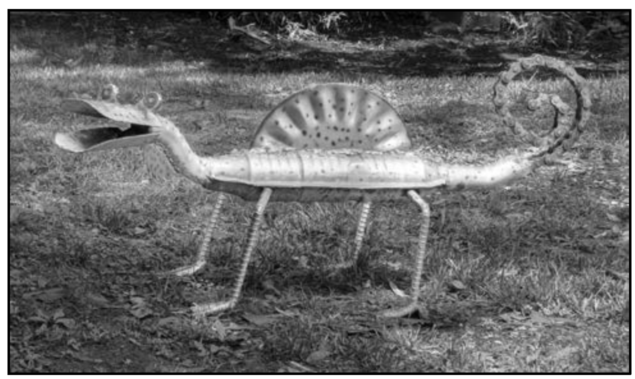
Photos and story by
Roger Carter
625 Lakeview Dr
Zionsville, IN 46077
drymarchonzz@hotmail.com

While on vacation, Holly and I stopped to see our friend Dave Stahl in Chattanooga, Tennessee, and he took us to the Chattanooga Zoo in the late afternoon.

Near the outdoor enclosure for the radiated tortoise, *Astrochelys radiata*, is a bronze statue of a tortoise. This is about the size of a radiated tortoise, but doesn't resemble one because it isn't shaped correctly.

Near the building that has all the marmosets is a metal statue of a frog that might be 12 inches long. I don't know what kind of steel this is made from but there are patches of rust on the statue so it may have been outside for a while. Near the frog is a sheet metal statue of what is probably meant to be some kind of lizard that is, maybe, three feet long, colored blue and white with what looks like a bicycle chain as a coiled up tail. There is also a metal sculpture of pipe and bars that sort of resembles some kind of insect although it only has four legs instead of six. There is also rust on the insect statue. The insect statue reminds me of a praying mantis without the front grasping claws.

Inside the enclosure of a Chinese alligator, *Alligator sinensis*, there is a large statue of some kind of crocodilian. This is placed far back from a chain-link fence and the glass front of the enclosure so I couldn't get what I would call a decent photograph, plus the grass in the enclosure is high so I couldn't see all of this statue and can't guess how long it is, but it must be several feet long. I think this statue might be made of wood because, while looking at the front of the statue's snout from my computer screen, it looks like wood that has weathered a little bit.



Herpetological Art in the Indian Camp Creek Park, near Foristell, Missouri—July 10, 2022

Photos and story by
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Zionsville, IN 46077
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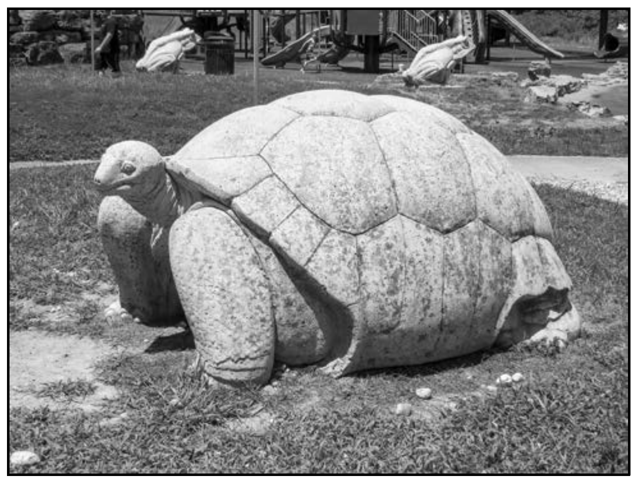
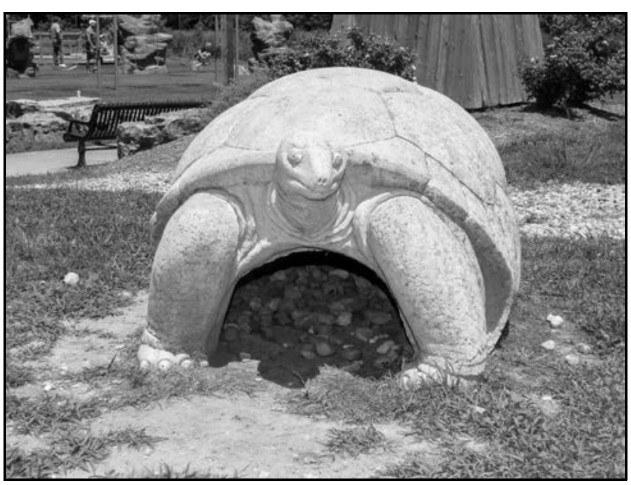
On a trip to the in-laws, who live near St. Louis, Missouri, we also went to the Indian Camp Creek Park which is located several miles west of St. Louis near Foristell, Missouri. We passed two locations that have pavilions with picnic tables, grills for cooking food, and playgrounds with swings, slides and other features that children can play on. Then we arrived at a third location with a pavilion, grills and playground, but which also has eight identical concrete statues of toads that are scattered around the picnic area and one statue of a tortoise. The toad statues are on a concrete base that is several inches thick and the toad with its base is approximately four feet tall. Seven of these statues are out in the open and one is located at the edge of a lake in some tall brush that makes this look like a toad that is partially hidden waiting to ambush prey. The tortoise is approximately the size of an adult Galapagos tortoise, but doesn't represent any actual tortoise, and is hollow with the opening between the front legs. This isn't a very large cavity but looks like it there might be enough room for one or two small children to get in there to play. I guess the statues are there for the children to play on, but I didn't see any children climbing on them. Sitting out in the hot sun all day, maybe the concrete is too hot. I searched through a few field guides to try to see if the toad statues represent a real species or not, without success. So I showed these pictures around and the best reply that I received was "It's just a stylized toad. It doesn't accurately represent any North American toad or frog." These statues have what could be parotoid glands but, on the side of the head, there are bumps where the tympanum would be. I think a lot of effort went into making the mold that made these toad statues, so whoever did this might as well have gone to a little more effort and made them look more like one of the toads found in Missouri (eastern American toad, *Anaxyrus americanus americanus*, dwarf American toad, *Anaxyrus americanus charlesmithi*, Great Plains toad, *Anaxyrus cognatus*, Rocky Mountain toad, *Anaxyrus woodhousei woodhousei* or Fowler's toad, *Anaxyrus fowleri*).

There are also two large metal sculptures of dragonflies and some kind of rope swing that, at first glance, I thought was meant to be a snake.





Herpetology 2023

In this column the editorial staff presents short abstracts of herpetological articles we have found of interest. This is not an attempt to summarize all of the research papers being published; it is an attempt to increase the reader's awareness of what herpetologists have been doing and publishing. The editor assumes full responsibility for any errors or misleading statements.

RECRUITMENT FAILURE IN A TURTLE POPULATION

J. B. Iverson [2022, Chelonian Conservation and Biology 21(2): 181-186] reports that the eruption of Mount Pinatubo in the Philippines in June 1991 reduced global temperatures over the following 2 yrs. The greatest suppression (apart from Antarctica) was centered in the northern Great Plains of North America, directly over his long-term turtle study site. Temperatures at that site in 1992 and 1993 were the coldest in at least 50 yrs. Normal annual hatchling recruitment of yellow mud turtles (*Kinosternon flavescens*) in the spring following incubation at that site averaged 375; however, only 3 hatchlings emerged in 1993 (1992 incubation cohort), and none emerged in 1994 (1993 incubation cohort). The depressed temperatures apparently prolonged incubation times to such an extent in 1992 and 1993 that hatching was nearly impossible before winter mortality. The result was a gap in the age class structure that was still evident 26 yrs later. This site is at the northern range limit of this species, and this event suggests that incubation temperatures (i.e., summer season length) may be responsible for that limit.

FIELD MARGINS MAY BENEFIT VIPERS

R. Hodges et al. [2023, The Herpetological Bulletin 163:15-20] report that in Britain, some reptile species have been formally recorded inhabiting arable field margins but previous reports on the incidence of northern vipers or adders, *Vipera berus*, in this situation have been anecdotal. In 2017, reptile monitoring was initiated in a field margin that had been created ten years earlier and was located near two chalk grassland nature reserves with established viper populations. In the first three years of recording, numbers of vipers in the field margin were low and limited to a few juveniles and adults. In the fourth year, there was a noticeable increase in number, which were now represented by all life stages. In the fifth year the population doubled again and then remained stable in the sixth year. A similar encounter trajectory was observed for grass snakes, while slow worms and common lizard encounters had different trajectories. There was some evidence of vipers moving between the nature reserves and field margin, even crossing a road to do so, but at least 75% of vipers in the field margin were only ever detected there. The arable field was mostly used for cropping cereals and oilseeds but, exceptionally, in the three years from 2016 to 2018 it was put down to herbal leys of red clover and grass. In the USA and continental Europe, red clover is known to be a preferred dietary item of voles, *Microtus* spp., and has been associated with vole population increase. It is suggested that the increase in the viper population in the field margin may relate to a rise in the number of voles, which are an important component of the viper diet. Likewise, for grass snakes, small mammals may contribute 25% or more of their diet. The use of herbal leys may present an important opportunity for the conservation of northern vipers in field margins and other adjacent habitats.

REPRODUCTION IN FLORIDA BOX TURTLES

J. Donini et al. [2022, Chelonian Conservation and Biology 21(2):218-224] note that box turtle (*Terrapene* spp.) reproduction has been relatively well studied in northern populations inhabiting more seasonal climates but is much less understood in the subtropics. The authors assessed female reproduction of *T. bauri* in southwestern Florida by quantifying courtship, mating, seasonal timing of nesting, clutch frequency, and clutch size. Box turtles were observed courting or mating in 10 out of 12 mo. Radiographs revealed oviducal eggs from January to August. To their knowledge, this is the earliest recorded detection of eggs in wild box turtles. Individual turtles produced 2–4 clutches of 1–5 eggs in a nesting season. This study provides further evidence that turtle populations at warmer climates exhibit extended reproductive seasons compared with similar populations in cooler climates.

COLORS OF NORTHERN PACIFIC RATTLESNAKES

J. Brooks et al. [2022, Herpetologica 78(3):192-200] note that northern pacific rattlesnakes (*Crotalus oreganus*) are ambush-hunting predators that rely on crypsis to forage and to avoid encounters with predators, yet little is known about color variation in this ubiquitous rattlesnake species. This study addressed how coloration and contrast in tail banding in *C. oreganus* vary among habitat types in Washington State. The authors also explored whether *C. oreganus* exhibit sexual dimorphism in coloration or tail band contrast (sexual dichromatism). They sampled 127 rattlesnakes from seven different populations across northern and central Washington state during spring emergence from overwintering hibernacula in 2017 and 2018. They characterized snake coloration as red/blue color ratios from standardized photographs, and used GIS supervised classification schemes of satellite imagery to characterize habitat. They used generalized linear models to assess relationships among snake color and tail bands, habitat, and sex. They found that coloration (red/blue color ratios) in *C. oreganus* varied greatly across the landscape, both within and among populations, likely a reflection of their variable and heterogenous shrub-steppe and forest ecotone habitats. In 20% of 21 pairwise comparisons, populations differed in body color. Rattlesnake coloration was not associated with habitat (amount of forested land within 0.5 km of the snake den), but male and female rattlesnakes showed different associations between color and percent forested habitat. Male rattlesnakes did not differ in body coloration from females, but males showed greater contrast than females in the black and white banding present on the tail. The authors discuss several, non-mutually exclusive, hypotheses for sexual dichromatism in tail band contrast, including the possibility that tail banding constitutes warning coloration in rattlesnakes. The results suggest that sexual dichromatism, and the role of tail banding in rattlesnake ecology, are topics worthy of further investigation.

TREEFROG THROAT COLORATION

G. Höbel et al. [2022, Journal of Herpetology 56(3):294-301] note that sexual dichromatism, where males and females of the same species differ in coloration, is best studied in diurnal animals. Nocturnal animals such as frogs do not seem good candidates for widespread sexual dichromatism, or for the use of visual signals in social communication in general. Yet, up to 25% of treefrog species show some degree of sexual difference in their dorsal coloration. The ventral side of frogs is hidden during rest, but the throat region becomes visible in active individuals, especially in calling males. The authors compiled a database of 249 treefrog species that include members of all seven subfamilies of the Family Hylidae. They document that the throat region of male frogs is frequently colorful and of a different color than the abdomen (ventral dichromatism), that there is interspecific variation in throat coloration, and that males and females differ in throat coloration (sexual dichromatism). They also examined intraspecific variation in throat coloration, using eastern gray treefrogs, *Dryophytes versicolor* (*Hyla versicolor*) as the focal species. They document that throat color is sexually dimorphic, that it varies among males, is associated with better body condition, and on average is darker in mated compared to unmated males. This study finds that throat color dichromatism is the most prevalent type of sexual dichromatism in treefrogs, and that throat coloration may have sexual signal function.

UNDERSTANDING GEOGRAPHIC DISTRIBUTIONS

T. P. Cutajar and J. J. L. Rowley [2022, Journal of Herpetology 56(3):318-323] note that understanding species' geographic distributions is important for informing their conservation; however, an accurate understanding of where species occur is often precluded by a paucity of species records. For taxa that are difficult to visually distinguish at the species level, this problem can be compounded by misidentification of existing records. Citizen science has emerged as a potentially powerful tool to increase species observation data, but whether it can meaningfully add to our understanding of the distributions of species that are typically difficult to identify is contentious. We evaluated the volume, spread, and species identification accuracy of 3 yr of data from an acoustics-based citizen science dataset with a national aggregate of species observations collected over more than 140 yr (i.e., unvouchered human observations, photo-vouchered citizen science observations, and preserved specimens) to demonstrate the boundaries of five small, morphologically conserved frog species in eastern Australia. The national aggregate contained the most species records; however, the annual rate of record collection was much greater in the acoustic citizen science dataset. A high proportion of likely misidentified records were detected in the national aggregate dataset. Spatial bias differed between datasets, with acoustic citizen science data more biased toward highly populated areas. The authors demonstrate that citizen science can collect large volumes of spatially and taxonomically valid data which, especially when used in combination with more traditionally collected species records, can inform the detailed delineation of ranges in historically confusing groups of frog species.

TRANSLOCATION OF GOPHER FROGS

T. D. Castellón et al. [2022, Herpetologica 78(3):161-168] note that translocation is increasingly used to move animals of conservation concern away from sites where habitat will be destroyed (mitigation translocation), but outcomes have rarely been adequately monitored, particularly for amphibians. They used radiotelemetry monitoring to assess survival and movement of 23 experimentally translocated, adult gopher frogs (*Lithobates capito*) at a recipient site in north-central Florida, USA. Although post-translocation monitoring was the primary goal, they also compared results with those of 24 non-translocated frogs that were monitored in three previous efforts, conducted at different locations and times. For both translocated and non-translocated frogs, movement was the most important predictor of mortality, with translocated frogs having a significantly higher probability of movement and higher mortality during the first month following release. However, there was no effect of translocation on survival after controlling for probability of movement because movement was dangerous for both translocated and nontranslocated frogs. Movement by translocated frogs was likely a behavioral response to the translocation experience, whereas movement by non-translocated frogs was associated with breeding pond visitation, which was not observed within the translocated group. Survival was high for both groups once they settled into underground refugia and movement declined. Despite the comparatively high mortality of translocated frogs immediately following release, more than half survived to the end of monitoring and remained in the vicinity of the release site, meeting an early benchmark of translocation success.

USING ROBOTIC LIZARDS

E. J. Mancero et al. [2022, Herpetologica 78(2):93-101] note that intrasexual selection through male competition favoring larger male body size is the preferred explanation for the evolution and maintenance of male-biased sexual size dimorphism among polygynous species. Although sexual selection has been well studied in some groups of lizards, sexual selection in the nine species of lava lizards (*Microlophus* spp.) of the Galápagos has received little attention. The purpose of this research was to test the importance of male body size in the context of sexual selection by both sexes. Using three different sizes of robotic models capable of emulating the appearance and display patterns of male San Cristóbal lava lizards (*M. bivittatus*), the authors analyzed the responses that the models elicited among free-ranging lizards of the same sex (confrontation) and opposite sex (courtship). Results showed that body size of both male lizards and robotic antagonists influenced the number of displays performed by males. Male body size positively influenced the number of aggressive responses, scaling with the size of the opponent. The model representing larger lizards received higher display counts from males. Body size of robotic models, but not female lizards, influenced the number of displays performed by females. Females responded the most to the small and large models. Display intensity was not affected by any of the variables considered for either sex. Results from this study support the hypothesis that male-biased sexual size dimorphism in *M. bivittatus* is driven at least in part by both intrasexual and intersexual selection favoring larger male body size.

UPCOMING MEETINGS

Monthly meetings of the Chicago Herpetological Society begin at 2:00 P.M. on the third Sunday of each month. Please try to join us online or *in person* at the Notebaert Nature Museum, 2430 N. Cannon Drive, Chicago. The next meeting will take place on May 21. **Anthony Pierlioni**, senior director/vice-president of theTurtleRoom (tTR) will be the speaker. The mission of tTR is to advance survival of the world's turtles and tortoises through collaborative education, conservation, and research programs.

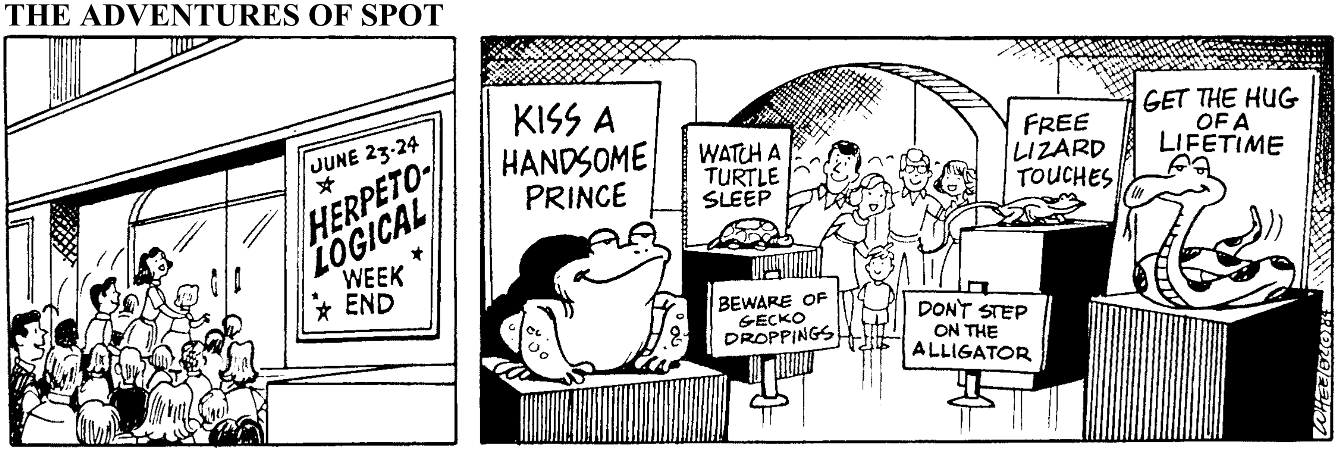
The June 18 meeting will be the annual members' **Show & Tell**. All CHS members are encouraged to display one of their favorite animals either at the in-person meeting or via Zoom. Be prepared to give a short (under five minutes) presentation to the group. Don't be shy. Neither age (yours) nor commonness (the animal's) should be a limitation. If you wish to present via Zoom, you must notify John Archer (jarcher@chicagoherp.org) beforehand.

Please check the CHS website or Facebook page each month for information on the program. Information about attending a Zoom webinar can be found here:
<https://support.zoom.us/hc/en-us/articles/115004954946-Joining-and-participating-in-a-webinar-attendee->

Board of Directors Meeting

Are you interested in how the decisions are made that determine how the Chicago Herpetological Society runs? And would you like to have input into those decisions? The next board meeting will be held online. If you wish to take part, please email: jarcher@chicagoherp.org.

THE ADVENTURES OF SPOT



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