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**Cover:** A Gila monster (*Heloderma suspectum*) climbs a pine tree to escape an annoying throng of photographers on 18 May 2013 at Boyce Thompson Arboretum, Superior, Arizona. Photograph by Charles Kazilek.

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## Notes on Mexican Herpetofauna 32: Ecological and Altitudinal Distribution of the Herpetofauna in the Sierra de Bustamante, Nuevo León, Mexico

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### Abstract

The Sierra de Bustamante is a mountain chain located in the north-northwestern portion of the state of Nuevo León, Mexico. A variety of elevational and plant community conditions are represented, allowing for the presence of a considerable number of reptile and amphibian species, which to date have been poorly documented. The objectives of the present study are to determine the herpetological species richness and the elevational and ecological distribution and conservation status of these species. Twelve field trips were conducted in the various plant communities. As a result, 29 species were reported, including five anurans, 17 saurians, four serpents, and three turtles. Our results demonstrated a preference for the riparian plant community (19 species), followed by submontane scrubland (17 species). According to the NOM-059-SEMARNAT-2010 scheme, 14 species are included in a protected category, with eight being of special concern and six threatened, representing 48% of the herpetofauna present at this site, an important factor to consider for its conservation.

**Keywords:** herpetofauna; mountains; Nuevo León, Mexico

### Resumen

La Sierra de Bustamante es una cadena de montañas situada en la porción norte-noroeste del estado de Nuevo León. Una variedad de altitud y condiciones están presentes lo cual permite una variedad de comunidades de plantas que a su vez permiten la presencia de un número considerable de reptiles y de anfibios, que hasta la fecha se han documentado pobremente documentada. Los objetivos del presente estudio son determinar la riqueza de especies herpetológicas y el estado de conservación y distribución altitudinal y ecológico de estas especies. Se realizaron 12 viajes de campo, estos se realizaron en las diferentes comunidades vegetales. Como resultado de este estudio, se reportaron 29 especies, incluyendo cinco anuros, 17 saurios, cuatro serpientes y tres tortugas. Nuestros resultados demostraron una preferencia por la comunidad de la planta riparia (19 especies), seguida por matorral submontano (17 especies). Según la norma oficial mexicana la NOM-059-SEMARNAT-2010, 14 especies están incluidas en esta norma, siendo ocho protección especial y seis amenazaron, los que representando una 48% de la herpetofauna presente en el sitio, una factor importante a tomar en cuenta.

**Palabras clave:** herpetofauna; montañas; Nuevo León, México

### Introduction

The Sierra de Bustamante is a mountain chain located in the north-northwestern portion of the state of Nuevo León, bordering the state of Coahuila. The chain extends through the municipalities of Bustamante, Lampazos de Naranjo, Mina, Salinas Victoria and Villaldama, in the state of Nuevo León, and part of the municipality of Candela in Coahuila (Anonymous, 2000). Due to its topography and location between the Sierra Madre Oriental in Mexico and the Great Plains of North America, a number of interesting vertebrate species can be found there (INEGI, 2008). Considering that the herpetofauna of this mountain chain has not been well studied, with only a few specimens having been collected on sporadic field trips, it is possible that

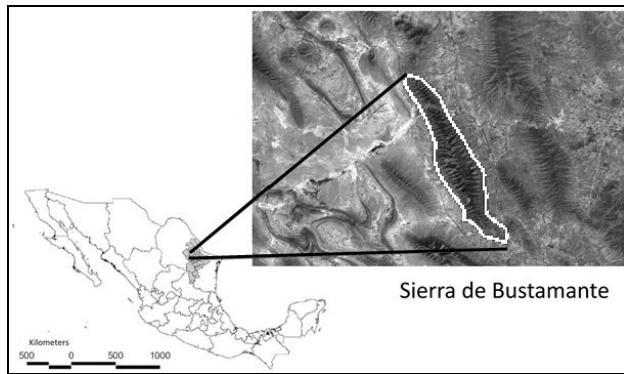
the number of amphibian and reptile species known might increase with more intensive collecting in the future. Because of its location on the border between Nuevo León and Coahuila, species occupying the Sierra de Bustamante might augment the faunal richness of both states.

Herpetologists who have contributed in the past to the knowledge of the herpetofaunal richness of Nuevo León are Martín del Campo (1953), Aseff-Martínez (1967), Velasco-Torres (1970), Treviño-Saldaña (1978), Contreras-Balderas et al. (1995), and Lazcano-Villareal et al. (2010). The herpetofauna of other mountainous areas in the state has been documented by Benavides-Ruiz (1987) for the municipality of Santiago, Banda-Leal (2002) and Lazcano et al. (2006) for Parque

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Satellite image of the Sierra de Bustamante in the state of Nuevo León, Mexico (Google Earth, 2018).

Ecológico Chipinque, and Gallardo-Valdez (2006) and Lazcano et al. (2009) for La Silla (Saddleback Mountain). Additional studies include Contreras-Lozano et al. (2007) in the Sierra de Picachos and Contreras-Lozano et al. (2015) in Parque Nacional Cumbres de Monterrey. The most recent studies of the herpetofauna in Nuevo León are those of Lemos-Espinal et al. (2016, 2018) and Nevárez-de los Reyes et al. (2016).

### Study area

The Sierra de Bustamante is considered a priority terrestrial region (*Region Terrestre Prioritaria* = RTP-77) (Arriaga Cabrera et al., 2000). It lies between latitudes 26°11'15"N and 26°43'19"N, and between longitudes 100°22'55"W and 100°46'23"W, and comprises a mountain chain in the north-western part of the state of Nuevo León that extends from the municipality of Candela in the state of Coahuila, thence throughout the municipalities of Bustamante, Lampazos de Naranjo, Mina, Salinas Victoria, and Villaldama in the state of Nuevo León. The climate is semiarid, temperate, with the highest average monthly high temperature no more than 22°C, and 5–10.2% of the annual rainfall coming in the summer. Elevation ranges between 550 and 2000 masl (meters above sea level). All these characteristics contribute to the Sierra de Bustamante's wide variety of plant communities starting with, at the lowest elevations, submontane scrubland with xerophytic and rosetophyllous vegetation, which is the predominant plant community. In addition, there are areas of chaparral, and oak and pine forest at the upper reaches of the mountain (Anonymous, 2000; Figure 1).

### Methods

After the plant communities were determined in the Sierra de Bustamante, 12 field trips were conducted during the months of September 2016 to August 2017 (each outing of 2–3 days duration) trying to cover the entirety of the different plant communities and physiography of the Sierra de Bustamante.

Within each plant community, transects were carried out using the inventory and sampling method. Specimens were located and captured on or beneath the substrate being used (stone mounds, dry logs, trees, concrete walls, earth, mud, etc.) (Campbell and Christman, 1982; Trumbower, 2012; Dodd, 2016) and the point of capture georeferenced with a GPS, using

a Garmin eTrexâ 20x. Photographic records of the different species were taken with a Nikon D3100. We reviewed literature on the behavior, substrate preferences and biology of the species encountered, and determined their status in SEMARNAT (2010) and the IUCN categorizations. We also used the Environmental Vulnerability Score (EVS), which consists of three scales that deal with geographical and ecological distribution, and reproductive mode/persecution index, which is allowed in cases where the details of the population status of a species are not available, so as to provide an estimate of the susceptibility of amphibians and reptiles to future environmental threats (Wilson et al., 2013 a,b).

The identification criteria for reptiles and amphibians were determined from Smith (1939), Smith and Taylor (1966), Behler and King (1992), Conant and Collins (1998), Stebbins (2003), Dixon and Werler (2005), Lemos-Espinal and Smith (2007), Lazcano et al. (2010) and Lemos-Espinal et al. (2018).

### Results

We registered 29 species (174 individuals), distributed as follows—*anurans*: 3 families, 5 genera and 5 species; *saurians*: 5 families, 7 genera, and 17 species; *serpents*: 3 families, 4 genera, and 4 species; *turtles*: 3 families, 3 genera, and 3 species (Table 1).

Vegetation community preference for amphibians found in the area is as follows: five species preferred riparian, submontane, and rosetophyllous scrubland. For 11 species of lizards, their preferences were either submontane, rosetophyllous scrubland or riparian, the 3 snake species preferences were mainly riparian community, and the 3 turtles species preferred the riparian community (Table 1).

The species we found that are listed in SEMARNAT (2010) are as follow: 14 have been given a status: 6 species considered of special concern and 8 as threatened, representing 48% of the herpetofauna known to be present in the Sierra de Bustamante. For IUCN assessments, all species are considered as Least Concern, with the exception of *Aspidoscelis marmoratus* for which information is not available. EVS scores indicate that the majority of the species fall into the medium category (13 species); the remainder are evenly divided between the low category (7 species) and the high category (7 species). No EVS scores were calculated for *Hemidactylus turcicus* or *Sceloporus variabilis*.

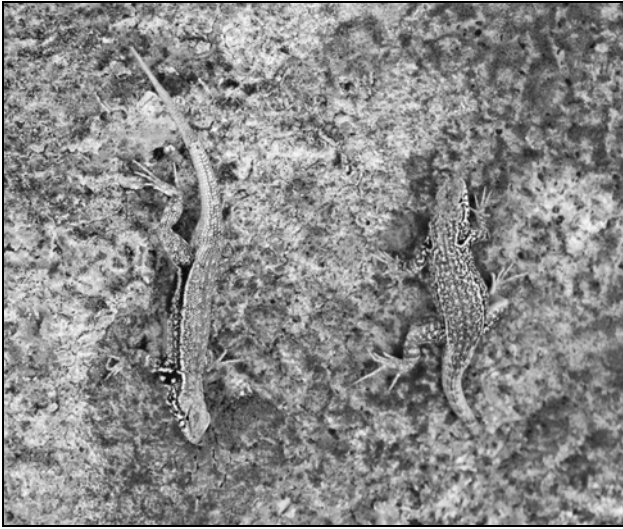
### Discussion

The herpetofauna presently known for Sierra de Bustamante totals 29 species, according the distribution maps from Martin del Campo (1953), Aseff-Martinez (1967), Contreras-Balderas et al. (1995), Lazcano et al. (2010), Nevárez-de los Reyes et al. (2016), Contreras-Lozano et al. (2015), Lemos-Espinal et al. (2016); Lemos-Espinal et al. (2018).

For the anurans *Anaxyrus punctatus*, *Incilius nebulifer*, *Lithobates berlandieri* and *Rhinella horribilis* the available literature indicates that these species are distributed in plant communities such as desert, arid or semiarid regions but it does not specify the type of vegetation where they were found (Lemos-Espinal and Smith, 2007; Lazcano et al., 2009;

**Table 1.** A preliminary herpetofaunal inventory of the Sierra de Bustamante, Nuevo Leon, Mexico. **Vegetation:** MS = Submontane scrubland; MR = Rosetophyllous scrubland; R = Riparian. **IUCN** = protection status according to the International Union for the Conservation of Nature: LC = least concern; SE = without status. **EVS** = Environmental Vulnerability Score sensu Wilson et al. (2013a,b): L = Low (3–9); M = Medium (10–13); H = High (14–18); **NOM** = protection status under NOM-ECOL-059-2010 (SEMARNAT, 2010): Pr = Protección Especial (Special Protection); A = Amenazada (Threatened); SE = without status.

	Order and Family	Species	Vegetation	Elevation (masl)	IUCN	EVS	NOM
Amphibia	Anura						
	Bufonidae	<i>Anaxyrus punctatus</i>	MS, MR	539	LC	L(5)	SE
		<i>Incilius nebulifer</i>	MS, MR, R	539–680	LC	L(6)	SE
		<i>Rhinella horribilis</i>	MS, MR, R	528–539	LC	L(3)	SE
	Eleutherodactylidae	<i>Eleutherodactylus cystignathoides</i>	R	641	LC	M(12)	SE
Ranidae	<i>Lithobates berlandieri</i>	MS, MR, R	466–553	LC	L(7)	Pr	
Reptilia	Squamata: Lizards						
	Crotaphytidae	<i>Crotaphytus collaris</i>	MS, MR	518–585	LC	M(13)	A
	Gekkonidae	<i>Hemidactylus turcicus</i>	R	528	LC	—	SE
	Phrynosomatidae	<i>Cophosaurus texanus</i>	MS, MR, R	515–599	LC	H(14)	A
		<i>Phrynosoma cornutum</i>	MS, MR	476–561	LC	M(11)	A
		<i>Phrynosoma modestum</i>	MS, MR	456–572	LC	M(12)	A
		<i>Sceloporus couchii</i>	R	612–687	LC	H(15)	SE
		<i>Sceloporus cowlesi</i>	MS, MR	540–550	LC	M(13)	A
		<i>Sceloporus cyanogenys</i>	MS, MR	545–554	LC	M(13)	SE
		<i>Sceloporus grammicus</i>	R	474–535	LC	L(9)	Pr
		<i>Sceloporus olivaceus</i>	MS, MR, R	474–602	LC	M(13)	SE
		<i>Sceloporus parvus</i>	R	474–720	LC	H(15)	SE
		<i>Sceloporus poinsettii</i>	MS	512	LC	M(12)	SE
	<i>Sceloporus variabilis</i>	R	527	LC	—	SE	
	Sphenomorphidae	<i>Scincella silvicola</i>	R	625	LC	M(12)	A
	Teiidae	<i>Aspidoscelis gularis</i>	MS, MR, R	474–688	LC	L(9)	SE
		<i>Aspidoscelis inornata</i>	MS, MR, R	545–625	LC	H(14)	SE
		<i>Aspidoscelis marmoratus</i>	MS, MR	562	SE	H(14)	SE
	Squamata: Snakes						
	Colubridae	<i>Pantherophis emoryi</i>	MS, MR	539	LC	M(13)	SE
	Natricidae	<i>Nerodia erythrogaster</i>	R	528	LC	M(11)	A
		<i>Thamnophis marcianus</i>	R	539	LC	M(10)	A
Viperidae	<i>Crotalus atrox</i>	R	673	LC	L(9)	Pr	
Testudines							
Kinosternidae	<i>Kinosternon flavescens</i>	R	516	LC	M(12)	Pr	
Testudinidae	<i>Gopherus berlandieri</i>	MS, MR	548–583	LC	H(18)	A	
Trionychidae	<i>Apalone spinifera</i>	R	535–620	LC	H(15)	Pr	



*Sceloporus couchii* exhibiting territorial behavior at the entrance to the canyon in Potrero, Villaldama, Nuevo León, México. Photograph by Jorge A. Contreras-Lozano.

Canseco-Márquez et al., 2010; Contreras-Lozano et al., 2015; Lemos-Espinal et al. (2016; 2018). In our study, we found them in rosetophyllous scrubland, submontane scrubland and riparian vegetation, adding this specific plant community to their preferred vegetation.

The reptile species *Aspidoscelis gularis*, *Crotaphytus collaris*, *Cophosaurus texanus*, *Phrynosoma cornutum*, *P. modestum*, *Sceloporus couchii*, *S. cyanogenys*, *S. olivaceus*, *S. poinsettii*, *Pantherophis emoryi* and *Gopherus berlandieri* are mentioned in the literature to have a distribution in arid and semiarid regions, deserts, riparian regions, grassland, forest, and scrubland without specifying the plant communities involved (Lemos-Espinal and Smith, 2007; Lazcano et al., 2009; Canseco-Marquez et al., 2010; Contreras-Lozano et al., 2015; Lemos-Espinal et al., 2016, Lemos-Espinal et al., 2018); Here we document their vegetational preferences as rosetophyllous scrubland, submontane scrubland, and riparian vegetation.

We found extensions to previously documented altitudinal ranges for four species: *Crotaphytus collaris* from 836–957 masl to 518 masl, *Phrynosoma modestum* from 600–1260 masl to 456 masl, *Sceloporus couchii* from 714–1615 masl to 612 masl, and *Sceloporus poinsettii* from 754–2215 masl to 512 masl (Lazcano et al., 2009; Contreras-Lozano et al., 2015).



*Phrynosoma cornutum* in a xerophytic scrubland plant community in the Sierra de Bustamante, Nuevo León, México. Photograph by Jorge A. Contreras-Lozano.



*Crotalus atrox* in a riparian plant community at the entrance to the canyon in Potrero, Villaldama, Nuevo León, México. Photograph by Jorge A. Contreras-Lozano.

The herpetofauna of Nuevo León comprises 139 species, including 22 anurans, four salamanders, 106 squamates, and seven turtles (Lemos-Espinal et al., 2016; Nevárez-de los Reyes et al., 2016; Lemos-Espinal et al., 2018). The herpetofauna reported for the Bustamante mountain range amounts to 29 species and represents 20.9% of the species reported for the state. Other natural protected areas have been subjected to herpetofaunal surveys, including Cerro de la Silla with 17 species (Lazcano et al., 2009), Cumbres de Monterrey National Park with 50 species (Contreras-Lozano et al., 2015), Cerro El Potosí with 24 species (Contreras-Lozano et al., 2010), and Sierra de Picachos with 33 species (Contreras-Lozano et al., 2007).

Arriaga Cabrera et al. (2000) mentioned the possibility of considering the Sierra de Bustamante as a Protected Natural Area but does not mention any specific herpetofaunal support. We have highlighted in our study the presence of 29 species, 13 of which are placed in a category in the Official Mexican Standard either as subject to special protection or threatened (SEMARNAT, 2010).

Wilson et al. (2013a,b) discussed the development and use of the EVS system of conservation assessment, as well as its advantages over the methodology of the IUCN system. We divided the scores for the members of the Nuevo León herpetofauna into three categories, low (3–9), medium (10–13), and high (14–19), following the procedure of Wilson et al. (2013a,b). Seven spe-



*Gopherus berlandieri* in a submontane scrubland community in the Sierra de Bustamante, Nuevo León, México. Photograph by Jorge A. Contreras-Lozano.



*Rhinella horribilis* near a riparian plant community in Ojo de Agua San Lorenzo, Bustamante, Nuevo León, México. Photograph by Jorge A. Contreras-Lozano.

cies fall in the high risk category: *Cophosaurus texanus*, *Sceloporus couchii*, *S. parvus*, *Aspidoscelis inornata*, *A. marmoratus*, *Gopherus berlandieri* and *Apalone spinifera*. Most of these species are limited in geographic or ecological distribution (Nevárez-de los Reyes et al., 2016).

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The information from this article and Nevárez-de los Reyes (2018) can reinforce the proposal to consider Sierra de Bustamante as a state natural monument (Martínez-Muñoz and Rodríguez-Gonzalez, 2018), which presented scientific information and evidence to the state and local municipality authorities that will allow the protection of this area, that way benefiting the local human communities and fauna/flora. We have also been involved in censusing of other vertebrates (mammals and birds) and their plant community preferences. This will further highlight the value of this area.

We recommend further intensive field trips to the Sierra de Bustamante. It is likely that such work will increase the number of documented herpetofaunal species. Some areas that are very difficult to access were not censused, but it is necessary to explore these higher elevational ranges.

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## Notes on Reproduction of Lowland Burrowing Treefrogs, *Smilisca fodiens* (Anura: Hylidae), from Sinaloa and Sonora, Mexico

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### Abstract

I report on a histological examination of gonads from 34 lowland burrowing treefrogs, *Smilisca fodiens*, from Mexico (Sinaloa  $n = 31$ ; Sonora  $n = 3$ ). The smallest mature males (sperm in lumina of seminiferous tubules) measured 43 mm SVL. All 20 males examined from June, July and August (combined) exhibited spermiogenesis. Thirteen females were in spawning condition from June to September (combined). The smallest mature females (spawning condition) measured 53 mm SVL. Reproduction of *S. fodiens* is in synchrony with the summer monsoon.

*Smilisca fodiens* (Boulenger, 1882) ranges from Pima County, Arizona, south in western Mexico from Sonora to Michoacán, Mexico (Stebbins and McGinnis, 2018). *Smilisca fodiens* reproduces in temporary pools formed by monsoonal rains (Murphy, 2018). Hardy and McDiarmid (1969) reported mating pairs were found on 20 August in Sinaloa, Mexico. Sullivan et al. (1996) observed *Smilisca* (as *Pternohyala*) *fodiens* chorusing activity in Pima County, Arizona, on 13 July. The biology of *Smilisca* (as *Pternohyala*) *fodiens* is summarized in Sredl (2005). In this paper I present data from a histological examination of *S. fodiens* gonadal material from Sinaloa and Sonora, Mexico. Utilization of museum collections for obtaining reproductive data avoids removing additional animals from the wild.

A sample of 34 *S. fodiens* collected from Sinaloa ( $n = 31$ ) and Sonora ( $n = 3$ ) Mexico consisting of 20 adult males (mean snout-vent length, SVL = 48.7 mm  $\pm$  3.8 SD, range = 43–55 mm), 11 adult females (mean SVL = 56.8 mm  $\pm$  4.2 SD, range = 49–62 mm) and 3 unsexed subadults (mean SVL = 25.0 mm  $\pm$  2.6 SD, range = 23–28 mm) was examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA. An unpaired  $t$ -test was used to test for differences between adult male and female SVLs (Instat, vers.3.0b, Graphpad Software, San Diego, CA).

A small incision was made in the lower part of the abdomen and the left testis was removed from males and a piece of the ovary from females. Gonads were embedded in paraffin, sections were cut at 5  $\mu$ m and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreiber, 1997). Histology slides were deposited at LACM.

The testicular morphology of *S. fodiens* is similar to that of other anurans as described in Ogielska and Bartmańska (2009a). Within the seminiferous tubules, spermiogenesis occurs in vesicles called cysts which remain closed until the late spermatid stage is reached; cysts then open and differentiating sperm reach the lumina of the seminiferous tubules (Ogielska and Bartmańska, 2009a). All 20 males: June ( $n = 4$ ), July ( $n = 13$ ), August ( $n = 3$ ) exhibited spermiogenesis in which sperm containing cysts had opened and clusters of sperm were abundant in the lumina of the seminiferous tubules. A ring of germinal cysts

was located on the inner periphery of each seminiferous tubule. The smallest reproductively active males (spermiogenesis) each measured 43 mm in SVL (LACM 90200, 90229) and were both collected in Sinaloa during July.

The mean SVL of *S. fodiens* females was significantly larger than that of males ( $t = 5.5$ ,  $df = 29$ ,  $P < 0.0001$ ). The ovaries of *S. fodiens* are typical of other anurans in consisting of paired organs located on the ventral sides of the kidneys; in adults they are filled with diplotene oocytes in various stages of development (Ogielska and Bartmańska, 2009b). Mature oocytes are filled with yolk droplets; the layer of surrounding follicular cells is thinly stretched. Two stages were present in the spawning cycle of *S. fodiens* (Table 1): “Ready to spawn” in which mature oocytes predominated, and “Not in spawning condition” in which early diplotene oocytes predominated. The smallest reproductively active females both measured 53 mm in SVL and were collected in July; LACM 37168 was from Sonora and was in spawning condition, LACM 90227 was from Sinaloa and contained occasional yolk filled oocytes. However, it is not known if this female would have spawned in the current reproductive period.

Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzábal, 2009). It is common in the amphibian ovary (Saidapur, 1978) and is the spontaneous digestion of a diplotene oocyte by its own hypertrophied and phagocytic granulosa cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmańska, 2009b). It is a significant factor in fecundity by reducing the number of ovulated oocytes (Uribe Aranzábal 2011). Atresia was noted in the ovaries of only 3/11 (27%) *S. fodiens* females. Atresia played an active role in the destruction of non-spawning follicles in LACM 90218 from August (late in the reproductive season). Granulosa cells had enlarged and were filled with

**Table 1.** Two monthly stages in the ovarian cycle of 11 adult female *Smilisca fodiens* from Mexico.

Month	$n$	Ready to spawn	Not in spawning condition
June	1	1	0
July	6	4	2
August	3	1	2
September	1	1	0

ingested yolk granules. Incidences of follicular atresia increase late in the reproductive season when yolking follicles that did not ovulate are resorbed (Goldberg, 1973). Saved energy will presumably be utilized in a future reproduction. See Saidapur and Nadkarni (1973) for a description of stages in follicular atresia in the frog ovary.

In conclusion, *S. fodiens* along with other southwestern anurans including *Scaphiopus couchii*, *Spea bombifrons*, *Anaxyrus debilis*, *A. retiformis*, *Incilius alvarius*, *Smilisca*

*fodiens* reproduce during the summer monsoon period (Brennan and Holycross, 2009). To that list should be added two bufonids from northwestern Mexico: *Incilius mazatlanensis* (Goldberg, 2017) and *Incilius marmoreus* (Goldberg, 2018).

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#### Appendix

Thirty-four *Smilisca fodiens* from Sinaloa, Mexico (n = 29) and Sonora, Mexico (n = 5) examined from the herpetology collection of the County Museum of Natural History (LACM), Los Angeles, California, USA.

**Sinaloa** LACM: 6373–6375, 6390, 6402, 51562, 90198-90203, 90205, 90206, 90208, 90214, 90217–90221, 90223, 90227–90232, 90234;

**Sonora** LACM: 37168, 50788, 65169, 65170, 90252.

## Crustacean Ectoparasites of Amphibians

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### Abstract

At least nine crustacean species (Branchiura and Copepoda) have been reported as ectoparasites of salamanders and frogs. All but one or two of these species are primarily parasites of a wide range of freshwater fishes. These organisms may significantly impact the fitness of their hosts, and their populations may be subject to periodic outbreaks, yet relatively little information has been published regarding their prevalence or pathogenicity. Implementation of quarantine procedures reduces the likelihood of infestations among captive amphibians, and medications used to treat infested aquarium fish appear to be effective treatments for infested amphibians. Human mediated introductions and changing climatic conditions may influence future parasite distribution, prevalence, and impact.

### Introduction

Conservation practice requires an understanding of the disease-causing organisms, parasites, and similar factors affecting host fitness. Amphibians serve as hosts for a wide variety of parasites, ranging from microorganisms to helminths and arthropods (Duellman and Trueb, 1986; Sutherland, 2005; Watermolen, 2014). Among the lesser known of these organisms, a small number of crustaceans from the subclasses Branchiura and Copepoda (Table 1) have been reported as ectoparasites of amphibians.

Commonly referred to as “fish lice,” branchiurans primarily parasitize freshwater fish. These tiny (3–6 mm long) crustaceans have a flattened, oval body that is almost entirely covered by a wide carapace. A pair of compound eyes is typically conspicuous. The mouthparts and first pair of antennae are modified to form a hooked, spiny proboscis and adhesive suckers. Branchiurans have four pairs of thoracic swimming legs and an unsegmented abdomen that lacks appendages. Currently, the subclass contains about 125 nominal species, all in the family Argulidae (Poly, 2008). Seven species have been reported from amphibian hosts (Table 2), with *Argulus ambystoma* being known only from its salamander host (Poly, 2003).

Copepods typically have a minute (1–2 mm long), cylindrical body with a rounded or beaked head that is fused with the first one or two thoracic segments<sup>1</sup>. The remainder of the thorax has three to five segments, each with limbs. The first pair of appendages are modified to assist in feeding. Most copepods have a single median compound eye and two pairs of antennae, the first pair often being long and conspicuous. The five-segmented abdomen is typically narrower than the thorax and lacks appendages, except for some tail-like “rami” at the tip. A little more than 2800 copepod species occupy freshwater habitats. Most are free-living, but about 330 species are parasitic, mostly on fish hosts (Boxshall and Defaye, 2008). The families Lernaeidae and Lernaeopodidae each include a species reported from amphibian

hosts (Table 2). Commonly referred to as the “anchor worm,” *Lernaea cyprinacea* is the species most frequently reported as an amphibian parasite. It is a Eurasian species that has become globally widespread (Boxshall and Defaye, 2008; Kupferberg et al., 2009).

Table 2 summarizes reports of crustacean parasites of amphibians in the form of a host-parasite checklist along with pertinent literature citations. Geographic locations are presented in the table as they appear in the original sources.

### Parasite Behavior and Effects on Hosts

Branchiurans are temporary ectoparasites that move freely about their host’s skin, but also can maintain fixed positions using the suckers and hooks on their first maxillae to cling to the host. They subsist by piercing the host’s skin and consuming its blood and body fluids; they may also feed on the protective mucous that covers the host’s scales or skin. Although they may attach anywhere on the host, branchiurans may be difficult to

**Table 1.** Classification of crustaceans parasitic on amphibians (after Martin and Davis, 2001).

Phylum Arthropoda
Subphylum Crustacea
Class Maxillopoda Dahl, 1956
Subclass Branchiura Thorell, 1864
Order Arguloidea Yamaguti, 1963
Family Argulidae Leach, 1819
Genus <i>Argulus</i>
Genus <i>Dolops</i>
Subclass Copepoda Milne-Edwards, 1840
Order Cyclopoidea Burmeister, 1834
Family Lernaeidae Cobbold, 1879
Genus <i>Lernaea</i>
Order Siphonostomatoida Thorell, 1859
Family Lernaeopodidae Milne-Edwards, 1840
Genus <i>Achtheres</i>

1. Representative photographs of *Argulus* (Branchiura) and *Lernaea* (Copepoda) are available at <[www.glsc.usgs.gov/greatlakescopepods/mainmenu.php](http://www.glsc.usgs.gov/greatlakescopepods/mainmenu.php)>.

2. Lemos de Castro and Gomes-Correa (1985) described *Argulus hylae* based on specimens taken from frogs, but the validity of this taxon remains in question due to a lack of available voucher specimens and its superficial treatment published as an abstract.

**Table 2.** Host-parasite list with geographic locations and literature citations.

<b>Ambystomatidae</b>
Lake Patzcuaro Salamander ( <i>Ambystoma dumerilii</i> ) <i>Argulus ambystoma</i> – Lake Patzcuaro, Michoacan, <b>Mexico</b> (Poly, 2003)
Axolotl ( <i>Ambystoma mexicanum</i> ) <i>Lernaea cyprinacea</i> – <b>Uruguay</b> (Carnevia and Speranza, 2003); Chapultepec Park, Mexico City, <b>Mexico</b> (Recuero et al., 2010); unspecified place (Melidone et al., 2004; Mutschmann, 2015)
<b>Dicamptodontidae</b>
California Giant Salamander ( <i>Dicamptodon ensatus</i> ) <i>Lernaea cyprinacea</i> – South Fork Eel River, Mendocino County, California, <b>USA</b> (Kupferberg et al., 2009)
<b>Proteidae</b>
Mudpuppy ( <i>Necturus maculosus</i> ) <i>Achtheres micropteri</i> – aquarium, Savannah Science Museum, Georgia, <b>USA</b> (Frick, 1999)
<b>Salamandridae</b>
Japanese Fire Belly Newt ( <i>Cynops pyrrhogaster</i> ) <i>Lernaea cyprinacea</i> – Hokkaido Prefecture, <b>Japan</b> (Okada, 1927; Nagasawa et al., 2007)
Smooth Newt ( <i>Lissotriton vulgaris</i> ) <i>Argulus japonicus</i> – <b>British Isles</b> (Bower-Shore, 1940)
Fire Salamander ( <i>Salamandra salamandra</i> ) <i>Argulus japonicus</i> – <b>Germany</b> (Sauer, 1977)
<b>Sirenidae</b>
Southern Dwarf Siren ( <i>Pseudobranchius axanthus</i> ) <i>Argulus americanus</i> – near Gainesville, Florida, <b>USA</b> (Goin and Ogren, 1959)
Greater Siren ( <i>Siren lacertina</i> ) <i>Achtheres micropteri</i> – Basin Road Pond, Chatham County, Georgia, <b>USA</b> (Frick, 1999)
<b>Hylidae</b>
Cordoba Treefrog ( <i>Hyla pulchella cordobae</i> ) <i>Lernaea</i> sp. – Arroyo Tanti, Tanti City, Córdoba Province, <b>Argentina</b> (Alcalde and Batistoni, 2005)
Unidentified Treefrog ( <i>Hyla</i> sp.) <i>Lernaea cyprinacea</i> – Twelve Pole Creek, Wayne County, West Virginia, <b>USA</b> (Aliff and Shoemaker, 1965)
Montevideo Treefrog ( <i>Hypsiboas pulchellus</i> ) <i>Argulus ventanensis</i> – Belisario stream, Villa Ventana, Buenos Aires Province, <b>Argentina</b> (Tanzola and Villegas-Ojeda, 2017)
<b>Ranidae</b>
Plains Leopard Frog ( <i>Lithobates blairi</i> ) <i>Lernaea</i> sp. – Kellerton Bird Conservation Area, Ringgold County, Iowa, <b>USA</b> (Swartz et al., 2019)
American Bullfrog ( <i>Lithobates catesbeianus</i> ) <i>Lernaea cyprinacea</i> – Tokyo, <b>Japan</b> (Okada, 1927); Brazos County, Texas, <b>USA</b> (Baldauf, 1961); laboratory (Shields and Tidd, 1963); Twelve Pole Creek, Wayne County, West Virginia, <b>USA</b> (Aliff and Shoemaker, 1965); laboratory and pond, Fairfield County, Ohio, <b>USA</b> (Tidd, 1970); Tupelo National Fish Hatchery, Mississippi, <b>USA</b> (Wellborn and Lindsey, 1970); commercial fish farm, Jaboticabal, Sao Paulo, <b>Brazil</b> (Martins and de Souza, 1995a); laboratory (Martins and de Souza, 1995b); Ohio, <b>USA</b> (Green et al., 2002); Hokkaido Prefecture, <b>Japan</b> (Nagasawa et al., 2007); South Fork Eel River, Mendocino County, California, <b>USA</b> (Kupferberg et al., 2009); Río de los Sauces and Toledo Stream, Córdoba Province, <b>Argentina</b> (Salinas et al., 2016) <i>Lernaea</i> sp. – Ohio, <b>USA</b> (Green et al., 2002)
Green Frog ( <i>Lithobates clamitans</i> ) <i>Lernaea cyprinacea</i> (includes <i>L. ranae</i> , which is almost certainly synonymous with <i>cyprinacea</i> ) – goldfish hatchery, near Cincinnati, Ohio, <b>USA</b> (Stunkard and Cable, 1931); laboratory and Olentangy River, near Columbus, Ohio, <b>USA</b> (Tidd, 1970); laboratory and farm pond, Ohio, <b>USA</b> (Shields and Tidd, 1974); Oconee, Ocmulgee, and Ogeechee rivers, Georgia, <b>USA</b> (Aliff et al., 1976); unspecified place (Hoffman, 1999)
River Frog ( <i>Lithobates heckscheri</i> ) <i>Argulus americanus</i> – Newman’s Lake, east of Gainesville, Alachua County, Florida, <b>USA</b> (Goin and Ogren, 1959); borrow pits, Osceola National Forest, Columbia County, Florida, <b>USA</b> (Clark, 2001) <i>Argulus diversus</i> – borrow pits, Osceola National Forest, Columbia County, Florida, <b>USA</b> (Clark, 2001) <i>Argulus</i> sp. – Pointsett State Park, Sumpter County, South Carolina, <b>USA</b> (Wolfe et al., 2001)

**Table 2 (cont'd).**

Northern Leopard Frog ( <i>Lithobates pipiens</i> ) <i>Lernaea cyprinacea</i> – laboratory and central Ohio streams, <b>USA</b> (Tidd, 1962; Shields and Tidd, 1963; Tidd and Shields, 1963; Tidd, 1970; Shields and Tidd, 1974; Shields and Goode, 1978)
Wood Frog ( <i>Lithobates sylvaticus</i> ) <i>Lernaea cyprinacea</i> – laboratory, Ohio, <b>USA</b> (Tidd, 1962)
Edible Frog ( <i>Pelophylax kl. esculentus</i> ) <i>Argulus foliaceus</i> – Europe (Vojtkova and Roca, 1996)
Marsh Frog ( <i>Pelophylax ridibundus</i> ) <i>Argulus</i> sp. – garden pond, Berlin, <b>Germany</b> (Paepke, 1998)
Foothill Yellow-legged Frog ( <i>Rana boylei</i> ) <i>Lernaea cyprinacea</i> – South Fork Eel River, Mendocino County, California, <b>USA</b> (Kupferberg et al., 2007; Kupferberg et al., 2009)
Copper-cheeked Frog ( <i>Rana chalconota</i> ) <i>Lernaea cyprinacea</i> – fish pond, Sukabumi, West Java, <b>Indonesia</b> (Tzi Ming, 2001)
Unidentified tadpole ( <i>Rana</i> sp.) <i>Argulus japonicus</i> – Europe (Wilson, 1902; Bower-Shore, 1940)
<b>Unidentified Frog Host</b>
<i>Argulus hylae</i> – <b>Brazil?</b> (Lemos de Castro and Gomes-Correa, 1985)
<i>Dolops ranarum</i> – Buboka, Western Nyansa, Africa (Wilson, 1902)
<i>Lernaea cyprinacea</i> – Missouri, <b>USA</b> (Hoffman, 1999)
<i>Lernaea</i> sp. – Fish Culture Research Station, Dor, <b>Israel</b> (Yashouv, 1959)

locate and observe due to their small size and near transparent bodies. For example, Sauer (1977) indicated the transparent bodies of *Argulus japonicus* made it difficult to see them even under magnification. In addition, Poly (2009) reported cryptic behaviors in which *Argulus ambystoma* responded to changes in light by hiding in the host salamander's gills.

Fish suffering from branchiuran infestations “show clear signs of irritation and changes of their behavior, such as avoidance of parasitized individuals, jumping, and scratching against different objects” (Suárez-Morales, 2015). While severe infestations have resulted in fish mortality (e.g., Schumacher, 1952), effects on amphibian host fitness have rarely been reported. Nonetheless, a single *Argulus americanus* appeared to be a contributing factor to the death of a southern dwarf siren (*Pseudobranchius axanthus*; Goin and Ogren, 1956) and an infestation of 32 *A. japonicus* apparently caused the death of a larval fire salamander (*Salamandra salamandra*; Sauer, 1977). Heavy infestations can damage the host's skin and underlying tissues, and secondary bacterial and viral infections may result from branchiuran feeding activity (Bower-Shore, 1940; Bauer et al., 1973; Ahne, 1985; Bondad-Reantaso et al., 2001).

Interestingly, some amphibians may have developed defense mechanisms against branchiuran infestations. In laboratory experiments, *A. japonicus* that attached themselves to the larvae of the common toad (*Bufo vulgaris*) appeared to die as a result (Herter, 1927). Similar observations, however, have not been made with other hosts.

Copepods like *Lernaea cyprinacea* typically complete their entire life cycle on a single host (Tidd, 1962). Dispersal generally occurs when free-swimming nauplii (first larval stages of copepodids) move between hosts, but late-stage copepodids may

also move from one host to another (Tidd, 1970). The first larval stage is taken up by a fish or salamander in the gills or by a tadpole through the spiracle. When infesting a tadpole, the copepodids remain within the mouth and branchial chambers for 10–12 days where they feed on the epithelial and underlying connective tissues (Shields and Tidd, 1963). Growth occurs rapidly with the fifth copepodid stage being reached within 144 hours (Tidd, 1970). Sexual differentiation and copulation occurs in the fifth copepodid stage (Shields and Tidd, 1974). Post-copulation, females undergo another molt, travel along the integument of the tadpole, and burrow through the skin into the musculature. Attachment sites can be anywhere, but are most often on the head, near the mouth or gills, in the cloaca, or at the juncture of the tail and body (Baldauf, 1961; Aliff and Shoemaker, 1965; Shields and Goode, 1978; Martins and Souza, 1995a; Alcalde and Batistoni, 2005; Kupferberg et al., 2009; Recuero et al., 2010; Salinas et al., 2016). Once embedded, the body of *L. cyprinacea* lengthens and the cephalothorax develops into an anchor-shaped process, the arms of which can extend into internal organs (Shields and Tidd, 1963). The body becomes worm-like in appearance and dangles from the host. The host tissues produce scar tissues around the parasite's “anchor” (Tidd and Shields, 1963). Host rejection of viable parasites has been reported and there is some evidence of acquired immunity (Shields and Tidd, 1963; Shields and Goode, 1978). While transforming, female copepods begin producing egg sacks, which are often the most visible sign of an infestation. The parasite and host may metamorphose together and post-metamorphic frogs can also become infested (Tidd, 1970; Wellborn and Lindsey, 1970; Salinas et al., 2016).

Some information has been published regarding *L. cyprinacea* prevalence (% hosts infested) and intensity (number

of parasites per host). In laboratory situations, Aliff and Shoemaker (1965) reported that the most heavily parasitized American bullfrog (*Lithobates catesbeianus*) tadpole in their study had five *Lernaea* attached, three at the body-tail junction and two on the lower lip, and Shields and Tidd (1974) reported 19–37 *L. cyprinacea* infesting ranid tadpoles in their experiments. In nature, prevalence rates can be relatively high. Tzi Ming (2001) reported that 67.3% (n = 144) of the copper-cheeked frog (*Rana chalconota*) tadpoles examined at a site in Indonesia were infested with 1–15 *L. cyprinacea*. Salinas et al. (2016) found 53.33–58.33% of bullfrog tadpoles collected from two streams in Argentina harbored a mean of 0.58–0.60 *L. cyprinacea* per tadpole. In addition, 38% of recently metamorphosed bullfrogs at one of their study sites were parasitized (mean abundance of *L. cyprinacea* = 0.38, maximum abundance = 2 per host; Salinas et al., 2016). At a fish hatchery in Mississippi, 75.0–85.7% of bullfrog adults and tadpoles were infested (mean abundance of *L. cyprinacea* = 2.67 per host; Wellborn and Lindsey, 1970). Alcalde and Batistoni (2005) found a maximum of four *Lernaea* sp. on Cordoba treefrog (*Hyla pulchella cordobae*) tadpoles in Argentina (prevalence = 19.6%).

The overall effects of copepod infestations on their amphibian hosts have not been well studied and reported observations have varied. The appetite, activity, and overall body condition of a captive axolotl (*Ambystoma mexicanum*) infested with *L. cyprinacea* appeared to be unaffected (Melidone et al., 2004). Infested California giant salamanders (*Dicamptodon ensatus*) appeared “morphologically normal” (Kupferburg et al., 2009). Similarly, a bullfrog tadpole infested with seven *L. cyprinacea* “displayed no recognized signs of distress” at the point at which it was undergoing metamorphosis (Baldauf, 1961). Martins and Souza (1995a), however, reported “high mortality range, lower appetite, equilibrium loss and apathy” among bullfrog tadpoles experimentally infested with *L. cyprinacea*. Tidd and Shields (1963) reported two cases in which *L. cyprinacea* penetrated their host tadpole’s dorsal surface, disrupted the spinal cord, and ultimately caused death. Green et al. (2002) attributed the deaths of 50 bullfrog tadpoles in Ohio to *Lernaea* infestations. Similarly, two mudpuppies (*Necturus maculosus*) affected by “massive” infestations of *Achtheres micropteri* died (Frick, 1999).

Copepod feeding clearly results in a localized inflammatory response, but according to Tidd and Shields (1963), the degree of injury depends “upon the sites in which the anchor processes develop and the extent and formation of connective tissue.” The initial period of parasite penetration (0–12 hrs.) can result in considerable bleeding and destruction of host tissues, and as “elongation accelerates, destruction of underlying tissue and the consequent inflammatory response, become more intensive” (Shields and Goode, 1978). Salinas et al. (2016) observed “inflammation, hemorrhage, and ulcers in the skin with mucus formation in the attachment area of the parasites.” Copepod infestations may contribute to developmental anomalies. Tzi Ming (2001) reported various limb abnormalities associated with *L. cyprinacea* infestations in copper-cheeked frog tadpoles (incidence of abnormal tadpoles = 0.06% of infested individuals), and Kupferberg et al. (2009) found the association between copepod infestation and limb abnormalities in Foothill yellow-legged frogs (*Rana boylei*) to be highly significant ( $P < 0.0001$ ).

Melidone et al. (2004) observed “mechanical damage” to the gills of an infested axolotl. Kupferburg et al. (2009) reported newly metamorphosed Foothill yellow-legged frogs infested with *L. cyprinacea* had smaller body sizes than uninfested frogs, a potential conservation concern because the body size of newly metamorphosed individuals may be closely correlated with over-winter survival and fitness.

Aside from physically damaging tissues and adversely affecting body condition, crustacean ectoparasites can also serve as intermediate hosts for disease microbes (e.g., *Aeromonas hydrophila*) and helminths that are parasites of fish, amphibians, birds, and mammals (Hoffman, 1999; Moravec et al., 1999; Suarez-Morales, 2015). Their functional role in the life cycles of these pathogenic organisms is an area that merits additional attention. Further investigation of population-level impacts to hosts may also be warranted.

### Prevention and Treatment in Captivity

Although most reports of crustaceans parasitizing amphibians come from natural settings, several cases have involved captive animals. Infestations of captive amphibians generally result from the introduction of rocks, plants, fish, or tadpoles from infested waterbodies. As stated earlier, close inspection is necessary to detect the parasites; they may, however, be easily overlooked, particularly in aquaculture situations (Boxshall and Defaye, 2008). This difficulty underscores the importance of implementing quarantine measures prior to introducing new materials into an existing husbandry set-up. Incoming organisms and materials should be examined for adult parasites and then monitored regularly throughout quarantine. When infestations are encountered and medicated, Melidone et al. (2004) further note the importance of placing treated animals in clean aquaria to eliminate the potential for re-infestation. Early detection and intervention typically lead to the most successful outcomes.

Various medications have been used to treat aquarium fish infested with crustacean ectoparasites and some of these have been applied to amphibians in captive situations. Martins and de Souza (1995b) exposed bullfrog tadpoles that were naturally infested with *L. cyprinacea* to three applications of 0.25 ppm trichlorfon 500 (Dipterex 500®) at 5-day intervals. The treatment effectively killed the parasites. Wolfe et al. (2001) controlled an *Argulus* infestation using a combination of 15 mg lufenuron (Program)/L water and 3 g sea salt (NaCl)/L water administered three times at weekly intervals. The infested river frog (*Lithobates heckscheri*) tadpoles experienced no apparent deleterious effects from this treatment. Jepson (2009) recommended a single dose of lufenuron at 0.088 mg/L for treatment of crustacean infestations. Melidone et al. (2004) used surgical forceps to manually remove *L. cyprinacea* from an infested axolotl and then administered 0.2 mg/kg ivermectin (Ivomec®), a drug that cannot be used with fish, twice at a 2-week interval. Fifteen days later the axolotl was free of parasites (Melidone et al., 2004). Other treatments mentioned in the literature include baths of 10–25 g NaCl/L water for 5–10 minutes and 10 mg potassium permanganate/L water for 5–60 minutes (Poynton and Whitaker, 2001; Pessier, 2002; Jepson, 2009).

## Discussion

At least nine crustacean species have been reported as parasites of nine salamander species and 12 frog species. Reports have originated in nine countries on five continents (Table 2). Branchiurans have generally been reported from lotic habitats, while copepods have been found in both lentic and lotic habitats. Although rarely documented, these crustacean parasites may be more common than previously recognized and additional cases likely await discovery. Non-native *Argulus* and *Lernaea* have already been introduced throughout North America and the Upper Midwest/Great Lakes region (Boxshall and Defaye, 2008; Poly, 2008; Muzzall and Whelan, 2011; Watermolen, 2017). Their introduction and spread to new areas may be facilitated by translocations of fish stocks and the horticulture and pet trade (Putz and Bowen, 1964; Boxshall and Defaye, 2008). For example, Carnevia and Speranza (2003) reported a case in which *L.*

*cyprinacea* was accidentally introduced to Uruguay with goldfish (*Carassius auratus*) and subsequently infested captive axolotls. Fortunately, common sense, preventative measures are available to prevent such dispersal.

Recent climate change and the resulting shifts in ecological conditions could support future dispersion of these crustacean parasites. Kupferberg et al. (2009) noted that outbreaks of *L. cyprinacea* in California were associated with periods of warm water temperatures, declining discharges, and shrinking pool sizes. Similar conditions have been found at other river sites where *L. cyprinacea* outbreaks have impacted fish. Such conditions may become more prevalent in some regions (CCSP, 2008; Lathrop et al., 2011). As climate continues to change, conditions may become more favorable to the fecundity, reproduction, and development of these parasites, which may influence their future distribution, prevalence, and impact.

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## March Madness, Monster Madness, and a Herper's Anticipation of April in Arizona

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As the first of these words are written, the author is immersed in a euphoric yet hectic state of being that exists every year at this point in time. We speak of what I call "March Madness." To most, March Madness is a term that describes college basketball tournaments. For me, the term is centered around an astronomical event known (in circles much higher than mine) as the vernal equinox. Said vernal equinox occurs when the planet earth in all its perennial swiveling and spinning glory tilts southward to the point where the sun is positioned directly above the equator. At that point, daylight and nighttime are nearly equal. For those of us in the northern hemisphere, a simpler term for the phenomenon is "spring." For those in the southern hemisphere, the simple term for vernal equinox is called something else altogether. But whatever it is called *way* down south is their problem, as this article has less than nothing to do with the likes of them. I have a hard enough time figuring out what is going on here, without "down there" muddying up my limited thinking prowess.

The date that the first day of spring happens is a moving target, ranging between 20 and 24 March every year. How solar positioning affects the herp activities is also a moving target, especially in the Chicago area. But here in Arizona, give or take a week, 20 March is a ground zero of sorts. The herps under my watch usually clear out within a week of the vernal equinox. The winter of 2018–2019 was a rough one for those of you in the Chicago area. It was also wet and cold (comparatively speaking) here in Arizona. We had snow at my house twice this winter. There has not been a single other snowstorm at my lordly estate in the previous 15 years that we have lived here. It was a miserably wet and sloppy winter here, but past experience has taught me that this sort of weather phenomenon sets up glorious conditions for both the herps and the herping. As these words are written, wildflowers have spread across the landscape in a manner not seen in more than 20 years. Much of the landscape rivals that seen in the famed movie, *The Wizard of Oz*. By the end of February, we were finding new dens of Western Diamond-backed Rattlesnakes (*Crotalus atrox* [hereafter referred to as CRAT or *atrox*]) in places where none were seen before. We spent many years in wild wonder seeking new dens in places where they *should* be, but weren't. We now speculate that the wetness has forced the herps out of holes where they normally have remained hidden. They are better off being cold and wet outside of their holes than cold and wet inside (Figure 1). My original intent was to write a March Madness column for the month of April. But so much has gone down, and so much is yet forthcoming, it might take me until next March to get it all on paper. Meanwhile, April is around the corner. While I currently wallow in herpetological heaven, I do look forward to what April will bring. It is the month that the lizards—which are *all* above average—begin to dot the landscape again. April is also the month that many species of snake that go missing for nearly six months begin to make their showing. It is the month when the Western Patch-nosed Snakes (*Salvadora hexalepis*)

dominate. The Sidewinders (*Crotalus cerastes*) also become active. Both species of snake just mentioned co-inhabit that patch of ground that I love the most—my 'winder spot. Should I ever move away from Arizona, and could only come back to visit sporadically, April would be the time of year that I would select to do so. Hence, we move on to some Aprils past, while reveling in the fact that it is just around the corner in the present.

About 20 miles north of the center of Tucson lies a mountain range called the Tortolita Mountains. While the Tortolitas are rather vast in the area that they cover, they don't exactly tower majestically above the flat landscape that surrounds them. At a distance, they are rather drab in appearance, mundane, not eye-catchers by any stretch of the imagination. I would venture that over half the people in Tucson, (the environmentally brain-dead half), have never even noticed them, let alone know them by name. Back in the early 1980s, this range was remote, and well outside the perimeter of civilization. When we wanted to get into the true wilds of Arizona, we'd drive up various two-tracks as far as we could to get to the southern edge of them, and then bushwhack in. We'd find lots of relics from the ancient ones. Arrowheads, pottery shards, petroglyphs. The southern Tortolitas were a little-known treasure, with steep, boulder-infested hillsides that were in turn studded with dense saguaro forests. They don't look like much from a distance, but once you're in the thick of them, there are some fantastic canyons and side drainages to explore.

There is a road called Tangerine Road that flanks the southern edge of the range. This was a paved road even in the 1980s, but traffic back then was near nil. It was a great road to cruise for herps. Back in 1983, I got my first glimpse of a wild Gila Monster (*Heloderma suspectum* [hereafter referred to as HESU or simply "monster"]) on that road. It was a DOR, but very



**Figure 1.** "They are better off being cold and wet outside of their holes than cold and wet inside." With most land dwelling reptiles, what is the part of the body that touches the ground? The belly, of course! This image of an unusual basking posture for a Gila Monster was taken just outside of its overwintering shelter on 27 February 2019. This day was the first warm-up following a week of cold and wet weather. Note that the animal's vent is in direct sunlight. This and all remaining images are by the author, and all are from Pinal County, Arizona.

fresh, with vibrant colors, and in pristine shape. I pried open its snappers, and marveled at the sharp, hooked teeth, and forked tongue. I was understandably excited with the find, and even picked it up off the road and put it in my vehicle. Off I drove with it lying on the floorboard of the passenger side of my Nissan. I was going to take it home to show my family and friends. But then, the laws being what they are, I got spooked, and took it back to where I found it. I lovingly placed it several paces off the road. I couldn't bear to put it back on the road as found. It somehow seemed more dignified to have its final resting place under a creosote bush, rather than leave it on the road as a miniature speed bump.

In April of 1985, I was barreling down Interstate 10 with a hiking buddy of mine. We were heading to the Chiricahua Mountains for a hike in the monument. About the time that we hit the Spanish Trail exit, on the far southeast side of Tucson, I saw a HESU traveling south across the freeway. It was just starting to enter the left lane of the highway. My poor hiking buddy will never understand what happened next, for John was not a herper. (In other words, he was "normal." They're all around us.) I locked up the brakes, veered right, and managed to come to a scorching stop about 100 meters past the point where the monster had been first spotted. Without a word, I swung open the door (not bothering to close it) and wind-sprinted back through the billowing black smoke that is synonymous with 20,000 miles of both the brake lining and tire rubber being erased from the respective life-expectancy of each.

These were the days when I *could* wind-sprint. I was lean, I was fast, I was strong—and *man* was I ever jacked up to catch that HESU! I'll never forget the jostling view of that monster crossing the left lane of I-10 as the ground evaporated beneath the rapidly rhythmic thudding of feet. By the time I pulled within 20 meters of the monster, despite the speed of my approach, and despite the determination and adrenaline flow, I began to see that this was going to end badly. The monster was on the centerline, and moving into the right lane. An 18 wheeler was bearing down on it like there was no tomorrow. I cut in front of the semi, head on, and tried to wave him over into the left lane as I closed the final distance between the monster and me. The plan in my mind was clear. The trucker would see me gunning for the monster, and then being the "knight of the road" that truckers are reputed to be, he would yield to the oncoming geek charge. But Mr. Trucker had other ideas. His remedy for the situation was to lay on his air horn, whilst staying his course. When I was a scant five meters from the monster, and perhaps 20 meters from the oncoming semi, I saw the hopelessness of it all. As I sprinted in front of the barreling semi to get to the left lane and out of his way, I tossed a "deer-in-the headlights" look his way. The burly, bearded sunovabitch was not attempting to slow down. If anything, he was speeding up! The last look I had of him was through his windshield. He was sitting high above me in the cab of his rig. And he was laughing! And then came the dwindling Doppler effect of the air horn roaring past, lessening in intensity as distance overcame sound, and the swirling road dust sandblasted my being. Far worse than that was the sight of my second-ever wild HESU plastered to the pavement like a bloody road Frisbee. Ten years of my life were lost in the bellicose cussing that followed. *What an asshole!*

I moved to Tucson in 1981. In selecting a place to start a new life, finding a wild HESU weighed in as a heavy factor in the relocation process. That is no kidding. I moved here out of the desire to pick off a life list species of herp. In 1983, the dead one on Tangerine Road came my way. Then, in 1985, it was literally "eastbound and down" on a major interstate with the second. It was not until April of 1989 that I saw my next wild HESU. And *finally*, that one was alive, kicking, and out of harm's way. It took me 7 years and 11 months to consummate my dream of seeing a living HESU in a pristine wilderness situation. And the location of this particular animal brings us back to the Tortolita Mountains. These days, Tangerine Road is no longer a quaint little paved road suitable for road cruising. It is now a 15-mile stretch of a four lane superhighway. There are still a few patches of wild Sonoran Desert flanking it, but it ain't much. And what little remains will surely fall soon. Many developments such as Dove Mountain, Stone Canyon, and too many others to enumerate here have engulfed the best of what the southern Tortolitas used to be. Tiger Woods has swung his driver in the exact spot where we used to herp.

But the north side of the range is still relatively pristine. And it was here, in a vast canyon bottom that some of us know as April Canyon, that I saw that first wild HESU. The story of this find has already been documented (see Repp, 1990). The experience of seeing that first wild HESU was one of reverence for this herper. It is only natural that I would hold the ground on which it was found in the same regard. And that experience alone—with a lizard that is *way* above average—is yet another reason to embrace April. Once a year, I go back to April Canyon. Thirty years later, it still remains largely unchanged from the day that the first one was found. And while deeply ensconced in the middle of March Madness and all that it brings, anticipation of what April Canyon 2019 will do for me is lovingly tucked away in the forefront of my mind. When conjuring memories of the best that can happen in April Canyon, 6 April 2013 comes to mind.

On this day, before heading to my *Heloderma* alma mater, Marty Feldner, Karla Moeller, Megan Morgan and I met at 0805. We were *supposed* to meet at 0800, but Marty was late by 5 minutes. As there was no sense whatsoever in being prompt if Marty was going to be late, I arrived just after he did. There was more than the usual flandickery in preparing to drive to our final destination. Marty had scooped a young male DOR Mojave Rattlesnake off the road enroute in, and no small amount of time was spent fondling and admiring that. Then, in order to make room for everybody, I had to unload 20 tons of camping gear into Karla's war wagon of a Suburban. But all that was eventually behind us. For the men on this journey, chivalry died back in the last century, when women started to demand equal rights. Hence, we put the women in the back of the bus, Marty promptly settled into the shotgun seat, and I took the wheel of my White Knight. *Bap!* We were heading eastward to April Canyon.

There was a brief moment of excitement when Marty spotted an average-sized male CRAT on the right side of the rugged quad trail that we were negotiating. The White Knight regurgitated its vehicular contents, and we all encircled the snake to commune with him for a few minutes. We left him none the worse for the wear, and he was no doubt happy to see us go. We arrived at April Canyon at precisely 0900. The air temp was 22°C, it was



**Figure 2.** A female Western Diamond-backed Rattlesnake (*Crotalus atrox*) found by the author on the visit to April Canyon on 6 April 2013. See text for details.

cloudless. My trusty Kestrel weather meter indicated 20% humidity, and a 0–3 mile-per-hour breeze. We were at 3400 feet in elevation. I’m the only one of the group who knows these things, as I was the only one to take the time to document it all. The other three left me behind like a soiled hanky while I did so.

I showed Karla this place because she needed to fully process ten different adult HESUs in April, and ten again in June. April Canyon is a place where that is possible. It was a study to determine drought-related physiological defense mechanisms in HESU (see Moeller et al., 2017). And my purpose for being there was to see herps in a place likely to yield plenty. Any HESUs are *always* a bonus wherever we roam.

By the time I had finished the initial documentation, my three companions were out of sight. At this point, April Canyon is a wide open sandy wash that narrows as one ascends. Both sides of the canyon are flanked with lush desert vegetation. The mesquites grow tall and mighty here, and dense thickets of hackberry and *nasty* catclaw abound. The sand revealed the footprints where my three companions had hiked. Hence, I was able to ascertain where the group did not walk, and started my route up in that direction. I immediately found an adult female CRAT stretched out in the sand, heading across the wash in westerly fashion (Figure 2). I tried snapping some undisturbed images, but she drew into a semi-defensive posture, and began backedpedaling away from me, with head held high and rattles singing. About the time this one was found, Marty found another. His was a male.

At 0925, I caught up with the group. They were all huddled

together in wash center. They had found their first HESU. It was an adult female that Marty had found in the center of the wash. She was found with snout in the sand, and had been digging. She was processed and released to get on with her life. Shortly after this experience, Megan was pointing to something chest high in the trees and murmuring in her soft voice. This eventually brought us all to her side. Thrust upon a horizontal branch of a mesquite tree was the severed head and neck of an *atrox*. It was a CRAT-sickle! It was fairly fresh, as the eyes were still in the sockets, and the black tongue still dangled out of its gaping mouth. (Figure 3). It served as a grotesque reminder that all who enter April Canyon are not nature lovers. It is this kind of unnecessary cruelty that drives us berserk. We grow ever-tired of the ignorance of those who invade nature under the guise of appreciating her, only to be offended when she comes calling. (Or, in this case, “comes crawling.”) It is impossible for us to fathom the contempt for living organisms that is shown by some of our citizens. What a disgrace!

The next round of excitement occurred when Marty spotted a mid-sized Gophersnake (*Pituophis catenifer*) sprawled lengthwise at the west edge of the wash. At first, the snake remained motionless, and we tried to move in for some pictures. Then, it began slithering slowly eastward across the wash in front of us. Megan had fallen behind us in the search effort, so we called her up for a look. Karla was on the slope above us, to the east of the action. She asked us if it was worth her while to come down to view the snake, and we replied that it was nothing spectacular. It was just shy of a meter long, just a scrawny “nuthin’ special” sort of Gophersnake. (How dare I say that a Gophersnake is “nothin’ special!” They’re *all* special, but not when the focus is on other things. Were it a five-foot-long hefty beauty, Karla would have been severely berated if she even hesitated to come down for a look.) Moments later, the nuthin’ special slid into some overhanging roots of a mesquite on the east berm of the wash. It was at this point that nuthin’ special morphed into “sumthin’ special,” for within the framework of those mesquite roots was a HESU!

“Now you can come down, Karla!”

We waited patiently before moving in to process this second monster, in hopes that maybe the Gophersnake would attempt to interact with it. But by this time, both animals were aware of our



**Figure 3.** “Thrust upon a horizontal branch of a mesquite tree was the severed head and neck of an *atrox*. It was fairly fresh, as the eyes were still in the sockets, and the black tongue still dangled out of its gaping mouth. It served as a grotesque reminder that all who enter April Canyon are not nature lovers. We grow ever-tired of the ignorance of those who invade nature under the guise of appreciating her, only to be offended when she comes calling.”



**Figure 4.** A Gophersnake led us to this, our second Gila Monster of the day. This is a posed image, taken after the processing. The scenic backdrop of this image reveals a glimpse of the splendor of April Canyon.

presence, spooked to the max, and there was to be no excitement—save for that of having two cool species of herp occupy the same patch of ground. The Gophersnake was left to get on with his life. The HESU did not get off quite that easily, but the processing went smoothly. This one was a dandy of a male. His mass was 591 grams, and he was 553 mm (21.8 inches) in total length. Certainly not a record length or mass by any means, but he was a healthy monster by Sonoran Desert standards (Figure 4).

Earlier in this narrative, the first glimmers of HESUs in my life were mentioned. By the time that first April Canyon HESU was discovered, I had a friendly association with one of the early monster masters in our region. We speak of Brent Martin. By the late 1980s, Brent claimed that he had amassed and processed over 200 of them. He was also quick to point out that this impressive total was accumulated through decades of seeking them. While I believed Brent, that number of 200 seemed astronomical. It was a record that I could never even approach. A careful search of my records indicates that our nuthin' special

Gophersnake led us to wild HESU number 305. The simple number of 305 just doesn't look right when spelled out numerically. That ain't saying it proper. Let's put that number in writing. THREE HUNDRED FIVE HESUs! Yeah, baby! And there wasn't even a ticker-tape parade to honor the event.

We left number 3-oh-5 to get on with his life. And the search for number 306 was on. It was ascertained that it was time to head back down the canyon. A short while later, Marty sounded off, "Monster!" This one was found sprawled in a dense thicket of catclaw, on the east berm of the wash. It was a vividly colored younger animal, which unfortunately was of no use to Karla. However, as a DNA sample, it *was* useful to those Marty and I serve. Mother Repp never raised a child so foolish as to plunge into a catclaw thicket after a monster that he didn't even find. My mind became a raging torrent of excuses for not ripping myself to shreds on account of this monster. I thought: "Marty found the darn thing, let *him* be the hero! Yeah! Let Marty do it! Go get her, boy!" By the time Marty had her, the harsh shrubbery was gaily festooned with strips of Marty-bacon. Let that be a lesson to the lad about finding things among pernicious plant parts!

This monster turned out to be a female. We estimated that she was entering the fourth year of her sweet young life. We all took turns taking pictures, and Karla drew a little blood for the DeNardo lab. Once we were done having our way with her, we simply let her go to see what she would do. What she did proved to be the highlight of the day. At the point where we turned her loose, she was roughly 20 meters up wash from her capture spot. Rather than heading in that direction, she bolted for the cover on the east berm. She approached a burly, vertical scaly trunk of a massive mesquite tree, and began deftly crawling up it. She stopped her ascent when she was just over two meters above the ground. She was a sitting duck for the photographs that followed (Figure 5). This is only the second time that I have witnessed a monster go arboreal. This puny N of 2 not only takes into consideration the 306 different wild HESUs observed over the past 25 years, but also includes well over 3,000 observations on telemetered animals. The first time we witnessed this happening



**Figure 5.** Following the processing, the third Gila Monster of the day climbed this mesquite tree. (Left) Close-up, (Right) backing off to show more of the situation. This Gila Monster climbed more than 2 meters up, and we speculate the motivation was escape.



**Figure 6.** This image, taken 25 April 2010, shows yet another Gila Monster taking to the trees. It is the speculation of this author that it climbed the palo verde tree to escape capture. It also may have gone arboreal to cool off. See Repp and Schuett (2010) for further elucidation.

was with our telemetered HESU#15. He earned the name “Tarzan” as a result of his climb (Figure 6). I have also seen one other image taken by Marty Feldner of yet a third HESU climbing a mesquite. With all three cases, the observers speculated that the climbing was done in an attempt to escape. Just a little over a month after this trip to April Canyon, on 18 May 2013, Karla and her current supervisor, Charles Kazilek, shot a video of one ascending, and eventually descending, (head first in both directions), a pine tree. Karla and Charles were part of a group picnic luncheon at Boyce Thompson Arboretum when the HESU was first spotted. The group crowded around the monster to get photographs. (Who wouldn’t?) At some point, the HESU decided that it had enough of this annoying human behavior, and briskly waddled right through the group. (The results of its charge, and the reaction of the people to it, was akin to Moses parting the Red Sea!). It deftly climbed about 8 feet up in the tree. Charles recently told me: “We got people to move away from the tree so that it would be encouraged to get down.” Once people backed off, the HESU crawled back down. In the other three cases, as well as the pine tree event, there is strong evidence that escape from human interlopers was the probable motive for climbing the tree. Unlike their cousins the Beaded Lizards, which routinely assail lofty heights while foraging for food, tree climbing is only rarely encountered with HESU.

Getting back to 6 April, whilst going off on a paragraph of bygone days, we left our young monster clinging tenaciously two meters above ground on the trunk of an acacia tree. There was some discussion amongst the fab four about leaving her there like so much painted fruit. But our desire to feed the local raptors was minimal. Hence she was snatched from her moorings and released into the briar patch from whence she came. It is hoped that she was able to snack on some of the Marty-bacon that was so generously hung for her.

It was 12:30 when we got back to the White Knight. I was a half-hour late for my first beer of the day. Those who bottle Dos Equis were on high alert, and the workers were fearful of lengthy furloughs. The world’s most interesting man grew boring, developed a stutter, and began picking his nose in public. On a more

personal note, by the time I got the cap off the bottle, little pink elephants were swirling about, and closing in on me in a most menacing manner. Disaster was narrowly averted here. Speaking of disasters, lunch came next. Marty and I are not accustomed to the field fare that the folk in DeNardo’s lab subsist upon. Instead of steak and lobster, these kids serve blobs of brown and red sticky substances slathered on Wonder Bread. To assure that they get all the essential vitamins and minerals, they often augment their meals by hacking open a can of Franco-American SpaghettiOs. (The gastric distress that follows such fare never fails to mandate a mounting of the porcelain throne whist mumbly “Oh Oh— Spaghetti-Os). And they think they are walking in tall cotton by eating junk like this! The temptation to hike back for some strips of Marty-bacon was strong, and we began eyeing the maggots in the abundant drying cowpies as potential side dishes. This is what you get when you let *kids* lead the charge! When left to our own devices, every meal is a banquet. The next time we are in Rome, we will *not* do as the Romans do!

By 1400, we were just sitting around looking at each other. Marty began to talk about eating people. Cannibalism is a favored topic of his, especially when he is feeling malnourished. I expect Marty to talk about eating people when he is hungry, so there was no problem thus far. When the ladies wholeheartedly joined in Marty’s conversation, things got a little scary. Talk of cannibalism often results when the troops in the field are underfed and bored. The idle mind is the devil’s workshop, and it was time to think of something to do. (Lest one of us wind up in the cooking pot). My suggestion that we road-cruise to 96 Hills in order to just keep moving was met with universal acceptance. Marty and I are old hands at counting lizards, and there were plenty to count on this hot spring afternoon. Soon, the boredom overtook the ladies, and they joined right in there to help.

“There are 2, no 3, no 4, 5-6-7, 9! 12! 14!” We were all singing out from all sides of the White Knight. Every 50 feet or so, we would jump the Zebra-tailed Lizards (*Callisaurus draconoides*) (Figure 7). When all was said and done with our otherwise pointless road cruise, we had racked up 237 of them! We also scored 10 Side-blotched Lizards (*Uta stansburiana*), 4 Clark’s Spiny Lizards (*Sceloporus clarkii*), 5 Desert Spiny Lizards (*Sceloporus magister*), 18 Greater Earless Lizards (*Cophosaurus texanus*), 6 Tiger Whiptails (*Aspidoscelis tigris*), 3 Tree Lizards



**Figure 7.** A Zebra-tailed Lizard (*Callisaurus draconoides*) exhibiting the tail-waving behavior that has earned it the common name. On 6 April 2013, the author and colleagues sighted 237 individuals. During the 19-years that this author has kept records on common lizards, year in and year out, the “Zeb”s are by far the most abundant reptile encountered.



**Figure 8.** A Leopard Lizard (*Gambelia wislizenii*) in situ, sunbathing. The month of April is when these fabulous “above average” lizards begin to make their appearance in Southern Arizona.

(*Urosaurus ornatus*), and 2 Leopard Lizards (*Gambelia wislizenii*) (Figure 8). The capper of the cruise occurred in the afternoon at 1610. I saw a smallish lizard waddle off to the side of the road into some tall grass. I stopped the vehicle, and was all sorts of insistent that we had just seen a Regal Horned Lizard (*Phrynosoma solare*). Others protested this not to be true. I resisted the urge to get aggressive in my assertions, as I really wasn’t that sure. But we kept looking anyhow, and sure enough, Karla fished the horny toad out of the shrubbery (Figure 9) The crowd went wild! By the time that dusk rolled around, and the lizard activity stopped, we had racked up 289 lizards, with ten different species represented. This particular cruise helped to build my lizard count for the year of 2013. The numbers of Zebra-tailed Lizards had been rather lackluster up to that point in time. It was one hell of a lizard day!

Just after the horned lizard, there was some universal lamenting about the lack of snakes on this road cruise. Just as soon as the grouching started, as if on cue, a meter-long, all-black Coachwhip (Figure 10) was observed in the center of the dusty road. It was one very jacked-up snake. The ground-hugging greased



**Figure 10.** This is one way to get them to stay still long enough to get an image! A black color morph of a Coachwhip (*Masticophis flagellum*) that has gone arboreal in a chain-fruit cholla. (Once again, doing so in an attempt to escape the photographer.)



**Figure 9.** The Regal Horned Lizard (*Phrynosoma solare*) found toward the end of the road cruise described in the text. This one was likely a young of the previous year.

lightning zipped to the side of the road, and evaporated, leaving a little black vapor trail in its wake. Despite further effort, that was to be the last good find of the day.

In closing this epic journey about a good herping day, perhaps a reminder to those of us who are blessed to live or visit Arizona is in order. When in this state, we are in a place that epitomizes freedom. We can roam at will through a variety of habitats that range from sand dunes to above timberline. We should never take our public lands for granted, for it is these places that allow escape from the rat race of daily living. We can travel dirt roads, find a hill to climb, stand alone, and take back something worth remembering. And best of all, we are in a place where at any given moment, a gaudy, orange-and-black, hefty lizard can lumber across our path, and make our day.

This here is Roger Repp, signing off from Southern Arizona, where the turtles are strong, the snakes are handsome, and the lizards are all above average.

### Epilogue

During the course of preparing this article, Repp approached Dr. Karla Moeller in order to get accurate details of what kind of tree the Gila Monster climbed in her observation of 18 May 2013. The discussion that followed not only resulted in the photo that graces the cover of this issue of the *Bulletin*, it also resurrected the video of the actual tree-climbing event. Three standout observations are included in this video. The first is a demonstration of a Gila Monster moving at top speed for quite a distance—as fast as Repp has ever seen a HESU move (out of over 3,300 observations). The second eye-opener is the way the HESU barrels fearlessly through a group of picnickers. And lastly, both the up and back down of the pine tree by this amazing monster is chronicled. To see this video, please enter the following link into your favorite search engine. It is well worth the effort: <<https://askabiologist.asu.edu/explore/gila-monsters>>

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## Herpetology 2019

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.

### RAINFALL AND PREDATION OF TERRAPIN NESTS

R. A. Czaja et al. [2018, *Journal of Herpetology* 52(4):402-405] note that many turtle species, including diamond-backed terrapins (*Malaclemys terrapin*), often nest shortly before and during rainstorms. The authors tested the hypothesis that rain can decrease the likelihood that nests will be depredated, presumably by reducing the chemical, tactile, or visual cues that predators use to locate turtle nests. They analyzed the impact of rainfall on predation rates of diamond-backed terrapin nests in Jamaica Bay Wildlife Refuge, New York, June–July 2016. Natural and artificial nests built on days with no rain or varying amounts of rain were monitored for 5 d after oviposition/construction. Predation rates were similar for both artificial and natural nests and decreased when nests were laid on rainy days. For artificial nests, that decrease was significant, and for natural nests the decrease was nearly significant. Predation rates on natural and artificial nests were inversely correlated with the amount of rain on the day nests were laid or constructed. These results indicate that selection may favor turtles that nest soon before or during rainfall.

### RELOCATION OF SEA TURTLE NESTS

M. Ware and M. M. P. B. Fuentes [2018, *Chelonian Conservation and Biology* 17(2):252-262] note that sea turtle nest relocation is a management strategy commonly used to mitigate hatchling mortality, particularly that due to wave wash-over and tidal groundwater inundation. Relocation can alter the incubation environment, so there is concern regarding potential modifications to embryonic development. Several studies have explored the effects of relocation on nest productivity; however, these studies often only compare reproductive output and incubation environments between relocated and in situ nests without accounting for the incubating environment of the original nest location. The authors assessed the differences in sand temperature, inundation exposure, grain size, and moisture content between the original and final locations of relocated nests at a loggerhead (*Caretta caretta*) nesting beach in Fort Morgan, Alabama, as well as differences in nest productivity between in situ and relocated nests. Differences in mean sand temperature, likelihood of inundation, and sand moisture between original–relocated locations and in situ–relocated nests were not significant. Emergence success was significantly lower in relocated vs. in situ nests, and sand grain distributions were significantly different between original and relocated nest locations. Given that relocation did not improve nest productivity nor reduce the likelihood of inundation, this practice conferred minimal net benefit to sea turtle nests on dissipative-to-intermediate beach conditions typical of the northern Gulf of Mexico. To improve the justification for nest relocation under these beach conditions, a better understanding of embryonic tolerance to inundation and clarification of relocation criteria and guidelines is required.

### VARIATIONS BETWEEN MORPHOTYPES

F. Quattrini et al. [2018, *Herpetologica* 74(4):311-322] note that adult males of the African treefrog species *Leptopelis flavomaculatus* occur in either brown or green color morphs. This study investigated whether the two color morphs of breeding males of *L. flavomaculatus* differ in traits other than color. The authors examined call differences (dominant frequencies and call durations), call-site selection, and body size. Results show differences in the call durations, dominant frequencies, mean call intensities, as well as in size (body length and body mass) of the two vocally active color morphs of this species. The two morphs were similar in their choice of plant species used as calling sites and the heights of those sites. Given the sensitivity of mate recognition systems for most anurans, these results provide evidence of both call and morphological variation between the two color morphs of this species, and establish a foundation for future phylogenetic and mating system studies to support the contention that the two color morphs of *L. flavomaculatus* might warrant taxonomic recognition as separate species.

### MASSASAUGA POPULATION SIZES

D. R. Bradke et al. [2018, *Journal of Herpetology* 52(4):387-397] note that destruction and fragmentation of wildlife habitat often results in small, isolated populations that are highly susceptible to extirpation. In many cases, however, estimates of population size are lacking, precluding accurate assessments of population viability and sound conservation management recommendations. The eastern massasauga (*Sistrurus catenatus*) is a federally threatened pitviper species that has been extirpated throughout much of its historic range attributable to agricultural conversion of wetland habitat and other synergistic threats. Population size is generally unknown among extant massasauga populations, making site-specific management difficult. This study estimated genetic effective population size ( $N_e$ ) and census population size ( $N_c$ ) for eastern massasaugas at two sites in southwest Michigan. For each population, mark–recapture models were used to estimate  $N_c$  and the linkage disequilibrium method was used to estimate  $N_e$ . Results revealed small  $N_e$ , with approximately 108 (95% CI = 87–165) and 148 (95% CI = 102–295) adults estimated at the study sites in Cass County and Barry County, respectively. Estimates of  $N_e$  were even smaller: approximately 29.5 (95% CI = 21.2–43.1) for Cass County and 44.2 (95% CI = 30.8–69.3) for Barry County. Additionally,  $N_e/N_c$  ratios were similar across study sites, suggesting some stability in this ratio for eastern massasaugas, at least for populations in close proximity. Although the study did not detect high levels of inbreeding or relatedness in either population, the authors caution that these small populations could become increasingly vulnerable to extirpation from unpredictable threats such as disease and climate change.



## DETECTING ALLIGATOR SNAPPING TURTLES

S. M. Feist et al. [2018, *Chelonian Conservation and Biology* 17(2):271-279] note that the alligator snapping turtle (*Macrochelys temminckii*) is under consideration for listing as a federally endangered species. Distributional data and estimates of population sizes are needed to make a sound decision regarding listing, but this information is largely unavailable due to the immense effort required for *M. temminckii* trapping surveys. To alleviate difficulty in detection and to help inform subsequent field-intensive survey efforts, the authors developed an environmental DNA (eDNA) method capable of providing presence data even in systems with high turbidity and suspended organic material. The assay utilizes probe-based quantitative polymerase chain reaction and reliably amplifies *M. temminckii* eDNA in both lentic and lotic systems, with no amplification observed in other nontarget, sympatric turtle species. The novel eDNA method developed, optimized, and field-tested in this study provides a promising tool for detection of alligator snapping turtles, with resultant presence data likely to prove beneficial for the management and conservation of this species.

## TRANSLOCATED HELLBENDERS

E. B. McCallen et al. [2018, *Herpetologica* 74(4):283-293] note that with amphibian declines at crisis levels, translocations, including population augmentations, are commonly used for amphibian conservation. Eastern hellbenders (*Cryptobranchus alleganiensis alleganiensis*) have declined to low densities in many areas of their range, making them ideal candidates for population augmentation. Both wild adults and captive-reared juveniles have been used for augmentations, but their suitability has never been directly compared. The authors used radio telemetry with eastern hellbenders to examine patterns of site fidelity, movement, and habitat use over a 2-yr period for adult residents, wild adult translocates, and captive-reared juvenile translocates. They used generalized linear models and generalized linear mixed models to identify temporal trends and explore the effects of residential status (resident vs. translocate) and origin/age (captive-reared juveniles vs. wild adults) on various ecological and behavioral traits relating to habitat. Site fidelity was high in adult residents and wild adult translocates, but lower in captive-reared juvenile translocates. Both adult and juvenile translocates had greater mean movement distances than residents, leading to larger home range sizes, but these differences decreased over time. Wild adult translocates had a higher probability of using artificial nest rocks than adult residents or captive-reared juvenile translocates. This pattern was most prevalent early in the study, indicating these shelters are particularly useful during the transition to release sites. Captive-reared juvenile translocates had lower site fidelity and utilized suboptimal habitat (smaller and fewer shelter rocks) compared to wild adults. Compared to previous studies, translocations had fewer negative effects on site residents or wild translocates and might be effective at promoting growth of hellbender populations. However, translocations of captive-reared juveniles were less successful. It is uncertain whether captive-rearing or ontogeny led to these differences, so both longer head-starting times and conditioning should be explored to improve outcomes in captive-reared juvenile cohorts.

## A HARVEST MODEL FOR AMERICAN ALLIGATORS

C. B. Eversole et al. [2018, *Herpetological Monographs* 32: 22-33] note that the American alligator (*Alligator mississippiensis*) is a crocodylian species that was once listed as endangered in the United States but is now harvested both recreationally and commercially throughout its range in the southeastern United States. Harvest of alligators typically includes egg collecting and hunting. However, review of scientific literature reveals that the effects of harvest on alligator populations have received little scientific scrutiny. The authors built a theoretical simulation model to evaluate the impact of several harvest strategies on long-term (i.e., 100 yr) alligator population trends. They used system dynamics software to develop the model and acquired data for the model from literature and field studies on alligator ecology. Although widely applicable across the species range and for other crocodylians, the Texas alligator management program served as an example for model use. Results of model simulations showed that current harvest (50% egg harvest, 2% subadult harvest, 2% adult harvest) is sustainable, but alligator populations will stabilize at levels below population potential. The best harvest scenario for a sustainable harvest that maintains alligator populations at a relatively unchanging level is a 38% egg harvest, 2% subadult harvest, and 2% adult harvest. An elevated egg harvest (80%) can be sustained if no hunting harvest occurs. Contrarily, an increased hunting harvest (4% subadult, 4% adult) can be sustained with no egg harvest. This model identifies the function of current alligator harvest within populations and provides a tool for future use in determining the effect of changes in harvest or life-history characteristics on alligator population dynamics.

## DEEP-NESTING MONITORS

J. S. Doody et al. [2018, *Herpetologica* 74(4):306-310] note that in oviparous reptiles with no parental care, the choice of nest site is a mother's final investment in her offspring. Although linkages between nest site choice, egg temperatures, and embryonic success have been well studied, much less is known about analogous linkages with soil moisture encompassing developing embryos. Most ground-nesting reptiles nest at depths <25 cm, with the deepest nests <1.0 m deep. Recently, however, the nests of two species of monitor lizards (*Varanus panoptes* and *V. gouldii*) have been discovered at depths of 2.3–3.0 m, suggesting that nesting at extreme depths in these species is an adaptive response to the lack of sufficient soil moisture at shallower depths. The authors examined this idea with *V. panoptes*, specifically predicting that deeper nests in a desert ecosystem compared with those in a savannah ecosystem are attributable to differences in the magnitude of rainfall. They excavated a communal nesting warren to a depth of 4 m and identified 11 fresh nests and 99 hatched nests. Mean nest depth in the present study was greater than that in savannah. However, nests were shallower than those of *V. gouldii* in the same general location, possibly because of local heterogeneity in soil moisture. Hatchlings excavated their own emergence burrows rather than following the burrows of their mothers, despite relatively great distances through resistant soils. Collectively, deep nesting creates energetic challenges for mothers and hatchlings, suggesting an adaptive function for the behavior.

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## NEW CHS MEMBERS THIS MONTH

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 Patricia Browne  
 Yanitta Cortez  
 Dawn DeBello-Rescigno  
 Melissa Forsberg  
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## UPCOMING MEETINGS

The next meeting of the Chicago Herpetological Society will be held at 7:30 P.M., Wednesday, April 24, at the Peggy Notebaert Nature Museum, Cannon Drive and Fullerton Parkway, in Chicago. The speaker will be **Chris Lechowicz**, director of the Wildlife & Habitat Management Program and staff herpetologist at the Sanibel Captiva Conservation Foundation (SCCF) in Sanibel, Florida. Chris grew up on the southwest side of Chicago and is a long-time member and past president of the CHS. His program is entitled “SCCF Pine Island Sound Eastern Indigo Snake Project: Current Challenges.” The project was developed in 2012 in Lee County, Florida, by the SCCF, a non-profit organization on Sanibel Island, after the eastern indigo snake disappeared from Captiva in 1988 and from Sanibel in 1999. Prior to the beginning of the project, the three other large islands in Pine Island Sound had recent unverified reports of eastern indigo snake sightings. Through permits from the U.S. Fish and Wildlife Service via the Oriante Society, an effort to assess, inventory, and develop plans to sustain this federal- and state-listed threatened species on the last islands in Florida known to harbor eastern indigo snakes began.

The speaker at the May 29 meeting has not yet been confirmed.

The regular monthly meetings of the Chicago Herpetological Society take place at Chicago’s newest museum—the **Peggy Notebaert Nature Museum**. This beautiful building is at Fullerton Parkway and Cannon Drive, directly across Fullerton from the Lincoln Park Zoo. Meetings are held the last Wednesday of each month, from 7:30 P.M. through 9:30 P.M. Parking is free on Cannon Drive. A plethora of CTA buses stop nearby.

### 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? If so, mark your calendar for the next board meeting, to take place at 7:30 P.M., May 17, 2019, at Papa Passero’s Pizzeria, 6326 S. Cass Ave., Westmont..

### The Chicago Turtle Club

The monthly meetings of the Chicago Turtle Club are informal; questions, children and animals are welcome. Meetings normally take place at the North Park Village Nature Center, 5801 N. Pulaski, in Chicago. Parking is free. For more info visit the group’s Facebook page.

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