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President's Letter – News and Announcements for an Active 2024!

Hello, springtime!

The wildflowers have just begun to bloom in the Tucson area after remarkable amounts of rain (albeit rather warm). Lizards have appeared on Tumamoc Hill, and some folks in the Tucson area are already beginning to see few snakes. Soon folks will also start to see Gila Monsters.

Fatal Gila Monster Bite

As an appreciator of our local reptiles, you will likely get asked about the recent Gila Monster that bit and killed its owner in Colorado. Some facts:

- While extremely painful, Gila Monster bites are rarely lethal. The only previous recorded fatality in the United States was in 1930.
- Gila Monster bites almost exclusively result from ignoring signs of agitation such as hissing, and intimidation, as well as improper or unnecessary handling.
- Gila Monsters are illegal to own without a specific permit in areas they are native to, and sometimes more.

Field Trips

We are moving behind the scenes to provide more field trip opportunities, and appreciate your patience as we build a sound framework for the range of activities we want to offer. If you are interested in helping, please contact us (cascabel1985@gmail.com).

Outreach and Events

By the time you've read this, THS will have participated in the Tucson Festival of Books. We are a popular attraction at the event's Science City area, reaching a couple thousand folks every time. This is all made possible by the efforts of organizers like Maggie Fusari and Patrick Brown, and volunteers who donate their time and patience to work as ambassadors to the world of creatures most people find frightening, revolting, but mostly misunderstood. We have a number of outreach and other events and opportunities

coming up this year. I will mention some here, but please look out for more detail forthcoming. Your participation is always welcome and appreciated.

Justin Schmidt Memorials: 23 and 30 March—There will be two memorial services for our friend Justin Schmidt, former THS supporter, world-renowned celebrity entomologist, known for his stinging insect pain index, and a conservation advocate. Contact me below for more information. You can also visit and contribute to Justin's memorial website at <https://bit.ly/3SZVJN6>

Jarchow Conservation Award: 30 March—The THS Jarchow Conservation Award is being presented to Dr. Lawrence L.C. Jones. The award honors James L. Jarchow DVM, and those whose conservation work benefiting the herpetofauna and their ecosystems of the desert regions of North America would benefit from it. More information below. While this may conflict with the Schmidt memorial, we have scheduled our event to allow some flexibility.

May field work opportunity—Dr. Javan M. Bauder (University of Arizona) is seeking applicants for two projects on: the population biology of Narrow-headed Gartersnakes (*Thamnophis rufipunctatus*), and the dispersal ecology of the American Bullfrog (*Lithobates catesbeianus*) in Coronado National Forest south of Tucson. For more information contact: troderick@arizona.edu (gartersnakes) — esudbeck@arizona.edu (bullfrogs).

2024 Southwest Partners in Amphibian and Reptile Conservation Meeting: 15-17 August—This meeting will be held at the Arizona-Sonora Desert Museum. More information forthcoming.

Biology of Lizards 2: 24-27 July—This meeting will be held in Rodeo, NM, at the Chiricahua Desert Museum and Geronimo Event Center. See biologyoflizards.com for more information. THS will have a table there; contact me below to help staff it.

SPEAKER

- 3 March 25: Paul Maier —Ten Years of Evolutionary Research on the Yosemite Toad (*Anaxyrus canorus*)

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- 54 "Atypical Anuran Amplexus between Western Spadefoot and Pacific Chorus Frog During an Explosive Breeding Event, in Fresno County, CA" by H. Isner et al.

Cover Photos information: (top) Photographer: Erik F. Enderson; Northern Spotted Box Turtle (*Terrapene nelsoni klauberi*). Northeast of Ónavas, Municipality of Ónavas, Sonora, Mexico. July 2008. **(bottom)** Photographer: Ana Lilia Reina-Guerrero; Desert Box Turtle (*Terrapene ornata luteola*). Mututicachi, Municipality of Bacoachi, Sonora, Mexico. July 2013.

22nd Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles: 25-28 July—This meeting will be in Tucson at the Loews Ventana Canyon Resort. See www.turtlesurvival.org/annual-symposium for more information. THS will have a table there – contact me below to help staff it.

As always, thanks for your support.



Robert A. Villa
cascabel1985@gmail.com



These photos of Drs. James L. Jarchow and Cecil R. Schwalbe were taken by Ed Tunstall (Arizona Herpetological Association). Presumably these photos were taken in Phoenix where Cecil was hired by Arizona Game and Fish Department as Arizona's first state herpetologist from 1984 to 1990 — as the envelope containing these photos was addressed to Cecil's office there. The paper prints of these images will go to Cecil's section at the University of Arizona Special Collections Library.



Paul Maier, Ph.D.

Population Geneticist for FamilyTreeDNA, Gene by Gene

Ten Years of Evolutionary Research on the Yosemite Toad (*Anaxyrus canorus*): What Can the Past and Present Tell Us About Their Future?

Monday, March 25, 2024: Meet at 7 pm MST in person in Room S225

Second floor of Environment and Natural Resources 2, University of Arizona, 1064 E. Lowell St., Tucson, AZ 85719

Enter from Lowell St., and follow stairs on the left, or elevators on the right

Free parking in lot south of the venue, or \$1/hr in adjacent garage (credit card only)

Attend virtually at: <https://arizona.zoom.us/j/87938352088>

Abstract: Yosemite toads (*Anaxyrus canorus*) are extremely vulnerable to ongoing climate change. Adults exclusively breed in the transient and exceptionally shallow ponds of mountain meadows making them highly dependent upon seasonal snowpack and associated groundwater and runoff levels. Tadpoles regularly face high desiccation mortality exacerbated by opportunistic parasites and predators. Adults and subadults are sensitive to temperature-induced reduction in body fat levels that can influence their overwintering survival and fecundity. Over the past decade, we have used genomic, climate, and landscape data to elucidate how this iconic species has previously adapted alongside climate experienced during the Pleistocene and present-day, to predict the future fate of the species. Pleistocene ice sheets have fractured their distribution into several “pure” and “fused” lineages, while modern-day populations are further divided into “hub” and “satellite” populations. In two recent publications, we forecast how 21st century climate change will encourage range shifts upward in elevation, while simultaneously favoring the adaptive success of certain higher elevation lineages. Our simulations predict a 29% demographic reduction over 90 years of climate scenario RCP 8.5, consistent with previous estimates. Our novel landscape genomic approach offers practical conservation suggestions, such as identifying climate refugia, protecting migrational corridors, and combining low-diversity lineages with similar adaptations into one conservation unit.

Bio: Dr. Paul Maier is the lead Population Geneticist at FamilyTreeDNA and Gene by Gene, where he builds ancestry estimation tools, and studies the evolutionary history of human life on earth. Since 2018, he has developed numerous products and features, including myOrigins® 3.0, the Chromosome Painter, Big Y Age Estimates, the FTDNATiP™ Report, the upcoming Mitotree, Geo-Genetic Triangulation (for Beethoven research), and now Globetrekker. Paul earned his Ph.D. in evolutionary biology, studying the genetic past, present, and future of a much squishier creature, the Yosemite



Paul Maier with study animal. Photo courtesy Paul Maier.

toad in the Sierra Nevada of California. His research used conservation genomics to inform the US Fish & Wildlife Service’s strategy for this federally threatened species. His work is published in journals such as *Heredity*, *Evolution*, *Frontiers*, *Evolutionary Applications*, *Current Biology*, and *Molecular Ecology*. While earning his doctorate, he worked as lead biologist for the US Geological Survey, and taught university students about genetics, evolution, zoology, and herpetology. His scientific outreach tries to emphasize the simplicity of DNA, amidst a complex field. He has given numerous talks, including at RootsTech, Jefferson Public Radio, the Int’l Conference on Genetic Genealogy, Portland ISOGG, and East Coast Genetic Genealogy Conference. He is passionate about using DNA to reconstruct the hidden stories of human and wildlife populations.



Yosemite toad (*Anaxyrus canorus*). Photo courtesy Paul Maier.

Our novel landscape genomic approach offers practical conservation suggestions, such as identifying climate refugia, protecting migrational corridors, and combining low-diversity lineages with similar adaptations into one conservation unit.

13th Jarchow Conservation Award – March 30th, 2024

The Board of Directors, Tucson Herpetological Society, Tucson, AZ; tucsonherps@gmail.com

It is with great pleasure that the Tucson Herpetological Society presents the 13th Jarchow Conservation Award (JCA) to Lawrence L. C. Jones. His excellent work ethic and his willingness to take on any project that serves the conservation of the native plants and animals of the Sonoran Desert — as well as the entire western United States — made his selection for the award a delightful effort. We anticipate that Larry will continue to add to his impressive dossier of herpetological research and conservation, and we look forward to watching and learning from his efforts.

Please join us!

Saturday March 30th

4-7 PM

Mission Garden

946 W Mission Ln

Tucson AZ 85745

Free to attend

RSVP by *Tuesday March 26* at:

<https://ths28.wildapricot.org/event-5618466>

Email questions to

tucsonherps@gmail.com

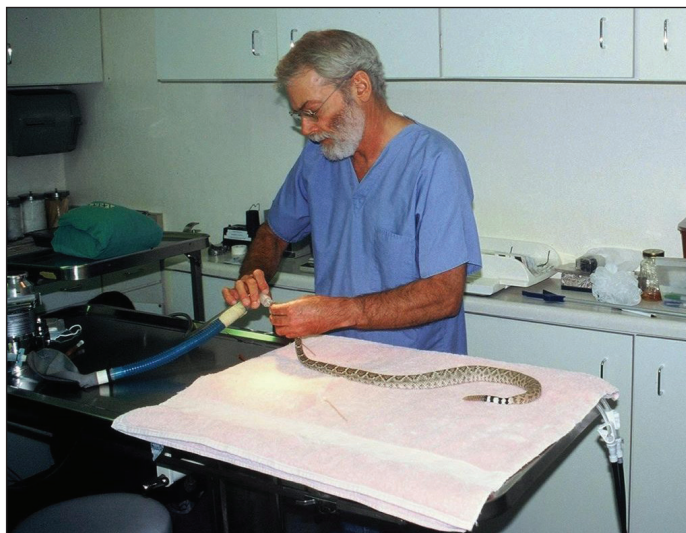
Pizza, cake, and drinks will be provided

as friends, colleagues, and family toast to Larry's accomplishments.

The Tucson Herpetological Society established the Jarchow Conservation Award — named for James L. Jarchow DVM of Tucson for his dedication and contributions to the conservation of amphibians and reptiles for more than 40 years. The first JCA was given to Dr. Jarchow on 15 September 1992.

The JCA honors individuals and organizations that have received little recognition, and whose conservation work would benefit from the JCA — consisting of a written citation, engraved plaque, lifetime membership to the THS, and \$500.

This award and what THS does is supported by your membership and donations. Thank you! See <https://tucsonherpsociety.org/projects/jcal> for more information about the award.



Dr. Jarchow anesthetizing a Western Diamond-backed Rattlesnake for surgical procedure, July, 2003. Photo by Roger Repp.

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The Tucson Herpetological Society established the Jarchow Conservation Award — named for James L. Jarchow DVM of Tucson for his dedication and contributions to the conservation of amphibians and reptiles for more than 40 years.

13th Jarchow Conservation Award Presented to Lawrence L.C. Jones

Roger Repp, Past President, Tucson Herpetological Society, Tucson, AZ; repproger22@gmail.com

On behalf of the Tucson Herpetological Society (THS) and the Jarchow Conservation Award nominating committee (JCA nom com), it is our pleasure to announce Lawrence L. C. Jones (AKA Larry “the Lizard Guy” Jones) as the recipient of the 13th Jarchow Conservation Award. Some of the criteria that was followed in awarding Larry the JCA is as follows:

The award was established to honor individuals or organizations for their service to the conservation of the amphibians and reptiles of the deserts of North America. Most desirable as candidates are individuals and organizations who have received little recognition and whose conservation work would benefit from the award.

The JCA nom com choice was based on a lifetime of Larry’s heroic educational endeavors, not to mention some formidable southwest Partners in Amphibian and Reptile Conservation (PARC) duties ahead, which all dovetailed nicely with the criteria above. Nearly every aspect of all other criteria also aligned with Larry receiving this award. His book publications, his 80 plus lead author papers, his enthusiastic approach to reptiles — backed by extraordinary examples of volunteerism — is what this award is all about. Those who attend his celebration, March 30, 4 to 7 PM at Mission Gardens Tucson will learn more, and rumors are that Dr. Jarchow himself may be there. See caption for Larry’s award under his photo for further information.

The award was established to honor individuals or organizations for their service to the conservation of the amphibians and reptiles of the deserts of North America. Most desirable as candidates are individuals and organizations who have received little recognition and whose conservation work would benefit from the award.



A historical moment for the study of Desert Iguanas (*Dipsosaurus dorsalis*) in the Tucson basin. Larry Jones displays the first lizard to enter his study in Saguaro National Park, 4 August 2020. He is poised to publish more natural history articles about our local “DIDOs” than any other individual or organization in the valley ever, and is also performing ground-breaking work with the Long-nosed Leopard Lizard (*Gambelia wislizenii*). He has founded two organizations, the sign on his shiny red jeep mentions: “Southwest Zoologist’s League, Research Conservation Education.” A lifetime of effort was spent with those last three words. Feel free to attend the award night, and prepare for a night of irreverent humor and great herp photos.

Notes on Reproduction of Dwarf American Toads, *Anaxyrus americanus charlesmithi* (Anura: Bufonidae), from Oklahoma

Stephen R. Goldberg, Whittier College, Department of Biology, Whittier, CA; sgoldberg@whittier.edu

The Dwarf American Toad, *Anaxyrus americanus charlesmithi* (Bragg, 1954) (Fig. 1 as *Anaxyrus americanus*) is known from southwest Indiana, and southern Illinois to eastern Oklahoma and northeast Texas (Conant and Collins 1998). It occurs in eastern Oklahoma in oak-hickory and pine-oak woodlands, moist prairies and along river bottoms (Sievert and Sievert 2021). It differs from *A. a. americanus* in being of consistently smaller size and in lacking mottling on the abdomen (Bragg 1954). *Anaxyrus a. charlesmithi* are usually reddish in color and have higher-pitched calls than *A. a. americanus* (Elliott et al. 2009). Breeding times for the subspecies *A. a. charlesmithi* in Oklahoma are February to July (Sievert and Sievert 2021); March to July in Arkansas (Trauth et al. 2004); February to May in Louisiana (Boundy and Carr 2017). In the current paper I present information on reproduction of the subspecies *Anaxyrus a. charlesmithi* in Oklahoma from a histological examination of gonadal tissues. The use of museum collections for obtaining reproductive data avoids euthanizing specimens and eliminates the need for collecting permits.

A sample of 29 *A. a. charlesmithi* from Oklahoma collected 1982 to 2017 (Appendix) consisting of 15 adult males (mean SVL = 58.9 mm \pm 2.1 SD, range = 56–63 mm) and 14 adult females (mean SVL = 64.9 mm \pm 5.3 SD, range = 53–72 mm) was examined from the herpetology collection of the Sam Noble Museum, University of Oklahoma (OMNH), Norman, Oklahoma, 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, USA).

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 left ovary from females. Gonads were embedded in paraffin, sections were cut at 5 μ m and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreiber 1997). Histology slides were deposited at OMNH.

The testicular morphology of *A. a. charlesmithi* is similar to that of other anurans as detailed in Ogielska and Bartmańska (2009a). Within the seminiferous tubules, spermatogenesis occurs in cysts which are 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). A ring of germinal cysts is located on the inner periphery of each seminiferous tubule. All 15 *A. a. charlesmithi* males in my sample were undergoing spermiogenesis. By month these were: February (*n* =



Fig. 1. American Toad (*Anaxyrus americanus*), Jacques-Cartier National Park, Quebec, Canada. Photo by Simon Pierre Barrette, 28 June 2009. This file is licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license (<https://creativecommons.org/licenses/by-sa/2.0/deed.en>).

2), March (*n* = 4), April (*n* = 3), May (*n* = 1), June (*n* = 3), July (*n* = 2). The smallest mature male (OMNH 44112), measured 56 mm SVL, and was from April. This is within the range of *A. a. charlesmithi* males from Cleveland County, Oklahoma (*n* = 25), 51 to 64 mm, mean = 56.9 mm (Bragg 1939).

The mean SVL of *A. a. charlesmithi* females was significantly larger than that of males (*t* = 4.0, *df* = 27, *P* = 0.0004). The ovaries of *A. a. charlesmithi* are typical of other anurans in being paired organs lying on the ventral sides of the kidneys. In adults the ovaries are filled with diplotene oocytes in various stages of development (Ogielska and Bartmańska 2009b). Mature oocytes are filled with yolk droplets; the surrounding layer of follicular cells is thinly stretched. All 14 *A. a. charlesmithi* females were in spawning condition in which mature oocytes predominated. By month these were: February (*n* = 1), March (*n* = 1), April (*n* = 2), May (*n* = 4), June (*n* = 1), July (*n* = 1), September (*n* = 2), October (*n* = 2). The smallest mature female (OMNH 44812) measured 53 mm SVL, was from October, and contained mature yolk-filled oocytes.

Nine of the fourteen *A. a. charlesmithi* females in spawning condition (64%) contained atretic oocytes. Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzabal 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 follicle cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmańska 2009b). See Saidapur and Nadkarni (1973) and Ogielska et al. (2010) for a detailed description of the

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stages of follicular atresia in the frog ovary. Atresia may influence the number of ovulated oocytes (Uribe Aranzábal 2011) and can remove females from the breeding population (Goldberg 2019).

Postovulatory follicles form when the ruptured follicle collapses after ovulation; the follicular lumen disappears and proliferating granulosa cells are surrounded by a fibrous capsule (Redshaw 1972). Postovulatory follicles are short-lived in most anuran species and are resorbed after a few weeks (Redshaw 1972). Postovulatory follicles (evidence of a recent spawning) were noted in two *A. a. charlesmithi* gravid females, one from February (OMNH 37663) and one from May (OMNH 41790). The concurrent presence of mature oocytes (subsequent spawning) and postovulatory follicles (previous spawning), in gravid females, suggests that some *A. a. charlesmithi* females may spawn more than once in the same year.

My finding of gravid *A. a. charlesmithi* from September and October indicates the potential for reproducing during these months. However, since there are no reports of autumn spawning for *A. americanus* (see Dodd 2023), it is likely the eggs are utilized during reproduction the following spring as occurs in *Rana boylei* and *Rana cascadae* both from California, reported by (Goldberg 2019, 2020). There is a report of *A. americanus*, in amplexus during September-October in Tennessee (Miller and Miller 2021), but no spawning was reported. Jørgensen et al. (1979) reported ovaries are close to breeding size by the time of hibernation in frogs from the temperate zone. It appears to be advantageous for frogs to be capable of spawning soon after emergence from hibernation, rather than needing to undergo a period of yolk deposition.

In conclusion, my findings support the statement of February to July breeding activities of *A. a. charlesmithi* by Sievert and Sievert (2021). I was not able to present a summary of monthly reproductive activity by state for *A. a. charlesmithi* as the two subspecies of *A. americanus* (*A. a. americanus* and *A. a. charlesmithi*) are not distinguished in much of the literature.

Acknowledgments—I thank Cameron D. Siler (OMNH) for permission to examine *A. a. charlesmithi* and Jessa L. Watters (OMNH) for facilitating the loan ZH.2020.9.

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Appendix: Twenty-nine *A. a. charlesmithi* from Oklahoma (by county) examined from the herpetology collection of the Sam Noble Museum, University of Oklahoma, Norman, Oklahoma, USA.

Adair: OMNH 38727; **Atoka:** OMNH 39096, 41787, 41790; **Cherokee:** OMNH 35800, 38050, 38051, 42471, 42476; **Cleveland:** OMNH 37662-37664, 41795, 43327, 44812; **Haskell:** OMNH 43333, 43339; **Latimer:** OMNH 44112, 47312; **Le Flore:** OMNH 35796, 35798, 39521, 39522, 40104, 42915; **Marshall:** OMNH 46107; **McCurain:** OMNH 39308, 39309; **Osage:** OMNH 32951.

Two-footed Worm Lizards (*Bipes*) in Arizona?

James C. Rorabaugh, U.S. Fish and Wildlife Service (retired), St. David, AZ; jrorabaugh@hotmail.com

Three species of Two-footed Worm Lizards compose the genus *Bipes*, including the Five-toed Worm Lizard (*B. biporus*, Fig. 1) of the southern Baja California Peninsula, Four-toed Worm Lizard (*B. canaliculatus*) of Guerrero and Michoacan, Mexico, and Three-toed Worm Lizard (*B. tridactylus*), which is only known from the Pacific Coast of Guerrero (Palacios-Aguilar and Flores-Villela 2018, Mahrtdt et al. 2022). Bipedidae and its single genus, *Bipes*, are the only Amphisbaenia that possess limbs. All three species have small, short front limbs with three to five digits. Worm Lizards are peculiar Saurians whose closest relatives are the Lacertidae of Africa, Europe, Asia, and the northern East Indies (Zug et al. 2001, Zheng and Weins 2016). *Bipes* range in size from 120 to 240 mm SVL (tail lengths range from 10-30% of SVL), and are blunt-headed and fossorial (Mahrtdt et al. 2022). They burrow by head-ramming in sandy soils and prey mainly on arthropods. They are oviparous, laying clutches of one to four eggs (Zug et al. 2001). *Bipes* are rarely found surface active, but can be found under logs and other surface debris. They are typically found in moist, sandy soils of arroyos, coastal and alluvial plains in river valleys, or under or around shrubs in sandy soils (Hodges and Perez-Ramos 2001). *Bipes biporus* occurs primarily in the relatively cool Vizcaino and Magdalena deserts of the southern Baja California Peninsula (Grismer 2002). *Bipes canaliculatus* occurs in rocky soils and loose gravel mostly in tropical dry forest (Ponce-Campos and García Aguayo 2007). *Bipes tridactylus* occurs in tropical dry forest and floodplains.

Both *B. canaliculatus* and *B. tridactylus* are also sometimes found in disturbed areas such as agriculture (Hodges and Perez-Ramos 2001, Canseco-Márquez et al. 2007).

The evidence from Arizona

E.H. Taylor (1938) was the first to suggest *Bipes* occurs in Arizona. He noted the following second-hand observations:

“During my collecting in southeastern Arizona during the summers of 1928-1930, and again in 1934, I have searched in vain for a species of *Bipes* which I believe inhabits southeastern Arizona. My first reason for this belief was based upon the statement of a placer-gold miner, in Ash Cañon in the Huachuca Mountains. He said that he had occasionally dug from the sand and gravel along the small creek in the cañon, “a small snake 10-14 inches long with two small legs near its head. They were purple or brown in color.”

In another nearby cañon, I visited Dr. Biedermann, then nearly ninety years of age, who had lived more than thirty years in the Huachucas and had made extensive collections of Lepidoptera for the museums of the world. He told me that there was “a rare chiroteles living in the mountains,” and that he believed he had one preserved. However, on examination of his small collection of reptiles the specimen could not be found.

While collecting on Mount Lemon, in the Santa Catalina Range, I stopped at a small hotel near the

Three species of Two-footed Worm Lizards compose the genus *Bipes*, including the Five-toed Worm Lizard (*B. biporus*, Fig. 1) of the southern Baja California Peninsula, Four-toed Worm Lizard (*B. canaliculatus*) of Guerrero and Michoacan, Mexico, and Three-toed Worm Lizard (*B. tridactylus*), which is only known from the Pacific Coast of Guerrero...



Fig. 1. Five-toed Worm Lizard (*Bipes biporus*) from near San Ignacio, Baja California Sur. Photo by Randall Babb.

summit. Mrs. Westbrook, the owner, warranted that I had found no snake like one she had found and kept for a pet. "It had a pair of legs coming out where its ears should be." It was found in the garden in the evening during a rainstorm. She had kept it for three months and it had escaped. Others vouched for the story, having seen the captive specimen.

The forest guard at the outlook station on Mount Lemon, told me that he had found in the Huachucas a specimen of a snake with "two legs on its neck. It was lavender and white below. The legs were so short that it didn't use them to walk on." Although a collector of snake skins as a hobby, he had not preserved the skin of the specimen, because it was too small.

Mr. Doty, of the Forest Service, whom I met on Mt. Lemon in 1934, told me that some months previously, his workers had killed three two-legged snakes while removing piles of rocks in order to drill post holes for telephone poles. He took me to the exact place. A day was spent in the vicinity but none was found. It was extremely dry at this time. It had been raining when they were killed."

Taylor concluded "I do not believe that all of these reports have been fabricated, and all seem to point to the same animal. It seems almost beyond question that a species of *Bipes* occurs in southeastern Arizona, at least in the Huachucas and the Santa Catalina Mountains, a real prize for some collector who will put forth the necessary effort to discover it."

No doubt based on Taylor's supposition, Smith and Taylor (1950) said that *Bipes* occurs in southeastern Arizona, but they did not name the species. Smith (1946), in his classic Handbook of Lizards, was confident enough of the presence of *Bipes* in Arizona that he included a species account and a map showing the possible distribution of the undefined species occurring in south-central southeastern Arizona and extending a short distance into Sonora, Mexico. However, neither Stebbins (1954) nor Lowe (1964) included *Bipes* among the herpetofauna of Arizona. Stebbins (1985), though, in his species account for *B. biporus* (in the Baja California Endemics chapter, page 243) noted that in "the early 1970's, Kenneth Swartz found a "worm lizard" in Paradise Valley near Phoenix. It was about 6 in. (15 cm) long; a bit thicker than a pencil; had pearly slightly translucent scales; legs about 3/16 in. (5 mm) long and 1/16 in. (2 mm) wide, tipped with tiny claws; and no trace of hind limbs. It crawled in clumsy, snakelike fashion and seemed to use its nose in digging when it was returned to its burrow. Termite tubes were present in the mud around the burrows." No specimens were collected or otherwise documented.

A reference that appears to have escaped the purview of herpetologists comes from the Journal of Arizona History (Proctor Redondo 1993). Margaret Proctor Redondo grew up at the Proctor Ranch on

the west side of the Santa Rita Mountains in the early 1900s. The Proctors maintained a small garden at the ranch. She notes, "While digging in the yard or garden, we would occasionally encounter an ajolote (*bipes*), a two-legged warm [sic] lizard about four inches long and a quarter inch in diameter with two very short legs towards the front. Iridescent blue-green, it has very beautiful color. The ajolote is never seen above ground, and it is extremely fast and slippery, making it very hard to catch. Nevertheless, we kids did manage to capture two or three. Only recently I learned that science has no knowledge of this elusive creature." (Proctor Redondo 1993). The location of the Proctor Ranch is confused by a map (page 235) included by James Griffith who wrote the introduction to Proctor Redondo (1993). It shows the ranch at the western base of Box Canyon. But Proctor Redondo (1993) says (page 255) it was about a mile west of White House, which would put it probably along or near present-day Proctor Road about a mile from the mouth of Madera Canyon.

Unverified reports of *Bipes* from outside of Arizona

Regarding another *Bipes* (besides *B. biporus*) in the Sonoran Desert region, Lowe (1994) commented, "If there is another *Bipes* not in Baja that is yet to be discovered, it should turn up on the Mexican mainland, outside of the Sonoran Desert." Lemos-Espinal et al. (2019) state that *Bipes biporus* has been observed at San Carlos Bay (Ballinger, pers. comm. 2009), but no specimens have been collected or otherwise documented. San Carlos is at the southern edge of the Central Gulf Coast Subdivision of Sonoran Desertscrub (Brown and Lowe 1994). Interestingly, *B. biporus* may have once been sympatric or in close proximity geographically with the other two species of *Bipes* because the Baja Peninsula was once part of the Mexican mainland, but when it broke away it migrated north. Cabo San Lucas was just north of Puerto Vallarta, Jalisco, 8-13 million years ago (Gastil et al. 1983, Grismer 2002), so the origins of any *Bipes* on the coast of Sonora may be more complex than a mere separation and isolation of mainland and peninsular populations caused by inundation of the Gulf of California.

Other reports of *Bipes* from the United States remain questionable. Somma (1993) noted unverified reports from Fort Collins and Loveland, Colorado, as well as an 1820's account from Little Panoche Creek in western Fresno or San Benito Co., California. An unverified, old record for *Bipes* is also known from an expedition to the Rocky Mountains (presumably what is now northeastern Colorado). On 27 June 1820 on the "South Fork Platte River, Ne-Bras-Ka Territory" "We observed in repeated instances, several individuals of a singular genus of reptiles (*Chirotes*, Cuv.) which in form resemble short serpents, but are more closely

Regarding another *Bipes* (besides *B. biporus*) in the Sonoran Desert region, Lowe (1994) commented, "If there is another *Bipes* not in Baja that is yet to be discovered, it should turn up on the Mexican mainland, outside of the Sonoran Desert."

allied to the lizards, by being furnished with two feet. They were so active that it was not without some difficulty that we succeeded in obtaining a specimen. Of this (as was our uniform custom, when any apparently new animal was presented) we immediately drew out a description. But as the specimen was unfortunately lost, and the description . . . carried off by our deserters, we are reduced to the necessity of merely indicating the probability of the existence of the chirotes lumbricoides of naturalists, within the territory of the United States” (James 1823, page 484). This report was analyzed in detail by Horstman (1998) who concluded “a reasonable person cannot summarily dismiss the notion that Edwin James and company did, indeed, observe, capture, and describe an amphisbaenid of the genus *Bipes* near the Colorado/Nebraska border in June 1820.” Campbell (1980) and Dundee (1980) also speculated that the report could be valid. Dundee (1980) provided another unverified report of a *Bipes* from the sand hills region of Nebraska. However, Gans and Papenfuss (1980) were unconvinced and particularly questioned the remark from James (1823) that the animals were so active that they were difficult to collect. *Bipes* move relatively slowly and are not difficult to catch (Gans and Papenfuss 1980).

The same issue plagues the Proctor Redondo account: “it is extremely fast and slippery, making it very hard to catch”. Furthermore, Proctor Redondo (1993) describes the color of the animals as “iridescent blue-green.” All three known *Bipes* are whitish-pink, pink, brown, or purplish. Additionally, at “four inches long”, the Proctor Redondo animals would be quite small for *Bipes*, but could have been small juveniles.

If not a *Bipes*, what were these people seeing?

So if the reports from Arizona are misidentifications, what did observers find? Mountain Skinks (*Plestiodon callicephalus*) occur in the Santa Rita Mountains and typically have brilliantly colored, blue tails (Holycross et al. 2022). They can be very difficult to catch, as well, quickly disappearing into surface debris. Could Margaret Proctor Redondo have mistaken Mountain Skinks for *Bipes* at the Proctor Ranch near the mouth of Madera Canyon? Possibly, but she states that some were caught and they had only two legs “toward the front”. Threadsnakes (*Rena*) in Arizona are fossorial serpents that superficially resemble small *Bipes*, but they lack legs. The reports from Taylor (1938) seem more credible than the Proctor Redondo report, at least based on the descriptions of the animals found. The early 1970s Paradise Valley report in Stebbins (1985) is a puzzle, as well. The description matches a *Bipes*, but the animal was not collected. The Phoenix area has become a hotspot for herpetological introductions, with one salamander, four anurans, four turtles, four lizards,

and one snake, all non-natives, having established populations there (Holycross et al. 2022). Could the possible *Bipes* observed in Paradise Valley have been a released or escaped individual, or transported to the area in the soil of a potted plant? No other reports of *Bipes* in the Phoenix area are known. One thing for certain, though, is that all reported Arizona *Bipes* were found in habitats much different than currently known species, which all occur in lowland, relatively cool southern deserts or tropical areas.

Conclusion

An enormous amount of herpetological work has occurred in Arizona since the possible *Bipes* were found in the Huachuca, Santa Rita, and Santa Catalina mountains. Is it plausible that in the intervening 90 or so years that a *Bipes* could have eluded detection in those sky islands or elsewhere? It seems very unlikely. But absence is difficult to prove. Paraphrasing Taylor (1938), *Bipes* may be out there in Arizona and what a prize it would be for the collector who puts forth the necessary effort to discover it.

Acknowledgments—Randall Babb reviewed a draft manuscript and provided valuable editorial and substantive input. Babb also graciously provided the image that is Figure 1.

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Sonoran Herpetologist Natural History Observations

The Tucson Herpetological Society invites your contributions to our Natural History Notes section. We are particularly interested in photographs and descriptions of amphibians and reptiles involved in noteworthy or unusual behaviors in the field. Notes can feature information such as diet, predation, community structure, interspecific behavior, or unusual locations or habitat use. Please submit your observations to Howard Clark, editor.sonoran.herp@gmail.com. Submissions should be brief and in electronic form.

Local Research News

The *Sonoran Herpetologist* welcomes short reports for our Local Research News. We are interested in articles that can update our readers on research about amphibians and reptiles in the Sonoran Desert region. These articles need be only a few paragraphs long and do not need to include data, specific localities, or other details. The emphasis should be on how science is being applied to herpetological questions. Please submit your materials to Howard Clark, editor.sonoran.herp@gmail.com. Submissions should be brief and in electronic form.

The Box Turtles (*Terrapene*, Emydidae) of Sonora, Mexico

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Abstract—The distribution and ecology of *Terrapene* box turtles in Sonora, Mexico are summarized. A total of 72 records of *T. nelsoni klauberi* (northern spotted or Sonoran box turtle) were mostly in the warm months, from 192 to 1870 m (avg. 895 m) elevation, in tropical habitats and temperate oak woodland and pine-oak forest in western slopes of the Sierra Madre Occidental north into the Sky Islands Region. A total of 37 records of *T. ornata luteola* (desert box turtle) were mostly in the warm months, from 626 to 1558 m (avg. 1169 m) elevation in temperate grasslands and Chihuahuan desertscrub in the borderlands of northeastern Sonora. The two species are potentially sympatric between the municipalities of Huépac and Opodepe in the Río Sonora drainage.

Resumen—Se presenta una síntesis de la distribución y ecología de las tortugas *Terrapene* en Sonora, México. Un total de 72 registros de *T. nelsoni klauberi* (tortuga de chispitas) se obtuvieron principalmente en los meses con calor, desde los 192 a 1870 m (promedio 895 m) de altitud, en hábitats tropicales y los encinales y bosques de pino-encino templados de las laderas occidentales de la Sierra Madre Occidental y la Región de las Islas Serranas al norte. Un total de 37 registros de *T. ornata luteola* se obtuvieron principalmente en los meses de calor, desde los 626 a 1558 m (promedio 1169 m) de altitud en pastizales templados y matorral desértico Chihuahuense en la zona fronteriza del noreste de Sonora. Es probable que estas dos especies ocurren de forma simpátrica entre los municipios de Huépac y Opodepe en la cuenca del Río Sonora.

Introduction

The terrestrial box turtle *Terrapene* is a genus of North American turtles in the Family Emydidae with *T. carolina* (common box turtle) and *T. ornata* (ornate box turtle) in the United States and *T. coahuila* (Coahuilan box turtle), *T. nelsoni* (spotted or sierra box turtle), and *T. ornata* in Mexico (Milstead and Tinkle 1967). The Mexican *T. mexicana* (Mexican box turtle)

and *T. yucatanana* (Yucatán box turtle) are variously considered subspecies of *T. carolina* (Dodd 2001) or as full species (Legler and Vogt 2013) in the Carolina Group, while *T. ornata* and *T. nelsoni* comprise the Ornata Group.

Here, we present the distribution and ecology of *T. nelsoni klauberi* (northern spotted or Sonoran box turtle; Fig. 1) and *T. ornata luteola* (desert box turtle) in the state of Sonora in northwestern Mexico (Fig. 2).



Fig. 1. Foothills thornscrub and riparian habitats of *T. nelsoni klauberi*. View of Río Áros from Northern Jaguar Reserve. Photo by Van Devender.

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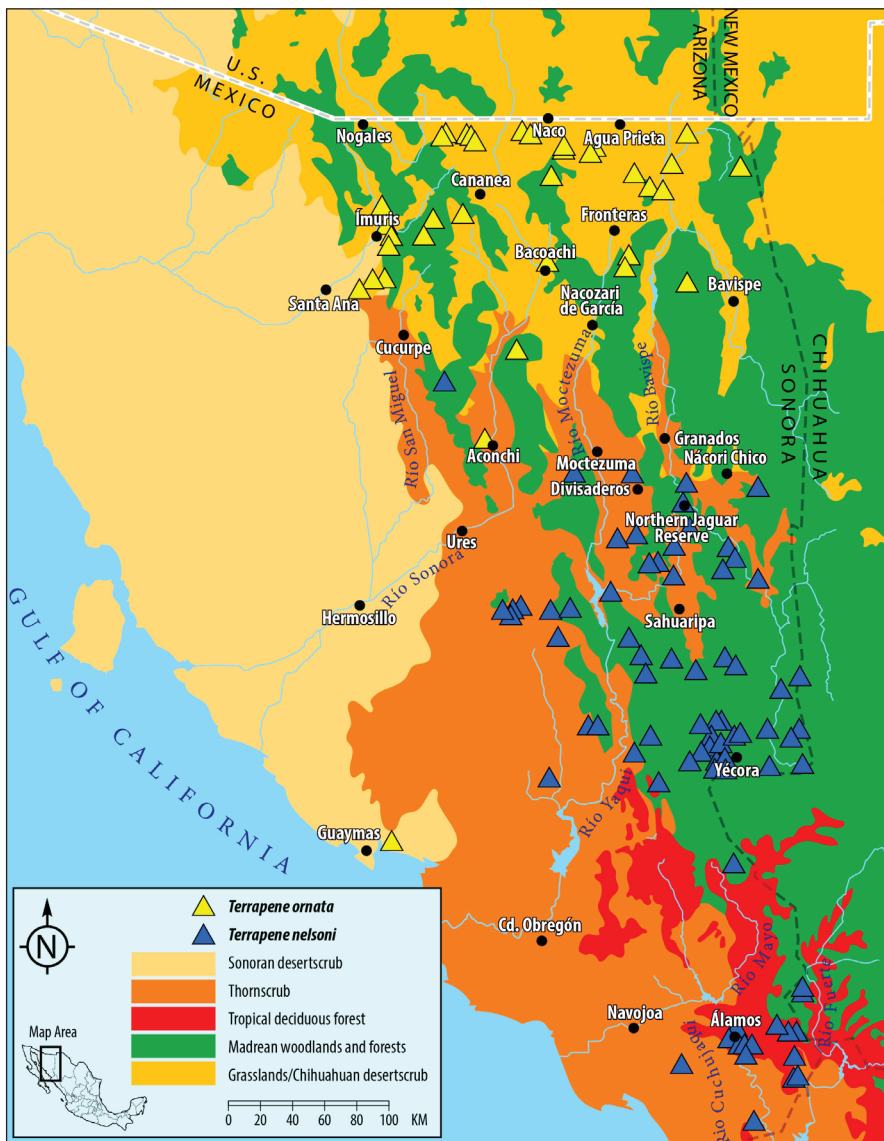


Fig. 2. Map of box turtle distribution in Sonora, Mexico. Blue triangles = *Terrapene nelsoni klauberi*. Yellow triangles = *T. ornata luteola*.

Methods

Biotic inventory expeditions in Sky Island Alliances' Madrean Archipelago Biodiversity Assessment (MABA, 2009-2014) and Greater Good Charities' Madrean Discovery Expeditions (MDE, 2015-2023) programs documented the diversity of animals and plants in Sonoran Sky Island mountain ranges. We searched VertNet, the Consortium of Small Vertebrate Collections, the SEINet database network, and *iNaturalist* for *Terrapene* records in Sonora. Observations and images from all MABA and MDE expeditions, trips to many other areas in Sonora, museum specimens, and literature records, including the *Terrapene* localities in this publication, are publicly available in the MDE database (madreandiscovery.org). The *T. nelsoni* specimen from Rancho Chairababi was deposited into the herpetological collection at the Universidad Autónoma de Baja California (UABC 2523).

Results

Northern spotted or Sonoran box turtle—Stejneger (1925) described *Terrapene nelsoni* from near Pedro Pablo, east of Acaponeta, Nayarit. Bogert (1943) described *T. klauberi* based on specimens from Rancho Güirocoba southeast of Álamos, Sonora. Mertens and Wermuth (1955) recognized it as a subspecies of *T. nelsoni* (Mertens and Wermuth 1955; see discussions in Milstead and Tinkle 1967, Buskirk and Ponce-Campos 2011; Fig. 3).

There are 72 Sonoran localities for *T. n. klauberi* in 20 municipalities in east-central and southern Sonora (Fig. 2); i.e., Álamos (Fig. 3A), Arivechi, Bacanora, Divisaderos, Granados, Mazatán, Moctezuma, Nácori Chico, Ónavas, Opodepe, Rosario, Sahuaripa (Fig. 3B), San Javier, San Pedro de la Cueva, Soyopa, Suaqui Grande, Tepache, Ures, Villa Pesqueira, and Yécora (Fig. 3C, 3D). The most records were from the mu-

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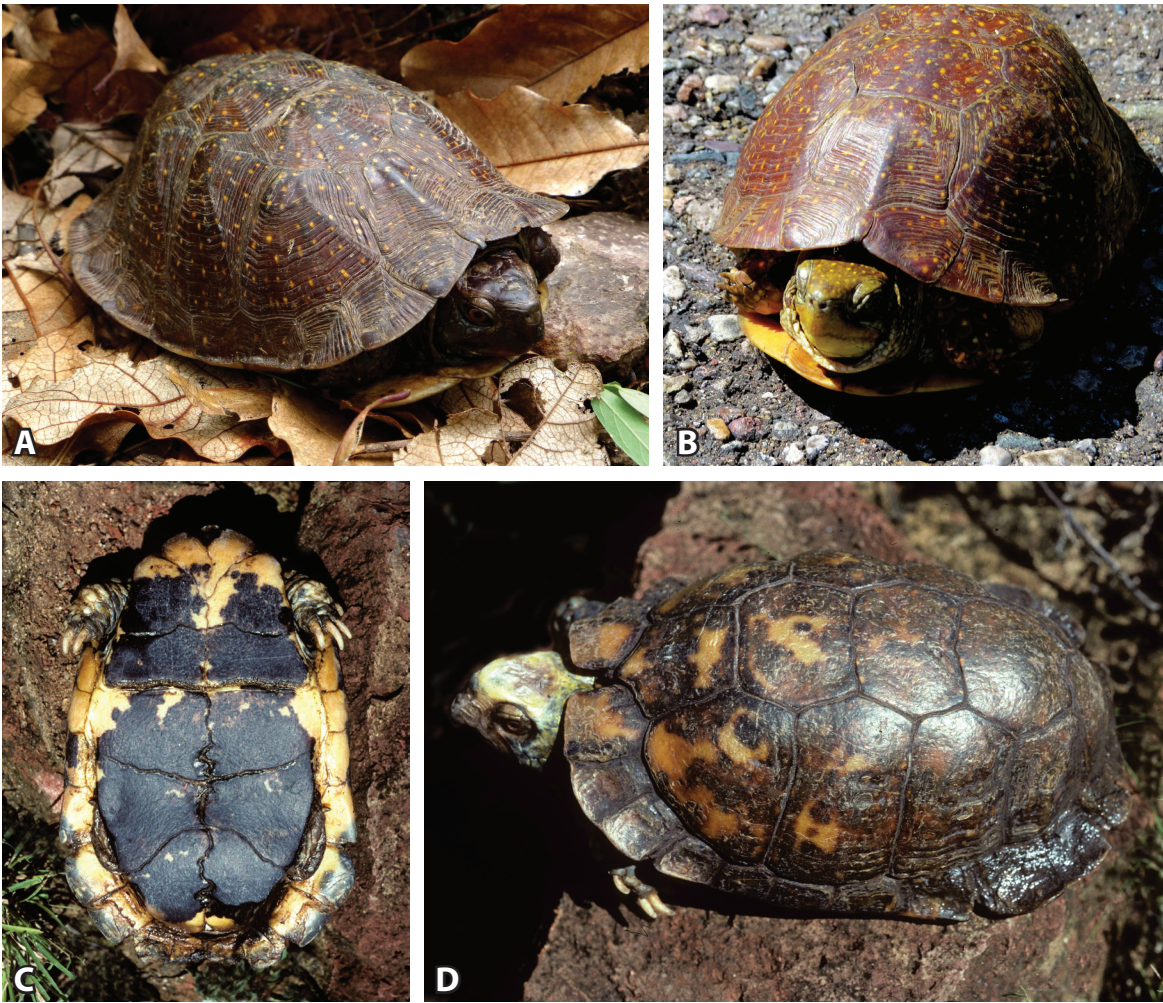


Fig. 3. *Terrapene nelsoni klauberi*. **A.** Santa Bárbara. Photo by Michael Chamberland. **B.** Southeast of Tepache. Photo by Gertrudis Yanes-Arvalo. **C. D.** Old individual near Tepoca. Photos by Van Devender.

municipalities of Álamos (16), Yécora (13), and Sahuaripa (12). The known distributional limits in Sonora are:

South: Rancho Güirocoba (26.903°N, Municipality of Álamos, Bogert 1943) and south into Sinaloa (Lemos-Espinal and Smith 2020).

North: Rancho Chairababi (30.185°N, Municipality of Opodepe; Fig. 3C).

East: Sierra Sahuaribo (108.654°W, Municipality of Álamos), east of Tarachi (108.662°W, Municipality of Sahuaripa), near Maycoba (108.670°W, Municipality of Yécora; Enderson et al. 2014), and Güirocoba, (108.674 to 108.695°W, Municipality of Álamos; Bogert 1943) and east into Chihuahua (Lemos-Espinal and Smith 2009)

West: Rancho Chairababi (110.542°W, Municipality of Opodepe) and Sierra Mazatán (110.200°N, Municipality of Mazatán).

Elevation: *T. n. klauberi* has been found at 192 to 1870 m (avg. 895 m) elevations in Sonora. The maximum elevation for *T. nelsoni* is 2135 m in the Sierra Pajaritos, Nayarit (Loc-B. et al. 2022).

Seasonal activity is greater in the warm months (50 observations, June-September) with fewer in spring (8 observations, March-May), fall (1 observation, October), and winter (2 observations, November, January).

Comment: Ground color ranges from blackish-brown to a rich auburn brown (Figs. 2A, 2B). Black color on underside of shell with yellow margins but lacking the narrow light striations of *T. ornata* is diagnostic (Fig. 3C). One old individual from south of Tepoca (Municipality of Yécora) had a yellow blotched pattern on a dark background without spots (Fig. 3D). Another old individual from Cañón Los Lobos, a tributary of Río Áros (Municipality of Nácori Chico; Fig. 1), had a similar pattern, but some of the epidermal scutes were missing, exposing carapace bone.

Desert box turtle—Agassiz (1857) described *Terrapene ornata* from specimens from Iowa and Missouri. Smith and Ramsey (1952) described *T. o. luteola* from specimens south of Van Horn, Texas (Fig. 4). The first record of *T. o. luteola* from Sonora was a specimen collected by F. Robinet on a Carl Lumholtz Expedition to Mexico (AMNH R-4602; Bogert 1943), likely in the 1890s.

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Fig. 4. *Terrapene ornata luteola*. **A. B.** North of Esqueda. Photos by Van Devender. **C.** Horn-colored adult. Near Agua Prieta. Photo by Chubel77. **D.** Fire-scarred adult. Agua Prieta. Photo by H. Daniel Pinto-Santana.

There are 36 Sonoran records of *T. ornata* in 12 municipalities in northeastern Sonora (Fig. 2): i.e., Agua Prieta, Arizpe, Bacoachi, Cananea, Fronteras, Huépac, Ímuris, Magdalena de Kino, Naco, Nacozari de García, Nogales, and Santa Cruz, plus a record in the Municipio de Guaymas in west-central Sonora. The most records were from the municipalities of Agua Prieta (8), Ímuris, Naco, and Santa Cruz (5 each; Fig. 6C). The known distributional limits in Sonora are:

South: Huépac (29.916°N, Municipality of Huépac). However, the record between Guaymas and Empalme near the coast (27.951°N; AMNH 73720) is 226 kilometers south-southwest of Huépac but was justly rejected by Legler and Vogt (2013). This is in an unlikely coastal thornscrub-Sonoran desertscrub transitional habitat on steep rocky slopes. Today the area is heavily invaded by the non-native buffelgrass (*Pennisetum ciliare*). Perhaps it was found near the Arizona border and transported southward by a traveler. In 1953, Mexico 15 was one of the few major north-south highways in Sonora.

North: San Pedro River at the Arizona border (31.331°N, Municipality of Naco) and north into Arizona.

East: Cajón Bonito (108.989°W, Municipality of

Agua Prieta) and east into Chihuahua (Lemos-Espinal and Smith 2009).

West: North of Santa Ana (111.01°W, Municipality of Magdalena de Kino).

Elevation: Excluding the Guaymas record (63 m elev.), *T. ornata* has been found at 626 to 1558 m (avg. 1169 m) elevations.

Seasonal activity is greater in the warm months (29 observations, June-September) than in spring (5 observations, April-May) or fall (2 observations, October).

Comments: In one old individual, the starburst pattern was reduced to a uniform horn color (Fig. 4C), typical of mature adults of both sexes gradually losing the light striations and becoming unicolored, except on the underside of the shell (Legler and Vogt 2013). One individual was badly scarred by fire (Fig. 4D). Both individuals were near Agua Prieta (Municipality of Agua Prieta).

Discussion

Habitat and dispersal: Box turtles live in upland habitats but are often found in linear riparian habitats such as river valleys. The principal rivers in the Sonoran distribution of *Terrapene n. klauberi* are the

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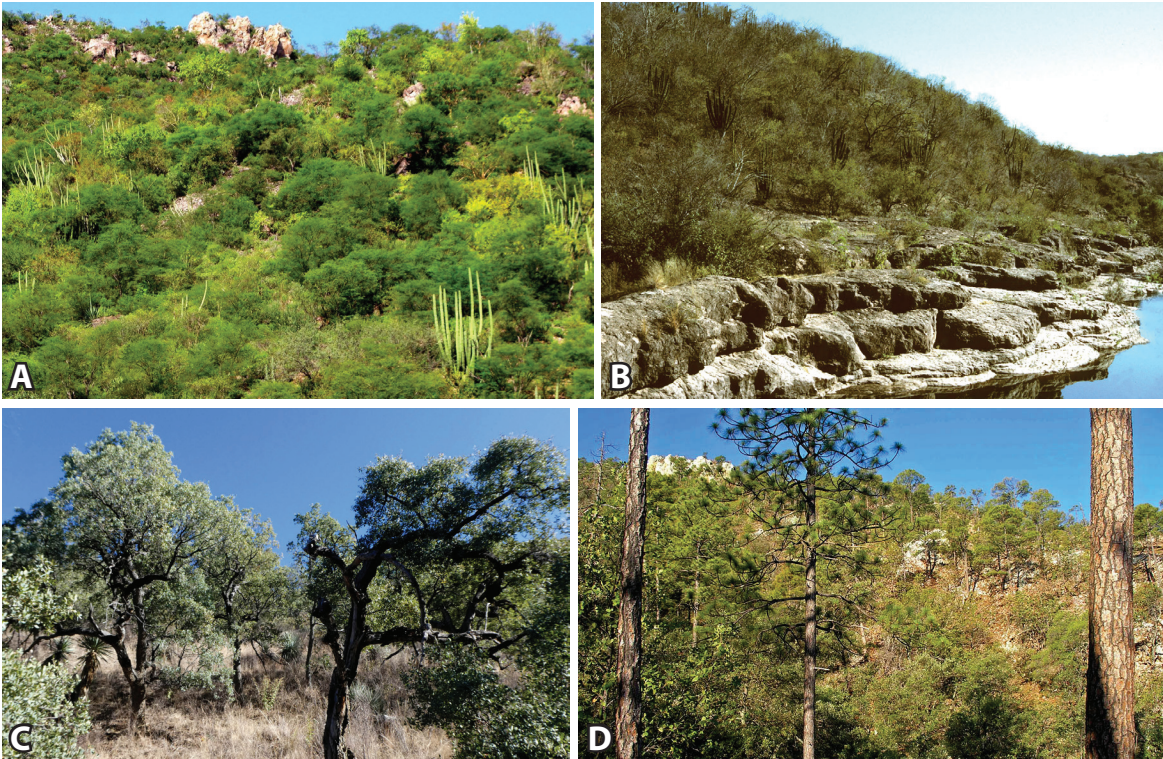


Fig. 5. *Terrapene nelsoni klauberi* habitats. **A.** Foothills thornscrub. Babisal, Northern Jaguar Reserve. Photo by Van Devender. **B.** Tropical deciduous forest. Río Cuchujaqui southeast of Álamos. Photo by Van Devender. **C.** Oak woodland. Rancho Chairababi. Photo by Ana Lilia Reina-Guerrero. **D.** Pine-oak forest. Sierra Bacadéhuachi. Photo by Sky Jacobs.

Ríos Cuchujaqui (a tributary of the Río Fuerte; Fig. 5B), Magdalena, Mayo, Santa Cruz (Fig. 6C), San Miguel (a tributary of the Río Sonora), San Pedro, Sonora, and Yaqui (Ríos Agua Prieta, Áros [Fig. 1], Bavispe, Cabullona, Moctezuma, and San Bernardino, as well as Arroyo Guadalupe and Cajón Bonito). Box turtles may disperse along pseudoriparian highways (Fig. 6D), where some are killed by vehicles. Considering that box turtles are occasionally kept as pets, some individuals may have been transported into peripheral areas by highway travelers.

Terrapene nelsoni is known from Jalisco to Sonora on the Pacific slopes of the Sierra Madre Occidental. It was recently discovered in Zacatecas (Rosales-Martínez et al. 2022). The northern subspecies *T. n. klauberi* is known from Sonora and adjacent Chihuahua and northern Sinaloa. The Rancho Chairababi locality reported here is considerably north of the potential distribution of *T. n. klauberi* postulated in Buskirk and Ponce-Campos (2011). Legler and Vogt (2013) considered the specimen from Terreros, Sinaloa (25.133°N, 107.867°W) as the southernmost *T. n. klauberi*, 146 km southeast of the type locality at Güirocoba (Bogert 1943, see Hardy and McDiarmid 1969).

In Sonora, 62 of 72 *T. n. klauberi* records are associated with vegetation. It was most common in tropical habitats on the western slopes of the Sierra Madre Occidental and in the Sky Islands Region (66.1%), including foothills thornscrub (41.9%; Figs. 1, 3B, 5A, 6D) and tropical deciduous forest (24.2%; Figs. 3C, 5B). It potentially occurs in foothills thornscrub north

of Rayón in the Río San Miguel drainage (29.700°N 110.654°W, Municipality of Rayón; the northernmost *Pachycereus pecten-aboriginum* [étcho cactus] locality). It may also occur between Turicachi and Presa Angostura (30.449°N 109.438°N, Municipality of Nacozari de García; the northernmost *Boa sigma* [Mexican West Coast Boa Constrictor] locality; Van Devender et al. 2020) in the northern Río Bavispe drainage. Its range extends in tropical deciduous forest eastward into the Sierra Madre Occidental to the Batopilas, Chínipas, and El Limón areas in southwestern-most Chihuahua (Lemos-Espinal and Smith 2009).

In the Sierra Madre Occidental in Sonora, *T. n. klauberi* has been found in temperate oak woodland (22.6%; Fig. 5C) and pine-oak forest (6.5%; Figs. 3A, 5D) at Santa Bárbara northeast of Álamos (Butterfield et al. 2021), the Sierra Sahuaribo east-southeast of San Bernardino, east of Tarachi, and in the Maycoba area (Enderson et al. 2014; Fig. 2). Three localities were in transitions between oak woodland and tropical vegetation (4.8%). It has not been found in the montane woodlands in Chihuahua east of Maycoba (Lemos-Espinal and Smith 2009) but may occur in tropical deciduous forest near Moris 30 km to the south-southeast in the upper Río Mayo drainage. They live in oak woodland in the Sky Islands Region in the Sierra Mazatán (29.088°N) and in the northernmost locality on Rancho Chairababi (30.185°N, Municipality of Opodepe; Fig. 5C).

Terrapene o. luteola is widespread from Chihuahua in the northwestern Mexican Plateau north to western

Terrapene nelsoni is known from Jalisco to Sonora on the Pacific slopes of the Sierra Madre Occidental. It was recently discovered in Zacatecas (Rosales-Martínez et al. 2022). The northern subspecies *T. n. klauberi* is known from Sonora and adjacent Chihuahua and northern Sinaloa.



Fig. 6. *Terrapene ornata luteola* habitats and highway. **A.** Desert grassland east of Cananea. Photo by Van Devender. **B.** Chihuahuan desert scrub. Sierra Anibácachi southwest of Agua Prieta. Photo by Van Devender. **C.** Riparian corridor through desert grassland. Río Santa Cruz south of Arizona border. Photo by Luis Gutiérrez. **D.** Dale S. Turner photographs roadkill on highway in foothills thornscrub. Sierra Murrieta near Bacanora. Photo by Charles Hedgcock.

Texas and west to southeastern Arizona and northeastern Sonora. In Sonora, 24 of 37 localities for *T. o. luteola* are in non-riparian desert and plains grassland (43.2%; Fig. 6A) and Chihuahuan desert scrub (21.6%; Fig. 6B). Its Sonoran range extends south of these core habitats along disturbed roadsides, in agricultural fields, and along riparian corridors.

Possible sympatry: The northernmost *T. n. klauberi* on Rancho Chairababi is 44 kilometers northwest of the southernmost *T. o. luteola* at Huépac (Fig. 2). Both localities are in the Río Sonora drainage. The Chairababi locality is in upland oak woodland while the Huépac locality is in a pseudoriparian agricultural field below the highway near the town and close to the Río Sonora. Potentially, *T. n. klauberi* could be present in foothills thornscrub and oak woodland in the nearby Sierra Aconchi above Huépac, increasing the chance of sympatry between the two species. If *T. n. klauberi* is eventually found east of Turicachi, it would be less than 15 km from the Esqueda (39.716°N 109.588°W) *T. ornata* locality with the possibility of sympatry in the Río Cabullona drainage (a western tributary of the Río Bavispe).

Box turtles are charismatic species in the herpetofauna of Sonora. Here, where the New World tropics meet the northern temperate zone, the

distributions of *Terrapene nelsoni* and *T. ornata*, the two members of the Ornata Group, come together from different biogeographic and deep historical pathways.

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Box turtles are charismatic species in the herpetofauna of Sonora. Here, where the New World tropics meet the northern temperate zone, the distributions of *Terrapene nelsoni* and *T. ornata*, the two members of the Ornata Group, come together from different biogeographic and deep historical pathways.

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Red List Status of *Gopherus morafkai* and Effects of Roads on Desert Tortoises

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At the end of 2023 the International Union for the Conservation of Nature and Natural Resources (IUCN) published the first formal assessment of the Sonoran Desert Tortoise (*Gopherus morafkai*) under their Red List criteria (Averill-Murray et al. 2023; Fig. 1). In it my co-authors and I applied existing data and novel analyses to Red List criteria A (population size reduction), B (geographic range), and E (quantitative analysis). The assessment revealed that the current estimated habitat of *G. morafkai* and the overall extent of its range exceed 98,000 km² and 200,000 km², respectively, both of which exceed the thresholds for threatened categories under criterion B. Likewise, published population viability analyses estimate extinction probabilities <10% over the next 100 years, a level that also does not meet the threshold for threatened categories under criterion E. However, steep declines recently have occurred in several local subpopulations in Arizona, especially in more arid parts of the range. I applied documented relationships of tortoise survival and drought to patterns of precipitation and drought prior to the period of population surveys to estimate population sizes back to the necessary three-generation period required by criterion A. From this, the Arizona population declined approximately 48% over three generations—or back to some time between 1895 and 1930 depending on how long a generation of *G. morafkai* actually is. Data on population trends are unavailable across the species' distribution in Mexico, but patterns of rainfall and drought across Sonora mirror

those in Arizona and suggest that Sonoran subpopulations likely increased and decreased similarly over time. As a result, application of the Red List criteria classifies *G. morafkai* as Vulnerable at this time, but it nearly qualifies as Endangered (population reduction > 50%).

Even though several local populations in Arizona have stabilized or increased, survival rates are predicted to decline with future drought conditions, which are expected to intensify with global climate change (Zylstra et al. 2013; see also the recently published paper by Sinervo et al. 2024). Other well-recognized threats to *G. morafkai* include habitat degradation from invasive plants (e.g., buffelgrass) and increased fire frequency. Habitat fragmentation from canals, highways, and urban or agricultural development are generally thought to affect long-term metapopulation dynamics (Howland and Rorabaugh 2002, Edwards et al. 2004; Figure 2) more than short-term population declines. However, roads remain important drivers of habitat loss, degradation, and fragmentation that affect both Sonoran Desert and global biodiversity.

Detrimental effects of roads include direct mortality of individual animals, spread of habitat-altering invasive plants, and loss of demographic and genetic connectivity of wildlife populations. For example, 70% of *G. morafkai* habitat in Arizona is within 1 km of human development, including roads (Carter et al. 2020). In addition, the probability of detection of *G. morafkai* by motorists is highest on maintained gravel roads compared to non-maintained gravel and

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The screenshot shows the IUCN Red List entry for *Gopherus morafkai*. At the top, there is a search bar and navigation links for 'Advanced', 'About', and 'Assessment process'. Below the search bar, there is a link to 'Jump to Sonoran Desert Tortoise: In detail'. A photograph of a Sonoran Desert Tortoise is displayed on the left. The main title is 'Sonoran Desert Tortoise' with the scientific name 'Gopherus morafkai' below it. An 'ABSTRACT' section states: 'Sonoran Desert Tortoise *Gopherus morafkai* has most recently been assessed for *The IUCN Red List of Threatened Species* in 2019. *Gopherus morafkai* is listed as Vulnerable under criteria A2abce+4abce.' Below the abstract, the 'THE RED LIST ASSESSMENT' section lists the authors: 'Averill-Murray, R.C., Rosen, P.C., Jones, C.A., Jones, T.R., Lara-Resendiz, R.A., Edwards, T., Karl, A. & Berry, K.H. 20...'. At the bottom, a horizontal bar shows the Red List categories: NOT EVALUATED (NE), DATA DEFICIENT (DD), LEAST CONCERN (LC), NEAR THREATENED (NT), **VULNERABLE (VU)**, ENDANGERED (EN), CRITICALLY ENDANGERED (CR), EXTINCT IN THE WILD (EW), and EXTINCT (EX).

Fig. 1. IUCN Red List assessment for *Gopherus morafkai*: <https://dx.doi.org/10.2305/IUCN.UK.2023-1.RLTS.T97246109A97246177.en>



Fig. 2. A paved divided highway, dirt roads, and a canal separate Picacho Peak from the Picacho Mountains (background), Pinal County, Arizona. Photo by Roy C. Averill-Murray.

paved roads, suggesting that illegal collection may contribute to local population declines in areas crossed by maintained gravel roads (Grandmaison and Frary 2012). Such areas near human-population centers may contribute to the higher apparent mortality nearer to cities reported by Zylstra et al. (2013).

Even though various management actions address the negative effects of roads on wildlife, most strategies for minimizing or mitigating the effects of roads are focused on the actual roads themselves (e.g., barrier fencing to keep tortoises off of highways) rather than on the collective travel network across landscapes. Therefore, the late Linda Allison and I recently summarized a growing body of literature that documents the effects of road density on wildlife populations (Averill-Murray and Allison 2023). This literature supports the application of limits on road density as a tool for managing cumulative effects. Based on documented examples across wildlife taxa, we recommended road densities—including all linear features used for travel, not just paved roads—of $<0.6 \text{ km/km}^2$ as a general target for travel management in areas where wildlife conservation is a priority. Lower densities may be necessary in particularly sensitive areas, whereas higher densities may be appropriate in areas less important to landscape-level conservation and wildlife connectivity. Public policy and funding also are needed to address challenges of enforcing off-highway vehicle regulations.

We then applied this overview to a case study of the Mojave Desert Tortoise (*Gopherus agassizii*). We found that tortoise populations declined between 2004 and 2014 within all designated conservation areas that had road densities $>0.75 \text{ km/km}^2$. Furthermore, every land

management plan across the range of *G. agassizii* in California, Nevada, Utah, and Arizona lacked any consideration of road density. We did not look specifically at management plans or population trends within the range of *G. morafkai*, but as mentioned above, roads also can affect their habitat and populations. Given the lack of road-density management within any federal management plan within the range of *G. agassizii*, I suspect that most if not all plans within the range of *G. morafkai* also fail to address this important issue, leaving any impacts of road density on *G. morafkai* unevaluated.

The stark contrast between tortoise population trends and existing road management led us to provide several travel management recommendations specific to *G. agassizii* conservation, many of which also apply to *G. morafkai*. First, identify the entire travel network, including paved, designated unpaved, and user-created routes, as well as open wash zones within management areas. Second, reduce total road density within the travel network to $<0.6 \text{ km/km}^2$ in conservation areas that currently exceed this threshold by administratively closing, signing, physically blocking, obscuring, and restoring excess unpaved routes. Specific actions for managing or setting different limits for road density depend on the site-specific biological or management context, for instance relative to habitat quality or proximity to designated tortoise conservation areas. Third, maintain population connectivity between conservation areas (Averill-Murray et al. 2021) by limiting road densities to $<0.75 \text{ km/km}^2$ within linkages of potential tortoise habitat between these areas. Even if the nature of the steep, rocky terrain favored by *G.*

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morafkai precludes excessively high road densities in that terrain, this recommendation is directly applicable to maintaining effective connectivity between populations (cf. Edwards et al. 2004, Averill-Murray and Averill-Murray 2005). Finally, increasing law enforcement and public outreach will improve enforcement and compliance of travel regulations, and installing tortoise-exclusion fencing along highways will reduce road kills and allow tortoise populations to reoccupy depleted areas adjacent to highways. Implementation of these recommendations would improve the prospects of reversing *G. agassizii* population declines and enhance conservation of *G. morafkai* and other wildlife populations.

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Relative Abundance and Surface Activity of Long-nosed Leopard Lizards (*Sauria: Gambelia wislizenii*) in Southern Arizona

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Relative abundance of the Long-nosed Leopard Lizard (*Gambelia wislizenii*) is enigmatic. It has been called “one of the commonest reptiles of the desert” (Taylor 1912), probably referring to Great Basin Desert populations, and this is supported by others discussing the same area (Linsdale 1938, Nussbaum et al. 1983, Pietruska 1986, Beever and Brussard 2004). My own impression of its abundance or visibility in the Great Basin Desert concurs with these authors; the species seems common-as-dirt in some areas, and it is not unusual to have two or three individuals within one’s view (Fig. 1). *Gambelia* can also be commonly encountered in the Mojave Desert. For example, in the Desert Tortoise Research Natural Area, California, Sanborn (1994) stated, “Leopard lizards were so abundant that in the early morning the nature trail seemed almost littered with them.” My personal experiences in southern California, frequenting the same general area as Sanborn (1994) and others (Tollestrup 1979, Persons and Nowak 2007) suggested the same. There is relatively little information on their abundance in the Chihuahuan and Sonoran Deserts. While common in some areas, this species is perceived as uncommon to rare, or at least rarely encountered, in much of its

range. This includes Colorado, much of western Texas, southern border of Arizona and California, and northern Mexico (Vitt and Ohmart 1978, McGuire 1996, Hammerson 1999, Hibbitts and Hibbitts 2015). In some areas, including parts of Arizona, it may be declining (Hammerson 1999, Lazaroff et al. 2006, Schorr et al. 2011, Flesch et al. 2021).

At some point after I moved to Arizona in 2002, I started wondering where all the leopard lizards were. I only saw a handful during my first fifteen years of living here. Other local colleagues also noted a relative dearth of observations in the area. Then in 2020, leopard lizards started appearing to me in Saguaro National Park (Tucson Mountain District, SNP), and I began to study them there. In 2021–2022, I added Ironwood Forest National Monument (IFNM) as a secondary site, but I visited there less frequently.

Personal observations and anecdotes are well and good, but I wondered what documentation there was on relative population sizes and/or encounters across their range. I began digging into the literature for quantified information on home ranges, densities, and relative abundance. In a nutshell, home range estimates were few and open for interpretation, so I will discuss

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Fig. 1. High densities and visibility of *Gambelia wislizenii* in the heart of the Great Basin Desert were very apparent when I took this photo in Churchill County, Nevada. This is in the same county where Pietruska (1986) did some of his important work on foraging biology. Photo by L.L.C. Jones.

that topic in a separate publication. Similarly, few studies have estimated densities. Tanner and Krogh (1974) estimated five individuals/ha at the Nevada Test Site in the Mojave Desert. Schorr and Lambert (2006) estimated 0.6/ha in western Colorado. In the northwestern Chihuahuan Desert of New Mexico, Whitford and Creusere (1977) reported densities, but these were embedded within graphs. However, it appears *G. wislizenii* was not detected on three of nine site-years, and when present, density was <1–3/ha.

Fortunately, there was some information on frequency of encounters from field surveys, inventories, and tallies. These were sometimes reported as “relative abundance,” but I prefer to think of this more as “relative detectability,” given the cryptic nature of this animal. A number of these reports were unpublished or in gray literature, including site-specific government surveys and symposium proceedings. There was enough information for me to compile a list of relative frequency of *G. wislizenii* to total lizards encountered (Table 1). I expect there are similar reports tucked away in the literature. Admittedly, this relative frequency comes with caveats. For example, authors often surveyed a large area that included a range of elevations and habitat types that are typically outside of occupied habitats. Not unexpectedly, common species, particularly *Uta stansburiana* (Common Side-blotched Lizard), *Callisaurus draconoides* (Zebra-tailed Lizard), and *Aspidoscelis tigris* (Tiger Whiptail) sometimes blew out the relative frequency in the Mojave and Sonoran deserts. Some studies were temporally constrained, so may have missed peak surface activity.

Despite these shortcomings, I find these tallies to be informative, as they show qualitative differences between sites within the four North American deserts. These studies suggest the Great Basin has a very high relative frequency, the Sonoran and Chihuahuan Deserts are low, and the Mojave is in between (Table 1). One nugget of information I find interesting, if not disturbing, is that there were zero detections reported by Flesch et al. (2021) in their Tucson urban-suburban lizard surveys, despite amassing nearly 12,000 observations. Similarly, no one has yet claimed my prize for a confirmed leopard lizard in Sabino Canyon Recreation Area during organized lizard walks (or even opportunistic), where a few historical records exist (Lazaroff et al. 2006).

In non-invasive visual surveys, lizards cannot be detected if they are not on the surface. However, a definition of “surface activity” is in order. Phrases such as “activity budget” and “activity pattern” are also commonly used to describe temporal habits of lizards in nature. The word “activity” appears in all, yet its meaning is not standardized, and rarely defined. In some cases, surface activity presumably refers to when lizards are actually moving on the surface, while in other cases (e.g., Creusere and Whitford 1982) it refers to the time of day when lizards are awake, and on the surface, even

if not moving. I ascribe to this second definition in this paper. Similarly, I define “mobility” as frequency of movement in a finite time frame, rather than the act of moving. Hence, high mobility refers to the animal frequently moving during a particular season or time of day.

The disparities in connotation add to confusion in the literature, especially when comparing between species and study areas. Case in point, Repp (1998) stated that *G. wislizenii* near Tucson is “*hugely* spring active,” (italics not added) with 59% of his 61 observations occurring in April and May. His sample size has increased after 30 years of tallies (1990–2020), but his findings are similar, with 55% of the detections (128/234) during those months (R. Repp., pers. comm., 16 January 2024). Fortunately, Roger Repp records tallies by month, which is also something I do, as it is integral to my studies on seasonality. He also tallies lizards near Tucson, as do I, and our relative frequencies were very similar (Table 1). I wondered if my findings would show the same distribution of observations across months, so I gleaned information on surface activity from my study.

Although the exact meaning of “spring active” is open for discussion, Repp (1998) was certainly referring to times when he observed lizards on the surface. For visual encounters in my study, I used Low-speed Road Transects (LSRT) as the main technique to document surface activity (Jones et al. 2022a). This method involves extremely slow driving while watching for lizards on the road and roadside. This technique works well on slow, native-material roads, but could be hazardous on higher-speed roads. Unfortunately, these surveys were insufficient to make sense of surface activity for this infrequently encountered animal. To improve sample sizes and help decipher patterns of surface activity using visual encounters (i.e., similar to Repp 1998), in this paper I am including all detections of *G. wislizenii* from all methods of visual observation, except for fixes on radiocollared animals (although I do include radiocollared individuals when I was not actively engaged in telemetry). The methods, which were described in more detail by Jones (2023a), included: LSRT (all years), general driving (all years), LizBlitz (i.e., continuous diurnal LSRT one day per month in 2023), trail hiking (2020), field-day tallies (2021), and road and upland walks (2022).

As a next step, I estimated a visual Encounter Rate (ER) to adjust for effort, in terms of observations/field day. In this case, a field day was 4–6 hours, starting at 0800 h on hot days and later on cool days. An early morning “burrow check” counted as zero field days because animals had not yet emerged. Conversely, LizBlitz days counted as three field days because of the additional effort. In addition to visual encounters, I conducted a radiotelemetry study of *G. wislizenii* from 2021–2023 at the same sites. The methodology is discussed elsewhere (Jones 2023a). This not only added

There was enough information for me to compile a list of relative frequency of *G. wislizenii* to total lizards encountered (Table 1). I expect there are similar reports tucked away in the literature.

Table 1. Relative frequency (%) of *Gambelia wislizenii* to total lizard observations from surveys by region (grouped by color), with source. *N* spp. = the total number of lizard species detected.

Region and habitat	%	<i>n</i> /total obs.	<i>n</i> spp.	Methods	Source
Great Basin, Southeast OR (± northern range limit), sage scrub	12.7	25/197	8	Visual, slowly walking, time-constrained	Werschkul (1982)
Great Basin Desert, central NV, sage scrub	14.6	15/103	11	Visual, walking nineteen 2.4-ha plots	Beever and Brussard (2004)
Western Mojave Desert, CA; desertscrub	2.1	8/373	7	Removal; visual-capture, walking, area-constrained	Bury (1982)
Mojave Desert, Mojave National Preserve, CA; desertscrub	3.5	39/1,123	14	Numerous techniques during herpetofaunal inventory	Persons and Nowak (2006)
Mojave Desert, Owens Valley, Manzanar, CA; desertscrub	0.9	7/762	7	Numerous techniques during herpetofaunal inventory	Persons et al. (2006)
Mojave Desert, Death Valley, CA; desertscrub	1.7	35/2,018	16	Numerous techniques during herpetofaunal inventory	Persons and Nowak (2007)
Mojave Desert, composite states; valley desertscrub	5.3	116/2,193	12	Museum records	Rosen (2007)
Sonoran Desert, Organ Pipe Cactus National Monument, AZ; Arizona Upland and lowland "Yuman Desert" desertscrub	0-0.9 *	0 - 117/13,211*	16	Long-term monitoring, including Lizard Line Transects and Time-constrained Surveys	Rosen and Lowe (1996)
Sonoran Desert, composite, AZ, SON; lowlands and Arizona Upland	1.4	86/6,151	14	Museum records	Rosen (2007)
Sonoran Desert, Tucson Valley, AZ; desertscrub-urban interface	0.0	0/11,804	12	Visual observation, walking transects	Flesch et al. (2021)
Sonoran Desert, AZ; bottomlands desertscrub, xeroriparian	1.3	6/424	14	A variety of methods used for this inventory and comparison to riparian areas (not included)	Rosen (2005); Tucson-San Xavier portion only
Sonoran Desert, Saguaro NP, west of Tucson, AZ; Arizona Upland	0.5	11/2,068	8	Systematic, visual observation. LSRT and Trail-hiking Surveys.	Jones et al. (2022a). Supersedes Jones (2020), which reported % = 0.8, 11/1,399
Sonoran Desert, near Tucson, AZ; desertscrub	0.6	71/11,527	8	Visual observation, tallies en route to, and during, other studies. 16 years of opportunistic tallies.	Repp <i>in</i> Jones et al. (2022a), Supplemental Information Table 2
Sonoran-Chihuahuan transition/Cochise Filter (Marijilda), AZ; semi-desert grassland and foothills	<0.1	4/8,498	15	LSRT and Trail-hiking Surveys.	Jones et al. (2022a); supersedes Jones (2013), which reported % = <0.1 (2/3,889, <i>n</i> = 13 spp.)
Chihuahuan Desert, bootheel, NM; creosote and other desertscrub habitat	1.7	24/1,418	11	Random walking through area	Baltosser and Best (1990)
Chihuahuan Desert, Sulphur Springs Valley, AZ; sacaton and tobosa bunchgrass habitat near Sonoran transition at Cochise Filter	1.7	2/116	20	Various plus museum records	Rosen et al. (1996)
Chihuahuan Desert, Sacramento Mountains and Tularosa Valley, NM. Foothill ecotone, arroyos and uplands	0.2	1/625	14	Drift fence arrays with pitfall and funnel traps	Jorgensen and Demarais (1998)
Chihuahuan Desert, San Pedro River Valley, AZ; Riparian and semidesert grasslands to desertscrub	0.8	2/225	21	Various, including pitfall and drift fences, walking, and museum records	Rosen et al. (2005)

*Somewhat unclear. There are apparent discrepancies.

insight into surface activity but also helped explain the circumstances behind visual encounters.

During the four years of study, field assistants and I visually detected 175 *G. wislizenii* (Fig. 2). Thirteen (8%) were from the creosote-velvet mesquite hummock habitat in the Sonoran Savannah Grassland study site in IFNM, so most (92%) were from the Arizona Upland study site in SNP. The percentages of detections by method of visual encounters were general driving (38%), LSRT (27%), LizBlitz (13%), day tallies (6%), second-hand telemetry (i.e., uncollared individual seen with or near a radiocollared individual, 5%), trail hiking (5%), and other activities (4%). Thus, the majority ($n = 147$, 84%) were seen from the road. Individuals were usually detected on road-associated anthropogenic features, including the berm (61%), roadway (7%), edge (1–3 m upland from the berm crest, 5%), water diversions (5%), and old piles of road-grading materials (3%). The other visual encounters were in the uplands (> 5 m beyond berm crest, 19%), or in arroyos (1%). Visually detecting *G. wislizenii* on the berm is not a novel tactic, as it has been previously noted (e.g., McGuire 1996, Cornett 2006, Hollingsworth 2009).

To give the reader some parameters of visual encounters when I was in the field, I include here some central tendencies: Time of day: $\bar{x} = 1013 \text{ h} \pm 179.6 \text{ min SD}$ ($n = 165$, range 0730–1800 h). Air temperature: $\bar{x} = 30.1 \text{ }^\circ\text{C} \pm 3.5 \text{ }^\circ\text{C SD}$ ($n = 161$, range 21–40 $^\circ\text{C}$). Julian date: $\bar{x} = 184 [3 \text{ July}] \pm 55 \text{ days SD}$ [8 May–26 August] ($n = 175$, range 97 [7 April]–311 [7 November]). Monthly counts (i.e., tallies, not ER): $\bar{x} = 8.8 \text{ visual encounters} \pm 10.4 \text{ SD}$ (range 0–40).

Data of ERs across years combined showed a bimodal pattern, with a larger peak in the spring and a lesser peak during the North American Monsoon (NAM; July through September, for my purposes) into early fall (Fig. 2). The ER trough was during the dry, hot times betwixt spring and NAM. The temporal position of the trough in any given year depended on when the summer rains arrived, and how producers and consumers developed through the season. Preliminary data analysis suggests a bimodal pattern is typical of total lizards in the study areas, except that the larger peak appears to be during the NAM (Fig. 2 inset, Jones 2023a). An important note is that early in the season all individual *G. wislizenii* were adults and subadults, while young-of-the-year (YoY) started to appear in late July and August, then dominated ERs in September–November (Fig. 3). As such, the NAM peak includes both YoY and adults. Interestingly, at IFNM, only one detection was during the spring (8%; it was in May), so 12/13 (92%) were during the NAM, with 8/13 (62%) in July. This is the same pattern seen for total lizards at IFNM; seasonality was unimodal there for total lizards, peaking during the NAM (Jones 2023a).

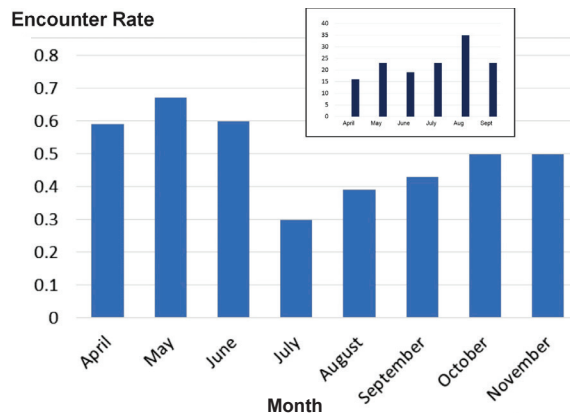


Fig. 2. Encounter Rate (observations/field day) of *Gambelia wislizenii* by month, 2020–2023 combined. The bimodal pattern of observations is typical of total lizards in the study area (inset, same axis labels, from LSRT reported by Jones 2023a), although the larger peak is usually during the NAM for total species. November should be viewed with caution as there were only a few warm days surveyed early in the month.

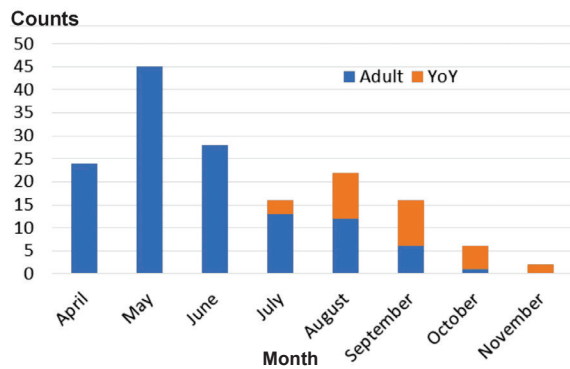


Fig. 3. Counts (tallies) of *Gambelia wislizenii* by month and age class. “Adult” includes adults and subadults that are not young-of-year (YoY). It is well established in the literature that for North American desert lizards, YoY are often more detectable on the surface than adults later in the active season.

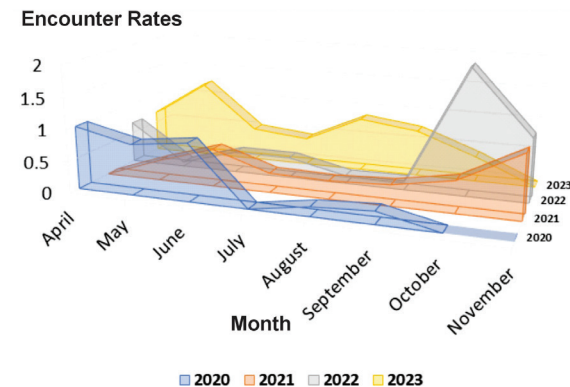


Fig. 4. Encounter Rates by month and year, showing high variability. Year 2023 was a banner year, as the ER was higher than previous years, there were more YoY detected, and it showed a bimodal, spring-centric, seasonal activity pattern similar to combined years.

Encounter Rates among months and years were variable (Fig. 4). Despite there being a much larger ER in 2023 ($\bar{x} = 0.82$ individuals/field day for entire year)

Data of ERs across years combined showed a bimodal pattern, with a larger peak in the spring and a lesser peak during the North American Monsoon (NAM; July through September, for my purposes) into early fall (Fig. 2). The ER trough was during the dry, hot times betwixt spring and NAM.

than previous years ($\bar{x} = 0.27\text{--}0.38$ individuals/field day), differences were not significant using monthly means across years (Kruskal-Wallis, $n = 175$, $P = 0.573$, $df = 3$). Only 2023 showed a bimodal pattern similar to the combined ERs. At first glance, the monthly distributions among other years appear weakly bimodal (skewed either to spring or NAM/fall) to random, but I expect peaks and troughs may correspond to weather events, or the lack thereof (Fig. 4). This will be analyzed later for all species. Besides a higher ER in 2023, that year also boasted the highest number of YoY encounters ($n = 24$, 67% of all years combined).

Radiotelemetry told a different story than visual encounters. I obtained 1,018 fixes from 23 *G. wislizenii* (two from IFNM, 21 from SNP). As best I could surmise, adult leopard lizards were usually surface active for most of the day, during warm weather, for the entire lizard season. However, I will need more radiotelemetry effort in the late afternoon to confirm this. A similar pattern was also noted by Tanner and Krogh (1974) in the Mojave Desert. On rare occasions during my study, adult *G. wislizenii* would remain subterranean for a few consecutive days, often after eating a large (presumably saurian) meal. One individual stayed mostly subterranean late in the season, but that was the exception. The take-home message from radiotelemetry suggests that nearly all adult leopard lizards were surface active during most of the daylight hours from mid-late April through early September.

Another contrast between visual and radiotelemetry detections was the relative number of encounters at road-associated topographic features. As mentioned above, 84% of the visual encounters were of animals

on or near the road. However, based on radiotelemetry fixes, only 1.4% (9/609) of surface-active animals were on the berm or road. Preliminary results (Jones 2023a) suggested that home ranges of *G. wislizenii* were primarily located in the uplands, away from the road, but often spanned both sides. This suggests *G. wislizenii* is typically seen on the road or berm when just passing through, or basking or ambushing prey for a brief period. Individuals did not seem to linger on the berm, as did some other species, most notably *Dipsosaurus dorsalis* (Desert Iguana) and *C. draconoides* (Jones 2023a).

While I did perceive a spring peak from visual observations, as did Repp (1998, pers. comm.), my ER was only 32% in April and May, opposed to his tallies of 55%. While this may seem like a substantial discrepancy, it can largely be explained by driving speed, study objectives, and probably correcting for effort. My assistants and I drove about 3.5–5 kph during LSRT and LizBlitz. Similarly, I typically drove 5–13 kph when specifically looking for *Gambelia* and *Dipsosaurus* to radiocollar. Conversely, Repp (*in* Jones et al. 2022a, Supplement 2; pers. comm.), indicated he was driving up to 50 kph on unpaved roads. His roadside tallies were opportunistic when traveling to study sites, so lizard detection was secondary to the objectives of his study, at least while driving. Hatchlings and small juvenile *G. wislizenii*, which can be prevalent during the summer and fall (Fig. 5), are very small (38–51 mm SVL, Parker and Pianka 1976) so are particularly difficult to detect when driving faster than LSRT. Although adults may be conspicuous when exposed on the road or a berm (Cornett 2006; R. Repp, pers.

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Fig. 5. Hatchling *Gambelia wislizenii*. These very small individuals are as cryptic as adults and very likely to remain undetected if surveyors are whizzing by in a car. This is the reason LSRT is done at a walking pace—plus, lizards are much more likely to flee from someone on foot than in a car (Jones et al. 2022a). Note the reddish spots that are diagnostic for hatchlings, although this character is surprisingly difficult to discern from any distance. Photo by L.L.C. Jones.

comm.), they are much more difficult to detect under vegetation in dappled shade, or in the nearby adjacent uplands, when driving at higher speeds (Jones et al. 2022a). The notion of undersampling small individuals at high speeds is validated by Repp (pers. comm.), who only detected five hatchlings in his 30 years of tallies. If my data were not adjusted for effort (i.e., reverting to tallies) and did not include YoY in the analysis, the monthly ratios from Repp's latest dataset and mine are virtually identical. My April-May tally total would be 56%. May alone would account for 35% in my study and 36% in Repp's.

My study had nearly six times as many average annual detections as Repp's, but again, this seems easily explained. I expect it is partly due to the differential objectives and speed of travel, as discussed above, but also I was out nearly every day, and we have different study sites. There could very well be differences in abundance. I suspect this is why *G. wislizenii* is so much easier to find at SNP than IFNM. At SNP, I may have stumbled upon a relative hotbed of leopard lizards in a single 1.8-km stretch of road, where the vast majority of my sightings were. I affectionately dubbed this stretch "Leopard Lizard Lane." On numerous occasions, three to six *Gambelia* were seen in a single day at SNP. Also, Repp's study spanned 30 years, while mine was four years. One of the years I surveyed produced the bumper crop of 2023, a year not included in Repp's sample.

Along those lines, why were detections from visual surveys during both of our studies so infrequent, considering the high level of surface activity suggested from radiotelemetry? The explanation to both of these topics probably has to do with mobility and crypsis. *Gambelia wislizenii* has variable mobility through the day and the year. After emergence from brumation in April, when air and surface temperatures are still relatively cool, leopard lizards are in poor body condition (Jones 2023a), so they must find food in order to survive and reproduce. Early in the season, they tend to be in an active hunting mode, so have relatively high mobility (Pietruska 1986; Jones et al. 2022b, 2023b). This is also the main time they look for mates (as suggested by Turner, *in* Repp 1998), and they may be exploring or seeking home ranges. It is easier for an observer to detect a leopard lizard that is itinerant than one that is static. Also, a highly mobile individual will cover more ground, so is presumably more likely to intercept the road and berm when traversing its home range. This concept of higher mobility during the cooler spring months, and at the morning and afternoon tail ends of hot days, is supported by other studies (McCoy 1967, Creusere and Whitford 1982, Pietruska 1986).

When leopard lizards have low mobility, as during hot weather, they tend to be superbly camouflaged. Numerous authors have commented on how visually cryptic *G. wislizenii* is, especially while in a motionless ambush mode in dappled sunlight under shrubs (e.g., Miller and Stebbins 1964, Sanborn 1994, Jones

2023b). However, this species is also surprisingly cryptic when out in the open, but not moving. I can attest to this from every time I walked in on a radiocollared individual. I would have to walk extremely slowly, then stop when I got near the animal for fear of stepping on it. I often had to visually scan for some time before finally detecting the nearby lizard. Many authors also noted how disinclined many leopard lizards are to flee when approached. For example, Jacobson et al. (2016) found that wild individuals did not usually flee humans until they were within 2 m. Indeed, radiocollared Long-nosed Leopard Lizards in my study quickly acclimated to my presence (except for two individuals), so most were even less likely to flee than uncollared individuals. My study animals often remained static when I was within a meter or two, and they even sought out the shade of my shadow on occasion.

My data suggest that *G. wislizenii* is more abundant than we might suppose from casual observation, but I cannot speak to densities without a population study, even on Leopard Lizard Lane. *Gambelia wislizenii* does not appear to be territorial (Tollestrup 1983, Lappin and Swinney 1999), but it would be a leap of faith to assume that my SNP study area has relatively high densities. This begs one final question: why is visual detection so much greater in the Great Basin and Mojave Deserts than study sites in southern Arizona? The simplest answer is that *G. wislizenii* might well indeed be more common in these northern areas. I suspect it may also have to do with visibility within different habitats, and perhaps different trophic levels.

In the Great Basin and Mojave Desert lowlands, there are widely scattered shrubs with much bare ground between. In my SNP study area, the vegetation is much denser (Jones 2023a), hampering visibility, and possibly accounting for a low population density. Schorr et al. (2011) and Steffen and Anderson (2006) demonstrated that *G. wislizenii* detections were inversely correlated to shrub cover or were found in areas of moderate shrub cover. Although my IFNM study area has widely scattered shrubs typical of lower western deserts, it is a seasonal grassland, so there is little bare ground during the NAM. Grasslands are often cited as being suboptimal habitat for this animal because it needs open ground to chase down prey (Werschkul 1982, Baltosser and Best 1990, Hammerson 1999, Schorr et al. 2011). However, having high detection rates in open terrain is not universal, as suggested by several studies, including Baltosser and Best (1990) in Chihuahuan desert scrub and Rosen and Lowe (1996) in Sonoran desert scrub. Studies such as these suggest low detection rates in some areas are more likely due to low densities than differential visibility.

The trophic level concept (see range-wide trends in Parker and Pianka 1976, although they combined Mojave and Sonoran Desert populations) is that densities are probably higher in the Great Basin than the Sonoran Desert because the former populations feed

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primarily on herbivorous arthropods, so are secondary consumers. Populations in the Sonoran Desert seem to rely more heavily on saurian prey (Parker and Pianka 1976, Jones 2023b), so are facultative tertiary (and sometimes quaternary) consumers. In the Mojave Desert they have a more catholic diet, but there can be a substantial contribution of saurian prey (Tollestrup 1979). The jury is out on the Chihuahuan Desert, although Mitchell (1984) and Han et al. (2021) found mostly insects in the diet. Lower densities at higher trophic levels is literally a textbook concept in ecology (e.g., Preisser 2007), so it would be expected that Sonoran Desert populations would be at a lower density than the Great Basin. Of course, among all populations there is regional variation in prey availability and feeding habits, so there are no absolutes. Whatever is going on with *G. wislizenii*, this species is always a treat to find, and I am looking forward to learning more about this fascinating creature's natural history.

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CURRENT RESEARCH

Western Kingbird (*Tyrannus verticalis*) Feeds Pacific Chorus Frog (*Pseudacris regilla*) to Fledglings — by Allison B. Titus, Center for Natural Lands Management, Temecula, California

Howard O. Clark, Jr., CWB®, Editor, Tucson Herpetological Society, Tucson, AZ; editor.sonoran.herp@gmail.com

On occasion, I like to highlight a current research paper published in other scientific journals. In addition to being editor of the *Sonoran Herpetologist*, I am also the Production Manager (i.e., layout editor) of *Western Wildlife*, the peer-reviewed journal of the Western Section of The Wildlife Society.

Recently, the *Western Wildlife* journal published a paper entitled, “Western Kingbird (*Tyrannus verticalis*) Feeds Pacific Chorus Frog (*Pseudacris regilla*) to Fledglings.” I found this paper interesting because it never occurred to me that passerine birds, that are primarily insectivores, may on occasion predate on vertebrates — in this case — chorus frogs. Here’s the abstract:

“Western Kingbirds (*Tyrannus verticalis*) are migratory flycatchers that breed in spring and summer in the Western U.S. and winters in Central America. They are insect specialists that supplement their diet with arthropods and

occasionally fruits and berries. Here, I report predation by a Western Kingbird on Pacific Chorus Frog (*Pseudacris regilla*) to feed to three fledglings in Sacramento County, California. Pacific Chorus Frogs are common prey for many guilds of birds in California but are not documented as prey to flycatchers. To the best of my knowledge, this is a novel observation of a Western Kingbird, an insectivorous aerial hunter, repeatedly catching and feeding Pacific Chorus Frogs to fledglings.”

If our readership has a paper they want featured in the *Sonoran Herpetologist*, please email me the article and I will provide a brief write-up in the journal.

Link to article:

https://wwwjournal.org/home/current_volume1

Eating Habits of *Crocodylus acutus* in Estuaries of Western México, with Comments on Dietary Diversity and Anthropogenic Impact

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Resumen (Spanish abstract)— Se caracterizó los hábitos alimenticios del cocodrilo de río y evaluamos el impacto antropogénico sobre estos, en esteros del sur de Nayarit (Esteros: el Becerro, Los Coamiles y Laguna el Quelele) y el norte de Jalisco (Estero Boca Negra, Laguna de San Juan, Majahuas y canales de La Pintada); entre agosto del 2010 y junio del 2011, se realizaron lavados gástricos a 25 cocodrilos vivos y se obtuvieron muestras del contenido estomacal por disección de 4 ejemplares muertos. Los cocodrilos se alimentan de insectos, arácnidos, escorpiones, crustáceos, peces, reptiles y aves, siendo los crustáceos e insectos las presas de mayor importancia. La variación de la diversidad dietaria no presentó variación significativa entre juveniles (0.19 nits/ind), subadultos (0.34 nits/ind) y adultos (0.13 nits/ind). El mayor solapamiento dietario fue entre las clases adyacentes subadultos y adultos (18.7 %); mientras que entre crías y adultos y entre juveniles y adultos, el traslape fue menor (12.5%).

Introduction

The American Crocodile (*Crocodylus acutus*) is distributed from the south of the U.S.A. (Florida) to the northern part of South America (Colombia, Peru, Venezuela and the Caribbean islands of Cuba, Jamaica, Haiti, and the Dominican Republic; Thorbjarnarson 1989, Sánchez 2001). In Mexico, it is distributed along the east and north coasts of the Yucatan Peninsula; the Grijalva and Usumacinta rivers (Ernst et al. 1999 in García-Grajales et al. 2007), and along

the Pacific coasts from the states of Sinaloa to Chiapas (Álvarez del Toro and Sigler 2001, Sigler 2010; Fig. 1). *Crocodylus acutus* has a very important role in the health of wetlands. As a predator, they contribute to the control of populations of other animals, incorporate nutrients into the ecosystem through their feces, and maintain open channels that connect to bodies of water (Casas-Andreu and Barrios-Quiroz 2003). In swampy areas, *C. acutus* builds circular pits that constitute the only refuge for aquatic fauna during the dry season (Kushlan 1974). The objective



Fig. 1. General distribution of *Crocodylus acutus*. Established populations (green) probably excised (Orange) rare or unconfirmed (light green). Author: Adam Britton; Taken from *Crocodylian.com*.

The American crocodile (*Crocodylus acutus*) is distributed from the south of the U.S.A. (Florida) to the northern part of South America (Colombia, Peru, Venezuela and the Caribbean islands of Cuba, Jamaica, Haiti, and the Dominican Republic; Thorbjarnarson, 1989, Sánchez 2001).

of this study is to characterize the feeding habits of the American Crocodile and evaluate the anthropogenic impact on crocodile feeding in the estuaries of southern Nayarit, and northern Jalisco.

Methods

Study region—Field work was carried out between August 2010 and June 2011 in estuaries of Bahía de Banderas, Nayarit, and Tomatlán, Jalisco. The estuaries of Bahía de Banderas – Estero el Becerro, Coamiles and Laguna El Quelele – are located north of the Ameca River and south of the Boca Negra estuary; while the estuaries of Tomatlán – Laguna de San Juan, Majahuas, and the channels of the town of La Pintada are located in the north of Jalisco. These wetlands are characteristic of coastal lagoons and estuaries, at the confluence of marine and continental water systems (Contreras 1993 *in* Hernández-Hurtado et al. 2011). The climate of the region is warm and subhumid, with summer rain preceded by a long dry season – type Aw according to the Köppen classification, modified by García (2004).

The Bahía de Banderas Municipality is located between the parallels 20° 24' and 20° 45' N and between the meridians 105° 14' and 105° 42' W. The average annual temperature is 26°C to 28°C. The average annual precipitation varies from 930.8 mm to 1,668 mm, mainly from June to September (Zepeda 2005). The coast includes sandy beaches, rocky coastline, wetlands, islands and rocky islets. Due to land use focused on the growth and development of tourism infrastructure, wetlands are continually shrinking and some sites have completely dried out (Cupul-Magaña 2004).

The coast of the Municipality of Tomatlán has a rainy tropical climate and belongs to the warm sub-humid zones. The average annual temperature varies from 26°C to 28°C with marked seasonality: the rainy season, from July to October (the warmest months, on average 28°C); and the dry season, from November to June (January considered the coldest month, on average 25°C). The average annual precipitation varies from 700 to 800 mm, with September being the rainiest month, due to the presence of cyclones and storms (Ramos and Vázquez 2004).

The coastal lagoon and estuary habitats are predominantly mangrove: *Rhizophora mangle*, *Laquncularia racemosa*, *Avicennia germinans*, and *Conocarpus erectus*. Other vegetation includes *Eichhornia* spp., *Nyphaea* spp., *Cynodon plectostachyus*, and *Hibiscus elatus*. In the surrounding hills, there is a variety of sub-deciduous tropical forests, tropical deciduous forests, low forests, grasslands, palm groves, and dune vegetation, which generates great biological diversity; and a variety of crops including lemon, mango, papaya, banana, jackfruit, and coconut (Delgadillo and Magaña 1999).

Field work—For the present study, we follow Platt et al. (2006). This includes capturing *C. acutus* for stomach flushing to record ingested prey, and the dissection of the stomachs of dead crocodiles. Most of the crocodiles were caught at night with the help of lamps. Juveniles (TL ≤1m) were captured by hand, and subadults (TL >1m) with a pole and rope – being released at the site of capture within 12 hours.

Once captured, they were measured to corresponding class: hatchlings (<60 cm), juveniles (60-120 cm), subadults (120-180 cm), adults (180-240 cm), and big adults (> 240 cm; Platt and Thorbjarnarson 2000). The stomach contents of 25 individuals were obtained using the stomach lavage method (Taylor et al. 1978). An appropriately sized piece of PVC pipe was wedged in the mouth of each individual to facilitate the introduction of a transparent hose of a suitable diameter and fastened with electrical tape wrapping the snout around the pipe. The hose was introduced through the pipe into the esophagus until it reached the stomach. Attached to the other end of the hose, a 20 ml syringe pushed distilled water into the stomach. Subsequently, a gentle abdominal massage was applied to encourage regurgitation of the food bolus to observe its contents.

The stomach contents were obtained by flushing the samples out of the crocodile at approximately 45° downward. The contents landed into a container strained with white cloth as a filter for as fine of samples possible. In addition, stomach contents were obtained through dissection of four crocodiles that were killed by gunfire, vehicular collision, or found dead of undetermined causes. The stomach contents were placed in separate plastic bags and transported cold (4°C) to avoid deterioration during the journey from the collection site to the TecMN Campus Bahía de Banderas (TecMN-ITBB) where they were preserved for analysis. In addition, a crocodile was observed ingesting remains of a roasted chicken that people threw at it from the edge of a body of water (Fig. 2).

Laboratory work—Samples of stomach contents were fixed in 10% formalin for a week to stop digestion. They were subsequently washed with running water and preserved in 70% alcohol for identification to the most specific taxonomic level. The prey was identified with the use of a microscope (model FP-24) to observe the characteristics of the prey based on the following identification guides: crustaceans (Crane 1947, Hendrickx 1993), beetles (Navarrete-Heredia et al. 2002), insects (Navarrete-Heredia and Fierro-López 2001), scorpions (Amat-García et al., 2007), and turtles (Rhodin et al. 2010). The stomach contents of the crocodiles were quantified both in abundance of the number of prey and in weight (g) of each prey, using a 0.1 g precision electronic scale (SHIMADZU model ATY224).

For the present study, we follow Platt et al. (2006). This includes capturing *C. acutus* for stomach flushing to record ingested prey, and the dissection of the stomachs of dead crocodiles.



Fig. 2. Procedure to obtain the stomach contents of the sampled organisms. **A)** Capture the organism; **B)** open the organism's snout; **C)** place the PVC tube and hold it and introduce the infusion until it reaches the stomach; and **D)** introduce water to fill the abdomen give a slight massage to the abdomen and place it at 45° to the body and obtain the stomach contents.

Statistical analysis—The sampled organisms were divided into classes according to their size (Platt and Thorbjarnarson 2000; Table 1). Based on the data obtained from the stomach content of each organism, in weight and number of prey, we applied the following diversity indices: Shannon-Wiener (Shannon and Wiener 1949) and Pielou Index (Pielou 1969). Additionally, the overlap (P) of the crocodile's dietary niche was determined based on its class (size), which measures the overlap within the study area based on its class size j and k . P is estimated by the equation of $\Sigma (\text{minimum } P_{ij}, P_{ik}) \times 100$, where P_{ij} and P_{ik} are the proportion of each prey category (i) used by classes j and k respectively, with a range from 0 to 1 where 0 = there are there is no overlap and 1 = there is complete overlap (Krebs 1989 in Platt et al. 2006).

Results

The Stomach's contents were obtained from a total of 30 crocodiles ranging in length from 34.7 to 390.0 LT. Of them, 25 were obtained by gastric lavage, four by dissections and one by observation of food intake.

Table 1. Classification by size classes of *Crocodylus acutus* by Platt and Thorbjarnarson (2000).

Total Length (cm)	Biological Phase
< 30	breeding
31 – 60	juveniles
61 – 90	subadult
90 – 180	adult
> 180	big adult

Of the 30 crocodiles, 19 were in the juvenile category, 6 in subadult, and 5 in adults (Tables 1 and 4).

Dietary diversity—16 different prey items were identified, belonging to 6 classes, 8 orders, 13 families, and 4 genera and/or species (Table 2). The dietary diversity found in stomach contents contains 6 categories of prey: aquatic and terrestrial insects, arachnids, crustaceans, fish, reptiles, and birds (Table 2). Insects of the order Coleoptera turned out to be the most diverse within the stomach contents, being represented by six families: Gyrinidae, Histeridae, Carabidae, Scarabaeidae, Buprestidae, and Dytiscidae (Table 2). Among reptiles, Red-eared Slider (*Trachemys scripta elegans*) and Green Iguana (*Iguana iguana*) were recorded. Both specimens were found in the same adult crocodile. Fish in the family Actinopterygii were found in the stomach contents of subadult juvenile crocodiles with an advanced degree of digestion. Some bird feathers were found in the stomach lavage of a subadult.

Relative importance of prey

Prey by taxonomic abundance—Crustaceans are a frequent component in the diet of crocodiles since they were found in nine samples (30%) of crocodiles of all sizes (Table 3). Crabs from the Grapsidae family were found in six samples (20%) and were recorded as being consumed in all size classes. Crabs of the infraorder Braquiura were present in three samples (10%), and these were also observed in all size classes. The

The Stomach's contents were obtained from a total of 30 crocodiles ranging in length from 34.7 to 390.0 LT. Of them, 25 were obtained by gastric lavage, four by dissections and one by observation of food intake.

Table 2. Prey items identified in the stomach contents of 30 *Crocodylus acutus* collected in the states of Jalisco and Nayarit (2010 - 2011). (IO: Infraorder, NI: Unidentified).

Category	Class	Order	Family	Genus and/or Species
Insects	Insecta	Coleoptera	Gyrinidae	
Histeridae				
Carabidae				
Scarabaeidae				
Buprestidae				
Dytiscidae				
Arachnids	Arachnida	Araneae	Pisauridae	
Scorpions	Buthidae			
Crustaceans	Malacostraca	Decapoda	Penaeidae	<i>Penaeus sp.</i>
Grapsidae				
IO Braquiura	NI			
Fish	Pisces	NI		
Reptiles	Sauropsida	Squamata	Iguanidae	<i>Iguana iguana</i>
Testudines	Emydidae			<i>T. scripta elegans</i>
Birds	Aves	NI	(only feathers)	

Arachnids are represented by spiders of the Pisauridae family, which was found in six of the stomach lavages of juvenile crocodiles, representing 20%, and the scorpions of the family Buthidae that were found in an adult crocodile along with the Red-eared Slider (Table 3). The Insect category was present in eight samples (27%), with the Carabidae and Dytiscidae families found in two samples and the other families were only observed in a single sample (Table 3). The other prey categories were recorded in only one sample (reptiles) or two samples (birds and fish).

Prey by weight—The reptiles *T. scripta elegans* (248.05 g.) and *I. iguana* (38.8 g.) represents the dietary component with the most weight. Another of the prey items with importance in terms of weight are the crabs of the Grapsidae family with 15.885 g. The other prey items have very little weight, less than 3.32 g. Other representative findings were flatworm and nematode parasites, which were found in 50% of the organisms sampled (Fig. 3). Five samples (16%) were reported with gastroliths, with a total weight of 842.54 g. In one of the samples 700 g of gastroliths were found; the other samples had 80.51 g, 60 and the other 2 samples less than 5 g.

Variation in dietary diversity—The crocodiles of Nayarit and Jalisco have two prey items in common: the crabs of the family Grapsidae and the Infraorder Braquiura. Nayarit crocodiles have five exclusive prey items, while nine prey items were found exclusively in Jalisco (Table 3). In relation to prey preference by size class, juveniles have seven exclusive prey-items. Big juveniles have a preference for two prey items and adults have four prey-items of their own. There are three prey items, which are shared between the size classes of crocodiles: Grapsid and Braquiuro crabs are food for all three age classes, while spiders of the family Pisauridae are shared between juveniles and subadults (Table 3). Dietary richness ranged between 1 and 4 prey items per sample, with an average of 1.6 prey items per sample. Juveniles show an average dietary richness of 1.4 prey items per sample, big juveniles had an average of 2.16 prey items per sample and adults had an average of 1.6 prey items per sample (Fig. 4). Although there are no significant differences, it could be that subadult are more opportunistic, and by changing the age structure for each 60 cm, the variation in type would present a change ($F = 2.333$, $P = 0.116$). Regarding the variation in dietary diversity

The crocodiles of Nayarit and Jalisco have two prey items in common: the crabs of the family Grapsidae and the Infraorder Braquiura. Nayarit crocodiles have five exclusive prey items, while nine prey items were found exclusively in Jalisco (Table 3).

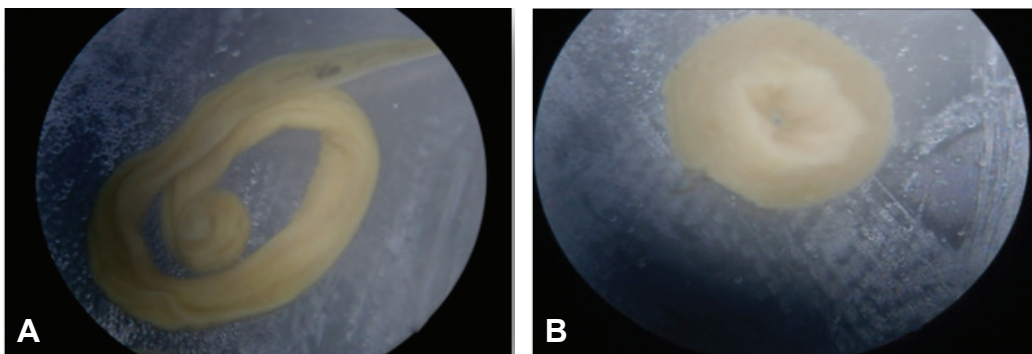


Fig. 3. Flatworm and nematode parasites, which were found in 50% of the organisms sampled: **A)** Nematoda; **B)** Platyhelminthes.

Table 3. Relative importance by Frequency and Weight of prey items of *Crocodylus acutus* in Jalisco and Nayarit by size class.

Prey Items	Juveniles		Subadult		Adult	
	Weight	Frequency	Weight	Frequency	Weight	Frequency
Taxon						
Braquiura	1.0 (5.2%)	0.1000	1.0 (16.6%)	0.0800	1.0 (20%)	3.0500
Grapsidae	3.0 (15.7%)	0.4250	2.0 (33.3%)	0.2600	1.0 (20%)	15.2000
Penaeus	1.0 (5.2%)	0.0300	0(0%)	0	0(0%)	0
Gyrinidae	1.0 (5.2%)	0.0300	0(0%)	0	0(0%)	0
Carabidae	2.0 (10.5%)	0.3700	0 (0%)	0	0(0%)	0
Hysteridae	1.0 (5.2%)	0.8000	0 (0%)	0	0(0%)	0
Scarabidae	0 (0%)	0	1.0 (16.6%)	0.0800	0(0%)	0
Buprestidae	0 (0%)	0	1.0 (16.6%)	0.0100	0(0%)	0
Pisuaridae	4.0 (21%)	0.4366	2.0 (33.3%)	0.0500	0(0%)	0
Buthidae	0(0%)	0	0 (0%)	0	1.0 (20%)	3.3200
Actinopterygii	2.0 (10.5%)	0.1900	0 (0%)	0	0 (0%)	0
<i>Iguana iguana</i>	0 (0%)	0	0 (0%)	0	1.0 (20%)	38.8000
<i>T. scripta elegans</i>	0 (0%)	0	0 (0%)	0	1.0 (20%)	248.0500
Aves	1.0 (5.2%)	1.1100	0 (0%)	0	0 (0%)	0
<i>Gallus gallus</i>	0 (0%)	0	0 (0%)	0	1.0 (20%)	250.0000*
Diversity H'		0.9416		0.6731		0.7782
Equity J'		0.9416		0.963		1
NON FOOD ITEMS						
Organic material	10 (52.6%)	8.7000	5.0 (83.3%)	13.8200	0(0%)	0
Synthetic fiber	1.0 (5.2%)	0.0001	0 (0%)	0	0(0%)	0
Plastic bags	0 (0%)	0	0(0%)	0	1.0 (20%)	7.3800
Plastic bottle	0 (0%)	0	0(0%)	0	1.0 (20%)	25.1000
Gastroliths	0 (0%)	0	2.0 (33.3%)	2.0290	3.0 (60%)	840.5100

* Estimated weight

based on the Shannon-Wiener index, juveniles have an average diversity of 0.19, subadult 0.34 and adults 0.13, without evidence of significant variation ($F = 0.936$, $P = 0.404$; Fig. 5). Pielou's J dietary equity showed average values between 0.09 in adults and 0.42 in subadult, but no significant variation was detected between size classes ($F = 1.346$, $P = 0.277$; Fig. 6). The greatest dietary overlap was between adjacent subadult and adult classes (18.7%); while between hatchlings and adults and between juveniles and adults, the overlap was lower (12.5%).

Anthropogenic impact on the diet of the American Crocodile—The anthropogenic waste found within the samples were synthetic fiber, plastic bags and bottles, which have a high frequency of 2 (3%) each of these wastes, with a weight of 32.48 g. Another serious anthropogenic problem was observed: the preparation of nests with leaf litter combined with urban waste such as buckets, shoes, food cans, paint, ropes, fishing and metal nets, glass bottles, diapers, disposable towels, cardboard boxes, and plastic waste. They look like piles of garbage rather than nests. Another anthropogenic problem observed was that wild crocodiles are being fed food that they would never consume, such as roast chicken. Introduced species such as the Red-eared Slider are also

observed. In addition, a sample was obtained from a crocodile that was run over on the Tepic-Puerto Vallarta highway (Mexico 200), and the stomach contents of an organism that was shot to death in the El Becerro estuary were also collected (Fig. 7).

Discussion

Method aspects—With the management method used to obtain samples from living organisms, no deaths of organisms occurred during this study, which leads us to consider it as an effective method as established by Platt et al. (2006). The stomach lavage technique is 95% or more effective in obtaining prey and non-food items from crocodiles. Abdominal palpation indicates that stomach lavage resulted in complete or almost complete gastric emptying. However, gastroliths are a problem when they exceed the diameter of the intubations, blocking the exit of stomach contents (Jackson et al. 1974, Fitzgerald 1989 in Platt 2006). It was also important to take advantage of the organisms that were found dead to carry out the dissection and total extraction of the stomach contents (Platt 2006). Observing the capture and consumption of prey is also an effective method, as it can clearly identify prey when hunted by the crocodiles. For

The anthropogenic waste found within the samples were synthetic fiber, plastic bags and bottles, which have a high frequency of 2 (3%) each of these wastes, with a weight of 32.48 g.

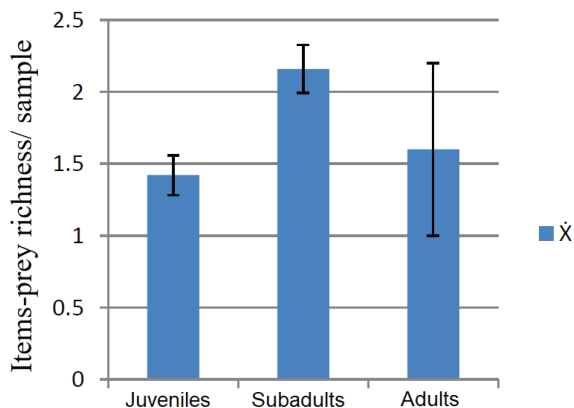


Fig. 4. Variation of dietary richness according to the size class of the American Crocodile (*Crocodylus acutus*) in the estuaries of Jalisco and Nayarit.

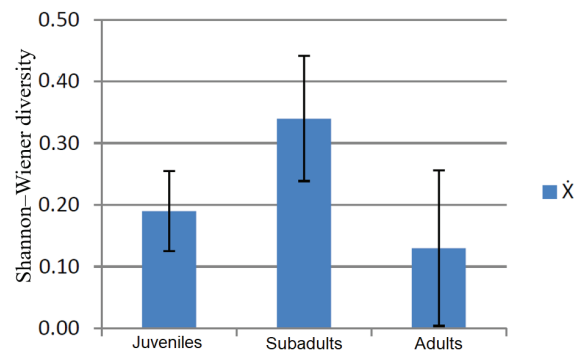


Fig. 5. Variation of dietary richness according to the size class of the American Crocodile (*Crocodylus acutus*) in the estuaries of Jalisco and Nayarit.

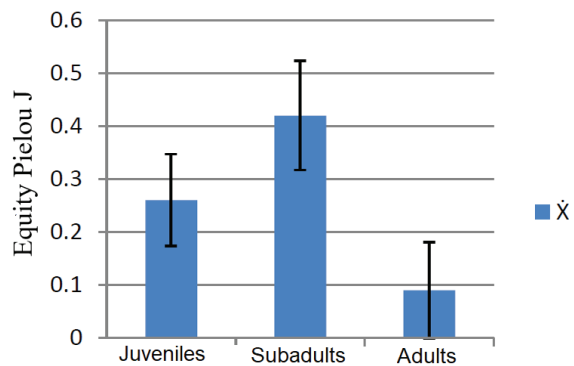


Fig. 6. Variation in dietary equity of Pielou's J of the American Crocodile (*Crocodylus acutus*) in the Jalisco and Nayarit estuaries.

example, Casas-Andreu and Barrios-Quiroz (2003) document a crocodile catching a heron.

Dietary diversity—The composition of the stomach contents of *C. acutus* sampled for this work is similar to those reported by Villegas and Schmitter (2008) – reporting fish, crustaceans, birds, mammals, and insects on the southern coast of Quintana Roo, Mexico. Similarly, adding other studies on the composition of the diet in *C. acutus*, Platt et al. (2013) document insects, mollusks, crustaceans, fish, reptiles, and birds for *C. acutus* in Coastal Belize. Likewise, Balaguera-Reina

et al. (2018) reported species such as insects, arachnids, crustaceans, fish, reptiles, birds, and mammals in the diet of *C. acutus* at Island Coiba, Panamá.

Relative importance of prey—The Grapsidae and Braquiura crabs are the most important groups since they are consistently consumed by crocodiles at all growth stages and estuaries of the two states. The Coleoptera group was the most diverse, followed by crustaceans and then arachnids, but being more frequent in juveniles and occasionally in subadult, since in this size class they begin to consume fish, bird, and Grapsid larvae. This diversity of organisms was also recorded by Cupul-Magaña et al. (2008), and was recorded in *C. moreletii* from Belize by Platt (2006). The fish group is rare in our samples. In the stomachs reviewed for this study, fish were found to be less frequent in all samples. Alternatively, Thorbjarnarson (1989) shows that *C. acutus* adults are mainly piscivorous. The most important prey items according to their weight in our study is the reptiles, with the Red-eared Slider (*T. scripta elegans*) and the Green Iguana (*Iguana iguana*), followed by the Grapsidae crabs, and the other items. Juveniles mainly consumed invertebrates such as Coleoptera, Arachnids, Grapsids, and as they grow, prefer to consume vertebrates such as fish, birds, and reptiles (Rainwater et al. 2022).

Variation in dietary diversity—The values obtained in dietary diversity (H') and equity (J) did not have a significant evaluation in the size class. Food diversity is greater in subadults, intermediate in juveniles, and low in adults. Greater dietary specialization is observed in subadults and juveniles than in adults due to the dependence on a limited number of prey choices, mainly insects and arachnids. These results are similar to those obtained by Platt (2006) with *C. moreletii* in Belize. Regarding the overlap between adjacent classes of *C. acutus*, the greatest overlap occurs between subadults and adults. This indicates that there is greater competition for prey among these classes and less competition between adults and juveniles. This type of overlap is also reported by Platt (2006), but in *C. moreletii* in Belize.

Anthropogenic impact—Pollution is the main factor that affects crocodiles – being killed by their consumption of garbage – in the same way it is observed in nests constructed with garbage. Another factor found in the present study was that of a crocodile killed by gunshots. Another was killed in a vehicle collision.

Conclusion

The main prey that makes up the diet are insects (Coleoptera, arachnids), crustaceans (Grapsidos, Brachyura), fish, reptiles, and birds. The variety

The composition of the stomach contents of *C. acutus* sampled for this work is similar to those reported by Villegas and Schmitter (2008) – reporting fish, crustaceans, birds, mammals, and insects on the southern coast of Quintana Roo, Mexico.

Table 4. Dietary diversity indices of the American Crocodile (*Crocodylus acutus*) in the estuaries of Jalisco and Nayarit.

N	Long	Class in	S	H'	J'
		Size	Abundance (No. Items)	Shannon (Nits/Ind)	Pielou's J
M 24	34.7	JP	2	0.56	0.8
M 1	37.5	JP	3	0.7	0.64
M 26	38	JP	1	0	0
M 18	40	JP	2	0.56	0.81
M 3	41	JP	2	0.66	0.95
M 4	41	JP	1	0	0
M 16	42	JP	1	0	0
M 19	42	JP	1	0	0
M 20	42	JP	1	0	0
M 25	45.6	JP	2	0.27	0.38
M 28	46.3	JP	1	0	0
M 2	46.5	JP	1	0	0
M 17	47	JP	1	0	0
M 23	49.5	JP	1	0	0
M 22	51	JP	1	0	0
M 6	52.2	JP	1	0	0
M 30	52.3	JP	2	0.69	1
M 13	57	JP	2	0.19	0.27
M 27	59.5	JP	1	0	0
M 12	60	JG	2	0.09	0.14
M 21	60	JG	2	0.41	0.59
M 14	60.5	JG	2	0.06	0.08
M 29	62.1	JG	2	0.33	0.48
M 15	75	JG	3	0.74	0.67
M 5	78.4	JG	2	0.41	0.59
M 11	195	A	1	0	0
M 7	197	A	4	0.63	0.45
M 8	210	A	1	0	0
M 10	358	A	1	0	0
M 9	390	A	1	0	0

of prey identified suggests a generalist diet. The most important group in the diet of *C. acutus* were crustaceans since they were found in all 3 classes and in organisms from both the states of Jalisco and Nayarit. As the size of the crocodiles increases, the ingestion of invertebrates is less frequent and the frequency of vertebrates increases. It was found that juveniles are consumers of arthropods, fish, and birds, while adult prey are mainly reptiles.

Likewise, humans have a great impact on crocodiles: destruction of their habitat, and urban waste is a cause of death for these organisms. It also probably affects the development of their nests, because they are no longer composed of natural materials. Vehicular collision and wanton killing by firearms is also a threat.

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Editorial comments—This article is translated from Spanish to English by the authors. I have made an effort to correct for syntax and items that may have been lost in translation. Please direct any questions in this regard to me, Robert A. Villa, at cascabel1985@gmail.com.

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Fig. 7. Anthropogenic impact on the diet of the American Crocodile: **A)** plastics and garbage bags and gastroliths found in the stomach; **B)** Nests modified with urban waste; **C)** *T. scripta elegans*, introduced species and sample in the stomach of *C. acutus*; **D)** Crocodile roadkill on the Tepic-Puerto Vallarta highway (Mexico 200).

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The Amphibians and Reptiles of Sierra Surutato, Sinaloa, Mexico

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The state of Sinaloa is a geographical area situated in the northwestern part of Mexico, which accommodates a total of 166 species of amphibians and reptiles (Frost 2023, Uetz et al. 2023). The significant abundance of herpetofauna in this region is of great interest due to the pronounced seasonal variations, the diversity of ecosystems, and the existence of the Mexican Transition Zone, which intersects within the state (Serrano et al. 2014, López-García and Morrone 2023). Nonetheless, the local herpetofauna has primarily been the subject of investigation in the coastal region and the southern part of Sinaloa, resulting in a scarcity of observations in the foothills of the Sierra Madre Occidental (Hardy and McDiarmid 1969, Castro-Bastidas and Serrano 2022). Therefore, the investigation of its mountainous formations arises as an essential task, given that the Sierra Madre Occidental has the potential to become a collection of diverse ecological systems, including not only native plant life, but also a wide range of amphibians and reptiles (Ochoa-Ochoa et al. 2012, Pío-León et al. 2023).

Sierra Surutato is a range of mountains situated to the northeast of the state of Sinaloa, Mexico, positioned on the periphery of the Sierra Madre Occidental. Botanist Howard S. Gentry provided a comprehensive account of various physiographic and botanical characteristics in 1946. Encompassing an area of over 300 km², the Surutato Natural Protected Area (NPA) is nestled amidst these mountains, with the town of the same name occupying a central position within the NPA (Fig. 1). In recent times, Surutato town has evolved into a focal point for burgeoning tourist activities.

Decades after Gentry's botanical exploration, between 1967 and 1971 Joseph F. Copp and Dennis E. Breedlove led by herpetologist Roy W. McDiarmid collected and described the herpetofauna of Sierra Surutato (McDiarmid et al. 1976). However, the exploration of McDiarmid's colleagues was during the dry season, probably because of the difficulty of accessing this area during the rainy season. In addition, they considered in their inventory species collected beyond the localities bordering Sierra Surutato proposed in 1946 by Gentry.

Biogeographically, Sierra Surutato presents a notable area of interest due to its designation as the northernmost boundary for various species of flora and fauna (Gentry 1946, Castro-Bastidas 2022). In addition, it possesses a remarkable assortment of endemic plants, leading to the proposition that it serves as a transitional zone for desert-tropical vegetation (Gentry 1946, Pío-León et al. 2023). Consequently, further exploration within this region would undoubtedly enrich the biodiversity documentation of Sinaloa while enhancing our comprehension of the distribution patterns exhibited by the native herpetofauna. Considering this, our study focused on examining the amphibian and reptile communities inhabiting Sierra Surutato during the rainy season of 2023, with the primary objective of contributing to and complementing the existing inventory of the region's herpetofauna.

Sierra Surutato possesses an extension stretching from northeast to southwest, measuring 90 km in length. This extension begins 14 km north of El Batamote and concludes at the Sinaloa riverbed

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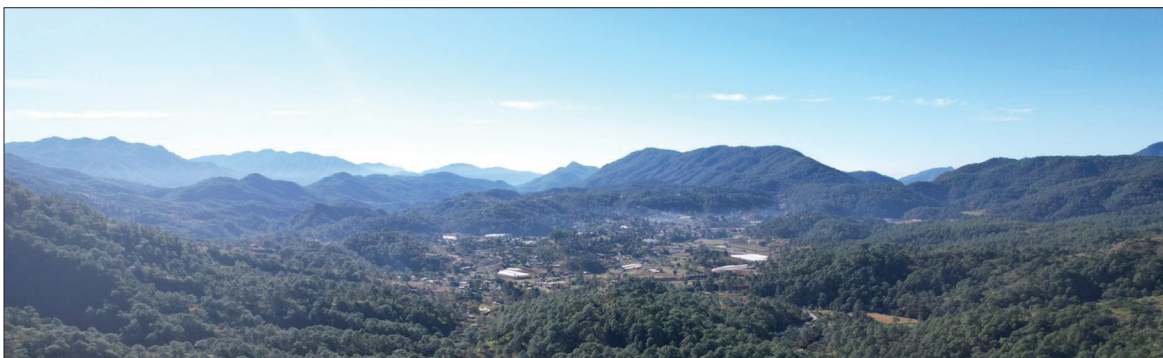


Fig. 1. The mountains of the town of Surutato. Photograph by Tiojari Dagoberto Guzmán-Galindo.

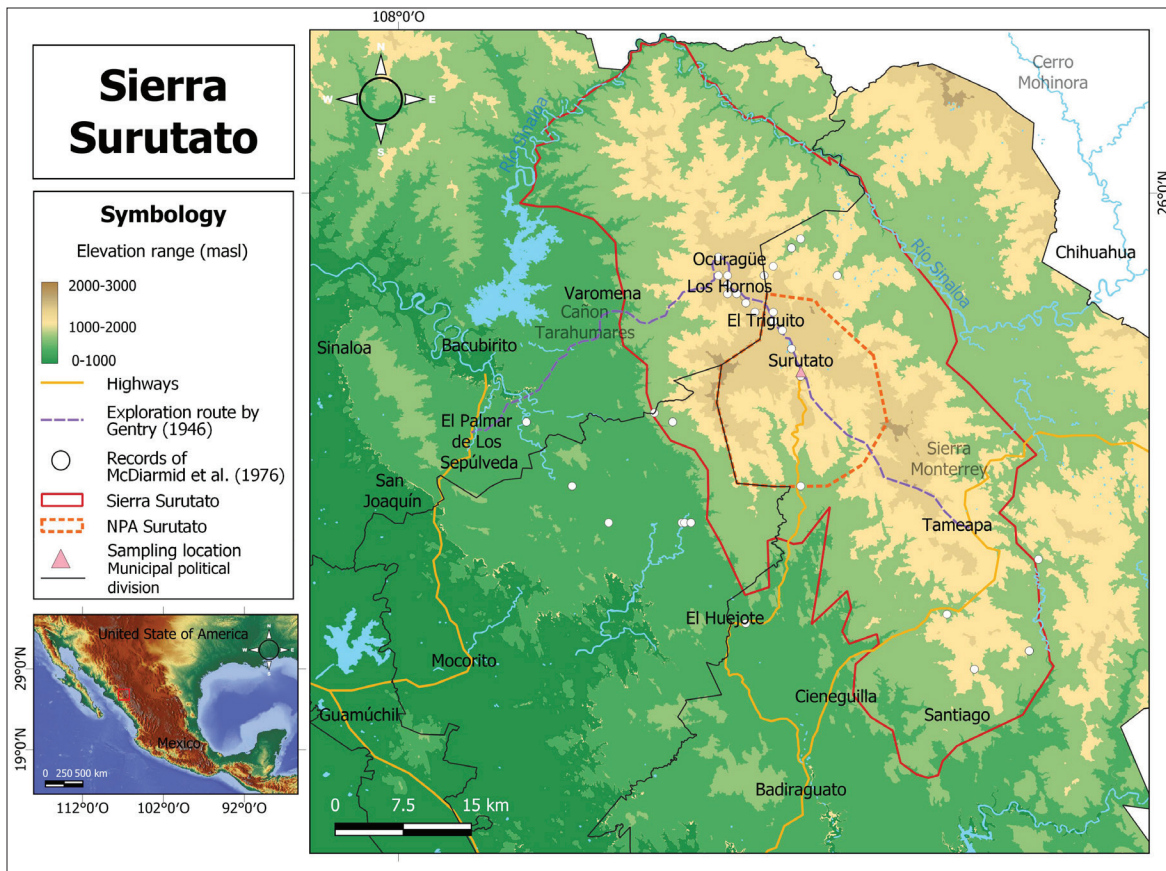


Fig. 2. Map of Sierra Surutato, Sinaloa, Mexico.

in the municipality of Sinaloa (26° 4'22.60 "N, 107°49'57.79 "W). It traverses through Surutato, continues to Tameapa, and eventually moves southwards to Santiago in Badiraguato (25°21'44.84 "N, 107°25'53.69 "W). The elevation within this area varies between 300 and 2200 meters above sea level (masl; Fig. 2). Furthermore, the prominent vegetation types within this region consist of tropical deciduous forest in the lower and middle altitude zones, while pine-oak forest thrives at higher elevations. The intermingling of tropical forest and oak can be observed around 800 masl.

We sampled amphibians and reptiles in the Surutato locality during the months of July, August, September, and October 2023. We actively search during the day and night, under and on rocks and logs for reptiles, and in streams for amphibians (Heyer et al. 1994, McDiarmid et al. 2012). Photographs and morphometric measurements were taken of all individuals found. For the species considered as new records, we obtained photo vouchers provided by the Los Angeles County Museum of Natural History, Photographic Collection (LACM PC). Species identification was based on the inventory of amphibians and reptiles by McDiarmid et al. (1976) and the documents in which the species were described. In addition, to complement the list of the herpetofauna in the region we also obtained scientific collection records from the Vertnet database (2023),

as well as citizen science records from the *iNaturalist* platform that have a shared author license for research purposes through the Global Biodiversity Information Facility (GBIF 2023a, b).

To define the boundaries of Sierra Surutato, we employed the research of Gentry (1946) and constructed a polygon representing the region utilizing a hypsometry shapefile provided by INEGI (2010) based on an elevation raster file (INEGI 2013). Furthermore, we utilized the NPA shapefiles of Mexico (CONABIO 2020) to ascertain the presence of species within the Surutato NPA. Additionally, we utilized Series VII of land use and vegetation (INEGI 2021) to identify the various types of vegetation under which amphibian and reptile species can be located in Sierra Surutato. Lastly, to determine the biogeographic province associated with the species, we relied on their distribution patterns and the research conducted by Morrone et al. (2017).

Our findings add 25 new local records for Sierra Surutato that were not included in the list of McDiarmid et al. (1976). We highlight two new collection records (*Craugastor augusti* and *Leptodaeira splendida*) and three new citizen science records (*Pituophis deppei*, *Micrurus distans* and *Terrapene nelsoni*) to the municipality of Badiraguato. Thus, the herpetofauna of Sierra Surutato is composed of 57 species in total: 14 amphibians and 43 reptiles (Table 1). The amphibians belong to the families: Bufonidae

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Table 1. Amphibians and reptiles of Sierra Surutato and nearby areas. Species with an asterisk (*) represent new local records not included by McDiarmid et al. (1976). We also indicate the occurrence of the different records of the study based on INEGI vegetation types and their inclusion in the list of species of NOM-059-SEMARNAT. Abbreviations of vegetation types: NPA Surutato (Natural Protected Area Surutato), Oak forest (OF), Pine forest (PF), Tropical deciduous forest (TDF), Grassland (GL). Abbreviations for biogeographic provinces (BP): Nearctic Province (NA), Neotropical Province (NT) and Transitional Distribution (TD).

Family	Scientific name	Common names	NPA Surutato	OF	PF	TDF	GL	BP	NOM-059
Amphibians									
Bufonidae	<i>Anaxyrus punctatus</i>	Red-spotted Toad				x		NA	
Bufonidae	<i>Incilius mccoysi*</i>	Chihuahuan Toad	x	x	x			NA	
Bufonidae	<i>Incilius mazatlanensis*</i>	Sinaloa Toad				x		NT	
Bufonidae	<i>Rhinella horribilis*</i>	Mesoamerican Cane Toad	x	x	x	x	x	NT	
Craugastoridae	<i>Craugastor augusti*</i>	Western Barking Frog	x	x	x	x		NT	
Hylidae	<i>Dryophytes arenicolor</i>	Canyon Treefrog	x	x	x	x	x	TD	
Hylidae	<i>Exerodonta smaragdina*</i>	Emerald Treefrog	x	x	x	x	x	NT	Pr
Hylidae	<i>Tlalocohyla smithii*</i>	Dwarf Mexican Treefrog				x		NT	
Phyllomedusidae	<i>Agalychnis dacnicolor</i>	Mexican Leaf Frog				x		NT	
Ranidae	<i>Lithobates forreri*</i>	Forrer's Leopard Frog				x		NT	Pr
Ranidae	<i>Lithobates magnaocularis</i>	Northwest Mexico Leopard Frog	x	x	x	x	x	TD	
Ranidae	<i>Lithobates pustulosus</i>	White-striped Frog	x	x	x	x		TD	Pr
Ranidae	<i>Lithobates tarahumarae</i>	Tarahumara Frog	x	x	x		x	NA	
Salamanders									
Ambystomatidae	<i>Ambystoma rosaceum</i>	Tarahumara Salamander	x	x	x			NA	Pr
Reptiles									
Lizards									
Anguidae	<i>Elgaria kingii</i>	Madrean Alligator Lizard	x	x	x	x		TD	Pr
Dactyloidae	<i>Anolis nebulosus</i>	Clouded Anole	x					NT	
Iguanidae	<i>Ctenosaura maculata</i>	Sonoran Spiny-tailed Iguana				x		NA	
Phrynosomatidae	<i>Holbrookia elegans</i>	Elegant Earless Lizard				x		NA	
Phrynosomatidae	<i>Sceloporus albiventris</i>	White-bellied Rough Lizard	x		x			NT	
Phrynosomatidae	<i>Sceloporus clarkii</i>	Southern Clark's Spiny Lizard	x	x	x	x	x	TD	
Phrynosomatidae	<i>Sceloporus jarrovi</i>	Yarrow's Spiny Lizard	x	x	x			NA	
Phrynosomatidae	<i>Sceloporus magister*</i>	Desert Spiny Lizard				x		NA	
Phrynosomatidae	<i>Sceloporus nelsoni</i>	Nelson's Spiny Lizard	x	x		x		NT	
Phrynosomatidae	<i>Sceloporus poinsettii</i>	Crevice Spiny Lizard	x	x	x		x	NA	
Phrynosomatidae	<i>Sceloporus spinosus</i>	Eastern Spiny Lizard				x		NT	
Phrynosomatidae	<i>Sceloporus virgatus</i>	Striped Plateau Lizard	x	x	x			NA	
Phrynosomatidae	<i>Urosaurus bicarinatus</i>	Tropical Tree Lizard				x		NT	
Phyllodactylidae	<i>Phyllodactylus tuberculatus*</i>	Yellow-bellied Gecko				x		TD	
Scincidae	<i>Plestiodon callicephalus</i>	Mountain Skink	x	x	x			TD	
Scincidae	<i>Plestiodon parviauriculatus</i>	Northern Pigmy Skink	x					NA	Pr
Teiidae	<i>Aspidoscelis costatus</i>	Western México Whiptail	x	x	x	x	x	NT	Pr
Snakes									
Colubridae	<i>Drymarchon melanurus*</i>	Central American Indigo Snake	x	x		x		TD	
Colubridae	<i>Gyalopion quadrangulare*</i>	Thornscrub Hook-nosed Snake				x	x	TD	Pr
Colubridae	<i>Lampropeltis polizona*</i>	Sinaloa False Coralsnake				x		NT	
Colubridae	<i>Masticophis flagellum</i>	Coachwhip				x		NA	A
Colubridae	<i>Masticophis metoivarius</i>	Neotropical Whipsnake	x	x		x	x	TD	A
Colubridae	<i>Phyllorhynchus browni*</i>	Saddled Leafnose Snake				x	x	NA	Pr

Table 1 (continued). Amphibians and reptiles of Sierra Surutato and nearby areas. Species with an asterisk (*) represent new local records not included by McDiarmid et al. (1976). We also indicate the occurrence of the different records of the study based on INEGI vegetation types and their inclusion in the list of species of NOM-059-SEMARNAT. Abbreviations of vegetation types: NPA Surutato (Natural Protected Area Surutato), Oak forest (OF), Pine forest (PF), Tropical deciduous forest (TDF), Grassland (GL). Abbreviations for biogeographic provinces (BP): Nearctic Province (NA), Neotropical Province (NT) and Transitional Distribution (TD).

Family	Scientific name	Common names	NPA Surutato	OF	PF	TDF	GL	BP	NOM-059
Colubridae	<i>Pituophis catenifer</i> *	Gopher Snake				x	x	NA	
Colubridae	<i>Pituophis deppesi</i> *	Mexican Bullsnake	x	x	x			NT	A
Colubridae	<i>Salvadora bairdi</i>	Baird's Patch-nosed Snake		x				NT	Pr
Colubridae	<i>Salvadora hexalepis</i>	Western Patch-nosed Snake					x	NA	
Colubridae	<i>Tantilla bocourti</i>	Bocourt's Blackheaded Snake				x		NT	
Colubridae	<i>Tantilla calamarina</i>	Pacific Coast Centipede Snake				x	x	NT	Pr
Colubridae	<i>Tantilla wilcoxi</i>	Chihuahuan Black-headed Snake	x	x	x			NA	
Colubridae	<i>Trimorphodon paucimaculatus</i> *	Sinaloan Lyresnake				x		NT	
Colubridae	<i>Trimorphodon tau</i>	Mexican Lyresnake	x	x	x			NT	
Dipsadidae	<i>Geophis dugesii</i> *	Dugés's Earth Snake	x	x	x			NT	
Dipsadidae	<i>Imantodes gemmistratus</i> *	Central American Tree Snake				x		NT	Pr
Dipsadidae	<i>Leptodeira splendida</i> *	Splendid Cat-eyed Snake	x	x	x	x		NT	
Dipsadidae	<i>Rhadinaea hesperia</i> *	Western Graceful Brownsnake				x	x	NT	Pr
Dipsadidae	<i>Tropidodipsas repleta</i> *	Snail snake	x	x	x			NA	
Elapidae	<i>Micrurus distans</i> *	Common Clear-banded Coral-snake	x	x	x	x	x	NT	Pr
Natricidae	<i>Storeria storerioides</i>	Mexican Brownsnake	x	x	x			NT	
Natricidae	<i>Thamnophis cyrtopsis</i>	Black-necked Gartersnake	x	x	x	x		TD	A
Viperidae	<i>Crotalus basiliscus</i> *	Mexican West Coast Rattlesnake	x	x	x	x	x	NT	Pr
Turtles									
Emydidae	<i>Terrapene nelsoni</i> *	Northern Spotted Box Turtle		x	x	x		NA	Pr
Kinosternidae	<i>Kinosternon integrum</i> *	Mexican Mud Turtle	x	x		x	x	NT	Pr

(4), Craugastoridae (1), Hylidae (3), Phyllomedusidae (1), Ranidae (4) and Ambystomatidae (1). Reptiles belong to the following families: Anguillidae (1), Dactyloidae (1), Iguanidae (1), Phrynosomatidae (10), Phyllodactylidae (1), Scincidae (2), Teiidae (1), Colubridae (15), Dipsadidae (5), Elapidae (1), Natricidae (2), Viperidae (1), Emydidae (1) and Kinosternidae (1). A total of 33 species are found in ANP Surutato, of which nine are amphibians and 24 are reptiles (see Table 1).

The biogeographic similarities of the herpetofauna of Sierra Surutato are predominantly Neotropical rather than Nearctic. As a result, 49.1% of the species are distributed within the Neotropical region, while 31.6% of the species have a Nearctic distribution. Additionally, 19.3% of the species display a transitional distribution between both regions (Table 1). Figures 3 and 4 show several examples of the amphibians and reptiles found in Sierra Surutato. Further information regarding the new findings and insights on the distribution of certain species are detailed below.

***Incilius occidentalis*.** Populations of *Bufo occidentalis* (*sensu lato*) from southwestern Chihuahua were assigned as *Incilius mccoysi* by Santos-Barrera and Flores-Villela (2011). Subsequently, populations of *I. mccoysi* were

recognized in northeastern Sonora, northwestern Durango, and northeastern Sinaloa (Streicher et al. 2014, Van Devender et al. 2022, Castro-Bastidas 2022). Therefore, populations from southern Durango to the Isthmus of Tehuantepec were considered *I. occidentalis* (Santos-Barrera 2014). However, in Sierra Surutato, some *Incilius* individuals found did not have a reddish coloration (Fig. 3A and B) contrary to the description of Santos-Barrera and Flores-Villela (2011) to designate *I. mccoysi*. Furthermore, instead of having a diffuse dorsal line, which is a diagnostic character of *I. mccoysi*, some had spots (Fig. 3C) and numerous conical granules on the body (Fig. 3A), while others had relatively smoother skin (Fig. 3B and C). In addition, the dorsolateral line of tubercles is barely distinguishable in some individuals (Fig. 3A and B). These are all characters more related to *I. occidentalis*, in addition to show a lighter coloration, fewer tubercles on the body, absence of a dorsolateral line of tubercles and a dorsal stripe reaching to the posterior part of the body (Santos-Barrera 2014). Therefore, we preliminarily suggest that the identification of some individuals correspond to *I. occidentalis* and that in the future the possibility of a species complex should be examined in Sierra Surutato.



Fig. 3. Morphological variability between individuals of the genus *Incilius* from Sierra Surutato. Photographs by Héctor Alexis Castro-Bastidas.

***Rhinella horribilis*.** This species has a wide distribution and is found in a great variety of habitats; however, Hardy and McDiarmid (1969) only recorded it in low altitude areas in Sinaloa. Later, McDiarmid et al. (1976) did not record it for Sierra Surutato. We observed that this species is mostly active at night on rainy days, although juveniles can be seen dispersing regardless of weather conditions (Fig. 4A). Inhabitants of Surutato commented that this species was not common in the region five years ago. This recent expansion of distribution in mountainous areas such as Sierra Surutato may be due to the adaptive abilities of *R. horribilis* to colonize new habitats and the increase in temperature at mountain elevations. Genetic studies of this species would allow us to understand its ecological dynamics in the area.

***Craugastor augusti*.** We found four individuals of this species at Surutato on 29 August (2350 h; 25°49'48.28 "N, 107°33'49.87 "W; WGS84; elevation 1540 masl), 2 September (2008 h; 25°49'51.97 "N, -107°33'43.84 "W; WGS84; elevation 1501 masl and 2115 h; 25°49'53.93 "N, 107°33'39.55 "W; WGS84; elevation 1541 masl) and 4 October (2330 h; 25°49'55.02 "N, 107°33'37.84 "W; WGS84; elevation 1548 masl) of 2023 in the same oak habitat on the rocks of a stream. Based on their size, these individuals were presumably three juveniles (15, 18, and 27 mm, Snout-vent length) and one adult (36 mm SVL) (LACM PC: 3030-3). From the banded coloration pattern of the hind limbs these individuals are probably the subspecies *C. augusti cactorum* (Fig. 4B; Zweifel 1956). These are the first records of *C. augusti* for the municipality of Badiraguato (Hardy and McDiarmid 1969).

***Lithobates tarahumarae*.** This is one of the few amphibian species in Sinaloa that are in some category of threat (VU: vulnerable by IUCN 2022), however, we did not observe any individuals of this species. Although, McDiarmid et al. (1976) recorded *L. tarahumarae* in Los Hornos, El Madroño and El Triguito. Recently, a citizen science record was shared on the *iNaturalist* platform of this species from September 2018 (*iNaturalist*: 112011251) near Santiago, Badiraguato, at the foot of Sierra Surutato and after 33 years without records in Sinaloa (last historical record: UAZ 52523). Specific expeditions

in search of *L. tarahumarae* in Sinaloa are necessary to know its conservation status.

***Ambystoma rosaceum*.** We did not find any individuals of this species during our sampling. This is probably because the Sierra Surutato population reproduces in February and not at the beginning of the rain season, as is characteristic of other populations of this species (McDiarmid et al. 1976, Anderson and Webb 1978). The first author (HACB) has observed that the reproductive season of the species begins in February, when eggs are observed attached to rocks in streams with little current. Hatchlings are observed until April, when they apparently transform to summer or migrate to ponds to spend the drier months of May through July (Fig. 4H and I). During the rainy season neotenic individuals are eventually observed in pairs (male and female) and salamanders in the fall (HACB, personal communication). These lack of observations during the rainy season of 2023 support the hypothesis that *A. rosaceum* in Surutato does not have an extended reproductive season (Anderson and Webb 1978). But it also warns about the conservation status of *A. rosaceum* populations in Sierra Surutato because it is likely that their hiddenness is associated to the increase of water extraction due to the increase of tourism and deforestation in the area. It is necessary to monitor this species and implement conservation strategies in the region.

***Drymarchon melanurus*.** On 30 July 2023 at 2205 h, we found the molt of an adult individual (LACM PC: 3022-4) in an oak habitat 2 km (airline) north of Surutato (25°49'51.99 "N, 107°33'49.08 "W; WGS84; elevation 1572 masl). This is the first evidence of the presence of this species in Sierra Surutato and the second record for the municipality of Badiraguato (Fig. 5F). This record extends the distribution of the species 50 km (airline) north of the nearest historical record in Badiraguato (KUH 83402).

***Pituophis deppei*.** On 25 November 2021 around 1630 h colleagues of HACB found an adult individual in Surutato (*iNaturalist* record number: 101976319), however, the individual fled and could not be captured. Two records of *P. deppei* were recently shared on the *iNaturalist* platform in Surutato (*iNaturalist*: 188315994 and 155967829). These records represent

Lithobates tarahumarae.

This is one of the few amphibian species in Sinaloa that are in some category of threat (VU: vulnerable by IUCN 2022), however, we did not observe any individuals of this species.

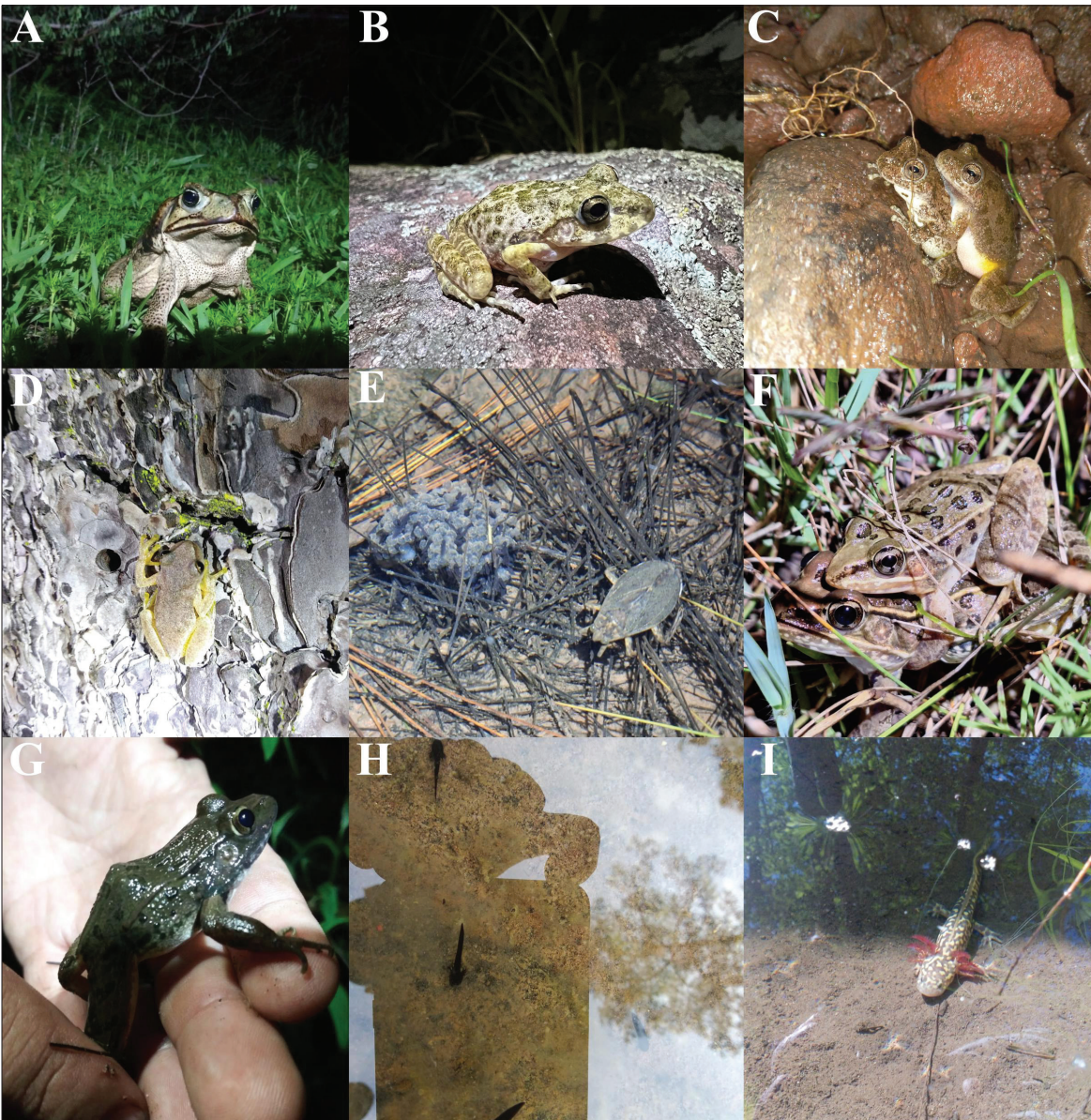


Fig. 4. Amphibians of Sierra Surutato: **A)** Adult of *Rhinella horribilis*, **B)** Adult of *Craugastor augusti*, **C)** Amplexus of *Dryophytes arenicolor*, **D)** Adult of *Exerodonta smaragdina*, **E)** Eggs of *Lithobates magnaocularis*, **F)** Amplexus of *L. magnaocularis*, **G)** Adult of *Lithobates pustulosus*, **H)** Larvae of *Ambystoma rosaceum* and **I)** Neotenic individual of *A. rosaceum*. Photographs by Héctor Alexis Castro-Bastidas (A, D, G, H, and I), Heleana Velarde-Urías (B), José David Jacobo-González (C) and José Manuel Serrano (E and F).

*Micrurus
distans distans.*

This species was only known from the lowland area of Sinaloa (Hardy and McDiarmid 1969).

the first evidence of the presence of *P. deppei* in the municipality of Badiraguato and extend the distribution of the species 90 km (airline) northeast of La Campana, Culiacán (UAZ 25815).

Leptodeira splendida ephippiata. On 30 July 2023 at 2309 h, we found a 54 mm SVL female adult individual (LACM PC: 3025-6) in a pine habitat on the bedrock of a stream 2.8 km (airline) north of Surutato (25°50'1.66 "N, 107°33'56.80 "W; WGS84; elevation 1554 masl). This record extends the distribution of the species 112 km (airline) north of the nearest record at Los Naranjos in the municipality of Culiacán (KUH 77976). Therefore, this is the first record of *L. splendida* for the municipality of Badiraguato (Fig. 5G).

Micrurus distans distans. This species was only known from the lowland area of Sinaloa (Hardy and

McDiarmid 1969). HACB comments that during the approximately five years visiting Surutato he had not encountered this species, until the night of 22 September 2023, however, he was unable to capture the individual after several attempts. Days later a record of an adult individual of *M. distans* (*iNaturalist*: 185234095) observed on 22 October 2022 around 1100 h at 1 km east of Surutato (25°48'26.09 "N, 107°32'58.81 "W; WGS84; elevation 1417 masl) was uploaded to the *iNaturalist* platform. This is the first record of the species in the municipality of Badiraguato, although its presence is common throughout the state.

Crotalus basiliscus. This species has a wide distribution throughout the state of Sinaloa; however, McDiarmid et al. (1976) did not record it for Sierra Surutato. On 30 August 2023 at 0949 h, we found



Fig. 5. Reptiles of Sierra Surutato: **A)** *Anolis nebulosus*, **B)** *Sceloporus albiventris*, **C)** *Sceloporus clarkii*, **D)** *Sceloporus poinsettii*, **E)** *Plestiodon parviauriculatus*, **F)** *Drymarchon melanurus* molt, **G)** *Leptodeira splendida*, **H)** *Geophis dugesii* (LACM PC: 3027-9) and **I)** *Crotalus basiliscus*. Photographs by Heleana Velarde-Urías (A, B, C, H, and I), Héctor Alexis Castro-Bastidas (D) and José David Jacobo-González (E, F, and G).

two adult individuals of this species 2 km north of Surutato (25°49'45.91 "N; 107°33'54.01 "W, WGS84; elevation 1529 masl). This species is common in this area, but local people often kill individuals encountered "to avoid a biting accident" (Fig. 5I).

***Terrapene nelsoni klauberi*.** Hardy and McDiarmid (1969) recorded the sighting of a skeleton of this species 3 km (airline) northwest of Las Mudas in the municipality of Salvador Alvarado (LACM 164113) and mentioned that there was an isolated population in the central region of Sinaloa. However, additional citizen science records of this species have been made in the municipalities of Badiraguato and Cosalá (GBIF 2023c). We highlight the citizen science record for Sierra Surutato, an adult individual observed in September 2015 near Tameapa (*iNaturalist*: 7473009).

Fifty-seven species of amphibians and reptiles are found within Sierra Surutato, 55% more species than those documented by McDiarmid et al. (1976). This increase in species richness is due to recent explorations and the contribution of citizen science records. It should be noted that McDiarmid et al. (1976) listed *Anaxyrus punctatus* and *Agalychnis dacnicolor*, even though they recorded both species outside the boundaries of Sierra Surutato. In this study we did not obtain records of these species within the mountainous region. However, we do not rule out that it is possible that both species are present in areas of low to moderate altitude, but this should be verified in the future.

Although the vegetation of Sierra Surutato tends to shift from a desert-tropical environment (Gentry 1946), its herpetofauna exhibits a greater resemblance

Fifty-seven species of amphibians and reptiles are found within Sierra Surutato, 55% more species than those documented by McDiarmid et al. (1976). This increase in species richness is due to recent explorations and the contribution of citizen science records.

to the Neotropical region rather than the Nearctic region. This biogeographic pattern may be a result of the convergence of Nearctic, Neotropical, and transitional species (Morrone 2005), and it could be attributed to the protective environment provided by the slopes of the Sierra Madre Occidental during the last interglacial period (McDiarmid et al. 1976), which should be indicated by a higher turnover of amphibians found in mountainous areas (Baselga et al. 2012). Unfortunately, our exploration only covers a small area in the central part of these mountains, so further exploration at the outskirts of Sierra Surutato could shed light on the turnover of amphibian and reptile species within the biogeographic transition zone (Serrano et al. 2014, Bezy et al. 2017, López-García and Morrone 2023).

During our task of identifying the species encountered, we observed several cases of morphological variability among species, including individuals of the genus *Incilius*, *C. augusti*, *Lithobates magnaocularis*, *Sceloporus clarkii*, *Sceloporus albiventris*, *Geophis dugesii* and *C. basiliscus*. HACB, during five years of exploration at the site, has observed the same in *Aspidoscelis costatus*, *Plestiodon parviauriculatus* and *Trimorphodon tau*. Similarly, McDiarmid et al. (1976) highlighted the morphological variability of several species in Sierra Surutato such as *A. rosaceum*, and possible hybridizations between *L. tarahumarae* and *Lithobates pustulosus*, *Sceloporus spinosus* and *Sceloporus poinsettii*, and suggested the need to examine these species. Although these aspects are also associated with niche differentiation, which includes tolerances and requirements of species with respect to environmental conditions and biotic interactions (Walczynska et al. 2023), morphological variability in amphibians and reptiles is well known (Kaliontzopoulou 2011), and morphological and genetic studies can help understand the identity of these species.

Of the 57 species of herpetofauna documented, 21 (38%) possess national recognition according to the Norma Oficial Mexicana NOM-059-SEMARNAT-2010 (Diario Oficial 2010), where four species are considered threatened (A = Threatened) and 17 have been granted special protection (Pr = Protected). It is noteworthy that solely reptile species fall under any category of risk. Nevertheless, when considering international standards, *L. tarahumarae* stands as the solitary amphibian species in the category of threat (IUCN 2022). However, the majority of amphibian and reptile species are likely susceptible to vulnerability due to the escalation of tourism activities within the region and the modification of communities because of climate change (Williams et al. 2022). Additionally, various instances of malformations, alongside the presence of endo- and ectoparasites in amphibians, have been identified in Sierra Surutato (HACB, unpublished data), thereby emphasizing the need for vigilance concerning the

health and preservation status of the species in this area. Consequently, we propose the implementation of long-term monitoring programs for amphibians and reptiles at large, the enactment of habitat conservation measures, and the encouragement of environmental tourism education in the region.

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Appendix. Acronyms of scientific collections and Universities: KUH (University of Kansas, Herpetology Collection), LACM (Los Angeles County Museum of Natural History, Vertebrate Collection), NHM (Natural History Museum, London) and UAZ (University of Arizona Amphibian and Reptile Collection).

Hind Limb Malformation in the Foothill Yellow-legged Frog, Sonoma County, California

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Physical malformations in amphibians have been recently reported (Sessions and Ruth 1990, Douran et al. 1998, Alvarez et al. 2021, Alvarez et al. 2023a, 2023b), and more specifically anurans have shown physical anomalies that originate from parasites (Tidd 1962, Johnson and Sutherland 2003, Kupferberg et al. 2009). Lotic habitats appear to support anurans that show malformations (Johnson and Chase 2004). However, Kupferberg et al. (2009), found that the copepod *Lernaea cyprinacea* can parasitize larval forms of foothill yellow-legged frogs (*Rana boylei*) in a lentic environment, the South Fork of the Eel River, Mendocino County, California, which led to malformations of the eyes, snout, and limbs.

The trematode parasite *Ribeiroia* spp. is also known to infect anuran larvae in California (Johnson et al. 2013, 2019) and appears to cause malformations during transition from larval to frog life stages (Johnson et al. 2002, 2013, 2019). Typically, these malformations occur in lentic habitats that are eutrophic, such as cattle stock ponds and marshes, that support the planorbid snail (family Planorbidae), which serves as the primary intermediate host for the parasite (Johnson and Chase 2004, Budria and Candolin 2014, JAA and DGC pers. obs.). Anurans are the secondary intermediate host and malformations occur most commonly at the developing limbs where the parasite enters the body (Johnson et al. 2002, 2019).

Here we describe a malformation of a juvenile foothill yellow-legged frog. Although extensive investigations have not occurred, the increasing reports of malformations in the species suggest that this phenomenon may be prevalent. This is of particular concern because the foothill yellow-legged frog is in decline, which has resulted in protections under the California and federal Endangered Species Acts (Patterson 2019, USFWS 2023).

Typically, foothill yellow-legged frogs utilize lotic habitats with cool, clear-water conditions (Storer 1925, Zweifel 1955), and only rarely occur in eutrophic, lentic habitats (Wilcox and Alvarez 2019). Therefore, we would anticipate the number of locations and frequency of occurrence of malformations of amphibians in lotic and oligotrophic conditions to be relatively low. Nevertheless, Alvarez et al. (2021) reported an idiopathic malformation of the hind limb of a post-metamorphic foothill yellow-legged frog in a tributary to Sonoma Creek in Sonoma County, California. Although we expected this to be an anomalous observation, we report a limb malformation in a post-metamorphic foothill yellow-legged frog from the mainstem Sonoma Creek, Sonoma County, California.

On 27 and 28 October 2023, we visually searched a 100 m section of Sonoma Creek, at an elevation of 400 m, from a small picnic area to an open creek crossing, near the headwaters. This site was located

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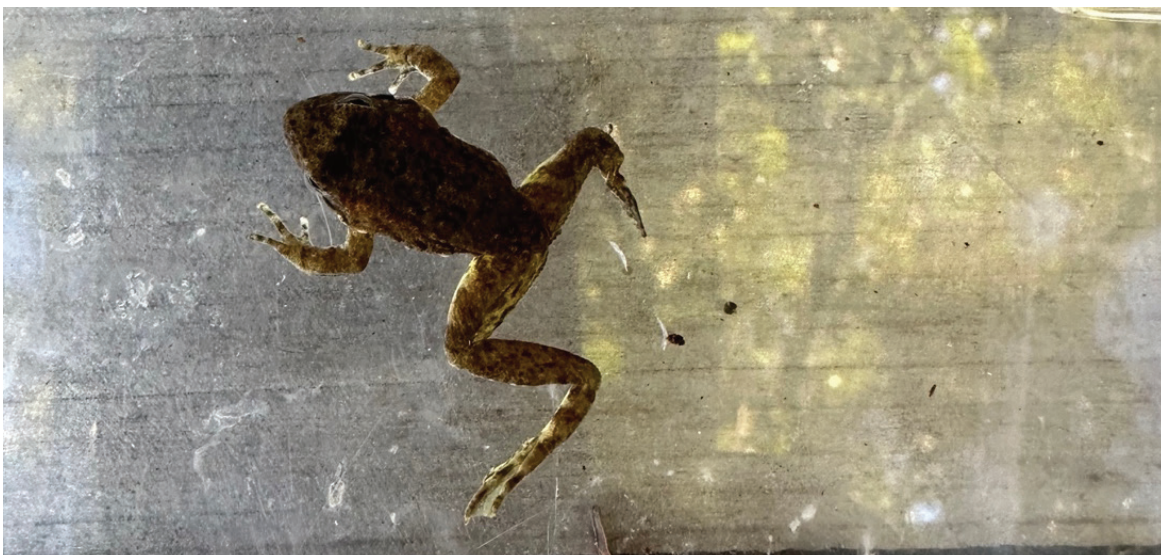


Fig. 1. A post-metamorphic foothill yellow-legged frog (*Rana boylei*), resting in water in a clear bin, showing a right rear malformed leg. Photo by authors.



Fig. 2. Magnified view of the malformed limb showing extreme reduction in the upper and lower leg, as well as the foot and toes of a post-metamorphic foothill yellow-legged frog. Photo by authors.

approximately 1-km upstream of the tributary confluence where a foothill yellow-legged frog malformation was reported four years earlier by Alvarez et al. (2021). This portion of the creek is perennial, with numerous small pools and short riffles and runs, and a substrate of gravel, cobble, and occasional boulders. The riparian area was dominated by a dense canopy of white alder (*Alnus rhombifolia*), California bay (*Umbellularia californica*), Oregon ash (*Fraxinus latifolia*), and coast live oak (*Quercus agrifolia*), with an understory of poison oak (*Toxicodendron pubescens*), California blackberry (*Rubus ursinus*), sedges (*Carex* spp.), and cow parsnip (*Heracleum lanatum*). The surrounding uplands were undeveloped and used for passive recreation. The portion of Sonoma Creek that we focused on was 1–2 m wide, approximately 15 cm deep, and had occasional pools as deep as 1 m. Water conditions were flowing, clear, and cool (approximately 11–13° C), with filamentous algae (Charophyta) along the shore. Syntopic with foothill yellow-legged frogs were California giant salamanders (*Dicamptodon ensatus*), western toad (*Anaxyrus boreus*), and Pacific Chorus Frog (*Pseudacris regilla*), all of which appeared typical, and showed no sign of malformations.

We hand-captured five foothill yellow-legged frogs (one adult and four post-metamorphic juveniles). All of the frogs were placed in a clear plastic bin for inspection. The adult and three of the post-metamorphic frogs appeared to be morphologically and behaviorally normal. The fourth post-metamorphic foothill yellow-legged frog was observed along the creek bank and

when we attempted to capture the frog, we noticed it moved slowly and jumped in an atypical fashion. Once placed in the examination bin, this frog hopped in small circles. Upon examination the right hind limb appeared to be malformed. We noted that the upper and lower leg, foot, and toes (i.e., femur, tibia, fibula, astragalus, calcaneum, and phalanges) were all reduced by approximately 60–70% (visually estimated), and surrounding musculature was markedly reduced or missing (Fig. 1 and 2). We closely examined the frog for any atypical growths, parasites, and/or injuries and found none. This malformation appeared morphometrically similar to the malformation observed by Alvarez et al. (2021) from the same creek system, including the same limb. We released the frog after the examination.

Our observation of a malformed foothill yellow-legged frog is the third report of malformations in this species (Kupferberg et al. 2009, Alvarez et al. 2021). However, this report stands out in that this is the second account in the same creek system, showing very similar malformations. In addition, the area in the report, along with Alvarez et al. (2021), is surrounded by undeveloped lands that would not provide nutrient inputs that typically cause eutrophication and the prevalence of parasitic *Ribeiroia*. This allows the possibility that a parasite that inhabits oligotrophic streams may be the cause of the observed malformation, such as copepod *Lernaea cyprinacea* reported by Kupferberg et al. (2009). To our knowledge, *Ribeiroia* spp. or *Lernaea cyprinacea* have not been reported from upper Sonoma Creek watershed. We did not determine

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the cause of the malformation we observed, and we acknowledge that other agents may be contributing to these malformations.

We contend that two observations of a similar malformation should elicit some effort to assess the rate of malformation in this system. A creek-wide survey during the post-metamorphic period could help to determine if these malformations are part of a pattern or simply coincidental. Due to the recent declines of some populations of the foothill yellow-legged frog in California (Patterson 2019), and the recent listing of the species as threatened or endangered by both State and federal resource agencies (Title 14, Section 670.1 [2020], 86-FR-73914 [2023]), we recommend further investigations into the possible causes and impacts of malformations in this species.

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Observation of a Mesquite Lizard (*Sceloporus grammicus*) With Low Body Condition

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Body condition is an ecological term used to denote the physical state or quality of an individual, usually serving as an indirect measure of energy status, this is, the amount of energy reserves (fat stores) available in one animal (Sion et al. 2021). In addition, body condition must reflect vulnerability to parasites and diseases (Argaez et al. 2018). This information helps explain the variations in individual fitness, since an animal with a better condition (more fat stores) has greater energy reserves compared to an animal in poor condition (Labocha et al. 2014). Body condition index is believed to have a direct impact on fitness and is used to evaluate the animal's health, and it is influenced by factors such as season, reproduction, survival, stress and fasting (McCaffrey et al. 2023).

The Mesquite Lizard (*Sceloporus grammicus*) is a small viviparous reptile, with populations distributed from sea level up to elevations above 4,000 m, with variations in coloration patterns and use of different microhabitats as rocks, trees, and is frequently found in human settlements (Ramírez-Bautista et al. 2014).

We collected lizards in El Cerrillo, Piedras Blancas in Toluca, Estado de México, México (located at 19.41181°N, -99.70067°W, datum WGS84, 2,605 m. elev.). The study site has a temperate sub-humid climate with a well-differentiated seasonality as well as

constant disturbance by both, agricultural and cattle raising practices (Gómez-Benitez et al. 2023).

On 29 January 2024, we captured 40 individuals (13 males and 27 females). The lizards were captured manually during sampling, and sexed based by the presence of post-cloacal scales in males. The following biometric data were recorded: snout vent length (SVL), and tail length (TL) were taken with a digital caliper (precision 0.01 mm) and body mass (BM) was obtained with a Pesola® spring scale (precision 0.5 g). Additionally, since the pregnancy period of the females alters weight, we only calculated the body condition index of males (BCI), from the residuals of a linear regression between log BM and log SVL (Rivera-Rea et al. 2023), where positive values signify that an individual has a greater body mass (a higher amount of stored fat) based on linear regression predicted by SVL, while negative values imply an individual has a lower body mass than expected (McCaffrey et al. 2023).

The SVL of a male was 63 mm, a tail of 82 mm, and mass of 5 g. This lizard showed emaciated conditions, without fat deposits visible in the body, a prominent easily visible vertebral column, and possessed a pale skin coloring (Fig. 1), this lizard had a low BCI = -2.68, compared to the average of other males collected in the same day (BCI = 0.19 ± 0.26 SE, range = from -1.3 to 1.82, $n = 12$; Fig. 2).

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Fig. 1. Adult male of *Sceloporus grammicus* with emaciated condition at El Cerrillo, Piedras Blancas, Toluca, Estado de México, México. Photo by Oswaldo Hernández-Gallegos.

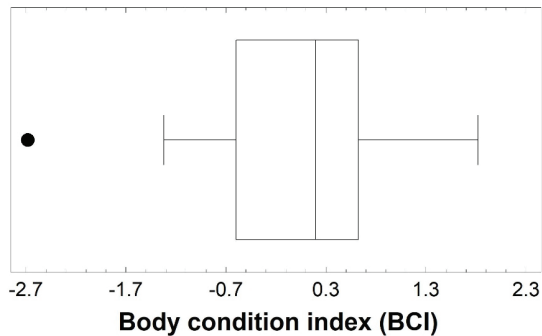


Fig. 2. Box-Plot of body condition index (BCI) estimated in males of Mesquite Lizard, *Sceloporus grammicus*. The filled circle corresponds to the emaciated lizard.

This finding is of special interest due to the rarity of observing this type of situation in the natural environment. It is probable that this lizard was ill, the signs and indicators being an unusually thin physical appearance, lusterless scales, limited movement, and a deficient escape behavior compared to conspecifics in the same study area, indicators of a lower healthy body condition. An emerging health problem in reptiles with similar symptoms is caused by *Cryptosporidium* spp. (Deming et al. 2008) or *Atadenovirus* (Wellehan et al. 2004), however, further studies are necessary to test this hypothesis.

Body condition in males has been suggested to respond to demands in supporting energy reserves, winter nutrition, and it may be affecting morphological or life-history traits such as growth rate and reproduction (Guillette and Bearce 1986, Ramírez-Bautista et al. 2006). Observations of this nature contribute to the understanding of the ecology and health of lizard populations and can be crucial for biodiversity conservation.

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Atypical Anuran Amplexus between Western Spadefoot and Pacific Chorus Frog During an Explosive Breeding Event, in Fresno County, CA

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Amplexus between different species of anurans, anurans and non-amphibians, anurans and inanimate objects, and live anurans and dead conspecifics has been reported worldwide, and reviewed (Pearl et al. 2005, Serrano et al. 2022a, 2022b, Alvarez, in review). These interactions have been variously reported with characterizations that include several dozen different words used to describe the behavior, including but not restricted to interspecific amplexus, heterospecific amplexus, hybridization, reproductive interference, Davian behavior, reproductive behavior, misdirected amplexus, and many other terms. Alvarez et al. (in review) summarized nearly 300 accounts of atypical amplexus and suggested nomenclature that would best describe all forms of atypical amplexus into three groups: interspecific amplexus, misdirected amplexus, and Davian behavior. Here we report on atypical amplexus that is interspecific and misdirected between a declining amphibian, the Western Spadefoot (*Spea hammondi*), and a commonly syntopic amphibian, the Pacific Chorus Frog (*Pseudacris regilla*).

During rain events that occurred on February 2 and 3, 2024, we conducted surveys of several vernal pools in Fresno County where we had previously observed

Western Spadefoot breeding, or suspected their presence. We approached pools during evening surveys with hand-held flashlights. These pools had choruses of Western Spadefoot that attracted our attention and which we investigated closely with the goal of detecting the presence and recording breeding activity of the species as part of a broader investigation into the species by the senior author.

We observed Western Spadefoot adults calling from the pool and several individuals appeared to be in amplexus. A closer investigation resulted in observations of several interspecific amplexal events made up of single Western Spadefoot adult and an amplexing male Pacific Chorus Frog. On two occasions, the Western Spadefoots were later identified as female as they were laying eggs while in amplexus with a chorus frog. The interspecific pairs moved around in 0-15 cm deep pools during the 1 hr observation time. Observations ended shortly after egg laying appeared to be complete.

We noted that at least two interspecific amplexing pairs, one on each night of observation, was in inguinal position (see Duellman and Trueb 1994; Fig. 1), where the chorus frog was grasping the waist of the Western

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Fig. 1. An adult male Pacific Chorus Frog (*Pseudacris regilla*) in inguinal amplexus with an adult female Western Spadefoot (*Spea hammondi*), in Fresno County, CA. Photo by D. Hardeman Jr.

Spadefoot—considered misdirected amplexus by Alvarez et al. (in review). In two additional amplexing pairs of spadefoot and chorus frogs, we noted they were in axillary amplexus (see Duellman and Trueb 1994; Fig. 2), which is considered typical for members of the family Hylidae (Halliday and Alder 2002, Wells and Schwartz 2007, Ethier et al. 2021).

Amplexus is a component in most anuran species and consists of a male grasping a female from behind with his forelimbs. Thus, not surprisingly, it has been interpreted as a behavior by which a male ensures the fidelity of its female partner during reproductive activity, increasing the chance of egg fertilization only by the amplexing male (Duellman and Trueb 1994, Wells and Swartz 2007, Carvajal-Castro et al. 2020). Sexual dimorphism can impose physical restrictions in some species, dictating the method by which males amplex (i.e., axillary, inguinal, cephalic, etc.; Duellman and Trueb 1994) whereby both individuals must appropriately align their respective cloacas so that egg fertilization is optimized (Davis and Halliday 1977, Robertson 1990, Carvajal-Castro 2020). Consistent with other genera in the Hylidae family, *Pseudacris* species typically perform axillary amplexus. The male mounts the female, grasps her directly behind the forelimbs, with the male cloaca positioned above the female cloaca (Wells and Schwartz 2007, Halliday and Adler 2022). Our observations suggest that the morphometric differences in Western Spadefoot and Pacific Chorus Frogs necessitated inguinal amplexus in at least two instances.

Different selective pressures are known to shape the behavioral, physiological, and morphological traits that characterize the diverse reproductive modes and behaviors in anurans in comparison to other vertebrates (Carvajal-Castro et al. 2020). This becomes particularly true when two species, closely related or not, are explosive breeders, and are syntopic at the time of breeding. Males of explosive breeding species that gather in dense aggregations may engage in “scramble competition,” which results in attempting amplexus with any individual, and struggling among themselves for possession of females (Wells 1977).

In the case we report here, both chorus frogs and spadefoots are explosive breeders, taking advantage of rain events and breeding in small, temporary pools (Stebbins 1954). Their behavioral ecology supports a need to amplex a potential mate prior to a competitor, potentially resulting in misdirected or interspecific amplexus. D’Amore et al. (2009) suggested that this type of atypical amplexus may be an evolutionary trap in that a declining species has a decreased chance of successful reproduction when interference occurs during the breeding event. Magnhagen (2003) and Alvarez (2011) added that amplexing pairs, particularly atypical amplexing individuals, may also increase predation potential by slowing the moment or escape ability of one of both animals. Further,

close interaction between interspecific pairings may also increase a risk of exposure and transmission of chytridiomycosis to one or both individuals. This should be considered when research is conducted on populations of anurans that are known to be infected by chytridiomycosis, ranavirus, or other pathogens (Rowley and Alford 2007, González-Mollinedo and Mármol-Kattán 2019).

We suspect that the female Western Spadefoot that we observed expelling eggs while amplexed by an interspecific male fell into an ecological trap in that her eggs were not likely fertilized, decreasing or eliminating any chance to reproduce in 2024. It isn’t clear how these two species reduce or avoid scramble competition when breeding at the same site during the same periods of time. We speculate that this type of syntopic occurrence is uncommon, with Pacific Chorus Frogs breeding over a longer period with fewer events that result in high intensity competition, while the spadefoot adults will typically breed during a shorter period and perhaps avoid or decrease interspecific amplexus by breeding slightly later in the season. We note, however, that in small isolated vernal pools, that may fill during a specific rain event, this behavior may occur with some level of frequency that may decrease reproductive output of Western Spadefoot, which is in decline throughout its range (Tompson et al. 2015).

Acknowledgments—We are very grateful to Addison Jane Isner who continually supports these field projects and accompanied us all over the countryside at all hours and weather conditions. We are also indebted to Tracy Sahagen for allowing us to set up base camp at her home after discovering the first Western Spadefoot in her front yard. We show up last minute, unannounced, late at night, weekdays, weekends, and holidays, and she has welcomed all of it.

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Amplexus is a component in most anuran species and consists of a male grasping a female from behind with his forelimbs. Thus, not surprisingly, it has been interpreted as a behavior by which a male ensures the fidelity of its female partner during reproductive activity, increasing the chance of egg fertilization only by the amplexing male ...

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Fig. 2. An adult male Pacific Chorus Frog in axillary amplexus with an adult female Western Spadefoot, in Fresno, County, CA. Photo by H. Isner.

MEETING MINUTES

BOD minutes can be found here:

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Membership Information

Individual	\$20	Sustaining	\$30
Family	\$25	Contributing	\$50
Student	\$14	Life	\$500

The Tucson Herpetological Society would like to thank existing members and new members for renewing their membership. We appreciate your support and are always looking for members to actively participate in THS activities and volunteer opportunities. It is a great way to be involved with the conservation of amphibians and reptiles in the Sonoran Desert.

Including the THS in your will is an excellent way to support the value of this organization and the conservation of the herpetofauna of the Sonoran Desert. We would like to recognize and thank anyone who has included the THS in their will. Please contact us so we can express our appreciation. For information about designating the THS in your will, please contact Maggie Fusari, Treasurer, Tucson Herpetological Society, at tucsonherps@gmail.com.

What is Wild Apricot, Why is THS using it, and How can you use it?

The Board of Directors, Tucson Herpetological Society, Tucson, AZ; tucsonherps@gmail.com

Wild Apricot (WA) is a commercial data management service. We pay a fee and they take care of our data, our financial transactions, and our messaging. They use a payment system, AffiniPay, that is similar to PayPal but free to use for us as WA users.

We are using it because our former system for managing our data is broken and unfixable. With WA (after we make some corrections to data as we imported them) we will have a professionally managed system that we can trust. Using it will make the job of reporting on our member, non-member contact, and donation data accurate, precise and easy. If you are a member or have contacted THS in the past, you are in our contact database. We imported all of you into WA.

First you need to reply to the email you received and click the link to set a password for yourself. You should then check your information, add your address, and note if there are any errors. Email tucsonherps@gmail.com if you find anything wrong. Also email us if you did not receive or you lost the link and we will resend.

All Contacts will receive our general emails from WA and the link to our quarterly Newsletter-Journal, the *Sonoran Herpetologist*, which is an excellent publication on herpetological topics.

If you are a Member you will have access to all the past issues of the *Sonoran Herpetologist*. WA will automatically notify you when your membership is due for renewal. You have choices. You can renew at the same level or change your level. You can renew for one year at a time or select one of the auto-renew levels for a small discount (because we are grateful to you for making it easier for us all).

You can pay right away, online, by signing on to the WA payment system, which is very similar to PayPal (We are using it because using PayPal would result in additional charges to THS). It is entirely trustworthy.

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If your membership is already lapsed, you can renew it as per the instructions above. We will send out an email via WA to all lapsed members, asking them to renew. If you are a non-member Contact, we hope you will join as a member. If you want to make a donation, you can do that from our website or from WA. If you have a problem, email tucsonherps@gmail.com and we will help you. We can send you a hard copy form for memberships and donations to send by regular mail if you prefer.

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The Tucson Herpetological Society invites your contributions to our Natural History Notes section. We are particularly interested in photographs and descriptions of amphibians and reptiles involved in noteworthy or unusual behaviors in the field. Notes can feature information such as diet, predation, community structure, interspecific behavior, or unusual locations or habitat use. Please submit your observations to Howard Clark, editor.sonoran.herp@gmail.com. Submissions should be brief and in electronic form.

Local Research News

The *Sonoran Herpetologist* welcomes short reports on Local Research News in our journal. We are interested in articles that can update our readers on research about amphibians and reptiles in the Sonoran Desert region. These articles need be only a few paragraphs long and do not need to include data, specific localities, or other details. The emphasis should be on how science is being applied to herpetological questions. Please submit your materials to Howard Clark, editor.sonoran.herp@gmail.com. Submissions should be brief and in electronic form.



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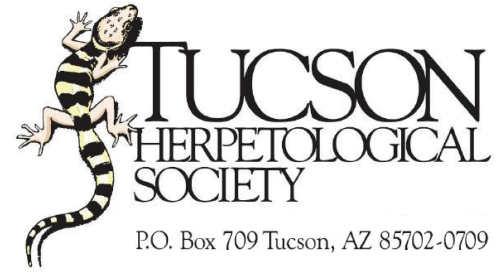
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