SONORAN HERPETOLOGIST

Newsletter-Journal of the Tucson Herpetological Society

September 2024
Volume 37
Number 3
ISSN 2333-8075 (online)
2577-9370 (print)

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President's Letter – Autumn of 2024

Hello, THS, I hope your summer was filled with herps and good summer tidings.

Annual Meeting, Elections, and Getting Involved

This November we will hold our annual business meeting, special speaker, other special activities, and elections at Brother John's pub on Monday, 18 November 2024. More information below.

Would you be interested in lending your skills to the THS? We would love to have more voices active in the THS, if not on the board. Officers are elected by the membership at the annual meeting, while directors are appointed by the current board of directors. If you are interested in running for President, Vice President, Secretary, or Treasurer, please contact Lee Oler at the announcement on p. 109. If you are interested in being a director or assisting with events, please contact me at *cascabel1985@gmail.com*.

In Memoriam of Warren Savary

This June, we lost good friend and former THS board member Warren Savary. While trained as an arachnologist, he was an enthusiastic supporter of our organization, served on the board for a few terms, and a good photographer. We send our condolences to his brother and longtime THS supporter Bill, who describes a humorous, but tender and formative moment with Warren:

> *I was maybe three years old, and Warren was a couple years younger. I was in the yard playing, and Warren was in a playpen. I found a large toad in the yard and was pretty excited about it—and Warren was the only person around to share the discovery with. So... I handed him the toad. At that age Warren had not yet refined his appreciation for herps, but his gastronomic interests were well developed. He took the toad from me with both hands and stuffed it into his mouth. Fortunately, the toad was far too big to actually fit in his mouth, and Warren had not yet acquired enough teeth to do any real damage—but my mother saw it from the kitchen and screamed, running towards Warren and shaking the toad out of his hands. This was followed by the questionable first aid practice of washing Warren's mouth out with laundry detergent (I think Tide was the brand involved). This incident left a strong impression on both Warren and I, and forever more we found herps fascinating.*

Photo courtesy of the Warren Savary estate.

Program and Conferences

This month we will have Dr. John Measey of Stellenbosch and Yunnan Universities presenting *The African Clawed Frog as a Global Invader*—Monday, 30 September 2024, 7p.m. MST, at 1675 E. Lowell St., as well as online via Zoom. More below.

This July the THS attended two simultaneous meetings: *Biology of Lizards 2* in Rodeo, NM, and the 22nd *Conservation and Biology of Tortoises and Freshwater Turtles* in Tucson. In Tucson, I was able to lead successful walks at Sabino Canyon, showing international visitors our beautiful desert and herpetofauna. At both events we sold merchandise and used books, raising a nice amount of money. If you have a herpetological and natural history library that you would like to donate to benefit the THS, and local and foreign students, let us know at *cascabel1985@gmail.com*.

Cover Photo information: Photo of Texas Horned Lizard (*Phrynosoma cornutum*) by Connor D. M. Pogue (Instagram: *@colubridconnor*; Flickr: *connordpogue*). Photo date: 8 July 2023. Photo Location: Apachian Valleys and Low Hills of Pima County, Arizona. As the sun nestled into the horizon, this horned lizard hastened for its nocturnal refugia. Fortunately, we persuaded it to pause briefly for a photo session before releasing it to continue its crepuscular wanderings.

Grants and Support

This year we visited the US captive assurance population for the Bolson Tortoise in New Mexico at the Ladder and Armendaris Ranches of the Ted Turner Reserves. The managers Chris Wiese and Scott Hillard hosted us over Memorial Day weekend as we explored the area with the *New Mexico Herpetological Society*, and discussed the diversity of issues that affect the survival of the tortoise. We pledged $1,000 toward genetic testing, and for their generosity to us, and the recovery project.

Additionally, we funded two project proposals from our Sonoran Desert Toad Fund (SDTF), totaling $4,000:

Dr. Karla Montaño Pérez and colleagues—$2,000—*Conservation of the Sonoran Desert Toad in the Sonoran Desert*—Dr. Pérez and her team have been regularly funded by the SDTF for their work in monitoring populations of, and educating the public on, the Sonoran Desert Toad.

Dr. José Manuel Serrano and colleagues—$2,000—*Knowledge of the Sonoran Desert Toad and Amphibian Diversity in Yoreme Communities of Northern Sinaloa, Mexico*—This team of biologists is seeking to understand the Sonoran Desert Toad in the southern edge of its range, as well as general amphibian populations in the northern area of the state of Sinaloa. Additionally, they will be interviewing members of the Yoreme (Mayo) culture to gain a socio-cultural context for the Sonoran Desert Toad, and other amphibians. We applaud these teams' efforts as scientists that value cultural, as well as academic perspectives in their approach to conservation.

We look forward to seeing you at the September and/or November meeting!

All best,

Robert

ANNOUNCEMENTS

Let's Do It Again—Annual Meeting on Monday, 18 November 2024

Lee Oler, Director, Tucson Herpetological Society, Tucson, AZ; *cloler@cox.net*

Last year our Annual Meeting was quite a success. This year we will do it again on Monday, 18 November 2024, at *Brother John's Beer, Bourbon, and BBQ*, 1801 N Stone Avenue in Tucson. Festivities start at 6 pm. The menu will be similar to last years. There will be a cash bar.

Our Silent Auction—I hope some of you remember Young Cage, a 2-time past president of THS and a wonderful photographer. One of his photographic works will lead off our Silent Auction. Young passed on 28 May 2012. We have the opportunity to honor his memory.

My brother-in-law and friend, Neil Carmony, gave me an awesome collection of wood turtles and ceramic turtles. Neil was a fine author and editor, a naturalist, and a fine person. He passed on 15 April 2021. We can include some of his collection in the auction or use as special prizes.

Election—We will have the election of officers—President, Vice President, Secretary, and Treasurer—on 18 November 2024, and also introduce the THS Board of Directors. AND, of course, we will have a phenomenal guest speaker. So please mark your calendars and plan to come to your Tucson Herpetological Society Annual Dinner and Meeting on Monday, 18 November 2024.

Stay tuned for more information.

Lee Oler, 520-990-3689 (cell)

The THS Election is Coming!

Lee Oler, Director, Tucson Herpetological Society, Tucson, AZ; *cloler@cox.net*

Four officers will be elected by the THS membership at the Annual Business Meeting on Monday, 18 November 2024. According to the bylaws, only members who are present at the Annual Meeting are permitted to vote. The officers elected at the Annual Meeting are President, Vice President, Secretary, and Treasurer. The date of the election must be announced 60 days before it takes place. The slate of candidates shall be presented to the THS membership 30 days before the election. Additional nominations may be made by THS members two weeks prior to the Annual Meeting. If you have questions or are interested in running for office, please contact me, Lee Oler, at 520-990-3689.

SPEAKER

John Measey, Ph.D.

Centre for Invasion Ecology, Stellenbosch University

The African Clawed Frog as a Global Invader

Monday, September 30, 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/85480004925*

African Clawed Frogs (*Xenopus laevis*), are considered to be the standard laboratory amphibian. The discovery in the 1930s that this species was easy to maintain and could be stimulated to breed year-round resulted in exports from its native southern Africa to all around the globe. The same traits that make it a good laboratory model organism also predispose it to becoming established and invading in many countries and climates. Unravelling the native and invasive biology of this species has taken me travelling on five continents over the last five years. In this presentation, I will provide some historical context for the invasions, aspects of the biology from the native and invasive range, and novel results of an ongoing investigation of the microbiome of this species. This is a story involving rapid evolutionary adaptation, amazing physiological capabilities and surprising revelations about terrestrial capabilities of what many regard as an aquatic frog. Lastly, I will provide some insight into the biology of an established population in Tucson, Arizona.

African Clawed Frog (*Xenopus laevis*). Photo courtesy of John Measey.

John Measey is a Professor at Yunnan University and Stellenbosch University (South Africa). He obtained his Ph.D. in zoology from Bristol University in the UK. Since then, John has worked on four continents investigating biological invasions. He spent 15 years in South Africa, becoming deputy director of the globally renowned Centre of Excellence for Invasion Biology (CIB). John uses small vertebrates to investigate rapid evolutionary responses comparing invasive and native populations. He has published his research in more than 200 peer reviewed papers, twenty book chapters and six books. He has written many popular articles as well as books on how to write (*https://howtowriteaphd.org*) and how to publish (*https://howtopublishscience.org/*) in the biological sciences.

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African Clawed Frog (*Xenopus laevis*). Photo courtesy of John Measey.

C.H. Lowe Research Fund: Sonoran Desert Road Ecology Study Published

Brian R. Blais, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ; *bblais@arizona.edu*

Coauthors and I recently published an open access study about aridland road ecology in the journal *Royal Society Open Science* (Blais et al. 2024). This work stemmed from a project that began in 2018, that was partially supported by Tucson Herpetological Society's Lowe Fund. This study focused on the biodiverse Sonoran Desert and covered rural intergrades around Phoenix and Tucson, Arizona. The following is an executive summary of the paper.

As drivers of urbanization churn and facilitate expansion, densities of linear infrastructure (e.g., roads) can soon follow. This, in turn, can affect wildlife directly (e.g., roadkill) and indirectly (e.g., road avoidance behaviors). To briefly recap the field of road ecology, studies have occurred globally with much focus on temperate/tropical climates, one or few target species (especially mammalian carnivores and large megafauna), and on high-traffic roadways such as highways. Less attention in road ecology has been given to aridland ecosystems, community assemblages (i.e., multi-species, especially amphibians and reptiles), and along lower functional class roads such as connectors and local roads that often comprise the gradient between natural and developed areas known as the wildland-urban interface (WUI). A better understanding of how wildlife are affected by and respond to roadways can inform natural resource and transportation management strategies to mitigate vehicle-wildlife conflicts and conserve biodiversity while facilitating human needs and growth.

We performed more than 200 low-speed, vehicle-based surveys (i.e., "road-cruising") to observe vertebrate animals along the WUI of southern Arizona's Sonoran Desert Ecoregion, 2018-2023 (Fig. 1). The purpose of this study was to assess the anthropogenic (human-induced), environmental, and temporal (seasonal) factors that influence roadkill of vertebrate animals in the WUI. Our eight routes comprised roads no greater than "collector" classification, contained sparse to moderate residential densities, and were absent of commercial development, i.e., we focused on rural zones with

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Fig. 1. Examples of animals observed during evening road cruise surveys in Arizona's Sonoran Desert; (top) Western Diamond-backed Rattlesnake (*Crotalus atrox*) and (bottom) Couch's Spadefoot Toad (*Scaphiopus couchii*). Photos by Brian R. Blais.

Fig. 2. Sample collage of diverse herpetofauna found dead along roadways in the wildland-urban interface of Arizona's Sonoran Desert. Photos by Brian R. Blais.

and without transit connectors and areas in suburban transition. We surveyed between April and November each year, starting at least 30 minutes after sunset—these timeframes correspond to peak daily and seasonal activity periods of much Sonoran Desert fauna. For example, many reptiles and mammals use nocturnal strategies to avoid the summertime heat, and amphibians utilize the rainy summer monsoon season for most of their surface activities. Post-sunset surveys also encompass many diurnal species heading to roost as well as rousing nocturnal species.

Our efforts (~4,800 km driven) yielded n = 2,019 vertebrates, of which 28.5% were roadkill including 179 amphibians, 177 reptiles, and 220 endothermic vertebrates ("warm blooded;" we combined birds with mammals due to ecological similarities and limited samples of the former). Routes in more developed/urbanized areas (vs. rural) were associated with fewer overall detections along roadways and increased roadkill of mammals and birds. Rural areas without high-volume road classification types yielded more detections of wildlife and the lowest rates of traffic and roadkill. Traffic volume was strongly associated with reduced abundance along roadways and increased roadkill of all vertebrate groups. A negative effect accrued at traffic rates of 20+ vehicles per hour (surveys averaged approximately 1.3 hours and 22 km). Our models predicted that at roughly 50 vehicles/hour, vertebrate occurrences reduced to less than one. Reptiles (snakes and lizards) were most susceptible to traffic; approximately 52% of all reptile encounters were roadkill and detrimental effects began at only 15 cars/hour for this group (Fig. 2). Daily low temperature and/or relative humidity were also associated with roadkill to various extents, and amphibian roadkill was influenced by the seasonal monsoon period.

The key findings of this study encompass environmental and anthropogenic factors that influence roadkill, which can be used to better

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inform transportation and wildlife management strategies. As human populations grow and subsequent urbanization sprawls into rural or undeveloped areas, it brings added challenges to ecosystems and wildlife therein. This work reveals that rural areas along aridland WUIs like the Sonoran Desert support a diverse array of species. However, increases in both development extent and traffic volume leads to increased roadkill or indirect effects across numerous species that can impact population dynamics in the long term. The effects from urbanization and traffic can be amplified during environmentally important periods, such as the summertime monsoon season. As aridland climates become warmer and drier, it may drive behavioral shifts in species and place more value on important hydrological features and migration corridors.

This study comes at a key time relative to transitions in the Sonoran Desert. One of the most biodiverse deserts in the world, the Sonoran (and much of the southwest) is expected to get hotter and drier with climate change. Precipitation patterns and extreme weather events are likely to be more intense when they occur. Many Sonoran Desert flora and fauna are already experiencing rapid disturbances along with the gradual changes. Additionally, anthropogenic demands for water and land for development can further strain natural resources. The Interstate-11 Corridor, which aims to connect Canada to Mexico, is currently in development planning stages in southern Arizona (*http://i11study.com/Arizona/index.asp*). The developers' preferred "West" option near Tucson would create a new highway west of the existing I-10 and bisect or come adjacent with numerous important biodiversity and cultural preserves, such as Ironwood National Forest, Saguaro National Park, Santa Cruz River Valley, and Tohono O'odham Nation. The I-11 West option would cross some of the roads (and putative wildlife hotspots) we surveyed for this project as well as complete an encirclement of Saguaro National Park (West District) by high-volume roadways. We acknowledge the economic prosperity of expanding infrastructure and promoting human advancement, but should it come as a sacrifice to invaluable and irreplaceable natural resources when it can be better mitigated to prevent functional ecosystem losses? In support of our principal findings that increased urbanization and traffic yield increased roadkill that may threaten long-term population dynamics, the I-11 West option would assuredly be detrimental to numerous ecosystem functions and values. To balance and protect key natural resource areas while accommodating growth, we recommend that developers consider their other "East" alternative to expand the existing I-10/I-19 corridor in the Tucson region (i.e., reject the preferred West option) as well as carefully consider placement of high-traffic roadway options respective of other important natural areas north of Tucson, AZ (e.g., Hassayampa ecosystems, Sonoran Desert National Monument). More broadly, we recommend that transportation and wildlife managers mitigate or avoid developing or expanding linear infrastructure near natural areas that possess high biodiversity, valuable waterways or migration corridors, and populations of threatened or road-vulnerable species.

This study comes at a key time relative to transitions in the Sonoran Desert. One of the most biodiverse deserts in the world, the Sonoran (and much of the southwest) is expected to get hotter and drier with climate change.

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OUTREACH

Request for Help: Gila Monster (*Heloderma suspectum*) Study

Anthony Pawlicki, Tucson Herpetological Society, Tucson, AZ; *anthonypawlicki12@gmail.com*

I am currently contracted to conduct a project on Gila Monsters (*Heloderma suspectum*) for the New Mexico Department of Game and Fish. The project focuses on obtaining genetic samples from Gila Monsters to get a better look at how the populations are doing in New Mexico. To get these samples, I must capture individuals and draw blood from them. The procedure is minimally invasive, and the Gila Monsters are released at the site of capture within 24 hours. By obtaining these samples, biologists can look at population connectivity, identify potential barriers to gene flow, determine the effective population size and relatedness among individuals, and see if there are any populations that are starting to inbreed. Gila Monsters are listed as Endangered in the state of New Mexico with a very restricted range in the southwestern portion of the state. This study will help better determine the status of the limited populations of Gila Monsters in New Mexico.

I am looking for any help in finding Gila Monsters. If you are in southwestern New Mexico and come across a Gila Monster, please notify me as soon as possible. I ask that you send a picture, location, and the date and time you found the individual. Please do not attempt to capture Gila Monsters, they are venomous and are also protected in the state of New Mexico and Arizona. I have a permit through the New Mexico Department of Game and Fish to handle them and obtain genetic samples. Additionally, if you find a dead Gila Monster, I will go out to collect it and have it kept in the collection at the Museum of Southwestern Biology in Albuquerque if it is in good shape. This will allow future researchers to use it. In addition to the dead specimens, I am storing blood samples from every individual captured at the Museum of Southwestern Biology to be utilized by any future researcher. Please feel free to reach out with any questions or information you may have.

Anthony Pawlicki
anthonypawlicki12@gmail.com | 224.234.0778

Photo A. A young Gila Monster (*Heloderma suspectum*) that excavated a lizard nest and has its head inside the nest chamber consuming eggs in New Mexico. **Photo B.** Anthony Pawlicki and Grace Laskey taking a genetic sample from a young-of-the-year Gila Monster in New Mexico. **Photo C.** The first Gila Monster, as found, for the project in New Mexico.

Notes on Reproduction of Red-Spotted Toads, *Anaxyrus punctatus* (Anura: Bufonidae), from Oklahoma

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

Anaxyrus punctatus (Baird and Girard, 1852) (Fig. 1) occurs from southern Nevada to parts of Kansas, Colorado, Oklahoma, Texas, California, and southward into Mexico (Dodd 2023). The biology of *A. punctatus* is summarized in Korky (1999). In the current paper I present data on the *A. punctatus* reproductive cycle from a histological examination of gonadal material from Oklahoma.

A sample of 21 *A. punctatus* from Oklahoma collected 1940 to 1988 (Appendix) consisting of 8 adult males (mean SVL = 46.9 mm ± 2.6 SD, range = 42-50 mm) and 13 adult females (mean SVL = 50.5 mm ± 3.2 SD, range = 45-55 mm) was examined from the herpetology collection of the Sam Noble Oklahoma Museum of Natural History (OMNH), Norman, Oklahoma USA (Appendix). Utilization of museum collections for obtaining reproductive data avoids removing additional animals from the wild. An unpaired *t*-test was used to test for differences between adult male and female SVLs.

A small incision was made in the lower part of the abdomen of the 21 adults 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 µm and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreibman 1997). Histology slides were deposited at OMNH.

The testicular morphology of *A. punctatus* is similar to that of other anurans as described 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). All 8 *A. punctatus* adult males were undergoing sperm formation (= spermiogenesis) in which clusters of sperm filled the seminiferous tubules. A ring of germinal cysts was located on the inner periphery of each seminiferous tubule. By month, numbers of *A. punctatus* males (n = 8) exhibiting spermiogenesis were: April (n = 2), May (n = 4), June (n = 1), July (n = 1). The smallest mature male (sperm in lumina of seminiferous tubules) measured 42 mm SVL and was from July (OMNH 30145). Wright and Wright (1949) reported adult *A. punctatus* males ranged from 40-68 mm in body size.

The mean SVL of *A. punctatus* adult females was significantly larger than that of males (t = 2.7, df = 19, P = 0.0157). The ovaries of *A. punctatus* are typical of other anurans in consisting of paired organs located on the ventral sides of the kidneys; in adults they are filled with diplotene oocytes in various stages of development (Ogielska and Bartmańska 2009b). Mature oocytes are filled with yolk droplets; the layer of surrounding follicular cells is thinly stretched. Two stages were present in the spawning cycle (Table 1): (1) "Ready to Spawn Condition" in which mature oocytes predominate. (2) "Vitellogenic Condition", follicles accumulating yolk for upcoming spawning. All females were in spawning condition except for the one from July (OMNH 30130) which was accumulating yolk for an upcoming spawning. It is conceivable this female may have already spawned earlier in the year. The smallest mature *A. punctatus* female (ready to spawn condition) measured 45 mm SVL (OMNH 32969) and was from May. Wright and Wright (1949) reported adult *A. punctatus* females ranged from 42-64 mm in body size.

Fig. 1. *Anaxyrus punctatus.* This image is licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license.

Anaxyrus punctatus (Baird and Girard, 1852) (Fig. 1) occurs from southern Nevada to parts of Kansas, Colorado, Oklahoma, Texas, California, and southward into Mexico (Dodd 2023). The biology of *A. punctatus* is summarized in Korky (1999).

Atretic follicles were noted in the ovaries of 11/13 (85 %) of the *A. punctatus* females. In early atresia the granulosa layer is slightly enlarged and contains ingested yolk granules. In late atresia the oocytes of these females are replaced by brownish vacuolated granulosa cells which invaded the lumen of the oocyte or solid black pigment containing cells. Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzábal 2009). It is common in the amphibian ovary (Saidapur 1978) and is the spontaneous digestion of a diplotene oocyte by its own hypertrophied and phagocytic granulosa cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmańska 2009b). See Saidapur and Nadkarni (1973) and Ogielska et al. (2010) for detailed descriptions of

Table 1. Two monthly stages in the spawning cycle of 13 adult female *A. punctatus* from Oklahoma.

Month	*n*	(1) "Ready to Spawn Condition"	(2) "Vitellogenic Condition"
April	4	4	0
May	5	5	0
June	2	2	0
July	1	0	1
September	1	1	0

follicular atresia in the frog ovary. Atresia plays an important role in fecundity by influencing numbers of ovulated oocytes (Uribe Aranzábal 2011). The causes of follicular atresia in non–mammalian vertebrates are not fully understood although it is associated with captivity, food availability, crowding and irradiation (Saidapur 1978). In amphibians adverse environmental conditions such as starvation and suboptimal lighting may cause atresia of vitellogenic oocytes (Jørgensen 1992). Incidences of follicular atresia increase late in the reproductive period (Saidapur 1978). Saved energy will be presumably utilized during a subsequent reproduction.

Times of breeding for *A. punctatus* throughout its range are shown in Table 2. *Anaxyrus punctatus* is in breeding condition from spring into autumn which allows for reproduction during periods of precipitation. In California, *A. punctatus* does not breed if environmental condition are not favorable (Tevis 1966). *Anaxyrus punctatus* may spawn as late as September in Oklahoma (Table 1).

Acknowledgments—I thank Cameron D. Siler (OMNH) for permission to examine *A. punctatus* and Jessa L. Watters (formerly of OMNH) for facilitating the loan ZH.2021.8.

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Times of breeding for *A. punctatus* throughout its range are shown in Table 2. *Anaxyrus punctatus* is in breeding condition from spring into autumn which allows for reproduction during periods of precipitation.

Table 2. Periods of reproduction for *A. punctatus* from different locations in Mexico and the United States.

Locality	Breeding Period	Source
Aguascalientes	summer rains	Vázquez Díaz and Quintero Díaz 2005
Arizona	March	Parker 1973
Arizona	spring and summer	Murphy 2019
Arizona	spring and summer	Holycross et al. 2022
Baja California	February through November	Grismer 2002
California	March to September	Lemm 2006
California	April to September	Stebbins and McGinnis 2012
California	March to July, November	Goldberg 2016
Colorado	May through August	Hammerson 1999
Hidalgo	Summer	Ramîrez-Bautista et al. 2014
Kansas	April to September	Collins et al. 2010
No specific locality	April to September	Wright and Wright 1949
Nuevo León	Three–week period (no dates given)	Lemos Espinal et al. 2018
Oklahoma	late spring to early summer	Sievert and Sievert 2021
Sonora	March–May (Canyons) or July into September (Valleys)	Rorabaugh and Lemos-Espinal 2016
Texas	March to September	Tipton et al. 2012

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Appendix: Twenty-one *A. punctatus* from Oklahoma examined by county from the herpetology collection of the Sam Noble Museum (OMNH), University of Oklahoma, Norman, Oklahoma. **Beckham:** OMNH 30130, 30145, 35549, 40337, 40338, 41813–41815, 43386, 43388, 43390; **Blaine:** OMNH 23288; **Cimarron:** OMNH 27468; **Comanche:** OMNH: 7336, 32964, 32965, 32969; **Greer:** OMNH 40099, 40100; **Harmon:** OMNH 25830; **Murray:** OMNH 30043.

RESEARCH ARTICLE

Field Update on American Bullfrog (*Lithobates catesbeianus*) Control Measures and the Effect on Foothill Yellow-legged Frog (*Rana boylii*) Observations in Sherlock Creek, Mariposa County, California

Jeff A. Alvarez, The Wildlife Project, PO Box 188888, Sacramento, CA; *jeff@thewildlifeproject.com*

Jeff Jones, United States Bureau of Land Management, 5152 Hillsdale Circle, El Dorado Hills, CA; *jwjones@blm.gov*

Control of American Bullfrogs (*Lithobates catesbeianus*) in California, and other regions of the west, has been shown to be effective in that bullfrog populations can be controlled (Adams and Pearl 2007, Kamoroff et al. 2020, Alvarez and Wilcox in press), and control can have positive effects on native species (Doubledee et al. 2003,Witmer et al. 2015, Alvarez and Wilcox, in press). Bullfrogs eat an enormous array of prey items, including native anurans, and are reported to be a conservation concern for declining species (Bury and Whelan 1984, Adams and Pearl 2007).

With the recent listing under the Federal Endangered Species Act (ESA), populations of Foothill Yellow-legged Frogs (*Rana boylii*) are under increased attention and factors contributing to their decline are being investigated (USFWS 2021). Confounding effects that contribute to declines should be considered in a management context, and if possible, addressed. This may include hydrologic conditions, potential dumping, mining, or construction activities, and the presence of non-native predatory species (Thomson 2016). Bullfrogs are known predators of Foothill Yellow-legged Frogs (Wilcox 2017) and may contribute to their decline locally or regionally. In the context of the known feeding behavior of bullfrogs, their presence has to be considered a potentially detrimental aspect of occupied habitats.

We surveyed a 1.6 km section of Sherlock Creek, upstream of its confluence with the Merced River, in Mariposa County California, with Foothill Yellow-legged Frogs being the focal animal. This population is considered endangered under ESA (USFWS 2021). Our goal was to determine if they were extant, and if so, were factors present that might be negatively impacting their population. Our surveys included a daytime component and a nighttime component, and each survey covered the same area of creek. Recent work by Alvarez et al. (in press) has shown that nighttime surveys are far more efficient at detecting the presence and numbers of Foothill Yellow-legged Frogs, when extant.

In 2022, we conducted two day and night surveys and found six Foothill Yellow-legged Frogs present during all surveys combined. Sub-adult and adult Foothill Yellow-legged Frogs were noted. We also detected nine adult bullfrogs (no larvae or subadults) sympatric with Foothill Yellow-legged Frogs. Eight of the nine bullfrogs were lethally removed from the site and stomach contents were examined. No Foothill Yellow-legged Frogs were detected in the stomach contents of frogs removed during our survey efforts.

In 2023, we returned to the same section of the creek and conducted similar surveys in a similar method throughout the same reach of the creek. We detected an increase in Foothill Yellow-legged Frogs from 2022 and a decrease in bullfrogs. In 2023, we found 1 larva, and 175 subadult and adult Foothill Yellow-legged Frogs (Figs. 1 and 2), while we found and lethally removed five adult bullfrogs (100% of those observed; no larvae or sub-adults) sympatric with Foothill Yellow-legged Frogs, all of which were lethally removed. Moreover, bullfrogs were found only on the extreme lower reach of the section of creek we surveyed.

Surveys and control efforts to detect both Foothill Yellow-legged Frogs and bullfrogs were conducted in the same portion of the same stream course, by the same individuals, during approximately the same time of year and time of day. We observed an increase in Foothill Yellow-legged Frogs from one year to the next (i.e., 6 to 175; 2,816% increase), following removal of bullfrogs from Sherlock Creek.

We found previous reports for the site, including in 1980, when a single Foothill Yellow-legged Frog was collected (MVZ 175103), and from anecdotal reports on the site from 2015, which included only a single Foothill Yellow-legged Frog and 132 bullfrogs. Additional surveys at Sherlock Creek from 1998, 2005, and 2008-2010 did not quantify numbers consistently, but did suggest persistence of the Foothill Yellow-legged Frogs in lower numbers (7-10 individuals; BLM, unpublished data).

We acknowledge that the time frame that we conducted our work was brief, and the time for recovery of the Foothill Yellow-legged Frog may not reflect long-term trends in the population. We also acknowledge that other factors could have contributed to a suppression of bullfrogs in the creek reach, including high winter water flows or factors that were not witnessed and could not be quantified.

Our experience with bullfrog control would suggest to us something similar to that we see in other locations; bullfrogs are highly susceptible to population

With the recent listing under the Federal Endangered Species Act (ESA), populations for Foothill Yellow-legged Frogs (*Rana boylii*) are under increased attention and factors contributing to their decline are being investigated (USFWS 2021). Confounding effects that contribute to declines should be considered in a management context, and if possible, addressed.

Fig. 1. Foothill Yellow-legged Frog larva in Sherlock Creek observed during the second year of bullfrog control, in 2023, Sherlock Creek, Mariposa County, CA.

Fig. 2. One of 175 foothill Yellow-legged Frogs present at Sherlock Creek, Mariposa County, California, in 2023, following bullfrog control activities at the site.

control, and local populations crash with sustained control efforts (Alvarez and Wilcox, in press). Further, when the number of individuals is low or very low, removal of the majority or all of the bullfrogs appears to have a positive impact on the potential prey base that remains.

We share these data as a brief update on an ongoing task of reducing or eliminating bullfrogs in Sherlock Creek for the benefit of Foothill Yellow-legged Frogs. We believe that in a short time we are seeing the benefits of control on this stretch of creek and will continue our efforts. We recommend, if possible, a more systematic study be conducted to determine the effort required to create a rebound in potential prey base in bullfrog occupied systems. Until that work is conducted, we feel that lethal control can have a positive impact on this endangered species.

Acknowledgements—The U.S. Bureau of Land Management (BLM) provided access to, and data collected from, Sherlock Creek. The Bison Creek Ranch graciously supported the project by facilitating access to the creek site, for which we are grateful. We also thank Andrea Adams for her insight and input into the Foothill Yellow-legged Frog population in this area. The Wildlife Project supported the preparation of the manuscript.

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...bullfrogs are highly susceptible to population control, and local populations crash with sustained control efforts (Alvarez and Wilcox, in press). Further, when the number of individuals is low or very low, removal of the majority or all of the bullfrogs appears to have a positive impact on the potential prey base that remains.

RESEARCH ARTICLE

A Comparison of Methods to Attach External Transmitters on the Imbricate Alligator Lizard, *Barisia imbricata* (Squamata: Anguidae)

Ailed Pérez-Pérez, Dulce Carolina Nápoles-Villanueva, Edgar de la Rosa-Silva, and Oswaldo Hernández-Gallegos, Laboratorio de Herpetología, Facultad de Ciencias, Universidad Autónoma del Estado de México, Instituto Literario #100 Centro, CP 50000, Toluca, Estado de México, México; *ailed.perez.perez@gmail.com*

The use of telemetry in studies under natural conditions provides important ecological information about the behavior of animals in their environment (Naef-Daenzer et al. 2005, White and Garrott 1990). The diverse morphology of lizards, as well as their habits and habitats, require adapting the methods of attaching external transmitters to the needs of each family or species. Thus, the principal limitation of radiotelemetry is the development of a reliable and safe fixation technique (Blomquist and Hunter 2007). Different methods to attach transmitters have been used on lizards with pronounced heads, pectoral or pelvic girdles (Riley et al. 2016) such as backpacks (*Amphibolurus muricatus*, Warner and Shine 2006, *Aspidoscelis* spp., Mundo Hernández et al. 2017), neck collars and glue (*Phrynosoma cornutum*, Miller et al. 2019), backpacks and glue (*Phrynosoma coronatum*, Richmond 1998), neck collars and backpacks (*Phrynosoma mcalli*, Fisher and Muth 1995), neck collars (*Phrynosoma orbiculare*, Martinez-Nova 2019), and pelvic girdles made from monofilament (*Cyclura* spp., Knapp and Owens 2005, *Aspidoscelis sexlineata*, Buffery et al. 2012). However, these methods are not suitable for use in Anguid lizards, as these lizards have a slender and elongated body, with small limbs that in some species are completely absent; they also lack a pronounced pectoral or pelvic girdle and possess smooth ventral scales (Canseco-Márquez and Gutiérrez-Mayén 2010). As a result, Anguid lizard morphology increases the difficulty of attaching external radio-transmitters, as they can easily slide off (Riley et al. 2016). This limits the use of telemetry for studies of mobility, home range, or habitat use in natural conditions. Only three telemetry studies have been performed in the family Anguidae, where different attachment methods have been used: glue on *Abronia campbelli* (Torres-Almazán 2012), monofilaments and glue on *Abronia graminea* (Clause 2018), and tape on *Gerrhonotus infernalis* (García-Bastida et al. 2012). We tested different external methods to attach transmitters on the Imbricate Alligator Lizard (*Barisia imbricata*).

The Imbricate Alligator Lizard is a viviparous lizard endemic to Mexico, listed as “Special Protection” (Pr) under the NOM-059-SEMARNAT-2010 (SEMARNAT 2010). We captured adult individuals of *B. imbricata* from Campus El Cerrillo, Piedras Blancas, Toluca, Estado de Mexico, México, with a weight above 20 g and Snout-Vent Length (SVL) greater than 112 mm. The lizards were captured by hand and transported to the Laboratorio de Herpetología (Facultad de Ciencias, Universidad Autónoma del Estado de México), so that a radiotransmitter (Telenax TXC-006G with battery life 80 or 170 days, weight 1.8 g) with an external whip antenna (13 cm), could be attached through three distinct methods. The lizards were kept in the laboratory for 24-48 hours for observation before being released, and then monitored 2-3 times per week using a receiver (Telenax RL-TLX) and yagi antenna.

Methods to Attach Transmitters

Collar + kinesiotape—Similarly to techniques used on *Phrynosoma mcalli* (Fisher and Muth 1995) and *Tiliqua rugosa* (Price-Rees and Shine 2011), we used a rectangle 1.5 cm × 3.5 cm of kinesiotape (cotton tape with acrylic glue) on which the transmitter was affixed with a 7-10 cm of pediatric feeding tube (with nylon thread placed inside; Fig. 1a). The tape was then folded in half to cover the transmitter and the feeding tube. The device was placed around the animal’s neck, tied with a knot, and then a drop of superglue was applied. The transmitter was attached to the animal’s body/back using kinesiotape (1 cm wide and 7 cm long; Fig. 1b, 1c).

Adhesive tape + kinesiotape—Based on the technique used by García-Bastida et al. (2012) as well as Madrid-Sotelo and García-Aguayo (2008), the transmitter was attached by adhesive tape to the back of the lizards. We looped the tape to the body, and then the transmitter was glued to the back using UHU® glue. A second loop with the tape was attached to further secure the transmitter (Fig. 1d, 1e). Due to the white color of the tape, a piece of camouflage-colored kinesiotape was placed on the back to avoid attracting the attention of predators (Fig. 1f).

Sports Tape® (Ruban Hockey Tape)—We made a modification to the technique of adhesive tape + kinesiotape, using SportsTape® (gripply, tightly woven poly-cotton cloth, black in color; Fig. 1g). We looped the tape to the body, then placed the transmitter on the back. Afterwards, we applied tape again in a second loop, then added a drop of UHU® glue in between the transmitter and the tape to further secure the transmitter (Fig. 1h, 1i).

The use of telemetry in studies under natural conditions provides important ecological information about the behavior of animals in their environment (Naef-Daenzer et al. 2005, White and Garrott 1990). The diverse morphology of lizards, as well as their habits and habitats, require adapting the methods of attaching external transmitters to the needs of each family or species.

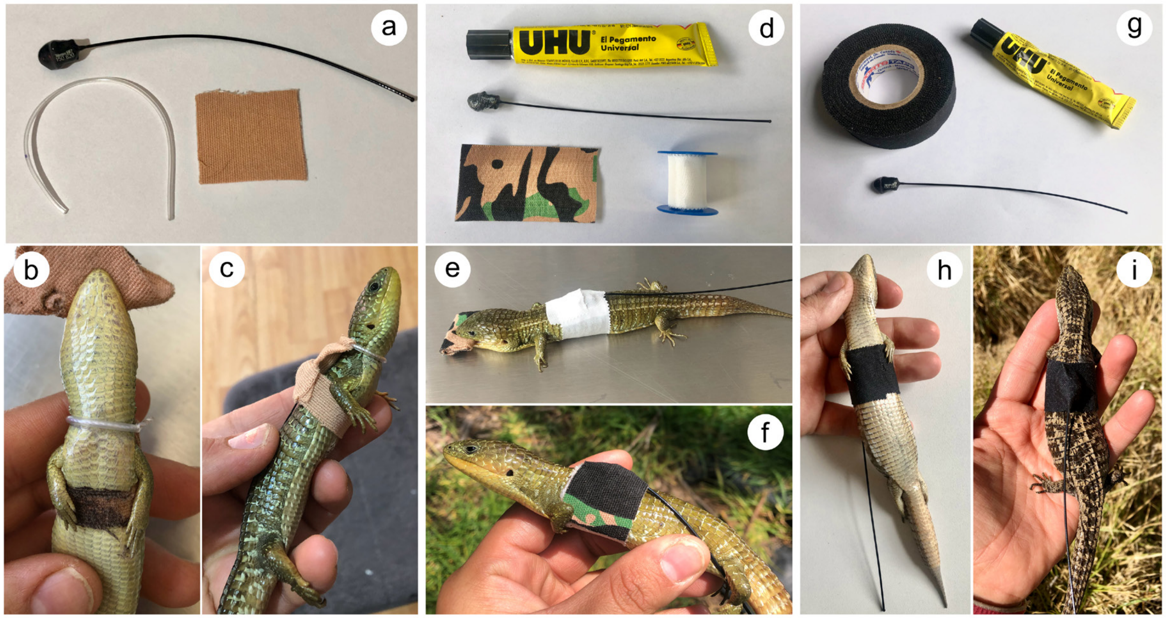

Fig. 1. Methods and materials used to attach transmitters in *Barisia imbricata*. **a)** Material used in collar + kinesiotape method, **b)** ventral view, and **c)** lateral view of collar + kinesiotape method; **d)** material used in adhesive tape + kinesiotape, **e)** lateral-dorsal view of adhesive tape with transmitter, **f)** camouflage-colored kinesiotape covering the adhesive tape, **g)** material used in Sports Tape® method, **h)** ventral view, and **i)** dorsal view using Sports Tape® (Photographs by Ailed Pérez-Pérez).

Results

Collar + kinesiotape—The average weight of the devices was 6.28% of the body weight (range 4.8-8.4% body weight). The mean time the transmitters remained attached was 6.3 days (range 4-8 days). Three lizards were equipped with this method. Once they were released in the field, two of the devices slipped off completely from the lizards, and we found only the transmitter (Fig. 2a). The other lizard was recaptured twice with the collar on its body (Fig. 2b). Each time, the device was readjusted and reattached, and the lizard released. Unfortunately, after we attempted to locate the lizard for the third time, only the transmitter was found.

Adhesive tape + kinesiotape—The average weight of these devices was 5.49% of the body weight (range 4.8-8.4% body weight). Seven lizards were equipped with this method. The mean time the transmitters remained attached was 11 days (range 1-41 days). Of the devices attached, two were found completely detached for the next search, one more was replaced before shedding, and in five of the lizards (twice for one), the tape was replaced because it became rolled up, causing some constriction in the abdomen (Fig. 2c).

Sports Tape® (Ruban Hockey Tape)—With this method, the lizards had a mean body weight gain of 7.22% (range 4.3-9.3% body weight). The average duration of the devices was 25.1 days (range 3-106 days). Thirteen lizards were equipped with this method (we employed it a total of 25 times). During the period where we employed this method, five transmitters ran out of battery, so they were not located again; three lizards had their transmitters replaced, as they had only a few days of battery life left; the tape was replaced on 4 different occasions, in different lizards, because it started to wear out or the transmitter could slip out of the tape. The transmitters of two lizards were found in the field due to shedding, and the transmitters had detached (Fig. 2d). Subsequently, we checked the onset of shedding in equipped lizards. Due to this, the tape was removed in 6 individuals, which were then transported to the laboratory and, once the shedding was complete, the tape and transmitter were reattached, and the lizards were released again. Two lizards (a male and a gravid female) were found dead in the field. We could not determine the cause of death of the male, however, when the female was dissected in the laboratory, it was found that two follicles had burst, causing the demise of the lizard. One more gravid female was predated upon, so we only located the transmitter (Fig. 2e). There are scant reports on the death of animals equipped with transmitters during scientific spatial studies. In one study, the survivorship of translocated wild-caught Texas Horned Lizards was low (Miller et al. 2019), and although the number of animals is small, it is still important to make the report, as this variable should be considered in future studies, even if the causes of death are not directly related to the use of transmitters.

Discussion

Of the techniques tested for attaching transmitters, we consider that the most appropriate for *Barisia imbricata* and the one that may be the most feasible

Of the techniques tested for attaching transmitters, we consider that the most appropriate for *Barisia imbricata* and the one that may be the most feasible for other species of the Anguidae family is the use of Sports Tape®, since it was the one that remained adhered the longest and presented the least difficulties.

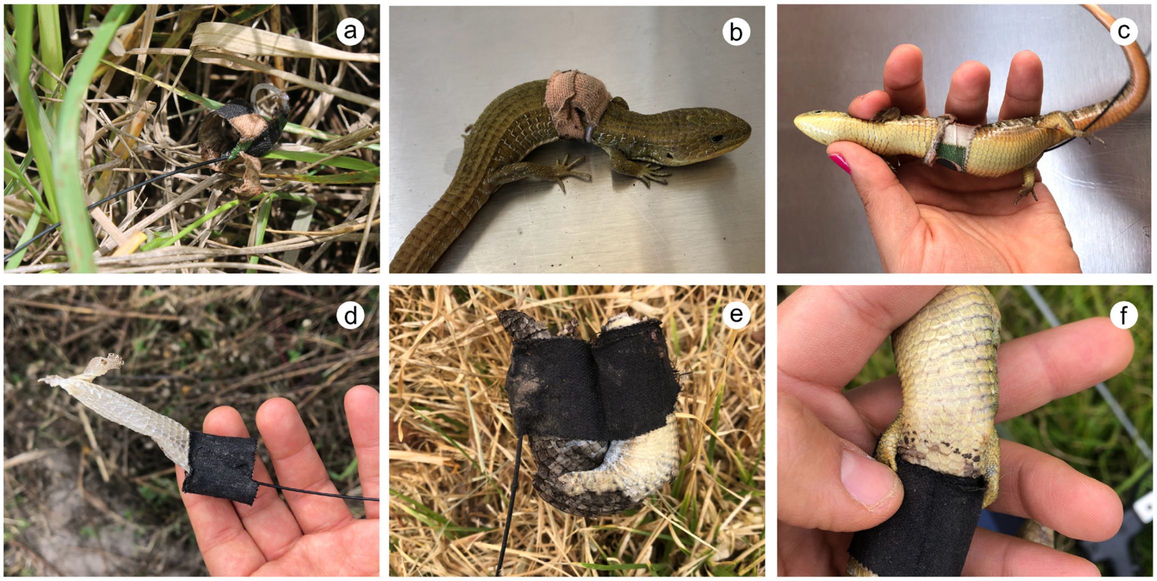

Fig. 2. Complications recorded with different transmitter attachment methods in *Barisia imbricata*. **a)** Detached transmitter found in the field, **b)** collar slipped on the abdomen, **c)** adhesive tape rolled up in the abdomen, **d)** transmitter detachment by shedding, **e)** lizard with transmitter depredated, and **f)** slight abrasions of the scales during the use on the Sports Tape® method (Photographs by Ailed Pérez-Pérez).

for other species of the Anguidae family is the use of Sports Tape®, since it was the one that remained adhered the longest and presented the least difficulties. As for the other procedures, due to the morphology of *Barisia imbricata,* the main difficulty with the collar + kinesiotape method was that the collar tube slipped into the body of the lizard, causing constriction in the abdomen.

The sampling period was carried out during a part of the rainy season, so the humidity of the environment and microhabitats contributed to the adhesive tape + kinesiotape method not remaining attached for very long, since the glue diluted. García-Bastida et al. (2012) mentioned that it can be a viable option in dry seasons, but in environments with high humidity or rain, it is not a suitable option since the risk of detachment of the devices is high. A great advantage of using Sports Tape® (Ruban Hockey Tape) is that the glue is more resistant to rain and humidity, and once the tape becomes wet and dries again, the glue does not lose adherence. This is important, as it allows for the tracking of animals without losing the transmitters due to detachment, even during the rainy season.

Due to the low weight of lizards, lightweight and short-lived transmitters must be used, so it is important to maximize sampling time (Refsnider et al. 2015) and avoid losses due to detachment; loss of devices due to shedding has been reported by Price-Rees and Shine (2011) and García-Bastida et al. (2012), so researchers must keep in mind that when using methods that stick directly to the skin, it is paramount to pay attention to the onset of shedding during sampling to minimize the loss of devices.

With the use of Sports Tape®, no issues were observed during lizard movement, though we detected slight scale abrasions in some individuals (Fig. 2f). Such minor damage, however, did not jeopardized the life of the lizards. In addition, it did not interfere with reproduction, as during the sampling, males with bites and gravid females were observed.

The average weight of the devices in the three methods used remained below that proposed by Knapp and Abarca (2009), which suggests not exceeding 7.5% of body weight in lizards. We also did not record any lizards trapped in the vegetation at any time during the sampling.

It is important to continue adapting transmitter attachment methods to the morphology and activity of the species under study. The use of telemetry in the Anguidae family involves a great challenge to keep the transmitters in place, so it is important to continue analyzing and discovering methods to use telemetry in these species, since the information obtained through telemetry can help us to improve conservation efforts in this family, via better understanding of their activity and habitat use, as little is known about these topics.

Acknowledgments—We thank Kenia Itzel Octaviano and Martin Rivera for their help in the field. We thank COMECyT for the financial support, and to the staff of the Facultad de Ciencias Agricolas de la Universidad Autónoma del Estado de México, especially Dr. Aaran Aquilino Morales Pérez.

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NATURAL HISTORY NOTE

An Additional Observation of Malformation in the Hind Limb of the Foothill Yellow-legged Frog (*Rana boylii*) in Santa Cruz County, California

Lawrence Erickson, Boulder Creek, CA; *L.erickson15260@gmail.com*

Matt Sharp Chaney, Midpeninsula Regional Open Space District, 5050 El Camino Real, Los Altos, CA; *mchaney@openspace.org*

The Foothill Yellow-legged Frog (*Rana boylii*) is a declining member of the family Ranidae, from the Pacific Coast of the United States (Patterson 2019, USFWS 2023). The species is faced with numerous compounding reasons for its decline, including an increase in invasive species invasions; habitat modification, alteration, or destruction (Thomson et al. 2015). The species has recently received an increase in investigations into its natural history, due in part to the listing of this frog as threatened in some locations and endangered in others, by both the State of California, and the United States Fish and Wildlife Service (Patterson 2019, USFWS 2023). Recent work has shown that an increase in reports of limb malformations is emerging in California. Herein we report a third observation of hind limb malformation in *R. boylii*.

At 1330 h on September 29, 2018, while conducting visual encounter surveys for population monitoring of *R. boylii* on Soquel Creek in the Soquel Demonstration State Forest, Santa Cruz County, California, USA (37.08673° N, 121.904712° W, WGS84, 220 m asl) we were walking along Soquel Creek counting *R. boylii* observations. We frequently encountered *R. boylii*, with adults and post-metamorphic frogs numbering approximately 35 individuals. While one of us (MSC) was attempting to take a close up *in-situ* photograph of a post-metamorphic *R. boylii* we noted that the frog made no attempt to flee, and at that point noticed the right rear leg was markedly smaller than the left. We picked up the frog for closer evaluation, and it still made no attempt to escape. The reduced sized limb did appear fully formed and likely functional (Fig. 1), and we did not note any difficulty with ambulation.

Reports of malformations in *R. boylii* have been few. Kupferberg et al. (2009) reported a malformation they believed was attributed to a parasitic copepod. Two additional reports from Alvarez et al. (2021) and Alvarez et al. (2024) reported a rear limb malformation in two *R. boylii* three years apart, but in the same stream system. Our report, from 172 km south, suggests that this type of malformation may be more widespread than previously reported.

Like those observations of Alvarez et al. (2021, 2024), we were not able to determine the cause of the malformation. Our direct observations suggest that this malformation limited natural movement, possibly decreasing the ability of the individual to avoid predation. We suggest that the increasing reports of malformations in *R. boylii* may be an additional stressor in a declining species, and should be investigated further.

Acknowledgments—We are grateful to Angela Bernheisel, Forest Manager of the Soquel Demonstration State Forest for her support with this work and to the California Department of Fish and Wildlife and Laura Patterson for the permit and MOU required to conduct this work (CDFW Scientific Collecting Permit SC-11505). We would also like to thank Jeff A. Alvarez for his guidance and assistance with documenting this observation, and for review of this manuscript.

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The Foothill Yellow-legged Frog (*Rana boylii*) is a declining member of the family Ranidae, from the Pacific Coast of the United States (Patterson 2019, USFWS 2023). The species is faced with numerous confounding reasons for its decline, including an increase in invasive species invasions; habitat modification, alteration, or destruction (Thomson et al. 2015).

Fig. 1. Post-metamorphic *Rana boylii* found on Soquel Creek, Sant Cruz County, CA, with a right rear limb malformation.

NATURAL HISTORY NOTE

Atypical Timing and Placement of Egg Masses by Foothill Yellow-legged Frogs (*Rana boylii*) Baird 1854

Jeffery T. Wilcox, Sonoma Mountain Ranch Preservation Foundation, 3124 Sonoma Mountain Road, Petaluma, CA; *jtwilcox@comcast.net*

Anna L. Erway, Department of Biology, Sonoma State University, Rohnert Park, CA; *annaerway@yahoo.com*

The Foothill Yellow-legged Frog (*Rana boylii*) is a stream obligate (but see Alvarez and Wilcox 2021) native to the coastal mountains of California and Oregon, where its range extends north into the Willamette Valley, and also east to the Sierra Nevada foothills of California (Storer 1925). *Rana boylii* are considered lek breeders; males arrive early at lekking sites to defend territories (Wheeler and Welsh 2008), with oviposition usually occurring between late March and early June (Storer 1925). Egg masses are traditionally attached to cobble or boulders substrates peripheral to the main stream channel in areas with slightly flowing water, although silt, sand, gravel, pebbles, and wood have also been observed as oviposition substrates (Fuller and Lind 1991, Wheeler and Welsh, van Hattem et al. 2021). As biphasic amphibians, *R. boylii* are compelled to time their larval stage to take advantage of the spring flush of algal growth brought on by lengthening daylight (Wassersug 1975, Wilbur 1980), yet not so early that rain-induced high flows scour egg masses from their attachment points (Mount 1995). Thus, *R. boylii* usually return to the same lekking areas (Kupferberg 1996), annually, after winter rains have diminished but flows are sufficiently high to support developing eggs and larvae through mid-summer (Storer 1925, Stebbins 1951, Zweifel 1955, Kupferberg 1996). Herein we report a case of oviposition conditions previously undescribed for *R. boylii*.

On the afternoon of 7 June 2021, the authors were working in the headwaters of Copeland Creek on the Mitsui Ranch Preserve in Sonoma County, California (38.331060 N, -122.577012 W, WGS 1984), when they detected three (*Rana boylii*) egg masses in an isolated pool. Drought conditions had diminished Copeland Creek to the point where few remaining pools had surface flow connecting them. West Pool was a slender, oblong depression that measured approximately 4 m long and nearly 1 m at its greatest width (Fig. 1). The pool was scoured into the south side of the channel against a precipitous bank. The south bank at West Pool is held to a near-vertical slope by the well-developed root system of a California bay-laurel (*Umbellularia californica*) tree, which is deeply undercut near the west (terminal) end of the pool. The three egg masses were attached to free-floating woody debris at the top of the water column where maximum channel depths were 9 cm, 10 cm, and 25 cm, respectively, from upstream to downstream (Fig. 2). The wood to which the egg masses were attached

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Fig. 1. Conditions of west pool during the time of observation. A stump is visible, at upper right, where the local power company cut two trees, creating a western exposure for sunlight on West Pool in Copeland Creek, Sonoma County, California. Photo by J. T. Wilcox.

Fig. 2. White pin flags mark the locations of three Foothill Yellow-legged Frog (*Rana boylii*) egg masses; two smaller masses are at the left flag and the larger one if at the right flag. Copeland Creek, Sonoma County, California. Photo by J.T. Wilcox.

Fig. 3. Hatching egg mass of a Foothill Yellow-legged Frog (*Rana boylii*) in Copeland Creek, Sonoma County, California, on 7 June 2021. Note the embryos clinging to the mass on the lower left. Photo by J.T. Wilcox.

was comprised of small, branched tree limbs > 2.54 cm in diameter. The two smallest egg masses were half the size of the third (more typical in size) and were located at shallower depths at the top of the pool. These two smaller egg masses were more advanced in development as indicated by hatched larvae that were closely associated with the outer margins of hatched egg capsules (Fig. 3). The larger egg mass was in a much earlier stage of development (Gosner stages 14-15). Some of the embryos on the outside of this mass were opaquely white, indicating they may have been unfertilized, or parasitized by fungus (Fig. 4).

In several ways, the oviposition sites we observed at West Pool do not conform to typical sites previously described for *R. boylii*. While categorizing key microhabitat components of oviposition sites, Lind et al. (2016) found that only 1% of egg masses were oviposited in mid-channel pools, and 1% of egg masses were oviposited in water with no flow. We noted that suitable (more typical) cobble substrate was available at the bottom of West Pool but was not used for oviposition at this time. *Rana boylii* egg masses have previously been observed attached to logs, but the percentage of egg masses reported attached to logs is very small: 1% reported in Fuller and Lind (1991), and 4% reported in Lind et al. (2016). Further, logs are a more permanent, solid substrate compared to very small, free-floating branches used in this observation.

We believe that rapid changes due to extreme drought conditions greatly influenced the site and timing of oviposition by *R. boylii*. Within Copeland Creek, the only previously known lekking ground was 200 m upstream in a series of runs, glides, and pools (Alvarez and Wilcox 2019); a reach of the creek with almost no canopy cover. The creek has been intensively surveyed over the past 11 breeding seasons (Rose et al. 2023) and no egg masses had ever been observed outside of the lekking area described above. However, extreme drought eliminated the option for ovipositing in the traditional lekking ground for *R. boylii* because this section completely dried in early April, before breeding occurred. At least three times, during weekly surveys, we observed amplexed *R. boylii* pairs progressively retreating downstream as stream pools dried.

Rana boylii prefers an open canopy for lekking (Zweifel 1955, Lind et al. 1996, Van Hattem et al. 2021). By the time of our observation, the reach of Copeland Creek contained within the Mitsui Ranch Preserve was reduced by drought to only four remaining pools with no measurable flow between them, and West Pool had the only open canopy. By approximately 1500 hrs, on the day of our observation, the sun reached the relatively open canopy of the western side and the pool was receiving full afternoon insolation.

Our observation suggests extreme drought may elicit an unusual response in breeding site choice

We believe that rapid changes due to extreme drought conditions greatly influenced the site and timing of oviposition by *R. boylii*.

Fig. 4. Irregularly-shaped Foothill Yellow-legged Frog (*Rana boylii*) egg mass attached to a floating stick over the deepest point in the center of the pool, at West Pool, Copeland Creek, Sonoma County, California on 7 June 2021. Photo by J.T. Wilcox.

and the timing of oviposition. Drought appears to have forced *R. boylii* to shift to a novel downstream oviposition site in Copeland Creek, resulting in oviposition at least 3 weeks later than any time recorded in the previous 12 years (J. Wilcox, unpubl. data), which is contrary to other observations from pond-breeding amphibians under prolonged drought on the same site. Wilcox et al. (2017) observed that drought conditions resulted in earlier breeding for California Newt (*Taricha torosa*) in a northern California pond, but rains arrived early that year and it appeared that *T. torosa* had the behavioral plasticity to take advantage of early rains. In this case, multiple *R. boylii* facultatively oviposited in an atypical setting in rapidly deteriorating, drought-induced conditions. In addition, each of the three females chose to attach egg masses to small floating woody debris at the top of the water column. We speculate that females may have chosen the best opportunity for sunlight exposure for the developing embryos, and perhaps where oxygen exchange was greatest due to surface mixing from wind disturbance on the pool surface. West Pool was completely dry within a week of our observation and all larvae perished. *Rana boylii* normally oviposit in quieter places after winter rains have peaked and flooding is less of a risk (Zweifel 1955). However, in an ephemeral stream such as Copeland Creek, delayed oviposition becomes an increasing risk in the face of stream flows ceasing all together. Many female amphibians commence atresia (phagocytic digestion of oocytes) when conditions become poor, presumably shunting much needed energy toward surviving harsh conditions (Ogielska and Bartmańska 2004). Since body size is correlated to the number of eggs in a clutch, young females of small body size may explain the small size of the masses we observed (Ogielska and Bartmańska 2004). Perhaps the naïveté of young *R. boylii* and the strong drive to reproduce overrides the message to conserve energy when confronted with extremes.

Acknowledgments—We are grateful to J. Alvarez for constructive comments on the manuscript, and to the Sonoma Mountain Ranch Preservation Foundation for access to the Mitsui Ranch Preserve and Copeland Creek.

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NATURAL HISTORY NOTE

Long-nosed Leopard Lizard (*Gambelia wislizenii*), Regal Horned Lizard (*Phrynosoma solare*), and other items in the diet of the Chihuahuan Raven (*Corvus cryptoleucus*) in Cochise County, Arizona

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

The Chihuahuan Raven (*Corvus cryptoleucus*) is commonly encountered in desert grasslands and desertscrub in southeastern Arizona, from the New Mexico border west to the Sonoita and San Rafael valleys, and occasionally as far west as western Pima Co. It is intermediate in size between the Common Raven (*Corvus corax*) and American Crow (*Corvus brachyrhychos*) and is best distinguished from them by snowy white base feathers on the neck (Wise-Gervais 2005, Stejskal and Rosenberg 2015). The Chihuahuan Raven is a generalist omnivore; a wide variety of plant and animal material compose the diet (Bailey 1928, Aldous 1942, Dwyer et al. 2020).

By far the most detailed study of the diet of the Chihuahuan Raven was conducted by Aldous (1942), who identified 288 different food items, including 214 animal and 74 plant taxa in 827 Chihuahuan Raven stomachs, mostly from Texas (his sample included 10 adults from Arizona). About half (49.67%) the food of the adult Chihuahuan Raven was composed of an assortment of animal matter, including earthworms, spiders and scorpions, centipedes and millepedes, insects, snails, amphibians, reptiles, birds and bird eggs, and mammals, chiefly carrion. Of the plants in the diet, grain sorghums were the most important and made up more than a fourth of the adult birds' diet by volume. A variety of other cultivated crops were found in the stomachs of Chihuahuan Ravens. Wild fruits (particularly prickly pear [*Opuntia* sp.] hackberry [*Celtis* sp.], and buckthorn [*Condalia* sp.]) are consumed in large quantities during the summer and early fall (Imler 1939, Aldous 1942, Oberholser 1974).

In the study by Aldous (1942), reptiles, amphibians, and fishes together made up only slightly more than 1 percent of the food of the adult Chihuahuan Ravens, but they occurred in almost 10 percent of the stomachs. In this group, reptiles, including lizards, snakes, and turtles, predominated, and of the reptiles, lizards were taken most frequently. The Texas Horned Lizard (*Phrynosoma cornutum*) was the most common lizard in the diet (from 5 stomachs). Sherbrooke (2003) noted that Chihuahuan Ravens often capture Texas Horned Lizards that they feed to their young in the nest. Earless Lizard (*Holbrookia* sp.) was found in 3 stomachs. Other lizards noted, and

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Fig. 1. Chihuahuan Raven (*Corvus cryptoleucus*) with Regal Horned Lizard (*Phrynosoma solare*).

only from one stomach each, included Anole (*Anolis* sp.), Long-nosed Leopard Lizard ("*Crotaphytus*" [= *Gambelia*] *wislizenii*), and Fence Lizard (*Sceloporus* "*undulatus*"); however, 52 lizards could not be identified to species. Lizards identified by Aldous (1942) as *Sceloporus undulatus* were likely either *S. cowlesi* or *S. consobrinus*, based on the distribution of those species and the Chihuahuan Raven and where Aldous did most of this work (Texas). The collection locations of the stomachs containing lizards were not presented, although most were from Texas.

Trail cameras or camera traps are battery-operated remote cameras, most of which use a passive infrared sensor to trigger the camera based on a differential in heat and motion between a subject and the background. They are designed mostly for medium to large mammals and are used primarily by hunters, wildlife enthusiasts, and researchers to capture images of mammals. Their design makes them less useful for monitoring amphibians and reptiles, but they have been valuable in capturing images of mammals and birds preying upon reptiles (Rorabaugh and Van Devender 2020).

I have maintained trail cameras on my property in Cochise Co., AZ (about 8 km NE of Saint David), since 2010. I frequently capture images of Chihuahuan Ravens, and at my wildlife water, they often bring in food items that they sometimes wash off in the water or they drink water after consuming a food item. Precise identification of food items is usually not possible, but I have captured images of Chihuahuan Ravens with the following items in their beaks: a corn cob, berries of Desert Sumac (*Rhus microphylla*), chunks of meat (likely roadkill), a small Desert Cottontail (*Sylvilagus audubonii*), Merriam Kangaroo Rat (*Dipodomys merriami*), other small mammals, small birds (mostly nestlings), a bird egg, lizards, and various items (discarded tortillas, etc.) from my compost pile.

I have, on numerous occasions, obtained trail camera images of Chihuahuan Ravens with horned lizards in their beaks (e.g., Fig. 1). For most of those, identification to species was not possible; however, on 12 July 2023 at 1108 hrs, I obtained a photo of a Chihuahuan Raven with a horned lizard in its beak that I tentatively identified as a Regal Horned Lizard (*Phrynosoma solare*) based on the arrangement of cranial horns. In June 2019, I captured an image of a Chihuahuan Raven with a Texas Horned Lizard in its beak (Fig. 2). The same month, I obtained a photo of a spiny lizard (*Sceloporus clarkii* or *S. magister*) in the beak of a Chihuahuan Raven. The horned lizard images are interesting in that I rarely see horned lizards on my property and I have only observed Regal Horned Lizards (see Rorabaugh 2017) on my land, although I have found Texas Horned Lizards as close as 1.2 km to the west. In May 2022 on Sibyl Road, about 7.7 km WSW of my property, I observed a Chihuahuan Raven take a Regal Horned Lizard off the pavement in front of me.

On 7 June 2024 at 0717 hrs, the trail camera at my wildlife water captured a Chihuahuan Raven with a juvenile Long-nosed Leopard Lizard in its beak (Fig. 3). I rarely observe Leopard Lizards on my property or in the surrounding area (Rorabaugh 2017). Based on my perusal of *Herpetological Review* and *Sonoran Herpetologist* natural history notes and other sources, this represents the only definitive observation of predation of a Long-nosed Leopard Lizard by a Chihuahuan Raven in Arizona, and the first observations of predation by that raven on Regal Horned Lizards.

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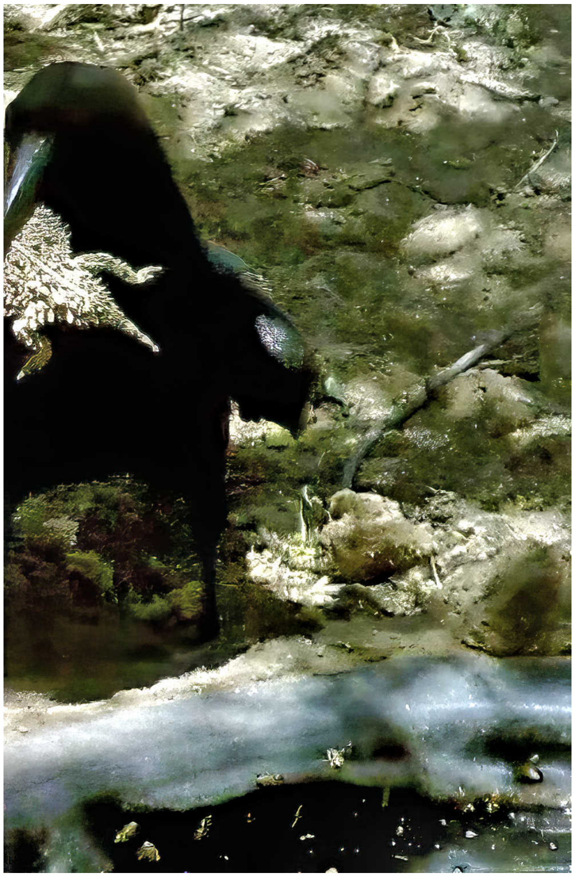

Fig. 2. Chihuahuan Raven (*Corvus cryptoleucus*) with Texas Horned Lizard (*Phrynosoma cornutum*).

Fig. 3. Chihuahuan Raven (*Corvus cryptoleucus*) with Long-nosed Leopard Lizard (*Gambelia wislizenii*).

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NATURAL HISTORY NOTE

First Record of Bifurcated Tail in *Ambystoma velasci* (Caudata: Ambystomatidae) within an Agroecosystem in Central Mexico

Emiliano Hernández -Jiménez, Alan Isaac Olvera-Mendoza, César A. Díaz-Marín*, and Aurelio Ramírez-Bautista, Laboratorio de Ecología del Paisaje y Ordenamiento Ambiental, Centro de Investigaciones Biológicas, Instituto de Ciencias Básicas e Ingeniería, Universidad Autónoma del Estado de Hidalgo, km 4.5 carretera Pachuca-Tulancingo, Mineral de la Reforma, Hidalgo, 42184, Mexico; **cesaardm@hotmail.com*

Although malformations are a quite common phenomenon in amphibians, great concern exists about their current increased incidence across populations of this vertebrate group. Different studies have pointed out that these anomalies may occur for multiple causes, including contamination of water (by heavy metal or fertilizers), habitat alteration, ultraviolet radiation (Pahkala et al. 2001), genotype, and infectious diseases by parasitism (Johnson et al. 2006). According to Lajmanovich et al. (2012), exposure to high concentrations of agrochemicals and heavy metals could promote malformations in the larval stages of amphibian species, specifically, duplication and bifurcation of tails in many cases (Pahkala et al. 2001).

Several studies have found different kinds of malformations in Mexican ambystomatids, the Plateau Tiger Salamander (*Ambystoma velasci*) is an endemic species of Mexico, occurring from the northern region (in the states of Chihuahua, Nuevo León, Colima, Querétaro, and San Luis Potosi) to the central part of the country (in the states of Hidalgo, Morelos, Puebla, Estado de México, and Tlaxcala; Smith and Taylor 1966, Ramírez-Bautista et al. 2014). In Hidalgo, this species inhabits permanent or temporal bodies of water in pine and pine-oak forests, as well as xeric scrublands in the municipalities of Acaxochitlán, Mineral del Chico, Cuautepec de Hinojosa, and Tepeapulco (Ramírez-Bautista et al. 2014). It is an insectivorous species, but there is evidence of cannibalism (Vite-Silva et al. 2009, Cruz-Hernández 2013). So far, ectrodactyly, brachydactyly, and increased number of toes (polydactly) are some of the malformations reported in *A. velasci* from agroecosystems in Querétaro (Cruz-Pérez et al. 2009).

On 9 September 2022, during a field sampling to determine the conservation status of *A. velasci* within a pine forest, we captured a juvenile salamander using a trawl net in a cattle pond within the locality of Cantarranas, municipality of Singuilucan, Hidalgo, Mexico (Fig. 1A, 19°59’12”N, 98°21’53”W, elev. 2623 m). Once captured, the snout-vent length (SVL) and tail length (TL) of the individual were measured with a digital caliper (± 0.001 mm), and body mass (BM) was registered using spring balance (± 0.25 gr). We determined that this juvenile (SVL: 74.46 mm, BM: 18.1 g) had a regenerated tail because it was abnormally short (33.40 mm), compared to the mean TL of others within the population (65.32 mm, *n* = 35). Additionally, it had an extra appendage in the middle zone of its tail, similar to a fin (Fig. 1B), which could represent the first record of bifurcated tail in *A. velasci*.

The use of agrochemicals is one of the potential causes of these kinds of malformations because the body of water where this individual was found is partially surrounded by agroecosystems, where some compounds might be filtering, and consequently, cause mutagenic effects on the morphology of this population of *A. velasci*, similar to other amphibian species (Lajmanovich et al. 2012). Additionally, tail loss may be related to a predation attempt by other vertebrate species or a conspecific, although aggressive interactions are rare in salamanders; however, there are records of cannibalism in this species (Vite-Silva et al. 2009). Finally, we considered that further monitoring of amphibian populations, like *A. velasci*, is necessary to assess the incidence of malformations and the potential environmental indicators that promote them, as well as to determine whether these morphological anomalies might influence the survivorship and reproduction of individuals.

According to Lajmanovich et al. (2012), exposure to high concentrations of agrochemicals and heavy metals could promote malformations in the larval stages of amphibian species, specifically, duplication and bifurcation of tails in many cases (Pahkala et al. 2001).

Acknowledgments—We thank the landowners and Telésforo Emiliano Vera for giving permission to access their land. We are also grateful to Joel Hernández and Ariadna Jiménez for providing accommodation and assistance during fieldwork. Fieldwork was conducted under collecting permits SGPA/DGVS/00959/22 and SGPA/DGVS/02608/22 issued by Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). This study was conducted according to the ethics and regulations for animal research of the Universidad Autónoma del Estado de Hidalgo and the national Mexican law NOM-051-ZOO-1995 (Norma Oficial Mexicana NOM-051-ZOO, 1995).

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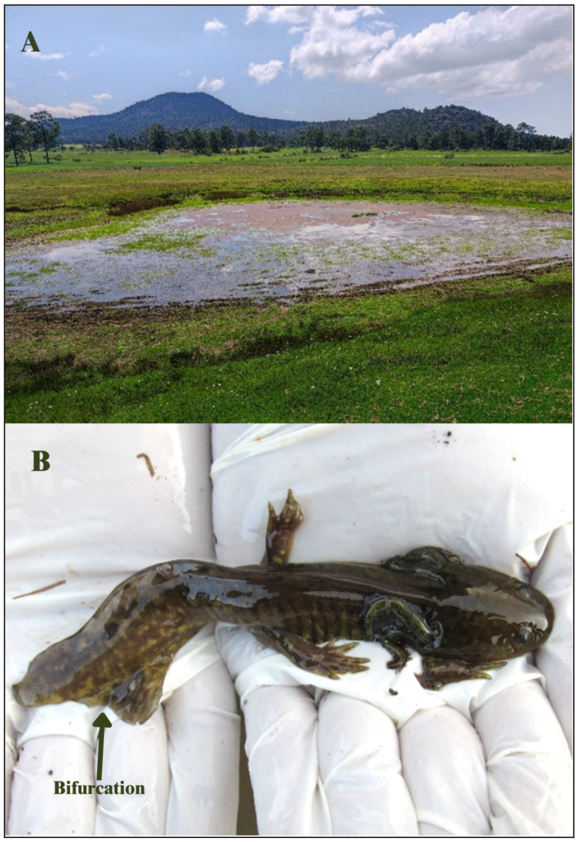

Fig. 1. Pond in the locality of Cantarranas within the municipality of Singuilucan, Hidalgo, Mexico **(A)**, where the juvenile Plateau Tiger Salamander (*A. velasci*) with bifurcated tail was captured **(B)**.

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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 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 Margaret Fusari, Treasurer, at *tucsonherps@gmail.com*.

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NATURAL HISTORY NOTE

A Case of Morphological Anomaly in the Pacific Tree Lizard, *Urosaurus bicarinatus* (Squamata: Phrynosomatidae), in Northwestern Mexico

Alvaro Monter-Pozos, Investigador independiente, Benito Juárez 77510, Quintana Roo, México

Héctor Alexis Castro-Bastidas, Posgrado en Ciencias Aplicadas al Aprovechamiento de los Recursos Naturales, Centro de Estudios "Justo Sierra" (CEJUS), Badiraguato 80600, Sinaloa, México; *salamander@cejus.edu.mx*

Morphological anomalies in reptiles, such as limb malformations, represent an important field of study due to their frequent occurrence in various species and their potential impact on the fitness and survival of affected individuals (Gleed-Owen 2012, Gkourtsouli-Antoniadou et al. 2017, Kolenda et al. 2017, Christopoulos and Pafilis 2020, Mora et al. 2020). It is suggested that morphological anomalies in reptiles have both genetic and environmental origins, reflecting the complex interaction between genetic predisposition and environmental factors during embryonic development (Rothschild et al. 2012, Kolenda et al. 2017, Christopoulos and Pafilis 2020).

In lizards, limb morphology is closely linked to the use of different habitats and microhabitats, reflecting both the conservation of ancestral traits and genetic variability among species (Vitt et al. 1997, Melville and Swain 2000, Herrel et al. 2002). This morphology also shows a positive correlation with locomotion ability, thereby influencing hierarchical position within the population (Robson and Miles 2000), suggesting greater selective pressure on limb morphology in males compared to females (Herrel et al. 2002). Consequently, any anomalies in these structures could impose a significant cost on the overall adaptive capacity of individuals (Gkourtsouli-Antoniadou et al. 2017).

The Pacific Tree Lizard (*Urosaurus bicarinatus*) is endemic to Mexico, with individuals reaching a Snout-Vent Length of 46 to 50 mm, and its distribution ranges from the state of Sonora to Michoacán (Smith and Taylor 1966). This small lizard exhibits notable adaptations to various habitat types, including dry tropical forests and xeric shrublands throughout its range (Ramírez-Bautista 1994, Hernández-Salinas et al. 2013). Despite its wide distribution and relative abundance within its range, no cases of morphological anomalies have been reported in this species to date. Here, we present the first documented case of a morphological anomaly in one of the hind limbs of a Pacific Tree Lizard.

On 10 July 2024, at approximately 0700 h, we found a *U. bicarinatus* of unidentified sex (Fig. 1A

It is suggested that morphological anomalies in reptiles have both genetic and environmental origins, reflecting the complex interaction between genetic predisposition and environmental factors during embryonic development...

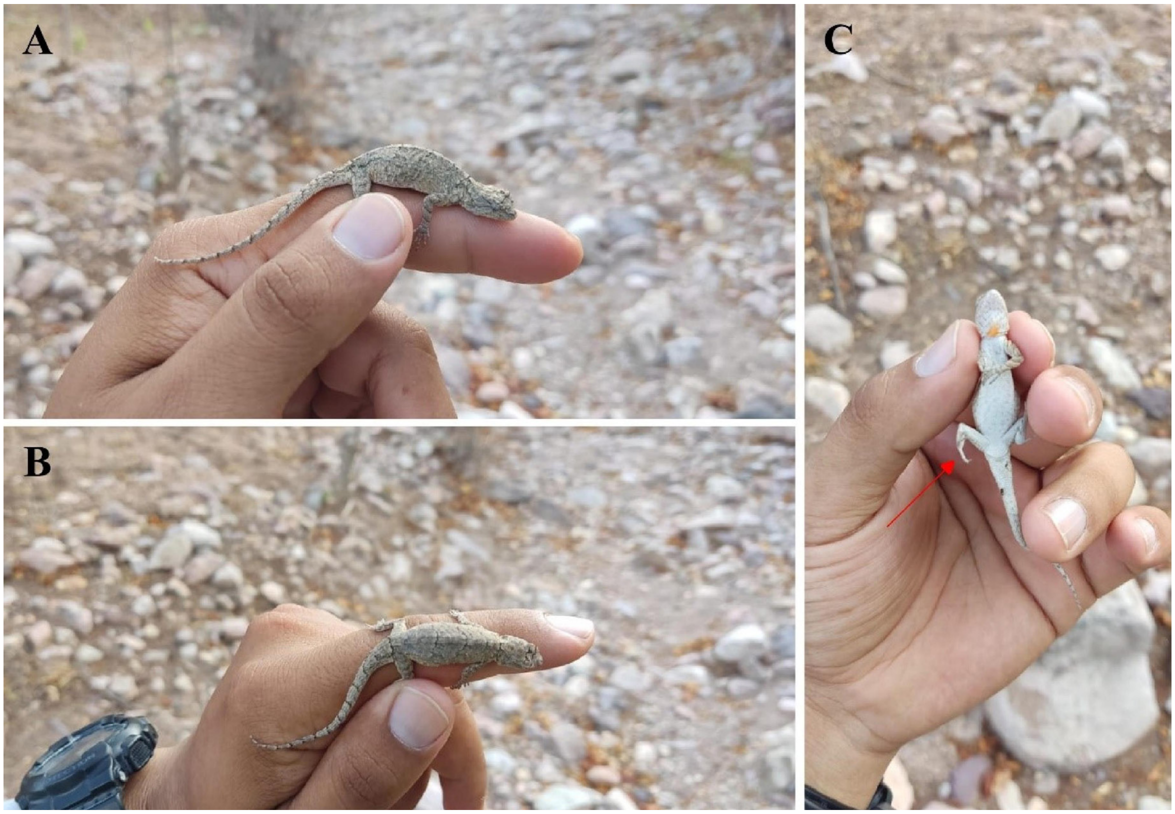

Fig. 1. A) Pacific Tree Lizard (*Urosaurus bicarinatus*); **B)** dorsal view of the individual; and **C)** demonstration of the morphological anomaly in the right hind limb. Photographs by Alvaro Monter-Pozos.

and B) 5 km southeast of San Blas, El Fuerte, Sinaloa, Mexico (26°04'08.79"N, 108°42'49.54"W, 91 m a.s.l.). The individual was found on the ground among leaf litter at the edge of a stream surrounded by scrubland. We photographed the individual and released it at the same location where it was found. This *U. bicarinatus* individual exhibited a partially underdeveloped right hind limb (Fig. C); the foot was present but lacked defined toe articulations. These limb characteristics suggest that this case could be a combination of ectrodactyly and syndactyly (Rothschild et al. 2012). Ectrodactyly would account for the absence of some toes, while syndactyly would explain the possible fusion of the toes. Releasing the individual in the field precluded further examinations.

Previous studies on different lizard species have identified two primary causes for limb anomalies: injuries during predation attempts and malformations during embryonic development (Raynaud 1990, Mora et al. 2020). Predators of phrynosomatid lizards are quite diverse and include mammals, birds, and snakes (Arnaud et al. 1993, Sherbrooke 2003, Ramírez-Bautista et al. 2016, Lemos-Espinal and Smith 2021). Particularly, snakes tend to attack and swallow their prey headfirst, while mammals and birds may grab lizards from any part of the body, including the limbs, which could explain the absence of limbs in some individuals (Sherbrooke 2003). However, we did not observe scarring on the affected limb area, so we cannot completely rule out embryonic developmental malformations as a contributing factor.

In other lizard species, individuals with limb morphological anomalies generally retain their mobility and escape ability, although they may have limitations in specific skills such as climbing (Gleed-Owen 2012, Kolenda et al. 2017, Christopoulos and Pafilis 2020, Mora et al. 2020). The presence of this anomaly in *U. bicarinatus* underscores the importance of further studies to determine whether these cases are predominantly influenced by environmental or genetic factors in this species.

In conclusion, this first record of ectrodactyly and syndactyly in *U. bicarinatus* provides an opportunity to delve deeper into the dynamics of interaction between predation and embryonic development in the expression of morphological anomalies in lizards. Future research could significantly contribute to our understanding of how these factors influence the adaptability and survival of affected individuals.

In conclusion, this first record of ectrodactyly and syndactyly in *U. bicarinatus* provides an opportunity to delve deeper into the dynamics of interaction between predation and embryonic development in the expression of morphological anomalies in lizards.

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NATURAL HISTORY NOTE

Rare Sighting of Blanford's Rock Agama, *Psammophilus blanfordanus* (Stoliczka, 1871), in Jhargram Hill of West Bengal, India

Suman Pratihar, Pabitra Mahata, Chandan Dandapat, Department of Zoology, Sukumar Sengupta Mahavidyalaya, Keshpur College, Paschim Medinipur, West Bengal 721150, India; *pratihar_vu@redifmail.com*

The reptile fauna of India is rich with a total of 572 species of which over 50% are endemic, and among them, 56 species belong to the family Agamidae (Aengals et al. 2018). Blanford's Rock Agama (*Psammophilus blanfordanus*) was first described by Stoliczka (1871), as *Charasia blanfordana*, on the basis of a few specimens collected from Central India, without any specific locality mentioned. This species was named after William Thomas Blanford (1832-1905), member of the Geological Survey of India. The common name 'rock-agama' suggests exclusive rock-dwelling habits but they are also found on tree trunks.

Blanford's Rock Agama is a species of lizard in the family Agamidae. The species is endemic to Peninsular India, and is one of two species in the genus *Psammophilus*. *P. blanfordanus* is distributed primarily to the east of the distribution of *P. dorsalis*. Unlike the other species, *P. blanfordanus* breeding males have a red body color restricted to the head and lacks the broad dorsal stripe. During the breeding season, males possess a dark, thick black stripe running from nostril to eyes, and then posterior above the tympanum to the shoulders. Females remain dull and cryptic grey in color. Diet is composed of all kinds of insects and arthropods.

In India the distribution is recorded in Gujarat, Bihar, Odisha, Central Provinces, Eastern Ghats, Travancore south to Trivandrum, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Kerala, and West Bengal state. A record from West Bengal (Pal et al. 2012) is tentatively regarded as a misidentified *P. blanfordanus*, since it is far from the nearest known other localities of *P. dorsalis*, but within the range of *P. blanfordanus*.

Jhargram is located at 22.45°N, 86.98°E, and has an average elevation of 81 m (265 ft). The district is part of the Chota Nagpur Plateau which gradually slopes down towards the east; hilly terrain occurs in the northwestern part of the district. The Kakrajhore area has the highest elevation of about 300 m. This area is covered with unfertile hard lateritic soil and rock. The weather, like much of Bengal, is extremely humid and tropical. Temperatures can reach as high as 46 °C (115 °F) in the hot and dry in summer months but can plummet to 8 °C (46 °F) in the chilly nights of December and January. During our survey we found many lizards including fan-throated lizards (*Sitana*)and

The reptile fauna of India is rich with a total of 572 species of which over 50% are endemic, and among them, 56 species belong to the family Agamidae (Aengals et al. 2018).

Fig. 1. Representative habitat at Jhargram Hill. Photo by the authors.

forest lizards (*Calotes*). But in our survey area (Fig. 1; 22°039'58"N, 86°041'37"E) we found a high density of agama lizards. We found adult males and females along with sub-adults for both sexes (Fig. 2A-D).We found this species in rocky deciduous forest habitat with large rocks and boulders mixed with vegetation.

Identification

Body dorso-ventrally flattened head comparatively large and set off from rest part of the body. Male larger than female; scale uniform and keeled. Juveniles and female are brown and grayish brown with dark brown patches, which excellently camouflage well with their surroundings. Juvenile appears just after the monsoon.

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Fig. 2A. Male Blanford's Rock Agama (*Psammophilus blanfordanus*); **B.** Sub-adult Blanford's Rock Agama; and **C and D.** Female Blanford's Rock Agama. All photos by the authors.

...in our survey area (22°039'58"N, 86°041'37"E) we found a high density of agama lizards. We found adult males and females along with sub-adults for both sexes.

FEATURE ARTICLE

Diploid Parthenogenetic Common Checkered Whiptail (*Aspidoscelis tesselatus*): Observations on the Species in Cimarron County in Extreme Western Oklahoma

Gavin H. Caldwell, Department of Natural Sciences, Northeastern State University, 611 North Grand Avenue, Tahlequah, OK; *caldwelg@nsuok.edu*

Billy E. Cantrell, Jr., Department of Natural Sciences, Northeastern State University, 611 North Grand Avenue, Tahlequah, OK; *cantre16@nsuok.edu*

Mark A. Paulissen, Department of Natural Sciences, Northeastern State University, 611 North Grand Avenue, Tahlequah, OK; *paulissen@nsuok.edu*

James E. Cordes, Division of Arts and Sciences, Louisiana State University Eunice, Eunice, LA; *jcordes@lsue.edu*

Greg Sievert, Emporia, KS; *gsievert@g.emporia.edu*

Lynnette Sievert, School of Science and Mathematics, Emporia State University, Emporia, KS; *desmoglover@gmail.com*

James M. Walker, Department of Biological Sciences, University of Arkansas, Fayetteville, AR; *jmwalker@uark.edu*

Introduction

The Common Checkered Whiptail (*Aspidoscelis tesselatus*; Say, 1823) has the most extensive natural geographic distribution among the eight diploid parthenogenetic species recognized in that genus [i.e., *A. cozumela* (Gadow, 1906), *A. maslini* (Fritts, 1969), and *A. rodecki* (McCoy and Maslin, 1962) in the *A. cozumela* species group; *A. laredoensis* (McKinney et al., 1973) and *A. preopatae* (Barley et al., 2021) in the *A. sexlineatus* group; *A. dixoni* (Scudday, 1973), *A. neomexicanus* (Lowe and Zweifel, 1952), and *A. tesselatus* (Say *in* James, 1823) in the *A. tesselatus* group]. The adaptability of *A. tesselatus* will become even more apparent in a forthcoming report by other scientists on its introduction to and establishment in habitats in California a great distance west of its natural geographic distribution area. Although Zweifel (1965) categorized the extensive color pattern variation in *Cnemidophorus* = *Aspidoscelis tesselatus* by recognition of informal pattern classes A, B, C, D, E, and F, subsequent studies have recognized A and B as belonging to the triploid parthenogenetic species *Cnemidophorus* = *Aspidoscelis neotesselatus* (Walker, Cordes, and Taylor, 1997) described by Walker et al. (1997) from southeastern Colorado and F as belonging to the diploid parthenogenetic species *Cnemidophorus* = *Aspidoscelis dixoni* (Scudday, 1973) described by Scudday (1973) from Hidalgo County, New Mexico, and arrays in Presidio County, Texas. These taxonomic reallocations of some of the pattern classes recognized by Zweifel (1965) to different species reduced the known distribution area of what we currently recognize as *A. tesselatus* by relatively small areas in Colorado, New Mexico, and Texas, USA. Walker et al. (1994), Walker et al. (1997), Cordes and Walker (2006), and Cole et al. (2007) recognized the arrays (we reserve the term population for species with males and females) of lizards in a small area of Hidalgo County, New Mexico, USA, as pattern class C of *A. dixoni*, and restricted pattern classes A and B of that species to relatively small areas in Presidio County, Texas. Two of us (JEC and JMW) have found one or more arrays of pattern classes C, D, and E of diploid *A. tesselatus* to be easily located, abundant, and readily observable at close range in a variety of habitats in parts of Colorado, New Mexico, and Texas, and Chihuahua state, México, as also indicated by Zweifel (1965), Taylor et al. (1996, 2005), Walker et al. (1997), and Taylor (2021). The only exception to the preceding statement pertains to the small geographic area of occurrence of *A. tesselatus* in Oklahoma, specifically in Cimarron County, which is the westernmost extension of the panhandle of the state. In fact, all the whiptail lizard specialists coauthoring this report (i.e., MAP, JEC, and JMW) have felt the sting of disappointment during repeated attempts to locate and study this species in the state! The total number of *A. tesselatus* pattern class C lizards observed during the many individual visits to Cimarron County by members of that group was one adult by JEC on 31 July 2015. The purpose of this report is to review what little is known about *A. tesselatus* in the state of Oklahoma and to document its current presence in the state through a series of recent observations made of this species in Cimarron County, Oklahoma.

The Common Checkered Whiptail (*Aspidoscelis tesselatus*; Say, 1823) has the most extensive natural geographic distribution among the eight diploid parthenogenetic species recognized in that genus...

Taxonomic Comments

We identified the pattern class of the Cimarron County, Oklahoma, all-female lizards based on videos, still images of lizards in the field, images of a lizard in hand, and previous examination of four preserved specimens from the Carnegie Museum with dates of collection (i.e., CM 48859-48860 collected on 10-11 June 1968, CM 93821-93822 collected on 4 August 1983). The Oklahoma array of *A. tesselatus* belongs to pattern class C of that species (*sensu* Zweifel 1965), which also naturally occurs in parts of the Texas panhandle, adjacent New Mexico, and southeastern

Fig. 1. A rocky, sparsely vegetated, and sun-drenched site resulting from human disturbances where a large (>90 mm SVL) third- or fourth-year adult of diploid parthenogenetic *Aspidoscelis tesselatus* pattern class C was observed along with three additional individuals of the species by GHC and BEC in Cimarron County, Oklahoma, on 29 July 2023. Note the camouflage effect of the dorsal pattern of the lizard.

Colorado (Zweifel 1965, Walker et al. 1997). The dorsal color pattern characteristics of individuals of *A. tesselatus* in Oklahoma includes a black dorsal ground color, retention of evidence of six cream, yellow-tan or gray primary stripes, a zig-zag cream, yellow-tan, or gray configuration in the vertebral field between the paravertebral stripes, which some scientists refer to as a vertebral or middorsal stripe, and extensive pale-hued bars connecting the irregular stripes as described by Zweifel (1965), Walker et al (1997), and shown in Figs. 1-2. Although the lizard in Fig. 1 has fragmented lateral stripes that are partly incorporated into lateral bars, the lizard in Fig. 2 has intact lateral stripes coalesced with lateral bars.

A possible source of confusion for the reader pertains to the nomenclature of the *A. tesselatus* complex, its evolutionary progenitors, and sympatric congeners. Reeder et al. (2002) accepted that *A. tesselatus* was derived from one or more hybrids between gonochoristic *A. tigris marmoratus* = *A. marmoratus marmoratus* and *A. gularis septemvittatus*. They resurrected the name *Aspidoscelis* from the synonymy of *Cnemidophorus* to partially correct paraphyly in the latter genus. Reeder et al. (2002) and Reeder and Cole (2005) considered the generic name *Aspidoscelis* to be of feminine grammatical gender. Thus, they reassigned and emended *Cnemidophorus neotesselatus to Aspidoscelis neotesselata*, *C. sexlineatus* to *A. sexlineata*, *C. tesselatus* to *A. tesselata*, *C. tigris marmoratus* to *A. tigris marmorata*, and *C. gularis septemvittatus* to *A. gularis septemvittata*. However, Tucker et al. (2016) reiterated the interpretation by Steyskal (1971) that the name *Aspidoscelis* must be treated as being of masculine grammatical gender. To quote Tucker et al. (2016): "According to ICZN (1999) Article 30.1.4.2. '…a genus-group name that is or ends in a word of common or variable gender (masculine or feminine) is to be treated as masculine unless its author, when establishing the name, stated that it is feminine or treated it as feminine in combination with an adjectival species-group name.'" "Because Fitzinger (1843: 20) did not state the gender of either name, and did not combine either name with its type species name (or any species-group name) to indicate gender, these genera must be treated as masculine." Thus, based on Tucker et al. (2016), the appropriate names are returned to *A. neotesselatus*, *A. sexlineatus*, *A. tesselatus*, *A. marmoratus marmoratus* (based on Hendricks and Dixon 1986), and *A. gularis septemvittatus* (based on Walker 1981a, b) for the taxa referenced herein.

Methods

An extensive literature search was conducted using standard search engines (primarily Google Scholar) and the Literature Cited sections of relevant articles. In addition, three separate searches for museum specimens of *A. tesselatus* in Oklahoma were conducted using VertNet. The first query used search term *Cnemidophorus tesselatus* Oklahoma, the second query used the search term *Aspidoscelis tesselata* Oklahoma, and the third query used the search term *Aspidoscelis tesselatus* Oklahoma. All three located museum specimens (see Results).

An extensive literature search was conducted using standard search engines (primarily Google Scholar) and the Literature Cited sections of relevant articles. In addition, three separate searches for museum specimens of *A. tesselatus* in Oklahoma were conducted using VertNet.

Fig. 2. Image of an unusually large (>90 mm SVL) and regal fourth- or fifth-year adult of diploid parthenogenetic *Aspidoscelis tesselatus* pattern class C photographed by anonymous as it was basking on a cement surface in downtown Kenton, Cimarron County, Oklahoma.

Field observations of *A. tesselatus* in Oklahoma were made by GHC and BEC who (inspired by completion of a herpetology course in the summer of 2023 taught by MAP) embarked on two field trips to search for amphibians and reptiles in Cimarron County during the summer of 2023. The focus of this report is an area in the immediate vicinity of Black Mesa State Park and Nature Preserve Visitor Center. Subsequently, we became aware of additional observations of *A. tesselatus* from within the small town of Kenton, Oklahoma. These are also included in this report.

Results

The first reports of *A. tesselatus* in Oklahoma were provided by Blair (1950) and Glass and Dundee (1950). The former author only mentioned collection of *Cnemidophorus grahamii* (Baird and Girard, 1852), now treated as a synonym of *A. tesselatus*, in Cimarron County. The more substantive latter reported was based on a single specimen of Common Checkered Whiptail collected on 10 August 1949, which was many years before Maslin (1962) reported that it is an all-female species. The single lizard of the species reported by Glass and Dundee (1950) was found in a pinon-juniper association in a canyon at an elevation of ca. 1341.1 m on the north side of legendary Black Mesa. Even at that time, the scarcity of the species in Cimarron County had become apparent as is indicated by the fact that it was the only individual of *A. tesselatus* observed in the area during a two-week period. However, numerous individuals of the smaller gonochoristic species *A. sexlineatus* (Six-lined Racerunner) were observed in that area over the same two-week period.

Knowledge of the status of *A. tesselatus* in Oklahoma, as well as the significance of this report, can be further understood by the following results from VertNet searches, which are universally available to internet users. The first query (*Cnemidophorus tesselatus* Oklahoma) located four specimens in the Carnegie Museum, the museum numbers for which were previously listed herein, of which two were collected in 1968 and two in 1983, the second query (*Aspidoscelis tesselata* Oklahoma) located three specimens all in the Texas Natural History Museum collected in 1958, and the third query (*Aspidoscelis tesselatus* Oklahoma) located five specimens in the Oklahoma Museum of Natural History collected in each of four years (with museum numbers) 1957 (29331), 1966 (32600), 1976 (35126-35127) and 1977 (29350). We are also aware of several additional specimens of the species in several teaching collections in Oklahoma; however, there are no substantial samples of *A. tesselatus* from Oklahoma in existence to our knowledge. Several general herpetological guides are available that include Oklahoma reptiles and briefly mention the species. The most recent of these is Sievert and Sievert (2021) who importantly reminds readers that the scarcity status of *A. tesselatus* locally is such that "This species has a closed season in Oklahoma and cannot be collected."

This report provides the first detailed observations on the biology of rarely observed diploid parthenogenetic *A. tesselatus*, identifiable as pattern class C (*sensu* Zweifel 1965). On 29 July 2023 at ca. 0940 h GHC and BEC observed the first of four adult individuals of *A. tesselatus* C that morning, all only a short distance from a cove of Lake Carl Etling (elev. ca. 1337.5 m; Fig. 4). The lizards observed *in situ* in Cimarron County on that date were active in largely unshaded patches of parched grassland habitat with

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Fig. 3. A sandy, sparsely vegetated, and sun-drenched site resulting from human disturbances where a moderately large (ca. 80 mm SVL) second-year individual of diploid parthenogenetic *Aspidoscelis tesselatus* pattern class C was captured and released by GHC and BEC in Cimarron County, Oklahoma, on 19 August 2023.

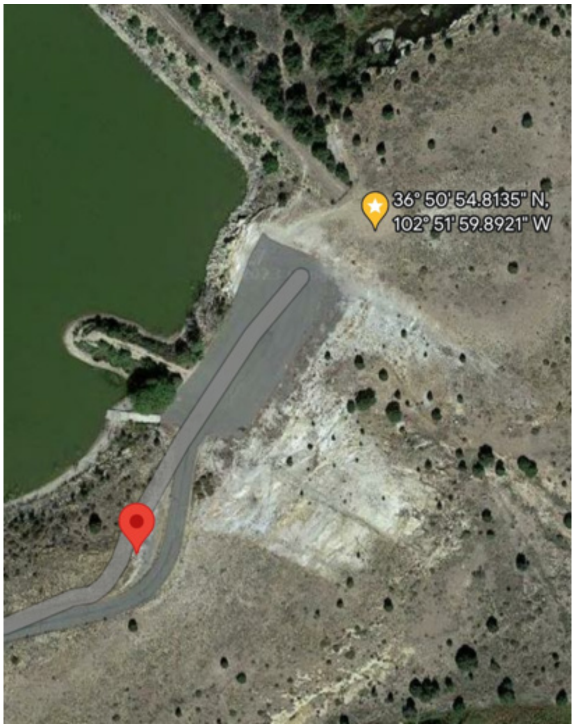

Fig. 4. Image copied from Google Earth with pins showing the geographical relationship between the sites where *Aspidoscelis tesselatus* pattern class C was observed on 29 July 2023 (lower left) and 19 August 2023 (upper right) near Lake Carl Etling, Black Mesa State Park and Nature Preserve Visitor Center, Cimarron County, Oklahoma.

scattered junipers (Fig. 1). Also notable were scattered ant mounds, large numbers of grasshoppers, and ample evidence of burrowing likely in part by individuals of *A. tesselatus* C. Potential cover available for use by the lizards was scattered about the mostly barren locale and included some large rocks, several brush piles, numerous clumps of cacti, and scattered yucca plants. Behaviorally, the animals were not flighty from mere human presence, which permitted the acquisition of a video and several still images at close range (e.g., Fig. 1). We estimated that the snout vent length (SVL) of the large reproductively mature lizard in Fig. 1 to be >90 mm SVL, which would place the individual in the third or fourth summer of life with an expected seasonal fecundity of two clutches of 3-5 eggs per clutch (Taylor et al. 1999a, b). The lizard in the image would have been easily collected were that an objective, as it jerkily moved about ca. 2.5 m from the human observers, occasionally stopping to press body and limbs against the essentially barren landscape for thermoregulation by basking (Fig. 1). The last two adults of *A. tesselatus* C observed on that date had an intriguing spatial relationship of one closely following the other in and out of clumps of yucca. These observations provided further evidence that *A. tesselatus* C is tolerant of, and even prospers, in disturbed habitats maintained by human activities (Walker et al. 1995, 1997).

A second visit to the general area at a site ca. 150 m from that on the first visit (Figs. 2-3), was undertaken on 19 August 2023. Near the dam of Lake Carl Etling and the parking lot on the side of road closest to the lake (elev. ca. 1316.4 m) one individual of *A. tesselatus* was observed at ca. 1304 h under the blistering air temperature of 99 °F. The apparent non-reproductive lizard, in its second year of life, was captured by noosing in a grass-scrubland area of habitat with a sandy substrate and rocky outcroppings (Fig. 3). This female, which was 80 mm in snout vent length (SVL) with a mass of 17.0 g, was stalked within a meter and noosed. When released within a few minutes it retreated at an incredible speed! Park rangers informed BEC and GHC that during the activity season of the species several individuals of *A. tesselatus* per day were usually observed in various parts of Black Mesa State Park and Nature Preserve Visitor Center; however, it is likely that late August was near the end of the summer activity season for adults of the species as reported for southeastern Colorado by Maslin (1966) and Taylor et al. (1999a).

Another observation on the adaptability of *A. tesselatus* C to areas dominated by humans in extreme western Oklahoma was provided by a resident of Kenton, Oklahoma, who sent images of adults *A. tesselatus* to GS and LS of Sievert and Sievert (2021). The images were accompanied by the note that three of these lizards were living in a yard in downtown Kenton. Existence of this species in human modified habitats has also been frequently observed by JEC and JMW in Colorado, New Mexico, and Texas in the USA and Chihuahua state in México (Walker et al. 1997). We have been notified that an introduced array of the species has also been discovered in such habitat in California far west of the natural distribution area of the species in New Mexico. We hypothesize that some of the advantages for the presence of *A. tesselatus* in such altered areas dominated by humans is that they provide an essentially predator free zone with open spaces for basking, retreat, and food gathering, conditions commonly exploited by this species (Walker et al. 1995, Taylor et al 1996, 1999b). There is also considerable anecdotal evidence that humans in an urban setting do not fear this lizard, and that they regard it as a regal addition to their environment. Its status is further enhanced by knowledge that it is among the small number of all-female vertebrate species in the world (see Vrijenhoek et al. 1989).

The basis for the historical lack of attention to the biology of *A. tesselatus* in Oklahoma compared to research on the species in Colorado, New Mexico, and Texas in the USA and Chihuahua state in México is a result of the scarcity of the species in Cimarron County. However, the underlying ecological basis for the dearth of specimens of *A. tesselatus* from the state in research collections and the scarcity of reports on the biology of *A. tesselatus* C in Cimarron County remains a perplexing enigma!

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Acknowledgments—Personnel of the Black Mesa State Park and Nature Preserve Visitor Center were kindly disposed and cooperative as to our interest in diploid parthenogenetic *Aspidoscelis tesselatus* pattern class C in Cimarron County, Oklahoma. In the distant past, curators at the Carnegie Museum kindly provided JMW with a loan of the several specimens listed of Common Checkered Whiptail from Oklahoma. Financial support for the second visit to Cimarron County by BEC, GHC, and Benjamin Woolen was provided by the Walker Family Trust administered by JMW. We are grateful to an anonymous contributor for Figure 2, based on an unspecified address in Kenton, Cimarron County, Oklahoma, to maintain privacy.

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NATURAL HISTORY NOTE

Mexican Spadefoot Toad, *Spea multiplicata*, in an Urban Habitat within Central Mexico

Oswaldo Hernández-Gallegos, Laboratorio de Herpetología, Facultad de Ciencias, Universidad Autónoma del Estado de México, Instituto Literario No. 100, Colonia Centro, Toluca, Estado de México, México, C. P. 50000; *ohg@uaemex.mx*

Gisela Granados-González, Laboratorio de Morfofisiología de la Reproducción, Facultad de Ciencias, Universidad Autónoma del Estado de México, Instituto Literario No. 100, Colonia Centro, Toluca, Estado de México, México, C. P. 50000

Aldo Gómez-Benitez, Departamento de Ciencias Ambientales, División de Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Unidad Lerma, Avenida de las Garzas No. 10, El Panteón, Lerma de Villada, Estado de México, México, C. P. 52005

Spea multiplicata, commonly known as the Mexican Spadefoot Toad, is a small to medium-sized burrowing toad, ranging from the southern United States to southern Mexico (Lemos Espinal and Dixon 2016). The Mexican Spadefoot Toad can be found at various elevations (from near sea level to around 2743 m a.s.l.), and in diverse habitats, including: “desert grassland, shortgrass plains, creosote bush and sagebrush desert, mixed grassland and chaparral, pine-oak woodlands, and open pine forests” (Stebbins 2003).

According to vulnerability established through the Environmental Vulnerability Score (EVS), *S. multiplicata* is classified as a species with low vulnerability (Wilson et al. 2013). Furthermore, in accordance with Mexican law, *S. multiplicata* is not included in the NOM-059-SEMARNAT-2010, and it is listed as Least Concern by the IUCN Red List.

On 30 August 30 2024, at 2115, we found two individuals of *S. multiplicata*. The individuals were a male with 51 mm SVL (Fig. 1) and a female with 57 mm SVL. Both individuals were recorded in the city of Metepec (population in 2020: 242,307 inhabitants), Estado de México, which is located in Central Mexico (19° 17’ 0.69” N, 99° 34’ 19.77” W; 2513 m a.s.l.; Fig. 2). The property is approximately 688.6 m² and is surrounded by houses with an asphalt road (Francisco I. Madero Street). The vegetation was mainly composed of grass, adorned with ornamental shrubs and fruit trees.

Apparently, *S. multiplicata* can inhabit human settlements when sufficient cover is available. Individuals

Spea multiplicata, commonly known as the Mexican Spadefoot Toad, is a small to medium-sized burrowing toad, ranging from the southern United States to southern Mexico (Lemos Espinal and Dixon 2016).

Fig. 1. *Spea multiplicata* male observed in an urban habitat in Metepec, Estado de México, Mexico. Photo courtesy of the authors.

of the Mexican Spadefoot Toad have been recorded in other urban locations in the city of Metepec. According to Osnaya Becerril (2017), *S. multiplicata* is tolerant to anthropogenic disturbances and is common in urban areas. Previous studies have found that other anurans in the Estado de México also inhabit urban environments (Gómez-Benitez et al. 2021). These records highlight the ability of some amphibian species to quickly adapt to sudden environmental changes, such as urbanization, which either demands rapid behavioral and ecological responses from the species or significantly affects their population abundance, potentially leading to local extinctions.

Acknowledgments—We thank the López Romero Family for permission to study *Spea multiplicata* on their property in Metepec, Estado de México, Mexico. We thank Edgar de la Rosa-Silva for reviewing a draft of this note.

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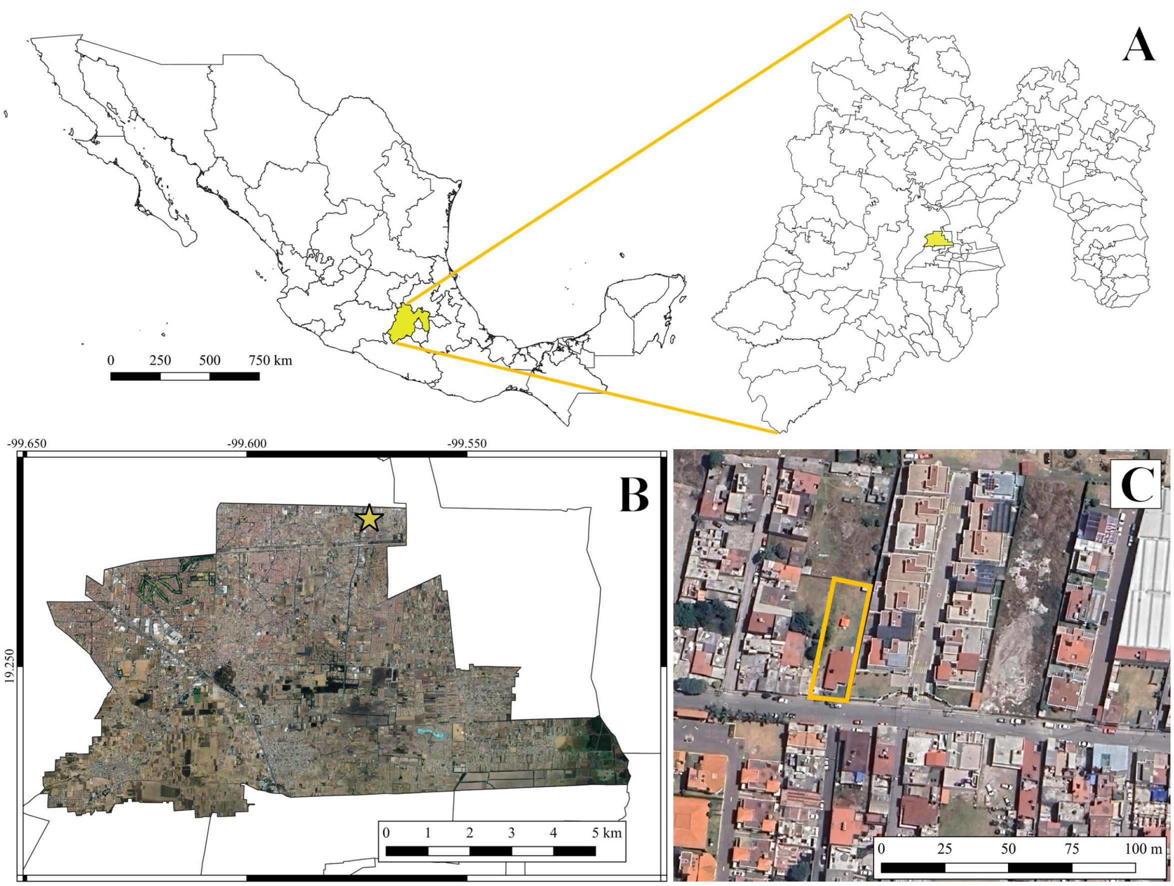

Fig. 2. A) Metepec location within the Estado de México, Mexico. **B and C)** Satellite images of the urban habitat in which two individuals of *Spea multiplicata* were observed. Both satellite images were obtained from Imágenes © Airbus, Maxar Technologies, © 2024 INEGI.

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