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Cover: Male Florida red-bellied turtle, *Pseudemys nelsoni*, at the Green Cay Nature Center, Palm Beach County, Florida. Photograph by Rachel Bladow.

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Do Snakes Have Necks?

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A review published in the June 2018 BCHS of our book, *Pythons of the World, Vol III: The Pythons of Asia and the Malay Archipelago* (2018), included an assertion that snakes have no necks. The reviewer, in reference to an illustration in the book (reproduced in Figure 1 below), wrote: "also, just to be picky on page 21 there is a drawing of a python with labels for gross external morphology that includes the 'neck'—snakes don't have necks, or if they do they [the necks] are only a couple of vertebrae long."

The reviewer went on to explain that "cervical vertebrae lack ribs, which means almost all of the vertebrae between the skull and the cloaca are thoracic vertebrae." We always have made every attempt to ensure that all the information in our books is accurate, and we were dismayed to consider that perhaps this illustration was incorrect. We had never questioned the existence of necks in snakes. So we took to the books to see if there was any basis to "neckless" snakes.

It appears to us that there are two different issues here. One issue is whether or not snakes have necks—this has a simple answer. The other is whether or not the vertebrae in the necks of snakes can be identified as cervical vertebrae—this turns out to be a more difficult question.

The simple answer is, yes, snakes absolutely have necks—all snakes have necks. Caldwell (2000) described the neck of a snake as "a body region that contains a variety of organ systems . . . the hyoid apparatus, esophagus, trachea, a discrete series of arteries, veins, motor nerves . . ." He goes on to state "as snakes still possess all of these structures, it can only be concluded that snakes have not lost their necks, only their pectoral girdles and forelimbs."

The external morphology of snakes can be compared to the regionalization of most terrestrial vertebrate bodies. As illustrated below in Figure 1, there are four general regions of a snake's body—the head, neck, body, and tail. The head, neck, and tail are labels that are commonly used for these body regions. Our use of the term "body," refers to that portion of the snake extending from just anterior to the heart back to the cloaca. Other authors have used the terms of *torso*, *trunk* and *thorax* to refer to this region of the body. Sood (1946) labeled the vertebrae in the ophidian neck region as "thoracic vertebrae," but this seems to have fallen from general use when referring to the ophidian axial skeleton. Common use of *thorax* or *thoracic* refers to a section of a vertebral column where the ribs join at midline, usually fused to a sternum or manubrium, creating a cage around the internal organs; the ribs of snakes never fuse at the ventral midline.

Researchers in many fields of science—anatomists, morphologists, phylogeneticists, osteologists, paleontologists, and now geneticists—have worked for centuries to answer the question "How did snakes attain the long, slender, legless body?" Obviously, the long slender body of snakes is due to the fact that snakes have evolved a long vertebral column.

All vertebrates undergo segmental development as embryos. The total length of snakes, from the head to the cloaca, is due to a significant increase in body segments. During the embryological development of a snake, a snake embryo rapidly grows a series of paired somites along the axis of the body. Each pair of somites becomes a segment. The first five segments become the skull and then each subsequent segment develops into a length of the body containing one vertebra, one ventral scale, and the appropriate internal structures and organs for that particular area of the body (Woltering, 2012). Snakes have far more vertebrae than most vertebrate animals.

However, the vertebral column of snakes is enigmatic. The vertebrae of snakes are remarkably uniform across all regions of the body as compared to variations seen in in the vertebral columns of other vertebrates. Sood (1946) notes that anatomists as far back as Meckel (1821–1833) and including D'Alton (1846), Grant (1841), Owen (1866), Hoffman (1890), Sedgwick (1905), Reynolds (1913), and Williston (1925) have all distinguished only two regions of the ophidian vertebral column: the *precaudal* region from the skull to the cloaca, and the *caudal* region (i.e., the tail). The precaudal region has been alternatively called the presacral or the precloacal region by several authors. The general consensus among these anatomists, including Sood (1946), was that snakes did not have necks and that the evolution of the elongated form of a snake was due to the elongation of the body and the disappearance of the neck.

According to Caldwell (2020), the common ancestor of all snakes was most likely not a marine reptile, nor a burrowing

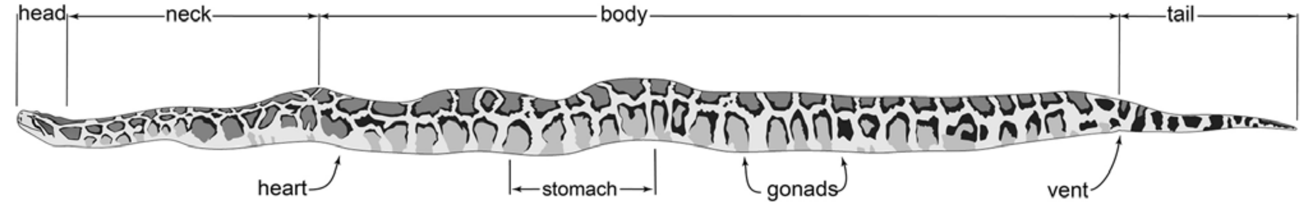

Figure 1. This is the image from page 21 of POWv3, *Pythons of Asia and the Malay Archipelago*, that elicited the comment that snakes do not have necks.

lizard, as have been commonly accepted hypotheses for many years. The ancestor of snakes was likely some type of terrestrial anguimorph lizard, a four-legged animal that likely had seven to 10 cervical vertebrae, maybe 50 or 60 lumbar vertebrae, and 60 to 80 caudal vertebrae. The fossil remains of this animal are not yet discovered, and neither are the fossils of four-legged snakes. There is little doubt that the ancestor of the snakes had cervical vertebrae.

The fossil history of modern snakes goes back 60 million years, back to the early Cenozoic in the Paleocene and Eocene epochs (Caldwell, 2020). Fossil evidence of the ancient lineages of snakes are known back to the middle Jurassic—the oldest known snake fossil at this time dates back to about 165 million years ago (Caldwell, 2020). Small delicate fossils from this distant age are rare, but the ancient history of the snakes and other related reptiles are becoming better known incrementally with new fossils being discovered and studied every year.

It's important to mention here that a fossil found in Brazil and dated to the lower Cretaceous was originally described, and received much publicity as a four-legged snake. Martill et al. (2015) described *Tetrapodophis amplectus*, a small and remarkably complete skeleton that they identified as the first-known four-legged snake. Subsequent studies of this fossil identify this species as a lizard and not a snake (Caldwell et al., 2016; Lee et al., 2016; Caldwell, 2020).

The conclusions of the earlier anatomists were largely supported by Hoffstetter and Gasc (1969) in a chapter in the first volume of *Biology of the Reptilia*. Caldwell (2020) states that the study of Hoffstetter and Gasc "swiftly became the gold standard on rules defining the presence or absence of a neck in lizards, inclusive of snake lizards [snakes]…" Hoffstetter and Gasc divided the vertebral column of snakes into three series—the presacral vertebrae (the vertebrae from the head to the cloaca), a few cloacal vertebrae and the caudal vertebrae in the tail. They stated that "in snake-like organisms, the presacral region is quite uniform. The absence of a pectoral girdle in all snakes makes it impossible to refer to the site of this organ in defining the boundary between the cervical and the trunk regions."

Hoffstetter and Gasc (1969) observed that certain anatomical structures associated with the neck-body boundary of vertebrate animals are positioned very differently in snakes. For example, the body wall musculature extends to the head yet the heart is positioned significantly further back into the body. Neck muscles found in other vertebrates are found in the neck region of snakes, but the origins and attachments are different. A major reason to not recognize the existence of the neck is the inability to exactly define the neck-body boundary.

According to Hoffstetter and Gasc (1969), the elongate form of modern snakes is due to the increase in the number of lumbar vertebrae, the complete loss of the pectoral girdle and forelimbs, the disappearance of the neck as defined by the presence of cervical vertebrae, and the repositioning of the major organs further back in the body. Traces of the neck remain, but they state that cervical vertebrae cannot be distinguished from the lumbar vertebrae in the uniform presacral series of vertebrae in the absence of a pectoral girdle that serves as the landmark that separates the neck and body. It is as if the increase of lumbar vertebrae pushed the body up into and through the neck, causing the disappearance of the cervical vertebrae and scattering cervical structures along the length of the neck region. Interestingly, the internal organs were not repositioned into the neck region, but remain in what we consider to be the trunk or the body.

Hoffstetter and Gasc (1969) note that all presacral vertebrae of snakes carry ribs except the atlas and axis, and consequently the anterior vertebrae in the presacral series cannot be considered to be cervical vertebrae as the cervical vertebrae of most vertebrates typically are without ribs. This is not universally true; many bird species have ribs on some of the cervical vertebrae, as do many lizard species. While we have not found this stated in the literature, we note that snakes use their elongated necks in locomotion, climbing, swimming, burrowing, striking, and constriction, uses of the neck that are not common in most vertebrates—the presence of cervical ribs may be functionally essential to the elongate and limbless body.

However, and in fact, the presacral vertebrae are not so uniform. They may all carry ribs but the anterior presacral vertebrae of snakes all have a structure on the ventral side of each vertebra, a long projection directed downward from each vertebra identified as a hypapophysis. The hypapophyses on Burmese python cervical vertebrae can be seen in Figure 2. Caldwell (2000) states that 40–70 anterior vertebrae of most snakes have hypapophyses. We examined a complete skeleton of a reticulated python (*Malayopython reticulatus*) and counted 61 anterior vertebrae with well-formed large hypapophyses, followed by a series of five vertebrae with hypapophyses that diminish in length along the series; that series is followed by the lumbar vertebrae of the body, where the hypapophysis is replaced with a haemal keel (a low, thin longitudinal ridge on the ventral side).

Contradicting their description of the uniformity of the presacral vertebrae of snakes, Hoffstetter and Gasc (1969) provide several graphs, each for a different snake species, that illustrate significant differences between the anterior and posterior presacral vertebrae due to the presence of hypapophyses along the anterior length of the vertebral series occurring exactly in the neck region. The transition from presence-to-absence of hypapophyses along the spine is sharply defined in the area of the heart (Malnate, 1972) and the posterior vertebrae are generally without hypapophyses.

Since the work of Hoffstetter and Gasc (1969), many anatomists and morphologists accepted the elongation of the body and the loss of the neck as the basis for the length and shape of modern snakes. However, several myologists have investigated the musculature of the anterior body of snakes looking for cervical muscles that are homologous to the cervical muscles in quadrupedal squamates. Pregill (1977) and Al Hassawi (2007) both found craniovertebral muscles in caenophidian snakes that are homologs of the neck muscles of lizards. Both concluded that snakes have myologically distinct necks, albeit shorter than a neck identified by the length of vertebrae with hypapophyses.

Tsuihiji et al. (2006) found a muscle in a snake identified as the *m. cervicoquadratus* that is a homolog of a muscle that originates on the pectoral girdle of tetrapodal squamates. In

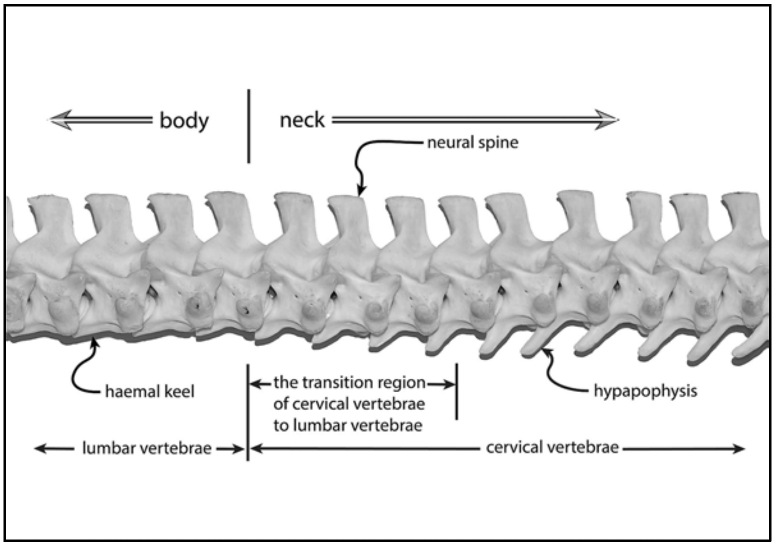

Figure 2. The area in the vertebral column of a Burmese python where the cervical vertebrae of the neck transition into the lumbar vertebrae of the body.

snakes, in the absence of the pectoral girdle, this muscle originates at the ventrolateral margin of the body on other muscles and dermis. Since the pectoral girdle is a traditional landmark in defining the neck-body boundary, the location of the origin of this muscle in modern snakes might indicate the location of the pectoral girdle of the limbed ancestor. That would then identify the neck-body boundary.

If the position of the origin of the *m. cervicoquadratus* does indicate the ancestral location of the pectoral girdle and the neck-body boundary, then the blind snakes would have necks 3–4 vertebrae in length, ranging up to the two included python species (*Python curtus* and *P. molurus*) with necks 10–11 vertebrae in length. Most of the snake species would have necks 5–7 vertebrae in length, which is similar to the number of cervical vertebrae in the tetrapodal squamates examined in the study. So based on myological characters, snakes would have necks, but not significantly longer necks than limbed squamates. Of course, as noted by Tsuihiji et al. (2006), it's possible that the locations of the origins of the *m. cervicoquadratus* in different species have become randomly placed by evolution and now have nothing to do with the location of the pectoral girdle of the limbed ancestor.

Tsuihiji et al. (2012) looked at the craniovertebral muscles in non-colubrid snakes and found that the musculature of the anterior-most precloacal vertebrae shows the same modifications as seen in quadrupedal squamates. The axial musculature in this area shows more cervical regionalization than is reflected by the morphology of the vertebral column. Based on the origins and insertions of the ophidian craniovertebral muscles, some modern snakes have somewhat longer necks than do most modern lizards, but longer only by a few vertebrae.

Caldwell (2020) repeatedly makes the argument that the data available from modern snakes cannot address the questions regarding the origin of snakes. Caldwell writes that using data in phylogenetic analyses based solely on extant snakes and lizards may scramble the attempt to provide an accurate picture of the common ancestor of snakes. Caldwell states "The modern fauna is so distant in time from the origin of snake lizards [snakes], and even from the Late Mesozoic origin of the modern snake body plan, that in many cases evolution through the last 100 million years has overprinted the neck identity onto the thorax and reduced the obviousness of the regionalized anatomy that normally characterizes the tetrapod axial skeleton." As clearly demonstrated in the morphometric study of Head and Polly (2015), the precloacal series of vertebrae in snakes is, in fact, more regionalized than was previously acknowledged in the literature. The neck is there—it's subtle and reduced, but it's there.

So where would one look to find the vertebrae in ophidian necks identified as cervical vertebrae? We found scattered references to ophidian cervical vertebrae in our literature search, but we found that it is paleontology that most commonly has identified and embraced the reality of ophidian cervical vertebrae. Relatively recent references to and descriptions of ophidian cervical vertebrae can be found in various paleontology and osteology texts (e.g., Romer, 1956; Holman, 2000; Tchernov et al., 2000; Scanlon, 2004; Palci and Caldwell, 2007). Szyndlar (1984) includes an illustration of a snake skeleton with the region of the neck clearly labeled and the individual types of vertebrae in the skeleton, including cervical vertebrae, plainly illustrated and identified. More recently, Caldwell (2020) makes a strong argument based on paleontological evidence for the presence of a neck and cervical vertebrae in modern snakes, primitive characters inherited from the earliest ophidian ancestors.

Caldwell (2020) states "it is now possible, however, to move beyond the character of absence of a neck because of the absence of the pectoral girdle, and this is because fossil snake lizards [snakes] possess distinctly regionalized vertebral columns despite the absence of pectoral girdle. They are snake lizards [snakes] even if they're missing essential categories observed in the crown group, or displaying anatomies lost in the crown group…"

We here digress to avoid confusion and to mention the interesting detail that Caldwell (2020) refers to all snakes as "snake lizards" throughout the book. This is based on cladistic analyses of the squamates that include data from the ancient species and lineages. The analyses support the hypothesis that snakes are a family within the infraorder Anguimorpha and should not be classified as a separate suborder, Serpentes. Caldwell presents a strong argument that snakes are, in fact, a type of lizard.

So do snakes have necks? We have spent days reading through the literature on snake vertebrae, and there are months more of reading that could be done on that topic. It seems that the basis of any controversy as to the reality of the ophidian neck is based on the identity of the vertebrae in the ophidian neck region of the body. Certainly in the limited reading we have done we have missed much and glossed over more, but nowhere did we find any dogmatic definition of a neck that states that the diagnostic character defining a neck is the presence of cervical vertebrae to compose the axial skeleton in that region of the body.

It seems obvious that any series of vertebrae passing through the neck region of a vertebrate animal would be identified as cervical vertebrae. To deny that snakes have necks is to admit a great unfamiliarity with the morphology and physiology of living snakes. Ophidian cervical vertebrae are the vertebrae found in the neck of a snake. To argue otherwise seems more a matter of semantics than of irrefutable argument.

Based on an overview of the many opinions and conclusions of the researchers from different scientific fields who have worked on the question we posed at the beginning of this article, it appears that there is no inarguable explanation as to how snakes evolved their slender, long and elegant bodies. Some will say that the bodies of snakes extend far forward of the heart but there are short necks; others will say that snakes have necks that are relatively longer than the necks of quadrupedal squamates, but not nearly as long as the series of anterior vertebrae with hypapophyses; some will contend that the anterior vertebrae with hypapophyses that extend from the head to the region of the heart are all cervical vertebrae. Tsuihiji et al. (2012) observed that the entire series of precaudal vertebrae of *Candoia paulsoni* and *Acrochordus granulatus* carry hypapophyses similar to what is seen on cervical vertebrae. Geneticists and embryologists have looked at the genetic controls for the somites, and the development of the segments in ophidian embryos without any clear or definitive answer as to the identity of the vertebrae in the ophidian neck (Woltering, 2012). And some still say snakes have no necks.

So after looking through the literature do we think pythons have necks? Yes, all snakes, including pythons, have necks. Based on the external morphology of snakes compared to the regionalization of essentially all vertebrate bodies, every snake's body is clearly divided into four regions—head, neck, body, and tail. The neck is the region from the back of the head to just anterior to the heart. And it seems most parsimonious to identify the series of vertebrae in that length of the body, the neck, as cervical vertebrae, regardless of the evolutionary origin, developmental origin, embryological origin or any other origin of that particular length of the precaudal vertebral column.

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News and Announcements

2020 CHS GRANT RECIPIENTS

The CHS Grants Committee has chosen the CHS grant recipients for 2020. The committee consisted of John Archer, Michael Dloogatch, Gery Herrmann, Robert Jadin and Jessica Wadleigh. This year we received 28 applications. After a difficult decision process, six grants were awarded, as follows:

- Justin Elden, Herpetology Department, St. Louis Zoological Park. "Constructing a Herpetarium to Benefit the Conservation of Endangered Guatemalan Herps" $1,000.
- Thornton Larson, Department of Biology, University of Texas at Arlington. "Cryptic Speciation of Fanged-frogs in the Volcanoes of Java and Sumatra (*Limnonectes kuhlii* Species Complex [Anura: Dicroglossidae])," $1,000.
- Joseph M. Redinger, Department of Biology, University of Central Arkansas. "Effect of a Top Predator (*Crotaphytus collaris*) on Prey Populations, Community Structures, and Ecosystem Function in Ozark Glades," $1,000.
- Tristan D. Schramer, Department of Biological Sciences, Clemson University. "The Peak of Extinction? Conservation Genomics and Hidden Diversity in Mexican Montane Pitvipers (Viperidae: *Cerrophidion*)," $1,000. [deferred to 2021 due to travel restrictions]
- Courtney Silver-Peavey, Department of Biological Sciences, Ohio University. "Carryover Effects of Pesticide Exposure and Pond Drying on Exploratory and Risk-taking Behavior in a Vernal Pool-breeding Amphibian, the Wood Frog," $1,000.
- Aamod Mohan Zambre, Department of Ecology, Evolution and Behavior, University of Minnesota. "Beauty in the Eye of the Beholder? Testing the Perceptual Tuning Hypothesis of Diversification of Sexual Signal Design in Fan-throated Lizards," $1,000.

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Miscellanea Herpetologica Gabonica XV

Olivier S. G. Pauwels [1, 2], Abraham Bamba Kaya [3], Larson Boundenga [4], Piero Carlino [5], Laurent Chirio [6], Mercedes J. Moreels [7], Stephan Morelle [8], Barthélémy Ngoubangoye [4], Lynn Pallemaerts [1] and Katharine Anne Abernethy [9]

Abstract

We present new Gabonese locality records, ecological and morphological data and unpublished material for *Pelusios gabonensis* (Pelomedusidae), *Kinixys erosa* (Testudinidae), *Hemidactylus mabouia* (Gekkonidae), *Lepidothyris striatus*, *Trachylepis affinis* (Scincidae), *Crotaphopeltis hotamboeia*, *Dipsadoboa underwoodi* and *D. viridis* (Colubridae), *Dendroaspis jamesoni*, *Naja annulata annulata*, *N. melanoleuca* and *N. nigricollis* (Elapidae), *Atractaspis boulengeri*, *Limaformosa savorgnani*, *Polemon fulvicollis*, *Psammophis mossambicus* (Lamprophiidae) and *Natriciteres fuliginoides* (Natricidae). One skink and two snake species are newly recorded from Haut-Ogooué and Ngounié provinces, respectively. We attribute all records of *Psammophis* spp. in Gabon to *P. mossambicus*. We report a case of predation by a Common chimpanzee (*Pan troglodytes*) on *Kinixys erosa* in Lopé National Park, by *Crotaphopeltis hotamboeia* on the Cameroon toad *Sclerophrys camerunensis* (Anura: Bufonidae), and by a *Naja annulata annulata* on Thollon's robber tetra *Brycinus tholloni* (Characiformes: Alestidae).

Keywords

Biodiversity, herpetofauna, Squamata, Testudines, bifid tail, chimpanzee, fish, prawn, protected areas, Gabon, Equatorial Africa.

Introduction

We continue our series *Miscellanea Herpetologica Gabonica*, initiated in 2008, and aiming at increasing the knowledge on the natural history and geographical distribution of the reptiles of Gabon. Most of the specimens presented in this volume were obtained during non-herpetological activities, encountered as dead-on-road individuals, or killed by villagers or fishermen. Some observations were made during ichthyological (LC), parasitological (LB and BN) and primatological (KAA) field studies. Others are unpublished outcomes of intensive herpetological studies in Haut-Ogooué in 2016–2018 (SM) and long-term surveys in Estuaire and Ogooué-Ivindo provinces (see among others Carlino and Pauwels, 2015, and Pauwels, Braun et al., 2017).

Material and Methods

Photographic and voucher material was identified using the keys and morphological information provided by Pauwels and Vande weghe (2008) and Wagner et al. (2009). Snake ventral scales were counted according to the method of Dowling (1951). Snake dorsal scale rows were counted at one head length behind head, at midbody (above the ventral corresponding to half of the total number of ventrals), and at one head length before vent; subcaudal counts exclude the terminal pointed scale. Paired meristic characters are given left/right. Morphological data of preserved specimens are presented in Table 1.

Abbreviations: Morphology: A = anal plate; AT = anterior temporals; DSR = number of dorsal scale rows; IL = number of infralabials, followed in brackets by the number of IL in contact with the first pair of sublinguals; K = keeled; Lor = number of loreal scales; PoO = number of postoculars; PreO = number of preoculars; PV = number of preventrals; SC = number of subcaudals; SL = supralabials, followed in brackets by the SL in contact with orbit; SubO = subocular; SVL = snout–vent length; TaL = tail length; U = unkeeled; VEN = number of ventral scales. Varia: alt. = altitude; Dept = Department; NP = National Park; Prov. = Province; PEM R = Port Elizabeth Museum (reptile collection), Humewood, South Africa; RBINS = Royal Belgian Institute of Natural Sciences, Brussels, Belgium; RMCA = Royal Museum for Central Africa, Tervuren, Belgium.

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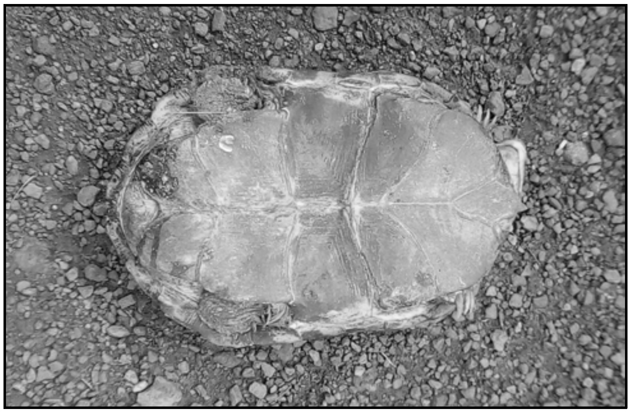

Figure 1. Live adult *Pelusios gabonensis* (ventral view) in Disofou, Nyanga Prov., southwestern Gabon. Photograph by Christophe Ngokomaka.

Results

Testudines
Pelomedusidae
Pelusios gabonensis (Duméril, 1856)
An adult individual was photographed in January 2018 by Christophe Ngokomaka in Disofou (2°52'59.0"S, 10°28'00.0"E), Basse-Banio Dept, Nyanga Prov. (Figure 1). New locality record. Within this dept, this species had already been recorded from Banio Lagoon (Maran and Pauwels, 2005).

Testudinidae
Kinixys erosa (Schweigger, 1812)
In 2000 KAA observed a female Common chimpanzee **(***Pan troglodytes***)** who had found a live *Kinixys erosa* in the *Station d'Etude des Gorilles et Chimpanzés* (SEGC), Lopé NP, Lopé Dept, Ogooué-Ivindo Prov., in central Gabon. The female was with a group but made no vocalization to attract other members. She climbed a tree carrying the tortoise in one hand and sat herself in a fork about 8 m high, where she could see the other group members on the ground, but they could not access her easily, so it seems that she did not intend to share the meat, and knew that the other chimpanzees would want to take some. She used her fingers to pull the legs from the tortoise, twisting each leg off and eating it. She then broke a small branch from the tree and used two sticks from it to poke into the opening where the head would come out and to force the shell apart. She then managed to pull the head out and off and to get her fingers into the broken opening to eat more of the inner meat. All this she did in silence and very fast, to not attract the attention of the others. However, she was then noticed and a young male climbed up behind her. She dropped the shell and went higher into the tree, clearly not wanting to be chased or punished for having the meat. Pika et al. (2019) were the first to publish observations of predation by Common chimpanzees on tortoises. Their observations involved the same tortoise species, but in Loango NP, southwestern Gabon.

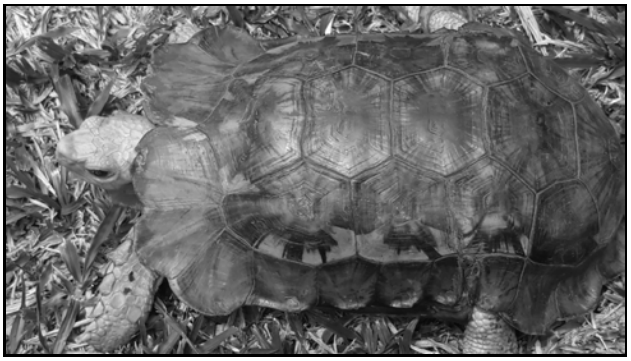

Figure 3. Live adult *Kinixys erosa* near Pana, Ogooué-Lolo Prov., southern-central Gabon. Photograph by B. Ngoubangoye.

Figure 2. Live adult female *Kinixys erosa* (dorsal view) near Akoumassi, Woleu-Ntem Prov., northern Gabon. Photograph by L. Boundenga.

In February 2016, LB photographed an adult female *Kinixys erosa* in Akoumassi (1°4'59''N, 11°28'59''E), Woleu Dept, Woleu-Ntem Prov. (Figure 2). New locality record; a few other records had previously been made in the surroundings of Oyem (Maran and Pauwels, 2005). In February 2018, BN encountered an adult individual in Pana (1°41'00.0"S, 12°39'00.0"E), Lombo-Bouenguidi Dept, Ogooué-Lolo Prov. (Figure 3), in the heart of the Chaillu Massif, about 20 km N of the border with the Republic of Congo. New locality record; from this dept, the species was already recorded from Koulamoutou (Maran and Pauwels, 2005). In March 2018, LB photographed an adult female nearby Mafouka (0°46'00.0"N, 12°58'00.0"E) along Zadie River, Ivindo Dept, Ogooué-Ivindo Prov. (Figure 4). New locality record. Several localities were already known within this dept (Maran and Pauwels, 2005). While this tortoise species is currently one of the most ubiquitous and most often documented reptiles of Gabon, it suffers everywhere from heavy hunting. It was reported from many localities throughout the country, but only a fraction of these records was vouchered by photographs or museum specimens.

Figure 4. Live adult female *Kinixys erosa* (dorsal view) near Mafouka, Ogooué-Ivindo Prov., northeastern Gabon. Photograph by L. Boundenga.

Figure 5. Live adult *Hemidactylus mabouia* with a bifid regenerated tail in Bakoumba, Haut-Ogooué Prov., southeastern Gabon. Photograph by S. Morelle.

Squamata
Gekkonidae
Hemidactylus mabouia (Moreau de Jonnès, 1818)
On 4 October 2016 SM photographed in Bakoumba (ca. 1°49'43.5"S, 13°00'08.7"E), Lékoko Dept, Haut-Ogooué Prov., an adult individual with a bifid regenerated tail (Figure 5). The species was already known from that locality (Pauwels, Morelle et al., 2019). It is the first record in Gabon of this anomaly of tail regeneration in Gekkonidae.

Scincidae
Lepidothyris striatus (Hallowell, 1854)
On 17 October 2018 LB photographed a freshly dead adult individual which had been killed by a gardener while it was basking on a house terrace in the compound of the CIRMF in Franceville, Passa Dept, Haut-Ogooué Prov. (Figure 6). New prov. record for the genus. In Gabon, this colorful but elusive species had so far been recorded from the provinces of Estuaire, Moyen-Ogooué, Ogooué-Ivindo and Ogooué-Maritime (Pauwels and Vande weghe, 2008; Wagner et al., 2009; Carlino and Pauwels, 2015), and it is most certainly present, but still undocumented, from Nyanga, Ogooué-Lolo and Woleu-Ntem provinces.

Trachylepis affinis (Gray, 1839)
The adult individual MSNS 279 was collected on 15 August 2012 in Mabounié, 40 km E-SE of Lambaréné, Ogooué & Lacs Dept, Moyen-Ogooué Prov. It shows a SVL of 80 mm, a TaL of 160 mm (tail original); supranasals not in contact but separated only by a point; prefrontals not in contact with each other; parietals in contact behind interparietal; 7/7 SL; 4/4 supraoculars; 6/6 supraciliaries; 32 MSR; three keels per dorsal scale. New locality record (reptile records for this dept were compiled by Pauwels, 2017).

Colubridae
Crotaphopeltis hotamboeia (Laurenti, 1768)
An adult White-lipped cat snake (RBINS 19196) was found dead-on-road in 2011 in Kanda (2°12'9.8"S, 11°31'45.2"E), Louetsi-Wano Dept, Ngounié Prov. It shows three pairs of sublinguals. New dept record (Pauwels and Vande weghe 2008). Its stomach contains the remains (posterior legs in good condition, anterior part of body mostly digested) of a subadult *Sclerophrys camerunensis* (Parker, 1936) (Anura: Bufonidae), ingested head first (identification of the toad confirmed by comparison with the subadult specimen RBINS 13321 from Loango NP in southwestern Gabon).

Figure 6. Freshly dead adult *Lepidothyris striatus* in Franceville, Haut-Ogooué Prov., southeastern Gabon. Photograph by L. Boundenga.

Dipsadoboa underwoodi Rasmussen, 1993
The adult Underwood's tree snake RBINS 19197 was found in Bilolo (Ndoubi; 2°4'45.9"S, 11°35'47.5"E), Boumi-Louetsi Dept, Ngounié Prov. It shows two pairs of sublinguals; 1+3+3 temporals on the left side, 1+2+3 on the right side. New prov. record (not recorded from the province by Pauwels and Vande weghe, 2008; Pauwels, Le Garff et al., 2016).

Dipsadoboa viridis (Peters, 1869)
An adult individual (RBINS 19184) was found dead on road at the eastern exit (1°54'32.1"S 11°55'31.8"E) of Mbigou, Boumi-Louetsi Dept, Ngounié Prov. It shows a temporal formula of 1+2 on each side, and two pairs of sublinguals, the anterior one slightly larger and longer than the posterior one. New locality record (the species was already known from other localities in the district, see Pauwels, Kamdem Toham et al., 2002; Dewynter et al., 2018).

Elapidae
Dendroaspis jamesoni (Traill, 1843)
An adult mamba was killed by villagers in Mimongo (1°49'4.5"S, 10°56'39.3"E; alt. 92 m asl), Tsamba-Magotsi Dpt., Ngounié Prov. with a machete. Only the head and neck could be preserved (RBINS 19183). On 4 November 2017, in the same dept, LC found a dead-on-road individual on the N1 Road near Mimongo (1°49'4.5"S, 10°56'39.3"E; alt. 92 m asl). New dept record (not recorded by Pauwels, Kamdem Toham et al., 2002; Pauwels and Vande weghe, 2008). On 26 January 2012 LC examined an adult dead-on-road individual in Tchad (0°52'51.5"S, 10°23'41.2"E; alt. 60 m asl), Ogooué & Lacs Dept, Moyen-Ogooué Prov. New locality (Pauwels, 2017). On 6 April 2012 LC examined an individual killed by villagers in Nombakélé (0°45'21.1"S, 10°21'39.5"E; alt. 50 m asl), Ogooué & Lacs Dept, Moyen-Ogooué Prov. New locality (Pauwels, 2017). In the same dept, LC saw on 13 May 2012 an individual crossing the trail to Maboumine (0°51'20.7"S, 10°25'59.0"E; alt. 95 m asl). New locality record. On 9 August 2017, while traveling by boat from Omboué to Port-Gentil, LC photographed an adult individual climbing into a palm tree on the bank of the

Figure 7. Adult *Dendroaspis jamesoni* climbing on a palm tree on the bank of the Ogooué River in Etimboue Dept, Ogooué-Maritime Prov. Photograph by L. Chirio.

Ogooué River (1°19'36.7"S, 9°05'34.0"E; alt. one m asl; Figure 7) in Etimboue Dept, Ogooué-Maritime Prov. New dept record. On 28 December 2017 LC saw an individual crossing the road (0°21'30.9"N, 10°23'30.2"E; alt. 157 m asl) to Violaineville, in the SEEF logging concession, Komo Dept, Estuaire Prov. New locality record; within Estuaire Prov., this snake was known from a single locality so far (Pauwels, Chirio et al., 2017), also at direct proximity to Crystal Mounts NP where the species is not yet recorded (Pauwels, 2016). On 9 July 2019 LC examined a dead-on-road individual in Bembikanni (0°57'26.4"S, 12°48'24.3"E; alt. 544 m asl), Mouloundou Dept, Ogooué-Lolo Prov. New locality record. Although it is a large and easily recognizable venomous snake, the distribution of Jameson's mamba in Gabon is still poorly documented.

Naja annulata annulata Buchholz & Peters in Peters, 1876
The preserved head (RMCA A1-090-R-0003; see Figure 8) reported by Pauwels, Gillet et al. (2018) from Mboumi (0°23'42.0"S, 10°49'00.0"E), Abanga-Bigné Dept, Moyen-Ogooué Prov. was actually collected in Toho forest river (0°28'12.0"N, 12°05'30.0"E), Mvoung Dept, Ogooué-Ivindo Prov., and belonged to the fishing net-drowned individual illustrated by Pauwels, Gillet et al. (2018: Fig. 9). Jean-François Gillet had made a *lapsus calami* when indicating the locality at the time of the deposition of this specimen to the RMCA (J.-F. Gillet, comm. pers. to OSGP, August 2018). On our request, the correction of the locality was made in the RMCA herpetological register (Danny Meirte, curator of the RMCA herpetological collections, pers. comm. to OSGP).

Figure 8. Preserved head of an adult *Naja annulata annulata* (RMCA A1-090-R-0003) from Toho river, Ogooué-Ivindo Prov., northeastern Gabon. Photograph by O. S. G. Pauwels.

The subadult individual RBINS 19180 was killed by fishermen in Dibouangui (2°06'40.6"S, 11°35'11.7"E; alt. 377 m asl), Boumi-Louetsi Dept, Ngounié Prov. Its stomach contains an adult Thollon's robber tetra *Brycinus tholloni* (Pellegrin, 1901) (Characiformes: Alestidae; RBINS 25687), ingested head first. The tetra had a total length of 96 mm, and contained itself the remains of a freshwater prawn (Crustacea: Palaemonidae: *Macrobrachium*). *Brycinus tholloni* is an uncommon Lower Guinea endemic fish found in the upper Ogooué and Nyanga basins in southern Gabon and in Kouilou basin in the Republic of Congo (Paugy and Schaefer, 2007; Moelants, 2010). New dept record; within Ngounié province, this aquatic cobra was only recorded from Ogoulou Dept (Pauwels and Lavoué, 2004). It is the third known locality within the Chaillu Massif (Dewynter et al., 2018; Pauwels, Kamdem Toham et al., 2002).

Naja melanoleuca Hallowell, 1857
In their review of the *Naja melanoleuca* species complex, Wüster et al. (2018) listed a tissue sample (voucher WW2873 - PEM R 16698) from "Ayol Alar, Ogooué-Ivindo Province" used for their molecular analyses, and provided a photograph of an adult individual from "Tsibilé." The latter individual is the same individual illustrated under a different angle by Pauwels, Gillet et al. (2018: Fig. 10)

Naja nigricollis Reinhardt, 1843
Pauwels, Morelle et al. (2019) recorded this spitting cobra from Léconi Park in Plateaux Dept, Haut-Ogooué Prov. based on a photograph of an adult individual taken on 15 December 2016 by E. Pendrié in a savanna area. This highly venomous savanna species had been reported only twice before from Gabon, based only on an unvouchered observation from Nyanga Prov. and on a photograph taken in Haut-Ogooué Prov. (Pauwels and Vande weghe 2008; Pauwels, Carlino et al., 2017). However, due to editorial constraints, the photograph documenting this third Gabonese record could not be presented by Pauwels, Morelle et al. (2019). We thus present it here (Figure 9). It would be important to collect and examine Gabonese individuals to confirm their exact identity.

Figure 9. Live adult *Naja nigricollis* in defensive posture in Léconi Park, Haut-Ogooué Prov., southeastern Gabon. Photograph by E. Pendrié.

Lamprophiidae

Atractaspis boulengeri Mocquard, 1897

The juvenile MSNS-REPT 281 was collected along the entrance road to Ipassa Research Station, Ivindo Dept, Ogooué-Ivindo Prov., on 21 November 2016. It was found at 6 PM under a fallen tree trunk in secondary forest. It shows a slender habitus, round pupils, divided nasals; 2 internasals; 2 prefrontals; on each side a temporal formula of 1+3; 2nd IL not fused with sublinguals; a single pair of sublinguals. Its umbilical scar is still visible on VEN 184-186. This uncommon species was known from Loa Loa in the buffer zone of Ivindo National Park (Carlino and Pauwels, 2015), but the present record is the first one from the park's core area.

Limaformosa savorgnani (Mocquard, 1887)

An adult individual was killed with a machete by a villager in a savanna area in Guidouma (1°42'20.3"S, 10°46'36.7"E; alt. 103 m asl), Tsamba-Magotsi Dept, Ngounié Prov. Only the head and neck, in poor condition, could be preserved (RBINS 19185). It shows a double keel on the vertebral row. New locality. This uncommon and poorly known species had already been once recorded from this Dept by Dewynter et al. (2017).

Polemon fulvicollis (Mocquard, 1887)

An adult (RBINS 19181) was found dead on a laterite road (1°54'1.6"S, 11°54'52.6"E) at the southern exit of Mbigou, Boumi-Louetsi Dept, Ngounié Prov. It shows a temporal formula of 1+1 on each side, and two pairs of sublinguals, the anterior one much wider and longer than the second one. New prov. record. In Gabon, this rarely encountered species was known only from the provinces of Haut-Ogooué, Ogooué-Ivindo and Ogooué-Lolo (Pauwels and Vande weghe, 2008; Pauwels, Carlino et al., 2016).

Psammophis mossambicus Peters, 1882

All *Psammophis* samples from Gabon used in the revision by Trape et al. (2019) turned out to be referable to *P. mossambicus*. No morphological or genetic differences between Gabonese populations have been recorded. All records of this genus from Gabon, made under *Psammophis phillipsii*, *P.* cf. *phillipsii* and *P. sibilans* (Kelly et al., 2008; Pauwels and Vande weghe, 2008 and references therein; Pauwels, Le Garff et al., 2016; Pauwels, 2017; Pauwels, Albert et al., 2017; Pauwels, Biyogho Bi Essono II et al., 2017; Pauwels, Gillet et al., 2018; Pauwels, Oger et al.,

Table 1. Morphological data for snakes. NA = not available. For the other abbreviations see Materials and Methods.

Species and collection number	SVL (mm)	TaL (mm)	DSR	PV+VEN	A	SC	SL	IL	Lor	PreO	SubO	PoO	AT
Colubridae													
Crotaphopeltis hotamboeia													
RBINS 19196	364	67	17-19-15, U	1+160, U	S	44, D, U	8(3-5)/8(3-5)	9(5)/9(5)	1/1	1/1	0/0	3/3	1/1
Dipsadoboa underwoodi													
RBINS 19197	390	119	17-17-13, U	1+190, U	S	79, S, U	9(4-6)/8(3-5)	9(4)/10(4)	1/1	1/1	0/0	2/2	1/1
D. viridis													
RBINS 19184	728	237	17-17-13, U	2+229, U	S	100, S, U	8(4-5)/8(4-5)	10(5)/11(6)	1/1	1*/2	0/0	2/1	1/1
Elapidae													
Dendroaspis jamesoni													
RBINS 19183	NA	NA	17-NA-NA, U	1+>37, U	NA	NA	7(4)/7(4)	8(4)/8(4)	0/0	3/3	1/1	2/2	1/1
Naja annulata annulata													
RBINS 19180	509	108	25-23-17, U	0+227, U	S	70, D, U	7(3-4)/7(3-4)	8(4)/8(4)	0/0	1/1	0/0	2/2	1/1
Lamprophiidae													
Atractaspis boulengeri													
MSNS-REPT 281	197	19	21-21-16, U	2+200, U	S	1D+5S+19D, U	5(3-4)/5(3-4)	6(3)/6(3)	0/0	1/1	0/0	1/1	1/1
Limaformosa savorgnani													
RBINS 19185	NA	NA	18-NA-NA, K	1+>27, K	NA	NA	7(3-5)/7(3-5)	NA	1/1	NA	0/0	2/2	1/1
Polemon fulvicollis													
RBINS 19181	339	22	15-15-15, U	4+255, U	D	24, D, U	7(3-4)/7(3-4)	7(4)/7(4)	0/0	1/1	0/0	1/1	1/1
Natricidae													
Natriciteres fuliginoides													
RBINS 19186	223	149	17-17-15, U	2+124, U	S	94, D, U	8(4-5)/8(4-5)	10(5)/9(5)	1/1	1/1	0/0	3/3	1/1

* On the left side, the lower preocular is fused with the loreal and is not counted.

2018; Pauwels, Morelle et al., 2019) are consequently referred here to *P. mossambicus*, the only species of the genus currently known to occur in the country.

On 14 July 2019, on the R16 road in Kellé I (1°36'45.6"S, 13°43'44.5"E; 413 m asl) between Franceville and Bongoville, Mpassa Dept, Haut-Ogooué Prov., LC examined a dead-on-road individual. New locality record (Pauwels, Morelle et al., 2019).

Natricidae

Natriciteres fuliginoides (Günther, 1858)

An adult individual (RBINS 19186) was found in Oyane (0°10'59.0"S, 9°19'1.0"E; alt. 8 m asl), Komo-Océan Dept, Estuaire Prov. It shows on both sides a temporal formula of 1+2+3. This new locality is situated at proximity to Wonga-Wongué Presidential Reserve, from where the species is not yet recorded (Pauwels and Vande weghe, 2008; Pauwels, 2016), but where it is certainly present.

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Notes on Reproduction of Strecker's Chorus Frog, *Pseudacris streckeri* (Anura: Hylidae), from Oklahoma

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Abstract

I conducted a histological examination of gonadal material from 46 *Pseudacris streckeri* from Oklahoma consisting of 18 adult males, 22 adult females and 6 juveniles. The smallest mature males (sperm in lumina of seminiferous tubules) measured 33 mm SVL. The smallest mature female (in spawning condition) measured 34 mm SVL. As previously reported for *P. streckeri*, reproduction occurs in the early part of the year. The presence of mature follicles (imminent spawning) and concurrent postovulatory follicles (from a recent spawning) in the same ovary, is histological evidence that *P. streckeri* females may spawn more than once in the same reproductive period. Histological examination of ovaries from congeneric species is warranted to ascertain if they also can spawn multiple times in the same reproductive season.

Strecker's chorus frog, *Pseudacris streckeri* Wright and Wright, 1933 occurs in south-central Kansas to the Gulf Coast of Texas, eastward into central Arkansas and northwest Louisiana where it is a winter and spring breeding species (Dodd, 2013). It is rarely seen outside of the breeding season (Sievert and Sievert, 2011). They spend much of the year in burrows they dig using their front legs (Green et al., 2013). The most detailed study on *P. streckeri* reproduction, including a description of eggs, hatching and tadpoles, is in Bragg (1942). Breeding sites for *P. streckeri* include floodplains of rivers, cattle tanks, ditches or flooded fields (Bragg, 1942). During years of insufficient rainfall, *P. streckeri* may not reproduce (Gray and Stegall, 1986). An early summary of the biology of *P. streckeri* is in Smith (1966). In this paper, I present data from a histological examination of *P. streckeri* gonadal material from Oklahoma. Utilization of museum collections for obtaining reproductive information avoids removing additional animals from the wild.

A sample of 46 *P. streckeri* from Oklahoma (Appendix), collected 1940 to 2015, was examined from the herpetology collection of the Sam Noble Museum (OMNH), University of Oklahoma, Norman, Oklahoma, USA. The sample comprised 18 adult males (mean snout–vent length, SVL = 35.8 mm ± 2.8 SD, range = 33–42 mm), 22 adult females (mean SVL= 37.0 mm ± 2.5 SD, range = 33–42 mm), two juvenile males, SVL = 28, 29 mm, one juvenile female, SVL = 27 mm and three unsexed juveniles, SVL = 23, 23, 28 mm.

A small incision was made in the lower part of the abdomen and the left testis was removed from males and a piece of the left ovary from females. Gonads were embedded in paraffin, sections were cut at 5 μm and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreibman, 1997). Histology slides were deposited at OMNH. An unpaired *t*-test was used to test for differences between male and female SVLs (Instat, vers. 3.0b, Graphpad Software, San Diego, CA).

There was no significant size difference between the mean SVL of adult male versus adult females of *P. streckeri* ($t = 1.51$, df = 38, $P = 0.14$). The testicular morphology of *P. streckeri* is similar to that of other anurans as described in Ogielska and Bartmañska (2009a). Within the seminiferous tubules, spermiogenesis 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 Bartmañska, 2009a). There was typically a tangled mass of spermatozoa in the lumen of each seminiferous tubule. Three stages were present in the *P. streckeri* testicular cycle (Table 1): (1) Abundant sperm present; (2) Reduced amounts of sperm present, compared to stage 1; (3) No sperm present. These findings reflect *P. streckeri* being a winter–spring breeder (Dodd, 2013). My findings of no sperm present in two *P. streckeri* males from April and reduced amounts of sperm in May, likely indicate that reproduction is coming to an end for the current breeding period. The smallest six mature males of *P. streckeri* measured 33 mm SVL (OMNH 27782, 38136, 38179, 39834, 44439, 44440). Wright and Wright (1970) reported *P. streckeri* adult males ranged from 25 to 41 mm SVL.

I am unable to speculate when the six *P. streckeri* juveniles (mean SVL = 26.3 mm ± 2.7 SD, range = 23–29 mm) would have reached adult sizes.

The ovaries of *P. streckeri* are similar to those of other anurans in being paired organs lying on the ventral sides of the kidneys; in adults the ovaries are filled with diplotene oocytes in various stages of development (Ogielska and Bartmañska, 2009b). Mature oocytes are filled with yolk droplets; the layer of surrounding follicular cells is thinly stretched. Three stages were

Table 1. Three monthly stages in the testicular cycle of 18 adult male *Pseudacris streckeri* from Oklahoma.

Month	n	Abundant sperm present	Reduced amounts of sperm present	No sperm present
January	1	1	0	0
February	2	2	0	0
March	7	7	0	0
April	7	5	0	2
May	1	0	1	0

Table 2. Three monthly stages in the ovarian cycle of 22 adult female *Pseudacris streckeri* from Oklahoma.

Month	n	Spawning condition	Vitellogenesis = yolking follicles*	Not in spawning condition
January	1	1	0	0
February	5	5	0	0
March	8	4	4	0
April	7	3	0	4
May	1	1	0	1

* *sensu* Uribe Aranzábal 2011.

Table 3. Months of breeding by state for *Pseudacris streckeri*.

Locality	Breeding period	Source
Arkansas	February to April	Trauth et al. 1990
Illinois	February to April	Phillips et al., 1999
Kansas	February to May	Collins et al., 2010
Louisiana	December to March	Boundy and Carr, 2017
Oklahoma	January to May	Bragg and Smith, 1942
Texas	January to April	Jameson, 1950
Texas	October to April	Blair, 1961
Texas	November to May	Tipton et al., 2012

noted in the ovarian cycle of *P. streckeri* (Table 2): Stage 1 (Spawning Condition) in which mature oocytes predominated, Stage 2 (Vitellogenesis, Yolking Follicles) in which follicles were accumulating yolk, comparable to secondary growth Stage 5, see Uribe Aranzábal, 2011; Stage 3 (Not in Spawning Condition) in which previtellogenic oocytes predominated. The smallest mature *P. streckeri* female (spawning condition) in my sample measured 34 mm SVL (OMNH 21883). Wright and Wright (1970) reported adult females of *P. streckeri* ranged from 32 to 46 mm.

Postovulatory follicles (evidence of a recent spawning) were noted in several *P. streckeri* females: February OMNH 25663; March OMNH 25677, 27761–27763, 27767, 39832; April OMNH 30498. Postovulatory follicles form when the ruptured follicle collapses after ovulation; the follicular lumen disappears and proliferating granulosa cells are surrounded by a fibrous capsule (Redshaw, 1972). Postovulatory follicles are short–lived in most anuran species and are resorbed after a few weeks (Redshaw, 1972). The presence of mature follicles for a subsequent spawning, with concurrent postovulatory follicles from a recent spawning, in the same ovary indicate *P. streckeri* may spawn a second time during the same reproductive period. This condition was noted in three *P. streckeri* females from March (OMNH 25677, 27762, 27763). Postovulatory follicles were also noted in females undergoing vitellogenesis (yolking follicles) comparable to Secondary Growth Stage 5 "progressive accumilation of yolk platelets" (Uribe Aranzábal, 2011): February (OMNH 25663), March (OMNH 39832) suggesting a second spawning might also be possible in the same reproductive season for these two females. However it is not possible to know if their vitellogenic follicles would have reached maturity in the current reproductive period. One female from April (OMNH 30498), not in spawning condition (Table 2) contained postovulatory follicles, indicating spawning had recently occurred. Since only early diplotene oocytes remained, no additional spawning was anticipated in the current year.

Eleven of 22 (50%) of the adult female *P. streckeri* in my sample contained atretic oocytes. 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 follicle cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmañska, 2009b). See Saidapur and Nadkarni (1973) and Ogielska et al. (2010) for a detailed description of the stages of follicular atresia in the frog ovary. Atresia may influence the number of ovulated oocytes (Uribe Aranzábal, 2011) and can remove females from the breeding population (Goldberg, 2019).

In conclusion, my data supports previous studies indicating *P. streckeri* reproduces in winter-spring (Table 3). The presence of mature follicles (imminent spawning) and concurrent postovulatory follicles (from a recent spawning) in the same ovary, is histological evidence that *P. streckeri* females may spawn more than once in the same reproductive period. Histological examination of congeneric species are warranted to ascertain if they also can spawn a second time during the same reproductive period.

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Appendix: Forty-six *P. streckeri* from Oklahoma examined (by county) from the herpetology collection of the Sam Noble Museum (OMNH), The University of Oklahoma, Norman, Oklahoma, USA. **Atoka**: OMNH 39223, 39224; **Choctaw**: OMNH 32920; Cleveland: OMNH 18483, 30459, 30496–30498, 38136, 39833–39835; **Comanche**: OMNH 25663, 27761–27767, 39832; **Grady**: OMNH 37694, 37696; **Leflore**: OMNH 44439, 44440; **Major**: OMNH 25666, 25667, 25676, 25677, 25683, 37755, 37757, 37758–37760; **Marshall**: OMNH 21883, 21888, 21893, 27782, 27789, 27794, 27826, 27807; **Pottawatomie**: OMNH 38179, 38181; **Tulsa:** OMNH 30458.

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MABI I'm Amazed!

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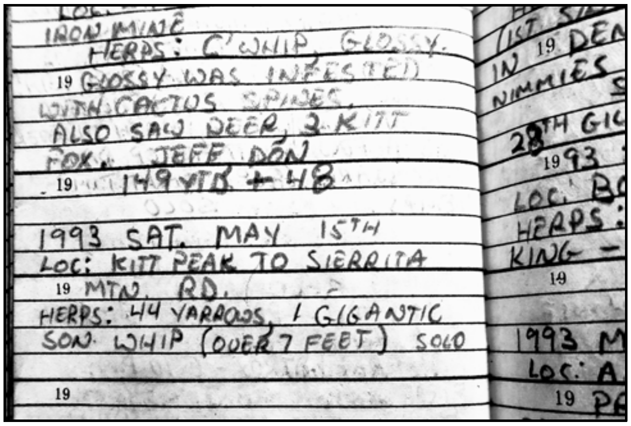
Figure 1. A typical adult Sonoran Whipsnake (*Masticophis bilineatus*), Pima County, Arizona. Image by Rob Winward.

For the past three years or so, my brain has locked onto a phrase that would make a *great* beginning to one of these columns. There would be a brief Roger Repp sort of paragraph—only a thousand words or so long—that would provide the set-up for the following sentence: "And suddenly, I saw the biggest kingsnake that I have ever seen in my life." Yup, that would be a great way to start a column. The one fly in the ointment is that I have never seen a kingsnake anywhere in the wild that was bigger than 3.5 feet (106 cm) long. "And then suddenly, I saw this monster of a kingsnake. He was over three feet long. He was all teeth at one end, and all musk at the other. I rolled up the sleeves of my tank top, and prepared to do battle." That doesn't quite cut it, does it? To be sure, I have seen some monster Eastern Kingsnakes—what I call the Chain Kingsnakes—that are over six feet long. These were captive animals that were brought to CHS meetings back in the late 1960s. Do such monsters still exist anywhere? I mean in captivity *or* the wild? Doubtful, but I'd love to hear about it in either case. Sadly, I must get this notion of starting a fantastic column on kingsnakes in this fashion out of my head. It's just as well; they are a dim-witted sort of snake anyhow. I think the only way they survive in the wild is by crawling around with their big mouths agape, and the foodstuffs just fall in. Anybody who has ever watched them feed in a captive situation will also wonder aloud how anything so stupid can survive in nature. I had one start eating his own tail once. I had to smack him upside the head a good one to get him to puke himself back out. I have no doubt that he would have devoured himself to the neck if I had not intervened. I can only imagine how he would have defecated/deposited himself back out at the end of the digestive process. They are *such* idiots!

Speaking of big snakes in the wild, as well as idiots, we are going to start this column in a rather unorthodox fashion. Please refer to Figure 2. This is a photo of a page from my very first herp journal. I have deliberately included bits of other entries in the image for the sake of authenticity. My field notes have always been written as documentation to myself. They were not written to impress anybody but me. There was never a reason to exaggerate in my notes—I would only be lying to myself if I did. The astute reader will note that only one full entry exists in the image. That was purposeful, as all I really want the reader to see in its entirety is what was written for 15 May 1993.The notation is minimal at best, but that was the way I did things between the years 1989 thru 1994. There is an inaccuracy in the notation of 15 May 1993. I wrote "GIGANTIC Son. Whip (over 7 feet)." Said "Son. Whip" was actually closer to nine feet than seven. I was afraid to write that down at the time, lest I one day be ridiculed for it. I was trying to build a reputation of credibility at the time. I was not anywhere near that goal in 1993, and if I went about spouting tales of nine-foot snakes of any kind my reputation would have been shot! Now, getting the truth about this snake out there is important enough to me that I don't care about any scoffing the information will receive. I know very well how ridiculous it seems. "Yeah, sure, Repp. A big one that got away—eh? What a pity . . . " Allow me to fill in a few more details about this snake, and how I ascertained its length.

We start with my shoe size. It is an 11½, and has been an 11½ for decades. Back when I was serving a useful purpose by machining various parts out of metal, I used a set of 12-inch dial calipers to measure roughly 90% of the parts that I made. I could measure any parts I made with these calipers to an accuracy of .001". (One thousandth of an inch. That is splitting the thickness of a human hair three times.) In the late 1980s, I was bored enough to measure one of my work boots with this caliper. From heel to toe it measured 11.995 inches. That is roughly two hair thicknesses shy of 12 inches—or one foot. Yes, the cornerstone of the English system of measurement is reputed to be the length of a king's foot. Which king is unclear to me, but had the Herp King of Arizona been born a little earlier, it would have been *my* foot that became *the* almighty hallowed foot in the English measuring system. I'll bet my foot is closer to an actual foot than this lesser king's foot was. Once again, I came into this world too late to earn the greatness that should have been my birthright.

The reader may ask: "Now why is this *idiot* talking about his foot being a foot? Why should we care about the size of his stinky feet?" My answer to this question, impatient ones, is in the story that is about to be relayed. And how did you know that my feet are stinky? As Figure 2 clearly demonstrates, the date of this event was 15 May 1993. I was driving down from the top of Kitt Peak Road when I saw it. I was just rounding a tight bend, and first saw it at a distance of perhaps 50 meters away. It was the biggest wild snake that I have ever seen. It was so big that I thought: "This can't be real." But it was! It was lying on the pavement, nearly ramrod straight, except for the tail. The tail was hooked in such fashion that the posture looked like an elongated J. (Actually, roughly double the size of a stump-ripper snake hook, and that would be a more accurate description of the posture and size.) The bottom of the J, the tail, was pointed toward me. The head of this snake was nearly touching the



IRON MINE
HERPS: C'WHIP, GLOSSY.
19 GLOSSY WAS INFESTED
WITH CACTUS SPINES.
ALSO SAW DEER, 3 KITT
FOX. JEFF DON
19 149 YTB + 48

1993 SAT. MAY 15TH
LOC: KITT PEAK TO SIERRITA
19 MTN. RD.
HERPS: 44 YARROWS, 1 GIGANTIC
SON. WHIP (OVER 7 FEET) SOLO

19

1ST S
IN 19 DEN
NIMMIES
28TH GI
1993
LOC. B
HERPS:
KING –
19
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Figure 2. Author's notes from 15 May 1993. The notes refer to an atypically large *Masticophis bilineatus* found on Kitt Peak Road (Arizona State Route 386). The author reveals that this snake was larger than the length of seven feet stated in these notes. See text for details.

center yellow line on the pavement. The bottom of the J was hooked just inside the white line that indicated the right edge of the road (between the right lane and shoulder). I pulled alongside of this snake in such fashion as my wheels straddled the tail, and the snake was perpendicular to my vehicle. I was looking straight down on it through my driver side window. It lay still for over a minute, and I made no moves to try to catch it. These days, I would have my little digital camera ready for such a sight, but this was before such useful things were part of my arsenal. I took the photo with my mind, burning where the tip of the snout lay with regard to the yellow "no passing stripe" in my brain. The snake was a Sonoran Whipsnake (*Masticophis bilineatus*). [Mostly MABI from this point on in this text.] Usually, larger-sized MABI are all sorts of beat up, bearing scars, blemishes, missing an eye, etc. But this *dandy* had not a mark on it. It was easily two inches in diameter, and it just sort of gleamed in the sun, its elongate dull gray to olive drab to turquoise dorsum glittering with the freshness of a recent shedding of the skin. In time, it glided off the road. I then stepped out of my vehicle, put my right heel at the edge of the same, and walked heel to toe to the point where the nose of the snake had ended. *It was eight of those footsteps*! I walked this off twice, and the answer was eight both times. And there was still more (at least one more) of those footsteps, under the vehicle before it departed. (When I pulled up to it, the front passenger tire was actually rolling behind the snake. I then hooked a sharp left to straddle it.) Yes sirs and ma'ams, it was a nine-foot-long MABI! I am a much better liar than to invent a nine-foot-long snake and call it a Sonoran Whipsnake. If I were going to fabricate such a story, I'd make the type of snake something more believable, like perhaps a Gophersnake, or Coachwhip. It has been my pleasure to recently review a masterful, soon-to-be-published work on MABI, and the longest ever recorded was just over six feet in total length.

I have only told this story a few times to friends, who, when they detect how earnest I am in reporting it, are polite enough not to scoff overtly about it. I have never put it in print. I did make a half-hearted effort to insert it into the chapter on MABI in the upcoming book *Snakes of Arizona*. The sounds of silence from the authors of that chapter indicated their enthusiasm with the information. And they didn't exactly jump at the chance to come measure one of my boots. In any case, I wish that I had recorded the actual length in my notes, but I knew that my stated "over 7 feet" wasn't going to be believed either. Perhaps one day, another impossibly *huge* Sonoran Whipsnake will be found and properly processed. Where there is one, there *has to be more*!

This all serves to remind me of something. It's a story that starts with: "On 15 May 1993, I was negotiating a tight mountain curve with my Suzuki Samurai, when suddenly, I saw the biggest Sonoran Whipsnake that I have ever seen in my life . . . "

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

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What You Missed at the February Meeting: Mike Redmer

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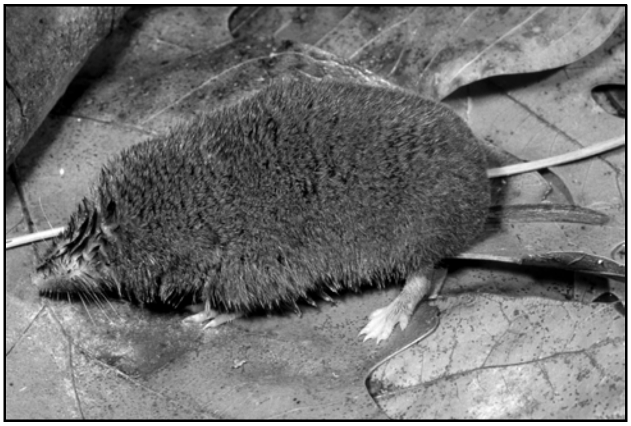
The star of Mike's talk, an eastern massasauga rattlesnake. Photograph by Mike Redmer.

Mike Redmer is a senior biologist for the Chicago Field Office of the U.S. Fish and Wildlife Service (USFWS). It's a cliché to disparage people who work for the government. Having been a recipient of your tax dollars, I can relate to the abused. While people who are on the U.S. payroll are no different from non-government employees in variety and competency, often the fact that dedicated and effective people quietly go about their important government jobs is buried under a cascade of critiques. Mike Redmer is one of the good ones. I've known him for a long time. He's been a member of your society since 1978 and has presented to the CHS before. But it's been too long, so Mike came to the meeting to talk about the important work going on with the eastern massasauga rattlesnake. He titled his talk "Where did Waldo go? The Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) as a Federally Listed Species."

Mike began with a description of the natural history of the snakes. Following his lead, I'm going to abbreviate the name as EMR. The snake has a wide geographic range around the Great Lakes and the upper Midwest and is one of the most northerly pit vipers in North America. In winter the snakes will hibernate in water, using crayfish or mammal burrows, tree-root holes, rock crevices or other cavities to reach the water table. During the active season from April to October EMRs may be found in or near grass-, cattail- or sedge-dominated habitats where they prey upon shrews, voles, frogs and other snakes. It was once thought that over most of their range EMRs relied mostly on voles as prey. More recent studies have shown that shrews are the most frequently consumed prey.

EMRs have a reputation for being secretive. You probably won't find them under cover objects, but with the proper search image, similar to what one might use in the game of Where's Waldo, you can find them right out in the open. It's still not an easy snake to find, but massasaugas are probably not as secretive as some literature claims. Because they likened the search to the above-mentioned game, the research group named the first snake of their study Waldo, and he was followed for a few years. Mike had several slides showing how the snakes can be pretty easy or very difficult to spot.

He next gave us a description of the process involved in listing the snake. While the Endangered Species Act was passed in 1973, the EMR was not looked at until the early nineties. As a result of status surveys, the snakes were listed as state endan-



A southern short-tailed shrew. Recent research describes this as a more popular food item the the previous top contender, the vole. Photograph by Mike Redmer.

Finding the snakes made easier with radio-tracking. This individual was one of the earliest to be monitored and was named Waldo. Photograph used with permission courtesy of the USFWS.

The title of Mike's talk came from finding the snakes not often under cover, but usually out in the open. Developing a good search image is essential (left). Though obviously finding them can still be difficult (right). Photographs by Mike Redmer.

gered in nine of the ten historic range states and as a species of special concern in Michigan. In 1999 the USFWS listed EMR as a candidate species, but without a budget no action was taken until 2014. From 2014 to 2016 a Species Status Assessment was conducted. That assessment identified where extant populations still occur vs. historic distribution and identified and evaluated how risk factors and life history traits interact to affect the species' continued existence. I was impressed by the work that goes into this assessment. Life history traits of the EMR involve some male combat, sexual maturity in the second full year of life, a female's first litter in or after the third full year of life, a relatively small litter size, females usually skipping a year between births, average life expectancy of 6–7 years and small population dynamics. Risk factors include not only the usual culprits such as habitat loss, habitat fragmentation, and persecution, but also changes in hydrology, climate, and susceptibility to disease.

Mike described how the USFWS factors in all of this to arrive at a comprehensive report on the status of EMR. He showed how scattered and isolated populations affect conservation efforts. He explored the paradox of how prescribed burns are absolutely essential to maintaining the open and sunny habitat the snakes need, but if performed at the wrong time can result in high mortality. He emphasized the need for continued research but explained that everything is expensive. And he showed how declines and losses in local populations have continued and in some cases even accelerated since the 1990s. Using population modeling, it is estimated that only ten percent of the historic populations will exist in 50 years.

I want my own feller/buncher so I can restore habitat. This machine cuts off multiple trees at a time. Unfortunately, it's an expensive way to restore habitat. Photograph used with permission courtesy of the USFWS.

He then defined "endangered" and "threatened" according to the Endangered Species Act. Endangered means that a species is likely to become extinct in the foreseeable future. Threatened means the species is likely to become endangered in the foreseeable future. Obviously, there is lack of specificity in those definitions. The foreseeable future was set at 50 years by the USFWS, so the researchers listed the snake as threatened based on the best models.

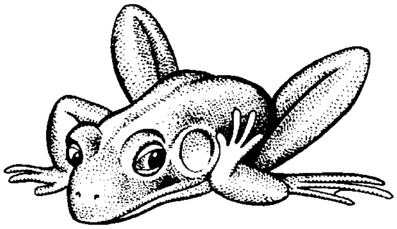
After a species is listed, a Recovery Plan is prepared. It happened that the USFWS released the recovery plan for EMR on the same day as our February meeting. One can find it easily by an online search and contribute comments on the plan. The plan includes monitoring, key research, disease and population health assessments, habitat protection, and habitat restoration. None of this is straightforward and all of it is expensive. Mike gave as an example habitat acquisition. This has some potential, but about 60% of known EMR populations already occur on protected or public lands, often where the species is still in decline. Monitoring is time consuming and expensive. Habitat restoration can be done and is frequently effective but very expensive. Mike described how a coalition of professionals from the government, academia, zoos, and some amateurs are attempting to set up monitoring and research on a representative sample of populations in order to gain as much knowledge as possible in an effective but practical way.

As always, you're missing much of Mike's talk in this brief description. He answered questions about captive breeding. He mentioned how some vipers can survive snake fungal disease, but once established in an EMR, the disease seems to be nearly 100% fatal. I learned new words such as ALEE effects and feller/buncher. Mike's talk was a fairly comprehensive exploration of the natural history of the massasauga, but mostly a detailed account of how a species comes to be listed and the problems and obstacles in trying to protect any species in danger. I already knew Mike as a caring and conscientious government employee, and I'm sure that anyone who attended the meeting not only came away educated about government procedures and rattlesnake facts, but also an appreciation of Mike's dedication to his work. He's an excellent presenter. It's great to have him as a member.

Bulletin of the Chicago Herpetological Society 55(3):68, 2020

The Tympanum

Raymond Hoser is a controversial figure in the field of herpetology because of his self-published taxonomic descriptions and revisions. Raymond, who hails from Australia, has been a CHS member for more than 25 years. The following piece is excerpted from a press release that Raymond submitted to the editor.



Newly discovered species of crocodile is not so new after all!

In a supposedly peer reviewed paper, a group of so-called scientists alleged they had found a new species of crocodile in southern New Guinea and proceeded to formally name it *Crocodylus halli*, Murray et al. 2019.

Their key findings had in fact been lifted from a 7-year-old paper that had already discovered and named the very same species using the same morphological data. Using almost identical morphological and geographical data, Australian scientist Raymond Hoser, better known as The Snake Man, had identified and named the southern New Guinea species as separate to the better known northern species. The name assigned was *Crocodylus* [as *Oopholis*] *adelynhoserae* (Hoser, 2012). The 2019 paper by Murray et al. does not cite the earlier Hoser work in any way, shape or form, even though it is clear much of what is within their paper has been effectively lifted from it. Instead the authors have marketed the contents of their 2019 paper as their own original work and discovery. While authors overlooking earlier important papers was common in years past, it is rare in the present time due to the fact that scientific papers are databased and widely accessible almost immediately after publication.

The papers of Hoser, and the crocodile one from 2012 in particular, have been widely publicised and cited, including in some of the most widely read herpetological journals on the planet. This means that it would be effectively impossible for four authors, all in the same research space (Crocodiles) and one or more alleged peer reviewers would all be unaware of the 2012 Hoser paper and the data presented within it.

In terms of a reviewer, it would be impossible to miss the obvious fact that the key evidence and findings in both the 2012 and 2019 papers are identical.

At the time Hoser's 2012 paper was published he was widely accused of "taxonomic vandalism" (including in a recklessly written and long ago discredited blog piece on the "Scientific American" website). Taxonomic vandalism is a nefarious practice of recklessly renaming species that have already been named. Hoser challenged this claim on the basis his two newly discovered species of crocodiles, one from Australia and one from southern New Guinea, were in fact different and he said he had evidence in his paper that supported this.

Since then, Northern Territory Crocodile experts have confirmed the genetic distinctiveness of the species Hoser named from there, namely *Crocodylus* (as *Oopholis*) *jackyhoserae* (Hoser, 2012), and now the paper of Murray et al. does the same for the New Guinea species *Crocodylus adelynhoserae* (Hoser, 2012) in that they do present a limited amount of further supporting data beyond what Hoser first published in 2012.

Ironically, it is the actions of Murray et al. 2019, that constitute taxonomic vandalism. Hoser has contacted the editor of the PRINO (Peer reviewed in name only) journal *Copeia* already seeking they immediately retract their paper on the basis of plagiarisation and taxonomic vandalism, or to at least correct the illegal coining of a new name for a long discovered species in breach of the rules of the International Commission of Nomenclature and the International Code of Nomenclature.

In any event, one thing is clear and undeniable. The allegedly newly discovered species of crocodile from southern New Guinea is not so new after all. It was formally discovered and named 7 long years ago by longstanding CHS member and reptile conservationist Raymond Hoser.

The two relevant papers are as follows:

Hoser, Raymond T. 2012. A review of the taxonomy of the living Crocodiles including the description of three new tribes, a new genus, and two new species. Australasian Journal of Herpetology 14:9-16. Full text available at: http://www.smuggled.com/Issue-14-9-16.pdf

and

Christopher M. Murray, Peter Russo, Alexander Zorrilla, and Caleb D. McMahan. 2019. Divergent Morphology among Populations of the New Guinea Crocodile, *Crocodylus novaeguineae* (Schmidt, 1928): Diagnosis of an Independent Lineage and Description of a New Species. Copeia, 107(3):517-523. Full text available at: https://bioone.org/journals/copeia/volume-107/issue-3/CG-19-240/Divergent-Morphology-among-Populations-of-the-New-Guinea-Crocodile-Crocodylus/10.1643/CG-19-240.full?fbclid=IwAR2sGH3LpTBuYF0MHrehfs_A0WWpbXzRHWVTAx6CmV10egHsz89Way8l_PI

Raymond Hoser, viper007@live.com.au

Bulletin of the Chicago Herpetological Society 55(3):69-71, 2019

Herpetology 2020

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

VISUAL ENCOUNTER SURVEYS

B. Lardner et al. [2019, Herpetologica 75(3):218-223] note that visual encounter survey efforts can be defined and constrained by duration, distance, or both duration and distance simultaneously. This study examines the optimal walking pace that will maximize the number of animal detections within a limited time frame. The authors predicted that animal sighting rate per unit of distance would decline with increasing pace, but that maximal sighting rate per unit of time would occur at some intermediate pace because walking faster means covering more ground and passing more animals that could potentially be detected. We conducted a controlled experiment during which we searched for brown treesnakes (*Boiga irregularis*) while walking 220-m-long transects at three different speeds. For transects inside the forest, detection rate per unit distance decreased (nonlinearly) with increasing pace. When considering catch per unit time, however, we found 5% more snakes at the medium pace compared with the slow pace, and 63% more snakes at the fast pace compared with the slow pace. The pattern appeared different for surveys along forest edges with higher vegetation density, in which snakes might be more difficult to spot. Surprisingly, pace had no detectable effect on the body sizes or perch heights of snakes successfully detected. Finding the optimal search pace for a particular study organism in a focal habitat has the potential to substantially increase survey cost-efficacy.

IDENTIFYING SEA TURTLE HOME RANGES

D. S. Baumbach et al. [2019, Chelonian Conservation and Biology 18(2):133-144] note that individuals of the public regularly come in contact with animals and, as citizen-scientists, may represent a relatively constant source of data for researchers through written forms, web maps, or smartphone applications. The authors collected hawksbill (*Eretmochelys imbricata*) sightings from citizen-scientists using a new geographic information systems web map and smartphone application, and then calculated home ranges of individual turtles to gain insights into hawksbill movements within a marine protected area in Roatán, Honduras. They found that 3 of 4 individual turtles had home ranges of less than 1 km^2 within the West Bay and West End zones of the marine protected area, whereas the fourth turtle had a home range of 1.44 km^2 that extended from West Bay to Sandy Bay. They also found significantly more prey sponge in the West Bay and West End zones than in the Sandy Bay zone and suggest the small home ranges of hawksbills in this study may be due to the abundance of prey sponges within the Sandy Bay West End Marine Reserve. This study is the first to use citizen-science data collected via web-based and smartphone geographic information systems software to identify sea turtle home ranges. The results correspond well to prior home range estimations derived using very high frequency radio telemetry. This method using citizen-based data may potentially be applied around the world to any animals with home ranges.

SALAMANDERS ON THE VERGE

A. Hernandez et al. [2019, The Herpetological Bulletin 148:15-21] note that Mexico is a hotspot of salamander diversity and harbors 18 species of the genus *Ambystoma* (Amphibia: Urodela) widely distributed from the Sierra Madre Occidental to the Trans-Mexican Volcanic Belt. These species are highly threatened by various factors and some of them are considered nearly extinct in the wild. The Michoacan stream salamander, *Ambystoma ordinarium*, and the yellow-peppered salamander, *A. flavipiperatum*, are two endemic and scarce species from Mexico living in isolated and declining populations. Few observations have been made on them in their natural habitat since their original description. This study reports new data regarding the biology and habitats of *A. ordinarium* observed at Rio Bello, 2,120 m a.s.l., Morelia city, Michoacan state, and for *A. flavipiperatum* at Sierra de Quila, 2,165 m a.s.l., 100 km south from Guadalajara city, Jalisco state. For *A. ordinarium* the authors found one neotenic adult male and two dead adult females in a small shallow stream located within a fragmented fir, oak and pine forest. For *A. flavipiperatum* they recorded an adult male and a female both neotenic, one clutch of eggs, and eleven larvae inhabiting a slow-moving stream located through a riparian habitat surrounded by a large pine-oak forest. These observations confirm that both species are highly endangered, capable of facultative neoteny and occur in small slow-moving streams surrounded by coniferous forests. Morphology, geographical distribution and conservation status are discussed.

ACCELEROMETERS IN TURTLE NESTS

N. Rollinson et al. [2019, Journal of Herpetology 53(4):302-309] note that phenological timing is of central interest to evolutionary ecologists because it is associated with fitness, but there has been limited study in animal groups with relatively secretive habits such as reptiles. This is especially true for the timing of hatchling behavior in wild reptile nests, likely attributable to few noninvasive methods for estimating parameters associated with egg hatching. Tri-axial accelerometers, small data loggers that measure rotation and inclination, can accurately quantify hatchling movement in wild reptile nests. In June 2018, the authors deployed an accelerometer in each of five freshly laid snapping turtle (*Chelydra serpentina*) nests in Algonquin Provincial Park, Ontario, Canada. In September 2018, nests were visited once daily to quantify the timing of hatchling emergence. The accelerometers worked as expected: there was statistically significant correspondence between the timing of accelerometer rotation in the nest (caused by movement of the hatchlings) and the timing of hatchling emergence. Furthermore, the number of hatchlings emerging from a nest was strongly and significantly correlated with the extent of accelerometer displacement. This new technique allows new types of phenological data to be collected. It requires minimal effort and financial investment and thus is accessible to a broad range of research programs.

ORIGINS OF INVASIVE BOAS ON COZUMEL

M. Suárez-Atilano [2019, Copeia 107(4):606-621] note that nvasive species represent a major threat for biodiversity. The numbers of independent introductions, introduced propagules, and introduction episodes are critical aspects for invasion success. The invasive population of the snake *Boa constrictor* in the Mexican Caribbean (Cozumel Island) has been studied ecologically and genetically, but, despite several lines of evidence suggesting its invasive nature, a full account of its invasive history is lacking. The authors aimed to reconstruct the boa's invasion history by deciphering the original source(s) of the Cozumel population, routes of invasion, likely number of propagules, and estimation of historical genetic and demographic parameters, based on a comprehensive set of analytical tools. The phylogenetic relationship of the Cozumel boa within the *Boa constrictor* complex was unknown; hence, to identify the source populations, they first needed to clarify its genealogical relationships. They used mitochondrial and nuclear sequences and nuclear microsatellites, together with the widest geographic sampling along the species' entire continental distribution. This genetic approach demonstrated that the Cozumel population was derived from an admixture of individuals from different geographic localities. Moreover, demography results allowed successful confirmation of both anecdotal and previous genetic information, concordant with a scenario in which a likely small number of propagules were released on the island about 50 years ago. Notably, national law hinders the possibility of performing any control protocols for the boa, hence the results highlight a rather unique conservation paradox, where the Cozumel boa has a novel endangered protected species status as *B. imperator*, but it is also an invasive exotic predator threatening the critically endangered endemic and native biota of Cozumel. Therefore, any conservation decisions should consider that boas in Cozumel are invasive, opening the possibility to legally allow implementing control or eradication programs.

POPULATION TRENDS IN UK ADDERS

E. Gardner et al. [2019, The Herpetological Journal 29(1):57-70] report that concern has been growing about the status of UK adder populations, with expert opinion reporting widespread declines. Assessing the true scale of these declines, however, has been hampered by a lack of quantitative data. Make the Adder Count began in 2005 as a national surveillance program collecting standardized counts of adders lying-out after emerging from hibernation. Data contributed from 260 sites confirmed a significant decline, on average, across sites with small populations, while the few with large populations (<10% of sites) are weakly increasing. If these trends continue, within 15–20 years adders will be restricted to a few large population sites, significantly increasing the extinction risk for this priority species in the UK. Public pressure/disturbance was reported as the most frequent negative factor affecting sites, followed by habitat management and habitat fragmentation. Negative impacts from habitat management were reported almost as frequently as positive impacts, suggesting many management plans do not adequately consider the requirements of adders. The data set also demonstrated earlier emergence among males, in warmer springs and at more northerly sites.

PREGNANT PYGMY RATTLESNAKES

C. M. Lind et al. [2019, Journal of Herpetology 53(4):282-288] note that in viviparous organisms, the ability to feed while pregnant may mitigate energetic trade-offs experienced during the reproductive process and enhance fecundity. However, anorexia during pregnancy has been reported in many crotaline snakes. The potential costs and benefits of feeding while pregnant are not completely described in the literature, and experimental studies have been conducted in a limited number of taxa, resulting in incomplete understanding of the forces that may underlie the evolution of anorexia in pregnant snakes. The authors examine the impact of food supplementation during mid to late pregnancy on mothers and offspring in a viviparous crotaline snake species, the pygmy rattlesnake (*Sistrurus miliarius*). Specifically, they offered multiple large meals to mothers held in outdoor enclosures and measured a suite of maternal and offspring traits including maternal body condition, offspring length and mass, maternal disease state, and offspring foraging behaviors. They focused on interactions between feeding, clinical signs of snake fungal disease (SFD), and the presence of its causative agent, *Ophidiomyces ophiodiicola*, in mothers. Pregnant females fed readily when offered food, but feeding did not impact offspring traits. Food supplementation significantly increased maternal postparturient body condition, but also increased clinical signs of disease in mothers and led to a significantly higher reproductive failure rate in the treatment group, particularly in mothers afflicted with SFD. These results suggest that food supplementation during pregnancy may disrupt the reproductive process in pregnant rattlesnakes, and that such disruption is particularly pronounced in mothers suffering from SFD.

SPATIAL ECOLOGY OF TIMBER RATTLESNAKES

C. E. Petersen et al. [2019, Herpetologica 75(2):162-174] note that despite large-scale population decline and geographic range contraction, timber rattlesnakes (*Crotalus horridus*) continue to occupy sites across much of eastern North America, including a diversity of habitat types. The objective of this study was to examine the influence of intrinsic and extrinsic factors on the movement and activity range of timber rattlesnakes in the Coastal Plain of southeastern Virginia. To do so, the authors analyzed the movements of 54 radio-implanted snakes over a period of 17 yr, with individuals being tracked for 1–6 yr, amounting to more than 14,000 snake locations. Consistent with previous studies, our results showed strong sexual differences in movements, with average daily and annual movements of males exceeding those of females. Mean annual movements of males were approximately 1.8 times greater than those of females, with a peak in male movements in late summer, associated with mate searching. Similarly, all estimates of activity ranges (using minimum convex polygon and kernel methods) were larger for males, with overall activity ranges approximately three times greater than for females. Gravid females had somewhat smaller movements and activity ranges than nongravid females, with early-season movements of gravid individuals to the birthing site, followed by shorter movements within that site, interpreted as serving a thermoregulatory function. The number of locations and body mass (of males) also appeared as significant factors in some models, although sex was the dominant factor in all models.

GENOTYPING DESERT TORTOISE SCAT

A. Mitelberg et al. [2019, Chelonian Conservation and Biology 18(2):123-132] tested extraction protocols on scat samples from the threatened Mojave Desert tortoise, *Gopherus agassizii*, to evaluate whether scat-based mark–recapture and population genetic monitoring studies are feasible. They extracted DNA from *G. agassizii* scat samples collected in California and Nevada using several extraction protocols and evaluated the reliability of resulting genotypes. They also assessed probabilities of identity and sibship, and locus amplification quality, and calculated genotyping error rates for 19 microsatellite loci to determine the best set of loci to use with *G. agassizii* scat extractions. It was found that genotype quality depended more on the sample quality than on the extraction method, and that the Qiagen DNeasy Plant Mini extraction kit is an efficient method for extracting tortoise DNA from tortoise scat. The authors identified 6 *G. agassizii* microsatellite loci that can be used to generate a unique molecular tag for individual tortoises, and characterized the reliability of an additional 13 microsatellite loci for use in population genetic analyses where additional power at the expense of some increase in error may be advantageous. As proof of concept, with very low error rates, they matched 3 opportunistically collected scat samples to blood genotypes from animals captured during population surveys within the study area and discovered at least 3 new individuals, even after 2 yrs of extensive survey work. These results suggest that genotyping of field-collected scat can complement existing methods used in long-term demographic and movement studies of *G. agassizii* and other, closely related, tortoise species.

HEALTH SCREENING BURMESE STAR TORTOISES

B. L. Raphael et al. [2019, Chelonian Conservation and Biology 18(2):153-162] note that the once abundant Burmese star tortoise (*Geochelone platynota*) was functionally extirpated from Myanmar largely due to exploitation for wildlife trade markets. *Geochelone platynota* is endemic to the dry zone of central Myanmar, a desert-like region formed by the rain shadow of the western mountains. To prevent biological extinction, ex situ captive assurance colonies were established and a captive breeding program was initiated. Three major assurance colonies of Burmese star tortoises in Myanmar produced approximately > 14,000 individuals between 2004 and 2018. In 2013 and 2014, the Wildlife Conservation Society, Turtle Survival Alliance, and Myanmar Forestry Department performed health assessments on 539 tortoises prior to reintroduction. Tortoises were negative by polymerase chain reaction for the presence of *Mycoplasma* spp., ranavirus, herpesvirus, and the intranuclear coccidian parasite of Testudines. Results from hematologic assessment of all study tortoises were consistent with published data on other species of healthy tortoises. Such health assessments, including physical examination, hematologic analysis and molecular pathogen screening, are important to generate baseline information about potential circulating organisms or pathogens. Additionally, health assessments ensure the success of repatriation projects by both assuring that potential pathogens associated with disease are not inadvertently introduced into the wild, and that individuals slated for release are healthy enough to weather the rigors of reintroduction.

LIFE HISTORY FROM MUSEUM SPECIMENS

N. M. Caruso and L. J. Rissler [2019, Copeia 107(4):622-631] note that amphibian life history strategies can vary across broad geographic patterns, which have been explained, at least in part, by how development, growth, maintenance, and reproduction respond to temperature. However, there is a dearth of information regarding life history traits and their variation among populations for many amphibian species, which prevents assessment of these broad patterns among species. Therefore, the authors used museum specimens to assess the variation in reproductive condition of *Plethodon montanus* across its range and used skeletochronology at five populations along an elevational gradient to determine the elevational variation in age, growth rate, and asymptotic size. They found that body size and temperature seasonality best explained the variation in the presence of eggs and a mental gland, whereas body size alone best explained the presence of enlarged pigmented testes. They also found that longevity in *P. montanus* is at least 12 years with higher elevations having a higher proportion of older individuals compared to lower elevations and that size was a better explanation of reproductive condition than age across the elevation. The results further demonstrate the importance of body size for amphibian life history traits and the utility of museum specimens to estimate these traits. Variation in reproductive condition across the range of *P. montanus* is likely the result of variation in growing season length. Lastly, the authors found evidence suggesting asymptotic size and growth rates may have changed over the last half century, which would ultimately affect fertility and other life history traits and warrants future studies.

MULTIPLE PATERNITY IN INDIGO SNAKES

J. Deitloff et al. [2019, Herpetologica 75(3):224-232] note that multiple paternity of clutches is common in many vertebrates, including snakes, and understanding how frequently it occurs within a species is important for determining the role it might play in conserving that species. One such species, *Drymarchon couperi* (eastern indigo snakes), is the subject of an ongoing captive-breeding program and repatriation project in the southeastern United States. Many characteristics of the reproductive biology of this species are poorly understood, including whether clutches are sired by more than one male, and which characteristics, if any, are selected in potential mates. Sexual dichromatism has been suggested to occur in this species and, as such, one characteristic that might play a role in sexual selection is color. The first objective was to determine if multiple paternity occurs in source and repatriated populations of *D. couperi*. Second, the authors examined whether color might play a role in sexual selection or sex identification. Therefore, they also tested hypotheses examining associations between color, heritability, and multiple paternity. They found that multiple paternity likely occurred in ~31% of the clutches. Furthermore, heritability of color was relatively high, but single-sired and multisired clutches were similar in color and in the variability of color within a clutch. The authors conclude that management of *D. couperi* could benefit by exposing captive-bred females to multiple males within a mating season. This will allow for use of stored sperm to inseminate eggs after release or for females to seek new mates among the repatriated population.

Advertisements

For sale: **highest quality frozen rodents**. I have been raising rodents for over 30 years and can supply you with the highest quality mice available in the U.S. These are always exceptionally clean and healthy with no urine odor or mixed in bedding. I feed these to my own reptile collection exclusively and so make sure they are the best available. All rodents are produced from my personal breeding colony and are fed exceptional high protein, low fat rodent diets; no dog food is ever used. Additionally, all mice are flash frozen and are separate in the bag, not frozen together. I also have ultra low shipping prices to most areas of the U.S. and can beat others shipping prices considerably. I specialize in the smaller mice sizes and currently have the following four sizes available: Small pink mice (1 day old—1 gm) , $25 /100; Large pink mice (4 to 5 days old—2 to 3 gm), $27.50 /100; Small fuzzy mice (7 to 8 days old—5 to 6 gm), $30/100; Large fuzzy mice / hoppers (10 to 12 days old—8 to 10 gm), $35/100 Contact Kelly Haller at 785-224-7291 or by e-mail at kelhal56@hotmail.com

Line ads in this publication are run free for CHS members—$2 per line for nonmembers. Any ad may be refused at the discretion of the Editor. Submit ads to mdloogatch@chicagoherp.org.

NEW CHS MEMBERS THIS MONTH

Jeremy Caseltine
Cindy Clendenin
Shaun Doyle
Stephanie Egan
Fitzhenry family
Noah Laporte
Vincent Mckinney
Angie Muhlbach
Michael Mungovan
Sue Naiden
Peterson family
Lisa Stuart
Isis Sykes
Julie Terrazas

UPCOMING MEETINGS

The March 25 meeting of the Chicago Herpetological Society has been cancelled.

Assuming that we do not have to cancel again, the speaker at the April 29 meeting will be **Dr. Kerry M. Kriger**, the founder and executive director of SAVE THE FROGS! (www.savethefrogs.com), a nonprofit organization dedicated to protecting amphibian populations. Dr. Kriger's presentation is entitled "SAVE THE FROGS!—Translating Science into Action." He will provide an introduction to the natural history of amphibians; the threats they face; why amphibians are important and worth saving; and ways SAVE THE FROGS! protects amphibians and empowers ordinary citizens to make extraordinary contributions to the betterment of the planet. The program features many of Dr. Kriger's photos of amphibians from around the world, and there will be a question and answer session afterwards.

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

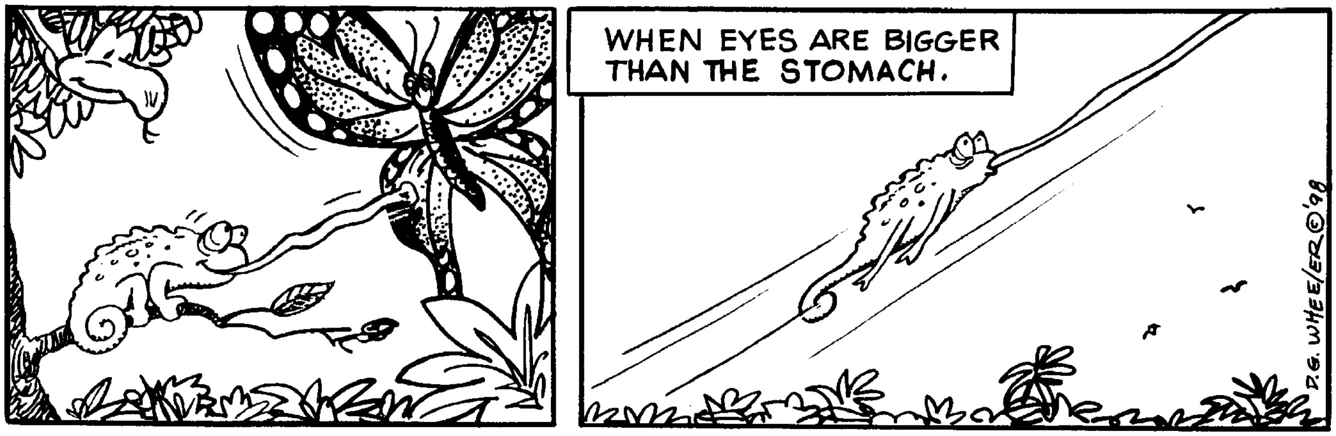
Board of Directors Meeting

Are you interested in how the decisions are made that determine how the Chicago Herpetological Society runs? And would you like to have input into those decisions? If so, mark your calendar for the next board meeting, scheduled to take place on Thursday evening, April 16. If you wish to attend please email mdloogatch@chicagoherp.org.

The Chicago Turtle Club

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

THE ADVENTURES OF SPOT



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