The Herpetological Bulletin

Issue 157, Autumn 2021

Published by the British Herpetological Society


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THE HERPETOLOGICAL BULLETIN

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Front Cover: The South America rattlesnake *Crotalus durissus* photographed by Silara Batista in Brazil, see article on p.21.

 Printed by: Bruce Clark (Printers), Units 7-8, Marybank Lane, Dundee, DD2 3DY, UK. ISSN 2634-1387.

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Registered Charity No. 205666

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RESEARCH ARTICLE

https://doi.org/10.33256/hb157.15

Ecological notes on the Cát Bà gecko *Goniurosaurus catbaensis*, a species endemic to the limestone karst islands of northern Vietnam

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ABSTRACT - The Cát Bà gecko *Goniurosaurus catbaensis* is endemic to Cát Bà and Ha Long islands of Vietnam. The ecology of this species is still scarcely studied but previous reports have suggested that the species is Endangered due to small population size and low ecological plasticity. We studied aspects of the ecology of this species between May 2019 and June 2020, along seven transects on Cát Bà island. At least 173 different individuals (possibly as many as 189) were recorded, with an equal sex-ratio and apparently no intersexual differences in adult body size. The species was clearly more widely distributed than previously supposed. We were able to confirm that *G. catbaensis* is a limestone karst microhabitat specialist, as the farthest sighting from a karst area was only 10 m. Geckos were observed at a mean height of 45 cm but up to 500 cm above ground, with males perching significantly higher than females. We observed these geckos at altitudes ranging from 11 to 228 m a.s.l.; much higher than previously recorded. Overall, our study revealed that this endemic gecko is certainly less threatened than previously feared.

INTRODUCTION

The genus *Goniurosaurus* (Eublepharidae) has a restricted range in Asia and consists of about 24 species that are characterised by predominantly nocturnal and terrestrial habits (Chen et al., 2014; Grismer et al., 1994; Honda & Ota, 2017; Ngo et al., 2016, 2019; Nguyen, 2011; Orlov et al., 2008; Vu et al., 2006; Wang et al., 2010; Zhou et al., 2018; Ziegler et al., 2008; Zhu et al., 2018, 2020; Qi et al., 2020; Uetz et al., 2020). Among them, five species of this genus occur in Vietnam (Nguyen, 2011), including the Cát Bà gecko *Goniurosaurus catbaensis* Ziegler, Truong, Schmitz, Stenke, Rösler, 2008.

The Cát Bà gecko is currently only known from two islands in northern Vietnam, Cát Bà, where it was discovered in 2008 (Ziegler et al., 2008), and Ha Long island. Since discovery there have been a few field surveys to define the ecology and conservation status of this species (Nguyen et al., 2016; Ngo et al., 2019a, 2019b) but little is known about its ecology. Due to a colourful appearance (Fig. 1), this gecko is threatened by pet trade exploitation, but also by habitat fragmentation due to agricultural development and the expansion of tourism (Ngo et al., 2019b), and it shown as Endangered (EN) in the IUCN Red List (2020). In order to guide future conservation/management action we have undertaken further field research to examine aspects of population ecology and habitat use.

MATERIALS & METHODS

Our survey was undertaken on Cát Bà Island (20° 47'19.46" N, 106° 59'14.56" E), one of 366 islands in the Cát Bà Archipelago, Ha Long Bay, north-eastern Vietnam. The island covers an area of 140 km^2 and roughly half of this is protected by the Cát Bà National Park where the survey was undertaken. The island has a limestone karst landscape which has allowed the creation of caves that are the preferred shelters of the Cát Bà gecko.

Our surveys were undertaken from 19:10 h to 23:40 h (Hanoi standard time), as previous reports indicated that the Cát Bà gecko is a nocturnal species (Ngo et al., 2019a). We searched for lizards along seven line transects that were designed using i) topographic and vegetation maps with 1/25,000 scale, ii) previous reports on the local distribution of the study species (Ngo et al., 2019a, 2019b), and iii) interviews with local people. We also used existing or newly created trails passing through different habitat types to facilitate transect surveys. In particular, we designed transects that passed through areas with caves and cliffs and valleys between limestone cliffs in the forest, where the probability of encountering Cát Bà geckos was thought to be high. The length of line transects ranged from 2.5 to 6.5 km depending on the topography. For each transect, we marked the starting point, the end point and the traveling distance by hand-held GPS. The locations of the seven line transects used in this

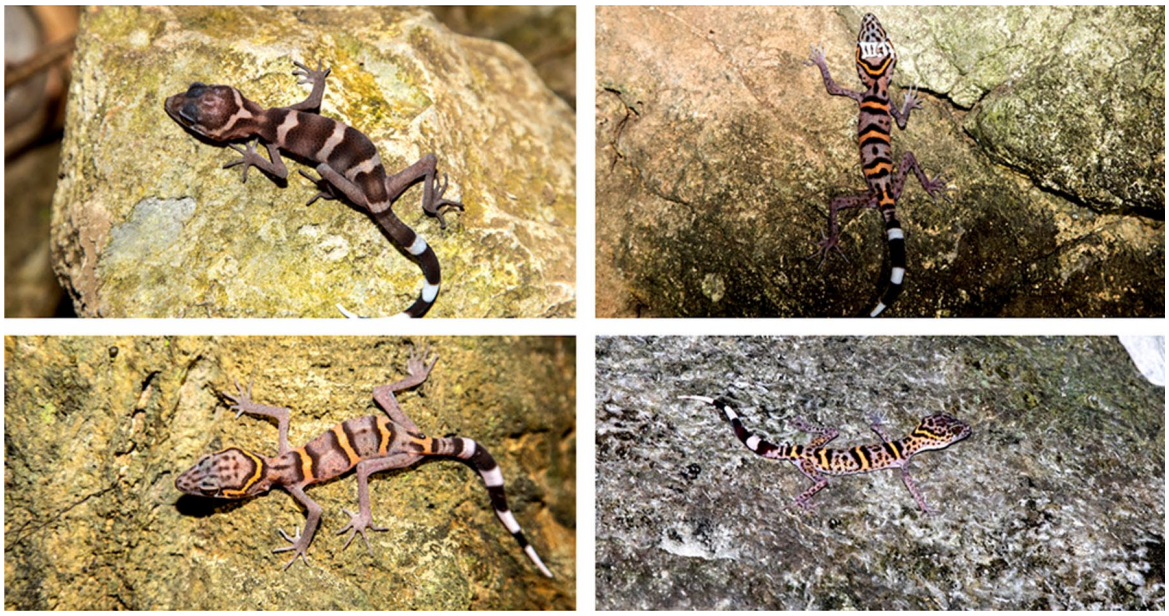

Figure 1. Some individual Cát Bà geckos observed during the study, note the upper left photograph is of a juvenile and lacks the dorsal yellow bars

study were: 1) Cát Bà National Park Center - Cát Bà Ngu Lam Peak, 2) Eo Bua ranger station - Ang Co, 3) Trung Trang cave - Uy Ban – Hospital cave, 4) Cát Bà - Ang Cu Ru, 5) Viet Hai village - Tien Duc cave - Ang Kho, 6) Gio Cung ranger station - Ang Ca Vuoc, and 7) Gio Cung ranger station - Ang Can. Five of these transects (#1, 2, 4, 6 & 7) had not previously been surveyed for geckos.

There were a total of 39 surveys in the period June 2019 to May 2020, although surveys were suspended in March 2020 due to Covid-19 lockdown. Survey effort varied by transect. Transects # 1, 2, and 3 were surveyed monthly, apart from March 2020. Transects #4, 6, and 7 only once (in April 2020), and transect # 5 once in November 2019 and twice in December 2019. Each survey had 3 - 4 surveyors (in most cases three).

We captured geckos by hand. Each captured gecko was measured in the field with electronic digital calipers (± 0.01mm) for snout-vent length (SVL), tail length (TL), head length from tip of snout to the posterior edge of ear (HL), and head width (HW) and weighed using an electronic balance (± 0.01g). The gender of each individual was determined based on external morphology: the adult males usually had a larger bulging tail base than females and had the anterior part of the vent more pronounced while females typically carried eggs (Ziegler et al., 2008). In order to tell the life stages apart, we considered as adults those individuals with SVL ≥ 105 mm, subadults those with 85 < SVL < 104.9 mm, and juveniles those with SVL ≤ 85 mm (Ziegler et al., 2008).

For each observed gecko, we recorded the temperature and humidity of where it was sighted with an electronic thermo-hygrometer (Extech 445702). We also noted: i) altitude of each record (m a.s.l.); ii) one of five habitat types (see below); iii) type of substrate used by the lizard (three categories: cliffs and rocks, branches, soil); iv) height of the animal from the ground (cm); v) location of the lizard when associated with a cave (either inside or outside). Each gecko record was assigned to one of the following five habitat types:

(i) Secondary forest on limestone hills (LHF): this is evergreen forest that was destroyed many years ago but is now being restored. The vegetation consisted of multi-tier canopy with pioneer trees, vines and large trees with DBH (diameter at breast height) >> 50 cm. This type of vegetation growing on ultramafic soil is different from the original evergreen forest. Indeed, in the past much of the forest area has been destroyed for charcoal and logging, including legal logging for timber by the Vietnamese government. The main vegetation includes *Burretiodendron hsienmu*, *Anogeissus acuminata*, *Streblus ilicifolius* and *Nageia fleuryi*.

(ii) Medium secondary forest on limestone hills (MHF) is similar to LHF, but with tree vegetation less well restored. The mean DBH was about 50 cm.

(iii) Poor secondary forest on limestone hills (PHF): has much less soil cover than LHF and very poor floral diversity. The canopy is more open than in LHF and trees are smaller (DBH << 50 cm).

(iv) Bamboo forests (BAF) consists of a monoculture of bamboos without any trees.

(v) Scrub grassland (SCR) is an open-bushy herbaceous area, with small regenerating trees (DBH < 6 cm).

(vi) Caves are widely distributed across the study area due to the limestone characteristics of the island.

We marked each individual on the head with semi-permanent paint using a code that records the line transect and the number of the individual, e.g. III.2 indicates Line transect # 3, 2nd individual encountered (Fig. 2). In addition, at the location where each gecko was captured, we marked nearby rock by painting the same symbol as that used for marking the head. Each captured gecko and capture location was photographed for easy re-identification in subsequent surveys. In some cases, we were unable to capture the geckos as they moved too quickly. In those cases, we recorded the GPS coordinates, altitude, air temperature, humidity, habitat type, and height of the animal's position relative to the ground.

Figure 2. A marked Cát Bà gecko on a rock showing the same symbol painted on its head and on the rock

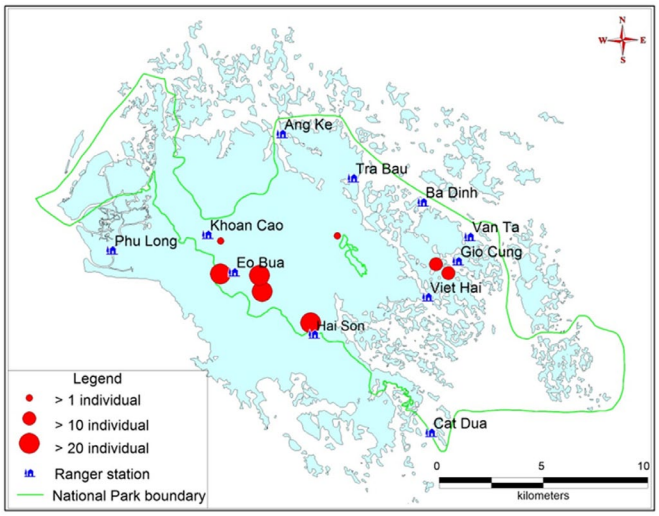

Figure 3. The magnitude of Cát Bà gecko counts at each of 7 transects – note that one of the transects (#3) is represented by two relatively distant records (see text for details)

Sex-ratio departure from equality and the frequency of gecko observations between different habitats were assessed by observed-versus-expected χ^2 tests. Intersexual differences in the means of morphometric traits (SVL and weight) were analyzed by Student t-test. For intersexual morphological comparisons, since all morphometric measurements were autocorrelated ($P < 0.05$), we used only SVL and weight as proxies of body size of each individual. Intersexual comparisons for associated mean humidity (%), mean ambient temperature, and mean height above ground were made by Mann-Whitney U-test, since the respective variables were not normally distributed (Shapiro Wilk test, $p < 0.001$). In the text, we presented means ± standard deviation and set the threshold for statistical significance at $p \leq 5$ %.

RESULTS

During the field investigation, we recorded 24 species of reptiles, belonging to 9 families (see Supplementary materials, Table S1). We recorded *G. catbaensis* individuals at all the seven surveyed transects (Fig. 2) and at four sites more than 20 individuals were observed (Fig. 2). It should be noted that Figure 2 shows eight location records even though there were only seven transects. This is because in transect #3 we recorded geckos at two distinct and relatively distant points, Trung Trang Cave and at Hospital Cave.

A minimum of 173 individuals were recorded, but for an additional 16 individuals we were unsure whether they were recaptures because their identification marks were illegible. Thus, it is possible that we may have recorded 189 different individuals. Of the different individuals (n = 173), 105 were adults, 38 sub-adults and 46 hatchlings; 69 were males, 90 females. A further 29 could not be sexed as either they were juveniles and/or because they could not be captured.

Table 1. Summary morphometrics for adult male and female Cát Bà geckos, SVL = snout-vent-length

Gender	Mean ±sd and (range)			
	n	SVL (mm)	n	Weight (g)
Female	79	107.8±7.2 (80.7-119.6)	71	19.9±4.1 (6.7-25.8)
Male	56	109.1±5.4 (90.6-121.8)	46	20.3±3.0 (12.7-27.8)

Body measurements were taken from 90 females, 69 males and 15 juveniles of unknown sex (a full listing is given in Supplementary Material, Table S2). A summary of the SVLs and weights of adult male and female geckos is given in Table 1. The females and males were similar with respect to both SVL ($t = 1.1$, $df = 132$, $p = 0.279$) and weight ($t = 0.55$, $df = 114$, $p = 0.581$). Adult sex-ratio appeared to be skewed to female but was not statistically significant ($\chi^2 = 3.02$, $df = 1$, $p = 0.082$). Unfortunately, the number of recaptures was too low to calculate a population size for the study area.

Although *G. catbaensis* individuals were observed in different types of habitats, there was an uneven frequency of sightings across habitats ($\chi^2 = 205.4$, $df = 6$, $p < 0.0001$): the majority of observations were in PHF (47.1 % of sightings, total n = 189), followed by BAF (19 %) and caves (15.9 %). LHF contributed to 10.1 % of the sightings, MHF with 6.9 % and SCR with just 1 %. In most cases, however, geckos were observed at less than 10 m away from a nearby karst rock, even if in different microhabitats. Geckos were observed up to a height of 5 m above the ground but were rarely seen at these heights and only in cave entrance areas. Instead they were on average 45 ± 77 cm (median = 15 cm) from the ground and 36.5 % of all the sightings (n = 189) were at ground level. On average males perched at an average of 51.3 ± 67.4 cm above ground while females perched on average of only 28.9 ± 73.5 cm, this difference was statistically significant (Mann-Whitney U-test: $z = 4.07$, $U = 1989$, $p < 0.0001$). These geckos were observed at an altitudinal range from 11 - 228 m a.s.l., with 76 individuals (46 %) being observed at 11 - 100 m, 86 (40 %) at 101-200 m, and 27 (14 %) at more than 200 m a.s.l..

In terms of microclimatic conditions, we recorded geckos at 20.6 - 30.5˚C and at 67 - 90 % relative humidity. The mean activity temperature was not different between sexes (females: 27.1 ± 1.9°C, n = 91; males: 27 ± 1.9°C, n = 69; Mann-Whitney U-test: z = 0.326, U = 3044.5, p = 0.745), and the same was true as for the relative humidity (females: 82.9 ± 4.2 %, n = 91; males: 81.9 ± 4.7 %, n = 69; Mann-Whitney U-test: z = 1.42, U = 3884.5, p = 0.155). Outside of these ranges of temperature and humidity, geckos were observed very rarely, particularly in the dry season from December to February (note that in March there were no field surveys) when the weather was dry and cold. Our observation rate of Cát Bà geckos from April to November was relatively stable but fell dramatically in December before beginning to rise again from February and was apparently restored by May (Fig. 4).

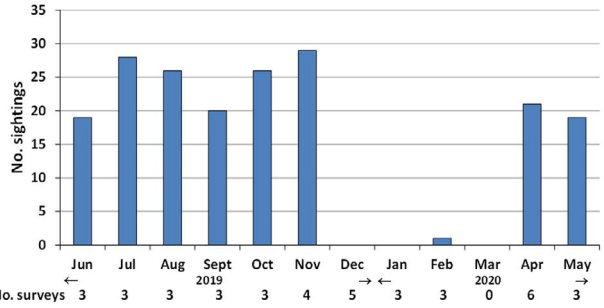

Figure 4. Monthly counts of Cát Bà gecko sightings from 7 transects on Cát Bà island – note there were no surveys in March 2020 due to COVID-19 lockdown and the transects surveyed varied by month (see text for details)

DISCUSSION

Previous studies have concluded that there are only small populations of *G. catbaensis*, that there are very few sites where the species is present, and that they occur in a narrow altitudinal range. Indeed, using capture-mark-recapture protocols in 2014-2015, population size of *G. catbaensis* in the whole of Cát Bà island was estimated to be around 16-24 adults (Ngo et al., 2016), and on Ha Long island (Quang Ninh province) in July 2017 and April 2018 to be about 124 – 129 individuals, with the abundance of sub-populations that had been impacted by anthropogenic pressures consisting of just 2 - 10 individuals (Ngo et al., 2019b).

Concerning the local distribution, Ziegler et al. (2008) recorded *G. catbaensis* in only three small areas (Ong Bi near Tra Bau ranger station, Trung Trang cave and Ang Dai area), and Ngo et al. (2016) recorded it in Viet Hai commune, Kim Giao area, May Bau area and Trung Trang cave area and Hospital cave. In addition, both Ziegler et al. (2008) and Nguyen (2011) indicated that this species is found only between 10-70 m a.s.l.. Our study adds considerably to previous data as it shows that the Cát Bà gecko is much more widely distributed on Cát Bà island, with clearly greater population sizes than previously estimated (Ngo et al., 2019b). Moreover, our research shows that this species has a large altitudinal range from 11 - 228 m a.s.l., and that, at an altitude of over 200 m, we were still able to capture 27 different individuals. Thus, we provide clear evidence that *G. catbaensis* is not as rare/threatened as previously supposed. We speculate that the inconsistencies among studies were mainly related to different field efforts: for instance, Ngo et al. (2016) recorded only 48 individuals in Cát Bà National Park but their study was only conducted for three months: June and August 2014 and May 2015. Ngo et al. (2016) first warned that there may be a serious conservation problem for the Cát Bà gecko, and therefore we decided to investigate the issue further. Based on the results obtained in the present study, we suggest that further studies on this, or other endemic geckos with narrow distribution, should be carried out over longer timespans in order to avoid underestimations of their abundance and distribution within a given study area.

Although the Cát Bà gecko is more widespread and abundant than previously estimated, our results confirmed earlier studies suggesting that *G. catbaensis* is a karst microhabitat specialist, as the greatest distance a sighting was made from a karst area was only about 10 m. However, these geckos may inhabit a suite of different habitats in proximity to limestone, thus our study widens the knowledge available on the habitat requirements of this species. For instance, *G. catbaensis* was previously reported to inhabit only the surroundings of large caves covered in part by primary forest vegetation and in the vicinity of primary shrub vegetation on limestone (Ngo et al., 2019a), whereas we found it in a much wider range of habitats. We also found that *G. catbaensis* can be found on relatively high perches (one individual was 5 m above ground), thus suggesting that further studies should better explore the vertical niche characteristics of this species. Furthermore, we demonstrated that males perched at significantly greater heights than females; this is similar to certain other species of lizards, for instance the African species *Agama agama* (Anibaldi et al., 1998; Amadi et al., 2021). In *A. agama* the intersexual differences in perching height is related to hierarchic/territorial behaviours, with dominant males patrolling females from above. We speculate that the same behaviour may occur also in *G. catbaensis* but since agamids are diurnal (but see Amadi et al., 2021) they may see much better from an elevated perch than geckos would see at night.

In terms of body size and sexual size dimorphism, our study showed that there were no significant differences between males and females. This finding is consistent with data of Ngo et al. (in press) (mean SVL ± SE - adult males 112.3 ± 0.8 mm, n=80; adult female 111.8±0.8 mm, n=93).

The absence of sightings from December to February showed that the above-ground activity of these geckos was affected by low temperatures (22.1-24.1 °C) and/or dry weather (humidity of 75-78 %). Indeed, our data on the temperature and relative humidity values during the period when the geckos were active corroborate those already reported (Ngo et al., 2019a; means of 26 °C and 84.9 %). It is likely that the apparent preference of this species for caves (Ngo et al., 2019a) may also be linked to a need, or preference for, stable microclimatic conditions, that may explain the relatively narrow range of temperatures and humidity at which active geckos were found.

ACKNOWLEDGEMENTS

We are thankful to the Wildlife Conservation Society (WCS) John Thorbjarnarson Fellowship for Reptile Research, which provided funding to undertake this study. Thanks to Mr. Kate Mastro for supporting the project program throughout the research process, the Leaders and staff of Cát Bà National Park for facilitating the field survey. In particular, we are grateful to Nguyen Xuan Khu, Nguyen Thi Trang, and Ngo Thi Thu Phuong, who assisted in field data collection during the study period. We are also indebted to the local communities in the three communes Gia Luan, Hai Son village of Tran Chau commune and Viet Hai commune for various types of advice when in the field. Our submitted manuscript benefitted from the helpful critical comments by Dr Lee L. Grismer.

REFERENCES

Amadi, N., Luiselli, L., Belema, R., Nyiwale, G.A., Wala, C., Urubia, N. & Meek, R. (2021). From diurnal to nocturnal activity: a case study of night-light niche expansion in *Agama agama* lizards. *Ethology Ecology & Evolution*. DOI: 10.1080/03949370.2021.1883120

Anibaldi, C., Luiselli, L. & Angelici, F.M. (1998). Notes on the ecology of a suburban population of rainbow lizards in coastal Kenya. *African Journal of Ecology* 36: 199–206.

Chen, T.-B., Meng, Y.-J., Jiang, K., Li, P.-P., Wen, B.-H., Lu, W., Lazell, J. & Hou, M. (2014). New record of the leopard gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) for China and habitat partitioning between geographically and phylogenetically close leopard geckos. *Reptiles & Amphibians* 21: 16–27.

Grismer, L.L., Ota, H. & Tanaka, S. (1994). Phylogeny, classification, and biogeography of *Goniurosaurus kuroiwae* (Squamata: Eublepharidae) from the Ryukyu Archipelago, Japan, with description of a new subspecies. *Zoological Science* 11: 319-335.

Honda, M. & Ota, H. (2017). On the live coloration and partial mitochondrial DNA sequences in the topotypic population of *Goniurosaurus kuroiwae orientalis* (Squamata: Eublepharidae), with description of a new subspecies from Tokashikijima Island, Ryukyu Archipelago, Japan. *Asian Herpetological Research* 8: 96–107.

IUCN (2020). The IUCN Red List of Threatened Species. Available at www.iucnredlist.org (last accessed: 25 February 2021).

Ngo, H.N., Ziegler, T., Nguyen, T.Q., Pham, C.T., Nguyen, T.T., Le, M.D. & van Schingen, M. (2016). First population assessment of two cryptic Tiger Geckos (*Goniurosaurus*) from northern Vietnam: Implications for conservation. *Amphibian & Reptile Conservation* 10: 34–45 (e120).

Ngo, H.N., Le, Q.T., Nguyen, Q.T., Le, D.M., van Schingen, M. & Ziegler, T. (2019a). First record of the Cát Bà tiger gecko, *Goniurosaurus catbaensis*, from Ha Long Bay, Quang Ninh Province, Vietnam: Microhabitat selection, potential distribution, and threat evaluation. *Amphibian & Reptile Conservation* 13: 1-13.

Ngo, H.N., Nguyen, T.Q., Phan, T.Q., van Schingen, M. & Ziegler, T. (2019b). A case study on trade in threatened Tiger Geckos (*Goniurosaurus*) in Vietnam including updated information on the abundance of the Endangered *G. catbaensis*. *Nature Conservation* 33: 1-19.

Ngo, H.N., Nguyen, H.Q, Tran, H.M, Ngo, H.T, Le, D.M., Gewiss, L.R., van Schingen-Khan, M., Nguyen, T.Q. & Ziegler, T. (2021). A morphological and molecular review of the genus *Goniurosaurus*, including an identification key. *European Journal of Taxonomy* (in press).

Nguyen, Q.T., Ngo, N.H., Van Schingen, M. & Ziegler, T. (2016). *Goniurosaurus catbaensis*. The IUCN Red List of Threatened Species 2016: e.T18917684A18917688. DOI: 10.2305/IUCN.UK.2016-2.RLTS.T18917684A18917688.en. Downloaded on 25 February 2021.

Nguyen, T. (2011). Systematics, ecology, and conservation of the lizard fauna in northeastern Vietnam, with special focus on *Pseudocalotes* (Agamidae), *Goniurosaurus* (Eublepharidae), *Sphenomorphus* and *Tropidophorus* (Scincidae) from this country. Unpublished Thesis, Bonn University, Germany.

Nguyen, T.Q., Stenke, R., Nguyen, H.X. & Ziegler, T. (2011). The terrestrial reptilian fauna of the Biosphere Reserve Cát Bà Archipelago, Hai Phong, Vietnam. In: *Tropical Vertebrates in a Changing World*, 99-115 pp. Schuchmann, K-L. (Ed.). Bonner Zoologische Monographien, 57.

Qi, S., Grismer, L.L., Lyu, Z.-T., Zhang, L., Li, P.-P., Wang, Y.-Y. (2020). A definition of the *Goniurosaurus yingdeensis* group (Squamata, Eublepharidae) with the description of a new species. *ZooKeys* 986: 127-155.

Uetz, P., Freed, P. & Hošek, J.(Eds.) (2020). The Reptile Database, available at http://www.reptile-database.org (last accessed: 27 February 2021).

Van Schingen, M. (2014). Population status and autecology of *Shinisaurus crocodilurus* Ahl, 1930 in northeastern Vietnam. Unpublished MS Thesis, Cologne University, Germany.

Vu, N.T., Nguyen, Q.T., Grismer, L.L. & Ziegler, T. (2006). Fist record of the Chinese Leopard Gecko, *Goniurosaurus luii* (Reptilia: Eublepharidae) from Vietnam. *Current Herpetology* 25: 93–95.

Yang, J.H. & Chan, B.P. (2015). Two new species of the genus *Goniurosaurus* (Squâmta: Sauria: Eublepharidae) from southern China. *Zootaxa* 3980: 067-080.

Zhou, R.-B., Ning, W., Bei, C. & Bin, L. (2018). Morphological evidence uncovers a new species of *Goniurosaurus* (Squamata: Eublepharidae) from the Hainan Island, China. *Zootaxa* 4369: 281–291.

Zhu, X.-Y., Chu-Ze S., Yun-Fei L., Lin, C., Zheng, L., & Zhu-Qing, H. (2020). A new species of *Goniurosaurus* from Hainan Island, China based on molecular and morphological data (Squamata: Sauria: Eublepharidae). *Zootaxa* 4772: 349–360

Ziegler, T., Truong, N.Q., Schmitz, A., Stenke, R. & Rösler, H. (2008). A new species of *Goniurosaurus* from Cát Bà Island, Hai Phong, northern Vietnam (Squamata: Eublepharidae). *Zootaxa* 1771: 16–30.

Please note that the Supplementary Material for this article is available online via the Herpetological Bulletin website: https://thebhs.org/publications/the-herpetological-bulletin/issue-number-157-autumn-2021

Accepted: 4 May 2021

The Herpetological Bulletin 157, 2021: 6-11
RESEARCH ARTICLE
https://doi.org/10.33256/hb157.611

Evidence of cannibalism in a population of western Galápagos racers *Pseudalsophis occidentalis* (Serpentes: Colubridae)

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ABSTRACT - Cannibalism is a common behaviour among snakes, but it has not yet been verified for any of the nine species of Galápagos racer (*Pseudalsophis* spp.), a group endemic to the Galápagos archipelago, Ecuador. Galápagos racers are opportunistic generalists feeding on a variety of vertebrate prey. There are a few anecdotal and suspected attempts of cannibalism among Galápagos racers, but it is unclear whether this behaviour occurs and if so, how frequent it is. We analysed 61 faecal samples from western Galápagos racers (*Pseudalsophis occidentalis*). In addition to the remains of well-known prey items such as lizards, we found snake teeth and skin fragments in 11 samples. Combined with previous observations of attempted cannibalism between western Galápagos racers, our results represent evidence that this species consumes other racers as prey. Our study contributes to a growing knowledge of the natural history of Galápagos racers and highlights the role of these reptiles in complex trophic interactions in the Galápagos islands.

INTRODUCTION

Cannibalism, the consumption conspecific prey, including eggs or hatchlings, is widespread among reptiles, with numerous examples from snakes. There are two broad categories of cannibalism: filial cannibalism (consumption of close genetic relatives) and heterocannibalism (consumption of unrelated conspecifics) (Thomas & Manica, 2003; Ibáñez & Keyl, 2010). As examples of filial cannibalism, Colombian rainbow boas (*Epicrates maurus*) and emaciated post-parturient Mexican lance-headed rattlesnakes (*Crotalus polystictus*) consume undeveloped eggs and non-viable offspring as a behavioural tactic to recoup energy losses (Lourdais et al., 2005; Mociño-Deloya et al., 2009). Examples of heterocannibalism are numerous, both for captive and wild snakes: Mitchell (1986) reviewed reports of cannibalism for 101 species of snakes from 1894 to 1985. Since this review is outdated, and numerous new studies and reports have been published since, it is reasonable to assume that cannibalism occurs in many more species.

Occasional consumption of unrelated conspecifics tends to be regarded as rare, but it is unclear to what extent this reflects the difficulty of studying snake diets in the wild. For instance, only two cases of cannibalism in smooth snakes (*Coronella austriaca*) were confirmed in a 9-year study in southern England (Jofré & Reading, 2020). Similarly, populations of Florida cottonmouths (*Agkistrodon conanti*) in the Cedar Keys, Florida, have been studied since the late 1930s to the present (Lillywhite et al., 2002; Lillywhite et al., 2015) and although snake prey (salt marsh snakes, *Nerodia clarkii*) had been reported in their diet, attempts of conspecific cannibalism have only been observed as recently as 2015, possibly as a behavioural adjustment to a decrease in fish carrion that previously had been abundant (Sheehy III et al., 2017).

The Galápagos terrestrial snakes, or 'racers' are a monophyletic group of nine species (Zaher et al., 2019) that are widely distributed from sea level (Merlen & Thomas, 2013) to 1400 m a.s.l. (Arteaga & Guayasamín, 2020) and inhabit arid shrublands and deciduous forests (Christian, 2017). As a group, Galápagos terrestrial snakes remain poorly studied, chiefly due to the apparent low density of individuals across their geographic range, and the remoteness and inaccessibility of large populations. As a result, several aspects of their biology remain unknown.

Galápagos racers are regarded as opportunistic generalists that ingest prey head-first, feeding predominantly on small vertebrates such as lava lizards (*Microlophus* spp.), geckos (*Phyllodactylus* spp.), marine iguana hatchlings (*Amblyrhynchus cristatus*) (Ortiz-Catedral et al., 2019), and even small coastal fishes (Merlen & Thomas, 2013). In June 2015, R.W. observed three attempts of heterocannibalism in western Galápagos racers *Pseudalsophis occidentalis* (Van Denburgh, 1912) at Cabo Douglas, Fernandina Island. In two instances, the cannibal managed to subdue its prey but neither event resulted in full ingestion or death of the prey. In one instance (Fig. 1), the prey was subdued by its head, but it managed to free itself. In the other instance, the prey was ingested approximately half of its length, but the cannibal regurgitated the live snake. Regurgitation of live snake prey

Figure 1. An attempt of heterocannibalism among western Galápagos racers (*Pseudalsophis occidentalis*). The cannibal subdued a conspecific at Cabo Douglas, Fernandina Island, June 2015.

before full ingestion has been documented in California kingsnakes (*Lampropeltis californiae*) (Jackson et al., 2004) and black whip snakes (*Dolichophis jugularis*) (Göçmen et al., 2008). Christian (2017) reported snake teeth in the faeces of eastern Galápagos racers (*P. biserialis*) on Gardner-by-Floreana, but at the time these were regarded as the racer's own teeth, possibly ingested in the process of swallowing prey, or as part of the tooth replacement observed in snakes as suggested for other snake species (Abuys, 1987; Van Wyk, 1988).

As part of an ongoing large-scale study on the natural history and diversity of Galápagos racers, led by the Directorate of the Galápagos National Park, we analysed faecal samples of western Galápagos racers to better characterise the diversity of prey items consumed and to investigate whether remains of snake prey could be encountered. Faecal analyses have been used alone to study diet (Rudolph et al., 2002; Weatherhead et al., 2009) or to supplement stomach content studies in several snake species (Fitch, 1963; Slip & Shine, 1988; Agrimi & Luiselli, 1992; Daltry et al., 1998; Akani et al., 2001; Hill et al., 2001; Saviozzi & Zuffi, 2007; Cochran et al., 2021), and to document cannibalism in smooth snakes (*Coronella austriaca*) (Jofré & Reading, 2020) and false smooth snakes (*Macroprotodon cucullatus*) (Faraone et al., 2020). Here we present evidence of cannibalism in western Galápagos racers based on an analysis of faecal samples.

MATERIALS & METHODS

We captured western Galápagos racers on Fernandina Island, at Cape Douglas (0° 18' 17'' S, 91° 39' 13'' W) from 5th to 10th July 2018. The study site in Cape Douglas is a coastal area 17 ha in size, covered in arid scrub, 0-2 m a.s.l., with a vegetation community dominated by palo santo (*Bursera graveolens*), candelabro (*Jasminocereus thouarsi*) and thickets of monte salado (*Cryptocarpus pyriformis*).

We captured Galápagos racers by hand early in the morning or just before dusk as described in Ortiz-Catedral et al. (2019). We weighed each individual inside a cotton bag to the nearest 0.5 g, using a portable Pesola® scale, and measured the snout-vent length (SVL) to the nearest mm using string and a vinyl sewing tape. Individuals were sexed in the field by manual probing. This method consists of the slow introduction of a blunt, metal probe into the cloaca: in males, the probe enters deeper into the tail than in females (Gnudi et al., 2009). This method has been used successfully in various field studies (Blouin-Demers & Weatherhead, 2001; Willson et al., 2006; Evans et al., 2019). After sexing, the probe was sterilised with 96 % ethanol. To identify adult western Galápagos racers (total length > 59 cm) individually and as part of a mark-recapture study, a passive integrated transponder (PIT) (ID100 mini, TROVAN ®) was inserted subcutaneously along the posterior third of the venter anterior to the cloaca on snakes with a total length greater than 50 cm. Each snake was released at the site of capture approximately 35-60 min after faecal samples and measurements were obtained, or if snakes were captured after dusk, they were kept overnight in individual cotton bags and released before dawn the following day. Faecal samples (one sample per individual) were obtained using the palpation technique (Daltry et al., 1996; Williams et al., 2016), stored in either 2 ml or 5 ml micro-centrifuge tubes, and fixed in 1.5 – 2.5 ml of 96 % ethanol until examination for contents. This technique has been used previously in another study on the diet of Galápagos racers (Ortiz-Catedral et al., 2019), and other snake species (e.g., Reading & Jofré, 2013). Faecal samples were examined visually using a 5 MP USB digital microscope (Celestron Handheld Digital Pro, Celestron, Torrance CA.) at the Invertebrate Collection Lab of the Charles Darwin Research Station in Puerto Ayora, Santa Cruz, Ecuador.

We recorded the presence of prey remains and classified

these into broad categories: scales, invertebrate remains, feathers, hairs, bones and other undigested materials. Reference voucher specimens at the vertebrate collection at the Charles Darwin Research Station (darwinfoundation.org/en/datazone) were used to verify the identity of prey species or broader taxonomic categories, by comparing scales, hairs, claws, skin and feathers of voucher specimens. Snake faecal samples often contain material that is too digested to allow for accurate identification (see Ortiz-Catedral et al., 2019). Whenever such material was observed, it was classified as 'unidentified organic matter'. Whenever snake teeth were unambiguously identified, we made an attempt to count every tooth found in the faecal sample.

We compared morphological measurements and presence/absence of prey groups in samples using Welch's test, and conducted regression analyses on SVL/mass relationships between males and females. Minitab (Minitab 17 Statistical software, 2010) was used for all statistical analyses and values are presented as mean ± standard deviation.

RESULTS

We captured a total of 93 western Galápagos racers at Cape Douglas, Fernandina Island: 61 females (SVL range: 49.60 – 100 cm) and 32 males (SVL range: 40.50 – 95 cm). We successfully obtained faecal samples from 61 individuals (66 % of total), of which 21 contained identifiable prey remains. Of these, four samples contained small bone fragments that could not be identified to a taxonomic group (Table 1). Prey remains, other than snakes, included Isabela lava lizard (*Microlophus albermalensis*) scales; Galápagos leaf-toed gecko (*Phyllodactylus galapagensis*) scales; marine iguana (*Amblyrhynchus cristatus*) hatchling claws and scales; an unidentified feather and rodent hairs (Table 1). The number of prey types that could be identified per sample was one (n=16), two (n=4), or five (n=1). The remaining 40 faecal samples contained digested material without identifiable remains.

We encountered snake remains (teeth, scales and skin fragments) in 11 samples (Table 1). Two females, with the IDs, 215A (SVL = 75.50 cm, mass = 78 g) and B28E (SVL = 76.30 cm, mass = 180 g), contained 28 snake teeth, and 31 snake teeth respectively, plus snake skin fragments, respectively (Fig. 2). The average number of snake teeth in faecal samples of the other nine samples was five (range: 1-13). The body condition of females 215A and B28E, were outside (below and above respectively) of the 95 % confidence interval the regression of SVL on mass for females (Fig. 3). We did not detect significant differences in SVL between females with no prey remains in faeces (SVL = 81.20 ± 8.91 cm) and females with identifiable prey remains in faeces (SVL = 79.90 ± 12.40 cm; Welch's t = 0.408, p = 0.68, d.f. 20.8). Similarly, the SVL of males with no prey remains in faeces (SVL = 74.70 ± 11.10

Table 1. Prey species encountered in 21 faecal samples of western Galápagos racers (more than one prey type could be found per sample)

Class	Family	n	Prey species	Type
Reptilia	Tropiduridae	6	*Microlophus albermalensis*	S, C
	Phyllodactylidae	2	*Phyllodactylus galapagensis*	S
	Iguanidae	2	*Amblyrhynchus cristatus*	S, C
	Dipsadidae	11	*Pseudalsophis* spp.	T, S
Mammalia	Rodentia	1	Unidentified rodent hairs	H
Aves		1	Unidentified feather	F
Undetermined		4	Unidentified vertebrate	B

B = bone; C = claws; F = feather; H = hair; S = scales or skin; T = teeth

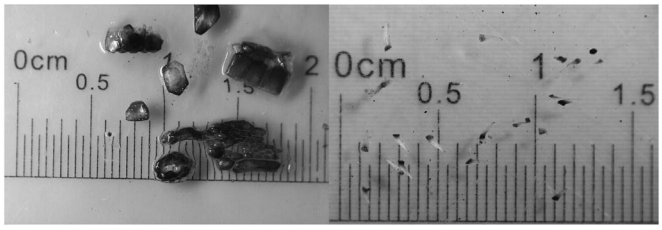

Figure 2. Snake remains in faecal samples of western Galápagos racers (*Pseudalsophis occidentalis*) - **Left:** snake skin fragments, individual B28E, **Right:** snake teeth, individual 215A

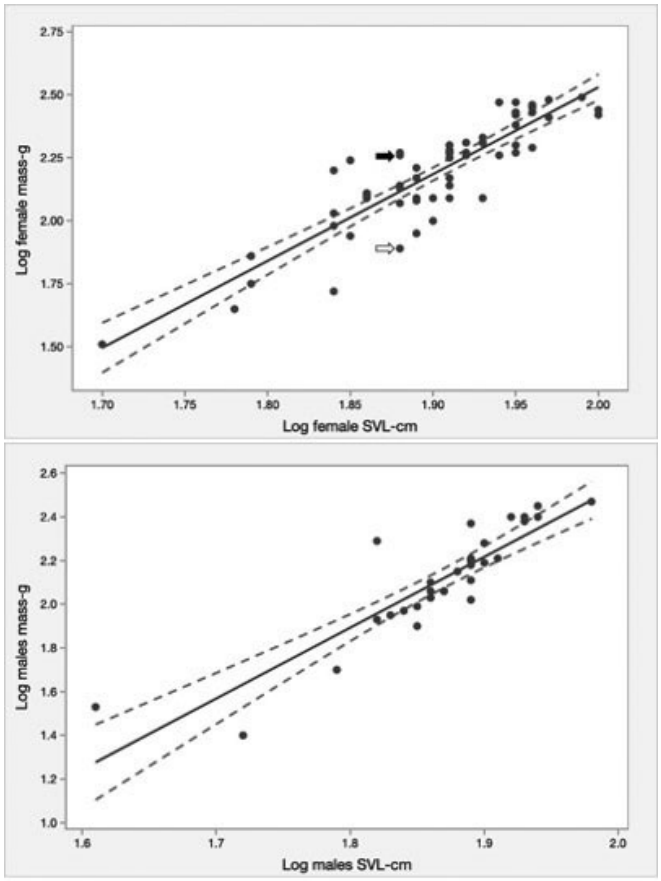

Figure 3. Regression analysis of western Galápagos racer (*Pseudalsophis occidentalis*) female (top) and male (bottom), $\log_{10}$ mass-g vs $\log_{10}$ SVL-cm with 95 % confidence intervals (dashed lines). **Female:** $\log_{10}$ mass-g = -4.36 + 3.44 $\log_{10}$ SVL cm; r^2 =78.70 %; P <0.001; n= 61; **Male:** $\log_{10}$ mass-g =-3.75 + 3.14 $\log_{10}$ SVL cm; r^2 =79.03 %; P <0.001; n= 32. Top panel: solid arrow- individual B28E; open arrow- individual 215A

cm) and males with visible prey remains in faeces (SVL = 68.50 ± 10.00 cm) did not differ significantly (Welch's t = 1.24, p = 0.26, d.f. 5.99).

DISCUSSION

Overall, the prey species listed here is similar to earlier studies that described the diet of Galápagos racers as including lava lizards, geckos, birds, and marine iguanas (Altamirano, 1996; Merlen & Thomas, 2013; Ortiz-Catedral et al., 2019), but with the noticeable addition of rodents. Native and introduced rodents have long been considered potential prey for Galápagos racers, but to the best of our knowledge our observations represent the first confirmed record in faecal samples of Galápagos racers. Our study site, Cabo Douglas on Fernandina Island, is free of introduced rodents (*Rattus* spp. and *Mus musculus*), but has populations of native rodents, known as "rice rats": *Nesoryzomys fernandinae* and *Nesoryzomys narboroughi* (Dowler et al., 2009), although which of these species had been consumed could not be determined from the available prey remains. Close relatives of *Pseudalsophis*, such as the West Indian racers in the genus *Alsophis*, are morphologically and ecologically similar to Galápagos racers and occasionally prey on small rodents such as *M. musculus* and juvenile *R. rattus* (Henderson & Powell, 2009; Questel, 2012), so although novel, this finding is not especially unexpected.

Our analysis revealed snake teeth in 11 samples, with a large number (≥ 28) in samples from two females. We cannot determine which proportion of the teeth encountered in our faecal samples represent the snake's own, resulting from breakage of teeth while swallowing prey (see Weatherhead et al., 2003) or as part of the natural teeth replacement (see Van Wyk, 1988). However, in two cases we encountered a large number of teeth, one alongside snake skin fragments, which clearly indicates ingestion of snake prey. Previous examination of eastern Galápagos racer faeces revealed the presence of variable numbers of teeth in faeces (Christian, 2017), some potentially lost as part of the normal process of tooth replacement or breaking off during prey ingestion, as described by other authors (Abuys, 1987; Van Wyk, 1988; Weatherhead et al., 2003). We do not know how many teeth can be lost at any one time as part of tooth replacement or prey handling in *Pseudalsophis*, but we suspect it is a small number rather than entire rows of teeth being lost at once. Based on museum specimens, Thomas (1997) conducted the most comprehensive morphological revision of the genus and reported dentition ranges from 10-15 maxillary teeth and 15-20 dentary teeth, with no mention of tooth loss in the specimens reviewed. Similarly, Maglio (1970) examined 200 skulls representing 33 dipsadine species in the West Indies and reported only small inter-specimen variation (± 2 teeth) in dental series, but no major instances of tooth loss. We suggest that if breaking-off of numerous teeth at a time were a common occurrence among *Pseudalsophis* and allies, this would have been noticed in museum specimens (i.e., empty sockets). During our own examinations of live and preserved specimens of Darwin's racer (*Pseudalsophis darwini*), painted racer (*Pseudalsophis steindachneri*), central Galápagos racer (*Pseudalsophis dorsalis*) and eastern Galápagos racer (*Pseudalsophis biserialis*), we have not detected significant tooth loss (Ortiz-Catedral, pers. obs.). Similarly, previous analyses of faecal samples in *Pseudalsophis* (Ortiz-Catedral et al., 2019; Christian, 2017) have not reported large numbers of teeth in the samples examined. To the best of our knowledge, no study has attempted to quantify tooth loss after prey handling in wild or captive snakes, therefore we are uncertain about the number of teeth that an individual snake could lose while ingesting prey.

Remains of snake skin associated with a case of cannibalism have been reported for a false smooth snake (*Macroprotodon cucullatus*) on Lampedusa Island (Faraone et al., 2020). We reject the possibility that the skin remains are indicative of a case of dermatophagy (shed-skin eating) (Weldon et al., 1993) because the skin fragments are pigmented, whereas western Galápagos racer shed skins, like those of most snakes, are pale and translucent. Coupled with earlier observations of attempted cannibalism at Cape Douglas (Fig. 1), we propose that our results represent evidence of cases of cannibalism in western Galápagos racers. Besides western Galápagos racers, another terrestrial snake inhabits Cape Douglas, the elusive Darwin's racer (*Pseudalsophis darwini*), a recently described small species (ca. 50 cm in length) (Zaher et al., 2018). Darwin's racers are uncommon, with only five individuals encountered in previous visits to Cape Douglas (Ortiz-Catedral & Ramirez, pers. obs.). In our study, we could not determine whether western Galápagos racers prey on *P. darwini* or whether the teeth and skin fragments encountered belong to *P. occidentalis* or *P. darwini*. The only observed instances of attempted cannibalism at this study site (Fig. 1) involved two *P. occidentalis*.

It is possible that the snake remains in individual 215A represent a case of scavenging on a dead snake, or cannibalistic carrion ingestion (sensu Lillywhite, 1982) rather than hunting of a live individual. Western Galápagos racers have been observed scavenging marine iguana hatchlings (Ortiz-Catedral et al., 2019). Thus, it is possible that western Galápagos racers consume snake carrion as part of a broader suite of prey, which is relatively common in snakes (DeVault & Krochmal, 2002). As direct observation of cannibalistic events is difficult to study in the wild, and observations of snakes hunting and subduing prey are infrequent (Cadena-Ortiz et al., 2017; Christian, 2017; Ortiz-Catedral et al., 2019), we suggest two alternative approaches could be used to determine the extent and temporal variability of their cannibalistic behaviour in Galápagos racers: induced regurgitation of prey by palpation (López & Giraudo, 2003) or remote videography (Glaudas et al., 2017). Galápagos racers seasonally aggregate to forage on hatchling marine iguanas on Fernandina Island (R. Wollocombe, pers. obs.) which represents an opportunity to use videography to assess hunting strategies and prey diversity. Other techniques used to study snake diet, such as stable isotopes and faecal eDNA, are unlikely to be capable of detecting cannibalism (Hobson & Welch, 1995; Brown et al., 2013).

Cannibalism among snakes has been explained as a random opportunistic occurrence or as a response to low body condition and starvation stress (Sandfoss et al., 2017; Sheehy, 2017). It is unclear whether individuals that ingested snakes in our study did so as a response to decreased body condition,

as part of routine active hunting, or by scavenging. Similarly, it is difficult to establish whether they consumed adults or other age-classes of their own species or Darwin's racers. Our study is limited as it only encompasses a single event sampling (i.e., one sample per individual taken over just six days), therefore we did not determine intra-annual variability in patterns of snake consumption. There are several small island populations of Galápagos racers that could be the focus of more detailed studies and that will help us understand cannibalistic behaviour among these snakes and help us understand the extent and variability of cannibalistic behaviour in this group of reptiles. Our study contributes important information about the trophic relationships of Galápagos racers, especially considering the limited information on the biology of this group, and the growing need to manage endangered species in the Galápagos archipelago.

ACKNOWLEDGEMENTS

We would like to thank Roberto "Robby" Pepolas, Alfredo Abad, Novarino Castillo and his team of porters. Also, thanks to Simon Villamar, Tui de Roy, Toby Nowlan and Sam Steward (Silverback Productions, UK) for sharing observations on sightings of Galápagos racers in Fernandina Island. We would like to thank Gustavo Jiménez-Uzcátegui for facilitating access to voucher specimens at the Vertebrate Collection Charles Darwin Research Station, Puerto Ayora. Support for fieldwork was kindly provided by Massey University, Silverback Films, Mohamed bin Zayed Species Conservation Fund and Galápagos Conservation Trust. We also thank Mr. Eduardo "Vico" Rosero, captain on the boat Queen Mabel, for assistance accessing field sites. We also thank two anonymous reviewers, and Dr. J. Daltry for valuable constructive criticism that greatly improved an earlier draft of this paper. Finally, we thank the Directorate of the Galápagos National Park for providing permission to access all locations and for the capture and handling of snakes according to protocols approved in permits PC 74-17 and PC 08-19.

REFERENCES

Abuys, A. (1987). The snakes of Surinam part XIX: Family Viperidae subfamily Crotaline (genus *Crotalus*). *Litteratura Serpentium* 7: 282-296.

Agrimi, U. & Luiselli, L. (1992). Feeding strategies of the viper *Vipera ursinii ursinii* (Reptilia: Viperidae) in the Apennine. *The Herpetological Journal* 2:37-42.

Akani, G.C., Capizzi, D. & Luiselli, L. (2001). *Mehelya crossi* (West African File Snake). Diet. *Herpetological Review* 32:49-50.

Altamirano, M.A. (1996). Potential Inflences of Biotic and Abiotic Factors on Patterns of Activity in Galápagos Snakes: Locomotory Performance or Prey Abundance? Unpublished MSc thesis, University of Albuquerque, Albuquerque, USA. 26 pp.

Arteaga, A., Bustamante, L., Vieira, J. & Guayasamin, J.M. (2020). Reptiles of Ecuador: Life in the middle of the world. Universidad Tecnologica IndoAmerica, Quito, Ecuador. 257 pp. DOI: 10.47051/MNHT9360

Blouin-Demers, G. & Weatherhead, P.J. (2001). Habitat use by Black rat snakes (*Elaphe obsoleta obsoleta*) in fragmented forests. *Ecology* 82: 2882-2896.

Brown, D.S., Ebenezer, K.L. & Symondson, W.O.C. (2013). Molecular analysis of the diets of snakes: changes in prey exploitation during development of the rare smooth snake *Coronella austriaca*. *Molecular Ecology* 23:3734-3743.

Cadena-Ortiz, H., Barahona, A., Bahamonde-Vinueza, D. & Brito, J.M. (2017). Anecdotal predation events of some snakes in Ecuador. *Herpetozoa* 30: 93-96.

Christian, E. (2017). Demography and conservation of the Floreana racer (*Pseudalsophis biserialis biserialis*) on Gardner-by-Floreana and Champion islets, Galápagos Islands, Ecuador. Unpublished MSc thesis, Massey University, Auckland, New Zealand. 186 pp.

Cochran, C.K.L., Edwards, Z.D., Travis, L.R., Pompe, & Hayes, W. K. (2021). Diet and feeding frequency in the Southwestern Speckled Rattlesnake (*Crotalus pyrrhus*): ontogenetic, sexual, geographic, and seasonal Variation. *Journal of Herpetology* 55:77-87.

Daltry, J.C., Wüster, W. & Thorpe, R.S. (1996). Diet and snake venom evolution. *Nature* 379: 537-540.

Daltry, J.C., Wüster, W. &. Thorpe, R.S. (1998). Intraspecific variation in the feeding ecology of the crotaline snake *Calloselasma rhodostoma* in Southeast Asia. *Journal of Herpetology* 32:198-205.

DeVault, T.L. & Krochmal, A.R. (2002). Scavenging by snakes: An examination of the literature. *Herpetologica* 58:429-436.

Dowler, R.C., Carroll, D.S. & Edwards, C.W. (2000). Rediscovery of rodents (Genus *Nesoryzomys*) considered extinct in the Galápagos Islands. *Oryx* 34: 109-117.

Evans, A.M., Choiniere, J.N. & Alexander, G.J. (2019). The cutting-edge morphology of the mole snake's dental apparatus. *PeerJ* 7: e6943

Faraone, F.P., Di Nicola, M.R. & Lo Valvo, M. (2020). A case of cannibalism in the false smooth snake *Macroprotodon cucullatus* on the island of Lampedusa. *The Herpetological Bulletin* 151: 43-44.

Fitch, H.S. (1963). Natural history of the black rat snake (*Elaphe o. obsoleta*) in Kansas. *Copeia* 1963:649-658.

Glaudas, X, Kearney, T.C., & Alexander, G.J. (2017). Museum specimen bias measures of snake diet: a case study using the ambush-foraging puff adder (*Bitis arietans*). *Herpetologica* 73: 121-128.

Gnudi, G., Volta, A., Di Ianni, F., Bonazzi, M., Manfredi, S. & Bertoni, G. (2009). Use of ultrasonography and contrast radiography for snake gender determination. *Radiology & Ultrasound* 50: 309-311.

Göçmen, B., Werner, Y.L. & Elbeyli, B. (2008). Cannibalism in *Dolichophis jugularis* (Serpentes: Colubridae): more than random? *Current Herpetology* 27: 1-7.

Henderson, R.W., & Powell, R. (2009). *Natural History of West Indian Reptiles and Amphibians*. Gainesville: University Press of Florida. 495 pp.

Hill, M.M.A., Powell, G.L. & Russell, A.P. (2001). Diet of the prairie rattlesnake, *Crotalus viridis viridis*, in southeastern Alberta. *Canadian Field-Naturalist* 115:241-246.

Hobson, K.A. & Welch, H.E. (1995). Cannibalism and trophic structure in a high Arctic lake: insights from stable-isotope analysis. *Canadian Journal of Fisheries and Aquatic*

Sciences 52:1195-1201.

Ibáñez, C.M. & Keyl, F. (2010). Cannibalism in cephalopods. *Reviews in Fish Biology and Fisheries* 20: 123-136.

Jackson, K., Kley, N. J. & Brainerd, E. L. (2004). How snakes eat snakes: the biomechanical challenges of ophiophagy for the California kingsnake, *Lampropeltis getula californiae* (Serpentes: Colubridae). *Zoology* 107: 191-200.

Jofré, G.M. & Reading, C.J. (2020). Cannibalism in smooth snakes, *Coronella austriaca*. *Herpetological Journal* 30: 168-172.

Lillywhite, H.B. (1982). Cannibalistic carrion ingestion by the Rattlesnake, *Crotalus viridis*. *Journal of Herpetology* 16: 95.

Lillywhite, H.B., Sheehy III, C.M. & McCue, M.D. (2002). Scavenging behaviors of cottonmouth snakes at island bird rookeries. *Herpetological Review* 33: 259-261.

López, M.S. & Giraudo, A.R. (2003). Diet of the large water snake *Hydrodynastes gigas* (Colubridae) from northeast Argentina. *Amphibia-reptilia* 25: 178-184.

Lourdais, O., Brischoux, F., Shine, R & Bonnet, X. (2005). Adaptive maternal cannibalism in snakes (*Epicrates cenchria maurus*, Boidae). *Biological Journal of the Linnean Society* 84: 767-774.

Maglio, V. J. (1970). West Indian Xenodontine colubrid snakes: the probable origin, phylogeny, and zoogeography. *Bulletin of the Museum of Comparative Zoology at Harvard College* 141: 1-54.

Merlen, G., & Thomas, R.A. (2013): A Galápagos ectothermic terrestrial snake gambles a potential chilly bath for a protein-rich dish of fish. *Herpetological Review* 44: 415-417.

Minitab 17 Statistical Software. (2010). Computer Software. State College, PA. Minitab, Inc. minitab.com

Mitchell, J. C. (1986). Cannibalism in reptiles: a worldwide review. *Herpetological Circular* 15: 37 pp.

Mociño-Deloya, E., Setser, K., Pleguezuelos, J.A., Kardon, A. & Lazcano, D. (2009). Cannibalism of nonviable offspring by postparturient Mexican lance-headed rattlesnakes, *Crotalus polystictus*. *Animal Behaviour* 77: 145-150.

Ortiz-Catedral, L., Christian, E., Skirrow, M.J.A., Rueda, D., Sevilla, C., Kumar, K., Reyes, E.M.R.R. & Daltry, J. (2019). Diet of six species of Galápagos terrestrial snakes (*Pseudalsophis* spp.) inferred from faecal samples. *Herpetology Note*s 12: 701-704.

Questel, K. (2012). Contribution à la connaissance d'Alsophis rijgersmaei (Squamata, Dipsadidae, Xenodontinae) Sur l'île de Saint-Barthélemy. Réserve Naturelle de Saint-Barthélemy & *Alsophis*, 24 pp.

Reading, C. & Jofré, G. (2013). Diet composition changes correlated with body size in the Smooth snake, *Coronella austriaca*, inhabiting lowland heath in southern England. *Amphibia-Reptilia* 34: 463-470.

Rodrigues da Silva Banci, K., Torello-Viera, N.F., Freitas, A.C. & Marques, O.A.V. (2017). Feeding on elongate prey: additional data for the coral snake *Micrurus corallinus* (Merrem, 1820) (Elapidae) and comments on aposematism. *Herpetology Notes* 10: 335-338.

Rudolph, D.C., Burgdorf, S.J., Conner, R.N., Collins, D., Saenz, S.C., Schaefer, R.R., Trees, T., Duran, C.M., Ealy, M. & Himes, J.G. (2002). Prey handling and diet of Louisiana Pinesnakes (*Pituophis ruthveni*) and Black Pinesnakes (*P. melanoleucus lodingi*), with comparisons to other selected colubrid snakes. *Herpetological Natural History* 9:57-62.

Sandfoss, M.R., Sheehy, C.M. III, & Lillywhite, H.B. (2017). Collapse of a unique insular bird-snake relationship. *Journal of Zoology* 304: 276-283.

Sheehy C.M. III, Sandfoss, M.R. & Lillywhite, H.B. (2017). Cannibalism and changing food resources in insular cottonmouth snakes. *Herpetological Review* 48: 310-312.

Saviozzi, P. & Zuffi, M.A.L. (1997). An integrated approach to the study of the diet of *Vipera aspis*. *Herpetological Review* 28: 23-24.

Slip, D.J. & Shine, R. (1988). Feeding habits of the diamond python, *Morelia s. spilota*: ambush predation by a boid snake. *Journal of Herpetology* 22:323-330.

Thomas, R.A. (1997). Galápagos Terrestrial Snakes: Biogeography and Systematics. *Herpetological Natural History* 5: 19-40.

Thomas, L.K. & Manica, A. (2003). Filial cannibalism in an assasin bug. *Animal Behaviour* 66: 205-210.

Weatherhead, P.J., Blouin-Demers, G. & Cavey, K.M. (2003). Seasonal and prey-seze dietary patterns of Black ratsnakes (*Elaphe obsoleta obsoleta*). *The American Midland Naturalist* 150: 275-281.

Weatherhead, P.J., Knox, J.M., Harvey, D.S., Wynn, D., Chiucchi, J. & Gibbs, H.L. (2009). Diet of *Sistrurus catenatus* in Ontario and Ohio: Effects of body size and habitat. *Journal of Herpetology* 43: 693-697.

Weldon, P.T., Demeter, B.J. & Rosscoe, R. (1993). A survey of shed skin-eating (dermatophagy) in amphibians and reptiles. *Journal of Herpetology* 27: 219-228.

Williams, R.J., Ross, T.N., Morton, M.N., Daltry, J.C., & Isidore, L. (2016): Update on the natural history and conservation status of the Saint Lucia racer, *Erythrolamprus ornatus* Garman, 1887 (Squamata: Dispsadidae). *Herpetology Notes* 9: 157-162.

Willson, J.D., Winne, C. T., Dorcas, M. E. & Gibbons, J. W. (2006). Post-drought responses of semi-aquatic snakes inhabiting an insolated wetland: insights on different strategies for persistence in a dynamic habitat. *Wetlands* 26: 1071-1078.

Wiseman, K.D., Greene, H. W., Koo, M.S. & Long, D.J. (2019). Feeding ecology of a generalist predator, the California Kingsnake (*Lampropeltis californiae*): why rare prey matter. *Herpetological Conservation and Biology* 14: 1-30.

Van Wyk, J. H. (1988). The diet of the rhombic skaapsteker, *Psammophylax rhombeatus rhombeatus* (Serpentes: Colubridae). *Navorsinge Van Die Nasionale Museum Bloemfontein* 5: 455-471.

Zaher, H., Yánez-Muñoz, M.H., Rodrigues, M.T., Graboski, R., Machado, F.A., Altamirano-Benavides, M., Bonatto, S.L., & Grazziotin, F.G. (2018). Origin and hidden diversity within the poorly known Galápagos snake radiation (Serpentes: Dipsadidae). *Systematics and Biodiversity* 16: 614-642.

Accepted:11 May 2021

The Herpetological Bulletin 157, 2021: 12-15
SHORT NOTE

https://doi.org/10.33256/hb157.1215

New locality records of the Mizo rain snake *Smithophis atemporalis* with meristic and morphometric data based on specimen collection and a citizen science initiative

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INTRODUCTION

Knowledge of the geographical distribution of a species is an important aspect in biodiversity conservation and management (van Maes et al., 2015), and it is among the parameters used to assess conservation threat status (IUCN Standards and Petitions Committee, 2019). Global scale issues such as land-use change and climate change have increased the need to map and predict the distribution of a species. However, species distribution modelling requires many years of field work in gathering information and has proved to be very expensive (Feldman et al., 2021). Citizen science, the cooperation between scientific experts and non-experts, is a rapidly expanding tool in the field of biodiversity documentation (Dickinson et al., 2012). Though the credibility and quality of data from citizen science poses a challenge (Tulloch et al., 2013; Cooper et al., 2014), citizen science programmes have been implemented on a wide range of taxa (van Strien et al., 2013). Social media, especially Facebook can be a useful platform for citizen science due to the high number of users and ease of interaction (Liberatore et al., 2018).

Snakes of the genus *Smithophis* Giri et al. (2019) are semi-aquatic, natricine colubrids distributed from north-east India through north-east Myanmar to south-west China (Giri et al., 2019; Vogel et al., 2020; Das et al., 2020). Giri et al. (2019) erected the genus to accommodate *Smithophis bicolor* (Blyth, 1854) (previously *Rhabdops bicolor*) and a new species *Smithophis atemporalis* Giri et al. (2019). Recently, two more species viz. *S. linearis* Vogel et al. (2020) (from south-western China and north-east Myanmar) and *Smithophis arunachalensis* Das et al. (2020) (from Arunachal state, north-east India) were added to the genus (Vogel et al., 2020; Das et al., 2020). The genus is characterised by having single prefrontal and internasal scales (Giri et al., 2019; Vogel et al., 2020). Little information is available on the distribution and natural history of these species (Giri et al., 2019; Vogel et al., 2020; Das et al., 2020). *Smithophis atemporalis* differs markedly from its congeners in lacking temporal scales. It is most similar to *S. arunachalensis* – both have a distinct lateral zigzag pattern with inverted 'V' shapes of the ventral colour extending dorsolaterally. However, *S. atemporalis* can be distinguished from *S. arunachalensis* in having a yellow to off-white venter in life (vs. bright yellow in *S. arunachalensis*). As of now, *S. atemporalis* is known with certainty only from Mizoram University campus (type locality) and its adjoining areas in Aizawl and Durtlang, and Bawngva village in Mamit district of Mizoram (Giri et al., 2019; Remruatpuii et al., 2020); an area of about 144 km^2 within the state of Mizoram. Herein, we map the distribution of *S. atemporalis* based on previous records, new voucher specimens and a citizen science initiative.

METHODS & MATERIALS

Specimen collection, preservation and morphological data

Specimens of *S. atemporalis* were collected from Mizoram state, India under a research and collection permit issued by the Department of Environment, Forest and Climate Change, Government of Mizoram. Specimens were preserved in 10 % formalin and later transferred to 70 % ethanol for longer preservation. Specimens were deposited at the Herpetological collections of the Systematics and Toxicology Laboratory (MZUHC), Department of Zoology, Mizoram

University, Mizoram, India. The following measurements and counts were taken following Giri et al. (2019): Tail length (TaL), Snout-vent length (SVL), Total length (TL), Ventral scales (VEN), Subcaudal scale (SC), Midbody scale rows (MSR), Supralabials (SL), Supralabials touching eye (SLTe), infralabials (IL), Temporals (T), Preocular (PreOc), Supraocular (SOc), Postocular (PosOc), Dark 'V's on body, Dark bands on tail. Bilateral scale counts (except subcaudal scales, which was counted only on the left side) separated by a comma are given in left, right order.

Citizen Science

For this purpose, we used the Facebook group "Zoram Rul Chanchin" as a platform. The group was created in October 2011, and at the time of writing there are about 2,950 members. Most of the authors of this study are administrators or moderators of this group. The activity in the group mainly involves users posting snake photos to obtain identifications. The unique colour pattern of *S. atemporalis* makes it a suitable candidate for mapping species distribution through citizen science as it can be easily identified from photographs. Members of the Facebook group who posted images of *S. atemporalis* were asked to provide locations for their sightings. The approximate geocoordinates of the specimens were recorded from Google Earth.

Determination of range

Geospatial data from the *S. atemporalis* records of previous studies and the current investigation were analysed using the QGIS open-source program. The extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites (IUCN, 2001). Range was determined using the minimum convex polygon method (Mohr, 1947; IUCN, 2001), defined as the smallest polygon in which none of the internal angles exceed 180 degrees and containing all the species records (IUCN, 2001). The area of this polygon was calculated by the QGIS software. This minimum convex polygon method is usually used to determine the home range size (Hayne, 1949; Harris et al., 1990) but more recently has been adapted to determine the extent of occurrence of a species (IUCN, 2001; Klemann & Vieira, 2013).

RESULTS & DISCUSSION

In this study, we collected six specimens of *S. atemporalis* from different localities within the state of Mizoram, India. These specimens generally agreed with the original descriptions of *S. atemporalis* (see details of measurements and counts in Table 1) except for the presence of two postocular scales on the left side of one individual (MZUHC 779, Fig. 1B). However, the second postocular is very small and seems to be an anomaly. Two of the voucher specimens were collected from within the known distribution of the species, whereas four specimens were collected from outside the known locality of the species.

Although several photos of *S. atemporalis* were posted in the Facebook group (even before the species was described), upon enquiry only twenty-three users replied mentioning actual localities where the photographs were taken. Images with locality data were posted between March 2012 to September 2020. Most of these were from outside the known distribution of the species.

Table 1. Meristic and morphometric data for examined specimens of *Smithophis atemporalis* (N=5)

Voucher number	MZUHC 1145	MZUHC 22	MZUHC 779	MZUHC 36	MZUHC 776	MZUHC 786
Sex	M	M	F	M	M	M
TaL (mm)	137*	136	64*	138	139	101
SVL (mm)	422	393	392	386	421	320
TL (mm)	559*	529	456*	524	560	421
VEN	198	200	198	200	200	191
SC	70*	77	70*	85	76	77
MSR	17	17	17	17	17	17
SL	5,5	5,5	5,5	5,5	5,5	5,5
SLTe	3rd,3rd	3rd,3rd	3rd,3rd	3rd,3rd	3rd,3rd	3rd,3rd
IL	6,7	5,5	6,6	5,5	7,7	6,6
T	0,0	0,0	0,0	0,0	0,0	0,0
PreOc	1,1	1,1	1,1	1,1	1,1	1,1
SOc	1,1	1,1	1,1	1,1	1,1	1,1
PosOc	1,1	1,1	2,1	1,1	1,1	1,1
Dark 'V's on body	34,35	35,34	35,35	39,38	35,37	33,32
Dark bands on tail	15,15*	18,16	15,15*	20,19	18,18	13,14

*indicates measure/count incomplete because end of tail missing

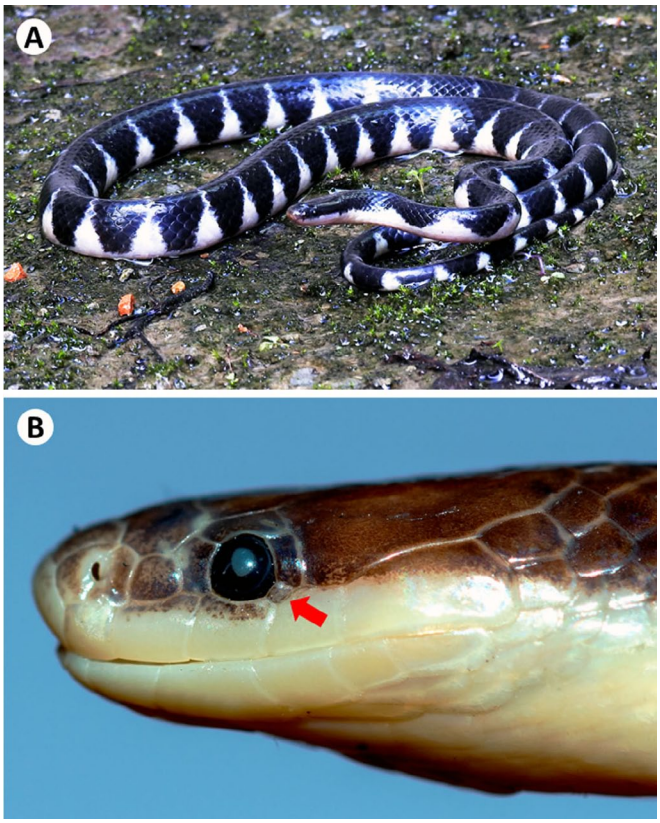

Figure 1. *Smithophis atemporalis* - **A.** Live photo of from Aizawl, Mizoram (unvouchered specimen), **B.** Lateral aspect of the left side of head in MZUHC 779 showing an anomalous second postocular scale (arrow)

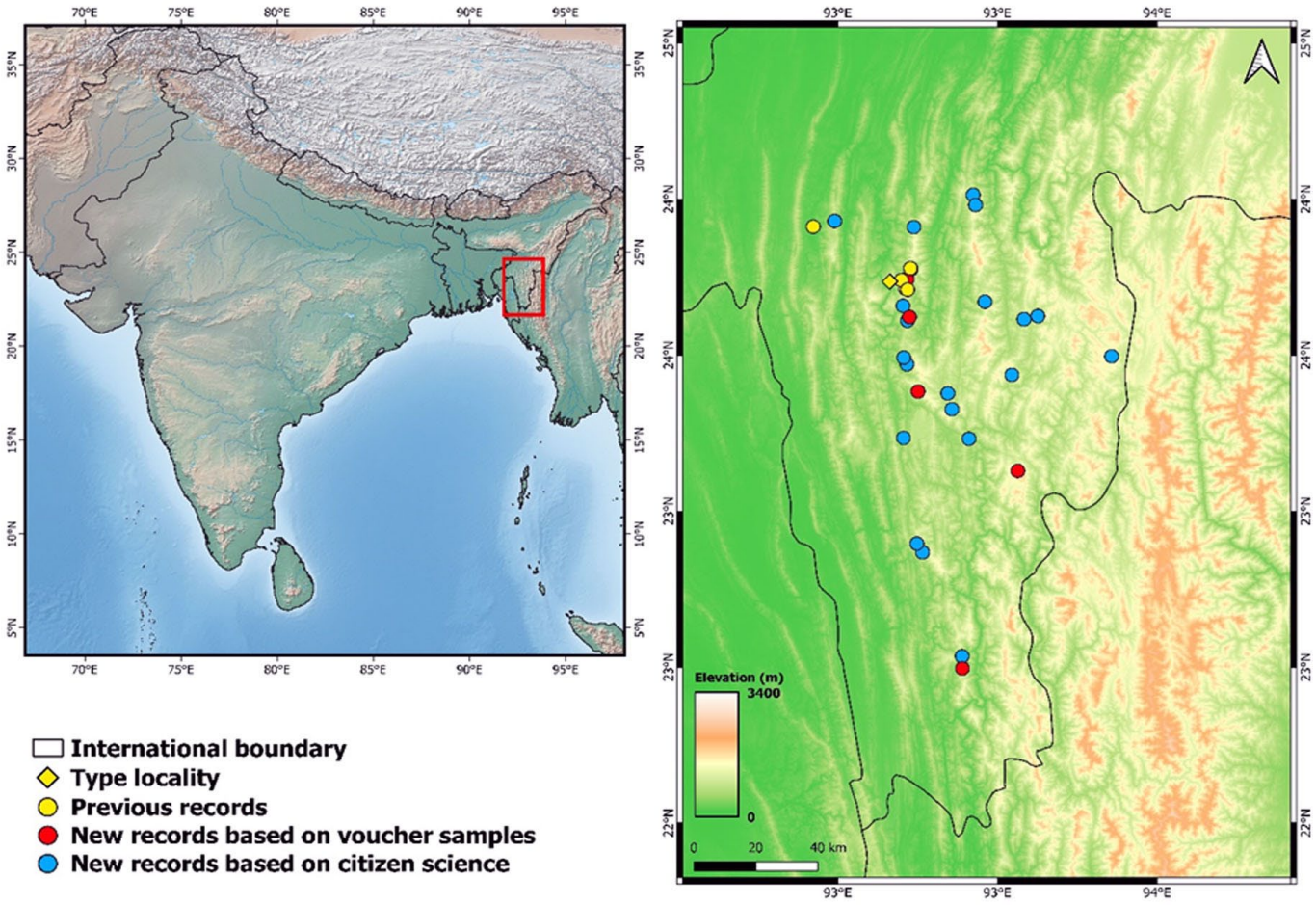

Figure 2. Known localities of *Smithophis atemporalis* based on previous records and present study

The present study adds valuable information to our knowledge of this little-known species and significantly increases its known range by approximately 34 km in a north-easterly direction, 68 km towards the east, 70 km in a south-easterly direction, 126 km towards the south and 80 km towards the west (Fig. 2). This increases the known area of this species from 144 km^2 to 8,196 km^2. From the present known records of the species, its distribution possibly extends to Tripura and Manipur states in India as it had been recorded from Bawngva village (ca. 9 km from Mizoram-Tripura border) and Darlawn village (ca. 11 km from Mizoram-Manipur border). Since photos and voucher specimens of *S. atemporalis* are available from near the Indo-Myanmar border (Champhai town and North Vanlaiphai village), the species is likely to be found in the adjacent Chin hills of Myanmar.

Although the species is not rare within Mizoram, little information is available on its distribution and natural history and the species is likely to qualify as Data Deficient based on criteria for the Red List of Threatened Species (IUCN Standards and Petitions Committee 2019).

ACKNOWLEDGEMENTS

We would like to thank the Chief Wildlife Warden, Environment, Forest and Climate Change Department, Government of Mizoram, India for issuing research and collection permit (A.38011/5/2011-CWLW/338) and members of the Facebook group, Zoram Rul Chanchin, who played a vital part in this study. EL thanks SERB-DST for providing fund towards laboratory facilities.

REFERENCES

Cooper, C.B., Shirk, J. & Zuckerberg, B. (2014). The invisible prevalence of citizen science in global research: Migratory birds and climate change. *PLoS ONE* 9: e106508. DOI: 10.1371/journal.pone.0106508

Das, A., Deepak, V., Captain, A., Wade, E.O.Z & Gower, D.J. (2020) Description of a new species of *Smithophis Giri* et al. 2019 (Serpentes: Colubridae: Natricinae) from Arunachal Pradesh, India. *Zootaxa* 4860: 267–283. DOI: 10.11646/zootaxa.4860.2.8

Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., Phillips, T. & Purcell, K. (2012). The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment* 10: 291–297. DOI: 10.1890/110236

Feldman, M.J., Imbeau, L., Marchand, P., Mazerolle, M.J., Darveau, M. & Fenton, N.J. (2021). Trends and gaps in the use of citizen science derived data as input for species distribution models: A quantitative review. *PLoS ONE* 16: e0234587. DOI: 10.1371/journal.pone.0234587

Giri, V.B., Gower, D.J., Das, A., Lalremsanga, H.T., Lalronunga,

S., Captain, A. & Deepak, V. (2019). A new genus and species of natricine snake from northeast India. *Zootaxa* 4603: 241–264. DOI: 10.11646/zootaxa.4603.2.2

Harris, S., Cresswell, W.J., Forde, P.G., Trewhella, W.J., Woollard, T. & Wray, S. (1990). Home-range analysis using radio-tracking data – a review of problems and techniques particularly as applied to the study of mammals. *Mammal Review* 20: 97–123. DOI: 10.1111/j.1365-2907.1990.tb00106.x

Hayne, D. (1949). Calculation of size of home range. I 30:1–18. DOI: 10.2307/1375189

IUCN (2001). IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland & Cambridge, UK.

IUCN Standards and Petitions Committee (2019). Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. http://www.iucnredlist.org/documents/RedListGuidelines.pdf (7 May 2021).

Klemann Jr., L. & Vieira, J.S. (2013). Assessing the extent of occurrence, area of occupancy, territory size, and population size of marsh tapaculo (*Scytalopus iraiensis*). *Animal Biodiversity and Conservation* 36.1: 47–57.

Liberatore, A., Bowkett, E., MacLeod, C.J., Spurr, E. & Longnecker, N. (2018). Social Media as a Platform for a Citizen Science Community of Practice. *Citizen Science: Theory and Practice* 3: 1–14. DOI: 10.5334/cstp.108

Mohr, C.O. (1947). Table of equivalent populations of North American small mammals. American Midland Naturalist 37: 223–249.

Remruatpuii, Lalbiakzuala & Lalremsanga, H.T. (2020). *Smithophis atemporalis* (Mizo Rain Snake). Reproduction and elevation. *Herpetological Review* 51: 156–157.

Tulloch, A.I., Possingham, H.P., Joseph, L.N., Szabo, J. & Martin, T.G. (2013). Realising the full potential of citizen science monitoring programs. *Biological Conservation* 165: 128–DOI: 10.1016/j.biocon.2013.05.025

van Maes, D., Isaac, N.J.B., Harrower, C.A., Collen, B., Roy, D.B. & van Strien, A.J. (2015). The use of opportunistic data for IUCN Red List assessments. *Biological Journal of the Linnean Society* 115: 690–706. DOI: 10.1111/bij.12530

van Strien, A.J., van Swaay, C.A.M. & Termaat, T. (2013). Opportunistic citizen science data of animal species produce reliable estimates of distribution trends if analysed with occupancy models. *Journal of Applied Ecology* 50: 1450–1458. DOI: 10.1111/1365-2664.12158

Vogel, G., Chen, Z., Deepak, V., Gower, D.J., Shi, J., Ding, L. & Hou, M. (2020). A new species of the genus *Smithophis* (Squamata: Serpentes: Natricidae) from southwestern China and northeastern Myanmar. *Zootaxa* 4803: 051–074. DOI: 10.11646/zootaxa.4803.1.3

Accepted: 4 June 2021

The Herpetological Bulletin 157, 2021: 16-20
SHORT NOTE
https://doi.org/10.33256/hb157.1620

Southern grey shrike as a predator of reptiles on the island of Gran Canaria and a comparison between island and mainland predation rates

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INTRODUCTION

Reptiles may be present at relatively high population densities on arid islands, which despite low primary productivity, have the advantage of relatively stable temperatures and high ambient humidity due to their proximity to the sea (Novosolov et al., 2016; Santini et al., 2018); in these situations birds are probably the most important predators of reptiles (Greene, 1988). To compare arid islands with mainland areas in the extent to which they contribute reptiles as prey species for birds, it is necessary to investigate the diet of bird species that breed in both habitats. One such species is the southern grey shrike (*Lanius meridionalis*) that can be found on the island of Gran Canaria and elsewhere in south-west Europe and discontinuous areas of North Africa, the Middle East and the northern parts of the Indian subcontinent (Madroño et al., 2004).

The diet of the southern grey shrike has been studied by investigation of 1) faecal pellets (Soler et al., 1983), 2) the bodies of reptiles impaled on spiny substrates (Keynan & Yosef, 2010), and 3) prey delivered to the nest (Budden & Wright, 2000), reported as either the number of prey items and/or the percentage of biomass contributed by reptiles.

A subspecies of shrike, *L. m. koenigi,* is endemic to the Canary Islands and breeds on several islands to the centre and east of the archipelago (Tenerife, Gran Canaria, Fuerteventura, Lobos, Lanzarote, La Graciosa and Alegranza) (Martín & Lorenzo, 2001); this is the only bird species that impales reptiles in the Canary Islands. Many of the reptiles available as prey on the Canary Islands are both endemic and also restricted to only certain islands (Machado et al., 1985; Barbadillo et al., 1999). There have been no previous published studies on the diet of the southern grey shrike on Gran Canaria, where there are at least six reptile species – the lizards *Tarentola boettgeri*, *Chalcides sexlineatus* and *Gallotia stehlini* are native, *Gallotia atlantica* is considered to be introduced from nearby islands (Mateo et al., 2011; Mateo, 2015), and the gecko *Hemidactylus turcicus* and the snake *Lampropeltis californiae* are both alien species (Mateo et al., 2011). The current study was undertaken in order to - 1) document the reptile species that are impaled on spiny shrubs or barbed wire by the southern grey shrike on the island of Gran Canaria, and 2) following a literature review, to compare the importance of reptiles as food for the southern grey shrike on islands and in mainland habitats.

MATERIALS & METHODS

Study area and field work

The study area is located in the municipality of Agüimes (Gran Canaria), with geographic limits at 27º 53' 28.00'' N // 15º 23' 40.00" W; 27º 52' 17.06'' N // 15º 23' 59.80" W, bordering the Special Conservation Zone (ZEC) ES7010052 "Punta de la Sal". It comprised two adjacent areas, one with natural spiny vegetation (15 hectares) and the other (0.084 hectares) without spiny vegetation but instead with an 87 m barbed wire fence providing artificial 'spines'. The area is an extremely arid coastal habitat containing halophytic plant species adapted to the lack of water and aeolian erosion. At least three shrub species (*Lycium intricatum*, *Convolvulus caput-medusae* and *Launaea arborescens*) provide spines on which shrikes could impale prey.

Observations in the field were made over 21 days, between November 2015 and December 2016, in four periods, covering all seasons (Table 1). During this time all the shrubs with potential as substrates for impalement and the barbed wire were visited and checked. The impaled prey could often be identified to species (which is not always possible for observations of pellets or prey delivered to the nest).

Inspections were made early in the morning and suitable shrubs and barbed wire were examined thoroughly. Exact geographic coordinates were taken for each impalement observation, as well as several photographs for subsequent identification of the species impaled. Impalements were left intact with a concealed white paper label attached to the branch next to each observation within each study period, to avoid subsequent duplications.

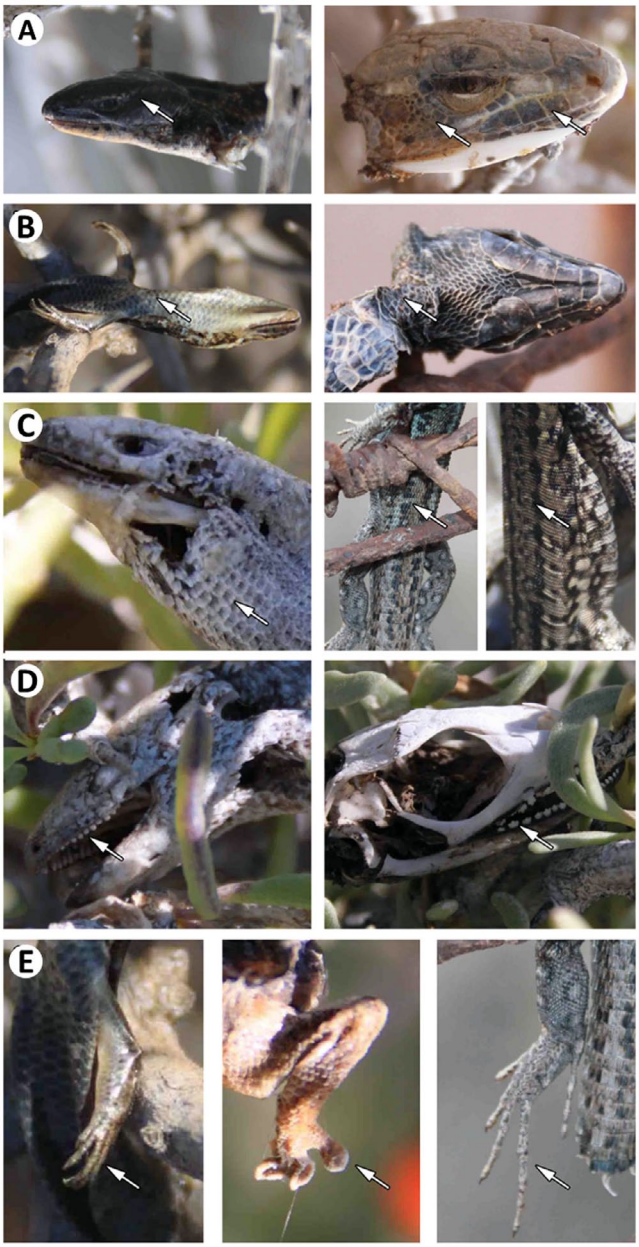

Figure 1. Criteria employed in reptile species identification- **A.** Scale shape along the head and number of labial scales (from left to right: Chalcides - regular scales; *G. stehlini* - irregular and five labial scales in front of subocular); **B.** Scale morphology (Chalcides - homogeneous; Gallotia - heterogeneous, smaller in the neck); **C.** Scale distribution (Chalcides - imbricate, they divide into three while they degrade, *G. atlantica* - low number of scale rows; *G. stehlini* - high number of rows); **D.** Dental cusps (Chalcides - one cusp; *G. stehlini* - three cusps); and **E.** Limb details (Chalcides - short; Tarentola - rounded; Gallotia - long).

For reptile species identification, we have followed Barbadillo et al. (1999) and special consideration was given to 1) the shape and scales of the skull, 2) the number of dental cusps, 3) the number and types of scales along the body, and 4) the shape and length of the limbs and fingers (Fig. 1).

Bibliographical review

During the first months of 2019, an exhaustive bibliographical search was made using search engines (Web of Knowledge and Google Scholar), with the following search terms: '*Lanius meridionalis*', '*Lanius excubitor*', 'bird predation on reptiles' and 'insular predation' (note that the southern grey shrike was formerly known as *Lanius excubitor*). The following information was extracted:

a) Country, province or island hosting the study

b) Form of sample (pellets, impaling or prey delivered to the nest)

c) Diet composition. Percentage of reptiles as a function of the total number of prey, and biomass percentage contributed by reptiles (when possible). Percentages were calculated as follows: when the study reported several species of reptiles separately, the percentages of each reptile species were added to calculate the percentage of reptiles as a whole over the total number of prey items consumed (with the biomass percentage calculated in the same way). When the diet was studied in different places within the same island or local administrative division, an average value was calculated. However, when the same study provided information on several different administrative divisions or islands, each area was treated separately. When monthly or seasonal data were provided, the annual average was calculated.

d) Predated species and families were recorded for each study. Prey items were considered as 'unidentified' when the family but not the species was mentioned. Some studies mentioned reptiles in the diet in a general way, although the species or family were not provided (e.g. Budden & Wright, 2000; Hódar, 2006; Lepley et al., 2004; Taibi et al., 2009). In all cases the percentages of prey or biomass were included when this information was available.

Statistical analyses

For the Gran Canaria data, a contingency table of counts of the total number of reptiles and other taxa (found impaled) on season were compared using a Fisher's Exact Test, considering only sampling periods 2, 3 and 4, in which the impalement period was known (period 1 observations included impalements that occurred at an unknown time before that period).

Four subsets of data were built following the literature review to compare 1) the percentages of reptiles as a proportion of the whole diet between the three forms of sample - impalement, pellet or nest delivery (n = 16); 2) basis of analysis - prey number or biomass percentage on pellets (n = 17); 3) pellets examined on mainland or island study areas compared by prey number (n = 11); 4) and the same as 3) but compared by prey biomass (n = 6).

The medians of groups of data were compared using the non-parametric Kruskal-Wallis test, Dunn's post-hoc test was used subsequently to make comparisons when there was more than two groups. The analyses were carried out in R, version 3.5.2. (R Core Team, 2018).

RESULTS

Impalement of reptiles by southern grey shrike on Gran Canaria

Reptiles were found both on shrubs (mainly *Lycium intricatum* but also *Plocoma pendulata* and *Juniperus turbinata*) and on the barbed wire. There was a total of 64 impalements (Table

1) that included three native reptile species (*T. boettgeri*, *C. sexlineatus* and *G. stehlini*), one introduced species *G. atlantica* and six degraded specimens that were identified as just *Gallotia* sp. Other taxa were also impaled, a single mouse (*Mus musculus*) and six insects (*Orthoptera* and *Coleoptera*). The impalements were recorded in four sampling periods (Table 1) and an analysis across these periods suggests that the counts of all impaled reptile prey and other taxa were not contingent on season (Fisher's Exact Test for Count Data, $p = 0.4$).

Table 1. Numbers of impaled reptile species and other taxa at various intervals from November 2015 to December 2016 on the island of Gran Canaria

Prey	Nov-Feb 2015-2016	Mar-Apr 2016	July-Sept 2016	Dec 2016	Total	% of all prey
Tarentola boettgeri	0	1	0	3	**4**	6.25
Chalcides sexlineatus	19	2	2	3	**26**	40.63
Gallotia stehlini	6	4	1	0	**11**	17.19
Gallotia atlantica	3	7	0	0	**10**	15.63
Gallotia sp.	3	1	0	2	**6**	9.38
Mus musculus	0	0	1	0	**1**	1.56
Insecta	2	2	1	1	**6**	9.38
Total reptiles	31	15	3	8	**57**	89.06
Total other taxa	2	2	2	1	**7**	10.94
Total of all prey	**33**	**17**	**5**	**9**	**64**	100

Bibliographical review

A total of 21 studies (22 with our study) provided information on reptiles predated by southern grey shrike, on five islands and eight mainland sites. Of these studies, eight present only an indication of the predated reptile species, the others list both the reptile species and give estimates of reptiles as a proportion of the total number of prey or as percentage of prey biomass. The full results including all 22 studies can be seen in Supplementary Materials (Table S1) while those with more detailed prey data are shown in Table 2.

Regarding the percentage of prey attributable to reptiles, observations of impalements revealed a considerably greater proportion of reptile prey than by observation of pellets or deliveries to nests (Fig. 2). However, statistically significant differences were only found between impalements and pellets (Dunn's post-hoc test: $p < 0.05$).

The biomass percentage of reptiles was obtained only in the studies on pellets, and this was greater than the percentage of reptiles as prey due to the large size of reptiles compared to other prey taxa such as insects (Kruskal-Wallis, $\chi 2 = 5.82$, $p < 0.05$, $df = 1$) (Fig. 2).

The biomass of reptile prey in pellets was greater from islands than mainland habitats (Kruskal-Wallis, $\chi^2 = 3.86$, $p < 0.05$, $df = 1$) (Fig. 2).

Table 2. Data from a bibliographical review and the current study on the reptile prey (all lizards) of the southern grey shrike from mainland or island habitats, showing the form in which the prey was sampled (impalements, pellets or nest deliveries), percentage of reptiles as a function of the total number of prey (% P) and/or percentage of biomass contributed by reptiles (% B)

Form of sample	Location	% P	% B	Phyllodactylidae	Scincidae	Lacertidae	Reference
Observations from mainland habitats							
Pellets	Granada, Spain	0.52					Soler el al., 1983
	León, Spain	2.29					Hernández et al., 1993
	France		1.43				Lepley et al., 2004
	Granada, Spain	10.15	27.31				Hodar, 2006
	Algeria	0.76					Taibi et al., 2009
	Algeria	5.46	45.73		*Chalcides ocellatus*	Unidentified	Taibi et al., 2018
Impalements	Badajoz, Spain	44				*Psammodromus hispanicus* *Lacerta lepida*	Hernández & Salgado, 1993
	León, Spain	16.8					Hernández, 1995
Nest	Israel	7.8					Budden & Wright, 2000
	Granada, Spain	1.18				Unidentified	Moreno-Rueda et al., 2016
Observations from island habitats							
Pellets	Fuerteventura, Spain	4.6		*Tarentola angustimentalis*		*Gallotia atlantica*	Grimm, 2005
	Lanzarote, Spain	10.8				*Gallotia atlantica*	Grimm, 2005
	Tenerife, Spain	3.8				*Gallotia galloti*	Grimm, 2005
	Tenerife, Spain	3.27	65.85	*Tarentola delalandii*		*Gallotia galloti*	Padilla et al., 2005
	Lanzarote, Spain	17.0	68.75			*Gallotia atlantica*	Padilla et al., 2009
	Tenerife, Spain	6.74	72.91			*Gallotia galloti*	Padilla et al., 2009
Impalements	Gran Canaria, Spain	89.06		*Tarentola boettgeri*	*Chalcides sexlineatus*	*Gallotia atlantica* *Gallotia stehlini*	This study

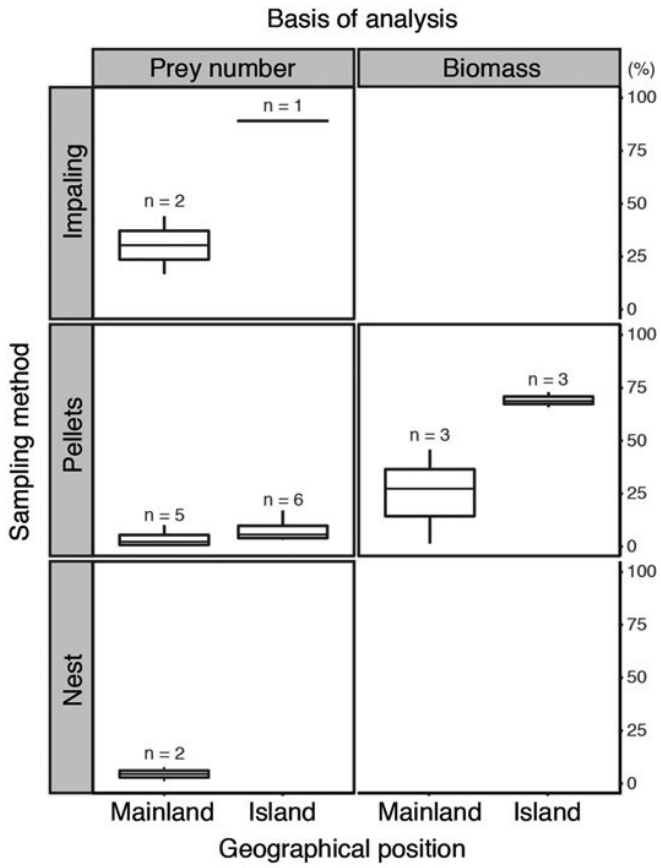

Figure 2. Box and whisker plot of data from the current study and literature (Table 2) for the percentage of reptiles prey items or of percentage reptile biomass in the diet of the southern grey shrike, sorted by study area (mainland and island) and form of sample (impalements, pellets or nest deliveries)

DISCUSSION

How sample form affects the study of diet

The form in which the sample was taken in each study had an important influence on the results. Observations of impaled prey provided higher percentages of reptiles than the other two techniques (i.e. pellets or prey delivered to the nest by the parents). This may be a result of southern grey shrikes mostly impaling only larger prey, small prey perhaps being consumed directly. Three of the seven impalement studies reviewed provided the percentages of reptiles with respect to the total number of prey consumed; in all these, percentages were quite high: 44 % (Hernández & Salgado, 1993); 16.8 % (Hernández, 1995), and 89.06 % (this study).

Reptiles in the diet of the southern grey shrike on the island of Gran Canaria

The diet of the southern grey shrike has previously been studied in the Iberian Peninsula, France, Israel, Yemen and Algeria as well as on other islands of the Canary archipelago (Table 2, Table S1). Despite the limitation of existing studies and considering that small sample sizes in statistical analyses mean that it was difficult to detect any differences, results presented here suggest that regardless of the form of sample and analysis type, reptiles are more common prey on islands than in mainland areas (Fig. 2).

This study presents the first information on the diet of the southern grey shrike in Gran Canaria. This bird species preys on the three native species (*T. boettgeri*, *C. sexlineatus* and *G. stehlini*), and the introduced species *Gallotia atlantica* (Mateo et al., 2011; Mateo, 2015). It can be suggested that the southern grey shrike does not show a clear food preference for a particular species or group, and that its diet is probably more conditioned by prey availability.

Opportunistic character of the southern grey shrike

The southern grey shrike feeds on the potential reptile families present at each site, as has been confirmed both in the island of Gran Canaria (Table 1) and in the other places where its diet has been studied (Table 2, Table S1), confirming their relative importance in its diet.

On many islands, the southern grey shrike remains in the same areas throughout all seasons of the year, probably because of the stable island climate and food availability; on Gran Canaria reptiles are active throughout all the year (Padilla et al., 2007 & 2009). On the contrary, the mainland southern grey shrikes have to migrate during winter (Madroño et al., 2004).

Studies of pellets in mainland areas demonstrate that the diet of the southern grey shrike diet consists mainly on invertebrates (*Coleoptera*, *Orthoptera* and *Hymenoptera*) and that the consumption of reptiles is greater during the warmer months of the year when they are active (Soler et al., 1983 & Hodar, 2006). Nevertheless, according to Hernández et al. (1993), for most of the year vertebrates make a greater calorific contribution than invertebrates to the diet of the southern grey shrike.

Statistical analysis of this study suggests a higher abundancy of reptiles in the diet of the southern grey shrike on islands than in mainland areas. Further studies should be made to confirm this pattern with special attention to making comparisons of the two habitats at the same time of year.

ACKNOWLEDGEMENTS

An anonymous reviewer made valuable suggestions for improving the original manuscript. We dedicate this work to Dr. Salvador Peris, who taught zoology to the two generations of biologists, authors of this manuscript, and instilled in the authors his interest for this species and many others in which he was specialist and pioneer. This work was carried without any funding.

REFERENCES

Barbadillo, L.J., Lacomba, J.I., Pérez Mellado, V., Sancho, V. & López-Jurado, L.F., (1999). *La Guía de campo de los anfibios y reptiles de la Península Ibérica, Baleares y Canarias*. Ed. Planeta, Barcelona. 423 pp.

Brown, R.P., Thorpe, R.S., & Báez, M. (1991). Parallel within-island microevolution of lizards on neighbouring islands. *Nature* 352: 60-62.

Buckley, L.B. & Jetz, W. (2007). Insularity and the determinants of lizard population density. *Ecology letters* 10: 481-489.

Budden, A.E. & Wright, J. (2000). Nestling diet, chick growth

and breeding success in the Southern Grey Shrike (*Lanius meridionalis*). *Ring* 22: 165-172.

Greene, H.W. (1988). Antipredator mechanisms in reptiles. In *Biology of the Reptilia*, 1-152 pp. Gans C. & Huey R.B. (Eds.). Alan R. Liss, New York.

Grimm, H. (2005). Zur Ernährung des Kanaren-Raubwürgers *Lanius meridionalis koenigi*. *Ornithologische Jahresberichte Museum Heineanum* 23: 11-28.

Hernández, A., Purroy, F.J. & Salgado, J.M. (1993). Variación estacional, solapamiento interespecífico y selección en la dieta de tres especies simpátricas de alcaudones *Lanius* spp. *Ardeola* 40: 143-154.

Hernández, Á. & Salgado, J.M. (1993). Almacenamiento de presas por el Alcaudón real (*Lanius excubitor*) en la Serena (Badajoz) y la Sierra de Cabo de Gata (Almería). *Butlletí del Grup Català d'Anellament* 10: 63-65.

Hernández, Á. (1995). Temporal-spatial patterns of food caching in two sympatric shrike species. *The Condor* 97: 1002-1010.

Hodar, J.A. (2006). Diet composition and prey choice of the southern grey shrike *Lanius meridionalis* L. in south-eastern Spain: the importance of vertebrates in the diet. *Ardeola* 53: 237-249.

Keynan, O. & Yosef, R. (2010). Temporal changes and sexual differences of impaling behavior in Southern Grey Shrike (*Lanius meridionalis*). *Behavioural Processes* 85: 47-51.

Lepley, M., Thevenot, M., Guillaume, C.P., Ponel, P. & Bayle, P. (2004). Diet of the nominate Southern Grey Shrike *Lanius meridionalis meridionalis* in the north of its range (Mediterranean France). *Bird Study* 51: 156-162.

MacArthur, R.H., Diamond, J.M. & Karr, J.R. (1972). Density compensation in island faunas. *Ecology* 53: 330–342.

Machado, A., Lopez-Jurado, L.F. & Martin, A. (1985). Conservation status of reptiles in the Canary Islands. *Bonner Zoologische Beitrage* 36: 585-606.

Madroño, A., González, G.G. & Atienza, J.C. (Eds.). 2004. Libro rojo de las aves de España. Organismo Autónomo Parques Nacionales. 452 pp.

Martín, A. & Lorenzo, J.A. (2001). Aves del archipiélago canario. Francisco Lemus. 787 pp.

Mateo, J.A., Ayres, C. & López-Jurado, L.F. (2011). Los anfibios y reptiles naturalizados en España. Historia y evolución de una problemática creciente. *Boletín de la Asociación Herpetológica Española* 22: 2-42.

Mateo, J.A. (2015). El lagarto atlántico (*Gallotia atlantica*) en Gran Canaria. *Boletín de la Asociación Herpetológica Española* 26: 61-63.

Moreno–Rueda, G., Abril–Colón, I., López–Orta, A., Álvarez–Benito, I., Castillo–Gómez, C., Comas, M. & Rivas J.M. (2016). Breeding ecology of the southern shrike (*Lanius meridionalis*) in an agrosystem of south–eastern Spain: the surprisingly excellent breeding success in a declining population. *Animal Biodiversity and Conservation* 39: 89-98.

Novosolov, M., Rodda, G.H., Feldman, A., Kadison, A.E., Dor, R. & Meiri, S. (2016). Power in numbers. Drivers of high population density in insular lizards. *Global Ecology and Biogeography* 25: 87-95.

Padilla, D.P., Nogales, M. & Marrero, P. (2007). Prey size selection of insular lizards by two sympatric predatory bird species. *Acta Ornithologica* 42: 167-172.

Padilla, D.P., González-Castro, A., Nieves, C. & Nogales, M. (2009). Trophic ecology of the southern grey shrike (*Lanius meridionalis*) in insular environments: the influence of altitude and seasonality. *Journal of Ornithology* 150: 557.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. www.R-project.org/.

Santini, L., Isaac, N.J., Maiorano, L., Ficetola, G.F., Huijbregts, M.A., Carbone, C. & Thuiller, W. (2018). Global drivers of population density in terrestrial vertebrates. *Global Ecology and Biogeography* 27: 968-979.

Soler, M., Zúñiga, J.M. & Camacho, I. (1983). *Alimentación y reproducción de algunas aves de la Hoya de Guadix:(sur de España)*. Trabajos monográficos Departamento de Zoología Universidad de Granada, 6: 27-100.

Taibi, A., Ababsa, L., Bendjoudi, D., Doumandji, S., Guezoul, O. & Lepley, M. (2009). Régimes alimentaires de deux sous-espèces de la pie-grièche méridionale *Lanius meridionalis* au Maghreb. *Alauda* 77: 281-285.

Taibi, A., Brahimi, D. & Doumandji, S. (2018). Food larders of the Southern Grey Shrike *Lanius meridionalis algeriensis* (Laniidae, Passeriformes) in Algeria. *North-Western Journal of Zoology* 14: 273-275.

Accepted: 16 March 2021

Please note that the Supplementary Material for this article is available online via the Herpetological Bulletin website: https://thebhs.org/publications/the-herpetological-bulletin/issue-number-157-autumn-2021

The Herpetological Bulletin 157, 2021: 21-24
SHORT COMMUNICATION

https://doi.org/10.33256/hb157.2124

Dominant and submissive behaviour in the rattlesnake *Crotalus durissus* under semi-natural conditions

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INTRODUCTION

Dominance behaviour can be described as interindividual interactions (physical or not) that induce one individual (subordinate) to avoid the other (dominant) (Carpenter, 1984). This behaviour has been more often related to reproductive events, such as combat, courtship, and copulation (Barker et al., 1979; Gillingham et al., 1983; Carpenter, 1984; Guedes et al., 2014). Dominance in snakes is rarely observed in the wild, probably because in most field studies there is a low encounter rate and in any case, monitoring may often be mistimed to observe this behaviour (Bennion & Parker, 1976). However, dominance has often been reported in captivity, an environment that seems to facilitate the formation of hierarchies (e.g., Carpenter et al., 1976; Carpenter & Gillingham, 1977; Carpenter, 1979; Barker et al., 1979; Gillingham et al., 1983; Carpenter, 1984; Guedes et al., 2014).

In snakes, dominant and submissive behaviours are relatively generalised (Carpenter, 1984). In combat rituals, a male tries to force his opponent down in at least two ways: (1) by quickly looping around his rival and toppling him over or (2) by lowering the head and anterior trunk on the anterior region of his opponent, forcing him down and pinning his anterior region to the substrate (Carpenter, 1984). The subordinate male assumes a submissive posture, including coiling, tail waving, hiding the head beneath the body, retreat, or flight (Carpenter, 1984).

In vipers, males typically raise the anterior trunk and position the head vertically to the ground while orienting themselves face to face or in the same direction. Their backs are usually in contact and sometimes partially intertwined (Carpenter & Ferguson, 1977). This pattern has been recorded in *Crotalus* (Langlada, 1975; Carpenter & Ferguson, 1977; Gillingham et al., 1983; Hayes, 1986; Almeida-Santos et al., 1990; Reed, 2003), *Bothrops* (Leloup, 1975; Almeida-Santos & Salomão, 2002; Almeida-Santos et al., 2017), and in species that perform dorsal tracking instead of trunk raising, such as *Vipera*, *Sistrurus*, and *Bitis* (Carpenter & Ferguson, 1977). Dominant and submissive behaviours among males may or may not occur before combat and courtship (Gillingham, 1983; Carpenter, 1984).

In the South American rattlesnake, *Crotalus durissus*, these rituals occur during the courtship/mating season in autumn (Almeida-Santos et al., 1990). Opponents raise and sometimes loosely intertwine their trunks in the posterior region while keeping their heads upright and oriented face to face or in the same direction. Both males swing the anterior trunk back and forth, pushing and pressing each other until they fall and restart a new bout (Langlada, 1975; Almeida-Santos et al., 1990). These rituals can last from a few minutes to several hours, and this variation may be related to environmental conditions or restrictions imposed by captivity (Almeida-Santos et al., 1990). Here, we report a sequence of interactions among captive male *C. durissus* that established a dominant-subordinate relationship during the mating season.

Behavioural observations were made at the serpentarium of the Instituto Butantan, municipality of São Paulo, state of São Paulo, south-eastern Brazil (23° 34' S; 46° 43' W). The serpentarium is a semi-natural outdoor enclosure (area = 183.22 m^2) designed to keep snakes in a semi-extensive breeding system (Leloup, 1984). It contains a grassy area, circular concrete shelters, artificial concrete burrows, stones, trees, and an artificial river (Gomes & Almeida-Santos, 2012). Snakes were kept under ambient conditions of temperature, photoperiod, and humidity at the time of observations. Specimens of both sexes were kept in the same area, and all individuals had their rattles marked with nail polish so that they could be identified without any physical restraint. We observed dominant and submissive behaviours in three adult males, hereafter, Alpha (1060 mm snout-vent length [SVL] and 950 g), Beta (1040 mm SVL and 720 g), and Gamma (1090 mm SVL and 770 g). These individuals had lived together in captivity for 179 days before observations commenced. Our behavioural nomenclature follows Carpenter (1976, 1979, 1984).

We observed two behavioural interactions in April 2014. At that time, five oestrous females and three males were kept in the serpentarium. The first interaction was observed on 10th April 2014, and was both videoed (BHS video, 2021) and photographed using a mobile phone. Alpha was found performing a solicitation display, pursuing, crawling over, and lying on Beta (Fig. 1A). Beta showed no interest in facing

Alpha, avoiding him and assuming a submissive posture. Alpha crawled over Beta toward the head while raising his anterior trunk. Beta retracted his body abruptly while waving his tail (Fig. 1B and C; BHS video). At the same time, Alpha raised his head and performed a vertical display while topping, forcing the anterior trunk and keeping his posterior trunk over the anterior portion of Beta's body, which was coiled with the head down (Fig. 1D and E). As soon as Alpha lowered his anterior trunk slightly, Beta fled (Fig. 1F). The following week, we observed Gamma exhibiting the same submissive behaviour (coiling and head down) to Alpha. Throughout the 2014 mating season, only Alpha was observed courting different females and copulated with one. Beta and Gamma remained distant, always occupying microhabitats different from those occupied by Alpha.

We observed several visual and tactile communications between male rattlesnakes that may be significant in establishing dominant-submissive relationships. The observed behavioural patterns classify Alpha as the dominant male and Beta and Gamma as the submissive ones (Carpenter et al., 1976; Carpenter & Gillingham, 1977; Carpenter, 1979; Barker et al., 1979; Gillingham et al., 1983;

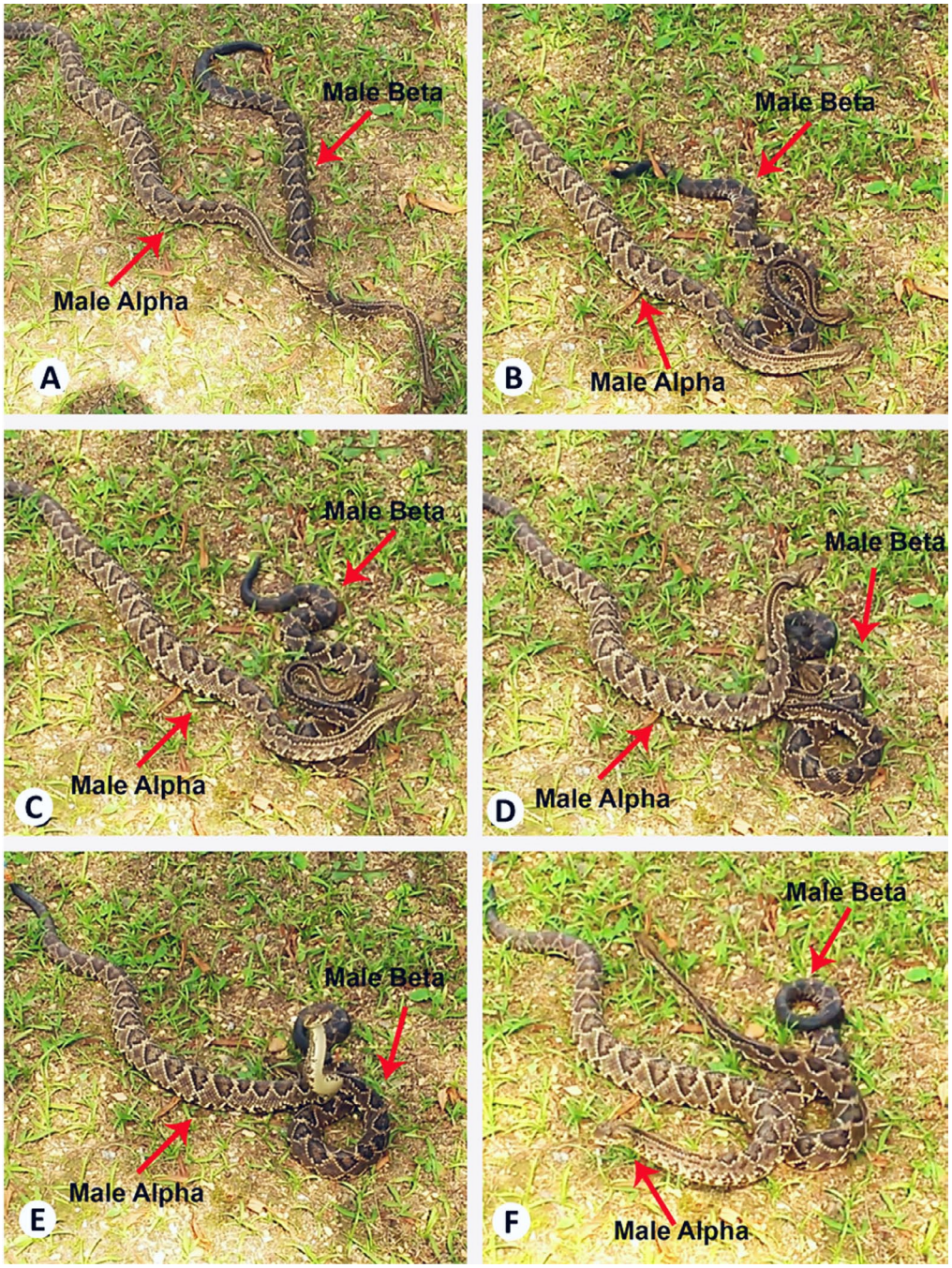

Figure 1. Behavioural sequence for establishing dominance and submission in captive male *Crotalus durissus*- **A.** Alpha approaches Beta and initiates contact by crawling over, **B.** Alpha approaches Beta, which coils, **C.** Alpha crawls over and lies on Beta, **D.** Alpha raises his head and anterior trunk and keeps his posterior trunk over Beta's anterior trunk and Beta shows a submissive posture (coiled and head down), **E.** Alpha crawls over Beta, which assumes a submissive posture, note the vertical display of Alpha (dominant male), and **F.** Alpha lies on Beta, which tries to flee

Carpenter, 1984). The tactile signs exhibited by the dominant male included crawling over, topping, and lying on, whereas the visual signs included vertical display, approach, pursuit, and solicitation display. The tactile and visual signs exhibited by the subordinate males included avoidance, flight (retreat), thrashing, tail waving, coiling, head down, and submissive posture (Fig. 1).

Snakes are seen as animals with little or no social behaviour (Wilson, 1975). However, individual recognition apparently occurs in aggregation behaviours (Clark, 2004; Skinner & Miller, 2020), as well as in the formation of a stable linear social hierarchy among captive male *Python molurus* (Barker et al., 1979). In our observations, the dominant male always pursued and remained over the subordinate males, exerting the classic dominance observed in male-male combat which prevented the subordinates from assuming any dominance posture. In turn, the subordinate males avoided the dominant male throughout the austral autumn. Furthermore, the subordinate males were never seen courting captive females, even days after the observed dominance actions. Indeed, subordinate males are believed to be sexually inhibited even days after the male-male combat, due to stress hormones levels, and their reproductive performance is probably reduced (Schuett, 1996; Schuett & Grober, 2000). On the other hand, in atypical situations of coexistence, such as in captivity, there may be some chemical or visual recognition in which subordinate male snakes recognise and avoid dominant ones, thus establishing social hierarchies (Barker et al., 1979; Clark, 2004; Skinner & Miller, 2020).

In some situations, body size may not be the main factor determining male reproductive success or establishing dominance (Barker et al., 1979; Muniz-da-Silva & Almeida-Santos, 2013; Glaudas et al., 2020a; Glaudas et al., 2020b). Nevertheless, body size does play an important role in determining dominance and subordination in snakes, as both our data and the literature show that dominant males are slightly larger and/or heavier than subordinate males (Carpenter, 1984; Guedes et al., 2014). Male-biased sexual size dimorphism is common in species that exhibit male-male combat, including *Crotalus* (Almeida-Santos et al., 1990; Shine, 1994; Senter et al., 2014) and, consequently, body size is under strong sexual selection (Shine, 1994). In our observations, the dominant male was the stoutest (not the longest) male in the serpentarium emphasising the importance of body weight rather than just length.

Because most observations on dominance in snakes have been made in captivity, it is likely that this environment favours the emergence of this hierarchical social relationship. Thus, the captive environment provides valuable opportunities to study behaviours that are difficult to observe in the wild (Carpenter et al., 1976; Carpenter & Gillingham, 1977; Carpenter, 1979; Barker et al., 1979; Gillingham et al., 1983; Carpenter, 1984; Guedes et al., 2014). Although male-male predatory combat (i.e. snakes fighting over food) and dominance/subordination behaviour have already been reported in captive *C. durissus* (Almeida-Santos et al., 1999), our report is the first detailing observations in semi-natural conditions (semi-extensive captivity) using video to enable a more detailed description (spatially and temporally) of these behaviours in a reproductive context.

ACKNOWLEDGEMENTS

We thank Nathália Anhesini for the video and Cristiene Rodrigues Martins for her help with the photos taken from the video. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

REFERENCES

Almeida-Santos, S.M., Laporta-Ferreira, I.L. & Puorto, G. (1990). Ritual de combate em *Crotalus durissus*. *Anais da Academia Brasileira de Ciências* 62: 418.

Almeida-Santos, S.M., Shidmit, F.L. & Balestrin, R.L. (1998). *Micrurus frontalis* (coral snake) male combat. *Herpetological Review* 29: 242.

Almeida-Santos, S.M., Salomão, M.G., Peneti, E.A., Sena, P.S. & Guimarães, E.S. (1999). Predatory combat and tail wrestling in hierarchical contexts of the Neotropical rattlesnake *Crotalus durissus terrificus* (Serpentes: Viperidae). *Amphibia-Reptilia* 20: 88-96.

Almeida-Santos, S.M. & Marques, O.A.V. (2002). Male-male ritual combat in the colubrid snake *Chironius bicarinatus* in the Atlantic forest, southeastern Brazil. *Amphibia-Reptilia* 23: 528- 533.

Almeida-Santos, S.M. & Salomão, M.G. (2002). Reproduction in neotropical pitvipers, with emphasis on species of the genus *Bothrops*. In: *Biology of the Vipers*, pp. 445-462. Schuett, G.W., Höggren, M., Douglas, M.E & Greene, H.W. (Eds.). 1st edition. Utah: Eagle Publ. Mountain.

Almeida-Santos, S.M., Barros, V.A., Rojas, C.A., Sueiro, L.R. & Nomura, R.H.C. (2017). Reproductive biology of the Brazilian lancehead, *Bothrops moojeni* (Serpentes, Viperidae), from the state of São Paulo, southeastern Brazil. *South American Journal of Herpetology* 12:174–181.

Barker, D.G., Murphy, J.B. & Smith, K.W. (1979). Social behavior in a captive group of Indian pythons, *Python molurus* (Serpentes, Boidae) with formation of a linear social hierarchy. *Copeia* 1979: 466-471.

Bennion, R.S. & Parker, W.S. (1976). Field observations on courtship and aggressive behavior in desert striped whipsnakes, *Masticophis t. taeniatus*. *Herpetologica* 32: 30-35.

BHS video (2021). Dominant and submissive behaviour in the South American rattlesnake (*Crotalus durissus*). https://youtu.be/2GCVJ6yQ9Dk

Carpenter, C.C. (1979). A combat ritual between two male pygmy rattlesnakes (*Sistrurus miliarius*). *Copeia* 1979: 638-643.

Carpenter, C.C. & Gillingham, J.C. (1977). a Combat Ritual between Two Male Speckled Kingsnakes (*Lampropeltis getulus holbrooki*: Colubridae, Serpentes) with Indications of Dominance. *The Southwestern Naturalist* 22: 517-524.

Carpenter, C.C., Gillingham, J.C. & Murphy, J.B. (1976): The combat ritual of the rock rattlesnake (*Crotalus lepidus*). *Copeia* 1976: 764-780.

Carpenter, C.C. (1977). Communication and display of snake. *American Zoologist* 17: 217-223.

Carpenter, C.C. & Ferguson, G.W. (1977). Variation and

evolution of stereotyped behavior in reptiles. In: *Biology of the Reptilia*. Ecology and behavior, pp. 335-354. Gans, C. (ed.). A. London: Academic Press Inc.

Carpenter, C.C. (1984): Dominance in Snakes. In: *Vertebrate: Ecology and Systematics*, pp. 195-202. Seigel, R. A. (ed.). University of Kansas.

Clark, R.W. (2004). Kin recognition in rattlesnakes. *Proceedings of the Royal Society B: Biological Sciences* 271: 243-245.

Glaudas, X., Rice, S.E., Clark, R.W. & Alexander, G. (2020a). The intensity of sexual selection, body size and reproductive success in a mating system with male–male combat: is bigger better? *Oikos* 129: 1011-1020.

Glaudas, X., Rice, S. E., Clark, R.W. & Alexander, G.J. (2020b). Male energy reserves, mate-searching activities, and reproductive success: alternative resource use strategies in a presumed capital breeder. *Oecologia* 194: 415-425.

Gillingham, J.C., Carpenter, C.C. & Murphy, J.B. (1983). Courtship, Male Combat and Dominance in the Western Diamondback Rattlesnake, *Crotalus atrox*. *Journal of Herpetology* 17: 265-270.

Gomes, C.A. & Almeida-Santos, S.M. (2012). Microhabitat use by species of the genera *Bothrops* and *Crotalus* (Viperidae) in semi-extensive captivity. *Journal of Venomous Animals and Toxins including Tropical Diseases* 18: 393-398.

Guedes, T., Guedes, A. & Almeida-Santos, S.M. (2019). Male-male fighting, dominance, and mating in *Epicrates assisi* (Serpentes: Boidae) in captivity. *Phyllomedusa: Journal of Herpetology* 18: 131-135.

Hayes, W.K. (1986) Observations of courtship in the rattlesnake, *Crotalus viridis oreganus*. *Journal of Herpetology* 20: 246–249.

Langlada, F.G. (1975). Combat-dance between males of Brazilian *Crotalus durissus*. *Journal of Herpetology* 9: 349-351.

Leloup, P. (1975). Observations sur La reproduction de *Bothrops moojeni* Hoge en captivite. *Acta Zoológica et Pathologica Antverpiensia* 62: 173-201.

Leloup, P. (1984). Various aspects of venomous snake breeding on a large scale. *Acta Zoologica et Pathologica Antverpiensia* 78: 177-198.

Muniz-da-Silva, D.F. & Almeida-Santos, S.M. (2013). Male-male ritual combat in *Spilotes pullatus* (Serpentes: Colubrinae). *Herpetological Bulletin* 126: 25-29.

Pizzatto, L., Haddad, R.M. & Almeida-Santos, S.M. (2006). Male-male ritualized combat in the Brazilian rainbow boa *Epicrates cenchria crassus*. *Herpetological Bulletin* 95: 16-20.

Reed, R.N. (2003). Courtship and copulation in the Grand Canyon rattlesnake, *Crotalus viridis abyssus*. *Herpetological Review* 34: 111–112.

Senter, P., Harris, S.M. & Kent, D.L. (2014). Phylogeny of Courtship and Male-Male Combat Behavior in Snakes. *PlosOne* 9: e107528.

Shine, R. (1994). Sexual size dimorphism in snakes revisited. *Copeia* 1994: 326-346.

Schuett, G.W. (1996). Fighting dynamics of male copperheads *Agkistrodon contortrix* (Serpentes: Viperidae): Stress-induced inhibition of sexual behavior in losers. *Zoo Biology* 15: 209-221.

Schuett, G.W., Grober, M.S. (2000). Post-fight levels of plasma lactate and corticosterone in male copperheads, *Agkistrodon contortrix* (Serpentes, Viperidae): differences between winners and losers. *Physiology & Behavior* 71: 335-341.

Skinner, M. & Miller, N. (2020). Aggregation and social interaction in garter snakes (*Thamnophis sirtalis sirtalis*). *Behavioral Ecology and Sociobiology* 74: 51.

Wilson, E.O. (1975). Sociobiology: the new synthesis. Cambridge, MA: Belknap Press of Harvard. 720 pp.

Accepted: 21 April 2021

The Herpetological Bulletin 157, 2021: 25-26
SHORT COMMUNICATION

https://doi.org/10.33256/hb157.2526

Successful nest intervention for declining turtle species - the northwestern pond turtle *Actinemys marmorata* and southwestern pond turtle *Actinemys pallida*

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INTRODUCTION

The northwestern pond turtle (*Actinemys marmorata*) and the southwestern pond turtle (*Actinemys pallida*) are both recognised as of conservation concern in California and have been reported to be in decline for several decades (Jennings & Hayes, 1994; Bury et al., 2012; Thompson et al., 2016). Both Bury et al. (2012) and Thompson et al. (2016) have attributed declines in both species to destruction or loss of nesting habitat; absence of protection for nesting sites; and a putative lack of information on nesting ecology. Our understanding of the nesting ecology of the species has benefitted from a species review (Bury et al., 2012) and publications dealing with nest site predation (Alvarez et al., 2014), atypical nesting behaviour (Alvarez & Davidson, 2018), and nest site selection (Riensche et al., 2019, Davidson & Alvarez, 2020). Both northwestern and southwestern pond turtles occur at our study site (at a ratio of 1:2 respectively) and we report here on a successful intervention to repair two nests, one that was predated and the other that was abandoned before completion.

We undertook a 6-year turtle nesting-ecology study (2013 – 2019) in Moorhen Marsh, a 21-acre man-made freshwater marsh that is associated with a waste-water treatment facility. During this study, we followed female *A. marmorata* and *A. pallida* from aquatic refuge sites to their presumed nesting locations in upland areas surrounding the aquatic breeding habitat. Each nesting female that was located was observed from approx. 50 m away, and typically behind cover, so that nest construction, oviposition, nest completion, and finally the return to aquatic refuge habitat could be closely observed using binoculars. As the two turtle species are not readily identifiable at this distance, hereafter they are referred to as *Actinemys* sp. Data on each of these nest locations were collected, a protective cage (modified from Graham, 1997) was secured over the nest, and the nest site was monitored until hatching (Davidson & Alvarez, 2020).

On 20th June 2015 a nesting turtle (*Actinemys* sp.) was located and observed. Following the completion of the nest, a protective cage was placed over the nest, which was then monitored. The following day the caged nest was examined and found to have been partially excavated. The nest plug was removed and the soil layer covering the eggs was missing so that the eggs were exposed (Fig. 1). We removed the cage, replaced a small amount of loose soil over the eggs, and then fashioned a funnel shaped plug from damp soil collected in the immediate area which was mixed with pond water. The new plug was pressed into the opening of the nest chamber and spread firmly into the surrounding soil. The newly sealed nest was monitored for the next 8 months.

Figure 1. Western pond turtle (*Actinemys* sp.) eggs (indicated by arrows) within a nest cavity that were left exposed by a predation attempt. The nest was plugged manually and produced viable neonates the following winter.

The following nesting season, on 26th June 2016, a pond turtle (*Actinemys* sp.) was found nesting in upland habitat about 2 m from aquatic refuge habitat. At some time in the process of nesting the turtle was disturbed, probably by the

presence of observers, which were only about 20 m from the nesting turtle. It immediately fled to aquatic refuge habitat. Upon investigation the nest was found to be incomplete with the eggs exposed. A similar procedure to that used the previous year was used to plug this nest and it was covered by a protective cage and monitored.

Both nests were very closely monitored. In late February 2015 and late February 2016 respectively, each of the two nests showed signs of emergence of nestling pond turtles. Within 3-4 days of a small (1 cm) opening, in what was presumed to be the nest chamber, hatchlings emerged. The nest from 2015 produced eight live neonate turtles, and the nest from 2016 produced seven live neonates and a single undeveloped egg. These counts are within the range reported by Holland (1994) for normal clutch size which averaged 6.1/nest and ranged from 1-13.

Although we cannot be certain, we believe that the only nesting attempt where our presence disturbed the turtle prior to the completion of its nest was that reported for 26th June 2016. Our approach to limiting turtle disturbance, by remaining 50 m away from a nesting turtle, was inferred to be effective as all other turtles engaged in active nest construction appeared to complete their nests.

Our work here suggests that the process of nest construction may be disrupted by predation attempts, which Alvarez et al. (2014) reported as "at a high level" at this site, or disturbance during the process of nest completion. Intervention at an early stage, presumably before environmental conditions affect eggs, can include recreating and placing nest plugs, which can lead to greater reproductive success. This is particularly important for species where nesting failure may be a contributing factor in their decline (Bury et al., 2012). To limit or eliminate disturbance to nesting turtles, we suggest maintaining a distance of at least 50 m which consequently requires the use of binoculars or a spotting scope to observe nesting turtles (Davidson & Alvarez, 2020). Nesting turtles should only be approached after the female has completed the nest, at which time the nest can be located, documented, and protected.

ACKNOWLEDGEMENTS

We are grateful to the Mt. View Sanitary District and their Board of Directors for support of turtle studies at Moorhen Marsh, Martinez, CA. This work benefited by a review and constructive comments from an anonymous reviewer. Work herein was conducted under a Lake and Streambank Alteration Agreement (1600-2016-0347-R3) provided by the California Department of Fish and Wildlife.

REFERENCES

Alvarez, J.A. & Davidson, K.A. (2018). *Actinemys marmorata* (northwestern pond turtle). Atypical nests. *Herpetological Review* 49: 101-103.

Alvarez, J.A., Davidson, K.A. & Foster, S.M. (2014). *Actinemys marmorata* (western pond turtle). Nest predation. *Herpetological Review* 45: 307-308.

Davidson, K.A. & Alvarez, J.A. (2020). A review and synopsis of nest site selection and site characteristics of western pond turtles. *Western Wildlife* 7: 42-49.

Bury, R.B., Welsh, H.H. Jr., Germano, D.J. & Ashton, D.T. (2012). *Western Pond Turtle: Biology, Sampling Techniques, Inventory and Monitoring, Conservation, and Management*. Northwest Fauna 7. 128 pp.

Graham, T. (1997). Effective predator excluders for turtle nests. *Herpetological Review* 28: 76.

Iverson, J.B., Meylan, P.A. & Seidel, M.E. (2017). Testudines - turtles. In *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in our Understanding*, 82-91 pp. Crother B.I. (Ed.). Society for the Study of Amphibians and Reptiles, Herpetological Circular 43 (8th Edition).

Jennings, M.R. & Hayes, M.P. (1994). *Amphibian and Reptile Species of Concern*. California Department of Fish and Game, Sacramento, California. 255 pp.

Riensche, D.L., Riensche, S.K. & Riensche, R.E. (2019). Habitat use, movement patterns, and nest site selection by western pond turtles (*Actinemys marmorata*) in a managed central California rangeland pond. *Northwestern Naturalist* 100: 90-101.

Spinks, P.Q., Thompson, R.C. & Shaffer, H.B. (2010). Nuclear gene phylogeography reveals the historical legacy of an ancient inland sea on lineages of the western pond turtle, *Emys marmorata* in California. *Molecular Ecology* 19: 542-556.

Spinks, P.Q., Thompson, R.C. & Shaffer, H.B. (2014). The advantages of going large: genome-wide SNPs clarify the complex population history and systematics of the threatened western pond turtle. *Molecular Ecology* 23: 2228-2241.

Spinks, P.Q., Thompson, R.C., McCartney-Melstad, E. & Shaffer, H.B. (2016). Phylogeny and temporal diversification of the New World pond turtles (Emydidae). *Molecular Phylogenetics and Evolution* 103: 85-97.

Thompson, R.C., Wright, A.N. & Shaffer, H.B. (2016). *California Amphibians and Reptile Species of Special Concern*. University of California Press, Berkeley, California. 390 pp.

Accepted: 29 April 2021

The Herpetological Bulletin 157, 2021: 27-28
SHORT COMMUNICATION

https://doi.org/10.33256/hb157.2728

Male genital/cloacal prolapse in wild marsh crocodiles *Crocodylus palustris*, Gujarat, India

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INTRODUCTION

The mugger crocodile (*Crocodylus palustris*) is quite common in many states of India (Choudhury & de Silva, 2013). A small, notable population of the species flourishes in the Charotar region of central Gujarat (Patel et al., 2014) and is well known for its calm behaviour and peaceful coexistence with human (Pooley et al., 2020). We have monitored this population for the last 10 years (Vyas, 2013; VNC, 2021) and have reported on aspects of behaviour, breeding, threats, and the impacts of human activities (Vasava et al., 2015; Vyas & Vasava, 2019; Vyas et al., 2020a & 2020b). Here, we report strange mortalities associated with male genital/cloacal prolapse.

In 2017, two muggers were observed at two different sites in waterbodies of Charotar, Gujarat. The first, on 1st October 2017, was of a juvenile (total body length 105 cm) found dead near the Mahi irrigation canal (22° 65'45" N; 072° 75'79" E) at Vaso, Kheda. The animal was lying on the canal road with no apparent injuries to the body apart from a dark red erect structure emerging from the vent on the right side the body (Fig. 1). The second, on 18th November 2017, was of an adult mugger (total body length 155 cm) found on the edge of Ram Sarovar (22° 39'3.30" N; 72° 45'7.49" E), near Vaso, Kheda. This animal was alive but inactive, and had no injury except a dark red bulge (10 cm) on left side of the vent (Fig. 2) a prolapsed cloaca. This animal was in a critical condition and died within 30-40 minutes before it could be transferred to the nearest rescues center for veterinary assistance.

In crocodiles, the retracted phallus is a distensible, grooved, unpaired organ located in the ventroposterior region of the cloaca, near the vent (Palmer et al., 1998). The phallus is primarily cartilaginous and has little erectile spongy tissue and becomes erect or retracts depending on vascular pressure (Kelly, 2013). Male genital prolapse (paraphimosis) is a common condition in reptiles (Bennett, 1996; Hernandez-Divers, 2004). In a literature survey, we were only able to find a single report of this condition in a crocodile. This was of a captive *Crocodylus niloticus* (Lankester & Hernandez, 2005) where it was suggested that the captive animal could be suffering from hypo-calcaemia owing to a diet of offal lacking sufficient calcium but no cause could be identified conclusively.

There are several possibilities for the cause of genital/cloacal prolapse, including trauma from bites by conspecifics, traction during copulation, infection, inflammation, neurologic deficits involving the retractor phallus muscles or cloacal sphincter, impaction of the cloaca with urates, and in captive crocodiles iatrogenic damage during probing.

Figure 1. A juvenile mugger (*Crocodylus palustris*)- **A.** As found dead on a canal road at Vaso, Kheda, Gujarat, **B.** Ventral aspect of the dead mugger, **C.** With prolapsed phallus

Figure 2. A large adult mugger (*Crocodylus palustris*) **A.** On the edge of Ram Sarovar, Nr. Vaso, Kheda, Gujaratinset, **B.** Showing detail of the prolapsed phallus

ACKNOWLEDGEMENTS

We are thankful to staff of the Forest Department and especially Principal Chief Conservator and Conservator of Forest, State Forest Department, Gujarat State. Special thanks to Dhaval Patel and volunteers of Voluntary Nature Conservancy, Anand for the support. Thanks, Vishal Misty for pictures credit and sharing.

REFERENCES

Bennett, R. A. (1996). Cloacal prolapse. In *Reptile Medicine and Surger*, pp. 355-357. Mader, D.R. (Ed.). W B. Saunders Co., Philadelphia, Pennsylvania.

Choudhury, B.C. & de Silva, A. (2013). *Crocodylus palustris*. The IUCN Red List of Threatened Species 2013. International Union for Conservation of Nature. www.IUCN.org.

Hernandez-Divers, S. J. (2004). Surgery: principles and techniques. In *Manual of Reptiles (2nd edition)*, Raiti, P. & Girling, S. (Eds.). British Small Animal Veterinary Association, Cheltenham, England. 147 pp.

Kelly, D.A. (2013). Penile anatomy and hypotheses of erectile function in the American Alligator (*Alligator mississippiensis*): Muscular eversion and elastic retraction. *The Anatomical Record* 296: 488-494.

Lankester, F. & Hernandez, D.S.J. (2005). Paraphimosis and amputation in a Nile crocodile (*Crocodylus niloticus*). *Journal of Zoo and Wildlife Medicine* 36: 698-701.

Palmer, B.D. & Uribe, M.C.A. (1998). Reproductive anatomy and physiology (an ecological and evolutionary perspective). In *The Biology, Husbandry and Healthcare of Reptiles, Volume I*, pp. 747-772. Ackerman, L. (Ed.). The Healthcare of Reptiles. TFH Publications, Neptune City, New Jersey.

Patel, D., A. Vasava, K. Patel, V. Mistry, M. Patel & Vyas, R. (2014). Attitudes, perceptions and knowledge of the local people regarding crocodile and their conservation in Charotar region, Gujarat, India, pp 336-347. In *Proceedings of the 23rd Working Meeting of the Crocodile Specialist Group IUCN*: The World Conservation Union, Gland, Switzerland and Cambridge, UK.

Pooley, S. S. Bhatia & Vasava, A. (2020). Rethinking the study of human-wildlife coexistence. *Conservation Biology*: 1-10. DOI: 10.1111/cobi.13653

Silva da, A. & Lenin, J. (2010). Mugger crocodile *Crocodylus palustris*. In: *Crocodiles (3rd edition)*, pp. 94-98. Manolis, S.C. & C. Stevenson (Eds,). Status Survey and Conservation Action Plan, India.

VNC (2021). 8th Charotar Crocodile Count- 2021, Voluntary Nature Conservancy, Gujarat, India. 12 pp.

Vyas, R. (2013). Recent scenario of Mugger (*Crocodylus plustris*) population in three districts of Gujarat State, India, pp. 220-226. In *Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group, IUCN*: Gland Switzerland.

Vyas R & Vasava, A. (2019). Mugger crocodile (*Crocodylus palustris*) mortality due to roads and railways in Gujarat, India. *Herpetological Conservation and Biology* 14: 615-626.

Vyas, R., Vasava, A. & Mistry, V. (2020a). Crocodile-vehicle collision: New threat to mugger crocodile (*Crocodylus palustris*) at Gujarat, India. *CSG Newsletter* 39(1): 15-19.

Vyas, R., Vasava, A. & Mistry, V. (2020b). Mugger crocodile (*Crocodylus palustris*) interactions with discarded rubbish in Central Gujarat, India. *CSG Newsletter* 39(2): 5-11.

Accepted: 31 March 2021

The Herpetological Bulletin 157, 2021: 29-31
SHORT COMMUNICATION

https://doi.org/10.33256/hb157.2931

New records and a compilation of the defensive behaviours of the colubrid snake *Erythrolamprus poecilogyrus*

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Erythrolamprus poecilogyrus (Wied-Neuwied, 1824), a colubrid snake in the sub-family Xenodontinae, is distributed throughout South America (Wallach et al., 2014; Uetz et al., 2021). In Brazil, it is widespread in the Atlantic Forest, Cerrado, Caatinga, Pampas grasslands, and Pantanal, with scattered records in the Amazonia and Guianan savannas (Nogueira et al., 2019). It can be found in a wide variety of habitats, from primary forests to disturbed areas (Martins et al., 2008; Sawaya et al., 2008; Loebmann & Haddad, 2010; Mesquita et al., 2013; Nogueira et al., 2019).

It is a common terrestrial species that primarily eats frogs and is active both during the day and night (Carreira et al., 2005; Alencar & Nascimento, 2014). Although there have been some studies of the defensive behaviour of *E. poecilogyrus* (Carreira et al., 2005; Martins et al., 2008; Sawaya et al., 2008; Mesquita et al., 2013), to date there has been no full account. Here, I present new records of the defensive tactics of this species based on my own field observations together with a compilation of all the defensive behaviours previously recorded for this species, without distinction between subspecies. I have followed the taxonomy according to Nogueira et al. (2019) and the definitions of defensive tactics of Greene (1988), Martins & Oliveira (1998) and Martins et al. (2008).

On 13th November 2020 at 22:00 h, in the municipality of Barras (42.296006° W, 4.253766° S, 85 m a.s.l.), Piauí State, north-eastern Brazil, I observed a domestic cat trying to prey on an adult *E. poecilogyrus*. With my approach the cat ran away and I could capture the snake for identification. The species was identified from descriptive characteristics based on Dixon & Markezich (1992). While I was handling the specimen with a herpetological hook to take pictures, the individual showed five different defensive behaviours in the following sequence: i) immobility (Fig. 1A); ii) raising of the

Figure 1. Adult individual of *Erythrolamprus poecilogyrus* exhibiting defensive behaviours- **A.** Remaining immobile, **B.** Raising the tail, **C.** Coiling the body with the head hidden (notice the injured tail tip after a failed predation attempt), **D.** Hooding behaviour

tail (Fig. 1B); iii) coiling of the body with iv) the head hidden (Fig. 1C). Afterwards, I placed the snake in a plastic container to transport it to a safer location. At this moment, it also exhibited v) hooding behaviour (Fig. 1D). Despite an injured tail, the specimen appeared to in good health so I released it in a safe place.

Previous reports state that *Erythrolamprus poecilogyrus* is not aggressive towards predators and tends to flee (Mesquita et al., 2013). Although this species may bite following provocation, it does not cause severe envenomation in humans (Quintela, 2010; Weinstein et al., 2011). The injured tail and the absence of injuries along the body suggest that raising the tail, body coiling and hiding the head could be efficient defensive behaviours for the protection and survival of this species. These behaviors may reflect several factors, such as vulnerability to visually oriented predators, how the habitat is used, morphological characteristics and phylogeny (Greene, 1979; Martins et al., 2008).

Most of the defensive behaviours observed in *E. poecilogyrus* have been reported for other congeners and even other clades (Martins et al., 2008). For example, immobility, head hiding and tail display are known in *E. aesculapii* (Sazima & Abe, 1991; Hudson & Sousa, 2019; Fiorillo et al., 2020) and *E. miliaris* (Muscat et al., 2016). Neck flattening behaviour, also called hooding, has already been observed in other species of the genus (as *E. miliaris*, Menezes et al., 2015; *E. viridis*, Andrade & Dias, 2017; *E. sagittifer*, Beconi et al., 2019), and also in other members of the Xenodontinae (e.g., *Thamnodynastes*, Franco et al., 2003; *Hydrodynastes*, Young & Kardong, 2010; *Xenodon*, Kahn, 2011).

The terminology for defensive behaviours in the literature appears to have produced some overlapping definitions. For example, 'body compression' that can be dorsoventral and total (as observed in *Crotalus durissus*, Benício & Martins, 2018), just some parts of the body – 'dorsoventral flattening of the anterior region of the body' (e.g., Zoysa et al., 2015), 'dorso-laterally flatten the neck' or 'lateral compression of the anterior region of the body' (as occurs in *Chironius, Philodryas*, *Phrynonax*, *Spilotes*, *Xenodon*, Santos-Costa et al., 2015). Furthermore, it is possible that what some authors are calling 'dorsoventral flattening of the gular region' (e.g., Mesquita et al., 2013) is actually the same thing as 'hooding behaviour'. Thus, as we observe new behaviours, it is necessary to develop better definitions and a standardisation terms in order to fully understand the diversity of snake defensive behaviours.

Previously, 10 defensive behaviours have been attributed to *E. poecilogyrus* but in this study I have been able to add a further five (Table 1). This study draws attention to the redundancy of some of the defensive behaviour terms used in the literature, the need for standardisation, and reinforces the importance of natural history in understanding the behavioral ecology of *Erythrolamprus poecilogyrus*.

Table 1. Defensive behaviours reported for *Erythrolamprus poecilogyrus*

Defensive mechanisms	References
Bite	Quintela (2010), Weinstein et al. (2011)
Body coiling	This study
Body compression (total)	Carreira et al. (2005), Martins et al. (2008), Sawaya et al. (2008), Mesquita et al. (2013)
Crypsis	Martins et al. (2008)
Cloacal discharge	Sawaya et al. (2008), Mesquita et al. (2013)
Dorsoventral flattening of the gular region	Mesquita et al. (2013)
Mouth gapping	Sawaya et al. (2008)
Head triangulation	Sawaya et al. (2008)
Hiding the head	This study
Hooding behaviour	This study
Immobility	This study
Mimicry	Martins et al. (2008)
Tail raising	This study
Body thrash	Sawaya et al. (2008)
Turning the body on its own axis	Mesquita et al. (2013)

ACKNOWLEDGEMENTS

I thank Rodrigo Castellari Gonzalez from Universidade Estadual do Ceará and two anonymous reviewers for the relevant suggestions and corrections that have considerably improved this manuscript. I also thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq (Proc. 151124/2020-5) for financial support.

REFERENCES

Alencar, L.R.V. & Nascimento, L.B. (2014). Natural history data of a common snake suggest interpopulational variation and conservatism in life history traits: the case of *Erythrolamprus poecilogyrus*. *The Herpetological Journal* 24: 79–85.

Andrade, H. & Dias, E.J.R. (2017). *Erythrolamprus viridis* (Green-snake): Defensive behavior. *Herpetological Review* 48: 859–859.

Beconi, H.C., Carosini, A. & Smith, P. (2019). Die Hard: How Paraguayan snakes avoid predation and live to tell the tale. *Herpetology Notes* 12: 513–518.

Benício, R.A. & Martins, M. (2018). Defensive behavior of a juvenile *Crotalus durissus* Linnaeus, 1758. *Herpetozoa* 30: 217–218.

Carreira, S., Meneghel, M. & Achaval, F. (2005). *Reptiles de Uruguay*. Montevideo: DI.R.A.C., Facultad de Ciencias, Universidad de la República. 639 pp.

Dixon, J.R. & Markezich, A.L. (1992). Taxonomy and geographic variation of *Liophis poecilogyrus* (Wied) from South America (Serpentes: Colubridae). *The Texas Journal of Science* 44: 131–166.

Fiorillo, B.F., da Silva, B.R., Menezes, F.A., Marques, O.A. & Martins, M. (2020). Composition and natural history of snakes from Etá farm region, Sete Barras, south-eastern Brazil. *ZooKeys* 931: 115–153.

Franco, F.L., Ferreira, T.G., Marques, O.A.V. & Sazima, I. (2003). A new species of hood-displaying *Thamnodynastes* (Serpentes: Colubridae) from the Atlantic forest in southeast Brazil. *Zootaxa* 334: 1–7.

Greene, H.W. (1988). Antipredator mechanisms in reptiles.

In *Biology of the Reptilia. Vol. 16: Ecology B: Defense and Life History*, 1-152 pp. Gans, C. & Huey, R.B. (Eds.). New York: Alan R. Liss, Inc.

Greene, H.W. (1979). Behavioral convergence in the defensive displays of snakes. *Experientia* 35: 747–748.

Hudson, A.A. & Sousa, B.M. (2019). *Erythrolamprus aesculapii* (False Coral Snake): Reproduction, diet and defensive behavior. *Herpetological Review* 50: 155–156.

Kahn, T.R. (2011). Cobra-like hooding and mouth-gapping in an atypically monocle patterned *Xenodon severus* (Linnaeus, 1758): a case of convergent evolutionary behavior? *Herpetotropicos* 6: 25–26.

Loebmann, D. & Haddad, C.F.B. (2010). Amphibians and reptiles from a highly diverse area of the Caatinga domain: composition and conservation implications. *Biota Neotropica* 10: 227–256.

Martins, M., Marques, O.A. & Sazima, I. (2008). How to be arboreal and diurnal and still stay alive: microhabitat use, time of activity, and defense in Neotropical forest snakes. *South American Journal of Herpetology* 3: 58–67.

Martins, M. & Oliveira, M.E. (1998). Natural history of snakes in forests of the Manaus region, Central Amazonia, Brazil. *Herpetological Natural History* 6: 78–150.

Menezes, F.A., Fiorillo, B.F. & Gonzalez, R.C. (2015). Hooding behavior in *Erythrolamprus miliaris* Linnaeus, 1758 (Serpentes: Dipsadidae). *Herpetology Notes* 8: 291–293.

Mesquita, P.C., Passos, D.C., Borges-Nojosa, D.M. & Cechin, S.Z. (2013). Ecologia e história natural das serpentes de uma área de Caatinga no nordeste brasileiro. *Papéis Avulsos de Zoologia* 53: 99–113.

Muscat, E., Rotenberg, E.L. & Machado, I.F. (2016). Death-feigning behaviour in an *Erythrolamprus miliaris* (Linnaeus, 1758) (Colubridae) water snake in Ubatuba, São Paulo, southeastern Brazil. *Herpetology Notes* 9: 95–97.

Nogueira, C.C. et al. (2019). Atlas of Brazilian snakes: verified point-locality maps to mitigate the Wallacean shortfall in a megadiverse snake fauna. *South American Journal of Herpetology* 14: 1–274.

Quintela, F.M. (2010). *Liophis poecilogyrus sublineatus* (Serpentes: Dipsadidae) bite and symptoms of envenomation. *Herpetology Notes* 3: 309–311.

Santos-Costa, M.C., Maschio, G.F. & Prudente, A.L.C. (2015). Natural history of snakes from Floresta Nacional de Caxiuanã, eastern Amazonia, Brazil. *Herpetology Notes* 8: 69–98.

Sawaya, R.J., Marques, O.A.V. & Martins, M. (2008). Composition and natural history of a Cerrado snake assemblage at Itirapina, São Paulo state, southeastern Brazil. *Biota Neotropica* 8: 127–149.

Sazima, I. & Abe, A.S. (1991). Habits of five Brazilian snakes with coral-snake pattern, including a summary of defensive tactics. *Studies on Neotropical Fauna and Environment* 26: 159–164.

Uetz, P., Freed, P. & Hošek, J. (2021). The Reptile Database. Available from: http://www.reptile-database.org. (accessed 15 Mar 2021).

Wallach, V., Williams, K.L. & Boundy, J. (2014). *Snakes of the World: A Catalogue of Living and Extinct Species*. Taylor and Francis: CRC Press. 1237 pp.

Weinstein, S.A., Warrell, D.A., White, J. & Keyler, D.E. (2011). *Venomous Bites from Non-Venomous Snakes: A Critical Analysis of Risk and Management of Colubrid Snake Bites*. Burlington, Massachusetts: Elsevier Ltd. 364 pp.

Young, B.A. & Kardong, K.V. (2010). The functional morphology of hooding in cobras. *The Journal of Experimental Biology* 213: 1521–1528.

Zoysa, H.K.S., Samarasinghe, D. & Wickramasinghe, S. (2015). *Dipsas catesbyi* (Catesby's Snail-eater). Defensive behavior. *Herpetological Review* 46: 643–643.

Accepted: 8 May 2021

The Herpetological Bulletin 157, 2021: 32-34
SHORT COMMUNICATION

https://doi.org/10.33256/hb157.3234

Decision making under risk of predation in the western whip snake *Hierophis viridiflavus*

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Theory predicts that during movement the decisions made by animals are influenced by the costs and benefits of movement and that this in turn is driven by landscape structure, for example degree of habitat patchiness and quality of the habitat matrix including predator and prey densities (e.g. Lima & Dill, 1990; Fahrig, 2007). Patch selection may vary not only in terms of foraging profitability, but also in terms of predation risk; although species that actively forage may encounter more prey species than ambush/sit and wait predators they are also likely to come into contact with more predators (Huey & Pianka, 1981). Movement may disrupt the benefits of camouflage and hence the risk levels involved in extensive movement require the evolution of a range of defence behaviours in the event of encountering a predator. Here we describe what appears to be a previously undocumented defensive behaviour in the western whip snake *Hierophis viridiflavus*.

The western whip snake is a habitat generalist, often found along woodland edges, bocages (i.e. farmland bordered by two hedgerows) where it forages widely; in other regions of western Europe it has been reported foraging up to 3 km from the winter den (Ciofi & Chelazzi, 1994). In the study area, this species can approach almost 2 metres in total length, and preys on fast moving animals including lizards, small mammals, birds and, amphibians (Rugiero & Luiselli, 1995; Capizzi & Luiselli, 1996). These snakes are extremely fast moving, so usually when basking or moving and encountering a potential predator their initial response will be to flee into cover. If caught or trapped they will bite fiercely and if this is ineffective some individuals will feign death (e.g. Rugiero, 1999). This range of behavioural responses is clearly effective since some individuals of *H. viridiflavus* attain ages of around 20 years or so (Fornasiero et al., 2016).

In anthropogenically modified environments, risk of predation during foraging is likely to increase due to increased frequency of contact with humans, domestic dogs and cats, among others (Bonnet et al., 1999; Rugiero & Luiselli, 2004; Meek, 2012). In this note we describe an anti-predator response by foraging *H. viridiflavus* when encountering humans and dogs, consisting of a combination of remaining completely motionless together with crypsis. All snakes described below were adults of at least 1 metre and were encountered during fieldwork on the edge of the village of Chasnais (46˚ 27`N;1˚ 53`W; 25m asl) in Vendée, western France.

The first observation of `total immobility` was during late afternoon June 2007 in a bocage area where one of us (RM and 3 dogs) made contact with a *H. viridiflavus*, approximately 1 metre in length, foraging in a bocage area with a matrix of dappled sunlight. The snake was moving through a small patch of grass between dense covered areas (bottom right in Fig. 1A). With visual contact it became totally immobile with the head raised above the top of the grass, a position it maintained until we had passed. None of the three dogs detected the snake, which moved away into the ditch area (on the right in Fig. 1A) once the `danger` had passed.

A large adult (likely in excess of 1.5 m – see Fig. 2) was seen moving along the base of a dried out drainage ditch

Figure 1. A. Bocage habitat showing the area where the snake described in Example 1 was encountered. The snake was moving towards the observer on the right of the picture but on reaching the grass became motionless (see text), **B.** Opening in the hedgerow (right) where the snakes in Example 2 (from left to right) and Example 3 (right to left) were attempting cross the clearing. Opening on left shows the direction of the hedgerow, which eventually leads to the Bocage habitat in A.

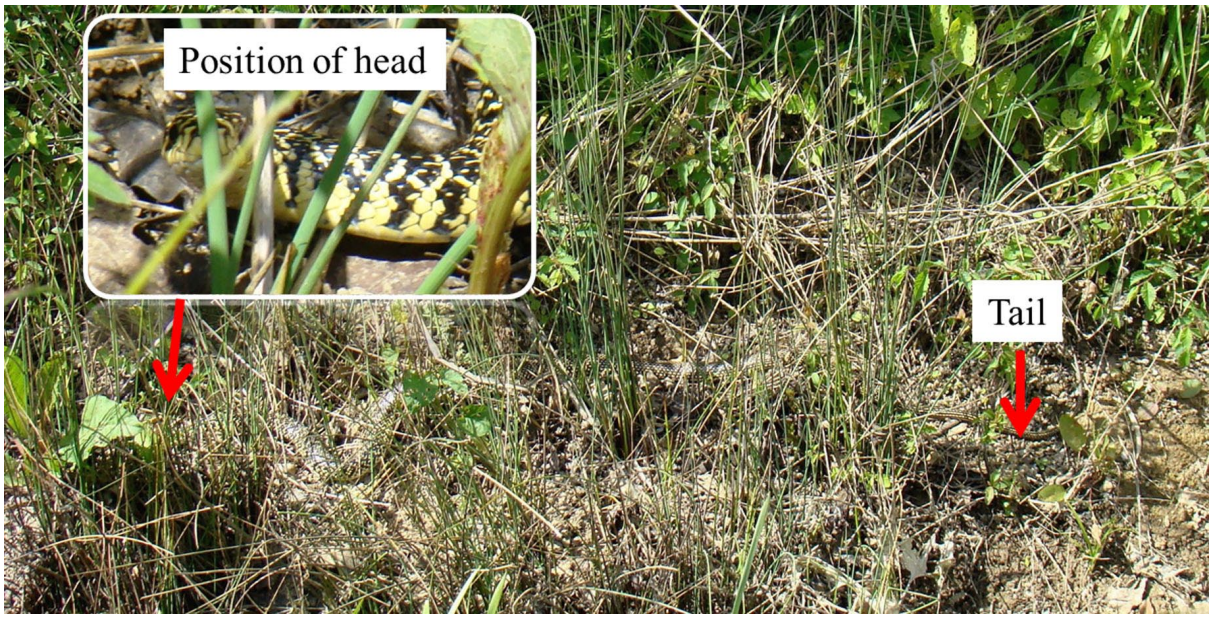

Figure 2. The snake described in Example 2 with insert showing detail of the snake's head, which is partly raised and focused on the observer

at the bottom of a hedgerow (Fig. 2) at around 15:30 h in June 2014. The snake was apparently attempting to cross the open ground between hedgerows (seen in Fig. 1B) from left to right. As in Example (1) the snake was in light vegetation, mostly grass. On detecting the observer the snake became motionless but remained focused on the observer (insert in Fig. 2). After we passed it retreated up the slope into the hedgerow from where it had emerged.

An adult male *H. viridiflavus* during May 2021 was attempting to cross between two sections of hedgerow from right to left (Fig. 1B). On sighting the observer the snake immediately adopted the total immobility posture with head raised just above the grass (Fig. 3). It was possible for the observer to walk around the snake and take several photographs while in this posture without it attempting to flee. After the encounter the snake retreated back into the hedge.

A basking adult *H. viridiflavus* was encountered in April 2015 situated around 3 m from dense cover of the hedgerow but in grass swards at heights of around at 20 - 30 cm (Fig. 4). A single observer approached the snake along with three dogs but it remained completely motionless, although apparently alert and aware of our approach but moved into the hedgerow after the group's passing.

These observations illustrate that a motionless stance along with crypsis were effective in avoiding detection by domestic dogs. In total, the behaviour formed only 7.3 % of 41 (9.8 % when example 4 is included) encounters with *H. viridiflavus*, in either the hedgerow or bocage. The behaviour has not been observed in the numerous *H. viridiflavus* encountered in natural areas in Italy (LL) and we could find no mention of it in papers on the ecology of this species including movement behaviour (e.g. Capula et al., 1997). Hence it may indeed be an infrequent behavioural response that until now has not been documented. However, as in the use of death feigning (Rugiero, 1999) it may be confined to certain individuals and certain circumstances including

Figure 3. Snake described in Example 3 showing the totally motionless snake just after it has emerged from the hedgerow. Although motionless the head is raised and focused on the observer. It was possible to walk around this snake and take several photographs without it moving.

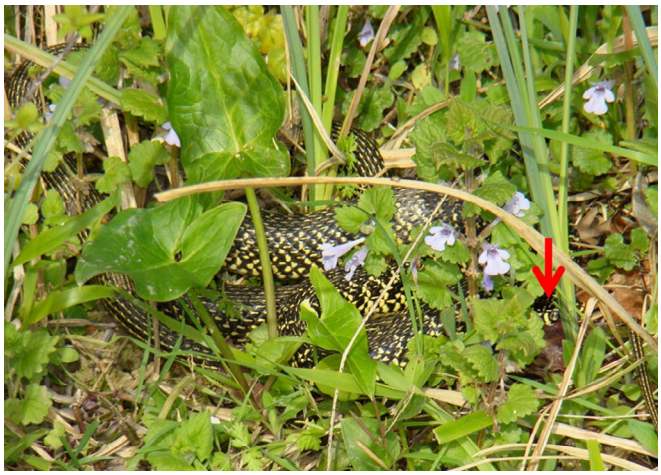

Figure 4. Snake described in Example 4 basking among grass and adopting the motionless behaviour, arrow shows position of head with a clear view of the eye

in human modified environments. Being motionless as a primary behavioural response is a novel addition to the behavioural sequence in *H. viridiflavus*, which is usually flight followed by fight. Flight mode in *H. viridiflavus* appears to also employ the `flicker fusion effect` (Umeton, et al., 2017) that can result in a change in the appearance of the snake when it moves rapidly. However, given that this is part of flight behaviour it indicates that in the examples here being motionless has been prioritised over alternative potential defensive options. Initiation of the behaviour will largely depend on the circumstances of the encounter and, critically, who detects the other first, predator or prey, since becoming motionless will be much less effective if it is the snake that is detected first. If the latter, then speed and the possible benefits of flight/ flicker fusion will be the usual primary response. For becoming motionless to be effective the snake must detect the predator first, which was the case in the examples given here. However, it is likely that both the distance between predator and prey as well as light levels in the immediate habitat (low light in Example 1) will influence a snake's decision making. It is also likely that if a snake detects a potential predator above a certain distance away then it is more likely that flight will be employed. The microhabitat of grass swards of around 30 cm in height probably also influenced decision-making since it is probably a high-risk situation in which to encounter certain predators.

Evolutionary selection for the assessment of risk and selection of optimum behaviour would certainly benefit individual fitness. Risk of predation will depend on lifestyle, quality of the matrix habitat and vary on a seasonal or daily basis. The expansion of fragmented landscapes in urban areas may increase the degree of predation risk from cats and dogs by altering habitat structure and changing the thermal environment (Evans, 2004; Zhou et al., 2011). *Hierophis viridiflavus* is known for pathway fidelity including to and from egg laying sites (Filippi et al., 2007; Zuffi et al., 2007; Bonnet et al., 2021) and presumably this behaviour is the product of natural selection to reduce predation risk as well as to locate prey. Of interest is that anti-predator behaviour and usual avoidance of high risk habitat in *H. viridiflavus*, especially in human altered landscapes, contrasts with male combat in this species (BHS video, 2021) that often occurs in open locations, including urban gardens, when the combatants appear oblivious to predation risk. This indicates sensitivity to risk is almost completely abandoned under certain circumstances.

ACKNOWLEDGEMENTS

We thank Prof. Rick Hodges and Dr. Wolfgang Wuster for very useful comments and suggestions on an earlier draft of the manuscript.

REFERENCES

BHS video (2021). Combat between male western whip snakes *Hierophis viridiflavus* https://youtu.be/dvwwdrqv6Mk

Bonnet, X., Naulleau, G. & Shine, R. (1999). The dangers of leaving home: dispersal and mortality in snakes. *Biological Conservation* 89: 39-50.

Bonnet, X., Jean-Marie Ballouared, J.M., Billy, G. & Meek, R. (2021). Repeated use of high risk nesting areas in the European whip snake, *Hierophis viridiflavus*. *Herpetological Journal* 31: 142-151. DOI: 10.33256/31.3.142150

Capizzi, D. & Luiselli, L. (1996). Feeding relationships and competitive interactions between phylogenetically unrelated predators (owls and snakes). *Acta Oecologica* 17: 265-284.

Capula, M., Filippi, E. & Luiselli, L. & Jesu, V.T. (1997). The ecology of the Western Whip Snake, *Coluber viridiflavus* (LACÉPÈDE, 1789), in Mediterranean Central Italy (Squamata: Serpentes: Colubridae). *Herpetozoa* 10: 65-79

Ciofi, C. & Chelazzi, G. (1994). Analysis of homing pattern in the colubrid snake *Coluber viridiflavus*. *Journal of Herpetology* 28: 477-484.

Evans K.L. (2004). The potential for interactions between predation and habitat change to cause population declines of farmland birds. *Ibis* 146:1-13. DOI: 10.1111/j.1474-919X.2004.00231.x

Fahrig, L. (2007). Non-optimal animal movement in human altered landscapes. *Functional Ecology* 21: 1003-1015.

Filippi, E., Anibaldi, C., Capizzi, D., Ceccarelli, A., Capula, M. & Luiselli, L. (2007). Long-term fidelity to communal oviposition sites in *Hierophis viridiflavus*. *Herpetological Journal* 17: 7-13.

Fornasiero, S., Bonnet, X., Dendi, F. & Zuffi, M.A.L. (2016). Growth, longevity and age at maturity in the European whip snakes, *Hierophis viridiflavus* and *H. carbonarius*. *Acta Herpetologica* 11: 135-149.

Huey, R. & Pianka, E. (1981). Ecological consequences of foraging mode. *Ecology* 62: 991-999.

Lima, S. & Dill, L. (1990). Behavioral decisions made under the risk of predation: a review and prospectus. *Canadian Journal of Zoology* 68: 619-640

Meek, R. (2012). Anthropogenic sources of mortality in the western whip snake, *Hierophis viridiflavus*, in a fragmented landscape in Western France. *The Herpetological Bulletin* 120: 4-8.

Rugiero, L. (1999). Death feigning in the Western whip snake, *Coluber viridiflavus*. *Amphibia-Reptilia* 20: 438-440

Rugiero, L. & Luiselli, L. (2004). Ecological notes on two colubrid snakes (*Coluber viridiflavus* and *Elaphe longissima*) in a suburban habitat (Rome, central Italy). *The Herpetological Bulletin* 87: 8-12.

Rugiero, L. & Luiselli, L. (1995). Food habits of the snake *Coluber viridiflavus* in relation to prey availability. *Amphibia-Reptilia* 16: 407-411.

Umeton D, Read., J.C.A. & Rowe, C. (2017). Unravelling the illusion of flicker fusion. *Biology Letters*. 13: 20160831. DOI: 10.1098/rsbl.2016.0831

Zhou W.Q., Huang G.L. & Cadenasso, M.L. (2011). Does spatial configuration matter? Understanding the effects of land cover pattern on land surface temperature in urban landscapes. *Landscape Urban Plan* 102: 54-63. DOI: 10.1016/j.landurbplan.2011.03.009

Zuffi, M., Bresciani, E., Fornasiero, S. & Dendi, F. (2007). Pheromone trailing in male European whip snakes, *Hierophis viridiflavus*. *Amphibia-Reptilia* 28: 555-559.

Accepted: 9 July 2021

The Herpetological Bulletin 157, 2021: 35-36
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.3536

Oophagy in the Smooth snake *Coronella austriaca* – first photographic record of bird egg predation

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The smooth snake *Coronella austriaca* is widely distributed throughout most of Europe and in Norway it is at the northern limit of its range. The species is common and diurnal but, lives a secretive life so that there is still much to learn of its natural behaviour. The diet of *C. austriaca* consists mainly of reptiles, and small mammals are eaten by adults, whose relative abundance in the diet varies according to their availability (Goddard, 1984; Reading & Jofré, 2013). Ophiophagy has been recorded for the smooth snake (Schreitmüller, 1920; Andren & Nilson, 1979; Rugiero et al., 1995; Reading & Jofré, 2013; Strugariu et al., 2014; Groen, 2018), as well as cannibalism (Drobenkov, 2014; Jofré & Reading, 2020). In Norway, the diet of the smooth snake consists mainly of slow worms *Anguis fragilis* and shrews *Sorex* sp. (Sørensen, 2014). Common lizards *Zootoca vivipara* are eaten where they coexist with the smooth snake, but they are absent from a large parts of the smooth snake's range.

Predation of reptile eggs by *C. austriaca* is mentioned in the book by Völkl & Käsewieter (2003, page 77), and this is known from much older literature (Werner, 1897; Saint Girons, 1955; Werner, 1959; Moreira et al., 2011; Lunghi et al., 2015). Stomach contents including lizard eggs have also been observed in smooth snakes from Northern Greece in 2009 and 2014 (Pål Sørensen, pers. obs.).

Smooth snakes are known to prey upon nestling birds although there are few reports of this (Schreitmüller, 1934; NCC-REPORT 1983; Sørensen, 2014). Predation on bird eggs seems to be even rarer than predation on lizard eggs. Despite several studies of the diet of wild smooth snakes across their geographic range (Goddard, 1984; Rugiero et al., 1995; Moreira et al., 2011; Brown, Ebenezer & Symondson, 2014; Sørensen, 2014; Reading & Jofré, 2013, 2018), the remains of bird eggs in the stomachs or faeces of smooth snakes has not been documented. However, Schreitmuller (1934) reports that captive smooth snakes ate the eggs of two birds, the black redstart *Phoenicurus ochruros* and house sparrow *Passer domesticus*. There is also an old report of a smooth snake climbing a tree and feeding on the blue eggs of a song trush *Turdus philomelos* (Zschokke, 1909/10). As the song thrush eggs were too big to be swallowed, Zschokke describes how the smooth snake moved one egg to rest on its coiled body inside the nest, and using its head the snake smashed the egg and ate the contents.

Here we present the first photographic record of a smooth snake predating bird eggs in southern Norway, along the west side of the Oslo fiord, in Sekkekilen, Trosbyfjorden, Bamble commune in Vestfold & Telemark county (58° 56'12.7" N 9° 35'14.3" E).

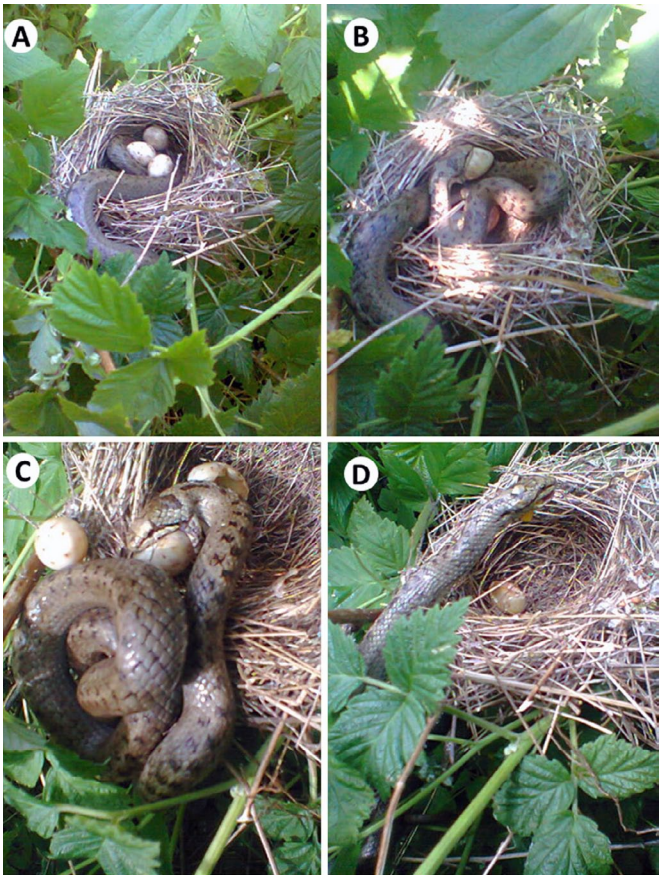

Figure 1. Smooth snake eating four eggs of a garden warbler in a nest in Norway, 2015 (photos A to D are in time sequence). The snake took 45 minutes to consume these eggs but had eaten an unknown number of eggs before the arrival of the photographer.

On 5th June 2015, the second author went for a walk when the sun was shining. Suddenly he heard the alarm call of a small bird. He moved towards the call that came from some dense bushes and once in the bushes he observed a bird's nest with a smooth snake in it about one meter above ground (Fig. 1). The snake did not move away, but continued to feed on the eggs, which probably belonged to a garden

warbler *Sylvia borin*. Photographs of the snake were taken using a cell phone camera. The smooth snake had a firm grip under the nest with the rear half of its body, which made it capable of moving its upper half and head on and inside the nest. The smooth snake took one egg carefully into its mouth and swallowed it without lifting its head. Each egg took several minutes to eat, and the snake made some bending and curling movements of its body after each egg. The photos show that at least one egg was broken in the nest, and that the snake ate its contents. The observation of egg predation lasted 45 minutes (10:16 h -11:01 h). However, it is not known when the smooth snake began eating, or how many eggs there were in the nest from the start. However, 4-6 eggs are normal for garden warblers. When the last egg was eaten, the smooth snake disappeared quickly. It is possible that predation by smooth snakes on bird egg is more common than previously thought; future dietary analysis will add to our knowledge of this.

ACKNOWLEDGEMENTS

We thank smooth snake researcher Pål Sørensen for valuable comments on the manuscript. We also thank the two anonymous reviewers for their suggestions.

REFERENCES

Andrén, C. & Nilson, G. (1979). Hasselsnoken (*Coronella austriaca*) i Norden – en isolerad ochekologiskt särställd ras? *Fauna och Flora* 74: 89–96.

Brown, D.S., Ebenezer, K.L. & Symondson, W.O.C. (2014). Molecular analysis of the diets of snakes: changes in prey exploitation during development of the rare smooth snake *Coronella austriaca*. *Molecular Ecology* 23: 3734-3743.

Drobenkov, S.M. (2014). Distribution, ecological traits and conservation of the smooth snake (*Coronella austriaca*) in Belarus. *Acta Biologica Universitatis Daugavpiliensis* 14: 21-27.

Goddard, P. (1984). Morphology, growth, food habits and population characteristics of the Smooth snake *Coronella austriaca* in southern Britain. *Journal of Zoology* 204: 241-257.

Jofré, G.M. & Reading, C.J. (2020). Cannibalism in smooth snakes, *Coronella austriaca*. *Herpetological Journal* 30: 168-172.

Lunghi, E., Corti, C. & Cencetti, T. (2015). Oophagy in the Smooth snake (*Coronella austriaca*). *The Herpetological Bulletin* 134: 35-36.

Moreira, P.L., Diamantino, J.L., Conde, J.C. & Martins, F.A.F. (2011). Smooth snakes at an Iberian mountain isolate and the relationship with competing southern smooth snakes. *Herpetological Journal* 22: 161-168.

NCC-REPORT (1983). The ecology and conservation of amphibian reptile species endangered in Britain. London (Nature Conservancy Council). 93pp.

Reading, C.J. & Jofré, G.M. (2013). Diet composition changes correlated with body size in the smooth snake, *Coronella austriaca*, inhabiting lowland heath in southern England. *Amphibia-Reptilia* 34: 463-470

Reading, C.J. & Jofré, G.M. (2018). The relative performance of the smooth snakes inhabiting open heathland and conifer plantations. *Forest Ecology and Management* 427: 333-341.

Rugiero, L., Capula, M., Filippi, E. & Luiselli, L., (1995). Food habits of Mediterranean populations of the Smooth snake (*Coronella austriaca*). *Herpetological Journal* 5: 316-318.

Saint Girons, H. (1955). Quelques observations sur la reconnaissance des proies chez les serpents. *Revue Ecologie (Terre et Vie)* 102: 159-197

Schreitmüller, W. (1918). Die Schlingnatter. *Blätter für Aquarien- und Terrarienkunde* 31: 310-311.

Schreitmüller, W. (1920). Die Schlingnatter first Kreuzotter. *Blätter für Aquarien- und Terrarienkunde* 31: 310-311.

Schreitmüller, W. (1934). *Coronella austriaca* LAURENTI first nestjunge Vogel. *Zoologischer Anzeiger* 108: 144.

Strugariu, A., Hutuleac-Volosciuc, M.V., Dinca, P.C., Zamfirescu, S. R. & Shalean, T.C. (2014). Smooth snake (*Coronella austriaca*) predation on a live grass snake (*Natrix natrix*) in eastern Romania. *Herpetologica Romanica* 8: 29-32.

Sørensen, Pål (2014). The smooth snake *Coronella austriaca* in Norway. *Fauna* 66: 110-123.

Völkl, W. & Käsewieter, D. (2003). Die Schlingnatter, ein heimlicher Jäger. *Beiheft der Zeitschrift für Feldherpetologie* 6. Laurenti Verlag, Bielefeld. 151 pp.

Werner, F. (1897). *Coronella austriaca* Laur. In *Die Reptilien und Amphibien Oesterreich-Ungarns*. Wien 1897. Verlag von A. Pichler's Witwe & Solin. Chapter 25.

Werner, L. (1959). Schlingnatter frist Eidechseneier. *Aquarien Terrarien* 6: 251.

Zschokke, W. (1909/10). Ein Nesträuber. *Ornithologischer Beobachter* 7: 55-57.

Accepted: 31 March 2021

The Herpetological Bulletin 157, 2021: 37
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.37

An unusual sleep posture for the oriental garden lizard *Calotes versicolor*

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The oriental garden lizard *Calotes versicolor* (Daudin, 1802) is a wide spread agamid species, ranging from Oman across southern and south-eastern Asia to Indochina, the Maldives, Reunion, Mauritius and Seychelles (Wei et al., 2018; Deb & Sengupta, 2020). On April 4, 2020 at 23:14 h, at the college campus of A.V.C. College (Autonomous), Mannampandal (11.1036° N, 79.6934° E; WGS 84; 39 m a.s.l.), Cauvery Delta region, Tamil Nadu, India, we were studying the perch selection of two sympatric agamid species, when we recorded the peculiar sleep posture of a sub-adult *C. versicolor*. The lizard was observed hanging from a grass twig by its jaws while its limbs provided no support and simply hung from the body (Fig. 1). Lizards typically choose narrow, unstable perch plants to sleep; this allows for the early detection of an approaching predator (Bors et al., 2020). We searched for predators nearby in case the lizard was feigning death as an anti-predator response (Sengupta et al., 2020) but none could be found. Upon closer observation, it could be seen that both eyelids of the lizard were closed and that it appeared to be asleep.

Figure 1. Peculiar sleep posture of a sub-adult *Calotes versicolor*

After completion of the survey at 23:55 h, we returned to the same location and found the individual in the same posture. When photographing this behaviour (due to the flash of the camera), the individual became alert and dropped down the ground and escaped. This peculiar sleep posture seems not to have been reported previously in *C. versicolor* or other lizard species and gives some insights into both the physical and behavioural capabilities of this species. Why this posture is adopted remains unknown but we suggest that it could be a defence against snakes as they typically swallow their prey head first and this posture would obstruct them. Alternatively, if such a posture actually made predation more likely for some types of predator then it might be induced by a parasite that is using the lizard as an intermediate host; such host manipulation by parasites is well known in other taxa (Heil, 2016).

ACKNOWLEDGEMENTS

The authors would like to thank Prayas Auddy, Digvijay Pattnaik and Hareesh Shasthri PR who have accompanied us in the field surveys.

REFERENCES

Bors, M., Mohanty, N.P., & Shankar, P.G. (2020). Anti-predatory sleep strategies are conserved in the agamid lizard *Monilesaurus rouxii*. *Behavioral Ecology and Sociobiology* 74: 1-8

Deb, P. & Sengupta, D. (2020). Road mortality on an Oriental Garden Lizard, *Calotes versicolor* (Daudin, 1802). *IRCF Reptiles & Amphibians* 27: 438-439.

Heil, M. (2016). Host manipulation by parasites: cases, patterns, and remaining doubts. *Frontiers in Ecology and Evolution*. DOI: 10.3389/fevo.2016.00080

Sengupta, D., Deb, P. & Auddy, P. (2020). Thanatosis in a Green Forest Lizard, *Calotes calotes* (Linnaeus 1758). *IRCF Reptiles & Amphibians* 27: 306-307.

Wei, X., Yan, L., Zhao, C., Zhang, Y., Xu, Y., Cai, B., Jiang, N. & Huang, Y. (2018). Geographic variation in body size and it's relationship with environmental gradients in the Oriental Garden Lizard, *Calotes versicolor*. *Ecology and Evolution* 8: 4443-4454.

Accepted: 2 April 2021

The Herpetological Bulletin 157, 2021: 38-39
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.3839

Male common midwife toad *Alytes obstetricans* depositing eggs in a flowerpot saucer in a suburban garden?

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The common midwife toad (*Alytes obstetricans*) is a small and stocky anuran, reaching a maximum length of 5.5 cm (Speybroeck et al., 2016). Midwife toads are well known for the behaviour that gives them their name, the parental care observed in males of carrying the eggs on their hind legs until they mature, which takes up to 32 days (Márquez, 1992). On average females lay about 42 eggs and males are able to carry multiple clutches simultaneously (Márquez, 1996), from different females and of varying stages of maturity (Raxworthy, 1990). Márquez (1996) regards males with less than 62 eggs to have only mated once, whereas males with 82 eggs or more can be considered to have mated with two or more females. *Alytes obstetricans* are widespread in Western Europe and extend as far north as northern France (Speybroeck et al., 2016). In 2017, 15 introduced populations were known to exist within Great Britain although due to their secretive nature there are likely more awaiting discovery (Allain & Goodman, 2017). New populations of *A. obstetricans* are still being discovered, such as the one in St. Neots, Cambridgeshire in 2018 (Allain & Goodman, 2019), and since then, a further dozen populations have been identified (unpublished data). The Cambridge population that this note concerns has been monitored since 2015.

Adult males are known to search their local environment for permanent aquatic habitats to deposit their eggs before the tadpoles are ready to hatch. Such habitats may include, but are not limited to, garden ponds, slow-moving rivers and occasionally gravel or clay pits. Permanent water bodies are said to be preferred as the tadpoles often over winter in water (Van der Meijden, 2010). We have previously found the tadpoles of *A. obstetricans* in a small number of garden ponds, which have been the focus of our ongoing study in order to establish where male *A. obstetricans* deposit their eggs. On the evening of 27th August 2020, while surveying an *A. obstetricans* population in an urban area of central Cambridge, an unusual observation was made. Instead of finding tadpoles in a pond, we discovered two tadpoles of quite different sizes (i.e. asynchronous development) in water contained by a ceramic flowerpot saucer (Fig. 1) at a location where midwife toads had been encountered in neighbouring gardens previously. The difference in size may indicate that the tadpoles are from different egg clutches and were therefore collected from different females. No further observations were made on these tadpoles, so it is not known if they metamorphosed successfully. The tadpoles in the flowerpot saucer were identified as those of a midwife toad based on their size (being greater in size than those of common frog or common toads), visual characteristics (such as the dark mottled tail), and the time of year as midwife toads are the only known anuran in Cambridge to have tadpoles that would be present in water bodies in late August.

Figure 1. One of the two common midwife toad (*Alytes obstetricans*) tadpoles developing within the ceramic saucer of a flowerpot in an urban garden in central Cambridge, England

Since 2015, more than 40 surveys have been carried out in residential gardens of Cambridge in the area where *A. obstetricans* are known to occur but this is the first time that we have discovered tadpoles in such a small and temporary water source. There appear to be two potential hypotheses to explain this observation, either a male toad deposited the eggs in the saucer or two eggs were carried there 'accidentally', perhaps by a predator. Potential predators include domestic cats, foxes, hedgehogs and corvid birds which on finding a male toad looking for water to deposit its eggs may attempt to eat it. When that happens there is the small possibility that the eggs (from a single or multiple females), which are embedded in an elastic strand, may get trapped in the jaws, bill, feet etc.. As the predator was in a garden with limited access to water, after eating the toad it may have taken a drink from the convenient saucer of water.

A few eggs may then have become deposited in the water in a manner very similar to the purposeful deposit of a male toad. If instead a male toad did actually deposit eggs in the saucer then this raises the question of whether males are capable of separating the accumulated multi-female egg strands into even smaller numbers prior to get deposition in available/suitable environments or whether all eggs were deposited in the saucer at once, and that only two tadpoles remained following cannibalism and/or competition with their conspecifics? Interestingly, the fact that two tadpoles of different sizes were observed is perhaps the tell-tale sign of eggs from a male midwife toad carrying an egg load derived from more than one female.

Most introduced midwife toad populations in Britain are restricted to private residential gardens or urban areas (Beebee & Griffiths, 2000); including the population where this observation took place. It has been reasonable to assume that permanent bodies of water such as garden ponds would be needed for the deposition and maturation of tadpoles until metamorphosis is complete. The observation that midwife toads may be able to exploit temporary water bodies such a saucer, suggests their adaptability to a suburban environment but also their ability to persist despite the lack of larger water bodies. Whilst the tadpoles observed were not seen to have metamorphosed, during previous surveys other recent metamorphs have been found sheltering within crevices in gardens that lack ponds. It is reasonable to assume that these individuals may also have been deposited in small temporary water bodies, such as flowerpot saucers. This would help to explain their observed persistence, and strong association, with urban and suburban environments in Britain.

ACKNOWLEDGEMENTS

We'd like to thank the residents of Cambridge for their continued support with this ongoing project, and for allowing us access to their gardens to survey for the presence of midwife toads. We'd also like to thank the CPARG volunteers that have assisted us with the monitoring of midwife toads within Cambridge.

REFERENCES

Allain, S.J.R. & Goodman, M.J. (2017). Using call playbacks to investigate a population of non-native midwife toads *Alytes obstetricans* (Laurenti, 1768) in Cambridge, UK. *Herpetological Bulletin* 140: 28-30.

Allain, S.J.R. & Goodman, M.J. (2019). New records of midwife toads (*Alytes obstetricans*) in Cambridgeshire. *Nature in Cambridgeshire* 61: 69-70.

Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles. A Natural History of the British Herpetofauna*. London: HarperCollins. 270 pp.

Márquez, R. (1992). Terrestrial paternal care and short breeding seasons: reproductive phenology of the midwife toads *Alytes obstetricans* and *A. cisternasii*. *Ecography* 15: 279–288.

Márquez, R. (1996). Egg mass and size of tadpoles at hatching in the midwife toads. *Alytes obstetricans* and *Alytes cisternasii*: implications for female choice. *Copeia* 1995: 824-831.

Raxworthy, C.J. (1990). Non-random mating by size in the midwife toad *Alytes obstetricans*: Bigger males carry more eggs. *Amphibia-Reptilia* 11: 247-252.

Speybroeck, J., Beukema, W., Bok, B. & Van Der Voort, J. (2016). *Field Guide to the Amphibians and Reptiles of Britain and Europe*. London, Bloomsbury Publishing. 432 pp.

Van der Meijden, A. (2010). *Alytes obstetricans* (Online). AmphibiaWeb. http://amphibiaweb.org/cgi/amphib_query?where-genus=Alytes&where-species=obstetricans. (Accessed April 2021)

Accepted: May 2021

The Herpetological Bulletin 157, 2021: 40-41
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.4041

First case of severe bloatedness in adult common brown frogs *Rana temporaria*

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Bloatedness is an externally visible non-skeletal anomaly describing inflation of the body by gas. This condition is often called 'oedema' (also spelt 'edema') however some authors differentiate between the two, using oedema only for intercellular accumulation of fluids. In a review of the literature, Henle et al. (2017) found 158 cases of bloatedness in over 51 amphibian species although only six of these were definitely caused by gas accumulation. In populations living in healthy environments the prevalence of bloatedness is very low – 0.01 % in 7,175 individuals of *Pseudacris regilla* (Johnson et al., 2001) and 0.09 % in 99,992 individuals of *Bufo bufo* (Wolf, 1994). In 228 *Rana arvalis* adults examined in forest city parks of Yekaterinburg (Russia) the prevalence of bloatedness was higher - 0.44 % - probably due to anthropopressure (Vershinin, 2005). The symptoms are not confined to adult amphibians, as gas accumulation has been reported in the tadpoles of *Lithobates sylvaticus* (Guderyahn, 2006), *Lithobates sphenocephalus* and *Rana aurora* (Reeves et al., 2013). An interesting and rare instance of bloatedness occurred when a pulmonary nematode *Rhabdias tokyoensis* managed to pierce the lung of the Japanese newts *Cynops pyrrhogaster* allowing air to fill the peritoneal cavity when inhaling. Such newts are severely distended and float at the surface of water (Pfeiffer & Asashima, 1997).

Here we report the first case of severe bloatedness (subcutaneous accumulation of gas) in European common brown frog (*Rana temporaria*). On the 12th May 2016, three bloated *R. temporaria* adult males and five healthy conspecifics were found during 2-3 hours of fieldwork in the polluted outskirts of Bielsko-Biała city, Poland (49° 48'38.1" N, 19° 05'20.6" E). The frogs were encountered near a stream and were syntopic with *Ichthyosaura alpestris*, *Bombina variegata*, *Bufo bufo* and *Salamandra salamandra*. Visible bloatedness in *R. temporaria* covered the whole body (Fig. 1) and the skin on dorsum was unnaturally stretched, cracked and with miniscule grey discolorations. The affected frogs walked awkwardly instead of jumping and we assume that they were preyed upon shortly thereafter. One individual was held in a box for further observation but the next day deflated and died. These frogs may have been bloated since their larval stage (Blaustein et al., 1997) due to genetic and / or environmental factors, in particular contact with polluted pond water during the breeding season. Further investigation is required to explain the cause and prevalence of bloatedness in this population of frogs.

Figure 1. Severely bloated adult male of *Rana temporaria* (left) and a healthy conspecific (right)

ACKNOWLEDGEMENTS

We are grateful to Anna Najbar for her help in the fieldwork.

REFERENCES

Blaustein A.R., Kiesecker J.M., Chivers D.P. & Anthony R.G. (1997). Ambient UV-B radiation causes deformities in amphibian embryos. *Proceedings of the National Academy of Sciences of the United States of America* 94: 13735–13737.

Guderyahn, L. (2006). Nationwide assessment of morphological abnormalities observed in amphibians collected from United States national wildlife refuges. U.S. Fisheries & Wildlife Service Report CBFO-C06-01

Henle, K., Dubois, A. & Vershinin, V. (2017). A review of anomalies in natural populations of amphibians and their potential causes. In: Studies on anomalies in natural populations of amphibians. *Mertensiella* 25: 57–164.

Johnson, P.T.J., Lunde, K.B., Ritchie, E.G., Reaser, J.K. & Launer, A.E. (2001). Morphological abnormality patterns in a California amphibian community. *Herpetologica* 57: 336–352.

Pfeiffer, C.J. & Asashima. M. (1997). Ultrastructure of *Rhabdias tokyoensis*, a pulmonary nematode of the Japanese newt (*Cynops pyrrhogaster*). *Amphibia-Reptilia* 18: 283–294.

Wolf, K.-R. (1994). Untersuchungen zur Biologie der Erdkröte *Bufo bufo* L. unter besonderer Berücksichtigung des Einflusses von Migrationshindernissen auf das Wanderverhalten und die Entwicklung von vier Erdkrötenpopulationen im Stadtgebiet von Osnabrück. New York, Edwin Mellen Press. 312 pp.

Vershinin, V.L. (2005). Morphological deviations in population *Rana arvalis* Nilss. on urbanized territories: spectrum, topography, frequency. In *Herpetologia Petropolitana*, pp. 311–313, Ananjeva, N. & Tsinenko O. (Eds.). Proceedings of the 12th Ordinary General Meeting of the Societas Europaea Herpetologica, August 12–16, 2003, St. Petersburg.

Accepted: 27 January 2021

The Herpetological Bulletin 157, 2021: 42-43
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.4243

Unusual posture of a male northern viper *Vipera berus* – a more efficient way to bask?

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The northern viper (*Vipera berus*) is widely distributed across Europe, central and eastern Asia and, being exceptionally tolerant of cold climates, is even found north of the Arctic Circle (Andersson, 2003). This northerly distribution is made possible, at least in part, by an exceptional ability to thermoregulate achieved by adopting optimal postures to absorb energy directly from sunlight, to the extent that *V. berus* has been referred to as a "posturing heliotherm" (Spellerberg, 1976). Here, we described for the first time the unusual posture of a male *V. berus* observed in a sand dunes area in north Wales.

On the 2nd April 2021, while surveying for vipers in the sand dune systems along the coast of Rhosneigr, Wales, we observed a male *V. berus* moving uphill through the vegetation at about 5 m from the path where we were standing. The air temperature was between 8°-10° C and a moderate breeze was blowing (approx. 33 km/h). After five minutes from the initial encounter, the animal started wrapping itself around a patch of grass, while slowly turning on its back. At the end of this process, the dark ventral surface of the animal was exposed at almost 90° to the sun (Fig. 1). The observation started around 12:20 h and the behaviour was still observable at 13:56 h when we left the site. During this time, the individual kept this position while slowly moving, thus exposing different sections of the ventral surface.

There are several potential explanations for the observed behaviour. First, the rotation of the body could have resulted from neurological damage. This seems unlikely as the animal appeared in good health and was initially observed moving smoothly through the vegetation at a quite steep angle, without showing any locomotory impediments. Second, our close proximity to the animal might have provoked it to feign death (thanatosis). Such behaviour has been observed previously (Hodges, 2013) but has few similarities with that described here and given that we were a few meters from the specimen it seems unlikely that our presence would have triggered such a response. Finally, it may simply be a basking behaviour that takes advantage of the viper's dark ventral colouration. According to the thermal melanism hypothesis, darker individuals living in cold climates would be able to increase their body temperature at a faster rate than light-coloured specimens (Trullas et al., 2007) and the thermal advantages proposed by this hypothesis have been supported in various studies on European vipers (Capula & Luiselli, 1994; Capula, Luiselli & Monney, 1995; Castella et al., 2013; Martínez-Freiría et al., 2020). Furthermore, a recent study has highlighted the overlooked adaptive role of the ventral colouration of vipers in heat transfer (Goldenberg et al., 2021). In this regard, our focal individual had, apart from its dark zig-zag stripe, a light dorsal background colouration, while its ventral scales were almost black. If this behaviour genuinely is basking then it would appeared to be the first time that it has been described in any snake, although this behaviour has been suggested for a similar posture taken by a lizard species, the slow worm *Anguis fragilis* (Hails & Strine, 2016).

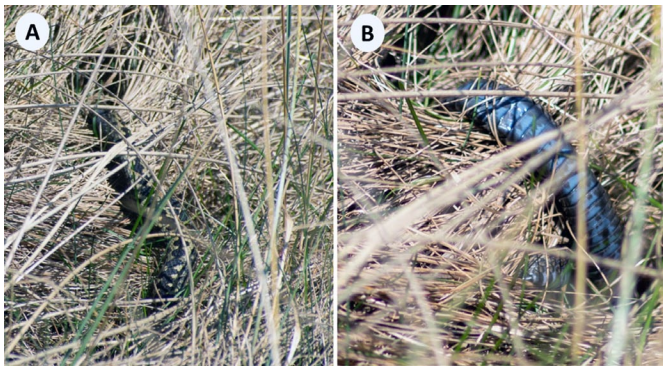

Figure 1. A male *Vipera berus* that rolled on to its back, so exposing its dark ventral surface to direct sun light – **A.** The male before it had rolled onto its back, **B.** The male on its back with ventral surface exposed to the sun

It seems likely that we have observed a previously unreported basking posture of *V. berus*; effectively a new posture for the posturing heliotherm (Spellerberg, 1976). Early spring represents a critical period for male northern vipers, during which basking efficiency is physiologically critical to both spermiogenesis and moulting that must be completed before mating can proceed (Nilson, 1980). Exposing its dark ventral surface to direct sunlight would have allowed this individual to warm up more rapidly, giving it a reproductive advantage over its conspecifics.

ACKNOWLEDGEMENTS

We thank Dr. James Hicks (Berkshire College of Agriculture, Maidenhead) and Dr. Wolfgang Wüster (Bangor University, Wales) for their help in reviewing and finalising the manuscript.

REFERENCES

Andersson, S. (2003). Hibernation, habitat and seasonal activity in the adder, *Vipera berus*, north of the Arctic Circle in Sweden. *Amphibia-Reptilia* 24: 449-457.

Capula, M. & Luiselli, L. (1994). Reproductive strategies in alpine adders, *Vipera berus*. The black females bear more often. *Acta Oecologica* (Montrouge) 15: 207-214.

Capula, M., Luiselli, L. & Monney, J.C. (1995). Correlates of melanism in a population of adders (*Vipera berus*) from the Swiss Alps and comparisons with other alpine populations. *Amphibia-Reptilia* 16: 323-330.

Castella, B., Golay, J., Monney, J.C., Golay, P., Mebert, K. & Dubey, S. (2013). Melanism, body condition and elevational distribution in the asp viper. *Journal of Zoology* 290: 273-280.

Goldenberg, J., D'Alba, L., Bisschop, K., Vanthournout, B. & Shawkey, M.D. (2021). Substrate thermal properties influence ventral brightness evolution in ectotherms. *Communications Biology* 4: 1-10.

Hails, E.L. & Strine, C.T. (2016). An "upside-down" juvenile slow-worm (*Anguis fragilis*): could this be a thermophilic behaviour? *The Herpetological Bulletin* 138: 42.

Hodges, R. (2013). *Vipera berus* (common viper): feigning death. *The Herpetological Bulletin* 125: 25-26.

Martínez-Freiría, F., Toyama, K.S., Freitas, I. & Kaliontzopoulou, A. (2020). Thermal melanism explains macroevolutionary variation of dorsal pigmentation in Eurasian vipers. *Scientific Reports* 10: 1-10.

Nilson, G. (1980). Male reproductive cycle of the European adder, *Vipera berus*, and its relation to annual activity periods. *Copeia* 1980: 729-737.

Spellerberg, I.F. (1976). Adaptations of reptiles to the cold. In *Morphology and Biology of Reptiles*, pp. 261-285. Bellairs A. d'A, & Cox C.B. (Eds.) Linnean Society Symposium Series 3. Academic Press, London.

Trullas, S.C., van Wyk, J.H. & Spotila, J.R. (2007). Thermal melanism in ectotherms. *Journal of Thermal Biology* 32: 235-245.

Accepted: 7 June 2021

The Herpetological Bulletin 157, 2021: 44-45
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.4445

Caudal autophagy in a sphaerodactyline gecko from the Peruvian Amazon

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Voluntary tail shedding (caudal autotomy), often accompanied with writhing of the shed tail in a way that distracts a predator, is a widespread adaptive strategy that can help lizards avoid predation (Vitt et al., 1977, Bateman & Fleming, 2009). Lizards with autotomised tails may experience reduced agility (Chapple & Swain, 2002) or social status (Martín & Salvador, 1993), and they will have fewer future opportunities to escape predators as caudal autotomy is usually only possible in original tail tissue (Bellairs & Bryant, 1985). In many species, caudal fat is a crucial energy resource so that the loss of the tail could be the difference between life and death (Daniels, 1984). In addition, regenerating a tail itself is costly and substantially increases a lizard's resting metabolic rate (Dial & Fitzpatrick, 1981).

Lizards are known to eat their shed tails (autophagy or self-cannibalism) and this offers an opportunity to recoup some of the energy loss associated with caudal autotomy. Observations of caudal autophagy in lizards remain exceedingly rare, with few documented accounts (e.g. Vitt et al., 1977, Iglesias-Carrasco & Cabido, 2016; Thanou & Kornilios, 2019). Lizard taxa that store substantial energy within their tails, including many geckos, should gain a large benefit from caudal autophagy following autotomy. For geckos, the fat stored in their tails has been widely demonstrated to be crucial to fitness (e.g. Daniels, 1984). Seventy-five years ago, a single observation of caudal autophagy in a New Guinean gekkonid (*Gehyra oceania*) was documented (Neill, 1946) but subsequently there appear to be no other accounts of caudal autophagy in any other gecko species.

Gonatodes humeralis is a sphaerodactyline gecko ranging throughout tropical South America, usually found on low tree trunks in primary and secondary forests (Bartlett & Bartlett, 2003). Male *G. humeralis* are brightly colored. A range of taxa, including birds and snakes, prey upon this small, diurnal species. *Gonatodes humeralis* uses antipredator tactics typical of this genus, including tail autotomy and easily torn skin ("regional integumentary loss"; Bauer et al., 1989). It is unknown whether this species stores fat in its tail.

On the late afternoon of 4th July 2019, we captured an adult male *G. humeralis* (snout-vent length = 4.0 cm; mass = 1.5 g) by hand outside of the Amazon Conservatory for Tropical Studies (3° 14' 44" S, 72° 55' 28" W) in the Peruvian Amazon, 67 miles north-east of Iquitos, Peru. It was placed in a jar with a breathable lid for transport back to the station. When removed from the jar at 20:41 h, we observed that its tail had been autotomised at 1.6 cm posterior to the cloaca and that the individual was in the process of ingesting its shed tail (Fig. 1). Approximately 1 cm of the shed tail extended from its mouth at this time (total shed tail piece = 3.0 cm). The individual was measured and photographed, and we placed it back into the jar. Almost 12 h later (08:05 h, 5th July 2019), we discovered that the individual had regurgitated its shed tail. We then released the individual at its site of capture.

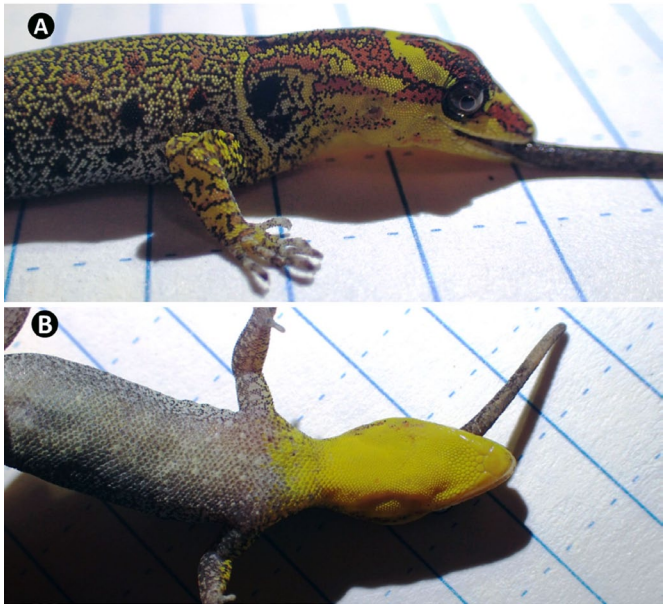

Figure 1. Adult male *Gonatodes humeralis* consuming its autotomised tail, shown in – **A.** Lateral view, and **B.** Ventral view

This observation expands knowledge of caudal autophagy to the sphaerodactyline geckos. Upon capture, the gecko's tail was intact and autotomy occurred in the transport container. Other than the initial capture, there was no other stressor that was likely to induce autotomy: the gecko was housed individually, not handled between initial capture and autotomy, and the jar did not present any obvious sites where the tail could become trapped or mechanically stressed. It would appear that autotomy was a result of the stress of capture and transport, as observed previously (Neill, 1946,

Thanou & Kornilios, 2019). Our results also corroborate those by Thanou & Kornilios (2019), in which autophagy was observed despite the stress of capture, and Johnson (2021), in which a salamander's self-cannibalised tail was regurgitated in captivity. Based on our observation, it is plausible that *G. humeralis* may ingest autotomised tails in nature. However, it remains unclear whether caudal autophagy is an adaptive behaviour or whether it is a case of mistaken identity where the lizard responds to a writhing shed tail in the same way as it would respond to any potential prey item that is moving.

ACKNOWLEDGEMENTS

We thank P. Poblete, S. Madigosky, and the Amazon Conservatory for Tropical Studies for support and assistance. Animal use was approved by Binghamton University (IACUC #830-19).

REFERENCES

Bartlett, R.D. & Bartlett, P. (2003). *Reptiles and Amphibians of the Amazon*. Gainesville: The University Press of Florida. 448 pp.

Bateman, P.W. & Fleming, P.A. (2009). To cut a long tail short: A review of lizard caudal autotomy studies carried out over the last 20 years. *Journal of Zoology* 277: 1–14.

Bauer, A.M., Russell, A.P. & Shadwick, R.E. (1989). Mechanical properties and morphological correlates of fragile skin in gekkonid lizards. *Journal of Experimental Biology* 145: 79–102.

Bellairs, A.A. & Bryant, S.V. (1985). Autotomy and regeneration in reptiles. In *Biology of the Reptilia: Development B*, 303–410 pp. Gans, C. & Billett, F.S. (Eds.). New York: John Wiley and Sons Publication.

Chapple, D.G. & Swain, R. (2002). Effect of caudal autotomy on locomotor performance in a viviparous skink, *Niveoscincus metallicus*. *Functional Ecology* 16: 817–825.

Daniels, C.B. (1984). The importance of caudal lipid in the gecko *Phyllodactylus marmoratus*. *Herpetologica* 40: 337–344.

Dial, B.E. & Fitzpatrick, L.C. (1981). The energetic costs of tail autotomy to reproduction in the lizard *Coleonyx brevis*. *Oecologia* 51: 310–317.

Iglesias-Carrasco, M. & Cabido, C. (2016). A case of tail autophagy in a male of the Iberian rock lizard, *Iberolacerta monticola*. *Salamandra* 52: 215–216.

Johnson, B.B. & Haines-Eitzen, E. (2021). Tail autophagy observed in a captive eastern redback salamander (*Plethodon cinereus*), but is unconfirmed in natural populations. *Herpetology Notes* 14: 189–191.

Martín, J. & Salvador, A. (1993). Tail loss reduces mating success in the Iberian rock-lizard, *Lacerta monticola*. *Behavioral Ecology and Sociobiology* 32: 185–189.

Neill, W.T. (1946). An autophagous lizard. *Copeia* 1946: 104.

Thanou, E. & Kornilios, P. (2019). Self-cannibalism in the Aegean wall-lizard, *Podarcis erhardii*. *The Herpetological Bulletin* 147: 26–27.

Vitt, L.J., Congdon, J.D. & Dickson, N.A. (1977). Adaptive strategies and energetics of tail autotomy in lizards. *Ecology* 58: 326–337.

Accepted: 8 June 2021

The Herpetological Bulletin 157, 2021: 46
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.46

Tadpoles of the midwife toad *Alytes obstetricans* scavenging carrion

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The common midwife toad (*Alytes obstetricans*) is not native to Great Britain but approximately thirty introduced populations are known (Allain & Goodman, 2017; unpublished data), the most well-known of which is in Bedford (Beebee & Griffiths, 2000). The tadpoles of *A. obstetricans* grow to 80 mm in length, or 90 mm in exceptional circumstances (Boulenger, 1896). This makes their tadpoles easily recognisable and conspicuous within a given body of water, as they dwarf those of any native anurans, especially given that *A. obstetricans* tadpoles may overwinter if laid too late in the season to metamorphose (Speybroeck et al., 2016).

The feeding biology of *A. obstetricans* tadpoles is not well known, which is the case for most species (Pryor, 2014). For the captive rearing of *Alytes* tadpoles, there is a tendency to assume that they are omnivorous, consequently they are offered fish flakes, trout pellets, grass pellets, tubifex worms and spirulina algae amongst others (Wells et al., 2015). While in a study of the effects of microplastics, the tadpoles were fed on a diet of periphyton, which can be found on most surfaces in aquatic ecosystems (Boyero et al., 2020). Following research into the digestive system of the species and through direct observation (Boulenger, 1896), it has been stated that the tadpoles of *A. obstetricans* are predators rather than scavengers.

At 12:03 h on 23 April 2021, approximately ten *A. obstetricans* tadpoles were observed feeding upon a recently deceased common frog *Rana temporaria* (Fig. 1; BHS video, 2021) at Hill Rise Nature Reserve, Bedford, Bedfordshire (52° 08'52" N, 000° 28'16" W), and a second group of approximately ten tadpoles were observed in the same pond, approximately 4 m away feeding upon a drowned earthworm (BHS video, 2021). This feeding behaviour was observed for several minutes, and it is our belief that these observations may represent the first report of carrion scavenging behaviour in *A. obstetricans*.

Figure 1. The tadpoles of the common midwife toad feeding on the carcass of the common frog

Most husbandry guidelines for *A. obstetricans* tadpoles state that they are herbivorous (Boyero et al., 2020; Wells et al., 2015) but in light of this observation of carnivorous behaviour, it appears that the tadpoles of *A. obstetricans* are similar to other anurans (such as *Rana temporaria*), which become omnivorous at later Gosner stages.

REFERENCES

Allain, S.J.R. & Goodman, M.J. (2017). Using call playbacks to investigate a population of non-native midwife toads *Alytes obstetricans* (Laurenti, 1768) in Cambridge, UK. *Herpetological Bulletin* 140: 28-30.

Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles. A Natural History of the British Herpetofauna*. London, HarperCollins. 270 pp.

BHS video. (2021). Tadpoles of the midwife toad *Alytes obstetricans* scavenging carrion. https://youtu.be/4tvaxPHEfHU

Boulenger, G.A. (1896). *The Tailless Batrachians of Europe*, Volume 1. London, Ray Society. 210 pp.

Boyero, L., López-Rojo, N., Bosch, J., Alonso, A., Correa-Araneda, F. & Pérez, J. (2020). Microplastics impair amphibian survival, body condition and function. *Chemosphere* 244: 125500.

Pryor, G.S. (2014). Tadpole nutritional ecology and digestive physiology: implications for captive rearing of larval anurans. *Zoo Biology* 33: 502-507.

Speybroeck, J., Beukema, W., Bok, B. & Van Der Voort, J. (2016). *Field Guide to the Amphibians and Reptiles of Britain and Europe*. London, Bloomsbury Publishing. 432 pp.

Wells, E., Garcia-Alonso, D., Rosa, G.M., Garcia, G. & Tapley, B. (2015). Amphibian Taxon Advisory Group Best Practice Guidelines for Midwife toads (*Alytes* sp.). https://www.eaza.net/assets/Uploads/CCC/2015-Midwife-toads-EAZA-Best-Practice-Guidelines-Approved.doc.pdf. (Accessed 9th May 2021).

Accepted: 9 June 2021

The Herpetological Bulletin 157, 2021: 47-48
NATURAL HISTORY NOTE

https://doi.org/10.33256/hb157.4748

Antipredator behaviours of the glass frog *Hyalinobatrachium iaspidiense* from eastern Amazonia, Brazil

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Anurans have developed diverse defensive postures and behaviours to avoid predation (Wells, 2007; Toledo et al., 2007, 2010 & 2011; Ferreira et al., 2019). For some species of glass frog (Anura: Centrolenidae) the patterns of parental care (Delia et al., 2017; Ospina-L et al., 2019; Valencia-Aguilar et al., 2021) and defensive postures (Rueda-Almonacid, 1994; Toledo et al., 2010; Escobar-Lasso & Rojas-Morales, 2012) have already been described. To provide more information and understanding of glass frogs, we describe here the antipredator behaviours displayed by *Hyalinobatrachium iaspidiense* (Ayarzaguena, 1992) from eastern Amazonia.

In the state of Amapá, *H. iaspidiense* was first recorded in the Cancão Municipal Natural Park, located in the municipality of Serra do Navio, Brazil (Silva e Silva & Costa-Campos, 2016). It is known to occur in sympatry with *Hyalinobatrachium mondolfii* Señaris & Ayarzagüena, 2001 (Figueiredo et al., 2020) but may be distinguished from it by the presence of a pale yellowish green dorsum with large and disruptive green marks, and small black spots, and the absence of humeral spines in males (Guayasamin & North, 2009; Castroviejo-Fisher et al., 2011).

On 14th February 2019, at 23.19 h, an adult male *H. iaspidiense* was recorded in the Cancão Municipal Natural Park (0.9138 °N, 52.9997 °W). When observed on the underside of a leaf blade, it displayed a defensive posture consisting of dorsoventral flattening of the body, it also retracted its limbs for a few minutes (Fig. 1A). After being disturbed, it remained in a higher than habitual sitting posture, which involved raising the rear of the body while extending the limbs (front and rear) (Fig. 1B). Moreover, when an egg clutch was brought close to where it was sitting, the male promptly displayed parental care (Fig. 1C). However, we do not know whether or not this clutch was related to this male, since in some glass frog species, adults may care for egg clutches that are not their own (alloparental care - Valencia-Aguilar et al., 2021). Furthermore, other males of the same species, other potential fathers, were observed calling at the same location.

According to Toledo et al. (2011) and Ferreira et al. (2019), the defensive postures we observed in *H. iaspidiense* are termed - crouching down, body elevation, and parental care. Crouching down is characterised by a lower than habitual sitting posture (Toledo et al., 2011). Body elevation is characterised by extension of anterior or all limbs, lifting the anuran body from the substrate (Ferreira et al., 2019);

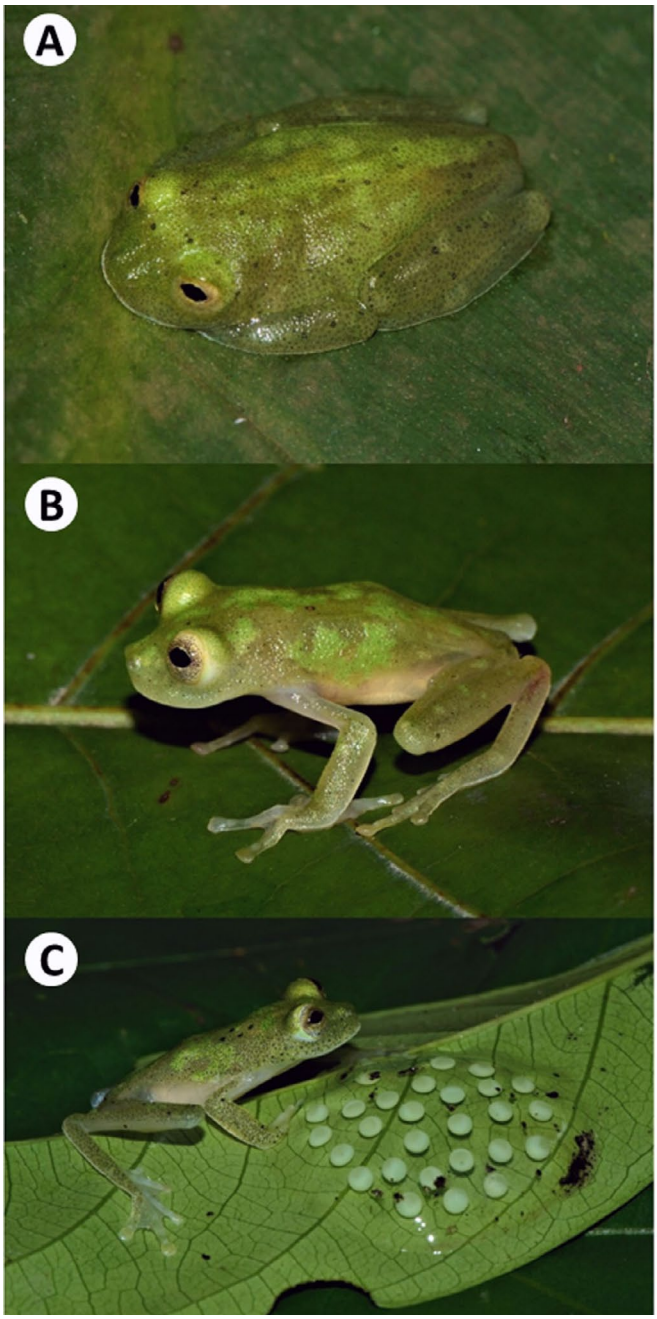

Figure 1. Defensive postures of *Hyalinobatrachium iaspidiense* from eastern Amazonia- **A.** Crouching down **B.** Body elevation **C**. Parental care

this defensive posture may increase the anuran's apparent size and threat to the potential predator (Williams et al., 2000). Finally, parental care of the egg clutch can help prevent predation and may also reduce dehydration of the eggs (Wells, 2007).

We hope that our observations may encourage researchers to seek robust data on defensive postures and parental care in this species. It may also offer a particular opportunity to investigate alloparental care.

ACKNOWLEDGEMENTS

We are grateful to Santiago Castroviejo-Fisher for the assistance in the glass frog identification. We thank Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio/SISBIO) for providing collection permits (#48102-2).

REFERENCES

Castroviejo-Fisher, S., Vilà, C., Ayarzagüena, J., Blanc, M. & Ernst, R. (2011). Species diversity of *Hyalinobatrachium* glassfrogs (Amphibia: Centrolenidae) from the Guiana Shield, with the description of two new species. *Zootaxa* 3132: 1-55.

Delia, J., Bravo-Valencia, L. & Warkentin, K. M. (2017). Patterns of parental care in Neotropical glassfrogs: fieldwork alters hypotheses of sex-role evolution. *Journal of Evolutionary Biology* 30: 898-914.

Escobar-Lasso, S. & Rojas-Morales, J.A. (2012). Antipredatory behaviors of the Colombian endemic glassfrog *Centrolene savagei* (Anura: Centrolenidae). *Boletín Científico Centro de Museos* 16: 226-232.

Ferreira, R.B., Lourenço-de-Moraes, R., Zocca, C., Duca, C. & Beard, K.H. (2019). Antipredator mechanisms of post-metamorphic anurans: a global database and classification system. *Behavioral Ecology and Sociobiology* 2019: 1-21.

Figueiredo, V.A.M.B., Tavares-Pinheiro, R., Freitas, A.P., Dias-Souza, M.C. & Costa-Campos, C.E. (2020). First records of the glass frogs *Hyalinobatrachium cappellei* (van Lidth de Jeude, 1904) and *H. mondolfii* Señaris & Ayarzagüena, 2001 (Anura, Centrolenidae) in the state of Amapá, Brazil. *Check List* 16: 1369-1374.

Guayasamin, J.M. & North, S. (2009). Amphibia, Centrolenidae, *Hyalinobatrachium iaspidiense*: distribution extension. *Check List* 5: 526-529.

Ospina-L, A.M., Navarro-Salcedo, P., Rios-Soto, J.A., Duarte-Marín, S. & Vargas-Salinas, F. (2019). Temporal patterns, benefits, and defensive behaviors associated with male parental care in the glassfrog *Centrolene savagei*. *Ethology Ecology & Evolution* 32: 162-174.

Rueda-Almonacid, J.V. (1994). Estudio anatómico y relaciones sistemáticas de Centrolene geckoideum (Salientia: Anura: centrolenidae). *Trianea* 5: 133-187.

Silva e Silva, Y.B. & Costa-Campos, C.E. (2016). *Hyalinobatrachium iaspidiense* (Ayarzaguena, 1992) (Anura: Centrolenidae): first record in Amapá state, Brazil and geographic distribution map. *Check List* 12: 1849.

Toledo, L.F., Ribeiro, R.S. & Haddad, C.F.B. (2007). Anurans as prey: an exploratory analysis and size relationships between predators and their prey. *Journal of Zoology* 271: 170-177.

Toledo, L.F., Sazima, I. & Haddad, C.F.B. (2010). Is it all death feigning? Case in anurans. *Journal of Natural History* 44: 1979-1988.

Toledo, L.F., Sazima, I. & Haddad, C.F.B. (2011). Behavioural defences of anurans: an overview. *Ethology Ecology & Evolution* 23: 1-25.

Valencia-Aguilar, A., Guayasamin, J.M. & Prado, C.P.A. (2021). Alloparental care in glassfrogs: males care for unrelated clutches only when associated with their own. *Scientific Reports* 11: 1386.

Wells, K.D. (2007). *The Ecology and Behavior of Amphibians*. University Chicago Press, Chicago, 1148 pp.

Williams, C.R., Brodie, E.D. Jr, Tyler, M.J. & Walker, S.J. (2000). Antipredator mechanisms of Australian frogs. *Journal of Herpetology* 34: 431-443.

Accepted: 14 July 2021

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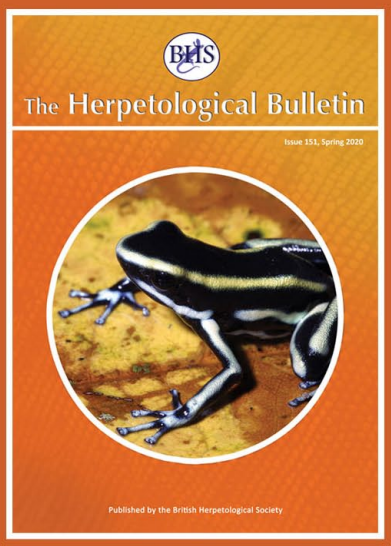
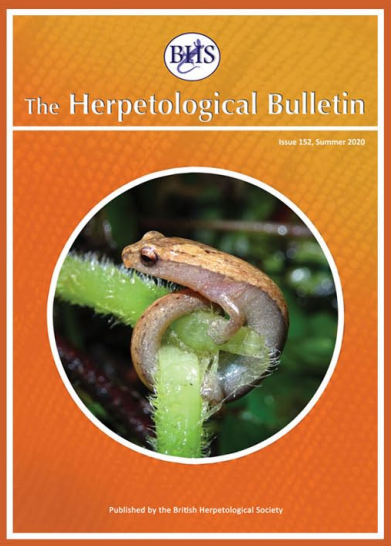

The Herpetological Bulletin
Issue 151, Spring 2020
Published by the British Herpetological Society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Issue 152, Summer 2020
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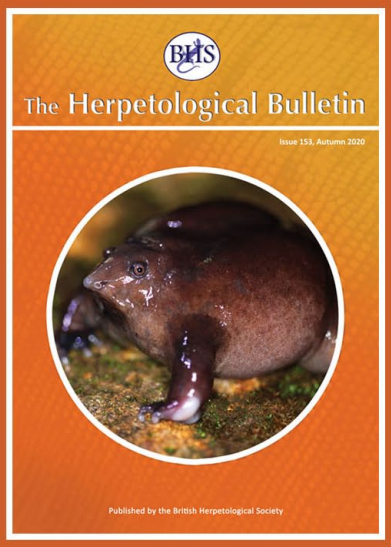
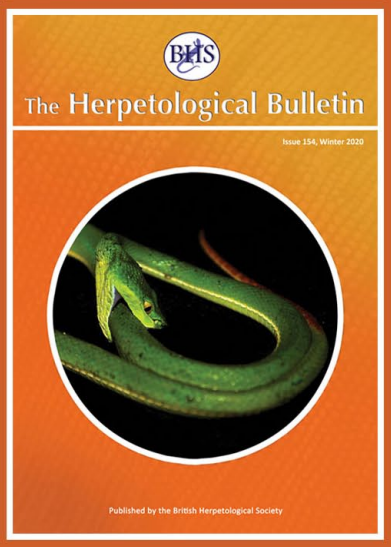

The Herpetological Bulletin
Issue 153, Autumn 2020
Published by the British Herpetological Society


The Herpetological Bulletin
Issue 154, Winter 2020
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