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Front Cover: A western spiny frog *Eleutherodactylus symingtoni*, Ecological Reserve El Salón, Sierra del Rosario Biosphere Reserve, Artemisa province, Cuba. Photo by Sergio L. del Castillo Domínguez. There is an article about this species on p 31.

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RESEARCH ARTICLE

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Predation of Endangered crowned river turtles *Hardella thurjii* by golden jackals *Canis aureus* in Keoladeo National Park, India

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ABSTRACT – The predation of an endangered species by its natural predators can severely impact its survival, even in protected areas. We report on the predation of the Endangered crowned river turtle *Hardella thurjii* by golden jackals *Canis aureus* in Keoladeo National Park in India. There were 48 predation instances over five months, particularly of gravid females during the breeding season. The concentration of predated carcasses along turtle breeding trails raises concerns about demographic impacts. These findings underscore the need for targeted conservation measures, such as monitoring jackal movement, installing barricades in predation hotspots, and providing care for injured turtles to reduce losses of *H. thurjii*.

INTRODUCTION

Predators have critical roles to play in the preservation of ecosystems (Ray, 2005) but depensatory predation can lead to the extinction of prey species, while regulatory predation allows prey species to thrive (Garrott et al., 2008). The current record of the predation of crowned river turtles *Hardella thurjii* by golden jackals *Canis aureus* raises concerns regarding the vulnerability of this Endangered species (Ahmed et al., 2021a). This observation, coupled with past unquantified records of predation on this species of turtle by jackals, vultures and eagles during the dry season in Bharatpur (Das & Bhupathy, 2009), has thrust *H. thurjii* into the spotlight as a species of conservation concern.

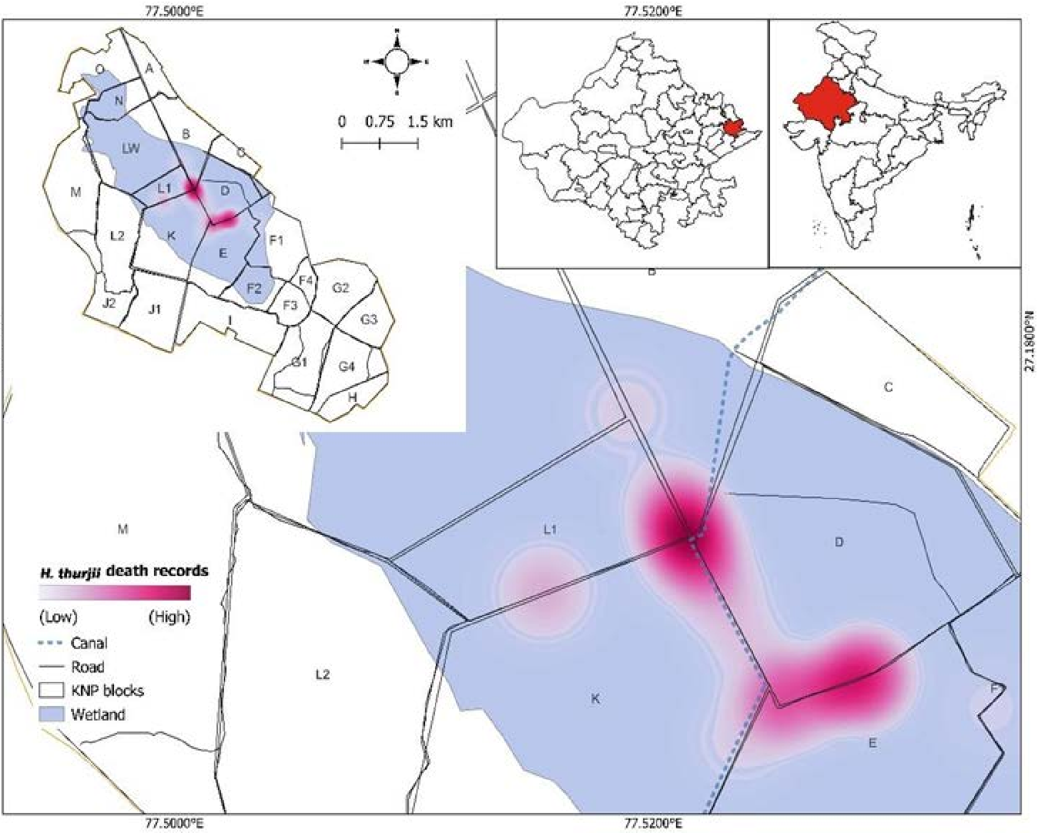

Figure 1. Heat map of mortality of *Hardella thurjii* at KNP

Hardella thurjii is an iconic species inhabiting the Ganga-Brahmaputra basin in Bangladesh and northern India, and the Indus basin in Pakistan and north India (Iverson, 1992). The IUCN classifies this species as Endangered, and its threats include loss of habitat, poaching and the pet trade (Das & Bhupathy, 2009). Female *H. thurjii* nest in sandbanks (Das & Bhupathy, 2009) where they lay 30–100 eggs in multiple clutches, each containing 8–13 eggs (Basu, 1998), and in a recent study, six dissected females were observed carrying 6–22 eggs each (Singh et al., 2022). It is not known whether females lay communally.

We address here the predation of *H. thurjii* during the breeding season by golden jackals in Keoladeo National Park (KNP), and its potential consequences on *H. thurjii*. KNP has an exceptionally high density of golden jackals (14.84 individuals/km^2) (Singh et al., 2016). However, there is a significant knowledge gap regarding their prey and feeding habits in KNP across all seasons, specifically their interaction with the *H. thurjii* and other reptiles. While studying the Indian rock python *Python molurus* and its coexisting fauna, we encountered opportunistic interactions between golden jackals and *H. thurjii*, leading to systematic monitoring. With few natural predators inside the park except pythons, which occasionally feed on golden jackals (Bhupathy et al., 2014), the unchecked increase in the jackal population could affect the park's ecosystem and its threatened species. While previous observations of interactions between golden jackals and *H. thurjii* exist (Das & Bhupathy, 2009), our study marks the first systematic effort to quantify these encounters. Through systematic observations and analysis, we seek to elucidate patterns of predation, spatial dynamics and the broader ecological implications of these interactions. By so doing, we aim to contribute valuable insights that can inform targeted conservation strategies for the coexistence of these threatened species within the delicate ecosystem of KNP.

MATERIALS & METHODS

Study area

KNP is situated in the Indian state of Rajasthan, and lies between latitudes 27° 07'06'' N and 27° 12'02'' N and longitudes 77° 29'05'' E and 77° 33'09'' E in the semi-arid zone (province 4A) of India (Fig. 1). The park has significant international ecological importance, and was declared a Ramsar site in 1981 and a World Heritage site in 1985. The park has a mosaic of habitats, including forest, woodland, scrub woodland, savannah woodland, low grasslands with scattered trees and scrub, plantations, and wetlands (Mathur et al., 2009).

Methodology

This study is part of an ongoing project on the Indian rock python, which aims to comprehensively understand the pythons' habitat use, behaviour and prey base by deploying camera traps throughout KNP. This project also focuses on the pythons' interactions with other species, including jackals. While undertaking regular fieldwork for this project, we encountered a series of *H. thurjii* mortalities from 6 August 2023 onwards. After encountering six mortalities within a short span of three days, we decided to systematically monitor specific areas where the occurrence of predation was concentrated. We positioned ten Browning Strike Force Pro DCL camera traps in areas exhibiting high turtle mortality from August to December 2023. Due to the daytime use of the trails by tourists, the traps were placed along the trails only from the hours of 18:00h–06:00h. While the cameras were removed during daylight hours, the sites were routinely monitored. The ten camera traps were programmed to capture three rapid photographs with a 1-second delay, while five traps were set to record 20-second videos in full HD with a 1-second

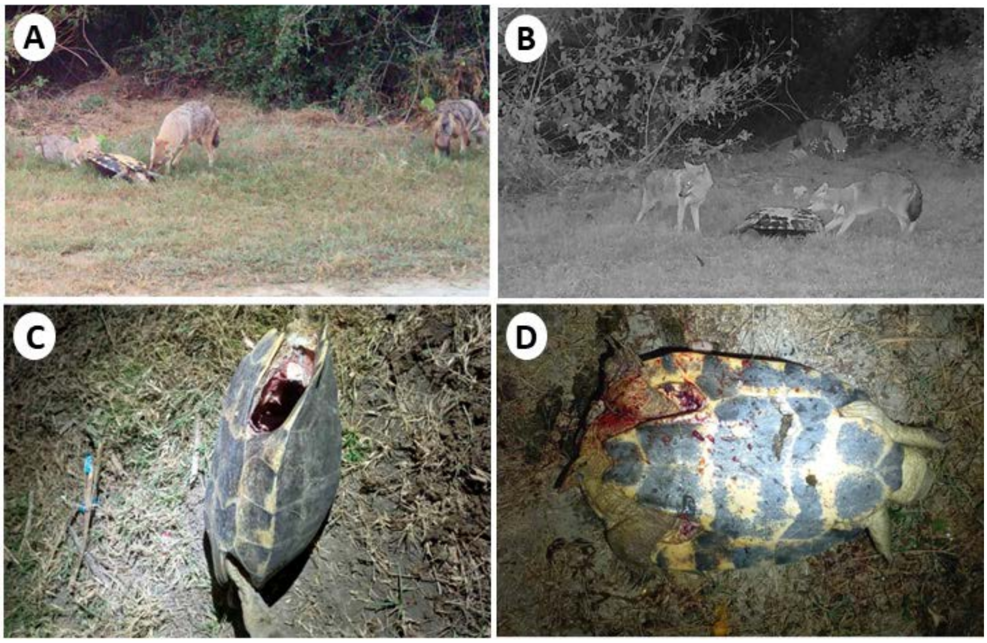

Figure 2. Predation of *Hardella thurjii* by golden jackals at KNP - **A.** & **B.** Camera trap images of jackal feeding and dragging the turtles, **C.** & **D.** Dead *Hardella thurjii*

Figure 3. Predation of *Hardella thurjii* by golden jackals at KNP - **A.** & **B.** Drag marks on the carapace of dead turtles, **C.** Eggs/egg shells near the carcasses of *Hardella thurjii*

delay. Each turtle carcass encountered was measured using a tape measure (Freemans), with measurements taken from the carapace and plastron. Features such as footprints, rake marks and drag marks on the carapace, and the presence of eggs were documented.

RESULTS

From August to December 2023, we documented 48 turtle carcasses, with the most deaths occurring in October (n = 28). These fatalities were primarily concentrated on the roads traversing the wetland habitat of D, K and E blocks within the park (Fig. 1). Upon locating live turtles, golden jackals were observed overturning them. They seized the turtles by their hind legs, pulling and dragging them for distances ranging from approximately 5 to 10 metres to a suitable feeding spot. After damaging the hind legs, they commenced feeding from the rear side, predominantly consuming the legs first, before removing the viscera (Fig. 2). Out of the 48 deaths, morphometric measurements and carcass status were collected for 24 individuals (Supplementary Material, Table 1S). Of the observed individuals, 35 were missing one or more limbs and their viscera were visible. The remaining 13 individuals were completely consumed. Except for drag marks (Fig. 3A & B), the carapaces were seen with no damage, injury or discolouration. Seven individuals were observed with egg counts ranging from 5 to 15; however, we could not obtain morphometric measurements and egg counts for three of them.

The morphological features of the carcass confirmed all as females except one during the study. In seven instances, we encountered eggs scattered around the turtle remains, and counted 15 eggshells near one (Fig. 3C). Moreover, on three occasions, Indian grey mongoose *Urva edwardsii* and twice Bengal monitor lizards *Varanus bengalensis* were observed feeding on the internal organs of a turtle carcass, which may have been inaccessible to jackals. Additionally, there was one instance where an Indian flapshell turtle *Lissemys punctata* was observed feeding on a deceased *H. thurjii*.

DISCUSSION

Hardella thurjii displays a unique characteristic within the chelonian community of KNP, as they may wander up to about 1 km in search of suitable nesting sites (Vijaya & Manna, 1982). Females typically commence egg-laying activities between September and November, coinciding with the post-monsoon period (Singh et al., 2022). In KNP, *H. thurjii* use trails and roads to reach other parts of the wetland during the breeding season, which co-incides with the time when golden jackal predation occurs. The number of deaths from September to November was highest during our five months of study, co-inciding with the egg-laying season (Chaudhuri, 1912; Singh et al., 2022).

In contrast to *H. thurjii*, golden jackals are widely present in all habitats in KNP, with an estimated density of 14.84 individuals/km^2 (Singh et al., 2016). From August to December 2023, an increase in the movements of golden jackal was observed within blocks D, K and E blocks of the park (Fig. 1). This was recorded in the camera traps deployed to study the pythons. The local guides and staff also confirmed increased jackal movement in the D, K and E blocks (Fig. 1) (the same blocks with the most *H. thurjii* fatalities) during the period. Numerous studies have documented the predation of turtles and tortoises by various predators across different regions. For instance, predation of turtles by jackals and foxes during the turtle breeding season has been observed at Akyatan Beach, Turkey (Brown & Macdonald, 1995). However, these observations did not identify specific predation on adult or gravid females. In the Goksu Delta, Turkey, jackals have been identified as a significant predator of loggerhead turtles *Caretta caretta* and green sea turtles *Chelonia mydas*, preying on nests, hatchlings, adult females and gravid females, thus posing a substantial threat to these populations (Akcinar et al., 2006). Additionally, reports from Sariska Tiger Reserve, Rajasthan, document instances of golden jackals feeding on reptiles, although predation on turtles was not specifically mentioned (Mukherjee et al., 2004). In KNP, predation on the turtle species *H. thurjii* by eagles, vultures and jackals has been reported previously , although the intensity of such predation has never been quantified (Das & Bhupathy, 2009).

The exceptionally high population density of jackals in KNP is supported by an abundance of prey species (Singh et al., 2016). During the breeding and egg-laying season of *H. thurjii*, the heightened movement of these turtles offers jackals an easily accessible secondary prey, necessitating less energy expenditure than hunting their primary prey. In the present study, 48 instances of turtle predation were documented, characterised by limb removal and consumption of the viscera, indicative of a specialised predation strategy by golden jackals. Previous golden jackal scat analyses in KNP did not reveal any reptile remains (Sankar, 1988; Singh et al., 2016). However, recent discussions with local guides and forest department personnel suggest a perceived increase in jackal predation on turtles over the past two to three years, although they were uncertain about the species involved.

The predation on *H. thurjii*, particularly gravid females, raises concerns regarding potential demographic impacts on this endangered species in KNP. The concentration of *H. thurjii* carcasses in specific areas, particularly the trails and paths used by turtles during their breeding period, highlights potential predation hotspots, possibly jeopardising the adult female population of this Endangered turtle species, which requires further investigation. Understanding the ramifications of jackal predation on the turtle population is crucial for effective conservation strategies. Further research is essential to explore the drivers behind this predation, and its possible conservation implications. There is a risk that species, such as the Endangered *H. thurjii*, may face local extinction if multiple predators indirectly contribute to their decline (DeCesare et al., 2010). According to Sinclair et al. (1998) and DeCesare et al. (2010), endangered species with below average fitness often become secondary prey, but the establishment of spatial refuges could mitigate depensatory predation and extirpation, thereby supporting conservation efforts. Even if the predation is mitigated, it may still take the *H. thurjii* population a long time to recover as has been the case with other examples of mass predation, for example a snapping turtle *Chelydra serpentina* population in Canada predated by river otters *Lontra canadensis* failed to produce any signs of recovery, even after 23 years (Keevil et al., 2018). Evidence suggests that turtles recover extremely slowly from such catastrophic events (Brooks et al., 1991; Mullin et al., 2020).

Continued depensatory predation on *H. thurjii* in the park may necessitate 'symptomatic' management strategies (Lessard et al., 2005; Sinclair & Byrom, 2006) to minimise these interactions. These 'symptomatic' management strategies require detailed research and may include (i) actively monitoring the movement of jackals during the turtle breeding season, especially in the hotspots (Fig. 1), (ii) installing necessary barricades, (iii) actively checking for injured turtles, and (iv) providing primary and urgent care for injured turtles. As a last resort, translocating jackals to other regions of the park could also be considered. Predation on gravid females, hatchlings and nests by jackals, foxes, armadillos, raptors and humans has in the past been mitigated using similar 'symptomatic' strategies during the breeding seasons of multiple turtle species. These include the loggerhead turtle *C. caretta*, green turtle *C. mydas*, leatherback turtle *Dermochelys coriacea*, and Kemp's ridley turtle *Lepidochelys kempii* at the Hobe Sound National Wildlife Refuge in Florida, USA (Engeman et al., 2003; 2005; 2012), the Blanding's turtle *Emydoidea blandingii* in South Carolina, USA (Beaudry et al., 2010), and the olive ridley turtle *Lepidochelys olivacea* in Orissa, India (Chattopadhyay et al., 2018). However, in the case of eastern long-necked turtles *Chelodina longicollis*, mitigation involved only headstarting, in which eggs were collected from the nest, incubated, and hatchlings raised until ready to be reintroduced into the wild (Spencer et al., 2017). Headstarting could be used if symptomatic management is ineffective in controlling jackal predation (Spencer et al., 2017). In conclusion, to mitigate the predation pressure on *H. thurjii* by golden jackals in KNP and ensure the future viability of this Endangered species, urgent research into their population dynamics and biology is essential.

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RESEARCH ARTICLE

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First record of the Italian wall lizard *Podarcis siculus* on the island of Crete, Greece

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ABSTRACT – The Italian wall lizard *Podarcis siculus* is a species distributed in Italy and the east Adriatic coast. It is also a well-known invasive species introduced into four continents and many countries outside its native range. In 2014, an established population of this species was recorded in Athens, Greece, which was identified as *Podarcis siculus campestris* by molecular analysis. Here, we report for the first time the presence of another subspecies, *Podarcis siculus siculus*, in Greece and specifically on the island of Crete. Tissue samples from six adult and subadult lizards were analysed to reconstruct a mitochondrial phylogeny using a segment of cytochrome b and all published sequences of native and introduced populations of *P. siculus*. We identified the source-population of the Cretan *P. siculus* to be located in Sicily, while the Athenian population originated from the Adriatic coast. This indicates two independent introduction events in a period of < 10 years. The Cretan population of *P. siculus* seems to be well established and may pose a future threat to the endemic Cretan wall lizard *Podarcis cretensis*.

INTRODUCTION

Invasive species constitute one of the major current threats to global biodiversity. They can harm native species in several ways, such as through predation (Cowie, 2001; Montes et al., 2022), hybridisation (Rhymer & Simberloff, 1996; Pinho et al., 2009), by the spread of alien parasites and pathogens (Chalkowski et al., 2018) and by competition for more suitable microhabitats and access to more abundant and higher-quality food (Petren & Case, 1996; Ranat et al., 2023). As a result, in many cases, native species are displaced, sometimes to the point of complete extinction (Towns et al., 2006; Lo Cascio & Sciberras, 2020). There are numerous cases of invasive species globally, that involve species from almost every taxon, such as mammals, fishes and reptiles (Blackburn et al., 2019). In the case of reptiles, the most probable reason for translocations is involuntary human-mediated transport, e.g. via the trade of plants, building materials etc. but also the pet trade and the accidental or even voluntary release of non-native pet-reptiles (Farashi & Alizadeh-Noughani, 2021).

The natural range of the Italian wall lizard *Podarcis siculus* includes most of Italy, excluding the northern mountainous region and the eastern Adriatic coasts. It is a medium-sized species, with a snout-vent length (SVL) of approximately 9 cm, characterised by a wide variety of colour patterns. Regarding its taxonomy, fifty-two subspecies were previously described (Henle & Klaver, 1986), but these have been refuted by more comprehensive studies, primarily based on mitochondrial DNA evidence. Podnar et al. (2005) described six mitochondrial clades, which were grouped into two main clades with three subclades each. Senczuk et al. (2017), using mitochondrial DNA analyses and a larger, more representative sample, identified seven mitochondrial clades, also divided into two main clades. The first main clade includes the regions of Sicily and Calabria (southern Italy) and corresponds to the subspecies *Podarcis siculus siculus*, while the second clade encompasses central and northern Italy as well as the eastern Adriatic coasts and represents the subspecies *Podarcis siculus campestris* (Podnar et al., 2005; Speybroeck et al., 2016; Senczuk et al., 2017).

Podarcis siculus is a well-known invasive species. Numerous cases have been documented of the species' introduction and even establishment and spread to various countries around the world, including Portugal (González de la Vega et al., 2001), Spain (Mertens & Wermuth, 1960), mainland France (Orsini, 1984) and Corsica (Sindaco et al., 2006), Great Britain (Hodgkins et al., 2012), Switzerland (Schulte & Gebhart, 2011), Greece (Adamopoulou, 2015), Turkey (Başoğlu & Baran, 1977), Cyprus and Montenegro (Speybroeck et al., 2016), Azerbaijan (Iskenderov et al., 2021), Russia (Tuniyev et al., 2020), Tunisia and Libya (Arnold & Ovenden, 1978), the United States (Deichsel et al., 2010; Kolbe et al., 2013) and Canada (Hanke & Deichsel, 2020).

On a herpetological tour that took place in October 2023 across a stream at Kladisos beach, near Chania, Crete, Greece (35° 30′42″ N, 24° 00′08″ E; Fig. 1), AZ encountered a robust population of *Podarcis* lizards. Adults and juveniles were mainly encountered basking on a wall beside the stream, in a habitat consisting of reeds and several species of non-native palms. This stream lies at the edge of a small semi-natural area of about fifteen hectares with sand dunes, surrounded by an urban landscape. Several (> 100) lizards were detected, and the inspection of their morphological characteristics suggested that they were probably Sicilian wall lizards. The aim of the current study was to identify these lizards at the species-level and to clarify their geographical origin using molecular techniques.

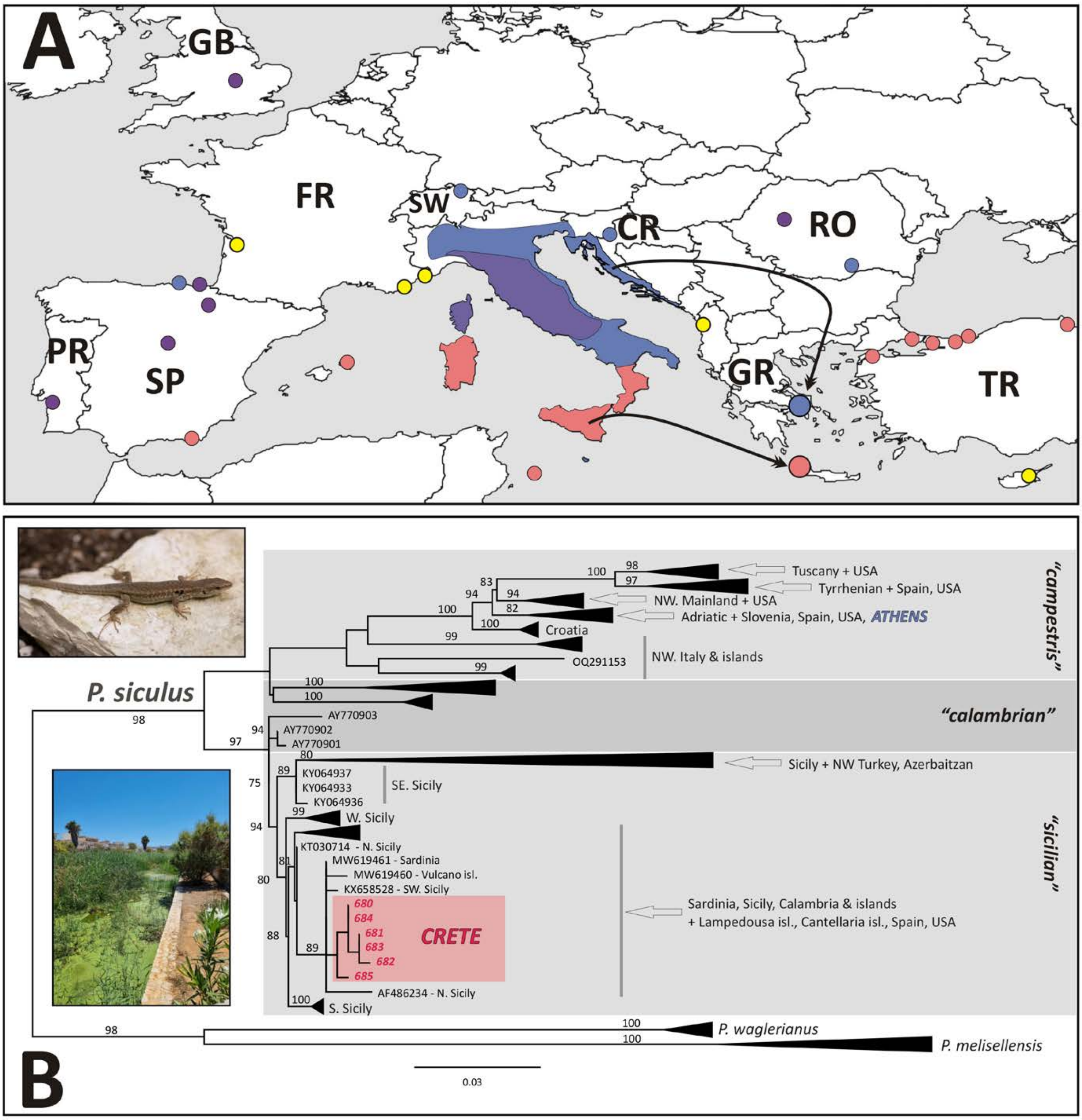

Figure 1. **A.** Map of the native geographical distribution of *Podarcis siculus* (coloured area) and the respective distribution of the main three mitochondrial lineages identified by Senćzuk et al. (2017) (pink, blue and purple). Introduced populations around the Mediterranean are shown with coloured circles, according to their origin (country names given with a two-letter code (after Mizsei et al., 2016: Speybroeck et al,, 2016; Koç et al., 2018; Oskyrko et al., 2022a). Yellow circles denote introduced populations of unknown origin. Big circles show the location of the two alien populations of Greece (Athens, blue; Crete, pink) and arrows show the source-location. **B.** The maximum-likelihood (ML) mitochondrial gene tree. The major phylogenetic clades are collapsed, except in the case where the Cretan specimens are placed. Nodal support is given in the values besides each remaining node as posterior probabilities and are shown only when > 50. The main three mitochondrial lineages are shaded and the geographical location of the individuals included in each lineage is given. The inserted photographs depict the habitat of the introduced Cretan population (Kladisos stream) and one of its individuals.

MATERIALS & METHODS

We visited the stream at Kladisos beach to collect tissue samples from the focal population of *Podarcis* lizards. Six individuals, two adults and four juveniles, were captured by hand and the autotomised tips of their tails were collected by gently pulling on the end of the tail until a small segment broke off along a fracture plane. Tail-tips preserved in 95% alcohol were transferred to the Evolutionary Biology Lab, Department of Biology, University of Patras, Greece, and deposited in its herpetological collection (voucher numbers 680–685). These tissue samples were processed through

DNA analysis to confirm the initial identification at the species level and to assess the phylogenetic position and geographical origin of the Cretan population.

Total DNA was extracted and the commonly used mitochondrial marker cytochrome b (cytb) was PCR-amplified, using the primers GluDG-L (5’ TGA CTT GAA RAA CCA YCG TTG 3’) and CB3H (5’ GGC AAA TAG GAA RTA TCA TTC 3’) from Palumbi (1991) and the sequencing protocol of Oskyrko et al. (2022b). PCR-products were sequenced in both forward and reverse directions and final sequences were approximately 500 bps long. The six sequences from the Cretan population were individually compared against the many thousands of sequences belonging to numerous representative species of the genus *Podarcis* that are deposited in GenBank. Specifically, we used the BLAST search-algorithm (https://blast.ncbi.nlm.nih.gov/Blast.cgi) for highly similar sequences (Mega BLAST) and found maximum similarity to *P. siculus*. One representative from several lineages of the peri-Mediterranean *Podarcis*, i.e. Spanish, Italian and Balkan wall-lizards (see Yang et al., 2021), was retrieved from GenBank and a preliminary, backbone phylogeny (not shown) was built including our own samples from Crete. The Cretan samples were placed in the *P. siculus* clade, verifying the original macroscopic identification at the species level.

In order to detect the source of the introduced Cretan population, we downloaded all available cytb sequences of *P. siculus* published in GenBank (> 600), excluding those of a dubious or unknown origin, a length of < 400 bps or a high percentage of missing data. The remaining sequences were aligned with ClustalX v.2.0.12 (Larkin et al., 2007). Our final dataset included the majority of published sequences from across the native range of *P. siculus*, all the localities where introduction of this species has been reported, and the newly founded population of Crete. Sequences of two closely related wall-lizard species, *Podarcis waglerianus* and *Podarcis melisellensis* served as outgroup, adding to a total of 786 sequences (Supplementary Table S1). A Maximum Likelyhood (ML) tree was reconstructed under the 3-codon partitioned scheme implemented in IQ-TREE v.1.6.7 (Nguyen et al., 2015). The best substitution model was determined with the modelfinder option (Chernomor et al., 2016; Kalyaanamoorthy et al., 2017) and nodal support of the tree was tested via 10,000 replicates of the SH-like approximate likelihood ratio test (SH-aLRT; Guindon et al., 2010). The analysis was repeated twice to ensure convergence.

RESULTS

Our six cytb sequences revealed four very similar haplotypes, differing among each other only in one or two single-site polymorphisms. None of these haplotypes was identical to any of the other analysed sequences either of native or introduced Sicilian wall lizards, but was almost identical to one haplotype from Alghero, north-west Sardinia and another from the Vulcano Isle (north-east Sicily) (Salvi et al., 2021). It should be noted that the lack of exact similarity among the Cretan haplotypes and other previously published sequences of *P. siculus* may not reflect true genetic divergence but could be due to differences in the methodological approach applied in each case (primer-pair, PCR-conditions, PCR-product length etc.).

The ML analyses returned the same tree (Fig. 1B), with a topology very similar to the numerous published mitochondrial phylogenies of *P. siculus*, for example those in Podnar et al. (2005), Silva-Rocha et al. (2014), Senczuk et al. (2017) and Oskyrko et al. (2022b). As in all previous phylogenies, we also retrieved several mitochondrial clades and subclades. The two major ones correspond to the two subspecies *P. s. campestris* and *P. s. siculus* which are geographically located at the north and south, respectively, of the natural distribution of the two species and meet in Calabria (southern Italy). In general, all sequences from Crete were placed in the same clade with sequences natively distributed in southern Italy (Calambria), Sicily and adjacent islands (Fig. 1B). This clade, named “the Sicilian” clade by many authors (e.g. Silva-Rocha et al., 2014), is also the origin of many worldwide, overseas invasions of the species, such as Sardinia (Senczuk et al., 2017), Menorca (Podnar et al., 2005) and California (Kolbe et al., 2013). Interestingly, another introduced population of this species that had been recently found in Athens, Greece (Adamopoulou, 2015; Fig. 1A) is placed in another clade, namely “the Campestris-sicula”, which corresponds to one of the subclades within the *P. s. campestris* subspecies (see also Silva-Rocha et al., 2014).

DISCUSSION

The Sicilian wall lizards found in west Crete share a very similar mtDNA haplotype with the Sicilian populations, a fact that implies that they are probably a result of a recent human-induced dispersal from there. However, we cannot exclude the possibility of a secondary dispersal from other introduced populations, such as Turkish or Sardinian ones. As documented in other cases, e.g. in Spanish or North American populations which originated from several different sources, the two currently known populations of *P. siculus* introduced in Greece originate from geographically distant regions and were established after two recent but distinct human-mediated events.

The Cretan population is probably very recent, as these lizards had not been observed until now, despite the high herpetological interest focused on Crete and the numerous scientific expeditions and herpetological tours of the past years. The ongoing transportation of people and products across the Mediterranean has acted as an agent for the passive dispersal of many reptiles (Bisbal-Chinesta et al., 2020 and references therein). In the case of *P. siculus* in Crete, we consider the plant trade to be the most probable means of the lizards’ transportation, since many exotic ornamental plants (i.e. *Trachycarpus fortunei, Livistona chinensis, Phoenix canariensis* and *Washingtonia robusta*) have been recently planted in the area around the Kladisos stream. The plant trade is also the most likely explanation for the Athenian population (Silva-Rocha et al., 2014) and for other invasive populations, i.e. in Catalonia (Rivera et al., 2011), Gorgona Island (Zuffi et al., 2022), and Great Britain (Clemens & Allain, 2021). Alternatively, the lizard’s transportation could be a result of the high touristic flow, e.g. yacht tours connecting popular touristic destinations, such as Sicily and Crete or the pet trade as suggested for various populations introduced to the United States (Kolbe et al., 2013).

The introduction and establishment of the Sicilian wall-lizard may eventually pose a serious threat to native *Podarcis* species. It has been documented that the extinction of *P. melliselensis* on several Adriatic islands was probably due to competitive exclusion following the introduction of *P. siculus* (Nevo et al., 1972). Hybridisation of introduced *P. siculus* with *Podarcis tiliguerta* (Capula, 2002), *P. waglerianus* (Capula, 1994) and *Podarcis raffonei* (Capula et al., 2002) has also been observed in Sardinia, Sicily and the Aeolian islands, respectively. In other cases, introduced *P. siculus* has now spread across the entire range of islands, such as Menorca, where the species had been introduced in historical times (Alcover, 1981), or the Gorgona Island where it has been recently introduced (probably within the last 25 years; Zuffi et al., 2022). In the case of Crete, it is possible that *P. siculus* will eventually constitute a significant threat to the endemic Cretan wall lizard, *Podarcis cretensis*. Currently, both species have been found to coexist in the same habitat, although the second one seems to be less abundant. Extensive future studies focusing on the geographical distribution and population size of the introduced lizard population are needed to map and estimate the extent of its establishment and spread. Population surveys and behavioural experiments investigating the interaction between *P. siculus* and *P. cretensis* will form the basis for designing management measures to prevent further spread of the species on the island. In several cases, the eradication of the established *P. siculus* population has been proposed or applied, wherever potential threats to the native species have been identified (Hodgkins et al., 2012; Adamopoulou & Pafilis, 2019). Given the endemic status of the Cretan wall lizard, such measures might also be implemented in Crete.

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Data accessibility

Mitochondrial cytb data are deposited in the NCBI Nucleotide Database (accession numbers: PQ591857 - PQ591862).

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SHORT NOTE

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Sporadic nesting records of the loggerhead sea turtle *Caretta caretta* along the Greek shores of the Aegean Sea

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ABSTRACT – In Greece, about 18% of loggerhead sea turtle nesting occurs around the Aegean Sea, on specific beaches that are monitored regularly. Sporadic nesting is also recorded incidentally in other areas. We present here the sporadic nesting events, along the Aegean coasts of Greece, for the 41-year period 1984–2024. Beaches with multiple nesting events, in the same or different nesting seasons, should be further investigated as this may lead to the discovery of new nesting sites that support regular nesting.

INTRODUCTION

The loggerhead turtle *Caretta caretta* (L.) is the most common species of marine turtle in the Mediterranean Sea where it breeds mainly in its eastern basin (Margaritoulis et al., 2003). Casale et al. (2018) identified 52 major nesting sites of loggerhead turtles around the Mediterranean using as a criterion sites exhibiting an average nesting magnitude of > 10 nests/year and an average nesting density of > 3 nests/km/year. These 52 sites comprise an average of 6,751 nests/year, with Greece hosting approximately 45.7% of these (Casale et al., 2018).

Within Greece, 82% of nesting occurs in the Ionian Sea, with the nesting sites of Zakynthos and Kyparissia Bay exhibiting the highest nest numbers and densities, while only 18% of nesting activity occurs in the Aegean Sea, primarily on the island of Crete (Casale et al., 2018). Since the beginning of the 1990s, the three major nesting sites on Crete have been monitored annually by ARCHELON (Margaritoulis & Panagopoulou, 2010). In addition, since 2016 the south-eastern coast of Lakonia, not included in the list of sites set by Casale et al. (2018), is monitored by a local organisation (Toulipa Goulimi) in co-operation with ARCHELON.

Besides the regular nesting that is monitored in these nesting areas, so-called ‘sporadic’ or ‘diffused’ nesting activity occurs across the country (Margaritoulis et al., 2003). Information on sporadic nesting is useful as it may result in the discovery of new regular nesting (Prato et al., 2022). Here, we present sporadic nesting records of loggerhead turtles that have been collected during 41 years along the Greek coasts of the Aegean Sea.

MATERIALS & METHODS

As early as 1984, ARCHELON encouraged its members and volunteers, and later the general public, to report any sea turtle nesting events encountered across the country. By ‘nesting event’ we consider the appearance of a sea turtle (adult or hatchling) on a beach, as well as tracks, imprinted on the beach sand, that are left either by adult turtles (after their emergence for nesting) or by hatchlings (after their emergence from a hatched nest). In the early years, such reports were collected in the form of hand-written messages, and later through the 24h-7d telephone line of the ARCHELON’s Sea Turtle Rescue Network and through email. In 2024, we developed a specific platform (in Greek and in English) on ARCHELON’s website https://archelon.gr/en/support-us/found-a-nest-or-hatchlings which was used directly by citizens. A number of records were also obtained from publicly shared information in social media.

Citizens were asked to provide photographic documentation and, if willing to do so, to protect the nest on site. Occasionally, the local Coast Guard or the municipality were called and assisted in the protection of the nest. Nesting events reported by citizens within the regularly monitored areas were not included. Photographs showing tracks, adult turtles or hatchlings were studied to confirm the nesting event and if possible to identify the turtle species.

We entered all records in an electronic database, this involved registering the date, the relevant municipality and the name of the beach, as well as the name and contact details of the reporter. We cleaned up the database, as much as possible, by deleting multiple reports of the same event and reports of hatchlings that were hatched from previously reported nests.

RESULTS & DISCUSSION

We recognised in total 577, presumably different, nesting events along the Greek coasts of the Aegean Sea (Fig. 1). However, due to difficulty in differentiating non-nesting emergences (when a female sea turtle crawls out of the water to lay eggs but then returns to the sea without nesting) and nestings, the results presented here should not be used as a measure of the frequency of nesting in a specific area but rather to indicate the beaches for which

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Figure 1. Nesting records of loggerhead sea turtles *Caretta caretta* on the Greek coasts of the Aegean Sea (area in blue) reported in the period 1984–2024. Numbers indicate different records on same or neighbouring beaches. The four areas, coloured in green, are sites of regular nesting monitored by ARCHELON.

turtles showed a preference for nesting. The opportunistic nature of data collection and the long period (> 40 years) of data accumulation, assures an acceptable general picture of the sporadic nesting distribution of *C. caretta* along the Greek shores of the Aegean Sea.

Nesting events were more frequent in southern latitudes, with maximum occurrence on Crete (309 events), and this may be due to the higher sea water temperatures in the southern Aegean in comparison to its northern part (Pastor et al., 2018). Northernmost events were reported from Samothraki (non-nesting emergence), Halkidiki (confirmed nests), Magnesia (confirmed nests) and Lesvos (confirmed nests). Of note, a non-nesting emergence of a loggerhead turtle was described by Kasparek (1991) on the western coast of Limnos Island.

Several areas, and specific beaches, exhibited repeated nestings during the same or subsequent seasons (e.g. Attica, eastern Peloponnese, Rhodes, Komi beach in southern Hios, Kantouni beach in Kalymnos), and this deserves further investigation. Five confirmed nests, not included in our database, were reported by Pietroluongo et al. (2021) for Samos Island. Sporadic nesting reports may provide strong clues leading to the discovery of new sites hosting regular nesting when the area in question is subject to adequate monitoring (Prato et al., 2022).

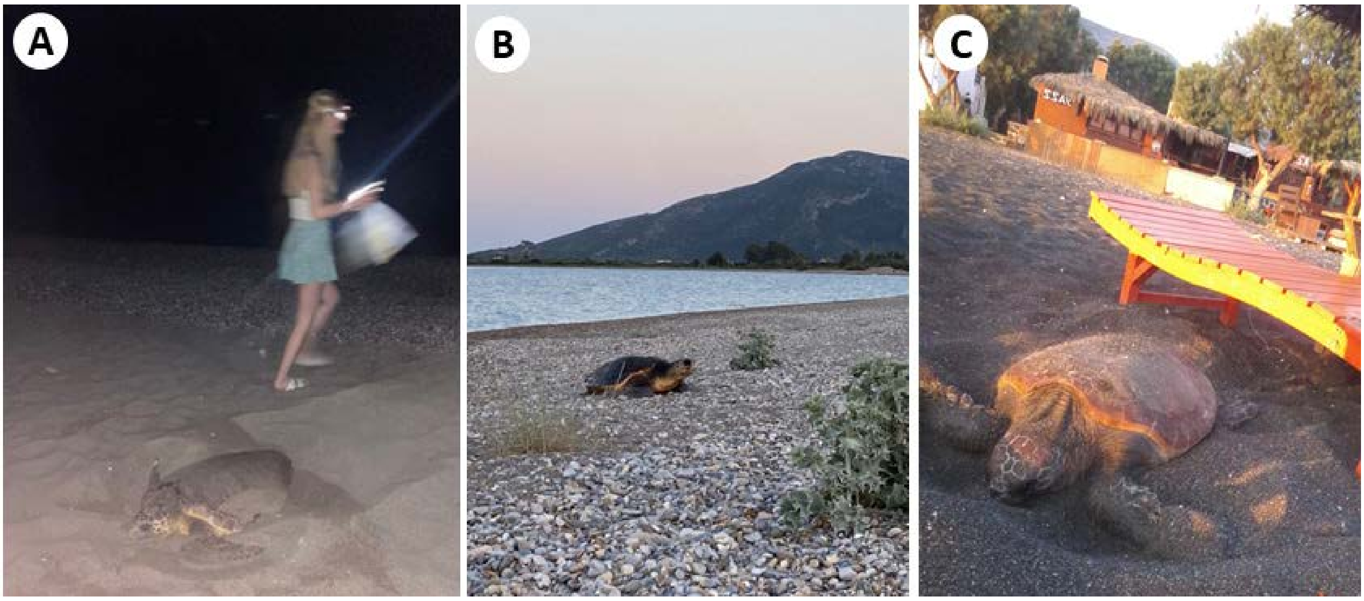

Figure 2. Emergent loggerheads, photographed by citizens - **A.** Lardos beach, Rhodes (4 July 2022), **B.** Daytime emergence at Moustou Lake, East Peloponnese (3 June 2022), **C.** Excavation of a body pit among beach furniture at Perissa beach, Thira Island (22 June 2018)

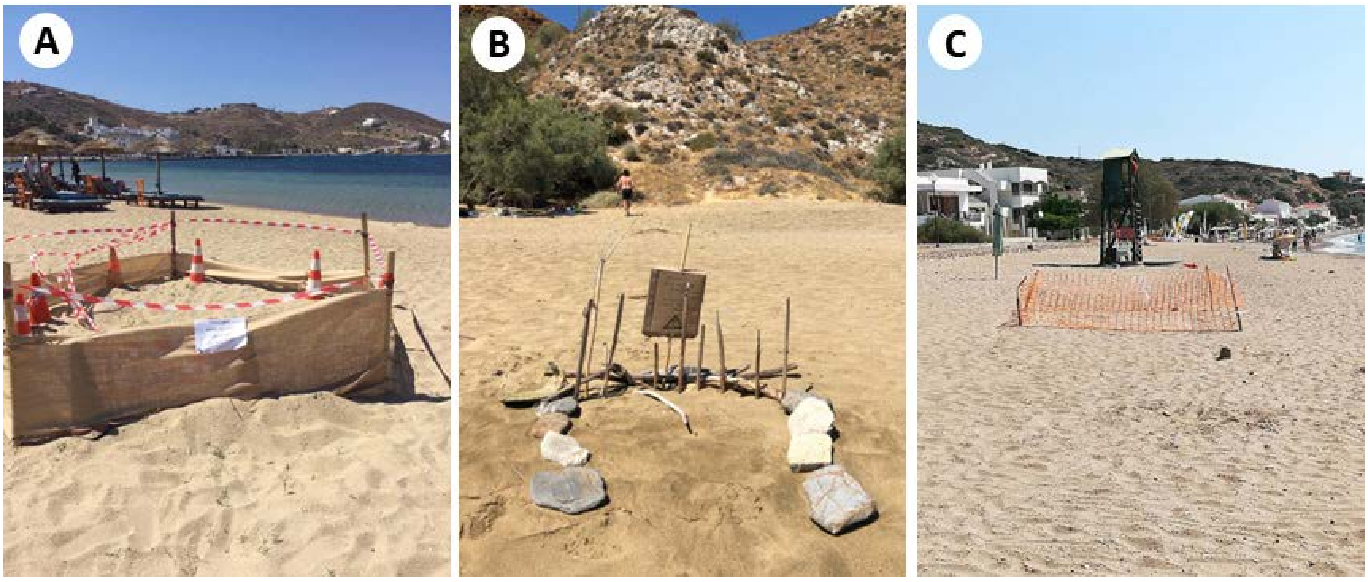

Figure 3. Makeshift protection of nests - **A.** Ios Island, Cyclades (11 July 2022), **B.** Anafi Island, Cyclades (28 July 2022), **C.** Komi, Hios Island (24 June 2018)

All photographed turtles, both adult females and hatchlings, were identified as loggerheads (Fig. 2).

Most nests, or possible nest sites, were protected by citizens or by the local Coast Guard or municipality, with makeshift constructions aiming primarily to prevent trampling (Fig. 3).

A similar spatial distribution of loggerhead nests appears along the Turkish coasts of the Aegean Sea with fewer nests reported in northern latitudes, as in Çanakkale province (39° 30.675′ N, 26° 05.024′ E) (Yalçın Özdilek et al., 2020), and on the Island of Gökçeada (Imvros) (Sandik et al., 2023). More nests have been reported in southern latitudes of Turkish coasts, as in Urla (Region İzmir, opposite to Hios), Kuşadası (Region Aydin, close to Samos), and Marmaris (Region Muğla, opposite to Kos and Rhodes) (Sandik et al., 2023).

Loggerhead turtles are not strongly philopatric so females may deviate from their usual nesting sites and explore other beaches (Carreras et al., 2018). Consequently, despite the incidental nature of our data, it seems reasonable to assume that loggerhead turtles may be expected to nest at any suitable beach in the Aegean Sea, at least south of 39° N.

ACKNOWLEDGEMENTS

We thank all those who spotted nesting events and made the effort to report them. We especially thank the Coast Guard officers and municipality personnel, the Hydrobiological Station of Rhodes, the Volunteers for Sea Turtle Protection in Sitia, the Naxos Wildlife Protection, the Management Agency of Parnon and Stavros Environmental Association Crete. Several ARCHELON volunteers helped in receiving and archiving sporadic nesting reports. Lenio Margaritouli made the graphics on a base map, from the MapTool program, provided by seaturtle.org.

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SHORT NOTE

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Pair bonding and multiple matings in the western green lizard *Lacerta bilineata*

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ABSTRACT – Few studies have focused on the activities of individual lizards, which have often been hampered by the problems of tracking them in natural environments. Using photographs, the behaviour of western green lizards *Lacerta bilineata* were observed during the springs of 2023 and 2024. The length of time that males paired with females varied from only a few days to over most of the reproductive season and in this time, two females, one during 2023 and one in 2024, mated with more than one male, suggesting that reproductive performance may be enhanced by polyandry. Furthermore, one of the females appears to have laid egg clutches twice within a year, a further enhancement of reproductive performance.

INTRODUCTION

The western green lizard *Lacerta bilineata* occupies a range of habitat types including woodland edges, hedgerows and scrub areas. It is one of the larger European lizards feeding mainly on invertebrates and occasionally other lizards (Street, 1979). In the study locality the main reproduction period is April to June during which males hold territories that are defended against other males. Females are usually intolerant of each other but mate and pair with males for varying time durations. Although there are several studies on the population ecology of *L. bilineata* there are few at the level of the individual, especially during the reproductive period (Meek & Luiselli, 2024a). In part this is due to the problems of tracking and identifying the lizards in dense vegetation. In addition, matings are often brief and hence observing this behaviour relies heavily on chance (Uller & Olsson, 2008). However, the data on the duration and extent of pair formation and social interactions are important in population ecology since they impact on spacing patterns and ultimately on reproductive success (e.g. Uller & Olsson, 2008). The present observations form part of a long-term study on the behaviour and population ecology of *L. bilineata* (e.g. Meek & Luiselli, 2020; 2022; 2024a; 2024b). The information presented here is derived from observations of longer-term pair bonding and mating frequencies in individual lizards during the spring/summer periods of 2023 and 2024. Although based on small sample sizes the observations give some insight into the behaviour of *L. bilineata* during the key reproductive period.

HABITAT & METHOD

The study locality was a hedgerow (Fig. 1) situated in western France (46° 27’ N, 1° 53’ E). It consisted of mostly low growing bushes (*Rubus fruticosus* and *Hedera helix*), ash trees (*Fraxinus excelsior*) and oaks (*Quercus robur*) bordered by a drainage ditch that was usually dry by June due to desiccation from high temperatures (Fig. 1B). A prominent plant was *Actium lappa*, where much of the basking and mating activities of female B and male C took place (Fig. 1A). The total length of the surveyed section was about 260 m. The area is an open system with no barriers to prevent lizards from entering or moving outside the study area.

Figure 1. Examples of hedgerow habitat showing where most basking and mating activities were observed - **A.** Where female B and male C were photographed, **B.** Where female A and males A and B were photographed

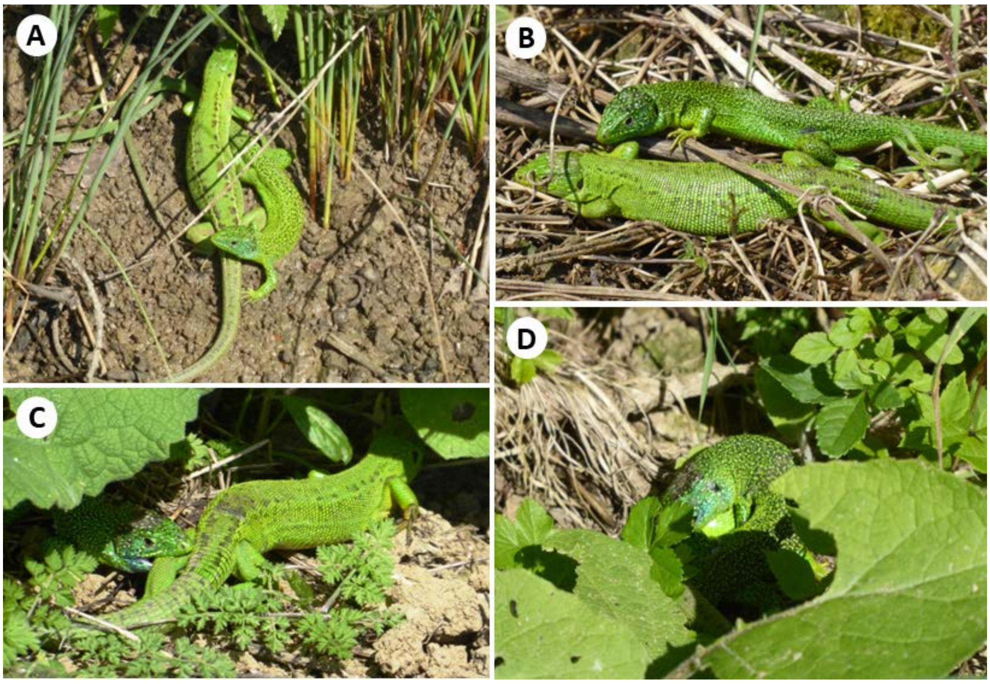

Figure 3. Reproductive behaviours of individually recognised western green lizards - **A.** Mating guarding of female A by male A during 2023, **B.** Mating guarding of female B by male C during 2024, **C.** & **D.** Parts of the mating sequence of female B and male C during late morning (beginning 11:50 h) on 3 June 2024, this pair remained together from April to June, copulation scars can be seen on female B from previous matings. This pair were observed mating twice and on both occasion the lizards were under the broad-leafed *Actium lappa* shown at the edge of the hedgerow in Fig 1A.

Except during inclement weather, daily sampling was approximately even across seasons and carried out 5–6 days each week for around 45–60 minutes daily and, depending on the weather conditions, undertaken between 08:30 h and 13:00 h by a single observer. The hedgerow was surveyed over a total of 1,560 m each day. Data collection was by surveying the entire study hedgerow an equal number of times daily and photographing all sighted lizards using a Lumix DMC-TZ70 camera. This was set to Intelligent-Auto mode for rapid use. When possible, several photographs of each lizard were taken and then individuals recognised by colour pattern differences including variation in the shades of green, dorsal spots and lines. This was aided by making use of the computer enlargement facility. Given the relatively low numbers of lizards present recognition error was likely small.

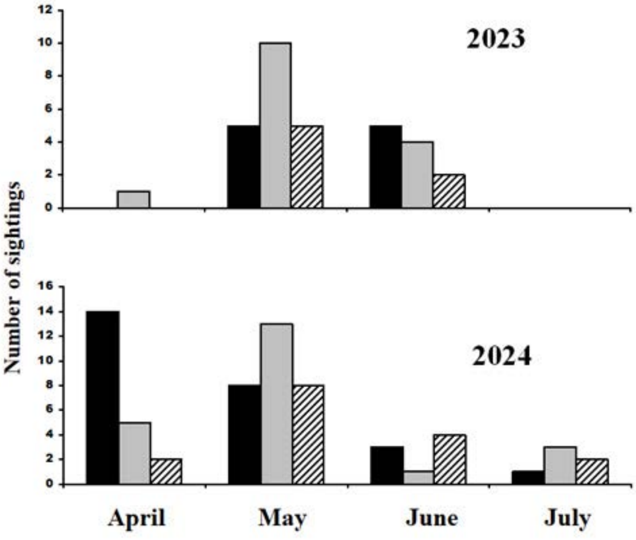

Figure 2. Sighting frequencies of adult western green lizards along a hedgerow, solitary males (black), females (grey) and lizards pairings (cross-hatched), in the main reproductive period for this species

RESULTS

In total, 32 lizard sightings were made during 2023 of which 25 were of solitary basking lizards with 7 sightings of males paired with females (= 21% of total). During 2024, there were a total of 64 sightings of which 16 were males paired with females (= 25% of total). Annual counts of lizards in pairs during the two years as proportions of total sightings were in good statistical agreement, two tailed z-score = 0.083, P = 0.4. A summary of monthly sighting frequencies, including sightings of pairs, is shown in Fig. 2.

2023. Male A was observed from 1 May to 27 May (27 days between first and last sighting) when it was seen a total of 16 times, 5 of these were with female A (Fig. 2A) with mating between the two on 12 May. First sighting of female A was on 28 April, which was observed 18 times from 16 May to 6 June giving a time span of 52 days. A second male, male B, was seen only twice, initially during solitary basking on 5 June and then mating with female A on 6 June.

2024. Male C was first observed on 8 April and subsequently 47 times until 14 July giving 98 days between first and last sighting. Female B was sighted from 18 April until 13 July, giving 87 days between the first and last sighting. Of these 22 were solitary basking and 16 occasions with male C (both shown in Fig. 3B). These two individuals were thus recorded together over a time span of 84 days. Female B was observed mating with male C on 9 May and 3 June (example in Fig. 3C & D). There were indications that she deposited two clutches of eggs, the first around 28 May and a second on July 7. This was based on noticeable loss of body mass and folds along the flanks on both occasions. A third male D, was seen only 4 times with female B but mated with her on 11 July. This indicates the female mated three times, with two different males, one being with the long time pairing partner male C twice and with the second male, which she paired with for only a limited time period.

DISCUSSION

The observations reported here present interesting new aspects of *L. bilineata* behaviour in a field context. For example the second egg clutch in female B was unexpected. Previously, double egg clutches had not been observed in any female during the 5-year study (Meek & Luiselli, 2024a). Literature searches showed no reports of second matings in *L. bilineata* in a field environment. A cooler and much wetter spring climate potentially increased invertebrate prey that could have provided sufficient nutrition to support a second egg clutch. This suggests that short-term changes in climate can impact the resources driving lizard behaviour at a finer level. The long duration of pairing behaviour, although in theory conferring benefits of shared vigilance both for detecting prey and predators, may actually increase risks. For example, pairings also increase probability of detection especially if one sex is paired with a much more visually noticeable individual (Fig. 3). May was a key month for reproductive activity (Fig. 2) with most sighting of individuals and lizard pairings, mating and egg laying but also the beginning of foraging activity of the saurophagous whip snake *Hierophis viridiflavus*. During 2024 three sightings of this species were on 19 May, 2 June and 3 June, possibly the same individual. Male C was photographed on June 5 showing tail loss of 4–5 cm that may have involved the foraging whip snake.

The observed multiple matings by both female *L. bilineata* are well known to occur in other lizards including lacertids where it leads to polyandry, for instance in *Psammodromus algirus* (Salvador & Veiga, 2001), *Lacerta agilis* (Gullberg & Tegelstrom, 1994; Olsson et al., 1996; 2011) and *Zootoca vivipara* (Fitze et al., 2005). In *L. agilis* polyandry involves sperm competition that produces egg clutches with high hatching success and juveniles with `good genes` resulting in offspring with high survivorship (Olsson et al., 2011). Male *L. agilis* also guard females as do male *L. bilineata* but the high frequencies of solitary female *L. bilineata* sightings compared to paired sightings suggests mate-guarding is more limited compared to other species of lizard (e.g. Cooper, 2003). Absent males would likely facilitate polyandry and support for this was seen in the second mating of female B during 2023 when she moved outside her normal territory, suggesting she may have been searching for a different mate. However, the present observations are based on a limited number of lizards living in a man-made ecotonal environment where the individual component of populations changed both within years and over multiple years (Meek & Luiselli, 2024a). Nevertheless, the observations here suggest that female *L. bilineata* increase reproductive effort by producing double egg clutches and potentially enhance hatchling quality by polyandry. Future research with more comprehensive data sets may give better insights in assessing the frequency of longer-term pairings and polyandry in female *L. bilineata* given that these are apparently key adaptive traits (Uller & Olsson, 2008).

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SHORT COMMUNICATION

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Responses of a copulating male common krait *Bungarus caeruleus* to the approaches of a rival male, with a link to video evidence

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The common krait *Bungarus caeruleus* is one of the most widespread krait species in South Asia, causing thousands of cases of snake bite morbidity annually (Bawaskar & Bawaskar, 2004; Ariaratnam et al., 2008). Currently, most of the information on the reproductive biology of *B. caeruleus* is confined to mating time and oviposition (Bannerman, 1905; Wall, 1908; Simon, 1942; Webb-Peploe, 1946). Herein we report observations of mating in the common krait *B. caeruleus* Schneider, 1801 with emphasis on the response of a mating male to a rival male.

While on a rescue call on 29 September 2023 at a residence in Billwagram, Bethuadahari, Nadia district, West Bengal (23° 34’37” N, 88° 23’02” E), DB observed a mating pair of *B. caeruleus* with the anterior portions of their bodies hidden inside a burrow in a boundary wall while the posterior portions, in copula, were outside the burrow and fully visible (Fig. 1A). A video recording was made of the behaviour shown by these snakes (BHS video, 2025). The female was slightly larger (~1 m) than the mating male (~0.9 m). According to local people, the snakes began mating at ca. 19:15 h, but our observations did not start until ca. 20:47 h, so that courtship behaviour was not recorded. A rival male approached the mating pair at ca. 21:02 h. The rival male touched the female’s posterior body with its rostral scale and started tongue-flicking. Despite having its head inside the burrow, the mating male sensed the rival and started twitching its tail. The rival turned its head slightly towards the tail movement, started twitching its own tail, and then placed its head in the burrow (Fig. 1B) while the mating male’s tail display continued. Shortly afterwards, the rival removed its head from the burrow (Fig. 1C) and tongue flicked the dorsum of the mating male’s body. This elicited a strong lateral jerk causing the rival to retract. This was followed by another sudden retraction when the wiggling tail-tip of the mating male touched the rival’s head. Thereafter, there was a retraction each time the rival’s head or neck came in contact with the twitching tail of the mating male. The mating male then removed its head from the burrow and there began a combat-like ritual with the rival (Fig. 1D). The mating male began intercepting the rival by lateral head-jerks along with tail-twitches. The rival swayed and made several quick retreats whenever the mating male’s head or tail touched the flanks of its head or neck. This ritual began at ca. 21:03 h and went on for approximately 97 seconds, with several short pauses of 3–10 seconds. At ca. 21:05 h the rival attempted to enter the burrow twice more with a gap of 10 seconds between each attempt, but was driven away by the mating male’s tactics. At 18 seconds after the second attempt, the rival approached the burrow one last time, turned back and left the site permanently. From first sensing the rival male up to its final retreat, the mating male continued its tail display for approximately 3

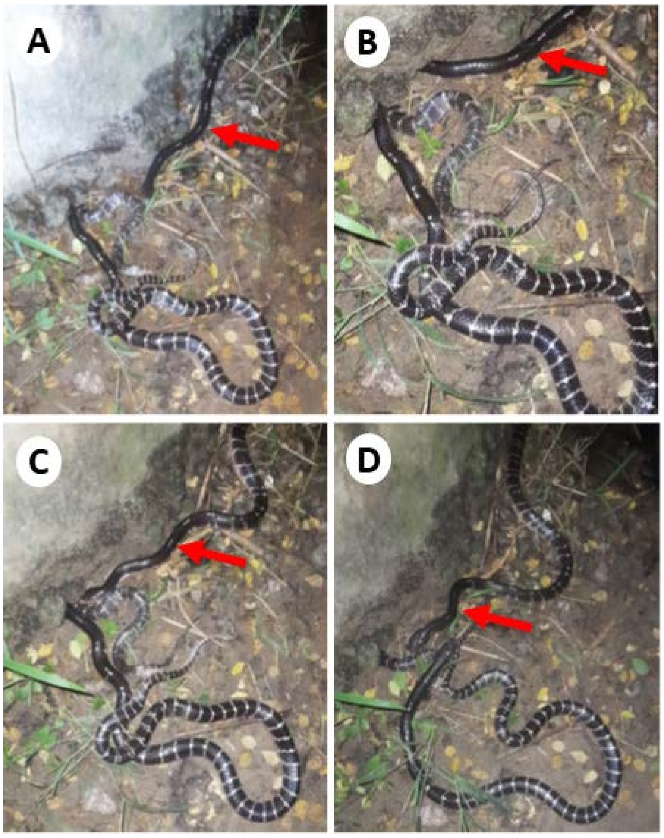

Figure 1. A mating pair of *Bungarus caeruleus* approached by a rival male (indicated by red arrows) - **A.** The partially visible mating pair with the anterior portion of their bodies in a burrow in a wall, a rival male is approaching from the right, **B.** The rival male has placed its head in the burrow, **C.** The rival male has withdrawn its head from the burrow, **D.** The mating male has withdrawn its head from the burrow and is engaging the rival

minutes 35 seconds. Copulation ended at ca. 21:13 h with visible separation of the genitalia, and the snakes left shortly afterwards.

The response of a mating male to a rival does not appear to have been recorded previously in *Bungarus* spp or other snakes. Unlike male combat, the male-male face-off in this case didn't involve attempts to pin down the opponent, possibly because this is impractical for a snake that is mating. The observed response would seem to be more similar to mate guarding behaviour that is shown by certain male snakes for some days after copulation, e.g. *Vipera berus* (Luiselli, 1995).

We are aware of two other observations of mating *B. caeruleus* in eastern and northern India. On 16 October 2023 on a rescue call, SG observed a mating pair of *B. caeruleus* in a residence in Koralimath, Bethuadahari, Nadia district, West Bengal (23° 34'59" N, 88° 22'22" E). The mating allegedly began at ca. 18:00 h and observation was continued from ca. 18:35 h onwards. The pair remained partially hidden inside a small burrow in the brick wall of a dilapidated house with only the caudal portions being visible (iNaturalist, 2024). The female showed signs of moulting. Mating continued until the snakes disengaged at ca. 20:10 h and went inside the burrow. We are also aware of an account and photos of *B. caeruleus* mating posted on Facebook (2024). The mating pair was observed near human settlements, in the early hours of 13 September 2019 in Aligarh city, Aligarh district, Uttar Pradesh (GPS waypoints unavailable). The pair copulated beside a mud wall, with the female being partially hidden inside a burrow in the wall. The pair was photographed and observed for nearly 20 minutes and left undisturbed thereafter.

Wall (1908) stated February and March to be the probable mating time of *B. caeruleus* whereas, Simon (1942) speculates November–early December to be the mating time based on his observation. Our observations suggest that at least in northern and eastern India, mating can begin from September (post-monsoon) onwards. Notably, this is similar to the mating time of this species in Sri Lanka (de Silva, 1986). Active use of natural hiding spots by the copulating snakes in all three cases suggests active threat avoidance.

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SHORT COMMUNICATION

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A new record of karstic limestone cave dwelling odorous frogs *Odorrana* sp. from western Guizhou

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Southern China is one of the diversity hotspots for odorous frogs (*Odorrana* spp.), a genus with a wide distribution in south-east Asia (Frost et al., 2024). Currently, there are 66 described species within the genus and of the 43 known from China, 28 are endemic (Frost et al., 2024). Guizhou province, located in south-western China, is known for its high species diversity due to the karstic mountain formations, limestone caves, and its role as a refuge from Quaternary glaciation events (Jiang et al., 2022). These characteristics provide a variety of microhabitats that are ideal for endemism and speciation. It is no wonder that new species, such as those from *Odorrana* have been described from this region as recently as 2024 (Li et al., 2024).

Most species of *Odorrana* inhabit high-gradient mountain-streams (Li et al., 2024), although several taxa have been found to inhabit karstic limestone caves. These include - *Odorrana lipuensis* which is known exclusively from the dark karstic limestone caves of eastern Guangxi, China (Mo et al., 2015); *Odorrana liboensis* known only from the dark karst cave of Maolan National Nature Reserve, Libo County, Guizhou province, China (Luo et al., 2021); and *Odorrana wuchuanensis* known to occur with a restricted distribution in dark caves in southern Guizhou to northern Guangxi, northern Guizhou in Wuchuan county and Hubei (IUCN, 2020; Wu, 1983).

While hiking in the karstic mountains near Xiabacun, Xixiu District, Anshun, Guizhou, I encountered individuals of the genus *Odorrana* twice within the limestone caves on these mountains and photographed them (Sony α-6400 with FE 2.8/50 macro lens). The first encounter occurred at 16:00 h on 4 October 2024, in a small limestone cave, with a water condensation stream in south-east of Xiabacun (26° 9’32.594” N, 105° 52’51.862’ E, altitude 500 m). The path to the cave entrance was modified with concrete stairs and wooden fencing up to the cave. The cave is heavily disturbed by humans, a path has been dug into the floor of the cave and loose pieces of sedimentary rock, dirt and trash were present within the cave. Upon entering the dark cave, three juvenile frogs were found on the ground on the dirt path, there were two brighter green ones and one darker green individual, each had black spotting on their backs and sides, with banding on arms and legs (Fig. 1). They scattered in reaction to torchlight and hid under loose rocks.

The second encounter occurred at 14:50 h on 7 October 2024, in a cave on the mountains of Xiabacun, Xixiu District, Anshun, Guizhou (26° 9’32.594” N, 105° 52’51.862’ E, altitude 500 m). Two adult *Odorrana* sp, in amplexus with the male positioned on top of the female, were spotted next to a large lake within a large karstic limestone cave in complete darkness; fish and crayfish were also observed within the lake. The cave and lake contained many loose rocks and litter resulting from human activity (Fig. 2). The male (around 10 cm) was smaller than the female (around 12 cm) (Fig. 2). In reaction to torchlight, the female frog remained still but upon being disturbed it jumped into the water and swam under a rock. I left the area but returned soon after, by which time the pair was back on land.

Figure 1. Three juvenile *Odorrana* sp. encountered within a cave, the bottom right photo shows the dark cave habitat where they were found

These frogs were observed in habitats that have been disturbed by human activity. As Guizhou develops and opens up to further tourism, it is paramount that we understand the diversity of potentially sensitive and endemic species, so that proper management and protection can be employed before it is too late. Both sightings were made in caves that were geographically close to each other. *Odorrana* is a particularly diverse genus in southern China so there are likely to be many more populations and perhaps new species that are in need of protection.

These sightings likely represent the first report of *Odorrana* in the karstic mountains of Anshun in western Guizhu. Although locals who frequent these limestone caves have seen and known about them, their presence has not been

Figure 2. Cave dwelling adult *Odorrana* sp. in amplexus (above) and the large cave with a lake in complete darkness (below), where they were living

reported online or in the scientific literature. The unusual cave dwelling habit of these frogs suggests that they may be a new species of cave dwelling *Odorrana* or alternatively they may be a new population of *O. wuchuanensis*. In the latter case, this would extend the range of this protected species, as the distribution of *O. wuchuanensis* is patchy with populations known from Hubei, Guizhou, to northern Guangxi. Accurate identification would require genetic sequencing, phylogenetic and phenotypic analysis. Future studies should be undertaken to sample the population of these cave dwelling frogs around Anshun, Guizhou, to fully understand the range, population, natural history, and identity of these frogs.

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SHORT COMMUNICATION

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First record of mating between a pair of putative *Crotalus basiliscus* and *Crotalus nigrescens* suggests the potential for hybridisation areas in the Sierra Madre Occidental, Mexico

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Hybridisation in rattlesnakes has been documented extensively (Klauber, 1972; Campbell & Lamar, 1989; Zancolli et al., 2016; Maag et al., 2023), and recent genomic evidence suggests that rattlesnake populations previously classified as subspecies are distinct species that frequently hybridise in areas where their ranges overlap (Myers et al., 2024). The rattlesnake *Crotalus basiliscus* and those formerly considered subspecies of *Crotalus molossus*, such as *Crotalus nigrescens*, have a wide distribution in North America (Fig. 1; Muñoz-Mora et al., 2022). *Crotalus basiliscus* is found along the west coast of Mexico from southern Sonora to Michoacán (McCranie, 1981; Goldberg et al., 2005), while *C. nigrescens* exhibits an extensive distribution across central and northern Mexico, ranging from the Sierra Madre Occidental to the northern side of the Trans-Mexican Volcanic Belt (Price, 1980; Muñoz-Mora et al., 2022).

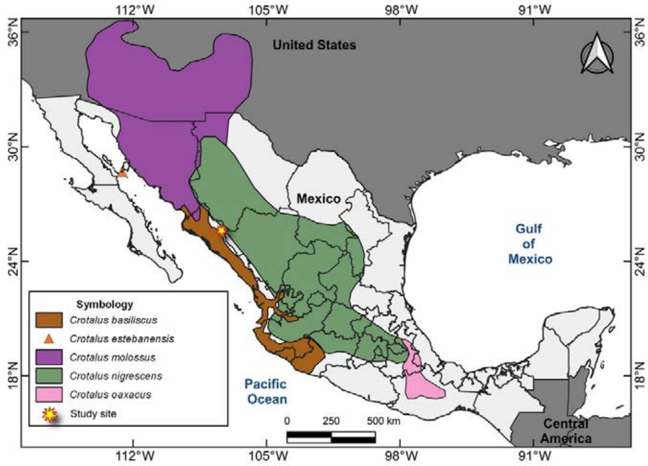

Figure 1. Distribution of *Crotalus basiliscus* and several species of the molossus group; *Crotalus ornatus* and *Crotalus totonacus* not included (Myers et al., 2024). The map is based on information in Price (1980), McCranie (1981), Lara-Galván et al. (2020), Muñoz-Mora et al. (2022), and historical records of the species (GBIF, 2024).

Figure 2. **A.** *Crotalus basiliscus*, **B.** The tails of both *Crotalus basiliscus* and *Crotalus nigrescens*, red arrow indicating a bulge in the female cloaca, **C.** & **D.** *Crotalus nigrescens*

The reproductive cycles of *C. basiliscus* and *C. nigrescens* bear a resemblance to that of other rattlesnakes of the molossus group with reproductive activity from late spring to early autumn (Goldberg, 1999; Goldberg et al., 2005). Both species are capable of sperm storage (both males and females) until the following season. Typically, female *C. basiliscus* demonstrate annual reproduce cycles (Goldberg et al., 2005), whereas *C. molossus* females exhibit biennial cycles, producing litters every other year (Goldberg, 1999).

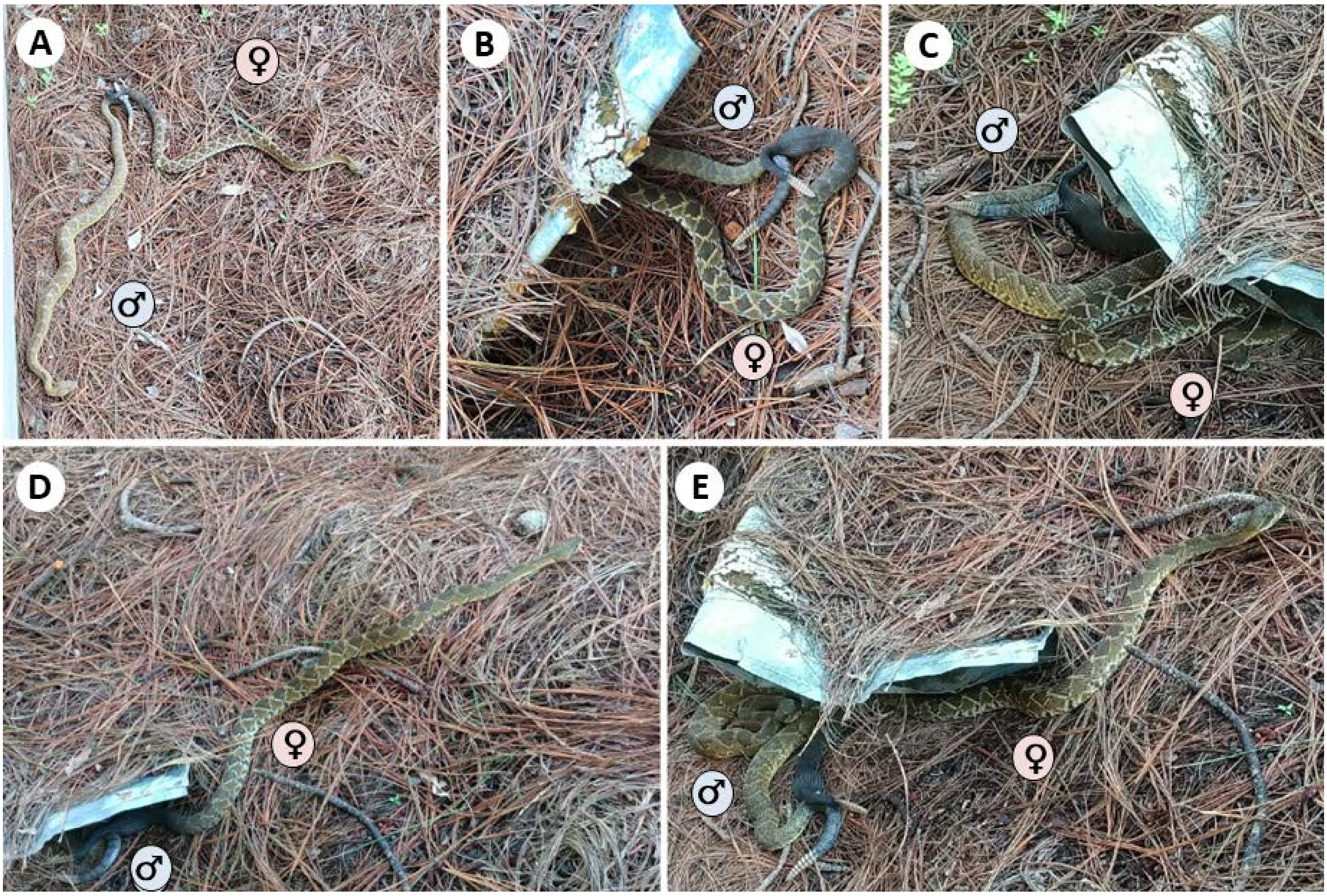

Figure 3. **A.-E.** Observation of mating between *Crotalus basiliscus* and *Crotalus nigrescens*

Although the geographic distributions of *C. basiliscus* and *C. molossus* group species are essentially mutually exclusive (Fig. 1), there is overlap and a high potential to overlap in some areas of their ranges (Price, 1980; McCranie, 1981; Muñoz-Mora et al., 2022; Lara-Galván et al., 2020). For example, Klauber (1952) noted cases of *C. molossus* from southern Sonora exhibiting traits intermediate with *C. basiliscus*, including head and tail length, hemipenial spine count, subcaudal count and colouration patterns. He also reported a specimen of *C. basiliscus* from Jalisco that resembled *C. nigrescens* owing to a reduced number of subcaudal scales and a black tail. Subsequently, Hardy & McDiarmid (1969) suggested that *C. basiliscus* and *C. molossus* are likely sympatric in northern Sinaloa based on morphological evidence. See Figure 1 for plenty of contact points and overlap.

Reports documenting instances of natural mating between different species are significant due to their implications for understanding speciation mechanisms and the development of reproductive barriers (Coyne & Orr, 2004). Studies on courtship in rattlesnakes include reports on both captive individuals (Perkins, 1943; Klauber, 1972; Armstrong & Murphy, 1979; van Der Heiden, 2019), and observations in the wild (Bryson & Lazcano, 2002; Prival et al., 2002; Clark et al., 2014; Almeida-Santos et al., 2021; Senter, 2022).

Here, we present an observation of mating between *C. basiliscus* and a putative individual of *C. nigrescens* in the north-east of Sinaloa, Mexico. Our record represents the first documented case of mating in these two species, and among the few cases where potential hybridisation under wild conditions has been documented photographically in rattlesnakes. The photographs have been catalogued in the Colección de Imágenes Herpetológicas del Museo de Zoología ‘Alfonso L. Herrera’ of the Universidad Nacional Autónoma de México (MZFC-HE-IMG225-229).

On 30 September 2023, at 09:50 h, during a visit to the Sierra Madre Occidental of Sinaloa, Mexico, we were alerted by personnel from the Centro de Estudios “Justo Sierra” (CEJUS) that a pair of mating rattlesnakes had been observed in the Surutato Ecological Preservation Zone (25° 49’ 45.91” N; 107° 33’ 54.08” W; WGS84; altitude 1,528 m a.s.l.) in the municipality of Badiraguato, Sinaloa, Mexico (Fig. 1). This observation took place on a sunny, clear morning, with a temperature of 24 °C and relative humidity of 68%, recorded immediately after encountering the rattlesnakes. The snakes were concealed behind a hut amidst pine needles. We observed them for approximately 3 h from a distance of 2.5 m without disturbing them; consequently there was no opportunity to measure them. The male had the typical appearance of *C. basiliscus* and the female resembled *C. nigrescens* (Fig. 2).

No courtship behaviours were observed, as the snakes were already copulating. The female had a noticeable bulge near the cloaca (Fig. 2B), undoubtedly the male’s engorged hemipenis. No bleeding was noted (Fig. 2B). A sequence of photographs was taken of the mating pair (Fig. 3 A–E). During copulation, we observed intermittent pulsing of the male’s tail without a specific movement pattern, while the female continuously followed the male with their cloacae connected (Fig. 3C & D). The male did not resist the female's movements (Fig. 3E). We left the site at 13:00 h as the female appeared restless and unable to separate from the male. Upon returning 3.5 h later (16:30 h), the snakes had departed. Local students from CEJUS reported that the rattlesnakes had likely been copulating for approximately 20 hours, as they had observed the snakes joined and intertwined on 29 September at 17:47 h, though this could not be confirmed directly. Armstrong & Murphy (1979) reported durations of 9.2 and 1.45 h for pairs of *C. molossus*, and up to 10 hours for captive *Crotalus willardi*. Klauber (1972) reported durations of 22.45 h in *Crotalus ruber* and 15 to 24 h in *C. willardi*. Although there are few records of copulation duration in wild rattlesnakes, durations of 24 to 28 h have been reported (Clark et al., 2014).

Future work should include genomic analysis of individuals in the various regions of contact and their putative hybrids.

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SHORT COMMUNICATION

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Predation of the Mongolia racerunner *Eremias argus* by bull-headed shrike *Lanius bucephalus* and frog-eating rat snake *Oocatochus rufodorsatus* in South Korea

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The Mongolia racerunner *Eremias argus*, which is considered to be endangered in South Korea (Song et al., 2013), is a small lacertid with a distribution encompassing the Korean Peninsula, Russia, China and Mongolia (Orlova et al., 2019). This lizard exhibits a preference for riverine and coastal sandy habitats (Cho & Son, 2024) where it employs crypsis to avoid detection by predators (Hahn, 1960), but it also demonstrates swift locomotion across sandy substrates to evade capture. Despite multiple studies examining the diet of the Mongolia racerunner, there are hardly any reports of its predation by other species.

On 30 September 2019 at 12:00 h, we attached a transmitter (0.35 g, BD-2X, Hologhil Systems Ltd, Canada) to 15 lizards and then released them on the coastal sand dune (36.412547 °N, 126.6375686 °E, WGS 84, 9 m a.s.l.) in Taean Province, the Republic of Korea. However, we lost the signal from one lizard at 15:00 h, which was the next tracking time. Then, at 12:00 h on 1 October, we found the lizard 187 m from its release point impaled on a chocolate vine *Akebia quinata*, still alive but barely moving (Fig. 1). Although the predation event was not directly observed, a bull-headed shrike *Lanius bucephalus*, a species known for impaling its prey, was observed in the vicinity. It is therefore reasonable to infer that this species was the predator in this instance.

Figure 1. An impaled Mongolia racerunner, probably predated by a bull-headed shrike

Figure 2. The partially digested remains of a Mongolia racerunner disgorged from a frog-eating rat snake

A second predation case was recorded on 16 May 2024 during a population study of Mongolia racerunners. A frog-eating rat snake *Oocatochus rufodorsatus* was found in the Baramarye sand dune, a Special Protection Area designated by the Korean government for Mongolia racerunners (36.412190 °N, 126.379265 °E, 1 m a.s.l.). When we palpated the snake's abdomen to retrieve its stomach contents, the partially digested remains of a Mongolia racerunner were disgorged (Fig. 2). *Oocatochus rufodorsatus* primarily inhabits freshwater environments, such as paddy fields and reservoirs, where it feeds on amphibians and fish (Heo et al., 2014). However, it has not previously been documented feeding on reptiles.

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SHORT COMMUNICATION

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Body bending in smooth snakes *Coronella austriaca* in Serbia

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Published rarely – and almost exclusively from subtropical regions – body bending is believed to serve as a defensive/warning/camouflage behaviour making a snake look like a vine or stick, something inedible, dangerous or dead (Duarte, 2012; Hauser et al., 2020). It is also known as liana-mimicry or kinking.

While searching for *Coronella* through e-mails and Facebook messages sent to the Serbian Herpetological Society since 2015, I retrieved three photographs of smooth snakes in this unusual zigzag posture. I could not contact the author of one of these to get his consent for publishing, hence only two body bending cases are presented here. Once again, the importance of citizens’ contribution to scientific research is demonstrated.

I found only a handful of papers describing this specific body bending behaviour (BBB) in snakes. The species proven so far to display BBB belong to the families Colubridae, Dipsadidae and Viperidae (Duarte, 2012; França et al., 2020; Hauser et al., 2022; Pokhilyuk & Maslova, 2025). In one of the most recent papers (2020), França et al. wrote about it as “one of the more rarely-reported and poorly understood defensive behaviours”. Still, in 2022, Hauser et al. stated that BBB “has been reported for less than a dozen different snake species from tropical and subtropical America” and reported the first records of this behaviour in snakes in Asia and southern Spain. The most recent findings originate from the Russian Far East (Pokhilyuk & Maslova, 2025). The BBB is clearly exhibited by more species – and in more regions – than was originally thought.

The parts of Serbia where *Coronella* individuals were photographed (Fig. 1A & B) are under sub-alpine (south-eastern Serbia) and moderate variants of continental climate (western Serbia and Šumadija). The third individual was observed in the town of Užice (app. 400 m a.s.l.), western Serbia. Therefore, however simple, the present note is possibly only the third regarding body bending in snakes outside (sub)tropical regions of the world.

Although wide, the distribution of the smooth snake in Serbia is underestimated, with huge gaps resulting from the lack of sightings i.e. targeted faunistic research (Tomović et al., 2015). The global deficiency of data regarding *Coronella* is due to its “cryptic behaviour and secretive lifestyle” (Goddard, 1984; Gleed-Owen, 2005). Bearing that in mind, finding smooth snakes in BBB is even more interesting.

Figure 1. Two *Coronella austriaca* displaying BBB - **A.** Gornje Gare village (south-eastern Serbia, app. 800 m a.s.l.; 2016), **B.** Rajac (Suvobor Mt., western Serbia – Šumadija, approx. 800 m a.s.l.; 2021)

Hauser et al. (2022) suggested that the function of BBB is “more often aposematic than cryptic” and that snakes display BBB more often than is formally known and published in the scientific literature. It was experimentally triggered in rat snakes in the USA (ibid.) and observed in captive specimens (França et al., 2020). An alternative hypothesis, that such a posture is a response to a threat by an insufficiently warmed snake, appears unlikely (Marques et al., 2006; França et al., 2020). It is neither only cryptic and defensive nor restricted to arboreal snakes (Marques et al., 2006; Maddock et al., 2011; Hauser et al., 2022; Pokhilyuk & Maslova, 2025). *Coronella* is not only terrestrial but also spends much time underground, although it can climb branches in search of bird eggs or nestlings (Gleed-Owen, 2005; Johansen & Flaatten, 2021).

All three snakes in the present report were seen on dirt/asphalt roads and possibly frightened by the approaching human(s). Hauser et al. (2022) and other authors also usually spotted kinking snakes on roads or paths: “Apparently BBB is triggered after snakes have been detected in opened areas”

(Duarte, 2012). This is probably because the snakes are most easily visible on roads, where they are fully exposed, devoid of shelter, taking this unusual 'play freeze' posture as if they were among vegetation. And we, the people, use paths and roads more often than thickets – where we have trouble spotting a snake in whichever posture it has adopted. The rarity of observations may be attributed to snakes' ability to blend with their background when not on open ground (França et al., 2020). We will probably never know the full repertoire of postures snakes may take when approached by a variety of predators in the wild.

Most species that Houser et al. (2022) described or reviewed are known as "aggressive" when defending themselves. *Coronella* also employs "several defensive strategies, including biting with a chewing action" (very aggressive compared to many other non-venomous snakes); also, it often flattens its head posteriorly and takes up a striking position, presumably to mimic *Vipera berus* (Gleed-Owen, 2005), which it resembles in colouration. Body bending is the smooth snake's additional reaction to threat.

There is still no definite conclusion regarding body bending in snakes. Because I do not have any information about the circumstances under which the smooth snakes in question were photographed or the surrounding habitats, I refrain from any new speculation. This behaviour remains to be studied directly. Surely, new information from engaged enthusiasts will significantly contribute to our data pool.

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SHORT COMMUNICATION

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Vocal repertoire of the Critically Endangered Cuban western spiny frog *Eleutherodactylus symingtoni*

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The western spiny frog *Eleutherodactylus symingtoni* Schwartz, 1957 is endemic to the forested karstic areas and caves in upland areas of western Cuba (Díaz & Cádiz, 2008; Rivalta González et al., 2014; Rodríguez-Cabrera & López-Silvero, 2022). It is one of the most threatened Cuban amphibians, listed as Critically Endangered under criterion C2a(i) due to its small population and continuing population decline caused by habitat loss. The total number of mature individuals in the population is uncertain, but it is suspected to be fewer than 250, with no more than 50 mature individuals in each subpopulation. Its mapped distribution covers an area of 4,202 km^2 (IUCN SSC Amphibian Specialist Group, 2023).

For a long time after its description *E. symingtoni* was considered mute (Schwartz & Henderson, 1991), but in 2007 different calls of its vocal repertoire were registered and described (Alonso Bosch et al., 2007; Díaz & Cádiz, 2007; Díaz et al., 2007). Males vocalise while widely separate from each other, mainly during the night, from the ground, rock walls of ancient ruins, and also from the vegetation to heights up to 1 m (Diaz & Cadiz, 2008; Henderson & Powell, 2009). However, most of the information related to its vocal activity comes from individuals from a single locality, Cueva del Basurero, Artemisa province (Alonso Bosch et al., 2007; Díaz & Cádiz, 2007; Díaz et al., 2007), where the species appears to be common and more abundant.

On 29 June 2024, during a short-term acoustic monitoring initiative for *E. symingtoni* in the Ecological Reserve El Salon in the nucleus area of the Sierra del Rosario Biosphere Reserve, Artemisa province (22° 49'48.97'' N, 82° 57'45.16" W), we detected an adult male calling in the middle of a very complex soundscape, with an intense acoustic activity of insects and other anurans (e.g. *Eleutherodactylus auriculatus*, *Eleutherodactylus eileenae* and *Eleutherodactylus olibrus*). The calls were recorded with a Zoom H1 portable digital audio recorder (sampling rate of 44100 Hz/16 bit) connected to a unidirectional microphone Sennheiser ME66/K6, located approximately 50 cm from the active male. Gain settings of the audio recorder were kept constant throughout the call recording. We obtained approximately five minutes of continuous recording of advertisement calls from the adult male *E. symingtoni*. The sound recording has been deposited in the scientific collection of the Fonoteca Zoológica of the Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain (FZ-SOUND CODE. 14860). The animal (Fig. 1A) was sighted vocalising from the ground, among the leaf litter of the evergreen forest typical of this region, at approximately 4 m from a mound of large rocks (Fig. 1B). The air temperature

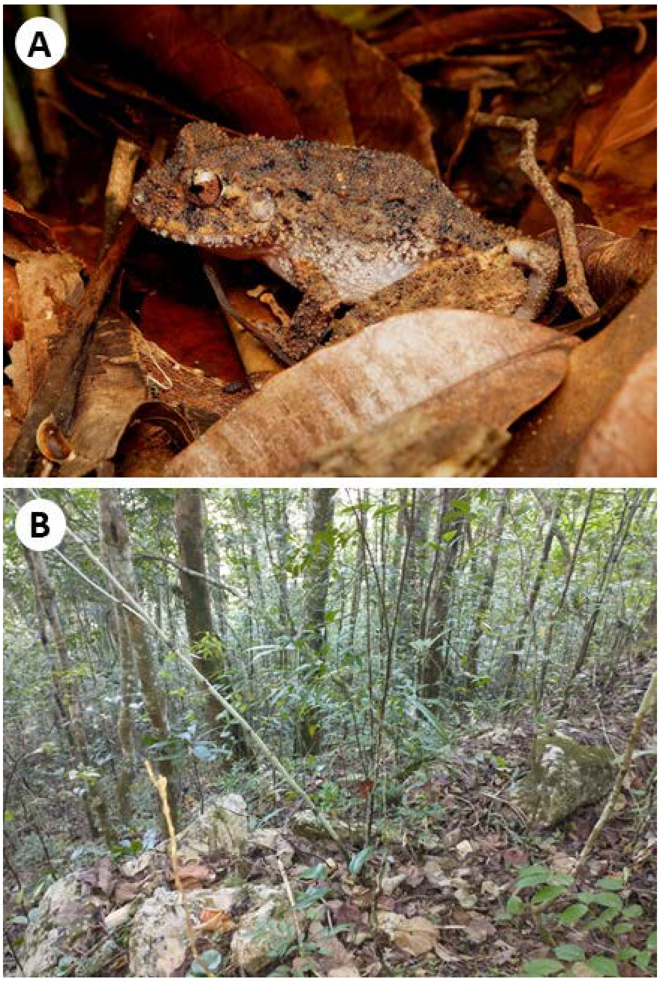

Figure 1. **A.** Calling adult male *Eleutherodactylus symingtoni* (SVL = 52.21mm), from El Salon Ecological Reserve, Sierra del Rosario, Artemisa province, Cuba, **B.** Microhabitat where this animal was observed and recorded

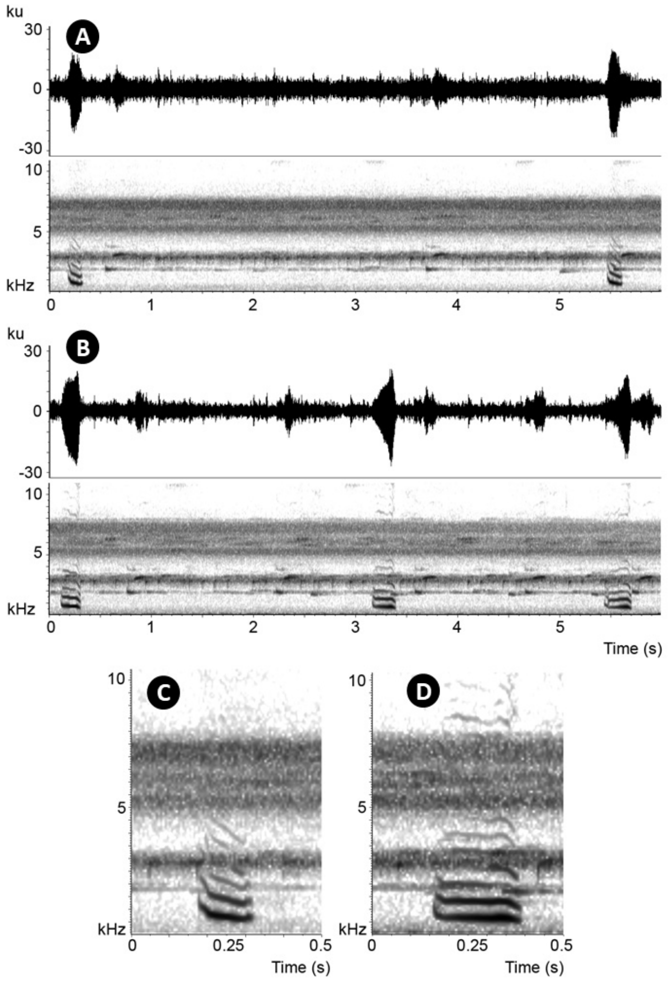

Figure 2. Oscillograms (top) and spectrograms (bottom) of a fragment of consecutive multi harmonic calls (single notes) of *Eleutherodactylus symingtoni*, from El Salon Ecological Reserve, Artemisa, Cuba - **A.** Calls from the beginning of the fragment, showing the descendent frequency modulation, **B.** Calls from the end of the fragment with notable changes in duration, call interval and frequency modulation pattern, **C.** Zoom of the first call represented in **A.**, **D.** Zoom of the second call represented in **B.** (Spectrograms produced with Raven with Hanning window function at 512 bands FFT resolution, overlap = 50%, Filter band pass 200-5000 Hz).

(26.4 °C) and relative humidity (100%) were measured using a HANNA Instruments thermohygrometer (± 0.1 °C, 1%) near the calling individual. The individual was captured and its snout-vent length (SVL) was measured using a caliper (± 0.01 mm). Then, the animal was released at the same site of capture. Recorded advertisement calls were visualised and analysed in Raven Pro 1.3 Software (Copyright 2003–2008 Cornell Lab of Ornithology Bioacoustics Research Program).

The first information about the acoustic emissions of *E. symingtoni* was provided by Alonso Bosch et al. (2007). These authors included in their Sound Guide of Calls of Amphibians of Cuba, one call emitted by an adult male from Cueva el Basurero, Artemisa province. Also, Díaz et al. (2007) offered the first acoustic characterisation of three types of call of this species based on calls produced by two individuals from the same locality. Vocalisations comprise mostly short calls (one or two notes) with a variable complex harmonic structure uttered at a relatively low rate of repetition (Díaz et al., 2007). Our observations and measurements from oscillograms and spectrograms of the advertisement calls are partially congruent with the published description of single notes by Díaz & Cádiz (2008). We followed the note-centred approach defining each call consisting of a single note (Koehler et al., 2017). The measured features fit within the wide range reported by previous authors. The beginning the calls (N = 20) consisted of multi harmonic single notes (call duration = 158.5 ± 8.0 ms, call interval = 5.20 ± 0.29 s, call rate = 32.09 calls/min, dominant frequency = 738.3 ± 43.7 Hz) with a notable descendent modulation in frequency (Fig. 2A). However, at the end of the recordings, we observed an important change in the signal structure toward longer calls (call duration = 243.3 ± 28.7 ms), shorter call intervals (call interval 3.00 ± 0.67 s), lower frequency modulation call (more flattened visually in the oscillograms), that were equally audible in terms of dominant frequency (660.5 ± 49.8 Hz) and relative intensity (Fig. 2B).

Díaz et al. (2007) noticed that when approached, males of *E. symingtoni* change the homogeneous one note calls for two note heterogeneous call sequences, or for a sporadic whistle, but the variation in the pattern of frequency modulation has not been reported previously, probably due to the difficulty of detecting and recognising these changes in complex environments. Although the calls of most Cuban amphibian species have been described, most research on acoustic spectral properties is restricted primarily to a few features, such as dominant frequency, frequency range and bandwidth, but there is little information about the relationship with the physical properties of the habitat or the social context. The environment constrains acoustic transmission when long-distance sound communication is used (Forrest, 1994; Farina, 2014). Certainly, the vocal repertoire of *E. symingtoni* is difficult to interpret in light of the acoustic adaptation hypothesis (Morton, 1975; Ey & Fischer, 2009). The variability in the temporal and spectral features of the signals, with changing patterns of frequency modulation and harmonic performance, generates problems in understanding the habitat-signal relationship in a species that may be vocally active in both very noisy forest habitats and in relatively silent environments, such as the interior of caves and karstic formations.

These observations on the vocal repertoire of *E. symingtoni* are a contribution to the design of a passive acoustic monitoring strategy that would allow the real status of the populations to be evaluated. This will contribute to mitigating the conservation threats faced by this species.

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SHORT COMMUNICATION

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The invasive brown anole *Anolis sagrei* introduced to Bioko island (Equatorial Guinea); a threat to the Gulf of Guinea

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The Gulf of Guinea, situated along the central-western coast of Africa, includes several tropical islands with unique ecosystems and numerous endemic species (Jones, 1994; Ceríaco et al., 2022). Currently, only one reptile species non-native to Africa, the blind snake *Indotyphlops braminus*, has been documented on these islands. Although its presence is well-known (Jesus et al., 2003), its ecological impact remains unclear. On Annobón Island, however, the introduced gecko *Hemidactylus mabouia*, an African species, shares habitats with the endemic *Hemidactylus newtoni* (Jesus et al., 2005), potentially causing competitive exclusion. In contrast, on Bioko Island, despite being the largest island in the Gulf of Guinea and the site of Equatorial Guinea's capital, no invasive reptile species had been recorded until now (Sánchez-Vialas et al., 2022).

In this note, we document the first introduced populations of the invasive lizard *Anolis sagrei* Duméril y Bibron, 1837 on Bioko. This species, native to Cuba and the Bahamas, is known for its successful establishment in numerous regions worldwide, often with substantial ecological impacts (Fisher et al., 2020; Bush et al., 2022). For example, it is known to alter the behaviour of native lizard species, and impact native ant communities, spiders and other arthropod populations (Kamath et al., 2013; Huang et al., 2008a; 2008b). It is also noted for its rapid population growth in new environments (Campbell & Echternacht, 2003).

The identification of these lizards as *A. sagrei* was based on a combination of morphological traits, consistent with those described for the species (Rodriguez-Schettino, 1999; Norval et al., 2002). Observations of *A. sagrei* on Bioko were documented at two distinct localities, approximately 14 km apart (Fig. 1). The first observation took place on 20 June 2024, when a single adult was found in a private garden in Malabo, perched on a mango tree (3° 45'17.8" N, 8° 46'57.0" E). The second population was recorded on 4 August 2024 in Sipopo (3° 45'31.5" N, 8° 54'06.1" E), where 15 specimens (10 adults and 5 juveniles) were sighted among garden vegetation near the beach (Fig. 2). The presence of juveniles at this site indicates that *A. sagrei* has established a breeding population on Bioko Island.

The introduction of *A. sagrei* to Africa was first documented in Luanda, Angola, in 2020 (Ceríaco & Bauer, 2020). According to literature and citizen science platforms such as iNaturalist, *A. sagrei* has spread to regions such as Singapore, Taiwan, Nepal, Israel, and numerous locations across the Americas, including various U.S. states (Hawaii, California, Florida, Texas, among others). The species' adaptability and potential ecological disruptions raise significant conservation concerns for Bioko and other Gulf of Guinea islands. In light of these potential ecological threats, conservation authorities and stakeholders should make immediate efforts to contain and prevent the spread of *A. sagrei* to safeguard the native biodiversity of Bioko and other regions across the Gulf of Guinea.

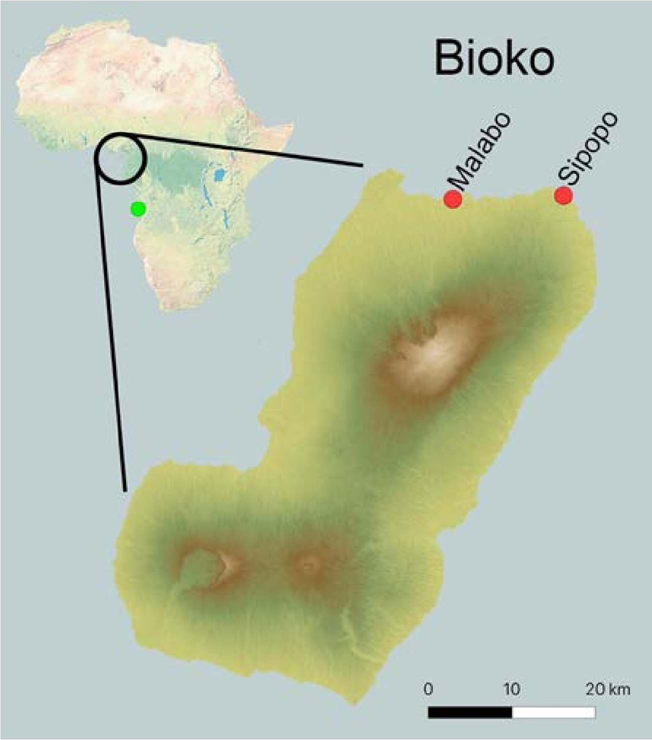

Figure 1. Documented localities of the introduced *Anolis sagrei* in Africa. The green dot depicts a previously reported population in Luanda, Angola. Red dots indicate the localities where this species has been recorded in Bioko, Equatorial Guinea

Figure 2. A selection of photographs of *Anolis sagrei* observed in Sipopo, Bioko

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SHORT COMMUNICATION

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Albinistic tadpoles of the Apennine yellow-bellied toad *Bombina variegata pachypus*: observations on their development and metamorphosis

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Colour anomalies resulting from a lack of pigments are widely reported in European anurans (Henle et al., 2017; Lunghi et al., 2017; Bruni et al., 2020; Allain et al., 2023). The main chromatic aberrations that are consistent with white and whitish colouring are albinism, leucism and hypomelanism (Henle et al., 2017). Except for albinism, where the colour of the eyes is typically reddish, the distinction in external appearance between the others is not always clear. Therefore, in the literature there are often cases of misidentification (Henle et al., 2017). Colour anomalies are even more difficult to identify when they occur in the larval stages (i.e. tadpoles) where the colour patterns are not as defined as in the adult individuals. Henle et al. (2017) classify light colouring or whitish tadpoles as 'albinistic pinto' using a picture of three *Bufotes viridis* tadpoles (a whitish albinistic, a light albinistic with a more normal colouration and a normal one). The authors specify that these kinds of tadpoles are often described as albino or leucistic. In the present study we report albinistic tadpoles in two populations of the endangered *Bombina variegata pachypus* (Bonaparte 1838), giving some information on their developmental problems during metamorphosis.

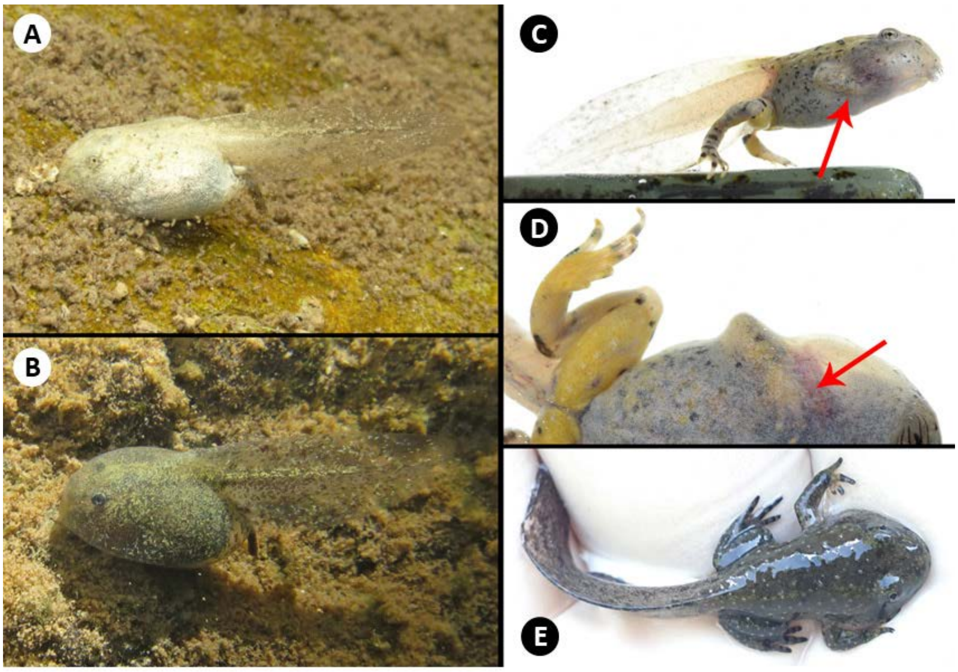

Figure 1. Comparison between normal and albinistic tadpoles of *Bombina variegata pachypus* - **A.** Albinistic tadpole, Gosner stage 32, **B.** Normally coloured tadpole, Gosner stage 31, **C.** & **D.** Albinistic tadpoles, Gosner stage 41, with internal fully developed hindlimbs, **E.** Normally coloured tadpole, Gosner stage 42, with emerged and fully developed hindlimbs. Red arrows indicate the position of internal fully developed forelimbs.

Table 1. Number of albinistic *Bombina variegata pachypus* at each site by date

Site	Date	Albinistic individuals	Notes
Lorsica	14 July 2017	3 tadpoles	
	9 August 2017	2 tadpoles	Both tadpoles had internal developed forelimbs
	17 August 2021	4 tadpoles	
	20 September 2021	1 tadpole	The tadpole had internal fully developed forelimbs
	10 August 2023	4 tadpoles	
	26 September 2023	2 froglets	One had a malformed eye
Sambuca Pistoiese	9 August 2020	1 tadpole	
	22 July 2021	2 tadpoles	
	12 August 2023	2 tadpoles	One of them had fully developed hindlimbs
	27 May 2024	1 tadpole	
	5 August 2024	3 tadpoles	Two of them had fully developed hindlimbs
	29 September 2024	1 tadpole	The tadpole had internal fully developed forelimbs

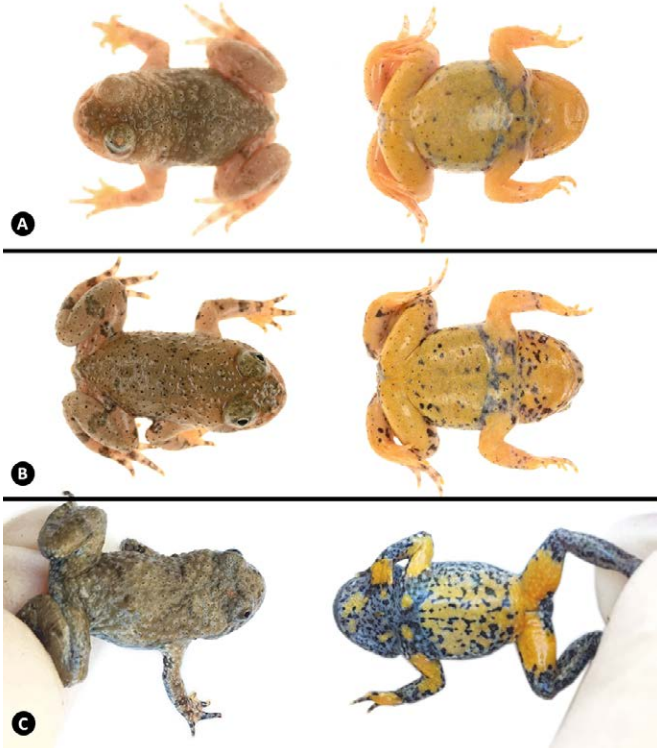

Figure 2. Comparison between normal and albinistic *Bombina variegata pachypus* froglets - **A.** Albinistic froglet with very light colouration and malformed eyes, **B.** Albinistic froglet with light colouration, **C.** Normally coloured froglet

The Italian endemic Apennine yellow-bellied toad is nowadays considered as a subspecies of *Bombina variegata* (Sindaco & Razzetti, 2021), a species in which albino tadpoles and froglets have been already reported (Neudorfer, 1989; Charbonnier et al., 2017). However, the only colour anomalies that have been recorded to date for *B. v. pachypus* are some albino tadpoles born and raised in captivity at a breeding centre (U. Fusini, pers. comm.). Normal metamorphosed individuals of this anuran present a brownish-greyish dorsal colouration and an aposematic ventral colouration with yellow or orange spots on a bluish and black background (Guarino et al., 2007). We found albinistic *B. v. pachypus* tadpoles (Fig. 1A) in different years in two populations in the northern part of the subspecies range in the municipalities of Lorsica (Genova, Liguria; approximate co-ordinates: 44° 26′ N, 9° 16′ E) and Sambuca Pistoiese (Pistoia, Tuscany; approximate co-ordinates: 44° 5′ N, 11° 1′ E). Both sites were visited on several occasions since 2010 and albinistic tadpoles were often observed; Lorsica site was visited since 2013 at least once a year and at least one albinistic tadpole was always present. Given our opportunistic and unstandardised visual sampling, we report only a series of annotated observations for both sites in Table 1; the actual number of observations of albinistic tadpoles is therefore greater and covers a greater number of years than shown.

For both sites, our observations mostly refer to tadpoles without limbs or with hindlimbs partially or fully developed. In some cases, the absence of tadpoles without forelimbs can be explained by individuals with internal fully developed forelimbs (Fig. 1C & D). Failure of forelimb emergence may reduce successful metamorphosis by albinistic tadpoles. At the Lorisca site, albinistic froglets were not observed until 26 September 2023 at 11:00 h (T max 26 °C, T min 19 °C), when two very light froglets were observed (Fig. 2A & B) among more than twenty normally coloured ones. The first froglet (Fig. 2A) was 1.7 cm SVL and weighed 0.7 g. It presented malformed eyes, the right one being covered with cutaneous tissue. The second froglet (Fig. 2B) was darker in colour, had normal eyes and was 1.8 cm SVL and weighed 0.7 g. When compared to normal *B. v. pachypus* froglets from the same site (Fig. 2C), the two albinistic froglets are lighter in colour and present scarce blue and black ventral pigmentation. Given the rarity of albinistic froglets and the absence of albinistic adults at both sites, we suggest that the mortality rate of these individuals is likely high. A similar phenomenon is reported in albinistic tadpoles of common frog *Rana temporaria* in the Piedmont region of Italy (Seglie & Martelli, undated). The authors observed several albinistic tadpoles over different years and reported that about 40% of them lacked one or both eyes and faced difficulties in metamorphosis, typically dying before completing the process. The presence of albinistic tadpoles might be a sign of genetic depletion in the population. Indeed, our observation sites are located at the northern range limits of a subspecies known for its 'southern genetic richness' (Canestrelli et al., 2006; Talarico et al., 2019; Bernabò et al., 2022).

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The temporary capture of photo-documented animals was conducted under the following ministerial permits: Ministero dell'Ambiente e della Tutela del Territorio e del Mare Prot. 0012442.13-06-2017 – ISPRA Prot. 0011110.26-05-2017; Ministero della Transizione Ecologica Prot. 0024526.28-02-2022 – ISPRA Prot. 0009384/2022, 23/02/2022.

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NATURAL HISTORY NOTE

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Is cartwheeling a common defensive mechanism in dwarf reed snakes *Pseudorabdion* spp? The case of *Pseudorabdion albonuchalis, with a link to video evidence*

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An unusual escape mechanism for a snake, termed cartwheeling, has recently been described for *Pseudorabdion longiceps* (Quah et al., 2023). On 20 July 2017, I recorded similar behaviour in a closely related species *Pseudorabdion albonuchalis*. This species is a small (up to 400 mm total length), short-tailed snake of the subfamily Calamariinae (Stuebing & Inger, 1999; Zaher et al., 2009). The body is slender with a black dorsum, brown venter and a broad yellow nuchal band. Its distribution is restricted to Borneo where it inhabits lowland dipterocarp forests up to 500 m above sea level, where it lives in the leaf litter and also burrows into the mat of hair roots under leaf litter (Das, 2012; Stuebing & Inger, 1999). However, feeding and reproductive behaviour as well as exact distribution have not been sufficiently investigated.

One individual of *P. albonuchalis* with a total length of 250 mm was found near Matang Family Park, Sarawak, Malaysia (1° 36’51” N, 110° 11’56” E, 120 m a. s. l.). It was encountered crossing a road at night (21:00 h) at an ambient temperature of approx. 27 °C. I did not notice any visible injuries to its body. Illuminated by a lamp it became motionless. When touched on the tail, the snake immediately reacted by two consecutive jumps (combined distance ca 1.5 m) directed away from the investigator (BHS video, 2025). This escape allowed the snake to reach the leaf litter at the edge of the road, where it attempted to conceal itself.

I repeated this provocation of defensive behaviour two more times and the result was the same. Since it is almost impossible to capture such behaviour using still photography, I provide frames extracted from the video recording (Fig. 1). The snake begins by forming a lateral loop using its anterior body followed by a rapid whip-like motion, which lifts the snake into the air. In the air the snake forms a circle and spins, allowing the snake to bounce off the ground after impact from the first jump. The snake always completed two jumps in rapid succession.

To avoid predation, snakes use various tactics, sometimes in combination, such as rapid escape; death feigning (thanatosis), often accompanied by the release of musk from cloacal glands; hiding the head beneath body, frequently complemented by defensive tail display; coiling into balls or loops; extending the neck; hissing; rattling; false strikes; biting; biting using venom; venom spitting

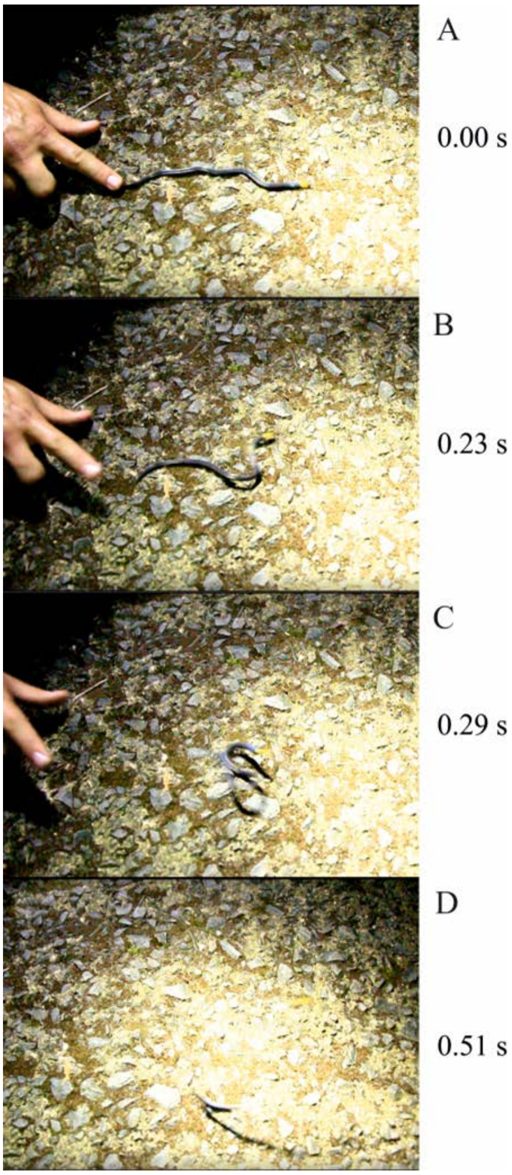

Figure 1. *Pseudorabdion albonuchalis* defensive reaction, frames taken from a video recording - **A.** The stimulus being applied to the snake, **B.** the snake quickly forms a lateral loop of its anterior body, **C.** followed by a rapid whip-like motion to jump, and **D.** the snake now distant from the potential predator (bottom middle, somewhat blurred as it is still in motion). Time in seconds is shown to the right of each frame. It took only 1 s for snake to complete the two consecutive jumps and the distance travelled was ca 1.5 m.

or using specialised nuchal glands for toxin secretion (Greene, 1973; 1988; Sazima & Abe, 1991; Gregory et al., 2007; Hutchinson et al., 2013; Jablonski & Hegner, 2016). False strikes at the attacker by some snake species might resemble jumping (Greene, 1988). However, none of these aggressive reactions are directed away from the attacker (Lillywhite, 2014) as has been observed with *Pseudorabdion* spp in both this study and by Quah et al. (2023). It would be of interest to investigate other species of the subfamily Calamariinae to establish the extent to which they share this behaviour.

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NATURAL HISTORY NOTE

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First record of phocomelia in a Brazilian anuran

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Environmental contamination has been linked to cases of morphological anomaly in amphibians worldwide with a notable increase in the number of such reports in recent decades (Henle et al., 2017a; White et al., 2023). Among the anomalies related to limb deformities there is phocomelia, a congenital malformation characterised by the absence of portions of the limb associated with the partial or total absence of the proximal segment, resulting in the development of distal bone structures (metacarpals/metatarsals/phalanges) in abnormal position (Meteyer, 2000a; Henle et al., 2017b). In this study, we report the first documented case of phocomelia in the frog *Thoropa miliaris* (Spix, 1824). This is an endemic species from the Atlantic Forest, found across eastern and south-eastern Brazil (Frost, 2024).

In April 2022, we examined an adult specimen of *T. miliaris* (CHNF 1419, snout-vent length 64.5 mm, female) that had been collected on 30 January 2022, in Juiz de Fora, Minas Gerais, Brazil (-21.77660, -43.29055, 648 m a.s.l.), under the SISBio collection authorisation number #77181–2. The specimen was preserved in 10% neutral buffered formalin and deposited in the Coleção Herpetológica do Norte Fluminense (CHNF) at the Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF). Externally, an anomaly was observed in the distal portion of the specimen's right hind-limb, characterised by a partial absence of the middle and distal thirds of the tibiofibula, evident in the topography. Additionally, two structures were visible adjacent to the ipsilateral femorotibial joint (Fig. 1A & B). A radiographic evaluation (Altus DR, Konica Minolta, model E7252FX) was performed to examine the bone anomalies. The images were processed using a digital detector AeroDR NS 14x17''. The radiographic examination confirmed the suspected alteration, revealing bone tissue within the aforementioned joint structures that had developed in an abnormal position, suggestive of metatarsals or phalanges (Fig. 1C & D). These findings indicate a case of phocomelia.

Although morphological anomalies in amphibians are frequently reported worldwide, cases of phocomelia are rare, with scattered records over the decades (Meteyer et al., 2000b; Peltzer et al., 2011; Marushchak & Muravynets, 2018). In Brazil, until September 2024, over 160 cases of anomalies in anurans had been recorded, but no case of phocomelia had been diagnosed (Baroni et al., 2024). It is important to note that in some cases there might be divergences in the classification of the bone anomaly, due to poor definition when analysed only by an external assessment of the specimen (Meteyer, 2000b), since a complementary evaluation with radiographic examination is necessary for a correct identification.

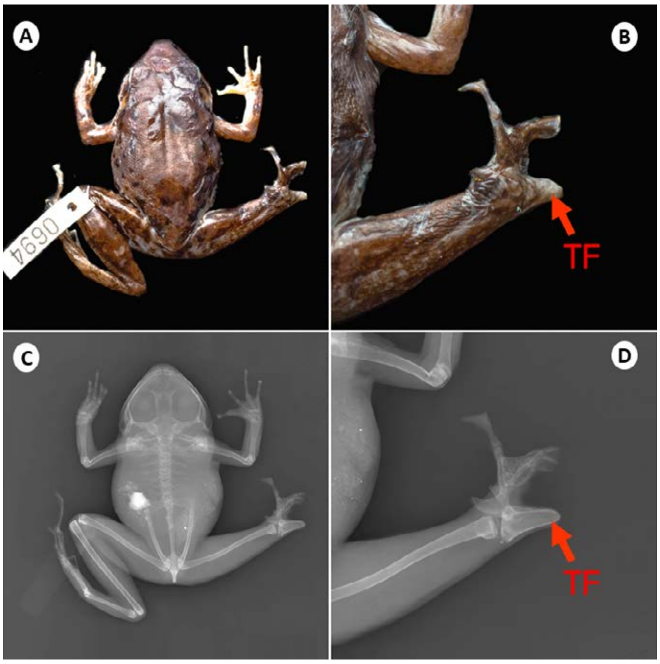

Figure 1. An adult individual of *Thoropa miliaris* showing phocomelia of the right hind-limb - **A.** & **B.** Photographs of the specimen, **C.** & **D.** Radiographs highlighting the classification of the bone anomaly as phocomelia, TF = remains of the tibiofibula

Although our report concerns a single individual and we did not determine the specific causes of the observed anomaly due to an unknown history, the documentation of phocomelia in *T. miliaris* is significant. It marks the first report of this rare malformation in an endemic species of the Atlantic Forest biodiversity hotspot. This finding emphasises the importance of using complementary diagnostic techniques, such as radiography, to better understand skeletal anomalies.

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NATURAL HISTORY NOTE

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First record of amelanism in the European pond turtle *Emys orbicularis*

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Skin colour anomalies occur when a pigment is absent or the production of a pigment is excessive or reduced (Betchel, 1978; Borteiro et al., 2021). Amelanistic reptiles are characterised with lack of the black-brown pigment melanin from their skin and this is different from another common trait albinism, where there is lack of melanin from all tissues including the eyes and internal organs (Bechtel, 1995). Amelanistic individuals may have red eyes caused by the lack of melanin but other colours may be visible on the body due to production of other pigments (Borteiro et al., 2021). This anomoly has been reported previously in turtles (Mora et al., 2022) but here we report the first record of amelanism in a European pond turtle *Emys orbicularis*.

On 28 March 2023, an amelanistic juvenile *E. orbicularis* (Fig. 1) was detected and collected in Veshmeh Sara village, Gilan, Iran (37° 20’45.0” N, 49° 11’28.6” E) from a paddy field and transferred to the first author’s personal collection. Its carapace was dominated by yellow pigmentation (Fig. 1) and the plastron was pale yellowish. The iris was pinkish with a reddish pupil. Normally, *E. orbicularis* has a dark brown or olive-brown carapace, head, neck, limbs and tail covered with yellow dots while the plastron is yellow, sometimes with irregular dark markings (Mozaffari et al., 2016). The species is sexually dimorphic with the colour of the iris in adult males red or orange but in juveniles and females it is yellow (Mozaffari et al., 2016).

Figure 1. Dorsal and lateral view of an amelanistic European pond turtle *Emys orbicularis*

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NATURAL HISTORY NOTE

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Cannibalism in the endemic Madeiran wall lizard *Teira dugesii*, an observation of intraspecific predation in its native range

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Endemic to the Madeira Archipelago, the Madeiran wall lizard *Teira dugesii* is a lacertid species widely distributed across the islands. Thriving in a variety of habitats, from rocky beaches and urban environments to laurel forests and mountain peaks, the species seeks refuge in stone walls and natural rock crevices (Sadek, 1981). *Teira dugesii* exhibits generalist feeding behaviour, with a diet primarily consisting of fruits, flowers and invertebrates. However, through observational studies and faecal analysis, it has also been shown to prey on Moorish Geckos *Tarentola mauritanica* and seabird chicks, including Monteiro's storm petrel *Hydrobates monteiroi* and Scopoli's shearwater *Calonectris diomedea* (Matias et al., 2009; Neves et al., 2022; Rato et al., 2022). Dietary flexibility allows the species to exploit a wide range of resources across different habitat types, contributing to its exceptionally high population densities – which are among the highest recorded for any terrestrial vertebrate (Koleska et al., 2017; Arbuckle & Nichols, 2023).

Here we report the first case of cannibalism within the species' native range. The predation event was observed at 11:10 h on 31 October 2024 along the Pico Ruivo hiking trail, at an altitude of 1,696 m (32° 45'37.9" N, 16° 56'20.7" W). We noticed approximately ten juveniles on a wall adjacent to the trail and stopped to observe. A large male emerged rapidly from a crevice and captured a juvenile by the neck, before retreating into the wall. One minute after the event, the adult re-emerged with the juvenile, which now appeared to be deceased and had been inverted (Fig. 1). The adult adjusted its grip on the juvenile multiple times, before retreating into the wall once again.

Gloor & Benito (2023) first reported cannibalism in *T. dugesii* in an invasive population in Lisbon. While these observations were caveated with the potential for opportunism, we believe that this additional report from the species' native range provides significant support to the proposal that cannibalism in *T. dugesii* is driven by high population density and intense intraspecific competition. During our visit to Madeira, we also noted that a large proportion of *T. dugesii* sightings across a range of sites were of juveniles. Given this seasonal abundance of juveniles, and the significantly larger size of adult males, cannibalism would benefit larger lizards by reducing competition whilst simultaneously allowing them to acquire the calories needed in environments with intense intraspecific competition (Cooper et al., 2015). Cannibalism among lacertids has been documented in various island species, where limited resources and high population densities are often cited as contributing factors (Žagar & Carretero, 2012; Mateo & Pleguezuelos, 2015; Madden & Brock, 2018).

Figure 1. An adult Madeiran wall lizard *Teira dugesii* preying on a juvenile of the same species

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Scavenging behaviour of the hump-nosed pit viper *Hypnale hypnale* in Goa, India

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Scavenging is an opportunistic feeding behaviour that has been commonly observed in snakes (DeVault & Krochmal, 2002). The hump-nosed pit viper *Hypnale hypnale* (Merrem, 1820), is widely distributed across Sri Lanka and the southern Western Ghats of India up to 16° latitude (Smith, 1943; Whitaker, 1978). In Goa, *H. hypnale* inhabits a variety of habitats, including semi-evergreen forests, moist deciduous forests and plantations. It is often found in terrestrial leaf litter or semi-arboreal shrubs where it is primarily an ambush predator, preying on skinks, frogs and lizards (Sawant et al., 2010).

On 14 November 2024, at approximately 19:25 h, we observed a rodent killed by a vehicle on the Mollem Highway in Goa (15° 22'22.6" N, 74° 13'53.7" E), India. Its body was severely ruptured, evidenced by intestinal rupturing but the head was intact. Shortly afterward, a hump-nosed pit viper approached the carcass and inspected it from head to tail. The snake began consuming the rodent headfirst. While consuming the rodent, the snake slowly retreated towards the side of the road into leaf litter (Fig. 1), probably as a response to a large crowd of people that had gathered to watch. It completely ingested the carcass within approximately ten minutes. During our frequent field visits to the Mollem Forest region, we have observed numerous road kill incidents involving rodents, amphibians, and reptiles. This observation provides the first conclusive evidence of *H. hypnale* scavenging, indicating that this species, while primarily an ambush predator, also adopts this opportunistic foraging strategy.

Figure 1. The hump-nosed pit viper *Hypnale hypnale* feeding on a road-killed rodent, slowly retreating back into leaf litter with the partially ingested carcass

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First record of a northern zigzag salamander *Plethodon dorsalis* predated by a cave orb-weaving spider

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Nowadays, arthropods are recognised as common vertebrate predators worldwide, especially of amphibians and reptiles (Nyffeler & Gibbons, 2022). *Plethodon dorsalis* is a ground dwelling salamander that is observed occasionally using caves for refuge, feeding and/or reproduction (Mohr, 1952; Holmann, 1955; Bausmann & Whitaker, 1987). The cave orb-weaving spider *Meta ovalis* (Gertsch, 1933) is usually observed in caves, in the twilight to dark zone, also under logs and anthropogenic environments, always associated with darkness (Gertsch, 1933; Rector, 2009).

On 12 October 2024, during a speleo-herpetological survey of Beauty cave in Mitchell, Indiana (38.7332, -86.3699; WGS 84, approx. 208 m a.s.l.), a juvenile northern zigzag salamander (approx. 16 mm SVL) was observed tangled in the web of a cave orb-weaving spider *Meta* cf. *ovalis* (Fig. 1). At the time of the observation, the spider was upon the dead body of the captured salamander. Located in the dark zone of the cave (approx. 25 m from the nearest entrance), the spider and its prey were observed for 10 minutes, at 3 m from the web to avoid major disturbance. In addition, from 5 to 30 m inside that gallery, I observed 11 *P. dorsalis* (eight juveniles and three adults) all close to the walls. Individuals of *M.* cf. *ovalis* were also very numerous in the cave. No specimen was handled or collected, and only photos were taken.

The European cave salamander *Speleomantes italicus* has been observed as the prey of a co-generic spider, *Meta menardi* (Pastorelli & Laghi, 2007). A few interactions between salamanders and spiders have been recorded in the United States that have been interpreted as defensive/offensive behaviour (Bradley & Eason, 2017; Hickerson et al., 2018), but actual predation has not been reported previously. It has been suggested that a large part of the diet of *P. dorsalis* consists of spiders (Holmann, 1955). Cross-predation is common between arthropods and vertebrates worldwide, especially between amphibians and arachnids (McCromick & Polis, 1982). In this respect, I suggest that in North America, cross-predation may occur between salamanders (e.g. *P. dorsalis, Plethodon glutinosus, Eurycea lucifuga, Eurycea longicaudata*, etc.) and arthropods that share caves, crevices and their surroundings either temporarily or permanently. Further studies are needed to elucidate the predation-prey relationships between amphibians and invertebrates in the oligotrophic environment of caves.

Figure 1. Juvenile *Plethodon dorsalis* tangled in the orb-weaved web, inset is a close up of the salamander

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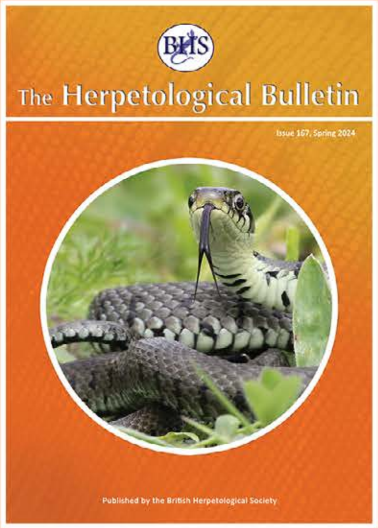

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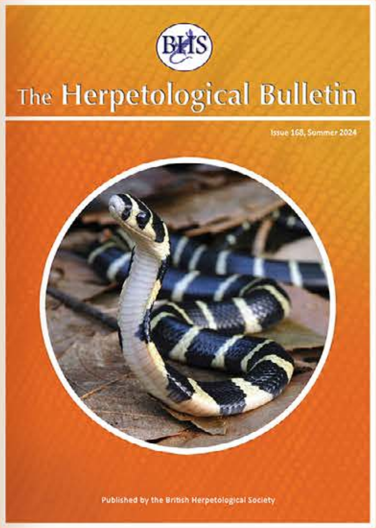

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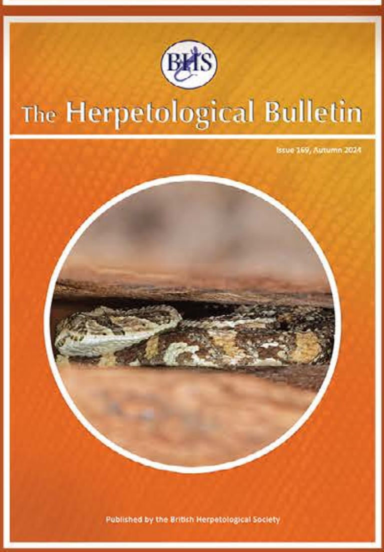

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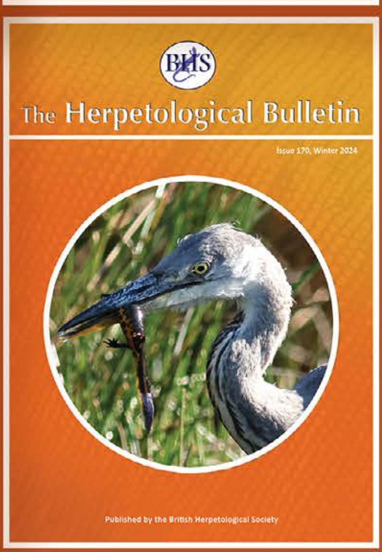

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