HAMADRYAD

VOL. 40, NO. 1 & 2 DECEMBER, 2023

HAMADRYAD

Journal of the Centre for Herpetology, Madras Crocodile Bank Trust

hamadryad.org

Front cover: *Indosylvirana* cf. *caesari*

Back cover: *Craspedocephalus malabaricus*

HAMADRYAD
Vol. 40 (1&2), December 2023.
Date of issue: 31 December 2023.
ISSN 2583-7818 (Online)

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Hamadryad Vol. 40 (1&2), pp. 1–10, 2023, ISSN: 2583-7818 (Online).

Rediscovery of the Black-banded sea snake *Hydrophis nigrocinctus* (Daudin, 1803) (Reptilia: Elapidae: Hydrophiinae) after over a century, with notes on reproduction and conservation status

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CITATION. Sarker, M.A.R., Sanders, K.L., Ukuwela, K.D.B., Lovlu, A.H. and Jaman, M.F. (2023) Rediscovery of the Black-banded sea snake *Hydrophis nigrocinctus* (Daudin, 1803) (Reptilia: Elapidae: Hydrophiinae) after over a century, with notes on reproduction and conservation status. *Hamadryad: 40, 1–10.*

ABSTRACT. The Black-banded sea snake, *Hydrophis nigrocinctus*, is a poorly known species first described in 1803 from a specimen collected from the waters of the Bay of Bengal in the Sundarbans near Kolkata, India. Since then, it has been further reported from the waters near the type locality (Kolkata, India) in 1849 and another specimen (recorded as *H. walli*) was caught in the Malay Archipelago in 1896. In February 2015, during our field survey in the Sundarbans in Bangladesh, we obtained a specimen of this species from fisheries bycatch. This marks the third known specimen and the first sighting of the species in Bangladesh recorded after over a century. We present morphological data and provide novel information on the reproductive status of this species based on the new specimen.

KEYWORDS. Asiatic sea snake, Bangladesh, Bay of Bengal, Data Deficient, Sundarbans

Introduction

The viviparous sea snakes (Elapidae: Hydrophiinae), a group representing more than 63 species, are widely distributed throughout the waters from the eastern Pacific to the western Indian Ocean (Rasmussen et al. 2011a; Elfes et al. 2013). The Indian Ocean is home to about 38 species of sea snakes (Ganesh et al. 2019; Ukuwella et al. 2022; IUCN 2023), of which 16 species have reportedly been found in the coastal waters bordering Bangladesh (IUCN-Bangladesh 2015; Sarker et al. 2017, 2023). Notably, three of the 16 sea snake species found in the waters of Bangladesh are categorized as Data Deficient by the International Union for Conservation of Nature (IUCN Red List, IUCN 2023), including the Black-banded sea snake, *Hydrophis nigrocinctus* (Daudin 1803) which is endemic to the coastal waters of the Bay of Bengal (Rasmussen and Lobo 2010). However, the Black-banded sea snake is only known from the specimens deposited in the British Natural History Museum collected during the 19th century from the Bay of Bengal (India) and the Malay Archipelago (Rasmussen et al. 2011b). *Hydrophis nigrocinctus* was also assumed to occur in the waters of Sri Lanka based on the report by Murthy (1977) from the southeast coast of India (in Madras, now Chennai), but no confirmed record has been found in Sri Lanka (de Silva 1994;

Somaweera and Somaweera 2009; Ukuwela et al. 2022). The Black-banded sea snake is in the Asiatic *Hydrophis nigrocinctus* group (Rasmussen et al. 2011b), which includes *H. hendersoni* (Smith 1926; McDowell 1972). However, recently, Rasmussen et al. (2011b) reassessed species in the Asiatic *Hydrophis nigrocinctus* group and determined there to be two distinct species: *H. nigrocinctus* (*H. walli* as a synonym) and *H. hendersoni* (Boulenger, 1903).

Hydrophis nigrocinctus was first described by Daudin (1803) based on an illustration in Russell (1801) of a specimen collected from the coastal waters of a river in the Sundarbans near Kolkata, India (Smith 1926, 1943; Rasmussen et al. 2011b). Subsequently, Gray (1849) mentioned another specimen of *H. nigrocinctus* from Bengal (Bangladesh – previously East Bengal and West Bengal of India were known as Bengal at that time). Boulenger (1896) described another specimen of *H. nigrocinctus* from the Malay Archipelago, which Kharin (1989) later redescribed as *Hydrophis* (*Disteira*) *walli*, and which has more recently been recognized as a synonym of *H. nigrocinctus* (Rasmussen et al. (2011b). Both Laidlaw (1901) and de Rooij (1917) reported *H. nigrocinctus* from Thailand (Patani), but Smith (1926) reidentified these specimens as *H. klossi*. Smith (1926, 1943) mentioned the occurrence of *H. nigrocinctus* from the Myanmar (previously Burmese) coast, which was originally a type of *Hydrophis* (*Disteira*) *hendersoni* (see details of specimens examined in Smith 1926: 45). In 1903, Boulenger described *Disteira hendersoni* based on a specimen from Yangon, Myanmar (previously Rangoon, Burma; Rasmussen et al. 2011b). However, Wall (1909) synonymized the genus *Hydrophis* with *Disteira* and subsequently placed *D. hendersoni* as a synonym of *Hydrophis nigrocinctus.*

Leviton et al. (2008) further reported *H. nigrocinctus* from Myanmar under the name *Disteira nigrocincta* and considered *D. hendersoni* a synonym of *D. nigrocinctus*. Thus, *H. nigrocinctus* and *H. hendersoni* were considered the same species until Rasmussen et al. (2011b) recognized them as separate species. The two can be easily distinguished by the number of maxillary teeth behind the fang (0–1 in *H. nigrocinctus* compared to 2–3 in *H. hendersoni*), head size (smaller in *H. nigrocinctus*), and variability in the number of scale rows around the neck, body, and ventrals (Table 1–2 in Rasmussen et al. 2011b).

Currently, *H. nigrocinctus* (*H. walli* as a synonym) is known from specimens collected in India (Sundarbans, Kolkata) and the Malay Archipelago (Rasmussen et al. 2011b). Based on Smith (1923, 1943), several authors presumed the occurrence of *H. nigrocinctus* in the coastal waters of the Sundarbans in Bangladesh, owing to the historical collective treatment as erstwhile Bengal (Muzaffar 2009; Rasmussen et al. 2011b; Khan 2013, 2015a, 2015b). However, these authors did not provide precise information specifying any voucher specimen from Bangladesh, so the occurrence records cannot be corroborated.

Until now, since the specimens collected in the 19th century and deposited in the British Natural History Museum, there have been no further documented occurrences of *H. nigrocinctus* (Rasmussen et al. 2011b; Ganesh et al. 2019), justifying *H. nigrocinctus* listed as Data Deficient (IUCN 2023; Rasmussen and Lobo 2010; Elfes et al. 2013). We herein report on a specimen of *H. nigrocinctus* we recently collected from the Sundarbans in Bangladesh, a location close to the type locality, along with its reproductive condition. This establishes the first confirmed record of this species in Bangladesh and an additional reported specimen from the Bay of Bengal since its original discovery more than 200 years ago.

Material and Methods

Sampling. A single specimen of *H. nigrocinctus* was collected in February 2015 during our survey in Dublar Char in the Sundarbans led by the two of the authors (MARS and AHL) with the assistance of the officials of the Bangladesh Forest Department. Dublar Char (21.77891°N, 89.54377°E), one of the southernmost small islands of Bangladesh in Sundarbans, falls within the boundary of Bagerhat District of Khulna Division, Bangladesh (Figure 1B). The specimen was collected by liaising with the fishermen, who temporarily stay on Dublar Char for fishing and processing dry fish during the winter season (Nov–Feb). A total of 18 dead sea snake specimens were collected during the survey from

Table 1. Comparison of external morphometric characters of the *Hydrophis nigrocinctus* specimen reported in the current study from the Sundarbans, Bangladesh with the other available specimens deposited in the British Natural History Museum according to Rasmussen et al. (2011b). M = male, F = female. "/" denotes those counts have been made on both sides.

	Available specimens of *H. nigrocinctus*			
	MHLB-0133 (F)	**Type (F)**	**BMNH 11.6.4.a (F)**	**Type *H. walli* (M)**
Supralabials	7/7	7/7	7/7	7/7
Pre-/post oculars	1/1-1/2	1/1-1/2	1/2-1/2	1/2-1/2
Temporals	2/2	2/2	2/2	2/2
Scales around neck	28	27	27	27
Scales around midbody	40	41	41	42
Ventrals	320	319	318	330
Maxillary teeth	1/1	0/1	1	0/0

Type(F) = Calcutta, Sundarbans; BMNH 11.6.4.a (F) = Bengal, Type of *H. walli* (M) = Malay Archipelago

fisheries bycatch but only one was identified as *Hydrophis nigrocinctus*. The fishermen randomly fish in shallow water near the coastline and river channels of the mangrove forest or into the open deep-sea water, therefore, the exact location of the specimen collection is unknown. We preserved all specimens in absolute ethanol after collection and deposited them in the Dhaka University Zoological Museum, Bangladesh for further study.

Specimen examination. We examined the external morphological characters (as described in Smith 1926 and Rasmussen et al. 2011b) of the specimen to confirm species identification. The number of ventral scales (scales from neck to cloaca), dorsal scales around neck (considered as a minimum count), and around midbody (considered as a maximum count) were counted following the methods in Smith (1926) and Rasmussen et al. (2011b). Sex was determined by examining the sex organ by dissection. Snout to vent length (SVL) and tail length (vent to the tip of the tail) were measured from the specimen using a measuring tape to the nearest mm and then summed to obtain the total length. Maxillary tooth counts were completed using a magnifying glass with 30x magnification capacity. The preserved specimen was dissected to examine the reproductive status and stomach contents. Reproductive condition was examined by the presence of eggs, embryos, or vitellogenic follicles in the oviducts of females (de Silva et al. 2011).

Results

Specimen Description (Figure 2–5). The specimen (MHLB-0133, adult, female) generally resembles the description of *H. nigrocinctus* provided by Smith (1926) and Rasmussen et al. (2011b) with regards to morphology, scale counts, number of maxillary teeth behind fangs, and colouration (Table 1).

The total length of the specimen is 1277 mm, of which the tail length is 132 mm. The body is much elongated with an elongated neck that is much narrower anteriorly compared to the posterior – about one-third the greatest width of the dorsal midbody. The head is small and the snout rounded. First and second supralabials (SL) are in contact with the nasal, SL2 and SL3 are in contact with preocular, SL3 and SL4 are touching eyes, and SL4 is entirely touching the eye. Four infralabials and two temporals are present on both sides. The mental scute is distinct, small, and triangular. Scales around the body are centrally keeled (Figure 4). Ventrals are distinct throughout and slightly larger than dorsal scales. Ventrals are hexagonal with two parallel longitudinal keels (Figure 4) and 46 subcaudal scales are present.

Colouration. The head of the specimen is yellow above with a black streak from the first supralabials to the eye below and a black triangular shape marking on the top of the head extending to the prefrontal. There are 54 bands in the body and nine on the tail. Bands are black and are prominently thick on the vertebra (till forebody or anterior body), eventually narrowing towards the ventral side. Some are incomplete ventrally, interspaced with grey above and yellow underneath. The tip of the tail is black.

Reproduction. The specimen was an adult female and was found in active reproductive condition when collected. We found 11 mature eggs in the oviduct. Among the eggs, the largest was 43.96 x 20.38 mm, and the smallest was 25.92 x 24.65 mm, with a mean of 34.2±5.6 x 21.2±2.1 mm (Figure 6).

Discussion

Distribution, Population status, and Taxonomy. Our findings provide the first precise report of the occurrence of *Hydrophis nigrocinctus* in the waters of Bangladesh, a country bordering the Bay of Bengal and situated close to the type locality of the species (Figure 1A). This study reports a specimen of *H. nigrocinctus* more than 100 years later since it was last reported in 1896 from the Malay Archipelago (recorded as *H. walli*) providing an additional specimen from the Bay of Bengal since its original discovery more than 200 years ago. Khan (2013) assumed *H. nigrocinctus* was a common species in the Sundarbans in Bangladesh without any confirmation or field surveys, yet this species has rarely been reported. Our findings of a single specimen of *H. nigrocinctus* among the 18 sea snakes collected during our surveys (the rest of them were identified as *Hydrophis schistosus*) suggests this species maybe uncommon but due to the limited information it remains challenging to draw any definitive conclusions regarding the distribution range and population status of *H. nigrocinctus*. Further extensive sampling in different localities in other coastal waters of Bangladesh (e.g., Chattogram regions and Saint Martin Island), including the Sundarbans may reveal more information about its distribution and population status in Bangladesh.

Because of a similar body colour pattern (yellowish with black bands), *H. nigrocinctus* can be superficially misidentified as *Hydrophis spiralis*. However, *H. nigrocinctus* is readily distinguished from *H. spiralis* by number of maxillary teeth behind the fang (0–1 in *H. nigrocinctus* vs. 6–7 in *H. spiralis*) and the number of temporal (two small vs. one large), marking on the head (triangular shaped vs horseshoe-shaped), scale morphology, and number of dark bands (Smith 1943; Rasmussen et al. 2011b; Ganesh et al. 2019). Therefore, specimens of *H. spiralis* de-

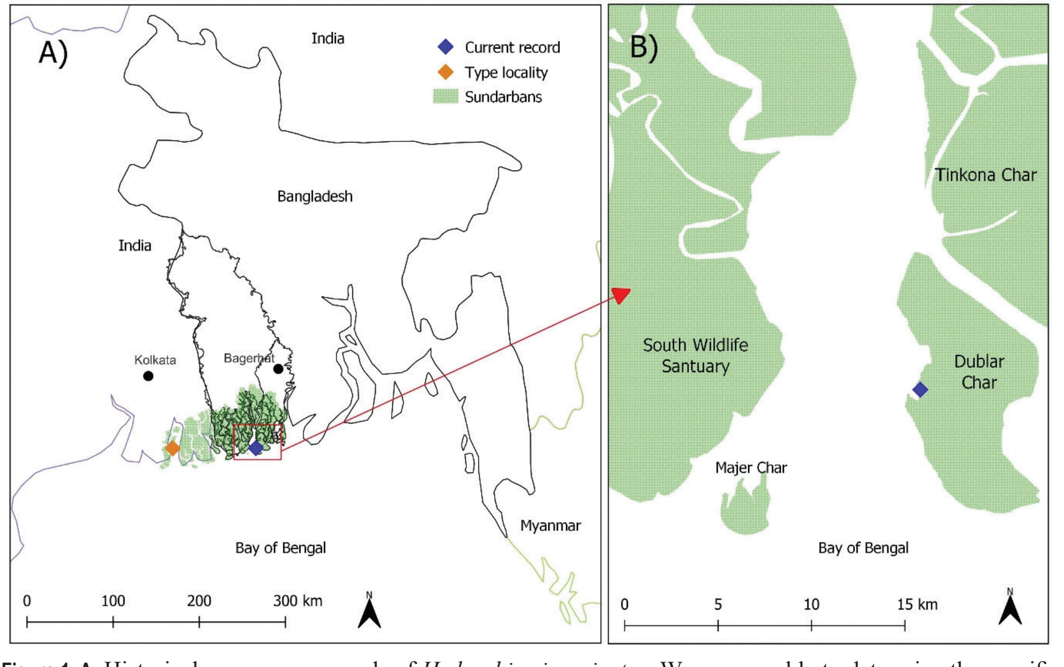

Figure 1. A. Historical occurrence records of *Hydrophis nigrocinctus.* We were unable to determine the specific location in the Malay Archipelago where Mr Bleeker collected the specimen (see Rasmussen et al 2011b), thus, it has been omitted from the map. **B.** Location of the fishing port where bycatch specimen of *H. nigrocinctus* MHLB-0133 was obtained from the fishermen in Dublar Char in Sundarbans, Bangladesh.

posited in various museums in Bangladesh and elsewhere (VertNet 2023; including the recently established Padma Bridge Museum in Bangladesh) can be re-examined to ensure they have been properly identified.

Natural history. Until now, there has been no information available on the reproductive biology of *H. nigrocinctus* (Smith 1926, 1946; Rasmussen et al. 2011b), thus this finding of active

Figure 2. A. dorsal and **B.** ventral view of the preserved *Hydrophis nigrocinctus* specimen (MHLB-0133) collected in the Sundarbans, Bangladesh.

reproductive status is the first to be reported for this species.

Conservation status. Globally *H. nigrocinctus* has been categorized as Data Deficient (DD) by the IUCN (Rasmussen and Lobo 2010) and in the absence of formal confirmation of the species in the waters of Bangladesh, *H. nigrocinctus* has been assessed locally as a species of Least Concern (IUCN-Bangladesh 2015). However, with our recent finding of just a single specimen from a location in the Sundarbans, we suggest that a conservation status of DD would

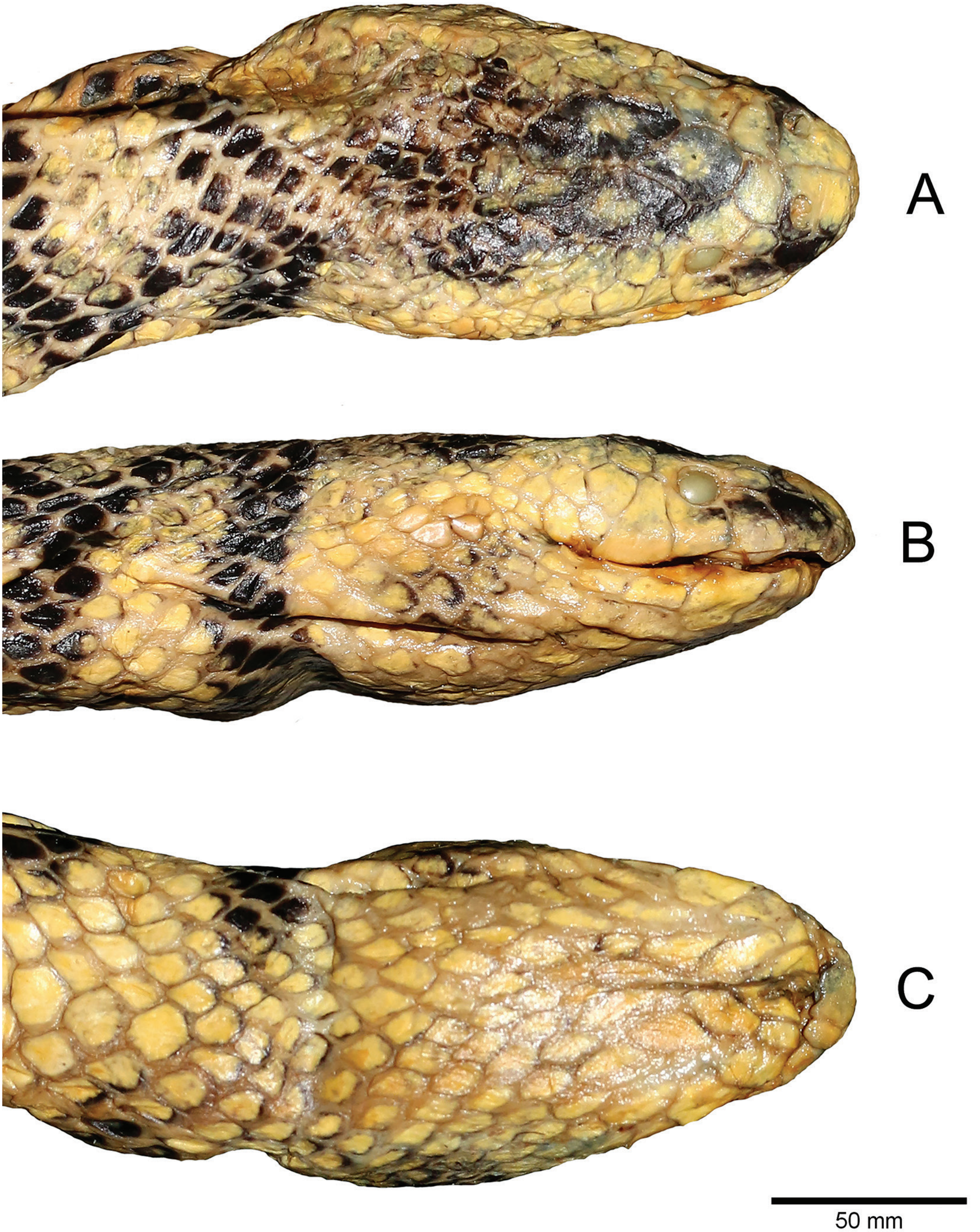

Figure 3. A. dorsal, **B.** lateral and **C.** ventral view of the head from the preserved *Hydrophis nigrocinctus* specimen (MHLB-0133) collected in Sundarbans, Bangladesh.

be appropriate until further information on its population status, local distribution, and threats are ascertained to avoid any future misleading conservation efforts. Among the 16 species of sea snakes occurring in the waters of Bangladesh, seven are poorly known and categorized as either DD (n = 3) or Not Evaluated (n = 4) (IUCN-Bangladesh 2015). The reporting of a rare species is an essential component of effective conservation action (Hoffman et al. 2008; Marshall et al. 2014; Udyawer et al. 2018, 2020; Rasmussen et al. 2021), therefore, our finding

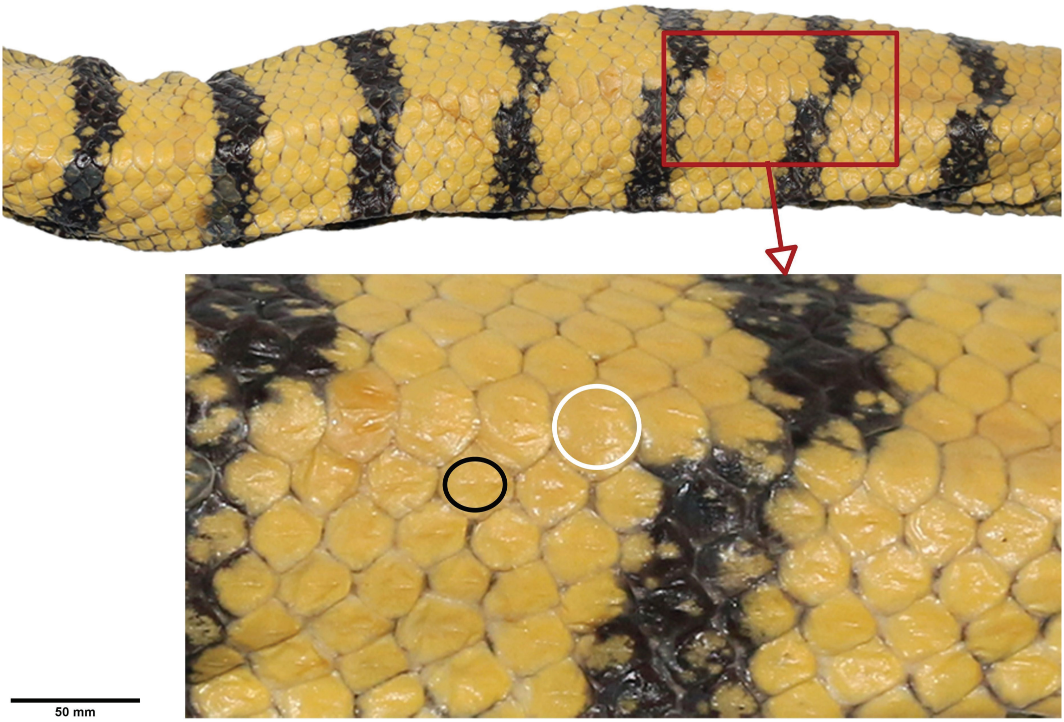

Figure 4. Section of the body scales from the preserved specimen of *Hydrophis nigrocinctus* specimen (MHLB-0133) showing the longitudinal keels — one keel in dorsal (circled black) and two in ventral (circled white) scales.

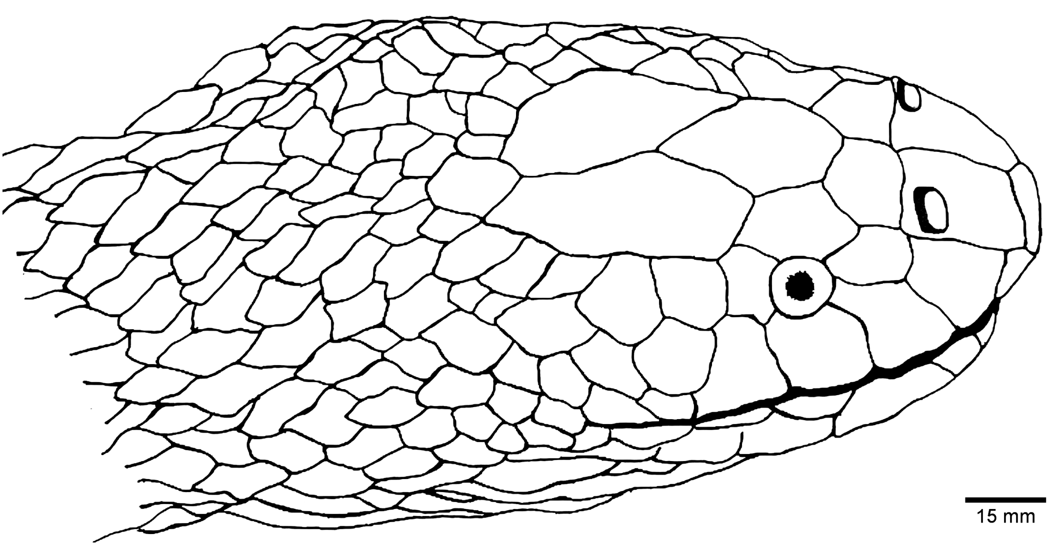

Figure 5. Typical head scalation in the *Hydrophis nigrocinctus* specimen (MHLB-0133) collected in the Sundarbans, Bangladesh (Illustrated by Anika Tabassum).

of this specimen may facilitate future research, species identification, and conservation management of sea snake species in Bangladesh. Our finding also indicates that marine snakes found in the Indian part of the Bay of Bengal may be co-distributed in the waters of Bangladesh since both are bordering countries within the Sundarbans region of the Bay of Bengal. The Sundarbans is known as a UNESCO World Heritage site, and the occurrence of this understudied and rare species highlights the importance of this area as a unique marine biodiversity area.

Acknowledgements

This work was supported by Mohamed Bin Zayed Species Conservation Fund (project no: 14258873) to Mohammad Abdur Razzaque Sarker. We thank the Bangladesh Forest Department for granting permission (letter no: 22.01.0000.01.23.2012.2159) to collect fishery bycatch sea snake specimens and deposit them in the Dhaka University Zoological Museum for study. We thank the locals and fishing communities in Coastal areas in the Sundarbans region in Bangladesh for helping us with information and specimen collection. We thank the University of New England's (UNE) DiverSCIfy program for editorial support and valuable comments by members of the Reptile Ecology and Environment Disturbance (REED) lab of UNE and anonymous reviewers to improve the manuscript.

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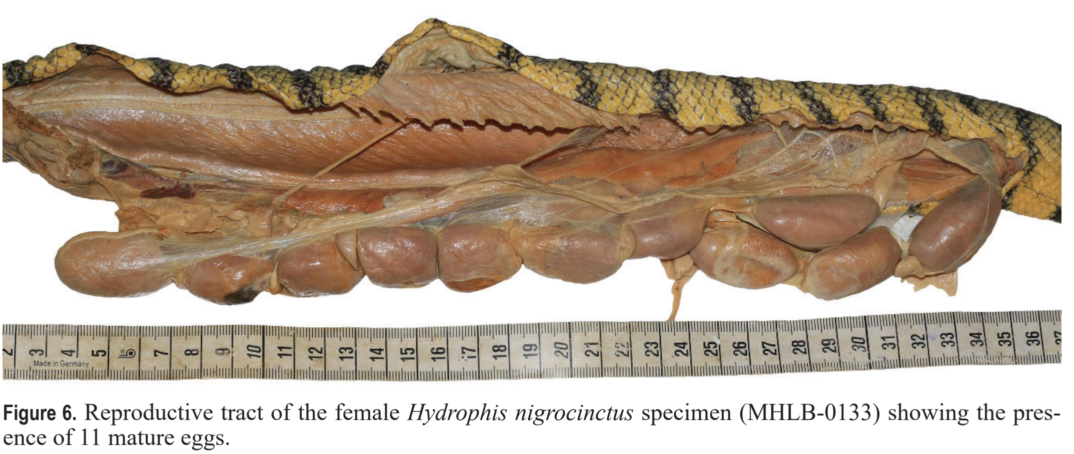

Figure 6. Reproductive tract of the female *Hydrophis nigrocinctus* specimen (MHLB-0133) showing the presence of 11 mature eggs.

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Date submitted 20/03/2023
Date accepted 21/09/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 11–23, 2023, ISSN: 2583-7818 (Online).

A rapid assessment of herpetofaunal diversity and mortality along a railway track in Northern Western Ghats, India

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CITATION. Banerjee, K., Nawani, S., Boruah, B., Habibi, B. and Das., A. (2023) A rapid assessment of herpetofaunal diversity and mortality along a railway track in Northern Western Ghats, India. *Hamadryad: 40, 11–23.*

ABSTRACT. We conducted a herpetofaunal survey along a 17 km stretch of railway track passing through the Kali Tiger Reserve in Karnataka State. Over a period of 13 days, we documented 48 species, representing around 43% of the known herpetofaunal diversity of the northern Western Ghats. Among the recorded diversity, 21 species are endemic and one additional species has been added to the faunal list as a new record for the state. Vulnerability of the herpetofauna is depicted and discussed in the light of the proposed double lane of the railway track and the need for future ecological research is emphasized.

KEYWORDS. Biodiversity hotspot, herpetofauna, protected area, linear infrastructures, threats

Introduction

The impact of roads on biodiversity has received considerable attention across different countries (Andrews 1990; Fahrig 2003; Benítez López et al. 2010; Barrientos and Borda de Água 2017). In contrast, the impacts of the railways on native wildlife are poorly known (Dorsey et al. 2015), and biased towards large mammals (Van der Grift 1999; Sarma et al. 2006). India, with the fourth largest railway network in the world, is no exception when it comes to railway related mortality of large mammals (Johnsingh et al. 1999; Sarma et al. 2006; Baskaran and Boominathan 2010; Joshi and Dixit 2012; Roy and Sukumar 2017), but herpetofaunal mortality records are largely anecdotal (Sivaraj et al. 2018; Vyas and Vasava 2019; Kumar and Prasad 2020). Railways are known to significantly restrict movement and cause mortality of herpetofauna (Berthoud and Antoniazza 1998; Ray et al. 2002; Budzik and Budzik 2014). Herpetofaunal mortalities on railway tracks often occur in remote locations where detectability and persistence rates of carcasses are poorly known (Barrientos et al. 2018). Such persistent threat may be detrimental to biodiversity hotspot regions such as the Western Ghats, which is known for its herpetofaunal endemism (Bossyut et al. 2004; Dutta et al. 2004; Vijaykumar et al. 2016; Aengles et al. 2018; Dahanukar and Molur 2020; AmphibiaWeb 2020).

With around 112 species of herpetofauna, comprising 47 species of amphibians and 65 species of reptiles, the northern Western Ghats holds almost one-fourth of the Western Ghats herpetofaunal diversity and endemicity (Ramachandra et al. 2012; Patel et al. 2018; Pande et al. 2019; Punjabi et al. 2020). Linear infrastructures such as an extensive road network and almost 345 km of railway lines, even within some protected areas (MoSPI 2019; Punjabi et al. 2020) are potential threats to the biodiversity of this region. With a directive from the Government of India, we conducted a rapid biodiversity assessment for prescribing mitigation measures for the proposed railway track doubling by The Railway Vikas Nigam Limited (RVNL) along a specified section of terrain from Tinaighat railway station to Caranzole railway station in northern Karnataka. The proposed area traverses

Table 1. Annotated checklist of herpetofauna recorded during the present survey.

Sl. No.	Family	Species Name	No. of Individuals recorded (VES)	IUCN status
		AMPHIBIANS		
ANURANS (Toads & Frogs)				
	Bufonidae	*Duttaphrynus melanostictus*	3	LC
	Dicroglossidae	*Euphlyctis* cf. *cyanophlyctis*	359	LC
		Hoplobatrachus tigerinus	1	LC
		Minervarya cf. *gomantaki* +	4	NE
		Minervarya cf. *mysorensis*+	20	DD
		Minervarya sp.	2	
		Minervarya syhadrensis +	64	LC
	Micrixalidae	*Micrixalus* aff. *uttarghati*+	16	NE
	Microhylidae	*Microhyla* aff. *ornata*	1	LC
		Uperodon mormorata +	2	EN
	Nyctibatrachidae	*Nyctibatrachus petraeus* ◦ +	50	LC
	Ranidae	*Clinotarsus curtipes*	21	NT
		Hydrophylax aff. *malabaricus*	7	LC
		Indosylvirana caesari +	85	NE
		Indosylvirana sp. +	10	VU
	Ranixalidae	*Indirana* cf. *salelkari* +	94	NE
		Indirana chiravasi +	6	NE
	Rhacophoridae	*Polypedates maculatus*	6	LC
		Pseudophilautus amboli +	10	CR
		*Raorchestes bombayensis** + ◦	65	VU
		Raorchestes sp.	_	
		Rhacophorus malabaricus +	1	LC
GYMNOPHIONA(Caecilians)				
	Grandisoniidae	*Gegeneophis danieli* + *	_	DD
	Ichthyophiidae	*Ichthyophis* sp.	_	
		REPTILES		
LIZARDS				
	Agamidae	*Calotes versicolor*	2	LC
		Monilesaurus rouxii +	1	LC
	Gekkonidae	*Cnemaspis flaviventralis* +	3	NE
		Hemidactylus cf. *murrayi*	4	NE
		Hemidactylus frenatus	1	LC
		Hemidactylus prashadi +	5	LC
		Hemidactylus whitakeri	1	NE
	Scincidae	*Eutropis carinata*	2	LC
		Eutropis macularia	2	NE
	Varanidae	*Varanus bengalensis*	_	VU

SNAKES			
Colubridae	*Ahaetulla borealis* + ◦	16	NE
	Boiga thackerayi +	1	NE
	Dendrelaphis tristis	_	LC
	Fowlea piscator	3	NE
	Hebius beddomei	_	LC
	Lycodon aulicus	1	LC
	Lycodon travancoricus	_	LC
	Oligodon taeniolatus	1	LC
	Ptyas mucosa	1	
	Rhabdops aquaticus	2	LC
Elapidae	*Bungarus caeruleus*	1	
Viperidae	*Craspedocephalus*(=*Trimeresurus*) *malabaricus* +	5	LC
	Hypnale hypnale + ◦	_	
TURTLE			
Geoemydidae	*Melanochelys trijuga*	1	LC

+ Western Ghats endemics; ◦ Castlerock as type locality; *New state record; LC = Least concern, CR = Critically endangered, EN = Endangered, VU = Vulnerable; NT = Near threatened, NE = Not evaluated.

through a heterogeneous habitat of the northern Western Ghats, which also falls under the protected area of Kali Tiger Reserve in Karnataka.

Materials and methods

Our field survey between 18th November and 3rd December 2020 coincided with the drier season in the Western Ghats (Kunte 1997; Balasubramanian et al. 2019). The temperature range during the study period was 19–29 °C and the average humidity was 70% (Source: World Weather Online, 2020). The vegetation type of the study area is composed of moist deciduous to semi-evergreen forests (Champion and Seth 1968). The survey was conducted along a 17 km railway section between the Tinaighat (15.4489º N, 74.3983º E, 658 m a.s.l.) and Caranzole (15.3731º N, 74.3114º E; 621 m a.s.l.) railway stations in Karnataka (Figure 1). We used time-constrained Visual Encounter Survey (VES) (Crump and Scott 1994) at 13 sites, investing a total of 39 person hours (three person/h). These one-hour surveys were conducted between 19:00 h. and 21:30 h. The survey sites were randomly selected within a buffer zone of 5–250 m from the railway track, maintaining a gap of at least 50–100 m between two consecutive sites. Within the selected buffer zone, night surveys (VES) were stratified across all potential herpetofaunal habitats around the railway track such as perennial streams, riparian zones, dry streambeds, and seasonal streams with lentic pools, based on accessibility. We also surveyed modified sites around the railway track sections where modifications, such as forest cutting, newly built cemented culverts, cemented constructions for newly proposed railway tracks, etc., had already taken place or were ongoing as a part of the proposed doubling. The sampling points along the track are shown in the map (Figure 1). We presume that our single, site-specific survey at a time of limited herpetofaunal activity helped avoid pseudo-replication. We have also included opportunistic observations to obtain the maximum record of the diversity.

Dead herpetofauna observed within five meters of railway ballast with signs of injury (such as lacerations on the skin, limbs, amputated body parts, crushed head etc.) and desiccation were considered to be rail kills. All findings of dead amphibians and reptiles were photographed and geo-referenced. Species identity was determined using Smith (1935, 1943); Das

Table 2. Diversity Index (DI) of herpetofauna from all survey sites from Tinaighat-Castlerock-Caranzol section.

Site	Species Richness	Total Individual counts	Species Encounter Rate	Individuals Encounter Rate	Shannon's Index	Simpson's Index	Habitat Types
1	9	45	3.00	15.00	1.46	0.65	**Perennial stream**
2	10	58	3.33	19.33	1.94	0.83	Perennial stream
3	5	14	1.67	4.67	1.53	0.77	Modified area
4	9	66	3.00	22.00	1.67	0.76	Stream riparian
5	8	198	2.67	66.00	0.95	0.52	Seasonal stream with lentic pools
6	8	24	2.67	8.00	1.89	0.82	Dry streambed
7	9	185	3.00	61.67	1.02	0.44	Seasonal stream with lentic pools
8	11	29	3.67	9.67	2.08	0.84	Stream riparian
9	12	72	4.00	24.00	1.22	0.47	Perennial stream
10	11	114	3.67	38.00	1.35	0.62	Stream riparian
11	13	19	4.33	6.33	2.35	0.88	Perennial stream
12	5	15	1.67	5.00	1.2	0.6	Seasonal stream with lentic pools
13	6	22	2.00	7.33	1.48	0.71	Modified area

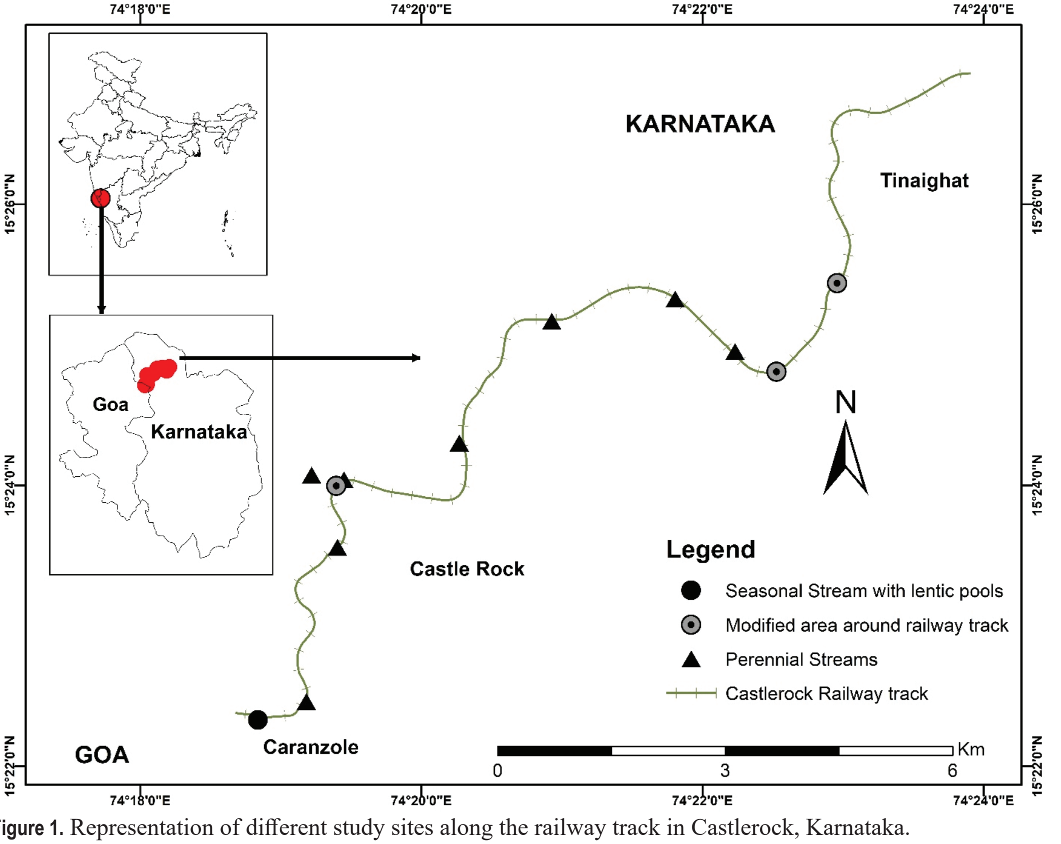

Figure 1. Representation of different study sites along the railway track in Castlerock, Karnataka.

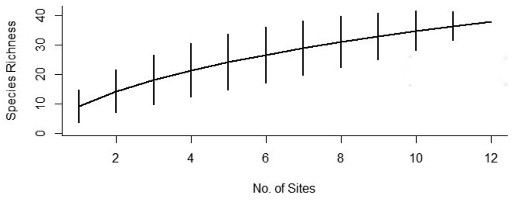

Figure 2. Species accumulation curve of all survey sites between Tinaighat-Castlerock-Caranzol section.

and Kunte (2005); Whitaker and Captain (2004, 2008); Gururaja (2012); Biju et al. (2014) and discussions with regional experts. No specimens were collected during the present study.

VES data were used to estimate the richness and encounter rates of herpetofaunal species. Shannon's diversity index, Simpson's diversity index, and species accumulation curve for all the species were also calculated. All data were analyzed in R studio (version 3.4.1). The study site map was prepared using ArcGIS 10.1 version.

Results

Species diversity and encounter rate. A total of 880 individuals belonging to 24 species of amphibians (19 genera and 10 families) and 24 species of reptiles (19 genera, eight families) were recorded (Table 1). The species accumulation curve was calculated, and it did not reach asymptote (Figure 2). A total of 14 species of herpetofauna were recorded from perennial streams followed by 10 species from seasonal streams, and seven species from arboreal habitats. Stream habitats also accounted for the maximum number of herpetofaunal counts with 361 individuals (six spp.) followed by the riparian zone with 233 individuals (eight spp.). Site 11 showed maximum species diversity and richness, followed by site 9 and site 5, which were the least diverse according to Shannon and Simpson's indices (Table 2). The distribution of species richness and individual count with respect to the distance from the railway track has also been shown in Figure 3 and Figure 4, respectively.

Euphlyctis cf. *cyanophlyctis* was found to be the most frequently encountered species (9.2/person-hour) among amphibians, and *Ahaetulla borealis* was the most frequently encountered reptile with 0.4/person-hour, followed by *Hemidactylus prashadi*, *Monilesaurus rouxii*, and *Hemidactylus frenatus*. Species such as *Hemidactylus whitakeri*, *Ptyas mucosa*, *Bungarus caeruleus*, *Duttaphrynus melanostictus*, and *Rhacophorus malabaricus* were recorded only once (Table 2).

Sightings of amphibians such as *Uperodon mormorata*, *Microhyla* aff. *ornata*, *Hoplobatrachus tigerinus*, and reptiles such as *Boiga thackerayi*, *Ptyas mucosa*, *Bungarus caeruleus*, *Hypnale hypnale*, etc., were based on opportunistic encounters.

Herpetofaunal mortality on railway tracks. We recorded 20 individuals belonging to 11 species as rail kills, comprising six species of reptiles and five species of amphibians. Of the recorded herpetofaunal mortality, there were three aquatic, two arboreal, one fossorial, and five terrestrial species. *Indosylvirana* sp. (n = 6) and *Ahaetulla borealis* (n = 3) were relatively more frequent as rail kills. Among others, reptiles such as *Hebius beddomei*, *Fowlea piscator*, *Lycodon travancoricus*, *Bungarus caeruleus*, *Dendrelaphis* sp. and amphibians such as *Duttaphrynus melanos-*

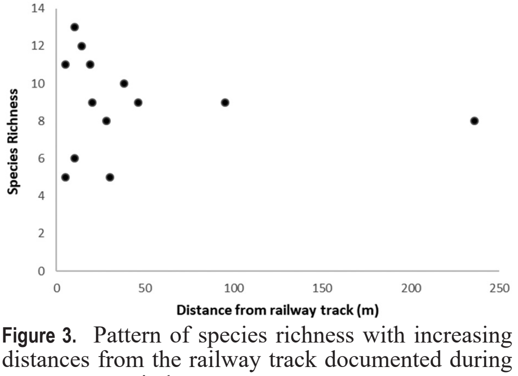

Figure 3. Pattern of species richness with increasing distances from the railway track documented during our survey period.

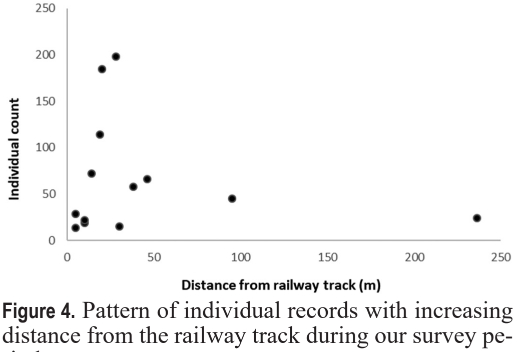

Figure 4. Pattern of individual records with increasing distance from the railway track during our survey period

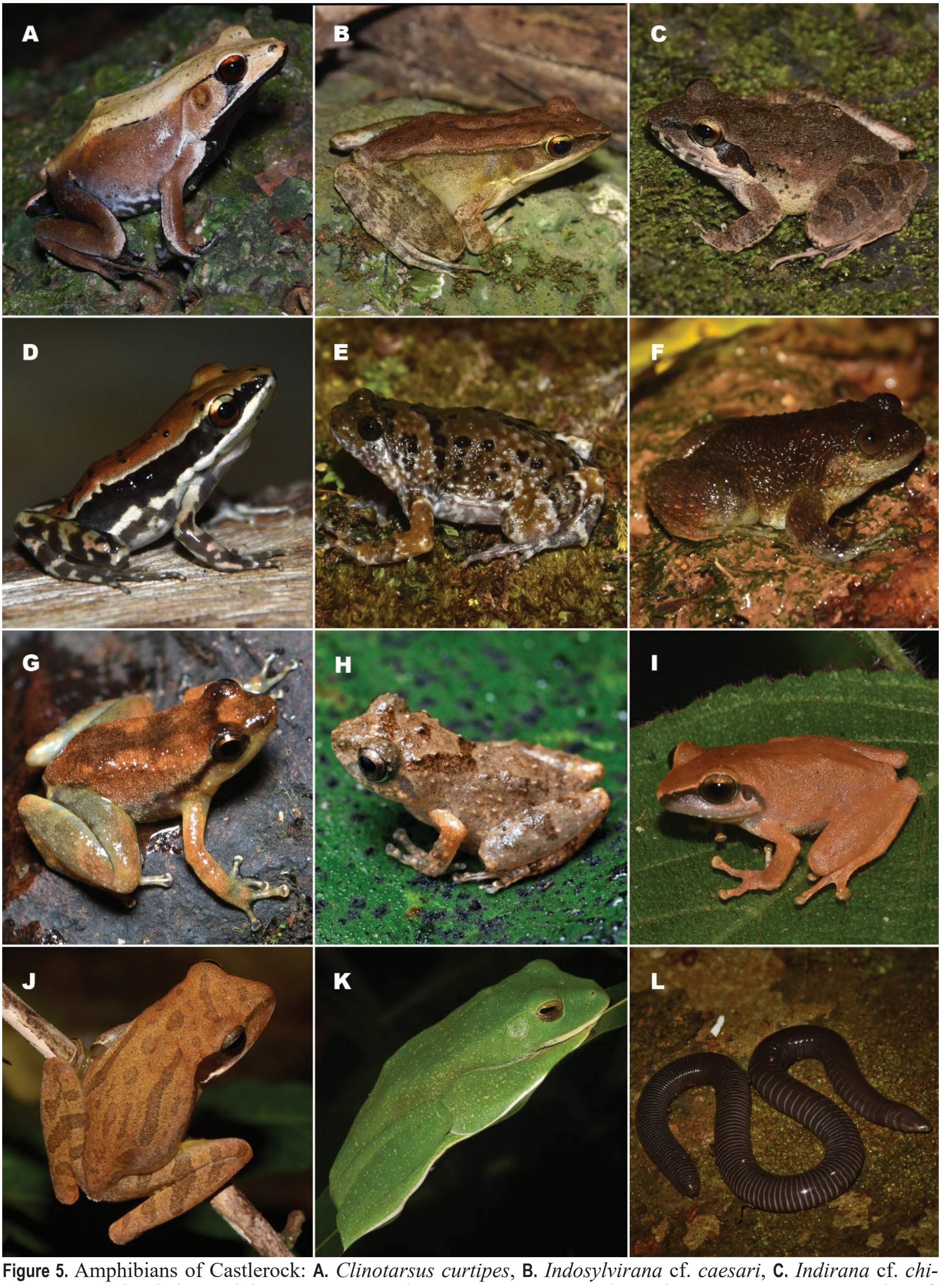

Figure 5. Amphibians of Castlerock: **A.** *Clinotarsus curtipes*, **B.** *Indosylvirana* cf. *caesari*, **C.** *Indirana* cf. *chiravasi*, **D.** *Hydrophylax malabaricus*, **E.** *Uperodon mormorata*, **F.** *Nyctibatrachus petraeus*◦, **G.** *Micrixalus* aff. *uttaraghati*, **H.** *Raorchestes bombayensis*◦, **I.** *Pseudophilautus amboli*, **J.** *Polypedates* cf. *maculatus*, **K.** *Rhacophorus malabaricus*, **L.** *Gegeneophis danieli** [*New state record, ◦Species with castle rock as type locality]

Figure 6. Reptiles of Castlerock: **A.** *Hemidactylus prashadi*, **B.** *Hemidactylus* cf. *whitakeri*, **C.** *Hemidactylus* cf. *murrayi*, **D.** *Hemidactylus frenatus*, **E.** *Monilesaurus rouxii*, **F.** *Oligodon taeniolatus*, **G.** *Lycodon travancoricus*, **H.** *Hebius beddomei*, **I.** *Ahaetulla borealis*◦, **J.** *Hypnale hypnale*◦, **K.** *Craspedocephalus*(= *Trimeresurus*) *malabaricus*, **L.** *Melanochelys trijuga*. [◦Species with castle rock as type locality]

Figure 7. Herpetofauna killed on the railway track: **A.** *Dendrelaphis* sp., **B.** *Bungarus caeruleus*, **C.** *Lycodon* sp., **D.** *Ahaetulla borealis*, **E.** *Indosylvirana* sp., **F.** *Ichthyophis* sp. (desiccated), **G.** *Hydrophylax* aff. *malabaricus*, **H.** *Hoplobatrachus tigerinus*.

tictus, *Hydrophylax* aff. *malabaricus*, *Raorchestes* sp., and *Ichthyophis* sp. were found as rail kills only once each.

We also recorded live individuals of *Monilesaurus rouxii*, *Duttaphrynus melanostictus*, *Pseudophilautus amboli*, *Indirana* sp., and *Hydrophylax* aff. *malabaricus* on the railway track.

Discussion

The survey was a part of the biodiversity assessment designed for a detailed study for prescribing preliminary mitigation measures for all taxa, keeping in view the expansion (doubling) of the 17 km stretch of railway track in the proposed study area. Our survey was planned to get an overview of the species that might be impacted due to the proposed doubling within the stipulated period of time given by the sanctioning authority (Railway Vikas Nigam Limited, GoI). However, our short rapid survey is just representative and not exhaustive in the context of the herpetofaunal diversity of northern Western Ghats. The study span was limited to approximately two weeks and also constrained by dry season effects. Sukumar and Sitharam (2017) reported 51 species from the study area with additional records of *Pedostibes tuberculosus*, *Phrynoderma aloysii*, *Uropeltis ellioti*, and *Python molurus*, which were not documented in the present study.

Out of 48 species recorded, the specific identity of a few cryptic herpetofaunal species could not be ascertained, conferred, or affined to any genus or species group (Table 1; Figures 5 and 6). The identity of a few rail-killed individuals could not be confirmed till the species level (viz. *Indosylvirana* sp., *Dendrelaphis* sp., and *Ichthyophis* sp.) due to their desiccated and mutilated status (Figure 7). Nonetheless, the recorded diversity includes 21 Western Ghat endemics with four species that were originally described from Castlerock (Table 1). Significantly, the record of *Micrixalus* aff. *uttaraghati* (K.V Gururaja, *pers. Comm.* January 2021) marks a noteworthy documentation as its range now extends to ca. 73 km south in Karnataka state (Figure 5G), and it was previously only known from its type locality in Amboli, Sindhudurg, Maharashtra (Biju et al. 2014), the Kulem region (Sukumar and Sitharam 2017), and from the state of Goa (Punjabi et al. 2020). Record of *Gegeneophis danieli* (Varad Giri *pers. comm.* May 2021) is also a new addition to the faunal list for the state of Karnataka (Figure 5L). This species was described from a single specimen in Amboli, Sindhudurg district, Maharashtra (Giri et al. 2003). Additionally, a record of the recently described *Boiga thackerayi* (Giri et al. 2019) from the study area also shows the vulnerability of the species from the expansion plan of the railway track.

Species associated with seasonal and perennial streams contribute to 43% of all recorded species, including the obligate stream breeding *Nyctibatrachus petraeus* (Willaert et al. 2016) and *Micrixalus* aff. *uttaraghati* (Biju et al. 2014). Record of single individuals of *Rhacophorus malabaricus* and *Gegeneophis danieli* perhaps indicate lower detectability of species that are known to be highly seasonal in breeding activities and movement (Bhatta 1998; Biju et al. 2013). Among reptiles, Gekkonids such as *H. prashadi* and *C. flaviventralis* were frequently observed under railway culverts, while *H.* cf. *murrayi* was recorded among dumped construction materials along the railway tracks. The distribution of species richness and individual numbers showed a clustered pattern within 50 m from the tracks (Figures 3 and 4). Such a pattern might be an outcome of seasonal constraints in recording "forest species" and increased records of "edge species". Nonetheless, such distribution strongly indicates the relative vulnerability of such fauna.

Mortality of nocturnal snakes such as *Bungarus* and *Lycodon* on the tracks may be attributed to their thigmothermic behaviour (Rodriguez et al. 1996; Lenders 2001; Gratison 2006). On the contrary, the high number of arboreal snakes appearing as rail kill either indicate their habitat preference, as members of the genus *Ahaetulla* are known to be present along forest fringes (Mohapatra et al. 2017; Deepak et al. 2019), or their sheer relative abundance in the study area (e.g., *Ahaetulla borealis*). Mortality for some amphibian species is probably related to their prolonged breeding activity (*Indosylvirana* sp.). Although limited to a single observation, less vagile animals like the caecilian (*Ichthyophis* sp.) might have faced desiccation while crossing the track (Figure 9F). Besides direct mortality, increased railway traffic might also lead to auditory masking in amphibians (Bee et al. 2007).

All these encounters were purely observational and the present study had no provisions or facilities to collect samples and conduct necropsy, which is a long procedure and demands a larger number of samples. The aim of the present study was primarily to assess the presence of animal signs and the abundance of species around the study area that can indicate any direct present or future impacts of railway traffic, and not to analyse the cause and time of death or injury assessments of herpetofauna. Also, there was no presence of other possible ways viz. human conflict, road traffic, etc., which could have otherwise caused the observed mortalities.

The study specifically highlights the importance of stream and riparian habitats as one of the critical refuges for several species of amphibians and reptiles. Additionally, the study portrays unforeseen threats that the herpetofauna of the present study site might face if the expansion of the railway line takes place. Henceforth, in case of any future development in terms of railway doubling or expansion, tunnel extension, culvert or underpass construction, fencing and barrier installation, etc., proper mitigation measures are of paramount importance as delineated in the Wildlife Institute of India reports (2016 and 2020). This also sets the platform for forthcoming explorations and calls for the need for thorough surveys in areas with linear infrastructures, specifically railway lines, which have remained fairly understudied to date.

Acknowledgements

We sincerely acknowledge the Chief Wildlife Warden, Govt. of Karnataka, and Field Director and staff of Kali Tiger Reserve for providing research permissions and extending necessary support during our field survey. We are thankful to Railway Vikas Nigam Limited for the funding, and the Director, Wildlife Institute of India (WII) for institutional support. Special thanks to teammates Akanksha Saxena, Zehidul Hussain, Lynette Gomes, and Kathan Bandyopadhyay for their constant support and encouragement. Gratitude to Varad Giri (Reliance Foundation), Saunak Pal (BNHS), K.V. Gururaja (Srishti Institute & Gubbi Labs), and Deepak V. (University of Wolverhampton, UK) for sharing their expertise.

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Date submitted 02/10/2022
Date accepted 12/07/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 24–28, 2023, ISSN: 2583-7818 (Online).

New records of Leith's softshell turtle, *Nilssonia leithii* (Gray, 1872), after 30 years from Kaveri River delta in Tamil Nadu, India

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CITATION. Gerard, J.D., Deepak, V., Ram, K., Christopher, P. and Fritz, U. (2023) New records of Leith's softshell turtle, *Nilssonia leithii* (Gray, 1872), after 30 years from Kaveri River delta in Tamil Nadu, India. *Hamadryad: 40, 24–28.*

ABSTRACT. *Nilssonia leithii* is an endemic species of softshell turtle from peninsular India, and though it has a widespread distribution, it is often difficult to spot. We report two new records of Leith's softshell turtle (*Nilssonia leithii*) from the Kaveri River in Tamil Nadu. These sightings have been made at a site 110 km upstream from the estuary. The last time this species was sighted in the Kaveri Delta region was 30 years ago.

KEYWORDS. conservation, distribution, new records, softshell turtle

Introduction

The Indian state of Tamil Nadu is home to six freshwater turtles. *Nilssonia leithii* and *Pelochelys cantorii* are two giant soft-shelled turtles distributed in the Kaveri River (Kalaiarasan et al. 1992; Melvinselvan and Nibedita 2017). *Nilssonia leithii* is endemic to peninsular India (Das 1995; Das et al. 2014) and was first described by Gray in 1872, based on a specimen collected by Dr. Leith from Poonah (now Pune), Maharashtra (Gray 1872). *Nilssonia leithii* is primarily found in rivers and reservoirs (Boulenger 1890; Annandale 1915; Moll and Vijaya 1986; Kalaiarasan et al. 1992; Thomas et al. 1997; Kumar 2004; Nameer et al. 2007; Praschag et al. 2007; Deepak and Vasudevan 2009). However, an individual was also recorded from Thrissur District, at the mouth of the Chalakudy River, suggestive of its occasional usage of estuarine habitats (Das et al. 2014). *Nilssonia leithii* is an elusive animal, difficult to spot even in protected areas. This could be due to the history of exploitation (Das et al. 2014). Two *N. leithii* were dug up from mud in the pool bed just after the winter months (dry season of the year) in the Nallamala Hills of the Eastern Ghats (Annandale 1915), suggesting that the species may aestivate during summer (Das et al. 2014). *Nilssonia leithii* has been reported from the Kaveri and Vaigai rivers in Tamil Nadu; Krishna and Godavari rivers in Andhra Pradesh; Thungabadhra, Neethravathi, and Kaveri rivers in Karnataka; Chalakudy, Bharathapuzha, and Chaliyar rivers in Kerala; Pawna river in Maharashtra; and the Godavari river in Orissa (Gray 1872; Boulenger 1890; Moll and Vijaya 1986; Kalaiarasan et al. 1992; Thomas et al. 1997; Kumar 2004; Vasudevan et al. 2006; Nameer et al. 2007; Praschag et al. 2007; Deepak and Vasudevan 2009; Chandra, K., Deepa, J., Raghunathan, C., Jadhav, S. S., & Karuthapandi, M. (2021). Current status of faunal diversity in Telangana: 1-394 (Published by the Director, Zool. Surv. India, Kolkata). Published: March; Mohan et al. 2021; R. Whittaker pers. comm.).

Despite being widely spread in peninsular India, data on this species' status, distribution, and ecology is sparse. It is locally exploited for food throughout peninsular India (Kumar 2004). They are under Schedule I of the Indian Wildlife (Protection) Act of 2022 (amended). Major threats faced by the species include the

Table 1. Previous and recent observations of *Nilssonia leithii* from Tamil Nadu, India

S. No	Location	Year	Individuals	Remark
1	Coleroon River, Sirkazhi	1991	1	Single specimen (Kalaiarasan et al. 1992)
2	Moyar River, Thengumarahada	1994	2	Two hatchlings; Sirsi, *unpubl. data*
3	Possible origin Vaigai River. Seized at Udumalaipet range, Anamalai Tiger Reserve.	2009	2	Two adults were poached and confiscated; V. Deepak, *pers. obs.* in Deepak and Vasudevan 2009.
4	Kaveri	2021	1	This study
5	Vennaru	2021	1	This study

unchecked consumption of turtle meat, habitat alteration, and destruction throughout its distribution, and the drastically changing riverine ecosystems due to various anthropogenic activities including pollution, sand mining, and other developmental structures such as dams (IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group 2000). The species is listed as "Critically Endangered" in the IUCN Red List, and *N. leithii* is declining throughout its range (Praschag et al. 2021). The last known record of this species from Tamil Nadu was during a short survey conducted at various locations near Thanjavur district between August, December 1990 and March 1991. A single specimen of *N. leithii* was caught from the Coleroon River by a local fisherman and was sold near Kollidam village, Sirkazhi, Tamil Nadu (Kalaiarasan et al. 1992). Since then, no sightings of the species from the Kaveri delta region have been recorded.

The Grand Anicut Dam region was surveyed to assess the population status of *Pelochelys cantorii* in the Kaveri River, Tamil Nadu. During our surveys, we came across two *N. leithii* individuals, from both Vennaru and Kaveri — two different distributaries of the river Kaveri. (Figure 1) *Nilssonia leithii* was identified based on unique characteristics such as the presence of yellowish-red or orange spots on the corner of the mouth and the distinctive head shape, with the help of photographs.

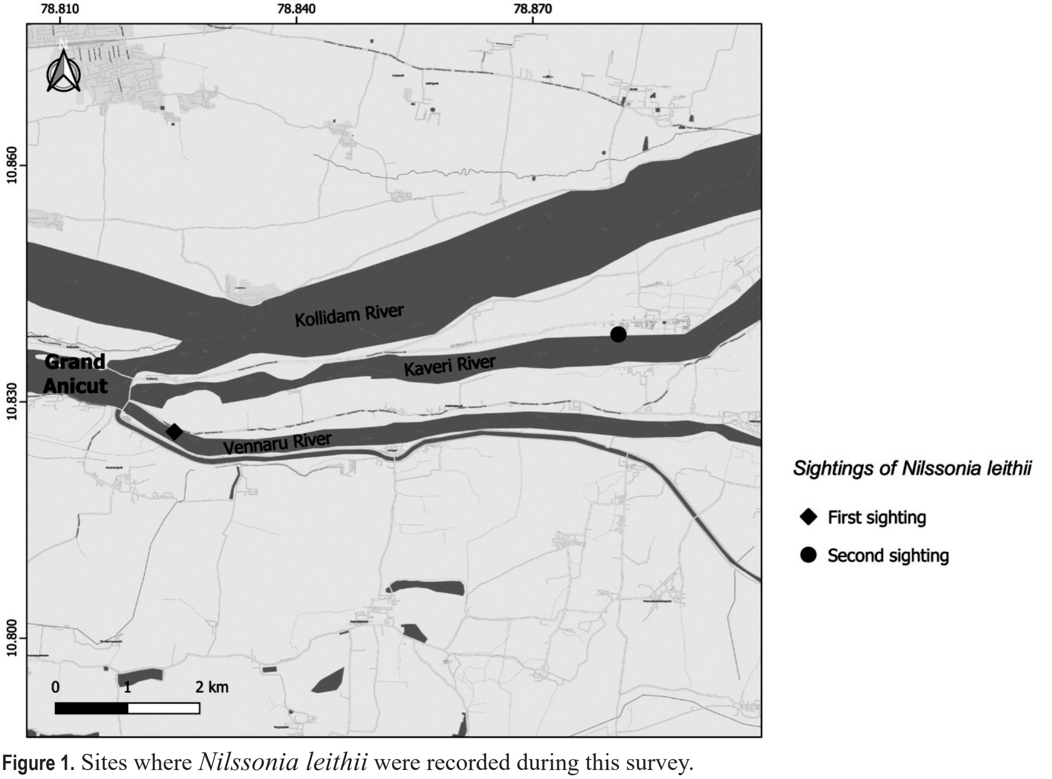

Figure 1. Sites where *Nilssonia leithii* were recorded during this survey.

Methods

Study area. Kaveri originates from southwestern Karnataka in the Brahmagiri range of Western Ghats and flows 800 km through Karnataka and Tamil Nadu, emptying into the Bay of Bengal (Singh and Rajamani 2001). Within Tamil Nadu, only a tiny stretch of the river falls in the relatively less exploited part of the river; the rest of the river flows through heavily populated regions of the state. Like many perennial rivers in India, the river course is polluted by industries along the river banks and disrupted by heavy sand mining. In Tamil Nadu, the river is dammed for irrigation at twelve locations, which also includes India's oldest and most functioning dam, the Grand Anicut built by King Kari Kala Chozhan. From Grand Anicut, the river splits into the four distributaries Kaveri, Kollidam, Vennaru, and Pudhu aaru. This region experiences the southwest monsoon from June to September and the northeast monsoon from October to December.

Field survey. In the summer of 2021 (April–June), we surveyed the Grand Anicut region. We carried out a visual encounter survey in the distributaries of the river Kaveri at the Grand Anicut dam, searching for basking turtles on the river bank and looking for the tracks on the sandy banks left during basking. Direct sightings of the turtles were made in the river when they surfaced for breathing.

Areas with sandbanks and deep waters in the river were considered suitable habitats for the turtles, and during the summer months, the wa-

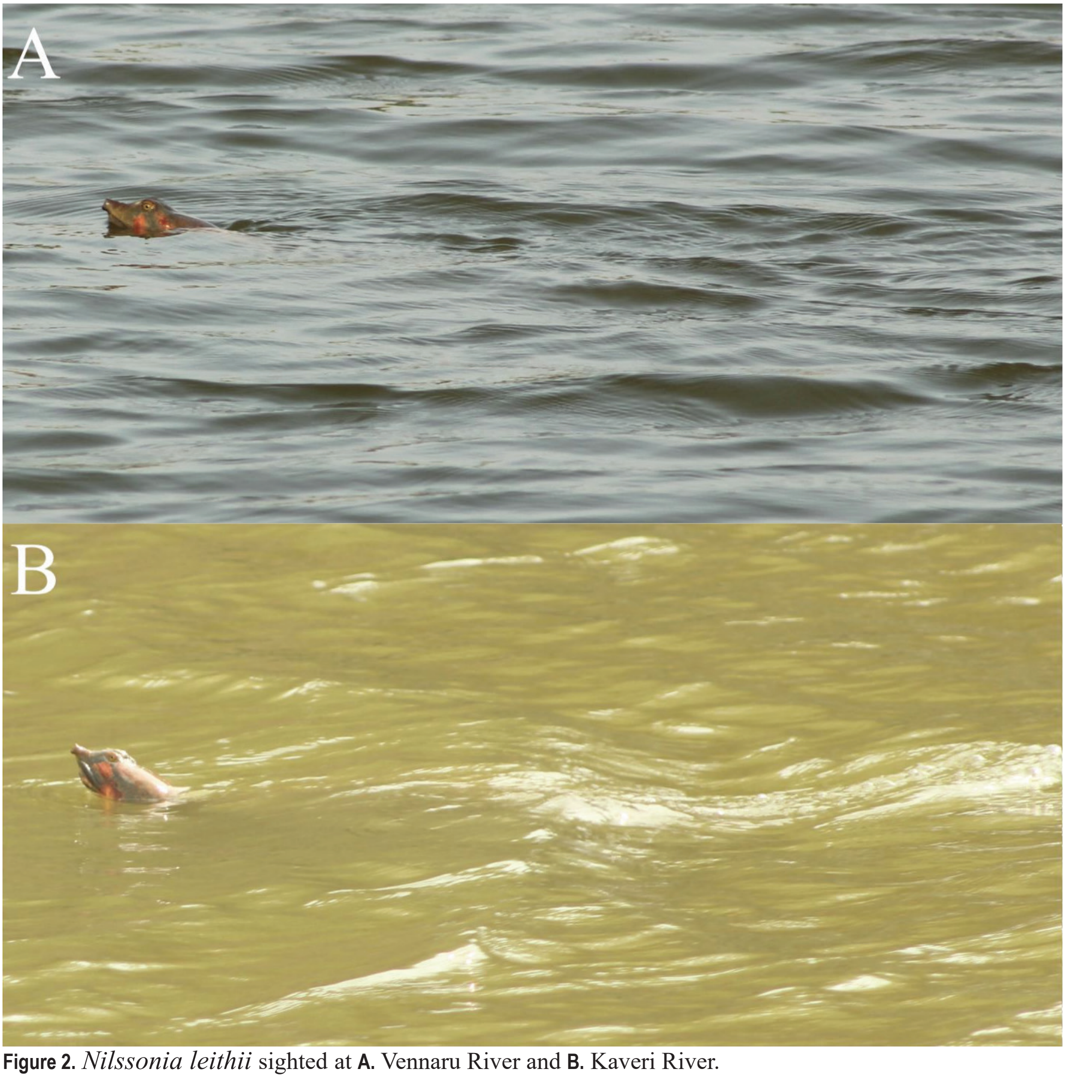

Figure 2. *Nilssonia leithii* sighted at **A.** Vennaru River and **B.** Kaveri River.

ter flow is low in most parts of the river, with only certain regions having enough flowing water suitable for these turtles. These habitats were regularly monitored in the early mornings and late evenings for direct and indirect signs of turtles. All the turtle sightings were photographed with a Canon 600D camera, and the GPS coordinates of the locations were noted using a Garmin GPS (GPSMAP 66st).

Results & Discussion

Our sightings are from the distributaries Vennaru and Kaveri near the Grand Anicut dam. On 16th April 2021, a turtle with a shell length of approximately 60–70 cm was sighted at Vennaru River (N 10.82 E 078.82) in a pool when it surfaced for breathing. It was identified as *N. leithii*, with photographs of the turtle head taken while surfacing. The second sighting was on 21st April 2021, at a village called Koviladi (N 10.83 E 078.88; Figure 2). The region where both turtles were sighted was approximately 125 km from the river estuary. Both sites had similar characteristics — approximately four to five-meter-tall sandbanks with five-meter-deep waters. The rivers in these sites were narrow compared to other regions (Figure 3). Both *N. leithii* and *P. cantorii* were spotted at these locations. The turtles surfaced frequently and were observed feeding on the invasive "*Tilapia*" and other small unidentified fishes in the region. Data on the status, distribution, and biology of *N. leithii* is lacking, and these large softshells are locally exploited throughout peninsular India (Kumar 2004). Extensive surveys are needed to identify breeding populations and the threats that these possibly last remaining populations face in Tamil Nadu.

Nilssonia leithii was first reported in Tamil Nadu state in 1991 (Kalaiarasan 1991). Since then, there have been only two additional records from the state (Table 1) and none from the Kaveri delta region.

Acknowledgements

The project "Population status of *Pelochelys cantorii* in Cauvery River, Tamil Nadu, India" was funded by the Turtle Conservation Fund and Global Wildlife Conservation (GWC), and we are grateful to them and Ella Outlaw (GWC) for her support. We also would like to thank all

Figure 3. Microhabitat in Vennaru River where individuals of *Nilssonia leithii* were recorded.

the local informants for their invaluable assistance in locating the turtles during our surveys.

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Date submitted 15/09/2022
Date accepted 17/11/2022
Available online

Hamadryad Vol. 40 (1&2), pp. 29–36, 2023, ISSN: 2583-7818 (Online).

A rapid survey of the anuran diversity at Nandi Hills and Moodiganahalli village, Chikkaballapur District, Karnataka, India

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CITATION. Nag, K.S.C., Deepak, P. and Hegde, A. (2023) A Rapid Survey of the Anuran Diversity at Nandi Hills and Moodiganahalli village, Chikkaballapur District, Karnataka, India. *Hamadryad: 40, 29–36.*

ABSTRACT. The current study conducted a comprehensive survey between July and August 2021 to assess the diversity of frogs in Nandi Hills (maximum elevation of 1478 m asl) and Moodiganahalli village, Bengaluru Rural, which is located approximately 13 km from Nandi Hills (965 m a.s.l.). The study employed opportunistic audio-visual surveys to identify anurans, with surveys conducted around natural and temporary water bodies. The preliminary survey revealed 12 species of anurans belonging to four families. The current inventory study of anuran species of Nandi hills opines that the anuran assemblages in these areas could be depauperate due to habitat loss and quality degradation in urban landscapes.

KEYWORDS. Anuran diversity, Habitat loss, Inventory, Nandi Hills, Peri-Urban

Introduction

The focal aim of ecology has always been to understand the patterns and processes that uphold biodiversity as critically important for the feasibility of any ecosystem (Tilman et al. 2014). Scientists argue that the various dimensions of biodiversity, such as genes, species, functional forms, adaptations, habitats, ecosystems, and variability within and between these factors are tightly interconnected. These factors affect the state, stability, and productivity of the ecosystem, as well as ecosystem services (Schneiders et al. 2012), thereby making biodiversity, an ecological, social, and economic issue. Ever-increasing land degradation, changing climate, fragmentation, deforestation, and urbanization owing to human pressure across the globe threaten biodiversity and associated ecosystem services (Foley et al. 2005; Ceballos et al. 2015; Jones et al. 2018). Measurements of species presence and absence alone are, thus, a paltry substitute for biodiversity value and biodiversity loss (Dorazio et al. 2011).

Patrick et al. (2014) notes that rapid biodiversity surveys have the potential to tackle the absence of baseline biodiversity data for conservation and management.

Anurans have been admirable site-specific bio-indicators (Pechmann and Wilbur 1994; Donnelly and Crump 1998) despite the negative effects of anthropogenic landscape change such as habitat loss, fragmentation, degradation, and isolation (Hamer and McDonnell 2008). Regardless of the species richness and abundance loss due to pollution-related causes (Collins and Storfer 2003; Hamer and McDonnell 2008), anurans have shown remarkable adaptations in urban habitats (Gibbs et al. 2005). In light of

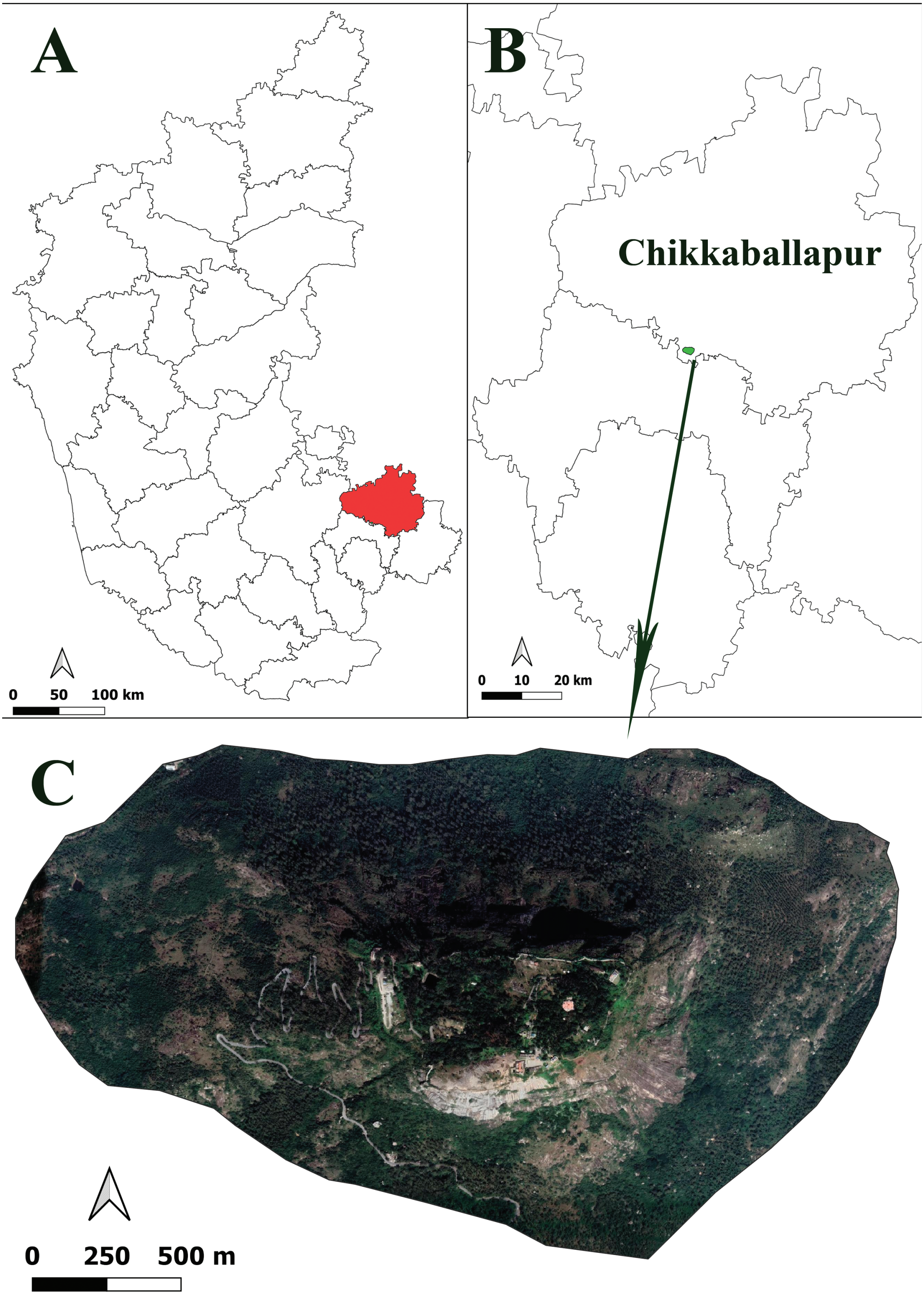

Figure 1. A. Political outline map of Karnataka (Red colour indicates Chikkaballapur district); **B.** Political boundaries of Chikkaballapur (Green colour indicates the study area); **C.** Topographical map representing the study area, Nandi Hills

the worldwide amphibian extinction catastrophe, Ceballos et al. (2020) contend that there is greater urgency than ever to identify anuran population decrease, highlighting the significance and need to document the presence of amphibian diversity.

Amphibian research in the state of Karnataka, India dates to 1876, when Günther described *Ansonia ornata* (now *Blaira ornata*) from the Western Ghats region. So far, a total of 100 species of amphibians have been reported from the state of Karnataka, out of which 26 are under the vulnerable list (Dinesh et al. 2021). Most of the amphibian studies in Karnataka were primarily focused on the Western Ghats region, which has been one of the global biodiversity hotspots and a habitat for unique lineages of anurans. Contrastingly, the Deccan plateau regions of Karnataka are understudied and neglected, needing detailed surveys to record the diversity in these ignored areas. The discovery of a new species of burrowing frog *Sphaerotheca bengaluru* (Deepak et al. 2020) from the peri-urban regions of Bengaluru provides evidence that anuran diversity needs to be further explored in the Deccan plateau regions of the state of Karnataka and elsewhere.

Since no satisfying baseline information was available in the literature so far, we aimed to assess the diversity and distribution of anurans from Nandi Hills, Bengaluru Rural, based on a rapid biodiversity assessment, and to strengthen future conservation strategies and policy-making initiatives in this region.

Materials and methods

Study area. A total of five visits were carried out between the months of July and August 2021, followed by a random opportunistic survey method using three-man hours between 18:00 hrs to 00:00 hrs at Nandi Hills and Moodiganahalli village to explore the anuran diversity of the regions. The Nandi hills (formerly known as Nandi Durga) is part of three rocky hills, located in the Chikkaballapur district of Karnataka, which is due north of Bengaluru at 60 km 13.366 N, 77.683 E with an elevation of 800 to 1480 m. Geologically, the Nandi Hills are a part of the Dharwad craton (Krabbendam and Palambakumbura 2018 and references therein) that is dated to be nearly 3.5 billion years old, and therefore, is an interesting landmass to study biodiversity. The hill range runs northwards to Gudibanda in Kolar district and extends to the state of Andhra Pradesh (Singh 1988). The hill range covers 2837 ha and comprises three main hillocks. Of the three hills, the Nandi Hills has an altitude of 1478 m a.s.l. The Arkavathi River originates at Nandi Hills, flows towards Ramanagara district, and joins the river Cauvery at Sangama, Kanakapura. The hills are known for its pleasant climate throughout the year. Most of the original forest covers on the hills have degraded and given way to secondary vegetation consisting of primary scrubs. The hill slopes and the valley are dominated by open scrub vegetation. *Eucalyptus globulus* (Australian Eucalyptus) and *Shorea roxburghii* (Taloora Lac Tree) have been introduced in some areas. However, some natural woodlands remain, particularly near the summit. Lantana weed has spread across the hills, displacing native flora. Scrub vegetation, interspersed with Eucalyptus, covers the hillsides (Praveen 2006; BirdLife International 2021).

Moodiganahalli is a small village close to Nandi hills in Devanahalli Taluk of the Bangalore Rural district in Karnataka, India. It is approximately 92.88 hectares in area. This village is mainly dominated by agricultural fields, where a majority of the water sources are wells, irrigation channels, and ponds. The area also includes scrub lands, plains, and grazing lands. Moodiganahalli comprises low-elevated lands in comparison to the Nandi Hills. The map (Figure 1) was generated using QGIS 3.12.2 and administrative map were obtained from gadm.org.

The study opportunistically conducted a thorough comprehensive survey during the monsoon season between the months of July and August 2021. The study employed (1) acoustic encounter surveys; and (2) visual encounter surveys (Rödel and Ernst 2004) to locate anurans with searches conducted around water bodies such as natural and temporary ponds. These methods rely on detecting all individuals seen and/or heard in a 25 m radius area for a 15 min period (Lips et al. 2001).

Surveys were carried out from the base of the hill and the surrounding regions, which include

Figure 2. Different habitats at Nandi Hills & Moodiganahalli village, which were surveyed during the present study.

secondary forests, open land, scrub jungles, agriculture lands, ponds, and artificial wetlands like water channels, and mud puddles. In the mid elevation (< 900 m) areas, the slopes and streams were sampled, while in the high elevation (> 900 m) regions, the artificial water tanks, canals, channel structures, ponds, wetlands, open lands, forests, and scrub forests were surveyed (Figure 2).

Frogs were acoustically located and identified up to the species level. Visual observations and morphological characters also aided in frog identification. All the breeding grounds and spawning sites were carefully examined for frogs and tadpoles. Other microhabitats in the forest patches, leaf litter, barks of trees, and shrubs were also inspected for frogs.

Specimens were collected and photographed under controlled conditions using Canon 6D Mark II camera and Tamron SP 180 mm F/3.5 Di 1:1 macro lens for further identification.

Results

Our study revealed 12 species of Anurans under four families (Table 1 & Figures 3, 4)

Discussion

Our rapid survey revealed 12 species of anurans belonging to four families (Table 1) giving us a coarse estimation of the distribution of these anurans found in the Nandi hills region and the surrounding areas. Among the 12 species reported here, members of the family Dicroglossidae and Microhylidae were found to be speciose (with five species each). In general, members of both these families are widespread due to their flexible environmental adaptability when compared to other habitat specialist frog species. Among the 10 species of both the families, nine species are distributed over a wide range, of which *S. bengaluru* described recently (Deepak et al. 2020) is known only from the surrounding regions of Bengaluru.

Interestingly, *S. bengaluru*, *S.* cf. *breviceps*, and *U. systoma* were located around the lower elevations around Moodiganahalli village, and not on of the higher elevations on Nandi hills, suggesting an elevational preference for these data deficient anurans.

Although the species list presented here is not exhaustive, chances of occurrence of the species

Table 1. Anuran species found in Nandi hills and surrounding areas along with altitude (in meters) and IUCN (International Union Conservation of Nature) status. *indicates the anuran species found in the low elevation areas surrounding Nandi hills. LC = least concern, DD = Data deficient, NE = Not evaluated.

Sl. No.	Family	Species	Altitude (m)	IUCN Status
1	Bufonidae	*Firouzophrynus peninsularis* (Rao, 1920)	800–1400	LC
2		*Euphlyctis cyanophlyctis* (Schneider 1799)	800–1400	LC
3		*Minervarya agricola* (Jerdon 1853)	800–1400	NE
4	Dicroglossidae	*Minervarya* cf. *syhadrensis* (Annandale 1919)	800–1400	LC
5		*Sphaerotheca bengaluru**	< 900	DD
6		*Sphaerotheca cf. breviceps**	< 900	LC
7		*Microhyla ornata* (Duméril and Bibron 1841)	800–1400	LC
8		*Microhyla rubra* (Jerdon 1853)	800–1400	LC
9	Microhylidae	*Uperodon systoma**	< 900	LC
10		*Uperodon taprobanicus* (Parker 1934)	800–1400	LC
11		*Uperodon variegatus* (Stoliczka 1872)	800–1400	LC
12	Rhacophoridae	*Polypedates maculatus* (Gray, 1830)	800–1400	LC

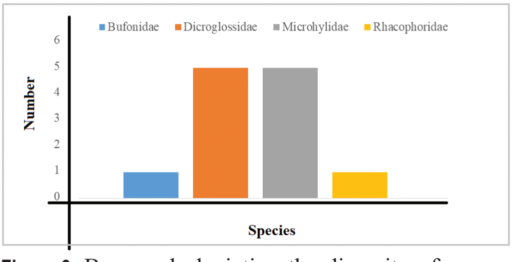

Figure 3. Bar graph depicting the diversity of anuran families from the study areas.

D. scaber, *Hoplobatrachus tigerinus*, *Phrynoderma hexadactylus*, and *Microhyla sholigari* along with rhacophorids from the study area cannot be ruled out at these elevations and habitats. The survey also focussed on finding the relict populations of *Minervarya kalinga* based on its records from two regions — the Eastern and Western Ghats (Hegde et al. 2020). However, perhaps because of limited time access, our search was futile, but we do not rule out the possibility of encountering *M. kalinga* in this habitat. Hence, more detailed surveys in this region are required to understand their habitat niche.

When compared to the biodiversity hotspots in the Indian subcontinent, other biogeographic regions such as the large Deccan range with hills, and plateaus, and the Eastern Ghats, which are discontinuous mountain ranges, have been hitherto neglected. Nandi Hills and other hills in the Deccan region are composed of characteristics of both the Eastern and the Western Ghats landscapes, and these might act as refugia to most of the primitive, rare, and endangered flora and fauna (Dinesh et al. 2018). They might also increase and support the diversity and density of flora and fauna in the surrounding plains.

Studies in the hills of the Deccan plateau regions of peninsular India are largely neglected because the majority of herpetofaunal studies are concentrated on the Western Ghat biodiversity hotspot. In the last two decades, numerous reptile species have been described from these landscapes, which also includes a shield tail species from Nandi Hills (Ganesh et al. 2021).

Nandi Hills, being a popular tourist destination, experiences a lot of vehicular movement, particularly during the weekends and the summer season. The traffic along these roads could be having a detrimental and possibly lethal effect on the anuran population. Given the fact that toads and frogs have short dispersal abilities in urbanized areas, (Hammer and Parris 2011) issues such as road accidents while crossing, exposure to runoff (oil), noise, vehicular exhaust/stone crushing emissions, and vibrations could be affecting the anuran assemblages in Nandi Hills and the surrounding areas either through direct or behavioural disturbances. Incidences such as landslides, forest fires, construction activities, car and bike race events, and illegal stone crushing at Nandi Hills (News Papers 2021) in recent times suggest that anuran assemblages in these areas could be depauperate due to habitat degradation and loss. Thus, the cur-

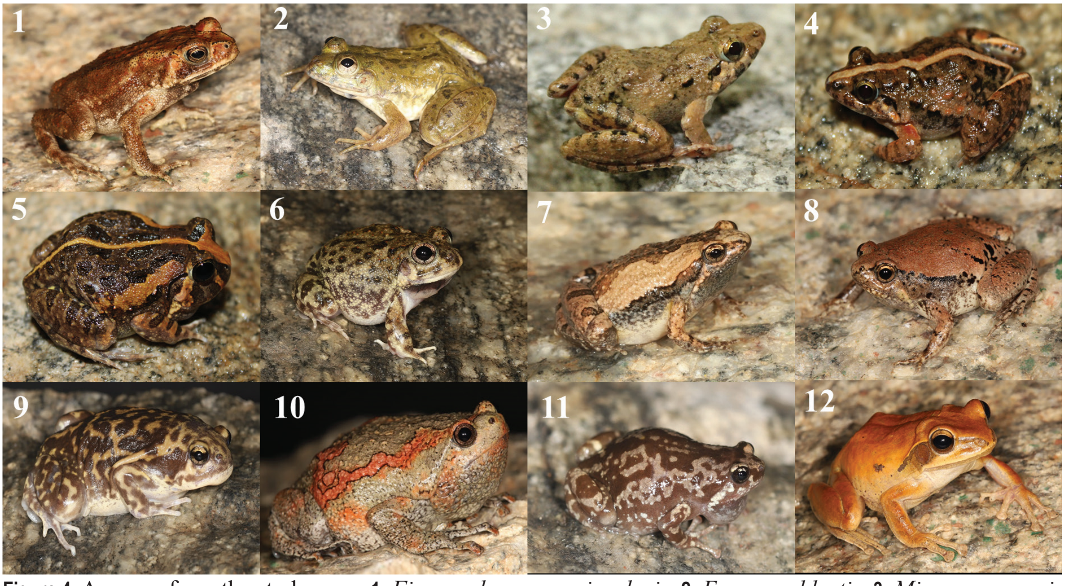

Figure 4. Anurans from the study areas **1.** *Firouzophrynus peninsularis*, **2.** *E. cyanophlyctis*, **3.** *Minervarya agricola*, **4.** *M.* cf. *syhadrensis*, **5.** *S. bengaluru**, **6.** *S.* cf. *breviceps**, **7.** *Microhyla ornata*, **8.** *M. rubra*, **9.** *Uperodon systoma**, **10.** *U. taprobanicus*, **11.** *U. variegatus*, **12.** *Polypedates maculatus* (*indicates the anuran species found in the surrounding low elevated areas of Nandi Hills)

rent preliminary inventory study suggests that conservation measures involving anurans in this region should consider the preservation of habitat mosaics and recommend future surveys with continuous monitoring to provide more accurate accounts of the current distributional and diversity patterns of anurans. Furthermore, future assessments should ensure continuous monitoring to provide more accurate accounts of the current distribution of organisms, and their causal explanations behind the differential success of taxa along ecological gradients in these critical and fragmented habitats.

Declaration of competing interest and funding

The authors declare that the present study did not seek any financial support from any organization, committee, group, or individual, and was a self-funded attempt.

Acknowledgements

The authors would like to thank Dr. K. P. Dinesh, ZSI Pune for his valuable inputs and insights during fieldwork. The authors also wish to thank the Senior Assistant Director, Horticulture Department, Nandi Hills Bengaluru who kindly facilitated permission for fieldwork at the study site. CN would like to thank Mr. Santhosh, Joint Registrar, JAIN (Deemed to be University) for all the cooperation towards this study. AH is thankful to Dr. Girish Kadadevaru for his continuous support. PD is grateful to the Principal and the Head of the Department of Zoology, Mount Carmel College, Autonomous, Bengaluru for their support and thankful to the Karnataka Forest Department for the field study permissions. The authors are also thankful to Alexander for his valuable contribution in volunteering for the survey. Finally, the authors thank the anonymous reviewers for all the suggestions and comments on this manuscript.

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Date submitted 13/12/2023
Date accepted 22/02/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 37–49, 2023, ISSN: 2583-7818 (Online).

Interpreting sea turtle stranding with reference to the spatiotemporal analysis of hotspots along Maharashtra: implications for sea turtle conservation in Maharashtra, India

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CITATION. Hatkar, P., Bagaria, P., Vinherkar, D., Kansara, D. and Patel, S. (2023) Interpreting Sea turtle stranding with reference to the spatiotemporal analysis of hotspots along Maharashtra: implications for sea turtle conservation in Maharashtra, India. *Hamadryad: 40, 37–49.*

ABSTRACT. **Sea turtles are affected by various natural calamities and disasters apart from those caused by human-induced activities, including fishing operations. Stranded carcasses of marine megafauna can provide valuable information on the cause of death at sea. However, interpreting the results can be challenging because stranding probabilities are usually very low and highly variable in space and time. However, it is crucial for the management of such species. Knowledge of the spatial and temporal distribution of specific mortality sources is crucial for managing species vulnerable to human interactions. Beach cast carcasses represent an unknown fraction of at-sea mortalities. Data on stranded sea turtles were examined between 1981 and 2021 along the Maharashtra coast (N = 510) to detect spatio-temporal patterns and understand the factors that contribute to their mortality. We evaluated the distribution and magnitude of sea turtle mortality along the Maharashtra coast. These data are valuable for directing and implementing specific and local mitigation measures along the Maharashtra coast, such as avoiding bycatch hotspots through fleet communication programs or area- and season-specific closures, enforceable legislation, effective penalties, and proper waste management. This study highlights the importance of addressing these data gaps and provides a meaningful conservation tool that can be applied to stranding data on sea turtles along the Konkan coast of India.**

KEYWORDS. **Conservation tool, Maharashtra, management, sea turtle, strandings**

Introduction

Marine turtles have been around for millions of years and have outlived dinosaurs. Being slow-growing and long-lived, turtles have played vital roles in maintaining the health of the oceans (Lovich et al. 2018). Their populations have experienced a global decline because of a history of intense commercial exploitation and harvest for eggs and meat (Tripathy and Choudhary 2007). Most of the work that has been carried out has focused on the conservation aspects of their biology and behaviour (Tripathy 2006). However, knowledge of mortality from natural events or anthropogenic threats is essential for conserving and managing marine organisms.

Five species of marine turtles are found in the Indian Ocean viz. the green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*) (Kar and Bhaskar 1982). All are found along the Maharashtra coast (Andhare and Hatkar 2015). All sea turtle species are listed on the IUCN Red List, CMS, and the green sea turtle and hawksbill turtle are included in Appendix I under CITES. They are also protected under the Wildlife Protection Act 1972. Most research on the Olive ridley turtle in India has focused on the mass nesting populations, with little attention given to the solitary nesting populations (Phillott and Rees 2018; Ortiz-Alvarez et al. 2020). Sea turtle strandings and subsequent dying provide an important opportunity to study turtle mortality and identify threats for future mitigation and conservation actions. However, identifying potential causes of mortality of stranded sea turtles can be highly challenging due to the state of carcass decomposition and the lack of clear physical evidence of the cause of mortality (Hart et al. 2006; Koch et al. 2013).

A survey along nesting beaches in 2014 indicated that hawksbill, green, and olive ridley turtles are regularly seen in nearshore waters and probably congregate in selected areas off the Sindhudurg coast during a particular time of the year (Andhare and Hatkar 2015). The nesting of green turtles is comparatively lower than that of the olive ridley in Sindhudurg. In January 2022, the Mangrove Foundation recorded three green turtle nests at Devbaug — Tarkarli beach, Wayangani, and Wayari in Sindhudurg. Local fishermen reported sighting several young hawksbill turtles during the monsoon season in the Devgad area (Andhare and Hatkar 2015).

When marine animals unintentionally wash up on shore and are alive, the event is called beaching, (CMFRI 2014). Most sea turtle strandings are of dead animals, but live specimens can also strand. Live ones are rescued and sent back into the sea by the local forest departments along with local fishermen and organizations (Pinjarkar 2020). They usually die unless humans intervene and push them back to sea or move them to rehabilitation facilities (Jefferson et al. 2011). Morphometric records of the dead stranded turtles were not available except for a few since data is maintained by the local forest departments with necropsy reports. There is no estimated population, along Maharashtra coast that needs to be monitored for turtle abundance. It is suspected that deaths have been caused by incidental capture and drowning. The major threats to the marine turtles of Maharashtra are nest predation, plastic pollution, poaching of eggs and adults, bycatch in illegal gill nets and trawl fishing, habitat degradation and entangling in ghost nets in the offshore waters where turtles die as incidental catch (Giri and Chaturvedi 2003; Sanaye and Pawar, 2009; Andhare and Hatkar 2015). Ghost nets are those that have been discarded, abandoned, or lost in the ocean, and there are no nearby recycling facilities for nets yet (Ninaware 2021). These details are crucial for the spatial planning for biodiversity conservation and rational planning of marine ecosystems, including those for sea turtles under threat due to developmental activities. This paper represents the first published attempt to integrate data on sea turtle strandings.

Study area

Maharashtra comprises a 720 km long indented coastline, marked by significant estuaries and narrow creeks. It comprises the coastal districts of Thane, Raigad, Greater Bombay, Ratnagiri, and Sindhudurg. The main drainage in the coastal area trends in a general east-west direction and flows to the Arabian Sea in the west. Kankauli, Savantwadi, Kudal, and Vaibhavwadi talukas from Sindhudurg, and Devrukh and Chiplun talukas from Ratnagiri fall under Eco- Sensitive Zone One (Shirke and Amritkar 2012). The coastal region of Maharashtra is known as Konkan, and the Konkan belt receives 2000 to 3000 mm of rainfall annually (Kehimkar 2017). There are 15 rivers and five major creeks along the coast. All creeks and estuaries drain in an east-west direction, flowing into the Arabian Sea.

The Maharashtra coast is well known for the sporadic nesting sites of olive ridley (Giri et al. 2006). The sporadic nesters nest anywhere and anytime along the coastline (Plotkin 2007). However, it also has a few occurrences of nesting of green and hawksbill turtles (Giri and Chaturvedi 2003). More than 15 important Coastal and Marine Biodiversity Areas have been identified in Maharashtra and included in the Coastal Regulation Zone (CRZ) -I. (Saravanan et al. 2013). The Ecologically Sensitive Zone (ESZ) refers to specific zones within the extended 'Eco-Sensitive Area' for which a particular set of regulatory or promotional activities have been proposed. Kankauli (N 16.2715, E 73.7127), Savantwadi (N 15.9114, E 73.8287), Kudal (N 15.9984, E 73.6790), and Vaibhavwadi (N 16.4981, E 73.7437) talukas from Sindhudurg, and Devrukh (N 17.0708, E 73.6211) and Chiplun (N 17.5345, E 73.5213) talukas from Ratnagiri fall under Ecological Sensitive Zone One via the Gazet of India Part II section 3 no. 3956 dated 4th October 2018 (Shirke and Amritkar 2012). Due to its high ecological importance, 29.12 square kilometres of the Sindhudurg Coastal and Marine Ecosystem (SCME) were designated as the Malvan Marine Sanctuary (M.M.S.) in 1987, and is one of 125 marine protected areas in India (Pisolkar and Chaudhary 2016).

Methodology

We compiled information on sea turtle strandings along the Maharashtra coastline from various published and unpublished sources, stranding networks, local forest departments, and newspaper reports from 1981 to 2021. We organized them into a single dataset. The relative data values presented across the timeline are dependent upon the data availability. In this study, any sea turtle found alive or dead on the beaches or floating in coastal waters was considered a stranding, except for nesting females (Foley et al. 2019). The following information was collected for each stranded turtle encountered — species, date, sex, and location (latitude and longitude). Live-stranded animals were transferred to the nearest sea turtle rehabilitation centre established by the Maharashtra Forest Department at Airoli and Dahanu. Information on the Dahanu coast was compiled and collected by the Dahanu-based non-governmental organization (N.G.O.) *Wildlife Conservation and Animal Welfare Association* (WCAWA) and the Dahanu forest department.

The data sourcing, compilation, and analysis were conducted as described below: The Sea Turtle rescue dataset was plotted in ArcMap 10.3. Grids of 10 x 10 km were generated. The rescue data points and grids were intersected to generate a count number in each grid, representing the number of rescue points in a single grid. Each grid's count of rescue points generated the sea turtle rescue heat maps. Furthermore, the stranding or rescue dataset was segregated into the pre-monsoon, monsoon, and post-monsoon seasons to represent the seasonal variation in sea turtle rescue. At the same time, the species-wise rescue maps were also generated to highlight the frequency of rescues in each species. We looked at the stranding records of sea turtles on decadal scales and visualized it on the R program using a bean plot package (Kampstra 2008).

Result

A total of 510 stranding records of sea turtles from the Maharashtra coast over the past 40 years from September 1981 to December 2021 were compiled (Table 1). The stranding peak season was observed in the monsoon season, i.e., June–August (Figures 1, 4, 5). High mortality of olive ridley turtles owing to incidental catch has become a regular annual phenomenon along the Maharashtra coast. During the study period nesting species such as olive ridley (N = 360), green turtle N = 127, were the highest and among non-nesting species hawkbill turtle N = 16, loggerhead turtle N = 5, and Leatherback turtle N = 3 were stranded with few reports along the Maharashtra coast (Figure 6). All stranded turtles that were caught were mostly females since males never return to the beach. The percentage of females and males in each of the species of stranded turtles were as follows: olive ridley females = 69.2%, males = 2.5%, unknown = 28.3%; green sea turtle females = 79.5%, males = 8.9%, unknown = 11.5%; hawkbill turtle females = 100%; loggerhead turtle females = 44.4%, males = 22.2%, unknown = 33.3%; and leatherback turtles unknown = 100% (Figure 3). The stranding of a non-nesting species in this area might indicate that the Maharashtra coastal areas are important foraging grounds or migratory pathways. Most sea turtles were caught in Dol net, hook, lines, gillnet, bag net, Rampani net, and ghost net. The highest stranding of sea turtle was observed during monsoon season (Figure 1, 7) compared to pre monsoon and post monsoon season (Figure 8, 9).

Table 1. Numbers of sea turtle strandings from 1984 to 2021

SN	Year	Number of sea turtles stranded/ injured/dead	Reference
1	1981	1	Karbhari, J.P. (1981)
2	1984	3	Karbhari, J.P. (1985)
3	1985	2	Karbhari, (1985); Karbhari, et al. 1986
4	1988	3	Katkar, (1989),
5	1991	3	Katkar 1988; Hotagi, (1992)
6	1995	2	Katkar, 1995.
7	1996	1	Jadhav (1996).
8	2000	29	Sahydri Nisarg Mitra
9	2000-2001	6	Sahydri Nisarg Mitra
10	2001	1	Sahydri Nisarg Mitra
11	2002-2003	2	Sahydri Nisarg Mitra
12	2003-2004	11	Sahydri Nisarg Mitra
13	2004	41	Katdare 2008, Sahydri Nisarg Mitra
14	2005-2006	8	Giri, V. (2006); *Giri, V. & Chaturvedi, N. 2006.*
15	2008	3	Sundaram and Josekutty (2009);
16	2011	2	Sahydri Nisarg Mitra
17	2012	1	Shiledar et al. (2012).
18	2013	6	Sundaram & Mane (2013); Dahanu forest dept and WCAWA
19	2014	28	Dahanu forest dept and WCAWA
20	2015	20	Dahanu forest dept and WCAWA
21	2016	24	Dahanu forest dept and WCAWA
22	2017	43	Dahanu forest dept and WCAWA; Singh V. A.(2017). Anonymous (2017)
23	2018	62	Dahanu forest dept and WCAWA Express News Service (2018)
24	2019	48	Hatkar, P et al. (2019); Dahanu forest dept and WCAWA
25	2020	59	Akshay Mandavkar pers comm; Dahanu Forest Dept and WCAWA, Shaunak Modi pers comm
26	2021	26	Umang Kale pers comm, Dahanu Forest Dept and WCAWA, Noah Shinde Pers communication

The stranding reports hotspots were Chikhale (N = 32), Nivati (N = 25), Chinchani (N = 23), Juhu (N = 23), Vengurla (N = 21), Dhakti Dahanu (N = 18), Khavane (N =14), Bordi (N = 12), and Dandi (N = 17) (Figure 2, 6). Of these turtles, 146 (54.8%) were released back into the sea after the rehabilitation process, 115 (43.2%) died during the rehabilitation, and five (2%) turtles were still in the rehabilitation process. Significant year-to-year variation in stranding rates was observed. This long-term study indicates that fishing-related or environmental factors might explain the temporal stranding patterns of marine turtles.

Spatial overlap was noted between potential mortality locations and gillnet and seine fisheries, providing important information for focusing future research on mitigating conflict between sea turtles and human activities. Turtles were entangled in ghost nets that had been discarded, abandoned, or lost in the ocean. Ghost nets pose a severe threat to marine megafauna throughout the world. Improvised net disposal facilities in ports can help reduce gear loss.

Discussion

Sea turtles play a vital role in ocean ecosystems. As sea turtle populations decline, their ability to perform vital roles in maintaining the health of the oceans also decreases. There is a need to ensure that their populations recover. Sea turtle interactions are problematic in pelagic longline, gillnet, set net, pound net, trawl, purse seine, and demersal longline fisheries that operate in the range of sea turtles, especially in the tropics and subtropics (F.A.O. 2010). In recent years there has been increased attention on the increased stranding records of sea turtles along the Maharashtra coast. The number of sea turtles inhabiting the waters off the Maharashtra coast is uncertain. However, this is the first study to analyze regular beach monitoring efforts for stranding. The results of this study provide the first attempt to predict sea turtle mortality location. Stranded sea turtles were recorded along the entire coast of Maharashtra. Present data needs further examination of the possible forcing effect of nearshore current patterns and tidal fluctuation.

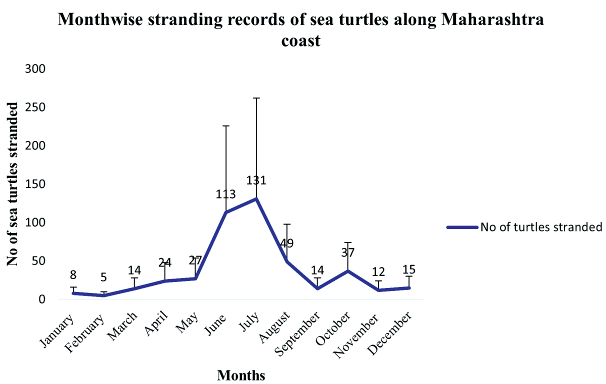

Figure 1. Monthly variation of sea turtle strandings along the Maharashtra coast

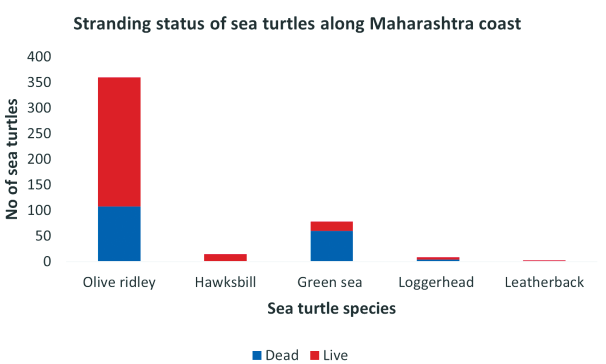

Figure 2. Stranding status of sea turtles along the Maharashtra coast during 1984–2021

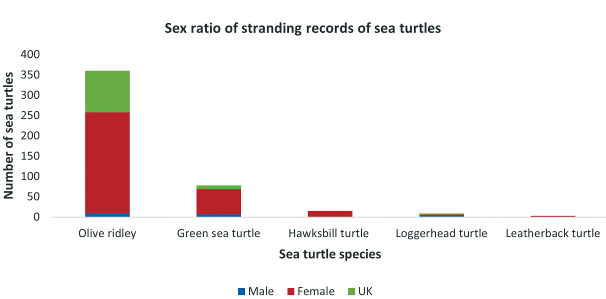

Figure 3. Sex ratio of stranding records of sea turtles along the Maharashtra coast 1984–2021

The olive ridley is the most abundantly found species along the Maharashtra coastline. The olive ridley and green turtles are frequently encountered as bycatch across the coast, suggesting a distribution in the West Coast's nearshore and offshore waters (Phillott and Rees 2018). The leatherbacks and loggerheads, on rare occasions, are encountered as bycatch in both the Arabian Sea and the Bay of Bengal (Shanker and Choudhury 2006; Hatkar et al. 2019). During the monsoon season, live-stranded female subadult hawksbill turtles (N = 16) were observed along Mumbai, Palghar, and Sindhudurg district coastlines. Local fishermen reported sighting several young Hawksbill turtles during the monsoon season in the Devgad area (Andhare and Hatkar 2015). Rarely, the leatherbacks and loggerheads are encountered as bycatch in the Arabian Sea. All female loggerhead turtles that were stranded live (N = 4), and dead (N = 1) were found along with Palghar and Sindhudurg districts during the monsoon season. Leatherback (N = 2) turtles were accidentally caught near Devbag near Malvan and Palghar district (Karbhari 1985; Karve 2020). Green turtles are stranded in nearshore waters, which are predominantly rocky with a luxuriant growth of seaweeds.

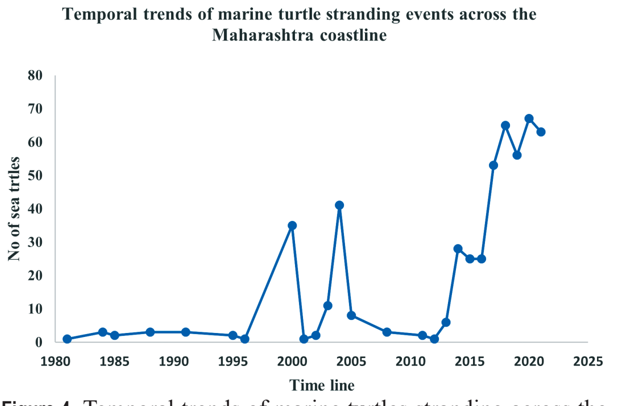

Figure 4. Temporal trends of marine turtles stranding across the Maharashtra coastline in the past 25 years

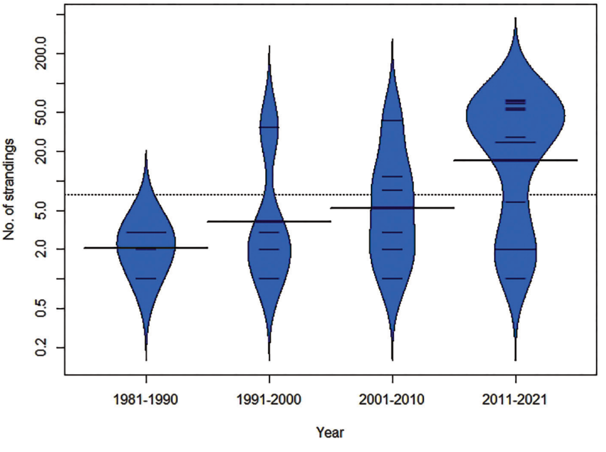

Figure 5. Decadal trends in sea turtle stranding events across the Maharashtra coastline

Halophila beccarii seagrass species are already recorded from Kolam, Tarkarli, Kalwall, and Achara (Bhosale 2003).

In Mumbai, the olive ridley turtles usually nest at Backbay, Juhu Chowpati, Girgaon Chowpati, Governor's Gate, Shivaji Park to Mahim, Juhu to Versova Mud Island, Gorai, Marve, Manori, Worli, and Vashi Creek (Kar and Bhaskar 1981; Chhapghar 2005; Giri and Chaturvedi 2006). In Shiroda and Tambaldeg, fishermen reported that green turtles occur in the seagrass beds in the nearshore waters (Andhare and Hatkar 2015). Green turtle nesting was also observed in Tarkarli, Achara, Kunkeshwar, Nivati, and Tondavali (Giri and Chaturvedi 2003). The potential nesting beaches from which there are reports of nesting of olive ridley are Kelus, Neevati, Khavane, Tondavali, Talashil, and Achara in Sindhudurg district, and Nevare, Varavade, Vetye, and Ambolgad in Ratnagiri district (Giri and Chaturvedi 2003). Significant aggregation of olive ridley turtles was also observed at Bombay, and Dahanu, Gorai, Khim, Manori and Versova have also recorded nesting of olive ridley turtles (Shaikh 1984). Recently, one leatherback turtle was caught in a fishing net near Bhate jetty in Mumbai (Katdare 2022).

The total area within the Dahanu Taluka for the location of permissible industries will be restricted to a maximum of 500 acres within the industrial areas earmarked in the Master Plan as per MoEF&CC notification dated 20th June 1991. Various projects have led to the fragmentation and further degradation of the pristine areas of Dahanu Taluka. Threats to offshore sites include fishery bycatch in different fishing gears (Phillott and Rees 2018). The average percentage of incidental catch is four to five turtles per trawler per year (Giri and Chaturvedi 2003). Adults and immature sea turtles are accidentally captured in fisheries ranging from highly mechanized operations to small-scale fishers. Fishing is intensively carried out all along the Maharashtra coast. Turtles are injured by the boat's propellers and caught in fishing nets all over the coast. Motorized fishing vessels with outboard motors (O.B.M.) generally operate up to about 50–60 m from the coast using long lines or spreading their nets for a few hours throughout the day. (F.A.O. 2010). Turtles trapped in the trawl net are dragged over for one to three hours. As a result, their heads are bludgeoned.

Extensive nest protection measures and hatcheries are maintained across the mainland coast (Phillott and Rees 2018). Worldwide in situ conservation has potentially contributed to the successful conservation of few sea turtle populations (Mazaris et al. 2017). In Tamil Nadu the TREE foundation rescues and rehabilitates sea turtles — they rescued 35 sea turtles, among which 11 were released (Dharini and Sriram 2015). Reliable data on sea turtle abundance and the numerous causes of turtle deaths, which are necessary for accurate population assessments,

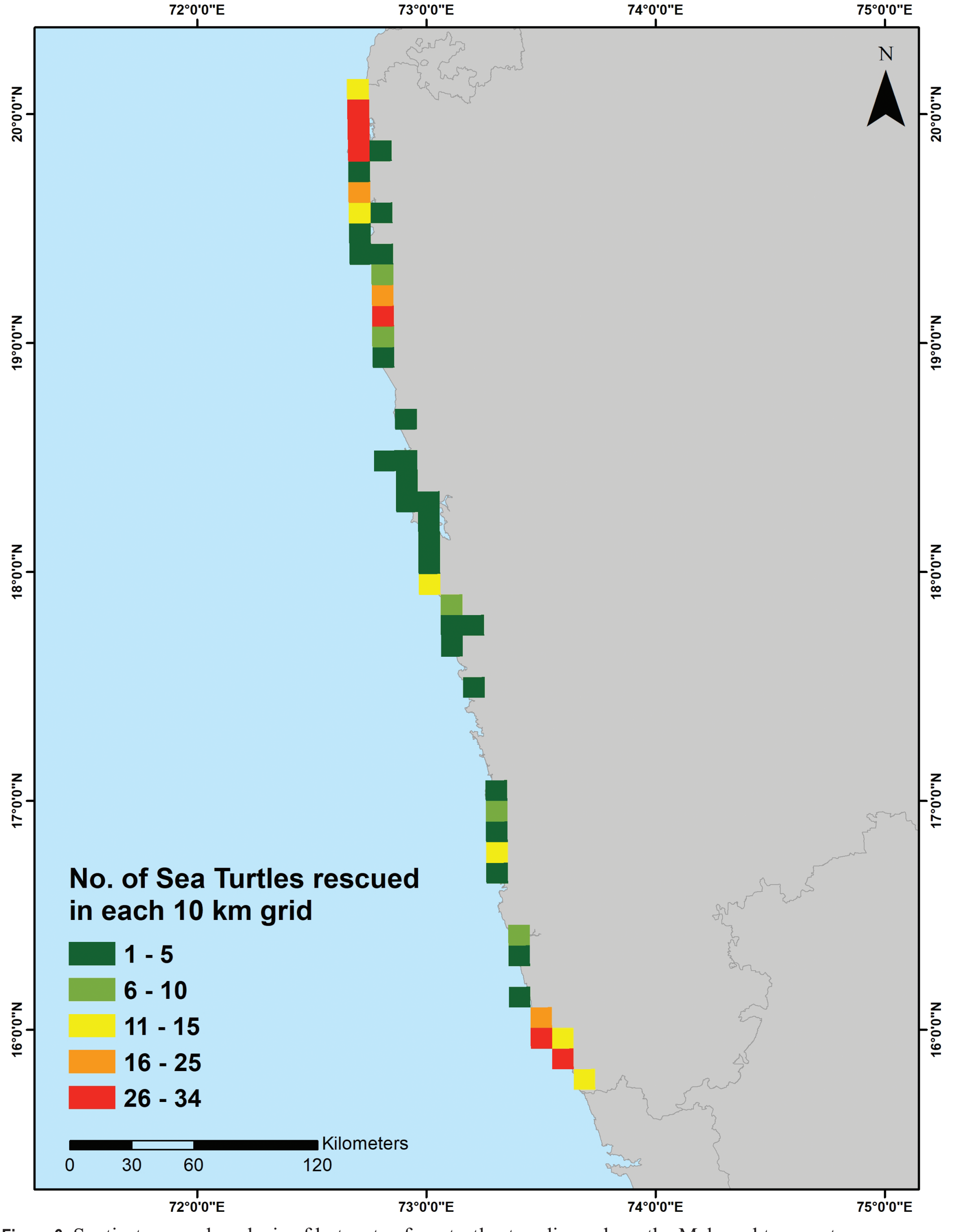

Figure 6. Spatio-temporal analysis of hotspots of sea turtle strandings along the Maharashtra coast

are generally unavailable (F.A.O. 2010). Actions that reduce interactions between fisheries and sea turtles and initiatives that address other threats to sea turtles may contribute to the recovery of turtle populations (F.A.O. 2010).

Temporal changes and their impact on Land Use and Land Cover (LULC) concerning habitats are not mapped (Pisolkar and Chaudhary 2016) in Sindhudurg. Due to education and awareness-raising activities, fishermen and locals have started actively participating in turtle conservation. Training courses on Turtle Excluder Devices and bycatch reduction devices should be conducted for fishermen. Locals earn their livelihood through tourism and thus benefit financially from extending protection to marine turtle nests. Ideally, attempts to investigate stranding patterns should account for factors that affect the initiation and duration of carcass buoyancy (e.g., turtle size, carcass decomposition rate, water temperature, and presence of scavengers) and the probability of carcass landfall (e.g., direction, intensity and seasonality of prevailing winds, surface and near-bottom current regimes, lunar tides, and the spatial proximity of mortality sources to shore) (N.R.C. 1990; Crowder et al. 1995; Epperly et al. 1996; Lewison et al. 2003). The all-India average of the monthly mean wind speed based upon 171 stations for 1961–2008, was the highest in June (10.6 kmph) and lowest in November (5.0 kmph) during (Jaswal and Koppar 2013). Mumbai, Thane, Ratnagiri, and Raigad were identified as the cyclone hotspot districts in Maharashtra (Jaswal and Koppar 2013). However, this information is not always available or known. Similarly, winter wind regimes may initiate net offshore flow in shelf waters, thus precluding or reducing carcass landfall (Epperly et al. 1995). Oceanic conditions that produce nearshore currents could facilitate the stranding of drifting turtle carcasses (Crowder et al. 1995) and partially explain the increased number of strandings observed during the monsoon seasons along the Maharashtra coast.

Potential causes of stranding of live or dead sea turtles can be assessed in live sea turtles and in case of carcasses in the early stages of decomposition, with the help of necropsy and external examination. Entanglement in lines, ropes or nets results in characteristic wounds or scars that entirely or partially encircle the front flipper and neck. Amputation of limbs may occur if turtles have been entangled in ghost gear for extended periods (Phillot and Godfrey 2019).

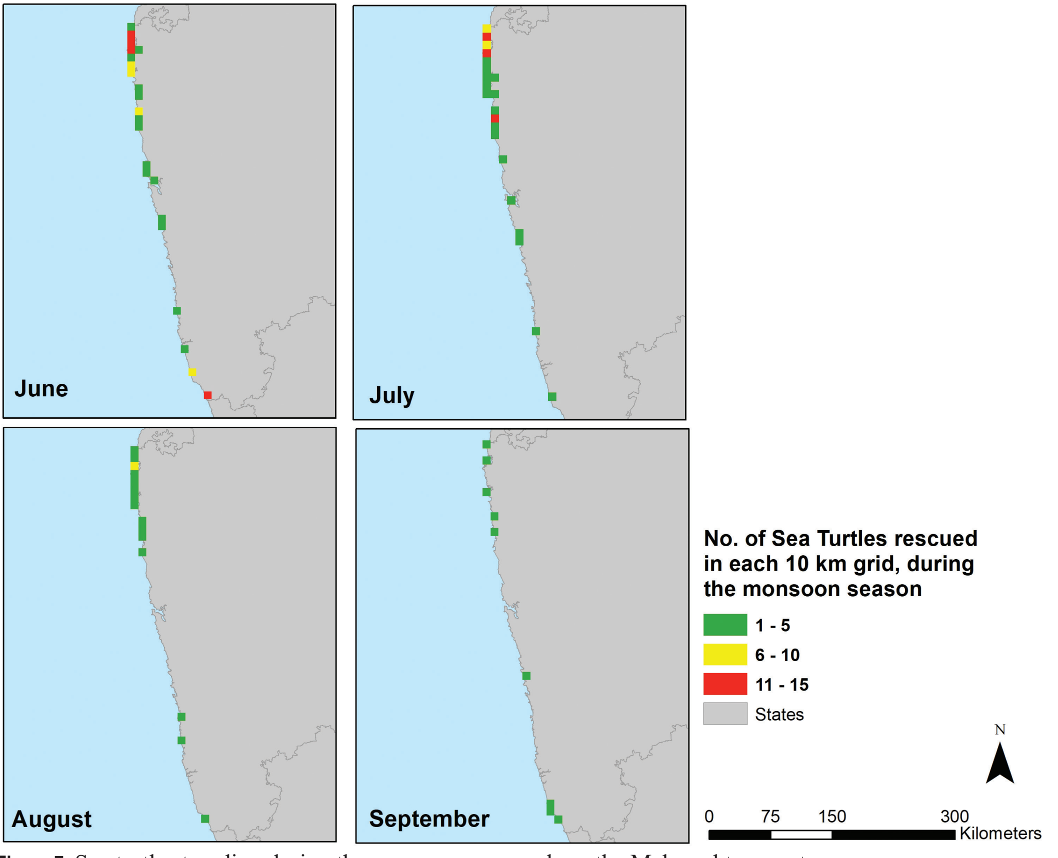

Figure 7. Sea turtle stranding during the monsoon season along the Maharashtra coast

Fishermen in Malvan and nearby villages know that turtles are endangered; hence, they actively participate in turtle conservation. If the turtles are caught in the fishing nets, they are immediately released. Further networking with fishing hamlets and deliberations with the fishermen about sea turtle conservation will certainly help enhance their appreciation and participation in saving these sea turtles.

Future directions

There is a dearth of information about the spatial occupancy and movement patterns of sea turtles that have been nesting on the beaches of this coast. The Wildlife Institute of India proposed tagging studies on the sea turtles inhabiting the Sindhudurg and Ratnagiri coasts to understand their post-nesting migration routes. Seven female olive ridleys have been tagged and tracked along Guhagar, Velas, and Anjarle. Rescue and rehabilitation centers are now established at Dahanu and Airoli, and will be established in Alibag, Dapoli, and Malvan. The tracking information will highlight the habitat use, movement, and nesting patterns of the turtles residing in the Arabian Sea. Hence, collecting information about stranded sea turtles, including the date, location, species, sex, carapace length, stage of decomposition, and potential cause and condition of each injury, can contribute to a broader assessment of the threats to sea turtles in regional and national waters. The Mangrove Foundation has already paid Rs. 40.48 lakhs to fishermen as compensation for releasing marine sea turtle species such as olive ridley (N = 138) and green sea turtles (N = 67), since December 2018 (Express News 2022). Due to education and awareness-raising activities through the local forest departments, the Mangrove Foundation, and local N.G.O.s such as Wildlife Conservation and Animal Welfare Association (WCAWA), Sahyadri Nisarg Mitra Sansthan, and RAWW (Resqink Association for Wildlife Welfare), with the local fishermen and

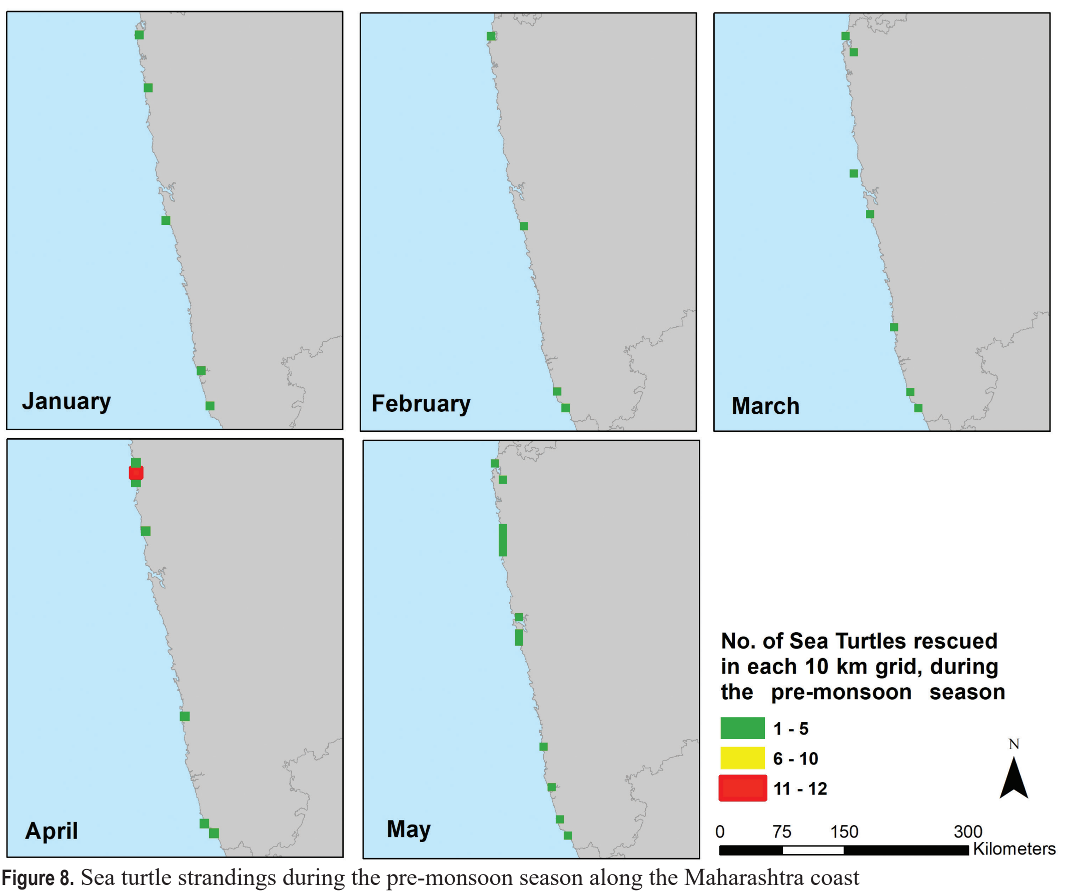

Figure 8. Sea turtle strandings during the pre-monsoon season along the Maharashtra coast

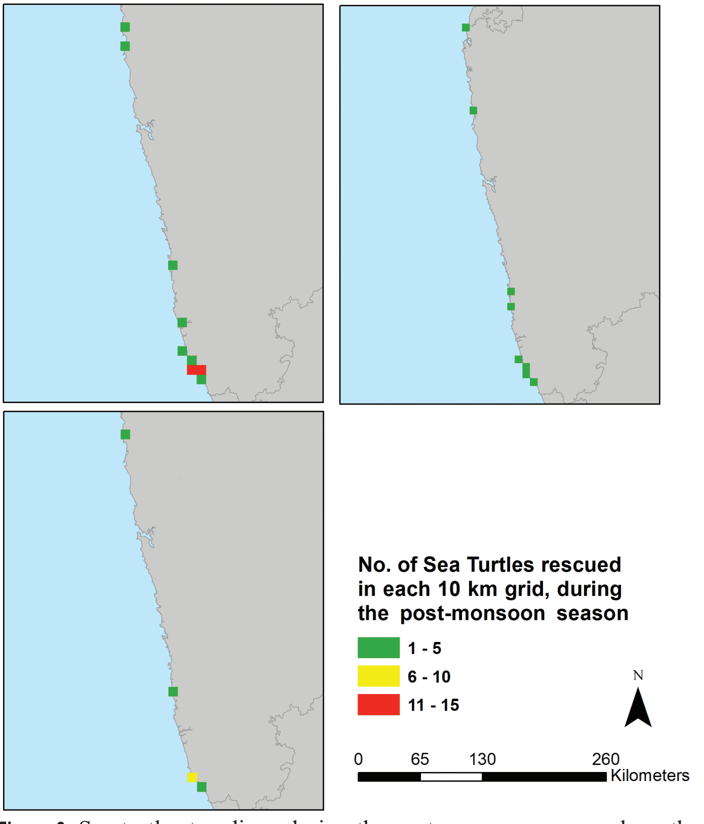

Figure 9. Sea turtle strandings during the post monsoon season along the Maharashtra coast

residents of those regions have started actively participating in turtle conservation.

Awareness among fishermen about not dumping ghost nets and plastic in the sea needs to be improved, and methods for solid waste management and processing of unused nets needs to be established. Proper net disposal facilities at each port need to be developed. These practices will help to reduce net disposal in the open ocean. Training for handling, stranding, or releasing sea turtles should be provided to the local residents and the local frontline staff. The turtle excluder device is still not being used along the Maharashtra coast. There is an additional need to assess the degree to which trawlers and long liners threaten turtles in Maharashtra. More proactive conservation measures are needed to protect sea turtles and rebuild their populations to healthy levels so that they can fulfil the whole extent of their roles in ocean ecosystems. More accurate documentation of factors that contribute to sea turtle stranding hotspots in Maharashtra will help researchers and conservationists influence and propose policies and work with local communities and fishermen to mitigate threats.

Acknowledgements

The authors thank Abhishek Satam, Sunil Belvekar, Noah Shinde, Amit Patil, Ajju Ambre, Govind Dhuri, Jagdish Todenk, Suraj Bhosale, and Shri. Vaibhav Borate, Sagar Maldkar, Shaunak Modi, Swapnil Tandel, Pradip Dingankar, Mohan Upadhyay, Akshay Mandavkar, Ganesh Nakhwa, Prof. Amol Handore, Dr. Swapnaja Mohite, Prof. Sumedha Korgaonkar, for providing local information on stranding sea turtles along Maharashtra coast.

We are also thankful for the support from Dahanu forest officials, Divisional Forest Officer Madhumita S., Chief Conservator of Forests T. Ramarao, and Maharashtra Principal Chief Conservator of Forests (PCCF) Shri. Y.L.P.Rao.

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Date submitted 20/12/2022
Date accepted 12/04/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 50–53, 2023,
ISSN: 2583-7818 (Online).

First record of intraspecific kleptoparasitism as a foraging strategy in anurans: Observed in the Matheran leaping-frog (*Indirana leithii*) from Maharashtra, India

CITATION. Amberkar, P. (2023) First record of intraspecific kleptoparasitism as a foraging strategy in anurans: Observed in the Matheran leaping-frog (*Indirana leithii*) from Maharashtra, India. *Hamadryad: 40, 50–53.*

KEYWORDS. Amphibians, intraspecific interactions, Matheran, Ranixalidae, Western Ghats

Kleptoparasitism is a form of resource acquisition in which an individual steals an already procured resource from another individual. Although this strategy has largely been documented in the form of food theft (Clay and Rothschild 1957; Iyengar 2008), ornithologists have expanded the definition of kleptoparasitism to include the theft of other resources such as nest material (VanderWerf 1998) and nesting sites (Kappes 1997). When an individual exhibits this behaviour towards a conspecific, it is termed as intraspecific kleptoparasitism. On the contrary, when an individual exhibits this behaviour towards an individual of another species this is termed as interspecific kleptoparasitism. Individuals who find and capture their own food are crucial to the survival of the kleptoparasite. The kleptoparasites are termed as 'scroungers' who depend on the 'producers' (Nishimura 2010). Kleptoparasitism as a foraging strategy has been observed in many vertebrate taxa, including birds (Brockmann and Barnard 1979), mammals (Gorman et al. 1998; Cusack et al. 2017), fishes (Wallace and Snyder 1988), and reptiles (Platt et al. 2007). Although, kleptoparasitic behaviour for other resources like female mates and perch site has been observed in anurans (Wells 2007; Modak et al. 2018), it has been observed as a foraging strategy only in captivity (Boice and Williams 1971). I present the first observation of intraspecific kleptoparasitism as a foraging strategy in the Matheran leaping-frog, *Indirana leithii* Boulenger, 1888 from Matheran, Raigad district, Maharashtra, India at the species' type locality.

Figure 1. Two individuals of *Indirana leithii* with an earthworm in their mouths

Figure 2. One individual flipping over the other individual

Indirana leithii is a species of terrestrial amphibians endemic to the Northern Western Ghats, in the states of Maharashtra and Gujarat, India (Modak et al. 2014). The type locality, Matheran, is a plateau (800 m asl), in Raigad district, Maharashtra. The vegetation on this plateau is semi-evergreen with high rainfall during the monsoon season and low temperatures relative to its surroundings. The individuals of *I. leithii* breed between June and September, and are abundant around small streams, forest floor, and human settlements in the type locality. Individuals of this species tend to congregate during the breeding season (up to 10 individuals at a site; Modak et al. 2018). Because of this aggregation during the breeding season, individuals tend to be agnostic towards each other. Males of *I. leithii* tend to exhibit kleptoparasitic behaviour towards conspecific males where they try to push out the male already in amplexus (Modak et al. 2018). Furthermore, attempted cannibalism has also been reported between individuals of the species (Kulkarni et al. 2020).

On 13th October 2019 at 23:00 h (IST), I observed intraspecific kleptoparasitism in *I. leithii* in Mathern, Raigad district, Maharashtra, India (19.0025 N, 73.2839 E). I found two adult individuals of *I. leithii* on the ground with either end of an earthworm (*Lumbricus* sp.) in their mouths (Figure 1). Both individuals attempted to pull the earthworm from each other's jaws by tugging from either end and thus causing the other individual to flip over. The flipping and tossing continued for another 5 minutes before one individual finally gave up and let the earthworm go. The victorious individual continued eating the earthworm while the other lay on its back for another 5 minutes, and then continued foraging (Figure 2). The two frogs were found adjacent to a drain with 15–20 individuals of *I. leithii*. The other individuals were actively moving and foraging.

The current observation is, to the best of my knowledge, the first record of kleptoparasitism as a foraging strategy in anurans in the wild. The choice of kleptoparasitism over other foraging strategies depends on various factors including competitive differences among individuals, the spatial distribution of prey and host, the abundance of prey, size of the prey, handling time of the prey, and group size of host (Iyengar 2008). The observed kleptoparasitic behaviour in this species can be an outcome of the high abundance of *I. leithii* at Matheran and the aggregation of individuals at the site (Modak et al. 2018). Since the earthworm was larger in size compared to the two individuals, there was an increase in the handling time of the prey. This could be the other reason for the scrounger to exhibit this behaviour. To this end, I provide a unique account of the interactions between two individuals in the wild. My observations provide insights into anuran behaviour in an extremely rare social circumstance.

Funding. This short-note is an outcome of a self-funded trip to Matheran.

Declaration. There is no conflict of interest with other studies.

Acknowledgements

I thank Mr. Shubham Soni and Dr. Seshadri K. S. for their valuable comments and inputs on the manuscript. I would also like to thank Mr. Manan Mehta and Mr. Anirudh Nippani for accompanying me in the field. I thank the editor of the journal and the anonymous reviewers for their valuable comments and suggestions.

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Date submitted 08/06/2023
Date accepted 12/08/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 53–59, 2023,
ISSN: 2583-7818 (Online).

Observations on arthropod predation of uropeltid snakes (Squamata: Uropeltidae) from the Western Ghats, India

CITATION. Karanth, D.N., Bhise, M.S., Praveen, H.N. and Cyriac, V.P. (2023) Observations on arthropod predation of uropeltid snakes (Squamata: Uropeltidae) from the Western Ghats, India. *Hamadryad: 40, 53–59.*

KEYWORDS. Ants, Centipede, Predator-prey interactions, *Rhinophis*, Shieldtail snakes, *Uropeltis*

The family Uropeltidae constitute a group of 65 species of poorly-known, small-sized snakes (usually <60 cm in total length), mostly restricted to the wet forests of peninsular India and Sri Lanka (Pyron et al. 2016; Uetz et al. 2023). Currently, the family has seven genera, all of which occur in India (Cyriac and Kodandaramaiah 2017; Sampaio et al. 2023). All members of the family are fossorial and have small, highly ossified, generally pointed heads and elongated bodies that allow them to burrow into the soil (Cyriac and Kodandaramaiah 2021). Many species also have a highly modified tail that terminates in a bony structure covered by one or more highly keratinised scales (Huntley et al. 2021). Owing to their secretive habits, these snakes are rarely encountered and very little is known about their ecology, behaviour, natural history and predator-prey interactions.

Although these snakes spend most of their time underground, they occasionally emerge to the surface and get predated upon by above-ground predators (Rajendran 1985; Cyriac and Kodandaramaiah 2019). Most observations of predation events on uropeltid snakes indicate that birds, such as jungle fowls, domestic chickens, peafowls, house crows, and thrushes are the main predators of these snakes (Rajendran 1985; Kumara and Chaitra 2001; Chandramouli and Ganesh 2010). Studies have suggested that the short, rounded, highly keratinized shielded tail in many uropeltid snakes mimic the snake's head (cephalic mimicry) and diverts the attacks of avian predators towards the highly protected tail (Gans 1986; Cyriac and Kodandaramaiah 2019). Experiments have also suggested that the conspicuous colourations in many uropeltid snakes function as warning signals advertising their long handling times associated with diverted attacks towards the tail, reducing avian predation rates (Cyriac and Kodandaramaiah 2019). However, little information is available on other non-avian predators of uropeltid snakes, and how these snakes respond to such predation events.

Apart from birds, mammals and snakes are reported to feed on uropeltid snakes. Rajendran (1985) reported that Wild Boars (*Sus cristatus*) and mongooses (*Urva* spp.) may feed on uropeltid snakes. Remains of a *Uropeltis* sp. was also recorded from the scat of an Asiatic Wild Dog (*Cuon alpinus*) (Krishnakumar et al. 2019). Uropeltids have also been found in the diet of a few snakes such as the Ceylon Krait, *Bungarus ceylonicus*, Spectacled Cobra, *Naja Naja*, Striped Coral Snake, *Calliophis nigrescens* and Vine snakes, *Ahaetulla* sp. (Slowinski 1994; Mukherjee and Bhupathy 2004; Lobo 2006; Datanwala and Durso 2020; Kalki and Weiss 2020). Apart from these records, there are no other observations on uropeltid predators. Here, we report multiple instances of predation by two species of ants and one observation of predation by centipede on three species of uropeltid snakes.

Ant predation on uropeltid snakes. On 11th September 2019, DK observed a swarm of Procession Ants (*Leptogenys* sp.) attacking a live adult *Rhinophis* cf. *sanguineus* at ca.16:22 hrs on a paved porch of a house near Huttinagadde (13°20'02.7"N, 75°23'10.9"E), Basarikatte, Koppa, Chikkamagaluru district of Karnataka. The observation was made a day after it had rained heavily and the weather was cloudy. The snake was identified as a *Rhinophis* cf. *sanguineus* based on its pointed head with a long rostral scale dividing the nasal scales and by its distinctive dome-like tail shield (Pyron et al. 2016). The snake had no apparent external injuries and was seen struggling to move away from the ants. It took about six hours for the ants to finish consuming most of the snake except for the posterior end of the snake. Upon checking the next day around 13:00 hrs, only a small part of the tail was left, leaving just the cranium and the vertebrae visible.

Two more instances of ants feeding on dead adult *Rhinophis* cf. *sanguineus* were observed on 19th October 2020 around 17:47 hrs close to the same location as the first observation. Both

Figure 1. Ant predation on uropeltid snakes near Basarikatte, Koppa, Chikkamagaluru district of Karnataka. **A** – A swarm of Procession Ants attacking a live *Rhinophis* cf. *sanguineus*; **B** – Close up of the Procession Ants (Leptogenys sp.) attacking the snake; **C** – A swarm of Short-legged Hunchbacked Ants (*Myrmicaria brunnea*) consuming *Rhinophis* cf. *sanguineus*; **D** – Close up of Short-legged Hunchbacked Ants (*Myrmicaria brunnea*) feeding on the snake; **E** – Vertebrae of *Rhinophis* cf. *sanguineus* after completely consuming the snake; **F** – A swarm of Short-legged Hunchbacked Ants (Myrmicaria brunnea) consuming a *Uropeltis* sp. **G** – A swarm of Short-legged Hunchbacked Ants (Myrmicaria brunnea) consuming a *Rhinophis* cf. *sanguineus*. (Photographs by Deepika N. Karanth).

the snakes were dead and were seen about 20 m from each other and were being consumed by a swarm of Short-legged Hunchbacked Ants (*Myrmicaria brunnea*). Upon checking the next day around 09:00 hrs, the ants were feeding on the tail of one of the shield tails and had some parts of the bones left behind.

A similar observation of Short-legged Hunchbacked Ants (*Myrmicaria brunnea*) feeding on a dead adult *Uropeltis* sp. was made on 4th July

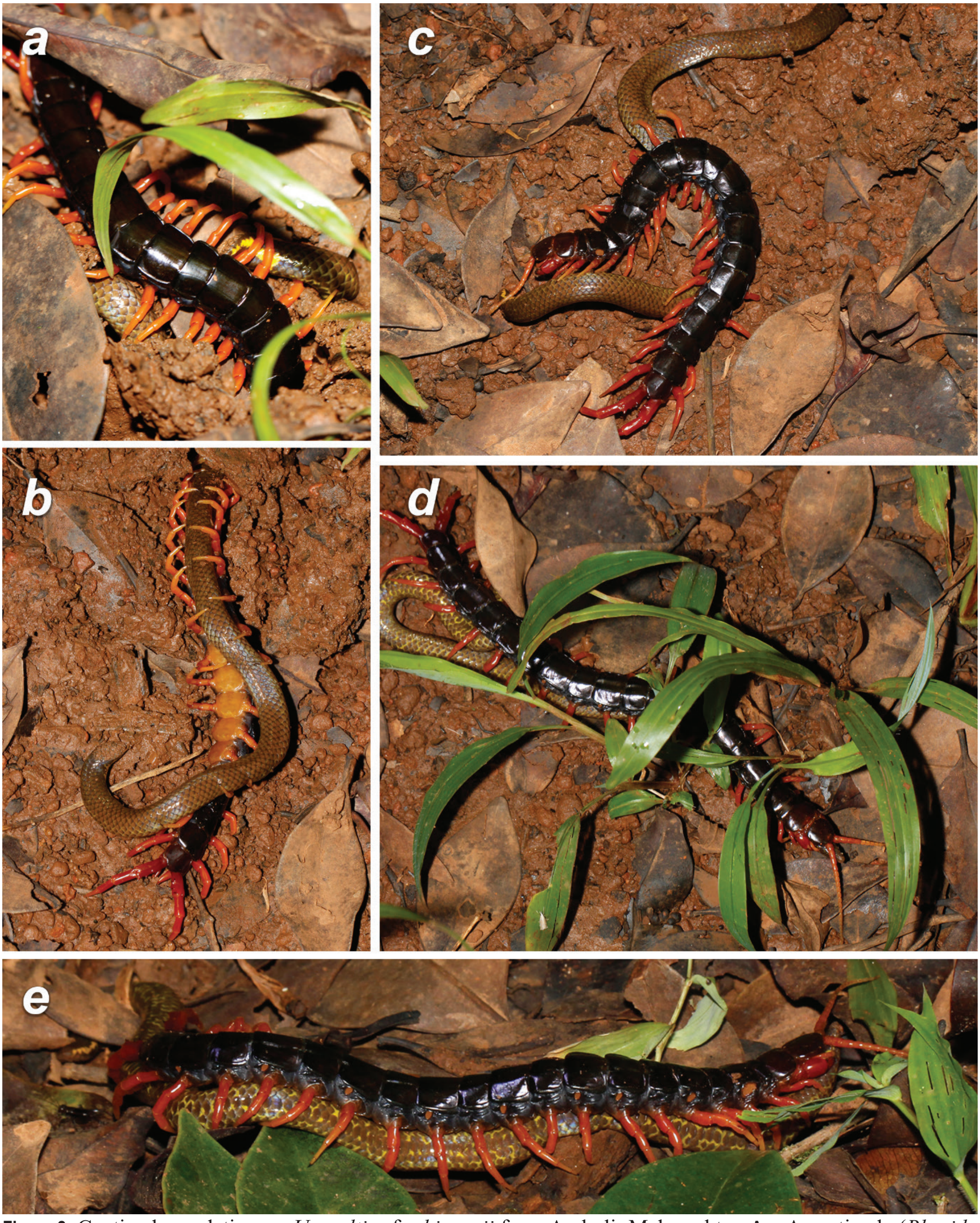

Figure 2. Centipede predation on *Uropeltis* cf. *phipsonii* from Amboli, Maharashtra. **A** – A centipede (*Rhysida* sp.) attacking a *Uropeltis* cf. *phipsonii* inside a burrow; **B** – The centipede clasping the anterior portion of the snake with its legs and pulling the snake out of its burrow; **C** – The centipede repositioning itself before pulling the snake out of the burrow; **D** – The centipede grabbing the snakes head by its forcipules; **E** – The centipede dragging the subdued snake away. (Photographs by Mahadev Suresh Bhise).

2021 around 14:58 hrs, a day after heavy rains near Huttinagadde (13°20’02.7” N, 75°23’10.9” E), Basarikatte, Koppa, Chikkamagaluru district of Karnataka. The snake was identified as *Uropeltis* sp. of the *ceylanica* group based on its size, robust body morphology, overall colouration (dorsally uniform brownish black with a blotched yellow pattern ventrally) and its distinctive, sharply truncated, flattened tail shield with rugose multicarinate scales (Pyron et al. 2016). The snake was found dead lying upside down near a small pond with portions of flesh eaten by the ants. There were no other visible injuries on the snake to the effect that the snake was killed by some other predator.

Two more instances of Short-legged Hunchbacked Ants (*Myrmicaria brunnea*) feeding on dead adult *Rhinophis* cf. *sanguineus* were documented on 18th October 2021 around 17:27 hrs close to the same location as all other observations. Both the individuals were found dead lying upside down in coils on the open ground ca. 5 m from each other. The first snake was already partially eaten with portions of the vertebrae visible on the anterior half of the snake. The second snake appeared to be freshly killed with only small portions of the flesh exposed by the ants.

Centipede predation on *Uropeltis* cf. *phipsonii*. Another observation of active predation was observed on a live *Uropeltis* cf. *phipsonii* by a centipede (*Rhysida* sp.) on 8th September 2018 at around 20:35 hrs near Amboli Botanical Garden (15°57’34” N, 73°59’57” E), Maharashtra, India. About an hour and a half after heavy rains, MKB found a centipede with its anterior half of the body inside loose wet soil and small coils and the tail end of a snake visible above the ground. The snake was identified as *Uropeltis* cf. *phipsonii* based on its size, overall colourations (dorsally uniform brown with irregularly broken crossbands of yellow dots ventrally) and distinctive, dorsally truncated, flattened tail shield with rugose multicarinate scales (Pyron et al. 2016). As the centipede pushed further into the burrow, the snake could be seen wiggling backwards out of the burrow. After about 27 minutes, the centipede clasped the anterior portion of the snake with its legs and began pulling the snake out of its burrow. At about 21:06 hrs; when the snake was almost out with just the anterior-most portion of the body in the burrow, the centipede let go of the snake, repositioned itself, and again crawled into the burrow and grabbed the snake by its forcipules and pulled the snake completely out of the burrow. The centipede was estimated to be about 100 mm long and was about 20 mm shorter than the snake. The snake was struggling initially but was eventually rendered motionless. After about five minutes, the centipede carried the snake away clasping it with its forcipules. The observation lasted about 36 minutes and the centipede disappeared into the undergrowth along with the snake.

Studies on prey-predator interactions in uropeltid snakes have considered birds as their primary predators (Gans 1986; Cyriac and Kodandaramaiah 2019). These studies suggest that the tail display (cephalic mimicry) and bright colourations in uropeltid snakes are part of an elaborate antipredatory strategy that reduce avian predation (Cyriac and Kodandaramaiah 2019). However, how these snakes respond to non-avian predators remain unknown, mostly because of the lack of information on other predators. Our note throws some light on the arthropod predators of these poorly-known fossorial snakes and also suggest that arthropods may be regularly predating on uropeltid snakes. Although five of our observations were on Short-legged Hunchbacked Ants (*Myrmicaria brunnea*) feeding on already dead uropeltid snakes, in at least two instances, the snake appeared to have been freshly killed with no obvious external injuries, suggesting that these observations were predation (rather than scavenging) events. Further, these ants have been classified as generalist omnivores (Baidya and Bagchi 2021), and have been observed actively feeding on live earthworms and other larger vertebrates (Pronoy Baidya pers. comm.).

Studies have indicated that birds and squamates are the primary predators of herpetofauna (Jaksić et al. 1983; Schalk and Cove 2018; Valdez 2020). However, recent reviews have also started to recognise arthropods as important predators of amphibians and reptiles (Toledo 2005; Valdez 2020). Among arthropods, spiders, scorpions and beetles have been found to be the main predators of squamate reptiles (O’Shea and Kelly 2017; Valdez 2020), while comparatively fewer reports exist on other groups of arthropods (von May et al. 2019; Valdez 2020). Ants being social hunters are known to attack larger prey, including snakes (Sazima 2015), and can have a significant impact on reptile populations. For instance, the presence of the red imported fire ants (*Solenopsis invicta*) has been associated with the decline in some ground-dwelling snake species (Tuberville et al. 2000). There are also several reports of centipedes predating on snakes (Arsovski et al. 2014; Chiacchio et al. 2017; von May et al. 2019; Vazifdar et al. 2021; Pwa et al. 2023), so much so that some centipede-eating snakes have specialised behaviours and skull morphologies that have evolved to protect them from retaliatory bites (Gripshover et al. 2023). Here, we add to these observations by reporting a total of seven observations of potential predation on fossorial uropeltid snakes by two species of ants and one species of centipede. However, further studies and experiments are required to understand the propensity of arthropod predation on uropeltid snakes and how these snakes respond to such predation attempts.

Acknowledgements

We thank Dhanya Bhalan and Pronoy Baidya for help with identifying the centipede and ant species. We thank Anuj Shinde and Harikrishnan S. for their comments on the manuscript and for curating data from citizen scientists for the Shieldtail Mapping Project, which led to this manuscript.

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Date submitted 23/08/2023
Date accepted 30/10/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 59–62, 2023,
ISSN: 2583-7818 (Online).

A regurgitation event in Indian Ratsnake *Ptyas mucosa* (LINNAEUS, 1758) provides insights into its diet

CITATION. Samson, K., Abinesh, A., Vishnu, C.S. and Sagadevan, R. (2023) A regurgitation event in Indian Ratsnake *Ptyas mucosa* (LINNAEUS, 1758) provides insights into its diet. *Hamadryad*. *Hamadryad: 40, 59–62.*

KEYWORDS. Birds, Diet, Eggs, Feeding, Rodents

The prey-predator relationship is a key component that explains the trophic ecology of an environment (Dorresteijn et al. 2015). Functionally, the mechanised prey-predator dynamics conceptualise the trophic cascade, which determines changes in prey abundance and behaviour (Silliman and Angelini 2012). The predatory dichotomy that includes active and ambush predators differ in foraging mode, which intertwines with morphological and behavioural traits through the adaptive syndrome hypothesis (Eckhardt 1979; McLaughlin 1989). The adaptive syndrome can enhance behavioural syndrome, which explains how behaviour changes in different foraging scenarios (Sih et al. 2004). The community profile is the size profile of prey species, and the food profile is the ingested species from the community profile, which is mediated through the prey-predatory dynamics (Griffiths 1975). The optimal foraging theory involves animals balancing energy expenditure with each predation event's success to avoid starvation. This relates to trade-offs in foraging ecology (Higginson and Ruxton 2015). The foraging pattern of predators can also switch depending on prey availability, abundance, and how widely the area is occupied by the prey species (Hirvonen 1999; Higginson and Ruxton 2015). Predators may choose their prey based on factors such as size and predation cost. Among active foragers, there is likely to be higher energy expenditure compared to ambush foragers (Downes 2002; Higginson and Ruxton 2015). This note reports an observation of the stomach contents in the active foraging Indian rat snake (*Ptyas mucosa*). The Indian rat snake is a common, widespread, non-venomous snake found across India in different habitats such as xeric regions, mesic habitats, coastal lines, open fields, deciduous forests, evergreen forests, scrub jungles, and agricultural lands (Whitaker and Captain 2004; Parmar and Tank 2019; Biodiversity portal 2023). The diet of *P. mucosa* varies with age and habitat. Juveniles primarily feed on insects, reptiles, and frogs but shift to consuming mammals, birds, fishes, amphibians, snakes, and other reptiles as they grow (Parmar and Patel 2022).

On 4th October 2018 at 17.00 h, we got a rescue call about a snake's presence inside a house near Thiyagarajar School of Management on Avaniyapuram road, Thirupparankundram, Madurai, Tamil Nadu (9.8796°N; 78.0863°E). We rushed to the spot and found an Indian Rat snake (*Ptyas mucosa*) approximately 7 feet in size hanging on the window. We gently rescued it from the house and brought it outside (Figure 1). Instantly, the snake started regurgitating a variety of prey items, including a marbled balloon frog (*Uperodon systoma*). This individual had an olive-yellowish dorsum with a marbled design and a smaller head with a blunt snout. We also spotted an unidentified rodent and a juvenile three-striped palm squirrel (*Funambulus palmarum*) with three stripes on its dorsum. Additionally, we found two bird eggs — one was broken with a partially grown juvenile bird inside. Later identification revealed that the eggs belonged to a white-breasted water hen (*Amau-*

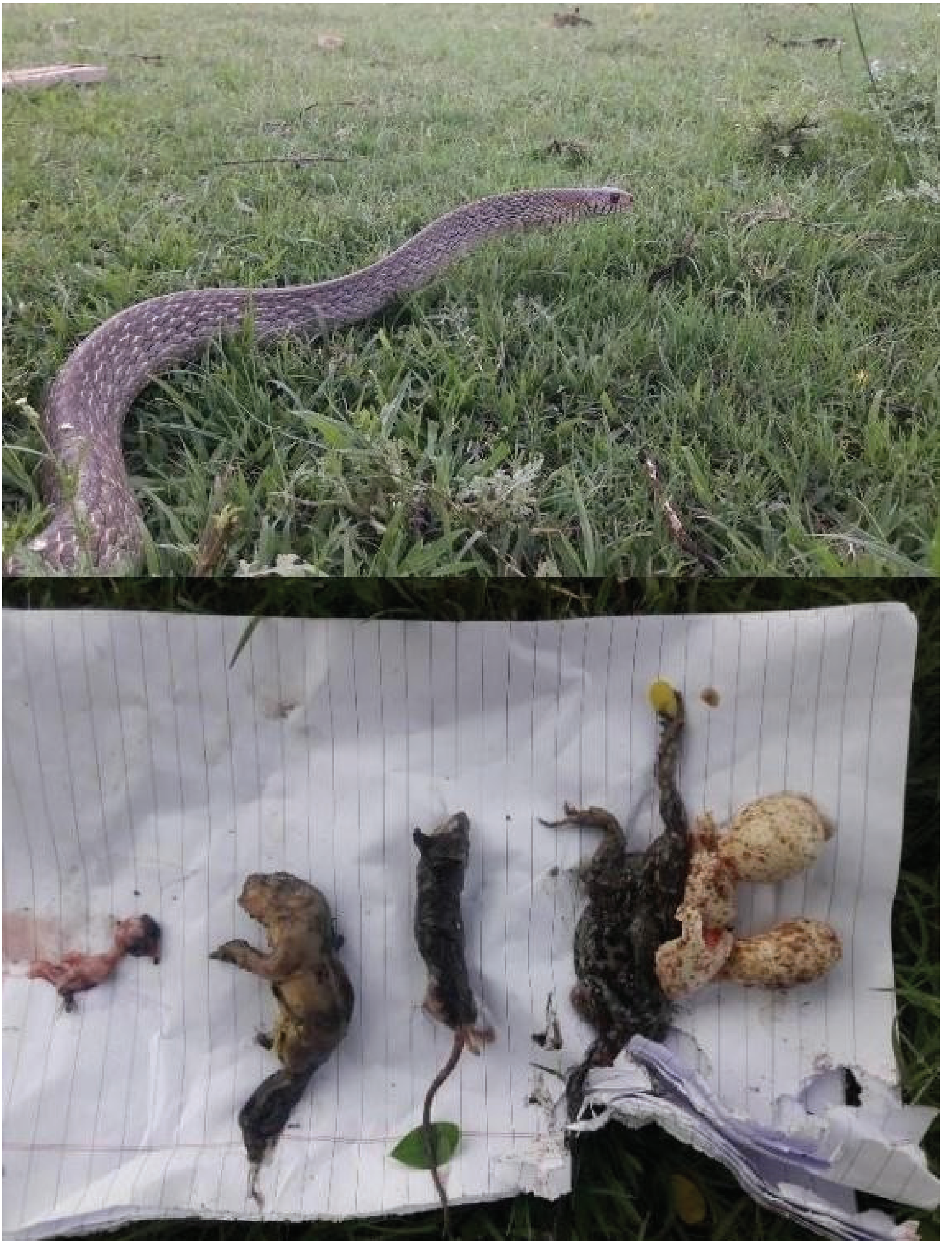

Figure 1. An array of regurgitated meals by *P. mucosa*, showcasing species names from left to right: *Amaurornis phoenicurus*, *Funambulus palmarum*, Unidentified Rodent, *Uperodon systoma*, and White-breasted Waterhen Eggs.

rornis phoenicurus; Anthal and Sahi 2017) (Figure 1). Subsequently, the snake was safely bagged and released into a nearby plot of agriculture land (9.8840°N; 78.0891°E).

Several prey items of *P. mucosa* have been reported in the literature, including *Eutropis dissimilis*, *Hoplobatrachus tigerinus*, *Euphlyctis cyanophlyctis*, *Fejervarya limnocharis*, and unidentified toads (Wall 1926; Dunn 1935; Minton 1966; Sharma and Vazirani 1977; Whitaker and Captain 2004). Studies have also documented unusual feeding and scavenging events in *P. mucosa*, such as consumption of plastics, onions, male contraceptives, cloth pieces, discarded socks, and polythene rolls (Sharma et al. 2016; Saha and Chaudhuri 2017; Chaudhuri et al. 2018; Parmar and Patel 2022).

In general, stomach content analyses in snakes have reported details on the diet and prey species that are known to occur in an ecosystem. However, this observation on the regurgitation by this *P. mucosa* individual indicates that the diet can consist of multiple species and diversified prey preferences in *P. mucosa*. This predation strategy may help maintain their metabolic energy requirements, as they are active foragers. Foraging is a basic and primary trade-off activity that limits prey dynamics such as availability, abundance, and spatiotemporal distribution (Higginson and Ruxton 2015). Higginson and Ruxton (2015) explained a relationship between prey statuses to predatory movement in environmental space, stressing the fact that active predators have a higher prey cost. The pressure of food consumption to either overcome or avoid starvation may cause the predator to engage in opportunistic foraging, and preying on what is available, which is seemingly costly, yet a viable option for generalists (Westoby 1978; Rex et al. 2010; Pereira et al. 2016).

The stomach content also gives an idea of the diet of a species, which would be important for the conservation of prey and predators. Regurgitation and aggressive behaviour during handling could be a defence mechanism to allow for a quick escape.

Perez-Ramos et al. (2018) reported regurgitation of three painted wood rats (*Neotoma picta*) by Barbour's montane pit viper (*Mixcoatalus barbouri*) from Mexico. This note reports the diet of *P. mucosa*, which includes different prey species of smaller size, indicating the individual's need to be an active forager in an environment where larger prey is lacking. However, we are aware that *P. mucosa* has a generalist diet and it may or may not consume a wide range of species at a single time. Since we could not find any other related observations for this snake, we conclude this to be significant. More studies on foraging aspects along with stomach content analyses across a spatiotemporal gradient would enhance the understanding of foraging behaviour and ecology of this common colubrid.

Acknowledgements

We would like to acknowledge the Tamil Nadu Forest Department for granting permission to rescue the snake. Additionally, our gratitude goes to Mr. Vivek Sharma for encouraging us to write this observation.

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Date submitted 07/03/2023
Date accepted 30/07/2023
Available online

Hamadryad Vol. 40 (1&2), pp. 62–66, 2023,
ISSN: 2583-7818 (Online).

Additional record of the Arrow-headed Trinket (*Coelognathus helena nigriangularis*, Mohapatra, Schulz, Helfenberger, Hofmann, and Dutta, 2016) from Rajasthan

CITATION. Imran, Ojha, A.P., Kumawat, R. and Soni. R. (2023) Additional record of the Arrow-headed Trinket (*Coelognathus helena ni-*

griangularis, Mohapatra, Schulz, Helfenberger, Hofmann, and Dutta, 2016) from Rajasthan. *Hamadryad*. *Hamadryad: 40, 62–66.*

KEYWORDS. Chittorgarh, Colubridae, endemic, India, Squamata, taxonomy

The Arrow-headed Trinket (*Coelognathus helena nigriangularis)* is a subspecies of the trinket snake (*Coelognathus helena*), belonging to the family Colubridae. The Arrow-headed Trinket is a medium-sized snake, with adults averaging around 1.2 to 1.5 m in length, and inhabits diverse habitats such as dry deciduous forests, scrublands, agricultural fields, and human settlements. Currently, *C. h. nigriangularis* is known to have a wide distribution and is recorded from Chhattisgarh, Andhra Pradesh, Madhya Pradesh, Maharashtra, Jharkhand, Odisha, Gujrat, and West Bengal (Lampe and Lindholm 1902; Edake 2011; Kumbhar et al. 2011; Schulz 2013; Srivastava et al. 2013; Kantimahanti et al. 2015; Mohapatra et al. 2016; Chowdhury et al. 2018; Ashaharraza and Bibekar 2019; Singh et al. 2020; Bhushan and Kumar 2021; Patel et al. 2021). In Rajasthan, this subspecies is reported from the Ranthambore tiger reserve in Sawai Madhopur District (Singh et al. 2020). Here, we report a new record of this subspecies from Rajasthan.

The field-based report was carried out in Chittorgarh, Rajasthan. The climate of Chittorgarh is dry, except during the monsoon season from July to September. The average annual rainfall of the district is 750–780 mm. The average temperature is 19–45 °C. The winter season in this area is from December to February, and summer is from March to June. The general landscape of this area includes hills composed of sedimentary rocks, including quartzites, shales, and limestone (Rathore et al. 2015). About 70–75% of the area is covered by a hilly terrain. The soils include black, brown, grayish-brown alluvial, and hilly soils (Central Ground Water Board 2007).

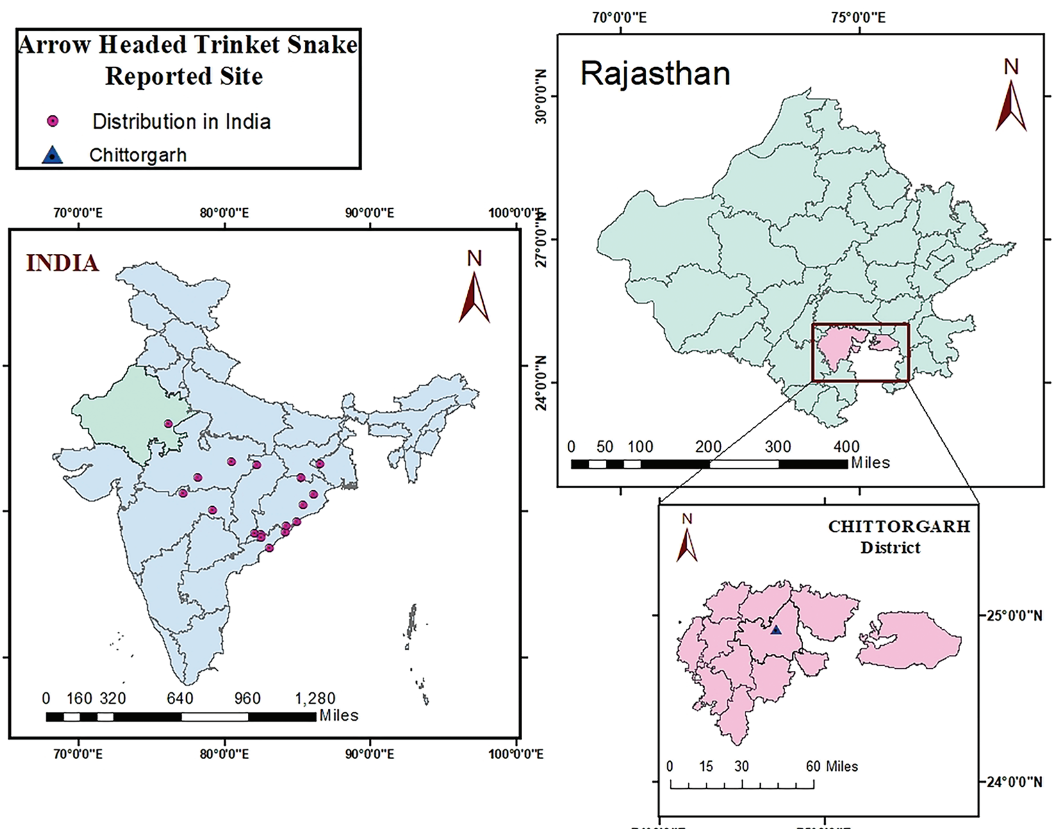

Figure 1. Map showing previous locality records of the Arrow-headed Trinket Snake (*Coelognathus helena nigriangularis*) in India (purple circle) and second record in Rajasthan (blue triangle).

Figure 2. Hathini Odhini landscape showing the habitat where the road-killed *C. h. nigriangularis* was found.

Figure 3. Roadkilled Arrow-headed Trinket Snake (*Coelognathus helena nigriangularis*) showing the full body view (top), and the dorsal (bottom right) and lateral (bottom left) views of head.

The forest type in this region is mostly mixed miscellaneous forests. These forests are open and consist of short trees belonging to thorny leguminous species. The forests chiefly consist of Dhok (*Anogeissus latifolia*), Safed Dhok (*Anogeissus pendula*), Arjun (*Terminalia arjuna*), Siris (*Albizia lebbeck*), Haritaki (*Terminalia chebula*), Palash (*Butea monosperma*), Chilbil (*Holoptelea integrifolia*), Anjan (*Hardwickia binata*), and Sheesham (*Dalbergia sissoo*). This region also harbours a rich diversity of snakes. Some of the common snakes found in this area include Common Indian Cobra (*Naja naja*), Indian Rat Snake (*Ptyas mucosa*), Indian Python (*Python molurus*), Red Sand Boa (*Eryx johnii*), Common Boa (*Eryx conicus*), Common Indian Krait (*Bungarus caeruleus*), and Cat Snake (*Boiga trigonata*).

While conducting field surveys in the Chittorgarh region, we recorded a roadkill specimen of the Arrow-headed Trinket Snake (*Coelognathus helena nigriangularis*) from Hathini Odhini (24°54'45.5"N 74°42'07.2"E) at an elevation of 565.09 m on August 1, 2022, at 09:00 am in the Chittorgarh district of Rajasthan (Figure1 & 2). The dead specimen had the typical inverted Y shaped marking that extended from the black marking on the ventrolateral side of the neck and joined at the base of the parietal shield, which is not seen in *C. h. helena* and *C. h. monticollaris* (Figure 3). The total length of the snake was 1184 mm and the snout-vent length (SVL) was 980 mm. The head was elongated; rostrum slightly seen from above the head; front bell shaped; nostril present more anterior to the snout then the eye; preocular easily visible from top of the head; nine supra-labials on each side of head, 5th and 6th supra-labials connected to the eyes, and 4th and 5th in contact with the preocular. About 24 zigzag bands were visible on the body, prominent on the anterior side. Behind the eye, a thin black line ran obliquely on each side of the head through the postocular and temporal scales. Another black line descended below the orbit through the 5th and 6th supra-labials and extended up to the lower labials. These characters confirmed the identity of the snake as *Coelognathus helena nigriangularis* (Mohapatra, Schulz, Helfenberger, Hofmann, and Dutta 2016).

While the Arrow-headed Trinket is not currently facing significant conservation threats in India, certain factors could impact its population in the future. Habitat loss due to urbanization, agriculture, and deforestation remains a concern. Additionally, accidental killing through road traffic, and intentional persecution by humans are potential threats. Our observation extends the distribution range of this snake by 212 km in the south-west direction from the closest known locality, which is reaching beyond the Ranthambore tiger reserve (Sawai Madhopur), and highlights its presence across different states of India.

Acknowledgements

The authors thank Kamaljeet Singh for being a field partner, Ashish Jangid for valuable comments, and Dharmendra Khandal for providing previous records about Trinket Snakes in Rajasthan.

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Date submitted 12/10/2022
Date accepted 25/10/2023
Available online

ERRATUM

Uchang-sa: A report on frog consumption around Dampa Tiger Reserve, Mizoram, northeast India

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The citation should read as follows:

Malsawmdawngliana, Kawlni, L., Lalronunga, S., Manral, U. and Das, A. (2022). Uchang-sa: A report on frog consumption around Dampa Tiger Reserve, Mizoram, northeast India. Hamadryad: 39, 30-36.