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Journal of Threatened Taxa

10.11609/jott.2025.17.4.26763-26938
www.threatenedtaxa.org

26 April 2025 (Online & Print)
17(4): 26763–26938
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

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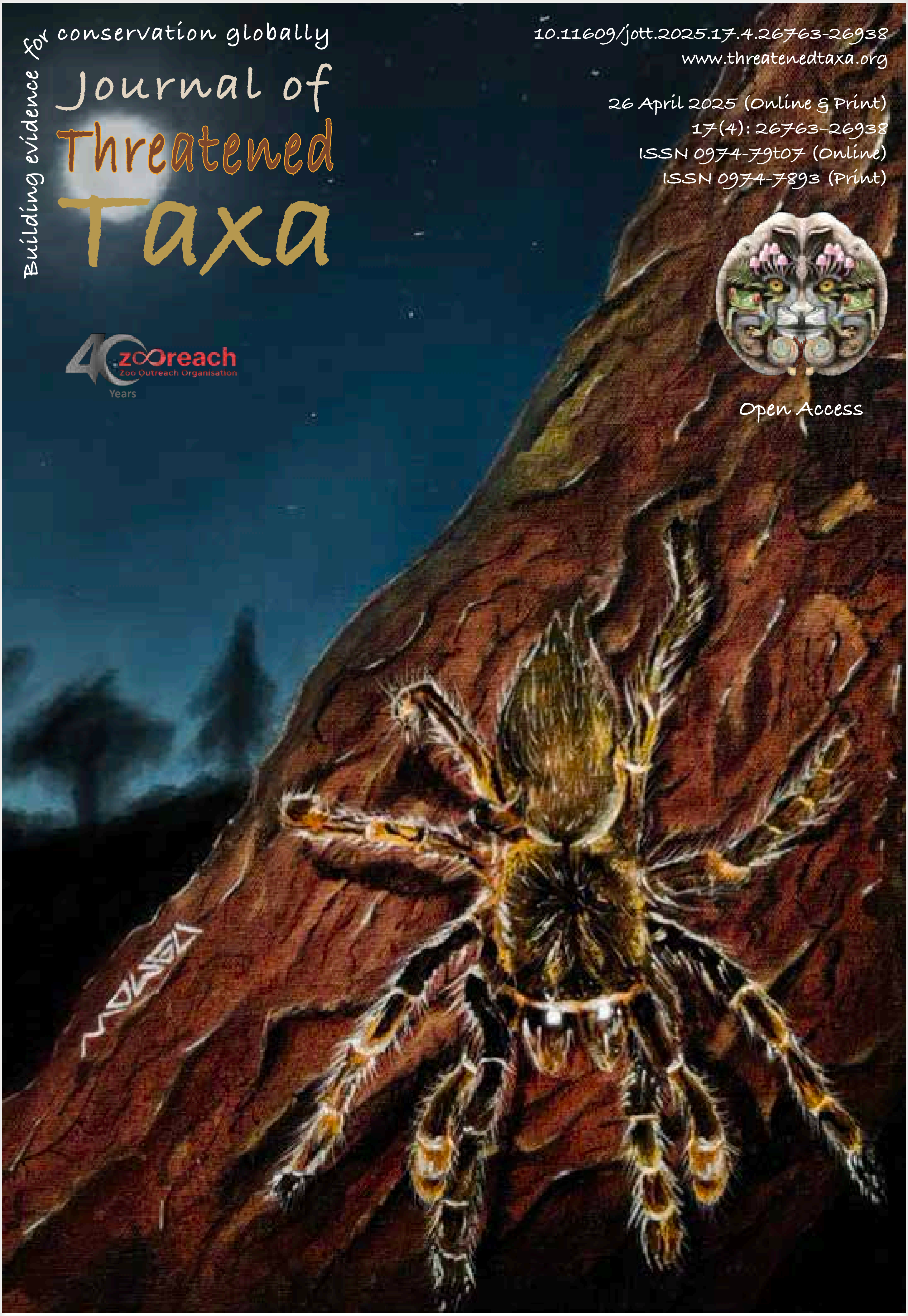

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

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Cover: Nilgiri Large Burrowing Spider *Haploclastus nilgirinus*. Acrylic on canvas. © Aakanksha Komanduri.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26763–26779

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9494.17.4.26763-26779

#9494 | Received 16 November 2024 | Final received 24 February 2025 | Finally accepted 18 March 2025

OPEN ACCESS

ARTICLE

Biodiversity in Garh Panchkot and surroundings (Purulia, West Bengal) of residential and migratory land vertebrates with special reference to endangered species

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Abstract: This study examined land vertebrate biodiversity in Garh Panchkot (Panchet Hill) and surrounding forest areas in Purulia, West Bengal. Opportunistic field surveys and direct specimen collection were used to assess the abundance of endangered and vulnerable species. Previous studies recorded 106 land vertebrate species in the region, with the highest diversity in the class Aves and the lowest abundance in the class Amphibia. Endangered species recorded in the current study included Peafowl *Pavo cristatus*, Sloth Bear *Melursus ursinus*, Common Langur *Semnopithecus entellus*, Rhesus Macaque *Macaca mulatta*, Indian Rock Python *Python molurus*, and Fishing cat *Prionailurus viverrinus*. Also observed were Black-headed Ibis *Threskiornis melanocephalus* and Striped Hyaena *Hyaena hyaena* classed as "Near Threatened," and White-rumped Vulture *Gyps bengalensis* designated "Critically Endangered". An analysis of likely threats to vulnerable species identified rapid urbanization, accompanied by increased air, water and noise pollution. The results of this study will be useful in establishing spatiotemporal distribution patterns of land vertebrates and especially threatened species, aiding efforts to promote bio-conservation and sustainable development.

Keywords: Bio-conservation, diversity, endangered species, land vertebrates, Panchet Hill, Purulia, spatiotemporal distribution, threats, vulnerable species.

Editor: Jayanta Kumar Mallick, Wildlife Wing, Kolkata, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Panja, A., B. Kahar & S. Chattaraj (2025). Biodiversity in Garh Panchkot and surroundings (Purulia, West Bengal) of residential and migratory land vertebrates with special reference to endangered species. *Journal of Threatened Taxa* 17(4): 26763–26779. https://doi.org/10.11609/jott.9494.17.4.26763-26779

Funding: None.

Competing interests: The authors declare no competing interests.

Data availability statement: The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

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Author contributions: AP wrote and conceptualised the manuscript. BK coordinated and analysed the data. SC captured the wild life photographs and organise the sample information. All authors contributed equally to the article and approved the submitted version.

Acknowledgements: The authors express their gratitude to the local tribal hunters and residents of the nearby villages in the Garh Panchkot hilly region for sharing valuable information that contributed to the study of biodiversity among land vertebrates in Garh Panchkot and its surrounding areas, Purulia, West Bengal, with a particular focus on endangered species.

INTRODUCTION

In the modern era, global biodiversity is progressively exhausted at a higher rate. Biodiversity has vital ecological role in maintaining the stability and support all forms of life within ecosystems. The term biodiversity loss, describes the reduction in genetic variability, biological diversity, and the natural ecosystem organizations (Sanyal et al. 2012; Achieng et al. 2023). India is regarded as one of the world's most varied nations, home to approximately 7–8 % of all known species as well as a few hotspots with diverse ecosystems, enhanced biodiversity (Himalaya, Indo-Burma, Western Ghats, Sundarbans) and it serves as a huge archive for traditional knowledge. Based on nationwide survey, it has been estimated that there are around 69 endemic bird species, 156 reptile species, and 110 endemic amphibian species in India (UNEP 2001; Rana & Kumar 2023). The recorded percentage of forest area in West Bengal is 13.38% (11,879 km^2) of the geographical area (88,752 km^2), whereas the corresponding data for Purulia District is 14% (Northern tropical dry deciduous forests cover an area of 876 km^2, which includes 112 km^2 of reserve forests, 729 km^2 of protected forests, and 35 km^2 of unclassed state forests and other areas) of the geographical area (6,259 km^2) (Annual Forest Administrative Report, West Bengal, 2021–2022). There are around eight different kinds of woods, each with a diverse range of vegetation and fauna. West Bengal's rich biodiversity combines the elements of the Himalayan, sub-Himalayan, and Gangetic plains in its diversified flora and wildlife. Garh Panchkot, a ruined fort, which dates back to probably the 90 AD is situated right by the Panchet Lake along the foothills of the famous Panchet Hill. This lush dense forested area was once fortified. Panchet Hill (Garh Panchkot) is located at the lateritic landscape of the Neturia Community development Block under the Raghunathpur subdivision of the Purulia District (northeastern tip of Purulia) and it has a maximum elevation of 650 m.

Garh Panchkot is rich in biological diversity. The inventories of flora in the sample plots include 40 tree species, 15 shrub species, seven liana species, and 18 herb species (https://westbengalforest.gov.in). Garh Panchkot also harbours 325 medicinal plants having rich gene pools of many threatened species. The lovely chirping and symphony of several bird species fill this remote, calm, and serene valley. In addition to the breathtaking beauty of nature, Garh Panchkot is renowned for its rich zoological treasure and a testament to a rich historical past. An assessment of the variety of bird species in and around Purulia Town, West Bengal, India, was conducted by Mahato et al. (2021). Mandal (2012) performed another investigation that identified uncommon macrophyte species connected to wetlands in the Purulia Districts. Raha & Pandey (2015) studied the hunting festival which causes a serious threat to the biodiversity of Ajodhya Hills, Purulia. Moreover, Samanta et al. (2017) and Das (2018) investigated on the butterfly diversity of Purulia, especially in the Baghmundi Region. Another study on diverse butterfly species and related host plants in Joychandi Hill of Purulia District, West Bengal was carried out by Chowdhury & Chowdhury (2020). Previously, a field study was performed on butterfly diversity in correlation to habitat utilization in Purulia (Das 2018). In addition, few more studies were done surrounding the Bagmundi Hill and Garh Panchkot area upon insect diversity (Sengupta et al. 2021; Mukherjee & Hossain 2024). Bhowmik et al. (2017) studied on snake biodiversity in Garh Panchakot and its surrounding areas in Purulia District. Another documentation was done by Samanta et al. (2021) on the globally threatened Indian Pangolin and its threats from Ajodhya Hills of Purulia. Sikdar et al. (2024) observed the coexistence of Indian Pangolin *Manis crassicaudata* (Mammalia: Pholidota: Manidae) and Indian Crested Porcupine *Hystrix indica* (Mammalia: Rodentia: Hystricidae) in Purulia District. Garh Panchkot, Purulia has been least explored regarding the threatened land vertebrate diversity and comparatively little published information is available to date. At present, there are scanty reports available on the prevalence of endangered faunal species in the Purulia District's Garh Panchkot region. The goal of the current field work is to gather up-to-date information about the land vertebrate species with special emphasis on the variety of Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR) in the Panchet Hill and adjoining forest areas. Investigating species abundance, likely causes of threats and extinction, and potential management approaches to save endangered species are the further objectives of the present study.

MATERIALS AND METHODS

Study area

The Purulia District is primarily associated with West Bengal's Chotanagpur Plateau. The district experiences subtropical weather, with summer temperatures reaching as high as 40^{0}C and winter lows of 7^{0}C with average rainfall 1,375.2 mm. The area is made up of highlands, low hills, scenery, and dense Sal Forest 0.61%, mixed dense forest 2.27%, open Sal Forest 1.80%, mixed open forest 12.20%, other social forestry plantations and degraded forests (https://purulia.gov.in). The majority of the rainfall runs off due to the topography's undulations. The hilly location of Garh Panchkot (23.6 ^{0}N & 86.7 ^{0}E) has been the primary focus of this investigation (Image 1). This study area is 60 km away from Purulia Town and is part of the Neturia Block. Nine villages surrounding the Panchet Hill (Bagmara, Puapur and Chalmara villages are situated at the northern side whereas Panchut and Gobag at the southern side; Rampur, Lakhmanpur, and Aamdanga on the western side of the hilly region) were selected during the study as the focal sites. The aforementioned villages surrounding the Panchet Hill were included in this study as these are the habitats of several vertebrate species, including Jungle Cat, Indian Flying Fox, House Rat, Bengal Fox, Indian Grey Mongoose, Common/Brahminy Skink, Oriental Garden Lizard and birds such as Kingfisher, Asian Openbill, Dove, Parakeet, Red-naped and Black-headed Ibis. The area is also home to endemic species, including Indian Pangolin, Indian Crested Porcupine, and Striped Hyena. For the detailed study regarding the species habits, richness, abundance and geographical distribution, investigation of regional sites is important.

Study design

The study was conducted from March 2023 to February 2024 to record the diversity of common and endangered species. These months were selected for the study so that the diverse kinds of faunal species can be accessed both during winter as well as summer

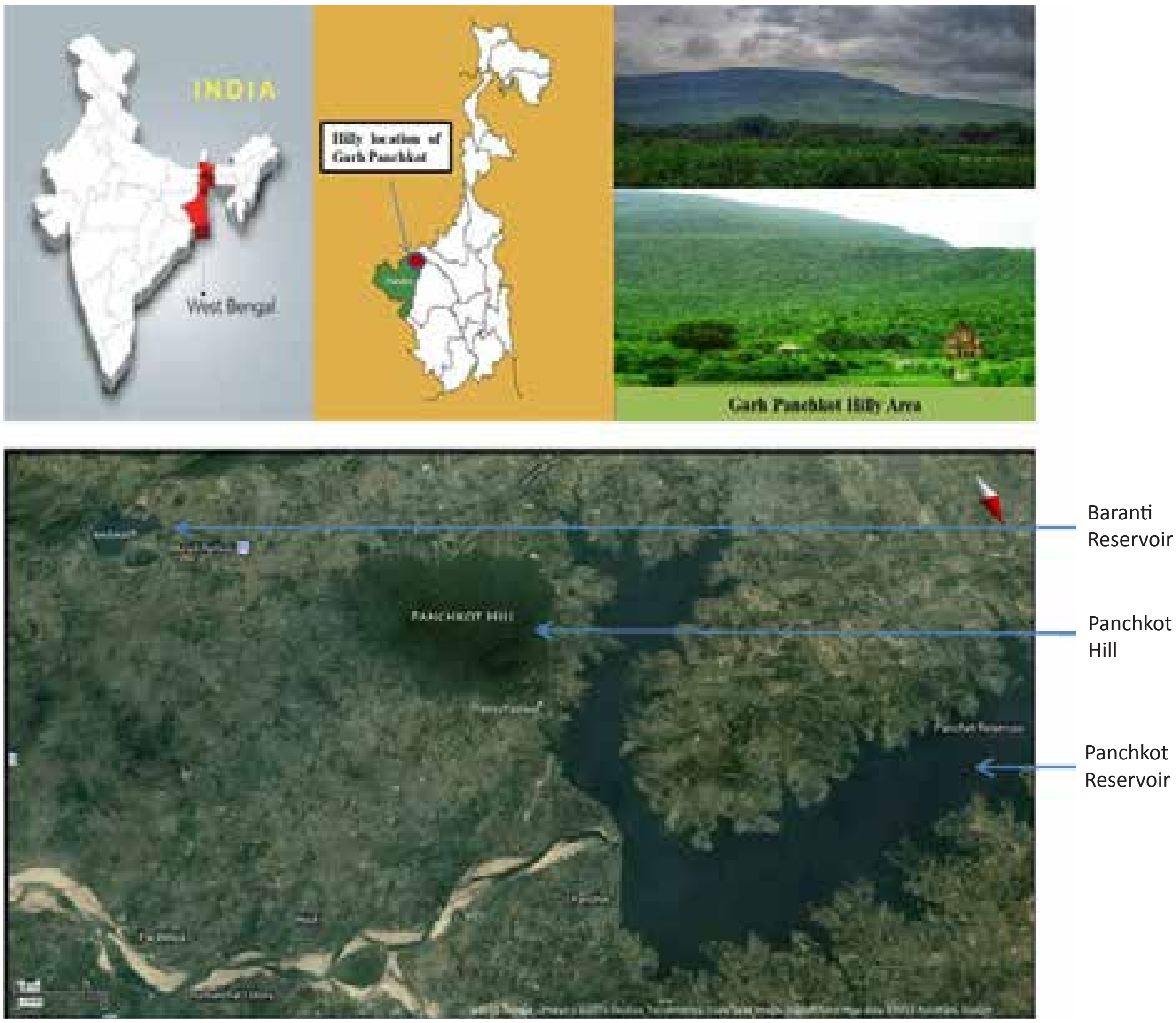

Image 1. The study site of present investigation of Panchet hill (Garh Panchkot) of Purulia District, West Bengal, India.

seasons. In addition, the selection of this period during the year prevents biases of vertebrate behaviour towards a particular season. The initial requirement was the selection of potential sampling sites which was accomplished by rigorous field survey and perception study of native villagers.

Data source and observation method

Both the primary and secondary data sources have been used in this study. In order to obtain primary data, field observations and documentation of endangered animal species were conducted, while a critical analysis of potential risks was accompanied. Quadrat analysis was included as a part of the study to further endorse if the chosen sampling sites could support the co-existence of different faunal species which might be endangered species. The data were collected by taking photographs of indirect evidence like animal footprints, and trails and by observing quills, faecal matter, and scales. The secondary data sources included several research articles, reputable websites (i.e., Google Scholar, Web of Science, Bio One), Wikipedia, Pub Med, and other online sources. Images of the various species that are accessible have been gathered. For the animal behavioural study of targeted animals, the selected appropriate time of investigation was one or two hours after dawn or before sunset as these times are devoid of much anthropological intervention. The species checklist was created in accordance with Mandal (2012) and Chattopadhyay et al. (2018).

Public interviews and perception study

Community interviews are one of the most well-known and cost-effective methods to determine the distribution of endangered species (Willcox et al. 2019). The local people can give an idea regarding the reduction in the number of wild animals overtime and the probable reason behind it. Local tribal hunters and common people of surrounding villages of Garh Panchkot hilly region (Baghmara, Rampur, Lakshmanpur, Aamdanga, Panchut, Ankduara, Gobag, Puapur, and Chalmara) were interviewed. The information obtained from local villagers were cross-checked by studying the existing scientific literature. The interviews which have been taken from local people are generally informal type. Most of the local tribal communities inhabiting the surrounding villages belong to lower socio-economic status. The objectives and primary intention of the survey have been clearly described to the common people. At each site 2–3 h have been invested for the interview process and the session was continued for 1–2 days in every alternate week. The studied villages are the homeland of different tribal communities like Bhumijs, Birhors, Kherias, Lodhas, Mundas, Oraons, Paharias, Santhals and most of these people are living below the poverty level. They are financially dependent on hunting in the forest region located nearby the Panchet Hilly region.

Data collection and analysis

The focus of the current study is solely on the endangered land vertebrate fauna. Throughout the study period, pertinent literature was used to identify several vertebrate species. From previous reports, several sampling techniques were followed in the current study to achieve the best results because there was no single sampling strategy that could be used to evaluate the vertebrate diversity fully (Table 1).

All of the study period's sampling data was collected from the first week of every month. To document the diversity and richness of birds, the line transect approach was used. The topography, roads, and bodies of water (rivers, ponds, & lakes) can all affect how long the migratory routes of the species under study are. To evaluate seasonal variations in the richness and number of faunal species, monthly data from a one-year study were further subdivided into four seasons: summer (March–May), monsoon (June–August), post-monsoon (September–November), and winter (December–February). There are certain animals which are not seasonal but found throughout the year (e.g., Cormorant, Cattle Egret, Kingfisher, Black Kite, Indian Hare, Common Palm Squirrel, & Indian Flying Fox).

Capturing photographs

A Nicon Aculon Binocular (A211 10–22 x 50) has been used for close observation of the encountered vertebrate species and a digital camera (Nicon D7200

Table 1. Methods used for studying different vertebrate classes (excluding fishes) from Panchet Hill ('+' indicates the method applied for studying the particular vertebrate class).

Method	Vertebrate class			
	Amphibia [8.73%]	Reptilia [17.47%]	Aves [59.23%]	Mammalia [15.56%]
Hand capturing	+	+	-	-
Extensive searches in micro-habitats	+	+	+	+
Opportunistic spotting	+	+	+	+
Call survey	+	-	+	-
Information from local villagers	+	+	+	+

with Nikkor Lens 70–300 mm) has also been used for capturing their photographs. Photographs and images are useful for distinguishing between various species. Data were collected by capturing photographs from the selected sites. Along with the pictures of different animals, termite mounds, nests, feeding signs on ground were also collected to trace the existence of different animals (Image 2). Data were collected during the day time randomly in each week during the studied period. Although, nocturnal observations were also carried out by using spot-light, headlight, and three celled torch. The duration of day along with night time observations was done from 0630 h to 1200 h with a midday break for three to four days in each area. The exact GPS coordinates were taken using GPS map camera application.

Quadrat method

Quadrat method (25 x 25 m) was used for analysing the faunal species found in the selected observation sites. In these places, camera traps were set up for investigation purpose. The data analysis procedure was repeated at least three times to avoid statistical biasness. The procedure was performed in the first week of each month and the minimum interval between two investigations was one month.

Species richness and diversity were calculated using Biodiversity Pro software (McAleece et al. 1997). The bird species diversity was calculated using the Shannon-Wiener Diversity index [$H' = \sum p_i \ln p_i$] and Shannon diversity index [$H_{max} = Log_{10}(S)$]. Measurement of Shannon's evenness index was calculated using the following formula $J = H'/ H_{max}$ (p_i = proportion of total sample belonging to i^{th} species, S = total number of species in habitats (species richness) (Magurran 2004).

Ethical permission

The present study was carried out by following all the instructions of the forest rangers. Some villagers were involved in the survey and they informed us regarding the availability of local endangered species. Evidence were also gathered with the help of some forest officers (anonymised for the sake of research integrity) of the Neturia block near Garh Panchkot. The participants for the survey were informed thoroughly regarding the survey goals, in their local languages without using scientific verbiage and the work was preceded only when they spontaneously consented to the contribution in the study. The survey-based fieldwork was undertaken and performed after getting permission from the Raghunathpur Range, Kangsabati (northern side) Forest division, Purulia, West Bengal.

During the data collection, special care was taken so that silence could be maintained and a hassle-free ambience can be prevailed without any major changes after the investigation. The data collection method was non-invasive, including field study, camera trapping, quadrat study, and collection of biological samples. Specific body parts (Quill, scales, skin, and a few epidermal derivatives) were only collected from the ground when these were shed off naturally from animal bodies.

RESULTS AND DISCUSSION

Purulia is characterised by many plateaus and rocky regions and covers an area of forest landscape [Northern tropical dry deciduous forest (5B/C1c)], with dominant tree species (as per importance value index (IVI)) *Terminalia anogeissiana*, *Lagerstroemia parvifolia*, *Shorea robusta*, *Terminalia alata*, *Careya arborea*, *Semecarpus anacardium*, *Lannea coromandelica*, *Aegle marmelos*, *Alangium salvifolium*, and *Croton persimili* (https://www.westbengalforest.gov.in/upload/publication/Garhpanchokot.pdf). The areas are bounded by the Ranchi and Hazaribag districts of Jharkhand on the western side, Singhbhum District of Jharkhand on the southern side, and Bokaro and Hazaribag districts of Jharkhand on the northern side. Garh Panchkot falls in the Raghunathpur Forest Range of Neturia Block in the Kangsabati (northern side) forest division in Purulia. The tropic of cancer passes through the district, so climatic variation can be observed across the line which is the major reason for the biodiversity of Purulia. The scattered vegetation, bare earth, and lack of cultivation are the characteristics of the Garh Panchkot Foothill region. The diversity of vertebrates in the Panchet Hilly region was previously documented by Chattopadhyay et al. (2018) and according to the study, with nine species (9%), amphibia had the lowest faunal diversity, followed by Reptilia (19 species, 18%), Mammalia (11 species, 14%), and Aves (63 species, 59%). In the present study, special emphasis has been given to diverse faunal availability in land area with special reference to endangered, threatened or near threatened organisms. The majority of the species recorded in this survey fall into the IUCN Red List 'Least Concern' category (2017). The miscellany of land vertebrates in the study area has been depicted in Table 2. In the present study, 103 different species have been studied with the highest species diversity observed in class Aves (61 species, 59.23%), followed

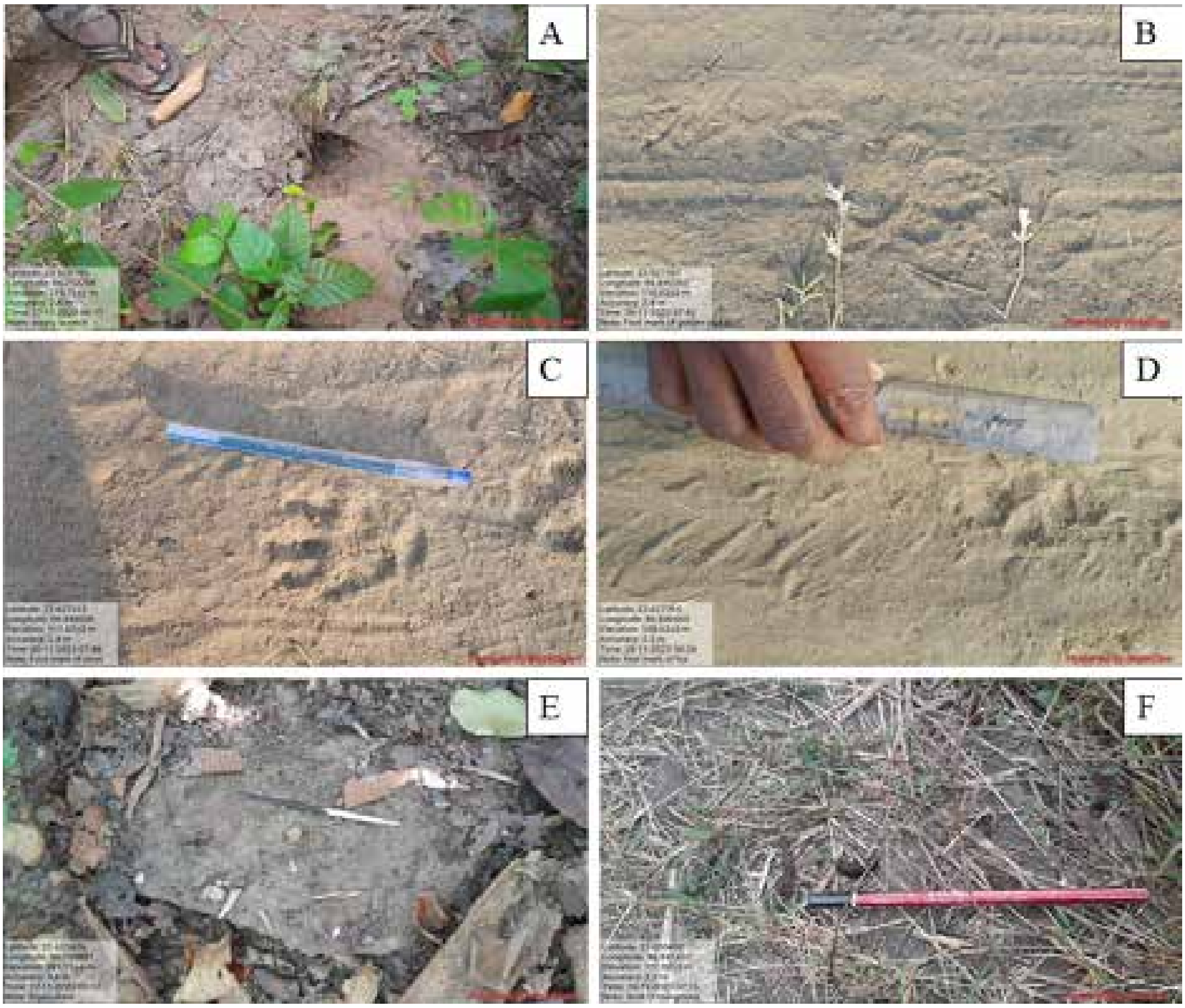

Image 2. Different body parts of animals including scales, spines, feathers, and faecal matter as well as behavioural activities like nest formations, scratches, and paw marks help detect the existence of different land vertebrates within the studied area: A—scratches of Indian Crested Porcupine *Hystrix indica*, | B—foot marks of Golden Jackle *Canis aureus* | C—foot marks of Asian Palm Civet *Paradoxurus hermaphroditus* | D—foot marks of Bengal Fox *Vulpes vulpes* | E—spines of Indian Crested Porcupine | F—scat of Indian Grey Mongoose *Urva edwardsii*. © Sujoy Chattaraj.

by Reptilia (18 species, 17.47%), Mammalia (15 species, 15.56%), and Amphibia (nine species, 8.73%).

In the Panchet Hilly region, the Black-headed Ibis *Threskiornis melanocephalus* and Striped Hyaena *Hyaena hyaena* are categorized as 'Near Threatened' vertebrate species; the White-rumped Vulture *Gyps bengalensis* is listed as 'Critically Endangered' (Table 2).

Amphibians including the Indian Cricket Frog, also known as the Rice Field Frog (Jijhi byng; *Fejervarya limnocharis*), and Indian Burrowing Frog (Gortobasi byng; *Sphaerotheca breviceps*) are less commonly found in this hilly region. Moreover, Indian Common Toad or Kuno byng *Duttaphrynus melanostictus,* Indian Bullfrog or Sona byng *Hoplobatrachus tigerinus,* Common Indian Tree Frog or Gecho byng *Polypedates maculatus,* Ornamented Pygmy Frog or Metho byng *Microhyla ornata* are found abundantly [Image 3.1–3.3]. The studied amphibians have been observed in different microhabitats including open surface, under vegetation, log, and in burrows.

Among different types of reptiles, snakes are predominantly found in Garh Panchkot and its surrounding areas. Russell's Viper is quite rare although it is found near Kashipur and Panchet Hilly region. Banded Krait *Bungarus fasciatus* is regarded as one of the most venomous snakes which measures about 2.01 m (Bhowmik 2017). Another poisonous snake is King Cobra *Ophiophagus hannah* which is obtained during the study and is categorised as vulnerable on the IUCN Red List due

Table 2. Diversity of land vertebrate species of Panchet hill and surrounding forests as recorded during the present study.

	Class / Common name	Local name	Scientific name	Authority	Abundance	IUCN Red List status
	Amphibia					
1.	Common Indian Toad	Kuno Byang	*Duttaphrynus melanostictus*	(Schneider, 1799)	++++	LC
2.	Indian Marbled Toad	Metho Byang	*Duttaphrynus stomaticus*	(Lütken, 1864)	++	LC
3.	Indian Cricket Frog or Rice Field Frog	Jhinjhi-Byang	*Fejervarya limnocharis*	(Gravenhorst, 1829)	+	LC
4.	Indian Burrowing Frog	Gortobasi Byang	*Sphaerotheca breviceps*	Schneider, 1799	+	LC
5.	Asian Painted Frog	Rongin Venpu Byang	*Kaloula pulchra*	Gray, 1831	++	LC
6.	Ornamented Pygmy Frog	Chhoto Loubichi Byang	*Microhyla ornata*	Duméril & Bibron, 1841	+++	LC
7.	Jerdon's Bull Frog	Jerdoner Kola Byang	*Hoplobatrachus crassus*	Jerdon, 1853	++	LC
8.	Magadha Burrowing Frog	-----	*Sphaerotheca magadha*	Dinesh, 2019	+	LC
9.	Indian Skipper Frog	Kotkoti Byang	*Euphlyctis cyanophlyctis*	Schneider, 1799	++	LC
	Reptilia					
1.	Forest Calotes	Jangli girgiti	*Monilesaurus rouxii*	Duméril & Bibron, 1837 vide Pal et al., 2018	+++	NA
2.	Brook's House Gecko	Grihabasi tiktiki	*Hemidactylus brookii*	Gray, 1845	++++	NA
3.	Indian Flapshell Turtle	Sundi/chiti kachim	*Lissemys punctata*	Bonnaterre C, 1789	++	LC
4.	Peninsular Rock Agama	Pahari girgiti	*Psammophilus dorsalis*	Gray et al, 1831	++	LC
5.	Oriental Garden Lizard	Baganer girgiti	*Calotes versicolor*	Daudin, 1802	++++	NA
6.	Common/Brahminy Skink	Boro Ghase Anjani	*Eutropis carinata*	Schneider, 1801	++	LC
7.	Asian Chameleon	Bohurupi	*Chamaeleo zeylanicus*	Laurenti, 1768	+	LC
8.	Common Indian Monitor	Go sanp	*Varanus bengalensis*	Daudin, 1802	++	LC
	Non- venomous snake					
9.	Indian Python	Ajogor sanp	*Python molurus*	Linnaeus, 1758	++	NA
10.	Indian Sand Boa	Thutu sanp	*Eryx johnii*	Linnaeus, 1758	+	NA
11.	Oriental Rat Snake	Sona dhamna	*Ptyas mucosa*	Linnaeus, 1758	++++	NA
12.	Buff-striped Keelback	Hele sanp	*Amphiesma stolatum*	Linnaeus, 1758	++++	NA
13.	Checkered Keelback	Joldhora	*Xenochrophis piscator*	Schneider, 1799	++++	NA
14.	Brahminy Blind Snake	Telega sanp	*Ramphotyphlops braminus*	Schneider, 1799	+++	NA
	Venomous snake					
15.	Common Krait	Chiti sanp	*Bungarus caeruleus*	Schneider, 1801	++++	NA
16.	Banded Krait	Sakhamuti	*Bungarus fasciatus*	Schneider, 1801	++	LC
17.	Russell's Viper	Chondrobora	*Daboia russelli*	(Shaw & Nodder, 1797)	++	NA
18.	Indian Cobra/ Spectacled Cobra	Gokhro	*Naja naja*	Cantor, 1836	++	LC
	Aves					
	Birds of Wetland					
1.	Eastern Cattle Egret	Gobok	*Ardea coromanda*	Boddaert, 1783	++++	LC
2.	Little Egret	Korchebok	*Egretta garzetta*	Linnaeus, 1766	++++	LC
3.	Asian Opened-billed Stork	Shamuk khol	*Anastomus oscitans*	Boddaert, 1783	++++	LC
4.	Black-headed Ibis	Kalomatha Kastechara	*Threskiornis melanocephalus*	Latham, 1790	+	NT
5.	Red-naped Ibis	Kalo Dochara	*Pseudibis papillosa*	Temminck, 1824	+	LC
6.	Little cormorant	Chhoto pankouri	*Microcarbo niger*	Vieillot, 1817	++	LC
7.	Oriental Darter	Gayar	*Anhinga melanogaster*	Pennant, 1769.	++	LC
8.	Black-necked Grebe	Pandubi	*Tachybaptus ruficollis*	*Pallas*, 1764	++	LC

	Class / Common name	Local name	Scientific name	Authority	Abundance	IUCN Red List status
9.	Lesser Whistling Duck	Chhoto sarali	*Dendrocygna javanica*	Horsfield, 1821	++	LC
10.	Small Kingfisher	Choto machranga	*Alcedo atthis*	Rafinesque, 1815	+++	LC
11.	White- breasted/throated Kingfisher	Sadabuk/gala machranga	*Halcyon smyrnensis*	Horsfield, 1821	+++	LC
12.	Asian Openbill	Shamuk khol	*Anastomus oscitans*	Boddaert, 1783	+++	LC
13.	Greater Adjutant Stork	Hargila	*Leptoptilos dubius*	Gmelin, 1789	++	LC
14.	Great Indian Bustard	Indian bustard	*Ardeotis nigriceps*	Vigors, 1831	++	LC
	Land birds					
15.	White-rumped Vulture	Bangla sokun	*Gyps bengalensis*	Gmelin, 1788	+	CE
16.	Brahminy Kite	Sonkhochil	*Haliastur indus*	Boddaert, 1783	++	LC
17.	Black Kite	Chil	*Milvus migrans*	Boddaert, 1783	++++	LC
18.	Blue Rock Pigeon	Jalali kobutor	*Columba livia*	Gmelin, 1789	++++	LC
19.	Eastern Spotted Dove	Tile ghughu	*Streptopelia chinensis*	Scopoli, 1782	++++	NA
20.	Red Turtle Dove	Lal ghughu	*Streptopelia tranquebarica*	Hermann, 1804	++	LC
21.	Rose-ringed Parakeet	Sobuj tia	*Psittacula krameri*	Scopoli, 1769	++++	LC
22.	Plum-headed Parakeet	Fultusi	*Psittacula cyanocephala*	Brisson, 1760	++	LC
23.	Spotted Owlet	Kuture pecha	*Athene brama*	Temminck, 1821	++	LC
24.	Eastern Barn Owl	Lakshmi pecha	*Tyto javanica*	Scopoli, 1769	++	LC
25.	Little Swift	Ghar Batasi	*Apus affinis*	Gray, 1830	+++	LC
26.	Indian Roller	Nilkontho	*Coracias benghalensis*	Linnaeus, 1758	+++	LC
27.	Grey Francolin	Titir	*Ortygornis pondicerianus*	Gmelin, 1789	++	LC
28.	Jungle Bush Quial	Bater	*Perdicula asiatica*	Latham, 1790	++	LC
29.	Common Hoopoe	Mohanchura	*Upupa epops*	Linnaeus, 1758	+++	LC
30.	Blue-throated Barbet	Basanta bouri	*Psilopogon asiaticus*	Lathm, 1790	+++	NA
31.	White Wagtail	Sada khanjan	*Motacilla alba*	Linnaeus, 1758	++++	LC
32.	Yellow Wagtail	Holud khanjan	*Motacilla flava*	Linnaeus, 1758	+++	LC
33.	Red-vented Bulbul	Bulbuli	*Pycnonotus cafer*	Linnaeus, 1766	++++	LC
34.	Brown Shrike	Badami kasai	*Lanius cristatus*	Linnaeus, 1758	++	LC
35.	Oriental Magpie-robin	Doyel	*Copsychus saularis*	Wagler, 1827	++++	LC
36.	Indian Robin	Shamya	*Copsychus fulicatus*	Linnaeus, 1766	+++	LC
37.	Purple Sunbird	Moutusi	*Nectarinia asiatica*	Lathm, 1790	+++	LC
38.	Indian Silverbill	Sormunia	*Euodice malabarica*	Linnaeus, 1758	+++	LC
39.	Baya Weaver	Babui	*Ploceus philippinus*	Linnaeus, 1758	+++	LC
40.	Brahminy Starling	Bamune salikh	*Sturnia pagodarum*	Gmelin, 1789	+++	LC
41.	Golden Oriole	Sonabou	*Oriolus kundoo*	Sykes, 1832	++	LC
42.	House Crow	Kak	*Corvus splendens*	Vieillot, 1817		LC
43.	Large-billed Crow	Darkak	*Corvus macrorhynchos*	Wagler, 1827	++	LC
	Migratory birds					
44.	Green Sandpiper	Sabuj batan	*Tringa ochropus*	Linnaeus, 1758	+	LC
45.	Marsh Sandpiper	Lariyati	*Tringa stagnatilis*	Bechstein, 1803	+	LC
46.	Common Sandpiper	Cha-pakhi	*Actitis hypoleucos*	Linnaeus, 1758	+++	LC
47.	Golden Plover	Swarna chatar	*Pluvialis fulva*	Gmelin, 1789	++	LC
48.	Tufted Duck	Isti kutum/ Tiki hans	*Aythya fuligula*	Linnaeus, 1758	+	LC
49.	Common Pochard	Bamunia hans	*Aythya ferina*	Linnaeus, 1758	+++	NT

	Class / Common name	Local name	Scientific name	Authority	Abundance	IUCN Red List status
50.	Eurasian Wigeon	Sinthi hans	*Mareca penelope*	Linnaeus, 1758	+++	LC
51.	Indian Spot-billed Duck	Deshi mete hans	*Anas poecilorhyncha*	Forster, 1781	+++	LC
52.	Common Moorhen	Jal murgi	*Gallinula chloropus*	Linnaeus, 1758	+++	LC
53.	Cotton Pygmy Goose	Dhala bali hans	*Nettapus coromandelianus*	Gmelin, 1789	+++	LC
54.	Yellow-wattled Lapwing	Halde gal ti ti	*Vanellus malabaricus*	Boddaert, 1783	+++	LC
55.	Red-wattled Lapwing	Lal gal ti ti	*Vanellus indicus*	Leclerc, 1781	+++	LC
56.	Peregrine Falcon	Baj pakhi	*Falco peregrines*	Tunstall, 1771	+++	LC
57.	Marsh Harrier	Halde khanjan	*Cirus aeruginosus*	Linnaeus, 1758	+++	LC
58.	Siberian Rubythroat	Siberian chunikanthi	*Calliope calliope*	Pallas, 1776	++	LC
59.	Northern Pintail	Lenja hans	*Anas acuta*	Linnaeus, 1758	+++	LC
60.	Northern Shoveler	Pantamukhi hans	*Spatula clypeata*	Linnaeus, 1758	+++	LC
61.	Greylag Goose	Mete raj hans	*Anser anser*	Linnaeus, 1758	+++	LC
	Mammalia					
	Diurnal					
1.	Indian Hare	Khorgosh	*Lepus nigricollis*	Cuvier, 1823	++	LC
2.	Common Palm Civet	Gondhogokul	*Paradoxurus hermaphroditus*	Pallas, 1777	++	LC
3.	Northern Plains GrayLangur	Hanuman	*Semnopithecus entellus*	Dufresne, 1797	+++	LC
4.	Indian Grey Mongoose	Neul	*Urva edwardsii*	E,Geoffroy Saint-Hilaire, 1818	++	LC
5.	Common Palm Squirrel	Kathbirali	*Funambulus palmarum*	Linnaeus, 1766	++++	LC
	Nocturnal					
6.	Indian Flying Fox	Badur	*Pteropus giganteus*	Temminck, 1825	++++	LC
7.	Indian Pygmy Bat	Chamchike	*Pipistrellus tenuis*	Temminck, 1840	++++	LC
8.	House Rat	Idur	*Rattus rattus*	Linnaeus, 1758	+++	LC
9.	House Mouse	Nengti idur	*Mus musculus*	Linnaeus, 1758	+++	LC
10.	House Shrew	Chucho	*Suncus murinus*	Carl Linnaeus, 1766	+++	LC
11.	Indian Mole-rat	Metho idur	*Bandicota bengalensis*	Haerdwicke & Grey, 1833	+++	LC
12.	Bengal Fox	Khaksial	*Vulpes bengalensis*	Shaw, 1800	++	LC
13.	Jungle Cat	Bonbiral	*Felis chaus*	Güldenstädt, 1776	+	LC
14.	Striped Hyaena	Lakra	*Hyaena hyaena*	Linnaeus, 1758	+	NT
15.	Indian Crested Porcupine	Sojaru	*Hystrix indica*	Kerr, 1792	+	LC

Abbreviations used: Relative abundance expressed as +—less abundant | ++++—more abundant | CE—Critically Endangered | LC—Least Concern | NA—This taxon has not yet been assessed on the IUCN Red List | NT—Near Threatened. Ref: Raha & Pandey 2015; Chattopadhyay et al. 2018.

to gross habitat destruction (Image 3.4). Dhaman *Ptyas mucosa* is commonly known as the Oriental Rat Snake; it is a non-venomous species of colubrid snake (1.5–1.95 m) (Image 3.5). The field study revealed the presence of Indian Rock Python *Python molurus* which is believed to be the longest snake (7.3–7.6 m) (Image 3.6). Apart from snake, several other reptiles are found abundantly in the studied hilly region including Yellow-bellied House Gecko *Hemidactylus flaviviridis,* Forest Calotes *Monilesaurus rouxii*, Asian Chameleon *Chamaeleo zeylanicus*, and Common/ Brahminy Skink *Eutropis carinata.* (Image 3.10–3.12). Here, in this present study, reptiles live in a variety of microhabitats, including terrestrial, aquatic, and arboreal environments. The observed snakes have been found from shaded small rocks, leaf litter, rotting logs, temporary pools, sun exposed rocks.

The avian species biodiversity depends on the pattern of landscape. The pattern of biodiversity alters with the climatic conditions, environmental factors, habitats and topography. Though Purulia is an arid district, there are certain local aquatic bodies including Saheb Bandh and Kansai River, which provide life support for the aquatic avian group. Due to the presence of large number of migratory birds, the species richness value becomes high in winter, especially in Baranti Dam and Saheb Bandh. According to ebird checklist at Garh Panchkot-Lalpur, 81 species have been recorded so far, although in the present study 61 species have been found. The avian food habit is influenced by scarcity of water and the lesser availability of foods according to seasonal variation. The birds of different feeding habits including omnivorous (15 species), carnivorous (seven species), invertivorous (four species), molluscivorous (three species), herbivorous (three species), granivorous (five species), insectivorous (15 species), frugivorous (four species), piscivorous (five species) found throughout the year enforces the fact. Most of the birds existing here are omnivores and insectivores which might be due to extreme weather condition of Purulia (Mahato et al. 2021). Among the different local bird species, Cattle Egret (Gobok), Little Egret (Korchebok), Asian Opened-billed Stork (Shamuk khol), Black-headed Ibis (Kalomatha kastechara), Red-naped Ibis (Kalo kastehara), Red-vented Bulbul (Bulbuli), Brown Shrike (Korkota), Oriental Magpie-robin (Doyel), Indian Robin (Shamya), Purple Sunbird (Moutusi) etc. are most commonly found whereas migratory birds include Lesser Whistling Duck, Cotton Pygmy Goose, Northern Pintail, Indian spot-billed duck, Northern Shoveler, and Greylag Goose (Image 3.13–3.21).

Various types of mammals with wide range of feeding habit and variable habitat are found during the studied period. Characteristically few of them exhibit nocturnal habit and adapted for highly developed eyesight, senses of hearing, and smell, e.g., certain species of Indian hare *Lepus nigricollis*, Indian Pygmy Bat *Pipistrellus tenuis*, Indian Flying Fox *Pteropus medius*, Hyena *Hyaena hyaena*, House Shrews *Suncus murinus* whereas considerable number of species are observed in daytime, e.g., Common Palm Squirrel *Funambulus palmarum*, Indian Mongoose *Urva edwardsii*, and Northern Plains Gray Langur *Semnopithecus entellus*. Few of them are carnivorous in nature, like the Striped Hyaena *Hyaena hyaena,* Bengal Fox *Vulpes bengalensis*, and Jungle Cat *Felis chaus* which feed on the flesh of other small animals or remnants of any debris generated from other animals. During the studied period, mammals have been observed from the vegetation of ground and canopy cover, rocky caves, underground holes, and crevices (Image 3.22–3.30).

Peafowl *Pavo cristatus*, Sloth Bear *Melursus ursinus*, Common Langur *Semnopithecus entellus*, Rhesus Macaque *Macaca mulatta*, Indian Rock Python *Python molurus*, and Fishing Cat *Prionailurus viverrinus* are among the endangered species discovered during the current study. The Black-headed Ibis *Threskiornis melanocephalus* and Striped Hyaena *Hyaena hyaena* are classed as 'Near Threatened', whilst the White-rumped Vulture *Gyps bengalensis* is designated as 'Critically Endangered'.

The Black-headed Ibis, or Oriental White Ibis *Threskiornis melanocephalus*, is a species of bird in the ibis family. The head and neck of this species are black, but its general plumage is white with black, with lengthy legs and a downward-curving beak. Despite being classified as a wetland species, this bird can also be found on land that borders wetlands, such as freshwater and saltwater marshes, reservoirs, lakes, and ponds; it can also be found in rice fields, recently ploughed crop fields, riversides, urban lakes, and open sewage gutters (Nandi et al. 2004; Roy et al. 2011; Khan et al. 2016). They often build their nests during the rainy season, which coincides with their breeding season. Similarly, another endangered bird species, *Pseudibis papillosa*, the Red-naped Ibis, is primarily found in marshes where it lives in flocks. It is commonly seen in small flocks of 2–4, which could be family groups, and rare to see larger groups. They have ruby red warty skin on the crown and a usually dark body with a white spot on the shoulder. It typically stays in pairs during the breeding season and makes a loud call to entice companions. Usually, they build their nests atop big trees or power towers (Nandi et al. 2004) (Image 4). Due to progressive urbanization and developmental activities, the natural habitats of these birds might be destroyed or degraded. It is observed that the wetlands are undergoing an unwanted rapid decline in biodiversity due to climate change, illegal hunting, huge pollution, deforestation, and eutrophication of wetlands.

With an unfeathered head and neck, the White-rumped Vulture *Gyps bengalensis* is a typical medium-sized vulture. These birds have short tail feathers, a white neck ruff, and very large wings. The adult's dark plumage is contrasted with pale features on the rump, underwing coverts, and back (Grimmett et al. 1998). Like other vultures, it hunts by flying high in thermals and seeing other scavengers (Image 4). It primarily feeds on carcasses. Consequently, there are some drugs (e.g. diclofenac) used for the treatment of livestock (cattle, donkeys) when they fall ill (Swan et al. 2006). Although, these drugs help the animals feel better, in majority of the cases, cattle will get sick again. When these animals die, the diclofenac remains in their system and the vultures who feed on these animals; they unknowingly

Image 3. Selected pictures of the different land vertebrates recorded from the forest region of Panchet Hill and adjacent areas. Amphibia (3.1–3.3): 3.1—Asian Painted Frog *Kaloula pulchra* | 3.2—Indian Common Toad *Duttaphrynus melanostictus* | 3.3—Indian Skipper Frog *Euohlyctis cyanophylactis* | Reptilia (3.4–3.12): 3.4—Indian Cobra *Naja naja* | 3.5—Dhaman *Ptyas mucosa* | 3.6—Indian Python *Python molurus* | 3.7—Raj Sanp *Bungarus fasciatus* | 3.8—Boa Sanp *Eryx johnii* | 3.9—Kalach or Common Krait *Bungarus caeruleus* | 3.10—Common Indian Monitor *Varanus bengalensis* | 3.11—Brahminy Skink *Eutropis carinata* | 3.12—Bronze Grass Skink *Mabuya macularia*. © Sujoy Chattaraj.

swallow the residual drugs which poison the vultures and causes serious kidney damage (Rana & Prakash 2003).

In general, Striped Hyenas are slightly smaller than spotted and brown hyenas. They have a big head, thick nose, large, pointed ears, and black eyes. These are mostly scavengers and frequently target humans for attack. Male and female Striped Hyenas cooperate with one another to raise their young, making them nocturnal and monogamous creatures (Alfred et al. 2002; Biswas et al. 2008) (Image 4). Due to the scavenging habits, the hyenas are often believed to deplete the livestock. This causes conflict with local communities and triggers the hunting of hyenas. A hyena was allegedly killed, beheaded and chopped into pieces by some residents of Dhanardih Village in Kashipur Block of Purulia in July, 2020. A 15-year-old Striped Hyena was killed by poachers at the Jharbagda Forest near Manbhum College campus

Image 3. Selected pictures of the different land vertebrates recorded from the forest region of Panchet Hill and adjacent areas. Aves (3.13–3.21): 3.13—Peacock *Pavo cristatus* | 3.14—Eastern Barn Owl *Tyto javanica* | 3.15—Rose-ringed Parakeet *Psittacula krameri* | Budgerigar Bird *Melopsittacus undulates* | 3.16—Spotted Dove *Streptopelia chinensis* | 3.17—Greater Adjutant Stork *Leptoptilos dubius* | 3.18—Small Kingfisher *Alcedo atthis* | 3.19—Indian Robin *Copsychus fulicatus* | 3.20—Baya Weaver *Ploceus philippinus* | 3.21—Little Swift *Apus affinis* | Mammalia (3.22–3.30): 3.22—Striped Hyaena *Hyaena hyaena* | 3.23—Elephant *Elephas maximus indicus* | 3.24—Northern Plains Gray Langur *Semnopithecus entellus* | 3.25—Indian Grey Mongoose *Urva edwardsii* | 3.26—House Rat *Rattus rattus* | 3.27—Wild Boar *Sus scrofa* | 3.28—Indian Crested Porcupine *Hystrix indica* | 3.29—Indian Pygmy Bat *Pipistrellus tenuis* | 3.30—Common Palm Civet *Paradoxurus hermaphroditus*. © Sujoy Chattaraj.

under Manbazar PS area in December, 2013. According to some previous literature reviews, there are nearly 15 contemporary records (2010–2021) in Bengal, from sites situated on the eastern side of the Chota Nagpur Plateau. These records indicated deaths of hyenas due to poaching, vehicle accidents, and retaliatory killings (Akash et al. 2021). According to Chattopadhyay et al. (2018), striped hyenas were observed from Medinipur-Purulia zone only once during their study period (two years) and the probable reason for their decline in number is human-hyena conflict.

According to the most recent animal census conducted in the forest of southern Bengal, the population of Indian pangolins *Manis crassicaudata* has dropped dramatically and 42 pangolins survived in the forest area of Purulia (Samanta et al. 2021). Several rocky cavities were detected at various places in the Panchkot Hilly region and surrounding forest areas, where the evidence of Indian pangolin and crested porcupine sharing their living space were identified. The focal rocky cavity was found in certain places in hilly forest areas where recent tail, drag-marks, footprints and claw marks of Pangolins were found [Image 4]. Few trees were identified (e.g. Karam *Neolamarckia cadamba*, Bael fruit *Aegle marmelos,* Tendu *Diospyros melanoxylon*) where both pangolins and porcupines are found in comparatively less number and vulnerable. These animals prefer to eat fruits, tubers, bulbs, and roots of plants (Sikdar et al. 2024). As per the native villagers there are several trees (White Siris *Albizia procera*, Indian Plum or Kul *Ziziphus mauritiana*, Banyan *Ficus benghalensis*, Palash *Butea monosperma*, Shisu *Dalbergia sissoo*) which are known to be the habitat of several land vertebrates including Spotted Dove *Streptopelia chinensis*, Parakeet *Psittacula krameri*, Pangolin *Manis crassicaudata*, Porcupine *Hystrix indica*, Palm Squirrel *Funambulus palmarum*, Gray Langur *Semnopithecus entellus*, Indian Flying Fox *Pteropus medius*, Pygmy Bat *Pipistrellus tenuis*. The possible reason for the Indian pangolin *Manis crassicaudata* and Indian crested porcupine *Hystrix indica* becoming endangered is excessive hunting and poaching for its meat which is consumed by native villagers as well as tribal communities as delicious food (Hughes 2014). The pangolin scales are also used for making different types of medicines for promoting blood circulation, stimulate lactation, cure rheumatisms, and reduce swelling (Mohapatra et al. 2015; Xu et al. 2016). The WWF has classified pangolins as an endangered species, marking their status in red ink (Tikadar 1983; WII ENVIS 2017).

Anthropogenic activity has an impact on the hilly Garh Panchkot Region both directly and indirectly. With the gradual increase of human population, their caste and religious faith as well as advancement of living standard, industrialization and urbanization, the forest range has started reducing and its floral and faunal variety affected severely. Under the administration of divisional headquarter at Purulia, there are eight territorial forest ranges (viz. Balarampur, Matha, Bagmundi, Ajodhya, Jhalda, Kotshila, Joypur and Arsha). The officers and staffs of forest department are trying to protect the faunal species of Garh Panchkot, but unable to restore the diversity of vegetation and the old glory of this hilly region possibly due to lack of proper management strategy and suitable planning (Raha & Pandey 2015). Moreover, there is a sponge iron factory within a radius of 100 m and the contaminants are typically deposited on top of the greenery (Image 5). It has been found that the ash and slag from factories cover the leaves with a layer of pollutants, which further destroy the delicate ecological balance and the nutrient cycles.

Moreover, fire is one of the major threats to wild life. Forest fire causes long-term negative impacts on faunal species including endangered species and destroys the floral diversity (trees, herbs, shrubs, grassland). Repeated firework can convert some shrublands to grasslands whereas fire exclusion transforms grassland into shrub-land and forest. Fires influence the animals by destroying their habitats. Generally, the fire season initiates from March/April and continues up to June (Jhariya & Raj 2014).

In addition to pollution, ancient tribal hunting festivals ("Shikar Parba") and cultural events held on the night of Buddha Purnima (Baishakhi Purnima) are major factors in the extinction of species. Santhal (local tribe) men wander in the forests and kill wild porcupines, pangolin, deer, monkeys, wild boar, and bears to acquire meat for its delicacy, and exoskeleton parts are made into rings to prevent rheumatic fevers (Banerjee 2022). The illegal hunting and poaching are thought of as a threat to the avian species. Most of the lakes in the district forest areas are surrounded by many tribal communities (Mahato et al. 2021). Generally, local tribal people hunt birds for their mental satisfaction as well as a source of food. Due to a lack of proper knowledge (literacy rate of Purulia - 64.48 %), they are not aware of the socioeconomic impact of avian species and the substantial role of the ecosystem (Mandal et al. 2023). Previously, Chattopadhyay et al. (2018) reported on the hunting of wild animals from the Garh Panchkot area. Ritualistic hunting and cultural events have been reported from the forest area of Jhargram, West Midnaporee,

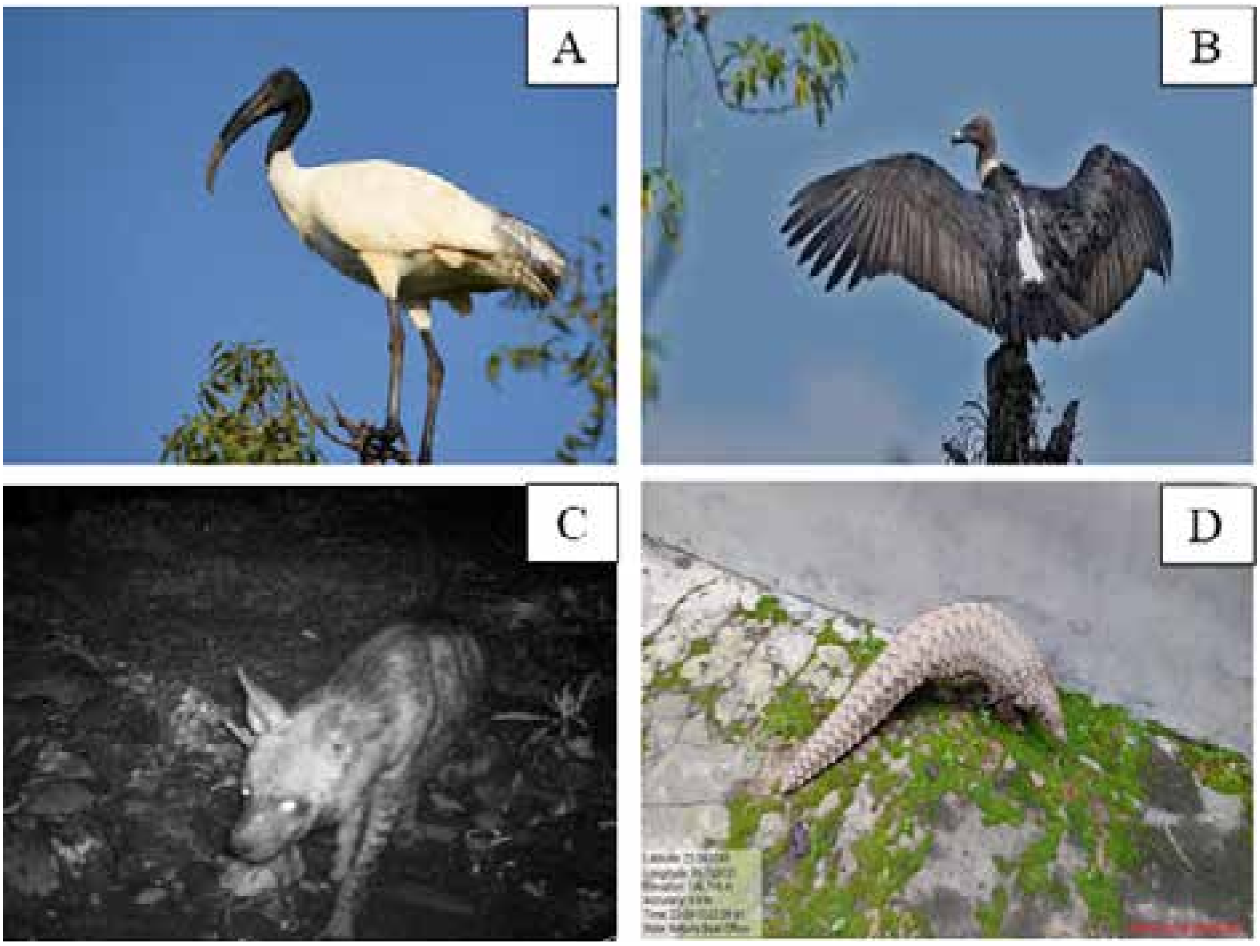

Image 4. A few threatened species observed in the Garh Panchkot Hilly region and its surroundings: A—Striped Hyena *Hyaena hyaena* | B—Black-headed Ibis *Threskiornis melanocephalus* | C—White-rumped Vulture *Gyps bengalensis* | D—Indian Pangolin *Manis crassicaudata*. © Sujoy Chattaraj.

and certain areas of Purulia (D'Cruze et al. 2024); the migratory bird population of the Purulia District has declined due to illegal hunting. In extent, Sikdar et al. (2024) reported tribal hunting of several mammalian species including Indian Pangolin *Manis crassicaudata* (Geoffroy, 1803) (Mammalia: Pholidota: Manidae) and Indian Crested Porcupine *Hystrix indica* (Kerr, 1792) (Mammalia: Rodentia: Hystricidae) in Purulia District. Deforestation causes rapid loss of habitat for migratory bird species (Mahato et al. 2021; Mahato 2021). The tribal community residing in the villages surrounding the hilly region, abolish the forest area vigorously. They often depend on the forest not only for fuel and wood collection but also as the main source of income for their daily life. Rapid destruction of the forest surrounding the wetland raises uncertainty in the avian diversity (Image 5).

Eutrophication is another threatening agent for making the wild fauna (e.g., Cattle Egret, Little Egret, Asian Open-billed Stork, Black-headed Ibis, Cormorant, Small Kingfisher, Greater Adjutant Stork) vulnerable. Algal bloom causes discolouration of water and depletes the oxygen level. In addition, the excessive growth of phytoplankton resists the sun light penetration beneath the lower depth of the water column [Image 5E]. Water pollution is now exponentially increased due to human activities like throwing plastics, garbage and waste food products into water bodies (Bashir et al. 2020; Wang et al. 2021) (Image 5).

Awareness programme should be generated regarding the conservation significance of faunal diversity and natural resources. In the foot hill region of Garh Panchkot, regular man-wildlife conflict has resulted in death of many wild animals. Human-elephant negative interactions have been reported previously from Purulia and Bankura districts due to several developmental activities (Mondal et al. 2016; Das Chatterjee & Mandal 2020). There are more than a few contemporary

Image 5. Major causes of biodiversity loss in Garh Panchkot Forest region and nearby wet land: A–B—Pollutants released from sponge iron factories located in Uttara and Gopalpur Villages, Purulia which are within 100 m radius of south-eastern face of Panchet Hill | C–D—Deforestation leads to extinction of several animal species due to destruction of natural habitat and severe climatic alteration | E—Eutrophication causes hypoxic condition in lakes and water bodies which in turn severely affect aquatic animal diversity. As a result, food sources of local or migratory birds are being lesser | F—Polythene bags and bottles loitering on lake side leading to lead poisoning and toxic effect on environment. © Sujoy Chattaraj.

records (2010–2021) upon human-hyena from Bengal, from sites specially located on the eastern limit of the Chota Nagpur Plateau including forest areas of Purulia District. These records noted around nine deaths due to poaching, avenging killings, and train accidents (Akash et al. 2021). Regarding this concern, anthropogenic activity (deforestation, urbanisation, industrialisation, and hunting) should be checked and well managed.

Sanctuaries and wildlife protected areas should be developed around the Garh Panchkot region to restore and conserve the entire biodiversity wealth of this hilly region. The concerned Forest Division should take more protective measures for preserving wildlife species as per the Schedules of Wildlife (Protection) Act. 1972 (Chakraborty & Kar 2004). Among the different wildlife protective approaches habitat conservation, wildlife sanctuaries, ex-situ conservation including zoological parks, botanical gardens, and wildlife safari, nature-based projects, sustainable land use, wildlife habitat creation, tree plantation, anti-poaching laws, public education are most important. There should be some strict management strategies for visitors to conserve the biodiversity of forests and wetlands. Government should take proper sustainable and holistic administrative strategies to make the land a plastic-free zone.

The present study is a pioneer investigation of endangered faunal species of the Garh Panchkot Hilly area and its surroundings; more research encompassing a wider range of plant and animal taxa will improve our understanding of the richness of wild species found in this particular area. The information gathered from this study will be useful in determining what needs to be done to conserve endangered and near-threatened species in order to ensure their long-term viability and best interests.

REFERENCES

Achieng, A.O., G.B. Arhonditsis, N. Mandrak, C. Febria, B. Opaa, T.J. Coffey, F.O. Masese, K. Irvine, Z.M. Ajode, K. Obiero, J.E. Barasa & B. Kaunda-Arara (2023). Monitoring biodiversity loss in rapidly changing Afrotropical ecosystems: an emerging imperative for governance and research. *Philosophical Transactions of the Royal Society B* 378(1881): 20220271. https://doi.org/10.1098/rstb.2022.0271

Akash, M., A. Dheer, S.M. Dloniak & A.P. Jacobson (2021). The faded stripes of Bengal: a historical perspective on the easternmost distribution of the Striped Hyena. *European Journal of Wildlife Research* 67(108): 1–12. https://doi.org/10.1007/s10344-021-01552-9

Alfred, J.R.B., N.K. Sinha & S. Chakraborty (2002). Checklist of Mammals of India.Published by Director, Zool. Surv. India, Kolkata. *Records of the Zoological Survey of India* Occasional Paper 199: 1–289.

Annual Administration Report (2021–22). Department of Forest, Government of West Bengal, 217–219 pp. https://www.westbengalforest.gov.in/publications_administrative_report_banabithi.php

Banerjee, A. (2022). Bodding's Santal Medicine and Connected Folklore vis-à-vis Vidyasagar's understanding of Anthropological Study. *Journal of the Asiatic Society* 63(4): 131–154.

Bashir, I., F.A. Lone, R.A. Bhat, S.A. Mir, Z.A. Dar & S.A. Dar (2020). Concerns and threats of contamination on aquatic ecosystems. *Bioremediation and Biotechnology* 27: 1–26. https://doi.org/10.1007/978-3-030-35691-0_1

Bhowmik, B. (2017). Studies on biodiversity of snake fauna in Purulia District with special reference to Garh Panchokot and its surroundings. *PANCHAKOTESSAYS* 8(2):1–9

Biswas, K.K., P.C. Saren & D. Basu (2008). Mammalian and avian fauna of some selected areas of Purulia District, West Bengal. *Records of the Zoological Survey of India* 108(3): 59–76.

Chakraborty, R. & S. Kar (2004). Assessment of habitat as well as avian and mammalian diversiiy in the Purulia District, West Bengal. *Records of the Zoological Survey of India* 103 (part–34): 87–124.

Chatterjee, N.D. & M. Mandal (2020). Human-elephant confict in Panchet Forest Division, Bankura, West Bengal, India. *Gajah* 51: 10–15.

Chattopadhyay, S., S. Dey & S.U. Roy (2018). On the diversity of the vertebrate fauna (excluding fishes) of Panchet Hill (Garh Panchkot), Purulia, West Bengal, India. *Journal of Threatened Taxa* 10(15): 12979–12985. https://doi.org/10.11609/jott.4102.10.15.12979-12985

Chowdhury, S & S.K. Chowdhury (2020). A study on butterfly diversity and related host plants in Joychandi Hill of Purulia District, West Bengal, India. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)* 14(10): 55–60.

Das, D. (2018). Butterfly (Lepidoptera: Rhopalocera) diversity in relation to habitat utilization at Jagannath Kishore College, Purulia, West Bengal (India). *Journal of Insect Biodiversity* 7(1): 1–16.

D'Cruze, N., A. Elwin, S. Ghosh, A.E. Asfaw, E. Coulthard, D. Megson, J. Norrey, S. Giri, V. Mishra, T. Adhya, S. Chatterjee, M. Banerjee, A. Banerjee & L. Harrington (2024). Ritualistic hunts: exploring the motivations and conservation implications in West Bengal, India. *Nature Conservation* 56: 243–273. https://doi.org/10.3897/natureconservation.56.132178

Grimmett, R., C. Inskipp & T. Inskipp (1998). *Birds of the Indian Subcontinent*. Oxford University Press, Delhi, 888 pp.

Hughes, J.E. (2014). Thinking (with) the Indian Pangolin: a humananimal perspective on India's colonial and princely histories. Nehru Memorial Museum and Library, Teen Murt House, New Delhi, India, 45 pp.

IUCN (2017). The IUCN Red List of Threatened Species. Version 2017–3. www.iucnredlist.org. Downloaded on 26 February 2018.

Jhariya, M.K. & A. Raj (2014). Effects of wildfires on flora, fauna and physico-chemical properties of soil—an overview. *Journal of Applied and Natural Science* 6(2): 887–897.

Khan, T.N., A. Sinha & P. Hazra (2016). Population trends and community composition of migratory waterbirds in three emerging wetlands of global significance in southwestern Bengal, India. *Journal of Threatened Taxa* 8(3): 8541–8555. https://doi.org/10.11609/jott.2652.8.3.8541-8555

Magurran, A.E. (2004). *Measuring Biological Diversity*. Blackwell Publishing, Oxford, 256 pp.

Mohapatra, R.K., S. Panda, M.V. Nair, L.N. Acharjyo & D.W.S. Challender (2015). A note on the illegal trade and use of pangolin body parts in India. *TRAFFIC Bulletin* 27(1): 33–40.

Mahato, S., S. Mandal & D. Das (2021). An appraisal of avian species diversity in and around Purulia Town, West Bengal, India. *Journal of Threatened Taxa* 13(3): 17906–17917. https://doi.org/10.11609/jott.4733.13.3.17906-17917

Mahato U. (2021). Deforestation induced change in subsistence pattern of the Kharia Tribe: a study from Purulia District. *Annals of Anthropological Research and Reviews* 1: 86–93.

Mandal, S.K. (2012). Survey of wetlands in Puruliya District, West Bengal, with special emphasis on their macrophytes. PhD Thesis. Department of Botany, The University of Burdwan, 377 pp.

Mandal, M., D. Ghosh, M. Karmakar, S. Mandi, P. Modak, B. Ghosh & D. Mandal (2023). Rural child health in India: the persistent nature of deprivation, undernutrition and the 2030 Agenda. *Environment, Development and Sustainability* 26: 4837–4860. https://doi.org/10.1007/s10668-023-02912-y

Martínez-Ramos, M., I.A. Ortiz-Rodríguez, D. Piñero, R. Dirzo & J. Sarukhán (2016). Anthropogenic disturbances jeopardize biodiversity conservation within tropical rainforest reserves. *Proceedings of the*

National Academy of Sciences 113(19): 5323–5328. https://doi.org/10.1073/pnas.1602893113

McAleece, N., J.D.G. Gage, P.J.D. Lambshead & G.L.J. Paterson (1997). BioDiversity Professional statistics analysis software. Jointly developed by the Scottish Association for Marine Science and the Natural History Museum, London.

Mukherjee, S.S. & A. Hossain (2024). Assemblage and diversity analysis of butterfly species in relation to climatic conditions in some tropical habitats: optimization through artificial neural network model. *Journal of Ecology and Environment* 48: 44. https://doi.org/10.5141/jee.24.065

Nandi, N.C., S. Bhuinya & S.R. Das (2004). Notes on mid-winter water birds population of some selected wetlands of Bankura and Purulia District, West Bengal. *Records of the Zoological Survey of India* 102(Part1–2): 47–51.

Raha, S. & S. Pandey (2015). The hunting festival — a serious threat to biodiversity of Ajodhya Hills, Purulia. *Panchakotessays* 6(1): 1–7.

Rana, A.K. & N. Kumar (2023). Current wildlife crime (Indian scenario): major challenges and prevention approaches. *Biodiversity Conservation* 32(5): 1473–1491. https://doi.org/10.1007/s10531-023-02577-z

Rana, G. & V. Prakash (2003). Cannibalism in Indian White-backed Vulture *Gyps bengalensis* in Keoladeo National Park, Bharatpur, Rajasthan. *Journal of the Bombay Natural History Society* 100: 116–117.

Roy, U.S., A.R. Goswami, A. Aich & S.K. Mukhopadhyay (2011). Changes in densities of water bird species in Santragachi Lake, India: potential effects on limnochemical variables. *Zoological Studies* 50(1): 76–84.

Samanta, S., D. Das & S. Mandal (2017). Butterfly fauna of Baghmundi, Purulia, West Bengal, India: a preliminary checklist. *Journal of Threatened Taxa* 9(5): 10198–10207. https://doi.org/10.11609/jott.2841.9.5.10198-10207

Samanta, S., S. Mahato & A. Mukherjee (2021). Documentation of the globally threatened Indian Pangolin and its threats from Ajodhya Hills, Purulia, West Bengal, India. Mammal Tales #36. In: *Zoo's Print* 36(12): 65–66.

Sanyal, A.K., J.R.B. Alfred, K. Venkataraman, S.K. Tiwari & S. Mitra (2012). *Status of Biodiversity of West Bengal*. Zoological Survey of India, Kolkata, 969 pp.

Sengupta, A., H. Ogale & E. Malaiyappan (2021). *Euploea sylvester* (Fabricius 1793) — Double-branded Crow. In: Kunte, K., S. Sondhi & P. Roy (eds.). *Butterflies of India,*v. 3.15. Indian Foundation for Butterflies. https://www.ifoundbutterflies.org/sp/972/Euploea-sylvester

Sikdar, D., S. Bhandari & S. Paira (2024). Coexistence of Indian Pangolin Maniscrassicaudata (Geoffroy 1803) (Mammalia: Pholidota: Manidae) and Indian Crested Porcupine Hystrixindica (Kerr 1792) (Mammalia: Rodentia: Hystricidae) in Purulia District, West Bengal, India. *Journal of Threatened Taxa* 16(2): 24630–24645. https://doi.org/10.11609/jott.8736.16.2.24630-24645

Swan, G., V. Naidoo, R. Cuthbert , R.E. Green, D. J. Pain, D. Swarup D, V. Prakash, M. Taggart, L. Bekker, D. Das, J. Diekmann, M. Diekmann, E. Killian, A. Meharg, R.C. Patra, M. Saini & K. Wolter (2006). Removing the threat of diclofenac to Critically Endangered Asian Vultures. *PLoS Biology* 4(3): e66. https://doi.org/10.1371/journal.pbio.0040066

Tikadar, B.K. (1983). *Threatened Animals of India*. Zoological Survey of India. Calcutta, 307 pp.

UNEP (2001). *India: State of the Environment 2001*. United Nations Environment Programme, Regional Resource Centre for Asia and the Pacific, Pathumthani, Thailand, xv + 171 pp.

Wang, H., J. García Molinos, J. Heino, H. Zhang, P. Zhang & J. Xu (2021). Eutrophication causes invertebrate biodiversity loss and decreases cross-taxon congruence across anthropogenically-disturbed lakes. *Environment International* 153: 106494. https://doi.org/10.1016/j.envint.2021.106494

WBFD (2017). West Bengal Forest Department. http://www.westbengalforest.gov.in/history.php. Accessed on 29 September 2017.

WII ENVIS (2017). ENVIS Centre on Wildlife & Protected Areas. https://www.wiienvis.nic.in/Database/Protected_Area_854.aspx. Accessed on 29 September 2018.

Willcox, D., H.C. Nash, S. Trageser, H.J. Kim, L. Hywood, E. Connelly, G. Ichu, J.K. Nyumu, C.L.M. Moumbolou, D.J. Ingram & D.W.S. Challender (2019). Evaluating methods for detecting and monitoring pangolin (Pholidota: Manidae) populations. *Global Ecology and Conservation* 17: e00539. https://doi.org/10.1016/j.gecco.2019.e00539

Xu, L., J. Guan, W. Lau & Y. Xiao (2016). An overview of pangolin trade in China. *TRAFFIC* 1–10. Accessed on 28th June, 2024. https://www.westbengalforest.gov.in/upload/publication/Garhpanchokot.pdf

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26780–26788

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9621.17.4.26780-26788

#9621 | Received 19 January 2025 | Final received 25 March 2025 | Finally accepted 03 April 2025

ARTICLE

Evaluating wildlife activity and corridor functionality: a study of underpasses in and around Rajaji National Park, India

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Abstract: Habitat fragmentation threatens biodiversity, making wildlife corridors vital for maintaining ecological connectivity. This study evaluated the functionality of three corridors—Chilla-Motichur, Teenpani, and Laltappar—in and around Rajaji National Park, Uttarakhand, India. We deployed camera traps at these corridors and surrounding forest areas for 8,198 trap nights to monitor the wildlife use of the corridors. We recorded 17 species of wild animals in the connected forested area and nine within the corridors. The Wild Pig *Sus scrofa* and Sambar *Rusa unicolor* were the most frequently captured species, with the highest Relative Abundance Index (RAI) in the Teenpani corridor. Activity patterns of wild species showed changes in the corridor compared to forest areas. Chital *Axis axis* exhibited continuous activity in corridors but an early-morning peak in forests (Δ = 0.68). Asiatic Elephant *Elephas maximus* shifted from daytime activity in forests to nocturnal peaks in corridors, likely avoiding human presence (Δ = 0.48). Sambar avoided daytime activity in the corridor compared to activity in the forest (Δ = 0.55), while Wild Pig maintained nocturnal peaks across both habitats (Δ = 0.71). Human activity, primarily diurnal, overlapped with Chital (Δ = 0.61) and increased potential encounters with Elephants and Leopards during evening hours (Δ = 0.25 and 0.39, respectively). Mitigation measures, such as habitat restoration and managing anthropogenic activities, are crucial for strengthening corridor functionality. The recent reintroduction of tigers in western Rajaji underscores the importance of these corridors for species connectivity and genetic exchange. This study provides valuable insights into managing wildlife corridors in human-dominated landscapes, highlighting their role in biodiversity conservation.

Keywords: Asiatic Elephant, camera trapping, conservation monitoring, habitat connectivity, human disturbance, infrastructure mitigation, species activity patterns.

Editor: Anonymity requested. **Date of publication:** 26 April 2025 (online & print)

Citation: Verma, N., S. Badola & S. Mondol (2025). Evaluating wildlife activity and corridor functionality: a study of underpasses in and around Rajaji National Park, India. *Journal of Threatened Taxa* 17(4): 26780–26788. https://doi.org/10.11609/jott.9621.17.4.26780-26788

Funding: All the equipment and logistics were supported by the Uttarakhand Forest Department.

Competing interests: The authors declare no competing interests.

Author details and **Author contributions:** Nishant Verma (APCCF, Uttarakhand Forest Department) conceptualised the study, conducted fieldwork, analysed data, and wrote the first draft. Saket Badola (former director, Rajaji Tiger Reserve) assisted with data collection and manuscript preparation. Samrat Mondol (scientist, Wildlife Institute of India) contributed to the study design and reviewed the manuscript.

Acknowledgements: We sincerely thank the Director, Rajaji Tiger Reserve, the Divisional Forest Officer, Dehradun Forest Division, and Dr. Samir Sinha, former Chief Wildlife Warden, Uttarakhand, for providing field logistics and the necessary permissions to conduct this research. We are grateful to Dr. Bivash Pandav, Wildlife Institute of India, for his invaluable guidance in planning and carrying out the study. Dr. Shivam Shrotriya is acknowledged for his guidance in data analysis and writing. We also extend our appreciation to the field staff for their dedication and support in carrying out the work.

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INTRODUCTION

The rapid expansion of human activities has led to significant alterations in natural landscapes. Habitat loss and fragmentation are two main contributors to biodiversity decline (Haddad et al. 2015). Anthropogenic habitat loss occurs when natural areas are converted for human activities such as agriculture, horticulture, infrastructure development, and urban expansion. Roads, railways, and urban expansion fragment once-continuous landscapes, thus impeding wildlife movement, disrupting ecological processes, and increasing the risk of local extinctions (Laurance et al. 2014; van der Ree et al. 2015). These processes disrupt habitat connectivity, impacting the movement, dispersal, and genetic exchange of wildlife populations (e.g., Callens et al. 2011; Napolitano et al. 2015). Such disruptions can have profound consequences, including population decline and loss of ecosystem functionality. Therefore, connecting natural habitats through ecological corridors is crucial for maintaining gene flow and population viability in the wild (Holderegger & Di Giulio 2010).

Wildlife corridors, composed of native vegetation, link larger habitat patches and facilitate animal movement (Burkart et al. 2016). By mitigating the effects of habitat loss and fragmentation, these corridors help sustain healthy animal populations and preserve biodiversity. In human-dominated landscapes, corridors are essential conservation tools, enabling wildlife to navigate fragmented habitats and reducing the risks of isolation and local extinctions.

The Terai Arc Landscape (TAL), spanning the Himalayan foothills in India and Nepal, is among the world's 200 globally significant ecoregions (Olson & Dinerstein 1998). This landscape harbours flagship species such as the Royal Bengal Tiger *Panthera tigris* and the Asiatic Elephant *Elephas maximus*, which require large, connected habitats for survival (Jhala et al. 2015). TAL is also a human-dominated landscape, facing significant challenges from expanding settlements, agriculture, and transportation infrastructure (Harihar & Pandav 2012). Corridors within this landscape are critical for maintaining connectivity between protected areas, yet many have become degraded due to anthropogenic pressures.

Rajaji National Park (RNP), spanning 820 km² within the western TAL, is a key protected area for Tigers, elephants, and other large mammals. This park is bifurcated into eastern and western sections by the Ganges River (Johnsingh et al. 2004). Additionally, highways and railway lines connecting Haridwar and Dehradun, two of Uttarakhand's most populated cities, create significant movement barriers for wildlife between protected areas and surrounding patches of reserve forests. Particularly, the connectivity between the Barkot Range of the territorial forest and the Kansrao Range of RNP is critical for elephant movement in this landscape (Johnsingh et al. 2004). Historically, the erstwhile Chilla-Motichur corridor played a crucial role in facilitating wildlife movement across both banks of the Ganges. This 3-km long and 1-km wide stretch of forest land that connects the Chilla Forest range on the eastern part of the Ganga to the Motichur Range on the west bank, is the only functional link between the eastern and western parts of RNP. While roads, railways, and irrigation channels hinder wildlife movement, roads pose the greatest barrier due to a continuous traffic flow. To address these challenges, three wildlife underpasses—Chilla-Motichur, Teenpani, and Laltappar—were constructed on the highway to provide connectivity between forested habitats within and around the park in 2021 (Nigam et al. 2022).

In this study, the current functionality of these three corridors were accessed in facilitating wildlife movement. Using camera-trap data, the activity patterns of key species — Leopard *Panthera pardus*, Asiatic Elephant, Spotted Deer or Chital *Axis axis*, Sambar *Rusa unicolor*, and Wild Boar *Sus scrofa*—were compared within the corridors and nearby forest ranges. It was also examined how human activities influence wildlife behaviour and corridor usage. By assessing corridor effectiveness, this study provides data-driven insights for enhancing connectivity and informing conservation planning in RNP and the broader TAL.

MATERIAL AND METHODS

Study Area

The study was conducted in the western part of Rajaji National Park (RNP), situated in Uttarakhand, India (30.248–29.850 ^{0}N & 77.878–78.444 ^{0}E), within the Terai Arc Landscape (TAL). The study focused on three wildlife corridors—Chilla-Motichur, Teenpani, and Laltappar—which have been established to connect fragmented forest patches of the Chilla, Motichur, & Kansrao ranges of RNP, and Barkot & Rishikesh ranges of the Dehradun Forest Division (Image 1). These corridors are intersected by major highways and railways, with underpasses designed to mitigate barriers to wildlife movement. The Chilla-Motichur underpass is 900 m

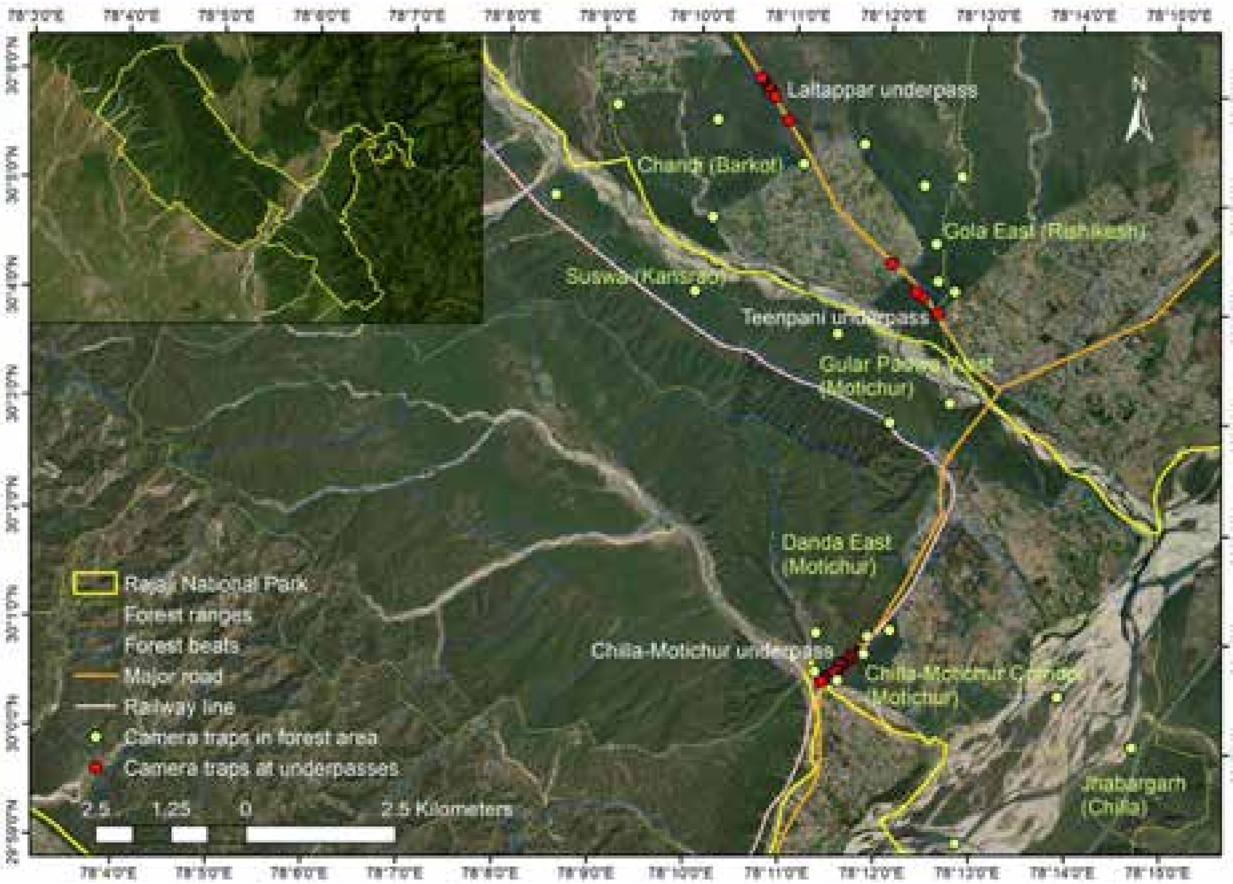

Image 1. Location of the three corridors — Laltappar, Teenpani, and Chilla-Motichur — at the boundary of the western Rajaji National Park. All three corridors are traversed by road, and wildlife underpasses are built on all three roads. Sampled forest beats are mentioned in green text.

long, while the Teenpani and Laltappar underpasses are each approximately 500 m in length. These underpasses provide critical connectivity between forested habitats in the park and adjacent territorial forests (Nigam et al. 2022).

The vegetation of RNP is primarily tropical moist and dry deciduous forests (Champion & Seth 1968), dominated by Sal *Shorea robusta*. Riverine forests and scrublands are also present. The region supports diverse wildlife, including flagship species such as the Tiger, Asiatic Elephant, and Leopard. It also harbours a rich diversity of avifauna and herpetofauna.

Camera-trapping

Camera traps were deployed between April and November 2022 across the corridors and adjacent forest ranges (Table 1). Sixty-four motion-triggered digital cameras (Cuddeback Model C1) were installed, yielding a total of 8,198 trap nights. Cameras were single-sided and mounted approximately 30–40 cm above ground level. Under the flyovers, the cameras were placed at a minimum of 25 m to a maximum of 100 m distance from each other along the flyover, so that any animal crossing the flyover would not be missed out. The Chilla-Motichur corridor was monitored by 24 cameras, whereas the Teenpani and Laltappar corridors each had eight cameras. Eight adjacent forest beats in five ranges of RNP and the Dehradun Forest division were sampled to understand the presence of wildlife. Three camera traps were deployed in each of the beats, except for six cameras in the Chandi beat of Barkot Range as it was relatively larger (Image 1, Table 1). Camera traps were strategically placed along trails, riverbanks, and other linear features to maximize the detection of medium- and large-sized mammals, which commonly use these pathways (Jhala et al. 2015). All the camera traps were active 24 h and monitored every fortnight to check the battery status and retrieve the data.

Data analyses

Species identification was conducted manually for each photograph by a single observer and verified by a

Table 1. Details of the survey effort during camera trapping at the corridors and adjacent forest ranges in and around the western Rajaji National Park.

Sites	Start date	End date	Total cameras	Total trap nights	Sampling coverage
Corridors					**Length (m)**
Laltappar	12.iv.2022	05.xi.2022	8	1656	500
Teenpani	10.vi.2022	05.xi.2022	8	1184	500
Chilla-Motichur	25.iv.2022	26.xi.2022	24	4485	900
Forest beats (ranges)					**Area (Km^2)**
Chandi (Barkot)	04.iii.2022	21.iv.2022	6	288	14.83
Jhabargarh (Chilla)	13.iii.2022	16.iv.2022	3	102	11.60
Suswa (Kansrow)	19.iii.2022	04.v.2022	3	138	6.14
Gola East (Rishikesh)	13.iii.2022	22.iv.2022	3	120	10.57
Chilla-Motichur Corridor (Motichur)	01.iv.2022	18.iv.2022	3	54	2.20
Danda East (Motichur)	16.iii.2022	19.iv.2022	3	102	6.12
Gular Parwa West (Motichur)	16.iii.2022	08.iv.2022	3	69	6.40

second observer. The date and time of each photograph were recorded from the image metadata, maintaining a time interval of 1 min for independent capture events. Wildlife presence in the connected forest areas and corridor underpasses was quantified using the relative abundance index (RAI), defined as the number of independent detections per 1,000 trap nights (O'Brien 2011). Comparative analyses of species activity patterns in forests and corridors, as well as their temporal overlap with humans, were conducted using the camtrapR package (version 2.3.0; Niedballa et al. 2016) in R (version 4.4.0; R Core Team 2024). Temporal overlap was estimated by the overlap coefficient Δ, which ranges from 0 (no overlap) to 1 (complete overlap) and is calculated using kernel density functions fitted to the time data of capture incidents of two species (Ridout & Linkie 2009).

RESULTS

Over 8,198 trap nights, camera traps recorded 17 species in the forest areas and nine in the corridors. Among the corridors, Chilla-Motichur and Laltappar had the highest species richness (seven species each), while Teenpani recorded six species (Image 2, Table 2). Teenpani had the highest relative abundance index (RAI) for Wild Boar (227.2) and Sambar (123.31) among the corridors, whereas Chilla-Motichur and Laltappar exhibited lower RAIs for most species (Table 2). In contrast, adjacent forest areas exhibited higher RAIs across all species, indicating a preference for less-disturbed habitats (Wilcoxon test: $V = 0$, $p < 0.001$).

Species exhibited distinct activity patterns between corridors and forest areas (Figure 1). Chital, the only diurnal species, exhibited activity throughout the 24-hour period in corridors, whereas it displayed a distinct early-morning peak inside the forest (Δ = 0.68). Leopards were uniformly active throughout the day in the forest but showed slightly reduced daytime activity in corridors (Δ = 0.71). Elephants exhibited contrasting activity patterns, with a daytime activity peak in forest ranges and a night-time peak in corridors (Δ = 0.48). Sambar displayed an early-morning activity peak in corridors, avoiding the daytime, while in the forest, it maintained activity throughout the day with increased movement during morning and evening hours (Δ = 0.55). Wild Pig activity remained consistent across both habitats, with peaks at night and reduced activity during the day (Δ = 0.71).

Human activity occurred exclusively during the daytime across all corridors, significantly overlapping with Chital (Δ = 0.61, Figure 1). Other species avoided times of peak human activity. The Leopard (Δ = 0.39) and the elephant (Δ = 0.25), both species frequently involved in negative human-wildlife interactions, showed increased overlap with human activity in the evening hours.

Image 2. Some of the wildlife species captured by camera traps at the corridors; top left to right: Asiatic Elephant, Sambar, Chital, and Barking Deer; bottom left to right: Leopard, Striped Hyena, and Wild Boar. © Uttarakhand Forest Deparment.

DISCUSSION

This study highlights both the significance and challenges of wildlife corridors in maintaining connectivity for species within fragmented habitats. The lower species richness observed in corridors (nine species) compared to forested areas (17 species) reflects the impact of disturbance and habitat fragmentation in human-dominated landscapes, a pattern consistent with global studies (Benítez-López et al. 2010; van der Ree et al. 2015).

Species activity patterns exhibited significant shifts within corridors compared to forest areas (Figure 1). Chital exhibited continuous activity throughout the daytime in corridors, whereas, in forests, its activity peaked during the early morning hours. Chital is primarily a diurnal species, with peak activity occurring at dawn and dusk. They spend most of their time feeding, followed by resting and social activities. This diurnal pattern is consistent across various habitats, including those with high human activity, where they may alter their behaviour to avoid disturbances (Rajawat & Chandra 2020; Dahya et al. 2023; Kumar et al. 2023). Leopards, known for their cathemeral activity (Palei et al. 2021; Dahya et al. 2023), exhibited uniform activity in forests but reduced daytime activity in corridors, possibly avoiding human activity. Elephants shifted their activity from a daytime peak in forests to a nocturnal peak in corridors, demonstrating their adaptability to avoid human encounters (Chakraborty et al. 2021). Sambar, predominantly nocturnal in other studies (Kumar et al. 2023), showed early-morning peaks in corridors, likely due to lower human presence at that time. Wild Boars maintained their nocturnal peaks across both habitats, consistent with findings from Dahya et al. (2023).

Human activity in corridors was predominantly diurnal, significantly overlapping with Chital activity, while other species mostly avoided peak human activity times. The overlap of Leopards and Elephants with human activity during evening hours is concerning, given

Table 2. Relative abundance index (per 1,000 trap nights) of the wildlife species, livestock, and humans captured at three corridors and adjacent forest areas in and around the western Rajaji National Park.

Species	Laltappar	Teenpani	Chilla-Motichur	Forest area
Barking Deer *Muntiacus muntjak*	0.6	-	0.22	12.9
Chital *Axis axis*	50.12	-	8.03	1363.44
Sambar *Rusa unicolor*	99.64	123.31	7.8	993.55
Nilgai *Boselaphus tragocamelus*	-	-	-	15.05
Asiatic Elephant *Elephas maximus*	19.93	2.53	0.89	172.04
Wild Boar *Sus scrofa*	13.89	227.2	22.07	223.66
Rhesus Macaque *Macaca mulatta*	1.81	-	1.34	43.01
Central Indian Langur *Semnopithecus entellus*	-	0.84	-	25.81
Indian Hare *Lepus nigricollis*	-	-	-	49.46
Indian Crested Porcupine *Hystrix indica*	-	3.38	-	49.46
Indian Peafowl *Pavo cristatus*	-	-	-	329.03
Indian Pangolin *Manis crassicaudata*	-	-	-	4.3
Leopard *Panthera pardus*	12.08	15.2	4.01	215.05
Tiger *Panthera tigris*	-	-	-	4.3
Striped Hyena *Hyaena hyaena*	-	-	-	21.51
Golden Jackal *Canis aureus*	-	-	-	4.3
Small Indian Civet *Viverricula indica*	-	-	-	17.2
Livestock	397.34	333.61	108.58	531.18
Human	752.42	26094.59	2360.98	206.45

the elevated risk of human-wildlife encounters (Figure 1). Such patterns, particularly involving species known to cause damage or pose danger in shared spaces, highlight the need for targeted management strategies.

The study also underscores the importance of infrastructure like underpasses in enhancing corridor functionality. Although highway underpasses support wildlife movement, parallel railway lines may act as significant barriers, particularly for elephants, necessitating targeted mitigation measures (Carvalho et al. 2017; Gilhooly et al. 2019). Additionally, debris from underpass construction, garbage dumping, and the use of old roads below the flyover at Teenpani exacerbate habitat degradation (Oro et al. 2013; Katlam et al. 2018). Habitat restoration, particularly in the Chilla-Motichur corridor, and increasing forested cover are crucial for improving corridor effectiveness (Dutta et al. 2018).

The translocation of four Tigers from Corbett Tiger Reserve to western Rajaji National Park (2021–2024) reinforces the importance of maintaining functional corridors (Times of India 2024, director, Rajaji Tiger Reserve pers. comm. 20.iii.2025). In 2022, a male Tiger was photo-captured in camera traps moving from the Chilla Range in the east to the Motichur Range in the western Rajaji using the reclaimed corridor under the Chilla-Motichur flyover. This observation signifies the successful restoration of historical connectivity between the eastern and western RNP. Furthermore, it highlights the critical role of the Chilla-Motichur corridor in Tiger conservation in this landscape. As Tigers recolonise the western TAL, maintaining and monitoring these corridors will be vital for their survival and genetic exchange. The corridor, is yet to be fully restored as an existing ammunition depot of the Indian army cuts through it leaving little space for unrestricted movement of wild animals.

The current study was limited in scope due to a smaller sample size, a lack of a more systematic sampling design, and coverage of only limited areas around the flyovers. Using more camera traps in a grid design could yield more information on the spatial use and abundance of wildlife populations in the landscape. Therefore, the analyses were restricted to RAI as an indicator of site use intensity. Interpreting RAI as abundance may be incorrect as the number of captures may be affected by habitat quality, disturbances, individual behaviour and camera placement (O'Brien 2011). Temporal activity may also be affected by similar biases in captures. Therefore,

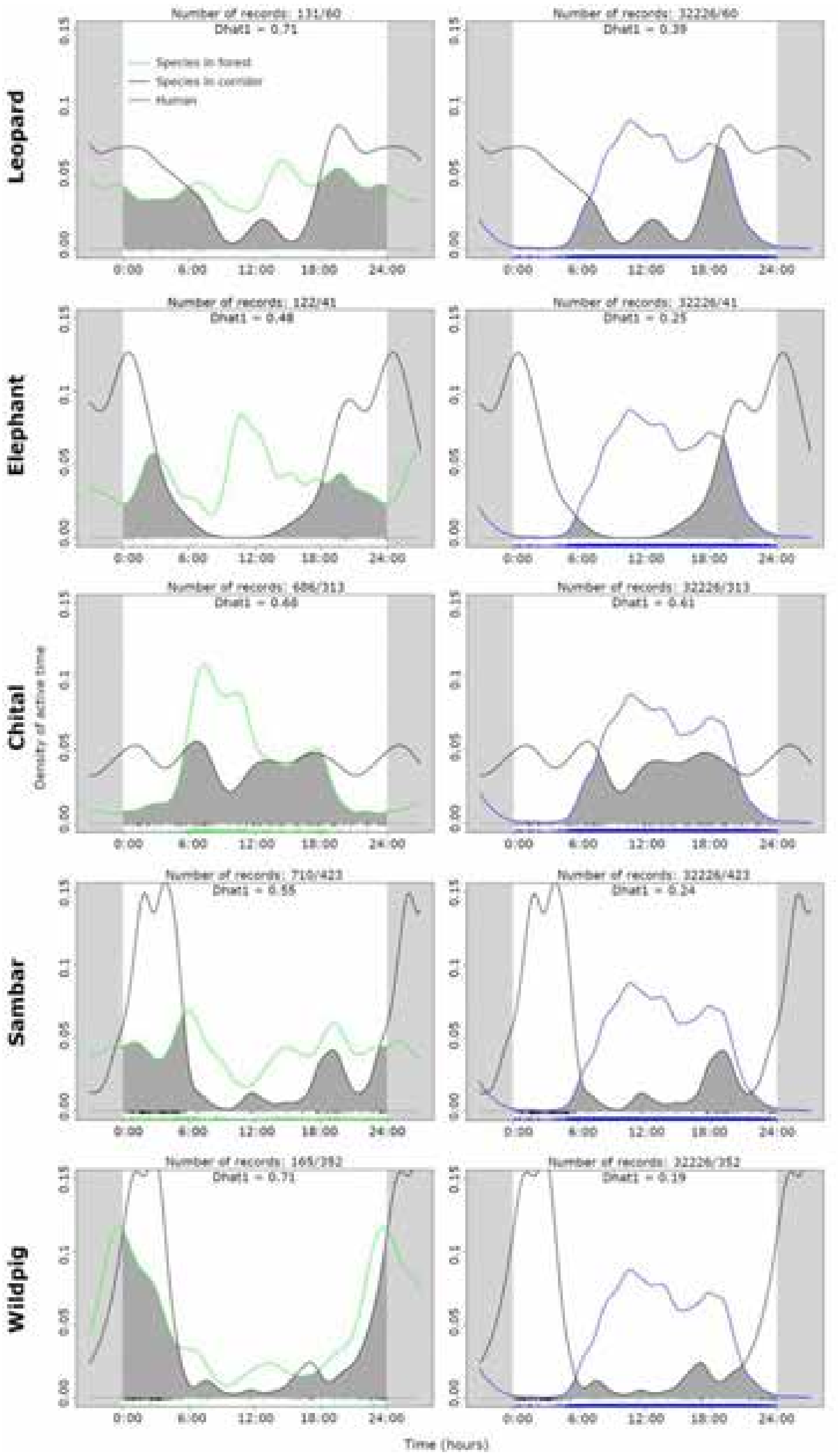

Figure 1. Comparison of the activity time of the five species frequently captured at the corridors around the western Rajaji National Park: Left—activity time of the species within the corridor and the forest ranges | right—activity overlap of the species with humans in the corridor. Dhat value represents the overlap coefficient.

temporal patterns were not analysed for all the captured species but focused only on the species with sufficient captures across the camera traps.

Nonetheless, this study provides valuable insights into the effectiveness of highway underpasses and the challenges of maintaining corridor functionality in human-dominated landscapes. Active measures are essential to enhance corridor utility, including habitat restoration to increase forest cover, shifting of the army's ammunition depot to fully restore the corridor, restricting human activity during critical wildlife movement times, ensuring proper disposal of construction debris and garbage, and implementing effective mitigation strategies for railways to facilitate safe crossings such as advance alert systems, improved braking systems in the trains, regular patrolling and crossing infrastructures (Carvalho et al. 2017). Continuous monitoring of corridor use is crucial, particularly with the recent reintroduction of Tigers, to support the long-term conservation of these apex predators and Elephants in the region.

The findings from this study offer broader conservation implications for wildlife corridors in other parts of the TAL and similarly fragmented habitats across India. The observed shifts in wildlife activity patterns and the influence of human presence highlight the urgent need for integrated infrastructure planning including road and rail barriers in preserving corridor functionality. These results can inform national-level policy on corridor identification, underpass design, and mitigation strategies, especially under frameworks such as India's Wildlife Action Plan (2017–2031), which prioritises connectivity conservation (MOECCF 2017). Furthermore, the study underscores the importance of long-term monitoring, offering a replicable approach for assessing corridor functionality in other Tiger and elephant landscapes.

REFERENCE

Benítez-López, A., R. Alkemade & P. Verweij (2010). The impacts of roads and other infrastructure on mammal and bird populations: a meta-analysis. *Biological Conservation* 143: 1307–1316. https://doi.org/10.1016/J.BIOCON.2010.02.009

Burkart, S., F. Gugerli, J. Senn, R. Kuehn & J. Bolliger (2016). Evaluating the functionality of expert-assessed wildlife corridors with genetic data from roe deer. *Basic and Applied Ecology* 17(1): 52–60. https://doi.org/10.1016/j.baae.2015.09.001

Callens, T., P. Galbusera, E. Matthysen, E.Y. Durand, M. Githiru, J.R. Huyghe & L. Lens (2011). Genetic signature of population fragmentation varies with mobility in seven bird species of a fragmented Kenyan cloud forest. *Molecular Ecology* 20: 1829–1844. https://doi.org/10.1111/j.1365-294X.2011.05028.x

Carvalho, F., S. Santos, A. Mira & R. Lourenço (2017). Methods to Monitor and Mitigate Wildlife Mortality in Railways, pp. 23–42. In: Borda-de-Água, L., R. Barrientos, P. Beja & H. Pereira (eds.). *Railway Ecology*. Springer, Cham, xxx + 320 pp. https://doi.org/10.1007/978-3-319-57496-7_3

Chakraborty, P., J. Borah, P. Bora, P., S. Dey, T. Sharma & S. Rongphar (2021). Camera trap based monitoring of a key wildlife corridor reveals opportunities and challenges for large mammal conservation in Assam, India. *Tropical Ecology* 62: 186–196. https://doi.org/10.1007/s42965-020-00138-x

Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India.* Manager of publications, 404 pp.

Dahya, M.N., R. Chaudhary, A. Shah & A. Kazi (2023). Assemblage, relative abundance and activity pattern of wild mammals in the human-dominated landscape of Vansda Taluka, Gujarat, India. *Mammalia* 87(5): 434–441. https://doi.org/10.1515/mammalia-2022-0130.

Dutta, T., S. Sharma & R. DeFries (2018). Targeting restoration sites to improve connectivity in a tiger conservation landscape in India. *PeerJ* 6: e5587. https://doi.org/10.7717/peerj.5587

Gilhooly, P., S. Nielsen, J. Whittington & C. St. Clair (2019). Wildlife mortality on roads and railways following highway mitigation. *Ecosphere* 10(2): e02597. https://doi.org/10.1002/ECS2.2597

Haddad, N., L.A. Brudvig, J. Clobert, K.F. Davies, A. Gonzalez, R.D. Holt, T.E. Lovejoy, J.O. Sexton, M.P. Austin, C.D. Collins, W.M. Cook, E.I. Damschen, R.M. Ewers, B.L. Foster, C.N. Jenkins, A.J. King, W.F. Laurance, D.J. Levey, C.R. Margules, B.A. Melbourne, A.O. Nicholls, J.L. Orrock, D. Song & J.R. Townshend (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances* 1: e1500052. https://doi.org/10.1126/sciadv.1500052

Harihar, A. & B. Pandav (2012). Influence of connectivity, wild prey and disturbance on occupancy of tigers in the human-dominated western Terai Arc landscape. *PLoS ONE* 7(7): e40105. https://doi.org/10.1371/journal.pone.0040105

Holderegger, R. & M. Di Giulio (2010). The genetic effects of roads: a review of empirical evidence. *Basic and Applied Ecology* 11(6): 522–531. https://doi.org/10.1016/j.baae.2010.06.006

Jhala, Y.V., Q. Qureshi & R. Gopal (2015). *Status of Tigers in India, 2014*. National Tiger Conservation Authority and Wildlife Institute of India, Dehradun, India, 460 pp.

Johnsingh, A.J.T., K. Ramesh, Q. Qureshi, A. David, S.P. Goyal, G.S. Rawat, K. Rajapandian & S. Prasad (2004). *Conservation Status of Tiger and Associated Species in the Terai Arc Landscape, India*. Wildlife Institute of India, Dehradun, India, viii + 110 pp.

Katlam, G., S. Prasad, M. Aggarwal & R. Kumar (2018). Trash on the menu. *Current Science* 115(12): 2322–2326.

Kumar, K.A., Q. Qureshi & Y.V. Jhala (2023). Impact of human activities on wild ungulates in Nagarjunsagar Srisailam Tiger Reserve, Andhra Pradesh, India. *Journal of Threatened Taxa* 15(5): 23147–23163. https://doi.org/10.11609/jott.8145.15.5.23147-23163

Laurance, W.F., G.R. Clements, S. Sloan, C.S. O'Connell, N.D. Mueller, M. Goosem, O. Venter, D.P. Edwards, B. Phalan, A. Balmford & A. van Der Ree (2014). A global strategy for road building. *Nature* 513(7517): 229–232. https://doi.org/10.1038/nature13717

Ministry of Environment, Forest and Climate Change (MOEFCC) (2017). India's National Wildlife Action Plan (2017–2031). Government of India. https://ntca.gov.in/assets/uploads/Reports/Others/Wildlife_Action_Plan_2017_31.pdf Downloaded on 22 March 2025.

Napolitano, S., D. Díaz, J. Sanderson, W.E. Johnson, K. Ritland, C.E. Ritland & E. Poulin (2015). Reduced genetic diversity and increased dispersal in Guigna *Leopardus guigna* in Chilean Fragmented landscapes. *Journal of Heredity* 106(S1): 522–536. https://doi.org/10.1093/jhered/esv025

Niedballa, J., R. Sollmann, A. Courtiol & A. Wilting (2016). camtrapR: an R package for efficient camera trap data management. *Methods in Ecology and Evolution* 7(12): 1457–1462. https://doi.org/10.1111/2041-210X.12600

Nigam, P., S. Mondol, B. Habib, N. Lakshminarayanan & J. Das (2022). *Quantitative Assessment of Animal Movement Through Newly*

Commissioned Wildlife Underpasses at the Chilla-Motichur and Kansrao-Barkot Corridors in the Rajaji Landscape, Uttarakhand. Wildlife Institute of India-Uttarakhand Forest Department, Dehradun, India, 30 pp.

Olson, D.M. & E. Dinerstein (1998). The Global 200: A representation approach to conserving the earth's most biologically valuable ecoregions. *Conservation Biology* 12(3): 502–515.

O'Brien, T.G. (2011). Abundance, Density, and Relative Abundance: A Conceptual Framework, pp. 71–96. In: O'Connell, A.F., J.D. Nichols & K.U. Karanth (eds.). *Camera Traps in Animal Ecology: Methods and Analyses*. Springer, New York, 271 pp.

Oro, D., M. Genovart, G. Tavecchia, M.S. Fowler & A. Martínez-Abraín (2013). Ecological and evolutionary implications of food subsidies from humans. *Ecology Letters* 16(12): 1501–1514.

Palei, H., T. Pradhan, H. Sahu & A. Nayak (2021). Diet and activity pattern of leopard in relation to prey in tropical forest ecosystems. *Mammalia* 88(1): 1–16. https://doi.org/10.1515/mammalia-2021-0003.

Rajawat, R., & S. Chandra (2020). Activity Pattern of Chital (*Axis axis*) in Mukandra Hills Tiger Reserve, India. *International Journal of Ecology and Environmental Sciences* 46: 173–176.

Ridout, M.S. & M. Linkie (2009). Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological, and Environmental Statistics* 14: 322–337. https://doi.org/10.1198/jabes.2009.08038

R Core Team (2024). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Times of India (2024). Fourth Tiger to be Translocated from Corbett to Rajaji Reserve. https://timesofindia.indiatimes.com/city/dehradun/fourth-tiger-to-be-translocated-from-corbett-to-rajaji-reserve-dehradun/articleshow/108417305.cms. Accessed on 04 January 2025.

van der Ree, R., J.A. Jaeger, E.A. van der Grift & A.P. Clevenger (2015). Effects of roads and traffic on wildlife populations and landscape function: Road ecology is moving toward larger scales. *Ecology and Society* 20(2): 1–15.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26789–26802

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9432.17.4.26789-26802

#9432 | Received 20 September 2024 | Final received 07 April 2025 | Finally accepted 11 April 2025

ARTICLE

Avifaunal diversity and conservation status of waterbirds in Pillaimadam Lagoon, Palk Bay, India

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Abstract: Avifaunal surveys are important for developing targeted conservation strategies for specific sites and species, especially in undocumented critical wintering grounds for shorebirds within the Central Asian Flyway. In this context, we present a first-time avifaunal checklist at the Pillaimadam Lagoon, Ramanathapuram District, Tamil Nadu. A total of 108 species of birds belonging to 43 families under 16 orders were recorded. Order Charadriiformes was the most prevalent (34 species), followed by Passeriformes (28 species), and Pelecaniformes (15 species). Family-wise, the highest species richness was recorded for Scolopacidae and Laridae (11 species each). Winter visitors accounted for 33.3% (36 species), with other categories including Resident (51 species), Resident/Non-Breeding (17 species), Local Migrant (3 species), and one Passage Migrant—Rosy Starling *Pastor roseus*. The lagoon harbours five 'Near Threatened', two 'Vulnerable', one 'Endangered' (Siberian Sand Plover *Charadrius mongolus*), and one unassessed species (Hanuman Plover *Charadrius seebohmi*) as per the IUCN Red List of Threatened Species, and 35 species enlisted in Appendix II of the Convention of the Conservation of Migratory Species of Wild Animals (CMS), emphasizing the need for conserving this coastal wetland as a 'protected area.' Hence, the current baseline data on avifaunal diversity is the first comprehensive bird list from Pillaimadam Lagoon.

Keywords: Central Asian Flyway, Gulf of Mannar, habitat, lagoon, protected area, shorebirds, waterbirds, wetland, winter visitors

Editor: Anil Kumar, Zoological Survey of India, Patna, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Byju, H., H. Maitreyi, N. Raveendran, S. Ravichandran & R. Vijayan (2025). Avifaunal diversity and conservation status of waterbirds in Pillaimadam Lagoon, Palk Bay, India. *Journal of Threatened Taxa* 17(4): 26789–26802. https://doi.org/10.11609/jott.9432.17.4.26789-26802

Funding: None.

Competing interests: The authors declare no competing interests.

Author details: Byju H, has worked on the shorebirds and waterbirds in the Gulf of Mannar region for the past decade and presently a member of the biodiversity panel of five bird sanctuaries, including three Ramsar sites in the district and the Gulf of Mannar Biosphere Reserve. Maitreyi H is a PhD scholar working on seabirds in the region. Raveendran N is a naturalist with a decade of experience in birds and awareness education, and serves as a biodiversity member in the bird sanctuaries and the Gulf of Mannar Biosphere Reserve. Ravichandran S is a professor with three decades of experience in marine ecology. Reshmi Vijayan is an associate professor working on birds and marine systems.

Author contributions: BH—conceptualisation, design of work, writing, and editing; MH—data curation, analysis, mapping, and writing; RN—data compilation, writing; SR—writing and editing; RV—writing.

Acknowledgements: We thank all our birding volunteers for several trips over the years for the bird monitoring activities. We are grateful to Kishore A C for helping with the map. Special thanks to Vidhya and Dharshini from the Lady Doak College Madurai and Priya Rajendran for their support in fieldwork. We are also grateful to the support of the forest department staff from the Mandapam range and the Gulf of Mannar Wildlife Division, including all the wardens, for their continuous support, active involvement, and guidance during several phases of the work. We also remember the contributions of a few local community members and the children who accompanied us several times.

Iragukal Amritha Nature Trust

INTRODUCTION

The study of avifaunal distribution is pivotal in understanding the ecological health of an area (Llanos et al. 2011; Fraixedas et al. 2020; Byju et al. 2024a), as birds serve as excellent bioindicators (Sekercioglu 2012; Egwumah et al. 2017) due to their sensitivity to environmental changes (Callaghan et al. 2019; Piersma & Lindstrom 2024) especially in diverse coastal environments (Jayanthi et al. 2021; Rashiba et al. 2022). Avifauna, encompassing all bird species within a particular region, provides critical insights into the broader ecological dynamics (Kati & Sekercioglu 2006; Byju et al. 2023a), including habitat quality (Naujokaitis-Lewis et al. 2009), food availability, and the impact of anthropogenic activities (Todd et al. 2016). Since global environment changes, such as habitat loss, and climate change, continue to accelerate, there is an increasing need to document and analyze the distribution patterns of bird species to initiate conservation strategies (Gadgil 1996; Gaston 2000; Byju et al. 2023b). Birds occupy varied ecological niches, making their distribution patterns reflective of the health of different ecosystems (Kazmierczak 2006; Grimmett et al. 2011). Changes in bird distribution can reveal changes in habitat conditions and biodiversity over the time (Kattan & Franco 2004; Hasuia et al. 2024). Understanding the patterns is particularly important in regions undergoing environmental changes (Huang et al. 2023; Byju et al. 2024b), as they can help prioritize conservation efforts and guide habitat management practices (Newton 2004; Paul & Cooper 2005).

Avifaunal distribution is influenced by habitat structure, food availability, predation pressure, and interspecific competition among the primary biotic factors, while climate, topography, water depth, salinity, and tidal patterns constitute important abiotic factors (Cody 1985; Day et al. 2012). Human activities, including urbanization, deforestation, and agricultural expansion, which often lead to habitat fragmentation and degradation, also have significant impact (Ma et al. 2023). In addition to these factors, broader climatic patterns, such as temperature and precipitation, play a crucial role in determining the geographical range of bird species (Thomas & Lennon 1999). Coastal lagoons are not an exception to these environmental changes and anthropogenic pressures (Kennish & Paerl 2010). Coastal lagoons are important for migratory waterbirds in their long inter-continental journeys (Alfaro & Clara 2007; Miotto et al. 2023) and are vital feeding, breeding, and resting grounds for numerous other bird species (Chandana et al. 2012; Silva et al. 2013). Coastal lagoon like Pillaimadam is one of such vital habitats and is also an important breeding site for the newly discovered taxa Hanuman Plover *Charadrius seebohmi* (Byju et al. 2023e). It is essential to monitor and study these ecosystems to formulate effective conservation strategies.

On the southeastern coast of India, the Ramanathapuram District of Tamil Nadu has five bird sanctuaries, including three Ramsar sites (Kanjirankulam Bird Sanctuary, Therthangal Bird Sanctuary and Chitrangudi Bird Sanctuary) and the Gulf of Mannar Biosphere Reserve (GoM) (Byju et al. 2023c). Recent studies from the area have been highlighted on the coastal regional avifauna from Valinokkam Lagoon (Byju et al. 2023b), 21 islands of GoM (Byju et al. 2023c) and Karangadu mangroves (Byju et al. 2023d). Pillaimadam Lagoon on Palk Bay is an unexplored area in terms of avifauna. Hence, the present study aimed to create comprehensive data on the avifauna with a focus on diversity, migratory status, and national and global conservation issues. This will assist the forest department in future for the conservation and management of the lagoon and upgrading it to a protected status.

MATERIALS AND METHODS

Study Area

The Pillaimadam Lagoon (9.282º N & 79.108º E) is situated in the Palk Bay region, a shallow marine region between India and Sri Lanka. The bottom of the lagoon is mostly muddy. The lagoon is bordered by grass on the landward area, invasive *Neltuma juliflora* and palm *Borassus flabellifer* trees, which provide a habitat for numerous land birds with sand dunes on the seaward side (Figure 1). The salinity fluctuates significantly between the monsoon and summer season. Rainwater from surrounding areas is emptied into the lagoon during the monsoon, and in the summer, it is cut off from the sea. The maximum salinity is 25 parts per thousand (ppt) in rainy seasons, and salt formations occur during summer as small fresh-water puddles are formed along the border of the lagoon during the monsoon (Balachandran 1990) which supports the breeding activities of a few waterbirds. Fishing activities are found only during a few months when the water is abundant. The presence of halophytes like *Arthocnemum macrostachyum* and the occasional presence of *Saueda* sp. is seen on the edges of the lagoons.

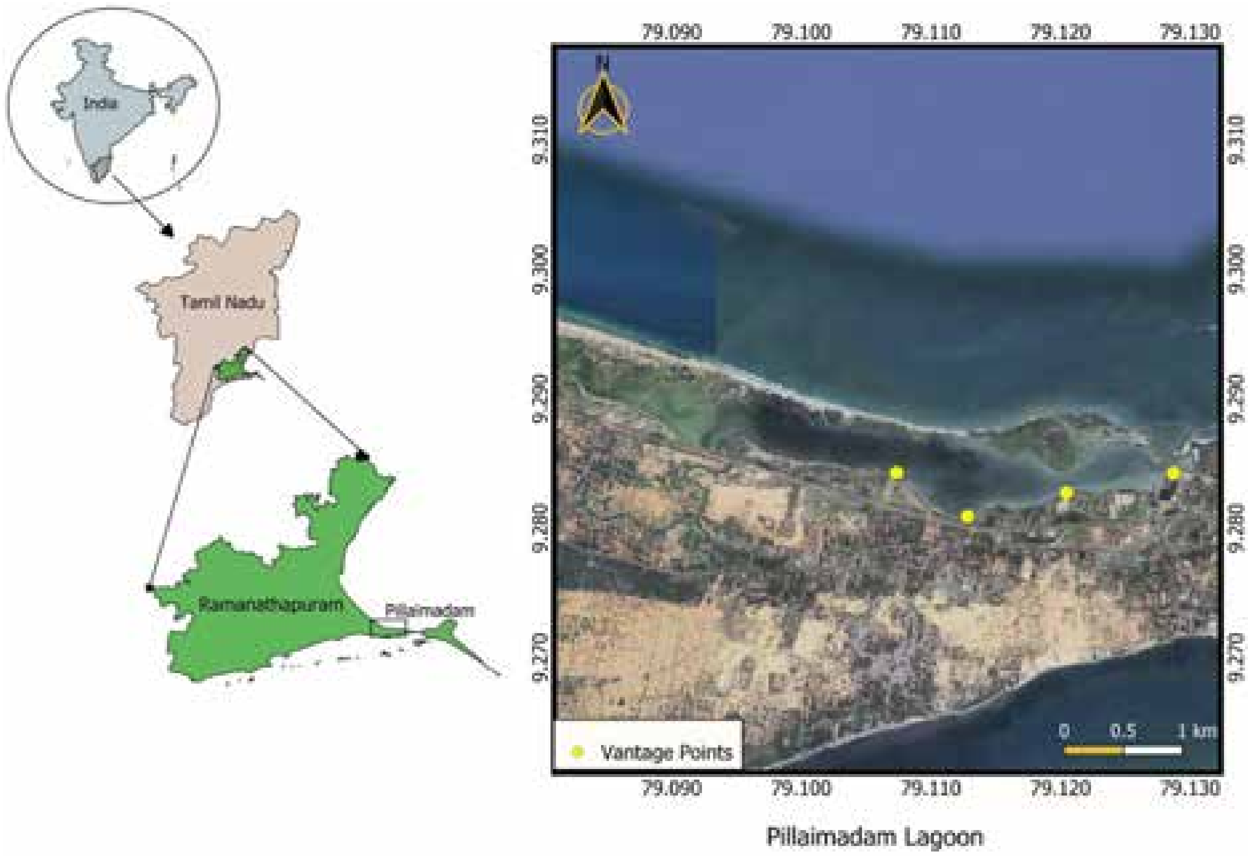

Figure 1. Pillaimadam Lagoon with scanning points.

Bird surveys and data analysis

Bird surveys were done once a month between August 2021 and July 2022 in all regional seasons – summer, pre-monsoon, monsoon, and post-monsoon to establish an avifaunal checklist. Surveys were conducted during low tides during the monsoon time for shorebirds, as in other seasons the sea mouth was closed to the lagoon, during the peak hours of their activity, from 0600–1000 h and 1600–1800 h. We followed both block count and direct visual count methods (Howes & Bakewell 1989; Bibby et al. 2000). In this method, four scanning points were used as points of count (Figure 1), birds in the blocks were observed using field binoculars (10 × 50) and spotting scopes (Vanguard 14*70) and photographed with a digital camera with 100–400 mm telephoto lens, and species not identified in the field were later identified with the help of field guides (Grimmett et al. 2011; Hayman et al. 2011). After arriving at each scanning point, the bird counts for the waterbirds started after five minutes, for birds to get acclimatized to the human presence. The observations recorded while moving from one scanning point to another were entered as incidental records. The data analysis was done using MS Excel 2019.

1. Migratory Status: The residential status of the birds is grouped under different categories like Resident (R), Resident/Not Breeding (R/NB), Passage Migrant (PM), and Winter Visitor (WV) depending on their timing and duration of occurrence (Grimmett et al. 2011).

2. Relative abundance: Based on the frequency of bird sightings the relative abundance of birds is documented as common (C) seven to nine times; uncommon (UC) three to six times; and rare (Ra) once or twice (MacKinnon & Phillipps 1993).

3. Relative Diversity: Relative diversity (RDi) was calculated to represent the percentage of total species within a family to the total number of species. It was calculated using the following formula (Koli 2014).

RDi = Number of species in a family / Total number of species × 100

4. IUCN status: IUCN Red List focus includes species classified as 'Least Concern' (LC), 'Near Threatened' (NT), 'Vulnerable' (VU), and 'Endangered' (EN) highlighting their conservation importance in Pillaimadam Lagoon. The common name, scientific name, IUCN Red List status, and migratory status are followed (Praveen & Jayapal 2023).

5. SOIB population trends: We considered the State of India's Bird (SOIB) report to analyze the current population trend of the bird species in India from the Pillaimadam Lagoon. The current trend corresponds to the average annual change in species abundance over the past eight years (2015–2022). According to SOIB, different categories of population trend indices are, Insufficient Data which means too few reports, Trend Inconclusive means 95% confidence interval >2%, Rapid Decline is decline >2.7%, Decline is >1.1%, Increase is >0.9%, and Rapid Increase is >1.6% (State of India's Bird 2023).

6. CMS status: We analyzed the conservation priority species based on the Convention for the Conservation of Migratory Species of Wild Animals (CMS). The avifaunal species listed in Appendix II of CMS correspond to migratory species that need international cooperation and international agreements for conservation and management (CMS 2024).

RESULTS

A total of 108 species of birds belonging to 43 families under 16 orders were recorded from the Pillaimadam Lagoon (Table 1). Order-wise, Charadriiformes were the most predominant (34 species in five families), followed by Passeriformes (28 species in 17 families), and Pelecaniformes (15 species in six families). In contrast, the orders Pheonicopteriformes, Caprimulgiformes, Gruiformes, Bucerotiformes, Strigiformes, Piciformes, and Psittaciformes were each represented by a single species (Figure 2). Families Scolopacidae and Laridae had 11 representative species each; followed by Charadriidae with nine species and Ardeidae with seven. Anatidae with three species was followed by Ciconiidae, Threskiornithidae, Phalacrocoracidae, and Burhinidae representing two species each, and Phoenicopteridae, Rallidae, Pelicanidae, Anhingidae, and Recurvirostridae with one species each (Table 1).

Migratory status

The residential status of the birds indicated that Winter Visitors (WV) constituted 33.3% (36 species) of the observed species (Figure 3). All the species recorded from Scolopacidae and Laridae are Winter Visitors (11 species each) and Charadriidae has seven Winter visitors and two Residents, i.e., Hanuman Plover *Charadrius seebohmi* and Red-wattled Lapwing *Vanellus indicus*. Resident species were the most dominant (51 species), followed by Resident/Not Breeding (17 species), three Local Migrants (LM) Western Reef Heron *Egretta gularis*, Oriental Honey Buzzard *Pernis ptilorhynchus* and White-bellied Sea Eagle *Haliaeetus leucogaster* and

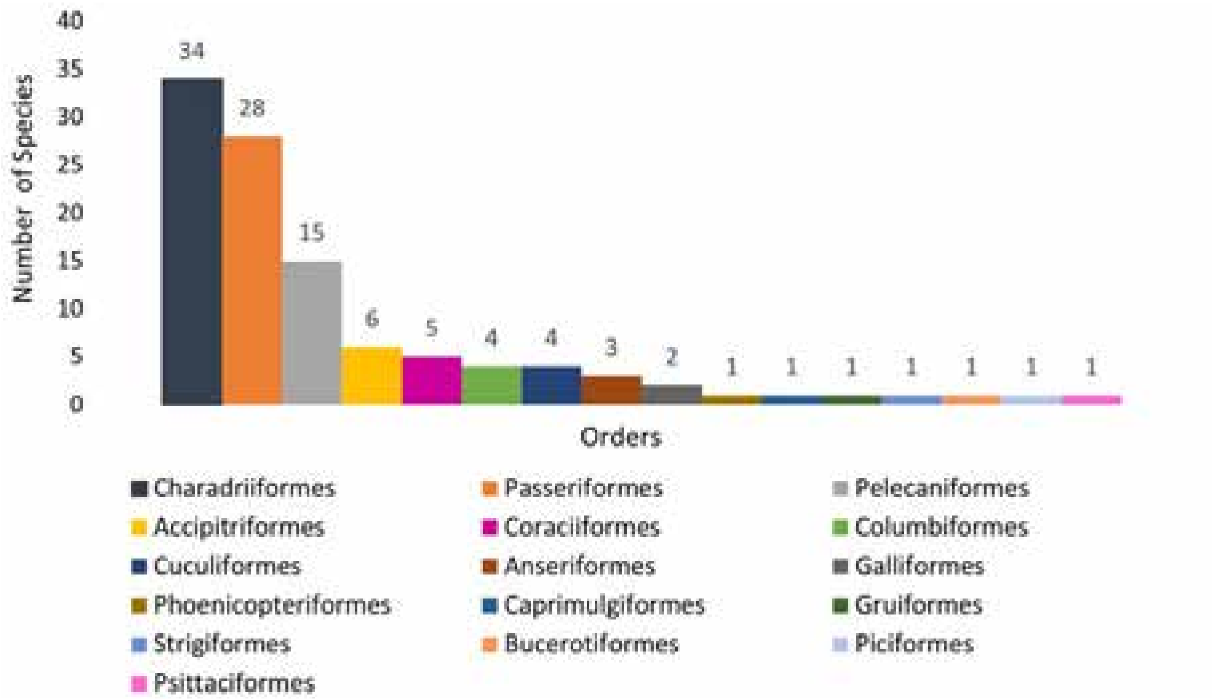

Figure 2. Order-wise graph representing the number of species in each order.

Table 1. Avifaunal checklist of Pillaimadam Lagoon.

Order/Family/Common name	Scientific name	IUCN Red List status	Population trends in India (SOIB 2023)	Resident status	Relative abundance	CMS status
Anseriformes						
Anatidae						
Garganey	*Spatula querquedula*	LC	Rapid decline	WV	Ra	Appendix II
Northern Shoveler	*Spatula clypeata*	LC	Rapid decline	WV	Ra	Appendix II
Northern Pintail	*Anas acuta*	LC	Rapid decline	WV	Ra	Appendix II
Phoenicopteriformes						
Phoenicopteridae						
Greater Flamingo	*Phoenicopterus roseus*	LC	Rapid decline	R/NB	UC	Appendix II
Columbiformes						
Columbidae						
Rock Pigeon	*Columba livia*	LC	Increase	R	C	—
Spotted Dove	*Spilopelia chinensis*	LC	Increase	R	C	—
Laughing Dove	*Spilopelia senegalensis*	LC	Trend inconclusive	R	C	—
Eurasian Collared Dove	*Streptopelia decaocto*	LC	Increase	R	C	—
Caprimulgiformes						
Apodidae						
Asian Palm Swift	*Cypsiurus balasiensis*	LC	Insufficient data	R	C	—
Cuculiformes						
Cuculidae						
Asian Koel	*Eudynamys scolopaceus*	LC	Increase	R	C	—
Greater Coucal	*Centropus sinensis*	LC	Rapid increase	R	C	—
Blue-faced Malkoha	*Phaenicophaeus viridirostris*	LC	Stable	R	C	—
Jacobin Cuckoo	*Clamator jacobinus*	LC	Stable	R/NB	C	—
Gruiformes						
Rallidae						
White-breasted Waterhen	*Amarurornis phoenicurus*	LC	Trend inconclusive	R/NB	C	—
Galliformes						
Phasianidae						
Grey Francolin	*Ortygornis pondicerianus*	LC	Increase	R	C	—
Indian Peafowl	*Pavo cristatus*	LC	Rapid increase	R	C	—
Pelecaniformes						
Ciconiidae						
Asian Openbill	*Anastomus oscitans*	LC	Trend inconclusive	R/NB	C	—
Painted Stork	*Mycteria leucocephala*	LC	Decline	R/NB	C	—
Pelecanidae						
Spot-billed Pelican	*Pelecanus philippensis*	NT	Rapid decline	R/NB	C	—
Ardeidae						
Cattle Egret	*Bubulcus ibis*	LC	Stable	R/NB	C	—
Grey Heron	*Ardea cinerea*	LC	Trend inconclusive	R/NB	C	—
Indian Pond Heron	*Ardeola grayii*	LC	Stable	R/NB	C	—
Intermediate Egret	*Ardea intermedia*	LC	Trend inconclusive	R/NB	C	—
Great Egret	*Ardea alba*	LC	Trend inconclusive	R/NB	C	Appendix II
Little Egret	*Egretta garzetta*	LC	Trend inconclusive	R/NB	C	—

Order/Family/Common name	Scientific name	IUCN Red List status	Population trends in India (SOIB 2023)	Resident status	Relative abundance	CMS status
Western Reef Heron	*Egretta gularis*	LC	Decline	LM	UC	—
Threskiornithidae						
Black-headed Ibis	*Threskiornis melanocephalus*	LC	Stable	R/NB	UC	—
Glossy Ibis	*Plegadis falcinellus*	LC	Stable	R/NB	UC	Appendix II
Phalacrocoracidae						
Indian Cormorant	*Phalacrocorax fuscicollis*	LC	Trend inconclusive	R/NB	C	—
Little Cormorant	*Phalacrocorax niger*	LC	Stable	R/NB	C	—
Anhingidae						
Oriental Darter	*Anhinga melanogaster*	LC	Stable	R/NB	UC	—
Charadriiformes						
Recurvirostridae						
Black-winged Stilt	*Himantopus himantopus*	LC	Trend inconclusive	R	C	Appendix II
Burhinidae						
Indian Thick-knee	*Burhinus indicus*	LC	Insufficient data	R	C	—
Great Thick-knee	*Esacus recurvirostris*	NT	Rapid decline	R	UC	—
Charadriidae						
Black-bellied Plover	*Pluvialis squatarola*	VU	Decline	WV	C	Appendix II
Pacific Golden Plover	*Pluvialis fulva*	LC	Stable	WV	Ra	—
Siberian Sand Plover	*Charadrius mongolus*	EN	Decline	WV	C	Appendix II
Greater Sand Plover	*Charadrius leschenaultii*	LC	Data Not available	WV	C	Appendix II
Kentish Plover	*Charadrius alexandrinus*	LC	Rapid decline	WV	C	Appendix II
Common Ringed Plover	*Charadrius hiaticula*	LC	Data Not available	WV	UC	Appendix II
Hanuman Plover	*Charadrius seebohmi*	NA	Data not available	R	C	
Little Ringed Plover	*Charadrius dubius*	LC	Rapid decline	WV	C	—
Red-wattled Lapwing	*Vanellus indicus*	LC	Trend inconclusive	R	C	—
Scolopacidae						
Whimbrel	*Numenius phaeopus*	LC	Trend inconclusive	WV	C	Appendix II
Eurasian Curlew	*Numenius arquata*	NT	Rapid decline	WV	C	Appendix II
Little Stint	*Calidris minuta*	LC	Rapid decline	WV	C	Appendix II
Curlew Sandpiper	*Calidris ferruginea*	VU	Decline	WV	C	Appendix II
Common Sandpiper	*Actitis hypoleucos*	LC	Decline	WV	UC	Appendix II
Ruddy Turnstone	*Arenaria interpres*	NT	Rapid decline	WV	C	Appendix II
Marsh Sandpiper	*Tringa stagnatilis*	LC	Rapid decline	WV	UC	Appendix II
Wood Sandpiper	*Tringa glareola*	LC	Decline	WV	UC	Appendix II
Common Greenshank	*Tringa nebularia*	LC	Rapid decline	WV	C	Appendix II
Common Redshank	*Tringa totanus*	LC	Decline	WV	C	Appendix II
Bar-tailed Godwit	*Limosa lapponica*	NT	Trend inconclusive	WV	UC	Appendix II
Laridae						
Slender-billed Gull	*Chroicocephalus genei*	LC	Rapid decline	WV	UC	Appendix II
Black-headed Gull	*Chroicocephalus ridibundus*	LC	Decline	WV	C	—
Brown-headed Gull	*Chroicocephalus brunnicephalus*	LC	Decline	WV	C	—
Lesser Black-backed Gull	*Larus fuscus*	LC	Stable	WV	UC	—
Greater Black-headed Gull	*Ichthyaetus ichthyaetus*	LC	Decline	WV	UC	Appendix II
Little Tern	*Sternula albifrons*	LC	Decline	WV	UC	Appendix II

Order/Family/Common name	Scientific name	IUCN Red List status	Population trends in India (SOIB 2023)	Resident status	Relative abundance	CMS status
Caspian Tern	*Hydroprogne caspia*	LC	Decline	WV	C	Appendix II
Greater Crested Tern	*Thalasseus bergii*	LC	Trend inconclusive	WV	C	Appendix II
Lesser Crested Tern	*Thalasseus bengalensis*	LC	Stable	WV	C	Appendix II
Gull-billed Tern	*Gelochelidon nilotica*	LC	Rapid decline	WV	Ra	Appendix II
Whiskered Tern	*Chlidonias hybrida*	LC	Rapid decline	WV	Ra	—
Accipitriformes						
Accipitridae						
Booted Eagle	*Hieraaetus pennatus*	LC	Trend inconclusive	WV	UC	Appendix II
Black Kite	*Milvus migrans*	LC	Trend inconclusive	R	C	Appendix II
Brahminy Kite	*Haliastur indus*	LC	Stable	R	C	—
Shikra	*Accipiter badius*	LC	Stable	R	C	Appendix II
Oriental Honey-buzzard	*Pernis ptilorhynchus*	LC	Stable	LM	UC	Appendix II
White-bellied Sea Eagle	*Haliaeetus leucogaster*	LC	Stable	LM	C	—
Strigiformes						
Strigidae						
Spotted Owlet	*Athene brama*	LC	Data not available	R	C	—
Bucerotiformes						
Upupidae						
Common Hoopoe	*Upupa epops*	LC	Trend inconclusive	R	C	—
Piciformes						
Picidae						
Black-rumped Flameback	*Dinopium benghalense*	LC	Trend inconclusive	R	C	—
Coraciiformes						
Meropidae						
Blue-tailed Bee-eater	*Merops philippinus*	LC	Rapid increase	R	C	—
Green Bee-eater	*Merops orientalis*	LC	Stable	R	C	—
Coraciidae						
Indian Roller	*Coracias benghalensis*	LC	Decline	R	C	—
Alcedinidae						
Pied Kingfisher	*Ceryle rudis*	LC	Decline	R	C	—
White-throated Kingfisher	*Halcyon smymensis*	LC	Trend inconclusive	R	C	—
Psittaciformes						
Psittacidae						
Rose-ringed Parakeet	*Psittacula krameri*	LC	Trend inconclusive	R	C	—
Passeriformes						
Artamidae						
Ashy Wood Swallow	*Artamus fuscus*	LC	Stable	R	C	—
Dicruridae						
Black Drongo	*Dicrurus macrocercus*	LC	Stable	R	C	—
Laniidae						
Brown Shrike	*Lanius cristatus*	LC	Stable	WV	UC	—
Corvidae						
House Crow	*Corvus splendens*	LC	Trend inconclusive	R	C	—
Large-billed Crow	*Corvus macrorhynchos*	LC	Stable	R	C	—
Rufous Treepie	*Dendrocitta vagabunda*	LC	Stable	R	C	—

Order/Family/Common name	Scientific name	IUCN Red List status	Population trends in India (SOIB 2023)	Resident status	Relative abundance	CMS status
Monarchidae						
Indian Paradise-flycatcher	*Tersiphone paradisi*	LC	Stable	R	UC	—
Nectariniidae						
Purple-rumped Sunbird	*Leptocoma zeylonica*	LC	Trend inconclusive	R	C	—
Purple Sunbird	*Cinnyris asiaticus*	LC	Trend inconclusive	R	C	—
Estrildidae						
Indian Silverbill	*Euodice malabarica*	LC	Trend inconclusive	R	C	—
Passeridae						
House Sparrow	*Passer domesticus*	LC	Decline	R	C	—
Motacillidae						
Paddy Field Pipit	*Anthus rufulus*	LC	Decline	R	C	—
White-browed Wagtail	*Motacilla maderaspatensis*	LC	Stable	R	C	—
Aegithinidae						
Common Iora	*Aegithina tiphia*	LC	Increase	R	Ra	—
Alaudidae						
Ashy Crowned Sparrow Lark	*Eremopterix griseus*	LC	Trend inconclusive	R	C	—
Jerdons Bushlark	*Mirafra affinis*	LC	Stable	R	C	—
Oriental Skylark	*Alauda gulgula*	LC	Rapid decline	R	C	—
Cisticolidae						
Common Tailorbird	*Orthotomus sutorius*	LC	Rapid increase	R	C	—
Ashy Prinia	*Prinia socialis*	LC	Increase	R	C	—
Leiotrichidae						
Yellow-billed Babbler	*Argya affinis*	LC	Stable	R	C	—
Acrocephalidae						
Blyth's Reed Warbler	*Acrocephalus dumetorum*	LC	Stable	WV	UC	—
Hirundinidae						
Barn Swallow	*Hirundo rustica*	LC	Decline	WV	Ra	—
Red-rumped Swallow	*Cecropis daurica*	LC	Stable	R	UC	—
Pycnonotidae						
Red-vented Bulbul	*Pycnonotus cafer*	LC	Trend inconclusive	R	C	—
White-browed Bulbul	*Pycnonotus luteolus*	LC	Rapid increase	R	UC	—
Sturnidae						
Brahminy Starling	*Sturnus pagodarum*	LC	Trend inconclusive	R	UC	—
Common Myna	*Acridotheres tristis*	LC	Stable	R	C	—
Rosy Starling	*Pastor roseus*	LC	Rapid decline	PM	UC	—

IUCN Red List status: LC—Least Concern | NT—Near Threatened | VU—Vulnerable | EN—Endangered | NA—Not assessed | Resident status: WV—Winter Visitor | LM—Local Migrant | R—Resident | R/NB—Resident/Non-Breeding | Relative abundance: C—Common | UC—Uncommon | Ra—Rare.

one Passage Migrant (PM) Rosy Starling *Pastor roseus.* The breeding shorebirds in the lagoon include Black-winged Stilt *Himantopus himantopus*, Indian Thick-knee *Burhinus indicus*, Great Thick-knee *Esacus recurvirostris*, regional endemic Hanuman Plover, and Red-wattled Lapwing (Table 1).

Relative abundance

The relative abundance indicated that 76 species were common (C), 24 were uncommon (UC), and eight were rare (Ra). The rare species include ducks like Garganey *Spatula querquedula*, Northern Shoveler *Spatula clypeata*, and Northern Pintail *Anas acuta*; shorebirds like Pacific Golden Plover *Pluvialis fulva;*

Image 1. Greater Flamingo *Phoenicopterus roseus*, an uncommon visitor to the site.

terns like Gull-billed Tern *Gelochelidon nilotica* and Whiskered Tern *Chlidonias hybrida*, and land birds namely, Common Iora *Aegithina tiphia* and Barn Swallow *Hirundo rustica*. The Uncommon ones were waterbirds like Greater Flamingo *Phoenicopterus roseus* (Image 1), Western Reef Heron, Black-headed Ibis *Threskiornis melanocephalus*, Glossy Ibis *Plegadis falcinellus*, Oriental Darter *Anhinga melanogaster*, Great Thick-knee, Common Ringed Plover *Charadrius hiaticula,* Common Sandpiper *Actitis hypoleucos*, Marsh Sandpiper *Tringa stagnatilis*, Common Greenshank *Tringa nebularia*, Bar-tailed Godwit *Limosa lapponica*, Slender-billed Gull *Chroicocephalus genei*, Lesser Black-backed Gull *Larus fuscus*, Greater Black-backed Gull *Ichthyaetus ichthyaetus* and Little Tern *Sternula albifrons* and land birds like Booted Eagle *Hieraaetus pennatus*, Oriental Honey Buzzard, Brown Shrike *Lanius cristatus*, Indian Paradise Flycatcher *Tersiphone paradisi*, Red-rumped Swallow *Cecropis daurica*, White-browed Bulbul *Pycnonotus luteolus*, Brahminy Starling *Sturnus pagodarum* and Rosy Starling (Table 1).

Relative Diversity (RDi)

Relative diversity index shows that families, i.e., Scolopacidae and Laridae dominate the landscape (10.2% and 11 species each), followed by Charadriidae (8.3% with 9 species), Ardeidae (6.5% with 7 species), and Accipitridae (5.6% with 6 species); Columbidae and Cuculidae (3.7% and 4 species each); Anatidae, Corvidae, Alaudidae, and Sturnidae (2.78% with 3 species each); Phasianidae, Ciconiidae, Threskiornithidae, Phalacrocoracidae, Burhinidae, Meropidae, Alcedinidae, Nectariniidae, Motacillidae, Cisticolidae, Hirundinidae, and Pycnonotidae (1.81 % and 2 species each); remaining 20 families constitute 0.93% and one species each (Table 2).

IUCN Red List Status

The site supported five 'Near Threatened' species which include four shorebirds and one waterbird: Bar-tailed Godwit*,* Eurasian Curlew *Numenius arquata,* Great Thick-knee, Ruddy Turnstone *Arenaria interpres* and Spot-billed Pelican *Pelecanus philippensis.* Two 'Vulnerable' species, Black-bellied Plover *Pluvialis squatarola* and Curlew Sandpiper *Calidris ferruginea,* one 'Endangered' species, namely, Siberian Sand Plover *Charadrius mongolus* and one species Hanuman Plover is Not Evaluated, remaining 99 species were assessed 'Least Concern' according to the IUCN Red List (IUCN 2024) (Figure 4).

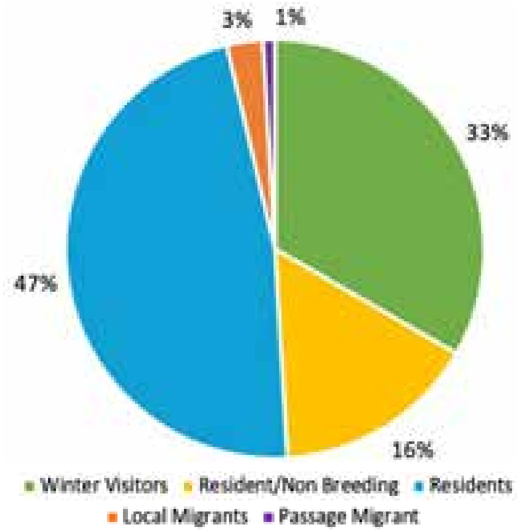

Figure 3. Representation of the residential status of the avifauna.

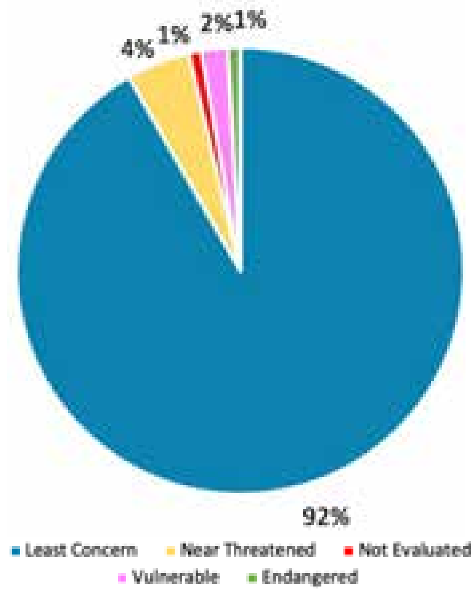

Figure 4. Representation of the IUCN Red List status of the avifauna.

SOIB population trends

Based on SOIB indices, we calculated the Indian national trends of the avifauna in Pillaimadam Lagoon as follows, 26% of species populations are stable; 24% are trend inconclusive and the rest are rapid increase (5%); increase (7%); decline (17%); and rapid decline (17%). The trend of four species was not available in SOIB including Spotted Owlet, Hanuman Plover, Common Ringed Plover, and Greater Sand Plover *Charadrius leschenaultii* (Table 1).

CMS Status

Among the 108 species from the Pillaimadam Lagoon, 32.4% (30 water birds and 4 land birds) are protected under the Convention on the Conservation of Migratory Species of Wild Animals under Appendix II (Table 1).

DISCUSSION

Among the 108 species, 50% were landbirds, and the order Passeriformes with 30 species dominated the terrestrial birds. This showed the lagoon supported these birds with suitable vegetative cover on the peripheries. The high representation of waterbirds in Pillaimadam Lagoon is consistent with the importance of such habitats as critical stopovers and wintering sites for migratory species (Skagen 2018). The dominance of the order Charadriiformes, with 34 species, aligns with studies of coastal ecosystems globally, where shorebirds are often the most abundant due to the availability of feeding grounds along intertidal zones (Warnock & Takekawa 2006; Manikannan et al. 2012). The Siberian Sand Plover, Little Stint, and Kentish Plover dominated the bird species populations. A minimum of a few hundred to one thousand individuals of these species were observed from the lagoon. In particular, the dominance of species such as Siberian Sand Plover and Little Stint reflects the lagoon's role in supporting many long-distance migrants. Similar patterns have been observed in wetland systems across India, where coastal and inland wetlands serve as essential wintering grounds for migratory shorebirds (Rahmani et al. 2016).

Most shorebird species were documented from late August until the end of May, while a few were found over the summer in small numbers during 15 June–31 July (Balachandran 1990) in the study area. We observed that 11 species of shorebirds over-summering here: Common Redshank *Tringa totanus,* Common Greenshank, Black-bellied Plover, Curlew Sandpiper, Ruddy Turnstone, Whimbrel *Numenius phaeopus,* Eurasian Curlew, Siberian Sand Plover, Greater Sand Plover, Kentish Plover *Charadrius alexandrines*, and Little Stint *Calidris minuta*. We also found some Lesser Crested Tern *Thalasseus bengalensis* and Greater Crested Terns *Thalasseus bergii* throughout the year. Similarly, several over-summering shorebird species have been reported from Kadalundi Vallikkunnu Community Reserve (KVCR) (Aarif et al. 2020) and Changaram wetlands (Anand et al. 2023) on the west coast and various sites on the south-east coast of India (Byju et al. 2024a). Hence, this leads to the elucidation that food resources for the over-summering shorebirds are available throughout the year

Table 2. Relative diversity index (RDi) of various avifaunal families in Pillaimadam Lagoon.

Families	Number of species	RDi (%)
Scolopacidae	11	10.19
Laridae	11	10.19
Charadriidae	9	8.33
Ardeidae	7	6.48
Accipitridae	6	5.56
Columbidae	4	3.70
Cuculidae	4	3.70
Anatidae	3	2.78
Corvidae	3	2.78
Alaudidae	3	2.78
Sturnidae	3	2.78
Phasianidae	2	1.85
Ciconiidae	2	1.85
Threskiornithidae	2	1.85
Phalacrocoracidae	2	1.85
Burhinidae	2	1.85
Meropidae	2	1.85
Alcedinidae	2	1.85
Nectariniidae	2	1.85
Motacillidae	2	1.85
Cisticolidae	2	1.85
Hirundinidae	2	1.85
Pycnonotidae	2	1.85
Phoenicopteridae	1	0.93
Apodidae	1	0.93
Rallidae	1	0.93
Pelecanidae	1	0.93
Anhingidae	1	0.93
Recurvirostridae	1	0.93
Strigidae	1	0.93
Upupidae	1	0.93
Picidae	1	0.93
Coraciidae	1	0.93
Psittacidae	1	0.93
Artamidae	1	0.93
Dicruridae	1	0.93
Laniidae	1	0.93
Monarchidae	1	0.93
Estrildidae	1	0.93
Passeridae	1	0.93
Aegithinidae	1	0.93
Leiotrichidae	1	0.93
Acrocephalidae	1	0.93

in this lagoon due to fresh seawater coming into the lagoon during the dry season as it gets completely cut off from the sea.

Among other water birds, including herons, egrets, and ibises, only one was a local migrant (LM), the Western Reef Heron, and the rest were residents and not breeding on the site. Twelve species were common, and five species were uncommon. The most dominant waterbird species identified in the lagoon were Intermediate Egret *Ardea intermedia*, Little Egret *Egreta garzeta*, and Indian Cormorant *Phalacrocorax fuscicollis*. Apart from the shorebirds and other waterbirds mentioned, five species of gulls, viz., Slender-billed Gull, Black-headed Gull *Chroicocephalus ridibundus,* Brown-headed Gull *Chroicocephalus brunnicephalus*, Lesser Black-backed Gull, and Greater Black-headed Gull were documented from this site. Of these, the most dominant ones were Black-headed and Brown-headed Gulls. Six species of terns, viz., Little Tern, Gull-billed Tern, Caspian Tern *Hydroprogne caspia*, Whiskered Tern, Greater Crested Tern and Lesser Crested Tern were also encountered. Greater Crested Tern, followed by the Lesser Crested Tern, were the most dominant of the group throughout the study period (Image 2).

Conservation status

Anthropogenic activities such as land reclamation, pollution, and over-extraction of water resources have degraded India's wetlands (Sundar & Kittur 2013), posing a serious threat to the bird species. The presence of five 'Near Threatened' species, two 'Vulnerable' and one 'Endangered' species highlights the ecological significance of this lagoon for bird conservation. The presence of probing birds like Bar-tailed Godwit, Curlew Sandpiper, and Eurasian Curlew reflects the lagoon's critical role as a stopover site during migration, providing essential feeding and resting areas. Great Thick-knee, a species typically found in coastal areas, further reinforces the site's ecological value. Hanuman Plover (Image 3), currently unassessed by the IUCN Red List, adds to the lagoon's conservation relevance, as little is known about this species' population trends and ecological requirements (Byju et al. 2023e), making it a subject of interest for further studies. The lagoon's suitability for these waterbirds may be attributed to its rich aquatic biodiversity, prey availability, and relatively undisturbed environment compared to other wetlands in the region. The observation that 32.4% of the recorded species from the study are being protected under CMS Appendix II suggests the need for international cooperation in managing and conserving this wetland (CMS 2024). As

Image 2. Greater Crested Tern *Thalasseus bergii* congregation is mostly seen throughout the year with few Caspian Terns *Hydroprogne caspia*.

Image 3. Regional endemic Hanuman Plover *Charadrius seebohmi* with chick.

noted in other studies, such recognitions highlight the importance of coordinated conservation efforts across migratory pathways (Kirby et al. 2008). Three species recorded in Pillaimadam, Bar-tailed Godwit, Whimbrel, and Curlew Sandpiper are also enlisted as Central Asian Flyway Priority Species in the Arctic Migratory Birds Initiative (AMBI), further emphasizing the need to secure this wetland (Arctic Council 2024).

According to the SoIB report, the national trends for many wetland-dependent species, especially the coastal wetland species indicate a population decline (State of India's Birds 2023). In Pillaimadam Lagoon, the trend analysis based on SoIB indices shows a mixed picture, with 34% of species populations declining or rapidly declining. This is a concerning statistic, reflecting broader patterns of wetland degradation, loss of breeding habitat, and declining prey availability (Wetlands International 2020). SoIB analysis results also mark the importance of extensive scientific documentation in such wetlands, as 24% of the species population trend in Pillaimadam could not be concluded because of too few reports. The results of this study align with the broader trends in wetland bird populations across the Indian subcontinent, even though the methods are not completely reliable (Maitreyi 2024).

Conservation Significance

Removal of invasive trees like *Neltuma juliflora* from the peripheries of the lagoon has dented the breeding population of Great Thick-knee and Black-winged Stilt in the area. These trees served as a natural barrier for the birds in the lagoon. The removal of these invasive trees should be carried out scientifically in phases to avoid any disturbance during the breeding season rather than removal in a single stroke, as a few landbirds also use these trees for nesting. The freshwater puddles that formed after the rains have completely exposed the area, making those patches vulnerable for birds for roosting and breeding due to consistent human activities. A basic avifaunal checklist in an unexplored area like this study provides baseline data for identifying potential new sites for conservation priority. Moreover, it attracts bird watchers, helps tourism with the local community's support and helps conservationists develop strategies to mitigate threats in the new wintering site in the CAF.

CONCLUSION

This study is noteworthy as this is the first avifaunal study from the area. Even though earlier avifaunal studies in the area were restricted to bird-ringing studies of gulls, terns, and shorebirds. This study could aid in filling knowledge gaps and help in conservation management understanding the distribution of bird species and prioritizing conservation of numerous waterbirds and shorebirds. Establishing this preliminary data could provide a basis for tracking bird population changes over time, which helps conservation efforts. Lack of formal protection for the habitat may also make it vulnerable to coastal reclamation projects. Prioritization of habitat conservation in the Lagoon should also be considered to save the breeding areas of regional endemic species like Hanuman Plover.

REFERENCES

Aarif, K.M., K. Sara, N. Aymen & A. Sama (2020). Over-summering abundance, species composition, and habitat use patterns at a globally important site for migratory shorebirds. *Journal of Ornithology* 132: 165–172.

Alfaro, M. & M. Clara (2007). Assemblage of shorebirds and seabirds on Rocha Lagoon sandbar, Uruguay. *Ornithologia Neotropical* 18: 421–434.

Anand, J., H. Byju, A. Nefa, S. Abhijith, O.R. Reshi & K.M. Aarif (2023). Conservation significance of Changaram wetlands a key wintering site for migratory shorebirds and other waterbirds in the western coast of Kerala, India. *Journal of Threatened Taxa* 15(1): 22410–22418. https://doi.org/10.11609/jott.8089.15.1.22410-22418

Arctic Council (2024). https://arcticcouncil.org/. Accessed on 13 September 2024.

Balachandran, S. (1990). Studies on the coastal birds of Mandapam and the neighbouring islands (Peninsular India). Ph.D. Thesis, Annamalai University, India, 170 pp.

Bibby, C.J., N.D. Burgess, D.A. Hill & S. Mustoe (2000). *Bird Census Techniques*. Academia Press, Belgium, 302 pp.

Byju, H., N. Raveendran, S. Ravichandran & R. Vijayan (2023a). A checklist of the avifauna of Samanatham tank, Madurai, Tamil Nadu, India. *Journal of Threatened Taxa* 15(9): 23857–23869. https://doi.org/10.11609/jott.8419.15.9.23857-23869

Byju, H., N. Raveendran, S. Ravichandran & R. Kishore (2023b). Importance of conserving a critical wintering ground for shorebirds in the Valinokkam Lagoon—a first study of the avifaunal distribution of the southeastern coast of India. *Journal of Threatened Taxa* 15(8): 23696–23709. https://doi.org/10.11609/jott.8494.15.8.23696-23709

Byju, H., N. Raveendran & S. Ravichandran (2023c). Distribution of avifauna on twenty-one islands of the Gulf of Mannar Biosphere Reserve, India. *Journal of Threatened Taxa* 15(2): 22574–22585. https://doi.org/10.11609/jott.8112.15.2.22574-22585

Byju, H., N. Raveendran, S. Ravichandran & R. Kishore (2023d). An annotated checklist of the avifauna of Karangadu mangrove forest, Ramanathapuram, Tamil Nadu, with notes on the site's importance for waterbird conservation. *Journal of Threatened Taxa* 15(3): 22813–22822. https://doi.org/10.11609/jott.8356.15.3.22813-22822

Byju H., N. Raveendran, S. Ravichandran & R Kishore (2023e). Additional Breeding records of Hanuman Plover *Charadrius seebohmi*, Hartert & A.C. Jackson, 1915 (Aves: Charadriiformes: Charadriidae) from southeastern coast of India. *Journal of Threatened Taxa* 15(4): 23114–23118. https://doi.org/10.11609/jott.8317.15.4.23114-23118

Byju, H., H. Maitreyi, N. Raveendran & S. Ravichandran (2024a). Declining trends of over-summering shorebird populations along the southeastern coasts of Tamil Nadu, India. *Journal of Threatened Taxa* 16(8): 25651–25662. https://doi.org/10.11609/jott.8921.16.8.25651-25662

Byju, H., N. Raveendran & H. Maitreyi (2024b). Avifaunal diversity assessment and conservation significance of Therthangal Bird Sanctuary, Ramanathapuram, Tamil Nadu: Insights about breeding waterbirds. *Journal of Threatened Taxa* 16(9): 25802–25815. https://doi.org/10.11609/jott.8999.16.9.25802-25815

Callaghan, C.T., G. Bino, R.E. Major, J.M. Martin, M.B. Lyons & R.T. Kingsford (2019). Heterogeneous urban green areas are bird diversity hotspots: insights using continental scale citizen science data. *Landscape Ecology* 34: 1231–1246. https://doi.org/10.1007/s10980-019-00851-6

Chandana, E.P.S., N.D.S. Amarasinghe & L.A. Samayawardhena (2012). Factors affecting the avifaunal distribution in the three lagoons (Malala, Embillakala and Bundala Lewaya) of Bundala National Park (A Ramsar Wetland) in Sri Lanka. *Ruhuna Journal of Science* 3(3): 34–43.

Cody, M.L. (1985). *Habitat Selection in Birds*. Academic Press, 560 pp.

Day, J.W., W.M. Kemp, A. Yáñez- Arancibia & B.C. Crump (2012). *Estuarine ecology*. *2nd ed*. John Wiley & Sons, 560 pp.

Egwumah, F.A., P.O. Egwumah & D.I. Edet (2017). Paramount roles of wild birds as bioindicators of contamination. *International Journal of Avian & Wildlife Biology* 2(6): 00041.

Fraixedas., S, A. Lindén, M. Piha, M. Cabeza, R. Gregory & A. Lehikoinen (2020). A state-of-the-art review on birds as indicators of biodiversity: Advances, challenges, and future directions. *Ecological Indicators* 118: 106728. https://doi.org/10.1016/j.ecolind.2020.106728

Gadgil, M. (1996). Documenting diversity: An experiment. *Current Science* 70: 36–44.

Gaston, K.J. (2000). Global patterns in biodiversity. *Nature* 405(6783): 220227. https://doi.org/10.1038/35012228

Grimmett, R., C. Inskipp & T. Inskipp (2011). *Birds of the India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives*. Princeton University Press, New Jersey, 528 pp.

Hasuia, É., A.C. Martensen, A. Uezu, R.G. Pimentel, F.N. Ramos, M.C. Ribeiro & J.P. Metzger (2024). Populations across bird species distribution ranges respond differently to habitat loss and fragmentation: implications for conservation strategies. *Perspectives in Ecology and Conservation* 22(1): 43–54

Hayman, P., J. Marchant & T. Prater (2011). *Shorebirds: An Identification Guide to the Waders of the World*. Christopher Helm Publishers, London, 413 pp.

Howes, J.G. & D. Bakewell (1989). *Shore Bird Studies Manual AWB*.

Publications No. 55 Kula Lumpur, 362 pp.

Huang, Z., L. Yalan, M. Weiqing, M. Xunqiang, X. Wenbin, Y. Haofan, H. Mengxuan & W. Yidong (2023). Study on suitability assessment of waterbird habitats along the Bohai Rim. *Ecological Indicators* 150: 110229. https://doi.org/10.1016/j.ecolind.2023.110229

IUCN (2024). The IUCN Red List of Threatened Species. Version 2024-2. Available at https://www.iucnredlist.org/species/230027154/234712764. Accessed on 5 November 2024.

Jayanthi, M., M. Samynathan, S. Thirumurthy, P. Kumararaja, M. Muralidhar & K.K. Vijayan (2021). Mapping coastal lagoon characteristics for the aquaculture suitability using multicriteria decision support (MCDS) spatial analysis: a case study from southeast coast of India. *Journal of Earth System Science* 130(1): 56. https://doi.org/10.1007/s12040-021-01560-y

Kattan, G.H. & P. Franco (2004). Bird diversity along elevational gradients in the Andes of Colombia: area and mass effects. *Global Ecology and Biogeography* 13: 451–458.

Kati, V. & C.H. Sekercioglu (2006). Diversity, ecological structure, and conservation of the landbird community of a Greek reserve. *Diversity & Distributions* 12: 620–629.

Kazmierczak, K. (2006). *A Field Guide To The Birds of India*. Pica Press Illustrated. United Kingdom, 352 pp.

Kennish, M.J. & H.W. Paerl (2010). *Coastal Lagoons: Critical Habitats of Environmental Change*. CRC Press, 568 pp.

Kirby, J.S., A.J. Stattersfield, S.H.M. Butchart, M.I. Evans, R.F. Grimmett, V.R. Jones, J. O'Sullivan, G.M. Tucker & I. Newton (2008). Key conservation issues for migratory land and waterbird species on the world's major flyways. *Bird Conservation International* 18(S1): 4973.

Koli, V.K. (2014). Diversity and status of avifauna in Todgarh Raoli wildlife Sanctuary, Rajasthan, India. *Journal of Asia-Pacific Biodiversity* 7(4): 401–407.

Llanos, F.A., M. Failla, G.J. García, P.M. Giovine, M. Carbajal, P.M. González, D.P. Barreto, P. Quillfeldt & J.F. Masello (2011). Birds from the endangered Monte, the Steppes, and Coastal biomes of the province of Río Negro, northern Patagonia, Argentina. *Checklist* 7(6): 782–797.

Ma, S., L.J. Wang, J. Jiang & Y.G. Zhao (2023). Direct and indirect effects of agricultural expansion and landscape fragmentation processes on natural habitats. *Agriculture, Ecosystems & Environment* 353: 108555. https://doi.org/10.1016/j.agee.2023.108555

MacKinnon, J. & K. Phillipps (1993). A Feld Guide to the Birds of Borneo, Sumatra, Java and Bali. Oxford University Press, Oxford, 391 pp.

Maitreyi, H. (2024). State of India's Birds report-a brief review. *Zoo's Print* 39(1): 119–124.

Manikannan, R., S. Asokan & A.M.S. Ali (2012). Abundance and Factors Affecting Population Characteristics of Waders (Charadriiformes) in Great Vedaranyam Swamp of Point Calimere Wildlife Sanctuary, Southeast Coast of India. *International Journal of Ecosystem* 2(1): 614. https://doi.org/10.5923/j.ije.20120201.02

Miotto, M.L., J.B. Gusmao, C. Domit & M.D. Domenico (2023). Environmental drivers of waterbird diversity in a world heritage subtropical estuarine system. *Estuarine, Coastal and Shelf Science* 288: 108343. https://doi.org/10.1016/j.ecss.2023.108343

Naujokaitis-Lewis, I., J. Curtis, P. Arcese & J. Rosenfeld (2009). Sensitivity analyses of spatial population viability analysis models for species at risk and habitat conservation planning. *Conservation Biology* 23: 225–229. https://doi.org/10.1111/j.15231739.2008.01066.x.

Newton, I. (2004). The recent declines of farmland bird populations in Britain: An appraisal of causal factors and conservation actions. *Ibis* 146(4): 579–600.

Paul, E. & R.J. Cooper (2005). New opportunities for bird conservation research. In: Ralph, C., R. John & D. Terrel (eds.). Bird Conservation Implementation and Integration in the Americas: *Proceedings of the Third International Partners in Flight Conference,* Asilomar, California (Vol. 2). US Department of Agriculture, Forest Service, Pacific Southwest Research Station: 191: 1008–1017.

Piersma, T. & Å. Lindstrom (2004). Migrating shorebirds as integrative sentinels of global environmental change. *Ibis* 146(S1): 61–69.

Praveen, J. & R. Jayapal (2023). Taxonomic updates to the checklists of birds of India and the South Asian region. *Indian BIRDS* 18(5): 131–134.

Rahmani, A.R., Z.U. Islam & R.M. Kasambe (2016). *Important Bird and Biodiversity Areas in India: Priority Sites for Conservation*. (Revised and updated). Bombay Natural History Society, Indian Bird Conservation Network, Royal Society for the Protection of Birds and BirdLife International (U.K.), 1992 pp + xii.

Rashiba, A.P., K. Jishnu, H. Byju, C.T. Shifa, J. Anand, K. Vichithra, Y. Xu, A. Nefla, S.B. Muzaffar, K.M. Aarif & K.A. Rubeena (2022). The paradox of shorebird diversity and abundance in the west coast and east coast of India: a comparative analysis. *Diversity* 14: 885. https://doi.org/10.3390/ d14100885

Sekercioglu, C.H. (2012). Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. *Journal of Ornithology* 153: 153–161. https://doi.org/10.1007/s1033601208694

Skagen, S.K. (2018). Migration stopovers and the conservation of Arctic breeding shorebirds. *Avian Conservation and Ecology* 13(1): 3.

Silva, E.I.L, J. Katupotha, O. Amarasinghe, H. Manthrithilake & R. Ariyaratna (2013). *Lagoons of Sri Lanka: from the origins to the present.* Summary Report, International Water Management Institute (IWMI), 122 pp. https://doi.org/10.5337/2013.215

State of India's Birds (2023). Range, trends, and conservation status. Available at https://stateofindiasbirds.in/ Accessed on 04 September 2024.

Sundar, K.S.G. & S. Kittur (2013). Can wetlands maintained for human use also help conserve biodiversity? *Agriculture, Ecosystems & Environment* 173: 6773.

Thomas, C.D. & J.J. Lennon (1999). Birds extend their ranges northwards. *Nature* 399(6733): 213.

Todd, B.D., J.P. Rose, S.J. Price & M.E. Dorcas (2016). Using citizen science data to identify the sensitivity of species to human land use. *Conservation Biology* 30: 1266–1276. https://doi.org/10.1111/cobi.12686

Warnock, N. & J.Y. Takekawa (2006). Habitat selection and movements of shorebirds in the San Francisco Bay Estuary. *Waterbirds* 29(3): 424–433.

Wetlands International (2020). *Waterbird Population Estimates.* (5th edition), Summary Report. Wetlands International, Wageningen, The Netherlands, 24 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26803–26813

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9436.17.4.26803-26813

#9436 | Received 26 September 2024 | Final received 26 February 2025 | Finally accepted 06 March 2025

OPEN ACCESS

ARTICLE

Comments on the systematics and morphology of *Smithophis bicolor* (Blyth, 1855) (Reptilia: Squamata: Natricidae) based on topotypical specimens from Meghalaya, India

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Abstract: The Natricid Snake *Smithophis bicolor* has been poorly studied and understood since its initial description in the mid-1800s. This study presents a detailed morphological description of *S. bicolor* based on five examined specimens including a freshly collected mutilated specimen from Meghalaya State, India. For the first time, genetic data has been obtained and analysed, providing novel insights into the species' phylogenetic position within its genus *Smithophis*. Morphological comparisons and molecular analyses using cytochrome b mitochondrial gene reveal subtle variations that contribute to a clearer understanding of the species' taxonomic identity. This study allows us to conclude that currently *S. bicolor* is restricted to the higher elevations of Meghalaya indicating that literature records mentioning the presence of this species from Mizoram actually represents a distinct, new unnamed lineage.

Keywords: Cytochrome b, hemipenis, herpetofauna, Khasi hills, Mairang, northeastern india, phylogeny, re-description, shillong plateau, taxonomy, type locality.

Khasi: Ia u bsein bala khot u *Smithophis bicolor* ym shym la pule bad sngewthuh bha naduh ba la batai nyngkong ia u ha ka shiteng jong ki snem 1800. Kane ka jingpule ka ai ia ka jingbatai bniah ia ka dur jong u ne u bsein, katkum ki san tylli ki nongmuna ba la bishar bniah kynthup ia u bsein ba lah iap ba dang shu lum thymmai na ka jylla Meghalaya, India. Ha ka sien kaba nyngkong, la ïoh ban bishar bniah ïa ki jingtip ba ïadei bad ki gene, kaba ai ïa ki jingshem ba thymmai shaphang ka kyrdan jinglong jing man (phylogenetic position) jong une bsein hapoh ka jait jong u *Smithophis*. Ka jingïanujor ïa ka dur jong ka met bad ki jingpeit bniah da kaba pyndonkam ïa ki mitochondrial gene ba la khot cytochrome b, ki pyni ïa ki jingiapher kiba rit kiba ïarap ban sngewthuh kham shai ïa ka jingbuh kyrteng jong kine ki jait bsein. Kane ka jingpule ka ailad ia ngi ban pynkut ba mynta u *S. bicolor* u don tang ha ki jaka ba kham sha jrong jong ka Meghalaya, watla ki jingthoh ki kdew ruh ia ka jingdon jong une u jait bsein ha Mizoram hynrei u lah ban dei u ba pher, u bym pat ai kyrteng.

Editor: S.R. Ganesh, Kalinga Foundation, Agumbe, India.

Date of publication: 26 April 2025 (online & print)

Citation: Purkayastha, J., B.M. Asem, H.T. Lalremsanga, M. Das, H. Warjri, G. Thongni & S.C. Bohra (2025). Comments on the systematics and morphology of *Smithophis bicolor* (Blyth, 1855) (Reptilia: Squamata: Natricidae) based on topotypical specimens from Meghalaya, India. *Journal of Threatened Taxa* 17(4): 26803–26813. https://doi.org/10.11609/jott.9436.17.4.26803-26813

Funding: Rufford Small Grants for Nature Conservation.

Competing interests: The authors declare that there are no conflicts of interest regarding the publication of this paper. All authors have participated in the research, design and drafting of this manuscript, and have reviewed and approved the final version. They have no financial or personal relationships that could inappropriately influence or bias the content of this work.

Author details and **Author contributions:** See end of this article.

Acknowledgements: We would like to thank chief wildlife warden (Environment, Forest and Climate Change) and Government of Meghalaya (Permit No.FOR.7/2021/216) for issuing the collection permit. We are also very thankful to the local community for supporting us in our field surveys. We are also thankful to MegLIFE and Rufford Small Grants Foundation for supporting this work. Finally we would like to thank the reviewers and the editor for substantially improving the manuscript through their inputs.

INTRODUCTION

Blyth (1855) described *Smithophis bicolor* in the genus *Calamaria* Boie, 1827 based on a single specimen (holotype ZSI 7030) provided by Mr. Robinson with the type locality recorded as Assam, India. In the same piece of work, Blyth (1855: p. 287) mentioned that the specimens provided by Mr. Robinson might be from Khasya Hills (present day Khasi Hills, Meghalaya State, India) or other upland territories. The holotype ZSI 7030 was mentioned to be with a dusky-plumbeous dorsal surface and a buffy white ventral surface, 17 mid-dorsal scale rows, 210 ventrals and 75 pairs of subcaudals, snout-vent length of 495 mm and a tail length of 111 mm. Boulenger (1893) allocated *bicolor* to the genus *Rhabdops* Boulenger and stated its distribution from Khasi Hills, Assam and Yunnan. *Rhabdops olivaceus* (Beddome 1863) with distribution in the Western Ghats, India is the type species of *Rhabdops* along with the recently described *Rhabdops aquaticus* Giri et al. 2017 also known from the Western Ghats, India whereas *Rhabdops bicolor* was the only species known from northeastern India. Based on genetics and disjunct distribution in Western Ghats and northeastern side, Giri et al. (2019) erected the genus *Smithophis* to accommodate northeastern populations (*bicolor*) and also described a new species in the genus namely *Smithophis atemporalis* noting that the genus *Smithophis* is more closely related to *Opisthotropis* and *Sinonatrix* than to *Rhabdops*. Furthermore, Giri et al. (2019) in their genetic assessment of *Smithophis bicolor* used data based on materials from Mizoram State, northeastern India. Since then, three more species were added to the genus, namely, *Smithophis arunachalensis* Das et al., 2020; *S. linearis* Vogel et al., 2020 and *S. mizoramensis* Mirza et al., 2024 (Mirza et al. 2024a). Chandramouli et al. (2021) provided a morphological description of an adult male topotypic specimen of *S. bicolor* from Shillong, in the Khasi Hills. Giri et al. (2019) in their genetic assessment of *S. bicolor* used data based on materials from Mizoram, India but missed out the typical population from the Khasi Hills of Meghalaya. In this study, based on fresh collection and museum specimens (Zoological Survey of India, Northeastern Regional Centre, Shillong, Meghalaya State, India) we provide additional morphological and molecular insights for *Smithophis bicolor* from its type locality and point to the possibility of existence of an undescribed *Smithophis* from Mizoram State, India, treated as *Smithophis* cf. *bicolor* by Giri et al. (2019).

MATERIALS AND METHODS

The study was conducted in Khasi hills of Meghalaya and throughout Mizoram after obtaining permission for collection within both the states from the chief wildlife warden of Environment, Forests and Climate Change Department, Government of Meghalaya and Mizoram (No. FOR./7/2021/216 for Meghalaya and A.33011/2/99-CWLW/225 for Mizoram). A road killed male specimen of *Smithophis bicolor* was collected from Mairang (ADBU-HN/HW0210), Eastern West Khasi Hills district (25.559°N, 91.635°E; altitude 1,564 m; see Image 1), Meghalaya, India by Holiness Warjri on 12 August 2024 at around 1230 h and has been deposited in the herpetological museum maintained by the Department of Zoology, Assam Don Bosco University, Sonapur, Assam, India. Furthermore, four samples (V1/ERS/ZSI-444, V1/ERS/ZSI-2592, V1/ERS/ZSI-3052 from Shillong, Meghalaya and VR/ERS/ZSI-725 from Umiam, Meghalaya) were also studied from the collection of Zoological Survey of India, Eastern Regional Station, Shillong, Meghalaya, India. Genomic DNA was extracted from ethanol (100%) preserved liver tissue of the specimen ADBU-HN/HW0210 using tissue kit (Qiagen) following manufacturer's instructions. Partial sequence of the mitochondrial cytochrome b gene was generated using the primer pair L14910 (GACCTGTGATMTGAAAAACCAYCGTTGT), H16064 (CTTTGGTTTACAAGAACAATGCTTTA) (Burbrink et al. 2000). Sequence chromatograms were quality checked, edited and assembled into contigs using Chromas and Sequence Scanner v1.0 (Applied Biosystems). Comparative cytochrome b (Table 1) sequences were used following Mirza et al. (2024) and were obtained from GenBank. Sequence alignment was done using MUSCLE (Edgar 2004) in MEGA7 (Tamura & Nei 1993; Kumar et al. 2016) with default parameter settings. Maximum likelihood (ML) phylogenetic tree was reconstructed using un-partitioned dataset in IQ-TREE (Nguyen et al. 2015) with the substitution model GTR+F+I+G4 selected based on the BIC scores by ModelFinder (Kalyaanamoorthy et al. 2017) implemented in the IQ-TREE (Nguyen et al. 2015). The ML analysis was run with an ultrafast bootstrap option (Minh et al. 2013) for 1000 iterations to assess clade support. The un-corrected pairwise p-distance was calculated in MEGA7 (Kumar et al. 2016) with pairwise deletions of missing data and gaps.

Morphometrics and meristics are taken as follows: HL (Head length taken from the retro articular process of the jaw to the tip of the snout), HW (Head width measured at the widest point of the head), HD (Head

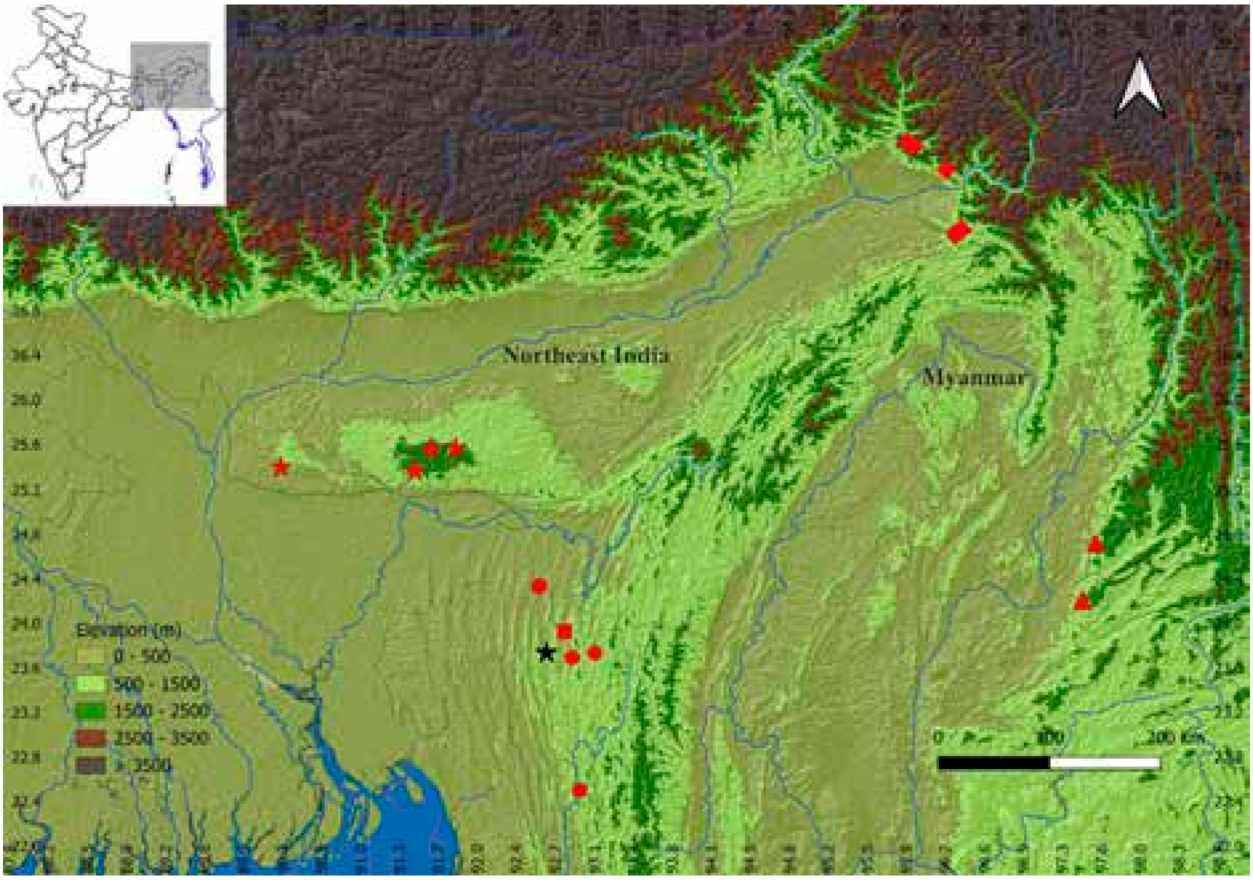

Image 1. The map showing distribution records of members of the genus *Smithophis* (red star: *S. bicolor*, red circle: *S. atemporalis*, red square: *S. mizoramensis*, black star: *Smithophis* sp. (mentioned as *Smitophis bicolor*, see Giri et al. 2019), red diamond: *S. arunachalensis*, red triangle: *S. linearis*).

depth measured at the greatest depth of the head), ED (Eye diameter taken horizontally at the outer margins of the orbit), ND (Greatest nostril diameter), NS (Nostril to snout distance taken from the anterior portion of nostril to the tip of the snout), EN (Eye to nostril distance taken from the anterior portion of orbit to the posterior margin of nostril openings), IND (Internarial distance measured between the two nostril openings), IOD (Inter orbital distance measured between the minimum distance of two outer orbital margins), PL (Greatest length of the parietal scale), SVL (Snout-vent length measured from the tip of the snout to the vent ventrally), TaL (Tail length measured from the vent to the tip of the tail ventrally), TL (Total length measured from the tip of the snout to the to the tip of the tail ventrally or dorsally), DSR (Dorsal scale rows counted in a row transversely in three sections, i.e., exactly one head length behind the neck, exactly in the midbody and exactly one head length before the vent dorsally), V (Number of ventral scales counted ventrally from the 1st scale just behind pre-ventrals till the last scale just before the anal plate), SC (Number of subcaudal scales beginning just behind the cloaca ventrally till the last scale in the tail excluding the terminal scute), SL (Number of supralabial scales counted on the upper lips), IL (Number of infralabial scales counted on the lower lips), COS (Number of circumorbital scales surrounding the orbit), Temp (Number of anterior plus posterior temporal scales in the lateral portion of the head), and Anal (Condition of the anal plate whether its divided or single).

RESULTS

Based on Cyt b (1109 bp) data generated in this study, the *Smithophis bicolor* from Mairang, Eastern west Khasi Hills, Meghalaya State was seen to show a sister relationship to *S. mizoramensis* differing in a low to moderate uncorrected p-distance of 4% whereas *S.* cf. *bicolor* from Mizoram State (Giri et al. 2019) was seen to be sister to the clade comprising *S. bicolor* (Mairang) + *S. mizoramensis*. *Smithophis* cf. *bicolor*

Table 1. List of cytochrome b sequences used in this study. New sequence entry in bold.

Species	Voucher	Genbank accession number	Location
Opisthotropis andersonii	SYS r001383	KY594735	Mt. Maofeng, Guangzhou, Guangdong, China
Opisthotropis cheni	YBU 071040 (=GP383)	GQ281779	Nanling NR, Guangdong, China
Opisthotropis daovantieni	FMNH 252009	OK315831	An Ke, Gia Lai, Vietnam
Opisthotropis durandi	NCSM 80739	MK941137	Nam Lan, Phosaly, Laos
Opisthotropis guangxiensis	GP746	GQ281776	Guangxi, China
Opisthotropis haihaensis	SYS r000537	MN890017	Quang Ninh, Vietnam
Opisthotropis hungtai 1	SYSr000538	MN890018	Mt. Wuhuang, Guangxi, China
Opisthotropis hungtai 2	SYS r000946	KY594748	Heishiding NR, Fengkai, Guangdong, China
Opisthotropis jacobi	ZFMK 100818	MG545602	Tam Dao NP, Vinh Phuc, Vietnam
Opisthotropis kuatunensis	SYS r000998	KY594745	Qixiling NR, Yongxin County, Jiangxi, China
Opisthotropis lateralis	ZMMU NAP-08678	OK315832	Xuan Son NP, Phu Tho, Vietnam
Opisthotropis latouchii	GP647	GQ281783	Fujian, China
Opisthotropis laui	SYS r001161	KY594738	Shangchuan Í., Taishan, Guangdong, China
Opisthotropis maxwelli	SYS r000841	KY594736	Nan'ao Is., Nan'ao, Guangdong, China
Opisthotropis shenzhenensis	SYS r001032	KY594729	Mt. Tiantou, Shenzhen, Guangdong, China
Opisthotropis typica	HT0794	LC325343	Malaysia
Opisthotropis voquyi	ZMMU R-16681	OK315833	Tay Yen Tu NR, Bac Giang, Vietnam
Opisthotropis zhaoermii	CIB110000	MG012801	Guzhang, Hunan, China
Smithophis atemporalis	BNHS 2366	MK350262	Mizoram, India
Smithophis cf. bicolor	BNHS 2369	MK350261	Mizoram, India
Smithophis cf. bicolor	MZMU 1798	PP996090	Aizawl, Mizoram, India
Smithophis bicolor	**ADBU-HN/ HW0210**	**PQ727125**	**Mairang, Eastern West Khasi Hills, Meghalaya, India**
Smithophis linearis	KIZ 059110	MT185677	Yunnan, China
Smithophis mizoramensis	BNHS 3766	PP996092	Suangpuilawn, Saitual, Mizoram, India
Smithophis mizoramensis	BNHS 3767	PP996093	Suangpuilawn, Saitual, Mizoram, India
Smithophis mizoramensis	BNHS 3768	PP996094	Suangpuilawn, Saitual, Mizoram, India
Smithophis mizoramensis	MZMU 2602	PP996091	Suangpuilawn, Saitual, Mizoram, India
Trimerodytes percarinata	ZMMU R-16444	OK315846	Pu Mat NP, Nghe An, Vietnam

from Mizoram differs by an uncorrected p-distance of at least 11.5% from the *S. bicolor* s. str. of Mairang, Eastern West Khasi Hills, Meghalaya State (nearly thrice as high as the divergence between *S. bicolor* s. str. and *S. mizoramensis*) (Figure 1, Table 2). Genetic divergence for the cytochrome b (cyt b) gene reveals that true *S. bicolor* is 4% to 14.3% divergent from other *Smithophis* species. Morphologically, the species *S. bicolor* differs from its sister *S. mizoramensis* mainly in body coloration as well as carination condition of the sacral scales.

Morphology of topotypical, Meghalaya specimens

(V1/ERS/ZSI-2592, V1/ERS/ZSI-725, V1/ERS/ZSI-3052, V1/ERS/ZSI-444, ADBU-HN/HW0210; Images 2–4): *Smithophis bicolor* is mainly characterized by having 17 smooth dorsal scale rows across the body without having any keeled sacral scales in males. It possesses temporal scales (1+1) and features 5 circum-orbital scales along with a single internasal and a single prefrontal scale. Tail is relatively short and ends with a short spine like scale. The examined specimens from Meghalaya exhibit an elongated body with a head slightly distinct from neck, little longer than broad (HW/HL 0.58–0.75), slightly flattened dorsoventrally (HL/HD 0.41–0.57). The eyes are moderately sized (ED/HL 0.12–0.19); nostrils are placed closer to snout than to the eye (NS/EN 0.69–0.88), relatively small in size (ND/ED 0.50–0.71); a pair of parietals, each parietal scale is relatively large, half or slightly more than half of head length (Parietal/HL 0.50–0.61); SVL ranges from 360–535 mm; TaL ranges from

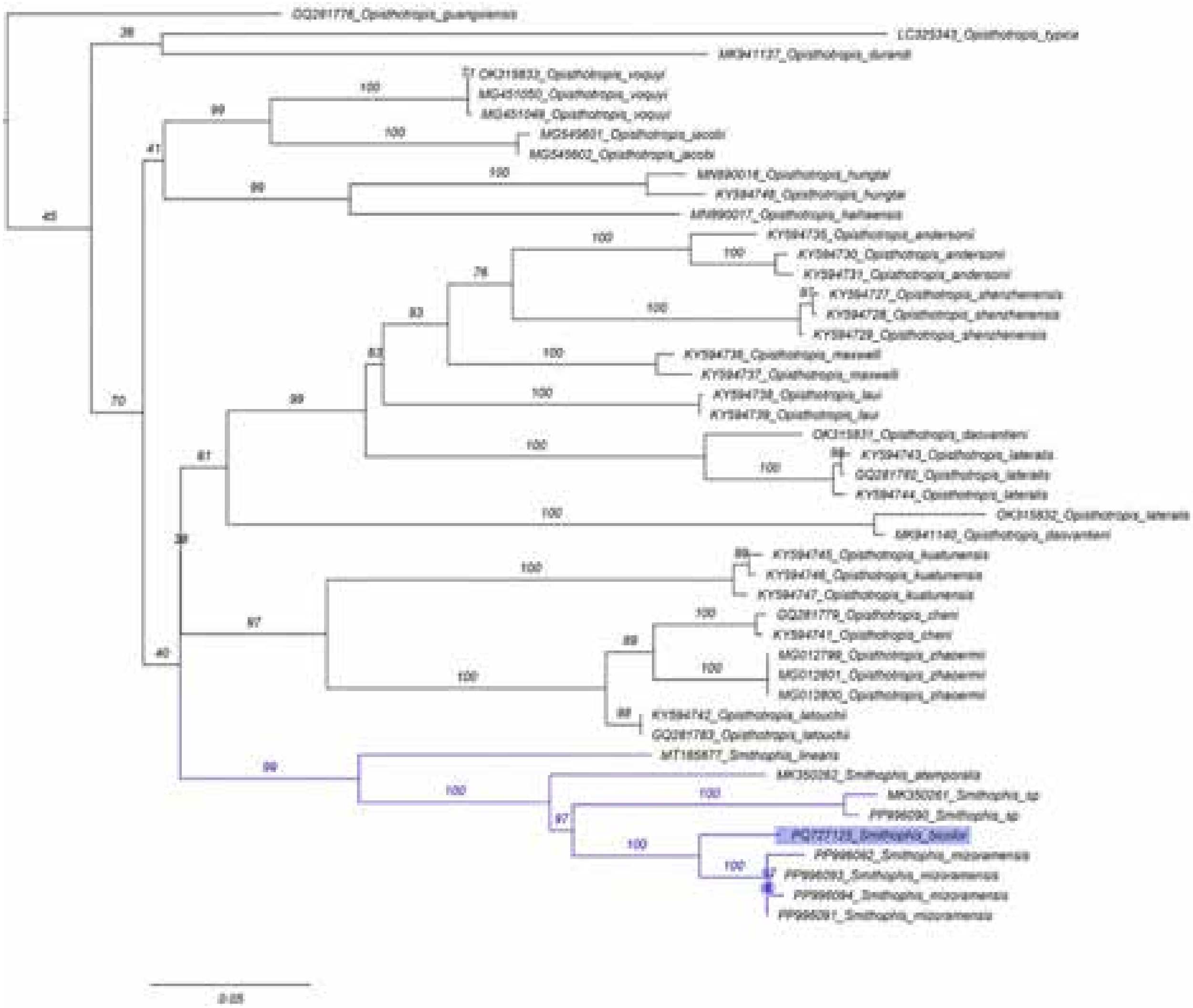

Figure 1. Maximum likelihood phylogeny showing the relationships amongst the members of genus *Smithophis* based on Cytochrome b mitochondrial gene. Preceding the species name is NCBI accession number and numbers at nodes represent bootstrap support values.

Table 2. Uncorrected p-distance between the members of the genus *Smithophis*.

PQ727125_*S._bicolor*								
PP996092_*S. mizoramensis*	0.040							
PP996093_*S._mizoramensis*	0.040	0.000						
PP996094_*S._mizoramensis*	0.040	0.000	0.000					
PP996091_*S._mizoramensis*	0.040	0.000	0.000	0.000				
MK350262_*S._atemporalis*	0.107	0.096	0.096	0.096	0.096			
MK350261_*S._cf. bicolor*	0.115	0.098	0.098	0.098	0.098	0.125		
PP996090_*S._ cf. bicolor*	0.115	0.098	0.098	0.098	0.098	0.125	0.000	
MT185677_*Smithophis_linearis*	0.143	0.138	0.138	0.138	0.138	0.156	0.169	0.169

110–160 mm; tail relatively short (TaL/SVL 0.30–0.44; TaL/TL 0.22–0.25); TL ranges from 470–690 mm. The meristic characteristics of the specimens are consistent across the examined specimens. All individuals possess 17–17–17 dorsal scale rows; Ventrals 209–212 in males and 192 in females; subcaudals 75–80 in males and 68 in

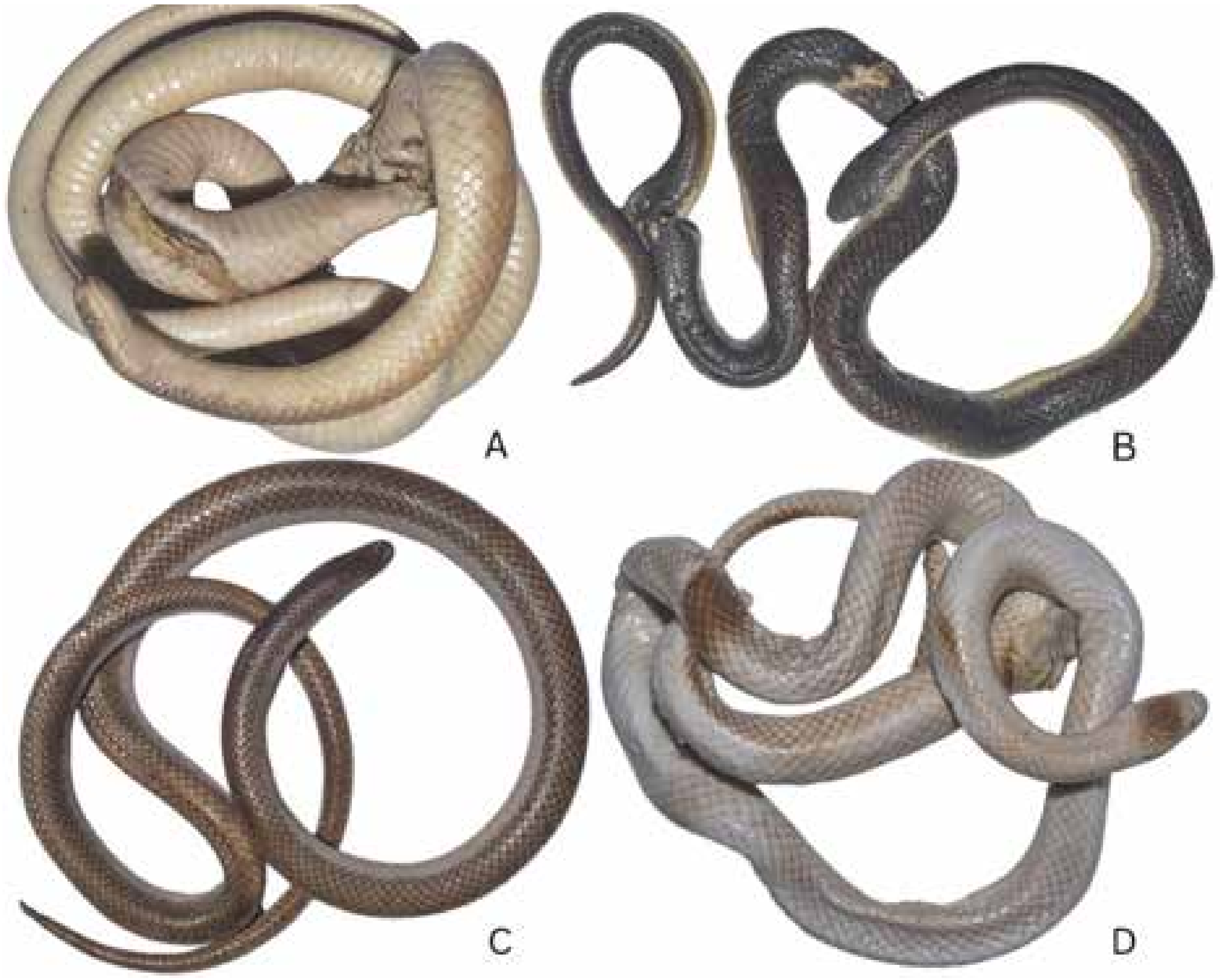

Image 2. Studied specimens of *Smithophis bicolor* from the collection of Zoological Survey of India, Eastern Regional Station, Shillong, Meghalaya (A—V1/ERS/ZSI 444 | B—V1/ERS/ZSI 725 | C—V1/ERS/ZSI 2592 | D—V1/ERS/ZSI 3052). © Jayaditya Purkayastha.

females; SL usually 5 and IL usually 6 or 7. One unsexed individual has 212 ventrals and 71 subcaudals, SL 5 on each side and IL 6 on each side. The circum-orbital scale count is uniform across all specimens, with five scales surrounding each eye. The temporal scales are arranged in a 1+1 pattern in all individuals and anal plate is divided in all specimens.

Sexual dimorphism

Based on our data, males of this species have ventrals ranging from 209 to 212 (versus 192 in a female), Sc ranging from 75 to 80 (*versus* 68 in a female) and Tal/TL ratio of 0.23 to 0.25 (versus 0.22 in a female).

Coloration in preservative (Image 2)

The specimens in ZSI, especially V1/ERS/ZSI 444 and 3052, have become completely faded in comparison to their coloration in life (read below), such that there is barely much difference between their dorsal and ventral colours, indicating bleaching of dorsal colour. Eyes became paler and pupil became light grey.

Coloration in life (based on live uncollected snakes; Image 3)

Smithophis bicolor we encountered had a dorsal region with uniformly shiny black above with a slightly violet tinge, whereas the ventral is uniformly (mostly) gambodge yellow in life. In the posterior half of the lateral region, a prominent, broad gambodge yellow stripe runs along the body, covering the ventrals. The dorsal and ventral coloration meet somewhat at the middle of the lateral region, giving it a typical bicoloured appearance which begins from the snout and extends up to the tip of the tail in life.

Image 3. Uncollected live specimens of *Smithophis bicolor* from Makwyarwat (Southeastern Khasi Hills, Meghalaya: A & B) and Mairang (eastern West Khasi Hills, Meghalaya, C & D). © Goldenstar Thongni and Holiness Warjri.

Hemipenial description (based on ADBU-HN/HW0210; Image 4)

Short and stout, characterized by heavy spinosity over the distal three-quarters, with the proximal one-quarter, near the base, exhibiting a somewhat calyculate texture. The spines are more pronounced and larger towards the intermediate region and the base, gradually becoming smaller and conspicuous, somewhat hair or serrations like towards the tip. The spines in hemipenis of *Smithophis bicolor* are much more pronounced than its sister taxa *S. mizoramensis*.

Comparisons

Smithophis bicolor has well defined temporal scales (1+1) vs. absent in *S. atemporalis*; *Smithophis bicolor* does not have keeled sacral scales in males vs. presence of keeled sacral scales in *S. arunachalensis* and *S. mizoramensis*. The dorsum is immaculate in *Smithophis bicolor vs.* either blotched or striped in all the other congeners. Furthermore, *Smithophis bicolor* has 4–5 circumorbital scales vs. 6–7 in *S. linearis*.

Table 3. Morphometric and meristic data of *Smithophis bicolor* from eastern and western Khasi Hills, Meghalaya State, India (-- indicates missing data). Measurements in mm.

Museum no.	V1/ERS/ ZSI-2592	V1/ERS/ ZSI-725	V1/ERS/ ZSI-3052	V1/ERS/ ZSI-444	ADBU-HN/ HW0210
Location	Fruit garden, Shillong	Tripura Castle Road, Shillong	Risa Colony, Shillong	Umiam, Umsaw, NEPA Campus	Mairang, Eastern West Khasi hills
Sex	Unsexed	Male	Female	Male	Male
HL	12.54	10.9	14.74	9.8	11
HW	8.28	7.52	9.79	7.48	7.5
HD	7.09	5.8	7.51	5.5	5.1
ED	1.8	1.9	1.51	1.62	1.7
ND	1.27	0.9	0.9	1.18	0.9
NS	1.94	1.6	1.9	1.43	1.8
EN	2.17	1.87	2.6	2.15	2.2
IND	3.48	3.4	3.45	3.2	3.4
IOD	5.8	5.34	5.77	5.2	4.8
PL	7.63	6	7.21	6.8	6.5
SVL	520	385	535	360	360
TaL	160	113	155	120	110
TL	680	498	690	480	470
DSR	17/17/17	17/17/17	17/17/17	17/17/17	17/17/17
V	212	209+	192	212	209
SC	71	75	68	80	76
SL (L/R)	5/5	5/5	5/5	5/5	5/--
IL (L/R)	6/6	6/6	6/6	7/6	--
COS	5	5	5	5	5
Temp	1+1	1+1	1+1	1+1	1+1
Anal	Divided	Divided	Divided	Divided	Divided

Natural history and distribution (Image 5)

Based on our current data, *Smithophis bicolor* is a terrestrial to semi-aquatic species which mainly prefers to live in close proximity to streams and other water bodies surrounded by semi-evergreen, evergreen, moist deciduous, montane forests and at times even moderately disturbed hilly areas. Based on the specimens, the species is found in areas of higher elevation ranging 1,000–1,700 m. All the freshly observed specimens from Meghalaya State were seen near streams, boulders with or without mosses, loose soils or roadside edges with or without mosses within wet montane or wet semi-evergreen or evergreen forests, particularly during the day. It has been observed that this species (just like other congeners) is often seen or becomes active during heavy rainfall. The current understanding based on the available data allows us to conclude that *Smithophis bicolor* is currently restricted to the higher elevations of Meghalaya State, particularly in the Khasi Hills and its adjacent areas, i.e., Garo hills whereas those reported as *S. bicolor* s. lat. from regions outside Meghalaya State might represent a different species.

DISCUSSION

Despite being one of the earliest described species of the genus *Smithophis*, *S. bicolor* lacked any new information until recent times (Chandramouli et al. 2021). This study not only gives genetic data from the type locality of *S. bicolor* but also provides expanded morphological description of the species based on multiple specimens. The examination of additional topotypic specimens of *S. bicolor* from Meghalaya resulting in this expanded morphological description makes the species better characterised in terms of its morphology. This provides a concrete dataset for researchers to describe as well as compare new and

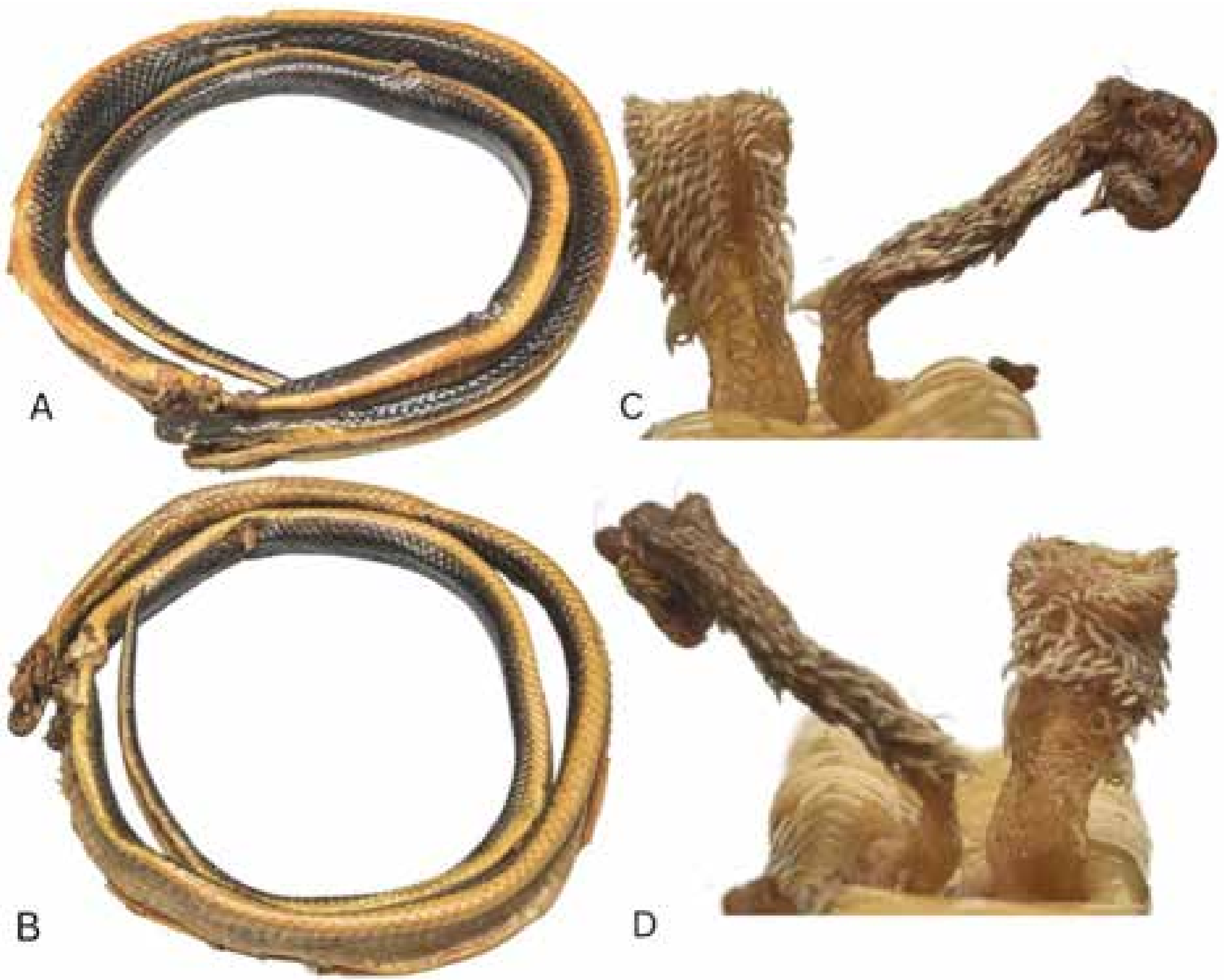

Image 4. Mutilated specimen (ADBU-HN/HW0210) of *Smithophis bicolor* from Mairang (Eastern West Khasi Hills, Meghalaya: A&B)—along with its hemipenis | C—sulcal surface | D—asulcal surface. © Sanath Chandra Bohra.

previously described species with the nominal taxon in the future. Furthermore, the population previously identified as *S. bicolor* from Mizoram (Giri et al. 2019) which represents a genetically and morphologically distinct lineage, will be formally described as a new species in our forthcoming publication in preparation.

Meghalaya State, which is rich in terms of biodiversity forms a part of the Indo-Burma biodiversity hotspot which lies on the southern bank of river Brahmaputra and has been relatively well surveyed historically, particularly during the time of British India. Since then, after a long time the state has witnessed a significant increase in the number of new herpetofaunal species descriptions in the past two decades alongside range extensions regarding certain species (e.g., Das et al. 2010; Mahony et al. 2011, 2013, 2018, 2020; Purkayastha & Matsui 2012; Datta-Roy et al. 2013; Kamei et al. 2013; Agarwal et al. 2018b; Purkayastha et al. 2020a,b; 2021; 2022; Rathee et al. 2022; Mirza et al. 2024b). Despite being a described species, further research and field work are necessary to properly understand the accurate distribution range, ecology, reproductive biology and conservation biology of *S. bicolor*. The Khasi Hill is the "type locality" for snake species like *Stoliczkia khasiensis* Jerdon, 1870 which is known just from a single specimen and since its description in 1870, the species was never reported for the second time as a result of which it has been considered as a lost species. This highlights the importance of conducting continuous as well as comprehensive herpetofaunal surveys throughout Khasi Hills and its adjoining hill ranges before the depletion of forest cover due to anthropogenic pressures.

We suggest further field investigations involving wide samplings throughout the given range of the genus *Smithophis* to understand the potential reason behind the diversification of these natricids that will definitely

Image 5. *Smithophis bicolor* in Makyrwat, southwestern Khasi Hills, Meghalaya, India. © Goldenstar Thongni and Holiness Warjri.

help to uncover further new unnamed populations in the region.

REFERENCES

Agarwal, I., S. Mahony, V.B. Giri, R. Chaitanya & A.M. Bauer (2018). Six new *Cyrtodactylus* (Squamata: Gekkonidae) from northeast India. *Zootaxa* 4524(5): 501–535. https://doi.org/10.11646/zootaxa.4524.5.1

Beddome, R.H. (1863). Further notes upon the snakes of the Madras Presidency; with descriptions of new species. *Madras Quarterly Journal of Medical Science* 6: 41–48 (Reprint: *Journal of the Society for the Bibliography of Natural Science* London, 1: 306–314, 1940).

Blyth, E. (1855). Notices and descriptions of various reptiles, new or little known (part 2). *Journal of Asiatic Society of Bengal, Calcutta* 23(3): 287–302 (1854).

Boulenger, G.A. (1893). *Catalogue of the Snakes in the British Museum*. (Natural History), London (Taylor & Francis), 448 pp.

Burbrink, F.T., R. Lawson, & J.B. Slowinski (2000). Mitochondrial DNA phylogeography of the polytypic North American Rat Snake *Elaphe obsoleta*: a critique of the subspecies concept. *Evolution* 54(6): 2107–2118.

Chandramouli, S.R., P. Karthik, R.S. Naveen, S. Babu, P.V. Karunakaran & H.N. Kumara (2021). A Two-colored Forestsnake, *Smithophis bicolor* (Blyth 1855) (Reptilia: Natricidae), from the Khasi Hills, Meghalaya, India. *Reptiles & Amphibians* 28(1): 24–25. https://doi.org/10.17161/randa.v28i1.15285

Das, A., V. Deepak, A. Captain, E.O. Wade & D.J. Gower (2020). Description of a new species of *Smithophis* Giri et al. 2019 (Serpentes: Colubridae: Natricinae) from Arunachal Pradesh, India. *Zootaxa* 4860(2): 267–283. https://doi.org/10.11646/zootaxa.4860.2.8

Das, I., R.K.L. Tron, D. Rangad & R.N. Hooroo (2010). A new species of *Leptolalax* (Anura: Megophryidae) from the sacred groves of Mawphlang, Meghalaya, north-eastern India. *Zootaxa* 2339(1): 44–56. https://doi.org/10.11646/zootaxa.2339.1.2

Datta-Roy, A., I. Das, A.M. Bauer, R.K.L. Tron & P. Karanth (2013). Lizard wears shades. A spectacled *Sphenomorphus* (Squamata: Scincidae), from the sacred forests of Mawphlang, Meghalaya, north-east India. *Zootaxa* 3701(2): 257–276. https://doi.org/10.11646/zootaxa.3701.2.7

Edgar, R.C. (2004). MUSCLE: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Research* 32: 1792–1797. https://doi.org/10.1093/nar/gkh340

Giri, V.B., R. Chaitanya, S. Mahony, S. Lalrounga, C. Lalrinchhana, A. Das, V. Sarkar, P. Karanth & V. Deepak (2019). On the systematic status of the genus *Oriocalotes* Günther, 1864 (Squamata: Agamidae: Draconinae) with the description of a new species from Mizoram state, northeast India. *Zootaxa* 4638(4): 451–484. https://doi.org/10.11646/zootaxa.4638.4.1

Giri, V.B., V. Deepak, A. Captain, A. Das, S. Das, K.P. Rajkumar, R.L. Rathish & D.J. Gower (2017). A new species of *Rhabdops* Boulenger, 1893 (Serpentes: Natricinae) from the northern Western Ghats region of India. *Zootaxa* 4319(1): 27–52. https://doi.org/10.11646/zootaxa.4319.1.2

Giri, V.B., D.J. Gower, A. Das, H.T. Lalremsanga, S. Lalronunga, A. Captain & V. Deepak (2019). A new genus and species of natricine snake from northeast India. *Zootaxa* 4603: 241–264. https://doi.org/10.11646/zootaxa.4603.2.2

Kalyaanamoorthy, S., B.Q. Minh, T.K. Wong, A.V. Haeseler & L.S. Jermiin (2017). ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* 14: 587–589. https://doi.org/10.1038/nmeth.4285

Kamei, R.G., D.J. Gower, M. Wilkinson & S.D. Biju (2013). Systematics of the caecilian family Chikilidae (Amphibia: Gymnophiona) with the description of three new species of *Chikila* from northeast India. *Zootaxa* 3666(4): 401–435. http://doi.org/10.11646/zootaxa.3666.4.1

Kumar, S., G. Stecher & K. Tamura (2016). MEGA7: molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution* 33: 1870–1874. https://doi.org/10.1093/molbev/msw054

Lanfear, R., P.B. Frandsen, A.M. Wright, T. Senfeld & B. Calcott (2017). PartitionFinder 2: new methods for selecting partitioned models of evolution for molecular and morphological phylogenetic analyses. *Molecular Biology and Evolution* 34: 772–773. https://doi.org/10.1093/molbev/msw260

Mahony, S., R.G. Kamei, E.C. Teeling & S.D. Biju (2018). Cryptic diversity within the *Megophrys major* species group (Amphibia: Megophryidae) of the Asian Horned Frogs: phylogenetic perspectives and a taxonomic revision of south Asian taxa, with descriptions of four new species. *Zootaxa* 4523(1): 1–96. https://doi.org/10.11646/zootaxa.4523.1.1

Mahony, S., R.G. Kamei, E.C. Teeling & S.D. Biju (2020). Taxonomic review of the Asian horned frogs (Amphibia: Megophrys Kuhl & Van Hasselt) of northeast India and Bangladesh previously misidentified as *M. parva* (Boulenger), with descriptions of three new species. *Journal of Natural History* 54(1–4): 119–194. https://doi.org/10.1080/00222933.2020.1736679

Mahony, S., S. Sengupta, R.G. Kamei & S.D. Biju (2011). A new low altitude species of *Megophrys* Kuhl and van Hasselt (Amphibia: Megophryidae), from Assam, northeast India. *Zootaxa* 3059: 36–46. https://doi.org/10.11646/zootaxa.3059.1.2

Mahony, S., E.C. Teeling & S.D. Biju (2013). Three new species of

Horned Frogs, *Megophrys* (Amphibia: Megophryidae), from northeast India, with a resolution to the identity of *Megophrys boettgeri* populations reported from the region. *Zootaxa* 3722(2): 143–169. https://doi.org/10.11646/zootaxa.3722.2.2

Minh B.Q., M.A.T. Nguyen & A.V. Haeseler (2013). Ultrafast approximation for phylogenetic bootstrap. *Molecular Biology and Evolution* 30: 1188–1195. https://doi.org/10.1093/molbev/mst024

Mirza, Z.A., V.K. Bhardwaj, J.C. Lalmuanawma, G. Choure, H.T. Lalremsanga, M. Vabeiryureilai, A. Captain, A. Zagade & H. Patel (2024a). A new species of *Smithophis* Giri et al. 2019 from the Indo-Burma Region. *Diversity* 16(8): 480. https://doi.org/10.3390/d16080480

Mirza, Z.A., S. Pattekar, S. Verma, B.L. Stuart, J. Purkayastha, P.P. Mohapatra & H. Patel (2024b). A new Long-snouted Vine Snake species in the genus Ahaetulla Link, 1807 (Colubridae: Chrysopeleinae) from India. *Journal of Asia-Pacific Biodiversity* 17(4): 696–703. https://doi.org/10.1016/j.japb.2024.04.017

Nguyen, L.T., H.A. Schmidt, A. Von Haeseler & B.Q. Minh (2015). IQ-TREE: a fast and effective stochastic algorithm for estimating maximum likelihood phylogenies. *Molecular Biology and Evolution* 32: 268–274. https://doi.org/10.1093/molbev/msu300

Purkayastha, J. & M. Matsui (2012). A new species of *Fejervarya* (Anura: Dicroglossidae) from Mawphlang, northeastern India. *Asian Herpetological Research* 3(1): 31–37. https://doi.org/10.3724/SP.J.1245.2012.00031

Purkayastha, J., S.C. Bohra & M. Das (2020a). First record of the Urban Bent-toed Gecko, *Cyrtodactylus urbanus* Purkayastha, Das, Bohra, Bauer, and Agarwal 2018 (Squamata: Gekkonidae), from Meghalaya, India. *ICRF Reptiles & Amphibians Conservation and Natural History* 27(3): 512–513. https://doi.org/10.17161/randa.v27i3.14901

Purkayastha, J., M. Das, S.C. Bohra, A.M. Bauer & I. Agarwal (2020b). Another new *Cyrtodactylus* (Squamata: Gekkonidae) from Guwahati, Assam, India. *Zootaxa* 4732(3): 375–392. https://doi.org/10.11646/zootaxa.4732.3.2

Purkayastha, J., H.T. Lalremsanga, S.C. Bohra, L. Biakzuala, H. Decemson, L. Muansanga, M. Vabeiryureilai, S. Chauhan & Y.S. Rathee (2021). Four new Bent-toed Geckos (*Cyrtodactylus* Gray: Squamata: Gekkonidae) from northeast India. *Zootaxa* 4980(3): 451–489. https://doi.org/10.11646/zootaxa.4980.3.2

Purkayastha, J., H.T. Lalremsanga, B. Litho, Y.S. Rathee, S.C. Bohra, M. Vabeiryureilai, L. Biakzuala & L. Muansanga (2022). Two new *Cyrtodactylus* (Squamata, Gekkonidae) from northeast India. *European Journal of Taxonomy* 794: 111–139. https://doi.org/10.5852/ejt.2022.794.1659

Rathee, Y.S., J. Purkayastha, H.T. Lalremsanga, S. Dalal, L. Biakzuala, L. Muansanga & Z.A. Mirza (2022). A new cryptic species of Green Pit Viper of the genus *Trimeresurus* Lacépède, 1804 (Serpentes, Viperidae) from northeast India. *PLoS One* 17(5): e0268402. https://doi.org/10.1371/journal.pone.0268402

Tamura, K. & M. Nei (1993). Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Molecular Biology and Evolution* 10: 512–526. https://doi.org/10.1093/oxfordjournals.molbev.a040023

Vogel, G., Z. Chen, V. Deepak, D.J. Gower, J. Shi, L.I. Ding & M. Hou (2020). A new species of the genus *Smithophis* (Squamata: Serpentes: Natricidae) from southwestern China and northeastern Myanmar. *Zootaxa* 4803(1): 51–74. https://doi.org/10.11646/zootaxa.4803.1.3

Threatened Taxa

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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26814–26823

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9137.17.4.26814-26823

#9137 | Received 09 May 2024 | Final received 27 March 2025 | Finally accepted 03 April 2025

OPEN ACCESS

ARTICLE

Diversity and distribution of fish in rivers Chinnar and Thenar and their tributary, southern Western Ghats, Tamil Nadu, India

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Abstract: The diversity and distribution of fishes were studied in the Chinnar and Thenar rivers of the Cauvery River basin of Anamalai Hills. A total of 14 sampling sites were randomly selected in this region, and fish sampling was carried out from April 2017 to May 2018. The high species diversity was recorded in downstream site 11, Thenar River (H' = 3.14), and low diversity was observed in upstream site 3, Chinnar River (H' = 1.64). Thirty-seven species of primary freshwater fishes belonging to four orders, 11 families, and 21 genera were recorded. The order Cypriniformes, with 26 species, dominate the fish assemblages (70.27%), followed by Perciformes with six species (16.21%), Siluriformes with four species (10.81%), and Synbranchiformes with one species (2.70%), respectively. Among the Cyprinids, *Devario aequipinnatus, Barilius getensis*, and *Garra mullya* had the highest local dominance (32% each) in this river's cape. The only one exotic species, *Oreochromis mossambicus,* was recorded at downstream sites of Amaravathi River. Among the recorded species, about 43% of fish species are endemic to the Western Ghats, seven species are listed as threatened, five as endangered, and two are vulnerable, according to the IUCN Red List.

Keywords: Anamalai Hills, Cypriniformes, conservation, freshwater fish diversity, habitat diversity, hill stream fishes, riverine ecosystem, River Amaravathi.

Editor: Hitesh Kardani, Kamdhenu University, Gandhinagar, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Kumar K.M., T.A. Karthika & K. Anvar (2025). Diversity and distribution of fish in rivers Chinnar and Thenar and their tributary, southern Western Ghats, Tamil Nadu, India. *Journal of Threatened Taxa* 17(4): 26814–26823. https://doi.org/10.11609/jott.9137.17.4.26814-26823

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interests: The authors declare no competing interests.

Ethical approval: The handling and testing of individual animals were carried out as per the guidelines of the Committee for Control and Supervision of Experiments on Animals (CPCSEA) and the Tamil Nadu Forest Department. No additional ethical approval was necessary because no invasive technique was used.

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Author contributions: KMK—conceptualization, methodology, data curation, writing – original draft, validation, supervision, review & editing. TAK—methodology, sample collection, validation, review & editing. KA—methodology, sample collection, validation, review & editing.

Acknowledgements: The authors sincerely thank the Tamil Nadu Forest Department for granting permission and providing necessary support to carry out this study in the Anamalai Tiger Reserve. We express our gratitude to the field staff and forest guards for their assistance during fieldwork.

INTRODUCTION

Freshwater habitats and species are one of the most endangered ecosystems in the world due to the growing demand for freshwater supply (Vörösmarty et al. 2010; Shukla & Bhat 2017; Tickner et al. 2020). Freshwater species are declining at a faster rate than terrestrial or marine counterparts, and native fishes are the worst affected among the aquatic organisms (Miqueleiz et al. 2022). Fish diversity is important to any aquatic environment as they deliver essential fish resources for human survival and long-term development (Gordon et al. 2018; Cheng et al. 2019). More than 1,000 species of fish are reported from the inland water bodies (Chandran et al. 2019), and 340 freshwater fish species have been reported from the Western Ghats (Thampy et al. 2021). Many freshwater habitats are under extensive human disturbance, leading to habitat loss and degraded aquatic habitats. Several freshwater fish species are now critically endangered in India (Kunda et al. 2022). Thus, understanding the fish diversity, distribution and ecological significance of the species of a particular area is essential for its conservation. The present study aims to document fish diversity in the Chinnar and Thenar rivers in the Anamalai Tiger Reserve. Historical documentation of fish species from this region is available from the 1950's. Silas (1951) recorded fish species from Anamalai and Nelliyampathy Hills. Later, Thomas et al. (1999) reported Chinnar and Pambar River fishes, followed by Rema Devi et al. (2005) with fishes of Anamalai Hill. The river habitats of Chinnar and Thenar have been highly modified since then due to activities of residing local communities. As a result, the status of many species residing in the rivers Chinnar and Thenar is not known.

MATERIALS AND METHODS

Study Area

The study area is located between 10.333–10.142 ^{0}N and 77.058–77.256 ^{0}E in the perennial rivers, Chinar, Thenar and their tributaries, in Anamalai Hills of southern Western Ghats. A good riparian vegetation cover, including herbs, shrubs, and trees, is usually found along the study streams. There are seven tribal settlements located along the Chinnar and Thenar rivers, which directly and indirectly depend on these rivers. The rivers, Chinnar and Thenar, flow eastwardly and form the Amaravathi River of the Cauvery River basin.

Sample Collection

Fish samples were collected from 14 sites using a cast net, gill net, and dragnet depending on the habitat from the Chinnar, Thenar, and Amaravathi rivers (Figure 1, Table 1). The samples were collected in both the pre- and post-rainy seasons at daytime (0700–1700) seasonally from April 2017 to May 2018. Each fish specimen was collected and preserved in 10% formalin to identify the species. Before preservation, each species was photographed with its original colour. The species were appropriately identified based on the keys provided in various taxonomic literature (Talwar & Jhingran 1991; Jayaram 2010). Most of the fish were measured in the field, individuals were counted and released back to the river. They were measured to the nearest millimetre to identify and study the taxonomical characters correctly.

Statistical Analysis

Fish species recorded from each site were subjected to different diversity analyses (Shannon index, Simpson's evenness index, Margalef species richness index, Berger Parker dominance index, and equitability index) (Chandran et al. 2019). Further, the fish abundance data were used to create a dendrogram based on the Bray-Curtis similarity index. All statistical analyses were performed using PAST (PAleontological Statistics) software, version 4.13 (Hammer et al. 2001; Chandran et al. 2019).

RESULTS

The Thenar and Chinnar rivers are perennial and converge to form the Amaravathi river, enabling fish to migrate through both rivers. Consequently, 14 sites were randomly selected across these rivers for the study. Thirty-seven species of freshwater fishes belonging to four orders, 11 families, and 21 genera were recorded from the 14 sampling locations in Chinnar and Thenar rivers. The fish species recorded from the study area are presented in Table 2. Image 1 shows the photographs of the fish species recorded at the study sites. Among the recorded fish species of Cypriniformes, 26 species have demonstrated the highest dominance among the order (70.27%), followed by Perciformes with six species (16.21%) and the catfish order Siluriformes accounting for four species (10.81%) (Figure 2). The Cyprinidae family of fish species has 12 species that have shown the most dominance, followed by the Danionidae eight species, Nemacheilidae with four species and the Bagridae with three species. Among the families, Cyprinidae (32.43%),

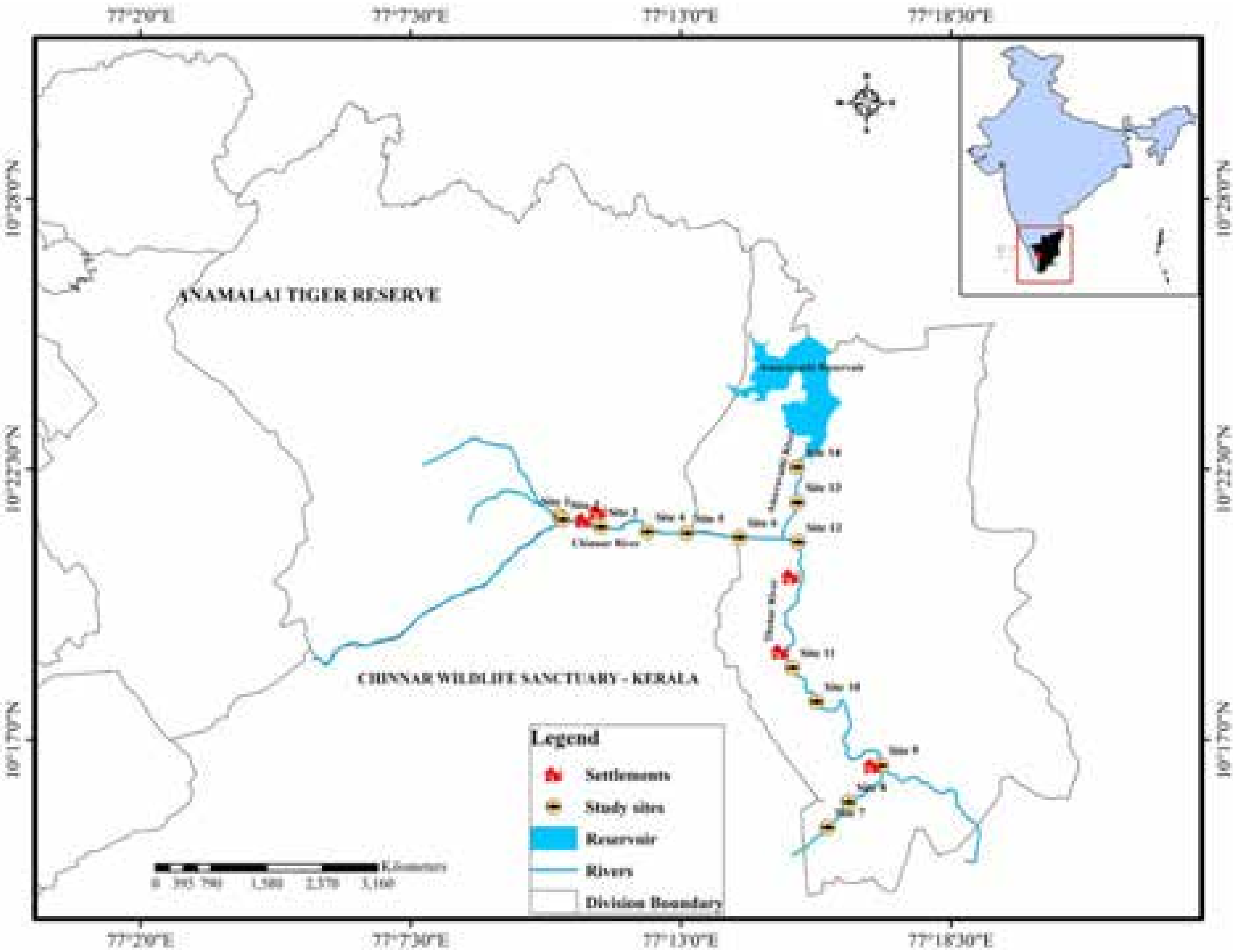

Figure 1. Study area and fish sampling site map.

Danionidae (21.62%), Nemacheilidae (10.81%), Bagridae (8.11%), Ambassidae (5.41%), Channidae (5.41%), and Balitoridae (2.70%) were the most species-rich (Figure 2). Furthermore, among the 14 study sites of the Chinnar and Thenar river systems, the maximum Shannon-Wiener index, and Margalef index of species diversity and richness was recorded in site 11 (H' = 3.139; S = 32), and low diversity and richness was recorded in site 3 (H' = 1.639; S = 6). The maximum species abundance of 820 was recorded at site 5, and minimum abundance of 106 was recorded at site 13. The maximum dominance (D = 0.262) was recorded at site 4, while the dominance was low in site 11 (D = 0.053). The maximum evenness (E = 0.937) was recorded at site 7, and the minimum evenness (E = 0.528) at site 4 (Table 3). A summary of fish assemblage structure in the Chinnar and Thenar Rivers is presented in Table 4. During this study, the following endemic and threatened fish species were recorded from the study area: *Haludaria fasciata*, *Haludaria melanampyx*, *Hypselobarbus dubius, Tor khudree, Tor*

Table 1. Stream type and altitude of the different sampling sites in the study area.

Location	Rivers	Stream type	Altitude (m)
Site 1	Chinnar	Upstream	644.95
Site 2	Chinnar	Upstream	623.92
Site 3	Chinnar	Upstream	549.85
Site 4	Chinnar	Upstream	488.89
Site 5	Chinnar	Upstream	474.87
Site 6	Chinnar	Downstream	455.98
Site 7	Thenar	Upstream	799.79
Site 8	Thenar	Upstream	723.90
Site 9	Thenar	Upstream	669.95
Site 10	Thenar	Midstream	583.99
Site 11	Thenar	Downstream	574.85
Site 12	Thenar	Downstream	449.88
Site 13	Amaravathi	Downstream	430.98
Site 14	Amaravathi	Downstream	381.00

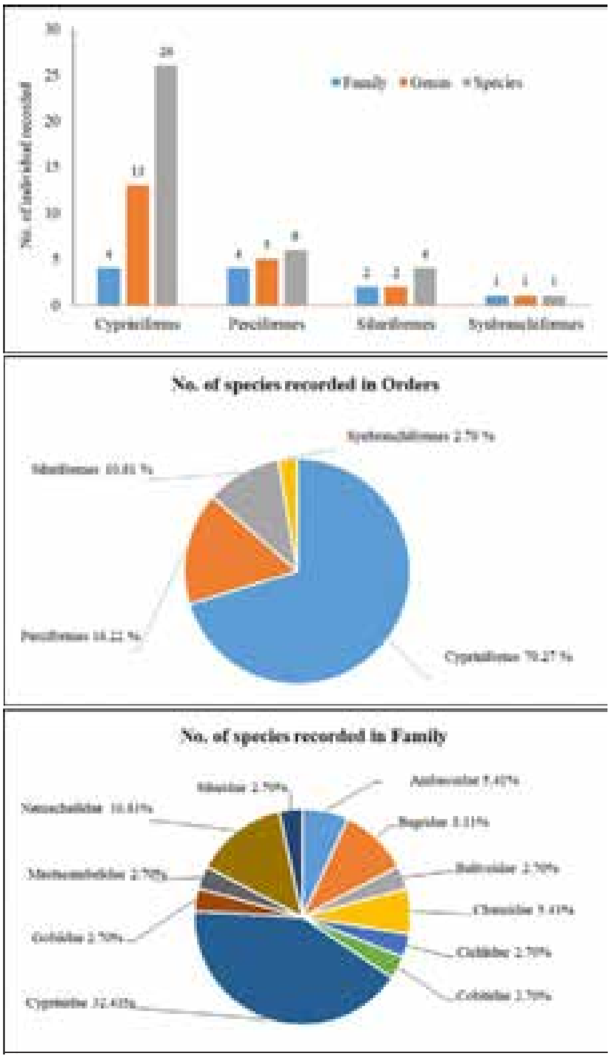

Figure 2. The bar chart diagram: a—representation of fishes in different orders, families and species among the Figure | b—total number of species richly order of total species in the 14 sites | c—percentage of species number of the most species-rich families to the total species in the 14 sites.

remadevii, Barilius gatensis, Devario aequipinnatus, *Garra mullya*, *Bhavania australis*, and *Nemacheilus rueppelli*. In addition, *Oreochromis mossambicus*, an exotic species, was also recorded. Almost 43% of fish species recorded within the research area are endemic to the Western Ghats, and only one introduced species was recorded during the period Table 4.

DISCUSSION

Fish are crucial to the continued life of aquatic habitats. They serve as a reliable gauge of ecological health. Additionally, they act like keystone species that significantly influence both their environment and other species (Whitfield & Elliott 2022). The Amaravathi river basin (river Chinnar and Thenar and their tributaries), being a perennial water source, supports a high diversity of fish species, but, in some parts of the sampled area, the diversity is very low because the area is prone to disturbance and contamination by the local people and introduced exotic fish species (Gibson et al. 1996; Sarkar et al. 2010; Joshi et al. 2021). Maximum species richness was recorded at site 11, followed by site 6 of midstream and downstream habitat. *Haludaria fasciata, Haludaria melanampyx, Barilius gatensis, Devario aequipinnatus, Garra mullya,* and *Nemacheilus rueppelli* were recorded in all study locations. Earlier work on the river Pambar of Chinnar Wildlife Sanctuary recorded 15 species in and around protected areas; among the species, eight are endemic to the Western Ghats (Thomas et al. 1999).

Along with the global problem of climatic changes, many species, especially endemic species, are also currently threatened by a number of human activities (Giannetto & Innal 2021). Sixteen species, such as *Haludaria fasciata, Haludaria melanampyx, Barbodes carnaticus, Salmostoma boopis, Tor malabaricus, Hypselobarbus mussullah, Hypselobarbus dubius, Barilius gatensis, Garra mcclellandi, Garra hughi, Garra stenorhynchus, Bhavania australis, Nemacheilus monilus, Nemacheilus rueppelli, Nemacheilus semiarmatus,* and *Nemacheilus guentheri* are endemic out of 37 species recorded in the survey (Dayal et al. 2014; https://www.iucnredlist.org 2024). It was reported that 59 species belong to Anamalai Hills region (Rema Devi et al. 2005), of which 30 are new additions to the Indira Gandhi Wildlife Sanctuary and 20 to the Nelliampathi Hill, including one new species. Fish diversity was recorded at around 69 species compared to the previous study. Biju et al. (1999) recorded 41 species in Kerala's Palakkad District, in a valley between the Anamalai and Nelliampathi Hill ranges of the Parambikulam Wildlife Sanctuary and the Chalakudy River system. Silas (1951) listed 10 species of fish from Neliampathi Hills and 25 species of fish from Anamalai Hills and their research expanded the range of several species that were previously restricted to the southern Western Ghats beyond the Palghat Gap.

Big barbs and mahseers, such as *Labeo calbasu*, *Puntius sarana*, *Hypselobarbus dobsoni*, *H. curmuca*, *H. dubius*, *H. dobsoni*, *Tor khudree*, and *Tor malabaricus*, were only permitted in large, deep pools (Arunachalam 2000). Furthermore, threatened and endemic species viz., *Barbodes carnaticus, Hypselobarbus mussullah, Hypselobarbus dubius, Tor khudree,* and *Tor malabaricus* were reported in the deep pools in the study area at sites

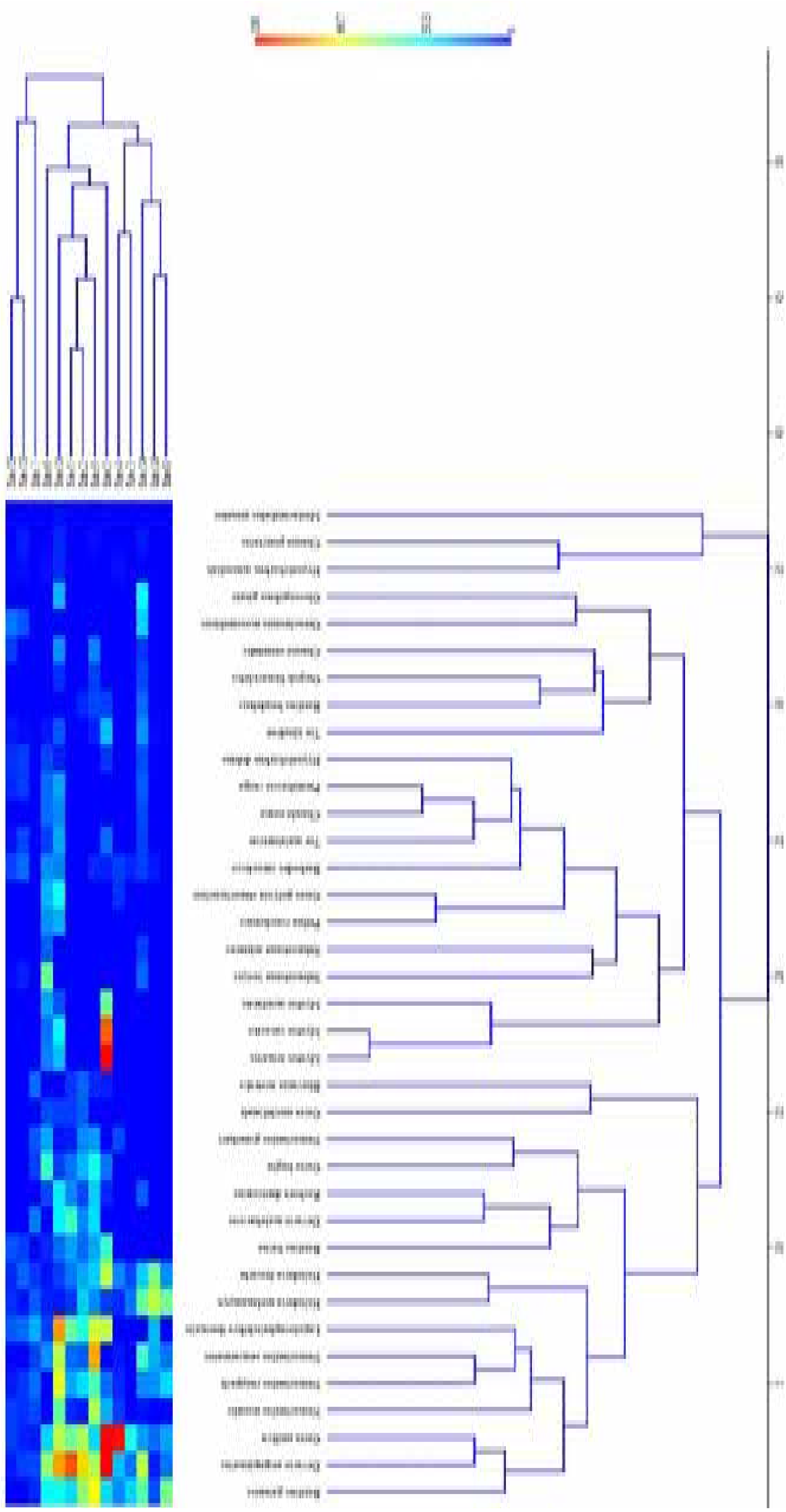

Figure 3. Dendrogram showing Bary-Curtis similarities between the study sites.

Table 2. Status of the fish species recorded from river Chinnar, Thenar, and Amaravathi.

	Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14
1	*Haludaria fasciata*	15	22	9	18	58	2	7	19	27	49	8	13	5	27
2	*Haludaria melanampyx*	7	27	15	5	8	4	12	48	18	58	3	2	6	47
3	*Pethia conchonius*	0	0	0	0	0	19	0	0	0	0	23	0	0	0
4	*Barbodes carnaticus*	0	0	5	8	4	19	0	0	5	3	17	14	9	8
5	*Salmostoma boopis*	0	0	0	0	0	47	0	0	0	0	0	4	1	13
6	*Salmostoma acinaces*	0	0	0	0	0	12	0	0	0	0	0	0	0	8
7	*Tor malabaricus*	0	0	0	0	14	8	0	0	0	0	22	9	2	8
8	*Tor khudree*	0	0	0	0	25	3	0	0	4	1	11	1	3	19
9	*Hypselobarbus mussullah*	0	0	0	2	0	2	0	0	0	0	5	2	1	0
10	*Hypselobarbus dubius*	0	0	0	0	7	9	0	0	0	0	4	8	6	10
11	*Barilius bendelisis*	0	5	0	0	8	0	0	0	9	0	0	0	0	14
12	*Barilius gatensis*	29	52	28	18	29	33	5	49	67	10	35	0	0	45
13	*Barilius barna*	21	14	0	0	41	5	0	0	22	0	14	8	11	0
14	*Devario malabaricus*	41	18	0	0	0	0	16	0	29	0	32	0	0	0
15	*Devario aequipinnatus*	89	72	15	25	109	53	9	15	56	4	79	8	3	58
16	*Rasbora daniconius*	18	9	0	0	5	9	0	0	27	0	31	0	0	12
17	*Garra mullya*	48	55	36	98	159	28	3	21	29	14	57	4	8	21
18	*Garra mcclellandi*	8	12	0	0	0	9	0	0	0	0	8	0	0	0
19	*Garra hughi*	15	24	0	0	15	41	8	0	36	0	8	0	0	0
20	*Garra gotyola stenorhynchus*	0	0	0	6	0	24	0	0	0	0	35	0	0	0
21	*Bhavania australis*	7	13	0	0	4	0	14	0	5	0	0	0	0	0
22	*Nemacheilus monilis*	5	3	0	8	23	0	9	0	56	0	46	6	8	2
23	*Nemacheilus rueppelli*	22	29	0	5	14	0	14	28	43	19	63	7	3	18
24	*Nemacheilus semiarmatus*	14	12	0	3	0	19	8	15	78	23	57	0	0	41
25	*Nemacheilus guentheri*	3	18	0	9	0	22	11	0	20	0	2	0	0	0
26	*Lepidocephalichthys thermalis*	47	38	0	0	59	8	23	0	60	24	80	14	12	0
27	*Mystus armatus*	0	0	0	0	102	17	0	0	0	0	25	0	0	0
28	*Mystus cavasius*	0	0	0	0	88	15	0	0	0	0	32	0	0	0
29	*Mystus montanus*	0	0	0	0	47	22	0	0	0	0	11	0	0	0
30	*Chanda nama*	0	0	0	0	0	14	0	0	0	0	18	0	0	9
31	*Parambassis ranga*	0	0	0	0	0	14	0	0	0	0	21	8	5	12
32	*Oreochromis mossambicus*	0	0	0	0	0	0	0	0	0	0	0	11	15	28
33	*Glossogobius giuris*	0	0	0	0	0	0	0	0	0	0	24	0	0	33
34	*Channa orientalis*	0	0	0	0	0	0	0	0	17	0	19	0	8	7
35	*Channa punctatus*	0	0	0	0	0	0	0	0	2	0	5	4	0	3
36	*Ompok bimaculatus*	0	0	0	0	0	0	0	0	8	0	6	0	0	9
37	*Mastacembelus armatus*	0	0	0	0	1	0	0	0	0	0	2	0	0	0

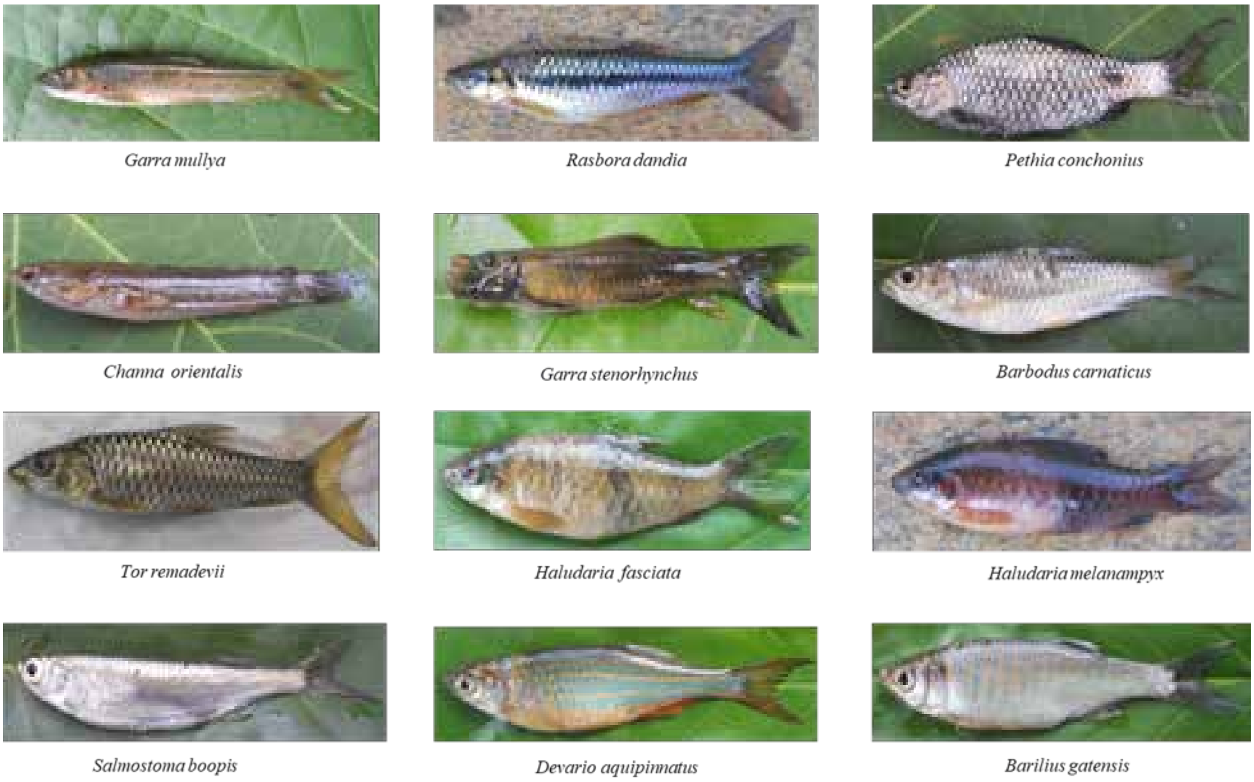

Image 1. Some fish species recorded from the Chinnar and Thenar rivers. © K. Mahesh Kumar.

5, 6, 10, 11, 12, 13, and 14, respectively. The richness of fish species in hill streams at higher elevations varies with altitude. As a result, species diversity decreases with increasing altitude, due to the fact that altitude has a considerable impact on species diversity (Johnson & Arunachalam 2009; Zhang et al. 2016). According to the Bary-Curtis similarity cluster analysis, there were two distinct clusters in the species composition of the research site basin. Whereas the remaining sites made up a different cluster, sites 12, and 13 downstream areas were divided into one cluster. Based on the cluster analysis sites 6 and 11, which were found to be the most species-rich sites. These sites 6 and 11, with richness 26 and 32, respectively, are located downstream, which is the main reason for their species richness. The frequently recorded species at these sites were *Devario aequipinnatus*, *Garra mullya*, *Barilius gatensis*, *Haludaria fasciata*, *Nemacheilus rueppelli*, *Nemacheilus semiarmatus*, *Haludaria fasciata*, *Haludaria melanampyx*, and *Lepidocephalichthys thermalis* (Table 3, Figure 3).

Midstream and downstream areas contained records of *Chanda nama*, *Parambassis ranga*, and *Glossogobius giuris*. Only in the middle of the Thenar River basin species like *Channa orientalis* and *Channa punctatus*, *Ompok bimaculatus* found frequently close to dam sites of downstream. *Mastacembelus armatus* was sampled near the middle and downstream of rocky habitats (Sokheng et al. 1999), while *Mystus* sp. was only discovered in a few locations of the hill stream (Rahman 1989). The three species *Pethia conchonius*, *Salmostoma boopis*, and *Salmostoma acinaces* are most prevalent at site 6, where the rivers Pambar and Chinnar join. In slow-moving sand and gravel habitats like mid and downstream areas, loaches such as *Nemacheilus* sp., *Bhavania australis*, and *Lepidocephalichthys thermalis* (Pethiyagoda 1991) were observed during the study. Around the world, exotic fish have been purposefully introduced for biological control, ornamental uses, and competitive fishing (Valero 2010). Introduced species such as *Cyprinus carpio communis* were reported in the previous study (Thomas et al. 1999) but not recorded during the survey, and *Oreochromis mossambicus* has been sighted in the downstream lowland areas in the present study. *Oreochromis mossambicus* was first introduced as an aquaculture object at the same time as commercial consumption. The extraordinary extinction of native species suggests that these invasive fish now make up the majority of the fish population (Xie et al. 2005).

Overfishing is increasingly believed to be the cause

Table 3. Variation in diversity factors along the different sites of rivers Chinnar and Thenar.

Factor / Site	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14
Richness	16	17	6	12	21	26	13	7	21	10	32	17	17	23
Abundance	389	423	108	205	820	458	139	195	618	205	803	123	106	452
Dominance index	0.1104	0.08952	0.2188	0.2626	0.1014	0.05838	0.08737	0.173	0.07297	0.1757	0.0532	0.06917	0.07296	0.06732
Shannon-Weiner diversity index	2.452	2.596	1.637	1.845	2.547	3.016	2.5	1.848	2.77	1.933	3.139	2.733	2.707	2.885
Simpson Evenness index	0.7256	0.7886	0.8566	0.5275	0.608	0.7851	0.9374	0.9064	0.7601	0.6914	0.721	0.9048	0.8816	0.7785
Margalef richness index	2.515	2.646	1.068	2.066	2.981	4.08	2.432	1.138	3.112	1.691	4.635	3.325	3.431	3.598
Equitability index	0.8843	0.9162	0.9136	0.7426	0.8366	0.9258	0.9748	0.9495	0.9099	0.8397	0.9056	0.9647	0.9555	0.9201

of the decline in freshwater biodiversity (Raghavan et al. 2011). Many such issues affecting the riparian forest, which directly influence the fish population are also a concern and threat in the region under study. In the Western Ghats, it was found that fish was the primary and most convenient source of animal food for indigenous people (Prajith et al. 2016). Fishing is usually a part-time activity for tribal women. Most people depend on fishing for their livelihood throughout the year. Fishing by poisoning the water with vegetable matter (*Curcuma augustifolia*) is being practised regularly and must be restricted (Kamalkishor & Kulkarni 2006). If indigenous species are not given considerable attention, they are more susceptible to environmental change, and threats to their habitat can result in their extinction (Giannetto & Innal 2021). In the very near future, indiscriminate fishing may result in the complete extinction of some freshwater fish species, particularly endangered species like *Tor khudree* and *Hypselobarbus dubius* (Radhakrishnan & Roshni 2024). A quantitative sustainable management and development programme should be carried out to ensure the availability of species, which are essential and on which the entire local communities depend socially and economically.

CONCLUSION

Protecting and maintaining the riparian habitats in these regions, especially by preventing forest fires, is essential. Raising awareness among forest-dwelling communities about the ecological significance of these valuable species is crucial, with a focus on discouraging harmful practices such as poisoning. Additionally, creating educational freshwater fish aquariums can foster greater awareness among schools and the public. The study identified 37 fish species in the Chinnar and Thenar rivers and their tributaries, with 43% being endemic to the Western Ghats. These ecologically and economically valuable species underscore the importance of continued conservation efforts in the region.

REFERENCES

Arunachalam, M. (2000). Assemblage structure of stream fishes in the Western Ghats (India). *Hydrobiologia* 430: 1–31. https://doi.org/10.1023/A:1004080829388

Biju, C.R., K.R. Thomas & C.R. Ajithkumar (1999). Ecology of hill streams of Western Ghats with special reference to fish communities. Final Report. Bombay Natural History Society, Mumbai, India, 203 pp.

Chandran, R., L.K. Tyagi, A.K. Jaiswar, S. Raizada, S. Mandal, T.S. Mayekar, A.S. Bisht, S.K. Singh & W.S. Lakra (2019). Diversity and distribution of fish fauna in the Ib River, a tributary of Mahanadi, India.

Table 4. Fish species recorded from river Chinnar, Thenar, and Amaravathi indicating the status.

	Taxon	Name of the species	Western Ghats endemic status	IUCN status
1	Order: Cypriniformes	*Haludaria fasciata*	Endemic	LC
2	Family: Cyprinidae	*Haludaria melanampyx*	Endemic	DD
3		*Pethia conchonius*	Non-endemic	LC
4		*Barbodes carnaticus*	Endemic	LC
5		*Salmostoma boopis*	Endemic	LC
6		*Salmostoma acinaces*	Non-endemic	LC
7		*Tor khudree*	Non-endemic	EN
8		*Tor remadevii*	Endemic	EN
9		*Hypselobarbus mussullah*	Endemic	EN
10		*Hypselobarbus dubius*	Endemic	EN
11		*Barilius bendelisis*	Non-endemic	LC
12		*Barilius gatensis*	Endemic	LC
13		*Barilius barna*	Non-endemic	LC
14		*Devario malabaricus*	Non-endemic	LC
15		*Devario aequipinnatus*	Non-endemic	LC
16		*Rasbora dandia*	Non-endemic	LC
17		*Garra mullya*	Non-endemic	LC
18		*Garra mcclellandi*	Endemic	LC
19		*Garra hughi*	Endemic	EN
20		*Garra stenorhynchus*	Endemic	LC
21	Family: Balitoridae	*Bhavania australis*	Endemic	LC
22	Family: Nemacheilidae	*Nemacheilus monilis*	Endemic	LC
23		*Nemacheilus rueppelli*	Endemic	LC
24		*Nemacheilus semiarmatus*	Endemic	LC
25		*Nemacheilus guentheri*	Endemic	LC
26	Family: Cobitidae	*Lepidocephalichthys thermalis*	Non-endemic	LC
27	Order: Siluriformes	*Mystus armatus*	Non-endemic	LC
28	Family: Bagridae	*Mystus cavasius*	Non-endemic	LC
29		*Mystus montanus*	Non-endemic	LC
30	Family: Siluridae	*Ompok bimaculatus*	Non-endemic	NT
31	Order: Perciformes	*Chanda nama*	Non-endemic	LC
32	Family: Ambassidae	*Parambassis ranga*	Non-endemic	LC
33	Family: Cichlidae	*Oreochromis mossambicus*	Introduced	VU
34	Family: Gobiidae	*Glossogobius giuris*	Non-endemic	LC
35	Family: Channidae	*Channa orientalis*	Non-endemic	VU
36		*Channa punctatus*	Non-endemic	LC
37	Order: Synbranchiformes	*Mastacembelus armatus*	Non-endemic	LC
	Family: Mastacembelidae			

Based on Dayal et al. (2014) | https://www.iucnredlist.org: CR—Critically Endangered | EN—Endangered | VU—Vulnerable | NT—Near Threatened | LC—Least Concern | DD—Data Deficient and endemic status level.

Indian Journal of Fisheries 66(1): 92–98. https://doi.org/10.21077/ijf.2019.66.1.70958-12

Cheng D., X. Zhao, J. Song, H. Sun, S. Wang, H. Bai & Q. Li (2019). Quantifying the distribution and diversity of fish species along elevational gradients in the Weihe River basin, northwest China. *Sustainability* 11(21): 6177. https://doi.org/10.3390/su11216177

Dayal, R., S.P. Singh, U.K. Sarkar, A.K. Pandey, A.K. Pathak & R. Chaturvedi (2014). Fish biodiversity of Western Ghats region of India: a review. *Journal of Experimental Zoology* 17(2): 377–399.

Giannetto, D. & D. Innal (2021). Status of endemic freshwater fish fauna inhabiting major lakes of Turkey under the threats of climate change and anthropogenic disturbances: a review. *Water* 13(11): 1534. https://doi.org/10.3390/w13111534

Gibson, G.R., M.T. Barbour, M. Stribling, J. Gerritsen & J.R. Karr (1996). *Biological Criteria: Technical Guidance for Streams and Small Rivers.* Revised edition. University of Washington, WA, 162 pp.

Gordon, T.A.C., H.R. Harding, F.K. Clever, I.K. Davidson, W. Davison, D.W. Montgomery, R.C. Weatherhead, F.M. Windsor, J.D. Armstrong, A. Bardonnet, E. Bergman, J.R. Britton, I.M. Côté, D. D'agostino, L.A. Greenberg, A.R. Harborne, K.K. Kahilainen, N.B. Metcalfe, S.C. Mills, N.J. Milner, F.H. Mittermayer, L. Montorio, S.L. Nedelec, J.M. Prokkola, L.A. Rutterford, A.G.V. Salvanes, S.D. Simpson, A. Vainikka, J.K. Pinnegar & E.M. Santos (2018). Fishes in a changing world: learning from the past to promote sustainability of fish populations. *Journal of Fish Biology* 92: 804–827. https://doi.org/10.1111/jfb.13546

Hammer, O., D.A.T. Harper & P.D. Ryan (2001). PAST: Paleontological Statistic software package for education and data analysis. *Paleontol Eletron* 4(1): 1–9. http://palaeoelectronica.org/2001_1/past/issue1_01.htm

Jayaram, K.C. (1999). *The Freshwater Fishes of the Indian Region*. Narendra Publishing House, New Delhi, xxvii + 551 pp.

Jayaram, K.C. (2010). *The Freshwater Fishes of Indian Region, 2nd Edition*. Narendra Publications, New Delhi. 119 pp.

Johnson, J.A. & M. Arunachalam (2009). Diversity, distribution and assemblage structure of fishes in streams of Southern Western Ghats, India. *Journal of Threatened Taxa* 1(10): 507–513. https://doi.org/10.11609/JoTT.o2146.507-13

Joshi, K.D., V.S. Basheer, A. Kumar, S.M. Srivastava, V. Sahu & K.K. Lal (2021). Alien fish species in open waters of India: appearance, establishment and impacts. *Indian Journal of Animal Sciences* 91(3): 167–173. https://doi.org/10.56093/ijans.v91i3.114139

Kamalkishor, H.N. & K.M. Kulkarni (2009). Fish stupefying plants used by the Gond tribal of Mendha Village of central India.

Kunda, M., D. Ray, D. Pandit & A. Harun-Al-Rashid (2022). Establishment of a fish sanctuary for conserving indigenous fishes in the largest freshwater swamp forest of Bangladesh: A community-based management approach. *Heliyon* 8(e09498): 1–13. https://doi.org/10.1016/j.heliyon.2022.e09498

Margalef, R. (1958). Temporal succession and spatial heterogeneity in phytoplankton, pp. 323–347. In: Buzzati-Traverso (Ed.), *Perspectives in Marine Biology*. University of California Press, Berkeley.

Menon, A.G.K. (1992). The fauna of the adjacent countries. Pisces. Vol. IV. Teleodtei-Cobitoidae. Part 2 Cobitatidae. ZSI, Madras, 600 pp.

Miqueleiz, I., R. Miranda, A.H. Ariño & T. Cancellario (2022). Effective reassessments of freshwater fish species: a case study in a Mediterranean peninsula. *Hydrobiologia* 849: 1339–1349. https://doi.org/10.1007/s10750-021-04644-4.

Pethiyagoda, R. (1991). *Freshwater Fishes of Sri Lanka*. The Wildlife Heritage Trust of Sri Lanka, Colombo, 362 pp.

Prajith, K.K., M.P. Remesan & L. Edwin (2016). Traditional wisdom of fishing techniques and rituals of Kuruman Tribe of Wayanad, Western Ghats. *Asian Agri-History* 20(2): 119–126.

Radhakrishnan, R.C. & K. Roshni (2024). Finfish harvest trends in the Chalakudy River within the Western Ghats biodiversity hotspot in the southwest of India: Finfish harvest trends in the Chalakudy River. *Sustainable Aquatic Research* 3(2): 107–126. https://doi.org/10.5281/zenodo.13341671

Raghavan R., A. Ali, N. Dahanukard & A. Rossera (2011). Is the Deccan Mahseer, *Tor khudree* (Sykes, 1839) (Pisces: Cyprinidae) fishery in the Western Ghats Hotspot sustainable? A participatory approach to stock assessment. *Fisheries Research* 110(1): 29–38. https://doi.org/10.1016/j.fishres.2011.03.008

Rahman, A.K.A (1989). *Freshwater Fishes of Bangladesh*. Zoological Society of Bangladesh. Department of Zoology, University of Dhaka, 364 pp.

Devi, K.D., T.J. Indra, M.B. Ragunathan & M.S. Ravichandran (2005). Fish fauna of Anamalai Hill ranges, Western Ghats, India. *Zoos' Print Journal* 20(3): 1809–1811. https://doi.org/10.11609/JoTT.ZPJ.1164a.1809-11

Sarkar, U.K., B.K. Gupta & W.S. Lakra (2010). Biodiversity, eco hydrology, threat status and conservation priority of freshwater fishes of river Gomti, a tributary of river Ganga (India). *Environmentalist* 30: 3–17. https://doi.org/10.1007/s10669-009-9237-1

Shannon, C.E. & W. Wiener (1963). *The Mathematical Theory of Communication*. Urbana, IL: University of Illinois Press, 127 pp.

Shukla, R. & A. Bhat (2017). Environmental drivers of α-diversity patterns in monsoonal tropical stream fish assemblages: a case study from tributaries of Narmada Basin, India. *Environmental Biology Fish* 100: 749–761. https://doi.org/10.1007/s10641-017-0601-6

Silas, A.G. (1951). On a collection of fish from the Anamalai and Nelliampathi Hill ranges (Western Ghats) with notes on its zoogeographical significance. *Journal of Bombay Natural History and Society* 49(4): 670–681.

Simpson, G.G. (1949). Measurement of diversity. *Nature* 136: 688.

Sokheng, C., C.K. Chhea, S. Viravong, K. Bouakhamvongsa, U. Suntornratana, N. Yoorong, N.T. Tung, T.Q. Bao, A.F. Poulsen & J.V. Jørgensen (1999). Fish migrations and spawning habits in the Mekong mainstream: a survey using local knowledge (basin-wide). Assessment of Mekong fisheries: Fish Migrations and Spawning and the Impact of Water Management Project (AMFC). AMFP Report 2/99. Vientiane, Lao, P.D.R.

Talwar, P.K. & A.G. Jhingran (1991). *Inland Fishes of India and Adjacent Countries, Vol. I & II*. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 507 pp.

Tickner, D., J.J. Opperman, R. Abell, M. Acreman, A.H. Arthington, S.E. Bunn, S. J. Cooke, J. Dalton, W. Darwall, G. Edwards, I. Harrison, K. Hughes, T. Jones, D. Leclère, A.J. Lynch, P. Leonard, M.E. Mcclain, D. Muruven, J.D. Olden, S.J. Ormerod, J. Robinson, R.E. Tharme, M. Thieme, K. Tockner, M. Wright & L. Young (2020). Bending the curve of global freshwater biodiversity loss: an emergency recovery plan. *BioScience* 70(4): 330–342. https://doi.org/10.1093/biosci/biaa002

Thampy, D.R., M.R. Sethu, M.B. Paul & C.P. Shaji (2021). Ichthyofaunal diversity in the upper-catchment of Kabini River in Wayanad part of Western Ghats, India. *Journal of Threatened Taxa* 13(2): 17651–17669. https://doi.org/10.1016/j.heliyon.2022.e09498

Thomas, R.K., C.R. Biju & C.R. Ajithkumar (1999). Additions to the fish fauna of Pambar River, Kerala. *Journal of the Bombay Natural History Society* 96(2): 332–334.

Valero, A. (2010). *Mating Interference Due to Introduction of Exotic Species,* pp. 412–415. In: Breed, M.D. & J. Moore (eds.). *Encyclopedia of Animal Behavior*. Academic Press Inc.(London) Ltd., 2672 pp.

Vörösmarty, C.J., P.B. McIntyre & M.O. Gessner (2010). Global threats to human water security and river biodiversity. *Nature* 467: 555–561. https://doi.org/10.1038/nature09549

Whitfield, A.K. & M. Elliott (2022). Fishes as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future. *Journal of Fish Biology* 61 (Supplement A): 229–250. https://doi.org/10.1111/j.1095-8649.2002.tb01773.x

Xie, L.Q., P. Xie, L.G. Guo, L. Li, Y. Miyabara & H.D. Park (2005). Organ distribution and bioaccumulation of microcystins in freshwater fish at different trophic levels from the eutrophic lake Chaohu, China. *Environmental Toxicology* 20(3): 293–300. https://doi.org/10.1002/tox.20120

Zhang, W., D. Huang, R. Wang, J. Liu & N. Du (2016). Altitudinal patterns of species diversity and phylogenetic diversity across temperate mountain forests of northern China. *PLOS ONE* 11(7): e0159995. https://doi.org/10.1371/journal.pone.0159995

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26824–26849

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9403.17.4.26824-26849

#9403 | Received 04 September 2024 | Final received 04 March 2025 | Finally accepted 27 March 2025

ARTICLE

Diversity and habitat preferences of butterflies (Insecta: Lepidoptera) in Dzongu, Mangan, Sikkim, India

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Abstract: The butterfly diversity of the Dzongu region of Mangan District, Sikkim was assessed between 2016 and 2024, revealing the presence of 420 species from 187 genera and six families. Nymphalidae emerged as the dominant family with 165 species across 68 genera, followed by the Lycaenidae with 92 species from 51 genera, Hesperiidae with 84 species from 44 genera, Papilionidae with 38 species from eight genera, Pieridae with 32 species from 13 genera, and Riodinidae with nine species from three genera. A total 118 butterfly species that were protected under the Indian Wildlife (Protection) Amendment Act, 2022, with the majority falling under Schedule II. Very rare documents included *Papilio krishna*, *Teinopalpus imperialis*, *Meandrusa lachinus*, *Stichophthalma camadeva*, *Euaspa pavo*, *Ionolyce helicon*, *Dodona adonira*, and *Koruthaialos butleri*, the state butterfly of Sikkim *Bassarona durga* and the newly discovered species, *Zographetus dzonguensis*. A total of 194 butterfly species exclusive to the northeastern region of India were documented. It was found that the sub-tropical hill forest supported the highest butterfly diversity with 395 species recorded, and the sub-alpine forest supported the lowest diversity with 13 species. The unique geographical features of Dzongu support a wide variety of butterfly species and the presence of more than half the species in Sikkim underscores the importance of prioritizing conservation efforts in this unique valley.

Keywords: Butterfly species, comprehensive checklist, field survey, Hesperiidae, Lycaenidae, northeastern India, northern Sikkim, Nymphalidae, Papilionidae, Pieridae, richness, Riodinidae.

Nepali: सिक्किमको मङ्गन जिल्लाको जोङ्गु क्षेत्रको पुतली विविधताको मूल्याङ्कन 2016 र 2024 को बीचमा गरिएको थियो, जसमा 187 वंश र छ परिवारका 420 प्रजातिहरूको उपस्थिति पत्ता लागेको थियो। निम्फालिडे 68 वंशमा 165 प्रजातिहरू सहित प्रमुख परिवारको रूपमा देखा परेका थिए, त्यसपछि 51 वंशबाट 92 प्रजातिहरू सहित लाइकेनिडे, 44 वंशबाट 84 प्रजातिहरू सहित हेस्पेरिडे, आठ वंशबाट 38 प्रजातिहरू सहित प्यापिलियोनिडे, 13 वंशबाट 32 प्रजातिहरू सहित पिएरिडे, र तीन वंशबाट नौ प्रजातिहरू सहित रियोडिनिडे रहेका थिए। भारतीय वन्यजन्तु (संरक्षण) संशोधन एक्ट, 2022 अन्तर्गत संरक्षित कुल 118 पुतली प्रजातिहरू, जसमध्ये धेरैजसो अनुसूची II अन्तर्गत पर्दछन्। धेरै दुर्लभ दस्तावेजहरूमा *Papilio krishna, Teinopalpus imperialis, Meandrusa lachinus, Stichophthalma camadeva, Euaspa pavo, Ionolyce helicon, Dodona adonira, Koruthaialos butleri* र सिक्किमको राज्य पुतली *Bassarona durga* र नयाँ पत्ता लागेको प्रजाति, *Zographetus dzonguensis* समावेश थिए। भारतको उत्तरपूर्वी क्षेत्रमा मात्र रहेका 194 पुतली प्रजातिहरूको अभिलेखीकरण गरिएको थियो। उप-उष्णकटिबंधीय पहाडी वनले 395 प्रजातिहरू रेकर्ड गरिएको उच्चतम पुतली विविधतालाई समर्थन गरेको पाइयो, र उप-अल्पाइन वनले 13 प्रजातिहरू रेकर्ड गरिएको सबैभन्दा कम विविधतालाई समर्थन गरेको पाइयो। जोङ्गुको अद्‌वितीय भौगोलिक विशेषताहरूले पुतली प्रजातिहरूको विस्तृत विविधतालाई समर्थन गर्दछ र सिक्किममा आधा भन्दा बढी प्रजातिहरूको उपस्थितिले यस अद्‌वितीय उपत्यकामा संरक्षण प्रयासहरूलाई प्राथमिकता दिनुको महत्त्वलाई जोड दिन्छ।

Editor: Meena Haribal, Ithaca, New York, USA.

Date of publication: 26 April 2025 (online & print)

Citation: Lepcha, S.W. & M.K. Thapa (2025). Diversity and habitat preferences of butterflies (Insecta: Lepidoptera) in Dzongu, Mangan, Sikkim, India. *Journal of Threatened Taxa* 17(4): 26824–26849. https://doi.org/10.11609/jott.9403.17.4.26824-26849

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interests: The authors declare no competing interests.

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Author contributions: SWL—conceptualization, data collection, fieldwork, paper review; MKT—conceptualization, data collection, paper review, data curation, formal analysis, methodology, writing—original draft and editing.

Acknowledgements: The authors are thankful to Sonam Pintso Sherpa and Nosang M. Limbu for their guidance, and Dr. Bharat Kumar Pradhan for your help. Special thanks to Mingdup Lepcha, Sonam Wangchuk Lepcha Jr., Lhendup Lepcha, Janukit Lepcha, Sonam Gyatso Lepcha, Dorjee Tshering Lepcha, Achintya P. Hazarika, Dawa Lepcha, Lhakpa Tshering Lepcha for continuous support and contributing few pictures of butterflies from Dzongu area.

INTRODUCTION

India is recognized as one of the 17 mega biodiversity countries globally, with northeastern India as a significant biodiversity hotspot. This region is further categorized into the northeastern hills, the eastern Himalaya, and the Brahmaputra Valley (Gogoi 2015). Sikkim, a small Himalayan State in northeastern India with a geographical area of 7,096 km², boasts an incredibly rich diversity of flora and fauna. It's unique geographical location, varied topography, fertile soil, ample rainfall, and numerous perennial streams make (Idrisi et al. 2010). Sikkim is considered one of the most biodiverse zones.

It is estimated that more than 40% of insect species are declining at a rate eight times faster than that of mammals, birds, and reptiles (Sánchez-Bayo & Wyckhuys 2019). The primary factors contributing to this decline include habitat loss, urbanization, pollution, pathogens or invasive species, and global climate change. Butterflies (Order: Lepidoptera), in particular, are regarded as excellent bio-indicators of environmental health due to their short life cycle and varied habitat needs and food preferences for activities such as mating, breeding, and nectaring. Their well-documented taxonomy, geographic distribution, and status make butterflies ideal subjects for biodiversity studies.

Globally, there are over 20,000 butterfly species (Happner 1998; Koneri et al. 2020), of which 1,502 species are found in India (Udaya et al. 2019). Remarkably, the state of Sikkim alone is home to approximately 700 of butterfly species (Haribal 1992; ENVIS 2015). Scant studies on butterfly diversity in northeastern India, the region's butterfly populations remain incompletely documented. Literature reveals that new species and previously unrecorded butterfly sightings are regularly being discovered and added to the list of butterflies in this northeastern region of India. Previous studies on the Lepidoptera fauna of the Sikkim Range in the eastern Himalaya date back to de Niceville's work from 1881–1885. In 1884, de Niceville provided an annotated overview of the state's fauna in a Gazetteer. Subsequent studies were carried out by Elwes (1882, 1888) and Dudgeon (1898, 1900–1901). Elwes (1888) compiled a catalogue of Sikkim's Lepidoptera, which was enhanced with additions, corrections, and distribution information by Otto Moeller (Maulik 2003). Haribal (1992) focused their work on lepidopteran species, especially butterflies, within the state. Gupta (2003) documented 155 species and subspecies of Nymphalid butterflies from Sikkim. Majumdar (2003) documented 227 butterfly species from the Pieridae and Hesperiidae families. The Hesperiidae family comprises the majority with 176 species, while the Pieridae family includes the remaining 51 species. Lepcha et al. (2021) recorded new distributional record for the *E. pavo* from Sikkim. Again, Lepcha et al. (2023) reported new distributional record of *Euaspa milionia* from the state in 2023. Lepcha (2023) published a guidebook on butterflies of Dzongu, which includes 368 species from the region in 2023. The primary aim of this paper is to compile a comprehensive checklist of butterflies in the Dzongu region, Mangan District of northern Sikkim, India.

MATERIALS AND METHODS

Study Area

The study was conducted to document the butterfly diversity in Dzongu, located in the Mangan District of northern Sikkim, India. Dzongu, roughly triangular in shape, is bounded by the Teesta River to the southeastern and the Talung River to the northeastern side. To the western side lies the southern part of the Himadri, or greater Himalayan ranges, where Mt. Kanchenjunga, the world's third-highest peak (at 8,598 m) is situated. Dzongu spans between 27.466–27.633 °N and 88.383–88.633 °E (Figure 1), with elevations ranging 700–6,000 m. The area covers a hilly terrain of 78 km^2 with dense forests (Purkayastha 2013).

The area boasts a unique and picturesque landscape of snow-clad mountains surrounded by steep, narrow valleys and gorges. The dense forest cover brings showers almost throughout the year. Bordering the Kanchenjunga Biosphere Reserve, Dzongu is also home to some of the ancient Buddhist monasteries and temples, adding cultural richness to its natural beauty. The geographical location of Dzongu isolates it from the rest of Sikkim. The area can be divided into three climatic zones: subtropical, temperate, and alpine, each rich in biodiversity.

Methods

The survey was designed with the primary objective of compiling a comprehensive checklist of butterflies from the Dzongu region in the Mangan District of northern Sikkim employing a range of established methodologies including the line transect method (Pollard 1977) and visual encounter survey (Heyer et al. 1994) to document butterfly species. These techniques ensured thorough habitat coverage.

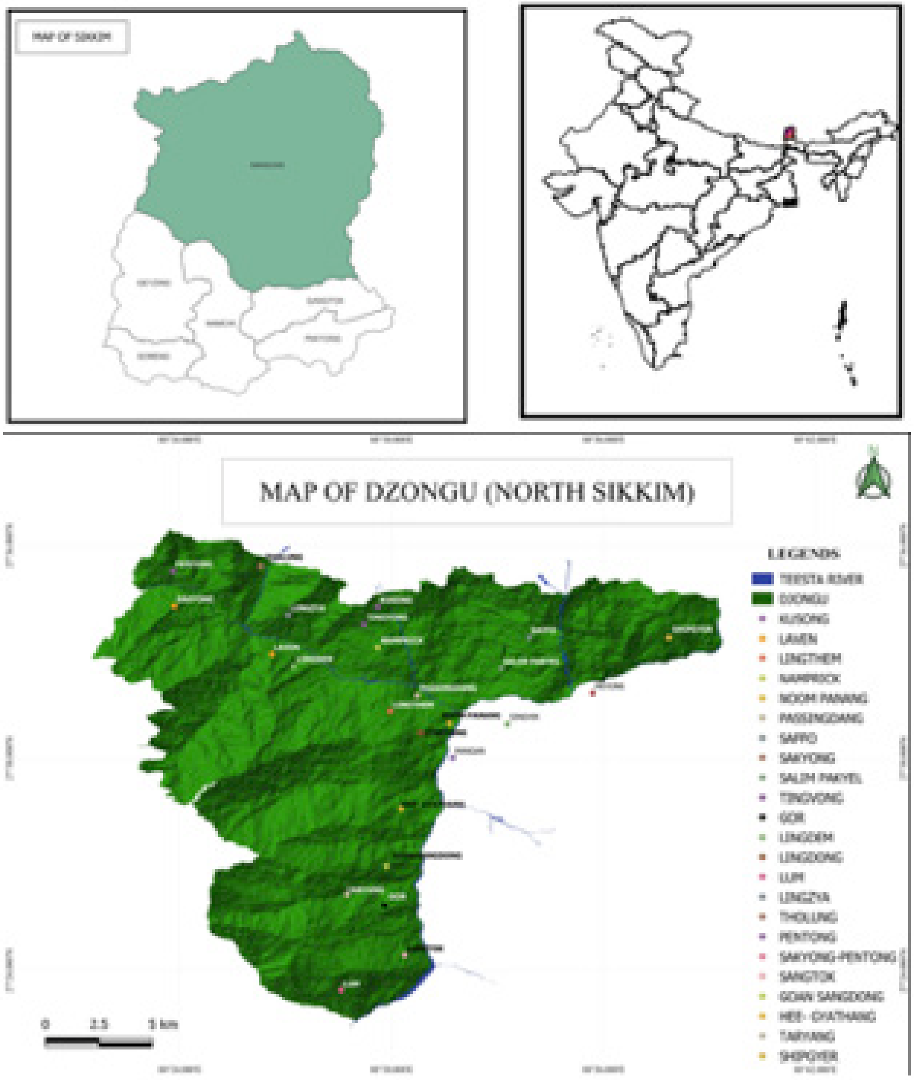


Figure 1. Map showing the study area in Dzongu, northern Sikkim, India.

Study design

The field survey was conducted over an extensive period of eight years, from 2016 to 2024. The year was divided into four distinct seasons: summer, monsoon, post-monsoon, and winter. Observations were meticulously carried out under favorable weather conditions, ensuring the absence of rain or strong winds. Data collection spanned eight hours each day, from 0600 to 1100 h and from 1400 to 1700 h. Field surveys were conducted five times during each season during the study period. As observation hours were allocated equally across all sampling sites, the total observation hrs per season were approximately consistent. To facilitate efficient data collection, the study area was divided into four habitat zones: tropical semi-evergreen forest (TSF), sub-tropical hill forest (STF), wet temperate forests (WTF) and sub-alpine forest (SAF) (Image 7). These zones were categorized based on the dominant vegetation types, and altitudine ranges as per Champion & Seth (1968).

Data collection and identification

During the fieldwork, data on all encountered butterflies were meticulously collected. Observations were conducted randomly along foot trails, stream and riverbeds, and grasslands bordering these areas. Photographic evidence was captured using a Canon D80 Camera. The survey was conducted across all forest habitats within the study area, spanning a total transect length of 35–40 km. Each transect path was monitored for butterfly records with a width of approximately 150 m on either side. Ten search paths were strategically chosen across different habitat types: three paths in tropical semi-evergreen forest (TSF) and sub-tropical hill forest (STF), and two paths in both wet temperate forest (WTF) and sub-alpine forest (SAF) habitats (Image 7). Adhering to conservation principles, no specimens were collected during the survey. A map of the study area (Figure 1) was created using Q-GIS software version 3.18, and data analysis was performed using Microsoft Office Excel 2007.

Species indentification was based on visual examination and color photographs, utilizing published guides for butterflies. Identification keys from Evans (1932), the photographic guide by Haribal (1992) and Kehimkar (2016), and the Butterflies of India website (https://www.ifoundbutterflies.org/) were employed.

RESULTS

The study identified a total of 420 butterfly species from 187 genera under 25 subfamilies and six families in Dzongu Valley, Mangan District of northern Sikkim (Table 1,2). Nymphalidae was the dominant family, represented by 68 genera and 165 species, followed by Lycaenidae with 51 genera and 92 species, Hesperiidae with 44 genera and 84 species, Papilionidae with eight genera and 38 species, Pieridae with 13 genera and 32 species, and Riodinidae with three genera and nine species (Table 1; Image 1–6). In total, 118 butterfly species are recognized as schedule species under the Wildlife (Protection) Amendment Act, 2022 (Anonymous 2022). Of these, 93 species are listed under Schedule II, while 25 species are included in Schedule I. The study also identified 194 species of endemic butterflies that are restricted to the northeastern region of India.

Diversity of butterflies in the study area

Nymphalidae showed the maximum species richness, comprising 39% with 165 species, followed by Lycaenidae (22% with 92 species), Hesperiidae (20% with 84 species), Papilionidae (9% with 38 species), Pieridae (8% with 32 species) and Riodinidae (2% with 9 species) (Figure 2). It was concluded that the Dzongu Valley is very rich in butterfly diversity.

Table 1. Family-wise composition of butterflies exhibiting the total number of genera and species in the study area.

	Family	Subfamily	Genera	Species
01	Papilionidae	01	08	38
02	Pieridae	02	13	32
03	Nymphalidae	12	68	165
04	Lycaenidae	06	51	92
05	Riodinidae	01	03	09
06	Hesperiidae	03	44	84
Total		25	187	420

Habitat types used by butterflies

Throughout the study, butterflies were observed across all four habitat types. It was found that the sub-tropical hill forest (STF) supported the highest diversity, with 395 species recorded. This was followed by TSF with 368 species, WTF with 168 species, and SAF with 13 species. Notably, SAF was not utilized by the Papilionidae and Hesperiidae families, while the other butterfly families were present across all four habitat types (Figure 3).

Comparative analysis of butterfly diversity of Sikkim and Dzongu

The study reveals a significant difference in species richness of Dzongu in comparison with Sikkim State. Dzongu, a small valley nestled in the northern part of Sikkim, is a remarkable region known for its rich biodiversity. The Dzongu Valley is home to an impressive total of 420 butterfly species, which comprises 60.95% of the entire butterfly species found in Sikkim. This high percentage highlights Dzongu as a significant biodiversity hotspot within the state, particularly in terms of Lepidoptera diversity.

The butterflies of Dzongu make up 60.95% of the total butterfly species in Sikkim.

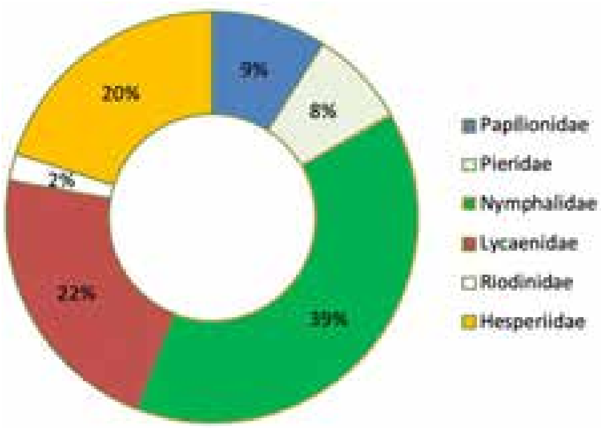


Figure 2. Family-wise distribution of butterflies from Dzongu, northern Sikkim, India.

Notes on selected species

1. *Papilio krishna* (Moore, 1858)
This butterfly is rare in Dzongu, observed in locations such as Ring Uung Kyoung, Tingvong, Laven, Passingdang, and Namprickdang. Occasionally, it was seen actively puddling with other butterflies.

2. *Teinopalpus imperialis* (Hope, 1843)
Two individuals were seen at Lingthem near Na-ar Uung Kyong and Gong-Lee in 2024. Both the individuals were seen during mud-puddling.

3. *Graphium paphus* (de Nicéville, 1886)
Graphium paphus, known as the Spectacle Swordtail, were seen in Ring Uung Kyoung, along the Rungyoung River belt, and in the Talong Chu River belt area in Dzongu.

4. *Meandrusa lachinus* (Fruhstorfer, 1902)
This species was observed in Lingthem and Laven, particularly in puddling areas near small river streams.

5. *Dercas lycorias* (Doubleday, 1842)
Commonly seen at Lingza waterfalls. Around 20–24 individuals were observed engaging in puddling behavior.

6. *Helcyra hemina* (Hewitson, 1864)
This butterfly was spotted first near Passingdang, mud puddling on roadside rocks. This species was noted for its high-speed flight. Another individual was seen again the following year in the same area, perched above tree leaves along the roadside.

7. *Calinaga gautama* (Moore, 1902)
First spotted at an elevation of 1,400 m in Panang Village near a villager's house. It was later observed at the Namprickdang riverside on wet stone puddling and again at Ring Uung Kyoung along the river belt with other butterflies.

8. *Bassarona durga* (Moore, 1858)
It is common in Dzongu, observed from lower to upper regions between June and October annually. It is often seen actively flying along roadsides, riverbelts, and in and around human habitats. This butterfly has been declared as the state butterfly of Sikkim on 5 June 2022, during World Environment Day.

9. *Euthalia franciae* (Gray, 1846)
This species has been recorded multiple times in Dzongu, particularly in areas such as Hee-Gyathang, Noam Panang, Passingdang, and Lingza. This species is especially active during the guava fruit season.

10. *Euthalia iva* (Moore, 1858)
Seen at Ring Uung Kyoung along the river belt, flying above short trees. It was also recorded at the Laven River belt and Passingdang along the roadside.

11. *Neurosigma siva* (Westwood, 1850)
Exclusively observed in upper Dzongu, particularly at Lingza Village and waterfall areas, as well as in the Bay area at elevations up to 2,200 m.

12. *Neptis manasa* (Moore, 1858)
Eight to nine individuals were observed in upper Dzongu, particularly between Mantam and Laven in roadside areas.

13. *Neptis nycteus* (de Nicéville, 1890)
Seen at Panang Village in human habitation. The butterfly was flying on top of trees.

14. *Stichophthalma camadeva* (Westwood, 1848)
The northern Jungle queen is frequently observed in the Noam Panang area, along roadsides in lower Dzongu, and even in upper Dzongu, particularly in bamboo forests. The number of sightings often exceeds 30–40 individuals annually.

15. *Lethe ramadeva* (de Nicéville, 1887)
Recorded at Lingthem, Ruklu, and Laven along roadside areas. Often seen basking.

16. *Lethe scanda* (Moore, 1858)
Three individuals were observed at distances from each other flying actively in Safo along the roadside area at an altitude above 1,925 m.

17. *Lethe gulnihal* (de Nicéville, 1887)
Lethe gulnihal was recorded for the first time in August 2024 from Saffo Village, Dzongu, at the elevation of 1,996 m. A total of five individuals were observed.

18. *Lethe serbonis* (Hewitson, 1876)
Three individuals were seen in the dense forest of the Talung area at elevations above 2,400 m.

19. *Lethe visrava* (Moore, 1866)
Commonly, seen in bamboo forest and forests of Noam Panang, Lingthem, Lingdem, and Laven.

20. *Neorina hilda* (Westwood, 1851)
Four individuals were observed in the dense forest of the Talung at elevations above 2,400 m.

21. *Lethe brisanda* (de Nicéville, 1886)
This butterfly occurred singularly among different areas in the densely forested Talung Valley (WTF).

22. *Iraota timoleon* (Stoll, 1790)
Two individuals were observed at the Passingdang Monastery.

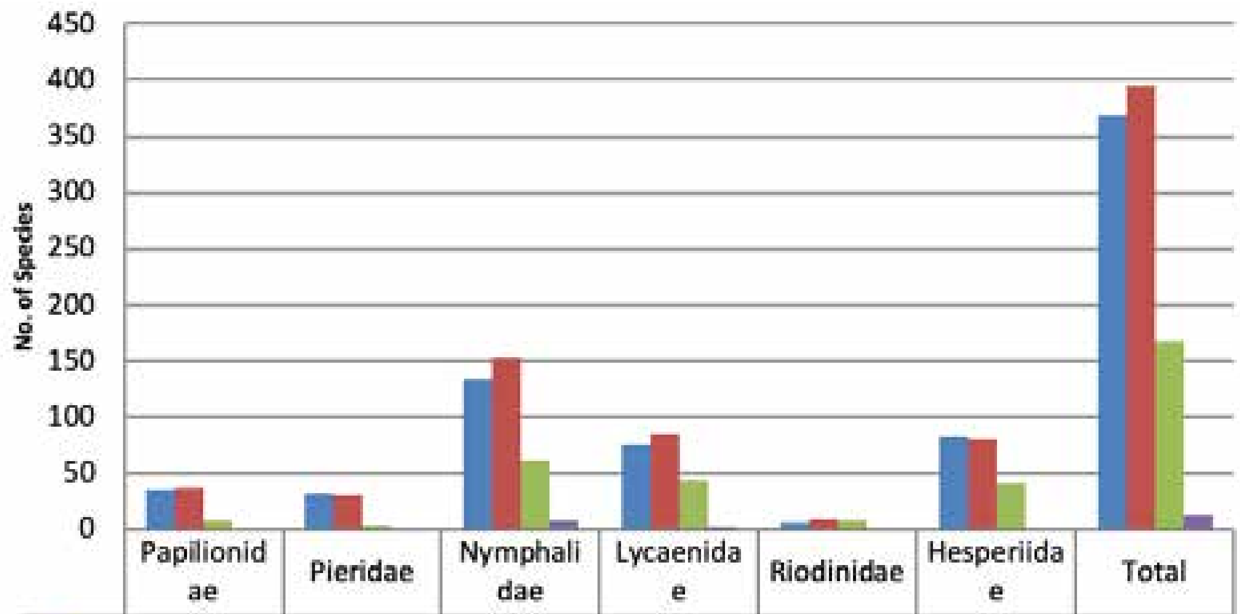
23. *Cigaritis rukma* (de Nicéville, 1889)
This species was observed at Laven, Lingza, Mantam, Passingdang, and Lingthem in open roadside or construction areas, with sightings typically involving multiple individuals.

24. *Cigaritis evansii* (Tytler, 1915)
Seen in Tingvong, Mantam, and Passingdang areas, primarily along open roadsides or in construction areas, often as multiple individuals.

25. *Euaspa milionia* (Hewitson, 1869)
The species was observed at Salim Pakyel, as it flew away high up into the trees.

26. *Dodona egeon* (Westwood, 1851)
This rare butterfly has been observed 15–17 times in Passingdang and Namprickdang, and 5–7 times at Mantam, Tingvong, and Laven, often along the roadside.

27. *Zographetus dzonguensis* Kunte et al. 2021
Zographetus dzonguensis, commonly known as the Chocolate-bordered Flitter, was first recorded in the Namprickdang area of upper Dzongu in 2016, with subsequent sightings in 2019 and 2020 during the months of September and October. In 2016, three individuals were observed; this number increased to



	Papilionidae	Pieridae	Nymphalidae	Lycaenidae	Riodinidae	Hesperiidae	Total
TSF	36	32	134	76	7	83	368
STF	37	30	153	86	9	80	395
WTF	8	4	62	44	8	42	168
SAF	0	1	8	3	1	0	13

Figure 3. Distribution of species among different habitats used by butterflies: TSF—tropical semi-evergreen forest | STF—sub-tropical hill forest | WTF—wet temperate forest | SAF—sub-alpine forest.

Table 2. Annotated list of butterflies recorded in Dzongu, northern Sikkim during the study period.

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
Family: Papilionidae **Subfamily: Papilioninae**					
1	*Graphium antiphates nebulosus*	Himalayan Five-bar Swordtail	TSF, STF		
2	*Graphium chironides chironides*	Darjeeling Veined Jay	TSF, STF		Endemic
3	*Graphium cloanthus cloanthus*	Himalayan Glassy Bluebottle	TSF, STF	SC II	
4	*Graphium doson axionides*	Himalayan Common Jay	TSF, STF		
5	*Graphium eurous sikkimica*	East Himalayan Six-bar Swordtail	TSF, STF		Endemic
6	*Graphium eurypylus acheron*	Indo-Chinese Great Jay	TSF, STF	SC II	Endemic
7	*Graphium macareus indicus*	East Himalayan Lesser Zebra	TSF, STF		Endemic
8	*Graphium paphus*	(Spectacle) Swordtail	TSF, STF		Endemic
9	*Graphium sarpedon sarpedon*	Oriental Common Bluebottle	TSF, STF	SC II	
10	*Graphium xenocles xenocles*	Great Zebra	TSF, STF		Endemic
11	*Graphium agamemnon agamemnon*	Oriental tailed Jay	TSF, STF		
12	*Papilio clytia*	Common Mime	TSF	SC II	
13	*Papilio agestor agestor*	East Himalayan Tawny Mime	TSF, STF		Endemic
14	*Papilio alcmenor alcmenor*	Khasi Red-breasted Mormon	TSF, STF		
15	*Papilio arcturus arcturus*	East Himalayan Blue Peacock	TSF, STF		Endemic
16	*Papilio bianor ganesa*	East Himalayan Common Peacock	TSF, STF, WTF		Endemic
17	*Papilio bootes janaka*	Himalayan- tailed Redbreast	TSF, STF	SC II	Endemic
18	*Papilio castor polias*	Himalayan Common Raven	TSF, STF		Endemic
19	*Papilio demoleus demoleus*	Northern Lime Butterfly	TSF, STF		
20	*Papilio epycides epycides*	Himalayan Lesser Mime	TSF, STF	SC II	Endemic
21	*Papilio helenus helenus*	Oriental Red Helen	TSF, STF		
22	*Papilio krishna krishna*	Himalayan Krishna Peacock	TSF, STF	SC I	Endemic
23	*Papilio chaon chaon*	Khasi Yellow Helen	TSF, STF		Endemic
24	*Papilio paris paris*	Chinese Paris Peacock	TSF, STF, WTF		
25	*Papilio polytes romulus*	Indian Common Mormon	TSF, STF		
26	*Papilio protenor euprotenor*	Himalayan Spangle	TSF, STF		
27	*Papilio janaka*	Red-banded Mormon	TSF, STF		
28	*Papilio agenor agenor*	Continental Great Mormon	TSF, STF, WTF		Endemic
29	*Meandrusa lachinus lachinus*	Himalayan Brown Gorgon	STF, WTF	SC II	Endemic
30	*Teinopalpus imperialis imperialis*	Himalayan Kaiser-i-Hind	STF	SC I	Endemic
31	*Atrophaneura adioneus*	Lesser Batwing	TSF, STF		
32	*Atrophaneura varuna*	Common Batwing	TSF, STF		
33	*Byasa dasarada dasarada*	East Himalayan Great Windmill	TSF, STF, WTF		Endemic
34	*Byasa latreillei latreillei*	Himalayan Rose Windmill	TSF, STF	SC II	
35	*Byasa polyeuctes polyeuctes*	Common Windmill	TSF, STF, WTF		Endemic
36	*Pachiopta aristolochiae aristolochiae*	Indian Common Rose	TSF, STF		
37	*Troides aeacus aeacus*	Khasi Golden Birdwing	TSF, STF, WTF	SC II	
38	*Troides helena cerberus*	Khasi Common Birdwing	TSF, STF, WTF		
Family: Pieridae **Subfamily: Coliadinae**					
39	*Catopsilia pomona pomona*	Oriental Lemon Emigrant	TSF, STF		
40	*Catopsilia pyranthe pyranthe*	Oriental Mottled Emigrant	TSF, STF		
41	*Colias fieldii fieldii*	Himalayan Dark Clouded Yellow	TSF, STF, WTF, CTF		

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
42	*Dercas lycorias lycorias*	Sylhet Plain Sulphur	TSF, STF, WTF	SC II	Endemic
43	*Dercas verhuelli doubledayi*	Indo-Chinese tailed Sulphur	TSF, STF, WTF		Endemic
44	*Eurema andersonii jordani*	Sikkim One-spot Grass Yellow	TSF, STF	SC II	
45	*Eurema blanda silhetana*	Sylhat Three-spot Grass Yellow	TSF, STF		
46	*Eurema brightta rubella*	Red-line Small Grass Yellow	TSF		
47	*Eurema hecabe hecabe*	Oriental Common Grass Yellow	TSF, STF		
48	*Eurema laeta laeta*	Indian Spotless Grass Yellow	TSF, STF		
49	*Eurema simulatrix sarinoides*	Changeable Grass Yellow	TSF		Endemic
50	*Gandaca harina assamica*	Assam Tree Yellow	TSF, STF		Endemic
Subfamily: Pierinae					
51	*Hebomoia glaucippe glaucippe*	Oriental Great Orange-tip	TSF, STF		Endemic
52	*Appias albina darada*	Common Albatross	TSF, STF	SC II	
53	*Appias indra indra*	Himalayan Plain Puffin	TSF, STF	SC II	Endemic
54	*Appias lalage lalage*	Himalayan Spot Puffin	TSF, STF		
55	*Appias lyncida eleonora*	Indo-Chinese Chocolate Albotross	TSF, STF	SC II	Endemic
56	*Belenois aurota aurota*	Indian Pioneer	TSF, STF		
57	*Cepora nadina nadina*	Khasi Lesser Gull	TSF, STF	SC II	Endemic
58	*Cepora nerissa nerissa*	Chinese Common Gull	TSF, STF		
59	*Delias acalis pyramus*	Himalayan Redbreast Jezebel	TSF, STF		
60	*Delias agostina agostina*	Sikkim Yellow Jezebel	TSF, STF		Endemic
61	*Delias belladonna ithiela*	Sikkim Hill Jezebel	TSF, STF		
62	*Delias descombesi descombesi*	Red-spot Jezebel	TSF, STF		Endemic
63	*Delias eucharis*	Indian Jezebel	TSF, STF		
64	*Delias hyparete indica*	Indian Painted Jezebel	TSF, STF		Endemic
65	*Delias pasithoe pasithoe*	Chinese Red-base Jezebel	TSF, STF		Endemic
66	*Delias sanaca bhutya*	Eastern Himalayan Pale Jezebel	TSF, STF	SC I	Endemic
67	*Pieris brassicae nepalensis*	Nepalese Large Cabbage White	TSF, STF, WTF		
68	*Pieris canidia indica*	Himalayan Cabbage White	TSF, STF		
69	*Pontia daplidice moorei*	Himalayan Bath White	TSF, STF		
70	*Ixias pyrene*	Yellow Orange-tip	TSF, STF		
Family: Nymphalidae **Subfamily: Danainae**					
71	*Danaus chrysippus chrysippus*	Orental Plain Tiger	TSF, STF		
72	*Danaus genutia genutia*	Oriental Striped Tiger	TSF, STF		
73	*Euploea core core*	Indian Common Crow	TSF, STF		
74	*Euploea mulciber mulciber*	Bengal Striped Blue Crow	TSF, STF		
75	*Parantica aglea melanoides*	Himalayan Glassy Tiger	TSF, STF		
76	*Parantica melaneus plataniston*	Himalayan Chocolate Tiger	TSF, STF		
77	*Parantica pedonga*	Pedong Tiger	TSF, STF		Endemic
78	*Parantica sita sita*	Himalayan Chestnut Tiger	TSF, STF		
79	*Tirumala limniace exoticus*	Oriental Blue Tiger	TSF, STF		
80	*Tirumala septentrionis septentrionis*	Oriential Dark Blue Tiger	TSF, STF		
Subfamily: Apaturinae					
81	*Euripus nyctelius nyctelius*	Courtesan	TSF, STF	SC II	Endemic
82	*Helcyra hemina hemina*	Indian White Emperor	TSF, STF	SC I	Endemic
83	*Herona marathus marathus*	Assam Pasha	TSF, STF	SC II	Endemic

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
84	*Hestinalis nama nama*	Sylhet Circe	TSF, STF, WTF		
85	*Mimathyma ambica ambica*	East Himalayan Purple Emperor	TSF, STF		
86	*Chitoria sordida sordida*	Sordid Emperor	TSF	SC II	Endemic
87	*Rohana parisatis parisatis*	Assam Black Prince	TSF, STF		
88	*Rohana parvata parvata*	Himalayan Brown Prince	STF, WTF	SC II	Endemic
89	*Sephisa chandra chandra*	Indian Eastern Courtier	TSF, STF, WTF	SC I	Endemic
Subfamily: Biblidinae					
90	*Ariadne merione tapestrina*	Intricate Common Castor	TSF, STF		
Subfamily: Calinaginae					
91	*Calinaga gautama*	Elongated Freak	TSF, STF		Endemic
Subfamily: Charaxinae					
92	*Charaxes bernardus hierax*	Variable Tawny Rajah	TSF, STF	SC II	
93	*Charaxes bharata*	Indian Nawab	TSF, STF		
94	*Charaxes dolon centralis*	Himalayan Stately Nawab	TSF, STF	SC II	Endemic
95	*Charaxes eudamippus eudamippus*	Himalayan Great Nawab	TSF, STF		
96	*Charaxes marmax marmax*	Yellow Rajah	TSF, STF	SC II	
Subfamily: Cyrestinae					
97	*Chersonesia risa risa*	Oriental Common Maplet	TSF, STF		
98	*Cyrestis thyodamas thyodamas*	Oriental Map Butterfly	TSF, STF		Endemic
Subfamily: Heliconiinae					
99	*Acraea issoria issoria*	Himalayan Yellow Coster	TSF, STF, WTF		
100	*Cethosia biblis tisamena*	Himalayan Red Lacewing	TSF, STF, WTF	SC II	Endemic
101	*Cethosia cyane cyane*	Bengal Leopard Lacewing	TSF, STF		
102	*Argynnis childreni childreni*	Himalayan Large Silverstripe	TSF, STF		
103	*Argynnis hyperbius hyperbius*	Chinese Tropical Fritillary	TSF, STF, WTF		
104	*Issoria issaea*	Himalayan Queen Fritillary	STF, WTF		
105	*Cirrochroa aoris aoris*	Himalayan Large Yeoman	TSF, STF		Endemic
106	*Phalanta phalantha*	Oriental Common Leopard	TSF, STF		
107	*Vindula erota erota*	Cruiser	TSF, STF		Endemic
Subfamily: Libytheinae					
108	*Libythea lepita lepita*	Himalayan Common Beak	TSF, STF	SC II	
109	*Libythea myrrha sanguinalis*	Ochreous Club Beak	TSF, STF		
Subfamily: Limenitidinae					
110	*Abrota ganga ganga*	Assam Sergeant-major	TSF, STF		Endemic
111	*Bassarona durga durga*	Himalayan Blue Duke	TSF, STF	SC I	Endemic
112	*Euthalia aconthea garuda*	Himalayan Common Baron	TSF, STF	SC II	
113	*Euthalia alpheda jama*	Himalayan Streaked Baron	TSF, STF		Endemic
114	*Euthalia franciae franciae*	Himalayan French Duke	TSF, STF, WTF	SC II	Endemic
115	*Euthalia iva iva*	Himalayan Grand Duke	TSF, STF	SC I	Endemic
116	*Euthalia lubentina lubentina*	Chinese Gaudy Baron	TSF, STF		
117	*Euthalia monina kesava*	Assam Powdered Baron	TSF, STF		Endemic
118	*Euthalia nara nara*	Himalayan Bronze Duke	TSF, STF, WTF	SC II	Endemic
119	*Euthalia phemius phemius*	Sylhet White-edged Blue Baron	TSF, STF		Endemic
120	*Euthalia sahadeva sahadeva*	Chinese Green Duke	TSF, STF, WTF		Endemic
121	*Euthalia saitaphernes saitaphernes*	Himalayan Spotless Baron	TSF, STF		Endemic
122	*Euthalia telchinia*	Blue Baron	TSF, STF	SC I	Endemic

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
123	*Neurosigma siva siva*	Sylhet Panther	STF, BTF	SC II	Endemic
124	*Tanaecia julii appiades*	Changeable Common Earl	TSF, STF		
125	*Athyma cama cama*	Himalayan Orange Staff Sergeant	TSF, STF		
126	*Athyma inara inara*	Colour Sergeant	TSF		
127	*Athyma jina jina*	Bhutan Sergeant	TSF, STF	SC I	Endemic
128	*Athyma orientalis*	Elongated Sergeant	TSF, STF, WTF		
129	*Athyma ranga ranga*	Himalayan Blackvein Sergeant	TSF, STF	SC II	Endemic
130	*Athyma selenophora bahula*	Sylhet Staff Sergreant	TSF, STF		Endemic
131	*Athyma zeroca zeroca*	Khasi Small Staff Sergeant	TSF, STF		
132	*Auzakia danava danava*	Indian Commodore	TSF, STF, WTF	SC II	
133	*Moduza procris procris*	Oriental Commander	TSF, STF, WTF		
134	*Parasarpa dudu dudu*	Sylhet White Commodore	TSF, STF, WTF	SC II	Endemic
135	*Parasarpa zayla zayla*	Himalayan Bicolor Commodore	TSF, STF, WTF		Endemic
136	*Sumalia daraxa daraxa*	Sylhet Green Commodore	TSF, STF, WTF		Endemic
137	*Sumalia zulema*	Scarce White Commodore	STF, WTF	SC I	Endemic
138	*Neptis ananta ochracea*	East Himalayan Yellow Sailer	TSF, STF, WTF		Endemic
139	*Neptis cartica cartica*	Himalayan Plain Sailer	TSF, STF		Endemic
140	*Neptis clinia susruta*	Himalayan Sullied Sailer	TSF, STF	SC II	Endemic
141	*Neptis hylas varmona*	Indian Common Sailer	TSF, STF		
142	*Neptis manasa manasa*	Himalayan Pale Hockeystick Sailer	TSF, STF, WTF	SC II	Endemic
143	*Neptis nata adipala*	Khasi Clear Sailer	TSF, STF		Endemic
144	*Neptis nycteus nycteus*	Sikkim Hockeystick Sailer	STF, WTF	SC I	Endemic
145	*Neptis pseudovikasi*	False Dingy Sailer	TSF, STF		
146	*Neptis radha radha*	Himalayan Great Yellow Sailer	TSF, STF	SC II	
147	*Neptis sankara amba*	East Himalayan Broad-banded Sailer	TSF, STF	SC II	Endemic
148	*Neptis sappho astola*	Himalayan Rusty Sailer	TSF, STF		
149	*Neptis soma soma*	Sylhet Creamy Sailer	TSF, STF	SC II	Endemic
150	*Neptis zaida bhutanica*	East Himalayan Pale Green Sailer	TSF, STF	SC II	
151	*Pantoporia hordonia hordonia*	Oriental Common Lascar	TSF, STF		
152	*Pantoporia paraka paraka*	Oriental Perak Lascar	TSF, STF		Endemic
153	*Phaedyma columella*	Short-banded Sailer	TSF, STF	SC II	
Subfamily: Pseudergolinae					
154	*Dichorragia nesimachus nesimachus*	Himalayan Constable	TSF, STF		
155	*Pseudergolis wedah wedah*	Himalayan Tabby	TSF, STF, WTF		
156	*Stibochiona nicea nicea*	Himalayan Popinjay	TSF, STF, WTF		
Subfamily: Satyrinae					
157	*Aemona amathusia*	Yellow Dryad	STF, WTF		Endemic
158	*Discophora sondaica zal*	Indian Common Duffer	TSF	SC I	Endemic
159	*Discophora timora timora*	Great Duffer	TSF		Endemic
160	*Enispe euthymius euthymius*	Himalayan Red Caliph	TSF, STF, WTF		Endemic
161	*Stichophthalma camadeva camadeva*	Northern Jungle Queen	TSF, STF	SC I	Endemic
162	*Thaumantis diores diores*	Assam Jungleglory	TSF, STF, WTF		Endemic
163	*Elymnias malelas malelas*	Bengal Spotted Palmfly	TSF, STF	SC II	Endemic
164	*Elymnias patna patna*	Larger Blue-striped Palmfly	TSF, STF		
165	*Elymnias vasudeva*	Jezebel Palmfly	TSF, STF	SC II	Endemic
166	*Melanitis leda leda*	Oriental Common Evening Brown	TSF, STF		

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
167	*Melanitis phedima bela*	Bengal Dark Evening Brown	TSF, STF, WTF		
168	*Melanitis zitenius zitenius*	Himalayan Great Evening Brown	TSF, STF	SC II	
169	*Aulocera brahminus*	Narrow-banded Satyr	STF		
170	*Aulocera loha japroa*	Doherty's Satyr	STF		Endemic
171	*Callerebia narasingha narasingha*	Himalayan Mottled Argus	TSF, STF	SC I	Endemic
172	*Callerebia scanda opima*	East Himalayan Pallid Argus	WTF	SC II	Endemic
173	*Lethe baladeva baladeva*	Himalayan Treble Silverstripe	TSF, STF, WTF	SC II	Endemic
174	*Lethe bhairava*	Rusty Forester	STF, WTF		Endemic
175	*Lethe brisanda*	Dark Forester	WTF	SC II	Endemic
176	*Lethe chandica chandica*	Darjeeling Angled Red Forester	TSF, STF		Endemic
177	*Lethe confusa confuse*	Himalayan Banded Treebrown	TSF, STF, WTF		
178	*Lethe distans*	Scarce Red Forester	TSF, STF	SC I	Endemic
179	*Lethe dura gammiei*	Bhutan Scarce Lilacfork	TSE, STF	SC I	Endemic
180	*Lethe gulnihal gulnihal*	Dull Forester	STF	SC I	Endemic
181	*Lethe isana dinarbas*	Himalayan Common Forester	STF, WTF	SC II	Endemic
182	*Lethe kansa*	Bamboo Forester	TSF, STF		
183	*Lethe latiaris latiaris*	Himalayan Pale Forester	STF, WTF	SC II	Endemic
184	*Lethe margaritae*	Bhutan Treebrown	STF, WTF	SC I	Endemic
185	*Lethe mekara mekara*	Darjeeling Common Red Forester	TSF, STF, WTF		Endemic
186	*Lethe nicetas*	Yellow Woodbrown	STF, WTF		
187	*Lethe nicetella*	Small Woodbrown	WTF, SAF	SC II	Endemic
188	*Lethe ramadeva*	Single Silverstripe	STF	SC I	Endemic
189	*Lethe scanda*	Blue Forester	STF, WTF	SC II	Endemic
190	*Lethe serbonis*	Brown Forester	WTF	SC II	Endemic
191	*Lethe siderea sidereal*	Himalayan Scarce Woodbrown	STF, WTF	SC II	
192	*Lethe sidonis*	Common Woodbrown	STF, WTF, SAF		
193	*Lethe sinorix sinorix*	Assam tailed Red Forester	TSF, STF	SC II	
194	*Lethe sura*	Lilacfork	STF, WTF		Endemic
195	*Lethe verma sintica*	East Himalayan Straight-banded Treebrown	TSF, STF, WTF		Endemic
196	*Lethe visrava*	White-edged Woodbrown	STF, WTF	SC II	Endemic
197	*Mycalesis francisca sanatana*	Himalayan Lilacine Bushbrown	TSF, STF		
198	*Mycalesis suaveolens suaveolens*	East Himalayan Vanilla Bushbrown	TSF, STF	SC II	Endemic
199	*Mycalesis visala visala*	Indian Long-branded Bushbrown	TSF, STF, WTF		
200	*Neope bhadra*	Tailed Labyrinth	TSF, STF, WTF		Endemic
201	*Neope pulaha pulaha*	East Himalayan Veined Labyrinth	TSF, STF, WTF	SC II	Endemic
202	*Neope yama yama*	Bhutanese Dusky Labyrinth	STF, WTF	SC II	Endemic
203	*Orinoma damaris damris*	Himalayan Tigerbrown	TSF, STF		
204	*Orsotriaena medus medus*	Oriental Medus Brown	TSF		
205	*Ragadia crisilda crisilda*	Sylhet White-striped Ringlet	TSF, STF	SC II	Endemic
206	*Ragadia crito*	Dusky-striped Ringlet	TSF, STF		Endemic
207	*Rhaphicera moorei mantra*	Himalayan Small Tawny Wall	WTF, SAF		Endemic
208	*Rhaphicera satricus satricus*	Himalayan Large Tawny Wall	WTF, SAF	SC II	Endemic
209	*Telinga heri*	Large-eyed Bushbrown	TSF, STF	SC II	
210	*Telinga malsara*	White-line Bushbrown	TSF, STF		Endemic
211	*Telinga mestra vetus*	Bhutan White-edged Bushbrown	STF, WTF	SC II	Endemic

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
212	*Telinga nicotia*	Bright-eye Bushbrown	TSF, STF		
213	*Ypthima baldus baldus*	Himalayan Common Five-ring	TSF, STF, WTF		
214	*Ypthima newara newara*	Himalayan Newar Three-ring	TSF, STF, WTF		Endemic
215	*Ypthima sacra sakra*	East Himalayan Five-ring	TSF, STF, WTF		
216	*Neorina hilda*	Yellow Owl	WTF, SAF	SC II	Endemic
Subfamily: Nymphalinae					
217	*Hypolimnas bolina jacintha*	Oriental Great Eggfly	TSF, STF		
218	*Junonia almana almana*	Oriental Peacock Pansy	STF		
219	*Junonia atlites atlites*	Oriental Grey Pansy	TSF, STF		
220	*Junonia hierta hierta*	Oriental Yellow Pansy	TSF, STF		
221	*Junonia iphita iphita*	Oriental Chocolate Pansy	TSF, STF, WTF		
222	*Junonia lemonias lemonias*	Lemon Pansy	TSF, STF		Endemic
223	*Junonia orithya*	Blue Pansy	STF		
224	*Doleschallia bisaltide indica*	Himalayan Autumn Leaf	TSF, STF	SC II	Endemic
225	*Kallima inachus inachus*	Himalayan Orange Oakleaf	TSF, STF, WTF		
226	*Kallima knyvettii*	Scarce Blue Oakleaf	TSF, STF	SC II	Endemic
227	*Aglais caschmirensis aesis*	Himalayan Tortoiseshell	TSF, STF, WTF, SAF		
228	*Kaniska canace canace*	Chinese Blue Admiral	TSF, STF, WTF		
229	*Symbrenthia brabira brabira*	Himalayan Yellow Jester	TSF, STF, WTF		
230	*Symbrenthia hypselis cotanda*	Himalayan Spotted Jester	TSF, STF		
231	*Symbrenthia lilaea khasiana*	Khasi Common Jester	TSF, STF, WTF		
232	*Symbrenthia niphanda niphanda*	Himalayan Blue-tailed Jester	TSF, STF, WTF	SC II	Endemic
233	*Symbrenthia silana*	Scarce Jester	TSF, STF	SC I	Endemic
234	*Vanessa cardui*	Painted Lady	TSF, STF, WTF, SAF		
235	*Vanessa indica indica*	Himalayan Red Admiral	TSF, STF, WTF, SAF		
Family: Lycaenidae **Subfamily: Curetinae**					
236	*Curetis bulis bulis*	Bright Sunbeam	TSF, STF		
Subfamily: Lycaeninae					
237	*Heliophorus brahma brahma*	Himalayan Golden Sapphire	TSF, STF, WTF, SAF		Endemic
238	*Heliophorus epicles latilimbata*	Himalayn Purple Sapphire	TSF, STF, WTF, SAF		
239	*Heliophorus indicus*	Dark Sapphire	TSF, STF, WTF		Endemic
240	*Heliophorus moorei moorei*	Bhutan Azure Sapphire	STF, WTF, SAF		Endemic
241	*Heliophorus tamu tamu*	Himalayan Powdery Green Sapphire	STF, WTF		
242	*Heliophorus pseudonexus*	Modest Sapphire	TSF, STF, WTF		Endemic
Subfamily: Miletinae					
243	*Allotinus drumila drumila*	Himalayan Crenulate Mottle	TSF, STF	SC I	
244	*Miletus chinensis assamensis*	Assam Common Mottle	TSF, STF		
245	*Taraka hamada mendesia*	Mendacious Forest Pierrot	TSF, STF		Endemic
Subfamily: Polyommatinae					
246	*Anthene emolus emolus*	Bengal Common Ciliate Blue	TSF, STF		
247	*Anthene lycaenina lycambes*	Himalayan Pointed Ciliate Blue	TSF, STF	SC II	Endemic
248	*Acytolepis puspa gisca*	Himalayan Common Hedge Blue	TSF, STF, WTF		
249	*Caleta elna noliteia*	Indo-Chinese Elbowed Pierrot	TSF, STF		

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
250	*Catochrysops panormus exiguus*	Malay Silver Forget-me-not	TSF, STF		
251	*Catochrysops strabo strabo*	Oriental Forget-me-not	TSF, STF		
252	*Celastrina argiolus iynteana*	Hill Hedge Blue	TSF, STF		Endemic
253	*Celastrina lavendularis*	Eastern Plain Hedge Blue	TSF, STF		
254	*Celatoxia marginata marginata*	Sikkim Margined Hedge Blue	TSF, STF		
255	*Chilades pandava pandava*	Oriental Plains Cupid	TSF, STF		
256	*Ionolyce helicon marguiana*	Pointed Lineblue	TSF	SC II	Endemic
257	*Jamides alecto eurysaces*	Himalayan Metallic Cerulean	TSF, STF, WTF	SC II	
258	*Jamides bochus bochus*	Indian Dark Cerulean	TSF, STF		
259	*Jamides celeno celeno*	Oriental Common Cerulean	TSF, STF, WTF		
260	*Jamides elpis*	Glistening Cerulean	TSF, STF, WTF		Endemic
261	*Jamides pura pura*	Continental White Cerulean	TSF, STF, WTF	SC II	Endemic
262	*Lampides boeticus*	Pea Blue	TSF, STF, WTF		
263	*Leptotes plinius plinius*	Zebra Blue	TSF, STF, WTF		
264	*Lestranicus transpectus*	White-banded Hedge Blue	TSF, STF		Endemic
265	*Megisba malaya sikkima*	Malayan	TSF, STF, WTF	SC II	
266	*Nacaduba beroe gythion*	Assam Opaque Six-Lineblue	STF		
267	*Nacaduba kurava euplea*	Sikkim Transparent Six-Lineblue	TSF, STF		
268	*Nacaduba pactolus continentalis*	Continental Large Four-Lineblue	TSF, STF	SC II	
269	*Neopithecops zalmora zalmora*	Myanmar Common Quaker	TSF, STF		
270	*Orthomiella pontis pontis*	Darjeeling Straightwing Blue	STF, WTF	SC II	Endemic
271	*Petrelaea dana*	Dingy Lineblue	TSF, STF, WTF		
272	*Prosotas bhutea*	Bhutia Lineblue	TSF, STF, WTF	SC II	Endemic
273	*Prosotas dubiosa indica*	Indian Tailless Lineblue	TSF, STF, WTF	SC II	
274	*Prosotas nora ardates*	Indian Common Lineblue	TSF, STF, WTF		
275	*Prosotas pia marginate*	Margined Additional Lineblue	TSF, STF, WTF		Endemic
276	*Tarucus ananda*	Dark Pierrot	TSF, STF		
277	*Udara albocaeruleus albocaeruleus*	Himalayan Albocerulean	TSF, STF	SC II	
278	*Udara dilectus dilectus*	Himalayan Pale Hedge Blue	TSF, STF, WTF		
279	*Pseudozizeeria maha maha*	Himalayan Pale Grass Blue	TSF, STF, WTF		
280	*Zizeeria karsandra*	Dark Grass Blue	TSF, STF, WTF		
281	*Zizula hylax hylax*	Indian Tiny Grass Blue	TSF, STF		
Subfamily: Poritiinae					
282	*Poritia hewitsoni hewitsoni*	Himalayan Common Gem	TSF, STF, WTF	SC II	
Subfamily: Theclinae					
283	*Iraota timoleon timoleon*	Oriental Silverstreak Blue	TSF, STF		
284	*Cigaritis evansii evansii*	Naga Rufous Silverline	TSF, STF, WTF		Endemic
285	*Cigaritis lohita himalayanus*	Himalayan Long-banded Silver	TSF, STF, WTF	SC II	
286	*Cigaritis rukma*	Cinnamon Silverline	TSF, STF, WTF		Endemic
287	*Cigaritis rukmini*	Khaki Silverline	TSF, STF, WTF	SC II	Endemic
288	*Cigaritis syama*	Club Silverline	TSF, STF, WTF		
289	*Arhopala bazalus teesta*	Teesta Powdered Oakblue	STF, WTF		
290	*Arhopala eumolphus eumolphus*	Bengal Green Oakblue	STF, WTF		
291	*Arhopala paraganesa zephyretta*	Patkai Dusky Bushblue	STF, WTF	SC II	Endemic
292	*Arhopala paramuta paramuta*	Sikkim Hooked Oakblue	STF, WTF		Endemic
293	*Arhopala rama*	Himalayan Dark Oakblue	STF, WTF		

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
294	*Arhopala singla*	Pointed Oakblue	STF, WTF		
295	*Flos areste*	Tailless Plushblue	STF, WTF	SC II	Endemic
296	*Flos chinensis*	Chinese Plushblue	STF, WTF		Endemic
297	*Flos fulgida fulgida*	Shining Plushblue	STF, WTF		Endemic
298	*Surendra quercetorum*	Himalayan Common Acacia Blue	TSF, STF		
299	*Acupicta delicatum*	Dark Tinsel	TSF, STF	SC II	Endemic
300	*Catapaecilma major*	Himalayan Common Tinsel	TSF, STF	SC II	
301	*Cheritrella truncipennis*	Truncate Imperial	STF, WTF	SC II	Endemic
302	*Drupadia scaeva cyara*	Himalayan Blue Posy	TSF, STF	SC I	Endemic
303	*Ticherra acte acte*	Himalayan Blue Imperial	TSF, STF, WTF		
304	*Deudorix epijarbas epijarbas*	Oriental Cornelian	TSF, STF		
305	*Rapala damona*	Malay Red Flash	TSF, STF		
306	*Rapala manea schistacea*	Bengal Slate Flash	TSF, STF		
307	*Rapala nissa ranta*	Himalayan Common Flash	TSF, STF		Endemic
308	*Rapala pheretima petosiris*	Copper Flash	TSF, STF		
309	*Rapala refulgens*	Refulgent Flash	TSF, STF	SC II	Endemic
310	*Rapala tara*	Branded Flash	TSF, STF		
311	*Rapala varuna*	Indigo Flash	TSF, STF	SC II	
312	*Sinthusa chandrana grotei*	East Himalayan Broad Spark	TSF, STF	SC II	Endemic
313	*Sinthusa nasaka amba*	Malayan Narrow Spark	TSF, STF	SC II	Endemic
314	*Hypolycaena erylus himavantus*	Sikkim Common Tit	TSF, STF		Endemic
315	*Hypolycaena kina kina*	Darjeeling Blue Tit	TSF, STF, WTF	SC II	
316	*Hypolycaena othona othona*	Oriental Orchid Tit	TSF, STF	SC I	
317	*Zeltus amasa amasa*	Indian Fluffy Tit	TSF, STF		
318	*Neocheritra fabronia fabronia*	Indo-Chinese Pale Grand Imperial	TSF, STF, WTF	SC II	Endemic
319	*Tajuria maculatus*	Spotted Royal	TSF, STF		
320	*Tajuria yajna istroidea*	Chestnut-and-Black Royal	TSF	SC I	Endemic
321	*Tajuria diaeus diaeus*	Himalayan Straightline Royal	TSF	SC II	
322	*Creon cleobis* (Godart, [1824])	Broad-tail Royal	TSF		
323	*Ancema ctesia ctesia*	Himalayan Bi-spot Royal	TSF, STF, WTF		
324	*Remelana jangala*	Northern Chocolate Royal	TSF, STF	SC II	Endemic
325	*Euaspa milionia milionia*	Himalayan Water Hairstreak	TSF, STF		
326	*Euaspa pavo*	Peacock Hairstreak	TSF, STF	SC I	Endemic
327	*Shirozuozephyrus kirbariensis*	Kirbari Hairstreak	STF	SC II	Endemic
Family: Riodinidae Subfamily: Nemeobiinae					
328	*Abisara chela chela*	Sikkim Spot Judy	TSF, STF, WTF		Endemic
329	*Abisara fylla*	Dark Judy	TSF, STF, WTF		
330	*Abisara neophron neophronides*	Khasi tailed Judy	TSF, STF, WTF		Endemic
331	*Dodona adonira*	Himalayan Striped Punch	STF, WTF	SC II	Endemic
332	*Dodona dipoea dipoea*	Himalayan Lesser Punch	STF, WTF, SAF	SC II	Endemic
333	*Dodona egeon egeon*	Himalayan Orange Punch	TSF, STF	SC II	
334	*Dodona eugenes venox*	Tailed Punch	TSF, STF, WTF		Endemic
335	*Dodona ouida ouida*	Darjeeling Mixed Punch	TSF, STF, WTF		Endemic
336	*Zemeros flegyas flegyas*	Himalayan Punchinello	TSF, STF, WTF		

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
Family: Hesperiidae **Subfamily: Coeliadinae**					
337	*Badamia exclamationis*	Brown Awl	TSF		
338	*Burara amara*	Small Green Awlet	TSF, STF		
339	*Burara gomata gomata*	Bengal Pale Green Awlet	TSF, STF		Endemic
340	*Burara jaina jaina*	Darjeeling Common Orange Awlet	TSF, STF		
341	*Burara oedipodea belesis*	Himalayan Branded Orange Awlet	TSF, STF		
342	*Burara vasutana*	Green Awlet	TSF, STF		
343	*Choaspes spp.*	Awlking spp.	TSF, STF		
344	*Hasora anura anura*	Himalayan Slate Awl	TSF, STF, WTF		
345	*Hasora badra badra*	Oriental Common Awl	TSF, STF		
346	*Hasora chromus chromus*	Oriental Common Banded Awl	TSF, STF		
347	*Hasora taminatus bhavara*	Himalayan White-banded Awl	TSF, STF, WTF		
348	*Hasora vita indica*	Indian Plain Banded Awl	TSF, STF, WTF		
Subfamily: Hesperiinae					
349	*Aeromachus jhora jhora*	Sikkim Grey Scrub Hopper	TSF, STF, WTF		Endemic
350	*Aeromachus pygmaeus*	Pygmy Scrub Hopper	TSF, STF, WTF		
351	*Aeromachus stigmata stigmata*	Himalayan Veined Scrub Hopper	TSF, STF, WTF		
352	*Ampittia subvittatus subradiatus*	Khasi Tiger Hopper	TSF, STF		Endemic
353	*Ancistroides nigrita diocles*	Bengal Chocolate Demon	TSF, STF, WTF		
354	*Erionota torus*	Rounded Palm-redeye	TSF, STF		
355	*Halpe aucma*	Gold-spotted Ace	TSF		Endemic
356	*Halpe filda*	Absent Ace	TSF, STF, WTF		Endemic
357	*Halpe zema zema*	Sikkim Zema Banded Ace	TSF, STF, WTF		Endemic
358	*Iambrix salsala salsala*	Eastern Chestnut Bob	TSF, STF		
359	*Koruthaialos butleri*	Dark Velvet Bob	TSF, STF		Endemic
360	*Matapa aria*	Common Branded Redeye	TSF, STF		
361	*Matapa cresta*	Fringed Branded Redeye	TSF, STF		
362	*Matapa druna*	Grey-branded Redeye	TSF, STF		
363	*Matapa sasivarna*	Black-veined Branded Redeye	TSF, STF		Endemic
364	*Notocrypta curvifascia*	Restricted Demon	TSF, STF, WTF		
365	*Notocrypta feisthamelii alysos*	Himalayan Spotted Demon	TSF, STF, WTF		
366	*Notocrypta paralysos*	Common Banded Demon	TSF, STF, WTF		
367	*Pedesta masuriensis masuriensis*	White-spotted Mussoorie Bush Bob	TSF, STF, WTF		
368	*Pedesta pandita*	Brown Bush Bob	TSF, STF, WTF		Endemic
369	*Pirdana major*	Himalayan Green-striped Palmer	TSF, STF		Endemic
370	*Pithauria murdava*	Dark Straw Ace	TSF, STF, WTF		Endemic
371	*Pithauria stramineipennis*	Light Straw Ace	TSF, STF, WTF		Endemic
372	*Scobura cephala*	Extra Forest Bob	TSF, STF		Endemic
373	*Sebastonyma dolopia*	Tufted Ace	TSF, STF, WTF		Endemic
374	*Sovia separata separata*	Chequered Ace	TSF, STF		
375	*Zographetus satwa*	Purple and Gold Flitter	TSF, STF		
376	*Zographetus dzonguensis*	Chocolate-bordered Flitter	TSF		Endemic
377	*Salanoemia noemi*	Yellow Spotted Lancer	TSF		Endemic
378	*Baoris farri*	Complete Paint-brush Swift	TSF, STF, WTF		
379	*Baoris pagana*	Figure-of-8 Swift	TSF, STF		Endemic

	Scientific name	Common name	Habitats	W(P)AA, 2022	Endemic to northeastern India
380	*Borbo bevani*	Lesser Rice Swift	TSF, STF		
381	*Borbo cinnara*	Rice Swift	TSF, STF		
382	*Caltoris tulsi tulsi*	Himalayan Purple Swift	TSF, STF, WTF		Endemic
383	*Parnara guttatus mangala*	Himalayan Straight Swift	TSF, STF, WTF		
384	*Pelopidas agna agna*	Bengal Obscure Branded Swift	TSF, STF		
385	*Pelopidas assamensis*	Great Swift	TSF, STF, WTF		
386	*Pelopidas sinensis*	Chinese Branded Swift	TSF, STF, WTF		
387	*Polytremis discreta discreta*	Himalayan White-fringed Swift	TSF, STF, WTF		
388	*Polytremis eltola eltola*	Darjeeling Yellow-spot Swift	TSF, STF, WTF		
389	*Cephrenes acalle oceanica*	Variable Plain Palm-Dart	TSF, STF, WTF		
390	*Oriens gola pseudolus*	Oriental Common Dartlet	TSF, STF, WTF		
391	*Oriens goloides*	Smaller Dartlet	TSF, STF, WTF		
392	*Telicota bambusae bambusae*	Oriental Dark Palm-Dart	TSF, STF, WTF		
Subfamily: Pyrginae					
393	*Celaenorrhinus badia*	Scarce Banded Flat	TSF, STF, WTF		Endemic
394	*Celaenorrhinus dhanada*	Yellow-banded Flat	TSF, STF, WTF		
395	*Celaenorrhinus leucocera*	Common Spotted Flat	TSF, STF, WTF		
396	*Celaenorrhinus munda*	Himalayan Spotted Flat	TSF, STF, WTF		
397	*Celaenorrhinus patula*	Large Spotted Flat	TSF, STF, WTF		Endemic
398	*Celaenorrhinus ratna*	East Himalayan Ratna Flat	TSF, STF, WTF		
399	*Celaenorrhinus putra putra*	Restricted Spotted Flat	TSF, STF, WTF		
400	*Pseudocoladenia dan fabia*	Himalayan Fulvous Pied Flat	TSF, STF, WTF		Endemic
401	*Pseudocoladenia fatua*	Ruddy Pied Flat	TSF, STF, WTF		Endemic
402	*Pseudocoladenia festa*	Dull Pied Flat	TSF, STF		Endemic
403	*Pintara tabrica*	Crenulate Orange Flat	TSF, STF		
404	*Capila jayadeva*	Striped Dawnfly	TSF, STF		Endemic
405	*Capila lidderdali*	Ringed Dawnfly	TSF, WTF		Endemic
406	*Chamunda chamunda*	Olive Flat	TSF, STF		Endemic
407	*Coladenia agni agni*	Himalayan Brown Pied Flat	TSF, STF		Endemic
408	*Coladenia hoenei*	Large Spot Pied Flat	TSF, STF		Endemic
409	*Ctenoptilum vasava vasava*	Himalayan Tawny Angle	TSF, STF		Endemic
410	*Darpa hanria*	Hairy Angle	TSF, STF, WTF		
411	*Gerosis phisara phisara*	Khasi Dusky Yellow-breast Flat	TSF, STF		Endemic
412	*Gerosis sinica narada*	Sikkim White Yellow-breasted Flat	TSF, STF		Endemic
413	*Mooreana trichoneura pralaya*	Yellow-veined Flat	TSF, STF		Endemic
414	*Odontoptilum angulata angulata*	Oriental Chestnut Angle	TSF, STF		
415	*Satarupa gopala gopala*	Sikkim Large White Flat	TSF, STF, WTF		Endemic
416	*Satarupa zulla zulla*	Himalayan Equal White Flat	TSF, STF, WTF		Endemic
417	*Seseria dohertyi dohertyi*	Himalayan Contiguous Seseria	TSF, STF		
418	*Seseria sambara sambara*	Himalayan Notched Seseria	TSF, STF		
419	*Tagiades litigiosa litigiosa*	Sylhet Water Snow Flat	TSF, STF, WTF		
420	*Tagiades menaka menaka*	Bengal Spotted Flat	TSF, STF, WTF		

TSF—Tropical semi-evergreen forest | STF—Sub-tropical hill forest | WTF—Wet temperate forest | SAF—Sub-alpine forest

Image 1. Papilionidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Graphium antiphates* | B—*Graphium chironides* | C—*Graphium eurous* | D—*Graphium paphus* | E—*Graphium xenocles* | F—*Graphium agamemnon* | G— *Papilio agestor* | H—*Papilio alcmenor* | I—*Papilio arcturus* | J—*Papilio bootes* | K—*Papilio demoleus* | L—*Papilio epycides* | M—*Papilio krishna* | N—*Papilio chaon* | O—*Papilio agenor* | P—*Meandrusa lachinus* | Q—*Teinopalpus imperialis* | R—*Byasa dasarada* | S—*Byasa latreillei* | T—*Troides aeacus*. © Monish Kumar Thapa, Sonam Wangchuk Lepcha and Q—Chumsi Lepcha.

13 individuals in 2019, but only two were recorded in 2020. This species was found at elevations just above 150 m, within jungle environments and along forest nursery roads. Notably, *Z. dzonguensis* was also observed actively flying around orange trees inside the jungle.

28. *Celaenorrhinus badia* (Hewitson, 1877)
First, this species was spotted inside the forested area at the village of Laven in Upper Dzongu, where five individuals were seen under the leaves. This species was later seen in the Namprickdang area, under similar conditions, with sightings ranging from four to six individuals.

29. *Chamunda chamunda* (Moore, 1866)
Observed in the Noam Village, inside a jungle near a small stream, where two individuals were seen actively flying under the leaves.

30. *Coladenia hoenei* (Evans, 1939)
Initially observed in the Namprickdang area, where

Image 2. Pieridae butterflies recorded in Dzongu, Sikkim during the study period: A—*Colias fieldii* | B—*Dercas lycorias* | C—*Eurema laeta* | D—*Hebomoia glaucippe* | E—*Appias albina* | F—*Appias lyncida* | G—*Cepora nerissa* | H—*Delias acalis* | I—*Delias agostina* | J—*Delias eucharis* | K—*Delias hyparete* | L—*Delias pasithoe* | M—*Delias sanaca* | N—*Pieris brassicae* | O—*Pontia daplidice* | P—*Ixias pyrene.* © Sonam Wangchuk Lepcha; C—Sonam Wangchuk Lepcha Jr.

a single specimen was seen flying among dry leaves. Another sighting occurred in Laven Village.

31. *Darpa hanria* (Moore, 1866)

Recorded at Lingza along a small river stream connected to the Talong Chu River, where it was found on a large rock with other butterflies during a sunny day. Later, this species was spotted at Blyokvoo, upper Dzongu, during mud puddling.

32. *Satarupa zulla* (Tytler, 1915)

This species was recorded in several locations including Laven, Passingdang, Panang, Tingvong, Blyokvoo, Ravong, and Phedang, lower Dzongu. Typically, individuals were seen singly, likely on bird droppings or mud, and were very active, commonly found on roadside rocks.

CONCLUSION

This long-term study allowed us to obtain a comprehensive understanding of the region's butterfly diversity and distribution. The study conducted in Dzongu Valley of northern Sikkim revealed a remarkable diversity of butterfly species, with a total of 420 species identified belonging to 187 genera under six families (Table 1). The survival of butterflies is closely linked to suitable habitats, the availability of nectar and host plants, and the conditions of their immediate environment, highlighting the interrelationship of these factors (Thapa et al. 2023). The availability of dissolved minerals in the water resources significantly contributes to the high butterfly diversity in the area, as it encourages adult butterflies to engage in mud-puddling in large groups on sandy patches along rivers. In Dzongu, these essential water resources include lakes, wetlands, and river beds, such as Tungkyong Dho (Lake)— a designated

Image 3a. Nymphalidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Danaus chrysippus* | B—*Tirumala limniace* | C—*Helcyra hemina* | D—*Herona marathus* | E—*Rohana parvata* | F—*Calinaga gautama* | G—*Charaxes marmax* | H—*Issoria issaea* | I— *Libythea myrrha* | J—*Bassarona durga* | K—*Euthalia franciae* | L—*Euthalia iva* | M—*Euthalia saitaphernes* | N—*Neurosigma siva* | O—*Parasarpa zayla* | P— *Neptis ananta* | Q—*Neptis manasa* | R—*Neptis nycteus* | S—*Aemona amathusia* | T—*Enispe euthymius.* © Sonam Wangchuk Lepcha & Monish Kumar Thapa; L—Mingdup Lepcha.

biodiversity Heritage Site of Dzongu- along with Lingthem Kyong, Talung Wetland, Lingdem Hotspring, Namprick Uung Kyong, Rungyoung River, Narim Uung Kyong, and others (Image 7). The presence of rare and exclusive butterfly species in the Dzongu region highlights the area's significant biodiversity potential and also indicates the presence of rare host plants.

The butterfly diversity in Dzongu is an indicator of rich biodiversity that includes a variety of flora and fauna thriving in pristine forests. The region is facing deforestation due to the expansion of human settlements, urbanization, and the clearing of land for agriculture. There is an urgent need to designate this forested region for heightened protection and conservation efforts, ensuring the preservation of its unique ecological value. This diversity not only enhances the ecological value of the region but also plays a crucial role in the broader environmental health of Sikkim, making it an invaluable area for both scientific study and conservation efforts. This study enriches

Image 3b. Nymphalidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Stichophthalma camadeva* | B—*Elymnias patna* | C—*Elymnias vasudeva* | D—*Callerebia narasingha* | E—*Callerebia scandal* | F—*Lethe baladeva* | G—*Lethe bhairava* | H—*Lethe brisanda* | I—*Lethe dura* | J—*Lethe margaritae* | K—*Lethe ramadeva* | L—*Lethe scanda* | M—*Lethe serbonis* | N—*Lethe visrava* | O—*Mycalesis suaveolens* | P—*Ragadia crisilda* | Q—*Rhaphicera satricus* | R—*Telinga mestra* | S—*Neorina hilda* | T—*Symbrenthia brabira.* © Sonam Wangchuk Lepcha; H—Dorjee Tshering Lepcha.

the understanding of butterfly diversity in northern Sikkim and also emphasizes the need for continued conservation efforts in these ecologically sensitive areas.

REFERENCES

Anonymous (2022). The Wildlife (Protection) Amendment Act, 2022.

Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Government of India Publication, New Delhi, India, 404 pp.

Dudgeon, G.C. (1898, 1900–1901). A catalogue of the Heteorocera of Sikkim and Bhutan. *Journal of Bombay Natural History Society* 9 (1898, O.S. unseen); 13 (9): 406–425 (1900–1901) (Lasiocampidae).

Elwes, H.J. (1882). On a collection of butterflies from Sikkim. *Proceedings of the Zoological Society of London* 50(3): 398–407. https://doi.org/10.1111/j.1096-3642.1882.tb02746.x

Elwes, H.J. (1888). A catalogue of Lepidoptera of Sikkim. *Transactions of the Entomological Society of London* 36(3): 269–465. https://doi.org/10.1111/j.1365-2311.1888.tb01313.x

ENVIS (2015). Environment & Wildlife Management Department, Government of Sikkim. Deorali, Gangtok Gangtok– 737102. Retrieved from www.sikenvis.nic.in

Evans, W.H. (1932). The Identification of Indian Butterflies. *Journal of*

Image 4a. Lycaenidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Heliophorus brahma* | B—*Heliophorus moorei* | C—*Heliophorus tamu* | D—*Heliophorus pseudonexus* | E—*Allotinus drumila* | F—*Caleta elna* | G—*Catochrysops panormus* | H—*Celastrina lavendularis* | I—*Chilades pandava* | J—*Ionolyce helicon* | K—*Jamides elpis* | L—*Leptotes plinius* | M—*Lestranicus transpectus* | N—*Nacaduba kurava* | O—*Nacaduba pactolus* | P—*Orthomiella pontis* | Q—*Petrelaea dana* | R—*Prosotas bhutea* | S—*Prosotas dubiosa* | T—*Prosotas pia.* © Sonam Wangchuk Lepcha; F—Dorjee Tshering Lepcha.

the Bombay Natural History Society 31: 49–83.

Gogoi, M.J. (2015). Observation on Lycaenid butterflies from Panbari Reserve forest and adjoining areas, Kaziranga, Assam, northeastern India. *Journal of Threatened Taxa* 7(15): 8259–8271. http://doi.org/10.11609/jott.2467.7.15.8259-8171

Gupta, I.J. (2003). *Insecta: Lepidoptera: Nymphalidae*. Zoological Survey of India, State Fauna Series 9, Fauna of Sikkim (Part-4) 27–91.

Happner, J.B. (1998). Classification of Lepidoptera. Part 1: Introduction. *Holarctic Lepidoptera* 5: 1–148.

Haribal, M. (1992). *The Butterflies of Sikkim Himalaya and their Natural History*. Sikkim Nature Conservation, Gangtok, 217 pp.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek & M.S. Foster (1994). *Measuring and Monitoring Biologial Diversity: Standard Methods for Amphibians*. Smithsonian Institution Press. Washington, 364 pp.

Idrisi, M.S., H.K. Badola & R. Singh (2010). Indigenous knowledge and medicinal use of plants by local communities in Rangit Valley, southern Sikkim, India. *NeBIO* 1(2): 34–45.

Kehimkar, I. (2016). *BNHS — Field Guides Butterflies of India*. Bombay Natural History Society, Mumbai, 528 pp.

Koneri, R., P.V. Maabuat & M.J. Nangoy (2020). The distribution and diversity of butterflies (Lepidoptera: Rhopalocera) in various urban forests in north Minahasa Regency, North Sulawesi Province, Indonesia. *Applied Ecology and Environmental Research* 18(2): 2295–2314. http://doi.org/10.15666/aeer/1802_22952314

Kunte, K.J. (1997). Seasonal patterns in butterfly abundance and

Image 4b. Lycaenidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Udara albocaeruleus* | B—*Cigaritis evansii* | C—*Cigaritis lohita* | D—*Cigaritis rukma* | E—*Cigaritis rukmini* | F—*Arhopala bazalus* | G—*Arhopala paramuta* | H—*Flos chinensis* | I—*Flos fulgida* | J—*Surendra quercetorum* | K—*Catapaecilma major* | L—*Cheritrella truncipennis* | M—*Drupadia scaeva* | N—*Deudorix epijarbas* | O—*Rapala damona* | P—*Rapala manea* | Q—*Rapala pheretima* | R—*Rapala varuna* | S—*Sinthusa chandrana* | T—*Sinthusa nasaka*. © Sonam Wangchuk Lepcha; E—Mingdup Lepcha; I & L—Sonam Wangchuk Lepcha JR.

species diversity in four tropical habitats in northern Western Ghats. *Journal of Biosciences* 22(5): 593–603. https://doi.org/10.1007/BF02703397

Lepcha, J., S.W. Lepcha, M.K. Thapa, A.P. Hazarika, N.M. Limboo & S.P. Sherpa (2021). New distributional record of *Euaspa* Moore, 1884 (Lepidoptera: Lycaenidae: Theclinae) from Sikkim, India. *Bionotes* 23(4): 156–157.

Lepcha, S.W. (2023). *Thamblyok*: *A Guide to the Butterflies of Dzongu–Sikkim Himalaya*, *1st Edition*. Lokmangal Mudranalaya, Maharashtra, 201 pp.

Lepcha, S.W., M. Lepcha, N.M. Limboo, S.P. Sherpa, S.W. Lepcha Jr. & M.K. Thapa (2023). New distribution record of *Euaspa milionia* Hewitson, 1869 (Lepidoptera: Lycaenidae: Theclinae) from Sikkim, India. *Bionotes* 25 (1&2): 57–59.

Majumdar (Chaudhury), M. (2003). *Insecta: Lepidoptera: Pieridae and Hesperiidae*. Zoological Survey of India, State Fauna Series 9, Fauna of Sikkim (Part-4), 109–146.

Maulik, D.R. (2003). *Insecta: Lepidoptera: Papilionidae Danainae (Nymphalidae), Lasiocampidae, Lymantriidae and Ratardidae*. Zoological Survey of India, State Fauna Series 9, Fauna of Sikkim (Part-4) 1–25.

Pollard, E. (1977). A method for assessing changes in the abundance of butterflies. *Biological Conservation* 12(2): 115–134. https://doi.org/10.1016/0006-3207(77)90065-9

Purkayastha, S. (2013). Hydro power development and the Lepchas: a case study of the Dzongu in Sikkim, India. *International Research Journal of Social Sciences* 2(8): 19–24.

Sánchez-Bayo, F. & K.A. Wyckhuys (2019). Worldwide decline of the

Image 4c. Lycaenidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Hypolycaena erylus* | B—*Hypolycaena kina* | C—*Hypolycaena othona* | D—*Zeltus amasa* | E—*Neocheritra fabronia* | F—*Tajuria maculatus* | G—*Tajuria yajna* | H—*Ancema ctesia* | I—*Remelana jangala* | J—*Euaspa milionia* | K—*Euaspa pavo.* © Sonam Wangchuk Lepcha; E—Lhendup Lepcha; K—Janukit Lepcha.

Image 5. Riodinidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Abisara chela* | B—*Abisara fylla* | C—*Abisara neophron* | D—*Dodona adonira* | E—*Dodona dipoea* | F—*Dodona egeon* | G—*Dodona ouida* | H—*Zemeros flegyas*. © Sonam Wangchuk Lepcha.

entomofauna: a review of its drivers. *Biological Conservation* 232: 8–27. https://doi.org/10.1016/j.biocon.2019.01.020

Thapa, M.K., M.K. Saikia & P.K. Saikia (2023). Larval hostplants' specificity of butterflies in Garbhanga Reserve Forest (Proposed Wildlife Sanctuary) and Rani Reserve Forest, Kamrup, Assam, India. *Asian Journal of Conservation Biology* 12(1): 134–142. https://doi.org/10.53562/ajcb.81075

Udaya, K.K., S. Bharath & S.S. Nagaraj (2019). *Winged Jewels: Let's Unfold their Graceful Wings*. Youth Forum for Nature (YoFoNa), College of Forestry, Sirsi, 70 pp.

Image 6a. Hesperiidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Badamia exclamationis* | B—*Burara amara* | C—*Burara gomata* | D—*Burara jaina* | E—*Burara vasutana* | F—*Choaspes* sp. / G—*Hasora anura* | H—*Hasora badra* | I—*Hasora taminatus* | J—*Hasora vita* | K—*Ampittia subvittatus* | L—*Erionota torus* | M—*Halpe filda* | N—*Halpe zema* | O—*Matapa cresta* | P—*Matapa druna* | Q—*Matapa sasivarna* / R—*Notocrypta feisthamelii* | S—*Pedesta pandita* | T—*Pirdana major*. © Sonam Wangchuk Lepcha; B— Sonam Pintso Sherpa.

Image 6b. Hesperiidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Sovia separata* | B—*Zographetus satwa* | C—*Zographetus dzonguensis* | D—*Baoris pagana* | E—*Caltoris tulsi* | F—*Pelopidas assamensis* | G—*Pelopidas sinensis* | H—*Cephrenes acalle* | I—*Celaenorrhinus badia* | J—*Celaenorrhinus dhanada* | K—*Celaenorrhinus patula* | L—*Celaenorrhinus ratna* | M—*Pseudocoladenia fatua* | N—*Pintara tabrica* | O—*Capila jayadeva* | P—*Capila lidderdali* | Q—*Chamunda chamunda* | R—*Coladenia agni* | S—*Coladenia hoenei* | T—*Ctenoptilum vasava*. © Sonam Wangchuk Lepcha; K—Lhendup Lepcha, J & L— Sonam Wangchuk Lepcha JR., O—Chuzing Lepcha, P— Sonam Gyatso Lepcha.

Image 6c. Hesperiidae butterflies recorded in Dzongu, Sikkim during the study period: A—*Darpa hanria* | B—*Gerosis phisara* | C—*Gerosis sinica* | D—*Mooreana trichoneura* | E—*Satarupa gopala* | F—*Satarupa zulla* | G—*Seseria dohertyi* | H—*Tagiades menaka.* © Sonam Wangchuk Lepcha

Image 7. Habitats of the study area. © Sonam Wangchuk Lepcha & Monish Kumar Thapa

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26850–26856

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9308.17.4.26850-26856

#9308 | Received 15 July 2024 | Final received 19 March 2025 | Finally accepted 01 April 2025

ARTICLE

Seasonal study on succession of forensically significant entomofauna under indoor environment in Punjab, India

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Abstract: This study was focused on the prevalence of carrion insects under indoor environment, during the five seasons, i.e., winter, summer, monsson, post-monsoon, and spring. The pig carcasses were placed inside a room and daily (morning and evening) observations were made to collect the insect in addition to room temperature and humidity. A total of 1,187 insect specimens belonging to three insect orders: Diptera (692), Coleoptera (467), and Hymenoptera (28), 10 families, and 32 species were collected during the five seasons. The abundance and richness of each species varied in each season. However, it has been observed that the decomposition of pig carcasses was prompt in the monsoon season followed by summer, spring, post-monsoon, and winter seasons. *Sarcophaga* (*Liosarcophaga*) *aegyptica, Boettcherisca bengalensis*, *Calliphora vicina*, *Megaselia scalaris* (Coffin fly) were the exclusive species collected during experimentation. The data collected from these seasonal experiments can serve as the baseline data for indoor homicides, suicides, and related crime investigations as the insects collected from these experiments will help in determining the post-mortem interval of corpses belonging to that geographic location.

Keywords: Carcasse, Carrion, Coleoptera, decomposition, Diptera, Hymenoptera, indoor cases, insects, observation, post-mortem interval.

Editor: R. Varatharajan, Chennai, Tamil Nadu, India.

Date of publication: 26 April 2025 (online & print)

Citation: Kaur, P. & M. Bala (2025). First photographic record of ferret badger *Melogale* sp. (Mammalia: Carnivora: Mustelidae) from the state of Tripura, India. *Journal of Threatened Taxa* 17(4): 26850–26856. https://doi.org/10.11609/jott.9308.17.4.26850-26856

Funding: University Grant Commission Grant No-RGNF201517SCPUN14046.

Competing interests: The authors declare no competing interests.

Author details: Madhu Bala, assistant professor, Department of Zoology and Environmental Sciences, Punjabi University, Patiala, working in the field of forensic entomology form the last 15 years. Succession studies were carried out to collect and study the biology of locally available blow flies, flesh flies and beetles of forensic importance that can be used in crime investigation. Morphological as well as molecular identifications of these arthropods have been done. Pawandeep Kaur, assistant professor, Sri Guru Gobind Singh College, Chandigarh, working with systematics of forensically relevant blowflies, flesh flies and beetles.

Author contributions: PK—data collection, manuscript preparation. MB—data authentication, manuscript editing.

Acknowledgements: Authors are thankful to the Department of Zoology and Environmental Sciences for providing the laboratory facilities during course of this study and University grant commission for funding this work under the grant number RGNF201517SCPUN14046.

ज्ञान-विज्ञान विमुक्तये

INTRODUCTION

The field of forensic entomology is concerned with using insects in legal investigations. Earlier studies have shown that insects are one of the major components of legal investigations (Ahmad & Ahmad 2002; Ahmad et al. 2011). Medico-legal forensic entomology is used in the estimation of post-mortem interval (PMI) along with the physiological and chemical changes that occur in the body before and after death, which are called antemortem and post-mortem changes respectively (Varatharajan & Sen 2000; Campobasso & Introna 2001). There are integral pathological changes such as rigor mortis, algor mortis, lividity, tissue autolysis, putrefaction, and bacterial activity that are accountable for PMI estimation, but they are reliable for just 72 hours (Henssge et al. 1995). However, the entomological methods of estimation of PMI are more rivaled in this field of science and help in finding the occurrence, distribution, abundance, richness, and species diversity of insect fauna visiting the carcasses during different decomposition stages. These entomological parameters are more reliable and undisputed compared to pathological methods, specifically during later stages of decay (Bala et al. 2016). Insects are ectothermic and specifically susceptible to climatic changes. Diversity and succession waves are affected by weather, temperature, relative humidity, body decomposition stage, size, and location of the carrion (Mann et al. 1990; Turchetto & Vanin 2004). Insect succession pattern in an indoor environment is quite different from outdoor environment. Under the indoor condition, the accessibility of carrion to entomofauna is restricted. This limitation can be attributed to factors such as physical barriers, lack of suitable entry points, or the absence of the necessary cues that attract decomposer insects. As a result, the decomposition process may be delayed or altered, leading to differences in the stages and patterns of decay compared to outdoor scenarios (Reibe & Madea 2010; Anderson 2011). It has been observed that many carrion insects in indoor environments are synanthropic (Anderson 2011). Various animals (pig, rabbit, cat, and rat) have been used as a research model to study successional and decomposition patterns (Early & Goff 1986; Tomberlin & Adler 1998; Anderson 2011; Bala & Kaur 2014; Zeariya et al. 2015; Kaur et al. 2020a). So, the aim of this study is to determine the insect succession pattern using pig carrion as a research model under indoor environmental conditions.

MATERIALS AND METHODS

Biological material

Two to six months old piglet carcasses (*Sus scrofa* L.) were used as a research model to collect the adult and immature insects from indoor. Piglet carcasses were procured from local slaughterhouse, and it was placed on the floor inside a room individually. There is no ethical issue, since dead piglets were utilized in this study. The experiments were conducted during winter, summer, monsoon, post-monsoon (2015), and spring season (2017). Five piglet carcasses, weighing 20 kg, were utilized during the study. The pig carcasses were placed on the floor inside the room (10'16'' × 8'-16''). The door of the room was kept closed. The window remains open to allow insect access and to allow some airflow. The observations were made two times a day, i.e., morning and evening. .The experimental site was an agricultural land (30.46574º N, 75.53275º E) at Ghawaddi village of Ludhiana, Punjab (India). The land was mainly used to grow paddy crop in summer and wheat crop in winter. Eucalyptus trees were the main flora of the area.

Sampling of carrion insects

The flies were captured by sweeping hand net over the pig carcasses and then transferred to the killing jar. The insect collection was done within 15 minutes to avoid disturbance to carcass. Beetles and ants were collected with the help of forceps and fine brushes enriched with alcohol. After killing, the flies were preserved in 70% ethanol. The vials were placed into wooden collection boxes. For the identification, specimens were first relaxed in the relaxing boxes and then stretched with the help of entomological pins. After stretching, the specimens were placed in the fumigated wooden collection boxes, with the labeling of date, time, and temperature. Naphthalene balls were also placed inside the wooden collection box to avoid fungal growth. The collected insects were identified with a Stereo zoom microscope (Rescholar, Model No.RI-90-01) and by running the keys based on their morphological characters (Nandi 2002).

Sampling and rearing of immature stages

Larvae were collected from the carcasses with the help of forceps and brought into the rearing lab. The larvae were then placed on the moist sawdust in the rearing jar provided with a piece (15 g) of chicken meat for feeding. The developmental stages were observed until the emergence of adult flies from the pupae. After the emergence, the flies were identified with the help of standard keys based on their morphological characters provided by the following sources and experts.

Identification of insects

Flies were identified based on morphological characters like anterior spiracle, gena, calypter etc. Dipteran flies were identified by following the fauna of British India. For the identification of adult flesh fly, the abdomen of the male was cut off and soaked in a 10% KOH solution for 24 hours for softening. The terminalia was dissected and structures like, fifth sternite, inner and outer forceps, phallus were separated. These structures were kept in clove oil for better visibility. Species were identified by utilizing the keys given by Senior-White et al. (1940) and Nandi (2002). Hymenopterans were identified by Prof. Himender Bharti, Department of Zoology and Environmental Sciences, Punjabi University, Patiala. Members of the Histeridae were identified by Dr. Tomas Lackner, Zoologische Staatssammlung Munich, Germany. For Demestidae, keys of Royal Entomological Society, London (Peacock 1993) were used. Scarabaeidae was identified with the help of Dr. Devanshu Gupta, Zoological Survey of India, Kolkata. Staphylinidae was identified by comparing it with the collection at the Department of Entomology, IARI, Delhi. Cleridae was identified with the keys from a thesis entitled "The checkered beetles (Coleoptera: Cleridae) of Florida" (Leavengood Jr. 2008).

RESULTS

During the period of five seasons such as winter, summer, monsoon, post-monsoon, and spring, nearly 692 dipterans, 467 beetles (Coleoptera), and 28 hymenopterans were collected from the indoor pig carcasses (Table 2). The observation has clearly indicated the remarkable differences in terms of occurrence, abundance, and richness of insect species in indoor pig carcasses during different decomposition stages and seasons. As mentioned by Goff (2009), four stages of decomposition were recognized, i.e., fresh, bloated, advanced decay, and dry decay stages.

1. **Fresh stage**: It begins a few moments after the placement of the carcasses in the room. A few calliphorid flies appeared on the carcasses during the first day of carcasses placement; later, fly eggs, and a few calliphorid larvae were collected from the body's natural orifices, i.e., eyes, mouth, ear, nose, and genital areas. The body colour changes to pale (Pallor mortis), and a strong odour of decomposition were noticed at the end of this stage. This stage persists for four days in winter three days each in post-monsoon and spring, two days in monsoon, and one day in summer (Table 1)

2. **Bloated stage**: The carcasses turn bluish and greenish (Rigor mortis), and the limbs get stiffened. Putrefaction begins with a robust putrefying odour, and fluid seepage starts from the mouth and genital organs. To prevent the spread of foul odour, door was always closed, and experimental site was away from residential area. The body turned balloon-like due to gas accumulation (methane, hydrogen sulphide, carbon dioxide, and hydrogen). The larvae of calliphorid species were also collected and found in abundance. During this stage maggot mass appeared on the mouth and abdomen, especially in the trunk region. This stage remained for six days in winter, three days in both summer and post-monsoon seasons, for a single day in monsoon, and four days in the spring season (Table 1).

3. **Active decay stage**: This stage begins with the origination of "maggot mass". Hundreds of fly larvae form maggot mass over the neck and abdominal region of the carcasses. Maggot mass elevates the body temperature of carcass, thus, enhancing decomposition. The abundance of beetles and fewer flies were also an indication of the beginning of this stage. The flesh was reduced, and the bony carcass became visible. Several histerid beetles were seen in this stage, while many post-feeding larvae and fewer pupae of dipteran flies were also noticed. The ants were also found feeding on the dried skin and fluid seepage. The stage stayed on the carcasses for six days in the winter season, four days in summer, for three days during monsoon, five days in post-monsoon, and four days in the spring season respectively (Table 1).

4. **Dry decay stage**: It begins when the bones of the carcasses are visible. The dry decay stage had no significant end and continued for several months. This stage had not shown any abundance of flies; only a few newly emerged flies and some specimens of coleopteran were collected from this stage during this season. The decay stage on indoor carcasses were observed for six days in the winter season, four days each during summer and monsoon seasons, five days in the post-monsoon season, and three days in the spring season respectively (Table 1).

Comparative account of insect succession and rate of decomposition

Winter season: It took 22 days for the carcass to decompose completely (Table 1). The rate of decomposition was slow because of low temperature.

Table 1. Duration of decomposition of pig carcasses at different seasons (2015 & 2017) in Punjab, India.

Stages of Decomposition	Winter (Feb, 2015) (Days)	Summer (June, 2015) (Days)	Monsoon (July, 2015) (Days)	Post-Monsoon (Nov, 2015) (Days)	Spring (March, 2017) (Days)
Fresh stage	0–4	0–1	0–2	0–3	0–3
Bloated stage	4–10	1–3	2–3	3–6	3–7
Active decay	10–16	3–7	3–6	7–11	7–11
Dry decay stage	16–22	7–11	6–10	11–16	11–14
Total	22	11	10	16	14

Table 2. Number of insects collected from indoor pig carcasses during diverse seasons.

Insect order	Season					Total fauna
	Winter	Summer	Monsoon	Post-monsoon	Spring	
Diptera	176 (51.7%)	127 (54.9%)	141 (69.1%)	110 (55.2%)	138 (64.7%)	692
Coleoptera	153 (45%)	97 (41.9%)	61 (29.9%)	89 (44.7%)	67 (31.4%)	467
Hymenoptera	11 (3.2%)	07 (3%)	2 (0.98%)	0	08 (8.2%)	28
Total fauna	340	231	204	199	213	1187

The average temperature and relative humidity during the experimental period are given in Table 4. A total of 340 specimens belonging to 24 species and 10 families of three insect orders (Diptera, Coleoptera, and Hymenoptera), were collected during winter season from indoor pig carcass, of which, a total of 176 specimens belonging to 15 species from five families under Diptera (Calliphoridae, Sarcophagidae, Muscidae, Anthomyiidae, and Phoridae) were collected from the fresh, bloated, advanced decay and dry decay stages of decomposition. While from order Coleoptera, 153 specimens of beetles belonging to nine species were collected during different decomposition stages. However, only 11 specimens of Hymenoptera belonging to *Anochaetus graeffei* were reported (Table 3).

Summer season: Pig carcass decomposed in 11 days, and the rate of decomposition was significantly faster than that of the winter season (Table 1). This could be attributed to the ambient temperature reached above 35^0C and ranged 31–35 ^{0}C. Increased temperature and optimum relative humidity which ranged 65–81 % (Table 4) accelerated the decomposition, thus the pig carcasses decomposed faster in the summer season. The record indicated the collection of 231 specimens belonging to 21 species of dipterans, beetles and Hymenoptera during the summer season's indoor pig carcass. Of which, 127 specimens belonging to order Diptera, 97 to order Coleoptera, and seven specimens from the order Hymenoptera were collected (Tables 2 & 3).

Monsoon season: The carcass decomposed in 10 days, which was faster than the summer as well as winter (Table 1). The reason for the faster decomposition could be due to high relative humidity ranged from 60 to 80% and temperature ranged 29–32 ^{0}C (Table 4). Heavy rainfall prevails in the monsoon season that tend to rise the humidity which accelerate the decomposition process as these are favourable conditions for bacterial activity as well as for insect development. A total of 204 insect specimens (Diptera – 141; Coleoptera – 61; Hymenoptera – 02) belonging to 14 species were collected from the indoor pig carcass during monsoon season (Tables 2 & 3).

Post-monsoon season: The carcass took 16 days to decompose completely during post-monsoon period (Table 1). The decomposition process was slow because of low temperature. The ambient mean temperature ranged 15–26 ^{0}C, change in relative humidity ranged 70–88 % (Table 4) and change in duration of day-night length, slowed the process of decomposition. A total of 199 specimens (Diptera – 110; Coleoptera – 89) belonging to 18 species were collected from this season. No hymenopteran species was observed over the carcass during this season (Tables 2 & 3).

Spring season: The carcass took 14 days to decompose completely (Table 1). The maximum temperature recorded was 25^0C and 90% relative humidity (Table 4). Rate of decomposition was appreciably increased as compared to winter season because of rise in room temperature. This happened because of sunny days during the earlier stages of decomposition (Figure 5).

Table 3. Diversity of insect fauna collected from indoor pig carcasses at different seasons in Punjab, India.

Order	Family	Winter	Summer	Monsoon	Post-monsoon	Spring
Diptera	Calliphoridae	*Chrysomya megacephala* *Chrysomya rufifacies* *Chrysomya albiceps* *Lucilia cuprina* *Lucilia sericata*	*L. cuprina* *L. sericata*	*C. megacephala* *C. rufifacies* *Calliphora vomitoria* *L. cuprina* *L. sericata*	*C. megacephala* *C. rufifacies* *L. cuprina* *L. sericata*	*C. megacephala* *C. rufifacies* *C. albiceps* *C. vomitoria* *Calliphora vicina* *L. cuprina* *L. sericata*
	Sarcophagidae	*Sarcophaga misera* *Sarcophaga dux* *Sarcophaga aegyptica* *Sarcophaga albiceps* *Boettcherisca nathani*	*Sarcophaga hirtipes* *S. misera* *S. dux* *S. albiceps* *B. nathani*	*S. albiceps*	*Sarcophaga sericea* *S. dux* *S. albiceps*	*S. misera* *S. dux* *S. sericea* *S. albiceps*
	Muscidae	*Musca domestica* *Musca sorbens* *Synthesiomyia nudiseta*	*M. domestica* *M. sorbens* *S. nudiseta*	*M. domestica* *M. sorbens*	*M. domestica*	*M. domestica* *M. sorbens*
	Anthomyiidae	*Anthomyia* sp.	*Anthomyia* sp.	*Anthomyia* sp.	*Anthomyia* sp.	*Anthomyia* sp.
	Phoridae	*Megaselia scalaris*	*M. scalaris*	*M. scalaris*	*M. scalaris*	*M. scalaris*
Coleoptera	Histeridae	*Saprinus pensylvanicus* *Saprinus quadriguttatus* *Saprinus splendens* *Atholus maindroni*	*S. pensylvanicus* *S. quadriguttatus* *S. splendens* *Saprinus interruptus* *Merohister jekeli*	*S. pensylvanicus* *S. quadriguttatus*	*S. pensylvanicus* *S. quadriguttatus*	*S. pensylvanicus* *S. quadriguttatus* *S. splendens*
	Scarabidae	*Caccobius vulcanus* *Onthophagus cervus*	*C. vulcanus*		*C. vulcanus* *O. cervus*	
	Dermestidae	*Dermestes maculatus*	*D. maculatus*	*D. maculatus*	*D. maculatus*	*D. maculatus*
	Cleridae	*Necrobia rufipes*	*N. rufipes*	*N. rufipes*	*N. rufipes*	*N. rufipes*
	Staphylinidae		*Creophilus maxillosus*		*Creophilous flavipenis* *C. maxillosus*	*C. flavipenis*
Hymenoptera	Formicidae	*Anochaetus graeffei*	*A. graeffei*	*A. graeffei*		*A. graeffei*
						Camponotus compressus

A total of 213 specimens (Diptera – 138; Coleoptera – 67; Hymenoptera – 08) belonging to 29 species were collected during this season (Tables 2 & 3).

DISCUSSION

The present study revealed that the rate of decomposition was slow under the indoor environment, during winter as compared to all other seasons. Decrease in temperature and relative humidity are factors responsible for gradual decomposition with a range of 16–24 ^{0}C and relative humidity range of 30–80 % (Table 4). Similar results were reported by Ahmad & Ahmad (2002) and Ahmad et al. (2011) by using monkey and pig carcasses, where it had been concluded that the indoor carcasses took longer to decompose than the outdoor carcasses. The observations made by Kumara et al. (2012) on human cadaver were quite similar to the indoor pig carcasses. Observations of that study also reported similar dipteran fauna, i.e., *Chrysomya megacephala* (Fabricius 1794) (46%), followed by *C. rufifacies* (Macquart, 1842) (22%), *Sarcophaga* (*Liopygia*) *ruficornis* (Fabricius 1974) (5%), *Sarcophaga* sp. (4%), *Synthesiomyia nudiseta* Wulp, 1883 (6%), *Megaselia* sp. (3%) and *Megaselia scalaris* (Loew, 1866), (2%). Al-Khalifa et al. (2020) and Al-Qahtni et al. (2020) had also made similar observations from the indoor human carcasses and found *Chrysomya albiceps*, *Musca domestica*, and *Dermestes maculatus* as the most abundant species and determined the PMI from the larvae of *Musca domestica* and *Dermestes maculatus*. Succession patterns spanning three seasons for the insect fauna on pig cadavers were studied in Changwon, South Korea in 2018 and 2019.

Table 4. Data on average temperature and humidity in case of indoor pig carcasses during various seasons in Punjab, India.

Days	Winter		Summer		Monsoon		Post-monsoon		Spring	
	Average temperature ^{0}C	h (%)	Average temperature ^{0}C	h. (%)	Average temperature ^{0}C	h. (%)	Average temperature ^{0}C.	h. (%)	Average temperature ^{0}C	h. (%)
1	16.95	80	31.7	75	31.45	66	25.15	70	19.25	76
2	19.85	44	32.55	78	31.4	80	24.7	76	18.35	68
3	18.25	49	28.25	70	30.2	76	24.65	79	17.6	63
4	25.15	30	31.65	65	30.25	60	25.3	77	18.7	54
5	18.15	33	33.0	75	32.6	63	25.3	75	18.3	60
6	18.6	35	34.65	81	31.85	70	24.0	80	18.4	70
7	16.8	76	34.1	80	30.5	68	25.3	79	18.35	64
8	23.4	28	34.05	81	31.1	67	26.35	76	11.45	94
9	24.55	41	33.35	80	31.75	64	23.4	83	14.7	80
10	19.8	42	33.1	80	30.15	72	25.3	77	13.0	94
11	16.65	58	33.0	79	29.15	60	25.4	72	14.8	80
12	16.5	56					24.55	78	14.6	94
13	16.1	66					23.25	81	15.65	86
14	~~17.3~~	62					15.35	88	16.3	78
15	19.3	66					23.25	83		
16	18.25	66					23.15	88		
17	18.8	56								
18	17.2	52								
19	22.0	65								
20	22.05	36								
21	23.25	39								
22	22.9	70								

Park et al. (2022) collected and identified 107 species belonging to 41 families in six orders. The sequence of insect succession followed a general pattern in which Diptera peaked initially and followed by Coleoptera which is akin to the present study. *Chrysomya pinguis* was identified as the most frequently visiting species, and act as forensic indicator in Changwon. *Calliphora nigribarbis* occurred exclusively in spring and autumn, and *Pheropsophus javanus* occurred exclusively in one locality only. Therefore, these species may be important for characterizing the different seasons or locations during PMI estimations. Almutava et al. (2024) explored the rate of decomposition of rabbit carcasses and the succession pattern of the associated dipteran flies in outdoor, indoor, and on the roof of a 4-story building during the summer and winter. A total of 6,069 flies were recorded. From roof maximum flies were collected in summer but the least in the winter, whereas the outdoor showed the most in the winter and least in the summer. In present study also maximum flies' diversity is in winter as compared to summers. Ten fly species belonging to eight families were identified in the winter, whereas six species from five families were collected in the summer. The most abundant species was *Musca domestica* Linnaeus (Muscidae) on the roof in the summer, while it was *Chrysomya albiceps* (Wiedemann) (Calliphoridae) outdoor in the winter.

CONCLUSION

It has been observed that *Sarcophaga* (*Liosarcophaga*) *aegyptica* was reported for the first time from India during this study. It was collected during the bloated and active decay stage of the winter and spring seasons. Adding to it, *Boettcherisca bengalensis* has been reported for the first time from northwestern India. *Boettcherisca bengalensis* was observed from the fresh and bloated stages of pig carcasses during the monsoon season. Furthermore, *Synthesiomyia nudiseta* was reported for the first time in India from pig carcasses and collected from active decay stage during winter, summer, and spring seasons only. *Calliphora vicina* and *Megaselia scalaris* were restricted to the seasons where *C. vicina* was only found in winter, spring, and summer seasons while *M. scalaris* (Coffin fly) was observed in all the seasons. *Chrysomya albiceps*, *Musca domestica*, and *Dermestes maculatus* were found to be the most abundant species throughout the study during all the seasons. It has been observed that the decomposition was appreciably quick during the monsoon followed by summer season, however it was slow or delayed in the winter followed by spring and post-monsoon season. The maximum species richness was observed during summer and spring seasons, followed by the winter, post-monsoon, and monsoon seasons. Maximum species abundance has been observed in the winter followed by summer, spring, post-monsoon, and monsoon season. From the elucidated uses of carrion insects in forensic entomology, it is evident that forensic entomology is an interesting aspect of entomology with useful application to investigation and in aiding justice. So, the data collected from this study will definitely form a reference or baseline data to solve crime cases. It will help in PMI estimation, especially in murders and suicides in indoor environments. Further, the chances of error in calculating the PMI will be less by using these kinds of studies as references.

REFERENCES

Ahmad, A. & A.H. Ahmad (2002). A preliminary study on the decomposition and dipteran associated with exposed carcasses in an oil palm plantation in Bandar Baharu, Kedah, Malaysia. *Tropical Biomedicine* 26(1): 1–10.

Ahmad, A.H., S.A.T. Dieng, H. Aziz & M. Boots (2011). Cadaver wrapping and arrival performance of adult flies in an oil palm plantation in northern peninsular Malaysia. *Journal of Medical Entomology* 48: 1236–1246. https://doi.org/10.1603/MI10247

Al-Khalifa, M.S., M.B.A. Mashaly & A.H. Al-Qahtni (2020). Insect species colonized indoor and outdoor human corpses in Riyadh, Saudi Arabia. *Journal of King Saud University* 32(3): 1812–1817. https://doi.org/10.1016/j.jksus.2020.01.034

Al-Qahtni, A.H., M.S. Al-Khalifa & A.M. Mashaly (2020). Two human cases associated with forensic insects in Riyadh, Saudi Arabia. *Saudi Journal of Biological Science* 27(3): 881–886. https://doi.org/10.1016/j.sjbs.2019.12.027

Anderson, G.S. (2011). Comparison of Decomposition Rates and Faunal Colonization of Carrion in Indoor and Outdoor Environments. *Journal of Forensic Science* 56: 136–142. https://doi.org/10.1111/j.1556-4029.2010.01539.x

Bala, M. & P. Kaur (2014). Insect faunal succession on buried piece of pork in the state of Punjab (India): A preliminary study. *Journal of Forensic Research* 5: 252. https://doi.org/10.4172/2157-7145.1000252

Bala, M., A. Sharma & N. Singh (2016). Case Study and PMI Estimation of Male Corpse from Ludhiana, Punjab, India: An Implication of ADH Method. *Indian Journal of Forensic Medicine & Toxicology* 10(2): 29–33. https://doi.org/10.5958/0973-9130.2016.00056.6

Campobasso, C.P. & F. Introna (2001). The forensic entomologist in the context of the forensic Pathologist's role. *Forensic Science International* 120: 132–9. https://doi.org/10.1016/s0379-0738(01)00425-x

Early, M. & M.L. Goff (1986). Arthropod succession patterns in exposed carrion on the Island of O'hau, Hawaiian Islands, USA. *Journal of Medical Entomology* 23(5): 520–531. https://doi.org/10.1093/jmedent/23.5.520

Hall, R.D. (2001). Introduction, pp. 1–15. *Perceptions and Status of Forensic Entomology*. CRC Press, Boca Raton, FL.

Goff, L. (2009). Early postmortem changes and stages of decomposition in exposed cadavers. *Experimental and Applied Acarology* 49(1–2): 21–36. https://doi.org/ 10.1007/s10493-009-9284-9

Henssge, C., B. Madea, B. Knight, L. Nokes & T. Krompecher (1995). The estimation of the Time Since Death in the Early Postmortem Interval. Arnold 262. https://doi.org/ 10.1007/s10493-009-9284-9

Kaur, P., M. Bala & F.M.A. AlGalil (2020). First report of *Boettcherisca nathani* Lopes, 1961 and *Boettcherisca bengalensis* Nandi, 1992 (Sarcophagidae: Diptera) from northwest India. *International Journal of Tropical Insect Science* 40: 441–447. https://doi.org/10.1007/s42690-019-00096-5

Kumara, T.K., R.H.L. Disney, A.A. Hassan, M. Flores, T.S. Hwa, Z. Mohamed & B. Singh (2012). Occurrence of oriental flies associated with indoor and outdoor human remains in the tropical climate of north Malaysia. *Journal of Vector Ecology* 37(1): 62–68. https://doi.org/ 10.1111/j.1948-7134.2012.00200.x

Leavengood, J.M. (2008). The checkered beetles (Coleoptera: Cleridae) of Florida. Master's Thesis. Graduate School, University of Florida, 206 pp.

Lord, W.D., & J.R. Stevenson (1986). *Directory of Forensic Entomologists*, *2nd Edition*. Defining Pest Management and Analyzing Information Center, Walter Reed Army Medical Center, Washington, DC.

Mann, R.W., W.M. Bass & L. Meadows (1990) Time since death and decomposition of the human body: Variables and observations in case and experimental field studies. *Journal of Forensic Science* 35(1): 103–11.

Nandi, B.C. (2002). Fauna of India and the adjacent countries- Diptera (VolumeX) Sarcophagidae, i–xxiv. Director ZSI Kolkata, India, 608 pp.

Peacock, E.R. (1993). *Handbooks for the Identification of British Insects*. Royal Entomological Society, London, 49 pp.

Reibe, S. & B. Madea (2010). How promptly do blow flies colonize fresh carcasses? A study comparing indoor with outdoor locations. *Forensic Science International* 195: 52–57. https://doi.org/10.1016/j.forsciint.2009.11.009

Senior, W.R., D. Aubertin & J. Smart (1940). *The Fauna of British India*, Including reminder of Oriental Region: Diptera, Vol 6 Family Calliphoridae. Taylor and Francis, London, 600 pp.

Varatharajan, R. & A. Sen (2000). Role of entomology in forensic science. *Current Science* 78(5): 101–102.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26857–26863

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9456.17.4.26857-26863

#9456 | Received 18 October 2024 | Final received 27 February 2025 | Finally accepted 21 March 2025

OPEN ACCESS

COMMUNICATION

First photographic record of ferret badger *Melogale* sp. (Mammalia: Carnivora: Mustelidae) from the state of Tripura, India

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Abstract: Photographic records of the elusive ferret badger *Melogale* sp. were documented from the tropical evergreen forest interspersed with patches of jhum (shifting) cultivation in the state of Tripura, India. Numerous photos on multiple occasions were documented using camera traps set up in the Gumti Wildlife Sanctuary during a mammalian survey; a total of 40 pictures were captured in a semi-dry seasonal stream which was located in between two active patches of jhum. The pictures documented the nocturnal foraging behavior of this lesser known species. This study provides the inaugural documented evidence of the ferret badger's presence in the state of Tripura. Previous camera-trap records come from neighboring states such as Arunachal Pradesh, Meghalaya, Mizoram, and Assam, emphasizing the importance of continued research to comprehensively map species distributions. Records like these, although seem anecdotal, bear invaluable significance in unraveling ecology and habitat use of these lesser studied species.

Keywords: Distribution, disturbed forest, ecology, evergreen forest, Gumti Wildlife Sanctuary, jhum cultivation, mammal, north-east, occurrence, threats.

Editor: Jayanta Kumar Mallick, Wildlife Wing, Kolkata, India.

Date of publication: 26 April 2025 (online & print)

Citation: Patil, O., A. Joshi & A. Parkar (2025). First photographic record of ferret badger *Melogale* sp. (Mammalia: Carnivora: Mustelidae) from the state of Tripura, India. *Journal of Threatened Taxa* 17(4): 26857–26863. https://doi.org/10.11609/jott.9456.17.4.26857-26863

Funding: The study was funded by The Habitats Trust.

Competing interests: The authors declare that there are no conflicts of interest regarding the publication of this paper. All authors have participated in the research, design and drafting of this manuscript, and have reviewed and approved the final version. They have no financial or personal relationships that could inappropriately influence or bias the content of this work.

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Author contributions: All authors contributed to data collection. Study conception, study design, preparation, data collection & analysis were performed by Omkar Patil & Ashutosh Joshi. The first draft of the manuscript was written by Omkar Patil & all authors contributed to refining & revising the manuscript.

Acknowledgements: We thank the officials and the ground staff at Tripura Forest Department, Government of Tripura for permitting us to conduct the study as well as facilitating and helping us throughout the study. We thank and acknowledge The Habitats Trust for funding the project and providing camera traps. We thank Mr Santhosh Pavagada from The Habitats Trust to provide valuable inputs in the manuscript. We thank board of directors and colleagues at Vivek PARC Foundation for their support. Our team members, Arthur Lewis, Kartheek Thevar, Raj Jadhav, and Sherly Barboza.

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INTRODUCTION

Small carnivores, including the members of the family Mustelidae, are among the least studied mammals across India. Ferret badgers are a cluster of five mustelid species indigenous to eastern and southeastern Asia. They are relatively smaller compared to those occurring sympatrically (badgers) and feature elongated bodies, prominently pointed snouts, and tails distinguished by their length and bushiness. The ferret badgers belong to the genus *Melogale,* which is the only genus of the monotypic mustelid, subfamily Helictidinae. They hail from the family Mustelidae, which includes various species of Badgers, Hog Badgers, Martens, Polecats, Weasels, Otters, Ferrets and many more across the world. In India, two species of ferret badgers (FB) have been observed, with their ranges majorly overlapping across the Asian mainland from northeastern Bangladesh (Islam et al. 2008; Akhtar et al. 2024), extending up to Nepal (Bhatta et al. 2021; Koju et al. 2021; Baral et al. 2022, 2024; Pathak et al. 2022; Thapa et al. 2024), Bhutan, northeastern India, China, and in some southeastern Asian countries such as Laos (Robichaud 2010; Coudrat & Nanthavong 2013), Cambodia (Schank et al. 2009), and Vietnam (Bahuguna & Mallick 2010; Nadler et al. 2011; Thapa et al. 2024). Like all of the FB species, the morphological attributes of Large-toothed or Burmese Ferret Badger *Melogale personata* and Small-toothed or Chinese Ferret Badger *Melogale moschata* bear a striking resemblance, leading to confusion regarding their identification and sympatric nature in the Asian mainland. The exact identification of a FB species typically necessitates examination of their dentition (Schank et al. 2009).

Ferret badgers have been relatively overlooked in scientific research for years, likely due to their elusive behavior and less attractive appearance compared to many other flagship mammals (Duckworth et al. 2016b). This lack of attention has resulted in an incomplete understanding of FB ecology, biology, life history traits, and conservation needs. Of the six species, the Small-toothed Ferret Badger *Melogale moschata* is the only FB species that has been extensively studied; it is listed as 'Least Concern' with a stable population trend on the IUCN Red List of Threatened Species (Duckworth et al. 2016a). Moreover, our knowledge about this species is primarily due to its involvement as an intermediate host for the acute respiratory syndrome coronavirus (SARS-CoV) (Guan et al. 2003). Conservation interest in other FB species, as well as most small carnivores, remains low, resulting in persistent knowledge gaps (Shepherd 2012). Records of FB have been documented from nearby states using various methods, a few of which have been a result of opportunistic sightings. Our study presents the first confirmed and scientific record of FB (*Melogale* sp.) from the Indian northeastern state of Tripura, along with some additional notes.

Significance of the study

The current record of the FB is a result of an assessment carried out in one of the most understudied parts of India. This emphasizes the importance of conducting studies in parts of India which are rich in biodiversity. Adding to this, the confirmed records of a rare species (the FB) shall bring it in limelight as they often linger in the shadows of megafauna such as the Clouded Leopard. Therefore, studies like this shall aid in promoting an in-depth research on such lesser-known species.

MATERIAL & METHODS

Study area

The current finding emerged from a rapid assessment survey to understand the status and distribution of mammals in Tripura's protected areas using camera traps and other conventional methods (Patil & Joshi 2024). The Gumti Wildlife Sanctuary (GWS) is the largest protected area in Tripura, covering 389.5 km² across the Dhalai, Khowai, and Gomati districts (coordinates: 23.834–23.389 ^{0}N & 91.707–91.920 ^{0}E) (Figure 1). Declared a sanctuary in 1989 to enhance wildlife management efforts (Deb et al. 2013), its headquarters are in Gandacherra, Dhalai. Located at the foothills of the Atharamura-Kalajhari range, GWS serves as a watershed for major regional rivers and tributaries (Deb et al. 2013). Dumboor Lake, approximately 41 km² in size, is a critical water source, receiving flow from the Gumti River and other rivulets, and maintaining the forest's biodiversity.

The sanctuary's varied terrain, from 31 m to 419 m, includes ridges, narrow valleys, and both seasonal and perennial streams, providing habitats for diverse biota. The undulating terrain is mainly in the western edge of GWS, with the lowest elevation at the western ridge's furthest corner (Deb et al. 2013). Gupta (1992) documented natural heterogeneous forests, including tropical evergreen, moist deciduous, and low alluvial woodlands, with scattered tropical evergreen forests and sporadic inner grasslands. The eastern side of the sanctuary features mixed deciduous forests. The low alluvial woodlands result largely from jhum (slash-

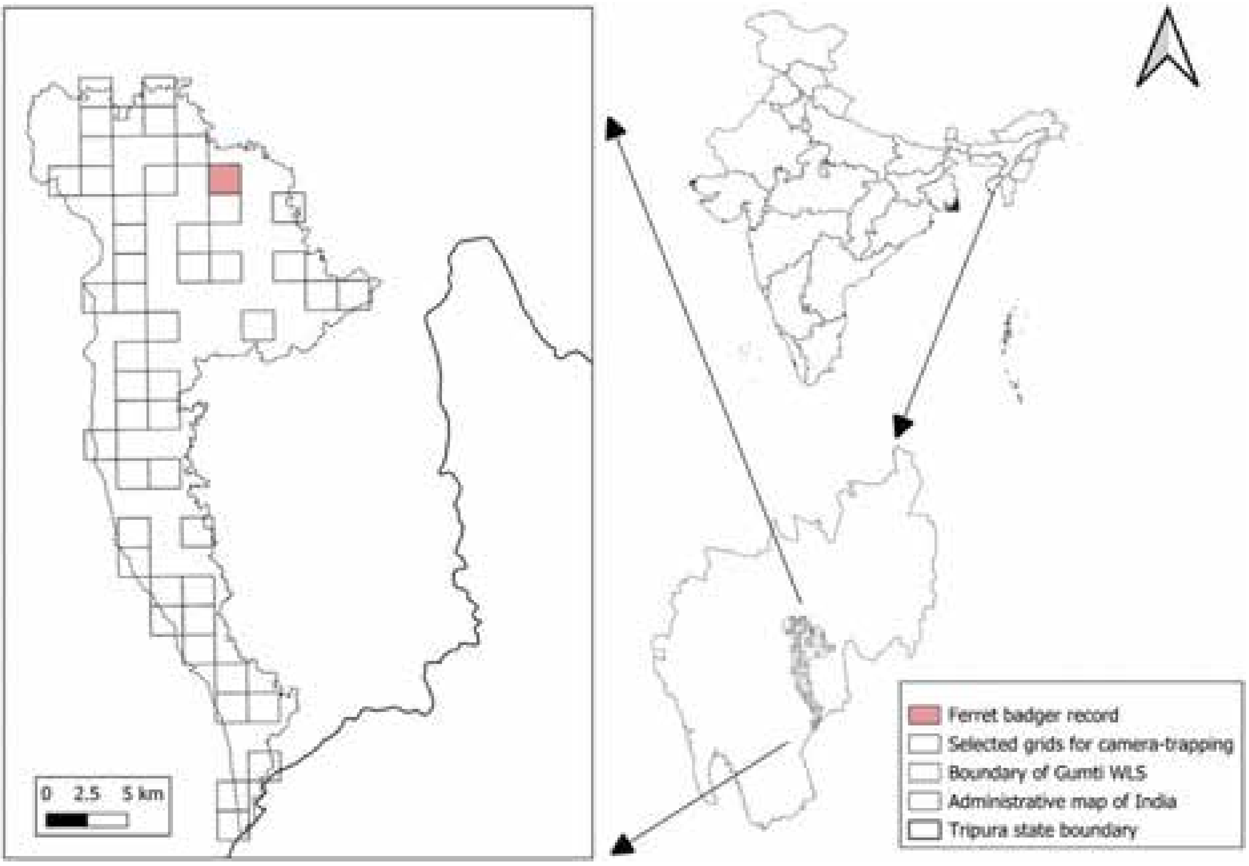

Figure 1. Location of Gumti Wildlife Sanctuary in the map of Tripura along with the sampled grids each measuring 4 km² along with the shaded grid where the ferret badger was recorded.

and-burn) cultivation and continuous grazing by local communities.

Methods

Camera trapping surveys were conducted in the GWS located in the Dhalai, Khowai and Gomati districts of Tripura between 10 March 2024 and 5 April 2024. The survey area was divided into 47 grids, each covering an area of 4 km^2. These grids were chosen based on their forest cover and limited to minimal anthropogenic pressure as identified through satellite imagery using Google Earth Pro and QGIS (V.3.30.2). The camera traps utilized in this exercise were the Spartan Lumen camera traps with white flashes & Cuddeback Xchange C1 with infrared flashes. Each grid was studied further to determine a camera trap location and was marked on the map. The feasibility of the trap locations was ascertained with the help from local forest staff such as Forest Guards, Rangers, Banmitra (friends-of-forests) and field facilitators. Special attention was provided to ensure safety from theft and to avoid human interference from Jhum cultivation activities while deploying camera traps at the predetermined location as animals generally avoid human-infested areas. Consequently, some camera traps were positioned in dry rivulets, ditches, and stream beds to achieve these objectives. Presence of secondary signs of mammalian fauna such as pugmarks, rake-marks, and droppings in an area were also considered while deciding the camera trap location. The camera traps were deployed on each trap location for a maximum of 10 days. Out of the 47 selected grids, camera traps were placed in 29 grids in a singular and paired manner. A total of 46 camera traps were deployed in the sanctuary, accounting to 280 trap nights between 10 March and 5 April 2024.

Based on the study model, we placed a pair of camera-traps in a semi-dry seasonal stream located in the Ganganagar forest range (23.750 ^{0}N & 91.816 ^{0}E) (Image 1). Since the location was right next to active jhum cultivation sites, finding a relatively less disturbed spot was difficult. The area had multiple hillocks juxtaposed to each other, forming a highly undulating terrain; while their slopes merged into one another, forming a network of small seasonal streams. We selected this spot for

Image 1. Habitat (dominated by jhum cultivation) near a camera-trap location where a ferret badger *Melogale* sp. was camera-trapped in Gumti Wildlife Sanctuary, Tripura, India. Photographed in March 2024. © Vivek PARC Foundation.

two major reasons: 1. It was a relatively undisturbed spot, according to the forest staff and 2. The location was riddled with numerous secondary signs such as pugmarks & droppings or scats indicating active usage by various mammalian species, possibly felids (cats), mustelids (badgers), viverrids (civets), and herpestids (mongoose). The cameras were monitored by the local Banmitras on a daily basis, however, the data were shifted from the memory cards to external hard drives upon their retrieval after 10 days.

RESULTS

The camera was deployed in the location during the second week of March 2024 between 12 March 2024 to 22 March 2024. During the course of 10 days, a ferret badger (*Melogale* sp.) was recorded on numerous occasions in that particular location (Image 2). The camera-trap data exclusively captured instances during the nighttime, aligning with findings from Wang & Fuller (2003) which studied the nocturnal activity patterns of *Melogale moschata*, in southeastern China.

From 10 trap nights at this location, 40 images of FB were produced on four separate occasions. Details of the photo captures are mentioned in Table 1.

Along with its nocturnal nature, the repeated appearance of the FB in the same locations could imply that the camera-trap station encompasses within the territory of that particular individual. It also provides us more insight about its habitat preference as it was documented in a matrix comprising of forests as well as jhum cultivation which corroborates with the findings of Kakati et al. (2014) in Arunachal Pradesh and Meghalaya.

DISCUSSION

Ferret badgers represent a group of carnivores that remain relatively understudied (Duckworth et al. 2016b). A study in the Hubei Houhe National Natural Reserve in Central China revealed that the Chinese Ferret Badger *Melogale moschata* is a legitimate disperser of seeds (Zhou et al. 2008). About eight species of plant seeds were discovered using fecal analysis. Similar to other Mustelids, the Chinese Ferret Badger exhibits a digging behavior to forage food, and the relatively smaller pits they dig may enhance the seedling survival. The authors emphasize on protection of the species as they are a fragmentation tolerant species and may aid in regeneration of degraded forests (Zhou et al. 2008). The Indian species of FB are included

Image 2. A camera-trap record of ferret badger *Melogale* sp. obtained during the survey in Gumti Wildlife Sanctuary, Tripura, India. © Vivek PARC Foundation; The Habitats Trust; Tripura Forest Department.

Table 1. Details of ferret badger *Melogale* sp. recorded during the camera trapping survey of mammals in March 2024 in Gumti Wildlife Sanctuary, Tripura, India.

Date (dd-mm-yy)	Time (from) (hh:mm:ss)	Time (to) (hh:mm:ss)	Total number of camera trap images	Remarks
12-03-24	19:06:52	19:07:59	13	- In a seasonal semi-dry stream surrounded by Jhum cultivation. - Three out of four times the FB was seen to use the same approach route towards the camera trap. - The time spent by the FB differs considerably in their capture duration.
13-03-24	18:58:20	19:00:14	18	
17-03-24	18:51:12	18:51:26	6	
20-03-24	10:23:36	10:23:41	3	

in the Schedule II of the Indian Wildlife Protection Act, 1972. It is important to highlight that although the genus *Melogale* is not included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2023), they are known to be victimized through substantial trade, particularly in Indo-Chinese markets which are increasingly shifting towards online platforms, posing challenges for tracing, as emphasized by Thomas et al. (2021). Small carnivores, including FB, are predominantly traded within Indonesia, either for consumption as meat or as live pets. However, the trade in such mammals often escapes attention and lacks monitoring (Shepherd 2012).

Despite the widespread perception of their distribution in northeastern India, empirical evidence from the wild is scarce. While both *Melogale personata* and *Melogale moschata* are categorized as 'Least Concern' in the IUCN Red List, it is essential to recognize that these assessments were likely the best possible outcomes given the available resources & constraints and were primarily based on infrequent observations or anecdotal records (Duckworth et al. 2016a,b). Consequently, the precise extent, distribution patterns, and population status of both the species within and outside India, remain unclear and warrant further investigation for clarification. In India, the geographical range of both FB species is primarily confined to the eight northeastern states, specifically Arunachal Pradesh, Assam, Meghalaya, Mizoram, Manipur, Nagaland, Tripura, and Sikkim along with sparse occurrences have also been documented in India, particularly in the state of West Bengal (Chakraborty & Bhattacharya 1999; Choudhury 2013). Notable proximity records stem from investigations conducted by Kakati et al. (2014), particularly in the Garo Hills region of Meghalaya. These studies employed camera traps, and one instance involved the identification of *Melogale personata* based on a recovered skull specimen. Most recent camera trap records of FB come from Manas National Park, Assam (Bhatt & Lyngdoh 2024). Furthermore, there have been four documented occurrences in close proximity to Balpakram National Park within the South Garo Hills District, and a fifth observation near the town of Tura situated in the western region of West Garo Hills District. The sixth sighting was reported from Chayang Tajo in the East Kameng district of Arunachal Pradesh (Kakati et al. 2014).

Both *Melogale personata* & *Melogale moschata* have been reported to be sympatric with each other. As documented in our research, the presence of FB has been noted in Jhum cultivations, as well as in both disturbed and undisturbed moist deciduous forests, and moist evergreen forests. Consistent with the findings of Kakati et al. (2014) from Arunachal Pradesh & Meghalaya, four of the observations in their study were situated in the vicinity of villages, disturbed forests, and jhum cultivations. Although previously available literature (Gupta 1999) mentions the presence of *Melogale personata* (and other related species from Mustelideae, Viverideae, & Herpestideae) from Tripura, the observations were predominantly based on examination of working plans, management plans, primate surveys where the data were solely based on reports from locals, forest staff and records from naturalists. In this light, our findings are the first conclusive evidence of the species, based on systematic scientific surveys. Our study corroborates the observation by Kakati et al. (2014), as images of FB were captured in the vicinity of Jhum cultivation site. This gives us an unprecedented opportunity to understand the natural history of these lesser studied species, particularly in such an anthropomorphized and dynamic landscape.

The Small-toothed Ferret Badger can be regarded as a seldom-captured mammal in camera trap surveys conducted across northeastern India, as evidenced by the limited photographic documentation of the genus (Datta et al. 2008; Kakati 2010). The low encounter rate with camera traps may arise from factors such as natural fluctuations in local population densities, inherent rarity of the species, the presence of anthropogenic threats, and/or limitations inherent to the camera-trapping methodology itself (Schank et al. 2009).

Based on the images produced in the camera trap, the FB was seen to be engaged in foraging behavior. Previous studies based on scat analysis of multiple species of small mammals in Taiwan reported omnivorous dietary habits of Small-toothed Ferret Badgers. A diverse array of food items including amphibians, carcasses of smaller birds & mammals, earthworms, eggs, fruits and snails have been documented from their scats (Chuang & Lee 1997).

Our photographic evidence of the FB marks a first scientifically confirmed record to the current checklist of mammals of Tripura. Furthermore, it underscores the imperative to investigate the natural history of small carnivores, particularly lesser known species, considering the looming threats to the habitat and dynamic ecological landscape of the state, to ensure their continued sustenance.

REFERENCES

Akhtar, T., N. Tabassum & S. Hasan (2024). Observations of Large-toothed Ferret Badger (*Melogale personata*) in Patharia Hil Reserve Forest at northeast Bangladesh. *Bangladesh Journal of Zoology* 52(2): 271–275. https://doi.org/10.3329/bjz.v52i2.77298

Bahuguna, N.C. & J.K. Mallick (2010). *Handbook of the Mammals of South Asia with Special Emphasis on India, Bhutan and Bangladesh.* Natraj Publishers, Dehradun, 109–206 pp.

Baral, R., Y. Ghimirey, B. Neupane, B. Lamichhane, S. Bhattarai& K. Bahadur Shah (2022). Photographic evidence of the Large-toothed Ferret Badger *Melogale personata* I. Geoffroy Saint-Hilaire (Carnivora: Musteliade) in the Annapurna Conservation Area, Nepal. *Journal of Animal Diversity* 4(1): 21–26. http://doi.org/10.52547/JAD.2022.4.1.3

Baral, B., G.B. Magar, S.R. Giri & R.S. Rai (2024). Distribution and new elevational record of *Melogale personata* (Carnivora: Mustelidae) from Khotang district, Nepal. *Mammalogy Notes* 10(1): 310. https://doi.org/10.47603/mano.v10n1.310

Bhatta, S., D. Khadka, G.P. Pokharel, K.R. Kafle, M.K. Dhamala, B.B. Khawas, R.P. Sapkota & J. Belant (2021). Range extension of the *Melogale personata* I. Geoffroy Saint-Hilaire, 1831 (Mustelidae) in Nepal. *Check List* 17(6): 1451–1454. https://doi.org/10.15560/17.6.1451

Bhatt, U. & S. Lyngdoh (2024). Caught in the act: Camera traps capture rare mammal species from biodiversity hotspot of Manas National Park, Assam, India. *Journal of the Bombay Natural History Society* 121(1): 1023–1043 Jan–Apr 2024. https://doi.org/10.15560/18.5.1023

Chakraborty, S. & U. Bhattacharyya (1999). Burmese Ferret-Badger, *Melogale personata* Geoffroy (Carnivora: Mustelidae) in Jalpaiguri District, West Bengal, India. *Tigerpaper* 26(2): 17–18.

Choudhury, A. (2013). *The Mammals of North east India.* Gibbon Books, Guwahati, Assam, India, 432 pp.

Chuang, S. & L. Lee (1997). Food habits of three carnivore species (*Viverricula indica*, *Herpestes ulva* and *Melogale moschata*) in Fushan Forest, northern Taiwan. *Journal of Zoology* 243: 71–79.

CITES (2023). *The CITES species*. www.cites.org. Downloaded on 5 May 2024.

Coudrat, C.N.Z. & C. Nanthavong (2013). A confirmed record of Large-toothed Ferret Badger *Melogale personata* from central Laos suggesting syntopy with Small-toothed Ferret Badger *M. moschata*. *Small Carnivore Conservation* 49: 48–50.

Datta, A., R. Naniwadekar & M.O. Anand (2008). Occurrence and conservation status of small carnivores in two protected areas in Arunachal Pradesh, North-east India. *Small Carnivore Conservation* 39: 1–10.

Deb, S., A. Ahmed & D. Datta (2013). An alternative approach for delineating eco-sensitive zones around a wildlife sanctuary applying geospatial techniques. *Environmental Monitoring and Assessment* 186(4): 2641–2651. https://doi.org/10.1007/s10661-013-3567-7

Duckworth, J.W., B. Long, D.H.A. Willcox, C.N.Z. Coudrat, R. J. Timmins, A.V. Abramov, B. Chan & W. Chutipong (2016a). *Melogale personata*. *The IUCN Red List of Threatened Species* 2016: e.T41627A45209826. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41627A45209826.en. Accessed on 26 April 2024.

Duckworth, J.W., A.V. Abramov, D.H.A Willcox, R.J. Timmins, A. Choudhury, S. Roberton, B. Long & M. Lau (2016b). *Melogale moschata*. *The IUCN Red List of Threatened Species* 2016: e.T41626A45209676. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41626A45209676.en. Accessed on 27 April 2024.

Government of Tripura, Forest Department (2020). Guideline for Eco Development and Microplanning in Gumti Wildlife Sanctuary. Government of Tripura, 1 pp

Guan, Y., B. Zheng, Y. He, X.L. Liu, Z. Zhuang, Y.M. Cheung, S. Luo, P.H. Li,L.J. Zhang, Y. Guan, K.M. Butt, K.H. Wong, K. Chan, W. Lim, K.F. Shortridge, K. Yuen, J.S.M. Peiris, & L.L.M. Poon (2003). Isolation and Characterization of Viruses Related to the SARS Coronavirus from Animals in Southern China. *Science* 302(5643): 276–278. https://doi.org/10.1126/science.1087139

Gupta, A.K. 1992. Management plan for Gumti Wildlife Sanctuary (1992–93 to 1997–98). Technical Report, Government of Tripura, India.

Gupta, A.K. (1999). Mustelids, Viverrids and Herpestids of Tripura. *ENVIS Bulletin: Wildlife and Protected Areas, Mustelids, Viverrids and Herpestids of India*, S.A. Hussain (editor), 2(2): 54–58.

Islam M.A., G.W. Chowdhury& J.L. Belant (2008). First record of the Large-toothed Ferret Badger *Melogale personata* in Bangladesh. *Small Carnivore Conservation* 39: 41–42.

Kakati, K. (2010). Camera-trapping survey of carnivores in the Jeypore-Dehing Landscape, Assam, India. Final Report to the Critical Ecosystem Partnership Fund-Eastern Himalayas, Guwahati, India.

Kakati, K., S. Srikant, H.G. Momin, F. Magne, P. Sangma, S. Sondhi, R. Naniwadekar, J. Borah, & D. Smith (2014). Records of ferret badgers *Melogale* from the states of Meghalaya and Arunachal Pradesh, India. *Small Carnivore Conservation* 51: 4–10

Koju, N. P., L.P. Poudyal, S.M. Paudel & K.B. Shah (2021). Record of Burmese Ferret Badger (*Melogale personata*, I. Geoffroy Saint-Hilaire, 1831) in Kathmandu, Nepal. *Nepalese Journal of Environmental Science* 10: 7–10.

Nadler, T., U. Streicher, C. Stefen, E. Schwierz & C. Roos (2011). A new species of ferret-badger, genus *Melogale*, from Vietnam. *Der Zoologische Garten* 80: 271–286. https://doi.org/10.1016/j.zoolgart.2011.08.004

Patil, O. & A. Joshi (2024). Status of mammals in the Protected Areas of Tripura: A Rapid Assessment. Vivek PARC Foundation. Submitted to the Tripura Forest Department. Supported by The Habitats Trust. 49–66 pp.

Pathak, A., C.P. Pokheral, P. Lamichhanne, S. Khanal, S. Lama, S. Phuyal, P. Kakshapati, P. Paudel & G. Koirala (2022). First photographic record of *Melogale personata* I. Geoffroy Saint-Hilaire, 1831 (Mustelidae) from the protected area of Nepal. *Species* 23(71): 5–8.

Robichaud, W.G. (2010). A field record of Small-toothed Ferret Badger *Melogale moschata* in Central Laos, and other recent records of ferret badgers from the country. *Small Carnivore Conservation* 42: 32–34.

Schank. C., E.H.B. Pollard, W. Sechrest, R. Timmins, J. Holden & J. Walston (2009). First confirmed records of Large-toothed Ferret Badger *Melogale personata* in Cambodia, with notes on country records of *Melogale*. *Small Carnivore Conservation* 40: 11–15.

Shepherd, C.R. (2012). Observations of small carnivores in Jakarta wildlife markets, Indonesia, with notes on trade in Javan ferret badger *Melogale orientalis* and on the increasing demand for common palm civet *Paradoxurus hermaphroditus* for civet coffee production. *Small Carnivore Conservation* 47: 38–41.

Thapa, G.B., D.R. Dahal, D. Maharjan & S. Thapa (2024). The craniodental structure of a Large-toothed Ferret Badger *Melogale personata* from Nepal. *Small Carnivore Conservation* 62: 1–4. https://smallcarnivoreconservation.com/index.php/sccg/article/view/6562 (Accessed: 27March2025).

Thomas, E., K.A. Nekaris, M. Imron, P. Cassey, C.R. Shepherd, & V. Nijman (2021). Shifts of trade in Javan ferret badgers *Melogale orientalis* from wildlife markets to online platforms: implications for conservation policy, human health and monitoring. *Endangered Species Research* 46: 67–78. https://doi.org/10.3354/esr01142

Ved, N. & L. Zathang (2014). Ferret-Badger Records from Mizoram, Meghalaya, and Nagaland, India. *Journal of the Bombay Natural History Society* 111(1): 41–43. https://doi.org/10.17087/BNHS/2014/V111I1/56526

Wang, H. & T.K. Fuller (2003). Ferret badger *Melogale moschata* activity, movements, and den site use in southeastern China. *Acta Theriologica* 48(1): 73–78. https://doi.org/10.1007/BF03194267

Zhou, Y.B., L. Zhang, Y. Kaneko, C. Newman, & X.M. Wang (2008). Frugivory and seed dispersal by a small carnivore, the Chinese ferret-badger, *Melogale moschata*, in a fragmented subtropical forest of central China. *Forest Ecology and Management* 255(5–6): 1595–1603. https://doi.org/10.1016/j.foreco.2007.11.018

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26864–26871

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9562.17.4.26864-26871

#9562 | Received 17 December 2024 | Final received 31 January 2025 | Finally accepted 11 March 2025

COMMUNICATION

An update on the status of some Data Deficient bat species from India

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Abstract: Globally, a significant percentage of bat species are classified as Data Deficient indicating a shortage of sufficient data on distribution and abundance to make a status assessment. Among these species, 12 species also occur within the political boundary of India. Based on scattered data generated over the last eight years, an update is presented on the occurrence status of five of the Data Deficient bat species in India. A call for a renewed push in field studies is needed to enhance the understanding of the chiropteran fauna of India. A National Red List Assessment of Indian Bat fauna is also suggested as a priority exercise for developing a country- specific conservation plan.

Keywords: Chiroptera, Himalaya, morphometrics, National Red List, status assessment, Vespertilionidae.

Editor: H. Raghuram, Sri S. Ramasamy Naidu Memorial College, Sattur, Tamil Nadu, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Saikia, U., M. Ruedi & R. Chakravarty (2025). An update on the status of some Data Deficient bat species from India. *Journal of Threatened Taxa* 17(4): 26864–26871. https://doi.org/10.11609/jott.9562.17.4.26864-26871

Funding: US was supported by Zoological Survey of India for field work. RC acknowledges Rufford Small Grants Foundation (Grant no. 24477-2), Idea Wild, and Elisabeth-Kalko Stiftung (OroVerde).

Competing interests: The authors declare no competing interests.

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Author contributions: All authors participated in the field surveys. US wrote the mss with inputs from other authors. All authors finally checked and approved the manuscript.

Acknowledgements: US is thankful to Dr. Dhriti Banerjee, Director, Zoological Survey of India for institutional support. US and MR also express thanks to the Director, ZSI for permitting institutional collaboration between ZSI and NHMG, Geneva. US and RC also express gratitude to the officials of the Forest Departments of Uttarakhand, Himachal Pradesh, Manipur, Meghalaya, Mizoram for survey permissions & logistical support. R. Chakravarty acknowledges funding support from Rufford Foundation, Idea Wild and Elisabeth Kalko Stiftung (OroVerde).

INTRODUCTION

The order Chiroptera comprising bats is one of the most speciose and widespread mammalian groups with 1,482 known species globally (Mammal Diversity Database 2024; Simmons & Cirranello 2024). Despite being diverse with a cosmopolitan distribution, bats tend to be understudied by zoologists and ecologists alike and therefore lack baseline information on many of these species. Consequently, a significant number of bat species remain poorly documented as reflected from global assessments. Out of the 1,336 bat species assessed by the International Union for Conservation of Nature globally, 236 species have been listed as Data Deficient (DD) indicating insufficient knowledge on abundance, distribution or taxonomic uncertainty to make a conservation assessment (IUCN 2024). In India, about 134 bat species are known (Srinivasulu et al. 2024) out of which 12 species are currently listed as DD by IUCN. Among these DD species, the Rainforest Tube-nosed Bat *Murina pluvialis*, Joffre's Pipistrelle *Mirostrellus joffrei*, Kashmir Cave Bat *Myotis longipes*, Burmese Whiskered Bat *Myotis montivagus*, and Hodgson's Long-eared Bat *Plecotus homochrous* are known by a few locality records in the Himalayan and northeastern region of India (Image 1). Starting 2017, the present authors had the opportunity to do bat sampling in several localities in the states of Uttarakhand, Himachal Pradesh, Manipur, Meghalaya, and Mizoram resulting in fresh collection of specimens of these species and additional field data. These specimens were deposited in the National Zoological Collection of the North Eastern Regional Centre (NERC) of Zoological Survey of India, Shillong. Based on these studies, an update is presented on the occurrence status of five of these bat species in India.

OBSERVATIONS

Murina pluvialis (Image 1A, Image 2)

The Rainforest Tube-nosed Bat *M. pluvialis* was discovered in 2012 from the village of Laitkynsew (780 m) in eastern Khasi Hills of Meghalaya (Ruedi et al. 2012) and until recent times was the only known from the type specimen (NERC registration No V/M/ERS/603). An old specimen in Zoological Survey of India, Shillong, collected from Shillong City (V/M/ERS/9565), is found to represent this species. Two female specimens were also collected from Risa Colony (1,540 m) and Madan Laban (1,600 m) within Shillong City in 2015 and 2018, respectively (V/M/ERS/323 and 444). A male specimen was mist netted in February 2015 at Tangsen (1,060 m) near cave Lanshat in eastern Jaintia Hills of Meghalaya (V/M/ERS/353). It was also reported that a large series of specimens identified as *Murina cyclotis* in the Field Museum of Natural History, Chicago indeed represent *M. pluvialis* (Ruedi & Csorba 2017). These specimens, 28 in total, were collected between 1952 and 1955 by American collector Walter N. Koelz and his Indian associate Rup Chand from Mawphlang (1,840 m) in eastern Khasi Hills district of Meghalaya. Another individual of this bat was observed by the first author in a torpid state hanging from a wall fig *Ficus pumila* in Shillong City in March 2021. Although *M. pluvialis* is superficially similar to the sympatric congener *M. cyclotis*, the former can be identified by their blackish hair roots on the ventral pelage as against lighter ventral hairs all along the length in the latter. It may further be mentioned that due to external similarity with *M. cyclotis*, this bat might have been overlooked or confused with the latter species in previous studies. Considering the large number of specimens collected in the past and the aforementioned recent records, this species is presumably of common occurrence in Khasi and Jaintia Hills region of Meghalaya. Interestingly, all the individuals recorded in Shillong were from an urban landscape, atypical for a reportedly forest dwelling group like *Murina* indicating this species is adepted to a human dominated landscape as well. The sampling efforts so far in other parts of northeastern India have failed to record this bat yet.

Mirostrellus joffrei (Image 1B, Image 3)

The Joffre's Pipistrelle *M. joffrei* was another poorly known species with a very few specimen records globally until recently. Previously, variously classified under genera *Nyctalus*, *Pipistrellus*, and *Hypsugo*, the species is now included under the newly erected monotypic genus *Mirostrellus* (Görföl et al. 2020). Currently it is known from several localities in Nepal, India, Myanmar, Vietnam, and China (Saikia et al. 2017; Görföl et al. 2020; Mou et al. 2024). In India, this bat was initially reported from Meghalaya and Sikkim (Saikia et al. 2017), it is now known from the western Himalayan state of Uttarakhand (Chakravarty et al. 2020) and Manipur and Mizoram in the eastern Himalayan Region as well (Saikia & Meetei 2022; Saikia & Chakravarty 2024). In Lamdan Village (1,270 m) in Manipur, two female specimens were captured in mist nets among mixed pine forest while in the periphery of Murlen National Park in Mizoram, three individuals were caught in mist nets near a water hole by the first author indicating their fairly common occurrence in suitable habitat. In Mandal (1,500 m) and Ansuya (2,200

Image 1. A–E: Portraits of the Data Deficient bat species reported in the study. A—*Murina pluvialis* | B—*Mirostrellus joffrei* | C—*Myotis longipes* | D—*Myotis montivagus* | E—*Plecotus homochrous* (not to scale). © A,B,D—Uttam Saikia | C—Manuel Ruedi | E—Rohit Chakravarty.

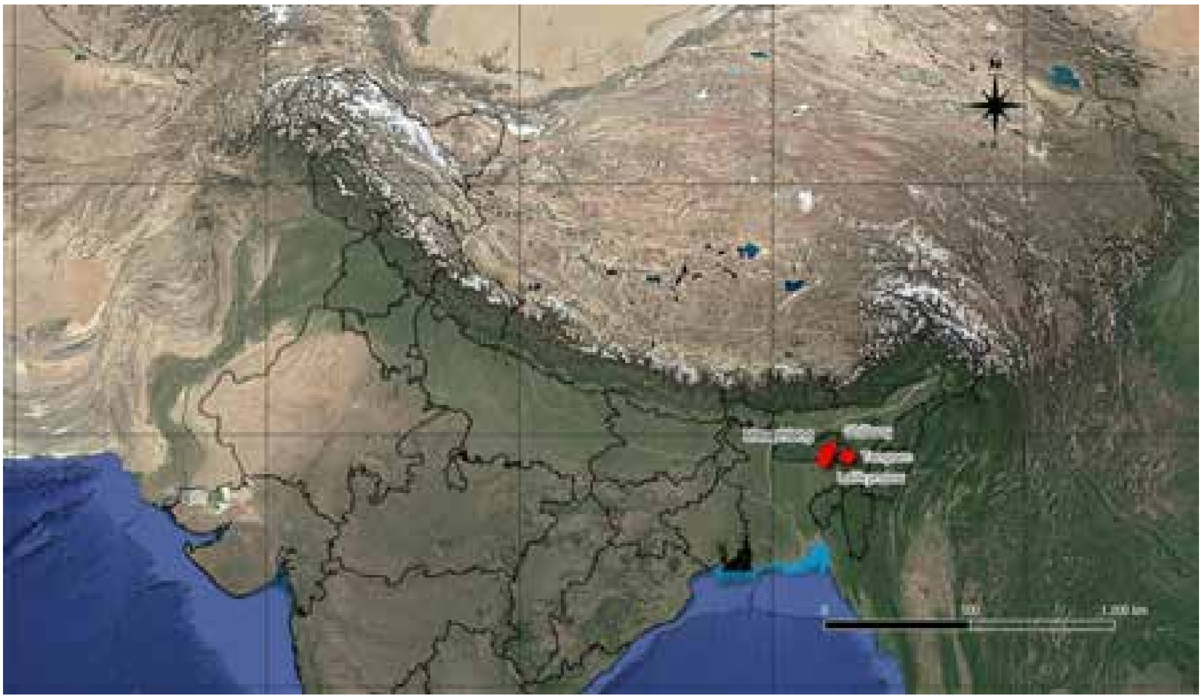

Image 2. Updated distribution records of *Murina pluvialis* in India.

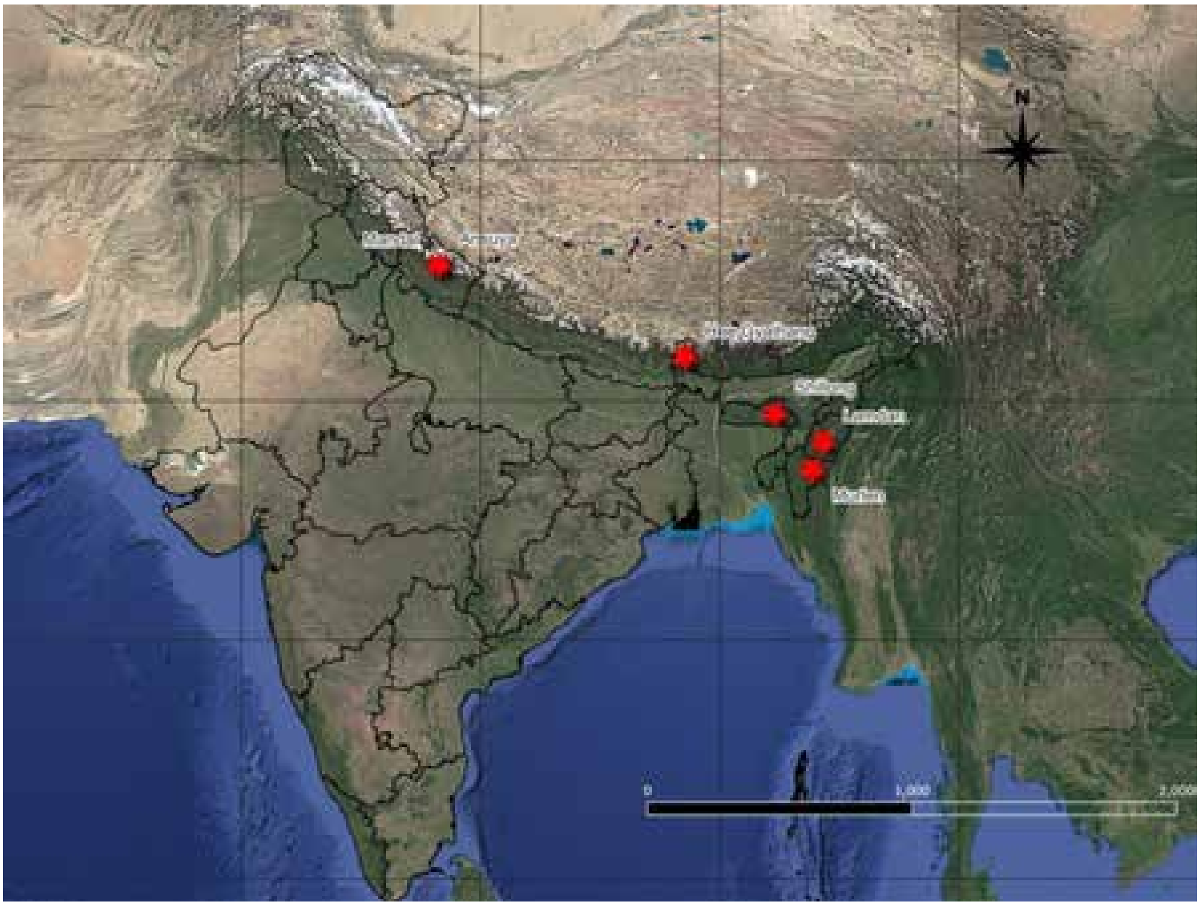

Image 3. Updated distribution records of *Mirostrellus joffrei* in India.

m) in Chamoli District of Uttarakhand, this bat is not uncommon in the forested habitat (Rohit Chakravarty pers. obs. 30th March 2018). Most females caught by the third author in Uttarakhand between late March and early May were pregnant. In comparison to other syntopic species of Mandal, *M. joffrei* seems to have an earlier onset of pregnancy (Rohit Chakravarty pers. obs. 30th March 2018, 6th and 19th April, 2021). Primarily occurring in higher elevations, the Indian records range 1,260–2,200 m and all of them were recorded in forest habitat or the vicinity. In China, this bat was reported at an elevation of 2,434m (Mou et al. 2024). Considering the extensive distribution in the Indo-Malayan Region from across the Himalayan Range, the southeastern Asia and extending till southern China and apparently not so uncommon occurrence, a fresh global status assessment of this species is warranted.

***Myotis longipes* (Image 1C, Image 4)**

The Kashmir Cave Bat *M. longipes* is another poorly known species in the Indian Himalaya. In view of insufficient information on the extent of occurrence, natural history, threats and conservation status, the IUCN categorized this species as DD (Kruskop 2016). Originally described from Bhima Devi Cave in Kashmir, this bat is reportedly known from Lawghar and Nangarhar Province of Afghanistan, Kashmir, Uttarakhand, and Meghalaya in India, western Nepal and Guizhou in southwestern China (Smith & Xie 2008; Kruskop 2016; Chakravarty et al. 2020). The previous record from Siju Cave in Meghalaya (Sinha 1994) which forms the basis for subsequent mentions of this species from Meghalaya is erroneous and represents Chinese Water Myotis *M. laniger*. In fact, our ongoing studies have indicated that all records of this bat in eastern Nepal and Indo-China might represent *M. laniger*. During the sampling in the western Himalaya, this species was recorded in a few localities in Solan District in Himachal Pradesh and also in Mandal, Woodstock School, Benog Wildlife Sanctuary and Ansuya Devi in Uttarakhand between elevations of 1,440–2,582 m (Chakravarty et al. 2020; Ruedi et al. 2021). All previous mentions of *M. mystacinus* from Himachal Pradesh indeed represent *M. longipes* (Ruedi et al. 2021). In Himachal Pradesh, this species was exclusively located in their day roost in caves, sometimes numbering over 500 individuals and sharing space with *R. lepidus* and *R. sinicus*. Although individual species were roosting in close proximity (could be influenced by space constraints), there was no intermixing between species. In Uttarakhand, the individuals were mist netted across forest brooks. The parturition period of this species in Himachal Pradesh is reported to be in June–July and females reportedly form maternity colony (Saikia et al. 2011) and females were observed with pups in early June in 2017.

***Myotis montivagus* (Image 1D, Image 5)**

Burmese Whiskered Myotis *M. montivagus* was

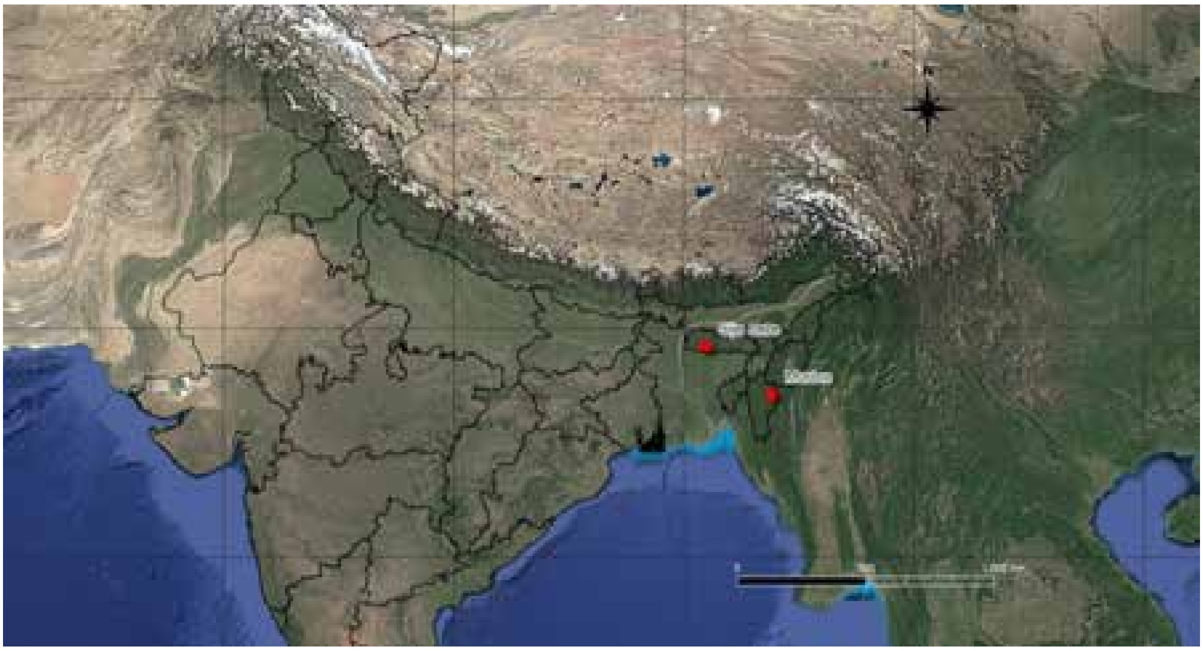

Image 4. Updated distribution records of *Myotis montivagus* in India.

described from Yunnan in China in 1874 and belongs to a taxonomically cryptic group of small-footed Myotis. Formerly, this species was recognized to have four subspecies with a wide distribution range from southeastern Asia, northeastern India, and peninsular India. Based on a detailed analysis of cranio-dental characters, all four subspecies were elevated to species rank (Görföl et al. 2013). The nominate subspecies *Myotis montivagus montivagus* has now been recognized as a distinct species *Myotis montivagus*, which is reportedly distributed in Yunnan in southern China, northern Myanmar, Laos, and Mizoram in northeastern India (Görföl et al. 2013). The peninsular Indian records of this species are now considered to belong to the Western Ghat endemic Peyton's Myotis *Myotis peytoni*. Till recently, the only genuine record of *M. montivagus* from India was from Sairep (1,500 m) in Lunglei District of Mizoram (Mandal et al. 2000). Sairep Village is situated in at a hilltop surrounded by dense evergreen vegetation and reportedly had a rich assemblage of bat fauna. The first author also revisited this area in 2023, *M. montivagus* could not be recorded. During the surveys, the first author also collected another specimen of this species from Siju Cave in southern Garo Hills in Meghalaya in 2018 (V/M/ERS/457). This bat was captured in a mist net set in front of the cave during evening hours, suggesting a subterranean roosting habit. This bat was again recorded from the periphery of Murlen National Park in Mizoram in 2022. Two individuals were mist netted around a water hole in a jhum field along Vapar-Murlen Road (1,480 m) although the surroundings had a dense covering of evergreen and semi-evergreen forest. Craniodentally, the Siju and Mizoram specimens agree well, but the former has larger morphological and cranial dimensions (Table 1). The call structure of this species from India has been described (Saikia & Chakravarty 2024). The Indian records for this bat lie between an elevation range of 70–1,500 m indicating adaptation to a broad elevation range.

***Plecotus homochrous* (Image 1E, Image 6)**

Hodgson's Long-eared Bat *Plecotus homochrous,* previously considered a synonym or a subspecies of the Brown Long-eared Bat *Plecotus auritus*, was recently assigned specific status (Spitzenberger et al. 2006). It is categorized as DD on account of insufficient information on the area of occupancy and population trend (Srinivasulu & Srinivasulu 2019). Recent surveys in Uttarakhand reported the species from four different locations: Devalsari, Dhanaulti, Ansuya, and Shokharakh ranging 1,700–3,000 m in elevation (Chakravarty et al. 2020). Between mid-April and mid-May in 2018, 2019, and 2021, this species was caught 17 times within the elevation of 2,000–3,000 m at Ansuya, Kanchula and Chopta in Kedarnath Wildlife Sanctuary, Chamoli District, Uttarakhand indicating that the bat is commonly occurring in suitable habitat in the western Himalaya. Four pregnant females were caught on 03 May 2018, and in late April 2021 between the elevation of 2,700–3,000

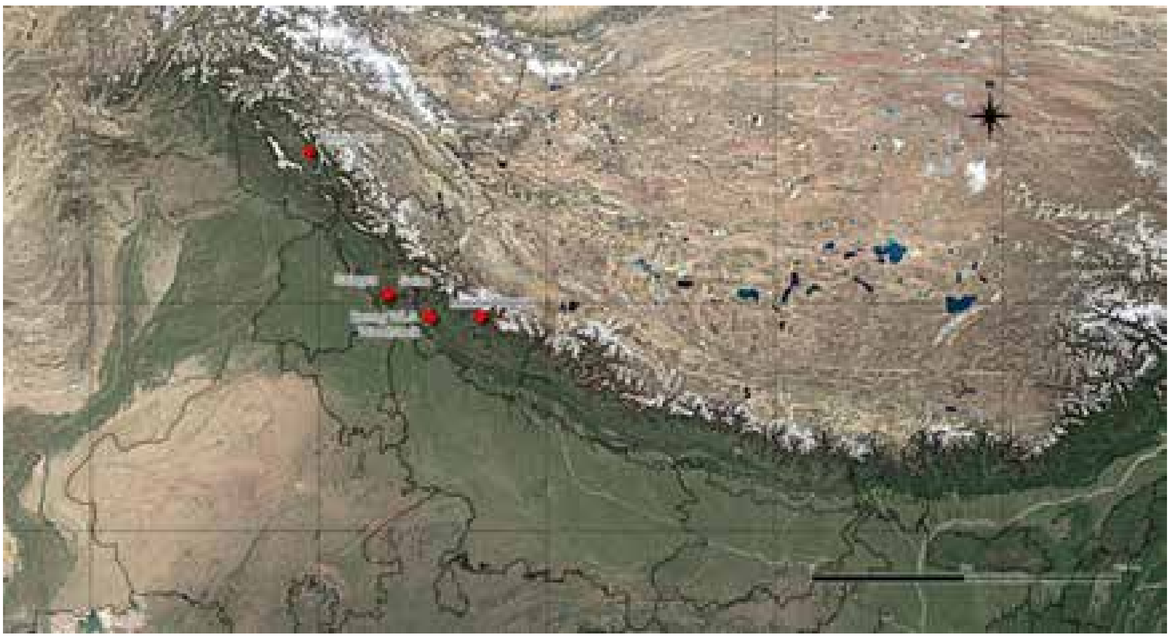

Image 5. Updated distribution records of *Myotis longipes* in India.

Table 1. Morphometrics of the five species of Data Deficient bats from India [1].

Parameters (in mm)	*Murina pluvialis* (V/M/ERS/353,444)	*Mirostrellus joffrei* (V/M/ERS/650684, 687)	*Myotis longipes* (V/M/ERS/439-442)	*Myotis montivagus* (V/M/ERS/457697, 704)	*Plecotus homochrous* (V/M/ERS/654)
FA	32, 34.1	36.7, 38.4, 38.0	36.6 (35.9–37.2)	39.4, 40.2, 42.9	36.2
HFCL	6.3, 7.9	7.6, 7.9, 8.7	8.7 (8.1–9)	8.7, 9.0, 10	7.3
TIB	15.3, 16.9	14.5, 14.7, 16.7	16.4 (15.8–16.8)	15.9, 17.4, 19	17.6
E	13.5, 14.9	8.6, 11.5	15.5 (14.9–16.3)	12.1, 12.9, 13.6	34.9
TR	6.4, 7.1	3.3 6.0	6.9 (6.5–7.5)	6.3, 6.9, 6.0	13.7
3MT	32	37.0, 37.7, 39.4	33.9 (33.4–34.9)	37.8, 40.2	34.2
4MT	30.6	36.8, 36.9, 38.0	33.2 (32.7–34.0)	36.6, 41.9	33.7
5MT	30.0	32.2, 32.6, 34.6	32.9 (32.6–33.6)	35.8, 40.5	32
GTLi	15.37, 15.65	14.9, 14.92	14.00, 13.67	15.51, 16.12	15.84
CBL	13.8	13.65, 13.02	13.3, 12.72	15.2	14.00
CCL	13.32, 13.92	14.12, 14.23	12.33, 12.06	14.28, 14.44	13.72
ZW	8.55, 9.00	10.82, 10.67	8.27, 8.57	10.82, 11.37	7.92
BW	7.33, 7.40	7.73, 8.00	6.71, 6.97	7.36, 7.57	7.53
MAB	7.37	8.68	7.08	8.25	8.43
POC	3.91, 4.16	4.58, 4.95	3.38, 3.44	4.10, 4.15	3.78
CM^3	5.06, 5.17	5.08, 5.22	5.28, 5.15	6.25, 6.52	5.18
M^3-M^3	5.20, 5.32	7.43, 7.02	5.58, 5.63	7.17, 7.08	5.82
C^1-C^1	3.93, 3.95	5.16	3.64, 3.70	4.22, 4.64	2.79
MLi	10.30, 10.6	10.74, 11.74	10.40, 10.11	11.90, 13.12	9.95
CM_3	5.63, 5.74	5.40, 5.68	5.48, 5.40	6.55, 7.13	5.84
COH	3.50	3.73, 4.00	2.72, 2.70	3.89, 3.00	2.66

[1] FA—Forearm length | E—Ear length | TR—Tragus length | HFCL—Hindfoot length including claw | FA—Forearm length | TB—Tibia length | 3MT—3rd metacarpal length | 4MT—4th metacarpal length | 5MT—5th metacarpal length | GTLi—Greatest length of skull including incisors | CBL—Condylobasal length | CCL—Condylocanine length | ZB—Zygomatic breadth | BW—Braincase width | MAB—Mastoid breadth | POC—Postorbital constriction | CM3—Maxillary toothrow length | M3M3—Width across third molars | C1C1—Width across canines | MLi—Length of mandible including incisors | CM3—Mandibular tooth row length | COH—Coronoid height.

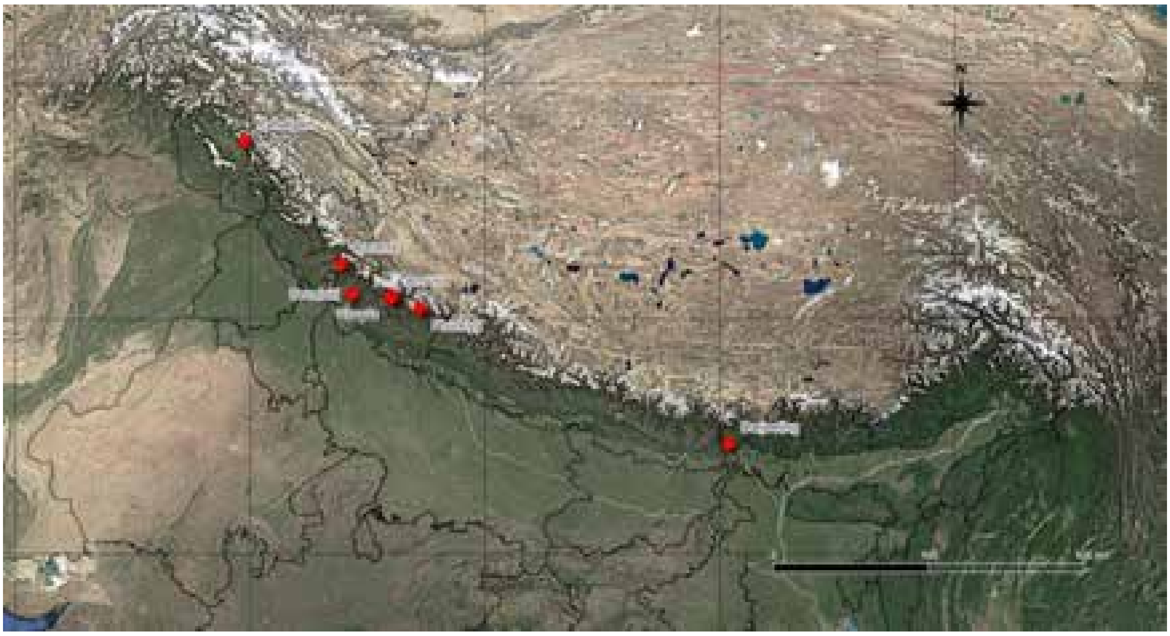

Image 6. Updated distribution records of *Plecotus homochrous* in India.

m. Differences were observed in the elevation ranges of *P. homochrous* and sympatric congener *Plecotus wardi* in Kedarnath Wildlife Sanctuary in Uttarakhand. The two species overlapped at 3000 m (the highest sampling point) but *P. wardi* was never caught below that elevation. Dietary studies show that *P. homochrous* is a dietary specialist probably predominantly consuming Noctuid moths (Chakravarty et al. 2023).

CONCLUSION

Evidently, the global status of a large number of bat species remains obscure at present including several Indian species. This is especially true for bats that occur in mountain ranges (Chakravarty et al. 2024). Although some information on the national status of five of these DD species occurring in the Himalaya and the hills of northeastern India has been updated, a lot more needs to be documented. To improve the knowledge of the bat fauna of the country, field studies specifically aimed at the DD and lesser known species should be considered a priority. Besides occurrence data, these studies should aim to generate biological information like breeding, population, diet, and also assess present and future threats. In the light of currently available information, afresh IUCN Red List status assessment of at least a few of these species like *M. joffrei*, *M. longipes*, and *P. homochrous*. This is important since the conservation policy decisions are mostly planned and implemented at the national level and guidelines for such exercises are already available (IUCN 2012).

REFERENCES

Chakravarty, R., M. Ruedi & F. Ishtiaq (2020.) A recent survey of bats with descriptions of echolocation calls and new records from the western Himalayan Region of Uttarakhand, India. *Acta Chiropterologica* 22(1): 197–224. https://doi.org/10.3161/15081109ACC2020.22.1.019

Chakravarty, R., V. Radchuk, K. Suryawanshi & C.C. Voigt (2024). Mountains host significantly more data deficient and threatened bat species than lowlands. *Biodiversity and Conservation* 33(14): 4355–4370. https://doi.org/10.1007/s10531-024-02958-y

Chakravarty, R., V. Radchuk, S. Managave & C.C. Voigt (2023). Increasing species richness along elevational gradients is associated with niche packing in bat assemblages. *Journal of Animal Ecology* 92: 863–874. https://doi.org/10.1111/1365-2656.13897

Görföl, T., P. Estók & G. Csorba (2013). The subspecies of *Myotis montivagus* — taxonomic revision and species limits (Mammalia: Chiroptera: Vespertilionidae). *Acta Zoologica Academiae Scientiarum Hungaricae* 59(1): 41–59.

Görföl, T., S.V. Kruskop, V.T. Tu, P. Estók, N.T. Son & G. Csorba (2020). A new genus of vespertilionid bat: the end of a long journey for Joffre's Pipistrelle (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 101(2): 331–348. https://doi.org/10.1093/jmammal/gyz202

IUCN (2012). *Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0*. Gland, Switzerland and Cambridge, UK, 41 pp.

IUCN (2024). The IUCN Red List of Threatened Species. Version 1014–1. https://www.iucnredlist.org

Kruskop, S.V. (2016). *Myotis longipes*. The IUCN Red List of Threatened Species 2016: e.T14175A22056206. https://doi.org/10.2305/IUCN.UK.20162.RLTS.T14175A22056206.en. Accessed on 17 December 2024

Mammal Diversity Database (2024). Mammal Diversity Database (Version 1.13) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.4139722

Mandal, A.K., A.K. Poddar & T.P. Bhattacharyya (2000). Further new records of bats from Mizoram, *India*. *Records of the Zoological Survey of India* 98(2): 147–154.

Mou, X., M. Li, B. Li, X. Luo & S. Li (2024). New record of Joffre's Pipistrelle, *Mirostrellus joffrei* (Chiroptera, Vespertilionidae), in China. *Biodiversity Data Journal* 12: e120923. https://doi.org/10.3897/BDJ.12.e120923

Ruedi, M. & G. Csorba (2017). *Murina pluvialis*. The IUCN Red List of Threatened Species 2017:e.T84548064A84548082. https://doi.org/10.2305/IUCN.UK.20172.RLTS.T84548064A84548082.en. Accessed on 17 December 2024

Ruedi, M., J. Biswas & G. Csorba (2012). Bats from the wet: two new species of Tube-nosed Bats (Chiroptera: Vespertilionidae) from Meghalaya, India. *Revue Suisse de Zoologie* 119(1): 111–135. https://doi.org/10.5962/bhl.part.150145

Ruedi, M., U. Saikia, A. Thabah, T. Görföl, S. Thapa & G. Csorba (2021). Molecular and morphological revision of small Myotinae from the Himalayas shed new light on the poorly known genus *Submyotodon* (Chiroptera: Vespertilionidae). *Mammalian Biology* 101: 465–480. https://doi.org/10.1007/s42991-020-00081-3

Saikia, U. & A.B. Meetei (2022). Diversity, distribution and abundance status of small mammalian fauna (Chiroptera, Rodentia and Eulipotyphla) of Manipur, India. *Journal of Threatened Taxa* 14(9): 21751–21768. https://doi.org/10.11609/jott.8050.14.9.21751-21768

Saikia, U., G. Csorba & M. Ruedi (2017). First records of *Hypsugo joffrei* (Thomas, 1915) and the revision of *Philetor brachypterus* (Temminck, 1840) (Chiroptera: Vespertilionidae) from the Indian Subcontinent. *Revue Suisse de Zoologie* 124(1): 83–89. https://doi.org/10.5281/zenodo.322668

Saikia, U., M.L. Thakur, M. Bawri & P.C. Bhattacherjee (2011). An inventory of the chiropteran fauna of Himachal Pradesh, northwestern India with some ecological observations. *Journal of Threatened Taxa* 3(4): 1637–1635. https://doi.org/10.11609/JoTT.o2409.1637-55

Saikia, U. & R. Chakravarty (2024). A preliminary assessment of the bat fauna (Mammalia: Chiroptera) of Murlen National Park, Mizoram, India: distribution, morphology, and echolocation. *Journal of Threatened Taxa* 16(6): 25422–25432. https://doi.org/10.11609/jott.8854.16.6.25422-25432

Smith, A.T. & Y. Xie (2008). *A Guide to the Mammals of China*. Princeton University Press, Princeton, New Jersey, 544pp.

Simmons, N.B. & A.L. Cirranello (2024). Bat species of the world: a taxonomic and georgraphic database 1.6. https://batnames.org/query.html. Accessed on 30 January 2025.

Sinha, Y.P. (1994). Occurrence of Kashmir Cave Bat *Myotis longipes* (Dobson, 1873) in Meghalaya, India. *Geobios New Report* 13(1): 68.

Spitzenberger, F., P.P. Strelkov, H. Winkler & E. Haring (2006). A preliminary revision of the genus *Plecotus* (Chiroptera, Vespertilionidae) based on genetic and morphological results. *Zoologica Scripta* 35 (3): 187–230. https://doi.org/10.1111/j.1463-6409.2006.00224.x

Srinivasulu, C., A. Srinivasulu & B. Srinivasulu (2024). Checklist of the bats of India (v1.5). https://threatenedtaxa.org/index.php/JoTT/checklist/bats/india. Date of publication: 1 August 2024. https://doi.org/10.11609/jott.checklist/india.bats. Accessed on 31st January, 2025

Srinivasulu, C. & B. Srinivasulu (2019). *Plecotus homochrous*. The IUCN Red List of Threatened Species 2019: e.T85537505A85537516. https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T85537505A85537516.en. Accessed on 21 November 2024.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26872–26878

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9545.17.4.26872-26878

#9545 | Received 10 December 2024 | Final received 15 April 2025 | Finally accepted 17 April 2025

COMMUNICATION

Distribution, perception, and conservation challenges of endemic Madras Hedgehog *Paraechinus nudiventris* in Tenkasi District, Tamil Nadu: insights from questionnaire surveys

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Abstract: The distribution patterns, recent sightings and people's perception of the endemic small mammal, Madras Hedgehog *Paraechinus nudiventris* of Tenkasi District, Tamil Nadu were identified through questionnaire surveys. This study gathered insights into the perceptions and interactions with 1,141 participants from 38 villages in Tenkasi District, Tamil Nadu. A total of 867 respondents provided valuable information, revealing that 34% had observed hedgehogs in their villages. Notably, 38% people reported night as the optimal time for sighting and while only 11% reported sighting in the afternoon. The rainy season, chosen by 53% of respondents, emerged as the key period for hedgehog sightings, likely associated with hedgehog breeding and increased foraging opportunities. Therefore, the traditional medicinal applications of using various hedgehog body parts, raising critical concerns regarding hunting practices and the ethical treatment of these animals. The combined pressures of increased urbanization, habitat loss, and hunting are contributing to a potential decline in populations of the Madras Hedgehog. Reports of roadkill and poaching urges the need for conservation efforts. The reliance on hedgehogs in local remedies, particularly for conditions such as coughs and rheumatism, exacerbates the threats to their survival. Therefore, these factors necessitate immediate action to implement effective conservation strategies that address both the preservation of this endemic species and the ethical considerations surrounding its use in traditional practices.

Keywords: Biodiversity, community engagement, conservation strategies, ecological awareness, human-wildlife interaction, traditional knowledge, wildlife protection.

Tamil: தமிழ்நாட்டின் தென்காசி மாவட்டத்தில் காணப்படும் சிறிய பாலூட்டியான தென்இந்திய முள்ளெலியின் (பராச்சினஸ் நுடிவென்ட்ரிசி) பரவல் முறைகள், வெவ்வேறு இடங்களிலும் அவற்றைப் பார்க்கப்பட்ட பதிவுகள் மற்றும் மக்களின் கண்ணோட்டம் ஆகியன கேள்வித்தாள் ஆய்வுகள் மூலம் வெளிக்கொணரப்பட்டது. இந்த ஆய்வில், தென்காசி மாவட்டத்தில் உள்ள 38 கிராமங்களைச் சேர்ந்த 1,141 பங்கேற்பாளர்களின் கருத்துக்கள், பட்டறிவுகள், கலந்துரையாடல் மூலம் சேகரிக்கப்பட்டது. மொத்தம் 867 நபர்கள் இந்த கணக்கெடுப்பில் பங்கேற்று மதிப்புமிக்க தகவல்களை வழங்கினர். 34% பேர் தங்கள் கிராமங்களில் முள்ளெலியைப் பார்த்ததாகத் தெரிவித்தனர். குறிப்பாக, 38% பேர் இரவு நேரத்தில் கண்டதாகவும், 11% பேர் நண்பகல் வேளையில் பார்த்ததாகவும் தெரிவித்தனர். 53% பேர் மழைக்காலத்தில் முள்ளெலிகள் கூடுதலாகத் தென்பட்டதாகத் தெரிவித்தனர். மழைக்காலமானது முள்ளெலிகளின் இனப்பெருக்கத்துடன் தொடர்புடையதாகவும், உணவு தேடிக் கூடுதலாக இங்கும் அங்கும் செல்வதாலும் அதனைப் பார்க்கும் வாய்ப்புகள் அதிகரித்திருக்கலாம். பாரம்பரிய மருத்துவத்தில் முள்ளெலியின் பல்வேறு பாகங்களையும் இவர்கள் பயன்படுத்துவதாக தெரிய வந்தது. பாரம்பரிய மருத்துவத்திற்காக இந்த விலங்குகளை வேட்டையாடும் நடைமுறைகளும், நெறிமுறைகளும் கவலை அளிப்பதாக உள்ளன. நகரமயமாக்கல், வாழ்விடச்சிதைவு மற்றும் வேட்டையாடுதல் ஆகியவற்றின் ஒருங்கிணைந்த அழுத்தத்தால் முள்ளெலிகளின் எண்ணிக்கை சரிவை நோக்கி சென்று கொண்டிருக்கின்றது. வாகனங்களில் சிக்கி சாலையில் அடிபடுதல், வேட்டை போன்ற காரணிகளும் இவற்றின் பாதுகாப்புக்கு அச்சுறுத்தலாக உள்ளன. இருமல் மற்றும் வாத நோயைப் போக்கும் மருந்து என நம்பப்படுவதால் முள்ளெலிகள் வேட்டையாடப் படலாம். இதனால் அவை அழிந்து போவதற்கான அச்சுறுத்தல்கள் மேலும் அதிகரிக்கிறது. மேற்கூறிய காரணிகள் யாவும் இந்த ஓரிடவாழ் உயிரினத்தின் பாதுகாப்பு மற்றும் அதனைச் சார்ந்திருக்கும் பாரம்பரிய நடைமுறைகளையும் காக்கும் வகையிலான மேம்பட்ட செயல்திட்டங்களை உடனடியாகச் செயல்படுத்த வேண்டும் என்பதை இந்த ஆய்வின் முடிவுகள் உணர்த்துகிறது.

Editor: S.S. Talmale, Zoological Survey of India, Pune, India.

Date of publication: 26 April 2025 (online & print)

Citation: Kumar, B. & A. Muthaiyan (2025). Distribution, perception, and conservation challenges of endemic Madras Hedgehog *Paraechinus nudiventris* in Tenkasi District, Tamil Nadu: insights from questionnaire surveys. *Journal of Threatened Taxa* 17(4): 26872–26878. https://doi.org/10.11609/jott.9545.17.4.26872-26878

Funding: TAAL Tech India Private Limited.

Competing interests: The authors declare no competing interests.

Author details, Author contributions & **Acknowledgements**: See end of this article.

INTRODUCTION

Small mammals are an important part of the global ecosystem, but there is a lack of data on their populations and the threats they face. This is partly due to their small size, nocturnal habits, and cryptic lifestyles, which make them difficult to study (Molur et al. 2005). Additionally, small mammals are often overlooked in conservation efforts, which tend to focus on larger, more charismatic animals. The lack of data on small mammals makes it difficult to assess the full extent of their decline for conservation strategies. Climate change, habitat fragmentation, and invasive species are some of the factors influencing their decline (Bertolino et al. 2015).

Tenkasi District, which was bifurcated from Tirunelveli District in the year of 2019 and emerged as the 33rd district in Tamil Nadu (Revenue Administration Jurisdiction, Bifurcation of Tirunelveli District (2019)), is located at the southern tip of the Western Ghats, serving as a haven for both flora and fauna. Adjacent to Tenkasi District, the Kalakkad Mundanthurai Tiger Reserve (KMTR), Nellai Wildlife Sanctuary, Periyar Tiger Reserve (PTR) and small pockets of reserve forest in the plains such as Uttumalai, Sivalar Kulam, and Mayamankurichi provide thriving habitats for faunal communities. The open grasslands and savannah in the region are characterized by tropical dry forests, tropical thorn forest and plains of vast expanses of low-lying vegetation, providing crucial habitats for a variety of wildlife. The tropical thorn forest exhibits an environment with petite, prickly trees that typically lose their leaves during the dry season. The ground level is comprised of lush, water-retaining plants, grasses adapted to arid conditions, and shrubs adorned with thorns. This region primarily receives its annual rainfall during the northeastern monsoon season (October–December) and faces dry from April to September. Notable species found in the tropical thorn forest area of this region include *Acacia, Chloroxylon, Commiphora,* and *Dalbergia* (Jha & Singh 1990). Historically, the Cheetah *Acinonyx jubatus venaticus* and Blackbucks *Antilope cervicapra* were recorded from the plains of this district, and now they are completely extinct (Rangarajan 1998). These grasslands not only support numerous plant and animal species but also provides a feeding ground for the cattle and livelihood for the communities (Image 1a). The mix of grasses and scattered trees, creating a unique ecosystem, is home to a rich assortment of flora and fauna, including grazing herbivores and the predators that rely on them for sustenance. These regions receive less rainfall, and vegetation tends to be adapted to the scarcity of water. Despite the challenging conditions, these areas still host an array of resilient plant species and wildlife specially adapted to the semi-arid climate, mainly small mammals.

The Madras Hedgehog belongs to the order Eulipotyphla of family Erinacidae, is one of India's small mammals, and is known to occur in plains and semi-arid parts of southern India. Although it was widely distributed in the plains of Tamil Nadu and has restricted distribution in Kerala and Andhra Pradesh, rigorous hunting of this species over a century throughout its range has led to a rapid and ongoing population collapse. It prefers open grasslands to forage; thorny scrubs and hedgerows to reproduce and nesting. Despite its ecological significance, this species faces numerous challenges, including habitat loss and illegal trade (Kumar & Nijman 2016; Kumar et al. 2018a,b). On the other hand, it is threatened by anthropogenic degradations, habitat loss and deforestation. Despite the widespread conversion of *P. nudiventris* habitat into agriculture, some small patches of grassland habitat still exist in agricultural fields as they are important for the population to survive (Kumar et al. 2018b). Nearly 70% of small mammal species in the Western Ghats of India are declining due to anthropogenic activities such as habitat loss, fragmentation, deforestation and mining (Nameer et al. 2001). Therefore, understanding their presence, perception and awareness in their habitat is crucial for future conservation efforts.

METHODS

Questionnaires have been valuable in assessing the presence and absence of hedgehogs (Hof 2009; Hof & Bright 2012; Williams et al. 2015). Specific geographic surveys were used to identify regional distributions and historical sightings, aiding in presence determination. While negative responses are equally important (Sjöström et al. 1999) as when people report absence, it confirms where the species isn't found, enhancing distribution mapping. Semi-structured questionnaires cover behaviour and activity, offering insights into ecological roles.

The results of a questionnaire survey were analysed that was conducted in 38 villages in Tenkasi District, Tamil Nadu, involving 1,141 participants and aimed to assess various aspects, like the presence of Madras Hedgehogs and also their activity patterns. These locations include human-dominated areas, to gauge the local population's perception of Madras Hedgehogs (Figure 1).

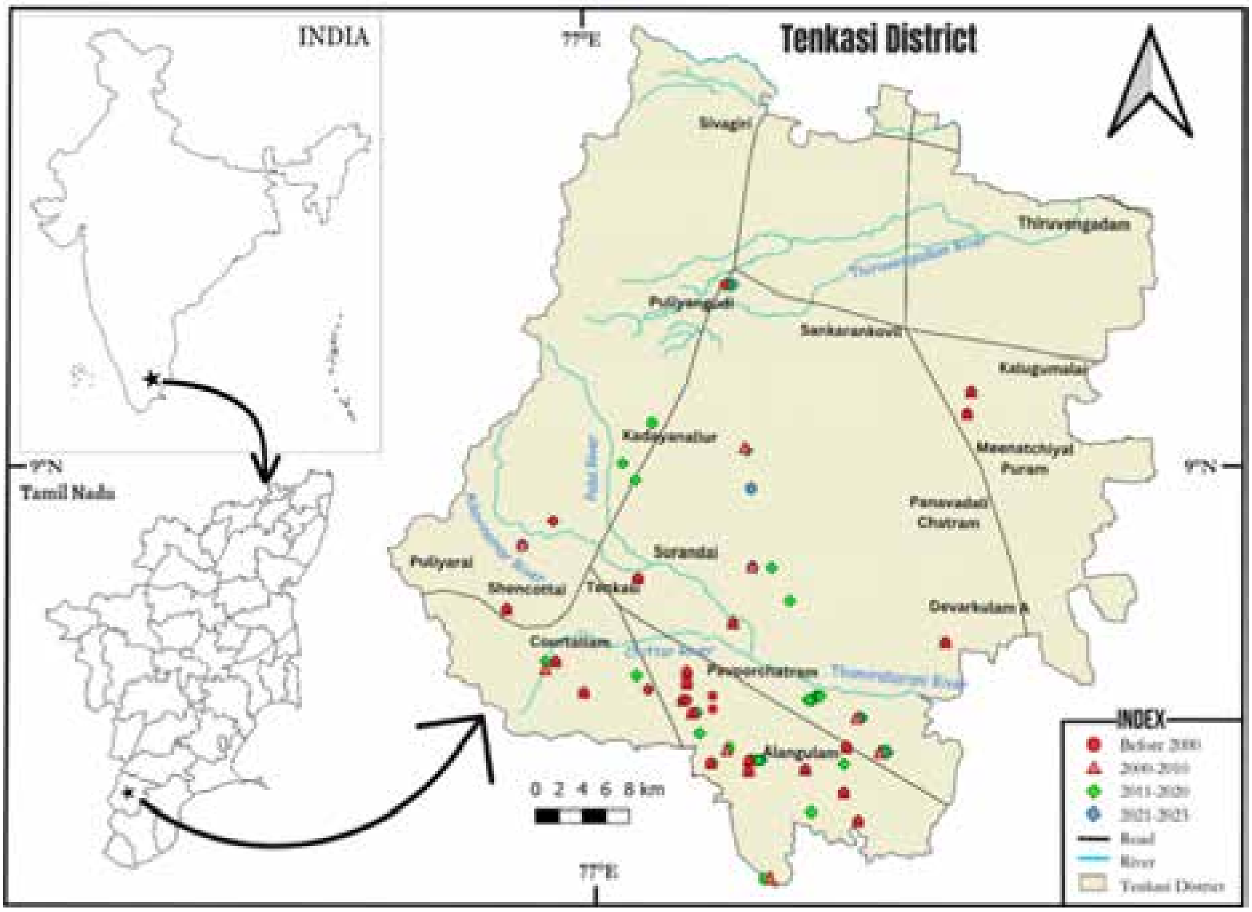

Figure 1. A Comparison of the *Paraechinus nudiventris* sighting between the current decade and previous years in Tenkasi District, Tamil Nadu. (Map source: https://www.istockphoto.com).

Questionnaire surveys efficiently gather insights from local communities (Kitchenham & Pfleeger 2002; Sirivongs et al. 2012) from their extensive experience in the hedgehog's habitat, which provides valuable data (Roopa & Rani 2012). The study area was classified into zones, such as villages and carried out random sampling surveys. Face-to-face interviews in the local language (Tamil) ensured effective communication, with prior informed consent from all respondents. The questionnaire covered respondent demographics, behavioural observations, traditional beliefs, presence and absence of hedgehogs, population changes, hunting, and recent sightings (pre- and post-2000). Microsoft Excel 2016 was used to analyse the data, while QGIS 3.32 LIMA was used for mapping the reported sightings in the listed villages.

RESULTS

In this survey, 1,141 respondents from 38 villages participated between July 2021 and September 2023. It's important to note that the data relies on self-reports, potentially influenced by recall bias. Filtering responses revealed that out of 867 participants, 295 (34%) reported Madras Hedgehog presence and 399 (46%) could distinguish Madras Hedgehogs from porcupines. As for preferred observation times, 104 (17%) suggested the early morning (0000–0600 h) in line with hedgehogs' nocturnal habits, meanwhile, 125 (20%) favoured morning hours (0600–1200 h), 70 (11%) opted for afternoons (1200–1600 h), and furthermore, 78 (12%) preferred early evenings (1600–1800 h), capturing the transition from rest to activity. A majority of 233 (38%) chose night-time (1800–0000 h) to see hedgehogs, aligning with their nocturnal nature. The rainy season received the highest response (53%), possibly due to mating and the abundance of invertebrate prey. Winter (25.3%) also exhibited favourable conditions, with the

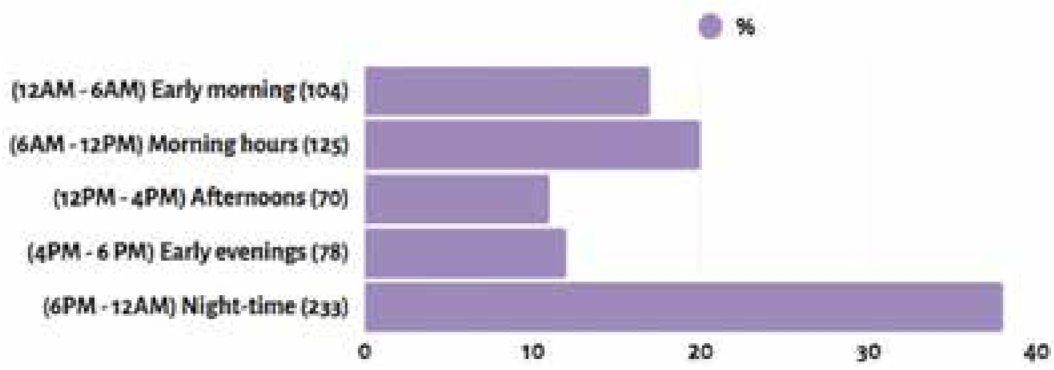

Figure 2. Temporal patterns of Madras Hedgehog sightings.

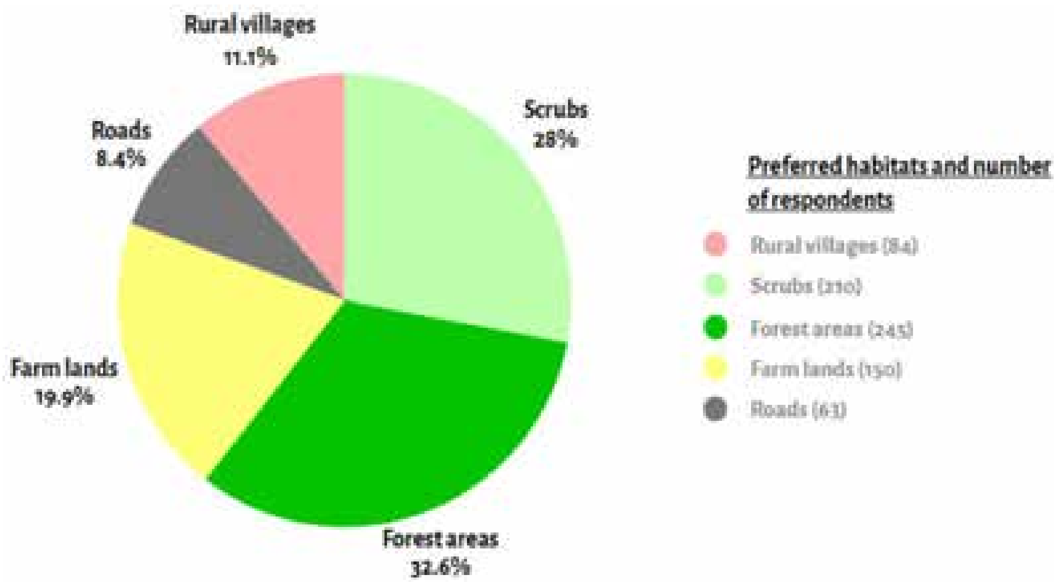

Figure 3. Madras Hedgehog sightings reported by the participants across different habitat types.

summer season (21%) being the least favoured.

Regarding habitat, the species is exclusively found in the lowlands of the eastern region of the southern Western Ghats (Kumara et al. 2023). The respondents identified potential sighting locations as follows: 84 (11.1%) in rural villages, 150 (19.9%) in farmlands, 210 (27.9%) in scrublands, 245 (32.5%) in forest areas, and 63 (8.4%) on roads.

The utilization of hedgehog body parts is believed to have various traditional and medicinal purposes, with certain body parts believed to possess specific properties to deal with whooping cough and other abnormalities. A significant number of respondents, 250 people (38%), indicated that hedgehogs are hunted for their skins, and 268 people (41%) for their spines. This practice is often associated with the use of hedgehog spines and skins in the production of traditional medicines, which are highly valued and not only available in black markets in Tenkasi, Tirunelveli, and Kanyakumari of Tamil Nadu State; but also traded both locally and across states. Cultural and traditional beliefs in the efficacy of hedgehog spines for medicinal purposes, which aids in treating various diseases like whooping cough, asthma, stomach aches, ear aches, and childcare medicines, as well as ritualistic purposes. Dried skin is believed to keep evil spirits from entering the home. A notable number of 123 people (19%) acknowledged that hunting hedgehogs for meat consumption is still practiced. Additionally, 79 (9%) reported keeping hedgehogs as pets, and 275 (31%) acknowledged using hedgehog body parts for traditional medicines. While it's essential to consider cultural and regional differences, this practice raises concerns about the ethical treatment of animals and potential impacts on local hedgehog populations (Figure 4).

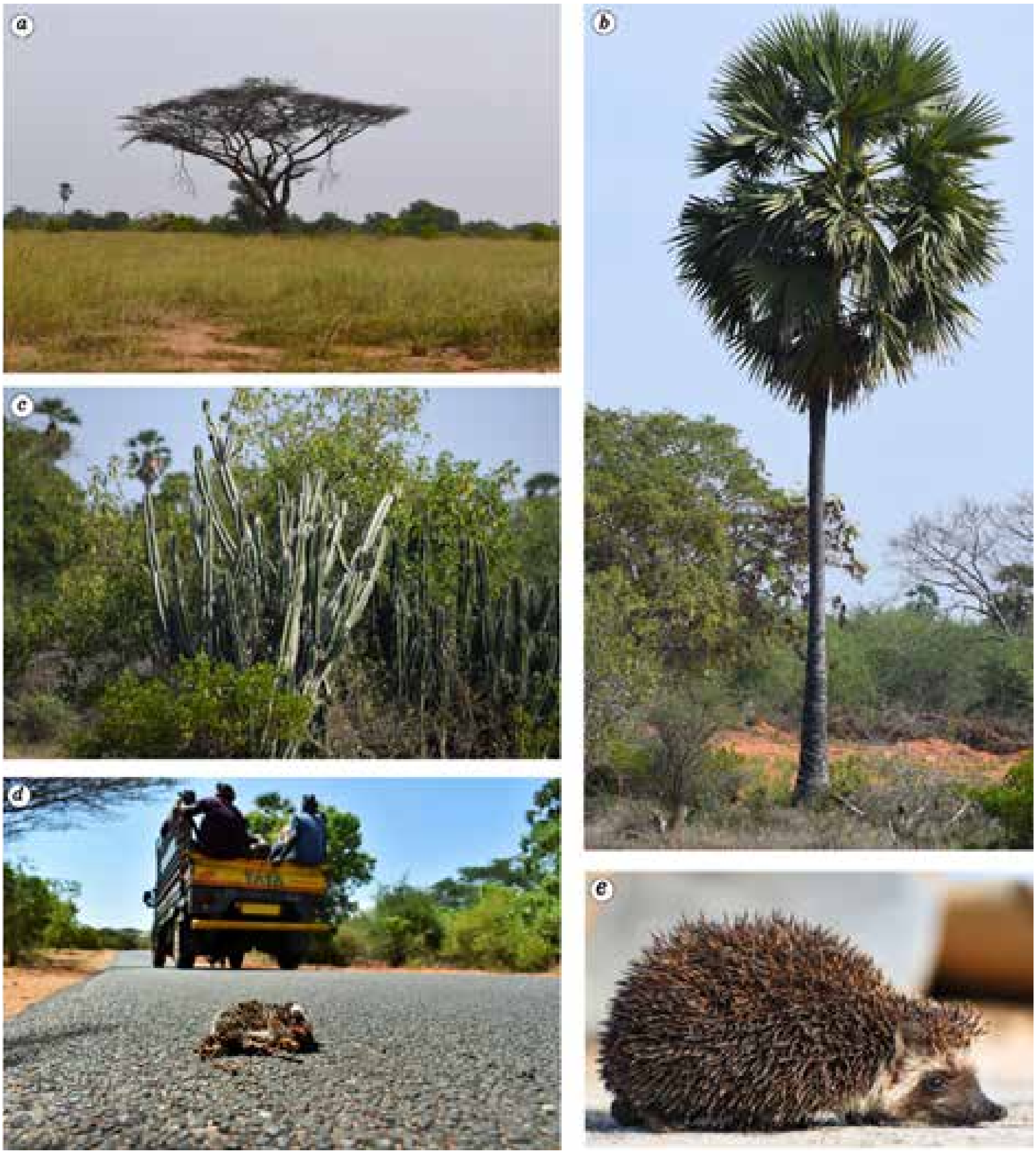

Image 1. a—Open grasslands with sparsely distributed *Acacia* spp. and other thorny shrubs form one of the notable habitats of *Paraechinus nudiventris* | b—*Borassus flabellifer*, being the prominent tree found in these landscapes and people often sight hedgehog under piles of fallen Palmyra leaves | c—*Cereus pterogonus* are often used as live fences by local people where the hedgehogs are occasionally seen | d—they are often victims of road kill | e—they are rarely found in the daytime foraging near human settlements. © Abinesh Muthaiyan.

Inadequate road signage and high-speed traffic elevate the risk of hedgehog roadkill due to their heat-basking behaviour, small size, and nocturnal habits (Image 1d). Anthropogenic activities in hedgehog habitats in Ayikudy, Alangulam, and Surandai areas, pushing hedgehogs closer to human settlements, windfarms, and roads in search of food and shelter (Image 1e). Moreover, 106 respondents (12%) acknowledged poaching in this district, highlighting the urgent need for increased protective measures. Additionally, 126 people (28%) perceived hedgehogs

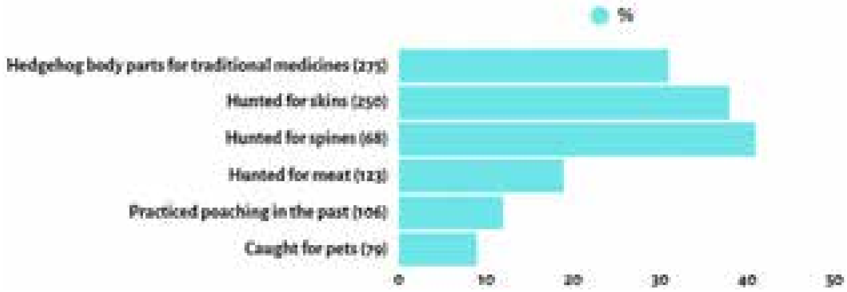

Figure 4. Consumption and use of Madras Hedgehog among people in and around the villages of the Tenkasi District.

Table 1. List of villages included in this survey.

	Surveyed villages in Tenkasi District, Tamil Nadu	GPS Co-ordinates
1	Ammaiyapuram	9.009, 77.447
2	Anavankudiyuruppu	8.720, 77.368
3	Arunachalapuram	9.101, 77.424
4	Avadaiyanoor	8.880, 77.386
5	Chinakumarpatti	8.856, 77.404
6	Chinanadanur	8.885, 77.399
7	Ilnaji	8.960, 77.278
8	Kalluthoor	8.902, 77.461
9	Kandapatti	8.815, 77.513
10	Karisalur	8.868, 77.405
11	Karumbanoor	8.855, 77.468
12	Karuthalingapuram	8.844, 77.405
13	Kulayaneri	9.006, 77.430
14	Gunaramanallur	8.931, 77.343
15	Malayankulam	9.146, 77.600
16	Mathalambaarai	8.906, 77.378
17	Mayamankurichi	8.893, 77.511
18	Mylapuram	8.779, 77.430
19	Nannagaram	8.945, 77.292
20	Nellaiyappurem	8.863, 77.417
21	Nettur	8.918, 77.531
22	Pa. Elanthakulam	9.126, 77.597
23	Pethanadarpatti	8.886, 77.408
24	Podiyunoor	8.881, 77.382
25	Poolangulam	8.861, 77.427
26	Pudupatti	8.835, 77.502
27	Salaiputhur	8.893, 77.422
28	Chellathayarpuram	8.872, 77.413
29	Sivalarkulam	8.868, 77.527
30	Sivalingapuram	8.913, 77.478
31	South Mylappuram	8.775, 77.431
32	Subramaniyapuram (Kattur)	8.985, 77.258
33	Thippanampatti	8.903, 77.375
34	Thirikoodapuram	9.125, 77.356
35	Thuppakudi	8.773, 77.445
36	Thuthikulam	8.910, 77.475
37	Vadamalaipatti	8.841, 77.425
38	Velliyammalpuram	9.015, 77.324

as rare, which may be influenced by factors like habitat loss, hunting, and environmental changes impacting hedgehog populations and biodiversity (Hof & Bright 2012). This indicates a decline in hedgehog sightings over the years from 2000 to 2023 due to various anthropogenic activities. The species is protected under Schedule II of Wildlife (Protection) Act, 1972 (amendment 2022); urgent conservation measures such as habitat protection, population research, prohibition of hunting and trading, as well as awareness campaigns for hedgehog conservation are necessary to reverse this declining trend.

REFERENCES

Bertolino, S., P. Colangelo, E. Mori & D. Capizzi (2015). Good for management, not for conservation: an overview of research, conservation and management of Italian small mammals. *Hystrix* 26(1): 1–11. https://doi.org/10.4404/hystrix-26.1-10263

Hof, A.R. (2009). A study of the current status of the hedgehog *Erinaceus europaeus* and its decline in Great Britain since 1960. PhD Thesis, University of London.

Hof, A.R. & P.W. Bright (2012). Factors affecting hedgehog presence on farmland as assessed by a questionnaire survey. *Acta Theriologica* 57: 79–88. https://doi.org/10.1007/s13364-011-0044-y

Jha, C.S. & J.S. Singh (1990). Composition and dynamics of dry tropical forest in relation to soil texture. *Journal of Vegetation Sciences* 1(5): 609–614. https://doi.org/10.2307/3235566

Kitchenham, B. & S.L. Pfleeger (2002). Principles of survey research part 4: questionnaire evaluation. ACM SIGSOFT. *Software Engineering Notes* 27(3): 20–23.

Kumar, B., J. Togo & R. Singh (2018a). The South Indian Hedgehog *Paraechinus nudiventris* (Horsfield, 1851): review of distribution data, additional localities and comments on habitat and conservation. *Mammalia* 83(4): 399–409. https://doi.org/10.1515/mammalia-2018-0128

Kumar, B. & V. Nijman (2016). Medicinal uses and trade of Madras Hedgehogs *Paraechinus nudiventris* in Tamil Nadu, India. *Traffic Bulletin* 28(1): 7–10.

Kumar, B., S. Babu & H.N. Kumara (2018b). Predicting the potential distribution of the lesser-known endemic Madras Hedgehog *Paraechinus nudiventris* (Order: Eulipotyphla, Family: Erinaceidae) in southern India. *Mammalia* 83(5): 470–478. https://doi.org/10.1515/mammalia-2018-0101

Kumara, H.N., S. Mahato, M. Singh, S. Molur & A.D. Velankar (2023). Mammalian diversity, distribution and potential key conservation areas in the Western Ghats. *Current Science* 124(1): 38–49.

Molur, S., C. Srinivasulu, B. Srinivasulu, S. Walker, P.O. Nameer &

L. Ravikumar (2005). *Status of South Asian Non-volant Small Mammals: Conservation Assessment and Management Plan (CAMP) Workshop Report*. Zoo Outreach Organization/CBSG-south Asia, Coimbatore, India, 618 pp.

Nameer, P.O., S. Molur & S. Walker (2001). Mammals of Western Ghats: a simplistic overview. *Zoos' Print Journal* 16(11): 629–639. https://doi.org/10.11609/JoTT.ZPJ.16.11.629-39

Rangarajan, M. (1998). The role of administration in extermination: fresh evidence on the cheetah *Acinonyx jubatus* in India. *Journal of the Bombay Natural History Society* 95: 328–332.

Revenue Administration Jurisdiction, Bifurcation of Tirunelveli District (2019). Creation of Tenkasi new district– ordered – notification under Tamil Nadu District Limits Act, 1865 – Issued. G.O.(Ms). No. 427 Dt: November 12, 2019.

Roopa, S. & M.S. Rani (2012). Questionnaire designing for a survey. *Journal of Indian Orthodontic Society* 46: 273–277. https://doi.org/10.5005/jp-journals-10021-1104

Sjöström, O., D. Holst & S.O. Lind (1999). Validity of a questionnaire survey: the role of non-response and incorrect answers. *Acta Odontologica Scandinavica* 57(5): 242–246. https://doi.org/10.1080/000163599428643

Sirivongs, K. & T. Tsuchiya (2012). Relationship between local residents' perceptions, attitudes and participation towards national protected areas: a case study of Phou Khao Khouay National Protected Area, central Lao PDR. *Forest Policy and Economics* 21: 92–100. https://doi.org/10.1016/j.forpol.2012.04.003

Williams, R.L., R. Stafford & A.E. Goodenough (2015). Biodiversity in urban gardens: assessing the accuracy of citizen science data on garden hedgehogs. *Urban Ecosystem* 18(3): 819–833. https://doi.org/10.1007/s11252-014-0431-7

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Author contributions: BK & AM—field work and research design; BK—concept, funding acquisition, supervision and final review; AM—data collection, manuscript writing and data analysis.

Acknowledgements: We sincerely express our gratitude to the Tamil Nadu Forest Department for granting us the necessary permissions to conduct our fieldwork (proceedings number: WL5(A)31710/2021; permission no: 92/2022). We would like to thank IUCN Small Mammal Specialist Group and People's Trust for Endangered Species for their support and encourgement. We extend our heartfelt thanks to Ms. Anitha Eswari and the dedicated team of volunteers who contributed in various stages of our fieldwork. We are deeply appreciative of our funding partner, TAAL Tech Private Limited, whose generous financial support made this project possible. We wish to acknowledge and thank all the local community members who generously shared their traditional knowledge and insights about the hedgehogs and their habitats. Their willingness to engage with us and contribute their perspectives enriched our understanding and significantly informed our study.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26879–26886

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.8974.17.4.26879-26886

#8974 | Received 16 February 2024 | Final received 05 April 2025 | Finally accepted 11 April 2025

COMMUNICATION

Notes on the interesting species *Tacca leontopetaloides* (L.) Kuntze

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Abstract: *Tacca leontopetaloides* is a species of flowering plant that belongs to the family Dioscoreaceae. The species generally grows in forests and shady areas during rainy seasons. The populations of this species were previously reported to exist in eastern India (West Bengal), have been steadily declining at an increasing rate. Present investigation in four states of eastern India revealed that the species is now only present in the two districts of West Bengal, i.e., Jhargram and Paschim Medinipur. In order to facilitate easy identification and conservation, the article provides a detailed description of the species, including its distribution, conservation status, economic and medicinal importance, figures, and photographs, along with the LM and SEM images of pollen.

Keywords: Conservation, distribution, Jhargram, medicinal importance, Paschim Medinipur, sacred groves.

Editor: Asok Ghosh, The University of Burdwan, West Bengal, India.

Date of publication: 26 April 2025 (online & print)

Citation: Saadi, S.M.A.I., M.S. Hossain, D. Bhunia, S.R. Islam, S. Tripathi, S. Sinha & A.K. Mondal (2025). Notes on the interesting species *Tacca leontopetaloides* (L.) Kuntze. *Journal of Threatened Taxa* 17(4): 26879–26886. https://doi.org/10.11609/jott.8974.17.4.26879-26886

Funding: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing interests: The authors declare no competing interests.

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Author contributions: SMAIS: Design and writing the original draft; Supervision, field survey; MSH: Create the study Map; DB: Formal analysis; SRI & SMAIS: Laboratory studies; ST: Drawing and editing; SS: Assistance in the field survey and critical comments for the preparation of manuscript; AKM: Read and approved the final manuscript.

Acknowledgements: The authors are thankful to the Jhargram and Gopegarh Forest Department for facilitating the exploration of different forest areas. We also thank to the authority of Aliah University, New Town, Kolkata for their support and all the research scholars in the Plant Taxonomy Laboratory, Department of Botany and Forestry, Vidyasagar University, Midnapore. We are highly acknowledged to Bose Institute, Kolkata, India for providing SEM facilities.

INTRODUCTION

Tacca leontopetaloides (L.) Kuntze is commonly known as East Indian Arrowroot, is also called Polynesian Arrowroot, and was previously placed under the family Taccaceae (Dumortier 1829). Recently, Caddick et al. (2002) treated *Tacca* J.R.Forst. & G.Forst. into Dioscoreaceae (APG II 2003) because *Tacca* shares many characteristics with other plants in Dioscoreaceae, such as having tuberous underground parts rich in steroidal saponins, petiolate reticulate-veined leaves, and reflexed stamens. However, *Tacca* is distinctive because of its acaulescent habit and unilocular ovaries with parietal placentation. According to POWO (2024+), *T. leontopetaloides* has 32 synonyms. Among them, a few heterotypic synonyms are *Tacca pinnatifida* var. *brownie*. (Seem.) F.M.Bailey, *T. pinnatifida* ssp. *interrupta* Warb. ex H.Limpr., *T. pinnatifida* ssp. *involucrata* (Schumach. & Thonn.) H.Limpr., *T. pinnatifida* ssp. *madagascariensis* H.Limpr. *T. pinnatifida* f. *obtusata* Limpr., *T. pinnatifida* var. *paeoniifolia* Domin, *T. pinnatifida* var. *permagna* Domin, and *T. umbrarum* Jum. & H.Perrier (http://apps.kew.org/wcsp/home.do). The plant is generally growing in the open forest but is occasionally seen in the rainforests. The genus *Tacca* comprised of about 20 species distributed in the tropical region of Asia (Chua et al. 2020). According to Meena & Yadav (2010) and USDA (2021), it is native to tropical Africa, the Indian subcontinent, Papua New Guinea, Indonesia, Malaysia, Philippines, Australia, Micronesia, Fiji, and Samoa. So far, the genus is represented by six species, viz., *Tacca chantrieri* André, *T. pinnatifida* Forst., *T. cristata* Jack., *T. integrifolia* Ker-Gawl., *T. laevis* Roxb. and *T. leontopetaloides* (L.) Kuntze in India (Baruah et al. 2015 & Saadi et al. 2020). The plant is cultivated in India and regarded as an economic food crop. According to Kay (1987), Polynesian arrowroot tubers are eaten as food in northern Nigeria, particularly at the time of the scarcity of other staple foods. The tuber of this plant used as a staple food in place of rice and flour, which is one of the sources of carbohydrates. In order to combat famine and food insecurity, the high carbohydrate content of its starch—83.07–88.07%—is beneficial for south coast populations in West Java (Wardah & Ariani 2014, 2015, 2020). Many Polynesian islands also employ the bitter raw tuber as a medicinal remedy for stomach problems, primarily diarrhoea and dysentery, hepatitis, guinea worm infection, and snake bites (Kay 1987).

In 2015, present authors conducted an intensive floristic survey and were able to collect the plant for the first time from the sacred groves of the Chilkigarh forest in Jhargram District, West Bengal during the rainy season in fruiting stage. In May 2020, the species was collected again from the sacred groves of the Gopegarh forest in Paschim Medinipur, West Bengal even though they were not fruiting at that time. Lastly, in October 2023, present authors explored for the species in Patna and Ranchi districts of Bihar and Jharkhand, respectively. However, *T. leontopetaloides* was not seen anywhere. The study critically examines collected specimens based on the different literature (Prain 1903; Thaker et al. 1970; Rao & Verma 1976; Ling 1985; Lakshminarasimhan 1996; Samvatsar 1996; Zhang & Li 2008; Meena & Yadav 2010; Borokini et al. 2014; Baruah et al. 2015; Yeng & Shen 2019; Kalita et al. 2022). This paper aims to provide a detailed account of the species, for future reference and conservation purposes.

MATERIALS AND METHODS

Several field surveys were conducted from 2015–2023 to estimate the population of *Tacca leontopetaloides* from eastern India (Figure 1). This study covered both disturbed (plant communities affected by human activities or natural events, leading to a reduction in biodiversity) and undisturbed (plant communities unaffected by major natural disturbances or human activities leading to rich biodiversity and more stable ecosystems) patches of vegetation in several districts of Bihar, Odisha, Jharkhand, and West Bengal. Additionally, the authors examined existing literature to see if there were any reports of this species from eastern India. In a detailed literature study, it was found that *T. pinnatifida* Forst, which is a synonym for *T. leontopetaloides*, was initially documented by D. Prain in 1903 from the Chota Nagpur Plateau. This area is currently part of Jharkhand and the surrounding regions of Chhattisgarh, Odisha, West Bengal, and Bihar. The present authors visited multiple locations in Odisha, Bihar, and Jharkhand to study this species. In West Bengal, authors conducted visits to 19 districts on multiple occasions, but only encountered the species in two districts: Paschim Medinipur (Gopegarh) and Jhargram (Chilkigarh). The Chilkigarh is a village in Jhargram located on the banks of the Dulung River and is known for its rich biodiversity, covering an area of about 0.0040 km^2 between 22.446–22.455 N and 86.874–86.881 E. The average elevation of the area is 60–85 m above the mean sea level. Gopegarh is located within the deciduous natural forest, on the banks of the Kangsabati River, covering an area of about 0.0071 km^2 between 22.418–22.424 N and 87.281–

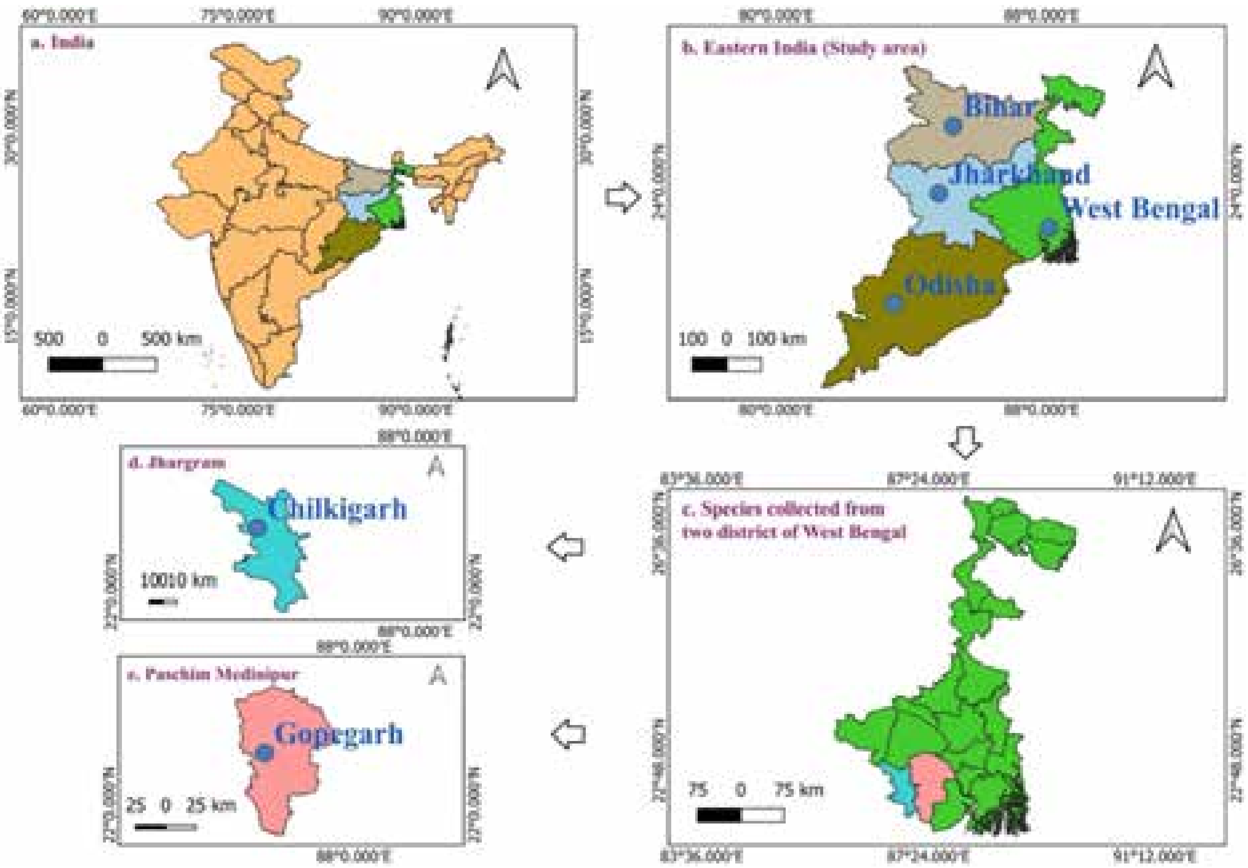

Figure 1. a—India | b—Eastern India | c—West Bengal | d—Jhargram |e—Paschim Medinipur. This figure shows the precise locations of collection sites from four states in Eastern India (the study area) as well as the collection areas of Gopegarh and Chilkigarh inside two districts of West Bengal (Map prepared using QGIS software).

87.277 E. The average elevation of the area is 55–86 m.

The collected specimens were processed to prepare voucher specimens and examined for detailed morphological study using a Carl Zeiss Stemi-508 microscope. For the pollen study, acetolyzed pollen (follows Erdtman 1960) grain was transferred to the SEM stubs, sputter-coated with gold for 2 minutes, and viewed under a Marlin scanning electron microscope (ZEISS FESEM SUPRA-40). Photographs of plant specimens and habitats were taken using a Nikon camera (Model-Z30). The herbarium specimens (00713 and 00722) were deposited at the Vidyasagar University Herbarium, West Bengal. The distribution status was determined by referring to 'Plants of the World Online' (POWO), relevant floras, and literature. To indicate the correct location of the study area, we prepared a map using QGIS 3.24.0 software.

RESULTS AND DISCUSSIONS

Taxonomic treatment

Tacca leontopetaloides (L.) Kuntze, Revis. Gen. Pl. 2: 704. 1891; Drenth in Blumea 20: 375.1972; Lakshminarsimhan in Sharma et al. (1996); Fl. Maharashtra State, Monocot 3:108. 1996; *Leontice leontopetaloides* L., Sp. Pl. 313. 1753; *Tacca pinnatifida* J.R.A.Forst., Char. Gen. 35: t. 35. 1776; Hook.F., Fl. Brit. India 6: 287. 1892; Cooke, Fl. Bombay 3:262. 1958 (Images 1 & 2).

It is an upright perennial herb with a dark brown, round or broadly ellipsoid-shaped tuber or Ovoid tuber several inches across (Flora of West Tropical Africa, Vol 3, Part 1), usually giving rise to one or two erect leaves 2–4 ft. high and an inflorescence 3–6 ft. high. On transverse section, the tuber is internally white, and it can measure 15–25 cm. in diameter. The plant has 1–3 large, radical leaves that are broadly obovate, ovate or oblong. The leaves are palmately 3-lobed and the lobes are pinnately lobed with undulate margins and reticulate veins.

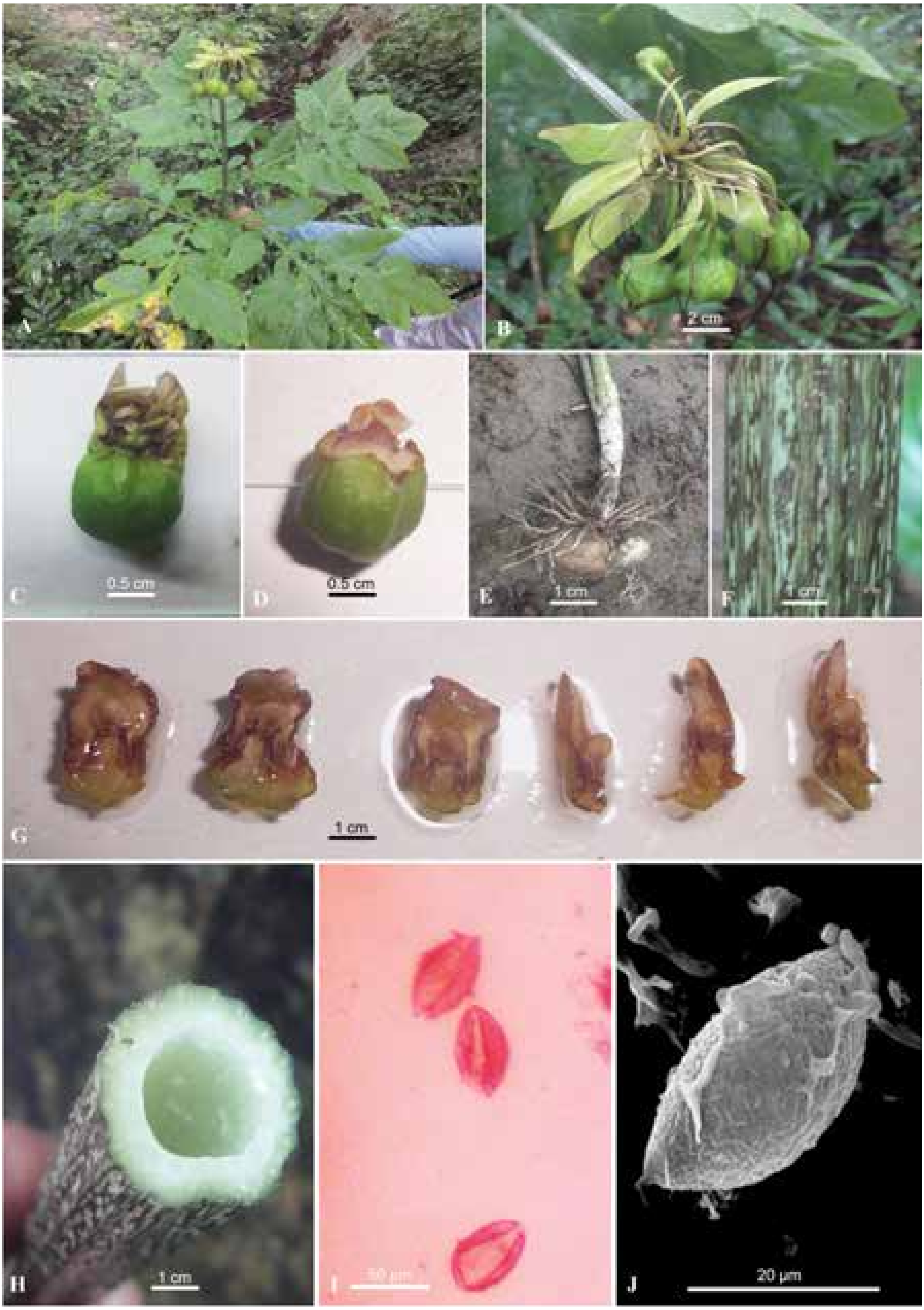

Image 1. *Tacca leontopetaloides* (L.) Kuntze: A—Habit | B—Infructescence | C—Single flower | D—Carpel | E—Corm | F—Outer surface of stem | G—Dissected flower with androecium | H—Hollow stem | I—Pollen under light microscope | J—Pollen under SEM. _© SMAIS, SRI and SS.

The petioles are 30–90 cm. long, hollow and striated. Scape is longer than the petiole and has 4–6 flowers at the apex of a long, leafless scape. Flowers are regular, bisexual and pedicellate. Bracts 6–12 in number, oblong-lanceolate that are recurved and striped with purple. It also has numerous filiform bracteoles that are longer than the bracts. Perianth is usually lurid, campanulate and 6-lobed. Stamens 6, adnate to the perianth tube or the base of the perianth lobes. Anthers have two ribs on the inner face, and the dehiscence is longitudinal. Carpels 3, connate in an inferior ovary, and many anatropous ovules. Style short, columnar and usually 3, cohered. Stigmas 3, petaloid and broad. Fruits globose or ovoid, indehiscent berries, many-seeded, seeds ovoid to ellipsoid, angular, and longitudinally striate.

Pollen character: Polar Axis (P)-17 (19.6) 26 µm; equatorial diameter (E)- 32 (35.75) 41 µm; P/E- 0.55 µm; exine thickness-2 µm; pollen shape-oblet to spheroidal; aperture type- monosulcate; aperture size-11 (16.53) 19 µm (Image 1I, 1J).

Vernacular names: English: Polynesian Arrowroot, East Indian Arrowroot, Bat Flower, Devil's Whiskers; Hindi: Ajeenamoti; Malayalam: Puliyar; Tamil: Kasippu; Bengali: Talmul

Phenology

Tacca leontopetaloides is known for its unique and conspicuous inflorescence that resembles bat's wing. The flowering and fruiting period may vary depending on the specific region and environmental conditions. This plant reproduces by two methods: sexually, through the production of flowers and seeds, and vegetatively, via rhizomes. The flowers are unique and quite distinct, and they may offer nectar to pollinators. It is typically found during the rainy season from April to October. However, it remains active throughout the year and dormant throughout the dry season from November to February. In India, the flowering and fruiting occur from July to October.

Distribution and Ecology

According to POWO (2024), *Tacca leontopetaloides* is reported from 80 out of 195 countries Worldwide. In India, it is reported from 13 out of 28 states and eight union territories according to the various sources (Prain 1903; Rao & Verma 1976; Lakshminarasimhan 1996; Samvatsar 1996; Meena & Yadav 2010; Saadi et al. 2020). This plant is usually found in forests, in damp and shady areas, and was found to be associated with some other trees like *Strychnosnux-vomica* L., *Adina cordifolia* (Roxb.) Hook.f., *Shorea robusta* Roth., *Tectona grandis* L.f., *Terminalia bellerica* (Gaertn.) Roxb., *Terminalia arjuna* (Roxb.) Wight & Arn., *Anacardium occidentale* L., *Madhuca longifolia* (J.Konig) J.F.Macbr., Brandis as well as lianas like *Bauhinia vahlii* Wight & Arn., *Ichnocarpus frutescens* R.Br and *Ziziphus mauritiana* Lam. along with some herbs like *Typhonium trilobatum* (L.) Schott., *Curculigo orchioides* Gaertn., *Amorphophallus bulbifer* (Roxb.) Blume, *Dioscorea bulbifera* L., *Oplismenus burmannii* (Retz.) P.Beauv., *Clerodendrum infortunatum* L., *Flacourtia indica* (Burm.f.) Merr., *Mesosphaerum suaveolens* (L.) Kuntze, *Chromolaena odorata* (L.) R.M.King & H.Rob., *Lippia alba* (Mill.) N.E.Br. ex Britton & P.Wilson.

Specimens examined

India, West Bengal**,** Chilkigarh forest, Jhargram district, 22.vi.2015, coll. Saadi et al., #00713; Same locality., 20.vi.2016, coll. Saadi & Sinha, #00722. Gopegarh, Paschim Medinipur district, 20.v.2019, coll. Saadi & Mondal, #00803 (all vouchers are deposited at Vidyasagar University Herbarium).

Economical and medicinal importance of *Tacca leontopetaloides*

The economic importance of Polynesian Arrowroot is not reflected in official statistics. However, research reports indicate that it is important at the local level as a reserve and ceremonial food. Interestingly, it can produce edible starch on marginal soils. According to (Olojede et al. 2009) a measure of the prepared starch weighing approximately 1 kg was sold between N100 (USD 0.78) and N120 (USD 0.94) back in 2009. It is a beloved food among many communities in the southern parts of Plateau State, as noted in a study by Ogbonna et al. (2017). The starch from this food is dried and used to prepare various types of puddings, porridge, and ceremonial foods among the Tiv people of north-central Nigeria, as reported by Ahemen & Raji (2008) and Amadi et al. (2018). In India, *T. leontopetaloides* tubers are usually cooked, and boiled with leaves of guava or tamarind to avoid the irritating properties of the tubers, or roasted as vegetables (Misra & Misra 2014).

The medicinal properties of different parts of *Tacca leontopetaloides*, such as roots and tubers, are used to treat various ailments. Specifically, bitter raw tubers are traditionally used to treat stomach ailments such as diarrhoea and dysentery (Kay 1987). Both the raw tubers and starch have been used to treat vomiting and diarrhoea in traditional Hawaiian communities (Krauss 1998). According to (Bosha et al. 2015), the traditional rulers have historically used it for their rituals and as an

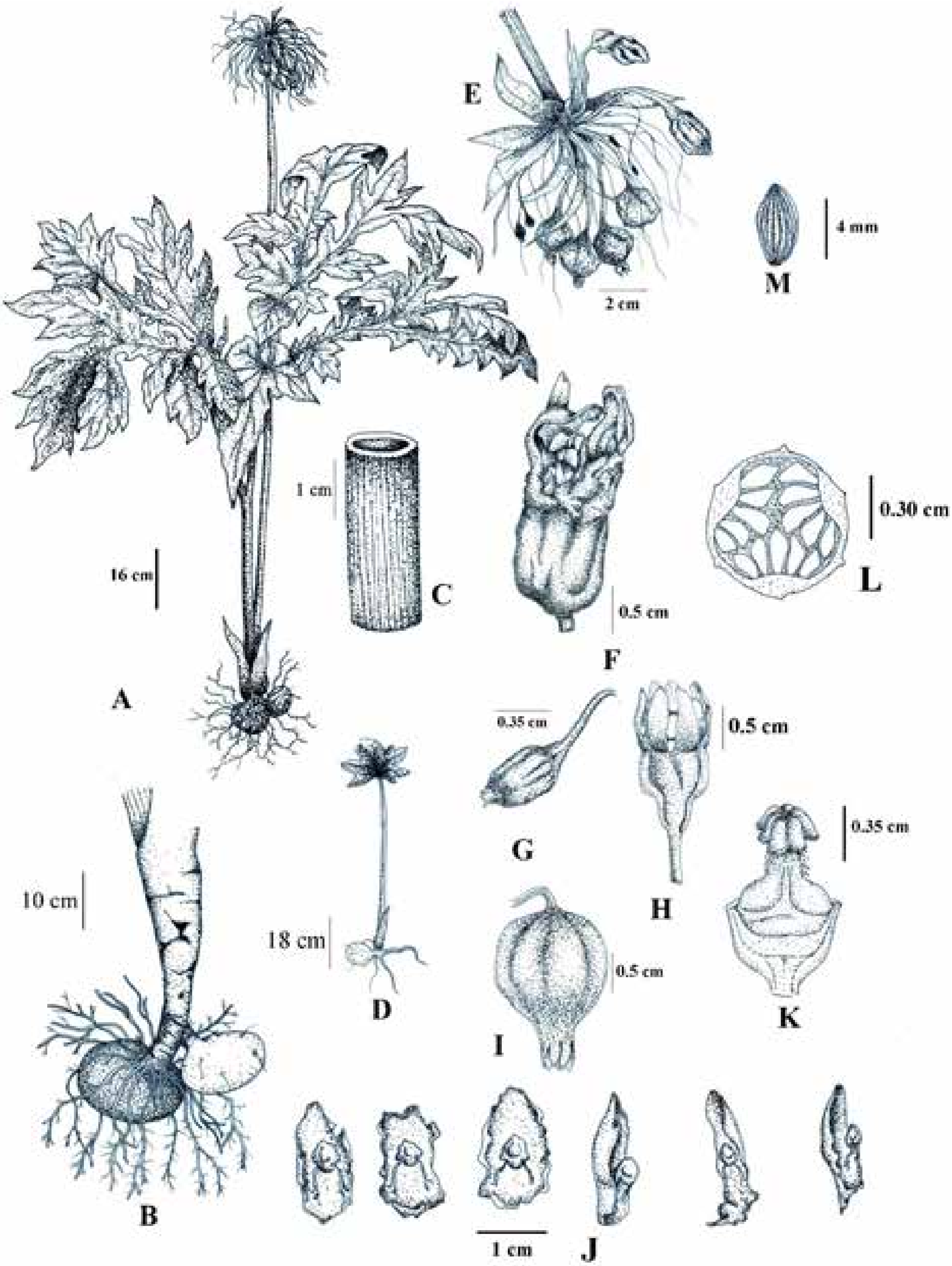

Figure 2. ***Tacca leontopetaloides*** **(L.) Kuntze: A—Flowering plant | B—Corn | C—Hallow Stem | D—Seedling plant | E—Infructescence | F—Single flower | G-H—Flower bud | I—Fruit | J—Dissected flower with androecium | K—Gynoecium | L—T.S of ovary | M—Seed. © SMAIS, SRI and SS.**

aphrodisiac. Additionally, the root starch is used to stiffen fabrics in some of the islands, as stated by (Ukpabi et al. 2009). Recently, it has been discovered that the marc of *Tacca* has antidiabetic effects, as mentioned by (Bosha et al. 2013). The rhizome possesses detoxifying, anti-inflammatory, and analgesic properties, and can cure abscesses in the stomach and duodenum, high blood pressure, hepatitis, gastralgia, burns, and ulcers (Zhang et al. 2007). During the present survey, we frequently inquire with local people about the ethnomedicinal uses. However, they only utilize tubers to treat piles, diarrhoea, and dysentery. Studies have shown that over 134 compounds with different bioactivities have been isolated from *Tacca* species including steroids, terpenoids, diaryheptanoids and taccalonolidesare said to have the potential to become anti-cancer drugs (Abdallah et al. 1990; Tinley et al. 2003).

Conservation status

After conducting a comprehensive survey of various locations in eastern India, we observed only four mature plants from Gopegarh forest, and 18 mature plants were found to spread across 60 acres in the Chilkigarh forest. Based on our present findings, it is evident that there are not many individuals of the species though, the species is globally 'Least Concern' (LC) (Contu 2013). Unfortunately, their numbers are declining due to land use changes, increased tourism, natural calamities, and overharvesting resulting. Conservation planning is essential to mitigate the impact of increasing human population and declining species, such as: (1) Select the regions where we want to conserve the species; (2) Restore damaged habitats by preventing human activity, eliminating invasive species, reducing erosion, preventing agricultural expansion and implementing sustainable management practices; (3) Reintroduce the plant species into their natural habitats by moving individual plants or seeds to establish or strengthen new populations where they have become locally rare; (4) Encourage the local people to cultivate *T. leontopetaloides* due to its economic and medicinal importance, as well as its high starch content (amylose and amylopectin) similar to that of a potato; and (5) Involve local communities, indigenous peoples, and stakeholders in conservation efforts. This includes empowering communities to manage natural resources sustainably, respecting traditional knowledge, and promoting livelihoods that are compatible with plant conservation.

REFERENCES

Abdallah, M.E., A. Aziz., K.R. Brain, G. Blunden, T. Crabb & A.K. Bashir (1990). Steroidal Sapogenins from *Tacca leontopetaloides*. *Planta Medica* 56(2): 218–221. https://doi.org/10.1055/s-2006-960929

Ahemen, S.A. & A.O. Raji (2008). Development and performance evaluation of a motorized rasping machine for *Tacca involucrata*. *Journal of Agricultural Engineering Technology* 16(1): 52–63.

Amadi, C.O., C.N. Ebeniro, A.G. Ironkwe, C.C. Nwokocha & G. Amadi (2018). Description of some morphological attributes of Polynesian Arrowroot from Benue State, Nigeria. *Nigerian Journal of Botany* 34(2): 289–298.

Angiosperm Phylogeny Group II (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society* 141(4): 399–436. https://doi.org/10.1046/j.1095-8339.2003.t01-1-00158.x

Baruah, S., J. Sarma & S.K. Brothakur (2015). *Tacca chantrieri* André (Taccaceae): A beautiful ornamental flora recorded as a new for India. *An International Journal of Environment and Biodiversity* 6(1): 18–20.

Borokini, T.I., A.E. Ayodele & A.J. Akinloye (2014). Morphological and anatomical studies on *Tacca leontopetaloides* (L.) Kuntze (Taccaceae) in Nigeria. *Research in Plant Biology* 4(5): 28–44.

Bosha, J.A., F.A. Gberinder & I.U. Asuzu (2013). Antihhyperglyceanic Effect of *Tacca involucrata* on Alloxan Induced Diebetic Rats. *Ghana Biomedical Convention*, *Cape Coast* 56.

Bosha, J.A, A.O. Anaga & I.U. Asuzu (2015). Chemical Composition of the Marc of a Wild Tropical Plant *Tacca involucrata* (Schumach and Thonn, 1827). *Food and Nutrition Sciences* 6(1): 135–140. https://doi.org/10.4236/fns.2015.61014

Caddick, L.R., P.J. Rudall, P. Wilkin, T.A.J. Hedderson & M.W. Chase (2002). Phylogenetics of Dioscoreales based on combined analyses of morphological and molecular data. *Botanical Journal of the Linnean Society* 138(2): 123–144. https://doi.org/10.1046/j.1095-8339.2002.138002123.x

Chua, K.S., A. Borkent & S.Y. Wong (2020). Floral biology and pollination strategy of seven *Tacca* species (Taccaceae). *Nordic Journal of Botany* 38(2): NJB-02594. https://doi.org/10.1111/njb.02594

Contu, S. (2013). *Tacca leontopetaloides*. *The IUCN Red List of Threatened Species*: e. T44392847A44503085. https://doi.org/10.2305/IUCN.UK.20132.RLTS.T44392847A44503085.en. Accessed on 12 September 2024.

Dumortier, B.C.J. (1829). *Analyse des familles des plantes, avec l'indication des principaux genres qui s'y rattachent Tournay: J.* Casterman aine.

Erdtman, G. (1960). The acetolysis method – a revised description. *Svensk Botanisk Tidskrift* 39: 561–564.

Kalita, N., K.K. Das, S. Mehmud, H. Roy & D. Sahariah (2022). Distribution of *Tacca chantrieri* (Taccaceae) in Assam, India. *Biological Spectrum*. EBH Publishers, Panbazar, Guwahati, India, 19 pp.

Kay, D. (1987). *Root Crops. 2nd edition.* In: Gooding, E.G.B. (ed.). Tropical Development and Research Institute, United Kingdom, 380 pp.

Krauss, B.H. (1998). Native Plants are used as Medicine in Hawaii. Retrieved from: https://uhawaii-kauai.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma9919255224605693&context=L&vid=01UHAWAII_KAUAI:KAUAI&lang=en&search_scope=DN_and_CI&adaptor=Local%20Search%20Engine&isFrbr=true&tab=Everything&query=any,contains,Native%20Plants%20are%20used%20as%20Medicine%20in%20Hawaii&offset=0

Lakshminarasimhan, P. (1996). Monocotyledones. In: Karthikeyan, S. & N.P. Singh (eds.). *Flora of Maharashtra State*. Botanical Survey of India, Calcutta, 794 pp.

Ling, P.P. (1985). Taccaceae. In: Chien, P. & T. Chih-Tsun (eds.). *Flora of Reipublica Popularis Sinica* 16: 42–54.

Meena, K. & B. Yadav (2010). *Tacca leontopetaloides* (Linn.) O. Kuntze (Taccaceae) – A new record to the flora of Rajasthan. *Indian Journal* *of Natural Products and Resources* 1(4): 512–514.

Misra, S. & M.K. Misra (2014). Original Article Ethno-botanical study of plants with edible underground parts of south Odisha, India. *International Journal of Agricultural and Food Science* 4(2): 51–58.

Ogbonna, A.I., S.O. Adepoju, C.I.C, Ogbonna, T. Yakubu, J.U. Itelima & V.Y. Dajin (2017). Root tuber of *Tacca leontopetaloides* L. (kunze) for food and nutritional security. *Microbiology: Current Research* 1(1): 7–13.

Olojede, A.O., A.O. Akinpelu, T.Y. Dalyop, D. Lenka, P. Iluebbey & A.G.O. Dixon (2009). Survey of Production, Utilization and Proximate Composition of Some Minor Root and Tuber Crops in Nigeria. *Nigerian Agricultural Journal* 40(1): 125–131.

POWO (2024). Plant of the World online. Facilitated by the Royal Botanical Gardens, Kew. *Tacca leontopetaloides* (L.) Kuntze https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names: 827910-1. Accessed on 12 September 2024.

Prain, D. (1903) (rep. ed. 1963). Bengal Plants. Vols.1–2. Botanical Survey of India. Calcutta, India 1314 pp.

Rao, A.S. & D.M. Verma (1976). Material towards a Monocot Flora of Assam-III (Taccaceae, Dioscoriaceae and Stemonaceae). *Ibid* 15: 189–203. https://doi.org/10.20324/nelumbo/v15/1973/75162

Saadi, S.M.A.I., I. Mondal, S. Sarkar & A.K. Mondal (2020). Medicinal plants diversity modelling using remote sensing & GIS technology of Chilkigarh, West Bengal, India. *Tropical Plant Research* 7(2): 440–451. https://doi.org/10.22271/tpr.2020.v7.i2.052

Samvatsar, S. (1996). The Flora of Western tribal Madhya Pradesh. Scientific Publishers, Jodhpur 441 pp.

Thaker, D.N., S.D. Sabnis & S.J. Bedi (1970). A contribution to the flora and vegetation of Kawat Range, Gujarat state, India. *Bulletin of the Botanical Survey of India* 12(1–4): 113–127.

Tinley, T.L., D.A. Randall-Hlubek, R.M. Leal, E.M. Jackson, J.W. Cessac, J.C. Quada, S.L. Mooberry (2003). Taccalonolides E and A: Plant-derived Steroids with Microtubule stabilizing activity. *Cancer Res* 63(12): 3211–20.

Ukpabi, U.J., E. Ukenye & A.O. Olojede (2009). Raw- Material Potentials of Nigerian Wild Polynesian Arrowroot (Tacca leontopetaloides) Tubers and Starch. *Journal of Food Technology* 7(4): 135–138.

USDA (2021). USDA Agricultural Research Service, National Plant Germplasm System. Germplasm Resources Information Network (GRIN Taxonomy). National Germplasm Resources Laboratory, Belts Tangden ville, Maryland. URL: https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomydetail?id=70775.

Wardah, W. & D. Ariani (2020). Ethnobotany study of Jalawure (Tacca leontopetaloides) as a source of nutrition quality improvement on the South Coastal people in West Java. *IOP Conference Series: Earth and Environmental Science* 458(1): 012047. https://doi.org/10.1088/1755-1315/458/1/012047

Wardah, W. & D. Ariani (2014). Proceedings of the 5th ASIAHORCs International Symposium (Bali) (Jakarta, Indonesia: LIPI).

Wardah, W. & D. Ariani (2015). Prosiding Seminar Nasional Sinergi Pangan, Pakan dan Energi Terbarukan (Yogyakarta) (Jakarta, Indonesia: Balai Pengembangan Proses dan Teknologi Kimia-LIPI).

Yeng, W.S. & C.K. Shen (2019). Phylogeny of Tacca (Taccaceae) and traits in reproductive structures, with description of a new Bornean species. *Biodiversitas Journal of Biological Diversity* 20(11): 3096–3118. https://doi.org/10.13057/biodiv/d201102

Zhang, L., J. Chen, D.Z. Li & Q.J. Li (2007). Reproductive Biology, Mating System, and Population Genetics of Devil Flower: An Autonomous Selfing Plant with Showy Floral Display. *Reproductive Biology* 1(2): 115–124.

Zhang, L. & Q.J. Li (2008). Tacca ampliplacenta (Taccaceae), a new species from Yunnan, China. *Annales Botanici Fennici* 45(4): 311–314. https://doi.org/10.5735/085.045.0412

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26887–26892

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9399.17.4.26887-26892

#9399 | Received 03 September 2024 | Final received 22 February 2025 | Finally accepted 27 March 2025

COMMUNICATION

Extended distribution of the rare basidiolichen *Sulzbacheromyces yunnanensis* (Lichenized Basidiomycota) from Mizoram, India

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Abstract: Basidiolichens are rare and understudied in India due to their confinement to specialized niches. *Sulzbacheromyces yunnanensis* D.Liu, Li S.Wang & Goffinet, a clavarioid basidiolichen is described herein for its expanded distribution from Mizoram, India based on morpho-anatomical characteristics and ITS sequence based phylogenetic analysis. A detailed account of the habitat preference and comparison with related taxa is also provided.

Keywords: *Crustose thallus*, diversity, Indo-Burma hotspot, Lepidostromataceae, lichen, morpho-molecular identification, new distribution, photobiont, soil habitat, taxonomy.

Editor: Avneet Pal Singh, Punjabi University, Patiala, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Thachunglura, V.L., P.K. Rai, Z. Chawngthu, L. Bochung, P.C. Vanlalhluna & J. Zothanzama (2025). Extended distribution of the rare basidiolichen *Sulzbacheromyces yunnanensis* (Lichenized Basidiomycota) from Mizoram, India. *Journal of Threatened Taxa* 17(4): 26887–26892. https://doi.org/10.11609/jott.9399.17.4.26887-26892

Funding: MoTT UGC-NFST.

Competing interests: The authors declare no competing interests.

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Author contributions: VLT, ZC, and LB collected the samples, carried out the identification, and conducted the phylogenetic analysis. JZT and PKR supervised the research and provided support in methodology and study design. VLT, PKR, PCV and JZT participated in writing, reviewing, and editing the manuscript.

Acknowledgements: The authors would like to thank the Ministry of Tribal Affairs, Government of India, for providing financial assistance in the form of the National Fellowship for Scheduled Tribes (NFST) (202021-NFST-MIZ-03084) to Mr. VL Thachunglura, research scholar - Department of Environmental Science, Mizoram University. We are grateful to DBT-NER (No. DBTNER/AAB/64/2017; dated 14.10.2019) for providing the essential laboratory facilities crucial for the successful completion of this study.

INTRODUCTION

The vast majority of lichenized fungi are classified within the phylum Ascomycota, while several smaller clades containing lichenized species are also present in Basidiomycota (Hodkinson et al. 2012). Basidiolichens exhibit a variety of growth forms, including crustose, squamulose (scale-like), foliose, or coral-like structures. Some resemble mushrooms with decurrent gills, while others appear as bracket fungi or crust-like resupinate basidiomata (Ertz et al. 2008). They were once considered to have a relatively small number of species, but recent studies have broadened our understanding of their diversity, with new species being discovered in various regions, particularly in the Neotropics (Lücking et al. 2014; Sulzbacher et al. 2016). They can be found in cosmopolitan to subcosmopolitan ranges as well as in regional to continental distributions (Oberwinkler 2012). Basidiolichens are comparatively understudied due to their confinement to specific ecological niches (Gasulla et al. 2020).

Among different families of the basidiolichens, Lepidostromataceae comprises three major genera, viz., *Lepidostroma* Mägd. & S.Winkl., having a squamulose thallus with medulla, *Ertzia* B.P.Hodk. & Lücking, with a microsquamulose thallus without medulla, and *Sulzbacheromyces* B.P.Hodk. & Lücking being distinguished by a crustose and membranaceous thallus (Hodkinson et al. 2014; Liu et al. 2019). *Sulzbacheromyces* is a pantropical genus of basidiolichens with 10 recognized species distributed across Africa, South America, and Asia: *S. arunachalensis* A.Debnath & Nayaka; *S. bicolor* Dong Liu, Li S.Wang & Goffinet; *S. caatingae* (Sulzbacher & Lücking) B.P.Hodk. & Lücking; *S. chocoensis* Coca, Lücking & B.Moncada; *S. fossicolus* (Corner) D.Liu & Li S.Wang; *S. leucodontius* Coca, Gómez-Gómez, Guzmán-Guillermo & Dal Forno; *S. miomboensis* DeKesel & Ertz; *S. sinensis* (R.H. Petersen & M. Zang) D.Liu & Li S.Wang; *S. tutunendo* Coca, Lücking & B.Moncada; and *S. yunnanensis* D.Liu, Li S.Wang & Goffinet (Liu et al. 2019; Coca et al. 2023; Debnath et al. 2025).

Initially, there were few reports of the genus *Sulzbacheromyces* from Asia, with *S. sinensis* found to have a broad distribution across Korea, China, Japan, Taiwan, Singapore, and Philippines. In contrast, other species, such as *S. bicolor*, *S. yunnanensis*, and *S. fossicolus* have much narrower distributions (Liu et al. 2019; Coca et al. 2023). The studies on the genus *Sulzbacheromyces* from India are limited. *S. fossicolus* (= *Multiclavula fossicola*) was reported from India by Petersen & Zang (1986). More recently, *S. arunachalensis* has been described as a new species from India, while *S. bicolor* and *S. yunnanensis* have been reported as new records. Mizoram, a small state in northeastern India, is well-known for its rich biodiversity (Zothanzama et al. 2016; Chawngthu et al. 2024), and the Hlimen forest is no exception to this. However, there are only a few reports of fungi from the state (Lalrinawmi et al. 2018; Thachunglura et al. 2024). Therefore, to address this gap, the present studies were taken up and a rare species of basidiolichen *Sulzbacheromyces yunnanensis* is being described from Mizoram, India based on morphological characteristics and molecular phylogenetic analyses.

MATERIALS AND METHODS

Collection site

Hlimen Forest is located approximately 7 km south of Aizawl, the capital of Mizoram, between 23.6824 ^{0}N and 92.7164 ^{0}E. The landscape is hilly, with altitude ranging 1,100–1,200 m. The region is primarily composed of tertiary rocks from the Bhuban sub-group. The region experiences an average temperature of 26.1 °C and provides ideal conditions for the growth of fungi. The Hlimen Forest is highly diverse and plays a crucial role in maintaining ecological stability. The common tree species in Hlimen Forest include *Aporusa octandra*, *Lithocarpus xylocarpa*, *Macaranga indica*, *Callicarpa arborea*, *Albizia chinensis*, *Anogeissus acuminata*, *Archidendron monadelphum*, *Emblica officinalis*, *Lithocarpus elegans*, *Litsea monopetala*, and *Morus macroura*.

Morphological observation, DNA extraction, PCR, and sequencing

Basidiomata were collected from Hlimen Forest, Aizawl, Mizoram and were initially cleaned from forest debris and identified using standard mycotaxonomical methods and authenticated by referring Liu et al. (2017) and Suwannarach et al. (2019). The colour description was based on Kornerup & Wanscher (1978). The microscopic characteristics of the specimens were recorded using the compound microscope (Carl ZEISS Axio Lab.A1). For microscopic observations, sections of basidioma were mounted in Melzer's reagent, 5% (w/v) potassium hydroxide (KOH) solution after staining with 1% (w/v) Congo red solution. For molecular analysis following Zothanzama et al. (2016) and reference therein, DNA was extracted using the Cetyltrimethylammonium bromide (CTAB) method, amplified with polymerase chain reaction (PCR) using internal transcribed spacer (ITS1 and ITS4) primers, and sequenced using Sanger sequencing.

Phylogenetic analysis

To construct phylogeny of major lineages, representative taxa of members from the major species were chosen. Model testing and maximum likelihood (ML) phylogenetic analyses were conducted in RAxMLGUI 2.0 (Edler et al. 2020) with the recommended parameters to determine the best tree topology and bootstrap support values from 1,000 search replicates, which are summarized in the phylogenetic tree. Model testing is carried out using the inbuilt program ModelTest-NG (Darriba et al. 2020) to select the best substitution model based on the corrected Akaike information criterion (AIC; Burnham & Anderson 2002).

RESULTS AND DISCUSSION

Taxonomy

Sulzbacheromyces yunnanensis D.Liu, Li S.Wang & Goffinet

Image 1

Description: Thallus crustose, covering an area of 0.5–45 mm diameter, distinct, dark green in shaded areas or depressions, yellow-green, indistinguishable from soil on exposed ground; forming a thin layer on the substrate, containing clusters of single-celled chlorococcoid algae, without prothallus. Photobiont 4–9.5 µm in diameter, globose to sub globose, smooth, contiguous, surrounded by a single layer of hyaline hyphae. Basidioma solid, clavarioid, fusiform, simple, with two conspicuous, wide, longitudinal depressions or grooves, never circled by transverse cracks at maturity, apex obtuse to narrowly obtuse to truncate, 24–60 × 0.5–2.5 mm, with hymenium covering the upper part, surface pruinose, without tomentum at the base, orange or yellow when exposed to direct sunshine, base dark ochraceous, ochraceous upon drying. Tramal hyphae 2–7.5 µm in diameter, parallel, clamped, slightly thick-walled, with bulbous apex. Hymenium 70–80 µm thick. Basidia 50–75 × 5–6.5 µm, oblong when young, subclavate to clavate with age, thin-walled, hyaline, 4-spored, with basal clamp connections, fragile sterigmata 4.5–5 µm long. Basidiospores 8.3–12.5 × 3.5–5.8 µm (n = 50), Q = 2.0–2.4, ellipsoid to slightly reniform, thin-walled, hyaline, smooth, hilar appendix present, guttulate or not.

Specimens examined—India, Mizoram, Aizawl district, Hlimen, on soil, elev. 1,128 m, 24 May 2022, Thachunglura VL, Chawngthu Z & Bochung L, MZU/JZT-VL/2022/004; MZU/JZT-VL/2022/006, GenBank PQ222572 & PQ222573.

Distribution and Ecology: China (Liu et al. 2017), Thailand (Suwannarach et al. 2019), India – Arunachal Pradesh (Debnath et al. 2025), Mizoram – Hlimen, Aizawl District (Present study). *Sulzbacheromyces yunnanensis* grows on soil near an informal path, in an area characterized by thick sandstones interbedded with thin shale. It thrives in this environment alongside *Chromolaena odorata*, indicating its preference for exposed substrates and moderate disturbance.

Remarks: Phylogenetic analysis was conducted using ITS sequence data from the collected specimens, along with 42 strains obtained through BLAST search (NCBI) and recent publications. *Ganoderma enigmaticum* (NR_132918) was selected as the outgroup and the best-scoring RA × ML tree is presented in Figure 1. The tree topologies derived from ML and maximum parsimony (MP) methods were consistent with earlier investigations (Liu et al. 2017). *Sulzbacheromyces* species were segregated into seven clades, grouping alongside *Leptosporomyces* and *Lepidostroma* in the phylogenetic tree. Our sequences (PQ222572 and PQ222573) formed an independent clade, representing a distinct lineage when compared with other *S. yunnanensis* specimens, and clustered together with 99% ML and MP support.

The identified species *S. yunnanensis* closely resembles other species within *Sulzbacheromyces*, such as *S. caatingae*, *S. chocoensis*, *S. sinensis*, and *S. tutunendo*. However, it is distinguished by comparatively longer basidia and basidiospores (Table 1). The tramal hyphae, hymenium structure, and basidiospores dimensions were found to be nearly identical to those reported by Liu et al. (2017) and Suwannarach et al. (2019). Additionally, the ITS sequence analysis confirmed the distinctness of *S. yunnanensis* from other species of the genus and supports the morphology based identification of the collected specimens. This finding is ecologically significant as it extends the known range of *S. yunnanensis*, suggesting greater adaptability to diverse habitats within the Asian region. Our collection extended

Table 1. Comparison of basidia and basidiospores sizes in *Sulzbacheromyces yunnanensis* and related taxa.

Species	Basidia (µm)	Basidiospores (µm)	References
S. caatingae	23–45 × 4–7	6.5 × 3.9	Sulzbacher et al. 2016
S. chocoensis	25–40 × 5–7	4 × 6	Coca et al. 2018
S. sinensis	13–50 × 2.5–8	5.9–11.5 × 4.5–7	Liu et al. 2017
S. tutunendo	25–40 × 5–7	4 × 6	Coca et al. 2018
S. yunnanensis	50–75 × 5–6.5	8.3–12.5 × 3.5–5.8	This study

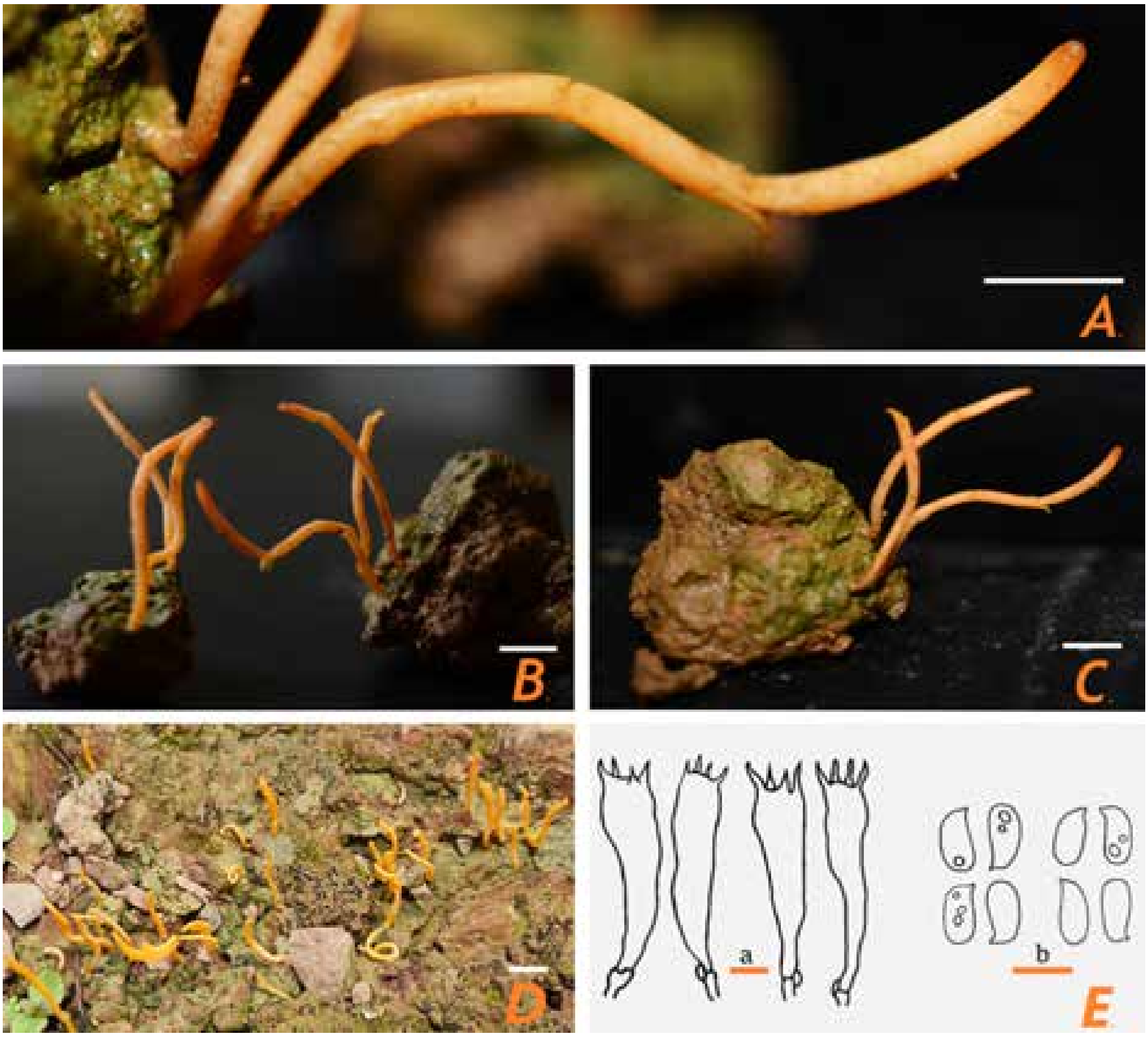

Image 1. Field and laboratory photographs of *Sulzbacheromyces yunnanensis* (MZU/JZT-VL/2022/004) collected from Hlimen Forest: A–C—basidiomes closed-up | D—basidiomes in field | E—(a) basidia (b) basidiospores. Scale bars: 10 mm (A–D) | 10 µm (E—a,b). © Zohmangaiha Chawngthu

the distribution of the genus *Sulzbacheromyces* and the presence of *S. yunnanensis* in Hlimen forest, India aligns with its occurrence in subtropical forests of China and Thailand. This finding corroborates the recent report of *S. yunnanensis* from northeastern India (Debnath et al. 2025) and provides additional data on its habitat, morphology, and phylogenetic placement, further enhancing our understanding of this rare basidiolichen in India. However, only around 264 species of macrofungi have been reported from Mizoram (Thachunglura et al. 2024), which is relatively low considering the rich forest ecosystems and favorable climatic conditions. This indicates that the fungal diversity of the region remains largely unexplored. Therefore, it is essential to conduct regular and extensive surveys to document the full range of macrofungal species. Such studies are crucial not only for biodiversity conservation but also for understanding the ecological roles of these fungi and their potential applications in food, medicine, and biotechnology. The favorable environmental conditions of northeastern India may support its growth, highlighting the need for further research within this important region of the Indo-Burma global biodiversity hotspot.

REFERENCES

Burnham, K.P. & D.R. Anderson (2002). *Model selection and multimodel inference: A practical information-theoretic approach, 2nd Edition*. Springer-Verlag, New York.

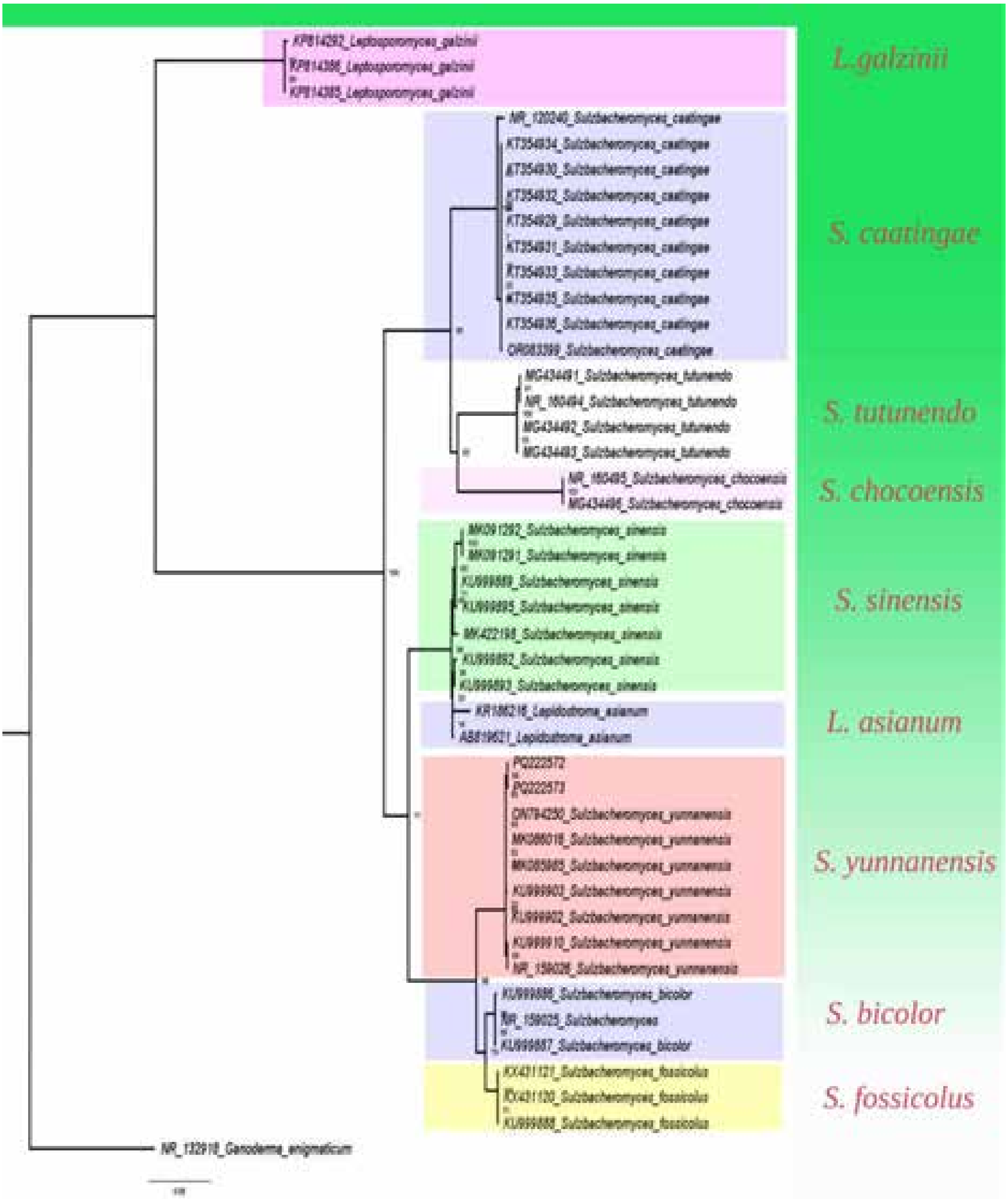

Figure 1. Phylogenetic tree of *Sulzbacheromyces yunnanensis* and related species obtained with maximum likelihood method based on the ITS region. Numbers below the branches are bootstrap percentage values based on 1,000 replicates, ML/MP bootstrap support values greater than 50%.

Chawngthu, Z., V.L. Thachunglura, J. Zothanzama & J. Khumlianlal (2024). Risk assessment of heavy metals in wild mushroom from Mizoram, India. *Environmental Pollution and Management* 1: 147–151. https://doi.org/10.1016/j.epm.2024.09.001

Coca, L.F., S.G. Gómez, J.G. Guzmán, E.T. Trujillo, L. Clavijo, A. Zuluaga, M. Dal-Forno & H.T. Lumbsch (2023). *Sulzbacheromyces leucodontium* (Basidiomycota, Lepidostromataceae), a new species of basidiolichen widely distributed in the Neotropics. *Phytotaxa* 597(2): 153–164. https://doi.org/10.11646/phytotaxa.597.2.5

Coca, L.F., R. Lücking & B. Moncada (2018). Two new, sympatric and semi-cryptic species of *Sulzbacheromyces* (Lichenized Basidiomycota, Lepidostromatales) from the Chocó Biogeographic Region in Colombia. *The Bryologist* 121(3): 297–305. https://doi.org/10.1639/0007-2745-121.3.297

Darriba, D., D. Posada, A.M. Kozlov, A. Stamatakis, B. Morel & T. Flouri (2020). ModelTest-NG: A new and scalable tool for the selection of DNA and protein evolutionary models. *Molecular Biology and Evolution* 37: 291–294. https://doi.org/10.1093/molbev/msz189

Debnath, A., N. Sanjeeva, J. Siljo & N. Roshinikumar (2025). New species and new records of the basidiolichen *Sulzbacheromyces* (Lepidostromataceae) from India. *Phytotaxa* 683(3): 189–204. https://doi.org/10.11646/phytotaxa.683.3.1.

Edler, D., J. Klein, A. Antonelli & D. Silvestro (2020). raxmlGUI 2.0: A graphical interface and toolkit for phylogenetic analyses using RAxML. *Methods in Ecology and Evolution* 12: 373–377. https://doi.org/10.1111/2041-210x.13512

Ertz, D., J.D. Lawrey, M. Sikaroodi, E. Fischer, D. Killmann & D. Sérusiaux (2008). A new lineage of lichenized basidiomycetes inferred from a two-gene phylogeny: The Lepidostromataceae with three species from the tropics. *American Journal of Botany* 95: 1548–1556. https://doi.org/10.3732/ajb.0800232

Gasulla, F., J.M. Barrasa, L.M. Casano & E.M. del Campo (2020). Symbiont composition of the basidiolichen *Lichenomphalia meridionalis* varies with altitude in the Iberian Peninsula. *The Lichenologist* 52: 17–26. https://doi.org/10.1017/s002428291900046x

Hodkinson, B.P., J.K. Uehling & M.E. Smith (2012). *Lepidostroma vilgalysii*, a new basidiolichen from the New World. *Mycological Progress* 11(3): 827–833. https://doi.org/10.1007/s11557-011-0800-z

Hodkinson, B.P., B. Moncada & R. Lücking (2014). Lepidostromatales, a new order of lichenized fungi (Basidiomycota, Agaricomycetes), with two new genera, *Ertzia* and *Sulzbacheromyces*, and one new species, *Lepidostroma winklerianum*. *Fungal Diversity* 64: 165–169.

Kornerup, A. & J. Wanscher (1978). Metheun Hand Book of Colour. 3rd Edition, Metheun London Ltd., London, 144–148.

Lalrinawmi, H., J. Zothanzama, B.W. Held, J.M.C. Vabeikhokhei, Zohmangaiha & R.A. Blanchette (2018). The gilled mushroom *Amanita spissacea* (Amanitaceae): a new report for India. *Journal of Threatened Taxa* 10 (10): 12413–12417. https://doi.org/10.11609/jott.3471.10.10.12413-12417

Liu, D., B. Goffinet, D. Ertz, A.D. Kesel, X. Wang, J.S. Hur, H. Shi, Y. Zhang, M. Yang & L. Wang (2017). Circumscription and phylogeny of the Lepidostromatales (Lichenized Basidiomycota) following discovery of new species from China and Africa. *Mycologia* 109(5): 730–748. https://doi.org/10.1080/00275514.2017.1406767

Liu, D., X. Yu Wang, L.S. Wang, N. Maekawa & J.S. Hur (2019). *Sulzbacheromyces sinensis*, an unexpected basidiolichen, was newly discovered from the Korean Peninsula and Philippines, with a phylogenetic reconstruction of genus *Sulzbacheromyces*. *Mycobiology* 47: 191–199. https://doi.org/10.1080/12298093.2019.1617825

Lücking, R., M. Dal-Forno, M. Sikaroodi, P.M. Gillevet, F. Bungartz, B. Moncada, A. Yánez-Ayabaca, J.L. Chaves, L.F. Coca & J.D. Lawrey (2014). A single macrolichen constitutes hundreds of unrecognized species. *Proceedings of the National Academy of Sciences* 111(30): 11091–11096. https://doi.org/10.1073/pnas.1403517111

Oberwinkler, F. (2012). Basidiolichens, pp. 341–362. In: Hock, B. *The Mycota, Vol - 9. Fungal Associations, 2nd ed.* Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-30826-0_16

Petersen, R.H. & M. Zang (1986). New or interesting clavarioid fungi from Yunnan, China. *Acta Botanica Yunnanica* 8: 281–294.

Sulzbacher, M.A., F. Wartchow, C.L. Ovrebo, J.O. Sousa, I.G. Baseia, B. Moncada & R. Lücking (2015). *Sulzbacheromyces caatingae*: notes on its systematics, morphology, and distribution based on ITS barcoding sequences. *The Lichenologist* 48(1): 61–70. https://doi.org/10.1017/s0024282915000420

Suwannarach, N., J. Kumla, K. Satienperakul, W. Sungpalee, S. Hermhuk, P. Suttiprapan, K. Sri-Ngernyuang & S. Lumyong (2019). *Sulzbacheromyces yunnanensis*, a new record for Thailand. *Mycotaxon* 134: 215–219. https://doi.org/10.5248/134.215

Thachunglura, V.L., P.K. Rai, J. Khumlianlal & J. Zothanzama (2024). A checklist of wild mushrooms in Mizoram, Northeast India. *Plant Pathology and Quarantine* 14(1): 125–142. https://doi.org/10.5943/ppq/14/1/11

Zothanzama, J., R.A. Blanchette, S. Redford, B. Held, Zohmangaiha & J.M.C. Vabeikhokhei (2016). Using molecular characterization as a tool for identification of fungi from Mizoram, India, pp. 165–177. In: Eckman, K. & L. Ralte (eds.). *Integrated Land Use Management in the Eastern Himalayas*. *Vol 2*. Akansha Publishing House, New Delhi.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26893–26897
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.9261.17.4.26893-26897
#9261 | Received 04 July 2024 | Final received 09 March 2025 | Finally accepted 14 April 2025

SHORT COMMUNICATION

First photographic record of a Leopard Cat *Prionailurus bengalensis* (Kerr, 1792) (Mammalia: Carnivora: Felidae) in central India

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Abstract: We report the first documented presence of the Leopard Cat *Prionailurus bengalensis* in central India, significantly expanding the known range of the species. Camera trapping in Pench Tiger Reserve from 3 February to 3 March 2024, Maharashtra, revealed the presence of a Leopard Cat in one of 296 surveyed grid cells of 2 km^2 each. The detection occurred in a seasonal stream with undulating, rocky terrain, and 40% canopy cover. The surrounding habitat was characterized by a mix of dense forest and human-dominated landscape, consistent with the species' known adaptability and tolerance of human disturbance. This unexpected finding challenges previous assumptions about Leopard Cat distribution in India and has important implications for felid conservation in the region. Further studies would be required to ascertain whether this individual belongs to a distinct population or is an extension of already reported population in the country.

Keywords: Camera trap, conservation, landsacpe, Pench Tiger Reserve, small wild cat, tropical dry deciduous forest, wild cat, wildlife.

The Leopard Cat *Prionailurus bengalensis* is a small wild cat with a wide geographical distribution in southern and eastern Asia, which inhabits tropical dipterocarp, evergreen, temperate broadleaf, and coniferous forests to shrublands and grasslands (Azlan & Sharma 2006; Thapa et al. 2013; Bashir et al. 2013; Lee et al. 2015; Petersen et al. 2019; Wu et al. 2020; Ghimirey et al. 2023). It is listed as 'Least Concern' in the IUCN Red List (Ghimirey et al. 2023).

In India, it is afforded the highest protection level under Schedule I of the Wildlife (Protection) Amendment Act (2022) (Ministry of Law and Justice 2022). It occurs in protected areas in the Himalayas and Terai (Mukherjee et al. 2010; Bashir et al. 2013; Noor et al. 2017; Srivastava et al. 2020; Jhala et al. 2020), the Eastern and Western Ghats (Mukherjee et al. 2010; Kumara et al. 2014; Srivathsa et al. 2015; Aditya & Ganesh 2016; Nikhil & Nameer 2017; Sreekumar & Nameer 2018; Jhala et al. 2020). In northeastern India, it has been recorded in several protected areas (Datta et al. 2008; Goswami & Ganesh 2011; Selvan et al. 2014; Joshi et al. 2019; Mukherjee et al. 2019; Jhala et al. 2020). Its presence has not been reported in central India (Jhala et al. 2020), and it is absent in museum collections from this region of India (Mukherjee et al. 2010). A study using molecular techniques and niche modelling showed a low probability of the Leopard Cat occurring in regions with temperatures above 38°C in the warmest month (Mukherjee et al. 2010). However, certain central Indian

Editor: Angie Appel, Wild Cat Network, Germany. **Date of publication:** 26 April 2025 (online & print)

Citation: Shukla, P.N., B. Habib, V.K. Mishra, S.L. Bobade, E.C. Rao & Kanishka (2025). First photographic record of a Leopard Cat *Prionailurus bengalensis* (Kerr, 1792) (Mammalia: Carnivora: Felidae) in central India. *Journal of Threatened Taxa* 17(4): 26893–26897. https://doi.org/10.11609/jott.9261.17.4.26893-26897

Funding: No funding was received to conduct this research.

Competing interests: The authors declare no competing interests.

Acknowledgements: We express our sincere gratitude to the Maharashtra Forest Department, which provided us the opportunity to carry out this work. We are thankful to the entire field staff and officers who helped in the collection of the data in the field.

pockets have been proposed to be probable habitat of the Leopard Cat (Ghimirey et al. 2023). Considering its vital role in its habitat, it is imperative to ascertain its presence in central India and other parts of the country to make efforts for its conservation at the landscape level.

We report the first photographic record of a Leopard Cat in Pench Tiger Reserve, Maharashtra, as well as central India.

Study area

The study was carried out in Pench Tiger Reserve located in Nagpur District of Maharashtra (Figure 1) and juxtaposed to the southern part of Pench Tiger Reserve in Madhya Pradesh. It comprises Pench National Park, Mansingh Deo Wildlife Sanctuary and Paoni & Nagalwadi Ranges (Dudipala et al. 2023). These ranges have been divided into beats and further into compartments for administrative purposes. The area of the Pench Tiger Reserve is over 740 km^2 including a core area of 483.96 km^2 and a buffer zone of 257.26 km^2. Human activities are restricted in the core area; most of the villages are located in the buffer zone, where most of the activities related to livelihood generation are allowed, such as collection of non-timber forest products, and other activities like developmental works are regulated (Shukla et al. 2025).

The northern part of Pench Tiger Reserve is hilly while the southern part is relatively plain, with an elevation gradient of 284–591 m. It is connected with Melghat Tiger Reserve to the east, Bor Tiger Reserve to the west, Navegaon-Nagzira Tiger Reserve to the southeast, Kanha Tiger Reserve to the north-east, and Pench Tiger Reserve to the north through corridors consisting of forest and non-forest areas (Jhala et al. 2020).

The major forest type in Pench Tiger Reserve is southern tropical dry deciduous forests dominated by Teak *Tectona grandis* along with *Terminalia tomentosa*, *Sterculia urens*, *Largerstroemia parviflora*, *Anogeissus latifolia*, *Pterocarpus marsupium*, *Bombax ceiba*, *Aegle marmelos*, *Boswellia serrata*, and *Chloroxylon swietenia* as associated tree species (Champion & Seth 1968). The area has dry weather for most of the year and receives 1,000–1,200 mm annual rainfall during the monsoon season of June to September (Shukla et al. 2025). Summer season is hot from March to June with a maximum temperature of 45°C in May (Shukla et al. 2025). November to January is the period of winter season with average minimum temperature of 12°C (Dudipala et al. 2023).

Material and Methods

We used Cuddeback C1, Cuddeback Colour Professional, and Bolyguard camera traps during the survey, which were set to taking one photograph per trigger. Each camera trap was assigned a unique identification number, and their memory cards were cleaned and double-checked to prevent data contamination.

We divided the survey area into 296 grid cells of 2 km^2 each and deployed 592 camera traps as pairs in a radius of 500 m from the centres of the cells at a height of 40–60 cm above ground. Camera traps were active for 24 hours during 31 days from 3 February to 3 March 2024. We determined the location of each camera trap using a Garmin etrex10 GPS device, which was set to the default geodetic datum WGS 84.

Results

A solitary Leopard Cat was recorded on 7 February 2024 at 02.05 hours at 21.568 ^{0}N, 79.144 ^{0}E (Image 1) inside a seasonal stream, which was predominantly dry except for a few small pools of stagnant water and some boulders along the bed. The stream had a low incline on the sides and loose gravel soil underneath dry leaf litter. The terrain was undulating with rocky outcrops. The vegetation was sparse near the village but denser towards the forest. The canopy cover was about 40%, dominated by Teak. The presence of pellets and hoof marks of herbivores was observed across the compartment. The camera trap location was 2 km away from Narhar village located in the Nagalwadi range of Parshioni taluka of Nagpur District.

Discussion

Our record of the Leopard Cat is the first in Pench Tiger Reserve and in the Deccan Plateau of central India. In Pench Tiger Reserve, it was not recorded during past camera trap surveys despite an effort of 15,291 camera trap days in 421 locations in 2018 alone (Jhala et al. 2020). The lack of previous records of the Leopard Cat in central India may be due to its lower population density in this region than estimated in temperate Himalayan habitats (Bashir et al. 2013), wet semi-evergreen and moist deciduous forests in southwestern India (Srivathsa et al. 2015), and evergreen forests in Thailand and Cambodia (Petersen et al. 2019; Pin et al. 2022). Dry deciduous forests are likely to represent suboptimal habitat for the Leopard Cat (Pin et al. 2022), thus restraining detection probability.

The location of this record is close to the possible Leopard Cat harbouring area in central India as per

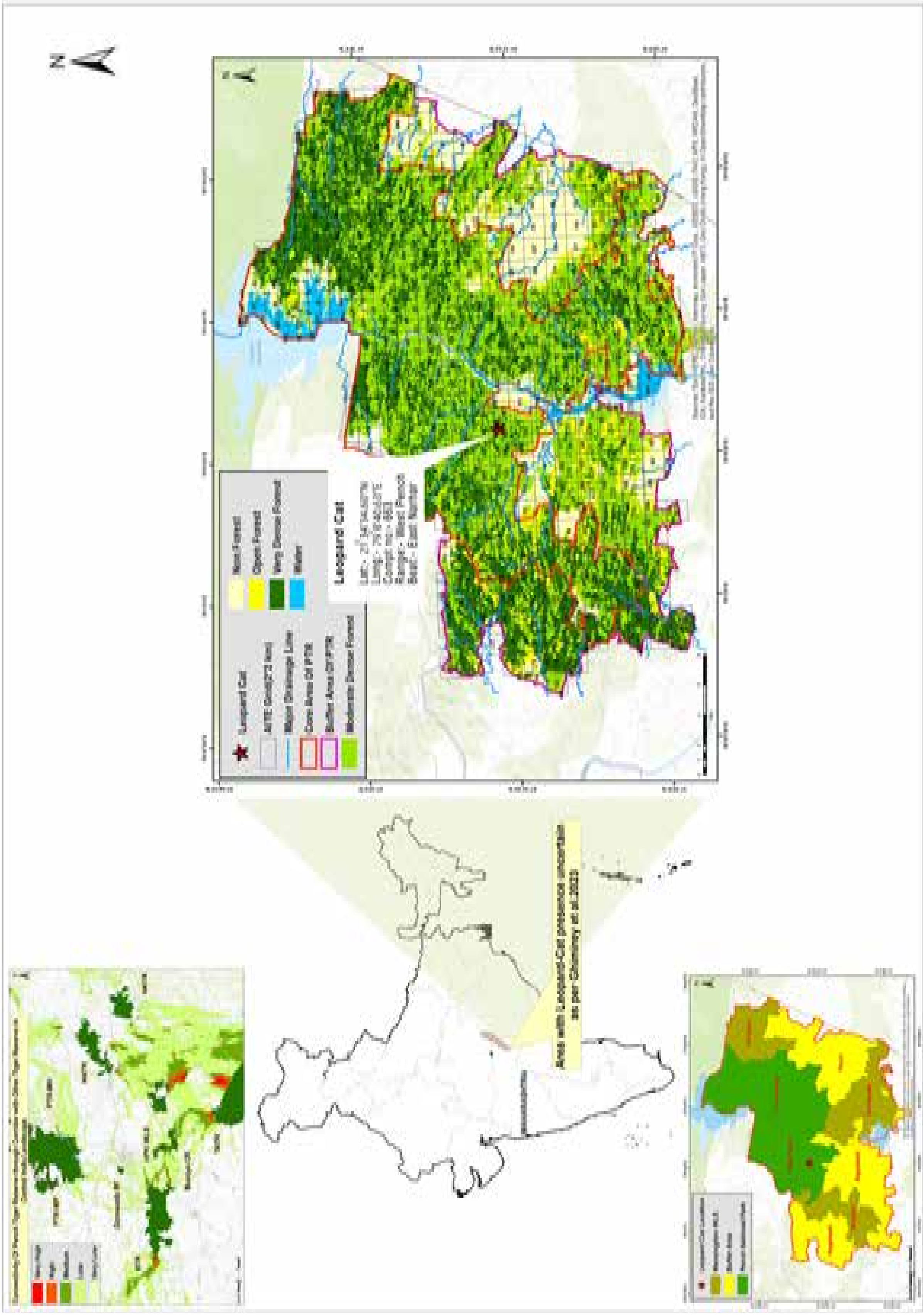

Figure 1. Map of the Pench Tiger Reserve, Nagpur, Maharashra, India showing study area.

Image 1. Camera trap Photograph of Leopard Cat *Prionailurus bengalensis* from Pench Tiger Reserve on 7 February 2024. © All authors.

Ghimirey et al. (2023). In view of temperatures reaching 45°C in May (Shukla et al. 2025), this record refutes the notion that 38 °C may be the upper threshold for the presence of the Leopard Cat (Mukherjee et al. 2010). As shown by Petersen & Savini (2023), species distribution models based only on climatic data are questionable, but modelling approaches should also include forest cover and canopy height to improve their predictive accuracy.

Reporting the presence of the Leopard Cat in this landscape of central India is important from the conservation point of view. Extensive studies are required to determine its distribution, habitat preferences and population dynamics for devising a conservation strategy for maintaining a long-term sustainable population.

References

Aditya, V. & T. Ganesh (2016). Camera trap records of Rusty-spotted Cat *Prionailurus rubiginosus* and Leopard Cat *Prionailurus bengalensis* (Mammalia: Carnivora: Felidae) from Papikonda National Park, northern Eastern Ghats, India. *Journal of Threatened Taxa* 8(5): 8818–8819. https://doi.org/10.11609/jott.2401.8.5.8818-8819

Azlan, M.J. & D.S.K. Sharma (2006). The diversity and activity patterns of wild felids in a secondary forest in Peninsular Malaysia. *Oryx* 40(1): 36–41. https://doi.org/10.1017/S0030605306000147

Bashir, T., T. Bhattacharya, K. Poudyal, S. Sathyakumar & Q. Qureshi (2013). Estimating Leopard Cat *Prionailurus bengalensis* densities using photographic captures and recaptures. *Wildlife Biology* 19(4): 462–472. https://doi.org/10.2981/12-098

Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Manager of Publications, Government of India, Delhi, 404 pp.

Datta, A., M.O. Anand & R. Naniwadekar (2008). Empty forests: Large carnivore and prey abundance in Namdapha National Park, Northeast India. *Biological Conservation* 141: 1429–1435. https://doi.org/10.1016/j.biocon.2008.02.022

Dudipala, R., K. Chandramohan, A.S. Lakshmi, P.N. Shukla, S. Chepyala, V. Podishetti, S. Shakati, N. Basai & C.H. Bhargavi (2023). Species diversity, phytosociological attributes and regeneration status of Pench Tiger Reserve, Maharashtra, India. *International Journal of Environment and Climate Change* 13(10): 1743–1757. https://doi.org/10.9734/ijecc/2023/v13i102831

Ghimirey, Y., W. Petersen, N. Jahed, M. Akash, A.J. Lynam, S. Kun, J. Din, M.A. Nawaz, P. Singh, T. Dhendup, M.A.H. Chua, T.N.E. Gray & P.P. Kyaw (2023). *Prionailurus bengalensis* (amended version of 2022 assessment). The IUCN Red List of Threatened Species 2023: e.T223138747A226150742. Downloaded on 12

October 2024. https://doi.org/10.2305/IUCN.UK.2023-1.RLTS.T223138747A226150742.en

Goswami, R. & T. Ganesh (2011). Conservation amidst political unrest: the case of Manas National Park, India. *Current Science* 100(4): 445–446.

Jhala, Y.V, Q. Qureshi & A.K. Nayak (eds.) (2020). *Status of Tigers, copredators and prey in India, 2018*. National Tiger Conservation Authority, Government of India, New Delhi, and Wildlife Institute, Dehradun, 656 pp.

Joshi, B., B.L.N. Syiem, R. Kuotsu, A. Menon, J. Gogoi, V.R. Goswami & D. Vasudev (2019). Records of the Marbled Cat *Pardofelis marmorata* and the Asiatic Golden Cat *Catopuma temminckii* (Mammalia: *Carnivora: Felidae*) from the community forests surrounding the Dzükou Valley in Nagaland, India. *Journal of Threatened Taxa* 11(10): 14363–14367. https://doi.org/10.11609/jott.4921.11.10.14363-14367

Kumara, H.N., S.O. Thorat, K. Santhosh, R. Sashi & H.P. Ashwin (2014). Small carnivores of Biligiri Rangaswamy Temple Tiger Reserve, Karnataka, India. *Journal of Threatened Taxa* 6(12): 6534–6543. https://doi.org/10.11609/JoTT.o3766.6534-43

Lee, M.J., W. Song & S. Lee (2015). Habitat mapping of the Leopard Cat (*Prionailurus bengalensis*) in South Korea using GIS. *Sustainability* 7(4): 4668–4688. https://doi.org/10.3390/su7044668

Ministry of Law and Justice (2022). The Wild Life (Protection) Amendment Act, 2022. The Gazette of India Extraordinary, Part II, Section 1, New Delhi.

Mukherjee, S., A. Krishnan, K. Tamma, C. Home, R. Navya, S. Joseph, A. Das & U. Ramakrishnan (2010). Ecology driving genetic variation: a comparative phylogeography of Jungle Cat (*Felis chaus*) and Leopard Cat (*Prionailurus bengalensis*) in India. *PLoS One* 5(10): e13724. https://doi.org/10.1371/journal.pone.0013724

Mukherjee, S., P. Singh, A.P. Silva, C. Ri, K. Kakati, B. Borah, T. Tapi, S. Kadur, P. Choudhary, S. Srikant, S. Nadig, R. Navya, M. Björklund & U. Ramakrishnan (2019). Activity patterns of the small and medium felid (Mammalia: Carnivora: Felidae) guild in northeastern India. *Journal of Threatened Taxa* 11(4): 13432–13447. https://doi.org/10.11609/jott.4662.11.4.13432-13447

Nikhil, S. & P.O. Nameer (2017). Small carnivores of the montane forests of Eravikulam National Park in the Western Ghats, India. *Journal of Threatened Taxa* 9(11): 10880–10885. http://doi.org/10.11609/jott.2211.9.11.10880-10885

Noor, A., Z.R. Mir, G.G. Veeraswami & B. Habib (2017). Activity patterns and spatial co-occurrence of sympatric mammals in the moist temperate forest of the Kashmir Himalaya, India. *Folia Zoologica* 66(4): 231–241. https://doi.org/10.25225/fozo.v66.i4.a4.2017

Petersen, W.J., T. Savini, R. Steinmetz & D. Ngoprasert (2019). Estimating Leopard Cat *Prionailurus bengalensis* Kerr, 1792 (Carnivora: Felidae) density in a degraded tropical forest fragment in northeastern Thailand. *Journal of Threatened Taxa* 11(4): 13448–13458. https://doi.org/10.11609/jott.4553.11.4.13448-13458

Petersen, W.J. & T. Savini (2023). Lowland forest loss and climate-only species distribution models exaggerate a forest-dependent species' vulnerability to climate change. *Ecological Informatics* 78(12): 102327. https://doi.org/10.1016/j.ecoinf.2023.102327

Pin, C., C. Phan, J.F. Kamler, S. Rostro-García, U. Penjor, V. In, R. Crouthers, E. A. Macdonald, S. Chou & D.W. Macdonald (2022). Density and occupancy of Leopard Cats across different forest types in Cambodia. *Mammal Research* 67(3): 287–298. https://doi.org/10.1007/s13364-022-00634-6

Selvan, M., S. Lyngdoh, G.V. Gopi & B. Habib (2014). Density estimation of Leopard Cat *Prionailurus bengalensis* using capture recaptures sampling in lowland forest of Pakke Tiger Reserve, Arunachal Pradesh, India. *Mammalia* 78(4): 555–559. https://doi.org/10.1515/mammalia-2013-0084

Shukla, P.N., E.C. Rao & V.K. Mishra (2025). Factors infuencing livestock grazing in Pench Tiger Reserve, Maharashtra. *Discover Environment* 3: 33. https://doi.org/10.1007/s44274-025- 00216-8

Sreekumar, E.R. & P.O. Nameer (2018). Small carnivores of Wayanad Wildlife Sanctuary, the Southern Western Ghats, India. *Journal of Threatened Taxa* 8(11): 9306–9315. https://doi.org/10.11609/jott.3651.10.1.11218-11225

Srivastava, N., R. Krishnamurthy & S. Sathyakumar (2020). Avoidance or coexistence? The spatiotemporal patterns of wild mammals in a human-dominated landscape in the western Himalaya. *Mountain Research and Development* 40(2): R20–R31. https://doi.org/10.1659/MRD-JOURNAL-D-19-00046.1

Srivathsa, A., R. Parameshwaran, S. Sharma & K.K. Ullas (2015). Estimating population sizes of Leopard Cats in the Western Ghats using camera surveys. *Journal of Mammalogy* 96(4): 742–750. https://doi.org/10.1093/jmammal/gyv079

Thapa, K., N.M.B. Pradhan, J. Barker, M. Dhakal, A.R. Bhandari, G.S Gurung, D.P. Rai, G.J. Thapa, S. Shrestha & R.G. Singh (2013). High elevation record of Leopard Cat in the Kanchenjunga Conservation Area, Nepal. *Cat News* 58: 26–27.

Wu, J., J. Wang, Y. Zhu, X. Bu, R. Xiang, Q. Lu, S. Cui, Y. Hao, Y. Sheng & X. Meng (2020). Summer habitat selection and impacts of human disturbance on Leopard Cats (*Prionailurus bengalensis*). *Ecosystem Health and Sustainability* 6: 1856630. https://doi.org/10.1080/20964129.2020.1856630

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26898–26902

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9831.17.4.26898-26902

#9831 | Received 27 November 2024 | Final received 17 February 2025 | Finally accepted 09 April 2025

OPEN ACCESS

SHORT COMMUNICATION

New record of Mysore Slender Loris *Loris lydekkerianus* near Puducherry, India

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Abstract: The Mysore Slender Loris *Loris lydekkerianus*, a nocturnal and 'Near Threatened' primate, is found in the Eastern Ghats and eastern foothills of the southern Western Ghats; mainly occurs in dry deciduous, and scrub forests with high tree density areas. Three individuals of loris were sighted in the upper canopy of *Pterocarpus santalinus* and *Acacia auriculiformis* trees in the planted forest patches near Puducherry, southern India, during September and October in 2024. All three lorises were located within a 300-m radius, with inter-individual distances of 270–500 m. This was the first sighting of slender lorises near Puducherry. This observation reiterates the importance of continuous monitoring to better understand the recovery of biodiversity in the restored forests and its significance in conserving threatened native species such as the slender loris.

Keywords: Aranya forest, Auroville, density estimation, endangered species, nocturnal primate, primate conservation, restored forests.

Slender lorises are one of the two genera of nocturnal primates (genus *Loris*) that inhabit India and Sri Lanka (Nekaris 2001). Slender lorises are confined to India and Sri Lanka, where they inhabit moist to dry and lowland to montane forests (Singh et al. 2021). Three species of slender lorises are found in South Asia: the Mysore Slender Loris *Loris lydekkerianus* found in southern India and Sri Lanka, the Malabar Slender Loris *Loris malabaricus*, and the Red Slender Loris *Loris tardigradus,* found only in Sri Lanka (Groves 2001; Teja et al. 2023). The Mysore Slender Loris is a cryptic, solitary, and nocturnal primate, found in the dry deciduous and scrub forests of the Eastern Ghats, and southern Western Ghats (Singh et al. 1999, 2000; Molur et al. 2003; Radhakrishna et al. 2011; Teja et al. 2023).

In southern India, the highest number of loris sightings occur in dry deciduous forests, followed by moist deciduous forests, evergreen forests, and restored forests (Singh et al. 1999, 2000; Kumara et al. 2006; Radhakrishna et al. 2011; Kumara & Sasi 2014; Kumara et al. 2016). The variation in habitat preferences between regions highlights the slender loris' adaptability to different environments. The slender loris is primarily insectivorous, detecting prey mainly through vision, and smell. It uses acrobatic postures to catch insects like ants and termites, typically with one or two hands. It rarely drinks water, possibly obtaining hydration or detoxifying ants through fruit pods, and prefers terminal branches for foraging (Nekaris 2000, 2002, 2005; Radhakrishna & Singh 2002).

The Mysore Slender Loris and Malabar Slender Loris are both classified as 'Near Threatened' (Kumara et

Editor: Honnavalli N. Kumara, Salim Ali Centre for Ornithology and Natural History, Coimbatore, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Mani, S., P.A. Aathi, K. Sivakumar, A. Bystrom & D. Saravanan (2025). New record of Mysore Slender Loris *Loris lydekkerianus* near Puducherry, India. *Journal of Threatened Taxa* 17(4): 26898–26902. https://doi.org/10.11609/jott.9831.17.4.26898-26902

Funding: Zooreach Conservation Seed Grant (24ZCSG06M).

CSR initiative by BOSCH

Competing interests: The authors declare no competing interests.

Acknowledgements: We thank our dedicated volunteers: B.N. Achyutha, Anuvrinda Sharma, Aritra Bhattacharya, Kosturi Sen, Rajashree Sain, K. Sidharth, A.P. Kiran, M.C. Vayshak and Nivan Shanmugam (11 year old) for their help and support.

al. 2022a,b) and listed in the Schedule I of the Wildlife (Protection) Amendment Act, 2022. Hunting and trading of lorises or their parts are prohibited in India (Gnanaolivu et al. 2022). Major threats to its survival include habitat loss, fragmentation, poaching, and trapping for traditional medicine and biomedical research (Kumara et al. 2006). These factors are expected to cause further decline in loris populations (Molur et al. 2003). Slender loris conservation prospects are positive in certain regions due to the absence of human-loris interactions, as lorises don't compete with humans for resources. Additionally, cultivated areas with fences & roadside trees can serve as essential corridors for lorises that link fragmented forest patches (Singh et al. 1999). These factors offer potential for supporting loris populations. Therefore, the study aims to assess the distribution, and population density of slender loris in various restored forest patches near Puducherry region, evaluate habitat conditions, and identify threats to inform conservation strategies and management plans for this threatened species.

Methods

Study area

A survey on Mysore Slender Loris was conducted in the Aranya Forest and Sanctuary (11.573 ^{0}N, 79.460 ^{0}E), a restored man-made forest located in the west of the Villupuram District border between Tamil Nadu and Puducherry (Image 1). It spans 100 acres, 60% of which is managed by the Auroville Foundation, while the rest comprises previously barren, unused land. It is located 8 km north-west of Puducherry city and 2 km east of Puducherry's Ossudu Lake Bird Sanctuary. This forest habitat supports nearly 400 indigenous plant species, 240 bird species, including the Indian Eagle Owl *Bubo bengalensis*, and 54 butterfly species (D. Saravanan per. comm.). It is home to rare mammals such as Indian Crested Porcupines, Jungle Cats, Golden Jackals, Small Indian Civets, Palm Civets, and monitor lizards. Deep ravines and several seasonal streams mark the terrain.

The climate shows a mean annual temperature of 29.5 °C and an average annual rainfall of 1,200 mm. Monthly temperatures range 25–34 °C. The region experiences a

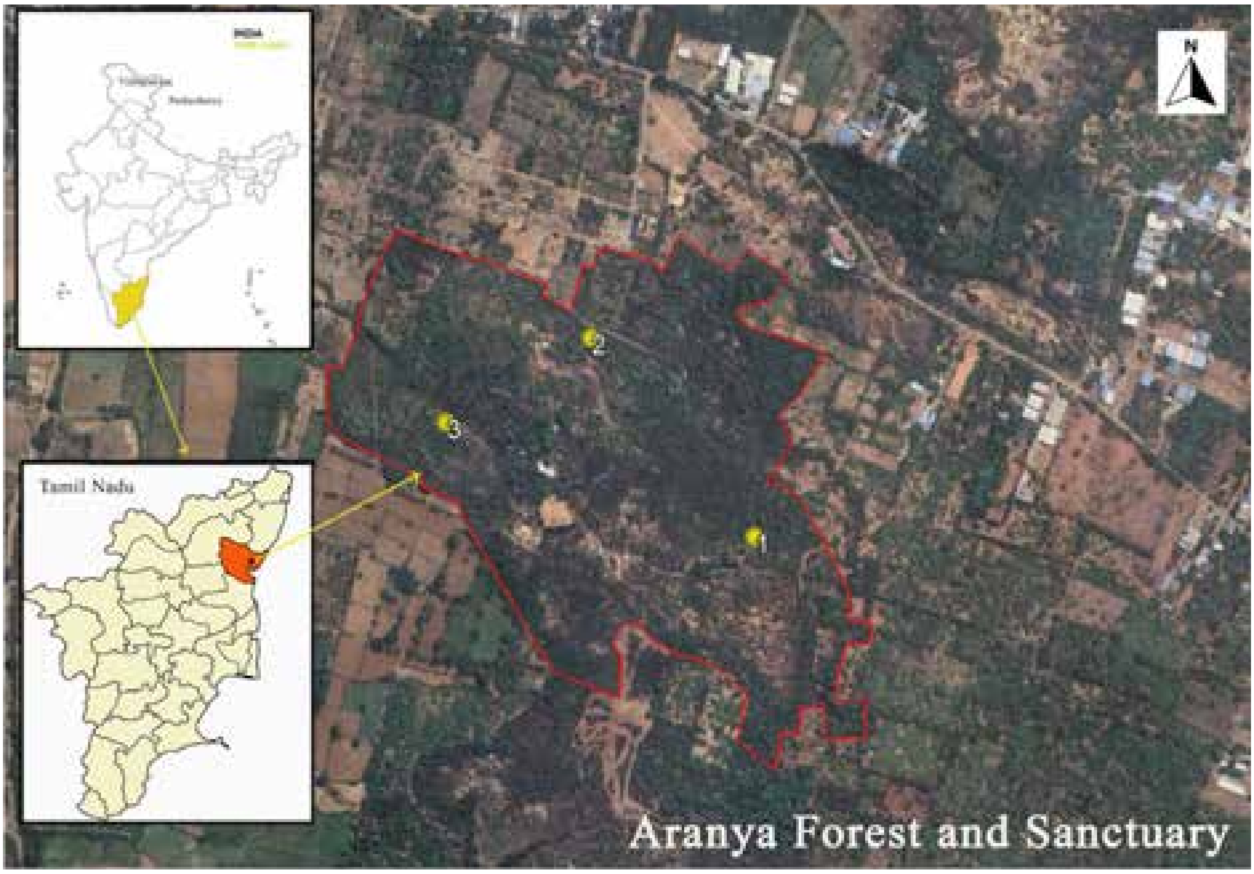

Image 1. Map and location of Mysore Slender Loris *Loris lyddekerianus* sightings recorded in the Aranya Forest and Sanctuary near Puducherry, Tamil Nadu, India.

tropical asymmetric climate, with most rainfall occurring during the north-east monsoon (October–December). In the Aranya Forest, the upper storey consists of tree species such as *Pterocarpus santalinus*, *Hardwickia binata*, *Acacia auriculiformis*, *Pterospermum canescens*, *Garcinia spicata*, *Lannea coromandelica*, *Chloroxylon swietenia*, and *Pongamia pinnata*. The middle storey features species like *Lepisanthes tetraphylla*, *Drypetes sepiaria*, *Psydrax dicoccos*, *Tricalysia sphaerocarpa*, *Diospyros ebenum*, and *Albizia amara*. The understorey is dominated by *Memecylon umbellatum* and *Glycosmis pentaphylla*.

Field survey

Surveys were conducted for loris on the extent of forest cover in the restored forests of the Auroville Bioregion. Depending on accessibility and terrain topography, foot transects were employed following the method described by Singh et al. (1999). We used all existing natural trails and roads for surveying loris. Night surveys were conducted between 1900 h and 2200 h with a team comprising 4–5 people walking at an average speed of 1.5 km/h along each side of the trails in September–October 2024. Flashlights and headlamps were used to detect the characteristic orange-red eye shine of the slender loris, which is visible from over 100 m and serves as a reliable indicator of their presence (Singh et al. 1999, 2000). The species was confirmed when individuals were visually sighted; vocalizations alone were not considered sufficient evidence. For each detection, the time of sighting, host tree species, and the number of individuals were recorded.

Results And Discussion

Over eight nights and a total of 24 hours of observations, we recorded sightings of three individuals of the Mysore Slender Lorises within the Aranya Forest and Sanctuary (Table 1). The first individual loris was observed in a *Pterocarpus santalinus* tree at an average height of 15 m, positioned within the terminal branches (Image 2). The loris was observed feeding, although the prey could not be identified due to rain, which limited visibility during the 20-minute observation from a distance of approximately 20 m. The individual appeared calm, displaying active behaviour with no signs of distress or aggression. The loris was observed detecting the prey visually, capturing it with acrobatic suspensory postures, and grasping it with one or both hands rather than directly with the mouth as similar to the observations of Nekaris (2001).

On a subsequent survey, we found two more individuals at a distance of 270 m interval. The second individual was located at an average height of 8 m in the terminal branches of a *Pterocarpus santalinus* tree that was sighted from a distance of 60 m. This individual exhibited quadrupedal locomotion with rapid movements along the terminal twigs, probably looking for prey. On the same night, the third individual was observed at a height of 8 m in an *Acacia auriculiformis* tree (Image 3). All lorises were observed on the terminal branches and twigs of large trees, where they frequently gathered ants or termites directly from the branches, appearing to rely primarily on sight, and smell for detecting prey (Nekaris & Rasmussen 2003). The richness of tree species emerged as a major factor in loris occupancy and abundance, as anthropogenic impacts tend to create secondary forests with higher species diversity, enhancing loris habitats (Morris 2010).

All three individuals were located within a 300-m radius, with inter-individual distances ranging 270–500 m, resulting in an average encounter rate of one individual/500 m walk. Most of the slender loris populations in Tamil Nadu were reported from the south-central districts, typically found at altitudes below 300 m, with some reaching up to 1,257 m (Singh et al. 2021). Singh et al. (1999) documented four individuals within a 50-m range in Dindigul, Tamil Nadu. However, abundance patterns of loris varied spatially, as south-central Tamil Nadu shows high slender loris population densities (2.21–0.75 /km), while densities in north-central, and western Tamil Nadu ranged 0.90–0.03 /km

Table 1. Observations of Mysore Slender Loris *Loris lyddekerianus* in the Aranya Forest and Sanctuary near Puducherry.

Date and time	Location	Host tree	Remarks
20.ix.2024 at 1950 h	11.574 N & 79.461 E; 75 m	*Pterocarpus santalinus* (Image 2)	Sighted at a height of 15 m with active behaviour, climbing up and down on the terminal branches. No agonistic behaviour was observed.
21.x.2024 at 1735 h	11.575 N & 79.463 E; 67 m	*Pterocarpus santalinus*	Sighted at a height of 8 m with active behaviour and quadrupedal rapid walk on the terminal twigs. Unable to take clear photos.
21.x.2024 at 2050 h	11.574 N & 79.455 E; 57 m	*Acacia auriculiformis* (Image 3)	Sighted at a height of 8 m with active behaviour, quadrupedal running, and climbing up and down on the terminal twigs. No agonistic behaviour was observed.

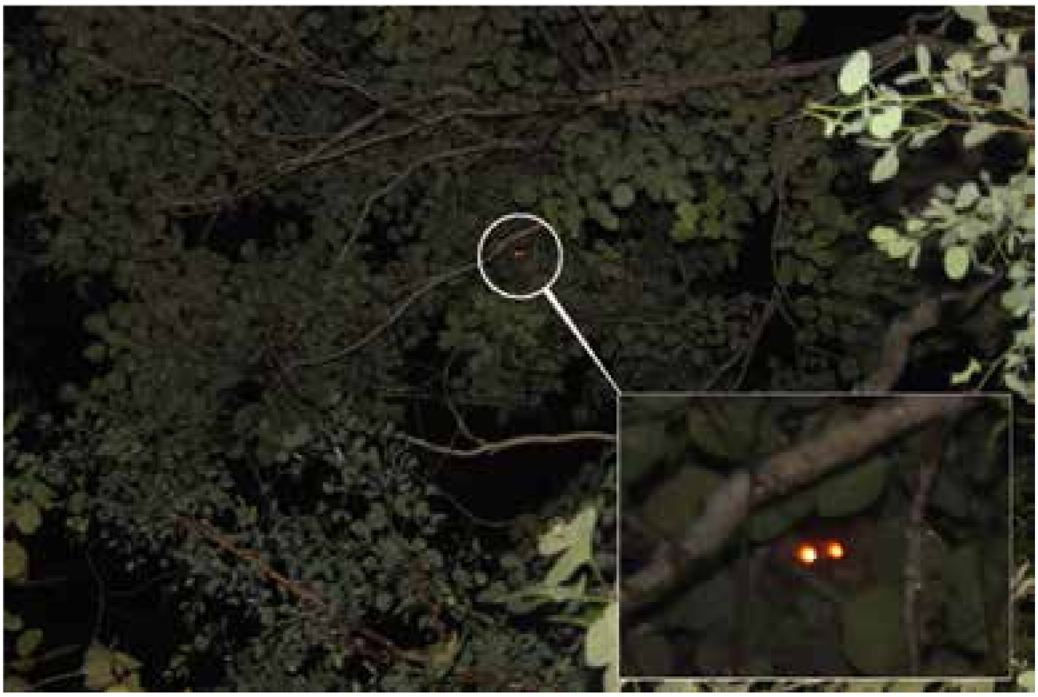

Image 2. Mysore Slender Loris *Loris lyddekerianus* on the *Pterocarpus santalinus*. © P. Aravind Aathi.

Image 3. Mysore Slender Loris *Loris lyddekerianus* on the *Acacia auriculiformis*. © P. Aravind Aathi.

and 0.25–0.01 /km, respectively (Kumara et al. 2016).

According to the slender loris occurrence recorded from 22 districts of Tamil Nadu (Kumara & Sasi 2014), the mean relative abundance of lorises varied between 0.03 /km and 2.21 /km. Of the 22 districts, three individuals were recorded in Villupuram District (one individual from Tirukoilur-Rishivandiyam reserve forest and two from Tirukoilur-Tandarpattu reserve forest). Whereas the present study site of the Aranya Forest and Sanctuary that is also located in the same Villupuram District but near Puducherry is reported for the first time with three individuals of Mysore Slender Loris, which is 65 km away from the previous sightings of loris, and there is no forest connectivity between Aranya Forests and Tirukoilur Reserve Forest. Though calls have been heard, there are no direct sightings recorded from the other restored forests of Auroville including Pitchandikulam, southern forests (Newland, Success, Forecomers, Ravena), and Auroville Botanical Garden. More surveys are required to confirm the occurrence of Mysore Slender Loris in the other restored forests of Auroville region.

Conclusions

First time observations of three Mysore Slender Lorises near Puducherry in the restored forests of Auroville, provides valuable data on their distribution range, and habitat use in the restored forests. Continued monitoring is essential to gain a deeper understanding of their habitat use, behavioural ecology, food habits, and movement patterns of this species within both the Aranya Forest and Sanctuary, and other restored forests in Auroville. This study reveals that the restored forests can accommodate threatened species provided better management and protection.

References

Gnanaolivu, S.D., M. Campera, K.A.I. Nekaris, V. Nijman, R. Satish, S. Babu & M. Singh (2022). Medicine, black magic and supernatural beings: Cultural rituals as a significant threat to slender lorises in India. *People and Nature* 4: 1007–1019. https://doi.org/10.1002/pan3.10336

Groves, C.P. (2001). Primate taxonomy. Smithsonian Institution Press, Washington DC, 350 pp.

Kumara, H.N., K.A.I. Nekaris & M. Singh (2022a). *Loris lydekkerianus* ssp. *lydekkerianus*. The IUCN Red List of Threatened Species 2022: e.T44719A217742793. https://doi.org/10.2305/IUCN.UK.2022-1.RLTS.T44719A217742793.en. Accessed on 20 April 2025.

Kumara, H.N., K.A.I. Nekaris & M. Singh (2022b). *Loris lydekkerianus* ssp. *malabaricus* (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2022: e.T44720A217744540. https://doi.org/10.2305/IUCN.UK.2022-1.RLTS.T44720A217744540.en. Accessed on 20 April 2025.

Kumara, H.N., M. Singh & S. Kumar (2006). Distribution, habitat correlates, and conservation of *Loris lydekkerianus* in Karnataka, India. *International Journal of Primatology* 27: 941–969.

Kumara, H.N. & R. Sasi (2014). Distribution Pattern of Slender Loris in Parts of Kerala and Tamil Nadu, India. SACON Technical Report-125, submitted to Primate Conservation Inc., USA. SACON, Coimbatore, India, 35 pp.

Kumara, H.N., R. Sasi, S. Chandran & S. Radhakrishna (2016). Distribution of the Grey Slender Loris (*Loris lyddekerianus* Cabrera, 1908) in Tamil Nadu, southern India. *Folia Primatologica* 87: 291–302.

Molur, S., D. Brandon-Jones, W. Dittus, A. Eudey, A. Kumar, M. Singh, M.M. Feeroz, M. Chalise, P. Priya & S. Walker (2003). Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report. Zoo Outreach Organisation/CBSG-South Asia, Coimbatore, India, viii + 432 pp.

Morris, R.J. (2010). Anthropogenic impacts on tropical forest biodiversity: A network structure and ecosystem functioning perspective. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 365: 3709–3718.

Nekaris, K.A.I. (2001). Activity Budget and Positional Behavior of the Mysore Slender Loris (*Loris tardigradus lydekkerianus*): Implications for Slow Climbing Locomotion. *Folia Primatologica* 72: 228–241.

Nekaris, K.A.I. & D.T. Rasmussen (2003). Diet and Feeding Behavior of Mysore Slender Lorises. *International Journal of Primatology* 24: 33–46.

Nekaris, K.A.I. (2000). The Socioecology of the Mysore Slender Loris (*Loris tardigradus lydekkerianus*) in Dindigul, Tamil Nadu, South India. PhD Thesis, Washington University, St Louis, Missouri (MO).

Nekaris, K.A.I. (2002). More evidence for visual predation in the slender loris. *American Journal of Physical Anthropology Supplement* 33: 117.

Nekaris, K.A.I. (2005). Foraging behaviour of the slender loris (*Loris lydekkerianus lydekkerianus*): Implications for theories of primate origins. *Journal of Human Evolution* 49: 289–300.

Radhakrishna, S. & M. Singh (2002). Home Range and Ranging Pattern in the Slender Loris (*Loris tardigradus lydekkerianus*). *Primates* 43: 237–248.

Radhakrishna, S., H.N. Kumara & R. Sasi (2011). Distribution patterns of slender loris subspecies (*Loris lydekkerianus*) in Kerala, southern India. *International Journal of Primatology* 32: 1007–1019.

Singh, M., D.G. Lindburg, A. Udhayan, M.A. Kumar & H.N. Kumara (1999). Status survey of slender loris *Loris tardigradus lydekkerianus* in Dindigul, Tamil Nadu, India. *Oryx* 33: 31–37.

Singh, M., M.A. Kumar, H.N. Kumara & S.M. Mohnot (2000). Distribution and conservation of slender lorises (*Loris tardigradus lydekkerianus*) in southern Andhra Pradesh, South India. *International Journal of Primatology* 21: 721–730.

Singh, M., M. Singh, H.N. Kumara, S. Kumar, S.D. Gnanaolivu & R. Sasi (2021). A review of research on the distribution, ecology, behaviour, and conservation of the Slender Loris *Loris lydekkerianus* (Mammalia: Primates: Lorisidae) in India. *Journal of Threatened Taxa* 13: 19540–19552. https://doi.org/10.11609/ jott.7562.13.11.19540-19552

Teja, V., S. Manu, H.N. Kumara & G. Umapathy (2023). Phylogenetic insights on the delineation of Mysore and Malabar subspecies of the Grey Slender Loris *Loris lydekkerianus* in southern India. *Journal of Threatened Taxa* 15: 23827–23835. https://doi.org/10.11609/jott.8491.15.9.23827-23835

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26903–26907

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.7576.17.4.26903-26907

#7576 | Received 17 July 2021 | Final received 07 March 2024 | Finally accepted 20 March 2025

OPEN ACCESS

SHORT COMMUNICATION

The brachypterous endemic genus *Ardistomopsis* (Coleoptera: Carabidae: Panagaeinae) of the Indian subcontinent: first report of *Ardistomopsis batesi* Straneo & Ball, 1989 and *Ardistomopsis marginicollis* (Schaum, 1864) (Coleoptera: Carabidae: Panagaeinae) from the Western Ghats and the biogeographical significance

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Abstract: The first reports of *Ardistomopsis batesi* and *A. marginicollis* of the Gondwanian tribe Peleciini from the high elevation tropical montane cloud forest and the low elevation Palakkad Gap in the Western Ghats, their distributional records and habitus of the Indian species are provided. The biogeographical significance of the first records of the species from the high and low elevations of the Western Ghats is explained.

Keywords: Deccan trap, *Disphaericus*, flightless ground beetles, global hotspot, gondwana land, oriental, Palakkad gap, peliciini, tropical montane cloud forest.

The Gondwanian tribe Peleciini Chaudoir, 1880 (enigmatic Gondwanian relict lineage) of subfamily Panagaeinae Hope, 1838 is represented by two subtribes, Agoniciina Sloane, 1920 and Peleciina Chaudoir, 1880 (Lorenz 2005). The subtribe Agoniciina is represented by two genera (*Agonica* Sloane, 1920 with three species and *Pseudagonica* Moore, 1960 with one species) with distribution confined to the island of Tasmania and adjacent southeastern Australia (Straneo & Ball 1989; Hackel & Farkac 2012). The subtribe Peleciina includes six genera, viz., *Dyschiridium* Chaudoir, 1861 with four species in Africa and one species in Indochina (Fedorenko 2014); *Disphaericus* Waterhouse, 1842 with 18 species in Africa; *Ardistomopsis* Straneo & Ball, 1989 with five species in oriental region (Figure 1); and the further three genera *Eripus* Dejean, 1829 with nine species, *Pelecium* Kirby, 1817 with 33 species and *Stricteripus* Straneo & Ball, 1989 with three species in Neotropical region (Straneo & Ball 1989; Hackel & Farkac 2012).

The brachypterous genus *Ardistomopsis* is known only from the Indian subcontinent (Image 1). This genus is represented by five species *A. andrewesi* Straneo & Ball, 1989, *A. batesi* Straneo & Ball, 1989, & *A. marginicollis* Schaum, 1864 in India and *A. myrmex* Andrewes, 1923 & *A. ovicollis* Bates, 1886 in Sri Lanka (Straneo & Ball 1989). It is hypothesized that ancestral peleciines were distributed in southern Gondwana land on upper Jurassic time and may have been adapted to warm-temperate-subtropical conditions. Subsequently, and possibly preceding the break-up of Gondwana

Editor: Hasko F. Nesemann, Hofheim am Taunus, State of Hesse, Germany. **Date of publication:** 26 April 2025 (online & print)

Citation: Jithmon, V.A., M. Divya & T.K. Sabu (2025).The brachypterous endemic genus *Ardistomopsis* (Coleoptera: Carabidae: Panagaeinae) of the Indian sub-continent: first report of *Ardistomopsis batesi* Straneo & Ball, 1989 and *Ardistomopsis marginicollis* (Schaum, 1864) (Coleoptera: Carabidae: Panagaeinae) from the Western Ghats and the biogeographical significance. *Journal of Threatened Taxa* 17(4): 26903–26907. https://doi.org/10.11609/jott.7576.17.4.26903-26907

Funding: Department of Science and Technology (DST SERB), Government of India.

Competing interests: The authors declare no competing interests.

Acknowledgements: The authors are thankful to Beulah Gardner (BMNH) for the images of the holotypes, James Hogan, Oxford museum for preliminary verification of genus status, Dmitri Fedorenko and Tian Mingyi for the suggestions and to Shiju T. Raj, for the field collection efforts. We also thank to the Kerala forest department for the collection permissions and DST SERB for the funding.

land, two lineages emerged: a northern one (ancestral Peleciina) that maintained and perhaps even extended a broad range of climatic tolerance and a southern one (ancestral Agonicina) that specialized for life in cool temperate conditions (Darlington 1961). The Oriental genus *Ardistomopsis*, is the sister group of Afrotropical genera *Dyschiridium* and *Disphaericus* falling under the ancestral Peleciina. However, the widely disjunct distribution of *Dyschiridium* in Africa and Indochina (Vietnam) indicates that *Dyschiridium* and *Ardistomopsis* were likely sympatric at least in India or in adjacent parts of Asia long after India separated from Gondwana land (Fedorenko 2014). In the present effort, the first reports of *Ardistomopsis batesi* Straneo & Ball, 1989 from the tropical montane cloud forest (TMCF) in the Western Ghats, global hotspot of biodiversity in south-west India and *A. marginicollis* Schaum, 1864 from the Palakkad Gap in the Western Ghats are provided.

Materials & Methods

The specimens were collected by hand picking from TMCF forest litter in an upper montane evergreen forest at Eravikulam National Park (ENP) and from Walayar Reserve Forest in Palakkad Gap. The identification was based on the descriptions of Straneo & Ball (1989) and comparison with the holotypes in BMNH. Measurements and images were taken with MC 170 microscope camera attached to Leica Stereozoom Microscope (M 205C). The material is deposited in the national insect collection of Zoological Survey of India, Western Ghats Regional Station, Kozhikode, Kerala, India (ZSI-Ca). Measurements are defined as follows:

TL—maximum length from apex of mandibles to the apices of elytra.

HL —maximum length of head from apex of labrum to apex of pronotum.

HW—maximum width of head including eyes along vertex.

PL—maximum length of pronotum along median line.

PW—maximum width of pronotum.

EL—maximum length of elytra.

EW—maximum width of elytra.

The names of depositories are abbreviated as follows:

BMNH—Natural History Museum, London, UK.

ZSI-Ca—Zoological Survey of India, Western Ghats Regional Station, Kozhikode, Kerala, India.

Results

1. *Ardistomopsis batesi* Straneo & Ball, 1989

(Image 2a & 2b)

Straneo & Ball, 1989: 126; Lorenz, 2005: 318.

Geographic Distribution: India (Madhya Pradesh: Jabalpur; Kerala: Eravikulam National Park).

Material examined: Allotype. (n = 1) female, labelled "India: Kerala: Eravikulam National Park: Umayamalai (10.173° N, 77.083° E), 25.V.2010, handpicking from forest litter, [leg.] Shiju T. Raj.", in ZSI-Ca. Holotype male, labelled "India Central Jabalpur IX.57 1600 ft., *Disphaericus ovicollis* Bates, S.L. Straneo det. 1960 (O specie prossima), *Ardistomopsis batesi* Straneo & Ball", NHMUK 14484259, in BMNH.

Measurements: Female (mm). TL = 5.1, HL = 0.5, HW = 0.9, PL = 1.5, PW = 1.45 EL = 2.8, EW = 2.0

Color: Body black. Femora and tibiae reddish-brown, tarsomeres reddish-yellow. Scape of antenna reddish-brown, remaining antennomeres reddish-yellow. Palpomeres yellowish-red. Abdomen brownish-black.

Head: with single pair of supraorbital setae, surface shining. Eyes protruding. Antennae slender, scape broad, segment 2–11 with apical ring of long elongate setae, segments 3–11 pubescent, Antennomeres 8–10 bead like, apical antennal segment elongated oval. Clypeus slightly concave. Labrum concave with middle of anterior margin deeply excavated, six setose, one pairs of long lateral setae. Mentum with broad median tooth. Neck wide, smooth and glossy.

Pronotum: transverse, orbicular. Dorsal surface smooth and shining, not iridescent. Median line shallow. Apical margin slightly sinuate, with a dense fringe of short hairs medially. Anterior and posterior angles rounded. Apical declivity rather gradual, not steep. Base narrower than apex. Proepipleura delimited dorsally by lateral grooves, dorsal surface markedly vaulted, single pair of lateral marginal setae.

Elytra: oval, smooth, convex, surface shining, not iridescent, intervals moderately convex. Elytron with striae shallow (especially basal parts of 6 and 7), striae punctate. Parascutellar setae present. Apex rounded and not emarginated.

Abdomen: Sternum VII posteriorly with eight setae irregularly distributed in female.

Legs: Fore tibia with notch of antennal cleaner near mid-length, presence of a deep furrow on outer lateral side running from the base to apex. Tarsomeres 2–4 of fore, middle and hind legs with adhesive setae.

Remarks: *Ardistomopsis batesi* is similar to *A. andrewesi* (Image 2d) in having the head with single pair of supraorbital setigerous punctures and surface of elytra

Figure 1. The known distribution pattern of southern Asian *Ardistomopsis* species.

shiny but not iridescent. *Ardistomopsis batesi* differs from *A. andrewesi* in having medially located antennal cleaner, orbicular pronotum with equal length and width (transverse) and shallow elytral striae whereas, *A. andrewesi* is with proximally located antennal cleaner, narrow and elongate pronotum and deep elytral striae.

Pronotum of *A. batesi* is described as "form typical for *Ardistomopsis* (Fig. 126)" (Straneo & Ball 1989) with no measurement details and the figure will lead to interpret it as narrow and elongated as in other *Ardistomopsis*. Verification of holotype established that the pronotum of *A. batesi* is transverse instead of the pronotum in *A. andrewesi*.

2. *Ardistomopsis marginicollis* (Schaum, 1864)
(Image 2c)

Disphaericus marginicollis Schaum, 1864: 122; Andrewes, 1927: 109; Csiki, 1929: 400; Andrewes, 1930: 153.

Ardistomopsis marginicollis Straneo & Ball, 1989: 124; Lorenz, 2005: 318.

Geographic Distribution: India: Tamil Nadu (Tharangambadi, Chennai); Karnataka (Bengaluru: Samanahally); Andhra Pradesh (Horsely hills); Kerala (Palakkad: Walayar Reserve Forest).

Material examined: (n = 1) female, labelled "India: Kerala: Walayar Reserve Forest (10.860° N, 76.829°

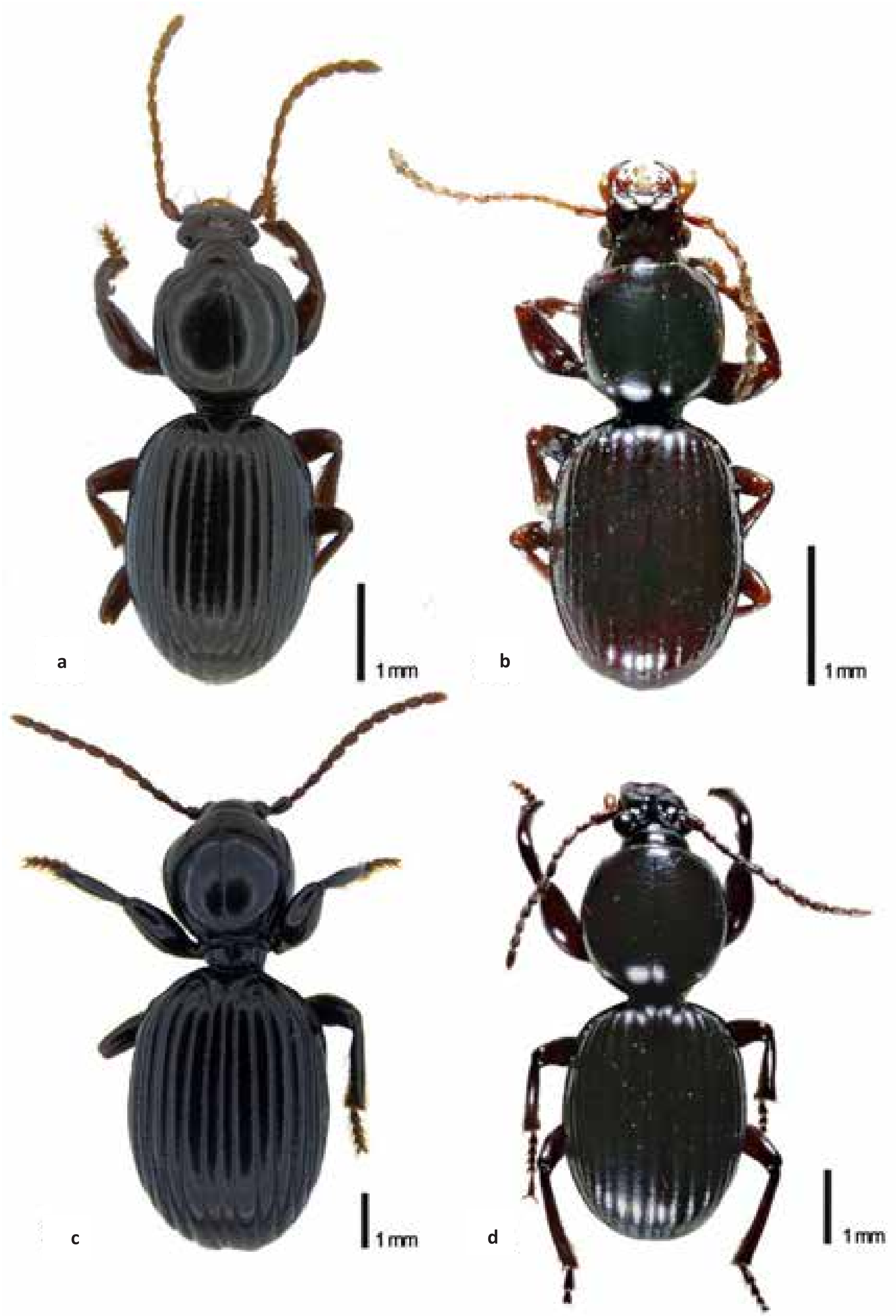

Image 1. Habitus of the Indian *Ardistomopsis* species: a—*Ardistomopsis batesi* Straneo & Ball, 1989, Allotype (female) | b—*Ardistomopsis batesi* Straneo & Ball, 1989 Holotype (Male) | c—*Ardistomopsis marginicollis* (Schaum, 1864) from the Western Ghats (female) | d—*Ardistomopsis andrewesi* Straneo & Ball, 1989, Holotype. © 1b&d—Beulah Gardner (BMNH), 1a&c—Jithmon V. A. and Divya M.

E) in the Palakkad Gap, 28.IV.2019, handpicking from understone, [leg.] Divya M.", in ZSI-Ca.

Measurements: Female (mm). TL = 8.40, HL = 1.68, HW = 1.08, PL = 2.19, PW = 2.0, EL = 4.20, EW = 3.0

Head: Median portion of fronto-clypeal suture distinct. Eyes protruding. Antennal segment 2–11 with apical ring of long elongate setae, segments 3–11 pubescent, Antennomeres 7–10 bead like, apical antennal segment elongated oval. Mandibles with both terebral and retinacular teeth, and occlusal margin of base smooth, with a row of few setae. Clypeus slightly concave with two lateral setae. Labrum six setose and deeply excavated in middle.

Pronotum: bordered and widest at middle region. Dorsal surface smooth and shining, not iridescent. Median line prominent and deep. Apical margin slightly sinuate, with a dense fringe of short hairs. Anterior and posterior angles rounded. Base narrower than apex. Single pair of lateral marginal setae present.

Elytra: oval, not pubescent, convex, surface shining, not iridescent. Intervals smooth, moderately convex. Elytral humeri markedly sloped. Parascutellar setae present. Apex rounded and not emarginated.

Remarks: *Ardistomopsis marginicollis* is similar to *A. batesi* in having the orbicular pronotum with almost equal length and width, medially located antennal cleaner and surface of elytra shiny but not iridescent. *Ardistomopsis marginicollis* differs from *A. batesi* in having head with two pairs of supraorbital setigerous punctures, deep elytral striae and abrupt posterior declivity.

Discussion

The genus *Ardistomopsis* is endemic to the Indian subcontinent and a member of the enigmatic Gondwanian relict lineage. It was reported with three species (*Ardistomopsis andrewesi*, *A. myrmex,* and *A. ovicollis*) in the Western Ghats and Sri Lanka hotspot of biodiversity and two species (*A. batesi* & *A. marginicollis*) with earlier records only from Chotanagpur region, southern boundaries of the Deccan plateau, and from the south-eastern coastal belts, all outside the Western Ghats in the Indian subcontinent (Andrewes 1930; Straneo & Ball 1989). The present records of the two species (*A. batesi* & *A. marginicollis*) from the Western Ghats have a great significance. It indicates that this Gondwana genus with all the member species present in the Western Ghats and Sri Lanka hotspot of biodiversity originated in the southern part of the Indian mainland before or after the separation from Gondwana land. Subsequently, the four species reached out to other regions of Indian mainland (*A. batesi* & *A. marginicollis*) and Sri Lanka (*A. myrmex* & *A. ovicollis*). The absence of *Ardistomopsis* species in the intervening regions of Deccan plateau between the Western Ghats and the Chotanagpur region in the Indian mainland may indicate that the genus *Ardistomopsis* is another example of the faunal elements that disappeared during the Deccan trap formation (Karanth 2006; Courtillot et al. 1988).

The exclusive and wider distribution of *A. marginicollis* is restricted to the lower elevations of the south and south eastern Indian region. The rest of the species in the Indian mainland are high elevation species. The record of *A. marginicollis* in the Palakkad Gap considered as the pathway for faunal movement between the moist western and dry eastern slopes of the Western Ghats mountain chain in southern India indicates that *A. marginicollis* could be the ancestor of all *Ardistomopsis* species present in Indian mainland and Sri Lanka. Close relationship of *A. marginicollis* with *A. batesi* in the higher elevation of the Western Ghats indicates that *A. batesi* is a derivative of *A. marginicollis.* Endemism of *A. myrmex* and *A. ovicollis* to Sri Lanka indicate that they evolved after the separation of Sri Lanka from Indian mainland.

References

Andrewes, H.E. (1927). Papers on Oriental Carabidae — XIX. *The Annals and Magazine of Natural History including Zoology, Botany and Geology* 9(19): 97–111.

Andrewes, H.E. (1930). *Catalogue of Indian Insects. Part 18. Carabidae*. Government of India Central Publication Branch, Calcutta, 388 pp.

Courtillot, V., G. Feraud, H. Maluski, D. Vandamme & M.G. Moreau (1988). Deccan flood basalts at the Cretaceous/ Tertiary boundary. *Nature* 333: 843–846. https://doi.org/10.1038/333843a0

Csiki, E. (1929). Harpalinae III. (Pars 104). Pp. 348–527. In: Junk W. & Schenkling S. (eds): *Coleopterorum Catalogus auspiciis et auxilio W. Junk, Volumen III*. Berlin: W. Junk, 1022 pp.

Darlington, P.J. (1961). Australian carabid beetles V. Transition of wet forest faunas from New Guinea to Tasmania. *Psyche* 68: 1–24. https://doi.org/10.1155/1961/64175

Fedorenko, D.N. (2014). *Dyschiridium belovi* sp. n., the first peleciine from Indochina (Coleoptera: Carabidae). *Russian Entomological Journal* 23(2): 107–111. https://doi.org/10.15298/rusentj.23.2.02

Hackel, M. & J. Farkac (2012). A checklist of the subfamily Panagaeinae Hope, 1838 of the World (Coleoptera: Carabidae). *Studies and Reports. Taxonomical Series* 8(1–2): 67–116.

Karanth, P. (2006). Out-of-India Gondwanan origin of some tropical Asian biota. *Current Science* 90(6): 789–792. https://www.jstor.org/stable/24089190

Lorenz, W. (2005). *Systematic List of Extant Ground Beetles of the World*. Second Edition. Published by the author, Tutzing, 530 pp.

Schaum, H.R. (1864). Beiträge zur Kenntnis einiger Carabicinen-Gattungen. *Berliner Entomologische Zeitschrift* 8: 114–126.

Straneo, S.L. & G.E. Ball (1989). Synopsis of the genera and subgenera of the tribe Peleciini, and revision of the neotropical and oriental species (Coleoptera: Carabidae). *Insecta Mundi* 3(2): 73–178. https://journals.flvc.org/mundi/article/view/24633/ 23964

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26908–26911

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9378.17.4.26908-26911

#9378 | Received 23 August 2024 | Final received 31 March 2024 | Finally accepted 11 April 2025

SHORT COMMUNICATION

First report of *Jauravia assamensis* Kapur, 1961 (Coleoptera: Coccinellidae) from West Bengal, India

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Abstract: The genus *Jauravia* Motschulsky, 1858 (Coleoptera: Coccinellidae) is distributed in India and nearby countries like Sri Lanka, Myanmar, and Nepal. The species, *Jauravia assamensis* Kapur, 1961 is reported from Assam, Manipur, and Maharashtra. In the present study, we are reporting this species for the first time from West Bengal.

Keywords: Coccinellinae, Darjeeling, description, distribution, Kalimpong, new record, ladybird beetle, predator, Sticholotidini, taxonomy.

A well-known and significant major group, ladybird beetles (Coleoptera: Coccinellidae) are sometimes referred to as ladybirds or lady beetles. The vivid colours of ladybirds, which are often red, orange, and black, greatly contribute to their appeal. Their wide appeal is manifested in the commercial and charitable organisations that use them as a motif. Coccinellidae is a speciose family of beetles with a worldwide distribution, currently including about 6,000 species classified in 370 genera (Ślipiński 2007). The Indian subcontinent is enriched with ladybird diversity, which houses more than 400 extant species belonging to 79 genera and 22 tribes (Poorani 2002). The coccinellid fauna of India is widespread and diversified. The composition of predatory coccinellids varies widely among various crop ecosystems. The vast variation in climate and vegetation at various altitudes and large land area are the key factors responsible for such an expanded biodiversity of coccinellids in West Bengal. West Bengal has a tropical climate. Based on soil characterisation, rainfall, temperature, and terrain, six main agro-climatic zones (hill zone, terai zone, old alluvial zone, new alluvial zone, red & laterite zone, and coastal & saline zone) have been identified in West Bengal. Looking at the unbounded alteration in climate at diverse elevations, there is very little work on taxonomy as well as biodiversity of coccinellids in West Bengal.

The genus *Jauravia* was erected by Motschulsky (1858) with two species *Jauravia pallidula* and *Jauravia limbata*. Kapur (1946) conducted and published a taxonomic revision of this genus with 11 species. According to Poorani (2002) 15 species of this genus are known from the Indian sub-continent. Earlier *Jauravia assamensis* Kapur was reported from Assam (Kapur 1961), Manipur (Chakrabarti et al. 2012), Maharashtra (Patil & Gaikwad 2023), and Sundarbazar (Sajan et al. 2018) from Nepal. The present study documents the existence of *J. assamensis* for the first time from West Bengal, India along with its illustration of diagnostic characteristics and short notes.

Editor: Aparna Kalawate, Zoological Survey of India, Pune, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Majumder, T., A. Adak & K. Roy (2025). First report of *Jauravia assamensis* Kapur, 1961 (Coleoptera: Coccinellidae) from West Bengal, India. *Journal of Threatened Taxa* 17(4): 26908–26911. https://doi.org/10.11609/jott.9378.17.4.26908-26911

Funding: Not funded by any external organization.

Competing interests: The authors declare no competing interests.

Acknowledgements: The authors humbly acknowledge the laboratory facility rendered by the Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal.

Materials and Methods

Study area: A single specimen was collected from Kalimpong district of West Bengal, India by the first author. The geocoordinate of the sampling place was 27.263–27.375 ^{0}N & 88.650–89.477 ^{0}E (Image 1).

Insect sampling method: The ladybird specimen was collected by a 'sweep sampling method', as suggested by Gadagkar et al. (1990). The collected ladybird beetle was brought to the laboratory for identification.

Preservation and identification of specimens

Immediately after field collection, the insect was put into killing jars. The specimen was euthanized with the fumes of ethyl acetate present in the killing jar. The killed insect was put in the glass vial, labelled properly, and brought to the laboratory. Later, the beetle was stretched and glued to the triangular card point. The beetle specimen was meticulously examined under a stereoscopic trinocular microscope OPTIKA SZM-T, fitted with camera for studying its morphological characters. Photographs of the habitus and different body parts were taken by using Samsung S22 Ultra smartphone. Later the images were edited in Adobe Photoshop 2020 and arranged in CorelDRAW 2018. Measurement was taken by ocular micrometer fitted in the eyepiece of microscope. Drawings were done by smart pen with the software PENUP of Samsung S22 Ultra smartphone. For dissection, the methodology described by Majerus & Kearns (1989) was used. Terminology used for adult morphology largely follows Ślipiński (2007).

Result and Discussion

A single notable individual of the ladybird species was encountered near the Bindu Village, Kalimpong (Image 1 & 2). The specimen was collected from a banyan tree. The species was confirmed as *J. assamensis* which is a first confirmed record for West Bengal, India.

Species account
Family: Coccinellidae Laterile, 1807
Subfamily: Coccinellinae Laterile, 1807
Tribe: Sticholotidini Weise, 1901
Genus *Jauravia* Motschulsky, 1858

***Jauravia assamensis* Kapur, 1961**
Material examined

West Bengal, Darjeeling, Kalimpong, Bindu Village, 27.263–27.375 ^{0}N & 88.650–89.477 ^{0}E, 600m, 14.xi.2022, coll. Tamoghno Majumder, 1 female, Banyan tree.

Description

Body length 1.960 mm and body width 1.862 mm. Form almost semi-rounded, dorsal side of the body mostly convex, and with sparse greyish pubescence

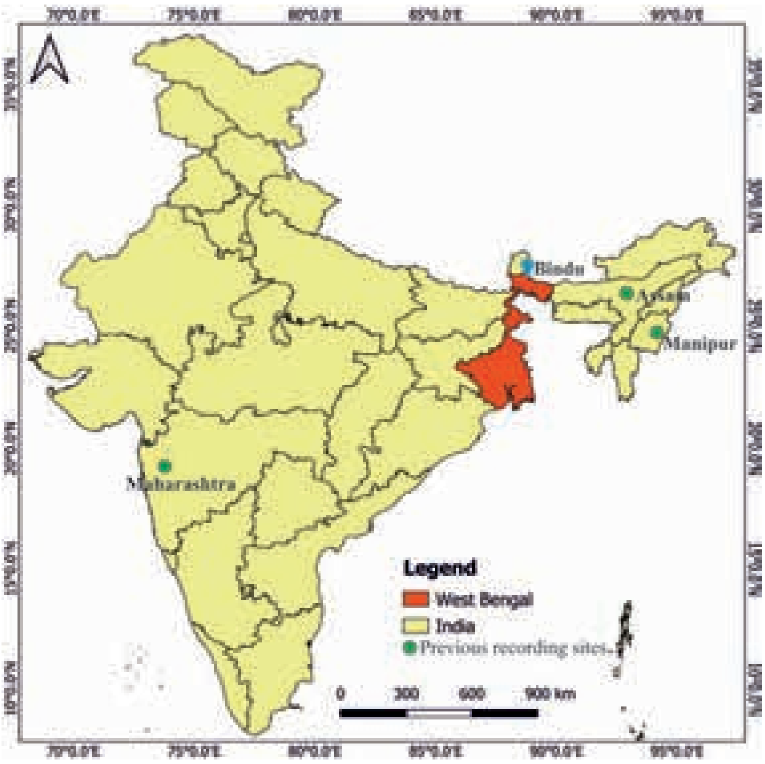

Image 1. Map showing location of the ladybird beetle observation place (Bindu, Kalimpong) West Bengal

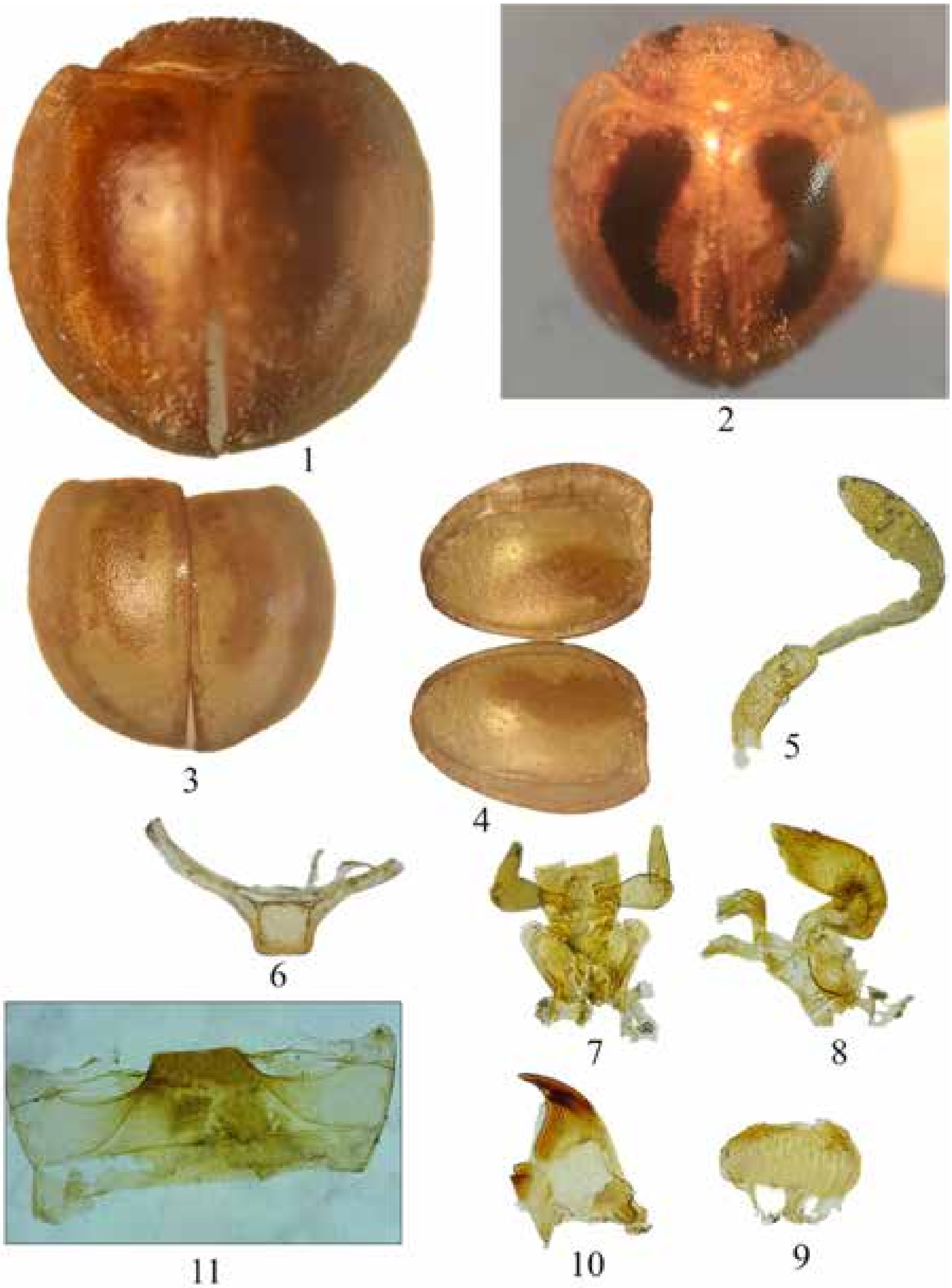

Image 2. Diagnostic characters of *Jauravia assamensis* Kapur: 1 & 2—adult (dorsal view) | 3—elytra (dorsal aspect) | 4—elytra (ventral aspect) | 5—antennae | 6—prosternal carinae | 7–10—mouthparts: 7—labium | 8—maxilla | 9—labrum | 10—mandible | 11—abdomen (ventrite 1 & 2).

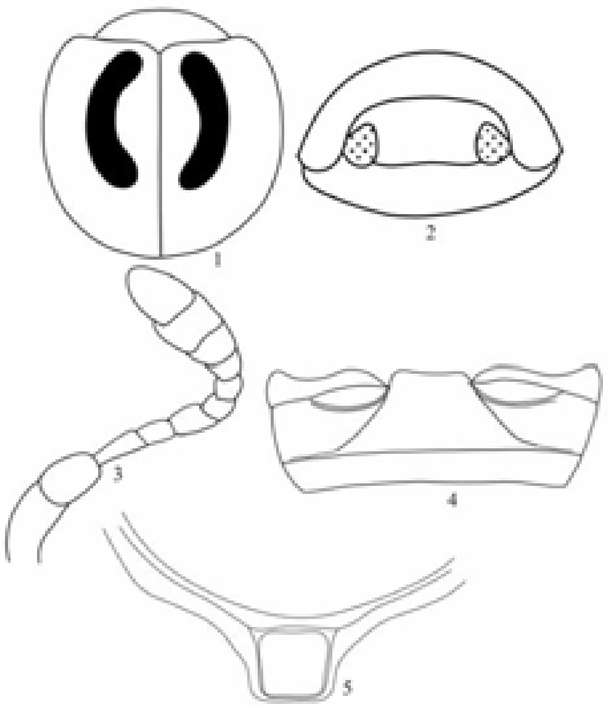

Figure 1. Line drawing of *Jauravia assamensis* Kapur: 1—adult (dorsal view) | 2—adult (frontal view) | 3—antennae | 4—abdomen (postcoxal line) | 5—prosternal carinae.

(Images 1(1,2); Figure 1(1)). Head and pronotum orange in colour with lightly distributed punctures (Image 2(2)). Prosternal carinae present, straight and slightly diverging anteriorly (Images 2(6); Figure 1(5)). Elytra orange in colour with distinguishable kidney-shaped black markings (Image 2(1,2,3)). Markings are rounded at both ends and its outer arc extends parallel to the elytral epipleuron (Images 2(2); Figure 1(1)). Elytral epipleuron is moderately broader (Image 2(4)). Scutellum very small. Antennae composed of 11 antennomeres, terminal antennomere narrowed apically (Images 2(5); Figure 1(3)). Mouthparts (Labium, maxilla, labrum, mandible) as illustrated (Image 2(7–10)). Eyes approximately oval, moderately small, widely separated, interocular distance about 3x as wide as an eye (Figure 1(2)). Ventral side of the body light orange in colour. Abdominal postcoxal line incomplete, reaching posterior margin of abdominal ventrite 1 and running along posterior margin, then almost touching lateral margin (Images 2(11); Figure 1(4)).

It is recorded from Assam, Manipur, and Maharashtra. Kapur (1961) specified *J. assamensis* is closely related to *Jauravia quadrinotata* Kapur in general appearance, but is easily distinguished from it by the following charcters: (i) *J. assamensis* is slightly smaller in size than *J. quadrinotata*; (ii) pattern of the black elytral markings in the two species is quite distinct; in *J. quadrinotata* there are two rounded spots on each elytron while in *J. assamensis* there is a well-defined, elongate, kidney-shaped elytral marking which does not show any tendency to break up into spots; and (iii) punctation on the elytra is coarser and sparser in *J. quadrinotata* than *J. assamensis*. The holotype of *J. assamensis* was recorded as feeding on aphids from Assam (Kapur 1961). This species was observed to be preyed upon *Aphis gossypii* (Glover 1877) and *Myzus persicae* (Sulzer, 1776) from Manipur (Chakrabarti et al. 2012). Detailed descriptions and illustrations of the habitus, genitalia, and the immature stages of *J. assamensis* were provided by earlier researchers (Kapur 1961; Patil & Gaikwad 2023). The present study unveiled a current new habitat, range extension, and new diagnostic characteristics like the antenna and abdominal post-coxal line of this species, which were not illustrated by earlier researchers.

References

Chakrabarti, S., S. Sarakar & M. Debanath (2012). Diversity, biology and biosystematics of aphidophagous predators of eastern Himalaya and Northeast India, pp. 129–147. In: Hartmann, M. & J. Weipert (eds). *Biodiversität und Naturausstattung im Himalaya IV*. Naturkundemuseum Erfurt, 488 pp.

Gadagkar, R., C. Krishnappa & P. Nair (1990). Insect species diversity in tropics: sampling methods and a case study. *Journal of the Bombay Natural History Society* 87(3): 337–353.

Kapur, A.P. (1946). VIII—A revision of the genus *Jauravia* Mots. (Coleoptera Coccinellidæ). *Annals and Magazine of Natural History* 13(98): 73–93.

Kapur, A.P. (1961). A New Species of the Genus *Jauravia* Mots. From India (Coleoptera: Coccinellidae). *Records of Zoological Survey of India* 59(1–2): 71–73. https://doi.org/10.26515/rzsi/v59/i1-2/1961/161573

Majerus, M. & P. Kearns (1989). *Ladybirds. Naturalist Handbooks 10*. Dorset: The Richmond Publishing Co Ltd., 116 pp.

Motschulsky, D. (1858). Insectes des Indes Orientales. *Etudes Entomologiques* 7: 20–112.

Poorani, J. (2002). An annotated checklist of the Coccinellidae (excluding Epilachninae) of the Indian subregion. *Oriental Insects* 36: 307–383. https://doi.org/10.1080/00305316.2002.10417335

Patil, P.B. & S.M. Gaikwad (2023). New record of *Jauravia assamensis* Kapur (Coleoptera: Coccinellidae) from peninsular India. *Indian Journal of Entomology* 85(3): 737–739. https://doi.org/10.55446/IJE.2021.365

Sajan, K.C., K. Kafle & A. Khadka (2018). Records of ladybeetles (Coleoptera: Coccinellidae) from hilly regions of Nepal. *Indian Journal of Entomology* 80(4): 1236–1248. https://doi.org/10.5958/0974-8172.2018.00242.0

Ślipiński, A. (2007). *Australia ladybird beetles (Coleoptera: Coccinellidae): Their biology and classification*. In Australian Biological Resources Study, Canberra, xviii + 286 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26912–26916

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9453.17.4.26912-26916

#9453 | Received 14 October 2024 | Final received 11 March 2025 | Finally accepted 10 April 2025

SHORT COMMUNICATION

First record of *Hycleus marcipoli* Pan & Bologna, 2014 (Coleoptera: Meloidae) as a pest of Common Beans in Kashmir Himalaya, India

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Abstract: Blister beetles are recognized as pests of agricultural crops due to their phytophagous habits and they produce cantharidin, a toxic compound that causes significant crop damage and poses health hazards. This study reports the first occurrence of *Hycleus marcipoli* (Coleoptera: Meloidae), an important member of the blister beetles feeding on Common Bean, *Phaseolus vulgaris* L. in the Kashmir Himalaya (India). The species was originally described in 2014 from China, Laos, and Thailand. This report represents a significant extension of its geographical range, emphasizing the need for further entomological surveys and taxonomic studies in the region. The species significantly impairs the reproductive potential of *P. vulgaris* resulting in reduced pod formation and overall yield decline. The present study provides a comprehensive taxonomic description of the species along with a detailed observation of the nature and extent of crop damage to *P. vulgaris*.

Keywords: Blister beetles, cantharidin, crop, ecology, inflorescence, legumes, new record, phytophagy, taxonomy, yield loss.

Blister beetles belonging to the family Meloidae are known to produce cantharidin, a toxic compound that induces irritation and formation of blisters in animals including humans, and hence named Blister Beetles (Ruiz-Torres et al. 2021). The family Meloidae consists of about 125 genera including around 3,000 described species (Bologna et al. 2008). They inhabit diverse ecosystems across the world with mostly phytophagous nature, primarily feeding on leaves and flowers (Bologna & Di Giulio 2011). Adult blister beetles are polyphagous pests preferably feeding on Cucurbitaceae, Leguminosae, Solanaceae, and Malvaceae families exhibiting gregarious behaviour and variable size. Blister beetles are commonly found in Pigeon Pea crops across Asia, leading to substantial damage through their feeding behaviour (Lawrence & Newton 1982). They feed on buds, flowers, tender pods, and leaves either individually or in groups leading to a reduction in the yield (Anand 1978). Different species of blister beetles including *Moloe rugosus*, *Mylabris phalerata*, and *Mylabris indica* have been reported to inflict damage to various crops across different regions of the world (Dutta & Singh 1991; Vivekananthan & Mathivannan 2010; El-Sheikh 2020). The previous work reveals that blister beetles are of utmost importance concerning damage inflicted on different types of crops especially leguminous crops. Among the diverse genera of blister beetles, the genus *Hycleus* Latreille, 1817 is recognised for its vast species diversity with about 500 identified species distributed across the Old World (Riccieri et al. 2020). *Hycleus* spp. are widely distributed in the Palaearctic, Oriental, and the Afrotropical Region excluding Madagascar (Bologna

Editor: Shiju T. Raj, St. Joseph's College, Kozhikode, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Shafi, F. & A.H. Mir (2025). First record of *Hycleus marcipoli* Pan & Bologna, 2014 (Coleoptera: Meloidae) as a pest of Common Beans in Kashmir Himalaya, India. *Journal of Threatened Taxa* 17(4): 26912–26916. https://doi.org/10.11609/jott.9453.17.4.26912-26916

Funding: The Council of Scientific and Industrial Research (CSIR), India.
[CSIR-JRF fellowship scheme (ID: 09/0251(15245)/2022-EMR-I)]

Competing interests: The authors declare no competing interests.

Acknowledgements: Grateful acknowledgment is extended to the Council of Scientific and Industrial Research (CSIR) for the financial support. The authors sincerely acknowledge the Department of Zoology, University of Kashmir, for providing laboratory and other necessary facilities. Special thanks are extended to A.A. Buhroo for providing the photography facility.

& Pinto 2002). During the flowering stage, leguminous crops are particularly vulnerable to damage from various species of *Hycleus*, which significantly impacts the seed-setting process (Lebesa et al. 2012).

In 2014, a new species, *Hycleus marcipoli* was identified, exhibiting a close phylogenetic association with *H. phaleratus* & *H. cichorii* (Pan et al. 2014; Wu et al. 2018). This species is documented for the first time in India as well as introduces a new host plant, i.e., *Phaseolus vulgaris* L.

Given the critical role of Blister Beetles in agroecosystems, *H. marcipoli* was observed during a routine field survey. The paper provides a detailed taxonomic description of the species along with the nature and extent of damage caused by it.

Materials and Methods

Surveys were conducted fortnightly at eight selected sites: Uri, Arin, Dragmula, Gutlibagh, Dara, Kular, Sopat, and Hermain (Table 1) throughout the Valley of Kashmir. The pest was observed at one site, Uri (34.066 ^{0}N & 74.093 ^{0}E), Baramulla, J&K, India. The beetles were collected from common bean fields with the help of a sweep net from blooming crops during the morning hours from 0800 h to 1100 h. Freshly collected specimens were immediately killed using ethyl acetate followed by dry preservation for identification (Nezhad-Ghaderi et al. 2021). The incidence of the pest was obtained by randomly selecting 10 plants from each selected field during each survey and then expressed as the percentage of plants infested with this pest over the total number of plants sampled. Photographs in the field were taken using a Canon EOS 7D SLR digital camera and Xiaomi- 11 Lite NE smartphone. Digital images of specimens and their body parts were captured using a Leica M205A stereo zoom microscope equipped with a Leica DFC295 camera and the imaging process was facilitated by Leica Automontage Software (Version 4.10). Map of the study sites (Figure 1) was generated by using ArcGIS Package Version 10.2.2. Photoshop 7.0 was used for organizing the images. The specimens are deposited in the museum of the Department of Zoology, University of Kashmir.

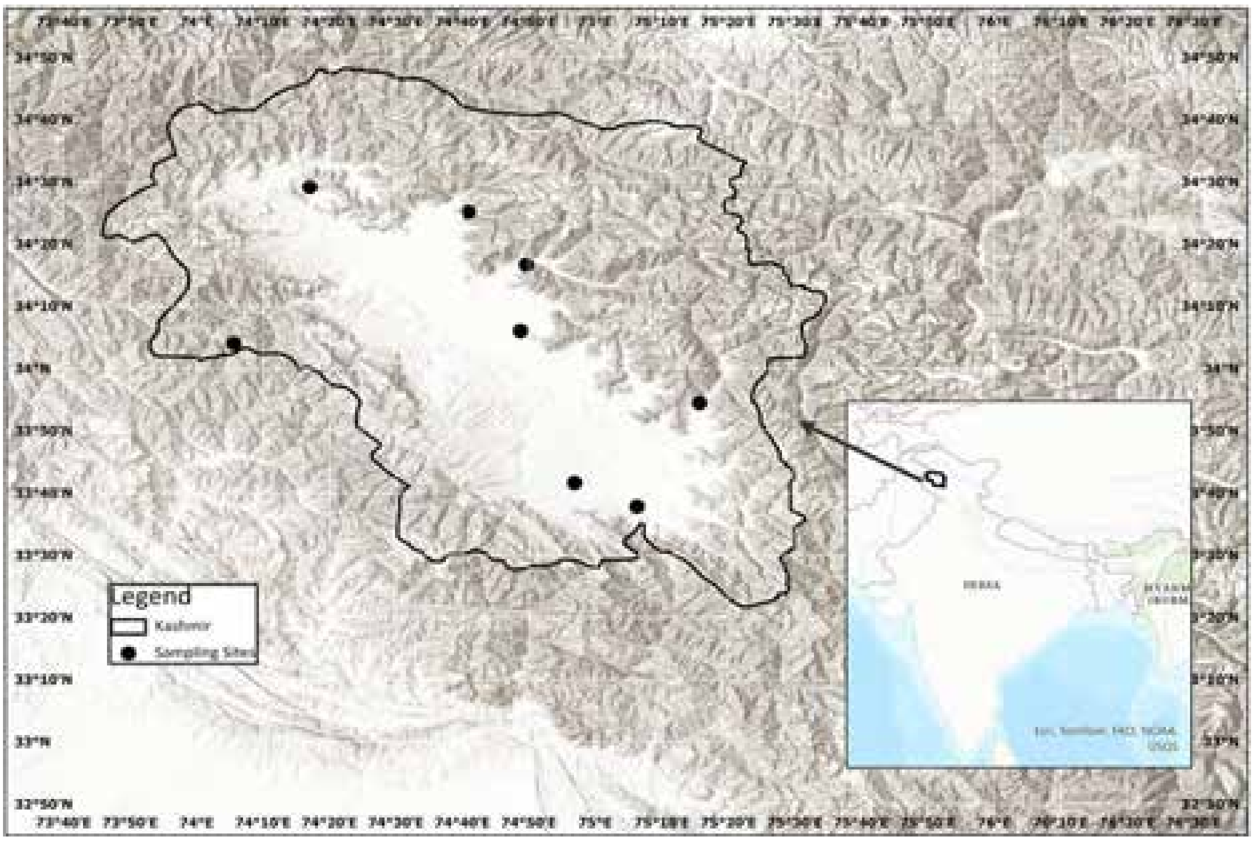

Figure 1. Map highlighting the study sites of Kashmir Himalaya, India.

Taxonomy

Hycleus marcipoli Pan & Bologna, 2014

- *Hycleus marcipoli* Pan & Bologna, 2014 (11–19)

Material examined: 4 female & 2 male, India: Jammu and Kashmir: Baramulla: Uri: Nambla, 34.066 ^{0}N & 74.093 ^{0}E, alt. 1,746 m, coll. Farhana Shafi.

Diagnosis: Adults ranging 26–38 mm in size (Figure 2A–D). Belongs to the Mesoscutatus type lineage, categorized under the phaleratus group. Phenotypically resembles *H. phaleratus*.

Body: Body black except for elytra. Elytra with four distinct testaceous (yellow-brown) markings (Figure 2E,F).

1. Two testaceous front spots: one near the axillary region and another near the scutellum.

2. Two testaceous fasciae: one medial and another subapical

Dorsum and venter with black setae except for elytral axillary spot, inner side of protibiae, and protarsal pads which have mixed yellow and black setae (Figure 2G,H)

Antennae: Clubbed structure with 11 segments. Antennomeres I–V glossy, VI–XI dull. Antennomere I, approximately as long as II & III combined. Antennomere III longer than IV. Antennomeres V–VIII, are similar in length. Antennomeres V–IX, gradually increase in width, except a slightly shorter X (Figure 2I).

Mesosternum: Exhibits the Mesoscutatus type. Fore margins of mesepisterna form a central groove, with nearly contacting margins.

Legs: Slender legs and tibial spurs. Protibiae: two spurs. Male protibiae external side with scattered longer setae, and apical setae longer extending to tarsomere I while, the inner side of both sexes is covered with dense golden setae. Protarsi in both sexes with distinct golden ventral pads. Protarsomeres slightly widen apically with dense long apical setae (Figure 2J).

Aedeagus: With two slender hooks: The proximal dorsal hook, is far from the distal one (Figure 2K).

Distribution: China (SE Gansu, Taiwan), Laos, Thailand (Pan et al. 2014), India (Uri, Kashmir).

Host plants: *Phaseolus vulgaris* L. (Specimens collected in the present study).

Nature and extent of damage

The insect was recorded to damage the *P. vulgaris* crops in the Uri Region of J&K. The beetles pestered the host plants from June to September with a peak intensity in August. The incidence began with the onset of inflorescence in the budding flowers. With the progress of crops towards full bloom the population of insects gradually increased, reaching its peak as the crop fully blossomed. A maximum of nine individuals were found to damage the flowers of a single plant. Adults were observed in loose groups displaying voracious behaviour targeting young flowers and buds with their biting and chewing mouthparts. Their feeding habits resulted in reducing the plant's reproductive potential. The insect damaged flowers and buds thereby hindering the process of pod formation. During mid-August, the insect exhibited its highest mean percent incidence of about 73.33 ± 6.66 accompanied by the highest mean number of 8.33 ± 0.88 individuals per plant. In cases of severe infestation, all the flowers of the plants were affected resulting in complete loss of inflorescence. Consequently, the crop suffered from reduced fruit setting and a decline in the overall yield highlighting the detrimental impact of this insect.

Table 1. Coordinates of the study sites.

Districts	Study sites	Latitude	Longitude
Baramulla	Uri	34.066	74.093
Bandipora	Arin	34.419	74.682
Kupwara	Dragmula	34.486	74.284
Ganderbal	Gutlibagh	34.277	74.827
Srinagar	Dara	34.100	74.822
Anantnag	Kular	33.907	75.261
Kulgam	Sopat	33.630	75.104
Shopian	Hermain	33.693	74.948

Discussion

Hycleus marcipoli first identified and described in China, Laos & Thailand is now recorded in the Kashmir Himalaya, India. This study presents the first record of *H. marcipoli* infesting *P. vulgaris* crops in the hilly regions of the Kashmir Valley. The common bean holds substantial economic importance in the region. The cultivation of Common Beans is highly significant for the rural communities residing in the Himalayan mountain region (Nasar et al. 2023). As a primary legume crop, it is vital for the local population and widely cultivated in northwestern Himalayan state of Jammu & Kashmir, India (Choudhary et al. 2018). This pest severely inflicts damage to the host crop and its potential to spread and establish raises a significant concern. The genus *Hycleus* is recognized for its vast diversity. Despite being a diverse group, it has received limited attention in terms of studies conducted in India. Although a few species within this genus including *H. pustulatus, H. orientalis, H. phalerata,* & *H. thunbergii* have been identified as infesting pigeon peas in India, there is limited

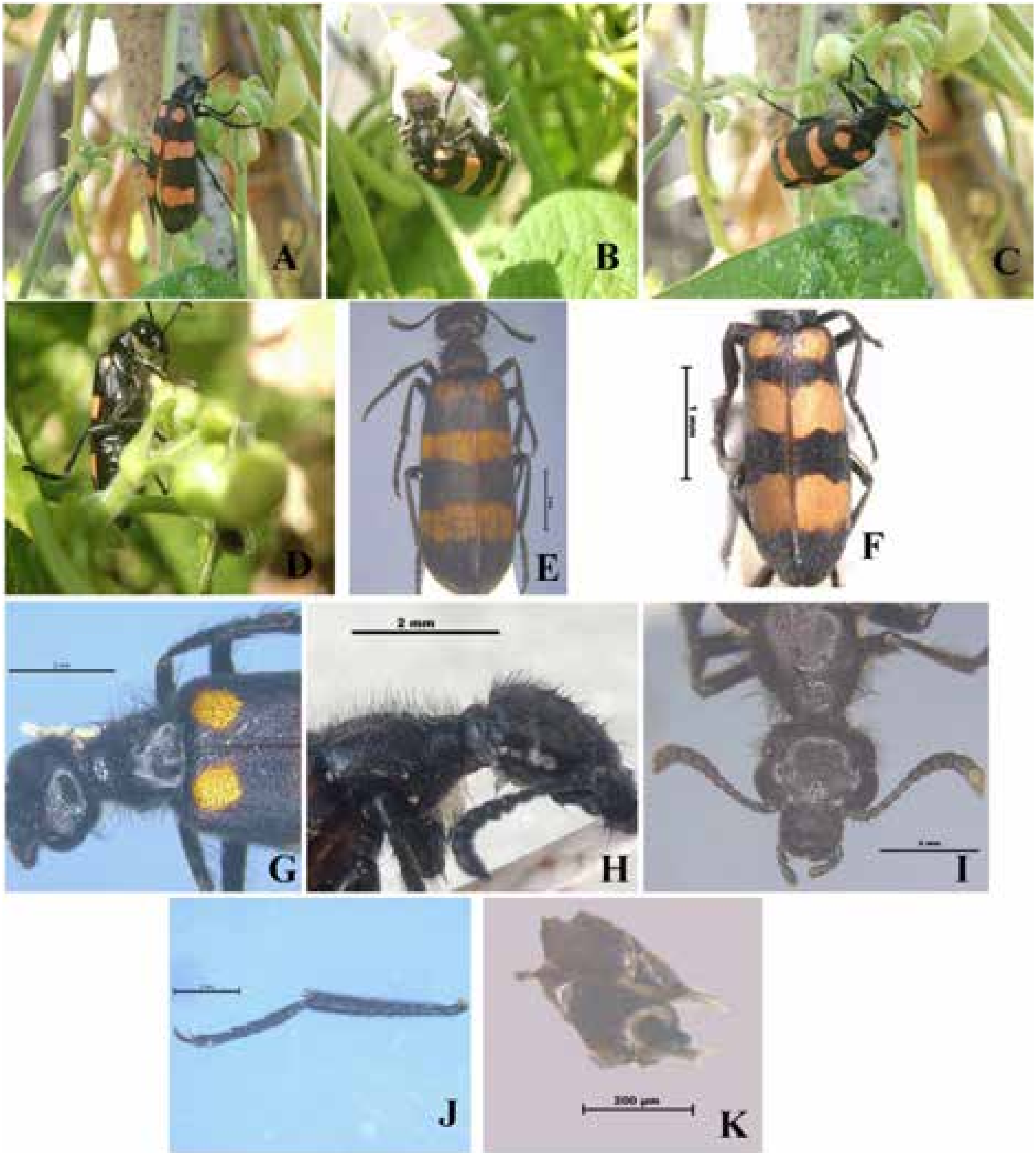

Image 1. A—*Hycleus marcipoli* | B&C—habitus | D—lateral view | E—dorsal view | F—elytra | G—black setae | H—yellow setae | I—antennae | J—leg | K—aedeagus. © Farhana Shafi.

information specifically on blister beetles of this group in the region. Another species identified as *H. polymorphus* was also documented in 2022 in India (Wankhade et al. 2022). Recognizing the importance of this group the current findings will contribute valuable insights to enhance the understanding of these insects. Further, the restricted presence of this species in the Uri Region is likely influenced by the area's distinct subtropical climate and ecotone system which differs from the temperate climate of other parts of Kashmir Valley. Moreover, the region's unique ecotone ecosystem, situated at the interface of distinct climatic zones, may play a critical role in supporting the presence of *H. marcipoli*. The transitional zone offers diverse habitats and microclimates conducive to the species' survival and restricted distribution. Thus, exploring the agricultural crops more extensively might reveal additional species within the genus. Identification of this species expands the number of *Hycleus* species in India, important for the diversity of insects especially in the oriental region, and for taxonomic studies as well. Additionally, it also holds the potential to unveil and record the presence of this species in other countries.

References

Anand, R.K. (1978). First record of *Meloe proscarabaeus* Linnaeus and *M. violaceus* Marsham (Coleoptera: Meloidae) from India, along with further description and a key to the Indian species. *Journal of Entomological Research* 2(1): 40–42.

Bologna, M.A. & J.D. Pinto (2002). The Old-World genera of Meloidae (Coleoptera): a key and synopsis. *Journal of Natural History* 36(17): 2013–2102. https://doi.org/10.1080/00222930110062318

Bologna, M.A., M. Oliverio, M. Pitzalis & P. Mariottini (2008). Phylogeny and evolutionary history of the blister beetles (Coleoptera, Meloidae). *Molecular Phylogenetics and Evolution* 48(2): 679–693. https://doi.org/10.1016/j.ympev.2008.04.019

Bologna, M.A. & A. Di Giulio (2011). Biological and morphological adaptations in the pre-imaginal phases of the beetle family Meloidae. *Atti Accademia Nazionale Italiana di Entomologia* 59: 141–152.

Choudhary, N., A. Hamid, B. Singh, I. Khandy, P.A. Sofi, M.A. Bhat & R.R. Mir (2018). Insight into the origin of the common bean (*Phaseolus vulgaris* L.) grown in the state of Jammu and Kashmir of the north-western Himalayas. *Genetic Resources and Crop Evolution* 65: 963–977. https://doi.org/10.1007/s10722-017-0588-z

Dutta, M. & B.V. Singh (1991). Blister beetle (Mylabris phalerata), a serious pest of pigeonpea in the lower hills of Uttar Pradesh. *International Pigeonpea newsletter* 10(29).

El-Sheikh, W. (2020). First record of Blister beetle *Meloe rugosus* M. (Coleoptera: Meloidae), as insect pest on some field crops in Farafra Oasis, western desert, Egypt. *Scientific Journal of Agricultural Sciences* 2(1): 26–30. https://doi.org/10.21608/sjas.2020.30914.1027

Lawrence, J.F. & A.F. Newton Jr (1982). Evolution and classification of beetles. *Annual review of ecology and systematics* 13(1): 261–290. https://www.jstor.org/stable/2097069

Lebesa, L.N., Z.R. Khan, K. Kruger, T.J. Bruce, A. Hassanali & J.A. Pickett (2012). Farmers' knowledge and perceptions of blister beetles, *Hycleus* spp. (Coleoptera: Meloidae), as pest herbivores of *Desmodium* legumes in western Kenya. *International Journal of Pest Management* 58(2): 165–174. https://doi.org/10.1080/09670874.2012.673032

Nasar, S., H. Shaheen, G. Murtaza, T. Tinghong, M. Arfan & M. Idrees (2023). Socioeconomic evaluation of common bean (*Phaseolus vulgaris* L.) cultivation in providing sustainable livelihood to the mountain populations of Kashmir Himalayas. *Plants* 12(1): 213. https://doi.org/10.3390/plants12010213

Nezhad-Ghaderi, S.S., J. Nozari, A.B. Dalfard & V.H. Naveh (2021). List of species of blister beetles (Coleoptera: Meloidae) in Kerman province, Iran. *Journal of Insect Biodiversity and Systematics* 7(1): 1–13. https://doi.org/10.52547/jibs.7.1.1

Pan, Z., M. Carosi & M.A. Bologna (2014). A new Eastern Asian *Hycleus* and key to the Chinese species of the phaleratus group (Coleoptera, Meloidae, Mylabrini). *ZooKeys* (463): 11. https://doi.org/10.3897/zookeys.463.8261

Riccieri, A., E. Mancini, D. Salvi & M.A. Bologna (2020). Phylogeny, biogeography and systematics of the hyper-diverse blister beetle genus *Hycleus* (Coleoptera: Meloidae). *Molecular Phylogenetics and Evolution* 144: 106706. https://doi.org/10.1016/j.ympev.2019.106706

Ruiz-Torres, L., P. Mora, A. Ruiz-Mena, J. Vela, F. J. Mancebo, E.E. Montiel & P. Lorite (2021). Cytogenetic analysis, heterochromatin characterization and location of the rDNA genes of *Hycleus scutellatus* (Coleoptera, Meloidae); a species with an unexpected high number of rDNA clusters. *Insects* 12(5): 385. https://doi.org/10.3390/insects12050385

Vivekananthan, T. & V. Mathivannan (2010). Effects of Phyto pesticide on the fat body of adult male blister beetle, *Mylabris indica* (Thungberg) (Coleoptera: Meloidae) in relation to reproduction. *World Journal of Zoology* 5(1): 01–06.

Wankhade, L.N. & P.A. Bidwai (2022). A preliminary study on some of the insect fauna during rainy season in the agricultural field of Karanja (Ghadge), District Wardha (Maharashtra) 10(1): 323–328. https://doi.org/10.22271/j.ento.2022.v10.i1d.8953

Wu, Y., Y. Liu & X. Chen (2018). The complete mitochondrial genomes of *Hycleus cichorii* and *Hycleus phaleratus* (Coleoptera: Meloidae). *Mitochondrial DNA Part B* 3(1): 159–160. https://doi.org/10.1080/23802359.2018.1431066

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26917–26922
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.9636.17.4.26917-26922
#9636 | Received 28 January 2025 | Final received 21 March 2025 | Finally accepted 05 April 2025
OPEN ACCESS
SHORT COMMUNICATION

Sonerila bababudangiriensis (Melastomataceae), a new species of herb from the Western Ghats of India

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Abstract: *Sonerila bababudangiriensis* is a caulescent or tuberous new species found in Bababudangiri, Chikkmagaluru District, Karnataka, which lies in the Western Ghats. The species has distinguished characteristics that sets it apart from the other species of the genus *Sonerila* worldwide. It is compared to *Sonerila wallichii* Benn., a species from the same habitat. The two species differ in characteristics such as tuber, leaf morphology, inflorescence structure, and micromorphology, which are described and illustrated in relevant images. The present report discusses the newly described species, *Sonerila bababudangiriensis*, from Western Ghats, India.

Keywords: Bababudangiri, caulescent, claret-tinge spine, evergreen forest, hill slopes, Karnataka, papillae, shola forest, *Sonerila,* stemless.

The family Melastomataceae Juss. is one of the most widely distributed plant families with approximately 169 accepted genera (POWO 2024) and 5,050 species according to earlier records. Later, the number was well established with approximately 5,858 species in 173 genera (Penneys et al. 2022; Ulloa Ulloa et al. 2022);, of which about 1,550 species occur in the Old World (Stevens 2012). The acrodromous venation of the leaves makes it easy to identify members of the family Melastomataceae (Hickey 1973). The tribe Sonerileae of the family Melastomataceae occurs in southeastern Asia and Madagascar with few species from the Neotropic region (Renner 1993). The genus *Sonerila* Roxb., is a species-rich and taxonomically complex genus distributed in the tropical Old World. It is represented approximately by 180 taxa (Cellinese 1997; Resmi et al. 2018; Resmi & Nampy 2021). The Genus *Sonerila* in India is represented by 49 species and one variety. Of these, 43 species are endemic to the Western Ghats (Resmi et al. 2021). In Karnataka, 14 species have been reported, including the *Sonerila talbotii* Giri & Nayar. and *Sonerila raghaviana* Ratheesh, Sunil, Nandakumar & Shaju. both of which are endemic to the state (Saldanha 1984; Giri & Nayar 1986; Sanjappa & Sringeswara 2019; Ravikumar et al. 2021; Karadakatti & Kakkalameli 2024). The present deliberation is on a new species from the Western Ghats of Karnataka India. The species shows distinct characteristics compared to the species of *Sonerila* from the world and even from the region found. The picture and line diagram or illustration show clear evidence for the species new to science (Images 1 & Figure 2). The key distinguishing features of *Sonerila wallichii* Benn. And the new species *Sonerila bababudangiriensis* are compared in Table 1. Additionally, micromorphological variations in pollen and seeds are discussed (Image 2) (Giri & Nayar 1986; Bhattacharya et al. 2006).

Editor: Kannan C.S. Warrier, KSCSTE - Kerala Forest Research Institute, Thrissur, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Karadakatti, P. & S.B. Kakkalameli (2025). *Sonerila bababudangiriensis* (Melastomataceae), a new species of herb from the Western Ghats of India. *Journal of Threatened Taxa* 17(4): 26917–26922. https://doi.org/10.11609/jott.9636.17.4.26917-26922

Funding: Backwards Classes Welfare Department (BCWD) - Fellowship, Karnataka State Government.

Competing interests: The authors declare no competing interests.

Acknowledgements: The work progression of new species was completed using USIC Karnataka University Dharwad. Field visiting and collection help by Shreyas Betageri, research scholar, Karnatak Science College Dharwad (KUD). The reporting lead promoting through submitting the species herbarium help by Dr A. N. Sringeswara sir Mahatma Gandhi Botanical Garden University of Agricultural Sciences GKVK Bengaluru. Dr. Siddappa B Kakkalameli, research supervisor, Davangere University, Shivagangothri, the greater direction in supporting and promising in the field of taxonomy.

Taxonomic description

Sonerila bababudangiriensis
Karadakatti & Kakkalameli sp. nov.
(Images 1, 2b,d; Figure 2)
urn:lsid:ipni.org:names:77360569-1

Holotypus: India, Karnataka, Chikmangaluru, Baba Budangiri, 13.404 N, 75.738 E, 01.09.2024, Prashant Karadakatti & Siddappa B. Kakkalameli, M008 (UASB5770), University of Agriculture Sciences, Bangalore.

Etymology: The specific epithet refers to the type locality that is Bababudangiri, from Chikkamagaluru District, Karnataka, India; the locality lies near the highest peak of Karnataka, Mullayangiri (1,930 m).

Diagnosis: Herb, perennial, erect, caulescent, tuber measures 1–1.5 cm diameter, spherical; habit 8–15 cm tall. Root branches fleshy, white to pale green at the lower to the upper. Leaves are 3–5 cm wide, 5–8 cm long, petiole 3–5 cm long with glabrous & claret tinge, six nerved, veins pinnate, three pairs arising from the base, 1–2 pairs from midrib above; lamina dark green dorsal side with claret tinge spines or papillae scattered measured 1–3 mm, claret at ventral side, glabrous, densely gland-dotted, serrate, leaf base slightly orbicular with equal base and cordate; petioles 3–6 cm long, claret tinge, subscapose. Inflorescence bostryx cyme, 5–15 cm long, 4–12 flowered, unbranched; peduncle 4–13 cm long, claret tinge to pale green, glabrous, slightly quadrangular; pedicels 5–8 mm long, gland-tipped trichomes pale green in color; one bract 2–3 mm long and two opposite bracteoles, not prominent 1–2 mm, pale green. Flowers trimerous 1.8–2 cm long; pedicel sub-angular, 3–6 mm long in fruit, pale green, gland-tipped trichomes; hypanthium campanulate, 1.5–2 cm include anther & gynoecium, three-lobed, pale green base, gland-tipped trichomes; petals three, 5–8 mm, polypetalous, ovate to oblong, mucronate apex, pale pink adaxial, abaxial white, darker midrib; sepals pale green, 1–3 mm, polysepalous, gland-tipped trichomes; stamens three alternate to petals, filaments short measured 2–4 mm, pale pink, glabrous; anthers three, yellow, beaked at apex, glabrous, 3–5 mm anther lobes dorsifixed, cordate at base; ovary inferior, style filiform 0.8–1 cm,

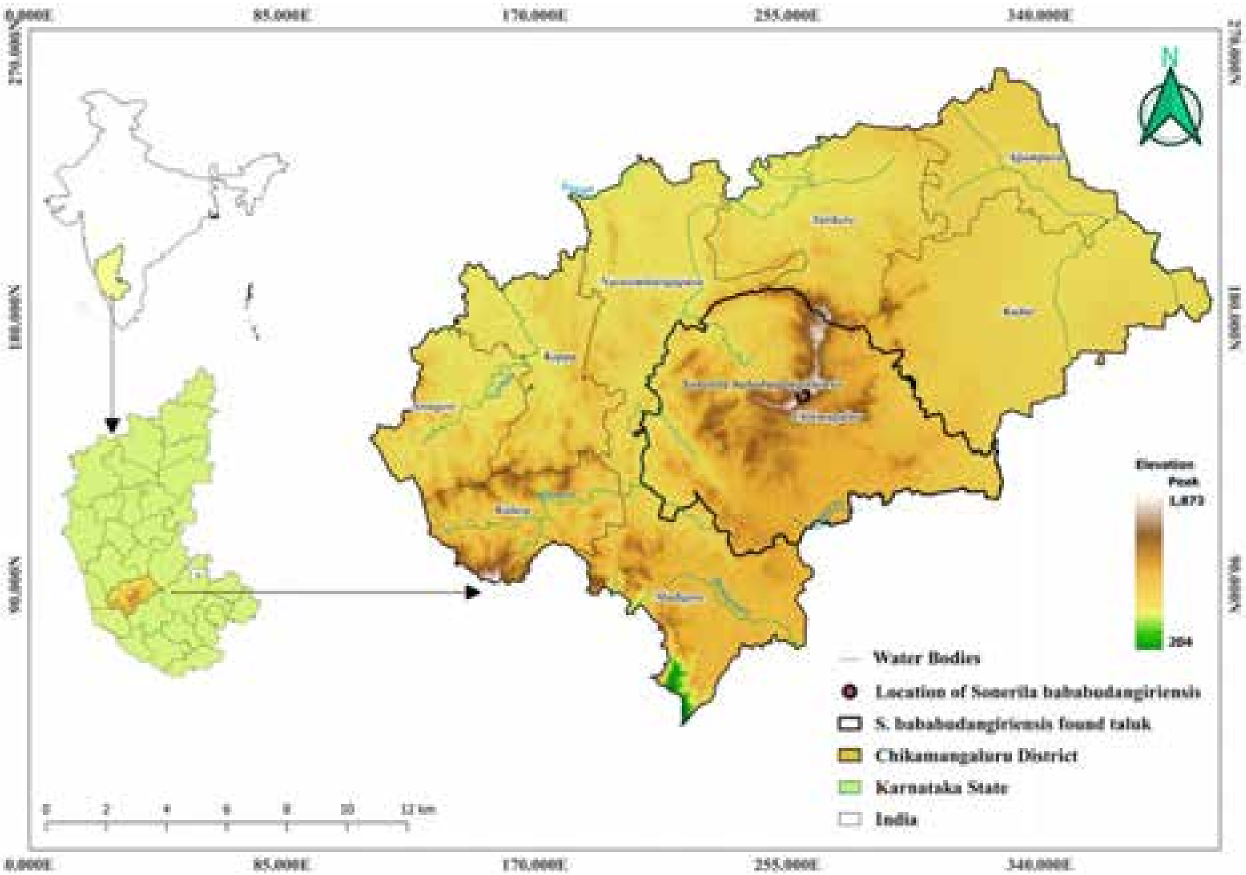

Figure 1. Distribution of *Sonerila bababudangiriensis* sp. nov. in Western Ghats of Karnataka.

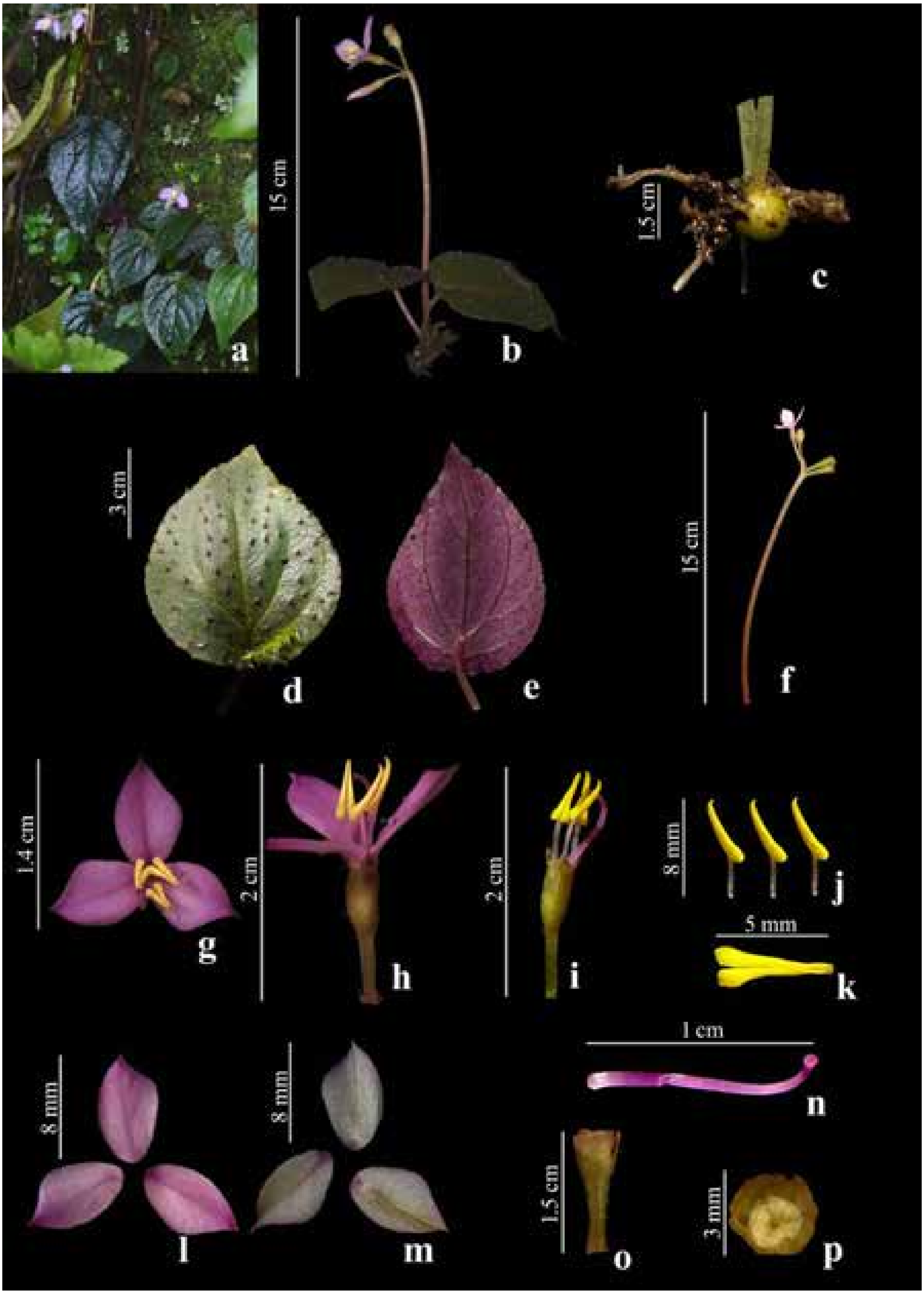

Image 1. *Sonerila bababudangiriensis* sp. nov.: a—habitat | b—habit | c—Caulescent tuber | d—leaf dorsal | e—leaf ventral | f—inflorescence | g—flower front view | h—flower side view | I—Hypanthium (Inc. Anther & Gynoecium) | j—stamens | k—anther | l—petal dorsal | m—petal ventral | n—gynoecium | o—fruit side view | & p—fruit front view. © Prashant Karadakatti & Shreyas Betageri.

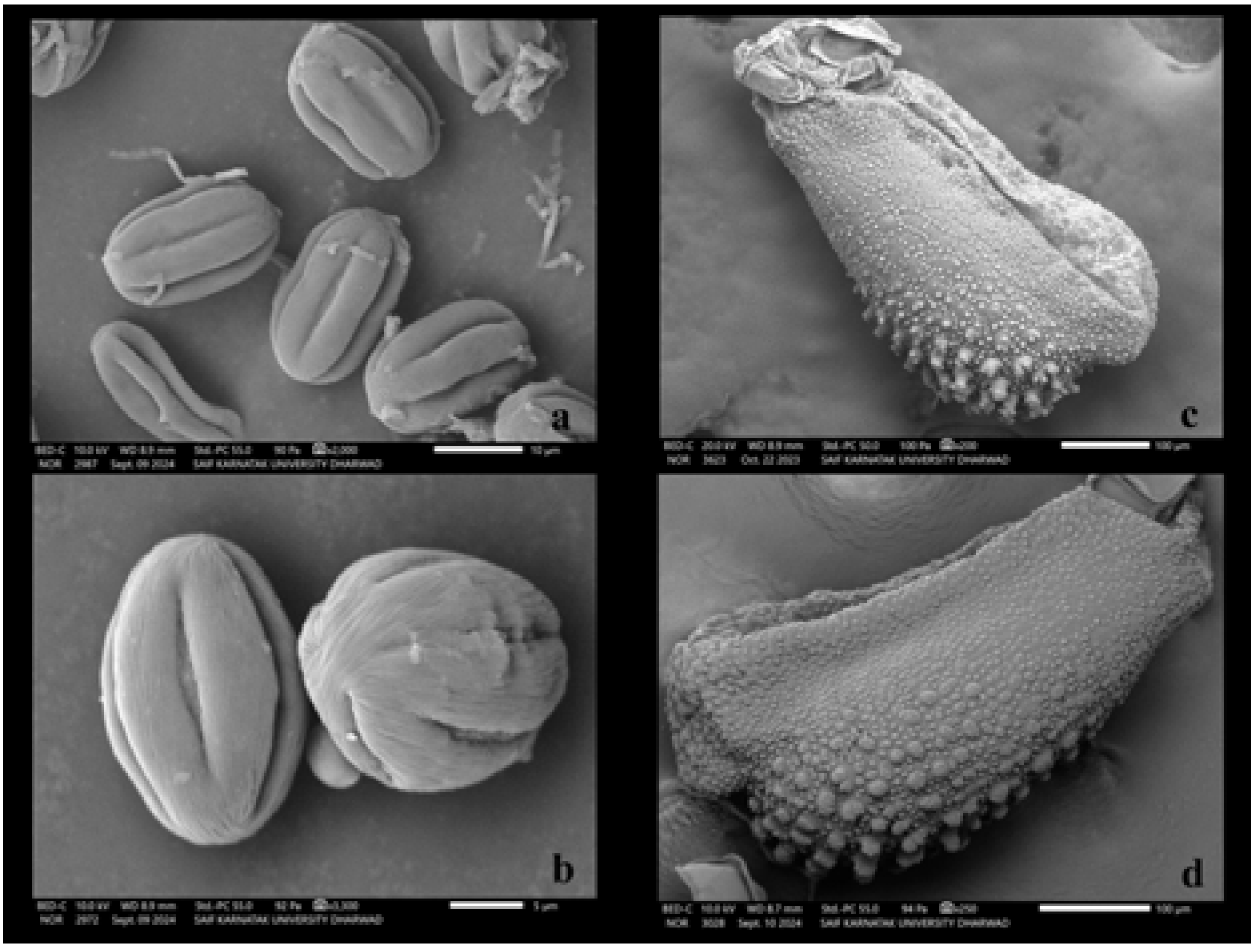

Image 2. a & c—Pollen & seed of *Sonerila wallichii* Benn. | b & d—Pollen and seed of *Sonerila bababudangiriensis* sp. nov. © Prashant Karadakatti & Shreyas Betageri

pale to dark pink at apex, glabrous, fruits capsule, pale green, 1.2–1.5 cm, gland-tipped trichomes, sometimes glabrous; seeds numerous, obovoid and pustulate.

Distribution: Type locality along roadside and slopes, near Bababudangiri, Chikkamagaluru District, Karnataka, India, 13.404, 75.738, 1,557 m elevation.

Habitat: Hill slopes, water stream, misty place, associated with *Sonerila wallichii* Benn, *Commelina indescense* E Barnes, *Osbeckia parvifolia* Arn, *Cyanotis* D Don, *Adiantum* L and *Selaginella* L.

Flowering and Fruiting: July to October.

Conservation Status: After several attempts to locate the species in the surrounding region, it was found in only one location—on the way to Bababudangiri, Chikkamagaluru District, Karnataka, India. A few individuals of the species are found at the type location within a 100 m range (water streams, road cuts, and slopes). Hence, the species may be categorized as Data Deficient (DD) due to insufficient knowledge of its distribution (IUCN Standards and Petition Committee 2024).

Micro morphology

Pollen morphology

The pollen grains of *Sonerila bababudangiriensis* sp. nov. and *S. wallichii* are studied as per the NPC classification (Erdtman 1969). The pollen grains of *S. bababudangiriensis* are quadrangular convex polar view, the accumulate obtuse in a rhombic shape at the equatorial view and the aperture heterocolpate, measures approximately 18–20 × 13–15 µm, small fibrous structures on the pollen surface, striate-reticulate. In *S. wallichii* Benn. pollen grains quadrangular convex polar view, non-angular truncate in elliptic shape, aperture heterocoplate, measures approximately 19–21 × 11–13 µm, fibrous structures on the pollen surface, striate-reticulate (Image 2).

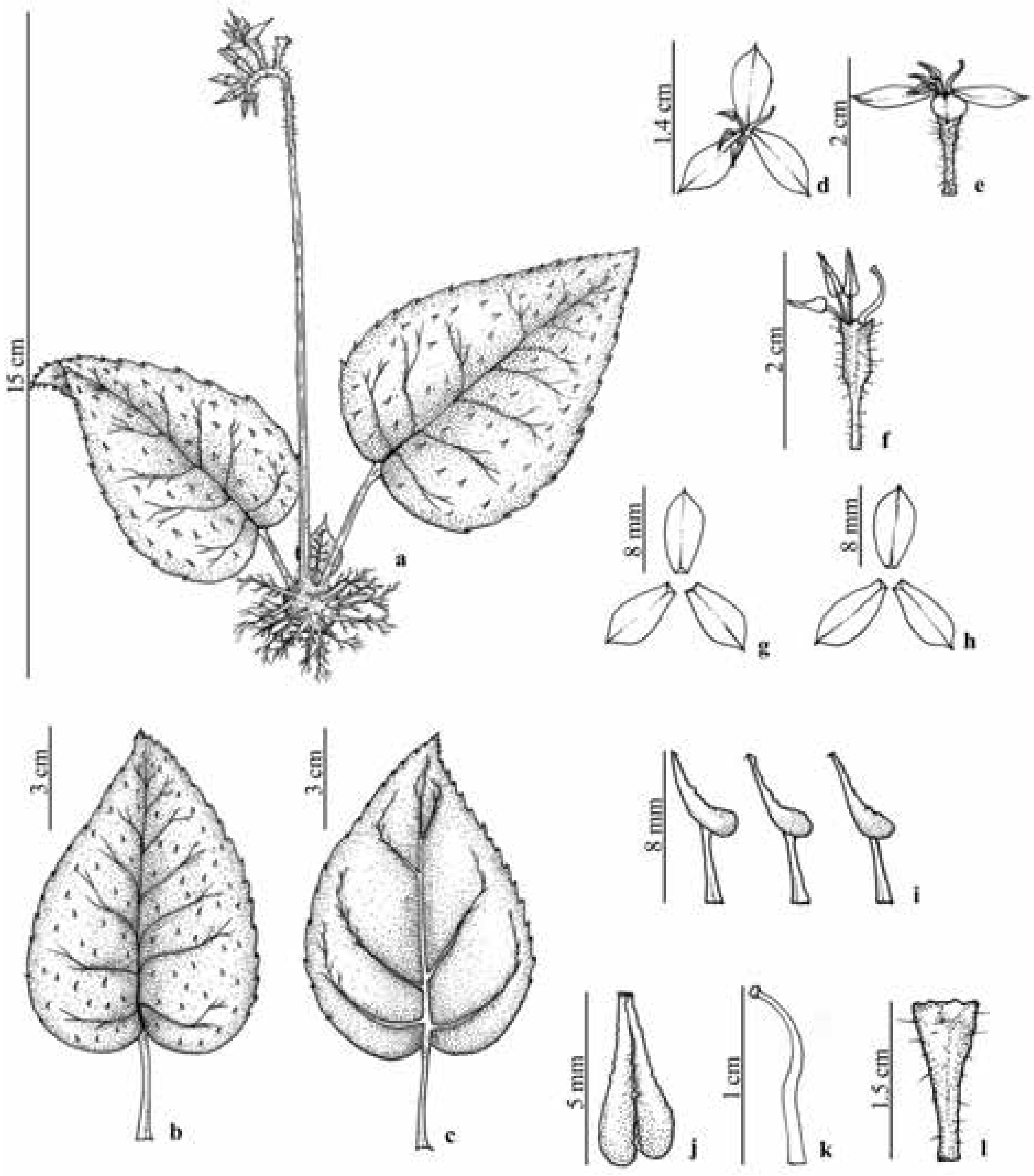

Figure 2. *Sonerila bababudangiriensis* sp. nov.: a—habit | b—leaf dorsal | c—leaf ventral | d—flower front view | e—flower side view | f—hypanthium | g—petal adaxial | h—petal abaxial | I—anthers | j—anther lobe | k— gynoecium | l—capsule. © Prashant Karadakatti.

Seed morphology

In *Sonerila bababudangiriensis* sp. nov. the seeds are numerous, ellipsoid, 500–580 × 220–250 µm, brown to dark brown, raphe remains out with dorsal surface tubercle, well-differentiated smaller and larger tubercles, from micropyle to dorsal shows small pusticles with larger tubercles, large tubercles measure about 8–18 × 10–20 µm in polar view, 5–10 × 5–8 µm in side view, small tubercles measures about 1–3 × 1–4 µm. Less exposed testa cells, margins undulated with each other about 30–40 × 10–15 µm. In the *S. wallichii* seeds numerous, ellipsoid, 492–630 × 211–225 µm,

Table 1. Comparison of the morphological characteristics of *Sonerila bababudangiriensis* sp. nov. & Sonerila wallichii.

Parts	*Sonerila bababudangiriensis* sp. nov.	*Sonerila wallichii*
Tuber	Small tuber 0.5–1.5 cm diameter.	Non-tuberous.
Leaf	Lamina 3–5 cm wide, 5–8 cm long, dark green dorsal side with claret tinge spines or papillae scattered, measuring about 1–3 mm, claret at ventral side, glabrous, densely gland-dotted, toothed margins, serrate, leaf base slightly orbicular with equal base and cordate.	Parrot green 4–10 cm wide, 3–14 cm long, 4–6 nerved, four pairs from the base, 4–12 pairs from the midrib, sparsely gland-tipped trichomes.
Inflorescence	Only one inflorescence from each individual, unbranched, bostryx cyme, 1.5–3 cm long, 4–12 flowered	Two to three inflorescences from each individual, unbranched, scorpioid cyme, 2–5 from each habit, and 5–18 flowers.
Flower	1.5–1.8 cm, trimerous, pale pink	1.5–2 cm, trimerous, rarely tetramerous, moderate pink.
Peduncle	Quadrangular, 4–13 cm long claret tinge to pale green & glabrous.	Quadrangular, 5–18 cm long pale green to white at tip with gland-tipped trichomes.
Hypanthium	Angular and sparsely gland-tipped trichomes.	Angular, glandular hairs or trichomes.
Petals	Pale pink; 5–8 mm ovate-oblong & acuminate, glabrous, thickened.	Moderate pink to dark pink; 4–10 mm ovate-oblong & acuminate glandular hairs on abaxial midrib.
Anthers	Long acuminate, beaked, deeply cordate; longer than the filament.	Long oblong to acuminate, beaked deeply cordate, equal to the filament.

brown to dark brown, raphe overlapped or closed at dorsal and comprised tubercles on the surface with well-differentiated smaller and larger tubercles, at the dorsal side both pusticles scattered lesser at micropyle, larger pusticles are in a pyramid-like structure, measured about 10–22 × 8–18 µm in polar view, 12–25 × 5–15 µm in side view, smaller tubercles measured about 1–3 × 1–5 µm. Less exposed testa cells, margins undulated with each other 25–35 × 12–14 µm (Image 2).

References

Bhattacharya, K., M.R. Majumdar & S.G. Bhattacharya (2006). *A Textbook of Palynology*. Bijay Publications, Kolkata, 352 pp.

Cellinese, N. (1997). Notes on the systematics and biogeography of the *Sonerila* generic alliance (Melastomataceae) with a special focus on fruit characters. *Tropical Biodiversity* 4(1): 83–93.

Erdtman, G. (1969). *Handbook of Palynology: Morphology–Taxonomy–Ecology:* An Introduction to the Study of Pollen Grains and Spores. København: Munksgaard Publication, Sweden, pp. 21–37. (Available at Thomas J. Bata Library, Trent University).

Giri, G.S. & M.P. Nayar (1986). A new species of *Sonerila* (Melastomataceae) from India. *Journal of Japanese Botany* 61(11): 344–348.

Hickey, L.J. (1973). Classification of the architecture of dicotyledonous leaves. *American Journal of Botany* 60(1): 17–33. https://doi.org/10.1002/j.1537-2197.1973.tb10192.x

IUCN Standards and Petitions Committee (2024). Guidelines for Using the IUCN - Red List Categories and Criteria. Version 16. Prepared by the Standards and Petitions, Committee. Downloadable from https://www.iucnredlist.org/documents/RedListGuidelines.pdf. Accessed on 25 January 2024.

Karadakatti, P. & S.B. Kakkalameli (2024). *Sonerila konkanensis* Resmi & Nampy (Melastomataceae)—an addition to the flora of Karnataka, India. *Journal of Threatened Taxa* 16(5): 25279–25282. https://doi.org/10.11609/jott.8882.16.5.25279-25282

Penneys, D., F. Almeda, M. Reginato, F.A. Michelangeli, R. Goldenberg, P.W. Fritsch & R.D. Stone (2022). A new Melastomataceae classification informed by molecular phylogenetics and morphology, pp. 109–166. In: Goldenberg, R., F.A. Michelangeli & Frank Almeda (eds.). *Systematics, Evolution, and Ecology of Melastomataceae*. Springer, Cham., xxiv + 793 pp. https://doi.org/10.1007/978-3-030-99742-7_5

Plants of the World Online (POWO) (2024). Kew Royal Botanic Garden. https://powo.science.kew.org/ (Accessed 25 Jan 2025).

Ravikumar, K., A.C. Tangavelou & A. Page (2021). *Seed Plants of Karnataka – A Concise Dictionary*. Foundation for revitalization of local health traditions trans-disciplinary university (FRLHT-TDU), Bengaluru. National Biodiversity Authority Chennai, 836 pp.

Renner, S.S. (1993). *Phylogeny and classification of the Melastomataceae and Memecylaceae*. *Nordic Journal of Botany* 13(5): 519–540.

Resmi, S., K.M. Manudev, C. Pramod & S. Nampy (2018). A new species of *Sonerila* (Melastomataceae: Sonerileae) from southern Western Ghats, India. *Phytotaxa* 333(2): 235–242. https://doi.org/10.11646/phytotaxa.333.2.7

Resmi, S. & S. Nampy (2021). A new addition to the stoloniferous *Sonerila* (Sonerileae, Melastomataceae) from southern Western Ghats, India. *Brittonia* 73(2): 195–202. https://doi.org/10.1007/s12228-021-09657-w

Saldanha, C.J. (1984). *Flora of Karnataka*, *Vol. 2*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, Calcutta, 37–46 pp.

Sanjappa, M. & A.N. Sringeswara (2019). *Flora of Karnataka a checklist - Vol. 2.* Karnataka Biodiversity Board, 495–497 pp.

Stevens, P.F. (2012). Angiosperm phylogeny website. http://www.mobot.org/MOBOT/research.APweb/ Accessed on 15 January 2012.

Ulloa, U.C., F. Almeda, R. Goldenberg, G. Kadereit, F.A. Michelangeli, D.S. Penneys, R.D. Stone & M.C. Veranso-Libalah (2022). Melastomataceae: Global diversity, distribution, and endemism, pp. 3–28. In: Goldenberg, R., F.A. Michelangeli, D.S. Penneys, R.D. Stone & M.C. Veranso-Libalah (eds.). *Systematics, Evolution, and Ecology of Melastomataceae*. Springer, Cham, xxiv + 793 pp. https://doi.org/10.1007/978-3-030-99742-7_1

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26923–26927
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.9057.17.4.26923-26927
#9057 | Received 03 April 2024 | Final received 28 March 2025 | Finally accepted 17 April 2025
OPEN ACCESS
SHORT COMMUNICATION

Rediscovery of *Phallus aurantiacus* Mont. from India and new distribution record from Odisha, India

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Abstract: *Phallus aurantiacus* Mont., a distinctive species of stinkhorn fungus within the family Phallaceae, is documented with detailed morphological features along with coloured illustrations for the first time from the state of Odisha, India. This notable range extension significantly expands the known distribution of the species within the Indian subcontinent.

Keywords: Biodiversity, India, macro-fungi, Odisha, phallus stinkhorns, taxonomy.

'Stinkhorn' refers to a broad range of macro-fungi with a distinctive horn-shaped slimy top. Stinkhorn is an artificial term for several genera and some eye-catching ones are *Aseroe* Labill, 1800, *Clathrus* P.Micheli ex L., *Claustula* K.M.Curtis, *Colus* Cavalier & Séchier, 1835; *Ileodictyon* Tul. & C.Tul., 1844, *Kobayasia* S.Imai & A.Kawam, *Laternea* Turpin, *Lysurus* Fr., *Mutinus* Fr., *Phallus* Junius ex L., *Pseudocolus* Lloyd, 1900. Fischer created the order Phallales, which included the stinkhorns (family Phallaceae) and lattice stinkhorns (family Clathraceae) mushrooms. Both families produce epigeous, spongy, fleshy bodies that allow them to expand rapidly as they absorb water from their environment. These taxa have fragrance which lures small insects, especially flies, which subsequently spread the spores. Insects have been known to perform the typical mycophagous behaviour on stinkhorns for almost a century, and almost all Phallaceae and Clathraceae species rely on them to spread their spores (Fulton 1889).

There has been a great deal of interest in *Phallus*, commonly known as stinkhorns, by mycologists because of their distinctive morphological phalloid basidiomata with bell-shaped to campanulate receptacles, cylindrical, hollow and spongy pseudostipes, saccate volva with

Editor: Anonymity requested. **Date of publication:** 26 April 2025 (online & print)

Citation: Sahoo, M.P., S. Sahu, S.N. Mallick, P.K. Das, Y. Rout, S. Dalabehera, S.P. Panda & V. Hallur (2025). Rediscovery of *Phallus aurantiacus* Mont. from India and new distribution record from Odisha, India. *Journal of Threatened Taxa* 17(4): 26923–26927. https://doi.org/10.11609/jott.9057.17.4.26923-26927

Funding: None.

Competing interests: The authors declare no competing interests.

Acknowledgements: We acknowledge Dr Manoj E Hembrom, scientist-C, AJC Bose Indian Botanic Garden, Botanical Survey of India, Howrah, West Bengal, for his contribution towards the identification of *Phallus aurantiacus* Mont.

a few simple or branched rhizomorphs, presence or absence of latticed indusium and the noticeable foetid or nauseating smell in most taxa (Li et al. 2020). The genus *Phallus* accounted for 107 records in Index Fungorum with 31 species as of 2016 and 212 records in the Mycobank as of 2025 (Li et al. 2016). However, to date only two species have been reported from Odisha: *P*. *multicolor* (Berk. & Broome) Cooke (Mahapatra et al. 2013) and *P*. *indusiatus* Vent. (Dash et al. 2010).

The third record of *Phallus* member as *P*. *aurantiacus* described in this article is recovered from Chandaka, Odisha. Stinkhorns are saprobic fungi that grow in areas that have organic matter and they grow naturally on Chandaka's roads, a part of Eastern Ghats situated in Odisha, showing dry deciduous woodland and the roads and trails that cross the protected area exhibit signs of habitat fragmentation. These mushrooms develop on a buildup of litter that is made up of bamboo shavings and litter. The goal of this study is to shed light on the remarkable biodiversity of the area.

Material and Methods

The morphological determination was performed on the basis of freshly gathered fruiting bodies following the methods described previously (Montagne 1841; Oso 1976; Kuo 2019) along with ex situ photography with the help of a digital camera. The dimensions, form, and colour of the taxonomic characters were recorded. For describing colour of basidiomata no specific colour codes were followed and it was given on the basis of general observation. The samples were kept in formaldehyde for further examination following which the sample was dried at 40–50 °C in a hot air oven before being put in airtight ziplock bag with a few moth balls and deposited in the Regional Plant Resource Center, Bhubaneswar, India, with accession number 8643. Methun Handbook of Colour (Kornerup & Wanscher 1978) were used to refer the colour code.

For microscopic examination, dried specimens were mounted with 5% KOH in order to rehydrate and examine the tissues of taxonomic importance followed by thin sections mounted in phloxine, cotton blue and Melzer's reagent successively. An optical Carl Zeiss Axiolab 5 microscope equipped with an Axiocam 208 camera was utilised, as described previously by Kuo 2019. Microscopic examination of hyphae/cells and spores with taxonomic significance were done under 40X and 100X objectives. Measurements were taken of 30 basidiospores and 10 hyphae randomly from different sections.

Result and Discussion

Taxonomy

Phallus aurantiacus Mont., *Annls Sci*. *Nat*., Bot., sér. 2 16: 277 (1841) (Image 1)

Immature basidiomata (egg) range from 20–35 x 10–

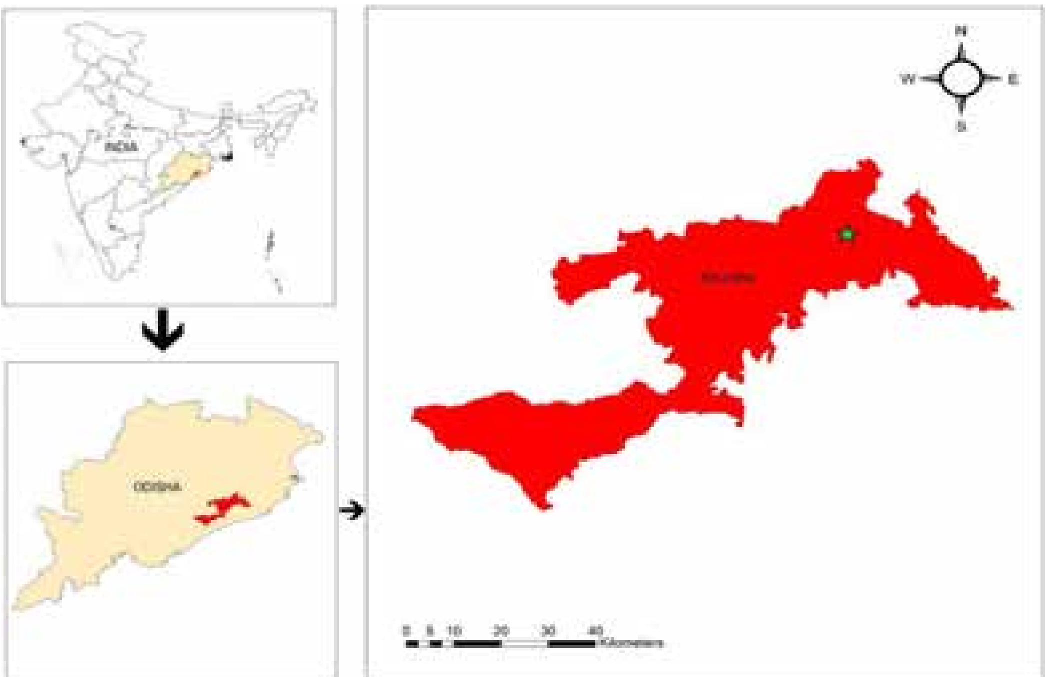

Figure 1. Location of *Phallus aurantiacus* Mont. in Odisha State of India along with habitats.

25 mm, exhibit a globose to subglobose to oval shape. They are situated below moderately branched, white-coloured rhizomorphs extending 50–60 mm in length, anchoring the eggs in a subterranean position within the soil. The exoperidium is characterized by its papery thin to membranous texture, presenting a coloration ranging from white (A1) to yellowish brown (5D8). The mesoperidium measures 5–6 mm in width, appearing thick and gelatinous with an olivaceous grey hue, while the endoperidium is papery thin and slightly darker than the mesoperidium. The gleba, approximately 8–9 mm wide, is slimy or sticky, exhibiting an olive brown (4D6) colouration surrounding the unexpanded, thick, chalky white (A1), narrowly hollow immature pseudostipe with a yellowish-orange (4B7) to yellow ochre (5C7) lumen, which develops into a pseudostipe with maturity. Dehiscence occurs through an apical irregular slit.

In fully matured basidiomata, the pseudostipe measures 110–130 × 15–20 mm and terminates apically with a head measuring 15–20 mm in length. The head is partially elongated, conical to fusiform in shape, and clearly distinguished from the pseudostipe. It is wider than the pseudostipe and has a single-chambered wall, opening internally and continuing externally. The surface of the head is rugulose with parenchymatous processes forming pockets, displaying colors ranging from orange (6B7) to pale orange (6A3), occasionally interspersed with a few delicate bands of whitish (A1) universal veil material. The cylindrical stalk, covered by a volva and slightly narrowing towards the base, is perforated throughout by pockets formed by pseudoparenchymatous processes. Similar to the head, its wall consists of a single chamber, opening externally and continuing internally. The gleba adheres mostly or entirely to the head except for the marginal apex, exhibiting a sticky or slimy texture and colours ranging from dark purple (14F8) to olive (4F8). The volva, measuring 20–30 mm in diameter, varies in colour from white (A1) to -light brown (7D5), emitting an unpleasant odour.

Basidiospores measure 4.0 × 2.4 µm, displaying an ellipsoid to sub-cylindrical shape with a smooth, thin-walled, hyaline, inamyloid, and acyanophilic structure. Pseudostipe cells range 37–65 µm in diameter, appearing irregularly sub-globose with a smooth, thick-walled (1–2 µm thick), hyaline, inamyloid, and acyanophilic composition. Volva hyphae measure 2–6 µm in width, presenting a thin-walled, smooth, hyaline, inamyloid, and acyanophilic structure.

Ecology: Uncommon in the study areas, gregarious to caespitose, in association with herbaceous elements such as *Bambusa bambos* (L.) Voss., *Chromolaena odorata* (L.) R.M.King & H.Rob., *Justicia japonica* Thunb., *Mimosa pudica* L., etc. and are part of the associated floristic population of the present species on the litter-covered clay or sandy soil in moderately shady places along with shrub population of the area and also seen in local bamboo vegetation.

Known distribution: Recorded from India, Africa (from Nigeria to South Africa after Oso BA 1976).

Specimen examined: India, Odisha, Chandaka Road, Bhubaneswar, Near Deras Dam, Chandaka, Bhubaneswar, Khordha, 20.3102 ^{0}N & 85.6908 ^{0}E, alt. 83 m, 15 August 2023, on the soil with litter.

Discussion

Members of the genus *Phallus* characteristically exhibit perforated apex, serrated margin bear digitiform, reticulate and half-free cap/ supported by cellulose-perforated orange colour stipe which arises from greyish-white bulbs having white rhizomorphs. Our specimens have sufficient macro and microscopic taxonomic features like orange colour fruiting bodies bearing olivaceous brown gleba at the apex macroscopically. At the same time, ellipsoid to subcylindrical spores with 4.0 × 2.4 µm are fairly similar to the circumscriptions provided by Montagne 1841 and Oso 1976 and Kuo 2019 successively. *P*. *rubicundus* (Bosc) Fr. and *P*. *rugulosus* (E.Fisch.) Lloydare taxa like *P. aurantiacus* and may easily be misidentified with the present one in the field. However, *P*. *rubicundus* has a thicker pink to red stem and a more consistently bell-shaped head whereas *P*. *rugulosus* is slenderer and, when fresh, presents a redder shade of orange (Kuo 2019).

While *P. indusiatus*, a mushroom used in Chinese cuisine, has been reported from Odisha (Dash et al. 2010) to the best of our knowledge, *P. aurantiacus* has not been reported from Odisha, and this is the second report in white literature after Montagne reports the macro fungus from Pondicherry Botanic Garden of south India in 1841 (Montagne 1841). After scrutiny of list and references on Phalleles of India (Butler & Bisby 1931; Bilgrami et al. 1979, 1981, 1991; Sarbhoy et al. 1996; Jamaluddin et al. 2004; Bisht 2008; Panda et al. 2019; Mahapatra et al. 2013, 2024; Manoharachary et al. 2022) we conclude this species as rediscovery after 138 years for the Indian Mycobiota. Although, two varieties of *Phallus aurantiacus* var. *aurantiacus* or *Phallus aurantiacus* var. *discolor* have been described in the past, we did not attempt to further characterise the present specimen owing to lack of robustness of current phylogenetic frameworks in Phallales to confidently support formal

Image 1. a—Habitat of *Phallus aurantiacus* Mont. ex situ | b & c—habit | d—habit of immature basidiomata (bulb) ex situ | e—vertical section of bulb showing exoperidium, mesoperidium, endoperidium, gleba, and pesudostipe | f—volva and basal part of stalk | g—head supported by pseudostipe (stalk and hollow nature) | h—basidiospores | i—pseudoparenchymatous cells of stipe under phase contrast microscopy. Bars h & i = 20 µ. © Malay Prithwiraj Sahoo & Prabhat Kumar Das.

recognition of subspecies or varieties (Melanda et al. 2021; Luangharn et al. 2024). This finding contributes to the overall knowledge of fungal biodiversity in Odisha and underscores the need for further mycological exploration in this region. Understanding the ecological and distributional patterns of fungi, especially those as intriguing as *P. aurantiacus*, is essential for conservation efforts and the preservation of ecosystems where these organisms play vital roles. This discovery is a testament to the ongoing discoveries awaiting mycologists in India, highlighting the importance of continued research to unveil the rich fungal diversity in this country.

References

Bilgrami, K.S., S. Jamaluddin & M.A. Rizwi (1979). *Fungi of India I List and References*. Today's and Tomorrow's Printer's and Publisher's, New Delhi, 467 pp.

Bilgrami, K.S., S. Jamaluddin & M.A. Rizwi (1981). *Fungi of India II Host Index and Addenda*. Today's and Tomorrow's Printer's and Publisher's, New Delhi, 128 pp.

Bilgrami, K.S., S. Jamaluddin & M.A. Rizwi (1991). *Fungi of India III List and References*. Today's and Tomorrow's Printer's & Publisher's, New Delhi, 798 pp.

Bisht, D. (2008). *Gasteromycetes (Lycoperdales & Related Fungi) of Uttarakhand*. BSI Project Report, Dehradun, 172 pp.

Butler, E.J. & G.R. Bisby (1931). *The Fungi of India*. The Imperial Council of Agricultural Research. Indian Science Monograph, 300 pp.

Dash, P.K., D.K. Sahu, S. Sahoo & R. Das (2010). *Phallus indusiatus* Vent. & Pers. (Basidiomycetes) - a new generic record from Eastern Ghats of India. *Journal of Threatened Taxa* 2(8): 1096–1098. https://doi.org/10.11609/JoTT.o2305.1096-8

Fulton, T.W. (1889). The dispersion of the spores of fungi by the agency of insects, with special reference to the Phalloidei. *Annals of Botany* 3: 207–238.

Jamaluddin, S., M.G. Goswami & B.M. Ojha (2004). *Fungi of India 1989–2001*. Scientific Publishers (India), Jodhpur, India, 326 pp.

Kornerup, A. & J.H. Wanscher (1978). *Methuen Hand Book of Colour*. Cox & Wymen Ltd., Fakenham, Norfolk, England, 255 pp.

Kuo, M. (2019). *Phallus aurantiacus*. http://www.mushroomexpert.com/phallus_aurantiacus.html. Accessed on 23 March 2025.

Li, H., X. Ma, P.E. Mortimer, S.C. Karunarathna, J. Xu & K.D. Hyde (2016). *Phallus haitangensis*, a new species of stinkhorn from Yunnan Province, China. *Phytotaxa* 280: 116–128.

Luangharn, T., T. Salichanh, A. Walker, & N. Thongklang (2024). Revealing two new records of *Phallus* (Phallaceae) from northern Thailand and optimizing conditions for mushroom mycelial growth. *Current Research in Environmental & Applied Mycology* 14(1): 108–121.

Manoharachary, C., N.S. Atri, T.P. Devi, D. Kamil, S.K. Singh & A.P. Singh (2022). *Bilgramis's Fungi of India List and References*. Today's and Tomorrow's Printer's & Publisher's, New Delhi, 475 pp.

Melanda, G.C.S., A.G.S. Silva-Filho, A.R. Lenz, N. Menolli Jr, A.A. Lima, R.J. Ferreira, N.M. Assis, T.S. Cabral, M.P. Martín & I.G. Baseia (2021). An overview of 24 years of molecular phylogenetic studies in Phallales (Basidiomycota) with notes on systematics, geographic distribution, lifestyle, and edibility. *Frontiers in Microbiology* 12: 689374. https://doi.org/10.3389/fmicb.2021.689374

Mahapatra, A.K., S.S. Tripathy & V. Kaviyarasan (2013). *Mushroom Diversity in Eastern Ghats of India*. Regional Plant Resource Centre, Bhubaneswar, 185 pp.

Montagne, C. (1841). Seconde centurie de Plantes cellulaires exotiques Nouvelles. *Annales des Sciences Naturelles; Botanique* 2(16): 266–282.

Oso, B.A. (1976). *Phallus aurantiacus* from Nigeria. *Mycologia* 68(5): 1076–82.

Panda, M.K., H.N. Thatoi, S.C. Sahu & K. Tayung (2019). Wild Edible Mushrooms of Northern Odisha, India: Data on Distribution and Utilization by Ethnic Communities. *Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences* 5(2): 248–268.

Sarbhoy, A.K., D.K. Agarwal & J.L. Varshney (1996). *Fungi of India (1982–1992).* CBS Publishers & Distributors, New Delhi, India, 350 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26928–26931
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.9106.17.4.26928-26931
#9106 | Received 18 April 2024 | Final received 25 February 2025 | Finally accepted 05 March 2025
SHORT COMMUNICATION

Occurrence of a rare desmid *Tetmemorus laevis* Ralfs ex Ralfs from Yumthang Valley, northern Sikkim with a note on the genus in India

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Abstract: The rare desmid genus *Tetmemorus* Ralfs ex Ralfs with a single species *T. laevis* Ralfs ex Ralfs is reported for the first time from the Yumthang Valley of northern Sikkim. This genus is characterized by apical incision apart from the lateral median constriction. Only five species have been reported from different parts of India. This is the first record of the specimen from eastern Himalaya as well as northern part of India. Occurrence of the other species of the genus in India has also been discussed.

Keywords: Algae, eastern Himalaya, new record, Phytoplankton, Sikkim.

Tetmemorus Ralfs ex Ralfs, an interesting desmid genus, was first described by Ralfs (1848) with its three species, viz., *T. brebissonii* Meneghini ex Ralfs, *T. laevis* Ralfs ex Ralfs, and *T. granulatus* Brébisson ex Ralfs. Although having an apical incision like *Euastrum* it differs from the latter in cylindrical body lacking any lobes or sinuation (Ralfs 1848).

Several species of *Tetmemorus* have been reported from different parts of the world but in India it was recorded by only a handful of investigators. First report of this genus was from upper Batong Valley, Sikkim by Dickie (1882). He reported *T. granulatus* Brébisson ex Ralfs from this region. Turner (1892) reported *T. brebisonii* Meneghini ex Ralfs from eastern India. Agarkar & Agarkar (1977) reported two taxa of *Tetmemorus*, viz., *T. brebissonii* var. *minor* De Bary and *T. laevis* Ralfs ex Ralfs from Pachmarhi, Madhya Pradesh. Later, Agarkar et al. (1983) reported *T. laevis* Ralfs ex Ralfs & *T. laevis* var. *minutus* (De Bary) Willi Krieger from Madhya Pradesh. *T. brebissonii* var. *minor* de Bary has been reported from Tamil Nadu (Suxena 1983). From Kerala *T. euastroides* A.M. Scott & Prescott was reported by Shaji et al. (1988) & *T. laevis* Ralfs ex Ralfs was recorded from Chathannoor (Sindhu & Panikkar 1995). *T. laevis* Ralfs ex Ralfs has been reported from West Bengal (Santra & Pal 2006). Distribution map of the recorded taxa in India is depicted in Figure 1.

During systematic investigations on desmids of eastern Himalaya the authors recorded *T. laevis* Ralfs ex Ralfs from the Yumthang Valley of northern Sikkim.

Materials and Methods

Algal samples were collected as algal mass by hand or by forceps and scalpels from different spots of this region at about 0930–1030 h (Das & Keshri 2016). Totally, 12 collections were made. Samples were mainly collected from small streams & wet rocks and immediately fixed on the spot in 5% formaldehyde aqueous solution. Water

Editor: Asheesh Shivam, Nehru Gram Bharati (Deemed to be University), Uttar Pradesh, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Das, D., J. Mal & J.P. Keshri (2025). Occurrence of a rare desmid *Tetmemorus laevis* Ralfs ex Ralfs from Yumthang Valley, northern Sikkim with a note on the genus in India. *Journal of Threatened Taxa* 17(4): 26928–26931. https://doi.org/10.11609/jott.9106.17.4.26928-26931

Funding: UGC, New Delhi & Ministry of Environment Forest & Climate Change for funding under AICOPTAX programme (No. F. No. 2018/15/2015-CS (Tax) dated 18th January 2018).

Competing interests: The authors declare no competing interests.

Acknowledgements: Authors acknowledge to UGC, New Delhi for financial support to carry out this investigation & head of the Department of Botany, The University of Burdwan for laboratory facilities. Special thanks are due to the Home Department, Govt. of Sikkim for various help and Forest Department, Govt. of Sikkim. Support of fund from MoEFCC in AICOPTAX programme is also highly acknowledged.

samples were preserved in 500 ml bottle with 1% Lugols' Iodine to study the microscopic phytoplanktons as well. The water temperature (using non-mercuric alcohol thermometer by Labworld), pH (using standard pH paper by Merck), and habitats were recorded during the study. Initial observations were made in the laboratory under Olympus GB compound microscope using GWF as mount medium (Bando 1988). Photomicrographs were also taken in Zeiss Axioscope plus research microscope with Axiocam-503 attachment.

Study area

Eastern Himalaya including Sikkim is considered as one of the four biodiversity hot spots in India (Hajra & Verma 1996). Sikkim is the home of several indigenous plant species. Several regions of eastern Himalaya are still unexplored. Most of the parts of northern Sikkim are even inaccessible and hence very little explored. Very few works in phycological investigations have been carried out from northern Sikkim till date. Santra (1984) recorded a few Cyanophyceae from northeastern Sikkim. Das & Keshri (2013) reported several algal taxa from Gurudongmar Lake.

In this work authors investigated an uncommon desmid taxon *Tetmemorus laevis* Ralfs ex Ralfs from Yumthung Valley, northern Sikkim (Figure 1). The extremely scenic Yumthang Valley is situated at an elevation of 3,545 m in the north of Sikkim and is popularly known as 'Valley

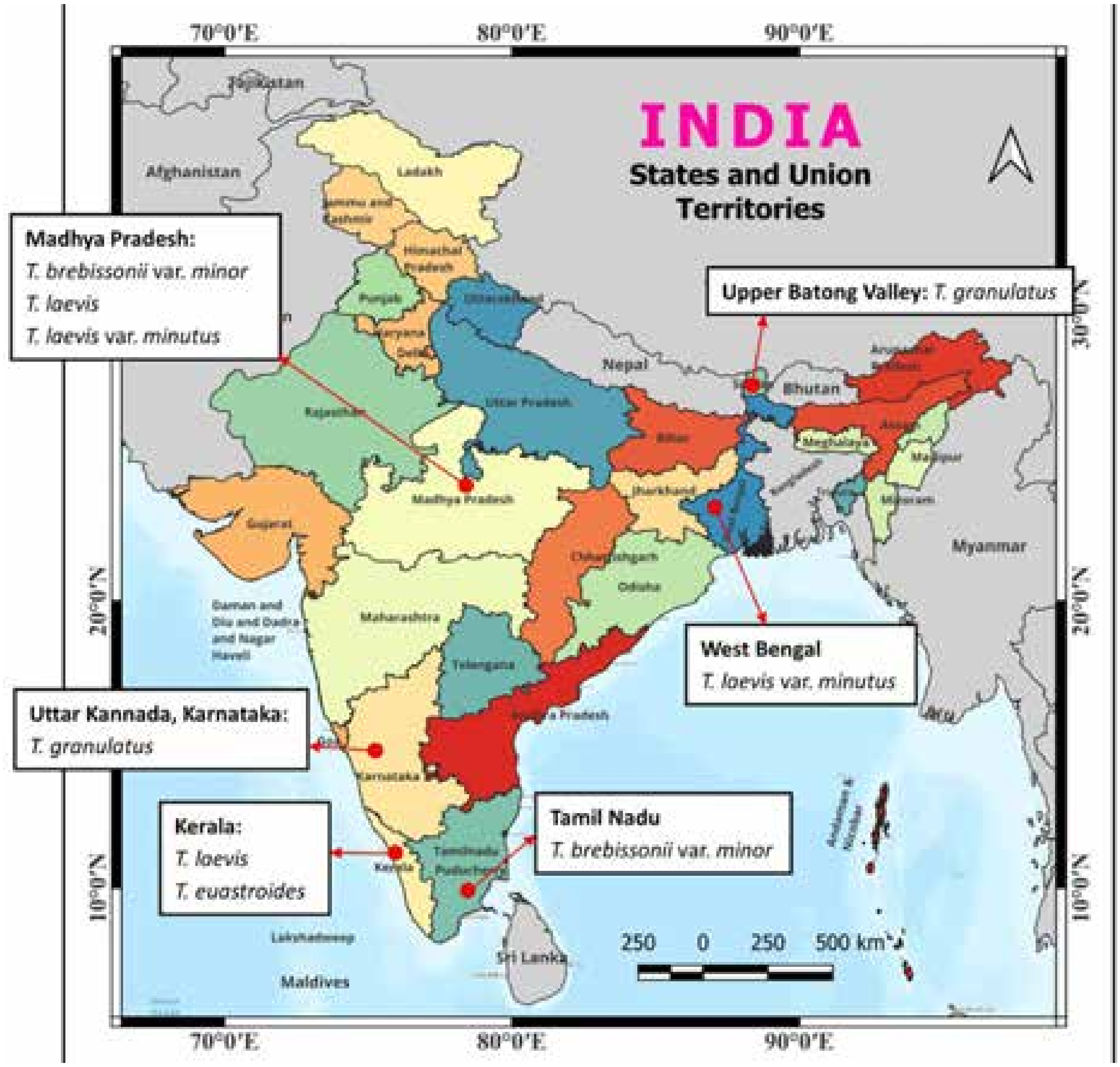

Figure 1. Distribution map of Tetmemorus in India (Source: https://www.geographicalanalysis.com).

of flowers' due to the intense blossom of *Rhododendron* flowers of various colours. This work has been carried out during the phycological exploration of eastern Himalaya by the authors during 2009–2015. This region is about 150 km away from Gangtok, the capital of Sikkim. The nearby inhabited area is Lachung.

Results

Tetmemorus laevis **Ralfs ex Ralfs** [Pl. 1, fig. A-C]

Ralfs 1848, p.146, pl. 24, f. 3a–g; Prescott et al. 1975, p. 149, pl. 56, f. 1–3, 6–8; John et al. 2011, p. 727, pl. 180K

Cells cylindrical, 3.87 times longer than broad, with a conspicuous, median constriction, and a deep & narrow apical incision in the broadly rounded apex; semicells in face view slightly tapered, lateral walls slightly concave; cell wall finely punctate; chloroplast axial, with 7–8 radiating longitudinal plates, pyrenoid large, single in each chloroplast.

Length: 85–86 µm, Breadth: 22–23 µm, Isthmus: 19–20 µm, Apex: 11–14 µm.

Distribution: India, Sikkim, northern Sikkim, Yumthang Valley, 27.80493° N, 88.70476° E, 5 May 2010, D. Das & J.P. Keshri.

Habitat: The alga is rare in the study area. It has been recorded as phytoplankton from running water of a small stream. water pH: 6, water temperature 7°C at the time of collection.

Discussion

Desmids are oligotrophic in occurrence, indicators of low pollution level & conductance (Brook 1981; Brook & Johnson 2011). Studies on its biodiversity are not

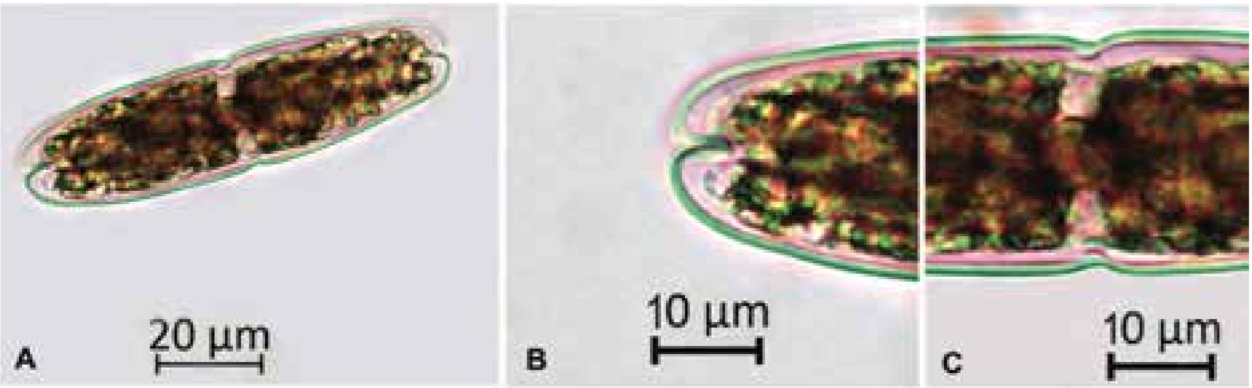

Image 1. *Tetmemorus laevis*: A—Entire view | B—Apical portion | C—Isthmus region. © Jai Prakash Keshri.

Table 1. Ecological notes of the samples collected from the field (Yumthang Valley).

Sample number	Co-ordinates	pH	Water temperature (°C)	Habitat
DD-656	27.79265° N 88.70560° E	6.5	6.5	Brown powdery mass with thin filamentous mass on the rock from a small water body.
DD-657	27.79723° N 88.70461° E	6.5	6.5	Brownish filament on the surface of a wet rock.
DD-658	27. 79873° N 88.70558° E	6.5	6.5	Powdery mass and filaments along with semi aquatic weeds from a shallow water body.
DD-659	27.79993° N 88.70543° E	6.0	6.5	Green filaments on the surface of the wet soil.
DD-660	27.80493° N 88.70476° E	6.0	7	Phytoplankton sample from running water of a small stream.
DD-661	27.80497° N 88.70476° E	6.5	7	Light green filaments on the water surface along with yellowish green filament and dark powdery mass of a small stream.
DD-662	27.80499° N 88.70476° E	6.5	7	Brownish mass on rock surface under water of a small stream.
DD-663	27.82468° N 88.69596° E	6.9	7.5	Bright green powdery mass on soil under water from a small water body.
DD-664	27.82468° N 88.69596° E	6.9	7	Dark green scum on the surface of a wet rock.
DD-665	27.82609° N 88.69581° E	6.9	7	Brownish powdery mass with wet moss on a tree trunk.
DD-666	27.82626° N 88.69585° E	6.5	7	Bluish scum on the surface of wet rock beside a small waterfall.
DD-667	27.82612° N 88.69564° E	6.5	7	Brownish powdery mass from a small water body beside a small waterfall.

extensive except a few (Turner 1892; Santra & Pal 2006; Das & Keshri 2016). The genus *Tetmemorus* is known to occur abundantly in shallow waters of wetlands and slow flowing streams but infrequent as metaphyton and plankton (Hall & McCourt 2015). This the third report of the species from India and first report from northeastern India. Earlier it was reported from Kerala (Sindhu & Panikkar 1995) and Madhya Pradesh (Agarkar 1977). Dickie (1882) reported *Tetmemorus granulatus* Brébisson ex Ralfs from northeastern India more than 125 years ago. This investigation added one more rare taxon which reveals that extensive investigations are needed in Sikkim. Since desmids are also indicator of low pollution further investigations may help in the typification of habitats (Bellinger & Sigee 2015).

References

Agarkar, M.S. & D.S. Agarkar (1977). Desmids from Panchmarhi, Madhya Pradesh, India. *Hydrobiologia* 54(1): 23–32.

Agarkar, D.S., M.S. Agarker & S. Banerjee (1983). Desmids of Jabalpur, Madhya Pradesh, India. *Bibliotheca Phycologica* 66: 333–370.

Bando, T. (1988). A revision of the genera *Docidium, Haplotaenium* and *Pleurotaenium* (Desmidiaceae, Chlorophyta) of Japan. *Journal of science of the Hiroshima University. Series B. Div. 2, Botany* 22 (1): 1–63.

Bellinger, E.G. & D.C. Sigee (2015). *Freshwater Algae: Identification, Enumeration and Use as Bioindicators*. John Wiley & Sons, UK, 275 pp.

Brook, A.J. (1981). *The Biology of Desmids.* Blackwell Scientific Publication, 276 pp.

Brook, A.J. & L.R. Johnson (2011). Zygnematales, pp. 576–608. In: John, D.M., B.A. Whitton & A.J. Brook (eds.). *The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae. 2nd Edition.* Cambridge University Press, Cambridge, 878 pp.

Das, D. & J.P. Keshri (2013). Algae from Gurudongmar Lake (North Sikkim, Eastern Himalaya). *NeBIO* 4(6): 61–69.

Das, D. & J.P. Keshri (2016). *Desmids of Eastern Himalaya*. Bibliotheca Phycologica: Band 119. Schweizerbart Science publishers, Stuttgart, Germany, 260 pp + 10 figures, 2 tables, 30 plates.

Dickie, G. (1882). Notes on algae from Himalayas. *The Journal of the Linnean Society. Botany* 19: 230–232.

Hall, J.D. & R.M. McCourt (2015). Conjugating green algae including desmids, pp. 429–457. In: Wehr, J.D., R.G. Sheath & J.P. Kociolek (eds.). *Freshwater Algae of North America: Ecology and Classification*. Academic Press, USA, 1049 pp.

Hajra, P.K. & D.M. Verma (1996). *Flora of Sikkim Vol. 1 (Monocotyledons).* Botanical Survey of India, 337 pp.

John, D.M., B.A. Whitton & A.J. Brook (eds.) (2011). *The Freshwater Algal Flora of The British Isles: An Identification Guide To Freshwater and Terrestrial Algae. 2nd Edition.* Cambridge University Press, Cambridge, 878 pp.

Prescott, G.W., H.T. Croasdale & W.C. Vinyard (1975). *A Synopsis of North American Desmids Part II: Placodermae Section 1.* University of Nebrasca Press, 275 pp.

Ralfs, J. (1848). *The British Desmidieae.* Reeve, Benham, and Reeve, London, xxii + 226 pp, 35 pls.

Santra, S.C. (1984). Algal flora of Sikkim Himalaya-I: A contribution to our knowledge of the blue-green algae of North-East Sikkim (India). *The Journal of Economic and Taxonomic Botany* 5(5): 1209–1219.

Santra, S.C. & U.C. Pal (2006). Desmid flora of Eastern India: Sikkim and West Bengal, pp. 409–513. In: Vidyavati & A.K. Mahato (eds.). *Recent Trends in Algal Taxonomy: Taxonomical and Cultural Studies, 2.* Associated Publishing Company, New Delhi, vii + 642 pp.

Shaji, C., L. Jose & R.J. Patel (1988). Addition of desmid flora of Kerala. *Phykos* 27: 32–37.

Sindhu, P. & M.V.N. Panikkar (1995). Desmids new to Kerala, India - 1. *Feddes Repertorium* 106(3–4): 317–323.

Suxena, M.R. (1983). Algae from Kodaikanal Hill, South India. *Bibliotheca Phycologica* 66: 43–99.

Turner, W.B. (1892). The fresh-water algae (Principally Desmidieae) of East India. *Kongliga Svenska Vetenskaps-Akademiens Handlingar* 25(5): 1–187, pls. I–XXIII.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26932–26935
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.9303.17.4.26932-26935
#9303 | Received 12 July 2024 | Final received 20 January 2025 | Finally accepted 19 April 2025
NOTE

Ophiorrhiza japonica Blume (Rubiaceae): a new record for India

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The *Ophiorrhiza* genus, belonging to Rubiaceae, comprises 378 accepted species distributed in tropical and subtropical regions of Asia, Australia, New Guinea, and the Pacific Islands (POWO 2024). There are 64 species of this genus in India (Deb & Mondal 1997; Barik et al. 2018; Hareesh & Sabu 2018; Taher et al. 2020; Nair et al. 2021; BSI 2024). *O. japonica* is reported to be found in China, Japan, Taiwan, and Vietnam (POWO 2024). Species of the genus are perennial or annual herbs, ranging from creepers to tall erect shrubs that have a woody base, with leaves of simple, uneven, opposite pairs, that vary in size from species to species. The flowers are pentamerous and epigynous. The fruit is berry-like with tiny rhomboidal seeds (Don 1834; Deb & Mondal 1997; Taher et al. 2020). With the inclusion of the newly recorded species, 64 species of the genus *Ophiorrhiza* are presently known to be reported in India, with 35 taxa possibly endemic to India.

During floristic exploration of Manipur, the *Ophiorrhiza* species was sighted in its natural habitat, which was then collected for identification. The plant specimen was recorded from Shirui peak (25.112° N, 94.454° E, 2,435 m), Ukhrul District, Manipur, India. The collected specimens were identified as *Ophiorrhiza japonica* Blume using pertinent literature (Don 1834; Nakamura et al. 2007; Chen & Taylor 2011; POWO 2024; Tropicos 2024) and type specimen images available at Kew herbarium and Herbarium Institute of Botany, Academia Sinica (HAST). This species is a new record to the flora of India. Deb & Mondal (1997), documented the medicinal values of *O. Japonica* in the Indian subcontinent but the geographic location of its occurrence in India was not mentioned. A sample of the specimen was brought to the Institute of Bioresources and Sustainable Development (IBSD), Imphal, and preserved in herbarium sheet for future reference. The descriptions of the plant are illustrated and described here in detail (Image 1).

Ophiorrhiza japonica Blume in Bijdr. Fl. Ned. Ind.: 978 (1826). *Ophiorrhiza acutiloba* Hayata Icon. Pl. Formosan. 2: 86 (1912). *Ophiorrhiza cavaleriei* H. Lév. Repert. Spec. Nov. Regni Veg. 13: 177 (1914). *Ophiorrhiza dimorphantha* Hayata in Icon. Pl. Formosan. 2: 86 (1912). *Ophiorrhiza eryei* Champ. in Hooker's J. Bot. Kew Gard. Misc. 4: 170 (1852). *Ophiorrhiza kwangsiensis* Merr. Ex Li in J. Arn. Arb. 24: 453 (1943). *Ophiorrhiza labordei* H.Lév. Repert. Spec. Nov. Regni Veg. 13: 177 (1914). *Ophiorrhiza monticola* Hayata Icon. Pl.

Editor: A.J. Solomon Raju, Andhra University, Visakhapatnam, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Chanu, N.M., P. Langkan, T.N. Khanganba & T. Biseshwori (2025). *Ophiorrhiza japonica* Blume (Rubiaceae): a new record for India. *Journal of Threatened Taxa* 17(4): 26932–26935. https://doi.org/10.11609/jott.9303.17.4.26932-26935

Funding: None.

Competing interests: The authors declare no competing interests.

Acknowledgements: We acknowledge the director, Institute of Bioresources and Sustainable Development- DBT, Imphal, Manipur, for encouraging and granting permission for field surveys. We are also thankful to the locals of Shirui Village for their co-operation. Further gratitude extended to Mayengbam Aldrin and lab members of Plant Systematics and Conservation Laboratory for their assistance in the study.

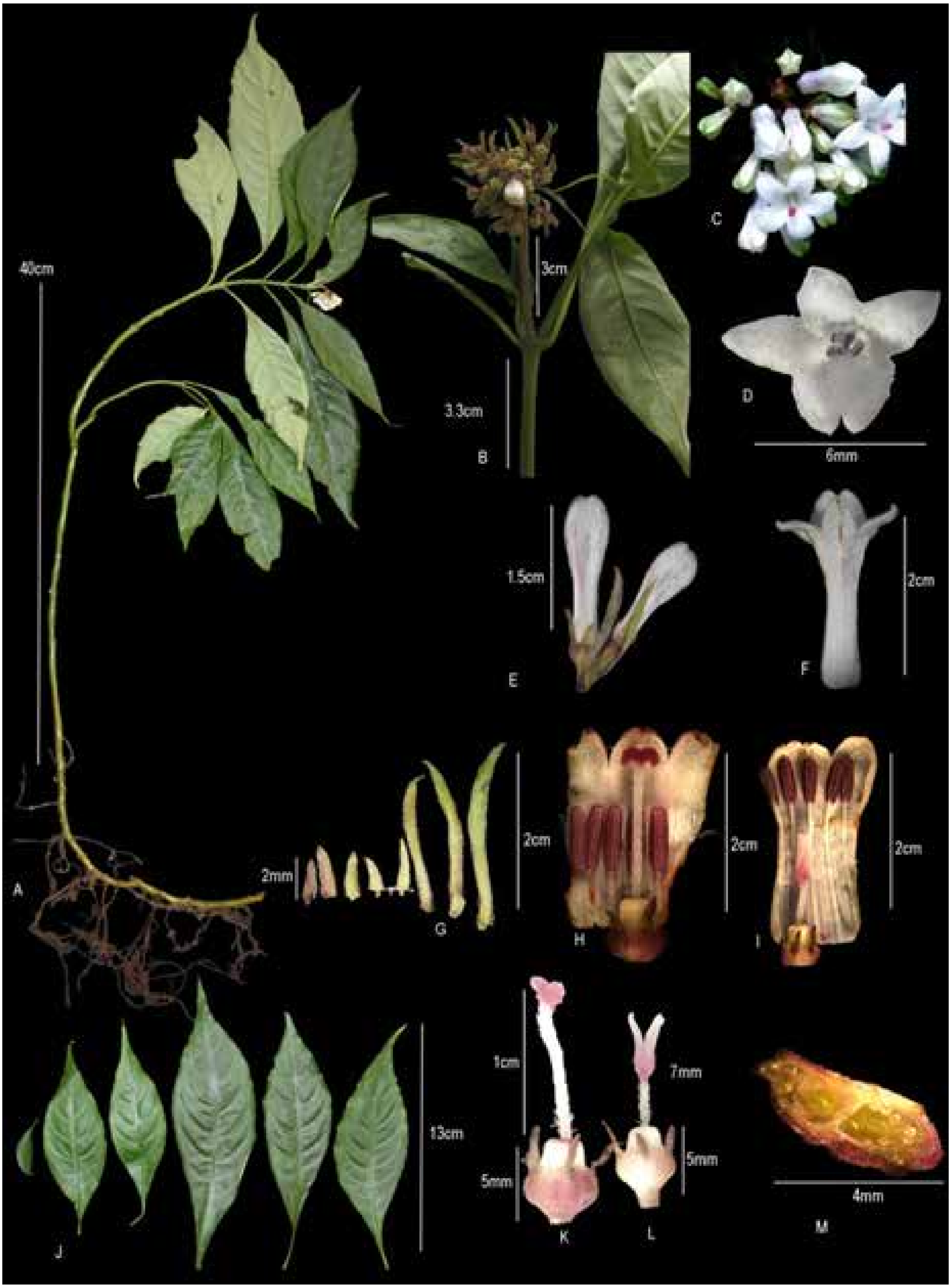

Image 1. *Ophiorrhiza japonica*: A—Plant | B—A twig with inflorescence | C—Inflorescence | D—Flower top view | E—Young flower buds | F—Corolla | G—Calyx and bracts | H—Longitudinally dissected long-styled flower | I—Longitudinally dissected short-styled flower | J—Leaves | K—Calyx with style and stigma of long styled flower | L—Calyx with style and stigma of short styled flower | M—Cross-section of ovary. © Peimichon Langkan.

Image 2. Herbarium specimen of *Ophiorrhiza japonica* prepared and deposited at Institute of Bioresources and Sustainable Development (IBSD/M-302).

Formosan. 2: 89 (1912). *Ophiorrhiza nigricans* H.S.Lo in Bull. Bot. Res., Harbin 10(2): 53 (1990). *Ophiorrhiza tashiroi* Maxim. Bull. Acad. Imp. Sci. Saint-Pétersbourg, sér. 3, 32: 489 (1888).

Type: Japan, Chiba Pref., Awa-gun, Mt. Kiyosumi, 1937-03-20, Tomitaro Makino 104364 (Isotype, HAST [62464 digital image!]; syn K [K000740554 digital image!]); Taiwan, Hualien County, Wanrong township, ca. 22 km from entrance of Wanjung forest road, 1,120 m, 1999-05-30, Wu, Shu-Hui 1398 (Isotype, HAST [78315 digital image!]).

Herb, 40–60 cm tall; stems weak and ascending, subterete, light green to dark green. Leaves uneven, opposite pairs, ovate, ovate-lanceolate, ovate-elliptic, elliptic, apex acute or acuminate, 2.5–14 x 0.7–4 cm, margins slightly upcurved, entire, 4–10 pairs of pinnate veins, adaxially darker, hispidulous or glabrous; abaxially, pale green, puberulent or glabrous. Petiole 0.4–3 cm, smooth or with fine trichomes or puberulent, stipules triangular, acute, caducous, 1–2 mm, glabrescent. Inflorescence cymose, congested cymose, with few to many flowers, hirtellous, puberulent or with strigose.

Heterostylous flowers; long style, 1 cm, with slender fascicled hairs around the anther, corolla white with a tinge of pale green at the outer tip, while short style, 0.7 cm, with fine short hairs, hirtellous, scattered sparsely around the throat of corolla, white to pale purplish-pink ombre towards the adaxial tip of corolla. Bracts persistent, linear lanceolate, 0.1–1 cm. Calyx smooth or pillose. Globular hypanthium, 1–5 mm, usually ribbed-pentamerous. Corolla funnel shaped tube, 1–2 cm, winged dorsally, outer glabrous to pubescent, pilosulous or hirtellous inside, apex rostrate, white or pinkish. Sub-mitriform capsules, pilosulous to glabrous reported, but capsules not seen at the time of collection.

Flowering and fruiting: December–April.

Vernacular name: Vanaohan (Local dialect).

Ecology and habitat: Wild, terrestrial, found growing in semi-deciduous, moist temperate forest.

Specimen examined: India, Manipur, Ukhrul, Shirui peak, 25.112° N, 94.454° E, 2,435 m, 22 March 2024, IBSD/M-302 (Image 2).

Distribution: India (Manipur), China, Japan, Taiwan, and Vietnam.

References

Barik, S.K., O.N. Tiwari, D. Adhikari, P.P. Singh, R. Tiwary & S. Barua (2018). Geographic distribution pattern of threatened plants of India and steps taken for their conservation. *Current science* 114(3): 470–503.

BSI (2024). *Ophiorrhiza*. Botanical Survey of India. https://efloraindia.bsi.gov.in. Accessed on 20 March 2024.

Chen, T. & C.M. Taylor (2011). *Ophiorrhiza* (Rubiaceae). In: Wu Z.Y., P.H. Raven & D.Y. Hong (Eds.). *Flora of China* 19: 258–282.

Deb, D.B. & D.C. Mondal (1997). Taxonomic revision of the genus *Ophiorrhiza L.* (Rubiaceae) in Indian subcontinent. *Nelumbo* 39: 1–148. https://doi.org/10.20324/nelumbo/v39/1997/74298

Don, G. (1834). General system of the Gardening and Botany, London, 3: 522. https://www.biodiversitylibrary.org/page/16486189

Hareesh, V.S. & M. Sabu (2018). The genus *Ophiorrhiza* (Rubiaceae) in Andaman and Nicobar Islands, India with a new species. *Phytotaxa* 383(3): 259–272. https://doi.org/10.11646/phytotaxa.383.3.3

Nair, A.S.V., A. Gangaprasad & K.B. Rameshkumar (2021). Notes on the ornamental potential of the genus *Ophiorrhiza* L. in the Western Ghats of India. *Abrahamia* 7(1): 16–23.

Nakamura, K., T. Denda, O. Kameshima & M. Yokota (2007). Breakdown of distyly in a tetraploid variety of *Ophiorrhiza japonica* (Rubiaceae) and its phylogenetic analysis. *Journal of Plant Research* 120: 501–509. https://doi.org/10.1007/s10265-007-0089-9

POWO (2024). Plants of the World Online. https://powo.science.kew.org. Accessed on 18 June 2024.

Taher, M., S.S. Shaari, D. Susanti, D. Arbain & Z.A. Zakaria (2020). Genus *Ophiorrhiza*: a review of its distribution, traditional uses, phytochemistry, biological activities and propagation. *Molecules* 25(11): 2611. https://doi.org/10.3390/molecules25112611

Tropicos (2024). Missouri Botanical Garden. http://www.tropicos.org/name/50058517. Accessed on 30 June 2024.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2025 | 17(4): 26936–26938

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9556.17.4.26936-26938

#9556 | Received 15 December 2024 | Final received 18 February 2025 | Finally accepted 03 April 2025

NOTE

Isodon neorensis Ranjan, G. Krishna & Anant Kumar (Lamiaceae): a new record for Sikkim Himalaya, India

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The genus *Isodon* (Schrad. ex Benth.) Spach (Lamiaceae: Nepetoideae: Ocimeae: Isodoninae) in India is represented by about 22 taxa distributed mostly in eastern and peninsular India (Anonymous 2020; Ranjan et al. 2022). During an exploration of Gangtok flora, an interesting species of the genus *Isodon* was collected from Daragaon region of Tadong, Gangtok, Sikkim. The striking characteristics of the species like red colored flowers on lax inflorescence were readily attractive. On further morphological examination, consultation of relevant literature (Ranjan et al. 2022; Wangchuk 2024) and herbarium consultation (CAL) revealed its identity as *Isodon neorensis* Ranjan, G. Krishna & Anant Kumar (2022). *Isodon neorensis* was recently described from Neora Valley National Park, Darjeeling, West Bengal based on the morphological characters. The species was not yet recorded from the state (Anant Kumar 2024 pers. comm.). The detailed description with notes on some variations, color plate is provided here for easy identification.

Taxonomic description

Isodon neorensis Ranjan, G. Krishna & Anant Kumar., Taiwania 67(2): 261. 2022: Wangchuck, S., Pleione 17(2): 218 – 221. 2023. (Image 1).

An erect herb, up to 1 m tall. Stems brown, quadrangular, unbranched, scabrous, internodes 3–8 cm long. Leaves opposite; petiole dark purplish, subterete, 3–6 cm long, scabrous; lamina ovate to cordate, 2–8 cm × 2–5 cm, base cuneate, truncate or cordate, margins bluntly dentate, apex acuminate, sparsely hairy above with scabrous veins, minute brownish-dotted beneath; veins impressed above, raised below. Inflorescence terminal or rarely axillary raceme composed of lax cymes, 10–25 cm, axis scabrid, cymes with peduncle 1–3 cm long, proximally scabrid, distally glabrescent; bracts broadly elliptic, ca. 1.5 cm across, scabrid; bracteoles linear, ca.1 mm long, scabrid; pedicels 0.8–2 cm long, scabrid. Calyx campanulate, ca. 1 mm long and sparsely glandular, anterior lip 2-lobed, ovate-oblong; posterior lip 3-lobed, each lobe triangular, apex acute; tube 8–10-nerved. Corolla maroon or deep red with white blotch on throat, mixed with red dots, ca. 3.5 mm long, glabrous; tube campanulate, ca. 2 mm long; posterior lip reflexed, 4-lobed, apically rounded, throat hairy; anterior lip ovate or obovate, 1.5–1.7 mm long, slightly concave, scattered glands outside. Stamens 4, dark red, exerted, inserted at the middle of the corolla tube; filaments slender, ca. 3 mm long; anthers flattened, elliptic, ca. 0.5 mm across, yellowish-white and black at maturity. Style

Editor: Afroz Alam, Banasthali Vidyapith, Rajasthan, India. **Date of publication:** 26 April 2025 (online & print)

Citation: Rai, P. (2025). *Isodon neorensis* Ranjan, G. Krishna & Anant Kumar (Lamiaceae): a new record for Sikkim Himalaya, India. *Journal of Threatened Taxa* 17(4): 26936–26938. https://doi.org/10.11609/jott.9556.17.4.26936-26938

Funding: None.

Competing interests: The author declares no competing interests.

Acknowledgements: The author is grateful to Dr. Anant Kumar, Department of Botany and Microbiology, Hemvati Nandan Bahuguna Garhwal University, Uttarakhand, India, for his invaluable input during the preparation of the manuscript. The author would also like to thank the Department of Forest and Environment, Deorali, Gangtok, for granting permission to conduct field explorations.

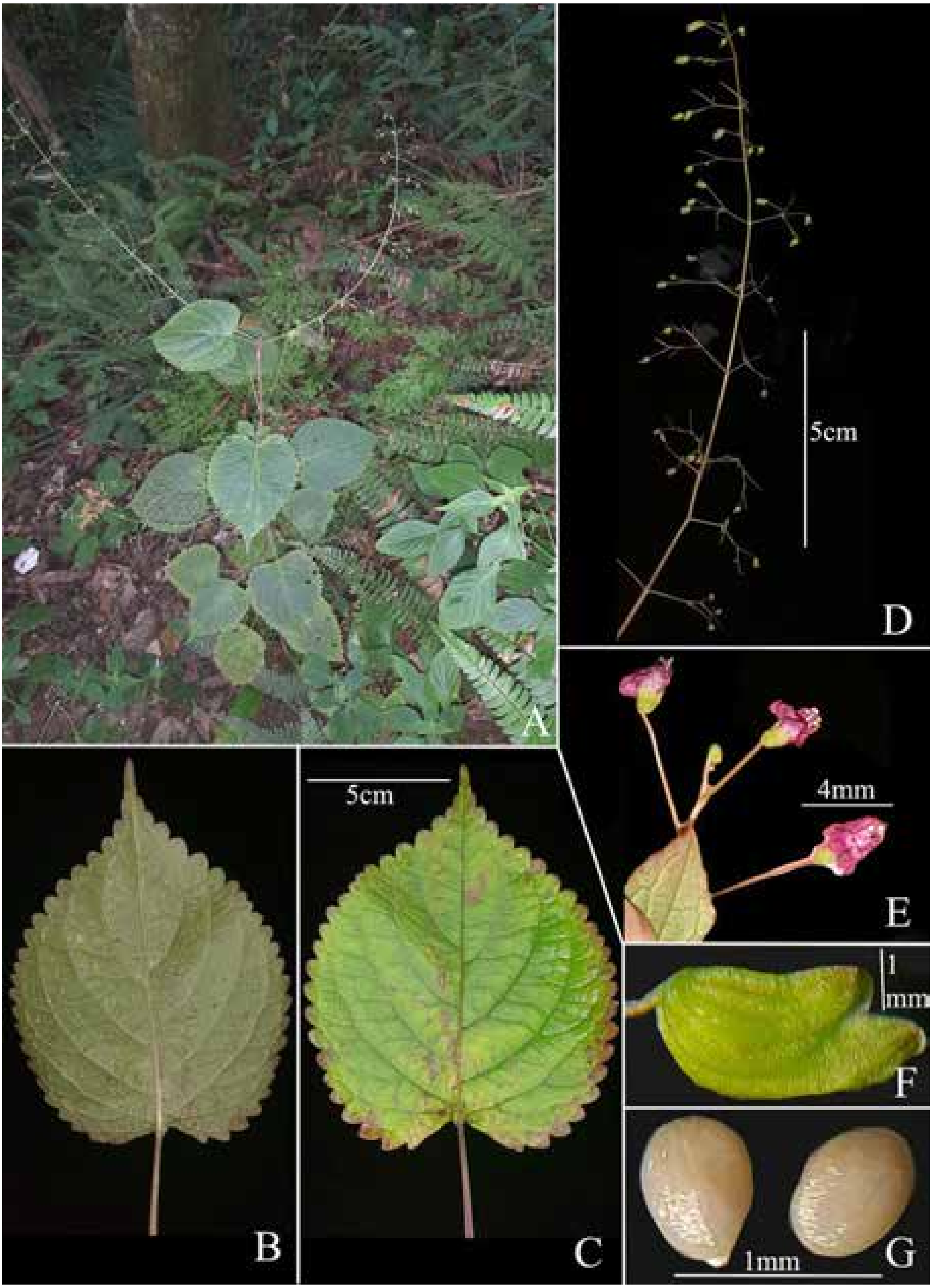

Image 1. ***Isodon neorensis*** **Ranjan, G. Krishna & Anant Kumar: A—Habit | B—Leaf (dorsal side) | C—Leaf (ventral side) | D—Inflorescence | E—Flower close up | F—Calyx remnants covering nutlets | G—Nutlets. © Pramod Rai.**

red, slender, gynobasic, ca. 5 mm long.

Flowering and fruiting: October–November.

Habitat: Growing on sub-tropical forest floor. Dominant associated trees were *Schima wallichii*, *Engelhardtia spicata*, *Mallotus denticulata*, *Pinus roxburghii*, *Alnus nepalensis* and *Leucosceptrum canum.* The population was growing in a disturbed habitat, on a highway roadside. Associated understorey species were *Hypoestes phyllostachya, Asystasia macrocarpa, Dicliptera chinensis, Pilea scripta*, and *Ophiopogon intermedius.* A single population was found in the study area with 16 individuals distributed randomly.

Distribution: India (West Bengal, Sikkim), Bhutan (Ranjan et al. 2022; Wangchuk 2024).

Specimen examined: India, Sikkim, Gangtok, Daragaon, 27.3060 ^{0}N, 88.5926 ^{0}E, 1,190 m, 29 October 2024, Pramod Rai P0507 (BSHC).

Notes: *I. neorensis* shares closeness with *I. lopanthoides* in the region. However, they can be distinguished as follows;

1. Stem scabrous, inflorescence racemic, flowers maroon or deep red, nutlet yellowish ……… ……………………………………………………. *I. neorensis*

1. Stem glabrous to pubescent, inflorescence paniculate, flowers white, nutlet brown ....*I. lopanthoides*

We also noted a few variations exhibited by our specimens (leaf bases are mostly cordate, the feature not known hitherto, and thus cordate leaves, a new shape variation of the species; flowering till October is also the most extended period noted so far).

References

Anonymous (2020). Flowering Plants of India-An Annotated Checklist (Dicotyledons). Botanical Survey of India, India. 2: 246.

Ranjan, V., G. Krishna & A. Kumar (2022). A new species of *Isodon* (Lamiaceae) from Indian Eastern Himalaya. *Taiwania* 67(2): 260–266. https://doi.org/10.6165/tai.2022.67.260

Wangchuk, S. (2023). *Isodon neorensis* Ranjan, G. Krishna & Anant Kumar (Lamiaceae): a new record for Bhutan. *Pleione* 17(2): 218–221. https://doi.org/10.26679/Pleione.17.2.2023.218-221

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org & ravi@zooreach.org

www.threatenedtaxa.org

OPEN ACCESS

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

April 2025 | Vol. 17 | No. 4 | Pages: 26763–26938
Date of Publication: 26 April 2025 (Online & Print)
DOI: 10.11609/jott.2025.17.4.26763-26938

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