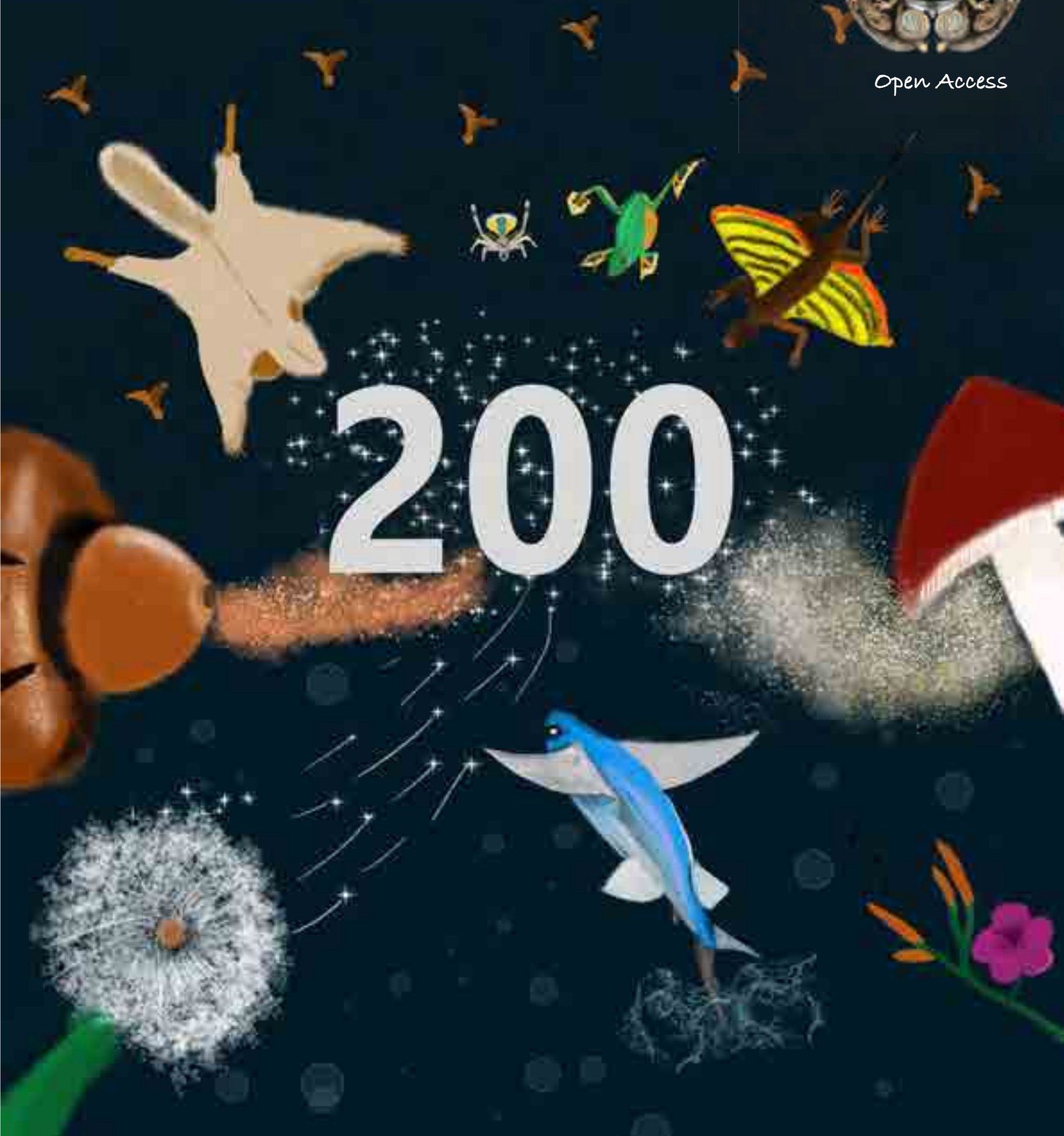
Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2023.15.2.22559-22770
www.threatenedtaxa.org

26 February 2023 (Online & Print)
15(2): 22559-22770
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Open Access



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

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

EDITORS

Founder & Chief Editor
Dr. Sanjay Molur
Wildlife Information Liaison Development (WILD) Society & Zoo Outreach Organization (ZOO), 43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641035, India

Deputy Chief Editor
Dr. Neelesh Dahanukar
Noida, Uttar Pradesh, India

Managing Editor
Mr. B. Ravichandran, WILD/ZOO, Coimbatore, India

Associate Editors
Dr. Mandar Paingankar, Government Science College Gadchiroli, Maharashtra 442605, India
Dr. Ulrike Streicher, Wildlife Veterinarian, Eugene, Oregon, USA
Ms. Priyanka Iyer, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India
Dr. B.A. Daniel, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India

Editorial Board
Dr. Russel Mittermeier
Executive Vice Chair, Conservation International, Arlington, Virginia 22202, USA

Prof. Mewa Singh Ph.D., FASc, FNA, FNASc, FNAPsy
Ramanna Fellow and Life-Long Distinguished Professor, Biopsychology Laboratory, and Institute of Excellence, University of Mysore, Mysuru, Karnataka 570006, India; Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and Adjunct Professor, National Institute of Advanced Studies, Bangalore

Stephen D. Nash
Scientific Illustrator, Conservation International, Dept. of Anatomical Sciences, Health Sciences Center, T-8, Room 045, Stony Brook University, Stony Brook, NY 11794-8081, USA

Dr. Fred Pluthero
Toronto, Canada

Dr. Priya Davidar
Sigur Nature Trust, Chadapatti, Mavinhalla PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin Fisher
Senior Associate Professor, Battcock Centre for Experimental Astrophysics, Cavendish Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK

Dr. John Fellowes
Honorary Assistant Professor, The Kadoorie Institute, 8/F, T.T. Tsui Building, The University of Hong Kong, Pokfulam Road, Hong Kong

Prof. Dr. Mirco Solé
Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Vice-coordenador do Programa de Pós-Graduação em Zoologia, Rodovia Ilhéus/Itabuna, Km 16 (45662-000) Salobrinho, Ilhéus - Bahia - Brasil

Dr. Rajeev Raghavan
Professor of Taxonomy, Kerala University of Fisheries & Ocean Studies, Kochi, Kerala, India

English Editors
Mrs. Mira Bhojwani, Pune, India
Dr. Fred Pluthero, Toronto, Canada
Mr. P. Ilangovan, Chennai, India
Ms. Sindhura Stothra Bhashyam, Hyderabad, India

Web Development
Mrs. Latha G. Ravikumar, ZOO/WILD, Coimbatore, India

Typesetting
Mrs. Radhika, ZOO, Coimbatore, India
Mrs. Geetha, ZOO, Coimbatore India

Fundraising/Communications
Mrs. Payal B. Molur, Coimbatore, India

Subject Editors 2019–2021

Fungi

Dr. B. Shivaraju, Bengaluru, Karnataka, India
Dr. R.K. Verma, Tropical Forest Research Institute, Jabalpur, India
Dr. Vatsavaya S. Raju, Kakatiay University, Warangal, Andhra Pradesh, India
Dr. M. Krishnappa, Jnana Sahyadri, Kuvempu University, Shimoga, Karnataka, India
Dr. K.R. Sridhar, Mangalore University, Mangalagangotri, Mangalore, Karnataka, India
Dr. Gunjan Biswas, Vidyasagar University, Midnapore, West Bengal, India

Plants

Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
Dr. N.P. Balakrishnan, Ret. Joint Director, BSI, Coimbatore, India
Dr. Shonil Bhagwat, Open University and University of Oxford, UK
Prof. D.J. Bhat, Retd. Professor, Goa University, Goa, India
Dr. Ferdinando Boero, Università del Salento, Lecce, Italy
Dr. Dale R. Calder, Royal Ontaro Museum, Toronto, Ontario, Canada
Dr. Cleofas Cervancia, Univ. of Philippines Los Baños College Laguna, Philippines
Dr. F.B. Vincent Florens, University of Mauritius, Mauritius
Dr. Merlin Franco, Curtin University, Malaysia
Dr. V. Irudayaraj, St. Xavier's College, Palayamkottai, Tamil Nadu, India
Dr. B.S. Kholia, Botanical Survey of India, Gangtok, Sikkim, India
Dr. Pankaj Kumar, Department of Plant and Soil Science, Texas Tech University, Lubbock, Texas, USA.
Dr. V. Sampath Kumar, Botanical Survey of India, Howrah, West Bengal, India
Dr. A.J. Solomon Raju, Andhra University, Visakhapatnam, India
Dr. Vijayasankar Raman, University of Mississippi, USA
Dr. B. Ravi Prasad Rao, Sri Krishnadevaraya University, Anantpur, India
Dr. K. Ravikumar, FRLHT, Bengaluru, Karnataka, India
Dr. Aparna Watve, Pune, Maharashtra, India
Dr. Qiang Liu, Xishuangbanna Tropical Botanical Garden, Yunnan, China
Dr. Noor Azhar Mohamed Shazili, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia
Dr. M.K. Vasudeva Rao, Shiv Ranjani Housing Society, Pune, Maharashtra, India
Prof. A.J. Solomon Raju, Andhra University, Visakhapatnam, India
Dr. Mandar Datar, Agharkar Research Institute, Pune, Maharashtra, India
Dr. M.K. Janarthanam, Goa University, Goa, India
Dr. K. Karthigeyan, Botanical Survey of India, India
Dr. Errol Vela, University of Montpellier, Montpellier, France
Dr. P. Lakshminarasimhan, Botanical Survey of India, Howrah, India
Dr. Larry R. Noblick, Montgomery Botanical Center, Miami, USA
Dr. K. Haridasan, Pallavur, Palakkad District, Kerala, India
Dr. Analinda Manila-Fajard, University of the Philippines Los Banos, Laguna, Philippines
Dr. P.A. Sinu, Central University of Kerala, Kasaragod, Kerala, India
Dr. Afroz Alam, Banasthali Vidyapith (accredited A grade by NAAC), Rajasthan, India
Dr. K.P. Rajesh, Zamorin's Guruvayurappan College, GA College PO, Kozhikode, Kerala, India
Dr. David E. Boufford, Harvard University Herbaria, Cambridge, MA 02138-2020, USA
Dr. Ritesh Kumar Choudhary, Agharkar Research Institute, Pune, Maharashtra, India
Dr. Navendu Page, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India
Dr. Kannan C.S. Warrier, Institute of Forest Genetics and Tree Breeding, Tamil Nadu, India

Invertebrates

Dr. R.K. Avasthi, Rohtak University, Haryana, India
Dr. D.B. Bastawade, Maharashtra, India
Dr. Partha Pratim Bhattacharjee, Tripura University, Suryamaninagar, India
Dr. Kailash Chandra, Zoological Survey of India, Jabalpur, Madhya Pradesh, India
Dr. Ansie Dippenaar-Schoeman, University of Pretoria, Queenswood, South Africa
Dr. Rory Dow, National Museum of natural History Naturalis, The Netherlands
Dr. Brian Fisher, California Academy of Sciences, USA
Dr. Richard Gallon, llandudno, North Wales, LL30 1UP
Dr. Hemant V. Ghate, Modern College, Pune, India
Dr. M. Monwar Hossain, Jahangirnagar University, Dhaka, Bangladesh
Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.
Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Pseudo-flying animals and wind-dependent seed & spore dispersers – made with digital painting in Krita. © Melito Prinson Pinto

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22559–22566

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

https://doi.org/10.11609/jott.7366.15.2.22559-22566

#7366 | Received 27 April 2021 | Final received 03 December 2022 | Finally accepted 19 December 2022

OPEN ACCESS

COMMUNICATION

Small Wild Cats Special Series

Sunda Clouded Leopard *Neofelis diardi* (Cuvier, 1823) (Mammalia: Carnivora: Felidae) occupancy in Borneo: results of a pilot vehicle spotlight transect survey

Jephte Sompud [1], Sze Lue Kee [2], Kurtis Jai-Chyi Pei [3], Paul Liau [4], Collin Goh [5] & Anthony J. Giordano [6]

[1,2] Forest Plantation and Agroforestry program, Faculty of Tropical Forestry, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia.

[3] Institute of Wildlife Conservation, College of Veterinary Medicine, National Pingtung University of Science and Technology, No. 1, Xuefu Road, Neipu, Pingtung, Taiwan ROC.

[4,5] KTS Plantation Sdn. Bhd., Level 1, Blok 5, Jalan Utara Batu 4, Bandar Pasaraya, 90000 Sandakan, Sabah, Malaysia.

[3,6] SPECIES, PO Box 7403 Ventura, California 93006, United States of America.

[1] jephte@ums.edu.my (corresponding author), [2] cyndaquil_kee@live.com, [3] kcjpei@mail.npust.edu.tw, [4] Paulktsp@gmail.com, [5] collingoh@yahoo.com, [6] species1@hotmail.com

Abstract: The Sunda Clouded Leopard *Neofelis diardi* on Borneo is threatened principally by deforestation for oil palm plantations and the indiscriminate use of illegal trapping. Sunda Clouded Leopard populations are decreasing across their range, and the species has been categorised as Vulnerable on the IUCN Red List. Despite the persistence of threats and numerous surveys in recent years, information on its ecology is still limited. Most studies to date have relied on the use of camera traps as their primary sampling tool, as it is challenging otherwise to gather data on Sunda Clouded Leopards. This study aimed to test the feasibility of estimating the Sunda Clouded Leopard occupancy using a different approach. We conducted vehicle spotlight transect surveys in a mixed-use forest reserve and logging concession in Sabah. We drove a cumulative total of 8,433 km of transects at night and documented the occurrence of Sunda Clouded Leopards in eight out of 31 predetermined long-distance transects, yielding a relatively low naïve occupancy rate (nO = 0.26). When accounting for imperfect detection (ρ = 0.15), null occupancy of Sunda Clouded Leopards appeared much higher (ψ = 0.55), though our parameter estimates lacked relative precision. Despite this, our results suggest there may be potential to further refine and adapt a basic, cost-effective monitoring approach in a local mixed-use reserve with the help of concession managers and additional improvements to study design. We caution, however, that not all study sites may be suited for this type of approach and strongly advise the development of pilot studies to evaluate their overall feasibility.

Keywords: Occupancy modelling, selective logging, survey methods, sustainable practices, vehicle transects.

Editor: Angie Appel, Wild Cat Network, Germany.

Date of publication: 26 February 2023 (online & print)

Citation: Sompud, J., S.L. Kee, K.J-C. Pei, P. Liau, C. Goh & A.J. Giordano (2023). Sunda Clouded Leopard *Neofelis diardi* (Cuvier, 1823) (Mammalia: Carnivora: Felidae) occupancy in Borneo: results of a pilot vehicle spotlight transect survey. *Journal of Threatened Taxa* 15(2): 22559–22566. https://doi.org/10.11609/jott.7366.15.2.22559-22566

Copyright: © Sompud et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: National Geographic Society, Universiti Malaysia Sabah grant and KTS Plantation Sdn Bhd.

Competing interests: The authors declare no competing interests.

Author details, Author contributions & Indonesian abstract: See end of this article.

Acknowledgements: This study was funded by the National Geographic Society (WW-112ER-17), Universiti Malaysia Sabah grant (SBK2024) and KTS Plantation Sdn Bhd. Special thanks to Sabah Forestry Department, Mr. Fadzil Yahya, and Mr. Janiu Gangon for granting us the research permits and for continuous support throughout this project. Individuals who helped us by providing logistical supports during this study were Mr. Peter Tiong, Mr. Ting Chung Kee, Mr. Andreas Apoi Ak Tama Stain, Mr. Sanchez Vincent John, Ms. Darrysie Salapan, Mr. Mohamad Jefli Bin Jamal, Mr. Basri Latif, and Ms. Lee Woon.

INTRODUCTION

Information on the biology of species and suitable techniques for their study are often fundamental to their management. An improved understanding of wildlife ecology can lead to more effective conservation strategies (Li et al. 2018) and ultimately prevent a species from going extinct. Among the world's endangered taxonomic groups are large predators (Fritz et al. 2009), which play an essential role in forest ecosystem processes and functioning (Ritchie et al. 2012). The Sunda Clouded Leopard *Neofelis diardi* is the largest obligate predator on Borneo (Matsuda et al. 2008; Payne et al. 1985). It has been categorised as Vulnerable on the IUCN Red List of Threatened Species and is also listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (Hearn et al. 2015).

The Sunda Clouded Leopard lives in a wide range of habitats, including lowland rainforest (Cheyne et al. 2013; Ross et al. 2013; Penjor et al. 2018), primary and selectively logged dipterocarp forest (Brodie et al. 2015; Hearn et al. 2016, 2019) and peat-swamp forest (Cheyne et al. 2013). Segaliud-Lokan Forest Reserve (SLFR) contains a lowland evergreen forest that serves as suitable habitat for the Sunda Clouded Leopard (Wilting et al. 2012). Selective-logging still occurs in this forest and is a practice that may still be compatible with long-term Sunda Clouded Leopard population viability if appropriately managed (Brodie & Giordano 2012). Despite its lower abundance in secondary forest, Brodie et al. (2015) found that Sunda Clouded Leopard habitat use increased toward the ecotones along edges between primary and selectively logged forest. They also found that although primary forest was still the more critical habitat for the Sunda Clouded Leopard, the importance of selectively logged forest to several larger ungulate species, including potential Sunda Clouded Leopard prey, may have provided some additional conservation value to those areas.

A previous survey in SLFR estimated the Sunda Clouded Leopard density in this area to be approximately one individual per 100 km^2 (Wilting et al. 2012), comparable to findings from another study site with a long logging history, the Maliau Basin (1.9 individuals/100 km^2) which occurs in the same general region (Brodie & Giordano 2012). These two studies and subsequent research on the Sunda Clouded Leopard (Bernard et al. 2013a,b; Brodie et al. 2017) all relied on camera trapping as their primary tool to estimate Sunda Clouded Leopard population status. Recent observations of Sunda Clouded Leopards made by staff and management in SLFR suggested that spotlight vehicle transects might be possible for investigating Sunda Clouded Leopard behaviour and activity. This observation was made during the initial site visit, when conversations first occurred between researchers, SLFR staff and management.

We conducted the first known pilot survey for Sunda Clouded Leopards using spotlight vehicle transects, with the objective of estimating occupancy and detection probability for the population in SLFR. We did this partly to evaluate the efficacy and feasibility of this approach, which has been used on felids and other carnivores elsewhere, to assess the occupancy of a 'large' tropical forest felid on Borneo. We also hoped to further understand the impact of various habitat and anthropogenic features on Sunda Clouded Leopard occupancy. We think that our findings have value for understanding how this methodology can be used in this type of habitat, as well as important conservation implications for reserve management and adjacent land uses.

Study Area

Segaliud Lokan Forest Reserve (SLFR) is a private logging concession located north-east of Deramakot Forest Reserve in the District of Sandakan, part of the Malaysian state of Sabah (Figure 1). Gazetted in 1955, the SLFR is approximately 570 km^2 (KTS Plantation 2019) and was subject to a conventional logging system until the mid-late 1990s (Wilting & Mohamed 2010). In 1994, the reserve's management was taken over by KTS Plantation Sdn Bhd and in 1998, a reduced impact logging (RIL) system was introduced to mitigate the potentially negative impacts of logging on native vegetation and wildlife (Yap et al. 2015). Today the SLFR consists of logged hill dipterocarp forests that provides refuge for many important threatened fauna in Borneo, including the Bornean Pygmy Elephant *Elephas maximus borneensis*, Tembadau, Bornean Orangutan *Pongo pygmaeus* and hornbills (KTS Plantation 2019).

MATERIALS AND METHODS

Data collection

We used a vehicle-based spotlight survey method (e.g. Henschel et al. 2016) to detect the presence of Sunda Clouded Leopards along logging roads in dense vegetation forest (Driessen & Hocking 1992). We spent 20 days each month conducting these surveys between October 2017 and December 2018. As this carnivore is

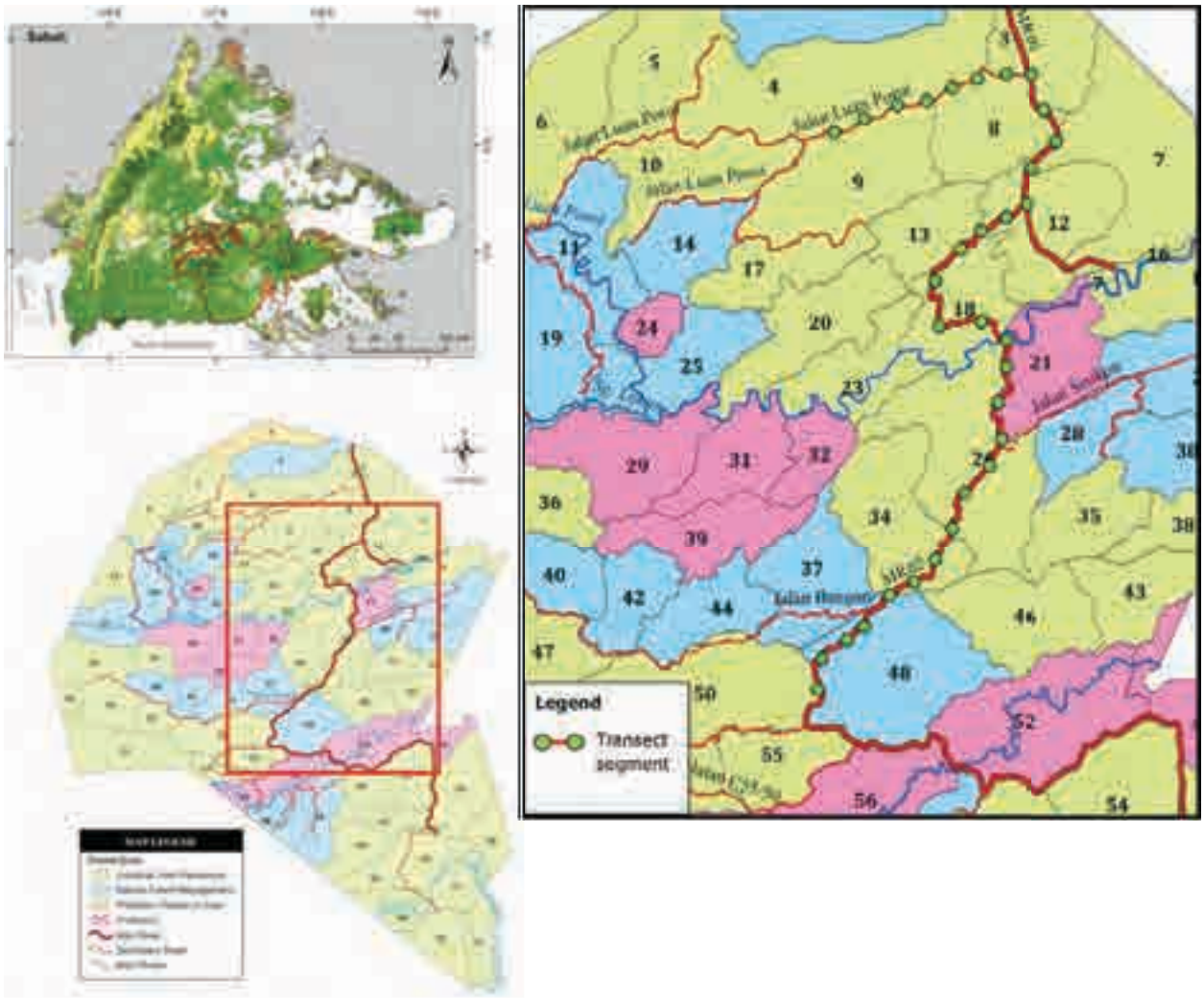


Figure 1. Location of Segaliud-Lokan Forest Reserve in Sabah, Malaysia (Source: KTS Plantation Sdn Bhd, 2011).

primarily nocturnal (Cheyne & Macdonald 2011; Brodie & Giordano 2012; Ross et al. 2013), all surveys were conducted at night between 1900 h and 2300 h. The survey team consisted of three persons: one person manned the vehicle, another person acted as a spotter using the spotlight, and the third person recorded all observations systematically. Dirt and gravel logging roads were targeted for surveys, as these were favourable pathways for the movement of Sunda Clouded Leopards (Wilting et al. 2006; Gordon & Stewart 2007; Brodie & Giordano 2012). When driving transects, we followed Roberts et al. (2006) in maintaining an average speed of 16–24 km/h.

In total, we established a 31 km spotlight "trail" (Figure 1) through primary and secondary logging roads, on which prior sightings of Sunda Clouded Leopards were reported by local staff. The total trail was divided into 31 distinct 1-km transect segments, along which each sighting of a Sunda Clouded Leopard was treated independently. To determine coarse-scale habitat use by the Sunda Clouded Leopard, we established and systematically sampled ten vegetation plots, each 10 m x 10 m in area along the forest's edge for every 1-km transect segment. Five pairs of vegetation plots were established, one on each side of the road, with intervals between adjacent plots on the same side ranging from 150 to 200 m (Figure 2).

To help characterise habitat in each plot, we recorded six variables, namely (1) tree species diversity, (2) slope, (3) percentage of understory vegetation cover, (4) percentage of canopy closure, (5) number of trees with diameter at breast height (DBH) > 10 cm, and (6) number of trees with DBH less than 10 cm (Table 1).

Data analysis

Our objectives were to estimate site occupancy and

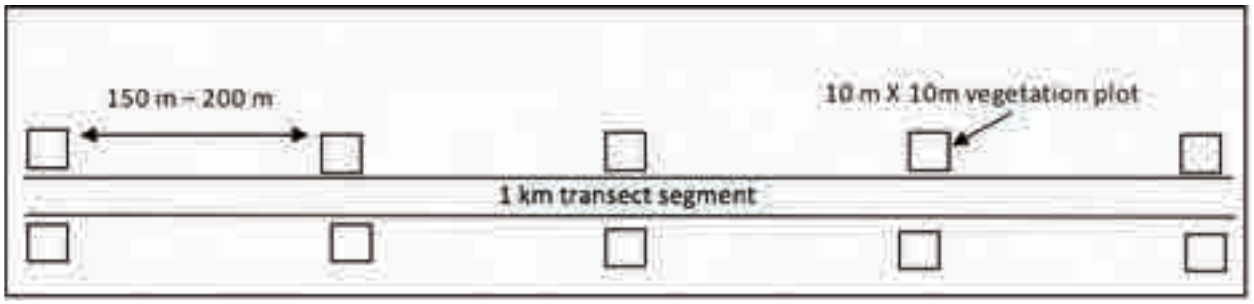


Figure 2. Vegetation plots established at 1 km transect segment.

the detection probability of Sunda Clouded Leopards in SLFR. We defined naïve occupancy (nO) for the entire sampling period as the ratio of sites where Sunda Clouded Leopards were sighted over the total number of sites surveyed. The site occupancy parameter (ψ) is defined as the estimated proportion of sites occupied by Sunda Clouded Leopards within our given area of inference (Mackenzie et al. 2006). Site occupancy (ψ) incorporates a distinct estimate of detection probability (ρ) as a way to model or account for "false absences" (Mackenzie et al. 2006), whereby a Sunda Clouded Leopard may be present but not detected in a segment or "site" during our survey. We used a single-season, single-species occupancy model to analyse all collected data and completed all analyses using the "Unmarked" package of Program R (R Development Core Team 2018).

RESULTS

We travelled 8,433 km in total of for all of our vehicle spotlight surveys, during which time we recorded 14 independent records of Sunda Clouded Leopards (Image 1). Individual Sunda Clouded Leopards were detected each month of the study period except February and March of 2019, for an average of one detection every 602.36 km. Overall we sighted Sunda Clouded Leopards in eight out of the 31 transect segments (Figure 3).

The average measurements for our vegetation sampling plots were as follows: (1) understory coverage = 79.34 ± 1.26% (mean ± SE); (2) canopy closure = 31.68 ± 2.60%; (3) stems and trunks = 325.00 ± 16.42 per ha; (4) tree seedling density = 315.81 ± 14.98 per ha; and (5) Shannon-Weiner diversity index of 2.16 ± 0.05 species per plot. The slope across sampled plots ranged from flat to slightly steep (<20°).

Based on our raw data, our overall naïve occupancy rate for the Sunda Clouded Leopard was relatively low (nO = 0.26). However, our estimate of null site occupancy (ψ) was more than twice as high (ψ = 0.55 ± 0.31; Table 2) as naïve occupancy, which suggests that the Sunda Clouded Leopard might use more than half of the sites in our transect. This discrepancy is probably because our estimate for null detection probability (ρ) was also very low (ρ = 0.14 ± 0.09) using this novel sampling methodology.

We also note that the precision for our null model estimate of site occupancy (ψ) was also very low, and that naïve occupancy (0.26) fell within one standard error of this estimate (0.24–0.86), albeit at the low end. Although we evaluated seven coarse-scale habitat models based on microhabitat variable we collected (Table 3), we found no evidence that these microhabitat variables significantly affected or were associated with Sunda Clouded Leopard occupancy ($p > 0.05$). Moreover, we found that all detection probability estimates for all models were low and varied very little ($0.09 < \rho < 0.15$). Therefore, based on the spotlight transect sampling approach and sample size we achieved, none of the covariates we assessed for this pilot appeared to influence detection probability (ρ).

DISCUSSION

Although our estimate of ψ (0.55) for SLFR's Sunda Clouded Leopard population was twice as much as that for naïve occupancy (nO = 0.26), we acknowledge that our sample size, even over 14 months, and our precision (± 0.31) relative to our estimate, was too low to be of practical use for monitoring or similar purposes. Unsurprisingly, all estimates of detection probability (ρ) were relatively low using this method (<0.15). Among the prominent factors that may have contributed to a low detection probability (ρ) for Sunda Clouded Leopards included the type and kind of vegetation adjacent to the road as potentially impacting observability or visibility; additionally, individual behaviour such as inter-individual

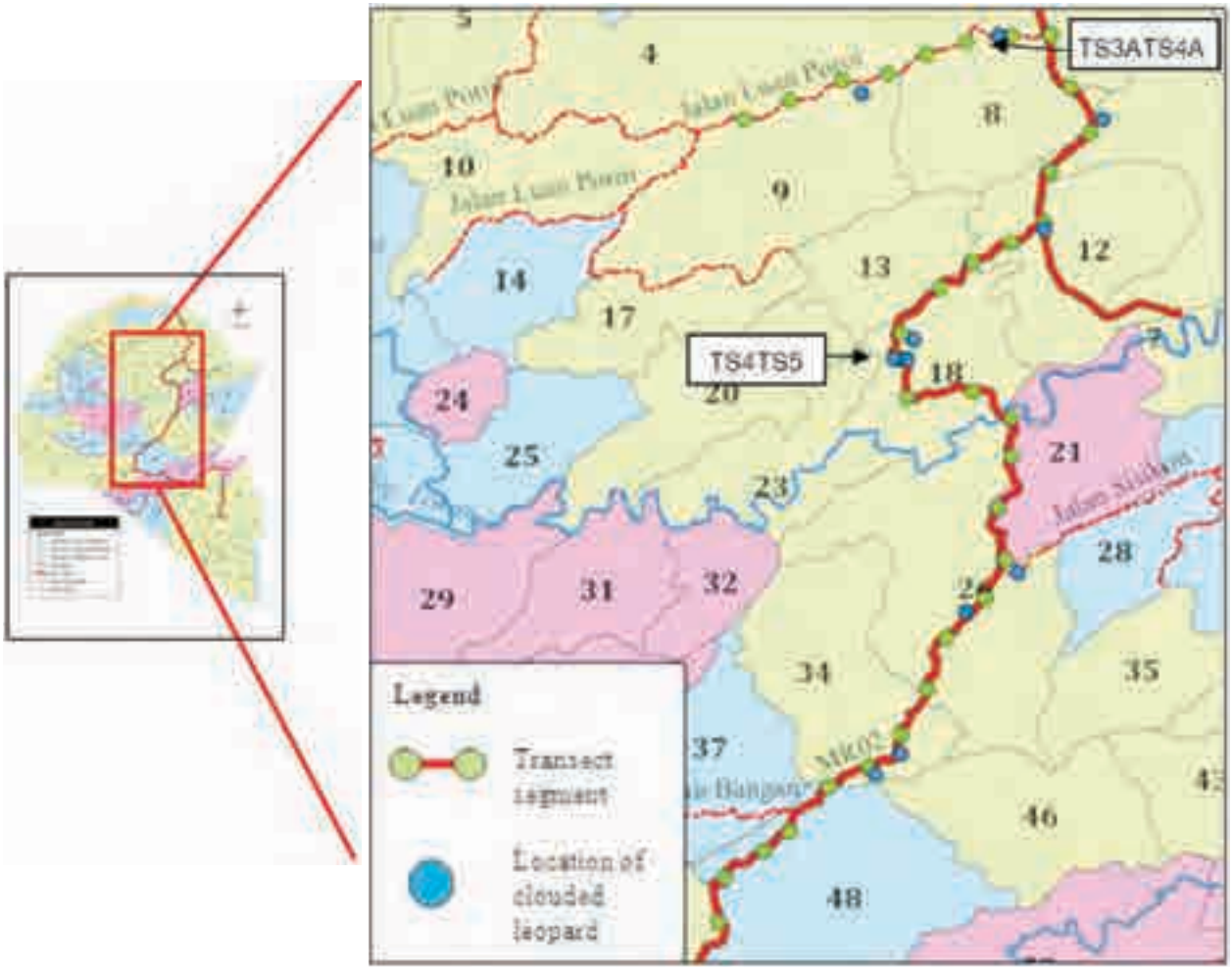


Figure 3. Location of Sunda clouded leopard observations along our 31 1-km transects.

Table 1. Habitat variables used in our investigation of Sunda Clouded Leopard occupancy in Segaliud Lokan Forest Reserve.

Habitat variables	Descriptions
Diversity of tree	Index of tree species diversity within the plot (diameter at breast height, or DBH of ≥10 cm) as calculated via the Shannon's Diversity Index.
Tree density	Tree density measured by the number of trees recorded with a DBH ≥10 cm per area.
Sapling/Seedling density	Sapling density refers to the number of trees recorded with a DBH ≤10 cm per area.
Slope	Slope measured by clinometers, and categorized as 0 (flat, 0–10˚), 1 (slightly steep, 11˚–20˚), and 2 (steep, >20˚).
Canopy closure (%)	Canopy closure % as measured using a densiometer; five canopy closure readings were taken for every transect segment.
Understory vegetation cover (%)	Estimated percentage of understory vegetation coverage, including grass, shrubs, and fern, by using visual assessment. This assessment was adapted from Chaves et al. (2016)

variability in response to vehicle noise, weather and sky conditions during and before the nights of sampling (Henschel et al. 2016) may have also played a role. Other factors that could have influenced Sunda Clouded Leopard activity and occupancy included the moon phase (Ampeng et al. 2018), and local prey availability (Bhatt et al. 2021; Ross et al. 2013). These potential covariates remain to be explored further to adapt our design, make it more efficient, and hopefully result in larger sample sizes during future surveys.

Of course, camera trapping surveys are still an optimal means to model medium-large terrestrial wildlife occupancy. However, we saw value in exploring this alternative approach at the behest of reserve management personnel given their previous and regular anecdotal observations. Based on the pilot data we collected, we think the integration of both camera trapping and vehicle transects would yield interesting comparisons for the whole area of SLFR. Increasing our

Table 2. Site occupancy parameter (ψ) estimate using vehicle transects for Sunda Clouded Leopard in Segaliud Lokan Forest Reserve, Sabah, Malaysia.

Occupancy model	K [1]	AIC [2]	ΔAIC [3]	ω [4]	ψ ± SE [5]	Estimate ± SE [6]	p-value [7]
ρ(.) ψ(Slope)	3	70.16	0.00	0.373	0.56 ± 0.31	– 0.258 ± 1.270	0.839
ρ(.) ψ(Sapling)	3	71.05	0.89	0.239	0.63 ± 0.38	0.514 ± 1.620	0.751
ρ(.) ψ(Diversity)	3	71.87	1.71	0.158	0.55 ± 0.31	0.186 ± 1.270	0.883
ρ(.) ψ(.)	2	72.69	2.53	0.105	0.55 ± 0.31		
ρ(.) ψ(Understory vegetation cover)	3	74.34	4.18	0.046	0.58 ± 0.34	– 0.343 ± 0.607	0.572
ρ(.) ψ(Density)	3	74.65	4.50	0.039	0.52 ± 0.30	– 0.490 ± 0.848	0.860
ρ(.) ψ(Canopy)	3	74.69	4.53	0.039	0.54 ± 0.30	– 0.143 ± 1.200	0.906

Note: [1] Number of parameters estimated, [2] Akaike information criterion, [3] Difference in AIC value relative to the top model, [4] AIC weight, [5] Averaged occupancy and SE values, [6] Coefficient of predictors in logit scale, and [7] significant level at 0.05.

Table 3. Detection probability (ρ) estimates using vehicle transects for Sunda Clouded Leopard in Segaliud Lokan Forest Reserve, Sabah, Malaysia.

Detection model	K [1]	AIC [2]	ΔAIC [3]	ω [4]	p ± SE [5]	Estimate ± SE [6]	p-value [7]
ρ(.) ψ(.)	2	72.69	0	0.290	0.14 ± 0.09		
ρ(Slope) ψ(.)	3	74.19	1.51	0.130	0.10 ± 0.03	– 0.320 ± 0.460	0.490
ρ(Sapling) ψ(.)	3	74.32	1.63	0.130	0.10 ± 0.03	0.240 ± 0.370	0.523
ρ(Understory vegetation cover) ψ(.)	3	74.47	1.78	0.120	0.15 ± 0.09	– 0.163 ± 0.343	0.634
ρ(Canopy) ψ(.)	3	74.49	1.80	0.120	0.14 ± 0.09	– 0.190 ± 0.430	0.662
ρ(Density) ψ(.)	3	74.52	1.84	0.110	0.14 ± 0.09	0.200 ± 0.550	0.717
ρ(Diversity) ψ(.)	3	74.68	2.00	0.110	0.09 ± 0.03	– 0.010 ± 0.460	0.982

Note: [1] Number of parameters estimated, [2] Akaike information criterion, [3] Difference in AIC value relative to the top model, [4] AIC weight, [5] Averaged detection and SE values, [6] Coefficient of predictors in logit scale, [7] significant level at 0.05.

effort during a single survey occasion, such as broadening transect coverage or using multiple survey teams, might increase the probability of detecting individual Sunda Clouded Leopards. Our pilot survey therefore serves as a starting point and provides a baseline, upon which to further develop tools for monitoring Sunda Clouded Leopards and their prey at multi-use forest plantations.

Finally, we would like to emphasise that another goal of this pilot study was that it serve as a practical, first-hand, participatory exercise for the staff of an extractive timber reserve, where selective logging still occurs today. As such, it represented the kind of experiential learning program that generally proves more effective than more traditional awareness campaigns or approaches (Higginbottom 2004). It also highlighted the challenges of using observations, however reportedly frequent based on anecdotal previous reports, as a tool for monitoring a nocturnal rainforest predator. By sharing these practical conclusions with the Sabah Wildlife and Sabah Forestry Departments, both of which had indicated an interest in our findings, we also hope we were able to better inform their own planning and decision-making as they applied these to other forest management areas.

REFERENCES

Ampeng, A., M.N. Shukor, S. Ahmad, H. Mohammad, S. Sabki, J. Liam, S. Osman, M. Bujang, A. Bujang & B.M. Mohd-Zain (2018). Preliminary findings on the activity patterns of the Clouded Leopard, *Neofelis diardi*, and its prey at Gunung Pueh National Park, Lundu, Sarawak. *Malaysian Applied Biology Journal* 47(3): 137–140.

Azlan, J.M. & D.S.K. Sharma (2006). The diversity and activity patterns of wild felids in a secondary forest in Peninsular Malaysia. *Oryx* 40(1): 1–6. https://doi.org/10.1017/S0030605306000147

Bernard, H., A.H. Amhad, J.F. Brodie, A.J. Giordano & W. Sinun (2013a). Bornean felids in and around the Imbak Canyon Conservation Area, Sabah, Malaysian Borneo. *Cat News* 58: 44–46.

Bernard, H., A.H. Ahmad, J.F. Brodie, A.J. Giordano, M. Lakim & R. Amat (2013b). Camera-trapping survey of mammals in and around Imbak Canyon Conservation Area in Sabah, Malaysian Borneo. *Raffles Bulletin of Zoology* 61(2): 861–870.

Bhatt, U., B.S. Adhikari, B. Habib & S. Lyngdoh (2021). Temporal interactions and moon illumination effect on mammals in a tropical semievergreen forest of Manas National Park, Assam, India. *Biotropica* 53(3): 831–845. https://doi.org/10.1111/btp.12917

Brodie, J.F. & A.J. Giordano (2012). Density of the Vulnerable Sunda

Image 1. Sunda Clouded Leopards recorded in Segaliud Lokan Forest Reserve during vehicle spotlight survey: a—found in TS4TS5 | b—was found in TS3ATS4A.

Clouded Leopard *Neofelis diardi* in a protected area in Sabah, Malaysian Borneo. *Oryx* 46(3): 427–430. https://doi.org/10.1017/S0030605312000087

Brodie, J.F., A.J. Giordano & L. Ambu (2015). Differential responses of large mammals to logging and edge effects. *Mammalian Biology* 80: 7–13. https://doi.org/10.1016/j.mambio.2014.06.001

Brodie, J.F., O.E. Helmy, J. Mohd-Azlan, A. Granados, H. Bernard, A.J. Giordano & E. Zipkin (2017). Models for assessing local-scale co-abundance of animal species while accounting for differential detectability and varied responses to the environment. *Biotropica* 50(1): 1–11. https://doi.org/10.1111/btp.12500

Chaves, W.A., K.E. Sieving & R.J.Jr. Fletcher (2016). Avian responses to reduce-impact logging in the southwestern Brazilian Amazon. *Forest Ecology and Management* 384: 147–156. https://doi.org/10.1016/j.foreco.2016.10.042

Cheyne, S.M. & D.W. Macdonald (2011). Wild felid diversity and activity patterns in Sabangau peat-swamp forest, Indonesian Borneo. *Oryx* 45(1): 119–124. https://doi.org/10.1017/S003060531000133X

Cheyne, S.M., D.J. Stark, S.H. Limin & D.W. Macdonald (2013). First estimates of population ecology and threats to Sunda Clouded Leopards *Neofelis diardi* in a peat-swamp forest, Indonesia. *Endangered Species Research* 22: 1–9. https://doi.org/10.3354/esr00525

Driessen, M.M. & G.J. Hocking (1992). *Review and Analysis of Spotlight Survey in Tasmania: 1975-1990.* Department of Parks, Wildlife and Heritage, Hobart.

Fritz, S.A., O.R.P. Bininda-Emonds & A. Purvis (2009). Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. *Ecology Letters* 12(6): 538–549. https://doi.org/10.1111/j.1461-0248.2009.01307.x

Gordon, C.H. & A-M.E. Stewart (2007). The use of logging roads by Clouded Leopards. *Cat News* 47: 12–13.

Haidir, I.A., Y. Dinata, M. Linkie & D.W. Macdonald (2013). Asiatic Golden Cat and Sunda Clouded Leopard occupancy in Kerinci Seblat landscape, West-Central Sumatra. *Cat News* 59: 7–10.

Hearn, A.J., J. Ross, D.W. Macdonald, G. Bolongon, S.M. Cheyne, A. Mohamed, H. Samejima, J.F. Brodie, A.J. Giordano, R. Alfred, R. Boonratana, H. Bernard, B. Loken, D.M. Augeri, M. Heydon, J. Hon, J. Mathai, A.J. Marshall, JD Pilgrim, C. Breitenmoser-Wursten, S. Kramer-Schadt & A. Wilting (2016). Predicted distribution of the

Sunda Clouded Leopard *Neofelis diardi* (Mammalia: Carnivora: Felidae) on Borneo. *Raffles Bulletin of Zoology* 33: 149–156.

Hearn, A., J. Ross, J.F. Brodie, S.M. Cheyne, I.A. Haidir, B. Loken, J. Mathai, A. Wilting & J. McCarthy (2015). *Neofelis diardi* (errata version published in 2016). The IUCN Red List of Threatened Species 2015: e.T136603A97212874. Accessed on 12 November 2022. https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T136603A50664601.en

Hearn, A.J., J. Ross, B. Henry, S.A. Bakar, B. Goossens, L.T. Hunter & D.W. Macdonald (2019). Responses of Sunda Clouded Leopard *Neofelis diardi* population density to anthropogenic disturbance: refining estimates of its conservation status in Sabah. *Oryx* 53(4): 643–653. https://doi.org/10.1017/S0030605317001065

Henschel, P., L.S. Petracca, L.T.B. Hunter, M. Kiki, C. Sewade, A. Tehou & H.S. Robinson (2016). Determine of distribution patterns and management needs in a critically endangered Lion *Panthera leo* population. *Frontiers in Ecology and Evolution* 4(110): 1–14. https://doi.org/10.3389/fevo.2016.00110

Higginbottom, K. (2004). *Wildlife Tourism: Impacts, Management and Planning*. Common Ground Publishing Pty Ltd, Australia, 301 pp.

KTS Plantation (2019). The Third Forest Management Plan (2018–2028): Segaliud Lokan Forest Reserve FMU19(B). KTS Plantation Sdn. Bhd., Sandakan.

KTS Plantation Sdn Bhd. (2015). Map of Segaliud Lokan Forest Reserve. Available online at https://www.segaliudlokan.com/

Li, X., W.V. Bleisch & X. Jiang (2018). Unveiling a wildlife haven: occupancy and activity patterns of mammals at a Tibetan sacred mountain. *European Journal of Wildlife Research* 64: 538–549. https://doi.org/10.1007/s10344-018-1213-y

MacKenzie, D.I., J.D. Nicholas, A.J. Royle, K.H. Pollock, L.L. Bailey & J.E. Hines. (2006). *Occupancy estimation and modelling: Inferring pattern and dynamics of species occurrence*. Academic Press, United State America.

Matsuda, I. & A. Tuuga & S. Higashi (2008). Clouded leopard (*Neofelis diardi*) predation on proboscis monkeys (*Nasalis larvatus*) in Sabah, Malaysia. *Primates* 49: 227–231. https://doi.org/10.1007/s10329-008-0085-2

Payne, J., C.M. Francis & K. Phillipps (1985). *Field Guide to the Mammals of Borneo*. Sabah Society, Kota Kinabalu, 332 pp.

R Development Core Team (2018). R: a language and environment for statistical computing, version 3.5.0. R Foundation for Statistical Computing, Vienna, Austria. Available online at https://www.R-project.org/

Ritchie, E.G., B. Elmhagen, A.S. Glen, M. Letnic, G. Ludwig & R.A. McDonald (2012). Ecosystem restoration with teeth: what role for predators? *Trends in Ecology and Evolution* 27(5): 265–271. https://doi.org/10.1016/j.tree.2012.01.001

Roberts, C.W., B.L. Pierce, A.W. Braden, R.R. Lopez, N.J. Silvy, P.A. Frank & D.Jr. Ransom (2006). Comparison of Camera and Road Survey Estimates for White-Tailed Deer. *The Journal of Wildlife Management* 70(1): 263–267. https://doi.org/10.2193/0022-541X(2006)70[263:COCARS]2.0.CO;2

Ross, J., A.J. Hearn, P.J. Johnson & D.W. Macdonald (2013). Activity patterns and temporal avoidance by prey in response to Sunda Clouded Leopard predation risk. *Journal of Zoology* 290(2): 96–106. https://doi.org/10.1111/jzo.12018

Yap, S.K., E. Marajan & M.R. Salim (2015). *Public summary second surveillance audit (Second cycle) on the Segaliud Lokan FMU for forest management certification*. SIRIM QAS International Sdn Bhd, Shah Alam, Selangor, 21 pp.

Sollmann, R., M. Linkie, I.A. Haidir & D.W. MacDonald (2014). Bringing clarity to the Clouded Leopard *Neofelis diardi*: first density estimates from Sumatra. *Oryx* 48(4): 536–539. https://doi.org/10.1017/S003060531400043X

Wilting, A. & A. Mohamed (2010). Wildlife surveys in Segaliud-Lokan Forest Reserve. Final Report. Retrieved from http://www.forest.sabah.gov.my/tangkulap/PDF/KTS_Final_report_ConCaSa.pd

Wilting, A., F. Fischer, S. Abu Bakar & K.E. Linsenmair (2006). Clouded Leopards, the secretive top-carnivore of South-East Asian rainforests: their distribution, status and conservation needs in Sabah, Malaysia. *BMC Ecology* 6: 16. https://doi.org/10.1186/1472-6785-6-16

Wilting, A., A. Mohamed, L.N. Ambu, P. Lagan, S. Mannan, H. Hofer & R. Sollmann (2012). Density of the Vulnerable Sunda Clouded Leopard *Neofelis diardi* in two commercial forest reserves in Sabah, Malaysian Borneo. *Oryx* 46(3): 423–426. https://doi.org/10.1017/S0030605311001694

Author details: Dr. Jephte Sompud is a senior lecturer and a researcher in Universiti Malaysia Sabah, Malaysia. He actively conducts research in wildlife science in different taxa for the conservation of many species. Ms. Sze Lue Kee is a researcher in University Malaysia Sabah. She has worked on study of birds in forest plantations. Prof. Dr Kurtis Pei Jai-Chyi is a professor at National Pintung University of Science and Technology. He is a trained zoologist and his research focuses on wildlife science. Mr. Paul Liau is a forester by profession. He is currently employed at KTS Plantation Sdn Bhd at Segaliud Lokan Forest Reserve as a planning and plantation manager. Mr. Collin Goh is the Sabah Area Officer at KTS Plantation Sdn Bhd. He oversees all forests operation and management of the companies in Sabah. Dr. Anthony J Giordano is the CEO and founder, and chief conservation officer for S.P.E.C.I.E.S., the Society for the Preservation of Endangered Carnivores and their International Ecological Study. He is a conservation biologist, wildlife ecologist, and entrepreneur with 30 years of experience working in more than as many countries around the world.

Author contributions: JS—acts as the first author of the manuscript that wrote the initial full draft of the manuscript. SLK—helped to collect the data and conducted the analysis. KPJ-C—contributed to the revision of the manuscript. PL—contributed to ensuring that all the field requirements during the study were met to allow for data collection. CG—ensured that the study was granted permission by the higher authority of the forest plantation company. AJG—contributed to editing the manuscript, and in interpreting and revising data analysis.

Malay Abstrak: Harimau Dahan Sunda Neofelis diardi di Borneo terancam yang terutamanya disebabkan oleh penebangan hutan untuk ladang kelapa sawit dan aktiviti perangkap haram. Populasi Harimau Dahan Sunda semakin berkurangan dan spesies ini telah dikategorikan sebagai mudah terdedah dalam Senarai Merah IUCN. Walaupun ancaman berterusan dan banyak tinjauan dalam beberapa tahun kebelakangan ini, namun maklumat mengenai ekologinya masih terhad. Kebanyakan kajian sehingga kini bergantung kepada penggunaan perangkap kamera sebagai alat pensampelan utama disebabkan mengumpul data tentang Harimau Dahan adalah mencabar. Kajian ini bertujuan untuk menguji kebolehlaksanaan menganggarkan Harimau Dahan Sunda menggunakan pendekatan berbeza. Kami menjalankan tinjauan transek lampu sorot kenderaan di hutan simpan guna-campuran dan konsesi pembalakan di Sabah. Kami memandu sejumlah 8,433 km transek pada waktu malam dan mendokumentasikan penemuan Harimau Dahan Sunda dalam lapan daripada 31 transek jarak jauh yang telah ditetapkan, menghasilkan kadar penghunian naif yang agak rendah (nO = 0.26). Apabila mengambil kira pengesanan tidak sempurna (ρ = 0.15), penghunian null Harimau Dahan Sunda kelihatan jauh lebih tinggi (Ψ = 0.55), walaupun anggaran parameter tidak mempunyai ketepatan relatif. Walaupun begitu, keputusan kami mencadangkan mungkin terdapat potensi untuk memperhalusi dan menyesuaikan pendekatan pemantauan asas dan kos efektif dalam rizab penggunaan campuran tempatan dengan bantuan pengurus konsesi dan penambahbaikan tambahan untuk reka bentuk kajian. Walaubagaimanapun, adalah ditekankan bahawa tidak kesemua tapak kajian mungkin bersesuaian dengan jenis pendekatan ini dan sangat menasihati pembangunan kajian rintis untuk menilai kebolehlaksanaan keseluruhannya.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22567–22573

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

https://doi.org/10.11609/jott.8082.15.2.22567-22573

#8082 | Received 30 June 2022 | Final received 11 January 2023 | Finally accepted 06 February 2023

OPEN ACCESS

COMMUNICATION

On the occurrence of Eurasian Otter *Lutra lutra* (Carnivora: Mustelidae) in Neeru stream of Chenab catchment, Jammu & Kashmir, India

Dinesh Singh [1], Anil Thakar [2] & Neeraj Sharma [3]

[1–3] Institute of Mountain Environment, Bhaderwah Campus, University of Jammu, Union territory of Jammu & Kashmir 182222, India.
[1] itzmed12@gmail.com, [2] anilenv0@gmail.com, [3] nirazsharma@gmail.com (corresponding author)

Abstract: This communication reports the first photographic record of Eurasian Otter *Lutra lutra* in a hill stream in Jammu & Kashmir, putting an end to doubts over its presence in the upper Chenab catchment. Three individuals were photographed during a limited camera trap survey conducted in Neeru stream, a left bank tributary of river Chenab during mid-October 2020. We argue that rapid human population influx, infrastructure expansion, and pollution have altered the hydro morphology of Neeru stream, affecting the otter population. This observation calls for more intensive otter surveys in the nearby smaller basins of Neeru, Kalnai, & Sewa and other large tributaries of Chenab River, combining occupancy surveys with camera traps for improved conservation and management of the species in the region.

Keywords: Camera trap, dense escape cover, flagship species, hill stream, holts and dens, semi-aquatic mammal, retaliatory killings, shore vegetation.

خلاصہ: یہ مواصلات جموں وکشمیر میں ایک پہاڑی ندی میں یوریشین اوٹر (لوٹرا لوٹر ا) کے پہلے فوٹو گرافیک ریکارڈ کی اطلاع دیتاہے، جس سے بالائی کھتہ چناب میں اس کی موجودگی پر شکوک وشبہات کا خاتمہ ہوتاہے۔اکتوبر 2020 کے وسط میں نیرو ندی میں منعقد کی گئی ایک محدودہ کیمرہ ٹریپ سروے کے دوران اوٹرکے تین افراد کی تصویر لی گئی ۔ ہم یہ دلیل دیتے ہیں کہ تیزی سے انسانی آبادی کی آمد ،انفراسٹریکچر کی توسیع اور آلودگی نے نیرو ندی کی آبی شکل وصورت کو تبدیل کردیا ہے، جس سے اوٹر کی آبادی متاثر ہورہی ہے۔ اس مشاہدے میں نیرو، کلنائی، سیوا اور دریائے چناب کی دیگر بڑی معاون ندیوں میں زیادہ گہرے اوٹر سروے کا مطالبہ کیا گیا ہے اور اس کے علاوہ اوٹرپرجاتی کے بہتر تحفظ اور انتظام کے لیے کیمرہ ٹریپس کے ساتھ ساتھ ا کوپنسی سروے کو بھی ترجیح دی جائے ۔

Editor: Honnavalli N. Kumara, Salim Ali Centre for Ornithology and Natural History, Coimbatore, India. **Date of publication:** 26 February 2023 (online & print)

Citation: Singh, D., A. Thakar & N. Sharma (2023). On the occurrence of Eurasian Otter *Lutra lutra* (Carnivora: Mustelidae) in Neeru stream of Chenab catchment, Jammu & Kashmir, India. *Journal of Threatened Taxa* 15(2): 22567–22573. https://doi.org/10.11609/jott.8082.15.2.22567-22573

Copyright: © Singh et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The surveys were partly funded by Department of Wildlife Protection, Govt. of Jammu and Kashmir.

Competing interests: The authors declare no competing interests.

Author details: Dr. Dinesh Singh is a lecturer in the Faculty of Life Sciences, Institute of Mountain Environment (IME), Bhaderwah Campus, University of Jammu. He received a doctorate for his work on 'Ecological attributes and vegetation responses to environmental variables in upper Bhaderwah Valley, J&K' in 2019. Aside from his interest in alpine vegetation and flora, he has contributed to the exploration of other animal groups in the region, including mammals, birds, odonata, and butterflies. Mr. Anil Thakar is a junior research fellow in NMHS sponsored project on 'Himalayan alpine biodiversity characterization and information system network'. Dr. Neeraj Sharma is an assistant professor in the Faculty of Life Sciences in IME, Bhaderwah Campus where he is actively involved in research on high altitude biodiversity, wildlife ecology, riparian ecology, avian ecology, and hill stream dynamics, as well as scientific outreach and extension on different facets of mountain environment. Besides investigating the externally aided projects on biodiversity monitoring and assessment in the region, he is actively engaged in guiding Ph.D students and research interns.

Author contributions: Dinesh Singh conducted the field surveys, camera trapping, data analysis and drafted the manuscript; Anil Thakar helped in camera trapping, data collection, analysis, and writing the manuscript; Neeraj Sharma conceptualized, designed, and executed the surveys, assisted first author in writing and editing the manuscript, and communicated with the journal.

Acknowledgements: Authors are thankful to Rector, Bhaderwah Campus, University of Jammu and Head, Department of Environmental Sciences, University of Jammu for their administrative support. The Department of Wildlife Protection, Govt. of Jammu and Kashmir is duly acknowledged for its unwavering support and patronage in conducting such explorations in the region. Muzaffar Ahmed, Asha Sohil, Vandana Dutt, Aasma Sharma and Ajaz Ansari are thanked for their help in field surveys.

INTRODUCTION

Otters, the semi-aquatic mammals of the family Mustelidae with seven genera and 13 species are found in every continent except Australia and Antarctica. Eurasian Otter *Lutra lutra,* a European and Asian member of the Otter subfamily *Lutrinae* is an elusive, solitary species with the largest range of any palearctic mammal covering parts of three continents: Europe, Asia, and Africa (Corbet 1996). Seven subspecies of Eurasian Otter (Bhattacharya et al. 2019) include *L.l. nair* (Cuvier, 1823) found in southern India, Sri Lanka, Nepal, Bhutan, & Myanmar; *L.l. kutab* (Schinz, 1844) in northern India—Kashmir; *L.l. aurobrunneus* (Hodgson, 1839) in Garhwal Himalaya & higher altitudes in Nepal; *L.l. monticolus* (Hodgson, 1839) in Himachal Pradesh, Sikkim, & Assam; *L.l. barang* (Cuvier, 1823) in southeastern Asia (Thailand, Indonesia, & Malaysia); *L.l. chinensis* (Gray, 1837) in southern China & Taiwan, and *L. l. lutra* (Linnaeus, 1758) in Europe & northern Africa. In India, it occurs in the north (Ladakh, Jammu & Kashmir, Himachal Pradesh, Uttarakhand), northeast (largely in Himalayan foothills), central (Madhya Pradesh), east (Odisha), and southern India covering parts of Kerala, Tamil Nadu, Karnataka, & Andhra Pradesh (Hussain 1993; Prater 1998). The species has been recorded from the northern mountains of Pakistan, Punatshanghchu basin of Bhutan (Yoxon & Yoxon 2019), and Nepal (Basnet et al. 2019; Shrestha et al. 2021).

Eurasian Otter is regarded as a flagship species and indicator of high-quality aquatic habitats (Macdonald & Mason 1994; Cianfrani et al. 2011) that obtains all its food from aquatic systems (Clavero et al. 2003; Krawczyk et al. 2016). They inhabit a wide variety of aquatic habitats, including highland and lowland lakes, rivers, marshes, streams, swamp forests, and coastal areas (Mason & Macdonald 1986). They occupy cold Himalayan streams and rivers, much like their temperate cousins across Europe and Asia (Prakash 2022), reaching 3,660 m in the Himalaya during summers (Prater 1971). Most of the animal activity is restricted to a narrow land-water interface (Kruuk et al. 1994), as they prefer swiftly flowing upper river sections (Kruuk 1995) which coincides with the upward migration of the carp and other fish spawning.

The species is classified as 'Near Threatened' (Loy et al. 2022) on the IUCN Red List and is listed in Appendix I of CITES (CITES 2023). The species became extinct in Japan in 1979 (Roos et al. 2015; Waku et al. 2016) and its populations in Europe and developing Asian countries have drastically declined in recent years (Balestrieri et al. 2016; Jha et al. 2020). The species is still hunted for their pelt, food, sport, and persecuted as a pest in many Asian countries, particularly China, India, and Nepal (Gomez et al. 2016). Along with habitat loss and pollution, climate change is a major cause of their declining population (Gomez et al. 2016; Gupta et al. 2020). After a catastrophic drop, otters are making a comeback across Europe (Loy et al. 2009, 2010; Romanowski et al. 2013), and other regions possibly as a result of legal protection and the ban on Polychlorinated biphenyls (Loy et al. 2015).

The Indian Otter population is severely fragmented across its distribution range, with isolated populations primarily confined to protected areas (Hussain 1999; Nawab 2007, 2009; Nawab & Gautam 2008) and high-altitude riverine ecosystems in the Indian Himalayan region (Pal et al. 2021). It has so far been reported from Nayamjang Chu River, Arunachal Pradesh (Bhattacharya et al. 2019), forests of Madhya Pradesh including Balaghat forest circle (Jena et al. 2016) and Satpura Tiger Reserve (Joshi et al. 2016), Periyar Tiger Reserve in Kerala & Kalakkad Mundanthurai Tiger Reserve, Tamil Nadu (Raha & Hussain 2016), Bhagirathi basin, Uttarakhand (Pal et al. 2021), and Sundargarh forest division, Odisha (Palei et al. 2022). The species was reported to occur in the Jammu & Kashmir divisions of the Union Territory of Jammu & Kashmir (Ahmad et al. 2020). Jamwal et al. (2016) and Shawl et al. (2008) confirmed its presence in Indus and its tributaries in Ladakh. Following the credible accounts of its historical presence in Neeru stream, researchers from the Institute of Mountain Environment, Bhaderwah conducted extensive investigations that included questionnaire surveys, direct surveys, and camera trapping including a joint sign survey in collaboration with Wild Otters Research Private Limited during July 2019. The current communication describes the first photographic record of this elusive semi-aquatic animal in Neeru stream.

MATERIAL AND METHODS

Study area

The study area is characterized by typical mountainous terrain comprised of high mountains, wide valleys, cliffs and gorges, and vast alpine meadows. The region is drained by Neeru stream, a 30-km long linear hydro-morphological unit (Image 1) that originates in Kailash Lake (3,900 m) and drains into the Chenab River at Pul-Doda (848 m). The perennial stream contributed by 13 major tributaries flows through a number of

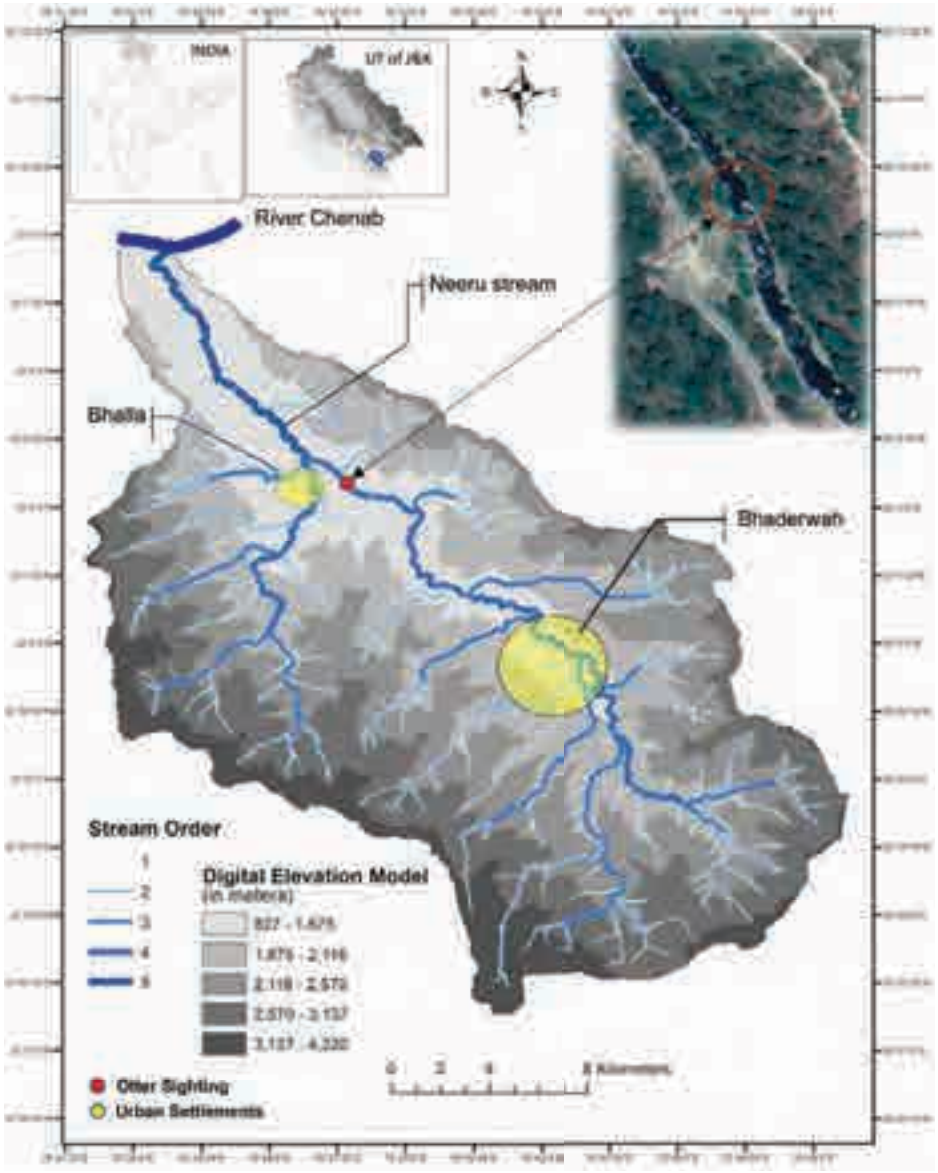


Image 1. Digital elevation map of the Neeru watershed showing the location of the Otter sighting (reference Google Earth image inset), drainage pattern, and major townships

small villages, semi-urban, and urbanised areas, with Bhaderwah being the largest settlement (Image 1). The region is distinguished by its usual cold climate, with short summers and long dry winters. The temperature varies with seasons and elevation and reaches sub-zero during the winters. Precipitation is largely determined by topography, ranging from 1,750 mm at lower and intermediate altitudes (<1,500 m) to 800 mm over 2,000 m. The vegetation varies from sub-temperate scrub at lower elevations to pure conifers and broad leaved-conifer mixed at the mid, and spruce-fir and kharsu oak at higher elevations marking the tree line.

Field data collection

We conducted a questionnaire survey in the upper Neeru stretch during 2016 and 2017 and found evidence of their historical presence. Following that, we initiated primary surveys for direct and indirect sightings looking for fresh sign (tracks; scats/spraints; evidence of foraging like remains of animal prey, especially, fish scales or bones and cartilages) lodging and dens (Gallant et al. 2008; Crimmins et al. 2009; Lesmeister & Nielsen 2011; Schooley et al. 2012) along the main channel and its major tributaries during 2019–2021. Although we were unable to establish a direct sighting, we were able to locate a few latrines in 2020. Subsequently, we deployed

five infra-red cameras at three probable locations like the mouth of dens, trails leading to dens, and stream banks near the latrine sites. The cameras were placed roughly 100 m apart and were retained in the field for five days from 17 to 21 October 2020.

RESULTS

The questionnaire surveys of 2016–17 indicated that otters inhabited along the whole length of the Neeru stream and all of its tributaries. The animal is locally known as 'Huder' or 'Hud'. According to the majority of respondents, the fish-eating animals resemble mongooses with a somewhat greyer coat and bigger stature. When foraging, most people described the sinuous up and down movement of a swimming otter, that scans its surroundings with just its head above water. To ascertain the presence of the animal, the surveys were conducted in July 2019, October 2020 and August 2021. On 15 October 2020, the team spotted a latrine mound with dark, greasy poop at the mouth of the holt near Bhalla (33.060 °N to 75.626°E, 1,240 m). Five camera traps were deployed at three sites which appeared to us as the probable dens of the otters. While sites 1 and 2 yielded no results, Site-3, the mouth of the den housing the latrine site, captured many photographs of two adults and one sub-adult (Image 2), confirming its presence. On 28 August 2021, while re-exploring the site, the team discovered scratches and marks in a nearby narrow crevice that was presumably used for resting and grooming (Image 3).

The species was identified as a Eurasian Otter *Lutra lutra* based on a dark brown dorsal coat with a pale silvery tinge on the neck, rounded head with stiff white vibrissae around the muzzle, semi-webbed feet with discernible toes, elongated body, and dorsoventrally flattened tail (Hussain 2013; Menon 2014). Most of the images were captured during the early morning. The location of otter sighting is characterised by a small

Image 2. Camera trap images of Eurasian Otter *Lutra lutra*: 1–3—adults | 4—sub-adult.

Image 3. Eurasian Otter signs in a shallow crevice likely used as a resting site: 5—pug | 6—scratch marks.

undisturbed narrow section of the stream with rocky banks, deep caves and crevices and shore vegetation comprising young stands of *Alnus nitida* making up the bulk of the riparian vegetation and *Pinus roxburghii* along the upper dry slopes. The stream is home to *Schizothorax richardsonii* and *Glyptosternum reticulatum,* the former being abundant and most relished fish in the region.

DISCUSSION

A considerable decline in the otter population in the Neeru stream over the past two decades, as indicated in the questionnaire surveys, raises concerns about the changing ecological dynamics of the stream. The sole sighting of the family, however, raised hope of the species existence and survival in the region. Since their presence goes unrecognised due to their secretive, solitary, and nocturnal habits (Pal et al. 2021), our limited survey does not rule out the presence of otter in other sections of the main channel and that of tributaries those are pristine. Though the otters have wide habitat preferences in terms of where they live, swim, hunt, and raise their young (Kruuk 1995; Reid et al. 2013), their preferred habitat is much more specific (Anoop & Hussain 2004). River topography affects the prey availability and consequently the distribution of otters. Otters largely prefer shallow braided river channels with shallow depth, moderate current, patches of muddy and sand substrate on the shoreline, and dense escape cover of vegetation in riparian habitats (Hussain & Choudhury 1997; Anoop & Hussain 2004; Acharya et al. 2010; Romanowski et al. 2013). Neeru being a typical hill stream offer but limited habitat conditions with rocky banks, deep crevices, thin sand shoulders, dense escape cover, and steep slopes. Several studies confirmed that otters avoid polluted water and persist in low-anthropogenic landscapes (Romanowski et al. 2013; Calzada et al. 2022) though in low numbers (Baltrūnaitė et al. 2009). Bhaderwah, a popular tourist destination over the years has experienced extensive urbanisation and infrastructure development, resulting in degraded surface water quality of Neeru stream over its whole course (Kumar et al. 2019, 2022). The stream serves as a sink for urban wastes, notably the plastic trash that penetrates crevices and holts during floods and clogs them. Stream bed mining for construction materials fragments habitats hence threatening their existence. Jenkins & Burrows (1980) and Macdonald & Mason (1983) revealed that poor-quality habitats are occasionally visited by otters. Several incidents of retaliatory killings, poaching, and predation by feral dogs have been reported by the locals during the interactions. Having established its presence, the study urges continued investigations on the species to better understand their distribution, ecology, and threat status as well as to develop appropriate conservation and management plans for its survival in the region.

REFERENCES

Acharya, P.M., P. Lamsal, S.L. Rajbhandari, P. Shrestha, D. Neupane, M. Pathak, M. Niraula, H.M. Lama & B. Lama (2010). Status and distribution of otters in Narayani River, Chitwan National Park. A first phase research report submitted to Rufford Foundation, U.K. 52 pp.

Ahmad, Z., H. Chaudhry, H. Ali, R. Atiq-ur, S.R. Ahmad, U. Ashraf, N. Nisar & A. Tahir (2020). Suitable habitat evaluation of Eurasian Otter (*Lutra Lutra*) In Khyber Pukhtunkhwa, Pakistan. *Transylvanian Review* 18: 4755–4766.

Anoop, K. & S. Hussain (2004). Factors affecting habitat selection by smooth-coated otters (*Lutra perspicillata*) in Kerala, *India. Journal of Zoology* 263(4): 417–423. https://doi.org/10.1017/S0952836904005461

Balestrieri, A., S. Messina & F. Pella (2016). Eurasian otter *Lutra lutra* in developing countries: a resurvey of Albania 22 years after the fall

of communism. *Oryx* 50: 368–373. https://doi.org/10.1017/S0030605314000921

Baltrūnaitė, L., L. Balčiauskas, R. Matulaitis & V. Stirkė (2009). Otter distribution in Lithuania in 2008 and changes in the last decade. *Journal of Ecology* 58: 94–102.

Basnet, A., B.S. Bist, P. Ghimire & P.M. Acharya (2019). Eurasian Otter (*Lutra lutra*): Exploring evidence in Nepal. *IUCN Otter Specialist Group Bulletin*. 36(3): 29–37. https://www.iucnosgbull.org/Volume37/Basnet_et_al_2020.html

Bhattacharya, M., T. Watham & G.V. Gopi (2019). Photographic Records of Eurasian Otter (*Lutra lutra* Linnaeus, 1758) from Nyamjang Chu River, Arunachal Pradesh, India. *IUCN Otter Specialist Group Bulletin* 36(2): 103–109.

Calzada, J., M. Clavero, M. Delibes & N. Fernández (2022). Human pressures constrain Eurasian otter occurrence in semiarid Northern Africa. *Biodiversity and Conservation* 31: 1519–1533. https://doi.org/10.1007/s10531-022-02405w

Cianfrani, C., G. Le Lay, L. Maiorano, H.F. Satizabal, A. Loy & A. Guisan (2011). Adapting global conservation strategies to climate change at the European scale: the otter as a flagship species. *Biological Conservation* 144: 2068–2080

CITES (2023). Convention on International Trade in Endangered Species of Wild Fauna and Flora. Appendices I, II and III https://cites.org/eng/app/appendices.php

Clavero, M., J. Prenda & M. Delibes (2003). Trophic diversity of the otter (*Lutra lutra* L.) in temperate and Mediterranean freshwater habitats. *Journal of Biogeography* 30: 761–769. https://doi.org/10.1046/j.1365-2699.2003. 00865.x

Corbet, G.H. (1996). *The Terrestrial Mammals of Western Europe*. Foulis, London, 200 pp.

Crimmins, S., M. Roberts, D.A. Hamilton & A.R. Mynsberge (2009). Seasonal detection rates of river otters (*Lontra canadensis*) using bridge-site and random-site survey. *Canadian Journal of Zoo*logy 87: 993–999.

Gallant, D., L. Vasseur & C.H. Bérubé (2008). Evaluating bridge ability to detect river otter *Lontra canadensis* presence: a comparative study. *Wildlife Biology* 14: 61–69.

Gomez, L., B.T.C. Leupen, M. Theng, K. Fernandez & M. Savage (2016). Report on Illegal otter trade: An analysis of seizures in selected Asian countries (1980–2015)- Summary. *IUCN Otter Specialist Group Bulletin* 34(2): 104–114.

Gupta, N., M. Everard, V. Tiwari, M.A. Chadwick, A. Nawab & S.A. Hussain (2020). The potential role of social media in support of otter conservation in the Indian Himalayan biodiversity hotspot. *OTTER, Journal of the International Otter Survival Fund* 6(1&2): 40–48.

Hussain, S.A. (1993). Aspects of the ecology of smooth-coated Indian Otter *Lutra perspicillata* in National Chambal Sanctuary. Ph.D. Thesis, Aligarh Muslim University, Aligarh, 206 pp.

Hussain, S.A. (1999). Status of otter conservation in India. *Environmental Information System Network Bulletin* on Wildlife and protected Areas. Wildlife Institute of India 2(2): 92–97.

Hussain, S.A. (2013). Otters, pp. 392–415. In: Johnsingh, A.J.T. & N. Manjrekar (eds.). *Mammals of South Asia*, Volume 1. Universities Press, India, 694 pp.

Hussain, S.A. & B.C Choudhury (1997). Distribution and status of the Smooth-coated Otter (*Lutrogale perspicillata*) in National Chambal Sanctuary, India. *Biological Conservation* 80(2): 199–206.

Jamwal, PS., J. Takpa, P. Chandan & M. Savage (2016). First Systematic Survey for Otter (*Lutra lutra*) in Ladakh, Indian Trans Himalayas. *IUCN Otter Specialist Group Bulletin* 33(1): 79–85.

Jena, J., D. Bhargava, J. Borah & S. Dey (2016). On the occurrence of the Eurasian Otter (*Lutra lutra* L.) in the forest of Balaghat, Madhya Pradesh, India. *IUCN Otter Specialist Group Bulletin* 33: 59–63.

Jenkins, D & G.O. Burrows (1980). Ecology of otters in northern Scotland. III. The use of faeces as indicators of otter (*Lutra lutra*) density and distribution. *Journal of Animal Ecology* 49(3): 755–774.

Jha, R.R., T. Silwal & G.M. Yoxon (2020). Status of otters in Nepal: a link with ancient waterways and people, pp. 409–418. In: Regmi, G. & F. Huettmann (eds.). *Hindu Kush-Himalaya Watersheds Downhill: Landscape Ecology and Conservation Perspectives*. Springer, Cham.

Joshi, A.S., V.M. Tumsare, A.K. Nagar, A.K. Mishra & M.P. Pariwakam (2016). Photographic Records of Eurasian Otter *Lutra lutra* from the Central Indian Landscape. *IUCN Otter Specialist Group Bulletin* 33(2): 73–78.

Krawczyk, A.J., M. Bogdziewicz, K. Majkowska & A. Glazaczow (2016). Diet composition of the Eurasian otter *Lutra lutra* in different freshwater habitats of temperate Europe: a review and meta-analysis. *Mammalian Review* 46: 106–113. https://doi.org/10.1111/mam.12054

Kruuk, H. (1995). Wild Otters: Predation and Populations. Oxford University Press, Oxford, 290 pp.

Kruuk, H., B. Kanchanasaka, S. O'Sullivan & S. Wanghongsa (1994). Niche separation in three sympatric otters *Lutra perspicillata*, *L. lutra* and *Aonyx cinerea* in Huai Kha Khaeng, Thailand. *Biological Conservation* 69: 115–120.

Kumar, R., A. Raina & N. Sharma (2019). Dataset on water quality characteristics of hill stream in Bhaderwah, Jammu and Kashmir. *Data in brief* 26: 2352–3409. https://doi.org/10.1016/j.dib.2019.104462

Kumar, R., V. Dutt., A. Raina & N. Sharma (2022). Spatial water quality assessment of a mountain stream in north-western India using multivariate statistical techniques. *Environmental Monitoring and Assessment* 194: 785. https://doi.org/10.1007/s10661-022-10386-0

Lesmeister, B.D. & C.K. Nielsen (2011). Protocol for Large-Scale Monitoring of Riparian Mammals. *Wildlife Biology in Practice* 7(2): 55-70.

Loy, A., A. Balestrieri, R. Bartolomei, L. Bonesi, M. Caldarella, G. De Castro, L. Della Salda, E. Fulco, R. Fusillo, P. Gariano, F. Imperi, F. Iordan, L. Lapini, L. Lerone, M. Marcelli, M. Marrese, M. Pavanello, C. Prigioni & D. Righetti (2015). The Eurasian Otter (*Lutra lutra*) in Italy: distribution, trend and threats. *Proceedings of European Otter Workshop* 32C: 9–10.

Loy, A., A. Kranz, A. Oleynikov, A. Roos, M. Savage & N. Duplaix (2022). *Lutra lutra* (amended version of 2021 assessment). The IUCN Red List of Threatened Species 2022: e.T12419A218069689. Accessed on 10 February 2023. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T12419A218069689.en

Loy A., L. Boitani, L. Bonesi, A. Canu, A. Di Croce, P.L. Fiorentino, P. Genovesi, L. Mattei, M. Panzacchi, C. Prigioni, E. Randi & G. Reggiani (2010). The Italian action plan for the endangered Eurasian otter *Lutra lutra*. *Hystrix*. 21: 19–33. https://doi.org/10.4404/hystrix-21.1-4483

Loy A., M.L. Carranza, C. Cianfrani, E. D'Alessandro, L. Bonesi, P. Di Marzio, M. Minotti & G. Reggiani (2009). Otter *Lutra lutra* population expansion: assessing habitat suitability and connectivity in southern Italy. *Folia Zoologica-Praha* 58: 309–326.

Macdonald, S.M. & C.F. Mason (1983). Some factors influencing the distribution of otters *Lutra lutra. Mammal Review* 13: 1–10.

Macdonald, S.M. & C.F Mason (1994). Status and Conservation Needs of the Otter (*Lutra lutra*) in the Western Palaearctic, Nature and environment series 67(18). Council of Europe.

Mason, C.F. & S.M. Macdonald (1986). Otters. Ecology and Conservation. Cambridge University Press, Cambridge, 248 pp.

Menon, V. (2014). *Indian Mammals: A Field Guide.* Hachete India, Gurgaon, 528 pp.

Nawab, A. (2007). Ecology of Otters in Corbett Tiger Reserve, Uttarakhand; India. PhD Thesis, Forest Research Institute, Dehradun, India.

Nawab, A. (2009). Aspects of the ecology of Smooth–coated Otter *Lutrogale perspicillata* Geoffroy St. Hilaire, 1826: A Review. *Journal of Bombay Natural History Society,* 106(1): 5–10.

Nawab, A. & P. Gautam (2008). Living on the edge: Otters in developing India. In: Wetlands–The Heart of Asia. *Procedings of the Asian Wetland Symposium* 106(1): 14.

Pal, R., A. Sharma, V.K. Dubey, T. Bhattacharya, J.A. Johnson, K. Sivakumar & S. Sathyakumar (2021). A rare photographic record of Eurasian Otter *Lutra lutra* with a note on its habitat from the Bhagirathi Basin, western Himalaya, India. *Journal of*

Threatened Taxa 13(13): 20072–20077. https://doi.org/10.11609/jott.6937.13.13. 20072-20077

Palei, N.C., H.S. Palei, S. Rath, B.P. Rath & A.K. Mishra (2022). Photographic record of Eurasian Otter *Lutra lutra* (Linnaeus, 1758) in Odisha, India. *IUCN Otter Specialist Group Bulletin* 39(2): 102–109.

Prakash, N. (2022). Let the River Run: Smooth-coated Otters on the Cauvery. Downloaded on 23 May 2022. https://roundglasssustain.com/photo-stories/smooth-coated-otter

Prater, S.H. (1971). *The book of Indian animals* Eleventh impression, Bombay Natural History Society. Oxford University Press, Calcutta.

Prater, S.H. (1998). *The Book of Indian Animals. Eleventh impression*. *Bombay Natural History Society.* Oxford University Press, Calcutta, Chennai, Delhi, Mumbai.

Raha, A. & S.A Hussain (2016). Factors affecting habitat selection by three sympatric otter species in the southern Western Ghats, India. *Acta Ecologica Sinica* 36: 45–49.

Reid, N., D. Thompson, B. Hayden, F. Marnell & I. Montgomery (2013). Review and metanalysis of diet suggest the Eurasian Otter (*Lutra lutra*) is likely to be a poor bioindicator. *Ecological indicators* 26: 5–13. https://doi.org/10.1016/j.ecolind.2012.10.017

Romanowski, J., M. Brzezinski & M. Zmihorski (2013). Habitat correlates of the Eurasian Otter recolonizing central Poland. *Acta Theriologica* 58: 149–155. https://doi.org/10.1007/s13364-012-0107-8

Roos, A., A. Loy, P. De Silva, P. Hajkova & B. Zemanová (2015). *Lutra*. The IUCN Red List of Threatened Species. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12419A21935287.en

Schooley, R., L.A. Cotner, A.A. Ahlers, E.J. Heske & J.M. Levengood (2012). Monitoring site occupancy for American mink in its native range. *Journal of Wildlife Management* 76: 824–831.

Shawl, T., J. Takpa., T. Phuntsog & Y. Panchaksharam (2008). Field Guide: Mammals of Ladakh. New Delhi: WWF-India, 108 pp.

Shrestha, M.B., G. Shrestha, S. Reule, S. Oli, T.B. Ghartimagar, G. Singh, D.M. Tripathi, C.J. Law, K.B. Shah & M. Savage (2021). First Evidence of Eurasian Otter in Nepal in Three Decades *International Union for Conservation of Nature Otter Specialist Group Bulletin* 38 (5): 279–291.

Waku, D., T. Segawa, T. Yonezawa, A. Akiyoshi, T. Ishige & Ueda (2016). Evaluating the Phylogenetic Status of the Extinct Japanese Otter on the Basis of Mitochondrial Genome Analysis. *PLoS ONE* 11(3): e0149341. https://doi.org/10.1371/journal.pone.014934

Yoxon, P. & B. Yoxon (2019). Eurasian Oter (*Lutra lutra*): A review of the current world status. Otter. *Journal of the International Otter Survival Fund* 5: 5–37.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22574–22585
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.8112.15.2.22574-22585
#8112 | Received 23 July 2022 | Final received 02 February 2023 | Finally accepted 23 February 2023

COMMUNICATION

Distribution of avifauna on twenty-one islands of the Gulf of Mannar Biosphere Reserve, India

H. Byju [1], N. Raveendran [2] & S. Ravichandran [3]

[1,3] Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu 608502, India.
[2] Iragukal Amritha Nature Trust, 61, Ramachandra Thadaga street, Thirumangalam, Madurai, Tamil Nadu 625706, India.
[1] byjuhi@gmail.com (corresponding author), [2] Iant.ravee@gmail.com, [3] sravicas@gmail.com

Abstract: Every research endeavour must start with closing the information gap about species distribution and biodiversity systematically. Even though enough avifaunal research has been done on the Gulf of Mannar, southeastern India, there have been limited studies about the avifauna from all 21 islands except two. Increasing species occurrence data on distribution from all the islands is highlighted for the future conservation plans for this Important Bird Area. We provide an updated and detailed checklist and distribution of bird groups for all islands individually from a sampling period of 2015–2022. A total of 96 bird species belonging to 34 families from 13 orders were recorded from all the islands; of which 58 species were waterbirds and other terrestrial ones. Of the 29 shorebird species recorded, one is Endangered and seven are Near Threatened by IUCN Red List. Some of the earlier recorded species, not seen in our survey, are not annotated as no record exists for the last decade.

Keywords: Central Asian Flyway, conservation, Gulls, shorebirds, terns, waterbirds.

Editor: C. Srinivasulu, Osmania University, Hyderabad, India. **Date of publication:** 26 February 2023 (online & print)

Citation: Byju, H., N. Raveendran & S. Ravichandran (2023). 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

Copyright: © Byju et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: None.

Competing interests: The authors declare no competing interests.

Author contributions: HB—designing and planning the work and writing; NR—designing and planning, writing; SR—writing.

Acknowledgements: We thank the entire team of the Gulf of Mannar Wildlife department and the Wildlife Wardens who served during the study period and facilitated and allowed us to do the work during the entire period. The boat operators and the support team including S Chandrasekharan, Abhishek, and veterinarian Ravi need to be specially mentioned. Our sincere gratitude to Dr. S. Balachandran of BNHS for guidance in many field visits and for vetting the list of birds. We also thank the anonymous reviewers and the editor for improving the manuscript.

INTRODUCTION

Bird surveys are valuable for learning about basic and applied ecology as well as for selecting conservation priority areas (Daniels et al. 1991; Peterson et al. 2000). To our knowledge, only two of the 21 islands in the Gulf of Mannar (GoM) has professional bird checklists (Balachandran 1990). One of the crucial requirements for determining a country's real wealth is to monitor its biodiversity. Monitoring of biodiversity can be used to assess the overall health of the ecosystem and is a cost-effective technique to keep track of all the good and negative changes that occur in biotic groups. Coastal wetlands' stability, health, and variability are frequently revealed by the status and distribution of coastal birds. The structural and functional components of an ecosystem can alter in a way that makes birds vulnerable. The primary elements that frequently determine the diversity and density of bird populations are food, shelter, and human disturbance (Ramesh & Ramachandran 2005).

With 10 distinctly different biogeographical zones and many different habitat types, India is known among the top 12 mega biodiversity countries supporting 1,348 bird species (Praveen & Jayapal 2022), constituting about 12% of the world's avifauna. The Indian subcontinent harbours 1,419 species of birds. Out of the bird species found in India, 310 species rely on wetlands (Kumar et al. 2005; Praveen et al. 2020; Praveen & Jayapal 2022). India remains in the core central region of the Central Asian Flyway (CAF) and holds some important wintering populations of water bird species. Among the global flyways of migration, the CAF supports 257 species of waterbirds. Of these, 81 species are migratory birds of CAF conservation concern, including three Critically Endangered species, six Endangered species, and 13 Near Threatened species. Being part of one of the key biodiversity hotspots in the world, the Gulf of Mannar Biosphere Reserve (GoMBR) is one of the important habitats for the coastal birds migrating as far as the Arctic circle. About 187 species of aquatic and terrestrial birds have been identified in this Important Bird Area (IBA) (Balachandran 1990, 1995), which is famous for waders and seabirds (marine terns and gulls) where sometimes >50,000 water birds are found including pelagic ones (Balachandran 1990). Its proximity to Sri Lanka makes this IBA an important site along the CAF for both migratory water birds and passerines (Zafar & Rahmani 2003). The area is of particular significance as these islands also serve as resting places for birds migrating to and from the nearby Sri Lankan islands. The Jaffna district of Sri Lanka which is the nearest to the GoMBR has 315 species of birds including the migratory shorebirds (Birdlife International 2022). As Sri Lanka is at the tip of peninsular India, many species migrate annually from the northern autumn-winter to the tropics along the Central Asian-Indian Flyway ending their southward journey on this island (Warakagoda & Sirivardana 2011). Most bird species in Sri Lanka are shared with the adjacent Indian mainland and the rest of Asia (Rasmussen 2005). Many migrant species occurring on the Indian mainland also occur in Sri Lanka (Rasmussen & Anderton 2005).

Bird distribution studies on the southeast coast of India were earlier done (Ali 1979; Ali & Ripley 1983). Biddulph (1938) studied the status of birds on Rameswaram Island. Balachandran (1990) studied the coastal birds of Mandapam and the neighbouring islands of peninsular India. Also, 15 species of migratory shorebirds and eight species of migratory terns were found to summer here, especially on Manoli Island and Hare Island (Balachandran 1990). The earlier studies were restricted only to two islands of the Mandapam region, Dhanushkodi and Pillaimadam lagoons, and have not included a checklist of the avifaunal species from all 21 islands. The present study lists the current diversity and distribution of coastal birds from all 21 islands of the GoMBR. This paper reports sight records of a few rare and threatened species, and updates the previous knowledge on the GoMBR with the first comprehensive list of the Island group's avifauna.

Study Area

The GoMBR, the first marine biosphere reserve of India, is located off the southern extremity of India. At distances ranging 0.2–8 km from the mainland, the GoMBR has a chain of 21 uninhabited islands, from Mandapam to Tuticorin covering 682.76 ha (Figure 1). Most of the islands are small, from a few hectares to less than 4 km^2, running roughly parallel to the coast. The GoMBR has a coastal length of about 141 km. At the end of the peninsular extension is Pamban Island, which is connected to the mainland by a railway bridge. The inshore region of Palk Bay is largely muddy, while the GoMBR, is rocky and interspersed with small areas of sand and mud (Balachandran 1995). The mixing of waters of Palk Bay and the Gulf of Mannar takes place through the Pamban Pass and Adam's Bridge between Dhanushkodi and the west coast of Sri Lanka (Jayaraman 1954). Like Chilika Lake in Odisha (an IBA) and Point Calimere in Tamil Nadu (an IBA), the GoMBR is extremely important for migrant and resident waders. On the Sri

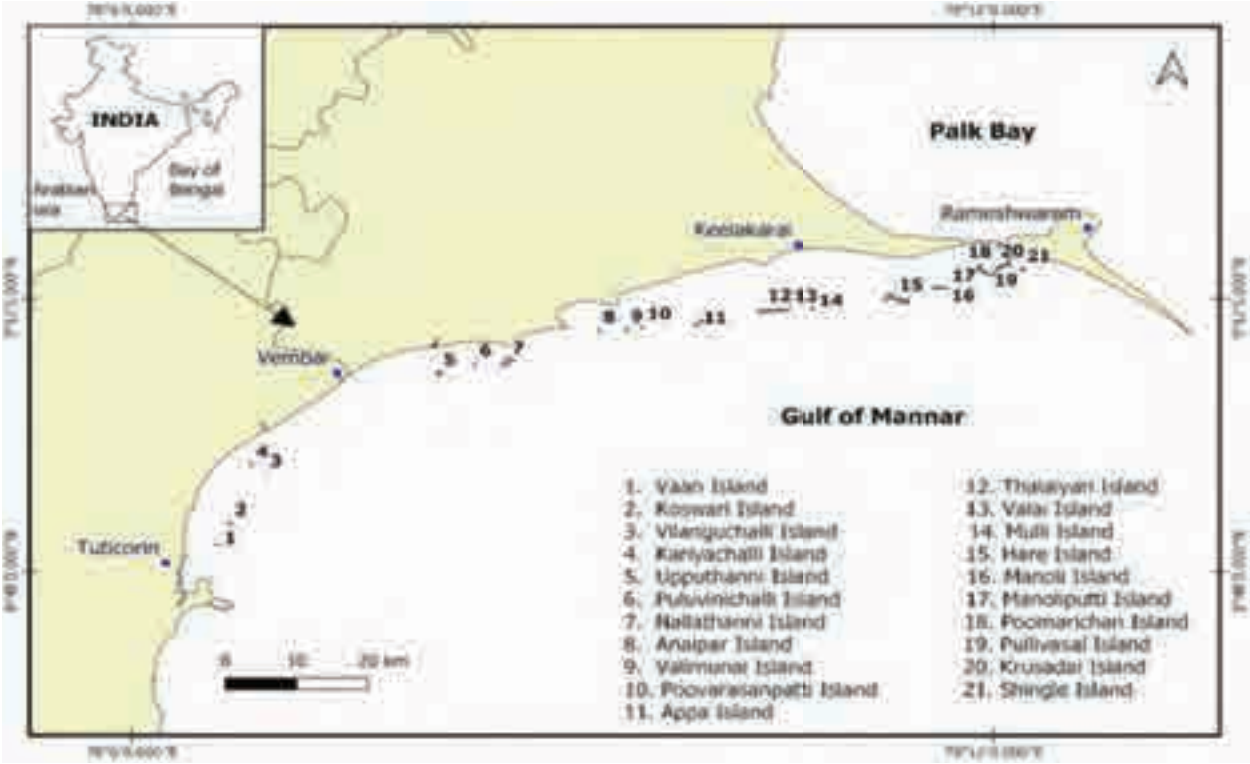


Figure 1. The Gulf of Mannar Biosphere Reserve, India depicting 21 islands where the present study was conducted.

Lanka side, about 10 km away, in the Jaffna district, there are four IBAs (Anatidal-Thondamannar, Araly South-Punale, Kaithady, and Kayts Island-Mandativu) (Anonymous 2003).

The size, form, height, and geomorphic characteristics of these islands vary considerably. The reduction of vegetation cover results from human habitat damage including illegal coral mining, dynamite fishing, and bottom trawling of which coral mining played a major role (Asir et al. 2020). These islands have sand dunes along their coastlines with salt-dominant plant species (e.g., *Sesuvium postulacastrum*, *Salicornia brachiata*). Some of the islands contain trees (e.g., *Acacia planifrons, Borassus flabellifer, Thespesia populnea, Prosopis chilensis*), while the marshy sections of some of the islands are occupied by mangroves (e.g., *Rhizophora mucronata, Avicennia marina*) and allied species (e.g., *Excoecaria agallocha, Salvadora persica, Pemphis acidula*) (GOMBRT 2012). Tropical weather prevails in the GoMBR due to the influence of both the South West and North East monsoons. Only a very small portion of the region's overall rainfall is caused by the South West monsoon. Between mid-October and mid-December, the north-east monsoon brings moderate to heavy rainfall along with occasional gales. The average annual rainfall ranges 762–1,270 mm. Atypically hot weather is prevalent from January to May. December is the month with the lowest temperature, which is 25°C. In the GoMBR's coastal regions, the wind velocity is typically high (Kumaraguru et al. 2006). From June to December, the wind blows north-northeasterly before switching to a westerly direction. In November, the wind speed is lowest and maximum in August (Venkatraman & Gokula 2009).

The islands that are subdivided as small groups based on the nearest land names are listed from south-west to north-east in various groups given below with the extent of land coverage in hectares. These islands, which are grouped into the Mandapam group, Keelakkarai group, Vembar group, and Tuticorin group (Table 1), are mainly of coral origin. As the coral reefs harbour a variety of sea animals and weeds, this stretch of sea is biologically rich on the eastern coast of India.

MATERIALS AND METHODS

Bird counts were carried out at these islands during both low and high tide using binoculars during the peak migratory period and intermittent data was collected during the non-migratory period of two years from February 2017 to March 2019. The annual bird

Table 1. The island groups with area details and location.

Island groups	Island Name	Latitude & Longitude	Area (Hectares)
1. Tuticorin islands	1. Vaan	8.83639°N 78.21047°E	16.00
	2. Koswari	8.86879°N 78.22506°E	19.50
	3. Vilanguchalli	8.93815°N 78.26969°E	0.95
	4. Kariyachalli	8.95409°N 78.25235°E	16.46
2. Vembar islands	1.Uppu Thanni	9.08921°N 78.49148°E	22.94
	2. Puluvini Challi	9.10320°N 78.53688°E	6.12
	3. Nalla Thanni	9.10667°N 78.57885°E	101.00
3. Kilakarai islands	1. Anaipar	9.15294°N 78.69481°E	11.00
	2. Valli Munai	9.15354°N 78.73052°E	6.72
	3. Poovarasan Patti (Kilinjan paar)	9.15413°N 78.76695°E	0.50
	4. Appa	9.16582°N 78.82596°E	28.63
	5. Talairi	9.18133°N 78.90673°E	75.15
	6. Valai	9.18421°N 78.93866°E	10.10
	7. Mulli	9.18641°N 78.96810°E	10.20
4. Mandapam islands	1. Hare (Musal)	9.19912°N 79.07530°E	124.00
	2. Manoli	9.21564°N 79.12834°E	25.90
	3. Manoli-putti	9.21581°N 79.12800°E	2.34
	4. Poomarichan	9.24538°N 79.17993°E	16.58
	5. Pullivasal	9.23699°N 79.19100°E	29.95
	6. Kurusadai	9.24690°N 79.20945°E	65.80
	7. Shingle	9.24174°N 79.23563°E	12.69

census for the years 2016, 2017, 2018, 2019, and 2022 conducted by the forest department, with bird watching volunteers and monitored by us, was also considered for the checklist. The frequency of visits depended on the availability of boats and the tidal movements.

Birds were counted using the direct count method from selected vantage points following Bibby et al. (2000). The observations recorded while moving from one scanning point to another were entered as incidental records. During low tide, the waders occur scattered all over the exposed intertidal area and shallow areas for feeding, facilitating easy identification. During high tide, they congregate in limited numbers and high tide roost is available for them to count if it is a smaller flock or estimate if the flock is denser (Howes & Bakewell 1989). Our main aim was to document the avifauna of all the islands and to provide information on species distribution. Terns and gulls feed in the sea and congregate at high tide roost, and they were documented during that time. Bird's congregation was photographed with 400 or 600 mm tele lens and were checked for their identification and enumeration (Hayman et al. 2011; Grimmett et al. 2014). The status of waterbirds was categorised as Common (seen on most of the visits), Uncommon (seen less than five times), and Rare (seen once or twice). The migratory status of waterbirds was classified as, Resident (R), Resident but not breeding (R/NB), Local Migrant (LM), and Winter Visitor (WV). We have considered the old checklist prepared from GoMBR for apprising since the entire 21 island bird records were missing from the past except for some. Also, some of the earlier recorded species of migratory shorebirds of the 1980s and early 2000s are not recorded at present in this area. The available checklist prepared through the earlier study of only the two islands was upgraded with the distribution status for all 21 islands. This species checklist can be used as a baseline reference for future monitoring of individual islands and conservation planning schemes adopted on the islands separately.

RESULTS AND DISCUSSION

The study recorded 96 species of birds belonging to 34 families and 13 orders from the 21 uninhabited islands of GoMBR during 2016–2022 (Table 2). The order Charadriiformes with 44 species belonging to six families dominated followed by Passeriformes with 22 species belonging to 13 families.

Water birds (n = 58) from the islands belonging to the orders Charadriiformes (with six families), Pelecaniformes (with two families), Anseriformes, Gruiformes, and Suliformes (with one family each) were recorded (Table 3). Among families, the Family Scolopacidae dominated (with 19 species), followed by Laridae (with 15 species), Ardeidae (with nine species), Charadridae (with six species), Burhinidae & Anatidae (with two species each), and Rallidae, Recurvirostridae, Dromadidae, & Threskiornithidae (each with one species) (Figure 2). The analysis of data on residential status revealed that out of 58 waterbird species, 15 were residents; whereas the 39 species were winter visitors (Table 3). Among the shorebirds, seven Near Threatened species (Bar-tailed Godwit *Limosa lapponica*, Black-tailed Godwit *Limosa limosa*, Red Knot *Calidris canutus*, Curlew Sandpiper *Calidris ferruginea,* Red-necked Stint *Calidris rufocollis*, Eurasian Curlew *Numenius arquata*, and Greater Thick-knee *Esacus recurvirostris*) and one Endangered species (Great Knot *Calidris tenuirostris*) were recorded.

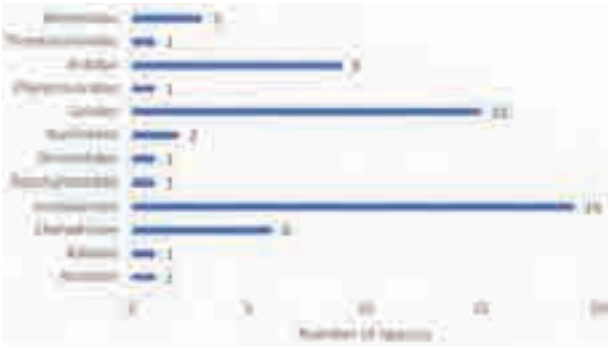


Figure 2. Family-wise species numbers of waterbirds in the islands of GoMBR, India.

Distribution Pattern of major coastal bird groups at different groups of islands

Mandapam group of islands is near the Pamban Bridge that connects the mainland with Rameswaram Island. Among all other groups of islands, the maximum number of species observed along with the highest number of some of the bird species were highest in these islands, especially on Manoli Island. The number of water bird species recorded on this island was the highest (inclusive of waders, ducks, terns, gulls, egrets, and herons). Even though the trend is similar to the early studies from these islands (Balachandran 1990; Daniel et al. 2007) overall count and the species diversity have significantly reduced (Balachandran 2006); the earlier record of 26 species (Balachandran 1990) had reduced to 19 species of shorebirds in our present study.

The inter-tidal zone around Manoli and Manoliputti islands is the only place where a good congregation of uncommon waders like Crab Plover *Dromas ardeola*, Bar-tailed Godwit *Limosa lapponica*, and Terek Sandpiper *Xenus cinereus* were observed. Crab plovers are only found in these groups of islands in the entire GoMBR (Byju 2020), hence the significance of the bird distribution studies of these islands. Our studies on other parts of the GoM including major congregation areas like Dhanushkodi lagoon and Pillaimadam where Crab plovers were earlier recorded were not recorded by us during the entire study period. The Northern Pin-tailed Ducks *Anas acuta* was seen on Manoli Island, this species was not reported in the earlier two studies (Balachandran 1990; Daniel et al. 2007) from these coral islands but were recorded from other areas of GoMBR. The absence of Eurasian Oystercatcher *Haematopus ostralegus* and Broad-billed Sandpiper *Calidris falcinellus* from the surveys done for several years shows the impact on habitat change and depletion of food in these islands, while the former being still reported from the southern coast end of Tuticorin and the latter being sighted by us from the Dhanushkodi lagoon of the GoMBR, both though less than ten individuals. Sivaperuman & Jayson (2012) reported that there is a positive correlation between the population fluctuation and distribution patterns of shorebirds with respect to their prey abundance. The increased numbers of Curlew Sandpiper *Calidris ferruginea* in the Kole wetland of Kerala's west coast are due to the abundance of polychaetes and crustaceans (Sivaperuman & Jayson 2012).

Pullivaasal and Poomarichan islands among the Mandapam group of islands recorded hundreds of Lesser Crested Tern *Thalasseus bengalensis* and Greater Crested Tern *Thalasseus bergii*, Pallas Gull *Ichthyaetus ichthyaetus*, Lesser Black-backed Gull *Larus fuscus*, Caspian Tern *Sterna caspia,* and Brown-headed Gull *Chroicocephalus brunnicephalus.* Regular records of Osprey *Pandion haliaetus* and occasional records of Peregrine Falcon *Falco peregrinus* and White-bellied Sea-eagle *Haliaeetus leucogaster* are from these islands. The dominant shorebird species were the Lesser Sand Plover *Charadrius mongolus*. Among all the water bird species recorded from this group of islands Gulls as a group were the dominant one. The highest count of Greater Crested Tern, Lesser Crested Tern, and Caspian Tern was observed during February. During December, the Lesser Crested Tern and Greater Crested Tern were the dominant species.

Kilakkarai, Tuticorin, and Vembar group of islands

The three groups of islands, Kilakarai, Tuticorin, and the Vembar, together constitute the remaining 14 islands. This group of islands recorded a smaller number of waders and less diversity of birds compared to the other seven islands of the Mandapam group were observed. The commonly recorded waders in all the islands include Lesser Sand Plover *Charadrius mongolus*, Kentish Plover *Charadrius alexandrinus*, and Ruddy Turnstone *Arenaria interpres*. Gulls and terns, and a few other waders as listed (Table 2). No single island in these three groups of islands supports more than 500 waterbirds and a family-wise abundance of waterbirds are given for all three island groups - Kilakarai, Vembar, and Tuticorin (Table 4). The first record of the Brown Noddy *Anous stolidus* from GoMBR was from Kariyashulli Island of the Tuticorin group. During January, Northern Pintail *Anas acuta* and Garganey A*nas querquedula* were higher in count exceeding 1,000 in numbers. As this is the first distribution checklist from these groups of islands, we cannot compare this with the population abundance or the loss of species diversity as from the Manoli and Hare

Table 2. Avifauna and their distribution on 21 islands of GoMBR, India.

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasanpatti	Vali munai	Anaipar	Nallathanni	Puluvinichalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Order: Anseriformes Family: Anatidae																						
Garganey	*Spatula querquedula*						√												√			
Northern Pintail	*Anas acuta*					√	√															
Order: Gruiformes Family: Rallidae																						
White-breasted Waterhen	*Amaurornis phoenicurus*						√															
Order: Charadriiformes Family: Charadriidae																						
Blackbellied Plover	*Pluvialis squatarola*	√	√		√	√	√	√				√	√			√				√		√
Kentish Plover	*Charadrius alexandrinus*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lesser Sand Plover	*Charadrius mongolus*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Greater Sand Plover	*Charadrius leschenaultii*					√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Pacific Golden Plover	*Pluvialis fulva*					√	√	√								√						
Red-wattled Lapwing	*Vanellus indicus*		√					√											√			
Family: Scolopacidae																						
Pin-tailed Snipe	*Gallinago stenura*							√														
Black-tailed Godwit	*Limosa limosa*					√	√															
Bar-tailed Godwit	*Limosa lapponica*					√	√	√														
Whimbrel	*Numenius phaeopus*	√				√	√	√														
Eurasian Curlew	*Numenius arquata*	√		√		√	√	√						√				√			√	
Common Redshank	*Tringa totanus*		√	√		√	√	√														
Common Greenshank	*Tringa nebularia*	√		√	√	√	√	√														
Green Sandpiper	*Tringa ochropus*					√	√															
Wood Sandpiper	*Tringa glareola*						√															
Terek Sandpiper	*Xenus cinereus*					√	√	√														
Common Sandpiper	*Actitis hypoleucos*	√	√	√	√	√	√	√	√						√	√		√		√	√	√
Ruddy Turnstone	*Arenaria interpres*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Great Knot	*Calidris tenuirostris*		√			√	√	√	√						√							
Red Knot	*Calidris canutus*				√	√	√	√														
Sanderling	*Calidris alba*					√	√	√														
Little Stint	*Calidris minuta*	√	√			√	√	√														
Red-necked Stint	*Calidris ruficollis*					√	√	√														
Dunlin	*Calidris alpina*					√	√	√														
Curlew Sandpiper	*Calidris ferruginea*					√	√	√														
Family: Recurvirostridae																						
Black-winged Stilt	*Himantopus himantopus*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√		√
Family: Dromadidae																						
Crab Plover	*Dromas ardeola*					√	√	√														

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasanpatti	Vali munai	Anaipar	Nallathanni	Puluvinichalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Family: Burhinidae																						
Indian Thick-knee	*Esacus magnirostris*					√	√	√														
Greater Thick-knee	*Esacus recurvirostris*	√																				
Family: Laridae																						
Lesser Black-backed Gull	*Larus fuscus*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Pallas's Gull	*Ichthyaetus ichthyaetus*					√	√	√														
Brown-headed Gull	*Chroicocephalus brunnicephalus*	√	√	√	√	√	√	√							√							
Blackheaded Gull	*Chroicocephalus ridibundus*	√	√	√	√	√	√	√	√						√	√	√				√	√
Slender-billed Gull	*Chroicocephalus genei*		√			√	√															
Gullbilled Tern	*Gelochelidon nilotica*					√	√	√											√	√		
Caspian Tern	*Hydroprogne caspia*	√	√		√	√	√	√	√	√		√	√	√	√	√					√	√
Lesser Crested Tern	*Thalasseus bengalensis*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Greater Crested Tern	*Thalasseus bergii*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Common Tern	*Sterna hirundo*					√	√	√		√										√		
Sandwich Tern	*Thalasseus sandvicensis*					√	√	√														
Saunder's Tern	*Sternula saundersi*					√	√	√														
Little Tern	*Sternula albifrons*	√	√			√	√	√	√	√		√	√	√		√	√				√	√
Whiskered Tern	*Chlidonias hybrida*	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√		√	√	√	√
Brown Noddy	*Anous stolidus*																			√		
Order: Suliformes Family: Phalacrocoracidae																						
Little Cormorant	*Microcarbo niger*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Order: Pelecaniformes Family: Ardeidae																						
Grey Heron	*Ardea cinerea*	√	√	√	√	√	√	√														√
Purple Heron	*Ardea purpurea*		√																	√		
Great Egret	*Ardea alba*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Little Egret	*Egretta garzetta*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Intermediate Egret	*Ardea intermedia*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Western Reef Heron	*Egretta gularis*		√			√	√	√														
Indian Pond Heron	*Ardeola grayii*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Straited Heron	*Butorides striata*	√	√	√		√	√	√					√									
Blackcrowned Night Heron	*Nycticorax nycticorax*		√																			
Family: Threskiornithidae																						
Eurasian Spoonbill	*Platalea leucorodia*		√																			
Order: Coraciiformes Family: Alcedinidae																						
White-throated Kingfisher	*Halcyon smyrnensis*		√			√	√	√							√							

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasanpatti	Vali munai	Anaipar	Nallathanni	Puluvinichalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Pied Kingfisher	*Ceryle rudis*		√																			
Common Kingfisher	*Alcedo atthis*		√			√	√										√					
Family: Meropidae																						
Blue-tailed Bee-eater	*Merops philippinus*					√	√	√							√					√		
Family: Coraciidae																						
Indian Roller	*Coracias benghalensis*		√																			
Order: Falconiformes Family: Falconidae																						
Common Kestrel	*Falco tinnunculus*					√	√							√			√					
Peregrine Falcon	*Falco peregrinus*						√															
Order: Accipitriformes Family: Accipitridae.																						
Black Kite	*Milvus migrans*	√	√			√	√		√													
Brahminy Kite	*Haliastur indus*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
White-bellied Sea Eagle	*Haliaeetus leucogaster*					√	√															
Family: Pandionidae																						
Osprey	*Pandion haliaetus*	√	√			√	√															
Order Psittaciformes Family: Psittaculidae																						
Rose-ringed Parakeet	*Psittacula krameri*		√																			
Order: Cuculiformes Family: Cuculidae																						
Jacobin Cuckoo	*Clamator jacobinus*		√																			
Chestnut-winged Cuckoo	*Clamator coromandus*		√				√															
Order: Apodiformes Family: Apodidae																						
Asian Palm Swift	*Cypsiurus balasiensis*	√	√				√								√							
Order: Bucerotiformes Family: Upupidae																						
Eurasian Hoopoe	*Upupa epops*		√																			
Order: Passeriformes Family: Dicrunidae																						
Black Drongo	*Dicrurus macrocercus*		√																			
Family: Corvidae																						
House Crow	*Corvus splendens*	√	√																			
Large-billed Crow	*Corvus macrorhynchos*	√	√																			
Family: Hirundinidae																						
Barn Swallow	*Hirundo rustica*	√	√				√					√										
Red-rumped Swallow	*Cecropis daurica*		√																			
Family: Alaudidae																						
Jerdon's Bushlark	*Mirafra affinis*		√																			
Ashy-crowned Sparrowlark	*Eremopterix griseus*		√																			
Oriental Skylark	*Alauda gulgula*	√	√			√	√					√										
Family: Pycnonotidae																						

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasanpatti	Vali munai	Anaipar	Nallathanni	Puluvinichalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Red-vented Bulbul	*Pycnonotus cafer*		√																			
Family: Cisticolidae																						
Plain Prinia	*Prinia inornata*		√																			
Zitting Cisticola	*Cisticola juncidis*		√																			
Common Tailorbird	*Orthotomus sutorius*		√																			
Family: Acrocephalidae																						
Blyth's Reed Warbler	*Acrocephalus dumetorum*		√				√															
Booted Warbler	*Iduna caligata*		√				√															
Family: Sturnidae																						
Rosy Starling	*Pastor roseus*		√																			
Family: Muscipidae																						
Indian Robin	*Copsychus fulicatus*		√																			
Family: Nectariniidae																						
Purple Sunbird	*Cinnyris asiaticus*					√	√	√							√							
Purple rumped Sunbird	*Leptocoma zeylonica*					√	√	√										√		√		
Family: Passeridae																						
House Sparrow	*Passer domesticus*		√																			
Yellow-throated Sparrow	*Gymnoris xanthocollis*		√														√					
Family: Estrildidae																						
Indian Silverbill	*Euodice malabarica*		√																			
Family: Motacillidae																						
White-browed Wagtail	*Motacilla maderaspatensis*		√		√																	

islands of the Mandapam group.

CONSERVATION IMPLICATIONS

A recent study done by Asir et al. (2020) using the mapping data and toposheets of the Survey of India from 1969–2018 for all the 21 islands of GoMBR reports that Vilanguchalli Island of the Tuticorin island group and Poovarasanpatti Island of Kilakkarai island group are almost submerged. Among the 21 islands, the area cover of 15 islands has reduced by 144.15 ha and four have their area expanded during the last 49 years. Asir et al. (2020) reported that overall, the Tuticorin group of islands has experienced the highest percentage of land cover reduction (78.55%), followed by Keelakarai (43.49%), Vembar (36.21%), and Mandapam (21.84%) groups. This might be the reason for fewer birds found in these three island groups in the present study. The four islands of the Mandapam group whose area has increased (16.44%) are Hare Island, Manoli Island, Krusadai Island, and Shingle Island (Asir et al. 2020). The abundance of the number of birds compared to other islands along with the diversity of species including the presence of Crab plovers and Pin-tailed ducks in these islands is a matter to be further investigated.

Shorebirds face threats from the degradation of intertidal habitats (Barter 2005; Moores et al. 2008) and the extension of mangroves (Augustinus 1995; Aarif et al. 2014). In the area between the Manoli and Manoliputti islands of the Mandapam group of islands, a vegetative structure had grown along with the extension of mangroves to the seaside degrading the intertidal zone for birds to forage and roost. It is explicit that these uninhabited islands possess a meager diversity and abundance of permanent resident birds. Even the scanty resident land birds are not distributed in all the islands as it appears to solely depend on the presence of humans,

Table 3. List of water birds recorded from the 21 islands of GoMBR, India.

	Common name	Scientific name	IUCN Red list status	Migration status
Order: Anseriformes Family: Anatidae				
1	Garganey	*Spatula querquedula*	LC	WV
2	Northern pintail	*Anas acuta*	LC	WV
Order: Gruiformes Family: Rallidae				
1	White-breasted waterhen	*Amaurornis phoenicurus*	LC	R
Order: Charadriiformes Family: Charadriidae				
1	Black-bellied plover	*Pluvialis squatarola*	LC	WV
2	Kentish Plover	*Charadrius alexandrinus*	LC	LM/R
3	Lesser Sand Plover	*Charadrius mongolus*	LC	WV
4	Greater Sand Plover	*Charadrius leschenaultii*	LC	WV
5	Pacific Golden Plover	*Pluvialis fulva*	LC	WV
6	Red-wattled Lapwing	*Vanellus indicus*	LC	R
Family: Scolopacidae				
1	Pin-tailed Snipe	*Gallinago stenura*	LC	WV
2	Black-tailed Godwit	*Limosa limosa*	NT	WV
3	Bar-tailed Godwit	*Limosa lapponica*	NT	WV
4	Whimbrel	*Numenius phaeopus*	LC	WV
5	Eurasian Curlew	*Numenius arquata*	NT	WV
6	Common Redshank	*Tringa totanus*	LC	WV
7	Common Greenshank	*Tringa nebularia*	LC	WV
8	Green Sandpiper	*Tringa ochropus*	LC	WV
9	Wood Sandpiper	*Tringa glareola*	LC	WV
10	Terek Sandpiper	*Xenus cinereus*	LC	WV
11	Common Sandpiper	*Actitis hypoleucos*	LC	WV
12	Ruddy Turnstone	*Arenaria interpres*	LC	WV
13	Great Knot	*Calidris tenuirostris*	EN	WV
14	Red Knot	*Calidris canutus*	NT	WV
15	Sanderling	*Calidris alba*	LC	WV
16	Little Stint	*Calidris minuta*	LC	WV
17	Red-necked Stint	*Calidris ruficollis*	NT	WV
18	Dunlin	*Calidris alpina*	LC	WV
19	Curlew Sandpiper	*Calidris ferruginea*	NT	WV
Family: Recurvirostridae				
1	Black-winged Stilt	*Himantopus himantopus*	LC	R
Family: Dromadidae				
1	Crab Plover	*Dromas ardeola*	LC	WV
Family: Burhinidae				
1	Indian Thick-knee	*Burhinus indicus*	LC	R
2	Greater Thick-knee	*Esacus recurvirostris*	NT	R
Family: Laridae				
1	Lesser Black-backed Gull	*Larus fuscus*	LC	WV
2	Pallas's Gull	*Ichthyaetus ichthyaetus*	LC	WV
3	Brown-headed Gull	*Chroicocephalus brunnicephalus*	LC	WV
4	Black-headed Gull	*Chroicocephalus ridibundus*	LC	WV
5	Slender bill Gull	*Chroicocephalus genei*	LC	WV
6	Gull-billed Tern	*Gelochelidon nilotica*	LC	WV
7	Caspian Tern	*Hydroprogne caspia*	LC	WV
8	Lesser Crested Tern	*Thalasseus bengalensis*	LC	R/LM
9	Greater Crested Tern	*Thalasseus bergii*	LC	WV
10	Common Tern	*Sterna hirundo*	LC	WV
11	Sandwich tern	*Thalasseus sandvicensis*	LC	WV
12	Saunders tern	*Sternula saundersi*	LC	WV
13	Little Tern	*Sternula albifrons*	LC	WV
14	Whiskered Tern	*Chlidonias hybrida*	LC	WV
15	Brown Noddy	*Anous stolidus*	LC	V
Order: Suliformes Family: Phalacrocoracidae				
1	Little Cormorant	*Microcarbo niger*	LC	R
Order: Pelecaniformes Family: Ardeidae				
1	Grey Heron	*Ardea cinerea*	LC	R
2	Purple Heron	*Ardea purpurea*	LC	R
3	Great Egret	*Ardea alba*	LC	R
4	Intermediate Egret	*Ardea intermedia*	LC	R
5	Little Egret	*Egretta garzetta*	LC	R
6	Western Reef Heron	*Egretta gularis*	LC	R/LM
7	Indian pond Heron	*Ardeola grayii*	LC	R
8	Striated Heron	*Butorides striata*	LC	R
9	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	R
Family: Threskiornithidae				
1	Eurasian Spoonbill	*Platalea leucorodia*	LC	R/NB

LC—Least Concern | NT—Near Threatened | EN—Endangered | V—Vagrant | WV—Winter Visitor | LM—Local Migrant | R—Resident | R/NB—Resident/ Non-Breeding.

Table 4. The Waterbird group population maximum estimated on the island subgroups of GoM-BR, India.

Families	Mandapam island group	Keezhakarai island group	Vembar island group	Tuticorin island group
Laridae	5000–10000	1000–2000	>1000	>500
Anatidae	2000–3000	<1000	-	-
Charadridriidae, Scolopacidae, Recurvirostridae, Dromididae, Burhinidae	3000–5000	>1000	>1000	>500
Rallidae, Phalacrocoracidae, Ardedae, Threskiornithridae	500–1000	200–300	100	300–500

as they are closely associated with the latter. One of the obstacles for the birds to colonize and thrive in this area could be the lack of habitat diversity in terms of flora, geography, and topography coupled with declining benthic diversity, which would provide a prey base. This is comparable to research on some significant atolls in the Lakshadweep Islands (Aju et al. 2021). Although there is a greater variety of birds in the Manoli group of islands than in past studies, their numbers are rapidly declining in GoMBR (Balachandran 2006).

Despite the Fisheries Department's efforts of educating and monitoring fishermen's community from preventing the indiscriminate destruction of marine life, it continues. We have observed that in some of the islands closer to the coast, the native vegetation has lost ground to the alien *Prosopis chilensis*, which has taken over. Although coral quarrying for industrial purposes has been outlawed, the coral reef has already been destroyed in several places. Corals, seagrass, and mangroves are among the three unique ecosystems present on the islands. Anthropogenic pressures like human settlements, though not permanent, are found on Poomarichan, Pullivasal, and Manoliputti islands in the Mandapam island group. They bring water from the shores for drinking and cook using the vegetation from the islands. Deployment of traditional fishing gear was infrequently recorded especially close to the mangrove fringes in many islands which offer an ideal foraging ground for large wading birds. Similar observations were reported in Kadalundi-Vallikunnu Community Reserve (KVCR), Kozhikode, and Malappuram districts, Kerala (Aarif et al. 2017). Proactive efforts to remove the discarded fishing gear or plastic debris from these islands, which are wintering as well as stopover grounds, could greatly reduce injuries to migratory birds. Aarif et al. (2021) found similar threats posed by leftover fishing gear injuring birds at KVCR. The long-distance migrant shorebirds are highly dependent on a series of key stop-over sites between wintering and more northerly breeding areas (Boere et al. 2006). Therefore, the linkage between the coral islands of GoMBR and other major shorebird habitats both within the east and west coast of India and other nearby countries like Sri Lanka coming under the CAF must be understood by regular and systematic monitoring as it holds several important long-distance migrant species.

CONCLUSION

The islands of GoMBR are home to a high bird diversity supported by large expanses of natural ecosystems. As there are still unaltered habitats in the study area, preemptive conservation initiatives could help to protect them in the future. To create successful conservation strategies, comprehensive assessments of species ecology, and occurrences are essential. However, to date, no regular bird monitoring efforts exist for all 21 islands, and many of the islands lack comprehensive checklists. The importance of local landscapes for the conservation of avifauna can only be understood by knowing the structure of the bird community of that region (Kattan & Franco 2004). Our distribution checklist can be used as baseline data for future monitoring and to measure conservation success. Considering the limited data available on species distributions and occurrences, this will foster to refine the scientific focus and knowledge as the continuous expansion of monitoring birds helps in maintaining the important sites of the congregation for some species like Crab Plover in GoMBR are restricted to only one or two islands in a single island group.

REFERENCES

Aarif, K.M., S.B. Muzaffar, S. Babu & P.K. Prasadan (2014). Shorebird assemblages respond to anthropogenic stress by altering habitat use in a wetland in India. *Biodiversity. Conservation* 23(3): 727–740. https://doi.org/10.1007/s10531-014-0630-9

Aarif, K.M., K. Shanij, T.C. Rubio, P.C. Rajeevan & M. Polakowski (2017). Population trend of wintering terns at a stop-over site

in Central Asian Flyway with special reference to the decline of Sandwich Tern. *Tropical Ecology* 58(2): 449–454.

Aarif, K.M., A. Nefla, T.R. Athira, P.K. Prasadan & S.B Muzaffar (2021). The costs of migration: injuries in migratory waterbirds along the west coast of India. *Saudi Journal of Biological Sciences* 28(11): 6030–6039. https://doi.org/10.1016/j.sjbs.2021.07.080

Aju, K.R., K.R. Sreenath, K.K. Joshi & A. Gopalakrishnan (2021). An updated ornithology of the Lakshadweep Islands. *Indian BIRDS* 17(2): 33–47.

Ali, S. (1979). *The Book of Indian Birds*. Bombay Natural History Society, Bombay, 186 pp.

Ali, S. & S.D. Ripley (1983). *Handbook of the Birds of India and Pakistan*. Compact edition. Oxford University Press, New Delhi & Oxford, 737 pp.

Anonymous (2003). Important Bird Areas of Sri Lanka: *Preliminary IBA Site Directory*. Field Ornithology Group of Sri Lanka, 130 pp.

Asir, N.G.G., P.D. Kumar & A. Arasamuthu (2020). Eroding islands of Gulf of Mannar, Southeast India: a consequence of long-term impact of coral mining and climate change. *Natural Hazards* 103: 103–119. https://doi.org/10.1007/s11069-020-03961-6

Augustinus, P.G.E.F. (1995). Geomorphology and Sedimentology of Mangroves, pp. 333–357. In Perillo G.M.E. (ed.). *Developments in Sedimentology.* Elsevier Science, 471pp.

Balachandran, S. (1990). Interesting bird records from Mandapam and its neighbouring islands. *Journal of the Bombay Natural History Society* 87: 456–457.

Balachandran, S. (1995). Shorebirds of the Marine National Park in the Gulf of Mannar, Tamil Nadu. *Journal of the Bombay Natural History Society* 92: 303–311.

Balachandran, S. (2006). The decline in wader populations along the east coast of India with special reference to Point Calimere, south-east India, pp. 296–301. In: Boere, G., C. Galbraith & D. Stroud (ed.). *Waterbirds Around the World*. The Stationary Office, Edinburgh, UK, 940 pp.

Barter, M.A. (2005). Yellow Sea-driven priorities for Australian shorebird researchers, pp. 158–160. In: Straw, P. (ed.) Status and Conservation of Shorebirds in the East Asian-Australasian Flyway. *Proceedings of the Australasian Shorebird Conference*, 13–15 December 2003, Canberra, Australia. International wader studies 17. Sydney, Australia, 199 pp.

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

Biddulph, C.H. (1938) The birds of Rameswaram Island. *Journal of the Bombay Natural History Society* 40: 238–256.

Birdlife International (2022). Avibase Bird checklist of Jaffna: http://www.birdlife.org/datazone/country/sri-lanka Accessed on 30 August 2022.

BirdLife International (2022). IUCN Red List for birds. http://www.birdlife.org. Accessed on 31 August 2022.

Boere, G.C. & D.A. Stroud (2006). The flyway concept: what it is and what it isn't, pp. 40-47. In: Boere, G.C., C.A. Galbraith & D.A. Stroud (eds.). *Waterbirds Around the World*. The Stationery Office, Edinburgh, 947 pp.

Byju, H. (2020). Interesting foraging behaviour of Crab Plover in Manali Island, Gulf of Mannar, India. *Zoo's Print* 35(12): 25–28.

Daniel, J.C., S. Balachandran & A. Arvind (2007). An assessment of the Environmental Economics of the Birds and Dugong habitats of the Gulf of Mannar Marine National Park – *Gulf of Mannar Final* Report (2005–2007). Bombay Natural History Society, Mumbai, 78 pp.

Daniels, R.J.R., M. Hegde, N.V. Joshi & M. Gadgil (1991). Assigning conservation value: a case study from India. *Conservation Biology* 5(4): 464–475.

GOMBRT (2012). Preliminary survey on plant-animal interactions and their impact on the recovery of insular fora of the Mandapam group of islands in the Gulf of Mannar Marine National Park, *Compendium of research findings on biodiversity conservation and sustainable use in Gulf of Mannar Biosphere Reserve*, Gulf of Mannar Biosphere Reserve Trust. Ramanathapuram 21(2): 367–375.

Grimmett, R., C. Inskipp & T. Inskipp (2014). *Birds of the Indian Subcontinent* 2nd ed. Christopher Helm, Oxford University Press, 528 pp.

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). *Shorebird Studies Manual*. AWB Publication No 55, Kuala Lumpur, 362 pp.

Jayaraman, R. (1954). Seasonal variations in salinity, dissolved oxygen, and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam (S. India). *Indian Journal of Fisheries* 1(1&2): 345–364.

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.

Kumar, A., J.P. Sati, P.C. Tak & J.R.B. Alfred (2005). *Handbook on Indian Wetland Birds and Their Conservation.* Zoological Survey of India, Kolkata, 500 pp.

Kumaraguru, A.K., V.E. Joseph, N. Marimuthu & J.J. Wilson (2006). *Scientific information on Gulf of Mannar - A Bibliography.* Centre for Marine and Coastal Studies, Madurai Kamaraj University, Madurai, Tamilnadu, 656 pp.

Moores, N., D. Rogers, R.H. Kim, C. Hassell, Gosbell, S.A. Kim & M.N. Park (2008). Saemangeum Shorebird Monitoring Program Report (2006–2008). http;//www.birdskorea.org/Habitats/Wetlands, 40 pp.

Peterson, A.T., L.G. Ball & K.W. Brady (2000). Distribution of the birds of the Philippines: biogeography and conservation priorities. *Bird Conservation International* 10(2): 149–167.

Praveen, J. & R. Jayapal (2022). Taxonomic updates to the checklists of birds of India, and the South Asian region. *IndianBIRDS* 18(1): 1–3.

Praveen, J., R. Jayapal & A. Pittie (2020). Taxonomic updates to the checklists of birds of India, and the South Asian region. *Indian BIRDS* 16(1): 12–19.

Ramesh, D.A. & S. Ramachandran (2005). Factors influencing flamingo (*Phoenicopterus roseuis*) (sic) distribution in the Pulicat Lagoon ecosystem, India. *Wetland Ecology and Management* 13: 69–72.

Rasmussen, P.C. (2005). Biogeographic and conservation implications of revised species limits and distributions of South Asian birds. *Zoologische Mededelingen Leiden* 79-3(13): 137–146.

Rasmussen, P.C. & J.C. Anderton (2005). *Birds of South Asia: The Ripley Guide*. *Vols. 1 and 2*. Smithsonian Institution and Lynx Edicions, Washington, D.C., and Barcelona, 683 pp.

Sivaperuman, C. & E.A. Jayson (2012). Population fluctuations of shore birds in the Kole wetlands, Kerala, India. *Journal of Annals Forestry* 20(1): 129–144.

Venkatraman, C. & V. Gokula (2009). Coastal Birds of Tamil Nadu. Records of the Zoological Survey of India. *Occasional Paper* No, 303: 64.

Warakogoda, D. & U. Sirivardana (2011). The avifauna of Sri Lanka: an overview of the current status. *Taprobanica* 1(1): 28–35. https://doi.org/10.4038/tapro.v1i1.2775

Zafar-ul-Islam, M. & A.R. Rahmani (2004). *Important Bird Areas in India*. *1st Edition*. Oxford University Press, BirdLife International, RSPB, & BNHS, 1152 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22586–22596
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.7879.15.2.22586-22596
#7879 | Received 13 February 2022 | Final received 14 January 2023 | Finally accepted 07 February 2023
OPEN ACCESS
COMMUNICATION

Habitats of House Sparrow *Passer domesticus* (Linnaeus, 1758) in Rameswaram Island, Tamil Nadu, India

M. Pandian

No. F1901, Taisha, Natesan Nagar West, Virugambakkam, Chennai, Tamil Nadu 600092, India.
pandian.m14@gmail.com

Abstract: This paper pertains to the nesting habitats of House Sparrow *Passer domesticus* with specific reference to population dynamics, nesting-related habits, nests, behaviours and other threats faced by these birds in Rameswaram Island. A total of 2,988 adult House Sparrows and 407 active nests were counted during the study. Of nests counted, 19% (n = 77) were solitary. The highest number of nests observed in a cluster was 9 (2 clusters). 60% of nests (n = 244) were found in concrete buildings, 39% (n = 159) in artificial nest-boxes, and 35% (n = 144) in cavities/crevices within buildings. House Sparrow population exhibited nesting plasticity, and 2% of nests were found constructed on vegetation. A wide variety of locally available materials, such as pieces of synthetic fishing nets, nylon ropes, and polythene papers were used for construction of nests. Sand and water bathing by birds were observed. Accidental fall of eggs and chicks, predation of nests by House Crows *Corvus splendens*, and unsuccessful attempts to predate adult birds by Black Kite *Milvus migrans* were observed, as well as opportunistic sightings of Shikra *Accipiter badius*.

Keywords: Nest boxes, nest colony, nesting plasticity, nest predation, Passeridae, Passeriformes, sand, water bathing.

Editor: P.O. Nameer, Kerala Agricultural University, Thrissur, India.

Date of publication: 26 February 2023 (online & print)

Citation: Pandian, M. (2023). Habitats of House Sparrow *Passer domesticus* (Linnaeus, 1758) in Rameswaram Island, Tamil Nadu, India. *Journal of Threatened Taxa* 15(2): 22586–22596. https://doi.org/10.11609/jott.7879.15.2.22586-22596

Copyright: © Pandian 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: None.

Competing interests: The author declares no competing interests.

Author details: M. Pandian has completed M.Sc., Ph.D., in botany and BLIS from University of Madras and Bachelor of Education (B.Ed.) from Annamalai University, Chidambaram and now serves in Tamil Nadu Police Department. His area of interest is ecology and nesting biology of birds and published a few papers on House Sparrows, Baya Weavers, Streaked Weaver and Black-breasted Weaver, Grey Francolins, Indian Flying Fox, munias and Ring-necked Parakeets.

Acknowledgements: I thank D. Balaji (Mailam) and K. Sriram (Rettanai) for assistance in data collection and photography, K. Mariappan (Sivagangai), B. Raja Prabhu, S.B. Ramkumar (Rameswaram) for help with identification of nesting sites, S. Suresh, assistant professor (Statistics), University of Madras, A. Giridharan (Minnal), and T. Selvapandian (Narasingapuram) for help with data analysis and preparation of map.

INTRODUCTION

The House Sparrow *Passer domesticus* (Linnaeus, 1758) (Aves: Passeriformes: Passeridae) is the most widespread bird in the world (Anderson 2006); its geographical range extending over Europe, North Africa, and parts of Asia including the Indian subcontinent. The House Sparrow was introduced into Argentina, Australia, Canada, Japan, Mauritius, Mexico, United States, Vietnam, and Zimbabwe (BirdLife International 2016). This species occurs throughout the Indian subcontinent (Ali & Ripley 1987), where breeding occurs from February to September. House Sparrows construct nests within buildings but generally modern construction designs across the world lack sites such as holes or crevices suitable for nesting for the House Sparrow (Vincent 2005; Shaw et al. 2008). Apart from buildings, nesting in trees & bushes is also a common behaviour of House Sparrow (Summers-Smith 1963; Van der Elst 1981) and this change of habitat from buildings to vegetation is indicated as an alternative option of birds in construction of nests (Morris & Tegetmeier 1896). In India, 27% nests in Arakku, Andhra Pradesh, (Dhanya & Azeez 2010), and 8% nests in Arakkonam Taluk, Tamil Nadu (Pandian 2021) occurred in vegetation. Birds exhibit a behavior of mud and water bathing, probably to remove ectoparasites and excess feather oil from plumage (Rothschild & Clay 1952; Van Liere 1992).

Populations of House Sparrows have declined across Eurasia (Leasure 2011; Prowse 2002; Mulsow 2005, 2006; Deepa 2013) due to various causes, such as shortage of food supply, predation (Bower 1999; Newton 2004), and increasing developmental activities (Summers-Smith 2003). Populations are reported to have decreased considerably in Bengaluru, Mumbai, Hyderabad, and West Bengal (Rajashekhar & Venkatesha 2008; Daniels 2008; Khera et al. 2010; Ghosh et al. 2010). According to a Bombay Natural History Society's study, the population of House Sparrow in India is lower at present than in the past and this is consistent across the country (Rahmani et al. 2013). International Union for Conservation of Nature (IUCN) Red List has evaluated the conservation status of House Sparrow as 'Least Concern' (BirdLife International 2016). No systematic account of habitats and nesting biology of House Sparrow in Rameswaram Island exists. The present study was carried out to fill this gap. The objectives of the study included examining: (1) What are the current population dynamics and nesting behaviours? (2) What are the nesting materials used? (3) Do the birds exhibit nesting plasticity? (4) Do they resort to sand or water bathing? and (5) What are the threats to their populations?

MATERIALS AND METHODS

Study Area

Rameswaram Island is the largest island in Tamil Nadu. Located in Ramanathapuram district it spreads over 67 km^2 with a human population of c. 82,000 (2011 Census). Tourism, pilgrimage, fishing, and cottage industries involving palm products are the major sources of income for the people here. Cultivation of traditional crops is conspicuous by its absence on this island. The average annual rain fall is 800 mm. The maximum and minimum annual temperatures in the district are 36°C and 20°C, respectively (Figure 1).

Note: List of villages are 1. Rameswaram Town (9.288195 N, 79.317409 E), 2. Karaiyur (9.277230 N, 79.31409 E), 3. Puthuroad (9.257055 N, 79.307291 E), 4. Verkodu (9.280038 N, 79.312003 E), 5. Mandapam (9.280970 N, 79.303836 E), and 6. Ponthampuli (9.285429 N, 79.303836 E).

Methods

With the help of two informants and two other field assistants, I visited Rameswaram island and identified populations of House Sparrows across 259 sites in six town/villages. I targeted sites where House Sparrows were definitely known to be living and which housed active nests. The identified sites, viz., temples, houses, streetlamp posts, sheds, grocery shops selling food grains, garbage bins on roads and streets, sea shore, and vegetation which attracts House Sparrows, were surveyed between 0600 h and 1800 h during the period from January to September 2021. Sizes of flocks, types of nesting locations, types of nesting sites and sizes of nesting colonies were determined by direct visual observation. The number of birds was enumerated by following total count method (Bibby et al. 2000) and analyzing the photographs taken when the birds were foraging or perching/roosting on any substrata. Other biological notes on House Sparrow populations like roosting sites, foraging behaviours, sand, water bathing, mating, type of nest materials, and probable threats to their populations were made by direct observation using field binoculars. No live nests, eggs, chicks or adult birds were handled during the study. Pearson's Correlation Coefficient test was used to test the correlations between the types of buildings/structures and number of nests observed on them and also between the types of nesting sites and number of nests observed on them.

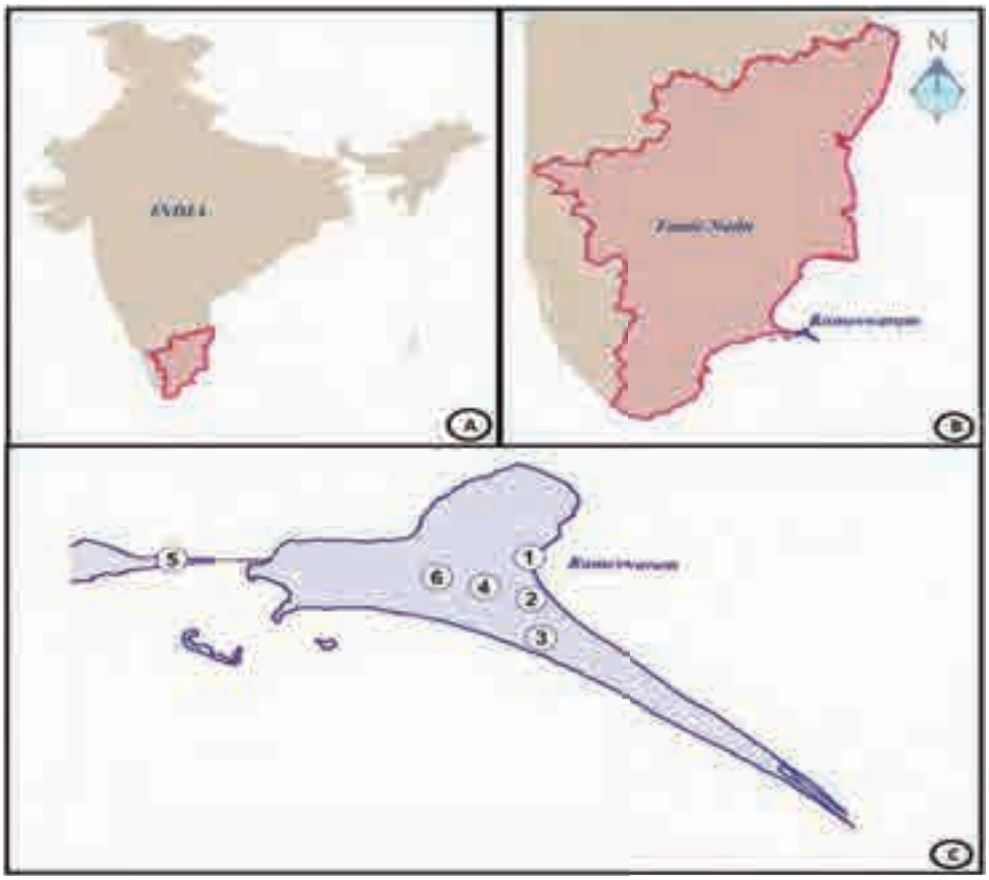


Figure 1. Study area map: A—India map showing Tamil Nadu | B—Tamil Nadu map showing Rameswaram | C—List of studied town and villages were marked in Rameswaram map.

Taking utmost care not to disturb the nests or birds, a minimum distance of c. 20 m was maintained during observations. Locations of all the nests and birds were determined using a standard GPS device (Garmin Etrex 20x). Photography and videography were done using a Nikon P1000 digital camera without disturbing the nests and birds. All the collected data were analyzed and presented as graphical representations.

RESULTS

A total of 2,988 adult House Sparrows (1,683 males & 1,305 females) and 407 nests were enumerated in six town/villages covering various nesting locations, such as concrete buildings, tiled houses, shops, temples, electric lamp posts/meter boxes, wells, thatched houses, culverts, abandoned boats, and shrubs in the island (Table 1). The maximum number of birds (106) in a flock were seen near Muthumariamman temple (9.292399 N, 79.318979 E). The maximum number of nests (9 each) were noticed at a bus stand (9.285616 N, 79.297799 E) and in a concrete building (9.284772 N, 79.311769 E).

Size of flocks

House Sparrows occurred as small flocks. No solitary bird was found in the study area. The size of flocks varied from 2 to 106 birds. Smaller size flocks were more in number, while larger flocks were rarer (Table 2).

Nesting locations

Almost 60% of the nests (n = 244) were found in concrete buildings (human dwellings & offices), followed by 13.3% nests (n = 54) in various commercial establishments (shops), 8.8% nests (n = 36) in tiled houses, 8.1% nests (n = 33) in temple buildings, and 4.2% nests (n = 17) in electric lamp posts/meter boxes. The remaining 5.7% nests (n = 23) were found in culverts, wrecked boats, sheds, wall of wells, thatched houses, and shrubs (Figure 2).

Selection of nesting sites

The study revealed that 39.1% nests (n = 159) were constructed in artificial nest-boxes (including two burnt

Table 1. Details of adult House Sparrows and nests enumerated in different places in the study area.

	Name of town/ village	No. of places	Total no. of adult birds counted	Percentage (%)	Total no. of nests counted	Percentage (%)
1	Rameswaram	171	2278	76.24	256	62.90
2	Karaiyur	32	171	5.72	73	17.94
3	Puthuroad	26	254	8.50	27	6.63
4	Verkodu	21	139	4.65	24	5.90
5	Mandapam	6	130	4.35	19	4.67
6	Ponthampuli	3	16	0.54	8	1.97
Total		259	2988	100	407	100

clay pots) placed in human residences and shops, followed by 35.4% nests (n = 144) in wall cavities/crevices in the buildings, 8.1% nests (n = 33) in pipe holes, 7.9% nests (n = 32) in the cavities/crevices of temples, 3.4% nests (n = 34) in electric lamp-posts, and 2.2% nests (n = 9) occurred in the door shutters of shops. The remaining 3.9% nests (n = 16) were observed in other structures, such as walls of wells, culverts, electric meter boxes, and shrubs (Figure 3).

Size of nest colonies

The number of nests in a nest colony varied from 1 to 9. Out of 407 nests enumerated, 51.35% nests (n=209) were found in clusters of 1–2 nests (including 77 solitary nests), 29.48% nests (n = 120) were found in cluster ranges of 3–4 nests, 9.09% nests (n = 37) were in the cluster ranges of 5–6 nests, and 5.65% nests (n = 23) were in the cluster ranges of 7–8 nests. The clusters containing highest number of nine nests each occurred in two places.

Nesting plasticity of House Sparrow

A small percentage (2%) of the total 407 nests was found in natural vegetation, such as *Ficus benghalensis* (Moraceae), *Tecoma stans* (Bignoniaceae), *Punica granatum* (Lythraceae), and *Citrus limon* (Rutaceae) in the study area. These nests were found woven into the inaccessible foliage parts of the plants and the nests were found spherical in shape with entrance on the sides. Another two nests were found in a damaged iron pipe of wrecked mechanized boat in the sea shore.

Nest materials

Observations through binoculars revealed that House Sparrows had used a wide variety of materials for construction nests. Dried grass and dried compound leaves, fibers peeled off from banana leaf sheaths in garlands (found abundantly around places of worships and markets), hay, jute fiber, pieces of rope made of jute, nylon ropes, synthetic fiber from bags, polythene papers, and tissue papers found in garbage bins or streets or backyards of human residences were used by the birds. Feathers of fowls were also observed in the nests. While constructing nests in culverts near sea shore and abandoned boats, the individuals of House Sparrows utilized pieces of torn fish nests made of synthetic fiber. The study also revealed that both male and female were engaged in the construction of nests (Image 3a–d, 3i).

Table 2. Details of flock sizes of House Sparrows in the study area.

Flock size grouping	Number of birds	Percentage of birds in the grouping
2–20	1260	42.17%
21–40	572	19.14%
41–60	524	17.54%
61–80	352	11.78%
81–100	174	5.82%
>100	106	3.55%

Foraging behaviours

During the study period, a total of 1,079 birds were found foraging, of which 30.58% birds (n = 330) were found foraging in the garbage by the side of streets, 16.03% birds (n = 173) were found foraging kitchen scraps in the backyards of human residences, and 11.58% birds (n = 125) were found foraging on spilled grains and food materials in the temple premises. People used to offer nine varieties of dry grains/pulses to Rameswaram temple and put them in a hundiyal (steel barrel with small opening). It was observed that individuals of House Sparrows had adapted to freely enter into the barrel, consume the grains, and come out after 3 to 5 minutes. Another 36.23% birds (n = 391) were found foraging on spilled food materials on the roads having

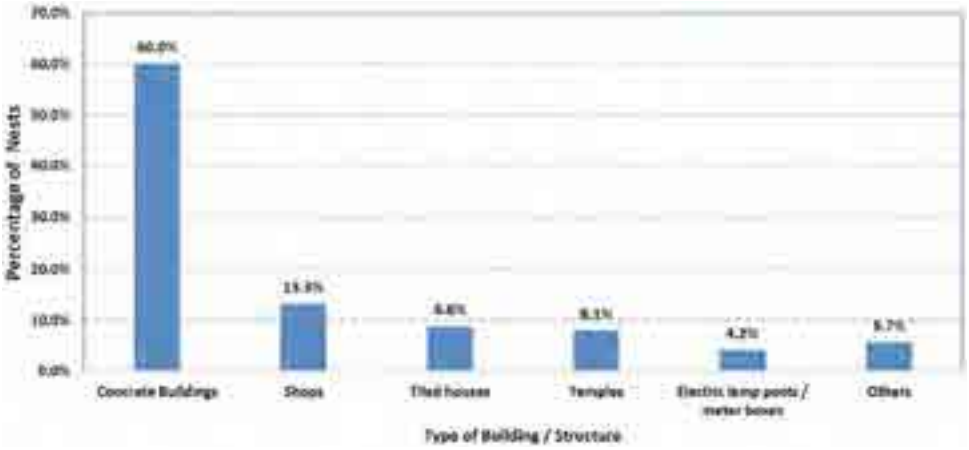


Figure 2. Percentage of nests of House Sparrows observed on various buildings/structures.

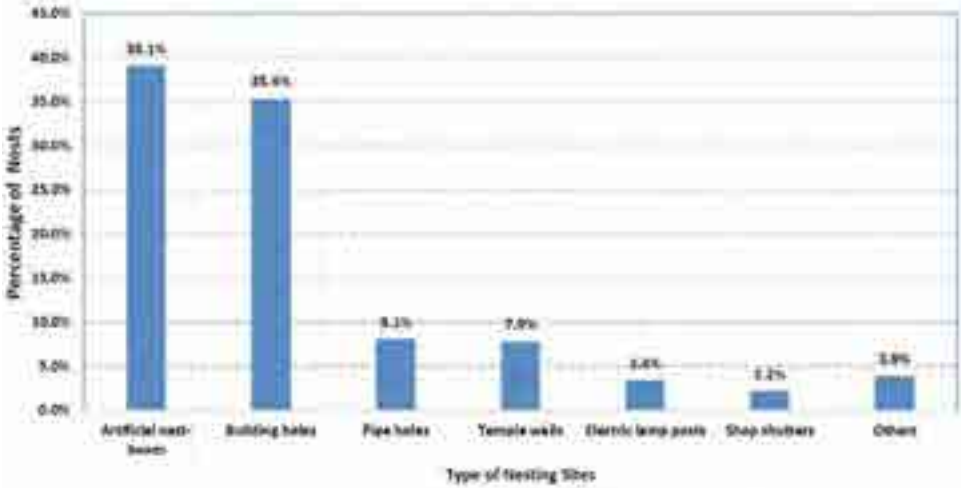


Figure 3. Percentage of nests of House Sparrows observed on various types of nesting sites.

busy vehicular traffic. The remaining 5.58% birds (n = 60) were observed in the hedges probably searching for worms, insects, and also in the vicinity of nests carrying prey to their chicks (Image 2).

Roosting behaviour

A total of 1,838 adult birds were found roosting on different substrata during the study period. Among the roosting birds, 45.64% birds (n = 839) were found roosting on various concrete buildings/tiled houses, 20.62% birds (n = 379) were found perching on overhead power transmission cables and lamp posts, 17.3% birds (n = 318) were found on temple towers, idols, walls, and grill gates in the premises of temples, and the remaining 16.44% birds (n = 302) occurred on trees and shrubs. Hence, the maximum number of birds were found roosting on concrete buildings, such as human residences, commercial establishments (shops), and tiled houses (Image 2a).

Sand and water bathing

The study revealed that individuals of House Sparrows used to take sand baths in the sandy beach and in the vacant sites of residential areas. A total of 12 incidents of sand baths involving 63 birds were observed. Four sand baths occurred between 1000 h and 1130 h in the forenoon and eight baths occurred between 1530 h and 1700 h in the afternoon. Each bird creates a small depression/pit in the sand using its beak and legs. Then the birds lower their breasts to the sand and flap their wings to spread sand particles over their entire bodies. They also use legs to spread sand and rub their heads on sand. Each sand bath took 2–7 minutes. Out of 63 birds, 27 took baths in more than one pit by frequently

changing the pits. Small groups consisting of 2–5 birds were found taking sand baths.

Eight birds were found taking baths in the stagnant water near a water tap. The duration of baths varied 3–5.5 min. Incidents of water baths were observed between 1500 h and 1630 h. After water baths, all the eight birds engaged in foraging on the ground (Image 3e,f).

Mating

Opportunistic sightings of twelve mating pairs were observed, the duration of mating varying 3–7.5 minutes. During every mating process, the pairs continued 4–7 copulations. All the mating process occurred within the building and no mating occurred on open places. In one instance, a male bird had attempted to do courtship/ copulation in an open lawn but ended in vain due to the resistance of female (Image 3g,h).

Threats to House Sparrow populations

Five incidents of House Crow damaging nests in lamp posts (2) and human residence (3) were observed during the study period. In four instances, damaged eggs (7) and dead chicks (3) were found on the ground, probably having fallen down from the nests. One incident of an unsuccessful attempt of Black Kite preying adult House Sparrow while the latter engaged in sand bathing was observed. Opportunistic sightings of Shikra in the vicinity of roosting sites at three places were observed, however, killing of House Sparrows by Shikra was not observed.

DISCUSSION

Nest colonies

Summers-Smith (2003) claims that the House Sparrow is a colonial nester and even a small decrease in the size of its nest colony can affect its reproduction in the UK. A study in Guwahati (Nath et al. 2015) shows that 64% nests were solitary and 36% of the nests were in colonies consisting of more than two nests. More than 90% of the nests were solitary in Arakkonam taluk of Tamil Nadu (Pandian 2021)., however, in the present study, 18.91% of nests were solitary. When compared to Guwahati (Assam) and Arakkonam taluk (Tamil Nadu) the number of solitary nests in the present study area was found to be minimal (18.91%). It indicates that majority of nests colonies (81.09%) contained more than two nests, however, the existence of solitary nests and their impacts on the reproduction of House Sparrows in the study area as stated by Summers-Smith (2003) requires further study.

Nesting plasticity of House Sparrow

Of the 407 nests examined, 39.7% of them (n = 159) were found in artificial nest-boxes placed by human residents. House Sparrows show greater tolerance to human presence, choose nest sites not in a rigid manner and can build nests in any random place including artificial nest-boxes, particularly when buildings lack suitable nesting sites as shown in north-western Europe (Munro & Rounds 1985; Shaw et al. 2008). House Sparrows have been shown to nest in artificial nest-boxes in urban, suburban, and rural areas of West Bengal (Bhattacharya et al. 2011). Rahmani et al. (2013) have stated that next to wall cavities in houses, the birds preferred artificial nest-boxes hung by people. The birds building nests in nest-boxes or crevices of buildings have greater reproductive success because of less mortality and emigration (Cink 1976). In the present study, the birds preferred to nest (39.7%) in artificial nest-boxes probably due to the non-availability of holes/cavities in the modern buildings and nest-boxes may offer safety to nests, eggs and chicks from wind, rain, and predatory animals as stated by Munro & Rounds (1985), Shaw et al. (2008), Bhattacharya et al. (2011), and Rahmani et al. (2013), but the rate of reproductive success in artificial nest-boxes as stated by Cink (1976) needs further study. Ali (1996) observed that House Sparrows also built nests in the spaces available on electricity meter boxes within human residences. The present study also confirms his findings that a small percentage of nests (1.23%) were constructed in the electricity meter boxes in five human residences. In Tasmania (Australia), House Sparrows have been found to exhibit nesting plasticity with a high rate of nesting (43%) in vegetation (Sheldon & Griffith 2017), challenging the previously held thoughts that the habit of constructing nests in the vegetation is an alternative nesting option when buildings lack cavities (Barrows 1889; Morris & Tagetmeir 1896; Summers-Smith 1963; Kulczycki & Mazur-Gierainska 1968; Van der Elst 1981; Salek et al. 2015). House Sparrow had been found to construct 8% nests on vegetation in Arakkonam taluk, Tamil Nadu (Pandian 2021). In the present study, the birds had constructed 2% nests in the vegetation, viz., *Ficus benghalensis* (Moraceae), *Tecoma stans* (Bignoniaceae), *Punica granatum* (Lythraceae), and *Citrus limon* (Rutaceae). This indicates that House Sparrows utilize every available platform to build nests. However, it requires further studies to verify the reasons for the incidence of non-cavity nesting behavior of House Sparrows in the study area. The present study also

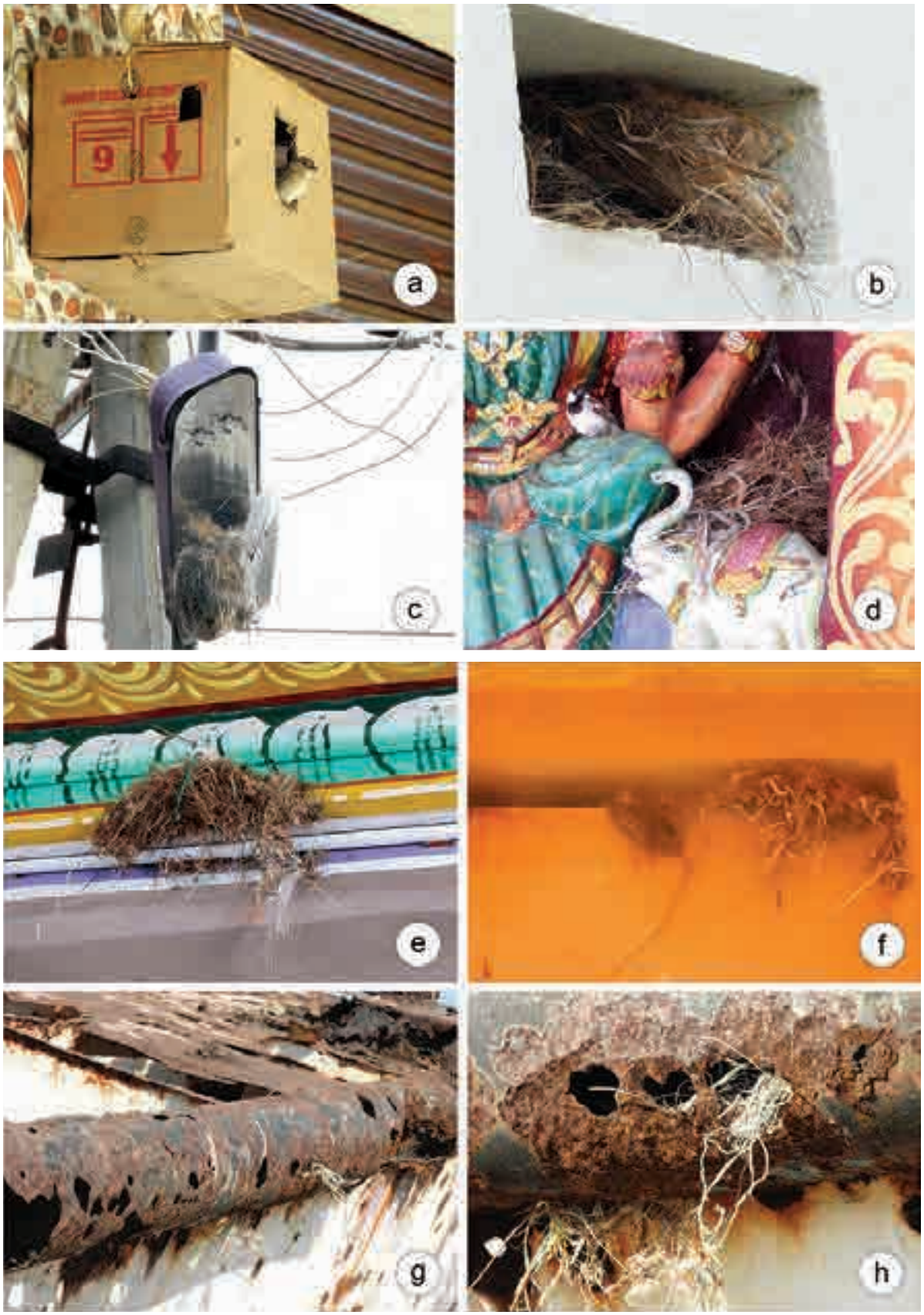


Image 1. Various nesting sites of House Sparrow: a—Artificial nest-box | b—Cavity in the wall of a human dwelling | c—Street lamp post | d—Idol in a temple | e—Temple wall cavity | f—Damaged pipe of a residential building | g–h—Abandoned fishing boat. © M. Pandian.

Image 2. Pictures show various foraging behaviours of House Sparrow: a—A male bird perched on traffic sign board | b—A male bird foraging in a fishing hamlet | c—A female bird foraging at a vacant site near temple premises | d—A male bird foraging near a cattle shed. © M. Pandian.

revealed that apart from nest-boxes, cavities/crevices in the buildings, and vegetation, the birds also utilized cavities found in the abandoned mechanized boats.

Nest materials

House Sparrows use a wide range of materials for construction of nests like, grass, stalks, plant roots, barks, inflorescences, threads, feathers, strings, yarn, wool, and pieces of paper (Indykiewicz 1991). However, the composition of nest materials may vary according to the local availability of the materials (Wimberger 1984). The present study also reveals that the birds used locally available materials for construction of nests, such as banana fibers from garlands around places of worships, dried leaves, grass, synthetic and jute fibers and pieces of rope around commercial establishments, pieces of polythene papers, tissue paper, and even pieces of torn synthetic fishing nets.

Sand and water bathing

Birds exhibit a behavior of mud bathing probably to remove excess feather oil from plumage (Van Liere 1992). Dusting with fine clay particles may reduce lice but dusting with sand or litter had little effect or no effect on ectoparasitic mites (Martin & Mullens 2012). In the present study also, individuals of House Sparrows took sand baths as stated by Van Liere (1992) and Martin & Mullens (2012).

Bathing in water and the subsequent preening helps the birds to get rid of parasites (Rothschild & Clay 1952). On the contrary, Moyer et al. (2002) stated that high humidity due to water bathing favours flourishing of ectoparasites ranging from feather lice to bacteria (Butt & Ichida 1999). The present observations of birds taking water bath corroborate the findings of Rothschild & Clay (1952) and Moyer et al. (2002); however, whether sand or water bath helps in removing of excess feather oil and ectoparasites requires further study.

Threats to House Sparrow populations

The analysis of data from six metro cities, such as Bengaluru, Chennai, Hyderabad, Kolkata, and Mumbai indicate a gradual decline in abundance of House Sparrows in urban centers. Reasons for the suspected

Image 3. Pictures showing various behaviours of House Sparrow: a—A male carries tissue paper as nesting material | b—A male carries dried leaf | c—A male collects fine synthetic fibers | d—A female plucks fibers from nylon rope | e—A pair takes sand bath | f—A female bird takes water bath |g—Male attempts to mate | h—Mating pair. © M. Pandian.

decline of House Sparrows in India may be due to decreasing populations of insects, environmental toxins and lack of suitable nesting sites (http://stateofbirdsofindia.in/wp-content/uploads/2020/02/SOIB_Web-version_Final_.pdf). During Citizen Sparrow study, Rahmani et al. (2013) had observed that in India, the House Sparrow populations were higher in the past (<2005) compared to the time period 2005–2012 and this trend was consistent in all the regions. In eastern Africa, House Crows are known to cause disturbance to nests of perching birds (Lim et al. 2003). House Crows are nuisance to House Sparrows because of their habit of nest predation in India (Khera et al. 2010). House Crow, rats, and domesticated cats have been found to predate on the eggs, chicks and adult birds in Chennai (Daniels 2008). The present study confirmed the views of Lim et al. (2003), Daniels (2008), and Khera et al. (2010) that House Crows predate the nests of House Sparrows, however, the impacts of other avian predators like Black Kite, Shikra and the reasons for declining populations of House Sparrows require further studies.

CONCLUSION

An investigation of nesting habitats of House Sparrow in Rameswaram island (active nests – 407 and adult birds – 2,988), revealed that nesting plasticity was strongly evident. Birds adapted to various aspects of architectural designs of houses by utilizing many available sites, including artificial nest boxes, wrecked boats, cavities/crevices found in the places of worships, and the vegetation around. They utilized locally available materials, including pieces of fishing nets and fibers from garlands available around places of worship. The habits of sand and water bathing occur among this species. The study area being an island and an important pilgrimage centre, the nesting habitats are under stress due to different kinds of land uses. Efforts needs to be made to create awareness among the local residents about the need to conserve declining populations of House Sparrows and establish more nesting sites in the newly constructed buildings. Continuous study is required to monitor the population dynamics of House Sparrows in this island. The detailed systematic survey covering the entire Ramanathapuram district will throw more light on the actual population status of House Sparrows in the district and help in drafting an action plan to conserve and widen their habitats to rural and urban areas.

REFERENCES

Ali, S. (1996). *The Book of Indian Birds*, *13th edition.* Oxford University Press, New Delhi, 466 pp.

Ali, S. & S.D. Ripley (1987). *Handbook of the Birds of India and Pakistan*, *Compact Edition*. Oxford University Press, New Delhi, 737 pp.

Anderson, T.R. (2006). *Biology of Ubiquitous House Sparrow: From Genes to Populations*.Oxford University Press, Oxford, 560 pp.

Barrows, W. B. (1889). 'The English Sparrow (*Passer domesticus*) in North America, Especially in Its Relations to Agriculture' US Department of Agriculture, Division of Economic Ornithology and Mammalogy, Bulletin No. 1.

Bhattacharya, R., R. Roy, S. Ghosh & A. Dey (2011). Observations on house sparrow at Bandel, Hoogly, pp. 147–152. Proceedings of National Seminar on Biodiversity, Water Resource and Climate Change Issues. Kalyani University, West Bengal.

Bibby C.J., N. D. Burgess, D.A. Hill & S.H. Mustoe (2000). *Bird Census Techniques, Second Edition*. Academic Press, London, Xvii+302 pp.

BirdLife International (2016). *Passer domesticus*: The Red List of Threatened Species. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T103818789A155522130.en (accessed on 19 August 2018).

Bower, S. (1999). Reproduction, habitat use and population structure of a flock of House Sparrow in Hamburg. *Hamburger avifaunistische Beitrage* 30: 97–123.

Butt, E.H. & J.M. Ichida (1999). Occurrence of feather degrading bacilli in the plumage of birds. *The Auk* 116: 364–372.

Cink, C.L. (1976). The influence of early learning on nest site selection in the House Sparrow. *Condor* 78: 103–104.

Daniels, R.J.R. (2008). Can we save the sparrow? *Current Science* 95: 1527–1528.

Deepa, M. (2013). The Sparrows: Concerns and Conservation, 18th April 2013. .

Dhanya, R. & P.A. Azees (2010). The House Sparrow *Passer domesticus* population of Arakku Township, Andhra Pradesh, India. *Indian Birds* 5: 180–181.

Ghosh, S., K. Kim & R. Bhattacharya (2010). A survey on House Sparrow population decline at Bandel, West Bengal, Indaia. *Journal of Korean Earth Science Society* 31: 448–453.

Indykiewicz, P. (1991). Nests and nest-sites of the house sparrow, *Passer domesticus (Linnaeu,1758)* in urban, suburban and rural environments. *Acta Zoologica Cracoviensia* 34: 475–495.

Khera, N., A. Das, S. Srivatsava & S. Jain (2010). Habitat-wise distribution of the house sparrow *(Passer domesticus)* in Delhi, India. *Urban Ecosystems* 13: 147–153.

Kulczycki & Mazur-Gierasinska (1968). Nesting of House Sparrows *Passer domesticus* (Linnaeus, 1758). *Acta Zoologica Cracoviensia* 9: 231–250.

Lim H.C., N.S. Sodhi, B.W. Brook & M.C.K. Soh (2003). Undesirable aliens: factors determining the distribution of three invasive bird species in Singapore. *Journal of Tropical Ecology* 19: 685–695.

Leasure, D.R. (2011). The House Sparrow *Passer domesticus* decline: conservation tools emerge from contrasting North American perspectives. *Indian Birds* 8: 22–23.

Martin, C.D. & B.A. Mullens (2012). Housing and dust bathing effects on northern fowl mites (*Ornithonyssus sylviarum*) and chicken body lice (*Menacanthus stramineus*) on hens. *Medical and Veterinary Entomology* 26: 323–333.

Morris, F.O. & W.B. Tagetmeier (1896). A natural history of the nests and eggs of British birds II, 4th edition, London: John C. Nimmo, London. https://doi.org/10.5962/bhl.title.18043

Moyer, B.R., D.M. Drown & D.H. Claton (2002). Low humidity reduces ectoparasite pressure: implications for host like history evolution. *Oikos* 97: 223–228.

Mulsow, R. (2005). Hmburg, pp. 127–152. In: Kelcey J.G. & G. Rheinwald (eds.). *Birds in European cities*. Ginster, St. Katharinen.

Mulsow, R. (2006). *The Birdlife of Hamburg*. Hamburger Avifauna Beitrage Special Edition IOC Hamburg, 45–76 pp.

Munro, H.L. & R.C. Rounds (1985). Selection of artificial nest sites

by five sympatric passerines. *Journal of Wildlife Management* 49: 264–276.

Nath, A., H. Singha, P. Deb, A.K. Das & B.P. Lahkar (2015). Nesting in a Crowd: Response of House Sparrow towards Proximity to Spatial Cues in Commercial Zones of Guwahati City. *Proceedings of the Zoological Society* 69: 249–254.

Newton, I. (2004). The recent declines of farmland bird population in Britain: an appraisal of casual factors and conservation factors. *Ibis* 146: 579–600.

Pandian, M. (2021). Population, Nesting, and Conservation Issues of House Sparrow *Passer domesticus* (Linn., 1758) in Rural Arakkonam, Vellore district, Tamil Nadu, India. *Journal of the Bombay Natural History Society* 118: 40–48.

Prowse, A. (2002). The urban decline of the house sparrow. *British Birds* 95: 143–146.

Rahmani, A.R., K.S. Karthik & S. Quader (2013). Investigating causes of House Sparrow population decline in Urban sub-habitats of India. Journal of the Bombay Natural History Society, Bombay, India, 99 pp.

Rajashekhar, S. & M.G. Venkatesha (2008). Occurrence of House Sparrow, *Passer domesticus indicus* in and around Bangalore. *Current Science* 94: 446–449.

Rothschild, M & T. Clay (1952). *Fleas, Flukes and Cuckoo: A Study of Bird Parasites*. Macmillon Co, New York, 304 pp.

Salek, M., J. Riegert & S. Grill (2015). House Sparrows (*Passer domesticus*) and Tree Sparrows (*Passer montanus*): fine scale distribution, population densities, and habitat selection in a central European city. *Acta Ortnithologica* 50: 22–232.

Shaw, L.M., Chamberlain & Evans (2008). The House Sparrow (Passer domesticus) in urban areas: reviewing a possible link between post-decline distribution and human socioeconomic status. *Journal of Ornithology* 149: 293–299.

Sheldon, E.L. & S.C. Griffith (2017). A high incidence of non-cavity nesting in an introduced population of House Sparrows suggests that the species should not be constrained by cavity-nest site availability. *Avian Research* 8: 29–37.

Summers-Smith, J.D. (1963). *The House Sparrow*. Harper Collins Publications, London

Summers-Smith, J.D. (2003). The decline of the House Sparrow: a review. *British Birds* 96: 439–446.

Van Der Elst, D. (1981). Notification du moineau danestique *Passer domesticus* dans les arbres en Wallonie. *Aves* 18: 123–127.

Van Liere, D.W. (1992). The significance of fowl's bathing in dust. *Animal Welfare* 1: 187–202.

Vincent, K. (2005). Investigating the causes of the decline of the urban house sparrow *Passer domesticus* in Britain. Ph.D dissertation. De Montfort University, Leicester, UK, 303 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22597–22605

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

https://doi.org/10.11609/jott.7103.15.2.22597-22605

#7103 | Received 21 January 2021 | Final received 07 September 2022 | Finally accepted 29 January 2023

OPEN ACCESS

COMMUNICATION

Seasonal diversity and dietary guild structure of birds in two Vindhyan gorge forests of Rajasthan, India

Ashvini Kumar Joshi

Wildlife and Conservation Research Laboratory, Department of Zoology, M.L.V. Government College, Bhilwara, Rajasthan 311001, India.
kashvini80@yahoo.com

Abstract: Habitat is the key factor of biodiversity conservation. In Vindhyan mountain range of India, there are many perennial and seasonal rivers which create deep gorges in their course of flow. Two Vindhyan gorges—Tahla and Chainpuriya—were studied to know their potential as bird habitat from July 2016 to June 2018 using line transect method during three season survey basis. The Tahla gorge had 74 bird species of 35 families (67 resident and 7 migratory). The Chainpuriya gorge had 60 bird species belonged to 31 families (53 resident and 7 migratory). Highest bird diversity (H_T = 3.55, H_{Ch} = 3.29) and richness (d_T = 9.63,d_{Ch} = 8.28) was found in summer and the least diversity (H_T = 3.40, H_{Ch} = 3.19) and richness (d_T = 7.95, d_{Ch} = 7.49) was found in monsoon. Birds of family Muscicapidae had highest relative diversity (T = 9.45, Ch = 13.33) in both the gorges. Insectivorous guild was most abundant followed by omnivorous, carnivorous, granivorous, frugivorous, and nectarivorous guilds. Wide range of habitats, variety of food, life resources, and undisturbed self-sustained ecosystem were important key factors for the rich diversity of birds in the gorges.

Keywords: Avifauna, Chainpuriya, gorge biodiversity, habitat, migratory birds, mountain range, northwestern India, Tahla.

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Joshi, A.K. (2023). Seasonal diversity and dietary guild structure of birds in two Vindhyan gorge forests of Rajasthan, India. *Journal of Threatened Taxa* 15(2): 22597–22605. https://doi.org/10.11609/jott.7103.15.2.22597-22605

Copyright: © Joshi 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: University Grant Commission New Delhi.

Competing interests: The author declares no competing interests.

Author details: Ashvini Kumar Joshi PhD, assistant professor (Zoology) in M.L.V.Government College Bhilwara (Rajasthan). Active researcher in gorge biodiversity, wildlife biology, ecology and limnology.

Acknowledgements: Author expresses his gratitude to Dr Chhaya Bhatnagar, assistant professor, MLS University, Udaipur for guidance and University Grant Commission, New Delhi for financial assistance for the research work.

INTRODUCTION

Rising anthropogenic activities worldwide lead to destruction and fragmentation of habitats, which are the serious threats to the bird community (Baral & Inskipp 2005; Gautam & Kafle 2007). But, there are a few habitats on Earth which naturally protects biodiversity in spite of all the threats. Gorges and canyons are among these places. Gorges and canyons are deep, narrow valleys, result of continuous land erosion by the water streams (Singh 2015). The deepness of gorges keep them isolated from the rest of the world and the self-sustained ecosystem supports a variety of life forms in them. These have diverse micro ecosystems due to variation in humidity, sunlight, temperature, and other abiotic factors (Mowbray & Henry 1968; Grant 2005). Along with the diverse ecosystem, undisturbed ecology, least human interference, favorable climatic conditions with sufficiency of life resources are some peculiar features of gorge habitat which make them 'nature conserved gene reservoirs'.

Rajasthan is the northwestern state of India where in Vindhyan range is one of the important mountain range with Aravalli. It spreads from Dholpur district in east to Chittorgarh districts in southern Rajasthan. A number of rivers have their origin from Vindhyas among which Berach, Kali Sindh, Chambal, Menali, Parwan are some representative rivers. These rivers cut the soft rocks of limestone and sandstone in their path to make deep gorges which are the characteristic of the Vindhyas.

Birds are important indicators of environmental health as they quickly respond to habitat change and disturbance (Mekonen 2017). So the status of bird community of a place is a glimpse of habitat sustainability. Diversity of birds of the gorges and canyons have been studied worldwide (Parnell & Quay 1964; Taylor 1989; Hornsby 1997; Nikolov & Spasov 2005; Patten et al. 2006; Spence et al. 2011; Malan & Lerm 2013; Kopij 2013), but neglected in India (Sharma & Singh 2006; Joshi & Bhatnagar 2016). So the present study is an effort to enlighten the bird diversity of two potential but lesser known Vindhyan gorges, which are not studied earlier.

Study Area

The study was conducted in two Vindhyan gorges, i.e., Tahla and Chainpuriya located in the district of Bhilwara, Rajasthan (Figure 1). The details of the gorges are as follows:.

1. Tahla: The gorge of Tahla (25.66^{0}N & 75.41^{0}E) is located 70 km away from the district headquarter and situated outside of village Tahla. The length of the gorge is 650 m. It is an open type of gorge with high east-facing cliffs (Image 1). The gorge has plenty of water in monsoon, but no surface water available in other seasons. Although, the presence of riparian vegetation indicates high ground water availability throughout the year.

2. Chainpuriya: The gorge of Chainpuriya (25.03^{0}N & 76.46^{0}E) is located 62 km from Bhilwara district headquarter and 1.5 km away the gorge of Tahla. It is 760 m long and comparatively narrow than the Tahla gorge (Image 2). The plateau on the terrace of the gorge is suffered from denudation. During monsoon, water collects from the highland and flows as a stream in the gorge, but does not accumulate due to lack of any pit or pond in it. High cliffs are totally wanting.

The study areas had a mixed type of vegetation including grasses, herbs, shrubs, and trees. The climate of the area was semi-dry type and the vegetation was dry mixed deciduous type having Dhauk *Anogeissus pendula*, Dhhak *Butea monosperma*, Gurjan *Lannea coromandelica*, Salar *Boswellia serrata*, Safed Dhauk *Anogeissus latifolia*, and Tendu *Diospyros melanoxylon* as principal vegetation. Riparian vegetation was also present in the bottom of the gorges near stream of water and the important were Arjuna *Terminalia arjuna*, Kadamb *Mitragyna parvifolia*, Baheda *Terminalia bellirica*, Makhania Jamun *Syzygium heyneanum*, Umara *Ficus glomerata*, Karmala *Mallotus philippensis*, and Khajoor *Phoenix sylvestris*.

MATERIAL AND METHODS

The study was conducted from July 2016 to June 2018. Three season survey (summer, winter, and monsoon) were designed for the study. Early morning visits from 0600 h to 0800 h in the summer and monsoon and 0700 h to 0900 h in winter were done. Days of rain and strong wind were avoided during monsoon. Line transect method (Bibby et al. 1998) was followed in which random transects of different length were laid on the roof and at bottom of the gorge in such a way that maximum microhabitat could be covered. Length of the transects was 520 m (roof) and 650 m (bottom) in Tahla gorge, while 470 m, 950 m (roof) and 760 m (bottom) was in Chainpuriya gorge. Birds were photographed in the field and identified using field guides (Ali & Ripley 2007; Grimmett et al. 2011) and listed according Grimmett et al. (2011).

The residential status of the birds was categorized as

Figure 1. Location of the study area.

Image 1. Overview of Tahla gorge.

Image 2. Overview of Chainpuriya gorge.

'winter migratory', 'summer migratory', and 'resident'. Birds were also categorized according to the guild as carnivorous, insectivorous, frugivorous, granivorous, omnivorous, and nectarivorous on the basis of Ali & Ripley (2007) and field observations. Occurrence of the bird in a habitat was classified into two classes. Birds which were found in the bottom or at the wall of the gorge were classified as 'In Gorge' (IG) and the birds which were observed on the terrace or the flat terrain immediately outside the gorge were classified as birds of 'Roof or the terrace of the gorge' (RG). During field visits the birds that were found to spend more time in the part of the gorge other than terrace, were determined as the birds of gorges in true sense. The local status of birds was measured on the basis of field observations. The bird which was seen many times during a visit was categorized as 'Very Common' (VC). The birds which were sited fewer times during the same visit were categorized as 'Common' (C) and the birds recorded only one or two times in all the field visits were kept in 'Occasional' (O) category. The relative diversity index (RDi) of bird families was calculated (Torre-Cuadros et al. 2007) using the following formula:

$$Rdi = \frac{\text{Number of bird species in a family}}{\text{Total number of species}}$$

Sorenson's index (Cs) was measured to know the similarity of bird community between both gorge habitats. This index is based on the presence-absence data of bird species. Value of the index ranges between 0 and 1. Where 0 reflects total dissimilarity and 1 reflects complete similarity. Seasonal data were pooled to understand the seasonal variation in bird assemblage. Further, we also calculated diversity indices Shanon-Wiener's diversity index (H), species evenness, and Margalef's richness index (d) using PAST 4.0 software. Threats to the habitat and biodiversity were also identified during the entire period of study and mitigation measures were suggested.

RESULTS AND DISCUSSION

A total of 74 bird species of 35 families were recorded in Tahla gorge among which 67 species were resident, four species were winter migratory and three species were summer migratory. Gorge of Chainpuriya had 60 bird species of 31 families out of which 53 were resident, five species were winter migratory and two species were summer migratory (Table 1). Seven bird species in Tahla gorge and 20 species in Chainpuriya gorge were recorded during previous study (Sharma & Singh 2006). There was a big difference in bird species number between two studies likely due to difference in study period and methodology.

Both the gorges were located only at a distance of 1.5 km but the bird species diversity (H = 3.46) and richness (d = 9.36) was higher in Tahla gorge than the bird species diversity (H = 3.29) and richness (d = 8.29) in Chainpuriya gorge (Table 4). More diverse habitats in Tahla gorge including high cliffs, variety of vegetations, accessibility of water, food and other life needs might liable for this high diversity, as species richness in a community increases as environmental heterogeneity increases on a variety of parameters and scales (Gould 2000). This heterogeneity might offer different choices for birds in terms of food and shelter and they prefer the habitat to live. However, water was a limiting factor for the birds in Tahla gorge as there was no perennial source of water or stream available in the gorge besides the rainfall. Some water used to store in the check dam but it was found that it dried up soon after monsoon. There were some locations in the gorge from where underground water bubbled out and deposits in a small pit. This very small quantity of water was available for birds in the hot summer. The less diversity of birds observed in the gorge of Chainpuriya might be due to the lack of any perennial source of water, no water storage structures, absence of high cliffs, denuded terrace of the gorge with less diverse and less dense vegetation, absence of grassland habitat, and the man-made green area to the opposite side of the village. The village had man-made agriculture land with plantation on the opposite side of the gorge as shelter for birds. Deficiency of water and other resources made the birds to move from the gorge to this agriculture land. No water birds were reported during the study period from the gorge as there was no water storage structure found. Lack of high cliffs had made the gorge a non-favourite habitat for cliff-lover birds. Vegetation characteristics were also not lucrative for the frugivorous birds. All these factors may be collectively responsible for less diverse bird community observed in the gorge of Chainpuriya.

Sorenson's Coefficient (Cs) showed a high similarity and less Beta diversity of birds between both the habitats (Cs = 0.782). These two gorges are located at a small distance of 1.5 km and the habitats resemble over several parameters such as forest cover, type of vegetation, rock bed, bed pool and many other ecological factors. The small distance and habitat resemblance between gorges bring this overlapping of bird communities result in low beta diversity.

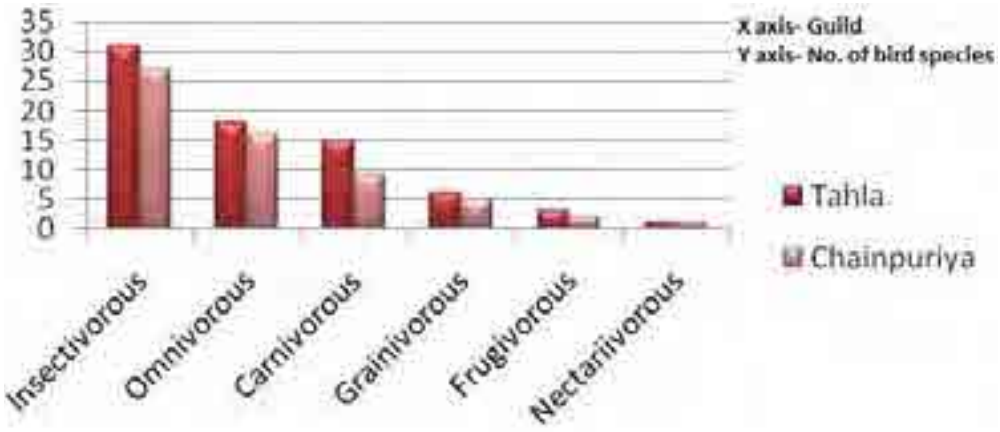


Figure 2. Guild of birds of Tahla and Chainpuriya gorges, Rajasthan, recorded from 2016 to 2018.

Analysis of data on relative diversity revealed that Muscicapidae (seven species, RDi = 9.45) along with Accipitridae (seven species, RDi = 9.45) had maximum diversity in Tahla gorge. It is followed by Columbidae (six species, RDi = 8.10), Cuculidae, Cisticolidae (four species, RDi = 5.40), and Phasianidae, Strigidae, & Campephagidae (three species, RDi = 4.05) families. Ten families had two species (RDi = 2.70) and 17 families were poorly represented (one species, RDi = 1.35) (Table 2). In Chainpuriya gorge, the most diverse bird family was Muscicapidae (eight species, RDi = 13.33). Columbidae, Cuculidae, Cisticolidae (four species, RDi = 6.66) were the second most diverse families followed by Sylviidae (three species, RDi = 5). Eleven families had two species (RDi = 3.33) and 15 families were poorly represented (one species, RDi = 1.66) (Table 3). Muscicapidae and Accipitridae showed the highest diversity in the gorges. The reason behind the high diversity of family Muscicapidae was the high density of insect (food) population in the gorges on account of high humidity and temperature variation, flowering vegetation, and grasses (Joshi & Bhatnagar 2016). Habitat characteristics of gorges likehigh cliffs, crevices, cavities are favourable for the birds of Accipitridae that may lead to high diversity of the birds of family Accipitridae.

In this study, the bird species were categorized into six major guilds (Figure 2) which showed that the habitat had a wide variety of food resources for the birds. The insectivorous guild was the most abundant (T = 31, Ch = 27). It was followed by omnivorous (T = 18, Ch = 16), carnivorous (T = 15, Ch = 9), granivorous (T = 6, Ch = 5), frugivorous (T = 3, Ch = 2), and nectarivorous (T = 1, Ch = 1) guilds. As it is mentioned before that the local climate and vegetation characteristics ensure high insect population for insect-eating birds. So the gorges have a lot of food for insectivorous birds' families Muscicapidae, Cuculidae, and Cisticolidae. The result is found with the study on a Vindhyan gorge of Kekariya by Joshi & Bhatnagar (2016) where the insectivorous guild was dominating. Birds of families Accipitridae, Tytonidae, and Strigidae are the birds of prey and made a significant account of carnivorous birds in the gorges. Tahla had 15 species and Chainpuriya had nine species of carnivorous birds. Besides, high cliffs, cavities, and caves in gorges are preferred habitat for the raptors. The population of grainivorous bird species of family Columbidae had supported by nearby cultivation fields and grasslands. Nectarivorous guild was represented by only a single bird species. Thus, the supporting environment and geography of the gorges is significant for the diversity of birds.

Seasonal changes in the bird richness and diversity was recorded in the gorges (Table 4). Both the gorges had the maximum bird diversity (H_T = 3.55, H_{Ch} = 3.29) in summer and the least diversity (H_T = 3.40, H_{Ch} = 3.19) in monsoon. Bird species richness was also maximum (d_T = 9.63, d_{CH} = 8.28) in summer and the least (d_T = 7.95, d_{CH} = 7.49) in monsoon season in both Tahla and Chainpuriya gorges. Gorges had all life resources for the birds including water. During summers these are the only place in the area for the birds to get water. In monsoon, birds can find their food and water easily in the surrounding area outside the gorge. So bird richness was recorded less in monsoon.

Breeding colonies of Long-billed Vultures *Gyps indicus* (Critically Endangered) and Egyptian Vulture *Neophron percnopterus* (Endangered) were recorded in the study. As literature stated that high cliffs are preferred nesting habitat of both Long-billed Vultures and Egyptian Vultures (Rahmani 2015; Manchiryala &

Table 1. Birds of two Vindhyan gorges, Bhilwara, Rajasthan.

Family	English name	Scientific name	RS	LG	LS	BS	Guild	Vindhyan Gorge	
								Tahla	Chainpuriya
Phasianidae	Grey Francolin	*Francolinus pondicerianus*	R	RG	O	PB	O	√	√
	Jungle Bush Quail	*Perdicula asiatica*	R	RG	C	PB	O	√	
	Indian Peafowl	*Pavo cristatus*	R	IG/RG	C	B	O	√	√
Ardeidae	Little Egret	*Egretta garzetta*	R	IG/RG	VC	B	C		√
	Cattle Egret	*Bubulcus ibis*	R	RG	VC	B	C	√	√
Falconidae	Common Kestrel	*Falco tinnunculus*	WM	RG	O	NC	C	√	√
Accipitridae	Egyptian Vulture	*Neophron percnopterus*	R	IG	C	B	C	√	
	Indian Vulture	*Gyps indicus*	R	IG	C	B	C	√	
	Crested Serpent Eagle	*Spilornis cheela*	R	RG	C	NC	C	√	
	Shikra	*Accipiter badius*	R	RG/IG	C	B	C	√	√
	Oriental Honey- buzzard	*Pernis ptilorhynchus*	R	RG	C	NC	C	√	
	Short-toed Snake Eagle	*Circaetus gallicus*	R	RG	O	NC	C	√	√
	Eurasian Sparrowhawk	*Accipiter nisus*	SM	IG	O	NC	C	√	
Columbidae	Common Pigeon	*Columba livia*	R	RG/IG	VC	B	G	√	√
	Eurasian Collared Dove	*Streptopelia decaocto*	R	RG/IG	VC	B	G	√	√
	Red Collared Dove	*Streptopelia tranquebarica*	R	RG	O	NC	G	√	
	Spotted Dove	*Stigmatopelia chinensis*	R	RG/IG	C	B	G	√	√
	Laughing Dove	*Stigmatopelia senegalensis*	R	RG/IG	VC	B	G	√	√
	Yellow-footed Green Pigeon	*Treron phoenicopterus*	R	RG/IG	C	B	F	√	
Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	R	RG/IG	VC	B	F	√	√
	Plum-headed Parakeet	*Psittacula cyanocephala*	R	RG/IG	C	B	F	√	√
Cuculidae	Jacobin Cuckoo	*Clamator jacobinus*	SM	RG	O	NC	I	√	√
	Common Hawk Cuckoo	*Hierococcyx varius*	SM	RG	O	NC	I	√	√
	Asian Koel	*Eudynamys scolopaceus*	R	RG/IG	VC	B	O	√	√
	Greater Coucal	*Centropus sinensis*	R	RG/IG	VC	B	C	√	√
Tytonidae	Barn Owl	*Tyto alba*	R	IG	O	NC	C		√
Strigidae	SpottedOwlet	*Athene brama*	R	RG/IG	O	B	C	√	√
	Brown Fish Owl	*Ketupa zeylonensis*	R	IG	C	NC	C	√	
	Mottled Wood-Owl	*Strix ocellata*	R	IG	C	NC	C	√	
Apodidae	Little Swift	*Apus affinis*	R	RG	VC	B	I	√	√
Coraciidae	Indian Roller	*Coracias benghalensis*	R	RG	C	B	C	√	√
Meropidae	Green Bee-eater	*Merops orientalis*	R	RG	VC	PB	I	√	√
Upupidae	Common Hoopoe	*Upupa epops*	R	RG	C	NC	I	√	√
Picidae	Lesser Goldenbacked	*Dinopium benghalense*	R	RG/IG	C	B	I	√	
	White-naped Woodpecker	*Chrysocolaptes festivus*	R	RG/IG	C	B	I	√	
Aegithinidae	Common Iora	*Aegithina tiphia*	R/ LM	RG/IG	C	NC	I	√	√
Campephagidae	Large Cuckooshrike	*Coracina macei*	R	RG	C	PB	I	√	
	Small Minivet	*Pericrocotus cinnamomeus*	R	RG/IG	C	NC	I	√	√
	Common Woodshrike	*Tephrodornis pondicerianus*	R	RG/IG	VC	B	I	√	√
Laniidae	Bay-backed Shrike	*Lanius vittatus*	R	RG	C	NC	C	√	
	Long-tailed Shrike	*Lanius schach*	R	RG	C	NC	C	√	
Oriolidae	Indian Golden Oriole	*Oriolus oriolus*	R/ LM	RG/IG	C	NC	O	√	

Family	English name	Scientific name	RS	LG	LS	BS	Guild	Vindhyan Gorge	
								Tahla	Chainpuriya
Dicruridae	Black Drongo	*Dicrurus macrocercus*	R	RG/IG	VC	B	I	√	√
	White-bellied Drongo	*Dicrurus caerulescens*	R	RG/IG	VC	B	I	√	√
Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	R	RG/IG	VC	PB	I	√	
Monarchidae	Asian Paradise-flycatcher	*Terpsiphone paradisi*	R/ LM	IG	C	PB	I	√	
Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	R	RG/IG	VC	B	O	√	√
Paridae	Great Tit	*Parus major*	R	RG/IG	VC	B	O	√	√
Hirundinidae	Dusky Crag Martin	*Ptyonoprogne concolor*	R	IG	VC	B	I	√	√
	Red-rumped Swallow	*Cecropis daurica*	R	IG	VC	B	I	√	√
Alaudidae	Indian Bush Lark	*Mirafra erythroptera*	R	RG	C	NC	O	√	√
	Ashy-crowned Sparrow-Lark	*Eremopterix griseus*	R	RG	VC	B	O	√	√
Cisticolidae	Ashy Prinia	*Prinia socialis*	R	RG/IG	VC	B	I	√	√
	Plain Prinia	*Prinia inornata*	R	RG/IG	VC	PB	I	√	√
	Rufous-fronted Prinia	*Prinia buchanani*	R	RG	C	NC	I		√
	Grey-breasted Prinia	*Prinia hodgsonii*	R	RG	C	NC	I	√	
	Common Tailorbird	*Orthotomus sutorius*	R	RG/IG	VC	B	I	√	√
Sylviidae	Lesser Whitethroat	*Sylvia cuouca*	WM	RG/IG	O	NC	I	√	√
	Sulphur bellied Warbler	*Phylloscopus griseolus*	R	RG/IG	C	NC	I	√	√
	Common Chiffchaff	*Phylloscopus collybita*	WM	RG/IG	O	NC	I		√
Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	R	RG/IG	VC	B	O	√	√
Timaliidae	Large Grey Babbler	*Turdoides malcolmi*	R	RG/IG	VC	PB	O	√	√
	Jungle Babbler	*Turdoides striata*	R	RG/IG	VC	B	O	√	√
Sturnidae	Bank Myna	*Acridotheres ginginianus*	R	RG/IG	VC	B	O		√
	Common Myna	*Acridotheres tristis*	R	RG	VC	B	O	√	
	Brahminy Starling	*Sturnia pagodarum*	R	RG	VC	B	O	√	√
Muscicapidae	Indian Robin	*Saxicoloides fulicatus*	R	RG	VC	B	I	√	√
	Black Redstart	*Phoenicurus ochruros*	R	RG	O	NC	I	√	√
	Common Stonechat	*Saxicola torquatus*	R	RG	O	NC	I	√	√
	Pied Bushchat	*Saxicola caprata*	R	RG	O	NC	I	√	√
	Desert Wheatear	*Oenanthe deserti*	R	RG	O	NC	I		√
	Brown Rock Chat	*Cercomela fusca*	R	RG/IG	C	B	I	√	√
	Variable Wheatear	*Oenanthe picata*	WM	RG	O	NC	I	√	√
	Blue Rock-Thrush	*Monticola saxatilis*	WM	RG	O	NC	I		√
	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	WM	IG	O	NC	I	√	
Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	R	RG/IG	VC	B	N	√	√
Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	R/ LM	RG/IG	O	NC	O	√	√
Passeridae	Chestnut-shouldered Petronia	*Gymnoris xanthocollis*	R	RG	VC	B	O	√	√
	Baya Weaver	*Ploceus philippinus*	R	RG	C	B	G	√	
Estrildidae	Indian Silverbill	*Euodice malabarica*	R	RG	O	B	O		√
	Scaly-breasted Munia	*Lonchura punctulata*	R	RG	C	NC	O	√	√
Emberizidae	Crested Bunting	*Melophus lathami*	R	RG	O	NC	G	√	√
Total								74	60

RS—Residential status | LG—Location in the gorge | LS—Local status | BS—Breeding status | R—Resident | WM—Winter migratory | SM—Summer migratory | RG—Roof of the gorge | IG—In the gorge | O—Omnivorous | C—Carnivorous | G—Granivorous | I—Insectivorous | N—Nectarivorous | B—Breeding | PB—Probable breeder | NC—Not confirm | O—Occasional | C—Common | VC—Very common.

Table 2. Relative diversity of birds of Tahla gorge.

Families of birds	No. of bird species	Relative diversity index (RDi)
Accipitridae, Muscicapidae	7	9.45
Columbidae	6	8.10
Cuculidae, Cisticolidae	4	5.40
Phasianidae, Strigidae, Campephagidae	3	4.05
Psittacidae, Picidae, ,Laniidae, Dicruridae, Hirundinidae, Alaudidae,Sylviidae, Timaliidae, Sturnidae, Passeridae	2	2.70
Ardeidae, Falconidae, Apodidae, Coraciidae, Meropidae, Upupidae, Aegithinidae, Oriolidae, Rhipiduridae, Monarchidae, Corvidae, Paridae, Pycnonotidae, Nectariniidae, Zosteropidae, Estrildidae, Emberizidae	1	1.35

Table 3. Relative diversity of birds of Chainpuriya gorge.

Families of birds	No. of bird species	Relative diversity index (RDi)
Muscicapidae	8	13.33
Columbidae, Cuculidae, Cisticolidae	4	6.66
Sylviidae	3	5
Phasianidae, Ardeidae, Accipitridae, Psittacidae, Alaudidae,Campephagidae, Dicruridae, Hirundinidae, Timaliidae, Sturnidae, Estrildidae	2	3.33
Falconidae, Tytonidae, Strigidae, Apodidae, Coraciidae, Paridae, Meropidae, Upupidae, Aegithinidae, Corvidae, Pycnonotidae, Nectariniidae, Zosteropidae, Passeridae, Emberizidae	1	1.66

Table 4. Bird diversity indexes in different seasons of the study period.

Gorge	Shanon's diversity index H				Species evenness				Margalef's richness index d			
	S	W	M	Mean ±SE	S	W	M	Mean ±SE	S	W	M	Mean ±SE
Tahla (T)	3.55	3.44	3.40	3.46 ±0.04	0.69	0.56	0.75	0.67 ±0.06	9.63	10.5	7.95	9.36 ±0.75
Chainpuriya (Ch)	3.29	3.37	3.19	3.29 ±0.05	0.61	0.61	0.61	0.61 ±0.00	8.28	9.11	7.49	8.29 ±0.47

S—Summer | W—Winter | M—Monsoon

Medicheti 2016). Tahla gorge had high east facing cliffs with no disturbance which may provide favourable habitat for these vultures. In contrary, lack of high cliffs in Chainpuriya, is not a suitable habitat for the vultures as well as other raptors.

Threats and conservation

Inspite of the rich biodiversity of gorges, several threats to the habitat and biodiversity were identified during this study. Illegal mining of sand stones and lime stones in the area, grazing pressure on the vegetation specially to the growing plants, firewood collection, soil erosion, lack of awareness regarding the rich biodiversity of the habitat and threats, and not having a proper management plan for the conservation were the principal threats. A proper strategy at both government and local level should be prepared to lighten the severity of the condition of gorge ecosystems. Restoration of deforested area is the immediate requirement to conserve biodiversity. Planned grazing in alternate areas can give enough time to restore plants. People are stakeholders of the natural resources of the gorges so these must be educated to conserve the resources for their sustainable use. Workshops for local school students should be organized near gorges to create awareness in the future generations. Tourist activities can be promoted with some precautions to generate income for the local people.

CONCLUSION

It can be inferred from the present study that these gorges have high potential to support birds from diverse families as well as diverse habit and habitat. A large number of birds with a high ratio of resident birds in these Vindhyan gorges substantiate high capacity of these habitats to sustain and conserve biodiversity.

REFERENCES

Ali, S. & S.D. Ripley (2007). *Handbook of the Birds of India and Pakistan*. Oxford University Press, New Delhi, India, Vol. 1–10.

Baral, H.S. & C. Inskipp (2005). Important Bird Areas in Nepal: Key Sites for Conservation. Bird Conservation Nepal and Birdlife International, 242 pp.

Bibby, C., M. Jones & S. Marsden (1998). Expedition field techniques Bird Surveys. Expedition Advisory Centre of Royal Geographical Society, 134 pp.

Gautam, R. & G. Kafle (2007). A preliminary survey of waterbirds in Phewalake, Kaski. *Danphe* 16(3/4): 6–8.

Grant, C. (2005). Carnarvon national park management plan.

Environmental Protection Agency, The State of Queensland, 51 pp.

Gould, W. (2000). Remote sensing of vegetation, plant species richness and regional biodiversity hotspots. *Ecological Application* 10: 1861–1870.

Grimmett, R., C. Inskipp & T. Inskipp (2011). *Birds of Indian Subcontinent*. Oxford University Press, New Delhi, India, 528 pp.

Hornsby, P. (1997). Records of birds seen at Brindana gorge, in the north flinder ranges, South Australia. *South Australian Ornithologist* 32: 118–122.

Joshi, A.K. & C. Bhatnagar (2016). Diversity and habitat association of birds in a Vindhyan gorge of Kekariya, Rajasthan, India. *Ambient Science* 3(2): 55–60.

Kopij, G. (2013). Avian assemblages of river gorges in the Maloti/Drakensberg 'hot-spot' region, southern Africa. *Zoology and Ecology* 23: 171–182.

Malan, G. & R.E. Lerm (2013). Association between avian assemblages and mountain bushveld communities along a single mountain slope in the Usuthu Gorge, South Africa. *Ostrich* 84: 63–69.

Manchiryala, R. & R.M. Medicheti (2016). Breeding biology of critically endangered long-billedvulture (*Gyps indicus*) ata uniquesite in Telangana state, India. *Ambient Science* 3(1): 49–51.

Mekonen, S. (2017). Birds as biodiversity and environmental indicator. *Advances in Life Science and Technology* 60: 16–22.

Mowbray, T.B. & J.O. Henry (1968). Vegetation gradients in relation to environment and phenology in a southern Blue Ridgegorge. *Ecological Monographs* 38: 309–344.

Nikolov, S. & S.D. Spasov (2005). Frequency, density and numbers of some breeding birds in the south part of Kresna gorge (SW Bulgaria). *Acrocephalus* 26: 273–282.

Parnell, J.F. & T.L. Quay (1964). The summer birds of the Toxway River gorge of southwestern North Carolina. *Wilson Bulletin* 76(2): 138–146.

Patten, M.A., D.L. Reinking & D.H. Wolfe (2006). Avifauna of the Four Canyon preserve, Ellis County, Oklahoma. *The Oklahoma Biological Survey*, 2nd Series 7: 11–20.

Rahmani, A.R. (2015). *Threatened Birds of India*. BNHS and Oxford University Press, Bombay, 870 pp.

Sharma, S.K. & B.P. Singh (2006). Birds of the gorges of Vindhyas in Rajasthan state. *Zoos Print Journal* 21: 2167–2169.

Shurulinkov, P. & I. Nikolov (1989). Recent status of the breeding avifauna in the canyons of RousenskiLom River system, north-eastern Bulgaria. Ciconia, 77 pp.

Taylor, D.M. (1989). Notes on Hells Canyon birds. *Great Basin Naturalist* 49: 279–287.

Torre-Cuadros, M.D., L.A.L.S. Herrando-Perez & K.R. Young (2007). Diversity and structure patterns for tropical montane and premontane, forests of central Peru, with an assessment of the use of higher-taxon surrogacy. *Biodiversity and Conservation* 16: 2965–2988.

Singh, S. (2015). *Geomorphology*. Pravalika Publications, Allahabad.

Spence, J.R., T.L. Charles & D.G. John (2011). Birds of Glen Canyon National Recreation Area, Utah and Arizona. *Western North American Naturalist* 5: 20–70.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22606–22610
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.8172.15.2.22606-22610
#8172 | Received 02 September 2022 | Final received 31 January 2023 | Finally accepted 07 February 2023

COMMUNICATION

Differential kleptoparasitic interactions of Himalayan Vulture *Gyps himalayensis* with conspecifics and heterospecifics during various stages of breeding

Hameem Mushtaq Wani

Department of Zoology, Central University of Kashmir, Ganderbal, Jammu and Kashmir 191201, India.
hameemwani@gmail.com

Abstract: Reports of kleptoparasitic events involving *Gyps himalayensis* (Himalayan Vulture) are limited. In this article we document intraspecific and interspecific kleptoparasitic interactions at nesting sites, and analyse factors influencing this behaviour. The study was carried out at Hirpora Wildlife Sanctuary of Kashmir Himalaya, at an elevation of about 2,546 m. We observed 61 instances of food theft involving conspecifics (n = 12) and heterospecifics (n = 49). The highest number of incidents were observed during the chick rearing period (n=40), followed by incubation (n = 10) and pre-laying periods (n = 5). We observed the highest number of attacks at nesting sites (n = 30) and the lowest in flight (n = 9).

Keywords: Himalaya, Hirpora Wildlife Sanctuary, Kashmir, Kleptoparasitism, nest, vulture.

Editor: Bahar S. Baviskar, Wild-CER, Nagpur, India. **Date of publication:** 26 February 2023 (online & print)

Citation: Wani, H.M. (2023). Differential kleptoparasitic interactions of Himalayan Vulture *Gyps himalayensis* with conspecifics and heterospecifics during various stages of breeding. *Journal of Threatened Taxa* 15(2): 22606–22610. https://doi.org/10.11609/jott.8172.15.2.22606-22610

Copyright: © Wani 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: None.

Competing interests: The author declares no competing interests.

Author details: Hameem Mushtaq Wani did his PhD programme from University of Kashmir, Srinagar. His doctoral thesis majorly focussed on bioecology and conservation status of vultures in Hirpora Wildlife Sanctuary of Kashmir Himalaya. He is currently working as a teaching faculty in the Department of Animal Science (Zoology), Central University of Kashmir, India.

Acknowledgements: Author is grateful to the Department of Wildlife Protection, Government of Jammu & Kashmir, for providing necessary permission to work in Hirpora Wildlife Sanctuary.

INTRODUCTION

Kleptoparasitism is the acquisition of resources by theft (Brockmann & Barnard 1979; Hadjichrysanthou et al. 2018) such as prey or other materials that require time and effort to obtain. The practice is not without risk, since a kleptoparasite might be injured by its victim if it defends its prey (Iyengar 2008; Hadjichrysanthou et al. 2018). This behaviour is relatively widespread among birds, particularly sea birds. Kleptoparasitic interactions involving vultures, for example the Lammergeier *Gypaetus barbatus* and Black Vulture *Aegypius monachus,* have been reported in the literature (Margalida & Heredia 2002). Data on this behaviour at nesting zones, however, is limited. This may be due to the fact that while vultures congregate at carcasses (Mundy et al. 1992) they carry food in their crop to the nest where chicks are fed via regurgitation (Mushtaq 2020), making theft by other birds difficult.

Himalayan Vultures feed on carcasses of dead animals (Image 2) (Wani et al. 2021) along with other scavengers including large billed crows and raven (Navaneethan et al. 2015). The availability of carrion can vary spatially and seasonally, thereby playing an important part in movement and distribution of species feeding on it (Wani et al. 2020). Himalayan vultures show intensive parental care during chick rearing periods. In this article, we documented intraspecific and interspecific kleptoparasitic interactions of Himalayan vulture at nesting sites, and analysed the factors influencing this behaviour.

Image 1. Hirpora Wildlife Sanctuary.

MATERIALS AND METHODS

Study area

Hirpora Wildlife Sanctuary spreads over an area of 341 km^2 in Shopian District, Kashmir. At an altitude of 2,546 m, the sanctuary is located between 33.3955 °N & 74.3940 °E. It has forests, pastures, scrub land, waste land water bodies. To the north, the sanctuary is bounded by Lake Gumsar, to the east by Rupri, to the south by Saransar, to the west by the Pir Panjal pass and to northeast by Hirpora village (Wani et al. 2020) (Image 1). The area is renowned for its rich floral and faunal diversity. The main faunal elements of the sanctuary include- Pir Panjal Markhor *Capra falconeri*, Himalayan Musk Deer *Moschus leucogaster*, Himalayan Black Bear *Ursus thibetanus*, Himalayan Brown Bear *Ursus arctos*, Leopard *Panthera pardus*, Red Fox *Vulpes vulpes*, and Tibetan Wolf *Canis lupus*. The vegetation of the sanctuary is divided into mixed coniferous forests, deciduous subalpine scrub forests and subalpine pastures. The coniferous forests are dominated by Kail pine, the sub alpine forests are dominated by fir while the deciduous subalpine scrub forests are dominated by Himalayan Birch *Betula utilis* and Juniper *Juniperus communis* (Wani et al. 2021).

Methods

Field work was undertaken in Hirpora Wildlife Sanctuary from June 2019 to May 2020. Observations on food stolen, species involved and situation in which they occurred (in flight, at nest and on feeding site) were made during pre-laying, incubation and chick rearing period with the help of 10X binocular. Observations were made from vantage points (at a distance of about 300–400 m) that allowed a good view of nesting and feeding sites. In all intraspecific interactions observed, we recorded the individuals' age which was determined by Grimmett et al. (2016).

Data analysis

Basic statistics such as, mean and standard deviation were calculated for all the variables and were given as X±SD. Statistical analysis were performed by using Windows based statistical packages- Micorsoft Excel

and MINITAB (Ryan et al. 1992). A non-parametric test, Kruskal-Wallis one way ANOVA was used for testing the null hypothesis at p <0.05.

RESULTS

We observed 61 Himalayan Vulture interactions of food theft, 12 with conspecifics and 49 with heterospecifics. These interactions varied among different sites and seasons (Table 4, Table 5). The various heterospecifics involved in these interactions included Bearded Vulture *Gypaetus barbatus* (n = 7), Common Raven *Corvus corax* (n = 22), Large-billed Crow *Corvus macrorhynchos* (n = 15), and House Crow *Corvus splendens* (n = 5).

Interactions with conspecifics

We observed a total of 12 interactions of Himalayan Vulture with conspecifics (Table 2). In eight interactions adult Himalayan vultures acted as kleptoparasites, and in four interactions sub-adult vultures acted as kleptoparasites. During the former case, four sub-adults and two adults acted as hosts whereas in the latter case, one adult and one sub-adult acted as hosts. All these interactions with conspecifics were statistically significant (H = 7.89; DF = 01; P <0.05) (Table 2).

Interactions with heterospecifics

We observed a total of 49 interactions of Himalayan Vulture with heterospecifics. All these interactions were statistically significant (H = 7.32; DF = 03; P <0.05). In 07 of these interactions, *Gypaetus barbatus* acted as kleptoparasite with 05 such interactions in which sub-adult Himalayan vulture acted as host. In rest of the two interactions, adult Himalayan vulture acted as host. Rest of the interactions involved different corvid species including- Common Raven *Corvus corax* (n = 22), Large-billed Crow *Corvus macrorhynchos* (n = 15), and House Crow *Corvus splendens* (n = 05). In 15 interactions with Common Raven, sub-adult Himalayan vulture individuals acted as hosts and in seven such interactions, adult Himalayan Vulture individuals acted as hosts. Similarly, in eight interactions with *Corvus macrorhynchos*, sub-adult Himalayan Vulture and in seven such interactions, adult Himalayan vulture acted as hosts. Among interactions with *Corvus splendens,* three interactions involve sub-adult Himalayan Vulture, and two interactions involve adult individuals as hosts (Table 1).

Table 1. Kleptoparasitic interactions of *Gyps himalayensis* with heterospecifics in Hirpora Wildlife Sanctuary.

Kleptoparasite	Host	
	Gyps himalayensis (Subadult)	*Gyps himalayensis* (Adult)
Gypaetus barbatus	05	02
Corvus corax	15	07
Corvus macrorhynchos	08	07
Corvus splendens	03	02
Kruskal-Wallis one way ANOVA	H = 7.32; DF = 03; P <0.05	

Table2. Kleptoparasitic interactions of *Gyps himalayensis* with conspecifics in Hirpora Wildlife Sanctuary.

	Host	Kleptoparasite	
	Gyps himalayensis	Subadult	Adult
Kleptoparasite	Sub-adult (04)	02	02
	Adult (08)	06	02
Kruskal-Wallis ANOVA	H = 7.89; DF = 01; P <0.05		

Table 3. Percentage of Kleptoparasitic attacks defended and not defended by *Gyps himalayensis* during Pre-laying, Incubation and Chick rearing period in Hirpora Wildlife Sanctuary.

Period	No. of attacks	Percentage of attacks	
		Defended (%)	Non-defended (%)
Pre-laying	**05**	5(100)	0(0.0)
Incubation	**16**	10(62.5)	6(37.5)
Chick rearing	**40**	36(90)	4(10.0)
Kruskal-Wallis one way ANOVA		H = 8.16; DF = 02; P <0.05	

Interactions during different periods

Highest number of attacks from both conspecifics and heterospecifics were observed during chick rearing period (n = 40) followed by incubation period (n = 10) and pre-laying period (n = 5). In chick rearing period, 90% attacks were defended successfully whereas in incubation period, only 62.5% of the attacks were defended successfully. However, during pre-laying period, all attacks from conspecifics and heterospecifics were defended successfully. The percentage of defended and non-defended attacks were statistically significant (H = 8.16; DF = 02; P <0.05) (Table 3).

Interactions at different sites

The number of interactions of Himalayan Vulture with its conspecifics and heterospecifics at different

Table 4. Kleptoparasitic interactions of *Gyps himalayensis* with conspecifics and heterospecifics in flight, at nest and at feeding site.

Place/Site	Thefts	Defended	Non-defended
Flight	09	07	02
Nest	30	29	01
Feeding site	22	15	07
Kruskal-Wallis one way ANOVA	H = 8.14; DF = 02; P <0.05		

Table 5. Kleptoparasitic interactions of *Gyps himalayensis* with conspecifics and heterospecifics during different seasons.

Season	Attacks	Attacks defended (%)	Attacks not defended (%)
Winter	28	92.85	7.15
Spring	12	83.33	16.67
Summer	14	57.14	42.86
Autumn	07	71.42	28.58

sites were statistically significant (H = 8.14; DF = 02; P <0.05). We observed highest number of attacks at nesting site (n = 30) and lowest number of attacks in flight (n = 09). A total of 22 attacks were observed at feeding sites. Among 30 attacks, at nest site, 29 were defended successfully. On the other hand, among 22 attacks at feeding sites, only 15 were defended and rest (31.81%) were not defended (Image 2). Out of nine attacks in flight, seven were defended and in two attacks, kleptoparasite remained successful in taking away the food from Himalayan Vulture (Table 4).

DISCUSSION

Kleptoparasitism occurs when there is an association between species. However, it is equally obvious, that kleptoparasitism does not always occur when two species are found together. Rather, there are various ecological and behavioural conditions that make kleptoparasitism particularly likely. These include- large concentration of host (John & Lee 2019), large quantities of food (Mullers & Amar 2015) large and high quality food items (Iyengar 2008), predictable food supply (Dekker et al. 2012), visibility to food items (John & Lee 2019), food shortage behaviour of parasite (Mullers & Amar 2015), behaviour and habitat of host (Hamilton 2002).

Our results suggested that the *Corvus corax, C. macrorhynchos* and *C. splendens* due to their little chance for foraging at carcass as compared to vultures, are making use of the spatial and temporal predictability of food resources by becoming kleptoparasites (Fisher 1985). Most of the thefts suffered at the nest by kleptoparasites took place during chick rearing, a period when food items often accumulate at the nest sites. Thefts in flight occurred during pre-laying and incubation period, a time when food availability is reduced and when weather may greatly limit the activities of foraging and locating food. For those age groups (principally <3 years, i.e., sub-adults) that are more dependent on predictable food sources such as feeding stations (Heredia 1991), this might be a foraging strategy used much more regularly. These results are in agreement with the idea that immature or inexperienced birds may compensate for their less effective foraging abilities by kleptoparasitism (Margalida & Bertran 2003). To the contrary, kleptoparasitism by adults could be an opportunistic foraging behaviour. Our observations were done in flight, in addition to nests and feeding sites. This accounts for the fact that breeding adults were the host bird in 79% of all observed events.

As a result of the cost/benefit rate, two factors would determine that the species that attempted stealing would resort to this indirect strategy: the territorial behaviour of the host species (Margalida & Bertran 2000) and the accumulation of food resources in nesting area.

Dominance of adults over immature is a well-documented phenomenon in raptors (Moreno-Opo et al. 2020), but a reverse dominance pattern also has been observed (Rodríguez-Estrella & Rivera-Rodriguez 1992). In the case of conspecifics, plumage colouration of Himalayan vulture adults could act as a status signal (Negro et al. 1999). This signal could be used by territorial adults to displace other immature Himalayan Vultures not by attacking them, but simply by signalling their status while approaching them (Bautista et al. 1998).

On the other hand, the Himalayan Vulture having low wing loading and its large wingspan give this species great dominance in flight (Donázar et al. 1993) and make it difficult for an opponent to steal food successfully. In the case of conspecifics, the fact that younger birds are less skilful in flight would mean that they would be less successful in actions of direct piracy, so that the energetic cost of those attempts might be greater than the likely benefits obtained from those actions (Fisher 1985; Moreno-Opo et al. 2020).

The Himalayan Vulture's attacks of intruders in the vicinity of the nest throughout the breeding season (Margalida & Bertran 2000) would act as deterrent

Image 2. Himalayan Vulture feeding on carcass of a buffalo.

and would make food at nest the least convenient for stealing. The success in aggressive encounters appears determined by the body size and condition, and the previous possession of the disputed resource (Bautista et al. 1998). In contrast, those species with higher aerial maneuverability but with smaller size, such as ravens, would have to focus their actions at the nest, where prey remains also accumulate. Obtaining prey remains there may be less costly for those birds: (1) adults are gradually less often present at the nest as the breeding season progress (Margalida & Bertran 2000) and (2) prey items present in the nest have a higher meat content as consequence of differential requirements in nutrients for the chick (Margalida & Bertran 2001).

REFERENCES

Bautista, L.M., J.C. Alonso & J.A. Alonso (1998). Foraging site displacement in Common Crane flocks. *Animal Behaviour* 56: 1237–1243.

Brockmann, H.J. & C.J. Barnard (1979). Kleptoparasitism in birds. *Animal Behaviour* 27: 487–514.

Dekker, D., M. Out, M. Tabak & R. Ydenberg (2012). The effect of kleptoparasitic bald eagles and gyrfalcons on the kill rate of peregrine falcons hunting dunlins wintering in British Columbia. *Condor* 114(2): 290–294.

Donázar, J.A., F. Hiraldo, F. & J. Bustamante (1993). Factors influencing nest site selection, breeding density and breeding success in the bearded vulture (*Gypaetus barbatus*). *Journal of Applied Ecology* 30: 504–514.

Fisher, D.L. (1985). Piracy behavior of wintering Bald Eagles. *Condor* 87: 246–251

Grimmett, R., C. Inskipp & T. Inskipp (2016). *Birds of Indian Subcontinent*. Bloomsbury publishing India, 528 pp.

Hadjichrysanthou, C., M. Broom & J. Rychtář (2018). Models of kleptoparasitism on networks: the effect of population structure on food stealing behaviour. *Journal of Mathematical Biology* 76: 1465–1488. https://doi.org/10.1007/s00285-017-1177-7

Hamilton, I.M. (2002). Kleptoparasitism and the distribution of unequal competitors. *Behavioural Ecology* 13(2): 260–267

Heredia, B. (Eds.) (1991). El plan coordinado de actuaciones para la protecci6n del quebrantahuesos. El quebrantahuesos (*Gypaetus barbatus*) en los Pirineos, 126pp.

Iyengar (2008). Kleptoparasitic interactions throughout the animal kingdom and a-re-evaluation, based on participant mobility, of the conditions promoting the evolution of kleptoparasitism. *Biological Journal of the Linnean Society* 93: 745–762.

John, J.R.M & W.S. Lee (2019). Kleptoparasitism of Shoebills Balaeniceps rex by African Fish Eagles Haliaeetus vocifer in Western Tanzania. *Tanzania Journal of Science* 45(2): 131–143.

Margalida, A. & J. Bertran (2000). Breeding behaviour of the Bearded Vulture *Gypaetus barbatus*- minimal sexual differences in parental activities. *Ibis* 142: 225

Margalida, A. & J. Bertran (2001). Function and temporal variation in use of ossuaries by Bearded Vultures (*Gypaetus barbatus*) during the nestling period. *Auk* 118: 785–789.

Margalida, A. & J. Bertran (2003). Interspecific and intraspecific kleptoparasitic interactions of the bearded vulture (*Gypaetus barbatus*) at nesting areas. *Journal of Raptor Research* 37: 157–160.

Margalilda, A. & R. Heredia (2002). Interspecific interaction between Lammergeier *Gypaetus barbatus* and Black Vulture *Aegypius monachus*: predation or kleptoparasitism? *Sandgrouse* 24: 138–139

Moreno-Opo, R., A. Trujillano & A. Margalida (2020). Larger size and older age confer competitive advantage: dominance hierarchy within European vulture guild. *Scientific Reports* 10, 2430 (2020). https://doi.org/10.1038/s41598-020-59387-4

Mullers, R.H.E. & A. Amar (2015). Shoebill Balaenicpes rex foraging behaviour in the Bangweulu Wetlands, Zambia. *Ostrich* 86(1&2): 113–118

Mundy, P., D. Butchart, J. Ledger & S. Piper (1992).*The vultures of Africa.* Acorn Books & Russel Friedman Books, Randburg and Halfway, 100 pp.

Mushtaq, H. (2020). Bioecology and conservation status of vultures in Hirpora Wildlife Sanctuary of Kashmir Himalaya. Ph.D. Thesis. Department of Zoology, University of Kashmir, 121 pp.

Navaneethan, B., K. Kalyansundaram Sankar, Q. Qureshi & M. Manjrekar (2015). The Status of Vultures in Bandhavgarh Tiger Reserve, Madhya Pradesh, Central India. *Journal of Threatened Taxa* 7(14): 8134–8138. https://doi.org/10.11609/jott.2428.7.14.8134-8138

Negro, J.J., A. Margalida, F. Hiraldo, & R. Heredia (1999). The function of cosmetic coloration of Bearded Vultures: when art imitates life. *Animal Behaviour* 58: F14–F17

Rodríguez-Estrella, R. & L.B. Rivera-Rodríguez (1992). Kleptoparasitism and other interactions of Crested Caracara in the Cape region, Baja California, Mexico. *Journal of Field Ornithology* 63: 177–180.

Ryan, F.B., B.L. Joiner & A.T. Ryan (1992).*MINITAB Handbook.* Boston PWS-KENT Publishing Company, 376 pp.

Wani, H.M., M.F. Fazili & R. Ahmad (2021). Seasonal habitat selection of *Gypshimalayensis* in Hirpora Wildlife Sanctuary, Jammu and Kashmir. *Indian Journal of Ecology* 48(2): 524–529.

Wani, H.M., M.F. Fazili, S.A. Charoo, B.A. Bhat & R.A. Bhat (2020). Evaluating population, threats and peoples attitude in relation to Himalayan vulture (*Gyps himalayensis*) in Hirpora Wildlife Sanctuary, Kashmir: A call for conservation. *Indian forester* 146 (10): 932–937. https//doi.org/10.36808/if/2020/v146i10/153858

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22611–22622

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

https://doi.org/10.11609/jott.7950.15.2.22611-22622

#7950 | Received 02 April 2022 | Final received 23 August 2022 | Finally accepted 25 October 2022

OPEN ACCESS

COMMUNICATION

Range extension of *Isthmoheros tuyrensis,* a threatened species of fish (Cichlidae) in Panama: including new ecological and morphological data

Arturo Dominici-Arosemena [1], Arturo Angulo [2], Haydee Osorio-Ugarte [3], Quiriatjaryn Ortega-Samaniego [4], Andrés Fraiz [5], Arminda Guerrel [6], Edgar Araúz [7], Jennyfer Montiel [8], Beatriz Medina [9], Yehudi Rodríguez-Arriatti [10], Yessenia González [11], Javier Pardo [12], Karly Urriola [13] & Adrián Ramos-Merchante [14]

[1,6,9,10,11,13] Universidad Marítima Internacional de Panamá (UMIP), Facultad de Ciencias del Mar, Apartado 0843-03561, Ciudad de Panamá, República de Panamá.

[2] Museo de Zoología, Centro de Investigación en Biodiversidad y Ecología Tropical (CIBET), Universidad de Costa Rica (UCR) 11501-2060, San Pedro de Montes de Oca, San José, Costa Rica.

[3] Universidad Tecnológica de Panamá (UTP), Apartado 0819-07219, El Dorado, Ciudad de Panamá.

[4] Instituto Universitario de Investigación de Ingeniería del Agua y Medio Ambiente Universidad Politécnica de Valencia, Camino de Vera S/N Valencia 46022 España.

[4] Ministerio de Ambiente de Panamá, Dirección Regional de Panamá Oeste, Avenida de las Américas, La Chorrera, República de Panamá.

[5] Wetlands International, Latinoamérica y el Caribe Apartado Postal 0819-03717, Ciudad de Panamá, República de Panamá.

[7,12] Universidad de Panamá (UP). Apartado 0824 Estafeta Universitaria, Ciudad de Panamá, República de Panamá.

[8] Universidad Autónoma de Chiriquí (UNACHI), El Cabrero, Ciudad de David, Provincia de Chiriquí, República de Panamá.

[14] Facultad de Ciencias Experimentales, Departamento de Ciencias Integradas, Universidad de Huelva, Campus Universitario El Carmen, Avda. Andalucía s/n, 21071 Huelva, España.

[1] adominici@umip.ac.pa (corresponding author), [2] arturo.angulosibaja@ucr.ac.cr, [3] haydee.osorio@utp.ac.pa, [4] quiorsa@doctor.upv.es, [5] andres.fraiz@wetlands.org, [6] arminda.guerrel@umip.ac.pa, [7] edgar.arauza@up.ac.pa, [8] jennyfer.montiel@unachi.ac.pa, [9] bmedina@umip.ac.pa, [10] yrodriguez@umip.ac.pa, [11] ygonzalez@umip.ac.pa, [12] javier.pardo@up.ac.pa, [13] kurriola@umip.ac.pa, [14] adrian.ramos@ciecema.uhu.es

Editor: Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, Cuernavaca, México. **Date of publication:** 26 February 2023 (online & print)

Citation: Dominici-Arosemena, A., A. Angulo, H. Osorio-Ugarte, Q. Ortega-Samaniego, A. Fraiz, A. Guerrel, E. Araúz, J. Montiel, B. Medina, Y. Rodríguez-Arriatti, Y. González, J. Pardo, K.Urriola & A. Ramos-Merchante (2023). Range extension of *Isthmoheros tuyrensis*, a threatened species of fish (Cichlidae) in Panama: including new ecological and morphological data. *Journal of Threatened Taxa* 15(2): 22611–22622. https://doi.org/10.11609/jott.7950.15.2.22611-22622

Copyright: © Dominici-Arosemena et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Grant IOMA-19-008 from the Panama National Secretary of Science and Technology (SENACYT).

Competing interests: The authors declare no competing interests.

Abstract, Keywords, Spanish abstract, Author details, Author contributions & Acknowledgements: See end of this article.

INTRODUCTION

Cichlids dispersed to northern Central America (from South America) early in the Cenozoic, long before the Plio-Pleistocene rise of the Isthmus of Panama (IOP; Matamoros et al. 2015). Currently, there is a relatively low species diversity and a limited number of cases of endemism within the Cichlidae in southern Central America. This is especially evident in the Pacific Slope of Eastern Panama (PSEP), as compared to the western side of Panama (which borders Costa Rica) and the rest of Central America, including Mexico (Matamoros et al. 2015). The PSEP includes 13 major river drainages starting from the west side of the Panama Canal (Comité de Alto Nivel de Seguridad Hídrica 2016) and is recognized within the Chocó Biogeographical Region (Matamoros et al. 2015).

Only two endemic species of cichlids have been documented in the PSEP, particularly in the Darien and Bayano River tributaries (Comité de Alto Nivel de Seguridad Hídrica, 2016). One of these is *Darienheros calobrensis* and the other is *Isthmoheros tuyrensis,* both recognized in monotypic genera (Rican et al. 2016). *Isthmoheros tuyrensis*, commonly known as "Aviente" in Spanish (González-Gutiérrez 2021), has been reported in both the Tuíra & Bayano river basins, in the Balsas & Urugantícito rivers within Darien National Park, as well as in the Mamatí river (Lyons 2020). It has been described as a detritivore with a lentic postcranial morphology (Rican et al. 2016).

Isthmoheros tuyrensis was previously classified in the genus *Vieja* (Kullander 2003; Garcés & García 2007; McMahan 2010; McMahan et al. 2015), however, Rican et al. (2016) concluded that *Vieja* is actually part of the herichthyine clade, while *Isthmoheros* is an amphilophine, more closely related to other middle American genera such as *Amatitlania*, *Amphilophus,* and *Parachromis*, among others. Moreover, Rican et al. (2016) stated that *Isthmoheros* has its sister genus on the opposite side of the Isthmus in western Panamá and southeastern Costa Rica (i.e., *Talamancaheros*), which also present a detritivore cranial morphology and a lentic postcranial morphology with an obscure breeding coloration (vs. a scraping cranial and a lotic postcranial morphology with a white and black breeding coloration). Moreover, despite some ecomorphological differences, both *Isthmoheros* and *Talamancaheros* share a similar semi-herbivorous diet, based in tooth morphology (Conkel 1993), and they are separated, according to Rican et al. (2016), by a long-isolated monophyletic lineage within the amphilophines, being the sister clade of the aforementioned *Darienheros* plus *Panamius* (Matamoros et al. 2015; Rican et al. 2016).

Isthmoheros tuyrensis faces several threats due to the increased spread of human activities in the eastern region of Panama; mainly due to the expansion of the urban footprint of the Panama City, originating from the Pacific entrance of the Panama Canal. Information on distribution and ecology of *I. tuyrensis* in the Eastern side of the IOP is relatively scarce and only a few comparative studies on ecomorphology have been done from collections in the Bayano River tributaries and the Darien region (Rican et al. 2016). Moreover, river basins towards the west of Panama (i.e., in the Panama District), have been relatively under sampled for freshwater fish species in general, including a lack of information on the distribution of endemic cichlids such as *I. tuyrensis*.

In this paper we report a new distribution range extension for *I. tuyrensis* in the Panama City area. This record is presented after conducting seasonal surveys in three river basins of the region. A morphological description of specimens is included as taxonomical validation for this new range extension. Moreover, our survey locations give us an idea of the potential barriers and distribution limits leading to the possible threat of extirpation of the species in this area, in particular from heavy pollution towards the west of Panama. Finally, we also provide and discuss data on several environmental parameters as a reference for the species' habitat condition in this region. This information will be relevant for future taxonomic and conservation studies, contributing to a better understanding on the biology of the species.

MATERIALS AND METHODS

Study Area

Although this paper is focused on specimens collected only in the Pacora river basin, the sampling effort was part of a broader study between September 2020–May 2021 in three rivers in the District of Panama: Matasnillo, Juan Díaz, and Pacora (Figure 1). All these rivers drain to the Pacific Ocean via the Bay of Panama and experience different levels of degradation due to human activities. These rivers are surrounded by commercial, industrial, and residential land, with an estimated of 1,098,068 people residing in an area of 191 km^2 (i.e., 540 inhabitants/km^2) (Municipio de Panamá 2019). Pressures such as water diversion, extraction of sand & gravel, polluted runoff from nearby agricultural & livestock production, improper use of soils, sanitary

Figure 1. The three sampled basins and localities in the Panama District area (Panama City), specific locations where *I. tuyrensis* was collected are pointed out.

landfills, urban development near drainage areas, sedimentation resulting from deforestation, and untreated sewage affect these three rivers. Moreover, previous reports suggest that these impacts are higher in the city's western side (ANAM 2009).

The Matasnillo River is the main tributary of river basin No. 142 (between Caimito and Juan Díaz River) and is located in the center of Panama City. It is 6 km long, with an annual precipitation of 1,500 l/m^{2,} and a 33 m^3/s flow. The whole basin, divided by the Panama Canal to the west, has an area of 137 km^2 and according to the last Panama census of population in 2010 has an estimated of 1,013,714 inhabitants. Both the Arraiján District at the west side of the Panama Canal and the main river at the city center are extremely channelized with little vegetation (Comité de Alto Nivel de Seguridad Hídrica, 2016). Compounding these threats are several sites where sewage tanks occupy river and stream easements, in parallel, the uncontrolled urban development hinders sewage infrastructure maintenance and repairs; this is a critical problem for many urban rivers in the Republic of Panama (MINSA 2019).

The Juan Díaz basin (basin No. 144) includes some of the largest rivers in the east side of the city. The basin is 351 km^2 & 22.5 km long, with an annual precipitation of 3,000 l/m^2 & flow of 5.1 m^3/s, and an estimated of 868,401 inhabitants (Comité de Alto Nivel de Seguridad Hídrica 2016). To date, the biodiversity of this basin has not been well studied and there is a lack of awareness regarding the area's natural capital, although recent studies have highlighted its importance and relevance at the ecosystem level (Charris-Palacios 2020). Moreover, there are several high-income housing projects currently planned in the basin, which threaten these natural areas and are faced with opposition from local communities, which depend on drinking water from the river (Ruiz 2018). The upper basin is also used by some local communities as a tourist attraction.

The Pacora River basin (basin No. 146) is 368 km^2 & 48 km long, with 2,750 l/m^2 in annual precipitation, an average flow rate of 11.1 m^3/s, and about 253,131 inhabitants (Comité de Alto Nivel de Seguridad Hídrica 2016). Although the Pacora River faces many of the same threats from expanding urbanization from the east, it also hosts some of the most important natural features (including beaches, pools, waterfalls, and forested areas) in the city. These attractions are connected to the city by a relatively good road network and are enjoyed predominantly by the local communities in addition to in-country tourists. The ecotourism potential of this area is recognized by the local government in the Panama City Resilience Strategy (Municipio de Panamá

2019), which recommends promoting the river's natural ecosystems and biodiversity, along with training tour guides, as a potential income generation activity for local communities. In addition, the Pacora River is a source of drinking water (after treatment in nearby plants), although it's not the sole water source for the urbanized area (García-Armuelles 2020).

Sampling effort at the three explored rivers

Fish sampling was conducted in the three river basins in a one-week period per season, including August–September (rainy season) 2020, February–March (dry season), and April (transition season) 2021. A total of 13 sampling sites were selected from the upper, middle, and lower river basins (Figure 1). At each site, depending on the riparian river structure, physiography, and river length & width, we selected a representative 100-m long transect. Fish were sampled in each transect using an Electro fisher (Halltech, HT-2000, 2020) for 45 minutes, according to the methodology described by Barvour et al. (1999), with voltage limits to 250 volts for areas with high conductivity (>300 µS/cm) and 750 volts for water with moderate to low conductivity (100–300 µS/cm). Since saltwater intrusion limits the use of electrical devices, we also employed a 213 cm long cast net with 1 cm mesh width, utilizing random throws for 30 minutes at each 100 m long transect.

Testing of water quality and physical parameters were carried out mostly using a multi parameter device (YSI Professional Plus 2015). The basic parameter data presented here include water temperature, pH, dissolved oxygen, and conductivity. Water samples were also collected in each locality to test for nitrate and fecal coliform levels. Samples were analyzed by a local laboratory (Ambitek Service Inc). River width was measured using a metric tape, depth with a limnometric rod, and flow with a current meter (Global Water BA1100 Model Fp111 Probe 3.7–6', 2017). Forest condition was assessed according to Munné et al. (2003) including qualitative in situ observations of gallery forest (as coverage percentages) within the upper, middle and lower sections on each river with 50 m long transects measuring on each side of the main riverbed.

Matasnillo River

Four fixed monitoring stations were established for repeated sampling in this basin during all seasons, one in the upper basin, one in the middle basin, and two in the lower basin. A single 100 m long section, due to the narrow river width, was sampled at each locality, totaling 400 m of sampling per season. This means that a total of 1,200 m were sampled during a total of 540 min (9 h), with heavy limitations due to saltwater intrusion, mainly in the lower basin. The river condition's regarding obstructive garbage, such as metal wires and cement structures, in addition to heavy pollution from sewage disposal, made it impossible to use a cast net in this river basin.

Juan Díaz River

Three fixed monitoring stations were established for repeated sampling in this basin during the rainy season and in-between seasons. During the dry season, an additional site located on the upper basin, inaccessible during the rainy season, was sampled. At all localities (one in the upper basin, one in the middle basin, and one in the lower basin), two 100 m long sections were sampled, totaling 600 m sampled during the rainy season, 600 m between seasons, and 800 m during the dry season. Grouping all the sections monitored during the three seasons using electrofishing, a total of 2,000 m were sampled for 900 min (15 h). For cast net sampling, we spent a total of 600 min (10 h) in this basin across all seasons.

Pacora River

Surveys were conducted in this basin in five fixed monitoring stations during the rainy season and the transition season. Due to the inclusion of one site that was unreachable in other seasons, six stations were monitored during the dry season. At all localities (one in the upper basin, one in the middle basin, and one in the lower basin), two 100 m long sections were sampled. For the rainy and transition seasons we completed a total of 1,000 m sampled; during the dry season a total of 1,200 m were sampled with electrofishing. Considering all the sections monitored during the three seasons, we had a total of 3,200 m sampled for 1,440 min (24 h). For cast net sampling we spent a total of 960 min (16 h).

For practical purposes, this paper is focused on the localities where specimens of *I. tuyrensis* were found (Tables 1 & 2).

Species identification and morphological assessment

For the identification of the species collected we consulted the specialized literature (e.g., Bussing 1998; Gonzalez 2021), including revisionary works and the original description of the species known to occur in the sampled area after Matamoros et al. (2015) and Rican et al. (2016). Specimens identified as *I. tuyrensis* were retained (both preserved and alive), photographed, and measured (see Table 3) according to McMahan et al.

Table 1. Collection localities, season, collecting methods and number of individuals of *Isthmoheros tuyrensis* found in the Pacora River.

Site number	Elevation (m)	Basin / Season*	Method	Ind	Size (cm)	Weight (g)
12	40	M/T	Cast net	1	16.0	63
13	52	M/R	Electrofishing	1	8.1	10
13	52	M/T	Electrofishing	1	8.1	10
14	20	L/ T	Cast net	2	8.1	10

*M—Middle Basin | L—Lower Basin | R—Rainy Season | T—Transition Season | Ind—Number of individuals collected

Table 2. Average Physical Parameters in the Pacora River, Panama City.

Parameter	Units	Average	Minimum	Maximum	SD
Temperature	°C	27.9	23.0	31.6*	2.14
PH	-	7.73	7.01	8.5	0.28
Conductivity	µS/cm	166.5	124.4	207.7**	21.83
DO	%	7.90	6.11	9.93	1.03
TDS	mg/L	87.04	2.8***	206.2	44.83
Nitrate	Mg/L N-NO_3	1.87	0.5	5.2****	1.53
Fecal Coliform	MPM/100 mL	1897	63	7701****	3126
Flow	Meters/ second	0.29	0	2.44	0.40
Width	M	22.47	6	53.6	9.30
Depth	Cm	39.08	0.8	100	27.76
Forest Condition	%	53	20	90*****	28.31

*Dry and transitional season, middle and lower basin | ** Transitional season, lower basin | *** Rainy season, middle basin | **** Rainy season, lower basin | ***** Upper basin.

(2015) and Rican et al. (2016). Counts (see Table 3) were done on preserved specimens according to Rican et al. (2016). Comparative morphometric and meristic data was obtained from the literature (McMahan et al. 2015; Rican et al. 2016).

RESULTS

Fish diversity

From a total of 9,259 fish specimens found in the sampled period, including 21 families, 40 genera, and 43 species (data under analysis for further publication), there were only two species of native cichlids. The most abundant species, with a total of 374 individuals, was the Chogorro (*Andinoacara coeruleopunctatus*). Of these 374 specimens, 134 were collected in Juan Díaz and 240 in Pacora, with zero individuals in Matasnillo.

On the other side, only five specimens of *I. tuyrensis* were collected (see morphological details/data below), all in the Pacora River (Table 1). Of these five specimens, two were found in the middle basin and captured with electrofishing (Figure 1, Site 13, Table 1), one was collected during the rainy and the other in the transition season; a third specimen was found at a middle basin (Figure 1, Site 12, Table 1), during the transition season; and the last two specimens were captured in the lower basin (Figure 1, Site 14, Table 1), during the transition season. These last three specimens (Sites 12 and 14) were captured using cast net.

At the time of this writing, three specimens of *I. tuyrensis* are preserved and housed at the "Dr. Luis Howell Rivero" Museum at the Center of Marine Biology and Limnology (CCML) in the University of Panama, Catalogue number MBML No 2151; while the two other specimens are maintained alive in an aquarium located in the International Maritime University of Panama's laboratory, in the Faculty of Marine Sciences. Pictures of one preserved specimen are provided in Images 1–2. Live specimens of *I. tuyrensis* are illustrated in Images 3–5.

Two exotic species of cichlids were also collected during our study. A total of 426 individuals of the Nile Tilapia (*Oreochromis niloticus*) were captured, 423

in Juan Díaz, 3 in Pacora, and zero in Matasnillo. A single specimen of the Jaguar Guapote (*Parachromis managuensis*), which is native from Honduras, Nicaragua, and Costa Rica, was found in the Juan Díaz river.

Species identification (*I. tuyrensis*) and morphological assessment

Identification of fishes as *I. tuyrensis*, comprising a new record for the Pacora river, was based on the following combination of distinctive characteristics which separate it from the other cichlid species occurring in the southern portion of Central America: body relatively robust and wide; second lower lip missing; teeth conical, without second cusp, but with tip labiolingually flattened; lateral line scales 31–32; anal fin spines 6–7; and coloration pattern (body grayish-green to greenish-brown, with 8–9 lateral black blotches, and several longitudinal series of small dark spots on the sides and fins). Complementary morphometric and meristic data for the species, based on three specimens measured, and analyzed, is provided in Table 3.

Environmental parameters at the sampled localities

The results for the environmental analysis are restricted to the Pacora River, since it is the only river where *I. tuyrensis* was found. The physiochemical and physical parameters are detailed in Table 2.

Physicochemical parameters

Temperature averaged 27.9 C, with maximum values in the dry season. The average pH was 7.73, with a maximum of 8.5 and similar values across all seasons. Conductivity showed high variation with higher values in the lower basin. Dissolved oxygen averaged 7.90%, with relatively low variation and maximum values in the upper basin. Nitrate levels showed an average of 1.87, increasing in the middle and lower basins during the rainy season. Fecal Coliform concentration showed higher values in the localities at the middle and lower portion of the basin, increasing during the rainy season (Table 2).

Physical parameters

Water flow averaged 0.29 m/s; with a range from 0 (no current) –2.44 m/s. River depth and width showed strong variation across sampled localities, both increasing during the rainy season. Forest coverage tended to increase towards the middle and upper basins, with a maximum of 90% coverage in the upper basin and an average of 53% along the entire basin (Table 2).

Table 3. Morphometric and meristic data of individuals of *I. tuyrensis* found in the Pacora River. Head measurements are expressed as percentages of the head length; body measurements are expressed as percentages of the standard length.

Measurement/Count	N1	N2	N3
Total length (cm)	10.51	10.12	19.47
Standard length (cm)	8.10	8.10	16.00
Head length (cm)	2.69	2.40	4.69
Snout length	27.43	25.54	26.08
Mouth length	16.43	19.85	19.09
Eye diameter	29.33	27.23	25.00
Post-ocular length	42.35	46.15	42.74
Head depth	106.57	120.00	130.11
Predorsal length	31.51	32.28	29.18
Prepectoral length	33.70	30.78	31.07
Pectoral length	28.24	27.95	30.60
Prepelvic length	35.67	30.59	35.96
Pelvic length	25.35	29.63	28.23
Preanal length	64.71	67.40	64.12
Dorsal fin base	55.31	56.48	59.07
Dorsal fin height	11.29	13.29	12.93
Anal fin base	24.26	25.02	24.05
Body depth	47.25	50.59	51.03
Caudal peduncle length	11.41	12.10	12.22
Caudal peduncle depth	14.06	15.34	14.91
Dorsal fin elements	XVI, 10	XVII, 10	XVII, 11
Pectoral fin elements	14	13	14
Anal fin elements	VII, 7	VI, 8	VI, 7
Lateral line scales	32	31	32

DISCUSSION

Species distribution and environmental limitations

Toward the western-most range limit for *I. tuyrensis*, Loftin (1965) reported its presence almost 6 km east from the town of Pacora (not the river basin), near the Señora River, which drains to the Bayano River. Our findings report, for the first time, the presence of this species in the Pacora River basin, about 20 km in a straight line from previously known localities in Central Panama. This finding raises questions about the possible past distribution of the species in other rivers in Central/Western Panama, given there is no previous records of the species in the rivers of Panama City.

In the neighboring Juan Díaz river, not a single specimen of *I. tuyrensis* was found during the three sampled seasons, although another native and even two others exotic (more generalist and less sensitive to

Image 1. Preserved specimen of *I. tuyrensis*, right side, 16 cm, collected at the Prison La Joya (Site #12) on transition season in May 2021, picture from 3 July 2021. © Javier Pardo, UP.

Image 2. Preserved specimen of *I. tuyrensis*, left side, 16 cm, collected at the Prision La Joya (Site # 12) on transition season in May 2021, picture from 3 July 2021. © Javier Pardo, UP.

Image 3. Live individual of *I. tuyrensis*, 15 cm, kept at the UMIP Aquarium, collected at the Restaurante Cabobre (Site # 13) in May 2021, picture from 13 December 2021. © Jafet Santos, UMIP.

Image 4. Same live individual of Image 4 kept at the UMIP Aquarium, 18 cm, picture from 21 March 2022. © Javier Pardo, UP.

Image 5. The two live individuals collected at the Restaurante Cabobre (Site # 13) keep at the UMIP Aquarium, 18 cm and 10 cm, picture from 21 March 2022. © Javier Pardo, UP.

environmental changes/disturbances) cichlid species were found. This river (Juan Díaz) is surrounded by densely populated areas at its middle and lower portions and is currently undergoing a rapid urbanization process. is most likely an unsuitable habitat for *I. tuyrensis,* although that does not mean that this species was not present in this river before 1970 when the uncontrolled urbanization started (Municipio de Panamá 2019). Both Juan Díaz and Pacora Rivers drain to the Panama Bay Ramsar Site (Kaufmann 2012; Suman 2014), however *I. tuyrensis* is not reported in any study in the area; moreover, in the past, only 9 individuals were found in surveys on the Darien Province in rivers such as Balsas, near the Colombian border (Garcés & García 2007). Unfortunately, this Ramsar Site does not include the middle river basin and covers little freshwater habitat, even though watersheds can be considered wetlands according to the Ramsar technical classification (Ramsar Convention Secretariat 2016).

Conservation issues

Some conservation issues, mainly related to the agricultural-urban expansion, habitat loss, and pollution, that are affecting negatively the current conservation and populational status and distribution of *I. tuyrensis* are discussed below.

Agricultural-urban expansion vs. habitat loss

A study of land uses in the Pacora River basin conducted by Rodríguez-Martínez (2019) discusses transitions of land type measured though Geographic Information Systems (GIS) via three classifications—deforestation, gain or loss of agricultural land, and expansion of the urban footprint; with a variation trend between the periods corresponding to the years 1992, 2000, 2009, and 2019. The transition that presented the greatest magnitude of variation was deforestation, with the greatest loss between 2009 and 2019 (4,996.4 ha). These results indicate that the most significant transition that occurred was the transformation of forest land into pasture for livestock, with losses of 3,031.7 ha, 1,991.6 ha, and 3,466.9 ha, respectively, in the three periods assessed. Another significant change presented in the study is the growth of the urban footprint, which went from 259.6 ha in 1992, to 642.2 ha in 2000, to 2,412.0 ha in 2019; a tenfold increase in less than 30 years. A management plan proposal for the Pacora River basin developed by PREVDA (2008) states that the basin is (in addition) exposed to a series of climate risks and extreme events ranging from heavy rainfall and floods to some periods of drought. Moreover, we observed that the river was blocked in multiple areas by local communities, especially during dry season, in order to create swimming areas. Currently there are no studies at this basin addressing the impact of the aforementioned factors, as well as of the deforestation due to livestock increasing, on the water availability, hydrological capacity, and biodiversity.

The impact from pollution

Regardless of the habitat connectivity and of their ability to survive in estuarine areas (as we found some specimens in the lower Pacora basin). Our surveys indicated that the Pacora River has an average pH of 7.7, with maximum values of 8.5, pointing to relatively alkaline waters with significant mineral input and less accumulation of organic material (Nilsson & Renöfält 2008). The presence of anthropogenic impacts from agricultural activity and urban sewage in some areas can contribute to denitrification, which may cause an increase of pH levels (He et al. 2017). On the other hand, our nitrate values showed an average value of 1.87 mg NO_3-N/l, with a maximum of 5.2 mg NO_3-N/l; little surprising was the fact that we did not find individuals of *I. tuyrensis* in localities with the highest nitrate values (Table 1 & Table 2). Although no information is available on nitrate toxicity for *I. tuyrensis* or for any of its close relatives, some studies have found that many freshwater fishes can exhibit increased mortality with nitrate levels between 1.1 and 4.5 mg NO_3-N/l (Camargo et al. 2005).

Many studies, on the other hand, have considered the agricultural leaching as the major factor driving the increase of conductivity and dissolved solids. For instance, in the geographically proximate region of the Costa Rican Pacific, Pérez-Castillo & Rodríguez (2008) incorporated the conductivity variable in their analyses of water quality in lagoons of the Palo Verde National Park, considering it an indicator for inorganic fertilizer presence and poor water quality. They established a 250 µS/cm maximum value for uncontaminated waters and a value of 1,500 µS/cm for heavily polluted waters. In other studies, specifically the Rincón River basin, also in the Costa Rican Pacific region, Beita-Sandí & Barahona-Palomo (2010) determined that average conductivity was 161.8 µS/cm, with a range from 92.7 µS/cm up to 249.6 µS/cm, thus, suggesting the area to be free of marine influence since none of the records exceeded 45.2 µS/cm (Villegas-Arguedas 2011). For the Pacora River, our minimum conductivity values were 124.4 µS/cm, with an average of 166.5 µS/cm, and tended to be higher in the middle and lower basin. This may be a product of the cumulative impact of agricultural activities from the

upper to the lower sections of the basin.

Moreover, Beita-Sandí & Barahona-Palomo (2010) found that the conductivity range in natural fresh waters in some Pacific Rivers in Costa Rica varied between 10 µS/cm & 350 µS/cm, while in areas with marine influence the values varied between 125 µS/cm & 2,200 µS/cm. We consider our conductivity and other pollution indicators discussed here to be high in the lower section of Pacora River, leading us to infer that the river, in addition to those discussed above, also has a marked marine influence. However, since higher conductivity values were obtained from collection localities near urbanized areas, we cannot conclude that these values are a natural characteristic of this river.

Although we used different voltage settings, electrofishing was probably affected in some cases by the high conductivity; on the other hand, in the lower & middle basin most collections were done using cast nets. More studies are necessary to confirm if *I. tuyrensis* prefer particular conditions at proximity with estuaries as occur in other cichlid genera (e.g., *Vieja*; Bussing 1998). Moreover, several studies mention that some fish can prefer aquatic habitats with specific requirements such as elevated values of water conductivity, but this can vary among species (Vieira & Tejerina; Garro 2020). The few individuals of *I. tuyrensi*s that we found in our study were collected in sites in the middle and lower river sections with intermediate to relatively high conductivity values. Thus, there is a possibility that these conductivity values are negatively affecting the population status of the species since they may be due to anthropogenic activities.

Authors including Mondal & Bath (2020) have found that conductivity and total dissolved solids affect negatively the water quality conditions; thus, tolerant species, particularly those peripheral and with broader distributions on the whole basin (which does not seem to be the case of *I. tuyrensi*s), are able to survive on high conductivity values. The same authors also stated that increased total dissolved solids and conductivity is related to reduced species richness and diversity of freshwater fish in tropical river basins. The same review concludes that an increase of nutrient contents in the water leads to an increase in primary productivity and persistence of periphyton feeding fishes, producing excessive algal growth, increased sediments, and an imbalanced food chain, which, again, seems not to be the case for *I. tuyrensi*s a detritivorous species (Rican et al. 2016).

Since the bacteria *Escherichia coli* is predominant in sewage; we consider that fecal pollution may represents a potential threat to *I. tuyrensis*. A study by Guzmán et al. (2004) where *E. coli* concentration was determined in digestive tracts and muscles of two species of fishes (*Jenynsia multidentata* and *Bryconamericus iheringi*) sampled at the same sites, showed higher concentrations of the bacteria in *J. multidentata* than in *B. iheringi*, thus indicating that the former species is more sensitive to the accumulation of the bacteria. Moreover, these authors concluded that increased bacteria concentration compromises the immunological system of these fish. Although we found no specific information for cichlids and considering that *E. coli* (measured by us as fecal coliform) is present in variable concentrations in all the sampled localities, we can conclude that *I. tuyrensis* is a sensitive species, since it was not found in the most polluted rivers (e.g., Juan Díaz;). On the other hand, no other cichlids were found in the nearby and heavily polluted Matasnillo river, which can provide us information on the tolerance levels of the species of this family to the fecal pollution.

Conservation measures

Habitat conditions and the permanence of this endemic species in the PSEP is not guaranteed if measures are not taken to control agricultural and urban footprint expansions. The Pacora River has a population of one of the only two endemic species of cichlids from this region, which is struggling to survive after its possible disappearance from nearby rivers toward the west. In terms of planning and environmental policies, recent management plans are non-existent except for an expired initiative that proposed integral management for the basin more than 10 years ago (PREVDA 2008). There are multiple threats to the Pacora river, and this species, posed by increased water demand for livestock, crops and industry, including the extraction of gravel, sand, and of non-metallic minerals directly from the river. These factors affect the biophysical and social components of the river basin where local communities, mostly living in poverty, are fighting for the right to healthy rivers, and ecosystems (Espinoza 2021).

Freshwater fishes are among the most threatened groups of species on the planet (Lacy et al. 2017). They have persisted for decades in tropical river basins and their ecological/environmental and socio-economical value is probably not fully understood by human communities, particularly in urban cities. As in other countries (see Lacy et al. 2017), neither local Panamanian stakeholders nor governments consider freshwater fishes to be a priority group in their Environmental Impact Assessment processes. We hope that this study can begin raising

awareness for riverine fishes and particularly for members of the Cichlidae. Panama's central and local governments should monitor biological indicators in its rivers and set priorities such as connecting the sewage system to the Juan Díaz Treatment Plant and increase sewage treatment capacity, instead of depositing sewage directly to the river (MINSA 2019; Municipality of Panama 2019). We also recommend training local tourist guides for eastern rivers such as Pacora, including the recognition of their unique and local biodiversity. Finally, actions outlined in the Panama City Resilience Strategy should be implemented within the next 10 years, according to existing regulations (Municipio de Panamá 2019).

Other functional and taxonomical aspects

Previous studies on *I. tuyrensis* noted the preference of this species for slow-moving waters. However, for the Pacora River, particularly at the lower basin, current velocity is relatively high. This is typical from rivers in this region of Panama, which is characterized by steep profiles and a shorter distance to the coast. This contrast, for example with the Bayano & Darien Rivers, in particular the Tuyra & Balsas rivers, where freshwater wetland ecosystems include lagoons with aquatic plants adapted to intermittent flooding (Ibáñez & Flores 2021).

Regarding the morphological data, despite our specimen count is scarce due to the low population densities of the species, the information provided here agree with the morphometric and meristic information published by previous authors (e.g., Kullander 2003; Rican et al. 2016); moreover, this study adds new and relevant information on the morphology of *I. tuyrensis*, contributing to its further diagnosis and characterization. This information could be relevant for taxonomic and descriptive studies, as well as in applied ecology research. Finally, our data provided limited information in terms of size classes, since four specimens measured about 8 cm and the maximum size reported was 16 cm. In this regard, previous authors (Kullander 2003; Rican et al. 2016) reported a maximum size of 23.5 cm for the species.

GENERAL CONCLUSIONS

The distribution limit for *I. tuyrensis* towards the west side of the PSEP is extended with our findings as the previous westernmost reports are limited to the Chichebre and Señora Rivers in the Bayano River basin (Lyons 2020). Most rivers of Panama City, such as the Juan Díaz, are heavily polluted and this could prevent or limit the presence of this species, which, based on our data, can be considered as sensitive to pollution. For the Matasnillo River, pollution and deforestation are even higher; moreover, this river shows high marine influence and conductivity values that exceeds 400 µs/cm in most sites. These issues (pollution, deforestation, river salinization, among others) call for the urgent implementation of restoration, conservation, and sanitation programs for all these rivers. This includes updating and implementing 1—the Pacora River Management Plan, buffering the spread of new urbanizations in the basin and 2—the Territorial Ordination Plan for the Panama City, which has already been developed, but is pending approval (IDOM SUMA CONTRANS 2017).

Although our study expands the geographic range of *I. tuyrensis* and furthers biological understanding of the species, it does not alter the fact that this species is listed as Vulnerable and likely to become endangered based on the criteria of the IUCN Endangered Species Red List. The relatively few known populations of this species (less than 10, based on Lyons 2020, including the new reported in this study) as herein discussed, are exposed to several threats including deforestation, agricultural expansion, mining activities, and road infrastructure development among others, not only on the central and western portion of the country but also within the Darien Region (Lyons 2020; Arcia-Jaramillo 2022). As we pointed out, this species is virtually lacking any effective protection along their distribution range, even in the eastern portion of the country (Arcia-Jaramillo 2022).

REFERENCES

Arcia-Jaramillo (2022). Parque Darién, joya natural bajo constante amenaza. *Diario La Prensa.* https://www.prensa.com/sociedad/parque-darien-joya-natural-bajo-constante-amenaza/

Beita-Sandí, W. & M. Barahona-Palomo (2010). Físico-química de las aguas superficiales de la cuenca del río Rincón, Península de Osa, Costa Rica. *Cuadernos de Investigación UNED* 2(2): 157–179.

Camargo, J.A., A. Alonso & A. Salamanca (2005). Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. *Chemosphere* 58: 1255–1267.

Charris-Palacios, A. (2020). Las dos caras del río Juan Díaz. *Periódico En Segundos.* https://ensegundos.com.pa/2020/08/30/las-dos-caras-del-rio-juan-diaz/

Comité de Alto Nivel de Seguridad Hídrica (2016). Plan Nacional de Seguridad Hídrica 2015-2050: Agua Para Todos**,** *Gobierno de la República de Panamá* 168 pp. https://www.undp.org/es/panama/publications/plan-nacional-de-seguridad-h%C3%ADdrica-2015-2050-agua-para-todos

Conkel, D. (1993). *Cichlids of North and Central America*. TFH Publications, 191 pp.

Espinoza, T. (2021). Comunidad teme afectaciones al río Pacora por posible extracción de arena *TVN Noticias Website.* https://www.tvn-

2.com/contenido_exclusivo/Comunidad afectaciones-Rio-Pacora-extraccion-contaminacion_0_5927407260.html

Garcés, H.A. & J. García (2007). Inventario ictiológico en la cuenca del Río Balsas, Parque Nacional Darién, Panamá *Tecnociencia* 9(2): 45–57.

García-Armuelles, L. (2020). IDAAN sectorizará Pacora. *Periódico La Estrella de Panamá.* https://www.laestrella.com.pa/nacional/200325/realizan-sectorizacion-planta-centenario-pacora

González-Gutiérrez, R. (2021). *Elementos de los peces dulceacuícolas de Panamá.* First personal Edition by González-Gutiérrez R. 290 pp.

Guzmán, M.C., M. de los Angeles Bistoni, L.M. Tamagnini & R.D. González (2004). Recovery of *Escherichia coli* in fresh water fish, *Jenynsia multidentata and Bryconamericus iheringi. Water Research* 38(9): 2368–2374.

Ibáñez, A. & R. Flores (2021). *Phyllanthus fluitans* (Phyllanthaceae): a new record of an aquatic plant for the nora of Panama/*Phyllanthus fluitans* (Phyllanthaceae): un nuevo registro de planta acuática para la nora de Panama. *Acta Botánica Mexicana* (128): 1G-1G. https://doi.org/10.21829/abm128.2021.1767

IDOM SUMA COTRANS (2017). Plan Estratégico Distrital, Política Locales y Plan Local de Ordenamiento Territorial del Distrito de Panamá", en base a la adjudicación de la Licitación por Mejor Valor Nº.2016-5-76-0-08-LV-008821. https://plandistritalpanama.com/

Kaufmann, K. (2012). *Nuestros Humedales, Nuestro Futuro: Plan de Conservación para los Humedales de la Bahía de Panamá* (Our Wetlands, Our Future: Conservation Plan for the Panama Bay Wetlands). Sociedad Audubon de Panamá/Panama Audubon Society, 70 pp.

Kullander, S.O. (2003). Cichlidae (Cichlids), pp. 605–654. In: Reis, R.E., S.O. Kullander & C.J. Ferraris Jr. (eds.). *Checklist of the Freshwater Fishes of South and Central America*. Porto Alegre: EDIPUCRS, Brasil.

Lacy, S., F. Meza & P. Marquet (2017). Can environmental impact assessments alone conserve freshwater fish biota? Review of the Chilean experience. *Environmental Impact Assessment Review.* 63: 87–94. https://doi.org/10.1016/j.eiar.2016.12.006

Loftin, H.G. (1965). The geographical distribution of freshwater fishes in Panama. *PhD Thesis, The Florida State University,* 278 pp

Lyons, T.J. (2020). *Isthmoheros tuyrensis*. The IUCN Red List of Threatened Species 2020: e.T152306277A152306353. Accessed on 21 May 2022. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T152306277A152306353.en

Matamoros, W.A., C.D. McMahan, P. Chakrabarty, J.S. Albert & J.F. Schaefer (2015). Derivation of the freshwater fish fauna of Central America revisited: Myers's hypothesis in the twenty-first century. *Cladistics* 31(2): 177–188. https://doi.org/10.1111/cla.12081

McMahan, C.D., A.D. Geheber & K.R. Piller (2010). Molecular systematics of the enigmatic Middle American genus *Vieja* (Teleostei: Cichlidae). *Molecular Phylogenetics and Evolution* 57: 1293–1300.

McMahan, C.D., W.A. Matamoros, K.R. Piller & P. Chakrabarty (2015). Taxonomy and systematics of the herichthyins (Cichlidae: Tribe Heroini), with the description of eight new Middle American Genera. *Zootaxa* 3999(2): 211–234. https://doi.org/10.11646/zootaxa.3999.2.3

Ministerio de Salud - Programa Saneamiento Panamá - MINSA (2019). La Contaminación del Río Matasnillo por Aguas Residuales Programa Saneamiento Panamá https://saneamientodepanama.gob.pa/la-contaminacion-del-rio-matasnillo-por-aguas-residuales/

Munné, A., N. Prat, C. Solá, N. Bonada & M. Rieradevall (2003). A simple field method for assessing the ecological quality of riparian habitat in rivers and streams: QBR index. *Aquatic Conservation: Marine and Freshwater Ecosystems* 13(2): 147–163. https://doi.org/10.1002/aqc.529

Municipio de Panamá (2019). Acuerdo Municipal Número 7 del 15 de enero 2019. Por el cual se Adopta la Estrategia de Resiliencia para la Ciudad de Panamá. Gaceta Oficial No. 28710-B, 1-190. https://www.gacetaoficial.gob.pa/pdfTemp/28710_B/71387.pdf

Nilsson, C. & B.M. Renöfält (2008). Linking flow regime and water quality in rivers: a challenge to adaptive catchment management. *Ecology and Society* 13: 18.

Pérez-Castillo, A. & A. Rodríguez (2008). Índice fisicoquímico de la calidad de agua para el manejo de lagunas tropicales de inundación. *Revista de Biología Tropical* 56(4): 1905–1918.

Programa Regional de Reducción de la Vulnerabilidad y Degradación Ambiental-PREVDA (2008). Formulación del plan estratégico para el manejo integrado de la cuenca del río Pacora. Panamá. Comisión Europea-SICA, 123 pp.

Ramsar Convention Secretariat (2016). An Introduction to the Convention on Wetlands (previously The Ramsar Convention Manual). Ramsar Handbook 5th Edition Sub-series I: Handbook 1 International Cooperation on Wetlands, 110 pp.

Rican, O., L. Pialek, K. Dragova & J. Novak (2016). Diversity and evolution of the Middle American cichlid fishes (Teleostei: Cichlidae) with revised classification.*Vertebrate. Zoology* 66(1): 3–102.

Rodríguez-Martínez, O.A. (2019). *Evaluación de escenarios de intervención para la implementación de buenas prácticas de manejo en la cuenca del río Pacora, Panamá*. Master's Thesis, Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica, 91 pp

Ruiz, L.M. (2018). Panamá: Moradores de La Primavera se organizan para enfrentar proyecto urbanístico. *Radiotemblor.* https://www.radiotemblor.org/panama-moradores-de-la-primavera-se-organizan-para-enfrentar-proyecto-urbanistico-audio-foto/#:~:text=Moradores%20de%20la%20comunidad%20de,costo%20de%20partida%20de%20%24150%2C000

Suman, D. (2014). Panama Bay Wetlands: Case Study of a Threatened Ecosystem. *Water Resources and Wetlands* 366–371.

Vieira, T.B. & F.L. Tejerina-Garro (2020). Relationships between environmental conditions and fish assemblages in tropical savanna headwater streams. *Scientific Reports* 10(1): 1–12. https://doi.org/10.1038/s41598-020-59207-9

Villegas-Arguedas, J.C. (2011). Relación entre la diversidad de ictiofauna y la calidad del agua en ríos con diferente grado de afectación por diques y canales en la zona sur de Costa Rica. Master's Thesis in Natural Resource Management and Protection. Universidad Estatal a Distancia – UNED, Costa Rica, 126 pp.

Abstract: There are two endemic species of Cichlidae in southern Central America, both found in the Pacific Slope of Eastern Panama (PSEP). One is *Isthmoheros tuyrensis,* which until now was presumed to be distributed in the Darien Province and the Bayano River basin. Information on distribution and ecology of *I. tuyrensis* is relatively scarce. In this investigation we report a new range extension for the species and provide additional morphological and ecological data. Fish were sampled using electrofishing and cast nets, in three river basins of the Panama District (Matasnillo, Juan Díaz, and Pacora) from August–September (rainy season) of 2020, February–March (dry season), and April (transition season) of 2021. Fish diversity, water quality, and physical parameters were gathered within the upper, middle, and lower portions of the three basins. This study focused on the localities where specimens of *I. tuyrensis* were found (i.e., Pacora river basin). The presence of the species in localities with significant anthropogenic threats results in a potential barrier for distribution, along with the possibility of extirpation due to heavy pollution – in particular from the rivers on the western side of Panama City. In addition, we note an increase in urban threat from the east of the city due to expanded development and agricultural activities. *I. tuyrensis*, the virtually unknown "Aveinte" in Spanish or the "Isthmian Hero", is listed as Vulnerable by the International Union for Conservation of Nature (IUCN)'s Red List and inhabits some river basins lacking effective protection, being the only endemic fish species located in an urban basin in the Pacific of Mesoamerica. The information on distribution, morphology, and ecology provided here will contribute to a better understanding of the species' biology and will aid the creation and implementation of management and conservation measures.

Keywords: Agriculture, Central American ichthyofauna, conservation actions, Eastern Panama, endemism, pollution, urban expansion.

Resumen: Existen dos casos de endemismo de cíclidos en el Sur de Centroamérica, i.e., en la Vertiente Pacífico del Este de Panamá. Una de estas especies es *I. tuyrensis*, cuya distribución conocida incluye los ríos de la Provincia de Darién y el Río Bayano. La información sobre distribución y ecología de *I. tuyrensis* es, no obstante, relativamente escasa. En esta contribución reportamos una extensión en el rango de distribución conocido para la especie, así como datos morfológicos y ecológicos adicionales. Se realizaron muestreos ictiológicos utilizando electropesca y atarrayas, en tres ríos del Distrito de Panamá (Ciudad de Panamá: Matasnillo, Juan Díaz y Pacora) entre agosto y septiembre (estación lluviosa) de 2020, febrero y marzo (estación seca) y abril (transición entre estación seca y lluviosa) de 2021. Se recopilaron datos sobre diversidad de peces y parámetros físicos y de calidad del agua en las zonas alta, media y baja de las tres cuencas. Este reporte se enfoca, no obstante, en la única zona en donde se encontraron ejemplares de la especie endémica mencionada (i.e., Pacora). La frecuencia de los censos frente a las amenazas muestra una posible barrera de distribución con posibilidad de extirpación, debido a la fuerte contaminación en los ríos, hacia el Oeste de la Ciudad de Panamá, acompañada de amenazas producto de la expansión urbana y las actividades agrícolas en el Distrito de Panamá. *I. tuyrensis*, el desconocido "Aveinte" o el "Héroe del Istmo", es una especie catalogada como vulnerable en la Lista Roja de Especies en Peligro de la UICN que habita en una zona que carece de protección efectiva; siendo la única especie de pez endémica ubicada en una cuenca urbana en el Pacífico de Mesoamérica. La información sobre distribución, morfología y ecología aquí provista se espera que contribuya a un mejor conocimiento y entendimiento de la biología de la especie, así como a la creación y promoción de medidas de manejo y conservación.

Acknowledgments: The data collected for this study was part of an interinstitutional and interdisciplinary project (IOMA-19-008: "Environmental impact of multistressors in aquatic ecosystems of the metropolitan area of Panama") funded by the Panama National Secretary of Science and Technology (SENACYT). The Funding source had no role in study design, data collection, interpretation of results or manuscript writing. Logistical and technical support was provided by the Panama City Municipality (Luis Norato, Paola Samaniego & Edwin García). Resource administration and technical coordination was conducted by the Wetlands International Regional Office. The International Maritime University of Panama (UMIP) contributed with logistic, sampling storage and processing space, as well as equipment and technical personnel. We thank the Panama Ministry of Environment (MiAmbiente, Environmental Performance Direction, Miguel Flores) for their additional contributions with transportation and technical personnel (MiAmbiente, Environmental Performance Direction, Veraguas Province, Leonel Rivera), along with the scientific permits to conduct this research. This full-length report is the result of the implementation of Panama District/ City River monitoring actions stated in the Panama City Resilience Strategy (Municipio de Panamá 2019) for the determination of biological water quality indicators related to fishes and invertebrates. UMIP Research Associate Isaac Pearlman contribute with the English language reviewing of this publication.

Author details: A.DOMINICI-AROSEMENA is a Panamanian Biologist, Professor & Director of the School of Marine and Environmental Resources at the Faculty of Marine Sciences at the International Maritime University Panama (UMIP). He's scientific work is focused on study the Ecology and Biogeography of Neotropical fishes along with the biodiversity assessments of Wetlands Ecosystems. A. ANGULO is a Costa Rican Ichthyologist with extensive experience in field inventories and museographic work in the Neotropics. He is Professor, Researcher and Curator of the Fish Collection at the University of Costa Rica (UCR). H. OSORIO-UGARTE is a Hydrologist, Civil Engineer and Researcher in Water Resources at the Faculty of Civil Engineering at the Technological University of Panama (UTP), she is in charge of the Geographic Information System and Director of the Urban Water and Forest Hydrology Research Group. Q. ORTEGA-SAMANIEGO is a Biologist specialized in Marine Biology, Limnology and Environmental Management. Currently she is a Panama Ministry of Environment collaborator and a doctoral student in the Water and Environmental Engineering Program at the Polytechnic University of Valencia, Spain. Her research is based on environmental impacts on aquatic ecosystems, with emphasis on the biotic component. A. FRAIZ is a Biologist specialized in Environmental Management with more than 15 years of experience in Coastal Management projects, he's research is focused on primary production, restoration of coastal ecosystems, coastal erosion, management and aquaculture. Currently he is a Technical Officer at the Wetlands International Foundation. A. GUERREL is currently a student a obtaining the Degree of Marine Biologist at UMIP, her thesis is focused on river plankton as indicator of water quality. E. ARAUZ is a Biologist, specialist in wildlife management and conservation, he currently works at the Natura Foundation in the management of environmental projects, and in research projects in the Wetlands International Foundation. He also is a professor of Biology and Ecology at the School of Biology at the University of Panama. J. MONTIEL is currently a student a obtaining the Degree in Environmental Sciences and Natural Resources at the Autonomous University of Chiriquí and is a pioneer in the implementation of the QBR index (riverine forest index) in Panama. B. MEDINA is a Biologist, Professor and specialist in Environmental Management and Marine Resources Development and Protection. She currently works as the Dean of the Faculty of Marine Sciences at UMIP. Y. RODRÍGUEZ-ARRIATTI is a Biologist specialized in Coastal Resources Management, Fisheries and Elasmobranchs. She is conducting research related to ichthyological resources that are part of the bycatch for various fisheries, as well as the compilation of a collection of otoliths for future studies of age structure and as reference material for analysis of stomach contents. Y. GONZALEZ is a specialist in Phyto-genetic Resources, Biotechnology and Biodiversity Conservation. She served as the Panama National Director of Protected Areas and Wildlife. Currently she is Academic Coordinator, Professor and Researcher in the Faculty of Marine Sciences at UMIP. J. PARDO is currently a student a obtaining the Degree in Marine Biology and Limnology at the University of Panama. He worked on long-term water quality monitoring projects and the restoration of mangroves in the Bay of Panama. He is a land and underwater photographer that works for environmental education in panels and conferences national and international. K. URRIOLA is a Biologist, researcher and Professor at UMIP specialized in Environmental Management and cetaceans. A. RAMOS-MERCHANTE has a PhD in Biology and a Bachelor of Environmental Sciences, he has dedicated his professional career to the conservation and management of continental aquatic environments through projects that apply the Water Framework Directive (DMA) and Monitoring Networks of the State of Quality of Hydrographic Basins. He is specialized in the monitoring of macroinvertebrates, aquatic macrophytes, continental ichthyofauna and riparian forest management.

Author contributions: Arturo Dominici-Arosemena- 1) Conceptualization, 2) Field Data collection, 3) Manuscript writing, 4) Acquisition of funds, 5) Project Administration & Coordination at UMIP 6) live animals management in the UMIP aquarium Arturo Angulo-Sibaja- 1) Conceptualization, 2) Morphometrical Analysis, 3) Manuscript writing, Haydeé Osorio- 1) Conceptualization, 2) Maps, 3) Hydrological Information, Quiriatjaryn Ortega- 1) Conceptualization, 2) Field Data collection, 3) Acquisition of funds, 5) Project Administration & Coordination, Andrés Fraiz- 1) Conceptualization 2) Field data collection 3) Acquisition of funds 4) Project Administration & Coordination in Wetlands International, Arminda Guerrel-1) Field Data Collection 2) Environmental data management 3) field assistant 4) Lab assistant, Edgar Araúz- 1) Conceptualization 2) Data collection 3) Lab assistant 4) Project Coordination in Wetlands International, Jennyfer Montiel- 1) Forest condition data, 2) field assistant Beatriz Medina- 1) Project Administration & Coordination at UMIP 2) Field data collection ,Yehudi Rodríguez-Arriatti- 1) Support for fieldwork coordination, 2) Field data collection, 3) live animals management at UMIP aquarium, Yessenia González- 1) Project Coordination at UMIP 2) Field data collection 3) Lab assistant, Javier Pardo-1) Photographic Material 2) Field Data collection, Karly Urriola-1) Support fieldwork coordination at UMIP, 2) Field Data collection, Adrián Ramos-Merchante 1) Methodology , 2) Team Training in the Panama City Rivers, for fish collecting methods & Data Interpretation.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22623–22631

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

https://doi.org/10.11609/jott.8096.15.2.22623-22631

#8096 | Received 09 July 2022 | Final received 04 January 2023 | Finally accepted 27 January 2023

OPEN ACCESS

COMMUNICATION

Tadpole morphology of Jerdon's Narrow-mouthed Frog *Uperodon montanus* (Jerdon, 1853) with a range and elevation extension report from Western Ghats, India

Amit Hegde [1], Girish Kadadevaru [2] & K.P. Dinesh [3]

[1,2] Breeding behaviour and Bioacoustics Lab, Department of Zoology, Karnatak University, Dharwad, Karnataka 580003, India.
[3] Zoological Survey of India (ZSI), Western Regional Centre (WRC), Pune, Maharashtra 411044, India.
[1] amithegdevargasara@gmail.com, [2] kadadevarug@gmail.com (corresponding author), [3] kpdinesh.zsi@gmail.com

Abstract: The study discusses about the new data on larval description, morphological features, larval ecology of stage 25–40 of the Jerdon's Narrow-mouthed Frog *Uperodon montanus* (Jerdon, 1853). Tadpoles were identified up to family and genus level based on the historical literature and the species level confirmation was done with molecular studies. We also present a new northern limit record of this species from the Pushpagiri hill ranges in Karnataka (12.669 N, 75.717 E) and a new highest elevation record of 1,916 m at Vaguvarai, Idukki, Kerala which are outside its currently known distribution and elevation ranges. As per the present work, the distribution range of U. montanus has extended northwards by 130 km and upwards by 216 m. Additionally, the IUCN Red List status for the species is also discussed based on the area of occupancy and extent of occurrence redone considering the new range envelope.

Keywords: Anura, Gosner stage 25, larval stages, montane endemism, Western Ghats.

Kannada abstract: ಪ್ರಸ್ತುತ ಸಂಶೋಧನೆಯಲ್ಲಿ, ಬೆಟ್ಟದ ಗಾಳಿಚೀಲಗಪ್ಪೆಯ (ವೈಜ್ಞಾನಿಕ ಹೆಸರು: *Uperodon montanus* (ಜೆರ್ಡನ್, 1853) ಗೊದ ಮೊಟ್ಟೆಯ ವೈಜ್ಞಾನಿಕ ಬೆಳವಣಿಗೆ ಹಂತ 25 ಹಾಗೂ 40 ರಬಾಹ್ಯ ರೂಪವಿಜ್ಞಾನ ವಿವರಣೆ ಬಗ್ಗೆ ಚರ್ಚಿಸಲಾಗಿದೆ ಮತ್ತು ಈ ಗೊದಮೊಟ್ಟೆಯ ವೈಜ್ಞಾನಿಕ ಪ್ರಭೇದ ಪತ್ತೆ ಹಚ್ಚುವುದಕ್ಕೆ ಆಣ್ವಿಕ ತಂತ್ರಜ್ಞಾನ ಸಹಾಯವನ್ನು ಪಡೆಯಲಾಗಿದೆ. ಈ ಕಪ್ಪೆಯು ಪಶ್ಚಿಮ ಘಟ್ಟದ ಕರ್ನಾಟಕ ಭಾಗದ ಪುಷ್ಪಗಿರಿ ಪರ್ವತ ಶ್ರೇಣಿಯಿಂದ, ತಮಿಳುನಾಡು ಭಾಗದ ತಿರುನಲ್ವೇಲಿಯ ಮುರುಂಗಾ ಮೊಟ್ಟೆ ಅರಣ್ಯಭರಿತ ಪರ್ವತ ಶ್ರೇಣಿಗಳವರೆಗೆ (ಸಮುದ್ರಮಟ್ಟದಿಂದ 800-1916 ಮೀಟರ್) ಇರುವುವಿಕೆಯನ್ನು ದೃಢಪಡಿಸಲಾಗಿದೆ. ಇದರಲ್ಲಿ ಈ ಕಪ್ಪೆಯು, ಪಶ್ಚಿಮ ಘಟ್ಟದಿಂದ ಉತ್ತರ ವ್ಯಾಪ್ತಿಯ ಹಾಗೂ ಸಮುದ್ರಮಟ್ಟದಿಂದ ಎತ್ತರದ ಹೊಸ ಪರಿಧಿಗಳ ದಾಖಲೆಗಳನ್ನು ಒಳಗೊಂಡಿರುತ್ತದೆ. ಹೊಸ ಶ್ರೇಣಿಯ ಆಧಾರದ ಮೇಲೆ ಪ್ರಭೇದದ ಐ ಯು ಸಿ ಎನ್ (IUCN) ಸಂರಕ್ಷಣಾ ಸ್ಥಿತಿಯ ಬಗ್ಗೆಯೂ ಚರ್ಚಿಸಲಾಗಿದೆ.

Editor: S.R. Ganesh, Chennai Snake Park, Chennai, India.

Date of publication: 26 February 2023 (online & print)

Citation: Hegde, A., G. Kadadevaru & K.P. Dinesh (2023). Tadpole morphology of Jerdon's Narrow-mouthed Frog *Uperodon montanus* (Jerdon, 1853) with a range and elevation extension report from Western Ghats, India. *Journal of Threatened Taxa* 15(2): 22623–22631. https://doi.org/10.11609/jott.8096.15.2.22623-22631

Copyright: © Hegde et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: University Research Studentship (URS),UGC SAP II Grant, DBT and SERB (SR/FR/LS-88/210/09.05.2012) fellowship, Critical Ecosystem Partnership Fund (Western Ghats) project.

Competing interests: The authors declare no competing interests.

Author details: Amit Hegde is currently pursuing PhD at Breeding Behaviour and Bioacoustics Laboratory, Karnatak University, Dharwad. His interest lies in the study of amphibians and their morphology, vocal behaviour, distribution patterns, breeding ecology and conservation especially from peninsular India. Girish Kadadevaru is working as an asociate professor in PG Department of Studies Zoology, Karnatak University. He has 33 years of teaching and research experience. His research interest is in breeding behaviour and bioacoustics of anurans, avian diversity and hydrobiology. K.P. Dinesh is a scientist working at Zoological Survey of India under the Ministry of Environment Forests and Climate Change, Government of India with a primary study interest on taxonomy of amphibians of India and their systematics and phylogenetics.

Author contributions: AH carried out field observation, data collection, analysis, interpretation, wrote draft, critical review and revision at different stages; GK has played a crucial role in monitoring and guiding the work; KPD helped in writing paper, generation of sequences, phylogenetics and field data collection.

Acknowledgements: Authors are indebted to P. Deepak, Mt. Carmel College for the support in molecular studies and generation of maps. The authors would like to place special thanks to the forest departments of Tamil Nadu, Kerala and Karnataka for their support in field studies. AH would like to thank Bose Madappa for the help in the field studies; Sunita Rao, Land and Lens India, Batt Anderson, Tom, Amila-Lupé Ellena Aguilar, Dinesh Kumar, KV Gururaja & Preeti Gururaja for the gadgets support and grateful to all Lab mates and Karnatak University for the URS (University Research Studentship) funding support. KPD is grateful to Karthik Shanker, CES, IISc Bangalore for the support; S.P. Vijayakumar and other team members of the Critical Ecosystem Partnership Fund (Western Ghats) project for the support in the field studies; DBT and SERB (SR/FR/LS-88/210/09.05.2012) for the fellowship and assistance to conduct part of this work; the Director, ZSI, Kolkata and the Officer-in-Charge, ZSI, WRC, Pune for the support. GGK is thankful for the UGC SAP project.

INTRODUCTION

Jerdon's Narrow-mouthed Frog *Uperodon montanus* (Jerdon, 1853) is endemic to the Western Ghats where it is distributed from near Wyanad south across the Palghat and the Shencottah gaps to the Agasthyamalai hills (Garg et al. 2018). It was first described by Jerdon in 1853 from the mountain streams of Wyanad (Garg et al. 2018). Later the species details which also include notes on tadpole morphology were added by Parker (1934). Recently, in the revisionary studies of the genus, the species was redescribed based on a freshly collected topotype (Garg et al. 2018). This frog is considered a montane species and is restricted to higher altitude ranges of 800 m to 1,700 m (Frost 2023). For breeding and spawning, it has a much more limited microhabitat within the habitat in landscape (Parker 1934; Garg et al. 2018). Tadpoles of *Uperodon* are free swimming and exotrophic (Altig & Johnston 1989; Garg et al. 2018). The tadpoles of the congeners can be classified and identified based on the variations in their tail morphology, the shape of the spiracular opening and the location of the mouth and spiracle (Garg et al. 2018).

During one of our regular field visits to Coorg, Western Ghats, we surveyed small rock pools beside the mountain streams in which tadpoles were observed. Efforts were made to identify the tadpoles based on the existing literature (Rao 1918, 1937; Parker 1934; Ramaswami 1940; Raj et al. 2017; Garg et al. 2018), and secondly genetic data. In the present study, we have appraised the description of morphometric characters, field observations of the tadpole of *Uperodon montanus*, especially in Gosner stages 25–40 and identification of the tadpole using mt 16S rRNA sequences. We also present new data on the distribution of this species with an extended geographical and elevational range.

MATERIALS AND METHODS

Observations on spawning ground and tadpoles of different stages were made. Tadpoles were photographed in nature without disturbing the individuals from the Brahmagiri range (11.969 N, 75.984 E, elevation 870 m) Coorg District, Karnataka State during the post-monsoon season, November 2021. Additionally, field surveys were conducted in several other parts of the Western Ghats during which *U. montanus* was observed. Developmental stages were identified based on the Gosner stages (Gosner 1960).

For detailed studies, tadpoles were collected (n = 7; Gosner stage 25) and were photographed under controlled conditions; specimens were euthanized using MS222 and tissue samples were fixed in 70% ethanol for molecular studies (n = 1) and morphometric measurement specimens (n = 6) were fixed in 10% buffered formalin for two days and preserved in a 1:1 mixture of 10% buffered formalin at the Gosner stage 25. Tadpole morphology and measurements were done using the Olympus stereo zoom microscope (8x magnification) (to the nearest 0.1 mm). Studied samples were deposited at the National Zoological Collections of the Zoological Survey of India ZSI/WRC/Pune(ZSI/WRC/V/A/2519–2524).

Protocols were followed after Hegde et al. (2020) for the generation of 16S rRNA gene sequence and phylogenetic studies. Sequences used in the studies are provided in Table 1. For calculating uncorrected pairwise genetic distances, MEGA 5.2 (Tamura et al. 2013) was used. The maximum likelihood (Ml) tree was generated with RaxMl (Silvestro & Michalak 2012) under the GTR+GAMMA+I model, with 1,000 thorough bootstrap replicates to assess node support, and FigTree v1.4.0 visualized the final consensus tree.

For mapping, the distribution range of the species was taken from the published literature in addition to the present record of tadpoles and the field studies of KPD and team between the period 2010–2020. The IUCN Red List criteria based on the extent of occurrence (EOO) and area of occupancy (AOO) for the species were estimated using the GeoCAT Geospatial Conservation Assessment Tool (Bachman et al. 2011).

Abbreviations

BH, Body height (the highest height of the body); BW, body width (the highest width of the body); ED, eye diameter (the greatest length of the orbit from the anterior margin to the posterior margin of the eye); END, Eye to nostril distance (from the anterior corner of the eye to the posterior margin of the naris (nostril)); HL, Head length; HW, Head width at the level of eyes; Snout to spiracle distance, from the tip of the snout to the posterior margin of the spiracle; IOD, Inter orbital distance; IND, inter-narial distance (measured from the centres of the narial apertures); LTF, Lower tail fin height (the highest height of the lower fin, from the lower margin of the lower fin to the lower margin of the tail musculature); MTH, Maximum height of tail (the highest height of the tail); tail height at mid-length of tail (including caudal fin); maximum tail height (tail height at the mid-length of the tail including caudal fin and tail musculature); NSD, Nostril to snout distance (from

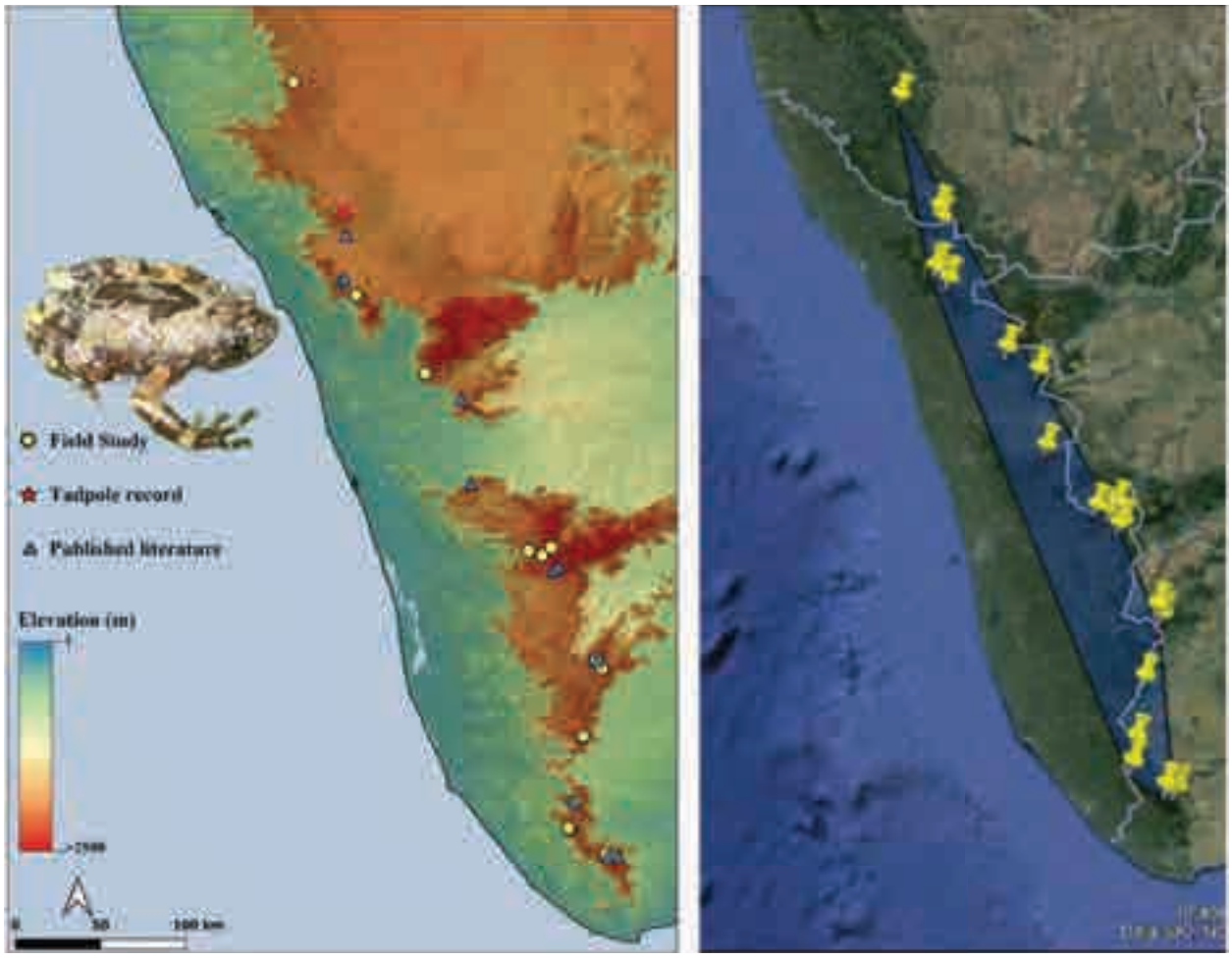


Image 1. Left: Distribution range of *Uperodon montanus* in the central and the southern Western Ghats; Right: extent of occurrence (EOO = 18,412.285 km2) and the area of occupancy (AOO = 96.000 km2).

the anterior margin of the naris to the tip of the snout); Tail length, from the junction of the posterior body and the tail musculature to the tip of the tail; TL, total length (sum of BL and TaL)(from the tip of the snout to the tip of the tail); TMH, Tail muscle height at the base of tail; TMW, tail muscle width (at the beginning of the tail); UTF, Upper tail fin height (the highest height of the upper fin, from the upper margin of the tail musculature to the upper margin of the upper fin).

RESULTS

Tadpole identification was confirmed as *Uperodon montanus* based on the sequences generated from the tadpole tissue samples collected during the present study (Figure 1; Table 2).

A total of 40 tadpoles were observed, out of which 37 tadpoles were of Gosner stage 25 and three tadpoles were of Gosner stage 40 in the rocky pools characterised by 80 cm in length, 50 cm in width and 15.5 cm depth in the steep slopes. These rock pools are situated close to the torrent and cascading third order streams with characteristic of water splashing activity from the stream cascades, especially during monsoon (Image 2H).

Tadpole external morphology (Gosner stage 25): Exotroph, neustonic tadpole, In *U. montanus* head part is dorsoventrally compressed or flattened, the mouth is situated at the terminal end and lateral eyes form part of the dorsal outline of the tadpole. Tail musculature is brown and unicoloured, comparatively denser towards the body and more stressed in the upper tail fin. The external opening of the cloaca is medial, vent-aperture of vent tube is in line with the axis of the ventral fin. The oral disc is terminally positioned without marginated papillae, labial teeth or hard beaks. The upper lip is slightly extended in the middle and emarginated on both the sides which cover the lower lip. During the feeding

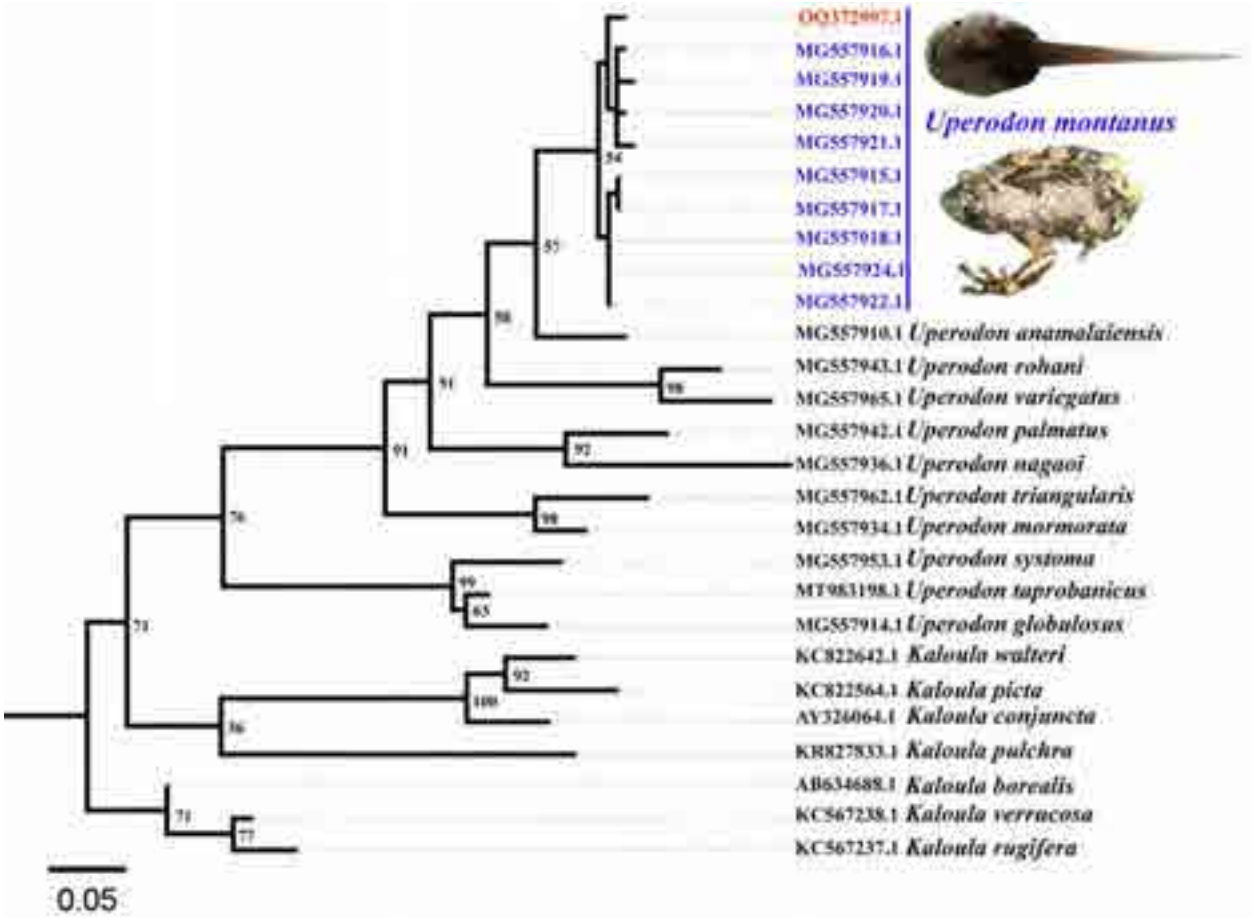


Figure 1. Figure 1. Maximum likelihood phylogeny for the *Uperodon montanus* having distribution in the Western Ghats with the present data based on 529bp mitochondrial 16SrRNA gene.

slight lower lip movement is observed. The lower lip is U-shaped with cuspate rounded jaw sheaths with no keratinisation. The lateral process is a poorly delimited posterolateral extension of the upper jaw, often non-serrate, long-extending well beyond the lower jaw. Paired ventrolateral spiracle, the external opening for the exit of water from the opercular chamber. Long tail fin with a rounded tip (Image 2).

Body measurements: Mean values (in mm) and standard deviations of measurements of the collected tadpoles (n = 6) of *U. montanus* at Gosner stage 25 as follows, TL: 17.2± 8.8; IOD: 2.9± 1.2; ED: 0.5± 0.2; IND: 1.0± 0.4; END: 1.3± 0.6; NSD: 1.0± 0.4; HW: 4.0± 1.7; Snout to spiracle distance: 4.3± 2.0; BW: 4.5± 1.9; HL: 6.3± 2.7; TMW: 1.6± 0.8; LTF: 0.7± 0.3; UTF: 0.8± 0.4; MTH: 2.7± 1.2; Tail length: 11.6± 5.4; TMH: 1.9± 0.9; BH: 2.4± 1.2 (Table 1).

Colour in life (Gosner stage 25): Brown pigment spots all over the body denser towards the forebrain, midbrain and gut regions. Near gills, reddish spots are seen from inside the body as the body is transparent. In notochord region of the tail near the body is dense. Comparatively dull brown patches surrounding the nostril are seen. The vent region is opaque without any brown pigments and the ventral side of the gut region is more transparent compared to the dorsal. The lower part of the tail is more transparent without many brown pigments like the upper part of the tail. Overall colour slightly varied between individuals within the same pool, further studies are needed in this regard (Image 2).

Colour in preservative (Gosner stage 25): The body is roughly dark brown in colouration and the eyes are dark. Brown pigments all over the body which are not uniform, comparatively less pigmented in the lower tail, tail tip, below the gut region and it is transparent outside the body region. Besides the forebrain and midbrain region bright patch is visible from inside the body, compared to the living tadpole.

Notes on the Gosner stage 40: Tadpoles were observed in nature, with no webbing in the hind limbs (subarticular tubercles are seen) and they are banded with golden stripes or radiant yellow. Body regions are

Table 1. Tadpole body measurements (in mm) of *Uperodon montanus* at Gosner stage 25 (n = 6) *(Prefix ZSI/WRC/V/A/) (17 morphometric measurements).

Reg. No*	2519	2520	2521	2522	2523	2524	Average ± SD (n = 6)
TL	15.4	15.8	17.3	23.2	16.7	15.3	17.2 ± 8.8
IOD	2.5	2.8	3.0	3.5	3.3	2.6	2.9 ± 1.2
ED	0.4	0.4	0.5	0.7	0.5	0.5	0.5 ± 0.2
IND	0.8	1.2	0.9	1.4	1.0	1.0	1.0 ± 0.4
END	1.1	1.3	1.3	1.7	1.5	1.2	1.3 ± 0.6
NSD	0.8	0.9	1.2	1.0	1.1	1.0	1.0 ± 0.4
HW	3.3	3.7	4.3	4.7	4.5	3.6	4.0 ± 1.7
Snout to spiracle distance	3.2	4.3	3.6	5.9	4.6	4.3	4.3 ± 2.0
BW	3.7	4.2	4.8	5.4	4.8	4.3	4.5 ± 1.9
HL	5.4	5.9	6.4	7.6	6.8	6.0	6.3 ± 2.7
TMW	1.4	1.4	1.7	2.6	1.8	1.0	1.6 ± 0.8
LTF	0.6	0.6	0.6	0.8	1.0	0.8	0.7 ± 0.3
UTF	0.6	0.7	0.7	0.9	1.1	1.0	0.8 ± 0.4
MTH	2.0	2.4	2.8	3.3	3.3	2.5	2.7 ± 1.2
Tail Length	10.0	10.5	10.9	15.6	13.4	9.3	11.6 ± 5.4
TMH	1.7	1.9	1.6	2.7	1.9	1.7	1.9 ± 0.9
BH	2.2	2.0	2.6	3.4	2.8	1.5	2.4 ± 1.2

coloured with dark brown, golden spots all over the body and it is uniform dorsally. However, near the upper tail notochord region, it is more prominent. Ventrally it is dark brown in colouration (Image 2I). In November (post-monsoon), the tadpoles were seen in the rock pools beside the mountain streams of the evergreen forests. Most of these pools/pockets had organic debris, leaf litter and aquatic insects. Within the single clutch or in the single pool after Gosner stage 25, there wasn't any uniformity in development stages between the tadpoles of this species, this might be related to the diet and competition.

Change in the tadpole body colouration was observed during the day and night. In the daytime, they looked comparatively darker and at night they were slightly transparent, especially observed for the Gosner stage 25. In these small rock pockets, the tadpoles above Gosner stage 25 rarely come to the surface during the daytime and they hide under the dark black decayed leaf litter and brown algal substrate. Tadpoles might be using the substrate as micro refugia. The body colour is adapted to blend with the dark substrate as the light penetration is comparatively low at the bottom (Image 2).

In the daytime, tadpoles of other species were encountered surrounding the study site in Brahmagiri, Kodagu, Karnataka including unidentified *Indosylvirana* and *Nyctibatrachus*. In the same location during

Table 2. Details of mt 16S sequences used for building the maximum likelihood (ML) tree.

GenBank accession number	Species	Reference
MG557910.1	*Uperodon anamalaiensis*	Garg et al. 2018
MG557914.1	*Uperodon globulosus*	Garg et al. 2018
MG557924.1	*Uperodon montanus*	Garg et al. 2018
MG557922.1	*Uperodon montanus*	Garg et al. 2018
MG557921.1	*Uperodon montanus*	Garg et al. 2018
MG557920.1	*Uperodon montanus*	Garg et al. 2018
MG557919.1	*Uperodon montanus*	Garg et al. 2018
MG557918.1	*Uperodon montanus*	Garg et al. 2018
MG557917.1	*Uperodon montanus*	Garg et al. 2018
MG557916.1	*Uperodon montanus*	Garg et al. 2018
MG557915.1	*Uperodon montanus*	Garg et al. 2018
MG557934.1	*Uperodon mormorata*	Garg et al. 2018
MG557936.1	*Uperodon nagaoi*	Garg et al. 2018
MG557942.1	*Uperodon palmatus*	Garg et al. 2018
MG557943.1	*Uperodon rohani*	Garg et al. 2018
MG557953.1	*Uperodon systoma*	Garg et al. 2018
MT983198.1	*Uperodon taprobanicus*	Garg et al. 2018
MG557962.1	*Uperodon triangularis*	Garg et al. 2018
MG557965.1	*Uperodon variegatus*	Garg et al. 2018
OQ372997.1	*Uperodon montanus*	Present study

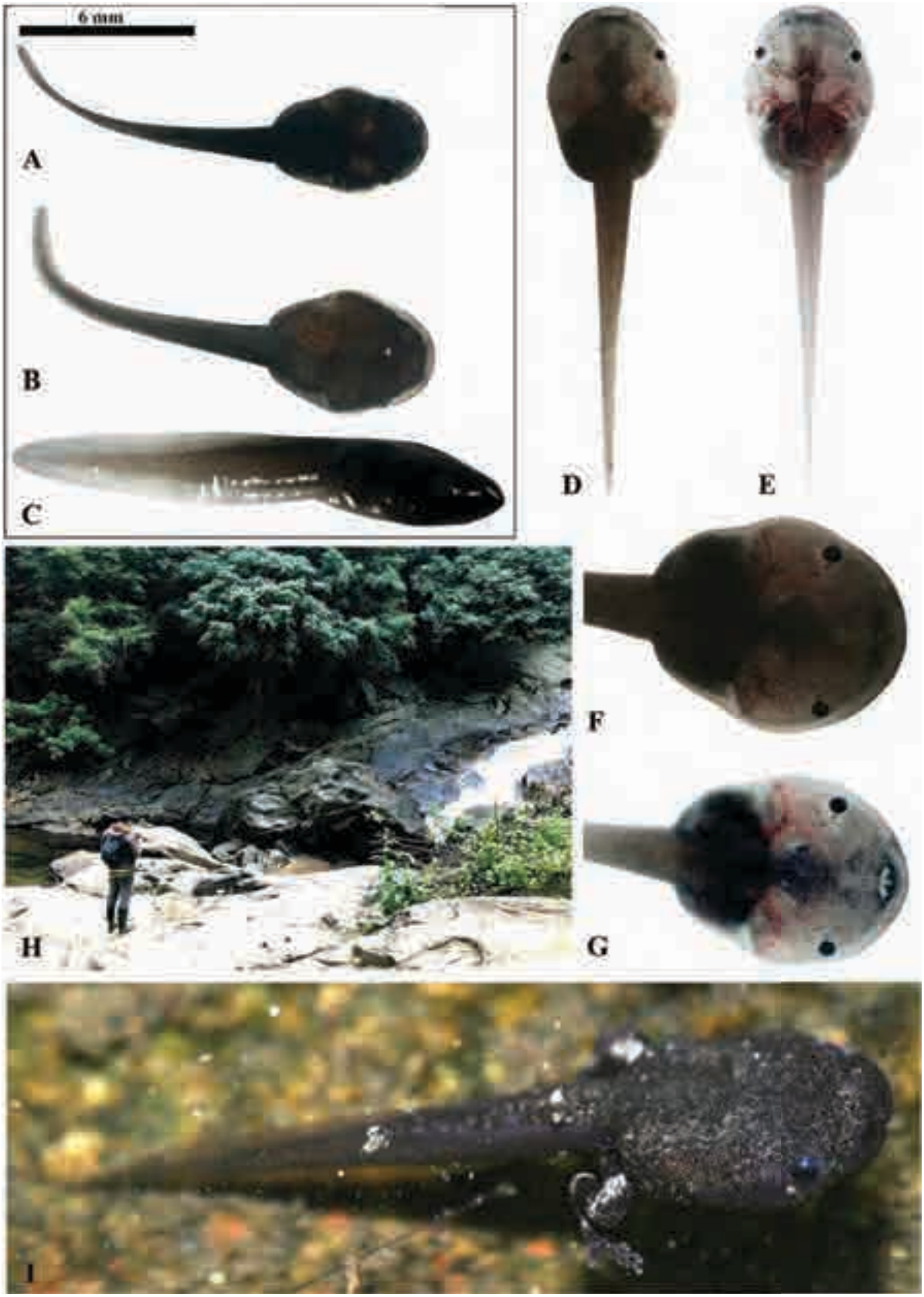


Image 2. Tadpole of *Uperodon montanus* (Gosner stage 25): A—Dorsal view | B—Ventral view | C—Lateral view (In preservation) (To scale); *U. montanus* tadpole in life (Gosner stage 25) dorsal view | D—During the day time | E—During the night time | F—Day time | G—Night time | H—Rocky pockets/pools beside the mountain streams | I—*U. montanus* Gosner stage 40 in natural habitat, in life. © Amit Hegde.

night hours, *Micrixalus*, *Nyctibatrachus*, *Indirana*, *Indosylvirana*, and *Raorchestes* species adults were observed.

Distribution of *U. montanus*:

During the present study, this species was observed from several localities across the Western Ghats (Table 3). The extent of occurrence (EOO) was calculated to be 18,418.65 km^2 which suggests 'Vulnerable' status and the area of occupancy (AOO) amounts to 96.00 km^2 which suggests 'Endangered' (Bachman et al. 2011) status. This species is restricted to mountain forests of the Western Ghats, especially in the southern part of central Western Ghats and southern Western Ghats. Our field data confirms the presence of the species from Toregadde forests in the foothills of Pushpagiri hill ranges in Karnataka which is the northern limit to Murunga mottai forests of Agasthyamalai hill ranges of Tamil Nadu which is the southern limit in the Western Ghats (Image 1). Our studies confirm the higher altitude record of species at 1,916 m that is 216 m above the previous report of 1,700 m (Frost 2023; Garg et al. 2018).

Table 3. Field locality details for the records of Uperodon montanus in the central and southern Western Ghats documented during the present study.

Lat. (N)	Lon. (E)	Altitude (metres)	Location in the Western Ghats
12.669	75.717	904	Tore gadde, Kodagu, Karnataka
11.970	75.985	870	Brahmagiri, Kodagu, Karnataka
11.531	76.053	926	Vythiri, Wyanad , Kerala
11.112	76.421	1,090	Silent Valley, Palakkad, Kerala
11.110	76.423	1,076	Silent Valley, Nilgiris, Tamil Nadu
11.110	76.420	1,089	Silent Valley, Nilgiris, Tamil Nadu
10.186	77.095	1,916	Vaguvarai, Idukki, Kerala
10.168	76.974	1,564	Edamalayar, Idukki, Kerala
10.143	77.045	1,752	Rajamalai, Idukki, Kerala
9.594	77.335	1,801	Brook's Peak, Idukki, Kerala
9.578	77.336	1,556	Upper Manalar, Theni, Tamil Nadu
9.540	77.365	1,494	Vellimalai, Theni, Tamil Nadu
9.540	77.365	1,506	Vellimalai, Theni, Tamil Nadu
9.179	77.265	1,351	Kudraikatti, Tirunelveli, Tamil Nadu
9.173	77.261	1,262	Kudraikatti, Tirunelveli, Tamil Nadu
8.828	77.217	1,249	Pandimalai forest, Kollam, Kerala
8.689	77.187	1,043	Pandipath, Thiruvananthapuram, Kerala
8.680	77.194	1,327	Pandipath, Thiruvananthapuram, Kerala
8.550	77.386	1,263	Kakachi, Tirunelveli, Tamil Nadu
8.533	77.432	1,279	Murunga mottai, Tirunelveli, Tamil Nadu

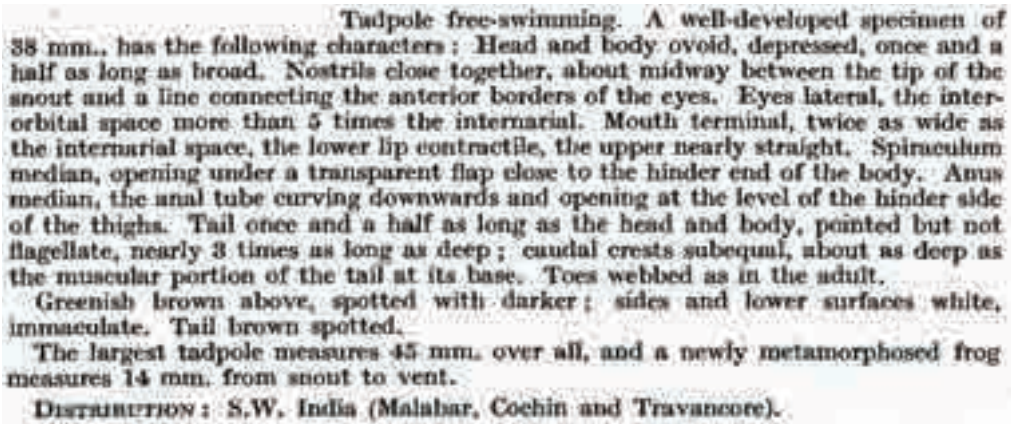
DISCUSSION

Molecular identification in tadpoles is particularly useful when the habitat has multiple species belonging to the same family or genus, where sympatric species share the same microhabitat. It is also very helpful where the two allopatric species meet at hybridising zones (where high elevation species share the same zone with mid elevational species or two species meet near the biogeographic barrier) or when the tadpoles show a great amount of morphological variation, polymorphism, and plasticity where morphological key characters are difficult to rely on. Historical descriptions provided by Parker (1934) were limited and it would have been difficult to identify the tadpole species without molecular studies in this context. A holistic approach to the morphological character of the tadpoles is much needed with molecular confirmation to make the morphological characters data set handy for the identification of the members of the genus or the family in the field/museum.

Parker's (1934) tadpole descriptions for *U. montanus*, developmental stages (Image 3) are not clear and sample sizes are not mentioned and it is difficult to conclude or compare the tadpole in gross scale; subsequent descriptions of tadpole stages by Gosner (1960) facilitated identifying the stages. Parker mentioned that the largest unstaged tadpole of *U. montanus* measures 45 mm. In our study out of six tadpoles (Gosner stage 25), the larger one measured 23.2 mm and the average was 17.2 mm ± 8.8.

Parker (1934) mentioned that Head length (HL) is one and a half times as long as body width (BW). In the present study, HL is 1.4 times bigger than BW; END is equal to NSD but in this studies, they are not equal and END is slightly longer than NSD; IOD is five times the IND, but in our studies, IOD is double the IND; TL is one and half time long as head length (HL) but in our studies, TL is 2.73 times bigger than the HL; UTF & LTF are not equal, they are highly variable, END is twice the ED (Table 1).

Chromatophores or colour pigments might play a very important role in visual communication between conspecifics and heterospecifics. Tadpoles with respect to different developmental stages show different colour variations, some may be adapted for crypsis and aposematism for survival (Toledo & Haddad 2009). The current study reports natural history observation of *U.*



Tadpole free-swimming. A well-developed specimen of 38 mm., has the following characters: Head and body ovoid, depressed, once and a half as long as broad. Nostrils close together, about midway between the tip of the snout and a line connecting the anterior borders of the eyes. Eyes lateral, the inter-orbital space more than 5 times the internarial. Mouth terminal, twice as wide as the internarial space, the lower lip contractile, the upper nearly straight. Spiraculum median, opening under a transparent flap close to the hinder end of the body. Anus median, the anal tube curving downwards and opening at the level of the hinder side of the thighs. Tail once and a half as long as the head and body, pointed but not flagellate, nearly 3 times as long as deep; caudal crests subequal, about as deep as the muscular portion of the tail at its base. Toes webbed as in the adult.

Greenish brown above, spotted with darker; sides and lower surfaces white, immaculate. Tail brown spotted.

The largest tadpole measures 45 mm. over all, and a newly metamorphosed frog measures 14 mm. from snout to vent.

DISTRIBUTION: S.W. India (Malabar, Cochin and Travancore).

Image 3. Tadpole description of *Uperodon montanus* is reproduced as in Parker (1934; p. 92).

montanus in the Gosner stage 25 changes colour with respect to the diel cycle. However, these are based only on visual observation in situ and photographs. More reproducible and objective studies are needed in this regard.

In the present work, Gosner stage 40 showed no webbing (n = 3); however, the sample size is small, so it will be interesting to study more about the tadpole webbing variation and tail fin with respect to different elevational and spawning ground variations. Garg et al. (2018) have already mentioned that the webbing of the *U. montanus* is highly variable and there are some studies reported globally on tadpole webbing variations (Goldberg & Fabrezi 2008). The studies on variations in tadpole morphology with respect to different environmental variables like water depth, temperature, oxygen levels and microhabitat features such as syntopy, predator, density and abundance will also be of great importance.

When the ambient temperature gets comparatively high (especially during the midnoon), water temperature increases, this might be one of the direct threats to several puddle tadpoles where mud puddles dry fast and rock pools (Chandramouli & Kalaimani 2014; Gaitonde et al. 2016) remain warmer for longer durations. Also, desiccation is the main cause of mortality, next to predation by some species of arthropods and aquatic beetles (Wells 2007).

The conservation status of *U. montanus* is listed as Near Threatened in the IUCN Red List (Biju et al. 2016; Das et al. 2020). To ascertain this status, reassessment was attempted in the present study to show the EOO suggesting Vulnerable status and the AOO suggesting Endangered status (Bachman et al. 2011). This species is restricted only to the mountain forests of the Western Ghats like the other two species *U. anamalaiensis* (Rao, 1937) and *U. triangularis* (Gunther, 1876) from the same genus (Garg et al. 2018). Suggesting 'Endangered' status for the species is a high priority conservation measure. Earlier reported northern limit of the range of distribution for this species was Thirunelli in Wyanad hill ranges of Kerala and the southern range of distribution was Kakachi in Agasthyamalai hill ranges of Tamil Nadu (Garg et al. 2018). Garg et al. (2018) presented several literature data citations and respective point localities from Karnataka and even Maharashtra parts of the Western Ghats, as those of *U. montanus*. Such literature records of *U. montanus* (sic) cover areas falling between Bisale Ghats, Karnataka up to Dangs in Gujarat (see Garg et al. 2018). Yet, their map indicates dots only till Goa Gap (Garg et al. 2018). So, due to imprecise taxonomic identities in many such reports, those records north of Wyanad are considered doubtful at best. Now our field data reveals the presence of the species from Tore gadde forests in the foothills of Pushpagiri hill ranges in Karnataka (Image 1) which is 130 km further northwards than the previous limit, Thirunelli. The previous record of altitude limit for the species was 1,700 m (Garg et al. 2018) but our studies extend much higher altitudinal range of 1,916 m from Vaguvarai, Idukki, Kerala. *Uperodon montanus* is an altitude and range specific anuran species that occurs within the central and southern Western Ghats and is known for scanty or imprecise reports (present study; Garg et al. 2018). Further studies are needed to understand its biphasic life, microhabitat preference, morphology, breeding behaviour, ecology, and ontogenetic variations.

REFERENCES

Altig, R. & G.F. Johnston (1989). Guilds of anuran larvae: relationships among developmental modes, morphologies, and habitats. *Herpetological Monographs* 3: 81–109. https://doi.org/10.2307/1466987

Bachman, S., J. Moat, A.W. Hill, J. de la Torre & B. Scott (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In: Smith, V. & L. Penev (Eds.). e-Infrastructures for data publishing in biodiversity science. *ZooKeys* 150: 117–126. https://doi.org/10.3897/zookeys.150.2109

Biju, S.D., G.D. Buddhe, S. Dutta, S., V.G. Broom, K. Vasudevan, C. Srinivasulu & S.P. Vijayakumar (2016). *Uperodon montanus*. The IUCN Red List of Threatened Species 2016: e.T57986A86524733. Accessed on 14 September 2022. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T57986A86524733.en

Chandramouli, S.R. & A. Kalaimani (2014). Description of the larvae of Günther's Toad *Duttaphrynus hololius* (Günther, 1876) (Anura: Bufonidae) with notes on development and oral ultra-structure. *Alytes* 31: 3–12.

Das, S., K.V. Gururaja, N. Modak, K.P. Rajkumar, K.S. Seshadri & V. Sankararaman (2020). Conservation Needs Assessment for *Uperodon montanus*, India (AArk/ASG India Assessment Workshop). Accessed 20 September 2022. https://conservationneeds.org/Assessment/AssessmentResults?assessmentId=5727&countryId=146&speciesId=96

Frost, D.R. (2023). Amphibian Species of the World: an Online Reference. Version 6.0 Electronic Database. American Museum of Natural History, New York. https://amphibiansoftheworld.amnh.org/. Accessed 23 January 2023.

Gaitonde, N., V. Giri & K. Kunte (2016). 'On the rocks': reproductive biology of the endemic toad *Xanthophryne* (Anura: Bufonidae) from the Western Ghats, India. *Journal of Natural History* 50(39–40): 2557–2572. https://doi.org/10.1080/00222933.2016.1200686

Garg, S., G. Senevirathne, N. Wijayathilaka, S. Phuge, K. Deuti, K. Manamendra-Arachchi, M. Meegaskumbura & S.D. Biju (2018). An integrative taxonomic review of the South Asian microhylid genus *Uperodon*. *Zootaxa* 4384(1): 1–88. https://doi.org/10.11646/zootaxa.4384.1.1

Goldberg, J. & M. Fabrezi (2008). Development and variation of the anuran webbed feet (Amphibia, Anura). *Zoological Journal of the Linnean Society* 152(1): 39–58. https://doi.org/10.1111/j.1096-3642.2007.00345.x

Gosner, K.L. (1960). A simplified table for staging anuran embryos and larvae with notes on Identification. *Herpetologica* 16(3): 183–190.

Hegde, A., K.P. Dinesh & G. Kadadevaru (2020). Phenotypic divergence in large sized cricket frog species that crossed the geographical barriers within peninsular India. *Zootaxa* 4838(2): 210–220. https://doi.org/10.11646/zootaxa.4838.2.3

Parker, H.W. (1934). *A Monograph of the Frogs of the Family Microhylidae*. London, (Trustees of the British Museum): I-III, 208 pp.

Raj, P., K. Vasudevan, G. Sahu & S. Dutta (2017). Larval taxonomy of Indian anurans, pp. 118–130. In: Das A. (ed.). *Diversity and ecology of Amphibians of India ENVIS bulletin: wildlife & protected Areas. Vol. 19.* Wildlife Institute of India, Dehradun, 319 pp.

Ramaswami, L.S. (1940). Some aspects of the chondrocranium in the tadpoles of South Indian frogs. *Journal of Mysore University* 1: 15–41.

Rao, C.R.N. (1918). Notes on tadpoles of Indian Engystomatidae. *Records of Indian Museum* 15: 41–45.

Rao, C.R.N. (1937). On some new forms of Batrachia from S. India. *Proceedings of the Indian Academy of Sciences*, *Section B6*: 387–427.

Silvestro, D. & I. Michalak (2012). RaxmlGUI: A graphical front-end for RAxMl. *Organisms Diversity and Evolution* 12(4): 335–337. https://doi.org/10.1007/s13127-011-0056-0

Tamura, K., G. Stecher, D. Peterson, A. Filipski & S. Kumar (2013). MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. *Molecular Biology and Evolution* 30(12): 2725–2729. https://doi.org/10.1093/molbev/mst197

Toledo, L.F. & C.F.B. Haddad (2009). Colors and some morphological traits as defensive mechanisms in anurans. *International Journal of Zoology* 2009: 1–12. https://doi.org/10.1155/2009/910892

Wells, K.D. (2007). *The Ecology and Behavior of Amphibians*. University of Chicago Press, 1,400 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22632–22653
OPEN ACCESS
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.7824.15.2.22632-22653
#7824 | Received 10 January 2022 | Final received 20 December 2022 | Finally accepted 18 February 2023
COMMUNICATION

An annotated checklist of the economically important family of moths (Lepidoptera: Heterocera: Noctuidae) of the northern Western Ghats, India, with notes on their type species, diversity, distribution, host plants, and an unusual new faunistic record

Aparna Sureshchandra Kalawate [1], Prachee Surwade [2] & S.N. Pawara [3]

[1,2] Zoological Survey of India, Western Regional Centre, Vidya Nagar, Sector-29, P.C.N.T. (PO), Rawet Road, Akurdi, Pune, Maharashtra 411044, India.
[3] S.G. Patil Arts, Science & Commerce College, Sakri, Maharashtra 424304, India.
[1] aparna_ent@yahoo.co.in (corresponding author), [2] pracheesurwade0987@gmail.com, [3] shitalnpawara@gmail.com

Abstract: This research is based on the surveys conducted from 2015–2018 resulting in identification of 37 species of 25 genera of noctuid moths. From the surveys, three new records including one unusual species namely, *Conservula indica* (Moore, 1867) are reported in the present study. A total of eight species of this family are reported as endemic. Two species—*C. indica* and *Pyrrhia umbra*—are reported first time from the Western Ghats part of Maharashtra. In this communication, notes on host plant, type species, endemic species with their distribution are provided.

Keywords: Biodiversity hotspot, endemic, genera, *Conservula indica*, faunistic survey, Maharashtra, *Pyrrhia umbra,* species, systematics, taxonomy.

सार: हे संशोधन 2015-2018 मध्ये केलेल्या सर्वेक्षणांवर आधारित आहे, ज्यामुळे नॉक्टिड पतंगांच्या 25 वंशाच्या 37 प्रजातींची ओळख पटली. सर्वेक्षणांमधून, सध्याच्या अभ्यासात *कन्झर्वुला इंडिका* (मूर, 1867) या असामान्य प्रजातीसह तीन नवीन नोंदी नोंदवल्या गेल्या आहेत. या कुटुंबातील एकूण आठ प्रजाती स्थानिक म्हणून नोंदवल्या गेल्या आहेत. दोन प्रजाती - *सी. इंडिका* आणि *पा. ओम्ब्रा* –महाराष्ट्राच्या पश्चिम घाट भागातून प्रथमच नोंदवल्या गेल्या आहेत. या लेखाच्या माध्यमातून, खाद्य वनस्पती, टाईप स्पिसीस, स्थानिक प्रजाती त्यांच्या वितरणासह माहिती प्रदान केली आहे.

Editor: Jatishwor Singh Irungbam, Sphingidae Museum, Pribram, Czech Republic. **Date of publication:** 26 February 2023 (online & print)

Citation: Kalawate, A.S., P. Surwade & S.N. Pawara (2023). An annotated checklist of the economically important family of moths (Lepidoptera: Heterocera: Noctuidae) of the northern Western Ghats, India, with notes on their type species, diversity, distribution, host plants, and an unusual new faunistic record. *Journal of Threatened Taxa* 15(2): 22632–22653. https://doi.org/10.11609/jott.7824.15.2.22632-22653

Copyright: © Kalawate et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The work is based on the annual research programme of Zoological Survey of India, WRC, Pune (Ministry of Environment & Forests, Govt. of India).

Competing interests: The authors declare no competing interests.

Author details: Aparna Sureshchandra Kalawate (ASK) is a senior scientist working in Zoological Survey of India, Western Regional Centre, Pune. She is an entomologist and her interest groups are moths and scarab beetles. She has more than 68 research papers published in peer reviewed journals. Prachee Surwade (PS) worked as a JRF in an entomology laboratory of ZSI, WRC, Pune from August, 2021 to August, 2022. Shital Pawara (SP) is a PhD student of SG Patil College, Sakri and her PhD thesis is on moths. She did her PhD research work at ZSI, WRC, Pune.

Author contributions: ASK—performed survey, collected and identified the moths and wrote the MS; PS—took the photographs and helped in curation and labeling; SNP—helped in preparing checklist.

Acknowledgements: The authors are grateful to the director, Zoological Survey of India (ZSI), Kolkata and the officer-in-charge, Zoological Survey of India, Western Regional Centre, Pune for providing necessary facilities and encouragement. The authors are thankful to the forest department for their cooperation and support during the survey. The authors acknowledge the survey team of ZSI Pune for collection efforts.

INTRODUCTION

Northern Western Ghats is a biodiversity hotspot with a high level of endemic species, facing biodiversity degradation by human exploitation. It is locally known as Sahyadri and is a chain of flat top mountains of about 750 km in length running parallel to western Coast of peninsular India from the river Tapi, southern Gujarat down south to Goa. The global conservation issue is the loss and fragmentation of tropical rainforest. Invertebrates are sensitive to the environmental changes and are important indicators to help us in understanding the effects of habitat fragmentation (Jansen 1997; Miyashita et al. 1998). Ockinger et al. (2010) reported that moths are sensitive to habitat fragmentation and the species whose larvae are monophagous are more affected by the loss of habitat. In recent past, considerable amount of research and conservation efforts have been carried out in this important ecoregion but is not sufficient. We need to record and conserve the species before its extinction.

Noctuid moths are also referred as owlet moths, are economically important group as the larva of most of them feeds on agricultural, horticultural, and forest plants. Correct identification of any species is necessary for development of suitable management practices. Maharashtra is an agriculturally important state of India, where the major occupation of people is agriculture. Despite various other reasons for low crop productivity, insect pest infestation is the major one. The immature stages of many noctuid genera have immense economic impact annually (Kitching 1984). The huge losses caused by them are counted in terms of millions of rupees every year which farmers spend for their control. As per Deshmukh et al. (2021), an additional cost of US$ 49.32 per ha, i.e., 10 times on pesticides was incurred by farmers to control a noctuid pest, *Spodoptera frugiperda* (Smith, 1797), in Karnataka. In millets, the voracious feeding of the noctuid pest results in complete defoliation (Gahukar & Reddy 2019). Another most dangerous pest is *Helicoverpa armigera* (Hübner, 1808) and alone is responsible for crop losses over INR 35,000 million annually in India (Kumar & Kapoor 2003). Very recently, the havoc caused by the invasive pest Fall Army Worm *S. frugiperda* is a classic example of how proper identification of the pest is important to control it in time. The distribution knowledge of such an economically important group of insects is vital for the economy of any country.

The most significant and outstanding contribution on the taxonomy of Indian Noctuidae was made by Hampson (1894, 1895) and published in Fauna of British India including Ceylon and Burma in two volumes. The classification of noctuid moth is highly unstable (Mitchell et al. 2000, 2006; Fibiger & Lafontaine 2005; Lafontaine & Fibiger 2006). Recently, due to the molecular studies conducted by Zahiri (2011, 2012) the classification has some stable status. In present study, the classification given by Holloway (2011) has been followed by incorporating subsequent changes (Zahiri et al 2011, 2012, 2013a, 2013b; Kononenko & Pinratana 2013). The distribution of the species was consulted from published literature (Zote et al. 2006; Sivasankaran et al. 2010, 2012; Kononenko & Pinratana 2013; Shashank & Singh 2014; Kononenko 2016; Das et al 2020; Nagrare et al. 2022).

On perusal of literature, it was found that, some literature is available on the noctuid fauna of southern Western Ghats (Sivasankaran et al. 2010, 2012) but no work so far has been carried out on noctuid fauna of this region. Hence, the present study was an taken up with an aim to document the noctuid moths from northern Western Ghats, Maharashtra. This study yielded in enumeration of 88 species of 44 genera from 13 subfamilies of noctuid moths from this region. Perhaps, this is the first report of documenting noctuid moths from this ecologically important biodiversity hotspot.

MATERIALS AND METHODS

Study Area

Field visits were undertaken in the northern Western Ghats region to collect and record the noctuid moths. Total 17 places in the northern Western Ghats were surveyed. The area surveyed and the geographical coordinated are given in Table 1 and also presented in Figure 1.

Collection and identification of specimens

Collection of specimens was done by light traps in the night. The collected specimens were euthanized by vapours of ethyl acetate and further processed in the laboratory by standard procedures in lepidopterology. The moths were identified with the help of available literature, viz. Hampson (1894, 1895), Bell & Scott (1937), and Holloway (1987; 1988). The classification followed is as per Nieukerken et al. (2011), Zahiri et al. (2010, 2011), and Kononenko & Pinratana (2013). The identified specimens have been deposited in the

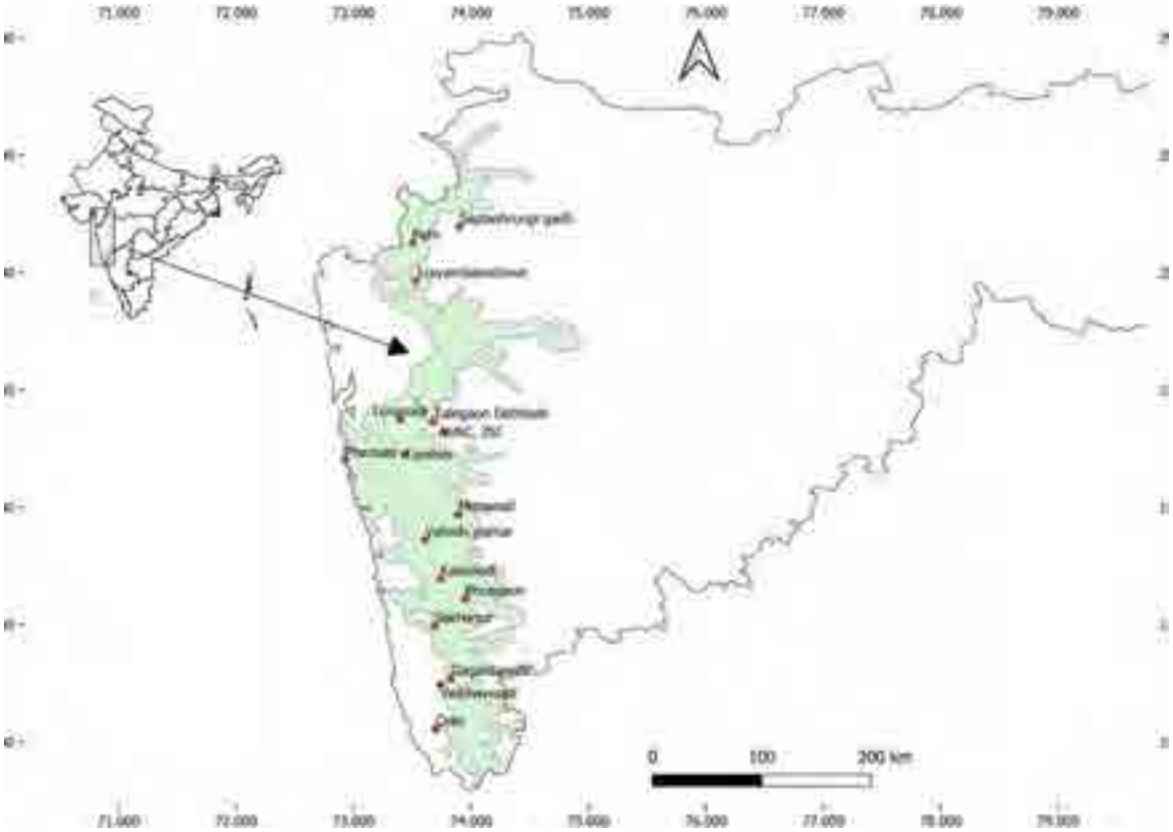


Figure 1. Survey localities in the northern Western Ghats.

National Zoological Collections of Zoological Survey of India, Western Regional Centre, Pune (ZSI-WRC). Some of the moths from the studied area have been shown in Image 1–3. Figure 1 represents the collection and survey localities. The details of the survey localities are given in Table 1.

RESULTS AND DISCUSSION

The aim of the present study was to ascertain the diversity of noctuid moths from the northern Western Ghats of Maharashtra. As the family has economic importance in agricultural, horticultural, and forest pest-disease, noctuid moths were assessed for their diversity. Proper control measures can be deployed to control the pest if it is identified correctly. Taxonomic documents and taxonomists help the agricultural scientist and the farmers in general to identify the pest correctly. This study was taken up to identify and document the noctuid fauna of the region and the surveys were undertaken during 2015–2018.

Totally, five surveys were undertaken (Figure 1) where a total of 37 species of noctuid moths have been documented in this study. The highest number of species reported in the present study is from Noctuinae (8) followed by Heliothinae (5), Eustrotiinae (5), Amphipyrinae (4), Bagisarinae (4), Plusiinae (4), Condicinae (3), Agaristinae (2), Aediinae (2), Eriopinae (1), and Dyopsinae (1).

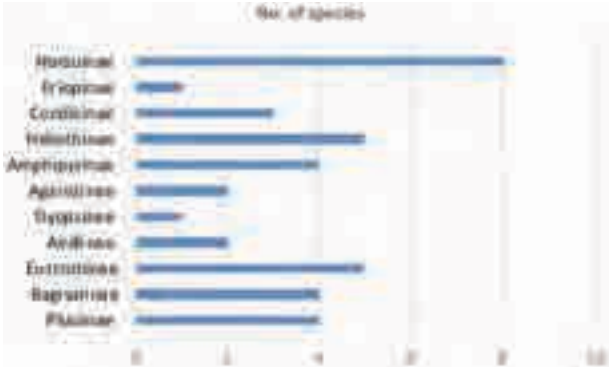


Figure 2. Number of species recorded in the subfamily.

A report of monophagous species namely, *C. indica* (Moore, 1867) in this study formed an unusual new distribution record from the Western Ghats (Earlier recorded from: Arunachal Pradesh, Sikkim, and Himachal

Table1. Details of the survey localitites with geocoordinates.

Locality	Latitude	Longitude
Lonavala	18.75	73.4
Oras	16.11	73.7
Bhosgaon	17.22	73.95
Menawali	17.94	73.89
Gaganbawda	16.54	73.83
Phansad	18.4	72.93
Talegaon dabhade	18.73	73.68
Sakharpa	16.99	73.69
Saptashrungi gadh	20.39	73.9
Tamhini	18.45	73.43
ZSI, WRC, campus	18.64	73.76
Valmiki pathar	17.72	73.61
Katewadi	17.39	73.74
Trayambakeshwar	19.93	73.53
Patan	17.37	17.37
Vaibhavwadi	16.49	73.74
Peth	20.25	73.5

Pradesh). A semi-epiphytic fern namely, *Pteridium revolutum* (Blume) Nakai (= *Pteridium aquilinum*) of family Dennstaedtiaceae is the host plant of *C. indica*. In the northern Western Ghats, *P. revolutum* is restricted from the medium–high elevation forest of Matheran-Mahabaleshwar (800–1,353 m). As per the reports of Kononenko & Pinratana (2013), *C. indica* occurred in the forest of Thailand up to 1,250 m altitude. Contrary to this, in the present study *C. indica* is recorded from Valmiki Pathar, Satara, India at 610 m altitude. As stated earlier, *C. indica* is reported from the Indian Himalayan region until this study. Though there are some photographs available on the citizen science website but no voucher based scientific document stating its occurrence from the studied area is available so far. Hence, this study forms an unusual new record of *C. indica* from the northern Western Ghats based on voucher specimen. Sivasakaran et al. (2017) listed the species in a checklist from Tamil Nadu, Western Ghats, India without photographs of the species. Rigorous studies are required to confirm the gaps areas of record of *C. indica* between Himalaya and the Western Ghats.

Chandra (2008) reported 11 Noctuidae species from Jabalpur. Sivasankaran et al. (2011) reported 154 species of noctuid moths classified under 85 genera and 23 subfamilies from Tamil Nadu part of Western Ghats (Nilgiri Biosphere and Kodaikanal hills). Fayle et al. (2007) collected 44 noctuid species near fields and gardens. They collected 13 noctuid species from both agriculture and forest area among which 25.9% and 24.7% noctuids were from agricultural and forest areas, respectively. Shubhalaxmi et al. (2011) reported 35 noctuid moths from the northern Western Ghats. Gurule & Nikam (2013) recorded 28 species of noctuid moths from Nashik, Dhule, Jalgaon, and Nandurbar districts of northern Maharashtra. Two-hundred-and-ninety-seven species of noctuid moths were reported by Mitra et al. (2019) from Maharashtra following the old system of classification. In majority of the published literature the old system of classification has been followed and they included some erebid moths like *Bastilla*, *Grammodes* under noctuid family. The systematic list of the taxa recorded form the study area is as under.

TAXONOMIC ACCOUNT

Order **Lepidoptera** Linnaeus, 1758
Suborder **Glossata** Fabricius, 1775
Superfamily **Noctuoidea** Latreille, 1809
Family **Noctuidae** Latreille, 1809
Subfamily **Plusiinae** Boisduval, [1828]
Tribe **Argyrogrammatini** Eichlin & Cunningham, 1978

***Trichoplusia* McDunnough, 1944**

1944. *Trichoplusia* McDunnough, *Mem. So. Calif. Acad. Sci.* 2(2)*:* 204.

Type Species: *Plusia brassicae* Riley, 1870 = *Trichoplusia ni* (Hübner, [1803])

1) *Trichoplusia ni* (Hubner, 1803)

[1803]. *Noctua ni Hübner, Samml. eur. Schmett*. [4]: pl. 58, f. 284.

Type locality: Europe.

Material examined: None.

Distribution: India (throughout including Maharashtra), Antilles, Brazil, Eurasia, Mexico, North America, northern Argentina, Oriental Region, Paraguay, southern Palearctic, southern Canada, USA.

Larval host Plants: polyphagous: *Ageratum conyzoides, Carthamus tinctorius, Helianthus annuus, Lactuca sativa, Taraxacum sect. Taraxacum, Zea mays* (Asteraceae); *Alcea rosea, Gossypium herbaceum, Gossypium barbadense* (Malvaceae); *Antirrhinum* spp. (Plantaginaceae); *Apium graveolens* (Apiaceae); *Asparagus officinalis* (Asparagaceae); *Beta vulgaris, Chenopodium album* (Amaranthaceae); *Brassica nigra, Brassica oleracea, Brassica rapa,*

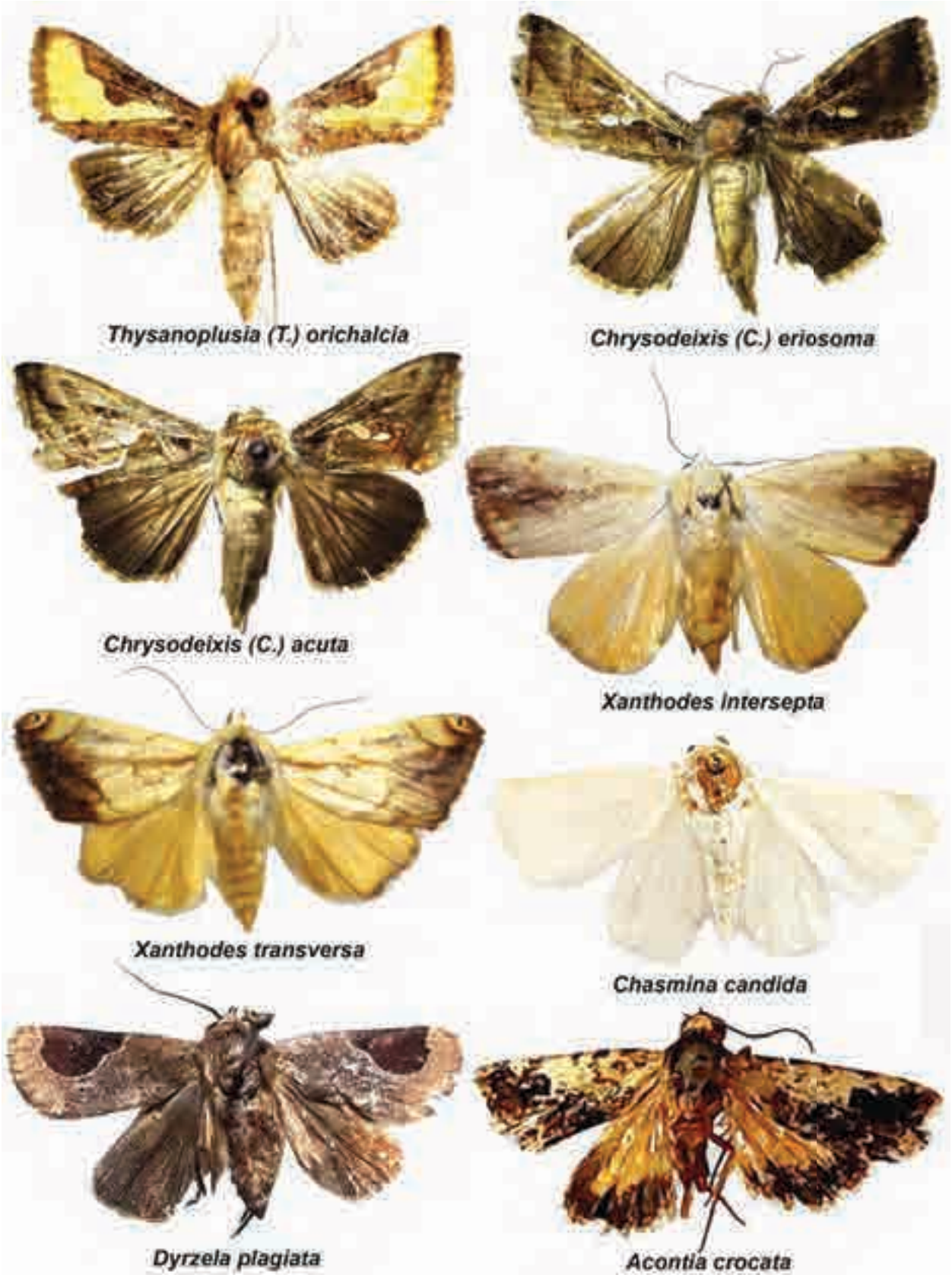


Image 1. Noctuid moths of northern Western Ghats. © Aparna Kalawate.

Citrullus lanatus, Cucurbita maxima (Cucurbitaceae); Zygophyllum arabicum (Zygophyllaceae); *Geranium* (Geraniaceae); *Glycine max* (Poaceae); *Ipomoea batatas* (Convolvulaceae); *Lathyrus odoratus, Melilotus indicus, Pisum sativum, Vigna unguiculata* (Fabaceae); *Solanum lycopersicum, Nicotiana glauca, Nicotiana tabacum, Solanum tuberosum* (Solanaceae); *Malus domestica* (Rosaceae); *Ocimum tenuiflorum* (Lamiaceae); *Papaver somniferum* (Papaveraceae); *Tropaeolum majus* (Tropaeolaceae); *Urtica dioica* (Urticaceae).

Thysanoplusia Ichinose, 1973

1973. *Thysanoplusia* Ichinose, *Kontyû* 41(2): 137.

Type Species: *Phytometra intermixta* Warren, 1973.

2) *Thysanoplusia (Thysanoplusia) intermixta* (Warren, 1913)

1913. *Phytometra intermixta* Warren, Seitz, *Grosschmett. Erde* 3: 357.

Type locality: China.

Material examined: None.

Distribution: India (Maharashtra & West Bengal), Canary Islands, China, Japan, Korea, Russia, southeastern Asia, Sri Lanka, Taiwan.

Larval host plants: Rosaceae, Fabaceae, Apiaceae, Linaceae, Lamiaceae, and Asteraceae.

3) *Thysanoplusia* (*Thysanoplusia*) *orichalcea* (Fabricius, 1775)

1775. *Noctua orichalcea* Fabricius, *Systema Ent.*: 607.

Type locality: India.

Material examined: 01 ex., Phansad, Raigad, 23.xi.2011, P.S. Bhatnagar & Party (L-1521); 01 ex., Phansad, Raigad, 22.xi.2011, P.S. Bhatnagar & Party (L-1520).

Distribution: India (Maharashtra, Tamil Nadu, West Bengal), Africa, southeastern Asia, Australia, New Zealand, southern Europe.

Larval host Plants: polyphagous: *Helianthus*, *Coreopsis* (Asteraceae); *Solanum tuberosum* (Solanaceae); *Glycine* (Fabaceae).

Vittaplusia Ronkay, Ronkay & Behounek, 2010

2010. *Vittaplusia* Ronkay, Ronkay & Behounek, *Witt Catalogue* 4: 74.

Type Species: *Plusia vittata* Wallengren, 1856.

4) *Vittaplusia (Petraplusia) obtusisigna* (Walker, 1858)

2010. *Vittaplusia (Petraplusia) obtusisigna*; Ronkay et al., *Witt Catalogue* 4: 14.

Type locality: Sri Lanka.

Material examined: None.

Distribution: India (Maharashtra, Tamil Nadu), Myanmar, Sri Lanka, and Thailand.

Larval host plants: Not known.

Ctenoplusia Dufay, 1970

1970. *Ctenoplusia* Dufay, *Faune Madagascar* 31: 91.

Type Species: *Plusia limbirena* Guenée, 1852.

5) *Ctenoplusia* (*Ctenoplusia*) *albostriata* (Bremer & Grey, 1853)

1853. *Plusia albostriata* Bremer & Grey, *Beitr. Schmett. nort. China*: 18.

Type locality: China (Beijing]).

Material examined: 01 ex., Lonavla, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1669); 01 ex., Satara, 10.xii.2017, A.S. Kalawate & Party (L-1658).

Distribution: India (Himachal Pradesh, Maharashtra, northwestern Himalaya, Odisha, Tamil Nadu), Australia, China, Fiji Islands, Indonesia, Japan, Korea, New Zealand, Russia, Rapa Island, Sri Lanka, southeastern Asia, and Taiwan.

Larval host plants: *Symphytum* (Boraginaceae); *Calystegia* (Convolvulaceae); *Aster, Dichrocephala, Elephantopus*, & *Erigeron* (Compositae); and *Calendula, Callistephus*, & *Dahlia* (Asteraceae).

6) *Ctenoplusia* (*Ctenoplusia*) *furcifera* (Walker, 1858)

1858. *Plusia furcifera* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 12: 927.

Type locality: Punjab [India].

Material examined: None.

Distribution: India (Himachal Pradesh, Kerala, Maharashtra, northwestern Himalaya, Tamil Nadu, West Bengal), Australia, South Africa, Taiwan, and Thailand.

Larval host plants: *Peristrophe* (Acanthaceae); *Coffea* (Rubiaceae).

Chrysodeixis Hübner, [1821]

[1821]. *Chrysodeixis* Hübner, *Verz. bek. Schmett*. 16: 252.

Type Species: *Phalaena chalcites* Esper, 1789.

7) *Chrysodeixis* (*Chrysodeixis*) *acuta* (Fabricius, 1775)

1858. *Plusia acuta* Walker, *List Spec. Lepid. Insects Colln Br. Mus*., 12: 922.

Type locality: Congo.

Material examined: 02 ex., Menawali, Wai Satara, 23.vii.2018, A.S. Kalawate & Party (L-1973); 01 ex.,

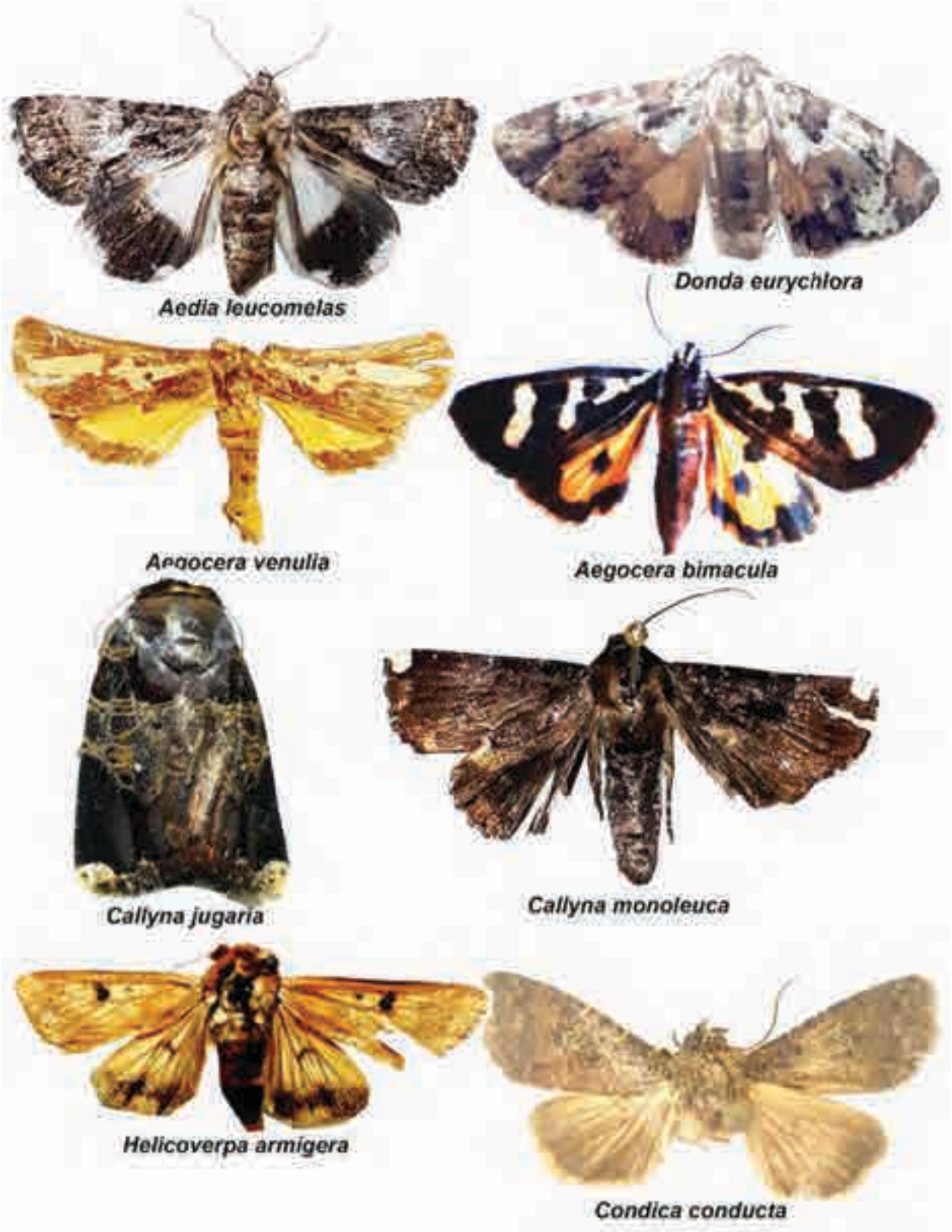


Image 2. Noctuid moths of northern Western Ghats. © Aparna Kalawate.

Oras, Sindhudurg, 27.ix.2016, V.D. Hegde & Party (L-1686); 01 ex., Gaganbawda, Kolhapur, 03.x.2017, V.D. Hegde & Party (L-1687); 02 ex., Gaganbawda, Kolhapur, 06.x.2017, V.D. Hegde & Party (L-1688); 11 ex., Lonavla, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1613).

Distribution: India (Kerala, Maharashtra, Tamil Nadu, West Bengal), Africa, Australia, China, Indonesia, and Japan.

Larval host plants: *Hordeum vulgare* (Poaceae); *Linum usitatissimum* (Linaceae); and *Sorghum bicolor* (Poaceae).

8) *Chrysodeixis* (*Chrysodeixis*) *eriosoma* (Doubleday, 1843)

1843. *Plusia eriosoma* Doubleday, in Dieffenbach, *Travels in New Zealand,* 2: 285.

Type locality: New Zealand.

Material examined: 25 ex., Lonavla, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1659); 01 ex., Menawali, Wai, Satara, 23.vii.2018, A.S. Kalawate & Party (L-1972).

Distribution: India (throughout including Maharashtra), Australia, China, Indonesia, Japan, Malaysia, New Zealand, New Guinea & neighbouring islands in the Pacific Ocean, and North & South America.

Larval host plants: polyphagous: Solanaceae; Convulvulaceae; Geraniaceae; Lamiaceae; Mimosaceae; Fabaceae; Passifloraceae; Cucurbitaceae; and Liliaceae.

Anadevidia *Kostrowicki,* 1961

1961. *Anadevidia Kostrowicki, Acta zool. cracov*. 6(10): 384.

Type Species: *Noctua peponis* Fabricius, 1775.

9) *Anadevidia peponis* (Fabricius, 1775)

1775. *Noctua peponis* Fabricius, *Syst. Ent.*: 608.

Type locality: East Indies.

Material examined: None.

Distribution: India (Maharashtra, Odisha), Australia, Japan, Korea, New Guinea, Taiwan, and Ussuri.

Larval host plants: *Citrullus lanatus*, *Cucumis sativus*, *Cucurbita moschata*, *Cucurbita pepo*, *Momordica chanrantia*, *Trichosanthes anguina, T. himalensis*, *T. cucumerina*, *Lagenaria siceraria*, and *Sechium edule* (Cucurbitaceae).

(I) Subfamily Bagisarinae Crumb, 1956

Xanthodes Guenée, 1852

1852. *Xanthodes* Guenée, *Hist. nat. Ins., Spec. gén. Lépid*. 6(Noct. 2): 209.

Type Species: *Phalaena malvae* Esper, 1805.

10) *Xanthodes intersepta* Guenée, 1852

1852. *Xanthodes intersepta* Guenée, *Species Général des Lépidoptéres* 6: 212.

Type locality: Indes Orientales (India).

Material examined: 01 ex. Lonavla, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1629).

Distribution: India (Maharashtra, Madhya Pradesh, Tamil Nadu) Burma, China, Hong Kong, Indonesia, Japan, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam.

Larval host plants: *Hibiscus*, *Kydia*, *Urena*, and *Abelmoschus esculentus* (Malvaceae).

11) *Xanthodes transversa* Guenée, 1852

1852. *Xanthodes transversa* Guenée, *Hist. nat. Ins., Spec. gén. Lépid*. 6(Noct. 2): 211.

Type locality: Indonesia; Bangladesh.

Material examined: 01 ex. Nandurbar, 28.viii.2019, S.N. Pawara (L-2287).

Distribution: India (Maharashtra, Andaman & Nicobar Island), Australia, Bangladesh, Bismarck Archipelago, Borneo, China, Hong Kong, Indonesia, Japan, Laos, Malaysia, Melanesia, Myanmar, Nepal, New Guinea, New Hebrides, Pakistan, Philippines, Singapore, Sri Lanka, southern China, southern Japan, Solomon Island, Thailand, Timor, Vanuatu, and Vietnam.

Larval host plants: *Barringtonia* (Lecythidaceae), *Urena*, *Abelmoschus*, *Alcea*, *Gossypium*, *Hibiscus*, *Kydia*, *Sida* (Malvaceae), *Psidium* (Myrtaceae), *Solanum* (Solanaceae), *Grewia* (Tiliaceae), *Citrus* (Rutaceae), and *Boehmeria* (Urticaceae).

Chasmina Walker, 1856

1856. *Chasmina* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 9: 69.

Type Species: *Chasmina cygnus* Walker, 1856.

12) *Chasmina candida* (Walker, 1865)

1865. *Arbasera candida* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus.*32: 638.

Type locality: Cambodia.

Material examined: 01 ex., Lonavala, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1819); 02 ex., Oras, Sindhudurg, 10.ix.2015, A.S. Kalawate & Party (L-1470).

Distribution: India (Maharashtra, Tamil Nadu, & Uttarakhand), Australia, Cambodia, eastern Africa, Fiji, Indonesia, Laos, Madagascar, Melanesia, New Guinea, New Caledonia, New Hebrides, Nepal, Philippines, Solomon Island, Sri Lanka, southern Japan, southern China, Seychelles, Taiwan, Thailand, Vietnam, and Vanuatu.

Image 3. Noctuid moths of northern Western Ghats. © Aparna Kalawate.

Larval host plants: *Talipariti tiliaceum* and *Hibiscus tiliaceus* (Malvaceae).

13) *Chasmina fasciculosa* Walker, 1858

1858. *Acontia fasciculosa* Walker, *Cat. Lep. Het.* B. M. xv, p. 1760.

Type locality: Sri Lanka.

Material examined: None.

Distribution: India (Maharashtra), China, Laos, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam.

Larval host plants: *Helicteres* (Malvaceae).

Dyrzela Walker, 1858

1858. *Dyrzela* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 15: 1758.

Type Species: *Dyrzela plagiata* Walker, 1858.

14) *Dyrzela plagiata* Walker (1857) 1858

(1857) 1858. *Dyrzela plagiata* Walker, *List of the Specimens of lepidopterous Insects in the Collection of the British Museum*, 15: 1758.

Type locality: Hindostan (India).

Material examined: 01 ex., Satara, 16.x.2016, P.S. Bhatnagar & Party (L-1891).

Distribution: India (Karnataka, Maharashtra, & Punjab), Thailand, Sri Lanka, Myanmar, Laos, Vietnam, Malaysia, Borneo, Indonesia, Philippines, and China.

Larval host plants: *Grewia* (Malvaceae).

Sphragifera Staudinger, 1892

1892. *Sphragifera* Staudinger, *in Romanoff, Mém. Lépid.* 6: 554.

Type Species: *Anthoecia sigillata* Ménétriés, 1859.

15) *Sphragifera rejecta* (Fabricius, 1775)

1775. *Noctua rejecta* Fabricius, *Syst. Ent*.: 601.

Type locality: India.

Material examined: None.

Distribution: India (Maharashtra, Punjab, & Tamil Nadu), China, Myanmar, Philippines, and Sri Lanka.

Larval host plants: Betulaceae; and Juglandacee.

Amyna Guenée in Boisduval & Guenée, 1852

1852. *Amyna* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* 5(Noct. 1): 406.

Type Species: *Amyna selenampha* Guenée, 1852.

16) *Amyna axis* (Guenée, 1852)

1775. *Noctua rejecta* Fabricius, *Syst. Ent*.: 601.

Type Locality: India.

Material examined: None.

Distribution: India (Tamil Nadu and Maharashtra), Australia, America, Africa, Arabia, Borneo, China, Fiji, Indonesia, Korea, Madagascar, Melanesia, Malaysia, New Guinea, New Hebrides, Near East, Nepal, Norfolk Island, New Caledonia, Pakistan, Polynesia, Samoa, south of Russian Far East, Sri Lanka, Solomon Isl., southern Japan, Thailand, Taiwan, Tonga, Vietnam, and Vanuatu.

Larval host plants: *Cannabis sativa* (Cannabaceae); *Chenopodium album* (Chenopodiaceae); and *Glycine max* (Fabaceae).

17) Amyna stellata Butler, 1878

1878. *Amyna stellata* Butler, *Ann. Mag. Nat. Hist*. (5)1(2): 162.

Type Locality: Japan.

Material examined: None.

Distribution: India (throughout including Maharashtra), Japan, China, Taiwan, Indian Subregion, and Sundaland.

Larval host plants: *Achyranthes* (Amaranthaceae).

(II) Subfamily Eustrotiinae Grote, 1882

Ozarba Walker, 1865

1865. *Ozarba* Walker, List Spec. *Lepid. Insects Colln Br. Mus*. 32: 684.

Type Species: *Ozarba punctigera* Walker, 1865.

18) *Ozarba badia* (Swinhoe, 1886)

1886. *Acontia badia* Swinhoe, *Proc. Zool. Soc. London* 1886:421–465.

Type Locality: Mhow (Madhya Pradesh).

Material examined: None.

Distribution: India (Madhya Pradesh).

Larval host plants: Not known.

Remark: Endemic to India.

19) *Ozarba itwarra* Swinhoe, 1885

1885. *Ozarba itwarra* Swinhoe, *Proc. Zool. Soc. London*: 452, pl. 27, f. 14.

Type Locality: Poona, Maharashtra.

Material examined: None.

Distribution: India (Maharashtra).

Larval host plants: Not known.

Remark: Endemic to India.

20) *Ozarba punctigera* Walker, 1865

1865. *Ozarba punctigera* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus.* 32: 685.

Type Locality: China; Australia.

Material examined: 05 ex., Lonavala, Pune,

23.viii.2017, A.S. Kalawate & Party (L-1804); 05 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1874).

Distribution: India (Himachal Pradesh, Maharashtra, southern India, & Uttarakhand), Australia, Indonesia, Korea, Japan, Nepal, Pakistan, southern China, South Africa, Thailand, and Taiwan.

Larval host plants: Gramineae.

21) *Ozarba rectifascia* (Hampson, 1894)

1894. *Metachrostis rectifascia* Hampson, *Fauna of British India*, Moths- II: 328–329.

Type Locality: Bombay (probably Bombay presidency during British India).

Material examined: None.

Distribution: India.

Larval host plants: Not known.

Remark: Endemic to India.

22) *Ozarba uberosa* (Swinhoe, 1885)

1885. *Metachrostis uberosa*, Swinhoe *Proc. Zool. Soc. London*: 457.

Type Locality: Poona (Maharashtra).

Material examined: None.

Distribution: India (Maharashtra, Tamil Nadu, & Western Ghats).

Larval host plants: Not known.

Remark: Endemic to India.

Deltote Reichenbach, 1817

1817. *Deltote* Reichenbach, *Jena. allg. Litt.-Ztg.* 1: 288.

Type Species: *Phalaena argentula* Hübner, 1787.

23) *Deltote marginata* (Walker, 1866)

1866. *Earias marginata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 35: 1775.

Type Locality: Java.

Material examined: 02 ex., Patan, Satara, 21.vii.2018, A.S. Kalawate & Party (L-1931); 01 ex., Koynanagar, Satara, 21.vii.2018, A.S. Kalawate & Party (L-1931); 01 ex., Nigadi, Nandurbar, 28.vi.2021, S.N. Pawara (L-3065); 01 ex., Patnadevi, Jalgaon, 14.viii.2021, A.S. Kalawate & Party (L-3227).

Distribution: India (Delhi, Maharashtra, & Manipur), China, Indonesia, and Myanmar.

Larval host plants: Not known.

Maliattha Walker, 1863

1863. *Maliattha* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 27: 86.

Type Species: *Maliattha separata* Walker, 1863.

24) *Maliattha fuliginosa* Warren, 1913

1913. *Maliattha fuliginosa* Warren, Eulenartige Nachtfalter *Gross-Schmett. Erde* 11: 280.

Type Locality: Bombay (probably Bombay presidency during British India).

Material examined: None.

Distribution: India.

Larval host plants: Not known.

Remark: Endemic to India.

25) *Maliattha quadripartita* Walker, 1865

1865. *Acontia quadripartita* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 33: 786.

Type Locality: North Hindostan (Northern India).

Material examined: None.

Distribution: India (Maharashtra & northern India), Indonesia, Myanmar, Nepal, New Guinea, southern China, Thailand, Taiwan, and Vietnam.

Larval host plants: Not known.

26) *Maliattha signifera* (Walker, 1858)

1858. *Acontia signifera* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 12: 796.

Type Locality: Northern India.

Material examined: None.

Distribution: India (Maharashtra & northern India), Australia, China, Japan, Korea, Taiwan, and Thailand.

Larval host plants: Not known.

(III) Subfamily Acontiinae Guenée, 1841

Tribe **Acontiini** Guenée, 1841

Acontia Ochsenheime 1816

1816. *Acontia* Ochsenheimer, *Schmett. Eur.* 4: 91.

Type Species: *Noctua solaris* Schiffermüller, 1775.

27) *Acontia* (*Emmelia*) *crocata* (Guenée, 1852)

1852. *Acontia crocata* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* 6 (Noct. 2): 218.

Type Locality: Almorah, northern India.

Material examined: 01 ex., Nandurbar, 15.vii.2021, S.N. Pawara (L-3189).

Distribution: India (Himachal Pradesh, Maharashtra, & Tamil Nadu), Australia, Bangladesh, China, Indonesia, Myanmar, Malay Peninsula, Nepal, Pakistan, Sri Lanka, Thailand, and Taiwan.

Larval host plants: *Ligustrum vulgare* (Oleaceae).

28) *Acontia discoidea* Hopffer, 1862

1862. *Acontia discoidea* Hopffer, *Peter's Reis. Moz*.: 433.

Type Locality: Mozambique

Material examined: None.

Distribution: India (Maharashtra) and Africa.

Larval host plants: *Abutilon, Hibiscus praeteritus*, and *Sida* (Malvaceae).

29) *Acontia flavonigra* (Swinhoe, 1884)

1884. *Rivula flavonigra* Swinhoe, *Proc. Zool. Soc. London*, 1884: 522.

Type Locality: Not known.

Material examined: None.

Distribution: India (Maharashtra & Telangana) and Pakistan.

Larval host plants: Not known.

30) *Acontia malvae* (Esper, 1796)

1796. *Xanthodes malvae* Esper, Schmett.: IV(2): 63.

Type Locality: Hungary.

Material examined: None.

Distribution: India (throughout including Maharashtra), Europe, and Taiwan.

Larval host plants: *Gossypium hirsutum* (Malvaceae).

31) *Acontia* (*Acontia*) *nitidula* (Fabricius, 1787)

1787. *Bombyx nitidula* Fabricius, *Mantissa Insectorum* 2: 126.

Type Locality: Coromandel [India].

Material examined: 01 ex., Langda Amba, Jalgaon, 29.vi.2019, A.S. Kalawate & Party (L-2559).

Distribution: India (Maharashtra), Thailand, China, Nepal, Myanmar, Ethiopia, and South Africa.

Larval host plants: *Abelmoschus esculentus* and *Gossypium* (Malvaceae).

32) *Acontia opalinoides* Guenee, 1852

1852. *Acontia opalinoides* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* 6(Noct. 2): 219.

Type Locality: "Cote de Coromandel" [India].

Material examined: None.

Distribution: India (Maharashtra), Africa, and Myanmar.

Larval host plants: *Abutilon* and *Gossypium* (Malvaceae).

33) *Acontia upsilon* (Walker, 1865)

1865. *Calophasia upsilon* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 33: 763.

Type Locality: Deccan (India).

Material examined: None.

Distribution: India (Maharashtra), and Africa.

Larval host plants: Not known.

34) *Acontia* (*Emmelia*) *binominata* (Butler, 1892)

1892. *Tarache binominata* Butler, *Entomologist* 25: 64

Type Locality: South Hindostan (India).

Material examined: None.

Distribution: India (Maharashtra) and Africa.

Larval host plants: Not known.

Emmelia Hübner, [1821]

[1821]. *Emmelia* Hübner, *Verz. bek. Schmett.* 16: 254.

Type Species: *Phalaena sulphuralis* Linnaeus, 1767.

35) *Emmelia basifera* (Walker, [1858])

[1858]. *Acontia basifera* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 12: 793.

Type Locality: Northern India.

Material examined: None.

Distribution: India (Maharashtra) and Africa.

Larval host plants: *Gossypium* (Malvaceae).

(IV) Subfamily Aediinae Beck, 1960

Aedia Hübner, [1823]

[1823]. *Aedia* Hübner, *Verz. bek. Schmett.* 17: 260.

Type Species: *Noctua funesta* Esper, 1786.

36) *Aedia leucomelas* (Linnaeus, 1758)

1758. *Noctua leucomelas* Linnaeus, *Syst. Nat.* (Edn 10) 1: 518.

Type Locality: Europe.

Material examined: 01 ex., Peth, Nashik, 23.x.2013, P.S. Bhatnagar & Party (L-1682); 01 ex., Bhosgaon, Patan, Satara, 12.vii.2017, A.S. Kalawate & Party (L-1770).

Distribution: India (Himachal Pradesh, Karnataka, & Maharashtra), Australia, Africa, Europe, Fiji, Indonesia, Japan, Korea, New Caledonia, New Hebrides, New Guinea, Near East, Nepal, Malaysia, Melanesia, Philippines, Samoa, Thailand, Taiwan, and Vanuatu.

Larval host plants: *Ipomoea batatas*, *Convolvulus* sp., and *Calystegia* (Convolvulaceae).

37) *Aedia acronyctoides* (Guenee, 1852)

1852. *Anophia arronyctoides* Guenee, *Noct.* 3: 47.

1894. *Catephia acronyctoides*: Hampson, *Fauna Brit. India, Moths,* 2: 482–483.

Type Locality: Van Diemen's land [Tasmania].

Material examined: 02 ex., Gaganbawda, Kolhapur,

03.x.2017, V.D. Hegde & Party (L-1683); 02 ex., Lonavala, 23.vii.2017, A.S. Kalawate & Party (L-1615).

Distribution: India (Andaman Islands, Haryana, Jharkhand, Madhya Pradesh, Maharashtra, & Tamil Nadu), Australia, Cambodia, Fiji, Indonesia, Laos, Myanmar, Malay Peninsula, Malaysia, New Guinea, Nepal, Philippines, Polynesia, Samoa, Taiwan, Thailand, Timor, and Vietnam.

Larval host plants: *Convonvulus*, *Ipomea*, *Merremia* (Convonvulaceae); *Limonia* (Rutaceae); and *Chondrilla* (Asteraceae).

38) *Aedia olivescens* (Guenee, 1852)

1852. *Anophia olivescens* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* 7(Noct. 3): 48.

Type Locality: Java.

Material examined: None.

Distribution: India (Andaman Islands, Assam, Himachal Pradesh, Jharkhand, Maharashtra, Punjab, & Uttar Pradesh), Pakistan, and Sri Lanka.

Larval host plants: *Convolvulus, Ipomoea, Merremia,* (Convonvulaceae); *Limonia* (Rutaceae); and *Lycopersicon, Solanum* (Solanaceae).

(V) Subfamily Pantheinae Smith, 1898

Trisula Moore, 1858

1858. *Trisula* Moore, in Horsfield & Moore, *Cat. Lep. Ins. Mus. Nat. East India House* 2: 420.

Type Species: *Trisula variegata* Moore, 1858.

39) *Trisula variegata* Moore, 1858

1858. *Trisula variegata* Moore, *Cat. Lep. Ins. Mus. Nat. East India House* 2: 420.

Material examined: None.

Type Locality: northern India, Madras (India).

Distribution: India (throughout including Maharashtra) and Sri Lanka.

Larval host plants: *Ficus religiosa* (Moraceae).

(VI) Subfamily Dyopsinae Guenée, 1852

Donda Moore, 1882

1882. *Donda* Moore, *Descr. Indian lep. Atkinson* 2: 161.

Type Species: *Dandaca eurychlora* Walker, 1882.

40) *Donda eurychlora* (Walker, 1858)

1858. *Dandaca eurychlora* Walker, *Walk. Cat.*, 15: 1670.

Type Locality: Hindostan, Canara [India].

Material examined: 02 ex., Lonavala, 23.viii.2017, A.S. Kalawate & party (L-1975).

Distribution: India (Karnataka, Kerala, Maharashtra, northern India, Sikkim, & Tamil Nadu), Nepal, and Malaysia.

Larval host plants: *Trema orientalis* (Cannabaceae) and *Bombax* (Bombacaceae).

41) *Donda ornata* Moore, 1883

1883. *Donda ornata* Moore, *Proc. zool. Soc. Lond*. 1883: 23, pl. 6, f. 3.

Type Locality: West Bengal (India).

Material examined: None.

Distribution: India (Maharashtra) and Bangladesh.

Larval host plants: *Bombax malabaricum* and *Oroma lagapos* (Bombacaceae).

Belciana Walker, 1862

1862. *Belciana* Walker, *J. Proc. Linn. Soc.* (Zool.) 6: 182.

Type Species: *Dandaca biformis* Walker, 1858.

42) *Belciana hemodi* (Felder & Rogenhofer, 1874)

1874. *Pandesma hemodi* Felder & Rogenhofer, *Reise Fregatte Novara, Bd* **2** (Abth. 2) (4): pl. 111, f. 25.

Type Locality: Himalaya.

Material examined: None.

Distribution: India (Maharashtra & Tamil Nadu), Sri Lanka, Indonesia, and Malaysia.

Larval host plants: *Shorea maximi* (Dipterocarpaceae) and *Heritiera* (Malvaceae).

43) *Belciana biformis* Walker, 1858

1858. *Dandaca biformis* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 15: 1671.

Type Locality: Borneo, Sarawak

Material examined: None.

Distribution: India (Maharashtra), Indonesia, Malaysia, and Sri Lanka.

Larval host plants: *Shorea maximi* (Dipterocarpaceae) and *Heritiera* (Malvaceae).

(VII) Subfamily Agaristinae Boisduval, 1833

Aegocera Latreille, 1809

1809. *Aegocera* Latreille, Genera *Crust. Insect*. 4: 211.

Type Species: *Phalaena venulia* Cramer, 1777.

44) *Aegocera bimacula* Walker, 1854

1854. *Aegocera bimacula* Walker, *List Spec. Lep. Ins.*

Coll. Brit. Mus., 1: 57.

Type Locality: Northern India.

Material examined: 02 ex., Jalgaon, 22.vi.2019. A.S. Kalawate & Party L-2566.

Distribution: India (Himachal Pradesh, Maharashtra, & Sikkim), Myanmar, and Sri Lanka.

Larval host plants: *Dillenia pentagyna* (Dilleniaceae) and *Leea guineensis* (Vitaceae).

45) *Aegocera venulia* (Cramer, [1777])

[1777]. *Phalaena venulia* Cramer, *Uitl. Kapellen* 2(9–16): 165.

Type Locality: Not known.

Material examined: 14 ex., Jalgaon, 30.vi.2019, A.S. Kalawate & Party (L-2538).

Distribution: India (Bihar, Maharashtra, Madhya Pradesh, Pondicherry, Rajasthan, subHimalayan tracts of Kashmir & Sikkim, plains of India, & Tamil Nadu) and Sri Lanka.

Larval host plants: *Boerhavia* sp. (Nyctaginaceae) and *Trianthema* (Aizoaceae).

Episteme Hübner, [1820]

[1820]. *Episteme* Hübner, *Verz. bek. Schmett.* 12: 179.

Type Species: *Phalaena lectrix* Linnaeus, 1764.

46) *Episteme adulatrix* (Kollar, [1844])

1844. *Eusemia adulatrix* Kollar, *Hugel's Kaschmir*, 4(2): 464.

Type Locality: Himalaya.

Material examined: None.

Distribution: India (throughout including Maharashtra), Nepal, China, and Myanmar.

Larval host plants: *Dioscorea pentaphylla, D. belophylla* (Dioscoreaceae); and *Solanum tuberosum* (Solanaceae).

(VIII) Subfamily Amphipyrinae Guenée, 1837

Callyna Guenée, 1852

1852. *Callyna* Guenée, *Hist. nat. Ins., Spec. gén. Lépid*. 5(Noct. 1): 112.

Type Species: *Callyna siderea* Guenée, 1852.

47) *Callyna costiplaga* Moore, [1885]

[1885]. *Callyna costiplaga* Moore, *Lepid. Ceylon* 3(2): 100.

Type Locality: Ceylon (Sri Lanka).

Material examined: 03 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1818).

Distribution: India (Kerala, Maharashtra, & Tamil Nadu), China, Indonesia, Philippines, Sri Lanka, and Thailand.

Larval host plants: Not known.

48) *Callyna jugaria* Walker, 1858

1858. *Callyna jugaria* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus* **15**: 1809.

Type Locality: Northern Hindustan (India).

Material examined: 02 ex., Ambegaon, Pune, 23.vii.2017, A.S. Kalawate & Party (L-1779); 01 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1820); 01 ex., Vaibhavwadi, Sindhudurg, 06.ix.2015, A.S. Kalawate & Party (L-1546).

Distribution: India (throughout including Maharashtra), Bangladesh, Myanmar, Nepal, Philippines, southern China, Sri Lanka, Thailand, Taiwan, and Vietnam

Larval host plants: *Cordia myxa* and *C. macleodii* (Boraginaceae).

49) *Callyna monoleuca* Walker, 1858

1858. *Callyna monoleuca* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus* 15: 1667.

Type Locality: Canara (India).

Material examined: 01 ex., Patan, Satara, 20.vii.2017, A.S. Kalawate & Party (L-1708); 01 ex., Valmiki Pathar, Satara, 18.vii.2017, A.S. Kalawate & Party (L-1748).

Distribution: India (Assam, Karnataka, Maharashtra, Sikkim, & Tamil Nadu), Australia, Indonesia, Laos, Myanmar, Malay Peninsula, Philippines, Nepal, Sri Lanka, Taiwan, Thailand, Vietnam, and western China.

Larval host plants: *Cordia myxa* and *C. macleodii* (Boraginaceae).

50) *Callyna siderea* Guenee, 1852

1852. *Callyna siderea* Guenée, *Hist. nat. Ins., Spec. gén. Lépid*. 5 (Noct. 1): 113.

Type Locality: Silhet (Bangladesh).

Material examined: None.

Distribution: India (Northern India including Himachal Pradesh, & Maharashtra) and Bangladesh.

Larval host plants: Not known.

(IX) Subfamily Heliothinae Boisduval, [1828] 1829

Helicoverpa Hardwick, 1965

1965. *Helicoverpa* Hardwick, *Ent. Soc. Canada, no.* 40: 1-247.

Type Species: *Noctua armigera* Hübner, 1808.

51) *Helicoverpa armigera* (Hübner, [1808])

[1808]. *Noctua armigera* Hübner, *Samml. Erop. Schmett*. 4**:** pl. 79.

Type Locality: Not known.

Material examined: 05 ex., Gaganbawda, Kolhapur, 03.x.2016, V.D. Hegde & Party (L-1543); 01 ex., Saptashrungi gadh, Nashik, 06.xi.2016, V.D. Hegde & Party (L-1542); 01 ex., Gaganbawda, Kolhapur, 02.x.2017, V.D. Hegde & Party (L-1679); 02 ex., Gaganbawda, Kolhapur, 06.x.2017, V.D. Hegde & Party (L-1680); 01 ex., Bhosgaon, Satara, 20.vii.2017, A.S. Kalawate & Party (L-1698); 01 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1814).

Distribution: India (throughout including Maharashtra), Australia, Afghanistan, China, central Asia, Europe, Indochina, Indonesia, Japan, Korea, Nepal, Near East, New Zealand, northern Africa, Old World. Pakistan, Philippines, Thailand, and Taiwan.

Larval host plants: Polyphagous: Acanthaceae; Aizoaceae; Alliaceae; Anacardiaceae; Apocynaceae; Cannabidaceae; Caryophyllaceae; Cleomaceae; Compositae; Cruciferae; Cucurbitaceae; Gramineae; Labiaceae; Leguminosae; Linaceae; Malvaceae; Musaceae; Papaveraceae; Resedaceae; Rosaceae; Rubiaceae; Rutaceae; Scrophulariaceae; Solanaceae; Vitaceae; and Zygophyllaceae.

52) *Helicoverpa assulta* (Guenée, 1852)

1852. *Heliothis assulta* Guenée, *Hist. nat. Ins., Spec. gén. Lépid*. 6 (Noct. 2): 178.

Type Locality: Tahiti.

Material examined: None.

Distribution: India (throughout including Maharashtra), Australia, China, Fiji, Guam, Indochina, Indonesia, Japan, Korea, Micronesia, Nepal, Near East, New Zealand, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and Tahiti.

Larval host plants: *Lycopersicon*, *Nicotiana*, *Physalis*, and *Solanum* (Solanaceae).

Heliothis Ochsenheimer, 1816

1816. *Heliothis* Ochsenheimer, *Schmett. Eur.* 4: 91.

Type Species: *Phalaena dipsacea* Linnaeus, 1767.

53) *Heliothis peltigera* ([Denis & Schiffermüller], 1775)

1775. *Noctua peltigera* Denis & Schiffermuller, *Wiell, Ven*. 89: 2.

Type Locality: Cote de Coromandel? [India].

Material examined: 01 ex., Gaganbawda, Kolhapur, 06.x.2016, V.D. Hegde & Party (L-1556); 01 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1815).

Distribution: India (Madhya Pradesh, Maharashtra, & Punjab), Afghanistan, Africa, Bangladesh, Laos, Europe, Kazakstan, northern & central Asia, Pakistan, and western China.

Larval host plants: polyphagous: *Carthamus*, *Calendula* (Asteraceae), and *Medicago* (Fabaceae).

Adisura Moore, 1881

1881. *Adisura* Moore, *Proceedings of the Zoological Society of London*, 1881:367.

Type Species: *Adisura atkinsoni* Moore, 1881.

54) *Adisura atkinsoni* Moore, 1881

1881. *Adisura atkinsoni* Moore, *Proc. Zool. Soc. Lond.*, 1881: 368.

Type Locality: Darjiling, West Bengal (India).

Material examined: 02 ex., Lonavala, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1809).

Distribution: India (Gujarat, Madhya Pradesh, Maharashtra (in this study) Tamil Nadu, & West Bengal), Africa, Cambodia, China, Indonesia, Japan, Korea, Madagascar, Sri Lanka, Thailand, and Vietnam.

Larval host plants: *Lablab pupureus* and *Cajanus cajan* (Fabaceae).

Remark: New record to Maharashtra.

55) *Adisura marginalis* (Walker, 1858)

1858. *Anthophila marginalis* Walker, *List Spec. lep. Ins. Coll. Brit. Mus.* 12: 830.

Type Locality: Northern India.

Material examined: 01 ex., Gaganbawda, Kolhapur, 6.x.2017, V.D. Hegde & Party (L-1735); 01 ex., Gaganbawda, Kolhapur, 2.x.2017, V.D. Hegde and Party (L-1736); 01 ex., Gaganbawda, Kolhapur, 3.x.2017, V.D. Hegde & Party (L-1737).

Distribution: India (Maharashtra, northern India, & West Bengal), Ambon, Indonesia, Moluccas, and Thailand.

Larval host plants: *Cajanus cajan* (Fabaceae).

Pyrrhia Hübner, [1821]

[1821]. *Pyrrhia* Hübner, *Verz. bek. Schmett.* 15: 233.

Type Species: *Noctua rutilago* Denis & Schiffermüller, 1775.

56) *Pyrrhia umbra* (Hufnagel, 1766)

1766. *Phalaena umbra* Hufnagel, *Berl. Mag*. 3: 294.

Type Locality: Berlin region.

Material examined: 01 ex., Satara, 15.vii.2017, A.S. Kalawate & Party (L-1765).

Distribution: India (Jammu & Kashmir and northern

India), Australia, Caucasus, central Asia, China, Europe, Iran, Kazakhstan, Nepal, southern Siberia, and Transcaucasia.

Larval host plants: *Ononis hircine, O. repens, O. spinosa, Genista tinctoria*, *Vicia cracca* (Fabaceae)*; Linaria vulgaris*, *L. bipartita*, *Antirrhinum majus* (Plantaginaceae); *Salix phylicifolia* (Salicaceae); *Polygonum lapathifolium* (Polygonaceae); *Rubus sp.* (Rosaceae); *Pentstemon barbatus* (Plantaginaceae); *Melampyrum nemorosum* (Orobanchaceae); and *Calendula officinalis* (Asteraceae).

Remark: Reported as a new record to Western Ghats (Kalawate 2022).

(X) Subfamily Condicinae Poole, 1995

Tribe **Condicini** Poole, 1995

Condica Walker, 1856

1856. *Condica* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 9: 240.

Type Species: *Condica palpalis* Walker, 1865.

57) *Condica conducta* (Walker, [1857] 1856)

[1857] 1856. *Caradrina conducta* Walker, *Cat*., 10: 296.

Type Locality: Congo.

Material examined: 01 ex., WRC, ZSI campus, Pune, 14.iii.2017, A.S. Kalawate & Party (L-1771); 01 ex., Lonavala, 23.viii.2017, A.S. Kalawate & Party (L-1823).

Distribution: India (throughout including Maharashtra), Africa, Sri Lanka, and Fiji.

Larval host plants: *Senecio* (Asteraceae); *Carthamus tinctorius*, *Dendranthema morifolium*, *Guizotia abyssinica*, *Coreopsis*, *Cosmos*, *Senecio*, *Chrysanthemum* (Compositae); *Corchorus* (Tiliaceae); and *Lepisanthes imbricata* (Sapindaceae).

58) *Condica dolorosa* (Walker, 1865)

1865. *Mamestra dolorosa* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus.* 32: 667.

Type Locality: Sri Lanka.

Material examined: 01 ex., WRC, ZSI, Pune campus, 14.iii.2017, A.S. Kalawate (L-1821).

Distribution: India (throughout including Maharashtra), Australia, China, Fiji, Indonesia, Malaysia, New Guinea, New Caledonia, Nepal, Polynesia, Philippines, Sri Lanka, Solomones, Taiwan, Thailand, and Vietnam.

Larval host plants: *Conyza*, *Elephantopus*, and *Blumea balsamifera* (Composita).

59) *Condica illecta* (Walker, 1865)

1865. *Perigea illecta* Walker, *List Spec. lipid. Ins. Coll. Brit. Mus.* 32: 684.

Type Locality: North Hindustan [India].

Material examined: 01 ex., Lonavala, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1822).

Distribution: India (Maharashtra), Australia, Borneo, China, Fiji, Indonesia, Japan, Korea, Laos, Malaysia, Melanesia, Nepal, New Caledonia, New Guinea, Oman, Philippines, Samoa, Saudi Arabia, Sri Lanka, Solomon Island, Taiwan, Thailand, Timor, Tonga, Vanuatu, Vietnam, and Yemen.

Larval host plants: *Ageratum, Dichrocephala*, *Elephantopus scaber*, *Emilia, Bidens*, *Carthamus*, *Cereopsis*, *Dahlia* (Compositae)*; Helianthus*, *Gnaphalium*, *Sonchus* (Asteraceae); and *Coffea* (Rubiaceae).

Prospalta Walker, [1858] 1857

[1858]. *Prospalta* Walker, *List Spec. Lepid. Insects Colln Br. us.* 13: 1079.

Type Species: *Prospalta leucospila* Walker, [1858].

60) *Prospalta leucospila* Walker, [1858]

[1858]. *Prospalta leucospila* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 13: 1114.

Type Locality: Hindostan [India].

Material examined: None.

Distribution: India (Arunachal Pradesh, Maharashtra, & Sikkim) and Nepal.

Larval host plants: Not known.

Iambia Walker, 1863

1863. *Iambia* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, 27: 109.

Type Species: *Iambia inferalis* Walker, 1863.

61) *Iambia pulla* (Swinhoe, 1885)

1885. *Acontia pulla* Swinhoe, *Proc. Zool. Soc. Lond*. 1885: 456, pl. 27, f. 15.

Type Locality: Poona (India).

Material examined: None.

Distribution: India (Himachal Pradesh, Punjab, Maharashtra, & West Bengal) and Sri Lanka.

Larval host plants: *Ziziphus* (Rhamnaceae).

(XI) Subfamily Eriopinae Herrich-Schäffer, [1851] 1845

Callopistria Hübner, [1821]

[1821]. *Callopistria* Hübner, *Verz. bek. Schmett*. 14: 216.

Type Species: *Phalaena juventina* Stoll, 1782.

62) *Callopistria maillardi* (Guenée, 1862)

1862. *Eriopus maillardi* Guenée, *Notes fur l'lle de la Réunion* (*Bourbon*) 2: 639.

2013. *Callopistria maillardi*: Kononenko and Pinratana, *Broth. St. Gabr. Thai. Bangk*.: 625pp.

Type Locality: Réunion.

Material examined: 01 ex., Tamhini, Pune, 19.ix.2018, A.S. Kalawate & Party (L-1872); 01 ex., Talegaon, Pune, 5.ix.2018, N. Upadhyay (L-1873).

Distribution: India (throughout including Maharashtra), Indonesia, Myanmar, and Sri Lanka.

Larval host plants: *Nephrolepis biserrata* (Lomariopsidaceae); *Asplenium nidus* (Aspleniaceae); *Pellaea viridis* (Pteridaceae); *Adiantum sp.* (Pteridaceae); and *Lygodium sp.* (Lygodiaceae).

63) *Callopistria callopistrioides* (Moore, 1881)

1881. *Thalpophila callopistrioides* Moore, *Proc. zool Soc. Lond.,* 1881:344.

Type Locality: Northern India.

Material examined: None.

Distribution: India (Maharashtra & northeastern Himalaya), Myanmar, Indonesia, Malaysia (Borneo), and Philippines.

Larval host plants: Not known.

64) *Callopistria apicalis* (Walker, 1855)

1855. *Mosara apicalis* Walker, *List specimens lepid. Insects Colln Br. Mus.* 5:1032.

Type Locality: Not known.

Material examined: None.

Distribution: India (Maharashtra), and Philippines.

Larval host plants: Not known.

(XII) Subfamily Noctuinae Latreille, 1809

Tribe **Prodeniini** Forbes, 1954

Spodoptera Guenée, 1852

1852. *Spodoptera* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* 5 (Noct. 1): 153.

Type Species: *Hadena mauritia* Boisduval, 1833.

65) *Spodoptera litura* (Fabricius, 1775)

1775. *Noctua litura* Fabricius *Entom. Syst. Emen. et Aucta. Sec. Classes*, *Ordines*, *Genera*, *Species*, *Adjectis Synonymis*, *Locis*, *Desc. Observatio.*: 601.

Type Locality: Darjeeling (India).

Material examined: 02 ex., Gaganbawda, Kolhapur, 02.x.2016, V.D. Hegde & Party (L-1681); 01 ex., Sakarpa, Ratnagiri, 29.x.2015, A.S. Kalawate & Party (L-1372); 01 ex., Gaganbawda, Kolhapur, 03.x.2016, V.D. Hegde & Party (L-1548); 01 ex., WRC, ZSI, Pune campus, 01.x.2015, A.S. Kalawate & Party (L-1549).

Distribution: India (Himachal Pradesh, Jharkhand, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Odisha, Punjab, Sikkim, Tripura, Tamil Nadu, Uttar Pradesh, & West Bengal), Autralo-Papuan, Borneo Java, Nepal, southern Myanmar, Sri Lanka, Singapore, Ethippian, Taiwan of oriental & also Palaearctic, and Hawaiian regions.

Larval host plants: polyphagus: *Allium* (Alliaceae); *Mangifera* (Anacardiaceae); *Carissa* (Apocynaceae); *Alocasia*, *Colocasia* (Araceae); *Basella* (Basellaceae); *Begonia* (Begoniaceae); *Canna* (Cannaceae); *Carica* (Caricaceae); *Casuarina* (Casuarinaceae); *Terminalia* (Combretaceae); *Blumea*, *Dahlia*, *Helianthus*, *Lactuca*, *Synedrella*, *Zinnia* (Compositae); *Ipomoea* (Convolvulaceae); *Brassica* (Cruciferae); *Cucurbita* (Cucurbitaceae); *Dioscorea* (Dioscoreaceae); *Diospyros* (Ebenaceae); *Euphorbia, Ricinus* (Euphorbiaceae); *Andropogon, Lepturus, Saccharum, Thuarea Zea* (Gramineae); *Cassytha* (Lauraceae); *Acacia, Canavalia, Dolichos, Glycine, Indigofera, Inocarpus, Medicago, Mimosa, Mucuna, Phaseolus, Sesbania* (Leguminosae); *Asparagus, Eucharis* (Liliaceae); *Geniostoma* (Loganiaceae); *Gossypium*, *Sida* (Malvaceae); *Ficus* (Moraceae); *Musa* (Musaceae); *Psidium* (Myrtaceae); *Boerhavia* (Nyctaginaceae); *Passiflora* (Passifloraceae); *Piper* (Piperaceae); *Polygonum* (Polygonaceae); *Eichhornia* (Pontederiaceae); *Rosa* (Rosaceae); *Morinda* (Rubiaceae); *Citrus* (Rutaceae); *Antirrhinum* (Scrophulariaceae); *Lycopersicon*, *Nicotiana*, *Solanum* (Solanaceae); *Theobroma* (Sterculiaceae); *Camellia* (Theaceae); *Triumfetta* (Tiliaceae) ; *Daucus* (Umbelliferae); *Laportea* (Urticaceae); and *Lantana*, *Tectona* (Verbenaceae).

66) *Spodoptera mauritia* (Boisduval, 1833)

1833. *Hadena mauritia* Boisduval, *Nouv. Ann. Mus. Hist. Nat. Paris,* 2(2): 240.

Type Locality: Mauritius, Bourbon.

Material examined: 01 ex., Gaganbawda, Kolhapur, 03.x.2016, V.D. Hegde & Party (L-1681).

Distribution: India (Andaman & Nicobar Island, Jharkhand, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Tamil Nadu, Uttar Pradesh, & West Bengal), Australo-Papuan, Ethiopio-Malagassic, Hawiian regions, Indonesia, Pakistan, Philippines of oriental, southern Myanmar, Sri Lanka, and western Malaysia.

Larval host plants: Gramineae; Compositae; Coniferae; Cruciferae; Cyperaceae; Malvaceae; Palmae;

Solanaceae.

67) *Spodoptera littoralis* (Boisduval, 1833)

1833. *Prodenia littoralis* Boisduval, *Fauna Ent. Madag*. *Lep*.: 91.

Type Locality: Kichwamba, Ankole, Uganda.

Material examined: None.

Distribution: India (throughout including Maharashtra), Africa, Europe, Greece, Israel, Italy, Portugal, Spain, Syria, and Turkey.

Larval host plants: polyphagus: *Gossypium hirsutum*, *Abelmoschus esculentus* (Malvaceae); Graminae; Euphorbiaceae; Cruciferaceae; Umbelliferae; Araceae; Solanaceae; Chenopodiaceae; Leguminosae; Capparidaceae; Labitaceae; Compositae; Rosaceae; Oleaceae; Anacardiaceae; Rutaceae; Apocynaceae; Fabaceae; Moraceae; Tiliaceae; and Myrtaceae.

Tribe Caradrini Boisduval, 1840

Subtribe **Athetiina** Fibiger & Lafontaine, 2005

Athetis Hübner, [1821]

[1821]. *Athetis* Hübner, *Verz. bek. Schmett.* 14: 209.

Type Species: *Noctua dasychira* Hübner, 1817.

68) *Athetis bremusa* (Swinhoe, 1885)

1885. *Caradrina bremusa* Swinhoe, *Proceedings of the Zoological Society of London*: 451.

Type Locality: Poona (India).

Material examined: 01 ex., WRC, ZSI campus, Pune, 21.xi.2016, A.S. Kalawate & Party (L-1684).

Distribution: India (Maharashtra), Myanmar, Sri Lanka, Taiwan, Thailand, and Vietnam.

Larval host plants: Not known.

69) *Athetis thoracica* (Moore, [1884])

[1884]. *Radinacra thoracica* Moore, *The Lepidoptera of Ceylon* 3: 31.

Type Locality: Sri Lanka.

Material examined: 04 ex., Lonavla, Pune, 23.viii.2017, A.S. Kalawate & Party (L-1729).

Distribution: India (Maharashtra & Tamil Nadu), Australia, Borneo, China, Fiji, Hawaii, Laos, Indonesia, Philippines, Malaysia, Myanmar, Melanesia, New Hebrides, Nepal, New Caledonia, New Guinea, Polynesia, Sri Lanka, Samoa, southern Japan, Solomon Isl., Taiwan, Thailand, Timor, Tonga, Vanuatu, and Vietnam.

Larval host plants: *Commelina* (Commelinaceae); *Ipomoea* (Convolvulaceae); *Syzygium* (Myrtaceae); *Portulaca* (Portulacaceae); *Nicotiana* (Solanaceae); *Camellia* (Theaceae); Gramineae; and Leguminosae.

70) *Athetis delecta* (Moore, 1881)

1881. *Caradrina delecta* Moore, *Proc. zool. Soc. Lond*. 1881: 349, pl. 38, f. 15.

Type Locality: Darjiling (India).

Material examined: None.

Distribution: India (Maharashtra), Myanmar, Nepal, Thailand, Vietnam, and western China.

Larval host plants: Not known.

71) *Athetis fasciata* (Moore, 1867)

1867. *Graphiphora fasciata* Moore, *Proc. zool. Soc. Lond*. 1867: 54.

Type Locality: Darjeeling (India).

Material examined: None.

Distribution: India (Maharashtra & Sikkim), Nepal, Thailand, and western China.

Larval host plants: Not known.

Tribe **Dypterygiini** Forbes, 1954

Aucha Walker, [1858]

[1858]. *Aucha* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* 13: 1137.

Type Species: *Aucha velans* Walker, 1858.

72) *Aucha nectens* (Walker, 1858)

1858. *Triphaena nectens* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 15: 1704.

Type Locality: Hindostan (India).

Material examined: None.

Distribution: India (Maharashtra) and Malaysia.

Larval host plants: Not knwon.

Trachea Ochsenheimer, 1816

1816. *Trachea* Ochsenheimer, *Schmett. Eur.* 4: 75.

Type Species: *Phalaena atriplicis* Linnaeus, 1758.

73) *Trachea auriplena* (Walker, 1857)

1857. *Eurois auriplena* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 11: 557.

Type Locality: Sri Lanka.

Material examined: None.

Distribution: India (Maharashtra), Thailand, Pakistan, northern India, Sri Lanka, Nepal, Bhutan, and northern Vietnam.

Larval host plants: Not known.

Tribe **Phlogophorini** Hampson, 1918

Conservula Grote, 1874

1874. *Conservula* Grote, *Bull. Buffalo Soc. nat. Sci.* 2: 17.

Type species: *Phlogophora anodonta* Guenée, 1852.

74) *Conservula indica* (Moore, 1867)

1867. *Phlogophora indica* Moore, *Proceedings of the Zoological Society of London*: 57.

Type Locality: Bengal [India].

Material examined: 02 ex., Valmiki Pathar, Patan, Satara, 18.vii.2017, A.S. Kalawate & Party (L-1752). Distribution: India (Arunachal Pradesh, Sikkim, & Himachal Pradesh), Bangladesh, Laos, Pakistan, southwestern China, Taiwan, Thailand, and Vietnam.

Larval host plants: *Pteridium aquilinum* (Dennstaedtiaceae).

Remark: New record for Western Ghats, Maharashtra.

Euplexia Stephens, 1829

1829. *Euplexia* Stephens, *Nom. Br. Insects*, **1829**: 41.

Type Species: *Phalaena lucipara* Linnaeus, 1758.

75) *Euplexia semifascia* (Walker, 1856)

1865. Hadena semifascia Walker, *List Spec. Lepid. Insects Colln Br. Mus*. **33**: 737.

Type Locality: South Hindostan (India).

Material examined: None.

Distribution: India (Northwestern Himalaya, Maharashtra, & Tamil Nadu) and Nepal.

Larval host plants: Not known.

Karana Moore, 1882

1882. *Karana* Moore, *Descr. Indian lep. Atkinson* 2: 106.

Type Species: *Karana decorata* Moore, 1882.

76) *Karana gemmifera* (Walker, 1857)

[1858]. *Plusia gemmifera* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 12: 934.

Type Locality: Not known.

Material examined: None.

Distribution: India (Himachal Pradesh, Maharashtra, Sikkim, & Tamil Nadu), Malay Peninsula, Malaysia, Myanmar, Nepal, southwestern China, Taiwan, and Thailand.

Larval host plants: Not known.

Pareuplexia Warren in Setiz, 1911

1911. *Pareuplexia* Warren, *Novit. zool.* 18: 140–148.

Type Species: *Naenia chalybeata* Moore, 1867.

77) *Pareuplexia metallica* (Walker, 1865)

1865. *Mamestra metallica* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. 32: 666.

Type Locality: Darjeeling (India).

Material examined: None.

Distribution: India (Bombay during British India=probably Maharashtra, Sikkim, & West Bengal).

Larval host plants: Not known.

Remark: Endemic to India.

Sasunaga Moore, 1881

1881. *Sasunaga* Moore, *Proc. zool. Soc. Lond.* 1881: 342.

Type Species: *Hadena tenebrosa* Moore, 1867.

78) *Sasunaga tenebrosa* Moore, 1867

1867. *Hadena tenebrosa* Moore, *Proc. Zool. Soc. Lond.* 1867: 59.

Type Locality: Bengal (India).

Material examined: None.

Distribution: India (Himachal Pradesh, Karnataka, Maharashtra, Sikkim, & Uttarakhand), Bangladesh, Borneo, Indonesia, Laos, Malaysia, Nepal, New Guinea, Pakistan, southwestern China, Singapore, Sri Lanka, Timor, Taiwan, Thailand, and Vietnam.

Larval host plants: *Ventilago* (Rhamnaceae).

79) *Sasunaga longiplaga* Warren, 1912

1912. *Sasunaga longiplaga* Warren, *Novit. zool*. 19: 15.

Type Locality: Penang (Malaysia).

Material examined: None.

Distribution: India (Maharashtra), Borneo, Indonesia, Japan, Korea, Malaysia, Malay Peninsula, Myanmar, Nepal, New Guinea, Philippines, southwestern China, Thailand, Taiwan, Timor, and Vietnam.

Larval host plants: Not known.

Tribe **Hadenini** Guenée, 1837

Subtribe **Leucaniina** Guenée, 1837

Leucania Ochsenheimer, 1816

1816. *Leucania* Ochsenheimer, *Schmett. Eur.* 4: 81.

80) *Leucania* (*Acantholeucania*) *loreyi* (Duponchel, 1827)

1827. *Noctua loreyi* Duponchel, *Lep. France*, 7: 81.

Type Locality: Dijon.

Material examined: 01 ex., Bhosgaon, Satara, 13.vii.2017, A.S. Kalawate & Party (L-1731); 01 ex., Forest RH, Bhosgaon, Satara, 17.vii.2017, A.S. Kalawate & Party (L-1699).

Distribution: India (throughout including Maharashtra), Europe, Malaysia, and Sri Lanka.

Larval host plants: *Oryza sativa*, *Zea mays*, and *Saccharum* (Poaceae).

81) *Leucania polemusa* Swinhoe, 1885

1885. *Leucania polemusa* Swinhoe, *Proc. Zool. Soc. Lond*. 447, pl. 27, f. 1.

Type Locality: Poona; Bombay (India).

Material examined: None.

Distribution: India (Maharashtra).

Larval host plants: Not known.

Remark: Endemic to India.

82) *Leucania vana* (Swinhoe, 1885)

1885. *Agrotis vana* Swinhoe, *Proc. Zool. Soc. Lond*. pl. 27, f. 9.

Type Locality: Poona; Sattara (Maharashtra, India).

Material examined: None.

Distribution: India (Maharashtra).

Larval host plants: Not known.

Remark: Endemic to India.

Tribe **Noctuini** Latreille, 1809

Subtribe **Agrotina** Rambur, 1848

Agrotis Ochsenheimer, 1816

1816. *Agrotis* Ochsenheimer, *Schmett. Eur.* 4: 66.

Type Species: *Noctua segetum* Denis & Schiffermüller, 1775.

83) *Agrotis biconica* Kollar, [1844]

[1844]. *Agrotis biconica* Kollar, in Hügel, *Kaschmir und das Reich der Siek* 4: 480.

Type Locality: Kashmir (India).

Material examined: None.

Distribution: India (Maharashtra, northwestern Himalayas, Punjab, Sikkim, & Tamil Nadu), Afghanistan, Iran, Madagascar, Myanmar, Pakistan, Sri Lanka, and Turkey.

Larval host plants: Not known.

84) *Agrotis ipsilon* (Hufnagel, 1766)

1766. *Phalaena ipsilon* Hufnagel, *Berlinisches Magazin*, 3: 416.

Type Locality: Germany.

Material examined: 01 ex., Talegaon, Pune, 08.viii.2017, N. Upadhyay (L-1946).

Distribution: India (throughout including Maharashtra), Universally distributed except South America.

Larval host plants: Polyphagous: *Crataegus sp.* (Rosaceae); Cruciferae; Chenopodiaceae; Compositae; Gramineae; and *Solanum tuberosum* (Solanaceae).

85) *Agrotis segetum* ([Denis & Schiffermüller], 1775)

1775. *Noctua segetum* Denis & Schiffermüller, *Ank. syst. Schmett. Wienergegend*: 81.

Type Locality: Vienna region.

Material examined: None.

Distribution: India (throughout including Maharashtra), Africa, Asia, China, Europe, Indochina, Indonesia, Japan, Korea, Madagascar, Nepal, New Guinea, Pakistan, Philippines, Thailand, and Taiwan.

Larval host plants: Polyphagous: Fabaceae; Amaryllidaceae; Asparagaceae; Brassicaceae; Theaceae; Casuarinaceae; Pinaceae; Asteraceae; Rubiaceae; Cucurbitaceae; Myrtaceae; Rosaceae; Malvaceae; Solanaceae; and Amaranthaceae.

Subtribe **Noctuina** Latreille, 1809

Xestia Hübner, 1818

1818. *Xestia* Hübner, *Zuträge Samml. exot. Schmett.* 1: 16.

Type Species: *Noctua ochreago* Hübner, 1790.

86) *Xestia c-nigrum* (Linnaeus, 1758)

1758. *Phalaena (Noctua) c-nigrum* Linnaeus, *Syst. Nat.* (Edn 10) 1: 516.

Type Locality: Europe.

Material examined: None.

Distribution: India (Meghalaya, Maharashtra, northwestern Himalaya, & Tamil Nadu), northern America, Europe, Japan, and Sri Lanka.

Larval host plants: *Chamaenerion angustifolium* (Onagraceae) and *Stellaria media* (Caryophyllaceae).

87) *Xestia semiherbida* (Walker, 1857)

1857. *Triphaena semiherbida* Walker, *Cat. Lep. Het*., 11: 743.

Type Locality: Northern India.

Material examined: None.

Distribution: India (Himachal Pradesh, Maharashtra, northern India, & Sikkim), Japan, and Taiwan.

Larval host plants: Not known.

Tribe **Glottulini** Guenee, 1852

Polytela Guenée, 1852

1852. *Polytela* Guenée, *Hist. nat. Insectes* (Spec. gén. Lépid.) 5: 113.

Type Species: *Bombyx gloriosae* Fabricius, 1775.

88) *Polytela gloriosae* Fabricius, 1781(Plate 1 E)

1781. *Polytela gloriosae* Fabricius, *Spec. Ins.* 2: 205.

Type Locality: "Habitat in Indiae orientalis Gloriosa" (India).

Material examined: 01 ex., Menawali, Wai, Satara, 23.vii.2018, A.S. Kalawate & Party (L-1971); 01 ex.,

Valmiki Pathar, Satara, 18.vii.2017, A.S. Kalawate & Party (L-1751); 01ex., WRC, ZSI, Pune campus, 7.viii.2017, A.S. Kalawate (L-1798).

Distribution: India (throughout including Maharashtra) and Sri Lanka.

Larval host plants: *Gloriosa superba* (Colchicaceae); *Crinum asiaticum*, *Amaryllis* (Amaryllidaceae); *Scadoxus multiflorus* (Amaryllidaceae); and *Lilium* (Liliaceae).

CONCLUSION

The present study provides an enumeration of total of 88 species of 44 genera from 13 subfamilies of noctuid family. Total eight species of noctuid moths reported endemic to India: *Leucania polemusa*; *Leucania vana*; *Ozarba badia*; *Ozarba itwarra*; *Ozarba rectifascia*; *Ozarba uberosa*; *Maliattha fuliginosa*, and *Pareuplexia metallica*. Two species namely, *C. indica* and *P. umbra* are reported first time from the Western Ghats' part of Maharashtra. *Adisura atkinsoni* is a new record to Maharashtra. This is the first report of documenting noctuid moths from the northern Western Ghats region. In future more extensive survey efforts will be undertaken to collect and record the diversity of the noctuid moth from northern Western Ghats.

REFERENCES

Bell, T.R.D & F.B. Scott (1937). The fauna of British India including Ceylon and Burma, Moths - Volume 5, Sphingidae. Taylor and Francis, London, 533pp.

Chandra, K. (2008). *Faunal Diversity of Jabalpur District, Madhya Pradesh*. Zoological Survey of India, Kolkata, 417 pp.

Das, A., A. Mazumder, P.C. Pathania & N. Singh (2020). Insecta, Lepidoptera (Moths). In: *Chandra, K., Raghunathan, C., Sureshan, P.M., Subramanian, K.A. & Rizvi, A.N. (Eds.), Faunal Diversity of Biogeographic Zones of India: Western Ghats*. Director, Zoological Survey of India, Kolkata, pp. 1–36.

Deshmukh, S.S., B.M. Prasanna, C.M. Kalleshwaraswamy, J. Jaba, & B. Choudhary (2021). Fall Armyworm (*Spodoptera frugiperda*), In: *Polyphagous Pests of Crops*. Springer Nature, Singapore, pp. 349–372. https://doi.org/10.1007/978-981-15-8075-8_8

Fayle, T.M., R.E. Sharp, M.E.N. Majerus (2007). The effect of moth trap type on catch size and composition in British Lepidoptera. *British Entomological and Natural History Society* 20: 221–232.

Fibiger, M. & J. D. Lafontaine (2005). A review of the higher classification of the Noctuoidea (Lepidoptera) with special reference to the Holarctic fauna. *Esperiana* 11: 7–92.

Gahukar, R.T & G.V.P. Reddy (2019). Management of Economically Important Insect Pests of Millet. *Journal of Integrated Pest Management* 10(1): 28. https://doi.org/10.1093/jipm/pmz026

Gurule, S. & S. Nikam (2013). The moths (Lepidoptera: Heterocera) of northern Maharashtra: a preliminary checklist. *Journal of Threatened Taxa* 5(12): 4693–4713. https://doi.org/10.11609/JoTT.o2555.4693-713

Hampson, G.F. (1894). *The Fauna of British India including Ceylon and Burma, Moths - Volume* 2. Taylor and Francis, London, 609 pp.

Hampson, G.F. (1895). *The fauna of British India including Ceylon and Burma, Moths - Volume* 3. Taylor and Francis, London, 546 pp.

Holloway, J.D. (1987). *The Moths of Borneo: Superfamily Bombycoidea: families Lasiocampidae, Eupterotidae, Bombycidae, Brahmaeidae, Saturniidae, Sphingidae. 199pp. Kuala Lumpur: Southdene.*

Holloway, J.D. (1988). *The Moths of Borneo Family Arctiidae, Subfamilies Syntominae, Euchromiinae, Arctiinae; Noctuidae misplaced in Arctiidae* (Camptoloma, *Aganainae*). 101 pp. Kuala Lumpur, Southdene.

Holloway, J.D. (2011). The Moths of Borneo. Part 2. *The moths of Borneo: families Phaudidae, Himantopteridae and Zygaenidae; revised and annotated checklist. Malayan Nature Journal* 63(1–2): 1–548.

Jansen, A. (1997). Terrestrial invertebrate community structure as an indicator of the success of a tropical rainforest restoration project. *Restoration Ecology* 5: 115–125.

Kalawate, A.S. (2022). Insecta: Lepidoptera: Heterocera (Moths). *Fauna of the Northern Western Ghats: Ecosystem Series*. *Zoological Survey of India* (Accepted).

Kitching, I.J. (1984). A historical review of the higher classification of the Noctuidae. *Bulletin of the British Museum Nature History* (*Entomology*) 49: 153–234.

Kononenko, V.S. & A. Pinratana (2013). Moth of Thailand Vol. 3, Part 2. Noctuoidea. An illustrated Catalogue of Erebidae, Nolidae, Euteliidae and Noctuidae (Insecta, Lepidoptera) in Thailand. Brothers of St. Gabriel in Thailand. Bangkok, 625 pp.

Kononenko, V.S. (2016). Family Noctuidae: Cuculliinae – Noctuinae, part (Lepidoptera). – Noctuoidea Sibiricae. Part 3. Proceedings of the Museum Witt Munich 5: 1–500, Munich – Vilnius.

Kumar, H. & A. Kapur (2003). Transgenic Bt crops as a component of Integrated Pest Management. *In*: Biotechnological Strategies in Agro-Processing. 85–104pp.

Lafontaine, J.D. & M. Fibiger (2006). Revised higher classification of the Noctuoidea (Lepidoptera). *Canadian Entomologist* 138: 610–635.

Mitchell, A., C. Mitter & J.C. Regier (2000). More taxa or more characters revisited: Combining data from nuclear protein-encoding genes for phylogenetic analyses of Noctuoidea (Insecta : Lepidoptera). *Systematic Biology* 49: 202–224.

Mitchell, A., C. Mitter & J.C. Regier (2006). Systematics and evolution of the cutworm moths (Lepidoptera: Noctuidae): evidence from two protein-coding nuclear genes. *Systematic Entomology* 31: 21–46, https://doi.org/10.1111/j.1365-3113.2005.00306.x

Mitra, B., K. Chandra, S.K.R. Shah, & J. Kumar (2019). Insecta: Lepidoptera. *Fauna of Maharashtra, State Fauna Series,* 20(Part-3): 89–209.

Miyashita, T., A. Shinkai & T. Chida (1998). The effects of forest fragmentation on web spider tropical rainforest restoration project. *Restoration Ecology* 2: 115–124.

Nagrare, V.S., B.F. Babasaheb, R. Kumar, V.C. Babu, K. Bhure, B. Naikwadi, N. Narkhedkar & V.N. Waghmare (2022). Arthropod pests and their natural enemies associated with cotton in India: A Review. *Indian Journal of Entomology* e21162. https://doi.org/10.5958/IJE.2022.167

Ockinger, E., O. Schweiger, T.O. Crist, D.M. Debinskim, J. Kraussm, M. Kuussaari, J.D. Petersen, J. Pöyry, J. Settele, K.S. Summerville, R. Bommarco (2010). Life-history traits predict species responses to habitat area and isolation: a cross-continental synthesis. *Ecological Letters* 13(8): 969–79. https://doi.org/10.1111/j.1461-0248.2010.01487.x

Sivasankaran, K., J.I. Madani, S. Ignacimuthu, M.G. Paulraj (2010). A survey of Euteliinae (Lepidoptera: Noctuidae) of Nilgiris, Tamil Nadu, India. *Entomon* 35(3): 175–182.

Sivasankaran, K., S. Gnanasekaran, D. Parandhaman, S. Ignacimuthu (2011). Diversity of Noctuid moths (Lepidoptera: noctuidae) in TamilNadu part of Western Ghats (Nilgiris biosphere and Kodaikanal hills), India. *Elixir Bio Diversity* 38: 4131–4134.

Sivasankaran, K., D. Parandhaman, S. Ignacimuthu (2012). Insecta,

Lepidoptera, Noctuidae, Catocalinae: New records from the state of Tamil Nadu and whole of India. *Check List* 8(4): 759–762.

Shashank, P.R. & L.R.K. Singh (2014). Checklist of the subfamily Plusiinae (Lepidoptera: Noctuidae) from India. *Indian Journal of Entomology* 76(3): 229–240.

Shubhalaxmi, V., R.C Kendrick, A. Vaidya, N. Kalagi, & A. Bhagwat (2011). Inventory of moth fauna (Lepidoptera: Heterocera) of the Northern Western Ghats, Maharashtra, India. *Journal of the Bombay Natural History Society* 108(3): 183–205.

Swinhoe, (1885). On the Lepidoptera of Bombay and the Deccan. Part I-IV *Proceedings of the Zoological Society of London* 1885: 124–148.

Zahiri, R., J.D. Holloway, I.J. Kitching, D. Lafontaine, M. Mutanen & N. Wahlberg (2011). Molecular phylogenetics of Erebidae (Lepidoptera, Noctuoidea). *Systematic Entomology* 1–23. https://dx.doi.org/10.1111/j.1365-3113.2011.00607.x

Zahiri, R., J.D. Holloway, I.J. Kitching, D. Lafontaine, M. Mutanen & N. Wahlberg (2012). Molecular phylogenetics of Erebidae (Lepidoptera, Noctuoidea). *Systematic Entomology* 37: 102–124.

Zahiri, R., J.D. Lafontaine, C. Schmidt, J.D. Holloway, I.J. Kitching, M. Mutanen, & N. Wahlberg (2013a). Relationships among the basal lineages of Noctuidae (Lepidoptera, Noctuoidea) based on eight gene regions. *Zoologica Scripta* 42: 488–507.

Zahiri, R., J.D. Lafontaine, J.D. Holloway, I.J. Kitching, B.Ch. Schmidtd, L. Kaila & N. Wahlberg (2013b). Major lineages of Nolidae (Lepidoptera, Noctuoidea) elucidated by molecular phylogenetics. *Cladistics* 29: 337–359.

Zote, V.K., G.G. Bilapate, R.M. Jadhav (2006). Life-fecundity tables of *Trichoplusia ni* (Hubner) on different host plants. *Journal of Maharashtra Agricultural Universities* 31(3): 314–317.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22654–22660

OPEN ACCESS

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

https://doi.org/10.11609/jott.8310.15.2.22654-22660

#8310 | Received 07 December 2022 | Final received 02 February 2023 | Finally accepted 08 February 2023

COMMUNICATION

Report of a tussock moth genus *Maeoproctis* (Lepidoptera: Erebidae: Lymantriinae: Nygmiini) from India

Gagan Preet Kour Bali [1] & **Amritpal Singh Kaleka** [2]

[1,2] Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab 147002, India.
[1] Department of Zoology, Eternal University, Baru Sahib, Himachal Pradesh 173101, India.
[1] gaganviren@gmail.com, [2] apskaleka@gmail.com (corresponding author)

Abstract: A new genus of Lymantriinae, *Maeoproctis* gen. nov. has been proposed with *Euproctis latifascia* (Walker) as its type species. The morphological descriptions and diagnosis have also been provided for the new genus. Another species *subfasciata* Walker has been shifted under the new genus as a new combination *Maeoproctis subfasciata* (Walker) comb. nov.

Keywords: *Maeoproctis*, *Euproctis, latifasciata*, *subfasciata*, Lymantriinae, India.

Abbreviations: 1A—First anal vein | 2A—Second anal vein | AED—Aedeagus | ANT.APO—Anterior apophyses | CRN—Cornuti | CRP.BU—Corpus bursae | CU_1—First cubital vein | CU_2—Second cubital vein | DU.BU—Ductus bursae | DU.EJ—Ductus ejaculatorius | JX—Juxta; |M_1—First median vein | M_2—Second median vein | M_3—Third median vein | PAP—Papilla analis | PO.APO—Posterior apophyses | R_1—First radial vein | R_2—Second radial vein | R_3—Third radial vein | R_4—Fourth radial vein | R_5—Fifth radial vein | SA—Saccus | Sc—Subcosta | Sc+R_1—Subcosta+First radial vein | TG—Tegumen | UN—Uncus | VIN—Vinculum | VLV—Valva.

ਸੰਖੇਪ: ਲਾਈਮੈਨਟਰੀਨੀ ਦੇ ਇੱਕ ਨਵੇਂ ਜੀਨਸ, ਮੀਉਪਰੋਕਟਿਸ ਜੀਨਸ ਨੋਵੇ ਨੂੰ ਯੂਰੋਪੀਰੋਕਟਿਸ ਲੈਟੀਫੇਸੀਆ (ਵਾਕਰ) ਬਤੌਰ ਇਸਦੀ ਕਿਸਮ ਸਪੀਸੀਜ ਦੇ ਨਾਲ ਪ੍ਰਸਤਾਵਿਤ ਕੀਤਾ ਗਿਆ। ਨਵੇਂ ਜੀਨਸ ਲਈ ਰੂਪ ਵਿਗਿਆਨਿਕ ਵਰਣਨ ਅਤੇ ਨਿਦਾਨ ਵੀ ਪ੍ਰਦਾਨ ਕੀਤੇ ਗਏ। ਇੱਕ ਹੋਰ ਸਪੀਸੀਜ਼ ਸਬਫੈਸੀਆਟਾ ਵਾਕਰ ਨੂੰ ਇਸ ਨਵੇ ਜੀਨਸ ਦੇ ਤਹਿਤ ਇੱਕ ਨਵੇਂ ਸੁਮੇਲ ਮੀਉਪਰੋਕਟਿਸ ਸਬਫੈਸੀਆਟਾ (ਵਾਕਰ) ਦੇ ਰੂਪ ਵਿੱਚ ਤਬਦੀਲ ਕੀਤਾ ਗਿਆ।

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Bali, G.P.K. & A.S. Kaleka (2023). Report of a tussock moth genus *Maeoproctis* (Lepidoptera: Erebidae: Lymantriinae: Nygmiini) from India. *Journal of Threatened Taxa* 15(2): 22654–22660. https://doi.org/10.11609/jott.8310.15.2.22654-22660

Copyright: © Bali & Kaleka 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: University Grants Commission, New Delhi (MANF Scheme); F1-17.1/2013-14/MANF/2013-14-SIK-27073 Dated: 6-02-2014.

Competing interests: The authors declare no competing interests.

Author details: Dr. Gagan Preet Kour Bali is currently affiliated with Eternal University, Baru Sahib as an assistant professor. Her area of interest is entomology and she is working to assess moth diversity from north-west Himalaya since 2014. She has contributed eight research papers in scientific Journals of repute. She is also associated with IntechOpen as an author & reviewer and contributed three book chapters pertaining to insects. Dr. Amritpal Singh Kaleka is serving as assistant professor in the Department of Zoology & Environmental Sciences, Punjabi University. His research fields include insect taxonomy, avian biology and environmental sciences. He successfully completed research projects from CSIR, DST, UGC and currently a research project under AICOPTAX scheme of MoEFCC is in progress.

Author contributions: Study design and article drafting—ASK & GPKB; field work—GPKB.

Acknowledgements: The authors extend their appreciation to the University Grants Commission, New Delhi for their financial assistance under MANF-2014 Scheme.

INTRODUCTION

The subfamily Lymantriinae is composed of seven well defined and distinct tribes, viz.: *Lymantriini* Hampson, *Orgyiini* Wallengren, *Nygmiini* Holloway, Leucomini Grote and *Arctornithini* Holoway, *Daplasini* Holloway & Wang, and *Locharinini* Holloway & Wang (Wang et al. 2015). The name 'Maeoproctis' has been proposed as a new genus referable to the tribe *Nygmiini* Holloway for the proper placement of two species, namely, *Euproctis latifascia* (Walker) and *Euproctis subfasciata* (Walker). Both the species are paler in general appearance and have very uniform distinct genitalic characters. In the present study, it has been concluded that both these species belong to a distinct genus rather than *Euproctis* Hübner and thus the new genus has been proposed for the proper placement of both species. *Euproctis latifascia* (Walker) has been proposed as its type species. This new genus is well defined on the basis of male genitalic features such as uncus represented by two narrow widely apart processes, short & distally bifid valva, and distinct tegumen. Though the genus *Euproctis* Hübner is closely allied to this new genus in general appearance and wing venation, it is distinct in terms of its male genitalic features such as unified uncus and simple uni-lobed valva. Chao (2003) outlined the genitalic characters of 103 species under the genus *Euproctis* Hübner in *Fauna Sinica*. Out of these, the three species—*hypoenops* Collenette, *schaliphora* Collenette, and *seitzi* Collenette—also completely conform the characterization of the new genus and can be transferred under it.

MATERIAL AND METHODS

The adult moths were collected from different localities of Himachal Pradesh, Jammu & Kashmir, and Uttarakhand using light traps equipped with a 160W mercury bulb and vertical white sheet. The methodology proposed by Zimmerman (1978) was followed for the study of wing venation. The male and female moths were dissected out to examine the external genitalic features (Robinson, 1976) and the terminology for naming various genitalic parts given by Klots (1970). After detailed study, the specimens were preserved in the Lepidoptera Lab, Department of Zoology & Environmental Sciences, Punjabi University Patiala.

RESULTS

The external morphological characters like ornamentation of antennae, legs and abdomen; wing maculation; wing venation and significantly the external genitalic features contributed towards the authentic identification and characterization of examined taxa. The genus *Maeoproctis* gen. nov. has been proposed new to science with *Euproctis latifascia* (Walker) as its type species. A new combination has also been proposed by shifting *Euproctis subfasciata* (Walker) under the new genus as *Maeoproctis subfasciata* (Walker) comb. nov.

***Maeoproctis* gen. nov.**

Type species: *Euproctis latifascia* (Walker, 1855).

Diagnosis: Medium sized moths, usually pale in colouration. Labial palpi large, hairy, obliquely porrect, reaching above the level of frons. Antennae bipectinate in both sexes, pectinations longer in males. Forewing with discal cell more than half the length of wing, closed; 1A and 2A from base of the wing; 3A absent; Cu_1, M_3 and M_2 from near lower angle of cell; M_1 from upper angle of cell; R_5-R_2 stalked from upper angle of cell, R_2 branching off towards apex; no aerole; Sc from base of wing, not reaching apex. Hindwing with discal cell more than half the length of wing, closed; 1A and 2A from base of the wing; 3A absent; Cu_1 and M_3 stalked from lower angle of cell; M_2 from above lower angle of cell; M_1 and Rs stalked from upper angle of cell. Legs dressed with scales; fore-tibia with an epiphysis; mid-tibia with one pair of tibial spurs; hind-tibia with two pairs of tibial spurs. Abdomen furnished with scales; distinct anal tuft in females. Male genitalia with uncus represented by two narrow widely apart processes making U-shaped appearance; tegumen broad, dumbbell-shaped, with knob-like protrusions on lateral sides of uncus; saccus prominent; juxta well developed; valva simple, short, distally bifid; aedeagus short, vesica armed with prominent spur. Female genitalia with corpus bursae long; signum absent; ductus bursae narrow; apophysis with dilated apices; papilla analis triangular, setosed; pseudo-papillae small, setosed.

Etymology: This new genus has been named after Koen V.N. Maes, an eminent Belgian entomologist.

Remarks: Two species were collected from different localities of Himachal Pradesh, Jammu & Kashmir, and Uttarakhand and identified as *latifascia* Walker and *subfasciata* Walker under genus *Euproctis* Hübner. Both the identified species are paler in general appearance and have very uniform distinct genitalic characters. It seemed that both these species belong to a distinct

genus rather than *Euproctis* Hübner and thus, genus *Maeoproctis* has been proposed as a new genus for the proper placement of both these species. *Euproctis latifascia* Walker has been proposed as its type species. This new genus is well defined on the basis of male genitalic features such as uncus represented by two narrow widely apart processes; short and distally bifid valva and distinct tegumen. Though the genus *Euproctis* Hübner is closely allied to this new genus in general appearance and wing venation, but it is distinct in terms of its male genitalic features such as unified uncus and simple, uni-lobed valva. Chao (2003) outlined the genitalic characters of 103 species under genus *Euproctis* Hübner in *Fauna Sinica*. Out of these, the three species, namely, *hypoenops* Collenette, *schaliphora* Collenette, and *seitzi* Collenette, also completely conform to the characterization of the new genus *Maeoproctis* and can be transferred under it.

***Maeoproctis latifascia* (Walker) comb. nov.**
(Image 1–10)

Leucoma latifascia Walker, 1855, *List Spec. Lepid. Insects Colln. Brit. Mus*., 4: 831.

Euproctis latifascia Walker: Hampson, 1892, *Moths India*, **1**: 472; Chao, 2003, *Fauna Sinica*, 30: 368; Smetacek, 2008, *Bionotes*, 10(1): 14; Kaleka, 2012, *Colemania*, 34: 4.

Euproctis antica Walker, 1855, *List Spec. Lepid. Insects Colln. Brit. Mus*., 4: 835; Swinhoe, 1922, *Ann. Mag. Nat. Hist.,* (9)10(58): 482.

Euproctis abdominalis Moore, 1888, *Proc. Zool. Soc. London*, 1888: 398; Swinhoe, 1922, *Ann. Mag. Nat. Hist.,* (9)10(58): 482.

Euproctis susisharyonis Strand, 1914, *Suppl. Entom.*, 3: 40.

Nygmia latifascia Swinhoe, 1922, *Ann. Mag. Nat. Hist*., (9)10(58): 482.

Type locality: Nepal

Diagnosis: Forewing without any medial band; vein M_2 from lower angle of cell. Male genitalia with uncus represented by two narrow widely apart processes making a U-shaped appearance, dorsally setosed, with blunt apices; juxta dome-shaped without any projection.

Description:

Male: Body length**:** 14–19 mm; wing expanse: 28–42 mm.

Female: Body length: 15–21 mm; wing expanse: 48–56 mm.

Head with vertex and frons clothed with creamish-white scales. Labial palpi fringed with creamish scales. Antennae with scape and flagellum covered with white scales. Thorax, collar, and tegula furnished with white scales. Legs dressed with creamish scales. Abdomen studded with black scales; underside with creamish scales; anal segment fringed with yellow scales in males; anal tuft brown. Forewing with ground colour creamish-white in males, pure white in females; without any marking. Hindwing with ground colour creamish-white in males, pure white in females; without any marking. Forewing with Cu_2 from well beyond two-third of cell having a short bar; Cu_1 from before lower angle of cell; M_3 and M_2 from lower angle of cell; M_1 from upper angle of cell; R_5-R_2 well stalked before upper angle of cell; R_1 from three-fourth of cell. Hindwing with Cu_2 from two-third of cell; Cu_1 and M_3 stalked from lower angle of cell; M_2 from above lower angle of cell; M_1 and Rs well stalked from upper angle of cell; Sc+R_1 from base of wing sending a bar to cell beyond its middle.

Male genitalia: Uncus of moderate size, represented by two narrow widely apart processes making a shape of U, dorsally setosed, with blunt apices; tegumen moderately sclerotized, bulbous on both sides having knob-like protrusions on lateral sides of uncus; vinculum quite narrow extending into prominent U-shaped saccus; juxta well-sclerotized, dome-shaped. Valva simple, moderately sclerotized; distally bifid with two processes, one large and broad, other narrow, both processes setosed. Aedeagus short, moderately sclerotized; proximal end rounded; ductus ejaculatorius entering near proximal end; vesica armed with a well sclerotized prominent spur.

Female genitalia: Corpus bursae narrow, long, membranous, without any distinct signum; ductus bursae narrow with wrinkled walls; entering into well-sclerotized tubular antrum; ostium bursae originating near middle of ductus bursae; sterigmatic plate triangular, well-sclerotized; apophysis narrow of moderate length, basal half moderately sclerotized, distal half semi-sclerotized, both pairs with spatulate apices, posterior apophysis shorter than anterior ones; papilla analis triangular, leaf-like, well setosed; pseudo-papillae small, triangular, well setosed with short and long setae.

Material examined: (39 males, 10 females): Himachal Pradesh: Andretta, 806 m, 32.040°N & 76.567°E, 08.x.2013, 18 males, 5 females; Baijnath, 998 m, 32.052°N & 76.648°E, 09.x.2013, 2 males; Basantpur, 2,148 m, 31.208°N & 77.174°E, 09.vii.2013, 4 males, Chamunda Devi, 996 m, 32.051°N & 76.643°E, 07.ix.2013, 13 males, 2 females; Naina Tikkar, 1,552 m, 30.804°N & 77.119°E, 05.vii.2014, 1 male; Jammu & Kashmir: Lamberi, 336 m,

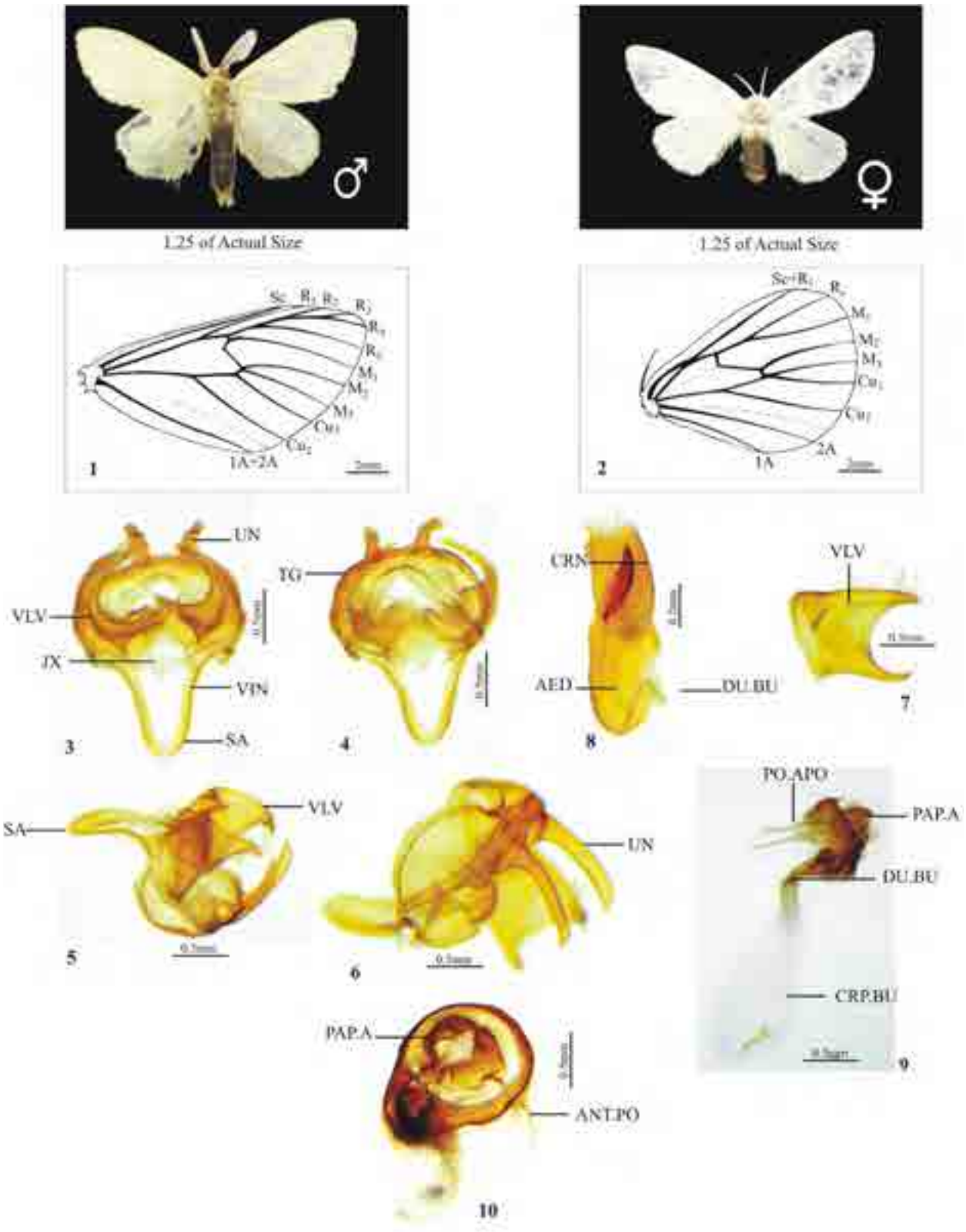


Image 1–10. *Maeoproctis latifascia* (Walker) comb. nov.: 1—Forewing | 2—Hindwing | 3—Male genitalia | 4—Ventral view | 5–6—Lateral view | 7—Valva | 8—Aedeagus | 9–10—Female genitalia.

33.130°N & 74.260°E, 11.ix.2013, 1 male; Uttarakhand: Dhobighat, 1,895 m, 29.886°N &79.045°E, 25.v.2014, 1 female; Makhti poukhri, 648 m, 30.628°N & 77.925°E, 19.v.2014, 2 females. Coll. Gagan Bali.

Distribution: India: Himachal Pradesh, Jammu & Kashmir, Manipur, Uttarakhand; China; Nepal (Walker 1855; Hampson 1892; Chao 2003; Smetacek 2008; Kaleka 2012).

Remarks: Walker (1855) described this species under genus *Leucoma* Stephens from Nepal. Hampson (1892) transferred it to the genus *Euproctis* Hübner. Chao (2003), Smetacek (2008), and Kaleka (2012) followed the same nomenclature. In the present studies, the species under reference has been proposed as the type species of the new genus *Maeoproctis.*

***Maeoproctis subfasciata* (Walker) comb. nov.**
(Image 11–17)

Artaxa subfasciata Walker, 1865, *List Spec. Lepid. Insects Colln. Brit. Mus*., 32: 332.

Euproctis subfasciata Hampson, 1892, *Moths India*, 1: 472; Collenette, 1934, *Novit. Zool*., 39: 142; Chao, 2003, *Fauna Sinica*, 30: 412–413.

Artaxa trifasciata Moore, 1879, *Descr. Indian Lepid. Atkison*, 1: 51.

Type Locality: India (Sikkim)

Diagnosis: Forewing with faint medial band; vein M_2 just above lower angle of cell. Male genitalia with large, V-shaped saccus; juxta with two flap-like projections.

Description:

Male: Body length: 8–16 mm; wing expanse: 34–40 mm.

Female: Not examined.

Head with vertex and frons clothed with creamish scales. Labial palpi fringed with fulvous scales. Antennae with scape and flagellum covered with fulvous scales. Thorax, collar and tegula suffused with fulvous scales, underside paler. Legs dressed with creamish scales. Abdomen furnished with black scales, underside with creamish scales; anal segment fringed with yellow scales. Forewing with ground colour creamish-white; nearly obsolete medial band. Hindwing with ground colour white, without any marking. Forewing with Cu_2 from beyond two-third of cell; Cu_1 from well before lower angle of cell; M_3 from lower angle of cell; M_2 just above lower angle of cell; M_1 from upper angle of cell; R_5-R_2 well stalked before upper angle of cell; R_1 from three-fourth of cell. Hindwing with Cu_2 from well beyond middle of cell; Cu_1 and M_3 shortly stalked from lower angle of cell; M_2 from well above lower angle of cell; M_1 and Rs well stalked from upper angle of cell; $Sc+R_1$ from base of wing anastomosing with cell well before its middle.

Male genitalia: Uncus represented by two narrow, long processes, widely apart making U-shaped appearance, well-sclerotized, tips nearly pointed; tegumen broad, both arms medially dilated, V-shaped, having quite small protrusions along lateral sides of uncus; vinculum quite narrow ending into large, vase-like saccus; juxta moderately sclerotized, represented by two flap-like projections. Valva simple, short and broad; moderately-sclerotized; distal end bifid with two setosed processes, one shorter and other longer. Aedeagus small, moderately sclerotized; proximal end rounded; ductus ejaculatorius entering near proximal end; vesica armed with a well-sclerotized prominent spur and a patch of numerous spines.

Material Examined: (7 males): Himachal Pradesh: Basantpur, 2,148 m, 31.208°N & 77.174°E, 09.vii.2013, 1 male; Chamunda Devi, 1,000 m 31.926°N & 76.087°E, 07.ix.2013, 2 males; Dhuan Devi, 1,653 m, 31.661°N & 77.012°E, 16.ix.2014, 1 male; Janitri, 2,100 m, 31.699°N & 76.804°E, 13.v.2015, 1 male; Naina Tikkar, 1,552 m, 30.804°N & 77.119°E, 05.vii.2014, 1 male; Urla, 1,189 m, 31.921°N & 76.878 °E, 17.v.2015, 1 male. Coll. Gagan Bali.

Distribution: India: Assam, Himachal Pradesh, Sikkim, West Bengal; China (Walker 1855; Hampson 1892; Chao 2003).

Remarks: Walker (1865) originally described this species under the genus *Artaxa* Walker from Sikkim. Hampson (1892) synonymised it under the genus *Euproctis* Hübner. Collenette (1934) and Chao (2003) followed the same nomenclature. In the present study, the status of the species *subfasciata* Walker has been updated by placing it under the new genus *Maeoproctis*. It is closely allied to *Maeoproctis latifascia* (Walker) comb. nov. in general appearance and can be easily differentiated on the basis of presence of a faint medial band on forewing. Its collection from Himachal Pradesh is its first record from northwestern India.

DISCUSSION

Hübner (1819) established the genus *Euproctis* with *Bombyx chrysorrhoea* Linnaeus as its type species from Europe. It is a large, diverse, and complicated genus comprising of more than 100 species (Chao 2003). Wang et al. (2015) also confirmed its polyphyletic nature. The taxonomic position of the species under reference

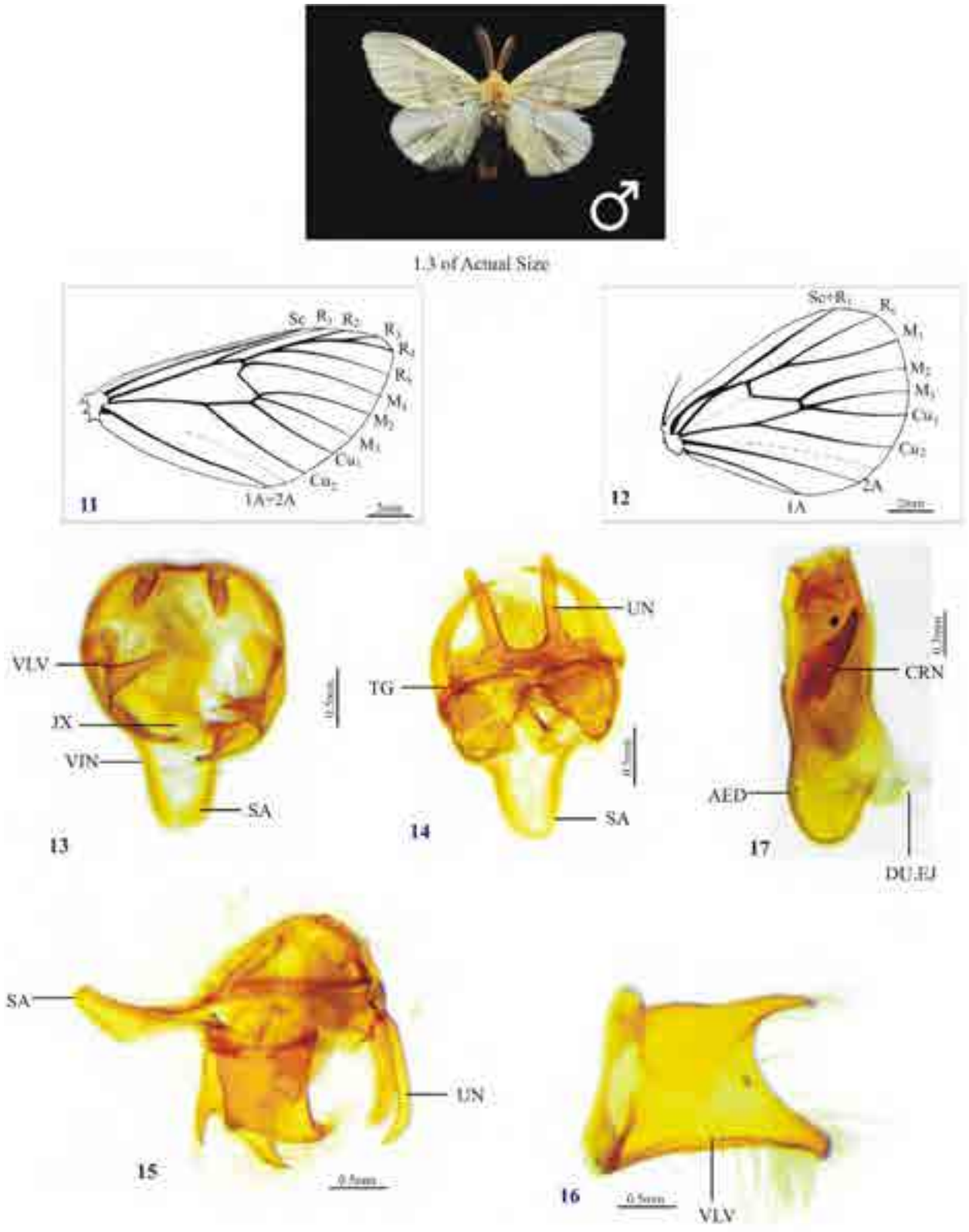


Image 11–17. *Maeoproctis subfasciata* (Walker) comb. n.: 11—Forewing | 12—Hindwing | 13—Male genitalia - ventral view | 14—Dorsal view | 15—Lateral view | 16—Valva | 17—Aedeagus.

is ambiguous as these species do not conform to the characterization of the genus *Euproctis* Hübner. The new genus, *Maeoproctis*, is also distinct from its allied genera namely, *Somena* Walker, *Orvasca* Walker, and *Sphrageidus* Maes, due to the presence of vein M_2 in the hindwing which is absent in all the three genera (Holloway 1999). The new genus is well defined on the basis of male genitalic features such as uncus with two narrow widely apart processes; short and distally bifid valva, and distinct tegumen. The taxonomic placement of species like *Euproctis latifascia* (Walker) and *Euproctis subfasciata* (Walker) has also been justified. Though the genus *Euproctis* Hübner is closely allied to the new genus in general appearance and wing venation, but it is distinct in terms of its male genitalic features such as unified uncus and simple uni-lobed valva. Chao (2003) outlined the genitalic characters of 103 species under the genus *Euproctis* Hübner in 'Fauna Sinica'. Out of these, the three species namely *hypoenops* Collenette, *schaliphora* Collenette, and *seitzi* Collenette also completely conform to the characterization of the new genus *Maeoproctis* and can be transferred under it.

REFERENCES

Chao, C.L. (2003). *Lepidoptera, Lymantriidae. Fauna Sinica*, vol.30. Beijing Science Press. 484 pp.

Collenette, C.L. (1934). The Lymantriidae of Kwang- Tung (S.E. China). *Novitates Zoologicae* 39: 137–150.

Hampson, G.F. (1892). *The Fauna of British India including Ceylon and Burma, Moths Volume 1*. Taylor and Francis, London, 527 pp.

Hübner, J. (1819). Verzeichniss bekannter. *Schmettlinge* 10: 145–160.

Kaleka, A.S. (2012). Diversity of tussock moths (Lepidoptera: Noctuoidea: Lymantriidae) of the western Himalayas. *Colemania* 31: 3–13.

Klots, A.B. (1970). Lepidoptera in "*Taxonomist's Glossary of genitalia in Insects*" (Ed. S.L. Tuxen) Munksgaard, Copenhagen 1970: 115–130.

Robinson, G.S. (1976). The preparation of slides of Lepidoptera genitalia with special reference to Microlepidoptera. *Entomologists Gazette* 27(2): 127–132.

Smetacek, P. (2008). Moths recorded from different elevations in Nainital district, Kumaon Himalaya, India. *Bionotes* 10: 4–15.

Walker, F. (1855). List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, London. 4: 776–976.

Wang, H., N. Wahlberg, N., J.D. Holloway, J. Bergsten, X. Fan, D.H. Janzen, W. Hallwachs, L. Wen, M. Wang & S. Nylin (2015). Molecular phylogeny of Lymantriinae (Lepidoptera, Noctuoidea, Erebidae) inferred from eight gene regions. *Cladistics* 31: 579–592.

Zimmerman, E.C. (1978). *Microlepidoptera Insects of Hawaii*, *Vol. 9*. University Press of Hawaii, Honolulu, 1903 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22661–22676

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

https://doi.org/10.11609/jott.7974.15.2.22661-22676

#7974 | Received 14 April 2022 | Final received 03 December 2022 | Finally accepted 10 February 2023

OPEN ACCESS

COMMUNICATION

Butterflies of Silent Valley National Park and its environs, Western Ghats of Kerala, India

Kalesh Sadasivan [1], P.C. Sujitha [2], Toms Augustine [3], Edayillam Kunhikrishnan [4], Vinayan P. Nair [5], M. Divin Murukesh [6] & Baiju Kochunarayanan [7]

[1,2,5,7] TNHS Lepidoptera Research Group (TLRG), Travancore Nature History Society (TNHS), Mathrubhumi Road, Vanchiyoor, Thiruvananthapuram, Kerala 695035, India.

[1] Greeshmam, BN439, Bapuji Nagar, Medical College Post, Thiruvananthapuram, Kerala 695011, India.

[2] Department of Zoology, University of Kerala, Kariavattom Campus, Thiruvananthapuram, Kerala 695581, India.

[3] Pathippallil House, Poovarani P.O, Kottayam, Kerala 686577, India.

[4] TC1/2021, Jayamanju, Edassery Nagar, Kumarapuram, Thiruvananthapuram, Kerala 695011, India.

[5] XV/446 A1, Nethaji Housing Colony, Trichambaram, Taliparamba P.O, Kannur, Kerala 670141, India.

[6] Centre for Conservation Ecology, Department of Zoology, MES Mampad College, Mampad College, P.O. Malappuram, Kerala 676542, India.

[7] Sreerangam, Puravoorkonam, Karakulam Post, Kerala 695564, India.

[1] kaleshs2002in@gmail.com (corresponding author), [2] sujeespc@gmail.com, [3] tomsaugustine@gmail.com, [4] ekunhi@gmail.com, [5] vinayanpnair@gmail.com, [6] divinwrct@gmail.com, [7] baijupaluvally@gmail.com

Abstract: The butterfly fauna of Silent Valley National Park (SVNP) and its buffer zone in Kerala is discussed. Of the 335 species listed from the Western Ghats (WG) and 326 from Kerala, 269 species were recorded from inside the boundaries of the core of SVNP, while an additional 21 species were confirmed from its buffer zone making a total of 290 species as an aggregate for SVNP and its environs. This included 19 species of Papilionidae, 26 Pieridae, 85 Nymphalidae, one Riodinidae, 82 Lycaenidae, and 77 Hesperiidae. Thirty-one species were strictly endemic to the Western Ghats and 63 species were listed in schedules of WPA 1972, and 19 species were in the IUCN Red Lists. The region harbours 89% of all butterflies of Kerala (326 species), and 87% of those seen in the Western Ghats (335 species). About 11% of butterfly fauna of SVNP is endemic to the Western Ghats. Silent Valley and adjoining regions have 86% of all IUCN Red listed species listed for Kerala and the WG. The region also holds 91% of the species listed under WPA known from Kerala and 90% of those listed from WG. Thus, SVNP and its environs are one of the richest regions with respect to butterflies.

Keywords: Lepidoptera, Checklist, endemics, grasslands, IUCN, Shola, WPA.

Abbreviations: ASL—Above sea level | TLRG—TNHS Lepidoptera Research Group | SVNP—Silent Valley National Park | TNHS—Travancore Nature History Society | IUCN—The International Union for Conservation of Nature | WG—Western Ghats | WPA—Indian Wildlife (Protection) Act 1972.

Editor: George Mathew, Kerala, India.

Date of publication: 26 February 2023 (online & print)

Citation: Sadasivan, K., P.C. Sujitha, T. Augustine, E. Kunhikrishnan, V.P. Nair, M.D. Murukesh & B. Kochunarayanan (2023). Butterflies of Silent Valley National Park and its environs, Western Ghats of Kerala, India. *Journal of Threatened Taxa* 15(2): 22661–22676. https://doi.org/10.11609/jott.7974.15.2.22661-22676

Copyright: © Sadasivan et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The second author duly acknowledges the financial assistance received from the University of Kerala as Post-Doctoral Fellowship.

Competing interests: The authors declare no competing interests.

Author details: Kalesh Sadasivan, research associate at Travancore Nature History Society (TNHS), works on natural history of Western Ghats, and is primarily interested in the ecology, taxonomy and distribution of butterflies, odonates, cicadas and ants. Sujitha PC, research associate at Travancore Nature History Society (TNHS), works on butterflies of Western Ghats and is currently working on lycaenid Myrmecophily. Toms Augustine is a naturalist interested in birds, butterflies and odonates of Western Ghats especially their distribution patterns. E. Kunhikrishnan is a retired faculty of zoology, who has worked extensively on Natural History and conservation of Western Ghats, and is a pioneer in butterfly research in Kerala. Vinayan P Nair, Zoology teacher at Government Vocational Higher Secondary School, Payyoli, Kozhikode and Research Associate at Travancore Nature History Society (TNHS), Trivandrum, Kerala. Currently involved in studying taxonomy of odonates of Western Ghats. Apart from odonates has specific interests in moths, butterflies, ants, mantids and wasps. M. Divin Murukesh works on bird communities of Silent Valley and adjoining landscapes. Baiju K is a research associate in TNHS working on butterflies of Kerala and their lifecycles.

Author contributions: KS and SPC conceived the idea and wrote the primary draft. KS, TA, EK, MDM, BK did field work and corrected the draft. SPC and VPN worked on the final manuscript.

Acknowledgements: We are thankful to the Kerala Forest and Wildlife Department for the survey permits. We are thankful to Suresh Elamon, M. Jafer Palot, and George Mathew for providing references and constructive inputs on the manuscript. We are grateful to Jayakumar, Director, Manoj K, and other members of TNHS, Trivandrum for their field assistance.

INTRODUCTION

Silent Valley National Park (SVNP) is located just north of the Palghat gap, on the southwestern slopes of the Nilgiri Landscape of the Western Ghats. The major portion of the division is in the Mannarkkad Taluk of Palakkad District in Kerala. A portion of the buffer zone is in Nilambur Taluk of Malappuram District. The area lies within the latitudes 11.03–11.22 ^{0}N and 76.40–76.53 ^{0}E. The Silent Valley Forest Division now comprises Silent Valley Range (143.52 km^2) and the buffer zone of Bhavani Range (94 km^2), thus making a total area of 237.52 km^2 (Image 1). The National Park and its buffer zone are surrounded by the reserved and vested forests of Attapady Range of Mannarkkad Division towards the east, Mannarkkad Range of Mannarkkad Division towards south & west, and Kalikavu Range of Nilambur South Division towards the north-west, and the forests of Mukurthi National Park of Tamil Nadu border on eastern limits (Anonymous 2012).

The terrain is generally undulating with steep escarpments and many hillocks. The elevation of this region ranges from 95 m at Thatthengalam to 2,383 m at the Anginda peak. Both the south-west monsoon and the north-east monsoon cause rains in this area. The major share, however, comes from the south-west monsoon, which sets in during the first week of June. The heaviest rainfall is during June, July, and August. As per data from weather recorded from forest sections the rainfall varies from 7,500 mm per year in the northern side to 2,800 mm (southeastern dry zone). The main drainage basins are of the river Kunthipuzha (Bharatapuzha) for the core zone, and Bhavanipuzha for the buffer zone (Nair 1991).

The average minimum temperature ranges 8–14 °C and the average maximum temperature varies 23–29 °C. The forests and environs of Silent Valley Division can be categorized into the following types based on Champion & Seth (1968): Southern Hill Top Tropical Evergreen Forest, West Coast Tropical Evergreen Forests, Cane Brakes, Wet Bamboo Brakes, West Coast Semi Evergreen Forests, West Coast Secondary Evergreen Dipterocarp Forests, Southern Sub-tropical Hill Forests, Reed Brakes, South Indian Sub-tropical Hill Savannah, Southern Montane Wet Temperate Forests, Southern Montane Wet Scrub, and Southern Montane Wet Grasslands (Image 2) (Nair 1991; Anonymous 2012). About 75–80% of the protected area is covered with thick woody vegetation and about 20% of the area has grasslands. The regions on the northwestern slopes have rich wet evergreen forests, while the southeastern borders have drier Dry Deciduous Scrub vegetation (Image 2).

The region has excellent biodiversity as exemplified by 2,000 species of plants, 41 species of mammals, 97 species of birds, 42 reptiles, and 46 amphibians reported there (Manoharan et al. 1999). The management plan of SVNP mentions 92 species of butterflies (Anonymous 2012). British naturalists like G.F. Hampson, J.A. Yates, W.H. Evans, and M.A. Wynter-Blyth. occasionally visited the region as gathered from their works, but the finer details of the visits are still unknown (Hampson 1888; Evans 1927; Yates 1935; Wynter-Blyth 1957). Larsen (1987a,b,c; 1988) briefly visited Mukkali in the 1980s while working on the butterflies of the Nilgiris District of Tamil Nadu. Yata & Gaonkar (1999) discovered and described new subspecies of *Eurema andersoni shimai* from Nilgiris, and mentioned the presence of this taxon as well as its host plants and flight periods. Mathew (1999) reported 96 species from SVNP during a study from 1987–1990. Mathew & Rahamathulla (1993) and Mathew (1994) surveyed butterflies and documented 100 species of butterflies. Reports of butterfly migrations were recorded from adjacent landscapes like Nilgiris by (Larsen 1978), and New Amarambalam Reserve Forest by Mathew & Binoy (2002).

No other published records are available on the butterfly fauna of this protected tract. There had not been any formally structured surveys for butterflies in the Silent Valley National Park and the first one was done by TNHS in association with SVNP in September 2016 with records of 180 species over a span of three days (Sadasivan & Jayakumar 2016). In this paper, we report 290 species of butterflies from SVNP, based on a review of past literature and our fieldwork in the region.

MATERIALS AND METHODS

This paper is a compilation of the field data from the authors over the last two decades. The previous literature on butterflies of the region Hampson (1888), Larsen (1987a,b,c, 1988), Mathew & Rahamathulla (1993), Mathew (1994, 1999), and Mathew & Binoy (2002) were reviewed. The data logged in the management plan (Anonymous 2012) was also consulted, as well as the report on the first comprehensive invertebrate survey of SVNP done in 2016 submitted by TNHS to the Kerala Forest Department (Sadasivan & Jayakumar 2016). In addition, the field data of the authors from casual visits to the region and a 4-day expedition from Mukurthi to Mukkali was also added. The standard transect methodology (3 km in 3 hours) was employed in field surveys with strategically placed basecamps covering

Image 1. Silent Valley National Park.

all habitats and elevational gradients of the National Park. The core region was assessed using Walakkad, Poochipara, Sispara, Punnamala, Havelock, Neelikkal, and Sairandry as the basecamps. The areas sampled in the buffer zone were Keerippara, Kottappuzha, Mukkali, Panthanthodu, Thudukki, and Thatthengalam. Occasional visits were done to Karuvarakundu in wetter evergreen Nilambur slopes on the northwest side and Mukkali side in the southeast dry zone. For all calculation purposes, the butterfly fauna of the core of SVNP and its buffer are considered together. The general taxonomic placement follows Evans (1927 & 1949), Larsen (1987–88), Gaonkar (1996), Kunte et al. (2021), and Sadasivan & Sengupta 2023 (in press). Geographical divisions and landscapes follow Sankar (2013) with necessary modifications. In this paper we have classified the occurrence data based on transect encounters with the status as Very Common (VC) if seen in >75% of transects, Common (C) if seen in 50–75%, Not Rare (NR) if seen in 25–50% transects, Rare (R) in a case seen in 5–25%, and Very Rare (VR) if seen in <5% of the transects. Doubtful records are mentioned under the discussion part of each family. Species of the genera *Mycalesis*, *Nacaduba*, *Pelopidas*, and *Potanthus* were identified based on examination of male brands, observation & rearing of early stages, and examination of the male genitalia of specimens outside protected areas adjoining the study region. Detailed analysis of transects with biodiversity indices and conservation values shall be published elsewhere. The global conservation status data was derived from the IUCN site http://www.iucnredlist.org (IUCN 2021). Indian Wildlife Protection Act (WPA) 1972 and its amendments till 2022 as the Wildlife (Protection) Amendment Act 2002 has been consulted to arrive at the species listed under the schedules.

RESULTS AND DISCUSSION

Western Ghats has 335 species and Kerala state has 326 species as per the latest estimates (Sadasivan & Sengupta 2023, in press; Sadasivan et al. 2023, in press). We found 290 species of butterflies from SVNP and its buffer zone. This included 19 species of Papilionidae, 26 species of Pieridae, 85 species of Nymphalidae, one species of Riodinidae, 82 Lycaenidae, and 77 species of Hesperiidae (Figure 1A). We found 269 species from inside the boundaries of the core of SVNP, while an additional 21 species were confirmed from its buffer zone. The records of 13 species need further confirmation.

Analysis of historical works in the SVNP and adjoining

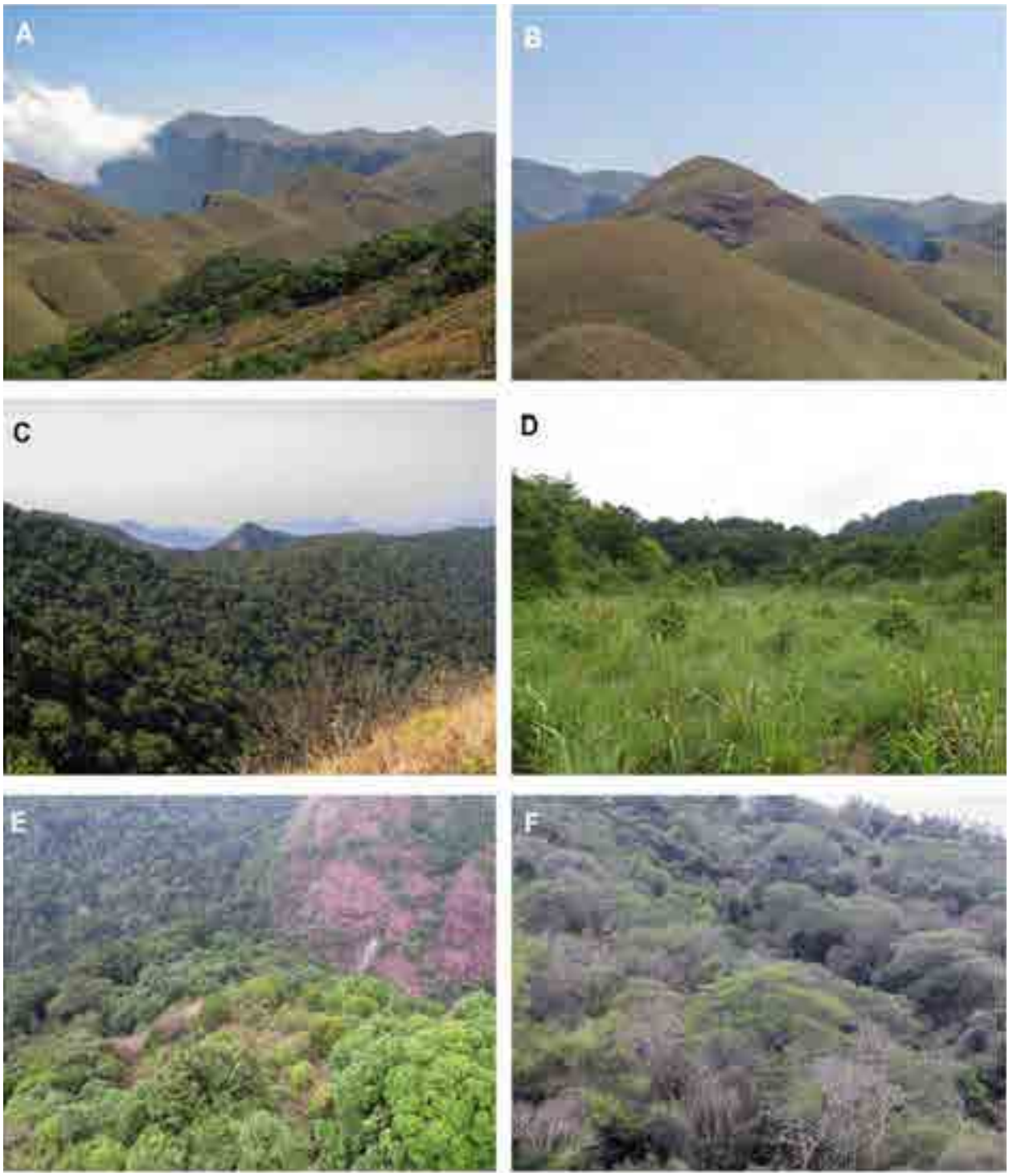


Image 2. Major vegetation types of SVNP: A—Southern Montane Wet Temperate Forests at Sispara | B—Southern Montane Wet Grasslands at Sispara | C—West Coast Tropical Evergreen Forests at Walakkad | D—Southern Sub-tropical Hill Forests Poochipara | E—West Coast Semi Evergreen Forests at Sairandhri | F—Dry Deciduous Scrub jungle at Attapady. © M. Divin Murukesh.

regions suggests the high diversity of butterflies. From the Nilgiri region, Hampson (1888) had 260 valid taxa, Yates (1935) included 282 species, Wynter-Blyth mentioned 290 species, and Larsen (1987–88) had 299 species. From the SVNP on the western slopes of the Nilgiris, we see that Mathew & Rahamathulla (1993), Mathew (1994, 1999), and Mathew & Binoy (2002) reported around 100 species. In this study, we report 290 species, a more realistic aggregate for a highly biodiverse region like SVNP. The reason for the lesser

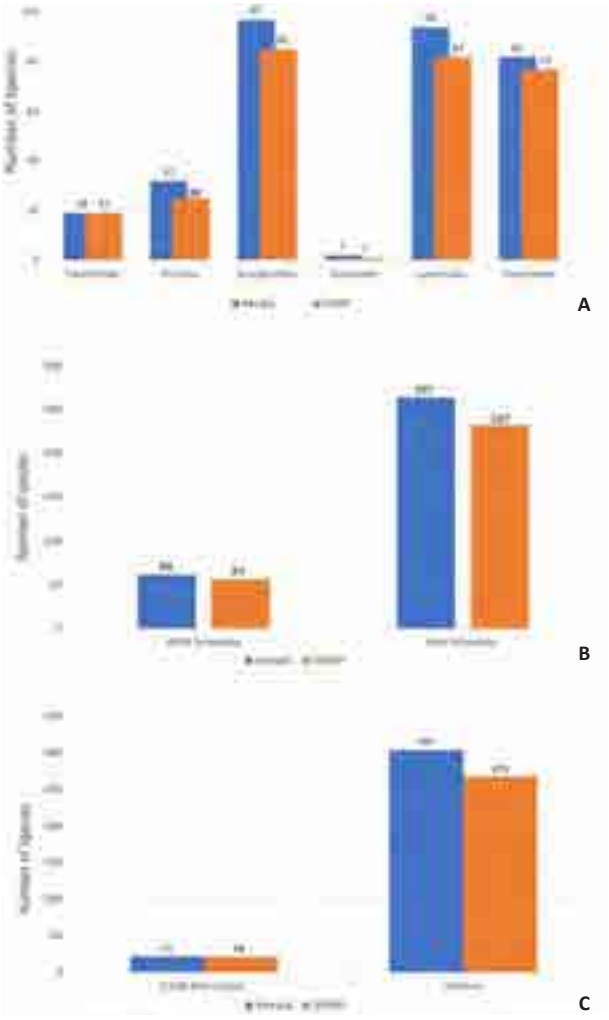


Figure 1. A—Family wise distribution of species in SVNP and Kerala | B—Number of species in the schedules of the WPA 1971 Kerala and SVNP | C—Number of species in the Red List of IUCN from Kerala and SVNP.

total compared to Nilgiris proper may be due to less land area and the absence of pure dry scrub vegetation in SVNP that harbours quite a few arid species in the northern slopes of Nilgiris.

All 19 species of Papilionidae seen in the Western Ghats and Kerala are recorded at SVNP. This includes the three strict Western Ghat endemics *namely Pachliopta pandiyana* (Moore, 1881), *Papilio liomedon* Moore, [1875] and *Papilio buddha* Westwood, 1872. All three species of peacocks *Papilio paris tamilana* Moore, 1881, *P. buddha* Westwood, 1872 and *P. crino* Fabricius, 1793 are seen in the region. Three species were not recorded in the core but were recorded from the buffer zone—*Graphium antiphates naira* (Moore, [1903]) from the northwestern wet zone and *Graphium nomius nomius* (Esper, 1799) and *Papilio crino* from the southeastern part of the dry zone.

In Pieridae only 26 species were documented in the core and buffer of SVNP. This includes the endemics *Eurema* (*Terias*) *nilgiriensis* (Yata, 1990), *Colias nilagiriensis* Felder & Felder, 1859 (Image 3A), and *Appias wardii* (Moore, 1884). Though absent inside SVNP, *Colotis amata* (Fabricius, 1775), *C. aurora* (Cramer, [1780]), *C. danae danae* (Fabricius, 1775), *C. etrida etrida* (Boisduval, 1836), and *C. fausta fulvia* (Wallace, 1867), were reported from the drier south-eastern border of the buffer zone. The presence of these straggler species in the SVNP needs further confirmation. These species are also listed in a paper on butterflies of Anaikatti, a region adjoining the south-eastern part of the SVNP (Selvaraj & Arun 2014). There are also reports of *Appias lalage lalage* (Doubleday, 1842), from Walakkad and Mukurthi.

Out of the 97 species of Nymphalidae in Kerala and the 100 in WG, SVNP and its environs have 85 species, including the following 12 Western Ghat endemics – *Parantirrhoea marshalli* Wood-Mason, 1881, *Kallima horsfieldii* Kollar, [1844], *Idea malabarica* (Moore, 1877), *Zipaetis saitis* Hewitson, 1863, *Cethosia mahratta* Moore, 1872 were from the wetter north-western Nilambur slopes; while *Mycalesis igilia* Fruhstorfer, 1911, *Mycalesis orcha* Evans, 1912, *Ypthima tabella* Marshall & de Nicéville, 1883 were from the grasslands; and *Telinga adolphei* (Guérin-Méneville, 1843) (Image 3E), *Ypthima chenu* (Guérin-Méneville, 1843) (Image 3C), *Argynnis hybrida* (Evans, 1912) (Image 3B), and *Parantica nilgiriensis* (Moore, 1877) (Image 3D), were recorded from Sispara region and adjoining Murkurthi border. *Ypthima asterope mahratta* Moore, 1884, and *Ypthima ceylonica* Hewitson, 1865 are included based on their records from the dry southeast. Three species from the dry southeast zone *Byblia ilithyia* (Drury, [1773]), *Charaxes agraria* Swinhoe, 1887, and *Symphaedra nais* (Forster, 1771), are needing further confirmation.

Of the two species of Riodinidae reported from the WG, only *Abisara bifasciata suffusa* Moore, 1882, was observed in the region. *Abisara echerius prunosa* Moore, 1879, is yet to be found here.

Lycaenidae was represented by 82 out of the 94 species in Kerala and 98 in the Western Ghats. Three strict endemic species reported were *Celatoxia albidisca* (Moore, [1884]), *Arhopala alea* (Hewitson, 1862), and *Curetis siva* Evans, 1954. Two species were included based on our records from the buffer zone, namely, *Nacaduba calauria evansi* Toxopeus, 1927, and *Thaduka multicaudata kanara* Evans, 1925: and three species from the south-west dry zone– *Hypolycaena nilgirica* Moore, [1884], *Tajuria jehana jehana* Moore, [1884],

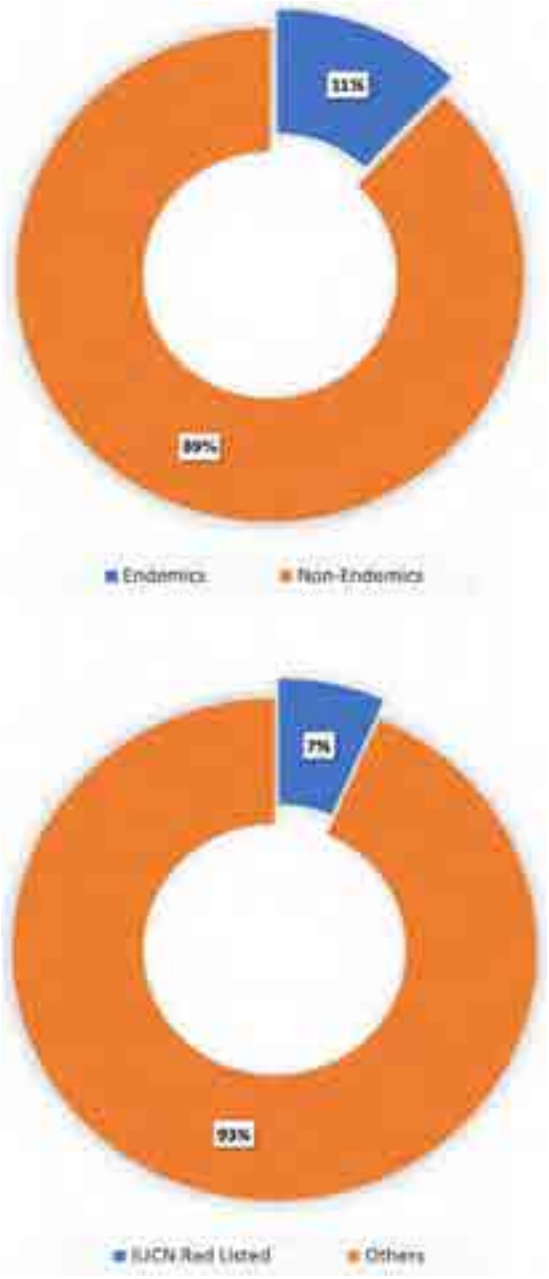


Figure 2. Species composition with respect to endemicity and IUCN Threatened list status: A—Endemics and non-endemics in SVNP | B—IUCN Red Listed and others.

and *Ancema sudica* (Evans, 1926). However, *Freyeria trochylus* (Freyer, 1845), *Arhopala bazaloides bazaloides* (Hewitson, 1878), *Tajuria maculatus* (Hewitson, 1865), and *Tajuria melastigma* de Nicéville, 1887, known from the adjacent Nilgiris and Nilambur valley are still unrecorded inside SVNP. *Udara akasa mavisa* (Fruhstorfer, 1917) (Image 3F), was common in the shola-grasslands of the region.

Seventy-seven species of Hesperiidae out of 82 in Kerala and Western Ghats were observed in SVNP. Both the endemic grassland-dependent Hedgehoppers *Baracus hampsoni* Elwes & Edwards, 1897, and *B. subditus* Moore, [1884] were recorded. The grassland species *Arnetta mercara* Evans, 1932, was not uncommon. *Quedara basiflava* (de Nicéville, [1889]), *Halpemorpha hyrtacus* (de Nicéville, 1897), *Halpe hindu* Evans, 1937, *Thoressa astigmata* (Swinhoe, 1890) (Image 3G), and *Thoressa honorei* (de Nicéville, 1887) were recorded in the wetter north-western slopes. *Thoressa sitala* (de Nicéville, 1885), *Oriens concinna* (Elwes & Edwards, 1897), and *Caltoris canaraica* (Moore, [1884]) (Image 3H), were found in the higher reaches >1200 m ASL. *Sarangesa purendra hopkinsi* Evans, 1921, *Caprona alida vespa* Evans, 1949 and *Aeromachus dubius dubius* Elwes & Edwards, 1897 were absent. While *Gerosis bhagava bhagava* (Moore, [1866]), and *Gomalia elma albofasciata* Moore, 1879, were found in the dry zone; *Spialia galba* (Fabricius, 1793), *Zographetus ogygia ogygia* (Hewitson, [1866]), *Cephrenes acalle oceanica* (Mabille, 1904), *Taractrocera maevius* (Fabricius, 1793), *Telicota colon colon* (Fabricius, 1775), *Baoris farri* (Moore, 1878), *Caltoris kumara kumara* (Moore, 1878), *Caltoris philippina philippina* (Herrich-Schäffer, 1869), and *Pelopidas conjuncta narooa* (Moore, 1878) were added from the northwest zone near the Nilambur slopes.

Endemicity

Sixty species out of the 290 species in SVNP and environs had some element of endemicity, of which 31 species were strictly endemic to the Western Ghats. Thus 11% of the butterflies in SVNP are WG endemics (Figure 3A). This is out of the 38 species that are currently considered strictly restricted to the Western Ghats. Thus, it hosts 82% of all the butterflies listed as strictly endemic to the Western Ghats. Of these, *Telinga adolphei*, *Argynnis hybrida*, *Mycalesis igilia*, *Mycalesis orcha*, and *Thoressa sitala* are montane endemics seen only in this Nilgiris-Coorg landscape of Western Ghats (Table 1). Since geographically restricted to a very small landscape inside the WG, they must be considered super-endemics.

IUCN Red List

SVNP and its environs had 19 species (6.55% of its butterfly fauna) listed in the IUCN Red List (Figure 1C, 2B). Seventeen species are listed under Least Concern and two species namely *Idea malabarica* and *Parantica nilgiriensis* are under the Near Threatened category. Except *Gomalia elma albofasciata* all others were listed inside the core zone (See Appendix I).

Table 1. Family-wise list of endemic species and their known distribution.

	Family	Taxon	Endemicity*
1	Papilionidae	*Troides minos* (Cramer, [1779])	WG & SI
2	Papilionidae	*Pachliopta pandiyana* (Moore, 1881)	WG
3	Papilionidae	*Pachliopta hector* (Linnaeus, 1758)	PI & SL
4	Papilionidae	*Graphium teredon* (Felder & Felder, 1865)	SI
5	Papilionidae	*Papilio dravidarum* Wood-Mason, 1880	SI
6	Papilionidae	*Papilio liomedon* Moore, [1875]	WG
7	Papilionidae	*Papilio buddha* Westwood, 1872	WG
8	Papilionidae	*Papilio crino* Fabricius, 1793	PI
9	Pieridae	*Eurema (Terias) nilgiriensis* (Yata, 1990)	WG
10	Pieridae	*Colias nilagiriensis* Felder & Felder, 1859	WG
11	Pieridae	*Prioneris sita* (Felder & Felder, 1865)	SI & SL
12	Pieridae	*Appias wardii* (Moore, 1884)	WG
13	Pieridae	*Pareronia ceylanica ceylanica* (Felder & Felder, 1865)	WG & SL
14	Nymphalidae	*Discophora lepida lepida* (Moore, 1857)	SI & SL
15	Nymphalidae	*Elymnias caudata* Butler, 1871	SI & SL
16	Nymphalidae	*Parantirrhoea marshalli* Wood-Mason, 1881	WG
17	Nymphalidae	*Lethe drypetis todara* Moore, 1881	SI & SL
18	Nymphalidae	*Mycalesis igilia* Fruhstorfer, 1911	WG
19	Nymphalidae	*Mycalesis junonia* Butler, 1868	SI
20	Nymphalidae	*Mycalesis orcha* Evans, 1912	WG
21	Nymphalidae	*Mycalesis subdita* Moore, 1892	SI & SL
22	Nymphalidae	*Telinga adolphei* (Guérin-Méneville, 1843)	WG
23	Nymphalidae	*Ypthima ceylonica* Hewitson, 1865	PI & SL
24	Nymphalidae	*Ypthima chenu* (Guérin-Méneville, 1843)	WG
25	Nymphalidae	*Ypthima striata* Hampson, 1888	SI
26	Nymphalidae	*Ypthima tabella* Marshall & de Nicéville, 1883	WG
27	Nymphalidae	*Zipaetis saitis* Hewitson, 1863	WG
28	Nymphalidae	*Cethosia mahratta* Moore, 1872	WG
29	Nymphalidae	*Argynnis hybrida* (Evans, 1912)	WG
30	Nymphalidae	*Cirrochroa thais thais* (Fabricius, 1787)	SI & SL
31	Nymphalidae	*Kallima horsfieldii* Kollar, [1844]	WG
32	Nymphalidae	*Idea malabarica* (Moore, 1877)	WG
33	Nymphalidae	*Parantica nilgiriensis* (Moore, 1877)	WG
34	Lycaenidae	*Celatoxia albidisca* (Moore, [1884])	WG
35	Lycaenidae	*Ionolyce helicon viola* (Moore, 1877)	WG & SL
36	Lycaenidae	*Nacaduba berenice plumbeomicans* (Wood-Mason & de Nicéville, 1881)	WG & SL
37	Lycaenidae	*Nacaduba calauria evansi* Toxopeus, 1927	WG & SL
38	Lycaenidae	*Cigaritis schistacea* (Moore, [1881])	PI & SL
39	Lycaenidae	*Arhopala alea* (Hewitson, 1862)	WG
40	Lycaenidae	*Rapala lankana* (Moore, 1879)	WG & SL
41	Lycaenidae	*Rathinda amor* (Fabricius, 1775)	PI & SL
42	Lycaenidae	*Hypolycaena nilgirica* Moore, [1884]	WG & SL
43	Lycaenidae	*Zeltus amasa amasa* (Hewitson, 1865)	India & SL
44	Lycaenidae	*Ancema sudica* (Evans, 1926)	WG
45	Lycaenidae	*Curetis siva* Evans, 1954	WG
46	Hesperiidae	*Celaenorrhinus ambareesa* (Moore, [1866])	PI
47	Hesperiidae	*Celaenorrhinus fusca* (Hampson, 1888)	PI
48	Hesperiidae	*Arnetta mercara* Evans, 1932	WG
49	Hesperiidae	*Arnetta vindhiana* (Moore, [1884])	PI
50	Hesperiidae	*Baracus hampsoni* Elwes & Edwards, 1897	WG
51	Hesperiidae	*Baracus subditus* Moore, [1884]	WG
52	Hesperiidae	*Quedara basiflava* (de Nicéville, [1889])	WG
53	Hesperiidae	*Halpemorpha hyrtacus* (de Nicéville, 1897)	WG
54	Hesperiidae	*Halpe hindu* Evans, 1937	SI
55	Hesperiidae	*Thoressa astigmata* (Swinhoe, 1890)	WG
56	Hesperiidae	*Thoressa sitala* (de Nicéville, 1885)	WG
57	Hesperiidae	*Thoressa honorei* (de Nicéville, 1887)	WG
58	Hesperiidae	*Oriens concinna* (Elwes & Edwards, 1897)	WG
59	Hesperiidae	*Potanthus diana* (Evans, 1932)	PI
60	Hesperiidae	*Caltoris canaraica* (Moore, [1884])	SI

*WG—Western Ghats | PI—Peninsular India | SL—Sri Lanka | SI—Southern India.

WPA 1972

Of the 69 species of butterflies protected under the WPA 1972 in Kerala, and 70 in WG, SVNP had 63 species under the schedules (Figure 1B). Thus 21.72% of all its butterfly fauna is under the WPA. The region also holds 91% of the species listed under WPA known from Kerala and 90% of those listed from WG. Under Schedule I there are four species, one species is under both Schedule I &II, 58 species are under Schedule II (See Appendix I).

CONCLUSIONS

With 269 species inside the core and with 290 species as an aggregate including the adjoining buffer zones (21 species), SVNP is one of the richest regions

Image 3. Some butterfly species endemic to Western Ghats and southern India recorded from SVNP: A—*Colias nilagiriensis* Felder & Felder, 1859 | B—*Argynnis hybrida* (Evans, 1912) | C—*Ypthima chenu* (Guérin-Méneville, 1843) | D—*Parantica nilgiriensis* (Moore, 1877) | E—*Telinga adolphei* (Guérin-Méneville, 1843) | F—*Udara akasa mavisa* (Fruhstorfer, 1917) | G—*Thoressa astigmata* (Swinhoe, 1890) | H—*Caltoris canaraica* (Moore, [1884]). © Kalesh Sadasivan.

with respect to butterflies. The region harbours 89% of all butterflies of Kerala (326 species) and 87% of those in the Western Ghats (335 species). Eleven percent of its butterfly fauna is endemic to the Western Ghats. It hosts 82% of all butterflies listed as endemic to the Western Ghats. Around 96% of all the IUCN Red listed species in Kerala and WG and 90 % of species listed in WPA from WG and 91% of them from Kerala are also found in the region. The diversity of the region with 290 species is much more than that of states like Goa (267 species), Maharashtra (257) species and Gujarat (169 species) along the Western Ghats. SVNP and its environs have rich butterfly diversity. The buffer zone has good diversity and significantly adds to the butterfly fauna of the core of SVNP. More areas from the drier southeast and the wet evergreen region to the northwest may be incorporated into the National Park, thereby preserving the remaining tracts of benchmark evergreen forests of southern India.

REFERENCES

Anonymous (2012). *Management plan of Silent Valley National Park, 2012–2022.* Published by Kerala Forests and Wildlife Department, Government of Kerala, 246 pp.

Evans, W.H. (1927). *The Identification of Indian butterflies (Ed 1).* Bombay Natural History Society xii+302 pp, 32 pl., 11 figs.

Evans, W.H. (1949). *A catalogue of the Hesperiidae from Europe, Asia, and Australia in the British Museum (Natural History).* British Museum of Natural History, London, 502 pp.

Gaonkar, H. (1996). *Butterflies of the Western Ghats, India (including Sri Lanka): A Biodiversity Assessment of a Threatened Mountain System.* Technical report to Centre for Ecological Sciences, Indian Institute of Science, Bangalore, 51 pp.

Hampson. G.F. (1888). The butterflies of the Nilgiri district, south India. *Journal of the Asiatic Society of Bengal* 47: 346–368.

IUCN (2021). The IUCN Red List of Threatened Species. Version 2021-1. https://www.iucnredlist.org. Downloaded on 03 June 2021.

Kunte, K., S. Sondhi & P. Roy (2021). Butterflies of India, v. 3.11. Indian Foundation for Butterflies. Accessed 15 May 2021.

Larsen, T.B. (1978). Butterfly migrations in the Nilgiri Hills of South India. *Journal of the Bombay Natural History Society* 74: 546–549.

Larsen, T.B. (1987a). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 84(1): 26–54.

Larsen, T.B. (1987b). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 84(2): 291–316.

Larsen, T.B. (1987c). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 84(3): 560–584.

Larsen, T.B. (1988). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 85(1): 26–43.

Manoharan, T.M., S.D. Biju, T.S. Nayar & P.S. Easa (1999). *Silent Valley – Whispers of Reason*, Kerala Forest Department, XXXI + 425 pp.

Mathew, G. (1994). Insect Biodiversity in tropical forests: a study with reference to butterflies and moths (Insecta: Lepidoptera) in the Silent Valley National Park (Kerala). *Advances in Forestry Research in India* 11: 134–171.

Mathew, G. (1999). Butterflies and Moths of Silent Valley National Park, pp. 291–296. In: Manoharan T.M., S.D. Biju, T.S. Nayar & P.S. Easa (eds.) *Silent Valley – Whispers of Reason*. Kerala Forest Department, XXXI + 425 pp.

Mathew, G. & C.F. Binoy (2002). Migration of butterflies (Lepidoptera: Rhopalocera) in the New Amarambalam Reserve Forest of the Nilgiri Biosphere Reserve. *Zoos' Print Journal* 17(8): 844–847.

Mathew, G. & V.K. Rahmathulla (1993). Studies on the butterflies of Silent Valley National Park. *Entomon* 18: 185–192.

Nair, S.C. (1991). *The Southern Western Ghats: a biodiversity conservation plan. Studies in Ecology and Sustainable Development–4*. Published by Indian National Trust for Art and Cultural heritage, New Delhi, 92 pp.

Sadasivan, K. & A. Sengupta (2023). The Butterflies of Western Ghats: their status and distribution. Journal of the Bombay Natural History Society (In press).

Sadasivan, K., P.C. Sujitha, M.J. Palot, V.C. Balakrishnan, T. Augustine, K. Baiju, J. Jebine & V. P. Nair (2023). The Butterflies (Lepidoptera: Rhopalocera) of Kerala - Status and Distribution. *Entomon* (In press).

Sadasivan, K. & K. Jayakumar (2016). Report on invertebrate survey of Silent Valley (Butterflies, Odonates and Ants). Travancore Nature History Society, Submitted to Kerala Forest Department, 11 pp.

Sankar, S. (2013). Landscape units: A biogeographical approach to the assessment and conservation of biodiversity in the Western Ghats of Kerala, Western Ghats. *Proceedings of the National seminar on Western Ghats Biogeography, Biodiversity & Conservation.* UGC Sponsored Three Day National Seminar 14th, 15th And 16th Of February 2013. Department of Botany NSS College, Manjeri, Malappuram, Kerala, 15–30.

Selvaraj, R. & P.R. Arun (2014). Butterflies of SACON (Sálim Ali Centre for Ornithology and Natural History) Campus, Anaikatti, Coimbatore. *SACON News* 11: 9–13.

Wynter-Blyth, M.A. (1957). Butterflies of the Indian Region. Bombay Natural History Society, Bombay, 523 pp.

Yata, O. & H. Gaonkar (1999). A new subspecies of *Eurema andersoni* (Lepidoptera: Pieridae) from South India. *Entomological Science* 2: 281–285.

Yates, J.A. (1935). Butterflies of Nilgiri District. *Journal of the Bombay Natural History Society* 38: 330–40.

Appendix 1. Checklist of butterflies of Silent Valley National Park and Its environs, Kerala.

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
Papilionidae						
1	*Troides minos* (Cramer, [1779]) — Sahyadri Birdwing	NR	WG & SI	LC	Sch II	H, C
2	*Pachliopta pandiyana* (Moore, 1881) — Malabar Rose	NR	WG	LC		H, C
3	*Pachliopta aristolochiae aristolochiae* (Fabricius, 1775) — Indian Common Rose	VC		LC		H, C
4	*Pachliopta hector* (Linnaeus, 1758) — Crimson Rose	C	PI & SL	LC	Sch II	H, C
5	*Graphium agamemnon menides* (Fruhstorfer, 1904) — Dakhan Tailed Jay	C				H, C
6	*Graphium antiphates naira* (Moore, [1903]) — Sahyadri Five-bar Swordtail	NR				C
7	*Graphium doson eleius* (Felder & Felder, 1864) — Dakhan Common Jay	C				H, C
8	*Graphium nomius nomius* (Esper, 1799) – Indian Spot Swordtail	NR				C
9	*Graphium teredon* (Felder & Felder, 1865) — Narrow-banded Bluebottle	C	SI		(Sch II)	H, C
10	*Papilio clytia clytia* Linnaeus, 1758 — Oriental Common Mime	NR			(Sch II)	H, C
11	*Papilio demoleus demoleus* Linnaeus, 1758 — Northern Lime Swallowtail	VC				H, C
12	*Papilio dravidarum* Wood-Mason, 1880 — Malabar Raven	R	SI			C
13	*Papilio helenus daksha* Hampson, 1888 — Sahyadri Red Helen	NR				H, C
14	*Papilio liomedon* Moore, [1875] — Malabar Banded Swallowtail	R	WG		Sch I	H, C
15	*Papilio polymnestor polymnestor* Cramer, [1775] — Indian Blue Mormon	NR				H, C
16	*Papilio polytes romulus* Cramer, [1775] — Indian Common Mormon	VC				H, C
17	*Papilio paris tamilana* Moore, 1881 — Sahyadri Paris Peacock	NR				H, C
18	*Papilio buddha* Westwood, 1872 — Malabar Banded Peacock	R	WG		Sch II	H, C
19	*Papilio crino* Fabricius, 1793 — Common Banded Peacock	NR	PI		Sch II	C
Pieridae						
20	*Catopsilia pomona pomona* (Fabricius, 1775) — Oriental Lemon Emigrant	VC				H, C
21	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758) — Oriental Mottled Emigrant	VC				H, C
22	*Eurema (Terias) andersoni shimai* Yata & Gaonkar, 1999 — Sahyadri One-spot Grass Yellow	R		LC	Sch II	C
23	*Eurema (Terias) nilgiriensis* (Yata, 1990) — Sahyadri Grass Yellow/Nilgiri grass yellow	R	WG			C
24	*Eurema (Terias) blanda silhetana* (Wallace, 1867) — Sylhet Three-spot Grass Yellow	C				H, C
25	*Eurema (Terias) hecabe hecabe* (Linnaeus, 1758) — Oriental Common Grass Yellow	VC				H, C
26	*Eurema laeta laeta* (Boisduval, 1836) — Indian Spotless Grass Yellow	NR				C
27	*Eurema brigitta rubella* (Wallace, 1867) — Small Grass Yellow	NR		LC		H, C
28	*Colias nilagiriensis* Felder & Felder, 1859 — Nilgiri Clouded Yellow	NR	WG			C
29	*Delias eucharis* (Drury, 1773) — Indian Jezebel	C				H, C
30	*Prioneris sita* (Felder & Felder, 1865) — Painted Sawtooth	R	SI & SL			C
31	*Pieris canidia canis* Evans, 1912 — Sahyadri Cabbage White	C				C
32	*Cepora nadina remba* (Moore, [1858]) — Sahyadri Lesser Gull	R			Sch II	H, C
33	*Cepora nerissa phryne* (Fabricius, 1775) — Dakhan Common Gull	C				H, C
34	*Belenois aurota aurota* (Fabricius, 1793) — Indian Pioneer	C		LC		C
35	*Appias (Catophaga) albina swinhoei* (Moore, 1905) — Sahyadri Common Albatross	C			Sch II	H, C
36	*Appias (Hiposcritia) indra shiva* (Swinhoe, 1885) — Sahyadri Plain Puffin	NR			Sch II	H, C
37	*Appias lalage lalage* (Doubleday, 1842) — Himalayan Spot Puffin	R				H, C
38	*Appias libythea* (Fabricius, 1775) — Western Striped Albatross	NR				H, C
39	*Appias lyncida latifasciata* Moore, 1881 — Sahyadri Chocolate Albatross	NR			Sch II	C
40	*Appias wardii* (Moore, 1884) — Sahyadri Albatross / Ward's Albatross	NR	WG		Sch II	C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
41	*Leptosia nina nina* (Fabricius, 1793) — Oriental Psyche	C				H, C
42	*Ixias pyrene sesia* (Fabricius, 1777) — Dakhan Yellow Orange-tip	C				C
43	*Pareronia ceylanica ceylanica* (Felder & Felder, 1865) — Sri Lankan Dark Wanderer	NR	WG & SL			C
44	*Pareronia hippia* (Fabricius, 1787) — Common Wanderer	C				C
45	*Hebomoia glaucippe australis* Butler, 1898 — Sahyadri Great Orange-tip	C				C
Nymphalidae						
46	*Discophora lepida lepida* (Moore, 1857) — Sahyadri Duffer	R	SI & SL			C
47	*Elymnias caudata* Butler, 1871 — Tailed Palmfly	C	SI & SL			H, C
48	*Melanitis leda leda* (Linnaeus, 1758) — Oriental Common Evening Brown	VC		LC		H, C
49	*Melanitis phedima varaha* Moore, 1857 — Sahyadri Dark Evening Brown	C				H, C
50	*Melanitis zitenius gokala* Moore, 1857 — Sahyadri Great Evening Brown	NR			Sch II	C
51	*Parantirrhoea marshalli* Wood-Mason, 1881 — Travancore Evening Brown	R	WG		Sch II	C
52	*Lethe drypetis todara* Moore, 1881 — Dakhan Treebrown	NR	SI & SL			C
53	*Lethe europa europa (*Fabricius, 1775) — Dakhan Bamboo Treebrown	NR			Sch I & II	H, C
54	*Lethe rohria neelgheriensis* (Guérin-Méneville, 1843) — Common Treebrown	C				H, C
55	*Mycalesis anaxias anaxias* Hewitson, 1862 — Sahyadri White-bar Bushbrown	NR			Sch II	H, C
56	*Mycalesis igilia* Fruhstorfer, 1911 — Sahyadri Small Long-brand Bushbrown	NR	WG			H, C
57	*Mycalesis junonia* Butler, 1868 — Malabar Glad-eye Bushbrown	C	SI			H, C
58	*Mycalesis mineus polydecta* (Cramer, [1777]) — Dakhan Dark-branded Bushbrown	C				C
59	*Mycalesis orcha* Evans, 1912 — Pale-brand Bushbrown	NR	WG			C
60	*Mycalesis perseus tabitha* (Fabricius, 1793) — Dakhan Common Bushbrown	C				C
61	*Mycalesis subdita* Moore, 1892 — Tamil Bushbrown	NR	SI & SL			C
62	*Mycalesis visala visala* Moore, [1858] — Indian Long-branded Bushbrown	NR				C
63	*Orsotriaena medus mandata* (Moore, 1857) — Sahyadri Medus Brown	NR				C
64	*Telinga adolphei* (Guérin-Méneville, 1843) — Red-eye Bushbrown	NR	WG			C
65	*Ypthima asterope mahratta* Moore, 1884 — Indian Common Three-ring	R				C
66	*Ypthima baldus baldus* (Fabricius, 1775) — Common Five-ring	VC				H, C
67	*Ypthima ceylonica* Hewitson, 1865 — White Four-ring	C	PI & SL			C
68	*Ypthima chenu* (Guérin-Méneville, 1843) — Nilgiri Four-ring	NR	WG			C
69	*Ypthima huebneri* Kirby, 1871 — Common Four-ring	VC				H, C
70	*Ypthima striata* Hampson, 1888 — Nilgiri Jewel Four-ring	R	SI			C
71	*Ypthima tabella* Marshall & de Nicéville, 1883 — Sahyadri Baby Five-ring	NR	WG			C
72	*Zipaetis saitis* Hewitson, 1863 — Banded Catseye	NR	WG		Sch II	H, C
73	*Euripus consimilis meridionalis* Wood-Mason, 1881 — Sahyadri Painted Courtesan	R			Sch II	C
74	*Rohana parisatis atacinus* Fruhstorfer, 1913 — Sahyadri Black Prince	NR		LC		C
75	*Ariadne ariadne indica* (Moore, 1884) — Indian Angled Castor	VC				C
76	*Ariadne merione merione* (Cramer, [1777]) — Dakhan Common Castor	VC				H, C
77	*Charaxes bharata* Felder & Felder, [1867] — Indian Nawab	C			(Sch II)	C
78	*Charaxes psaphon imna* Butler, 1870 — Indian Plain Tawny Rajah	NR			(Sch II)	C
79	*Charaxes schreiber wardii* (Moore, 1896) — Sahyadri Blue Nawab	VR			Sch I	C
80	*Charaxes solon solon* (Fabricius, 1793) — Pale Black Rajah	C			Sch II	C
81	*Cyrestis thyodamas indica* Evans, 1924 — Common Map	C				H, C
82	*Acraea terpsicore* (Linnaeus, 1758) — Tawny Coster	C				C
83	*Cethosia mahratta* Moore, 1872 — Sahyadri Lacewing	NR	WG		(Sch II)	H, C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
84	*Argynnis hybrida* (Evans, 1912) — Nilgiri Fritillary	NR	WG			C
85	*Cirrochroa thais thais* (Fabricius, 1787) — Sahyadri Yeoman	VC	SI & SL			H, C
86	*Cupha erymanthis maja* Fruhstorfer, 1898 — Sahyadri Rustic	VC				H, C
87	*Phalanta phalantha phalantha* (Drury, [1773]) — Oriental Common Leopard	VC				H, C
88	*Vindula erota saloma* de Nicéville, 1886 — Sahyadri Cruiser	C				H, C
89	*Libythea laius lepitoides* Moore, 1903 — Sahyadri Lobed Beak	NR			(Sch II)	C
90	*Libythea myrrha rama* Moore, 1872 — Sri Lankan Club Beak	C				C
91	*Dophla evelina laudabilis* Swinhoe, 1890 — Sahyadri Redspot Duke	NR			Sch II	C
92	*Euthalia aconthea meridionalis* Fruhstorfer, 1913 — Dakhan Baron	C			Sch II	H, C
93	*Euthalia lubentina lubentina* (Cramer, [1777]) — Sahyadri Gaudy Baron	NR				C
94	*Tanaecia lepidea miyana* (Fruhstorfer, 1913) — Peninsular Grey Count	NR			(Sch II)	C
95	*Athyma inara* Westwood, 1850 — Color Sergeant	NR				C
96	*Athyma perius perius* (Linnaeus, 1758) — Oriental Common Sergeant	NR				H, C
97	*Athyma ranga karwara* (Fruhstorfer, 1906) — Karwar Blackvein Sergeant	C			Sch II	C
98	*Athyma selenophora kanara* (Evans, 1924) — Staff Sergeant	NR				C
99	*Moduza procris procris* Fruhstorfer, 1906 — Sahyadri Commander	C				H, C
100	*Lasippa viraja kanara* (Evans, 1924) — Sahyadri Yellowjack Sailer	R			Sch II	C
101	*Neptis clinia kallaura* Moore, 1881 — Sahyadri Sullied Sailer	R			Sch II	C
102	*Neptis hylas varmona* Moore, 1872 — Indian Common Sailer	VC				C
103	*Neptis jumbah nalanda* Fruhstorfer, 1908 — Nalanda Chestnut-streaked Sailer	VC			Sch II	C
104	*Neptis nata hampsoni* Moore, 1899 — Sahyadri Clear Sailer	R				C
105	*Pantoporia hordonia hordonia* (Stoll, [1790]) — Oriental Common Lascar	NR				C
106	*Phaedyma columella nilgirica* (Moore, 1889) — Dakhan Short-banded Sailer	NR			Sch II	C
107	*Parthenos sylvia virens* Moore, 1877 — Sahyadri Clipper	C			Sch II	H, C
108	*Hypolimnas bolina jacintha* (Drury, 1773) — Oriental Great Eggfly	VC				H, C
109	*Hypolimnas misippus* (Linnaeus, 1764) — Danaid Eggfly	NR			Sch II	H, C
110	*Junonia almana almana* (Linnaeus, 1758) — Oriental Peacock Pansy	C		LC		H, C
111	*Junonia atlites atlites* (Linnaeus, 1763) — Oriental Grey Pansy	C				H, C
112	*Junonia hierta hierta* (Fabricius, 1798) — Oriental Yellow Pansy	C		LC		H, C
113	*Junonia iphita iphita* (Cramer, [1779]) — Chocolate Pansy	VC				
114	*Junonia lemonias lemonias* (Linnaeus, 1758) — Chinese Lemon Pansy	VC				H, C
115	*Junonia orithya* Butler, 1885 — Pale Blue Pansy	C				C
116	*Doleschallia bisaltide malabarica* Fruhstorfer, 1899 — Malabar Autumn Leaf	NR			Sch II	C
117	*Kallima horsfieldii* Kollar, [1844] — Southern Blue Oakleaf	NR	WG		Sch II	C
118	*Kaniska canace viridis* Evans, 1924 — Sahyadri Blue Admiral	NR				H, C
119	*Vanessa indica pholoe* (Fruhstorfer, 1912) — Sahyadri Red Admiral	NR				H, C
120	*Vanessa cardui* (Linnaeus, 1758) — Painted Lady	NR		LC		H, C
121	*Danaus chrysippus chrysippus* (Linnaeus, 1758) — Oriental Plain Tiger	VC				C
122	*Danaus genutia genutia* (Cramer, [1779]) — Oriental Striped Tiger	C				H, C
123	*Euploea core core* (Cramer, [1780]) — Indian Common Crow	VC		LC		H, C
124	*Euploea klugii kollari* Felder & Felder, [1865] — Brown King Crow	R				C
125	*Euploea sylvester coreta* (Godart, 1819) — Double-branded Black Crow	C				C
126	*Idea malabarica* (Moore, 1877) — Malabar Tree-Nymph	NR	WG	NT	Sch II	H, C
127	*Parantica aglea aglea* (Stoll, [1782]) — Coromandel Glassy Tiger	C				H, C
128	*Parantica nilgiriensis* (Moore, 1877) — Nilgiri Tiger	NR	WG	NT		H, C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
129	*Tirumala limniace exoticus* (Gmelin, 1790) — Oriental Blue Tiger	VC				H, C
130	*Tirumala septentrionis dravidarum* Fruhstorfer, 1899 — Dakhan Dark Blue Tiger	VC				C
Riodinidae						
131	*Abisara bifasciata suffusa* Moore, 1882 — Suffused Double-banded Judy	NR				H, C
Lycaenidae						
132	*Spalgis epius epius* (Westwood, 1852) — Oriental Apefly	C				C
133	*Anthene emolus emolus* (Godart, [1824]) — Bengal Common Ciliate Blue	NR				C
134	*Anthene lycaenina lycaenina* (Felder, 1868) — Dakhan Pointed Ciliate Blue	C			Sch II	C
135	*Acytolepis lilacea lilacea* (Hampson, 1889) — Sahyadri Lilac Hedge Blue	R			Sch II	C
136	*Acytolepis puspa felderi* Toxopeus, 1927 — Malabar Common Hedge Blue	VC				C
137	*Caleta decidia* (Hewitson, 1876) — Angled Pierrot	NR				H, C
138	*Castalius rosimon rosimon* (Fabricius, 1775) — Continental Common Pierrot	C				H, C
139	*Catochrysops strabo strabo* (Fabricius, 1793) — Oriental Forget-me-not	NR				C
140	*Celatoxia albidisca* (Moore, [1884]) — White-disc Hedge Blue	R	WG			C
141	*Celastrina lavendularis lavenduris* (Moore, 1877) — Sri Lankan Plain Hedge Blue	NR				H, C
142	*Chilades lajus lajus* (Stoll, [1780]) — Indian Lime Blue	C				C
143	*Luthrodes pandava pandava* (Horsfield, [1829]) — Oriental Plains Cupid	C				C
144	*Discolampa ethion ethion* Westwood, 1851 — Oriental Banded Blue Pierrot	NR				C
145	*Euchrysops cnejus cnejus* (Fabricius, 1798) — Oriental Gram Blue	C				C
146	*Everes lacturnus syntala* Cantlie, 1963 — Dakhan Cupid	C				C
147	*Freyeria putli* (Kollar, [1844]) — Oriental Grass Jewel	C				C
148	*Ionolyce helicon viola* (Moore, 1877) — Sri Lankan Pointed Lineblue	R	WG & SL		Sch II	C
149	*Jamides alecto eurysaces* (Fruhstorfer, 1916) — Himalayan Metallic Cerulean	NR			Sch II	H, C
150	*Jamides bochus bochus* (Stoll, [1782]) — Indian Dark Cerulean	C				H, C
151	*Jamides celeno celeno* (Cramer, [1775]) — Oriental Common Cerulean	VC				H, C
152	*Lampides boeticus* (Linnaeus, 1767) — Pea Blue	NR				C
153	*Leptotes plinius plinius* (Fabricius, 1793) — Asian Zebra Blue	C				C
154	*Megisba malaya thwaitesi* (Moore, [1881]) — Tailless Malayan	NR			Sch II	C
155	*Nacaduba beroe gythion* Fruhstorfer, 1916 — Assam Opaque Six-Lineblue	NR				C
156	*Nacaduba berenice plumbeomicans* (Wood-Mason & de Nicéville, 1881) — Rounded Six-Lineblue	R	WG & SL			C
157	*Nacaduba calauria evansi* Toxopeus, 1927 — Dark Ceylon Six-Lineblue	VR	WG & SL			C
158	*Nacaduba hermus sidoma* Fruhstorfer, 1916 — Dakhan Pale Four-Lineblue	NR			Sch II	C
159	*Nacaduba kurava canaraica* Toxopeus, 1927 — Karwar Transparent Six-Lineblue	NR				C
160	*Nacaduba pactolus continentalis* Fruhstorfer, 1916 — Continental Large Four-Lineblue	R			Sch II	C
161	*Neopithecops zalmora dharma* (Moore, [1881]) — Sri Lankan Common Quaker	NR				C
162	*Petrelaea dana* (de Nicéville, [1884]) — Dingy Lineblue	NR				C
163	*Prosotas dubiosa indica* (Evans, [1925]) — Indian Tailless Lineblue	C			Sch II	C
164	*Prosotas nora ardates* (Moore, [1875]) — Indian Common Lineblue	VC				C
165	*Prosotas noreia hampsonii* (de Nicéville, 1885) — Indian White-tipped Lineblue	R			Sch II	C
166	*Pseudozizeeria maha ossa* (Swinhoe, 1885) — Dakhan Pale Grass Blue	C				C
167	*Talicada nyseus nyseus* (Guérin-Méneville, 1843) — Indian Red Pierrot	C				C
168	*Tarucus ananda* (de Nicéville, [1883]) — Dark Pierrot	R				C
169	*Udara akasa mavisa* (Fruhstorfer, 1917) — Sahyadri White Hedge Blue	NR				H, C
170	*Zizeeria karsandra* (Moore, 1865) — Dark Grass Blue	VC				C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
171	*Zizina otis indica* (Murray, 1874) — Indian Lesser Grass Blue	C				C
172	*Zizula hylax hylax* (Fabricius, 1775) — Indian Tiny Grass Blue	VC		LC		C
173	*Amblypodia anita dina* Fruhstorfer, 1907 — Indian Purple Leaf Blue	NR				C
174	*Iraota timoleon arsaces* Fruhstorfer, 1907 — Dakhan Silverstreak Blue	R				C
175	*Thaduka multicaudata kanara* Evans, 1925 — Karwar Many-tailed Oakblue	NR			Sch II	C
176	*Cigaritis elima elima* (Moore, 1877) — Scare Shot Silverline	R			Sch II	C
177	*Cigaritis ictis ictis* (Hewitson, 1865) — Indian Common Shot Silverline	R				C
178	*Cigaritis lohita lazularia* (Moore, 1881) — Tamil Long-banded Silverline	NR			Sch II	C
179	*Cigaritis schistacea* (Moore, [1881]) — Plumbeous Silverline	NR				C
180	*Cigaritis vulcanus* (Fabricius, 1775) — Common Silverline	C	PI & SL			C
181	*Arhopala abseus indicus* Riley, 1923 — Indian Aberrant Oakblue	VR				C
182	*Arhopala alea* (Hewitson, 1862) — Sahyadri Rosy Oakblue	R	WG		Sch I	C
183	*Arhopala amantes amantes* (Hewitson, 1862) — Lankan Large Oakblue	C				H, C
184	*Arhopala centaurus pirama* (Moore, [1881]) — Tamil Centaur Oakblue	C				H, C
185	*Surendra quercetorum biplagiata* Butler, 1883 — Dakhan Common Acacia Blue	C				C
186	*Zinaspa todara todara* (Moore, [1884]) — Sahyadri Silver-streaked Acacia Blue	NR			Sch II	C
187	*Catapaecilma major callone* (Fruhstorfer, 1915) — Sahyadri Common Tinsel	R			Sch II	C
188	*Cheritra freja butleri* Cowan, 1965 — Sahyadri Common Imperial	C		LC		H, C
189	*Bindahara moorei* Fruhstorfer, 1904 — Blue-bordered Plane	R			(Sch II)	C
190	*Deudorix epijarbas epijarbas* (Moore, 1857) — Oriental Cornelian	NR				C
191	*Rapala iarbus sorya* (Kollar, [1844]) — Indian Red Flash	NR				C
192	*Rapala lankana* (Moore, 1879) — Malabar Flash	VR	WG & SL			C
193	*Rapala manea schistacea* (Moore, 1879) — Bengal Slate Flash	C				C
194	*Rapala varuna lazulina* (Moore, 1879) — Lazuli Flash	NR			Sch II	C
195	*Virachola isocrates* (Fabricius, 1793) — Common Guava Blue	NR				C
196	*Virachola perse ghela* Fruhstorfer, 1912 — Tamil Large Guava Blue	NR				C
197	*Horaga onyx cingalensis* Moore, [1884] — Bright Blue Common Onyx	R			Sch II	C
198	*Horaga viola* Moore, 1882 — Brown Onyx	VR				C
199	*Rathinda amor* (Fabricius, 1775) — Monkey Puzzle	C	PI & SL			C
200	*Hypolycaena othona othona* (Hewitson, 1865) — Oriental Orchid Tit	R			Sch I	C
201	*Hypolycaena nilgirica* Moore, [1884] — Nilgiri Tit	VR	WG & SL		Sch II	C
202	*Zeltus amasa amasa* (Hewitson, 1865) — Indian Fluffy Tit	R	India & SL			C
203	*Creon cleobis cleobis* (Godart, [1824]) — Bengal Broad-tail Royal	NR				C
204	*Pratapa deva deva* (Moore, [1858]) — Indian White Tufted Royal	NR			Sch II	C
205	*Rachana jalindra macanita* (Fruhstorfer, 1912) — Sahyadri Banded Royal	R			Sch II	C
206	*Tajuria cippus cippus* (Fabricius, 1798) — Indian Peacock Royal	C			Sch II	C
207	*Tajuria jehana jehana* Moore, [1884] — Indian Plains Blue Royal	C				C
208	*Loxura atymnus atymnus* (Stoll, [1780]) — Yamfly	C				C
209	*Ancema sudica* (Evans, 1926) — Sahyadri Silver Royal	R	WG		(Sch II)	C
210	*Zesius chrysomallus* Hübner, 1819 — Redspot	NR				C
211	*Curetis acuta dentata* Moore, 1879 — Indian Acute Sunbeam	NR				C
212	*Curetis siva* Evans, 1954 — Shiva Sunbeam	R	WG			C
213	*Curetis thetis* (Drury, [1773]) — Indian Sunbeam	C				H, C
Hesperiidae						
214	*Badamia exclamationis* (Fabricius, 1775) — Brown Awl	C				C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
215	*Bibasis sena sena* (Moore, [1866]) — Indian Orange-tail Awl	R			Sch II	C
216	*Burara gomata kanara* (Evans, 1926) — Sahyadri Pale Green Awlet	R				C
217	*Burara jaina fergusonii* (de Nicéville, [1893]) — Sahyadri Orange Awlet	NR				C
218	*Choaspes benjaminii benjaminii* (Guérin-Méneville, 1843) — Sahyadri Indian Awlking	R				C
219	*Hasora badra badra* (Moore, [1858]) — Oriental Common Awl	R				C
220	*Hasora chromus chromus* (Cramer, [1780]) — Oriental Common Banded Awl	VC				C
221	*Hasora taminatus taminatus* (Hübner, 1818) — Lankan White-banded Awl	R				C
222	*Hasora vitta indica* Evans, 1932 Indian — Plain Banded Awl	R				C
223	*Celaenorrhinus ambareesa* (Moore, [1866]) — Dakhan Spotted Flat	NR	PI			H, C
224	*Celaenorrhinus fusca* (Hampson, 1888) — Dusky Spotted Flat	NR	PI			C
225	*Celaenorrhinus leucocera* (Kollar, [1844]) — Common Spotted Flat	C				H, C
226	*Celaenorrhinus putra* (Moore, [1866]) — Bengal Restricted Spotted Flat	C				C
227	*Pseudocoladenia dan dan* (Fabricius, 1787) — Sahyadri Fulvous Pied Flat	C				C
228	*Sarangesa dasahara davidsoni* Moore, [1866] — Indian Common Small Flat	C				C
229	*Caprona agama agama* (Moore, [1858]) — Oriental Spotted Angle	R				C
230	*Caprona ransonnettii potiphera* (Hewitson, 1873) — Dakhan Golden Angle	C				C
231	*Coladenia indrani indra* Evans, 1926 — Dakhan Tricolor Pied Flat	NR				C
232	*Gerosis bhagava bhagava* (Moore, [1866]) — Bengal Yellow-breasted Flat	R				C
233	*Odontoptilum angulata angulata* (Felder, 1862) — Oriental Chestnut Angle	NR				C
234	*Tagiades gana silvia* Evans, 1934 — Dakhan Suffused Snow Flat	C				C
235	*Tagiades japetus obscurus* Mabille, 1877 — Dravidian Common Snow Flat	NR				C
236	*Tagiades litigiosa litigiosa* Möschler, 1878 — Sylhet Water Snow Flat	C				H, C
237	*Tapena thwaitesi* Moore, [1881] — Black Angle	NR				C
238	*Gomalia elma albofasciata* Moore, 1879 — African Marbled Skipper	NR		LC		C
239	*Spialia galba* (Fabricius, 1793) — Indian Grizzled Skipper	C				C
240	*Aeromachus pygmaeus* (Fabricius, 1775) — Pygmy Scrub Hopper	C				C
241	*Ampittia dioscorides dioscorides* (Fabricius, 1793) — Indian Bush Hopper	C				C
242	*Arnetta mercara* Evans, 1932 — Coorg Forest Bob	R	WG			C
243	*Arnetta vindhiana* (Moore, [1884]) — Vindhyan Bob	NR	PI			C
244	*Baracus hampsoni* Elwes & Edwards, 1897 — Malabar Hedge Hopper	NR	WG			C
245	*Baracus subditus* Moore, [1884] — Yellow-striped Hedge Hopper	R	WG			C
246	*Cupitha purreea* (Moore, 1877) — Wax Dart	R				C
247	*Erionota torus* Evans, 1941 — Rounded Palm-Redeye	C				C
248	*Gangara thyrsis thyrsis* (Fabricius, 1775) — Oriental Giant Redeye	C				C
249	*Hyarotis adrastus praba* (Moore, [1866]) — Bengal Tree Flitter	NR				C
250	*Iambrix salsala luteipalpis* (Plötz, 1886) — Southern Chestnut Bob	C				C
251	*Matapa aria* (Moore, [1866]) — Common Branded Red-Eye	C				C
252	*Notocrypta curvifascia curvifascia* (Felder & Felder, 1862) — Chinese Restricted Demon	NR				C
253	*Notocrypta paralysos mangla* Evans, 1949 — Sahyadri Common Banded Demon	NR				C
254	*Psolos fuligo subfasciatus* (Moore, 1878) — Indian Dusky Partwing	NR				C
255	*Quedara basiflava* (de Nicéville, [1889]) — Yellow-base Flitter	VR	WG			C
256	*Salanoemia sala* (Hewitson, [1866]) — Maculate Lancer	VR				C
257	*Suastus gremius gremius* (Fabricius, 1798) — Indian Palm Bob	C				C
258	*Suastus minuta bipunctus* Swinhoe, 1894 — Sahyadri Small Palm Bob	VR				C

	Common name-Subspecies scientific name	POP*	END**	IUCN+	WPA#	Source@
259	*Halpemorpha hyrtacus* (de Nicéville, 1897) – White-branded Ace/Bicolor Ace	R	WG			C
260	*Halpe hindu* Evans, 1937 — Sahyadri Banded Ace	C	SI		Sch II	C
261	*Halpe porus* (Mabille, [1877]) — Bispot Banded Ace	C				C
262	*Thoressa astigmata* (Swinhoe, 1890) — Unbranded Ace	NR	WG			C
263	*Thoressa sitala* (de Nicéville, 1885) — Nilgiri Plain Ace	R	WG			C
264	*Thoressa honorei* (de Nicéville, 1887) — Sahyadri Orange Ace	NR	WG			C
265	*Udaspes folus* (Cramer, [1775]) — Grass Demon	C				C
266	*Zographetus ogygia ogygia* (Hewitson, [1866]) — Continental Purple-spotted Flitter	VR				C
267	*Cephrenes acalle oceanica* (Mabille, 1904) — Variable Plain Palm-Dart	NR				C
268	*Oriens concinna* (Elwes & Edwards, 1897) — Sahyadri Dartlet	R	WG			C
269	*Oriens goloides* (Moore, [1881]) — Smaller Dartlet	C				C
270	*Potanthus diana* (Evans, 1932) — Chinese Dart	R	PI			C
271	*Potanthus pallidus* (Evans, 1932) — Pale Dart	R				C
272	*Potanthus palnia palnia* (Evans, 1914) — Palni Dart	C				H, C
273	*Potanthus pava pava* (Fruhstorfer, 1911) — Yellow Dart	R				H, C
274	*Potanthus pseudomaesa* (Moore, [1881]) — Indian Dart	NR				C
275	*Taractrocera ceramas* (Hewitson, 1868) — Incomplete Tawny-spotted Grass Dart	NR				H, C
276	*Taractrocera maevius* (Fabricius, 1793) — Oriental Grass Dart	NR				C
277	*Telicota bambusae bambusae* (Moore, 1878) — Oriental Dark Palm-Dart	C				H, C
278	*Telicota colon colon* (Fabricius, 1775) — Indian Pale Palm-Dart	NR				C
279	*Baoris farri* (Moore, 1878) — Complete Paint-brush Swift	NR				C
280	*Borbo bevani* (Moore, 1878) — Lesser Rice Swift	R				C
281	*Borbo cinnara* (Wallace, 1866) — Rice Swift	C				C
282	*Caltoris canaraica* (Moore, [1884]) — Karwar Swift	R	SI			H, C
283	*Caltoris kumara kumara* (Moore, 1878) — Sahyadri Blank Swift	NR				C
284	*Caltoris philippina philippina* (Herrich-Schäffer, 1869) — Philippine Swift	NR				C
285	*Parnara bada bada* (Moore, 1878) — Oriental Variable Swift	C				C
286	*Pelopidas agna agna* (Moore, [1866]) — Bengal Obscure Branded Swift	NR				C
287	*Pelopidas conjuncta narooa* (Moore, 1878) — Sahyadri Conjoined Swift	NR				C
288	*Pelopidas mathias mathias* (Fabricius, 1798) — Dakhan Small Branded Swift	C		LC		C
289	*Pelopidas subochracea subochracea* (Moore, 1878) — Bengal Large Branded Swift	NR				C
290	*Polytremis lubricans lubricans* (Herrich-Schäffer, 1869) — Oriental Contiguous Swift	NR				C

*POP—Population status as VC—Very Common | C—Common | NR—Not Rare | R—Rare | VR—Very Rare | **END—Endemicity as WG—Western Ghats | PI—Peninsular India | SL—Sri Lanka | SI—Southern India | +IUCN—IUCN Red List Status | #WPA—Indian Wildlife Protection Act and its amendments till 2023 Schedule as Sch. Parenthesis in Schedules indicate that the taxon is protected under the Wildlife (Protection) Amendment Act 2002 under its old taxonomic name | @Sources: H—Historical works (Mathew & Rahmathulla 1993; Mathew 1994 & 1999) | C—Current study.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22677–22685

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

https://doi.org/10.11609/jott.8005.15.2.22677-22685

#8005 | Received 03 May 2022 | Final received 07 February 2023 | Finally accepted 15 February 2023

OPEN ACCESS

COMMUNICATION

Notes on morphology and bionomics of *Urolabida histrionica* (Westwood) (Heteroptera: Urostylididae) from Assam, India

Sachin Ranade [1] & **Hemant V. Ghate** [2]

[1] Vulture Conservation Breeding Center, Rani, Kamrup, Assam 781131, India.
[2] Post-Graduate Research Centre, Department of Zoology, Modern College of Arts, Science & Commerce (Autonomous), Shivajinagar, Pune, Maharashtra 411005, India.
[1] sachinranade@yahoo.com, [2] hemantghate@gmail.com (corresponding author)

Abstract: Illustrated redescription of a colourful bug *Urolabida histrionica* (Westwood 1837), along with comments on bionomics, is presented for the first time from an Indian population. The host plant for this bug was identified as *Ficus hispida* L. f. (Moraceae).

Keywords: Bug, male and female genitalia, eggs, *Ficus hispida*, northeastern India, nymphs.

Editor: Hélcio R. Gil-Santana, Instituto Oswaldo Cruz, Rio de Janeiro, Brazil. **Date of publication:** 26 February 2023 (online & print)

Citation: Ranade, S. & H.V. Ghate (2023). Notes on morphology and bionomics of *Urolabida histrionica* (Westwood) (Heteroptera: Urostylididae) from Assam, India. *Journal of Threatened Taxa* 15(2): 22677–22685. https://doi.org/10.11609/jott.8005.15.2.22677-22685

Copyright: © Ranade & Ghate 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Self-funded.

Competing interests: The authors declare no competing interests.

Author details: SACHIN RANADE works in the Vulture Conservation Breeding Centre, Assam. His interests include study of diversity of Mantodea and Cassidinae. H.V. GHATE retired as Head of the Department of Zoology but continues to work on Heteroptera. Earlier he worked on Mantodea, Cerambycidae, aquatic beetles and freshwater sponges.

Author contributions: SR did all fieldwork and relevant observations, HVG studied morphology; both completed the manuscript.

Acknowledgements: SR is thankful to Bombay Natural History Society for support and encouragement. HVG is indebted to Dávid Rédei (National Chung Hsing University, Taiwan) for continuous support with literature and comments on the images; we also thank Ge Deyan (Chinese Academy of Sciences, Beijing, China) for helping us with literature. We sincerely thank Kaiqin Li (Kunming Natural History Museum of Zoology, Kunming Institute of Zoology, Academia Sinica, China) for translating part of the Chinese text from the paper cited here. We also thank Ms. Sayali Sheth for preparing photo plates. HVG is grateful to the authorities of Modern College for facilities and encouragement.

INTRODUCTION

Urostylididae are an Old-World group of bugs distributed from India through the Oriental region and into Japan and southeastern Asia. The family currently includes eight genera and over 170 species but information on the bionomics of these bugs is meagre; urostylidids have been recorded from a variety of plants, but there seems to be a preference for various tree species (Rider et al. 2018).

Atkinson (1889) had earlier documented the various species of Urostylididae (in British India), under the family 'Urostylina', and also given information about these species under three genera; this work included eight species under the genus *Urochela* Dallas, 1870, eight species under *Urostylis* Westwood, 1837, and seven under *Urolabida* Westwood, 1837 with a key to genera (total 23 species). Distant (1902) subsequently included 22 species under the same three genera: *Urostylis* (8 species), *Urochela* (8 species), and *Urolabida* (6 species) under the subfamily 'Urostylinae', six of these were new species and the remaining were briefly redescribed. Subsequently, Distant (1908) redescribed two more species of *Urostylis*. Thus the Fauna of British India volumes by Distant recorded 24 species under 'Urostylinae' sensu Distant. Although some additional species have been described in later years, e.g., by Yang (1938a), from India and some of the species listed in Fauna are not in the present Indian territory, some have undergone nomenclatural change, there is neither an updated list of the species of this family for India (the former lists being for 'British India'); there is no updated list for the world either and this lacuna was pointed out by Rider (2006) in the catalogue of Urostylididae of the Palearctic. As pointed out by Berger et al. (2001), the family name Urostylididae Dallas, 1851 is the grammatically correct spelling because it is based on the genus *Urostylis* Westwood, 1837 and the stem from which family name is to be derived is Urostylid and so the correct name would be Urostylididae; acceptance of this family name also removes homonymy with Urostylidae Bütschli, 1889 (in Ciliophora, Hypotrichia).

A species of Urostylididae collected from Assam was identified as *Urolabida histrionica* (Westwood 1837), based on the keys and descriptions in Distant (1902). *Urolabida* differs from the other two allied genera (*Urostylis* & *Urochela* known from India) by absence of ocelli. The colouration of the dry mounted specimen of this species is very different than that of the live insect; while the live insect shows large bands of yellow colour on green pronotum, scutellum, & hemelytra, and a pair of elongate black spots on corium (Image 1A), the dried insect appears uniformly brownish-yellow, with green tinge at places; only elongate black spots on corium and the fuscous areas on antennae remain unaffected by drying (Images 1B & 1C).

Distant (1902) had noted that this species is highly variable in hue and all the markings, except for the elongate black spot on the corium. The semicircular yellow band around posterior part of pronotum and scutellum was (presumably) responsible for the specific name *semicircularis* earlier given by Herrich-Schäffer (1839), who described and illustrated this species as *Typhlocoris semicircularis*. In recent years, Ahmad et al. (1992) studied a few species of Urostylididae (name used by these authors: Urostylidae) and carried out cladistics analysis based on four genera and five species and added details of male / female genitalia of some species, including that of *U. histrionica* (incorrectly spelled at places as *'historionica'*). Kumar (1971) also added information to the structure of male genitalia of this and a few other Urostylididae.

The present short note is based on the field observations on a population of this bug from Assam. The entire life cycle was completed on the host plant *Ficus hispida* L.f. (Moraceae). A brief photo essay of life history of this species is presented here which includes live photos of the bugs, their eggs, and nymphs as well as images of dried specimens illustrating morphology. A series of images of the male genitalia is also provided.

MATERIALS AND METHODS

Insects were photographed in the field (Kamrup, Assam: between December 2015 to October 2021 by S. Ranade) in natural condition using a digital SLR camera (Nikon D 850). Specimens were sent to Pune for further examination. Morphological study was carried out using Leica MZ 6 microscope with attached Canon PowerShot S50 camera (in Modern College, Pune). Measurements were done with Erma stage, ocular micrometer, and an accurate scale. The pygophore was detached from the body after treating the last two abdominal segments with hot 10% potassium hydroxide (KOH) solution. The pygophore was further boiled for 3 minutes in 10% KOH and the phallus and the parameres were separated in distilled water. The phallus was briefly stained with diluted methylene blue for examination. Subsequently, phallus and parameres were mounted in polyvinyl lacto-glycerol (PVLG) with lignin pink dye, and photographed. Each microscopic image presented here is prepared by

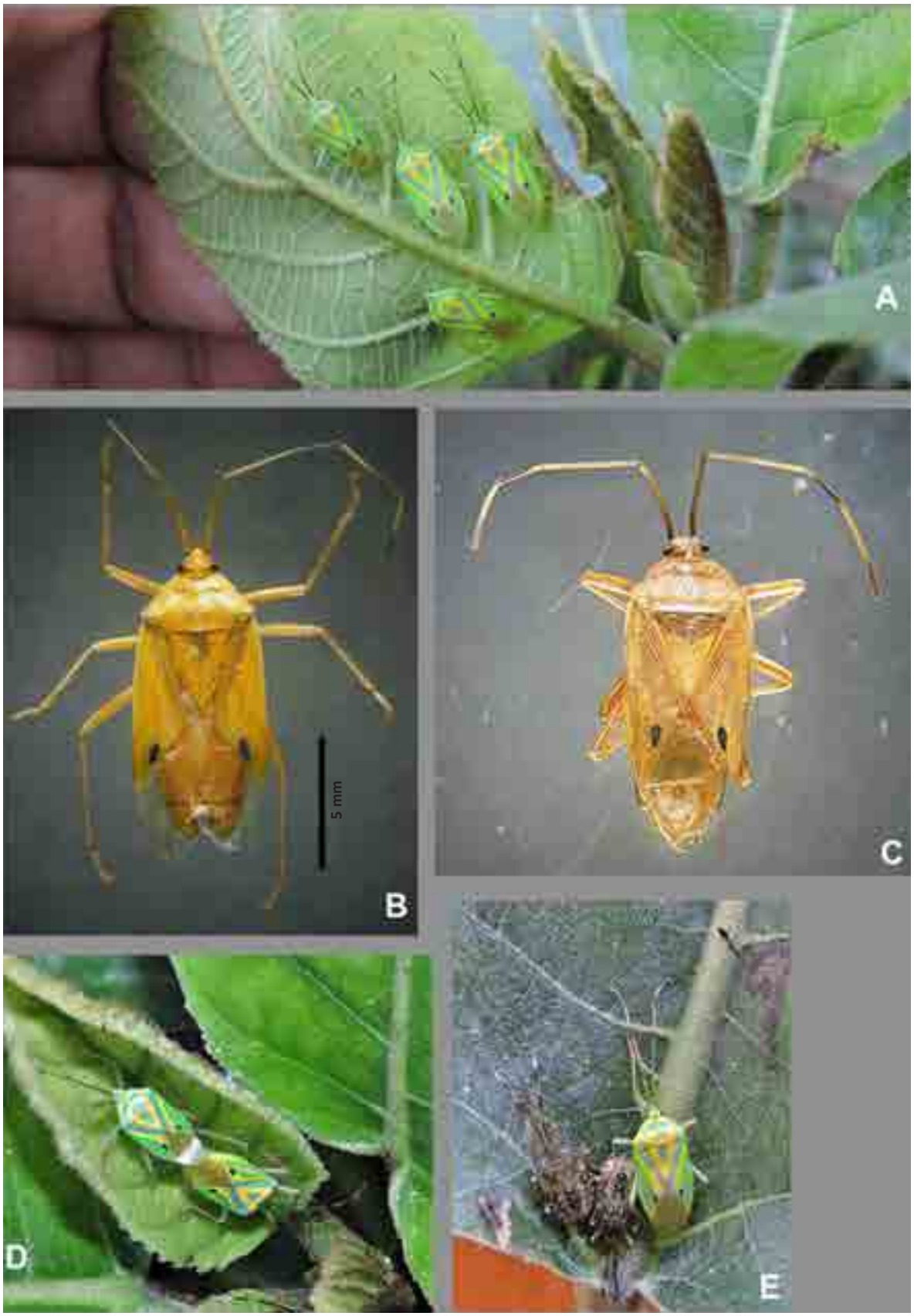


Image 1. *Urolabida histrionica* habitus: A, D, E—Live insects on host plant | B, C—Dried specimens, dorsal view (B), female (C), male | D—Mating pair | E—Imago with nymphs. © B,C—Hemant Ghate, A,D,E—Sachin Ranade.

photo-stacking several images taken at various focal planes, by using Combine ZM freeware.

RESULTS

Classification based on Rider (2006)

Taxonomy

Urostylididae Dallas, 1851
Urostylidinae Dallas, 1851
Urolabidini Stål, 1876
Urolabida Westwood, 1837
Urostylis histrionica Westwood, 1837
Typhlocoris semicircularis Herrich-Schäffer, 1839
Urolabida binotata Walker, 1867: 415
Urolabida histrionica (Westwood, 1837)

Bionomics

The observations given below were carried out by one of us (SR) in Kamrup District, Assam, opportunistically between December 2015 to October 2021. All of these are incidental observations and so some details are not available. Eggs or nymphs were not collected, only a pair of adults was collected in May 2016 for dissection. Subsequently, in October 2021 another pair (one male & one female) was collected for additional observations. Thus, two males and two females were preserved for subsequent morphological study at Modern College, Pune.

These bugs were first located during December 2015, on *Ficus hispida* plant that was about 100 cm tall. A few nymphs in III and IV instars were also present at that time, indicating that mating and egg laying probably happened in November. Subsequently, in late March 2016, some mating pairs were again located on the same plant (Image 1D); sometimes, IV instar nymphs were found with adults (Image 1E), confirming that this is the host plant.

The egg mass was observed on the underside of leaves, once in 2019 and thrice in 2020. On 11 May 2020, the act of egg laying was observed for the first time. Eggs appeared as pale-yellow translucent mass, with about 27 to 30 eggs in one mass. There was some opaque, cream coloured substance, deposited by the female, on top of each egg (Image 2A). Hatching took place in 4 days on 15 May. These first instar nymphs were oval, translucent with only three somewhat opaque marks on dorsal side. These bugs were feeding on the substance left over on the eggs for the next forty-eight hours, before molting on 17 May (Image 2B). In two days, these nymphs had turned brownish with very dark head, pronotum and antennae; there were prominent marks on abdominal tergites, mid-dorsally (scent gland area) and laterally. These nymphs still remained together around the egg mass and appeared to be feeding on host plant on the fourth or fifth day after hatching. The II instar onward the nymphs were seen in small groups (3 to 5 individuals or larger group, see Image 2C) at the base of leaves, sometimes accompanied by the adults (Image 1E). Actual metamorphosis, especially from V instar to adult change could not be observed.

The III to V instar nymphs were very unlike adults with grayish brown body and symmetrical pattern of dark brown markings dorsally on head, thorax and abdomen; some markings were pale magenta; even the antennae and legs showed colouration that was very different from that of the adult

Both, the adults and the nymphs, emit pungent smell yet this smell did not deter predatory insects like Asian Weaver Ant *Oecophylla smaragdina* while an unknown species of ant was found attacking the nymphs (Image 2D). The adults were attracted to the lights at night and were often hunted by spiders (Image 2E). A good population (8 to 10 individuals) of these bugs was often seen on this *Ficus* and was observed to breed at least twice during the year. The lockdown (of Covid pandemic) during part of 2020 and 2021 prevented more surveys and, especially lab work. But the bugs were again noted in October 2021on the same *Ficus* plants.

Adult colouration and morphology in brief

Colouration of the live bug is a symmetrical arrangement of green, bluish-green and yellow stripes on the dorsal side as shown in Image 1A. All this colouration is lost in drying, leaving only the black elongate spots in the middle on the posterior border of the corium. Head is bluish-green in median part while the sides are green and eyes are black. The first antennomere is usually dark green, the second is pale green while the remaining three are pale stramineous, but partly fuscous. A broad yellow semicircular band surrounding a bluish-green area at the base of the pronotum and continuation of that yellow band on scutellum, where it surrounds similar bluish-green central area of the scutellum, appears as a regular feature in all the specimens observed from Assam. Longitudinal oblique bands of bluish-green, yellow, dark green, pale green, and again dark green, from clavus to anterior border of the corium, are also seen in all members of the population. Legs are pale stramineous, with greenish tinge; all these characters are seen in the photo of the live bugs. The abdomen beneath is greenish or yellowish-green. Fine, short translucent setae are

Image 2. *Urolabida histrionica* eggs, nymphs, and predation.: A—Freshly deposited eggs | B—Freshly hatched one day nymphs | C—Aggregation in older nymphs | D—A nymph and ants | E—Adult bug trapped in spider web. © Sachin Ranade.

sparsely present on some parts of the body; these setae are especially prominent and relatively more in number on legs.

Structure

Body elongate oval. Head short, broader than long; clypeus prominent, slightly obliquely projecting in front of mandibular plates; antenniferous tubercles large, seen from dorsal side; eyes of moderate size, globular, projecting out of head profile and widely separated from each other; ocelli absent. Antennae very long (longer than body, see Images 1A, 1B), five segmented with the third antennomere shortest, slender except for the first antennomere which is relatively thicker. Labium slender, just reaching mesocoxae. Prothorax with pronotum twice broad than long, with distinct collar; pronotal sides (lateral margin) gently sinuate; humeral angles subprominent; a shallow but distinct transverse depression in anterior one-third; sparse and fine punctures present, especially in posterior two thirds of pronotum (Image 3A). Scutellum triangular, longer than broad, finely punctured. Prosternum and a part of mesosternum tumescent with a shallow median groove; procoxae closer to each other than meso- and metacoxae (Image 3B). Metathoracic scent gland prominent, projecting laterally with a tubular spout like peritreme (Image 4A). Evaporatorium not well developed. Hemelytra broad and long, passing well beyond abdominal apex; clavus and corium with fine punctures, opaque; membrane translucent through which abdominal segments can be seen in fresh specimens.

The abdomen has a distinct ventromedian elevated region in the male, not in the female. In the male the 7th sternum is deeply emarginated with a setose posterior border. The eighth sternum forms cavity to accommodate the cup like pygophore; dorsal opening of pygophore covered over by hemelytra; when hemelytra are displaced, widely open pygophore reveals dark brown, partly sclerotized, distal portions of the parameres (Image 4B). The pygophore is ventrally tumescent, with two lateral and one median process on the posteroventral border (Image 4C). The various other views of pygophore in situ as well as of detached pygophore are given here to clarify the position, shape, setosity and the posteroventral processes. Image 4D–F show the pygophore in situ in dorsolateral, lateral and posterior views, respectively. In an in situ position, it is apparent that eighth sternum is hollowed to accommodate pygophore; this fact is clear in dorsolateral and posterior views of tip of abdomen .

When detached from body, pygophore appears dorsally flat with wide posterior (distal) opening and round, large anterior (basal) opening; parameres as well as lateral tubercles on the inner wall of pygophore are visible (Image 5A). The general three lobed appearance and setose nature of posteroventral border is clearly observed (Image 5B). Lateral view shows cup-like nature of pygophore (Image 5C). A faint outline of phallus is also visible through KOH treated semi-transparent wall of pygophore in all the views.

Dorsal and ventral views of everted phallus are presented (Image 5D, 5E). Phallus is cylindrical in shape with the various conjunctival processes [dorso-median distal process single but bifurcate along entire length (Image 5E-A), membranous; ventromedian distal process more sclerotized and bifurcate (Image 5E-B); medio-lateral distal processes (Image 5E-C) and ventro-lateral distal processes are also present (Image 5E-D)] and are labelled in the ventral view of the phallus. Dorso-lateral distal conjunctival processes are seen in dorsal view (5D-A). The parameres are curved and sclerotized in distal third (Image 5F). Female Terminalia as shown in Image 5G.

DISCUSSION

Although the species was described over 180 years ago, in 1837, there is no published information on the bionomics of this species. In China the species was recently recorded on *Ficus hispida* (Peng et al. 2002). We also record the host plant to be *Ficus hispida*, a small tree common in northeastern India, on which the entire life cycle of this bug is completed. Except for the report from China (Peng et al. 2002), no plant of Moraceae has ever been recorded as host plant for any Urostylididae member so far; host plant of *U. histrionica* also is so far not recorded in any part of India (Rider 2015) (David Rider, on line resource Pentatomoidea Home page website). Thus, this becomes an additional and confirmed record of the host plant for this species in India (especially because life history was also completed on this *Ficus*) and also a confirmed record of a new family of host plant for the urostylidid bugs.

The deposition of special secretion / bacterial supplement (symbionts) on to eggs by the female is known in bugs; symbiotic bacteria in the Pentatomoidea include several lineages of Gammaproteobacteria that are vertically transmitted to the next generation by means of egg smearing (see Schuh & Weirauch 2020). It has been recently documented (Kaiwa et al. 2014) in

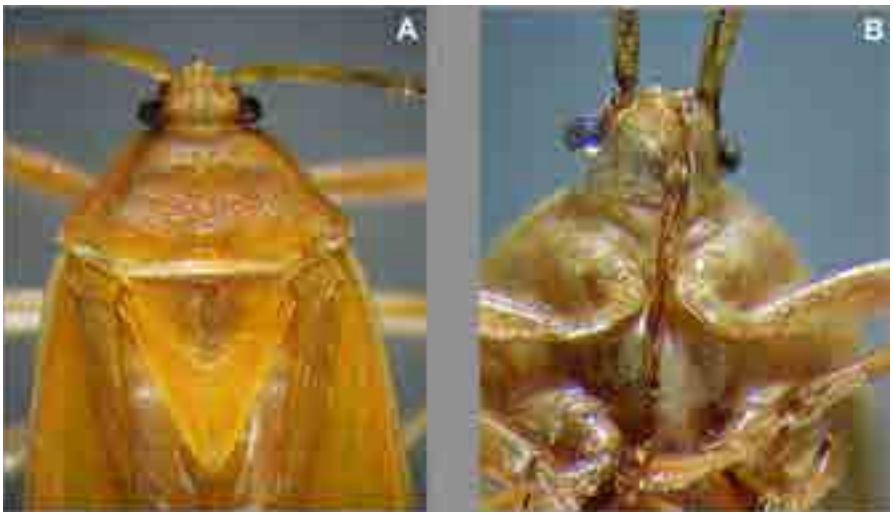


Image 3. *Urolabida histrionica* structure: A—Head & thorax, dorsal view | B—Head & sternum, ventral view. © H.V. Ghate.

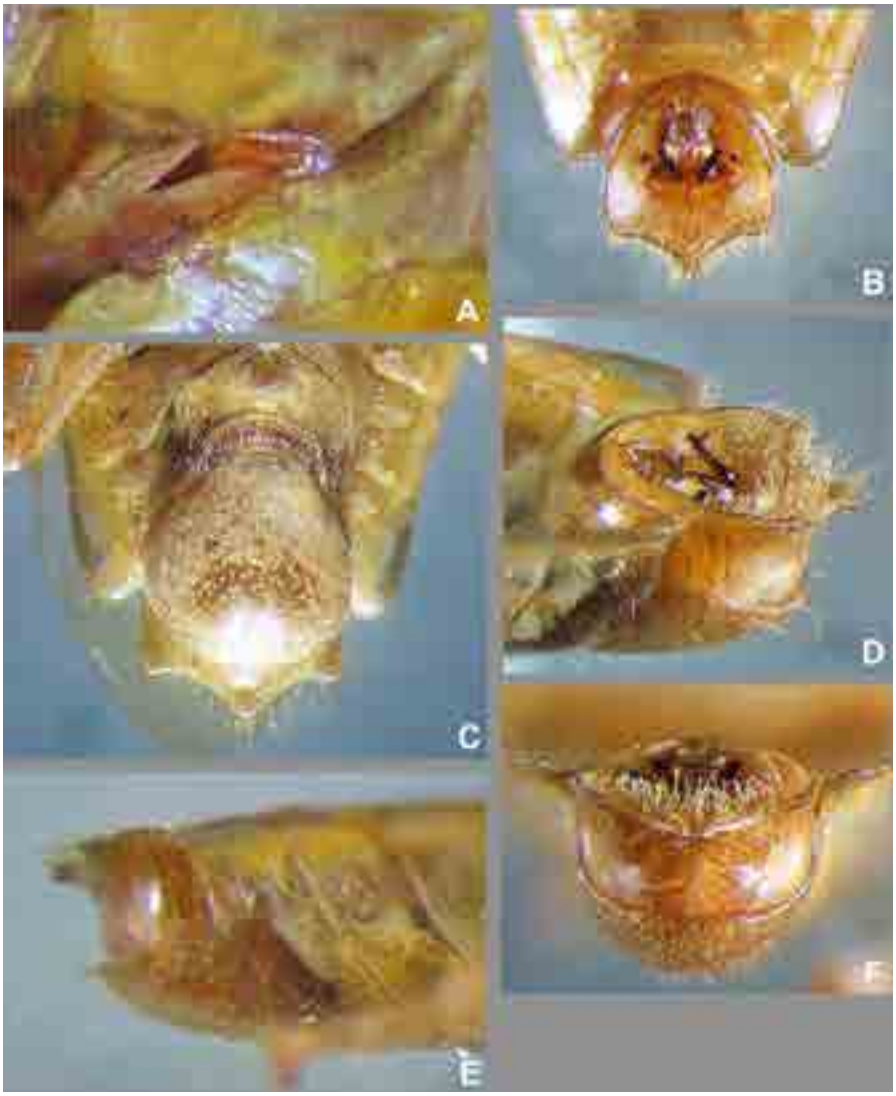


Image 4. *Urolabida histrionica* structure: A—Metathoracic scent gland spout | B–F—Male genitalia, pygophore in situ in dorsal (B), ventral (C), dorsolateral (D), lateral (E), and posterior (F) views. © H.V. Ghate.

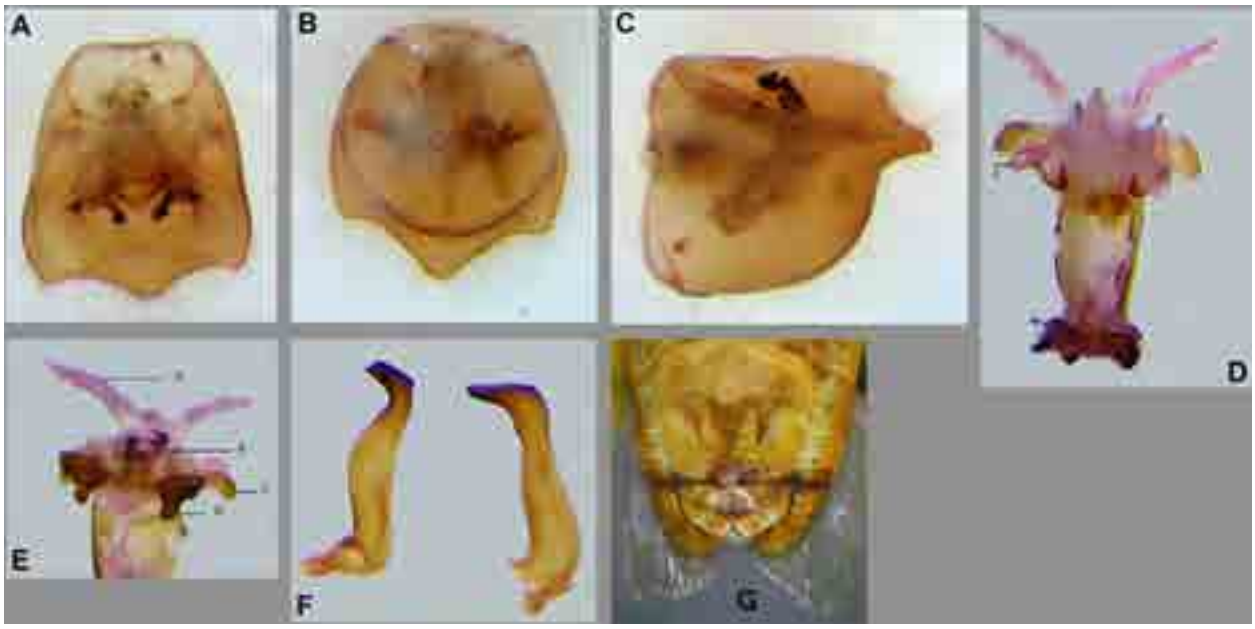


Image 5. *Urolabida histrionica* male genitalia: A–C—KOH treated pygophore, dorsal (A), ventral (B), and lateral (C) views | D & E—Phallus, dorsal (D) and apical half in ventral (E) views | F—Parameres, dorsal, and ventral views, respectively | G—Female Terminalia, ventral view. © H.V. Ghate.

two species of *Urostylis* wherein the female deposited a layer of jelly, which contains nutrition as well as symbiont bacteria, over eggs. Detailed work on this egg-covering jelly lead Kaiwa et al. (2014) to assign the following biological roles to this jelly: (1) protection of eggs against desiccation and microbial contamination, (2) immediate food source for nymphs, (3) supporting growth and survival of nymphs, (4) ensuring survival of the symbiotic bacteria outside the host body, and (5) ensuring successful vertical transmission of the symbiotic bacteria to the next generation. It is inferred from the above cited work that the jelly deposition in *U. histrionica* must also be serving the same function and it will be worthwhile to look at the symbionts deposited in this jelly.

Since it was not possible to collect and preserve the nymphs, detailed microscopic examination of eggs or nymphs was not possible during this study as lockdown due to covid pandemic affected this work.

Literature search revealed that there is a paucity of information on the bionomics of bugs of this family; in fact, no species found in India has been studied in detail. Even detailed morphology or redescription of the species present in India has not been done. Distribution data on most species is wanting and most species are known from northern or northeastern India.

Very brief description and a few diagrams of the male and female genitalia of *U. histrionica* were first provided by Yang (1938b) but this description was restricted to the structure of the pygophore and parameres only; aedeagus was not studied. Subsequently aedeagus was described and illustrated in detail by Kumar (1971). Ahmad et al. (1992) also gave brief description and illustrations of pygophore, aedeagus and parameres. Here we have provided digital illustrations of the pygophore, before and after detachment from the body, that clearly show its shape.

The aedeagus in dorsal and ventral views shows most of the characters described by Kumar (1971), but due to lack of sufficient material additional views could not be prepared. The various conjunctival processes are shown and labelled. Parameres are shown in dorsal and ventral view and are similar to the diagram given by Ahmad et al (1992) but the view of parameres given by Yang (1938b) is different and is not shown here.

Roca-Cusachs et al. (2021), while describing a new species under *Urolabida*, have discussed about the problems of taxonomy of Urostylididae and after examining material belonging to the current three urostylidid genera mentioned above, they feel that the presently described characters of these genera are insufficient for their clear delimitation; they even feel that the genus *Urolabida* should be redescribed, exclusively on the basis of type specimen, as the remaining species currently included in *Urolabida* may require erection of one or more new genera. We are of the opinion that molecular work coupled with morphological work may resolve the situation better.

It is clear therefore that there is a considerable gap in information about Urostylididae and so some efforts must be specifically directed at this family to resolve the various issues.

Measurements: Male (3): TL 9.5–9.7 mm, antennae 11–11.2 mm; Female (1) TL 11 mm, antennae 13 mm.

REFERENCES

Ahmad, I., M. Moizuddin & S. Kamaluddin (1992). A review of cladistics of Urostylidae Dallas (Hemiptera: Pentatomoidea) with keys to taxa of Indian subregion and description of four genera and five species including two new ones from Pakistan, Azad Kashmir and Bangladesh. *Philippine Journal of Science* 121: 263–297.

Atkinson, E.T. (1889). Notes on Indian Rhynchota Heteroptera, No. 5. *Journal of Asiatic Society of Bengal* 1: 20–109.

Berger, H., E. Heiss & I.M. Kerzhner (2001). Removal of Homonymy between Urostylidae Dallas, 1851 (Insecta, Heteroptera) and Urostylidae Bütschli, 1889 (Ciliophora, Hypotrichia). *Annalen des Naturhistorischen Museum in Wien* 103(B): 301–302.

Distant, W.L. (1902). *The Fauna of British India, including Ceylon and Burma. Rhynchota, 1 (Heteroptera).* Taylor & Francis, London, 438 pp.

Distant (1908). *The Fauna of British India, including Ceylon and Burma. Rhynchota, 4 (Heteroptera).* Taylor & Francis, London, 501 pp.

Herrich-Schäffer, G.A.W. (1839). *Die Wanzenartigen Insecten*. Getreu nach der Natur abgebildet und beschrieben. Fifth Volume, 1–108 [Tab CLXX, page 79–80]

Kaiwa, N., T. Hosokawa, N. Nikoh, M. Tanahashi, M. Moriyama, X-Ying Meng, T. Maeda, K. Yamaguchi, S. Shigenobu, M. Ito & T. Fukatsu (2014). Symbiont-Supplemented maternal investment underpinning host's ecological adaptation. *Current Biology* 24: 2465–2470.

Kumar, R. (1971). Morphology and Relationships of the Pentatomoidea (Heteroptera) 5 – Urostylidae. *The American Midland Naturalist* 85(1): 63–73.

Peng Y-Q., D-R. Yang & S-J. Sue (2002). Insect communities of *Ficus auriculata* and *Ficus hispida. Forest Research* 15(2) : 136–142. (In Chinese with English Summary)

Rider, D.A. (2006). Family Urostylidae. pages 102-116 In: Aukema, B. & C. Rieger (eds.). *Catalogue of the Heteroptera of the Palaearctic Region*. Vol. 5. The Netherlands Entomological Society, Amsterdam., xiii:550 pp.

Rider, D.A. (2015). Pentatomoidea Home Page https://www.ndsu.edu/pubweb/~rider/Pentatomoidea/Hosts/plant_Urostylididae.htm [accessed 20 February 2023]

Rider, D.A., C.F. Schwertner, J. Vilímová, D. Rédei, P. Kment & D.B. Thomas (2018). Higher Systematics of the Pentatomoidea. pages 25–200. In: McPherson, J.E. (ed.), *Invasive Stink Bugs and Related Species (Pentatomoidea) Biology, Higher Systematics, Semiochemistry, and Management.* CRC Press, London, 840 pp.

Roca-Cusachs, M. M. Paris, A. Mohagan & S. Jung (2021). *Urolabida graziae,* new urostylidid species from the Philippines with comments on the current taxonomy and systematics of the family (Hemiptera: Heteroptera: Urostylididae). *Zootaxa* 4958(1): 702–712.

Schuh, R.T. & C. Weirauch (2020). *True Bugs of the World (Hemiptera: Heteroptera). Classification and Natural History.* II Edition. Siri Scientific Press, Monograph Series, Vol. 8. 767 pp, with 32 color plates.

Yang, W.-I. (1938a). Eleven new species of Urostylidae.*Bulletin of the Fan Memorial Institute of Biology* 8(1): 49 –82.

Yang, W.-I. (1938b). A new method for the classification of urostylid insects. *Bulletin of the Fan Memorial Institute of Biology* 8(1): 35–48.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22686–22694

OPEN ACCESS

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

https://doi.org/10.11609/jott.8287.15.2.22686-22694

#8287 | Received 28 November 2022 | Final received 02 January 2023 | Finally accepted 09 February 2023

COMMUNICATION

Andromonoecy functional through heterostyly and large carpenter bees as principal pollinators in *Solanum carolinense* L. (Solanaceae)

Suvarna Raju Palathoti [1] & **Aluri Jacob Solomon Raju** [2]

[1] Department of Health, Safety and Environmental Management, International College of Engineering and Management, Muscat, Sultanate of Oman, Oman.

[2] Department of Environmental Sciences, Andhra University, Visakhapatnam, Andhra Pradesh 530003, India.

[1] suvarnarajup@rediffmail.com, [2] solomonraju@gmail.com (corresponding author)

Abstract. *Solanum carolinense* is a perennial shrubby weed. In this species, andromonoecy is functional through heterostyly represented by the production of long, semi-long, medium, & short-styled flower types and another flower type lacking style & stigma completely. All plants produce long-styled flowers while all individuals do not produce other flower types. The long- and semi-long-styled flowers are functionally co-sexual and produce fruit while the other flower types are functionally female-sterile and do not produce fruit. The position of style in long- and semi-long-styled flowers facilitates the act of pollination by pollinator bees. *Xylocopa* bees are large-bodied specialist bees which collect pollen from poricidal anthers efficiently in this plant by displaying buzzing behaviour and are treated as principal pollinators. The other bees are small-bodied and do not display buzzing behaviour to release pollen from poricidal anthers but they simply collect residual pollen available around the rim of the apical pore of the anthers, and hence they act as supplementary pollinators only. In this plant, the style length has a positive relationship with pollen deposition and a negative relationship with pollen removal in flowers visited by large carpenter bees of *Xylocopa* genus and hence, pollinator-specific interactions with flower morphology are important in the maintenance and perfect evolution of andromonoecy in this plant species. Florivory by *Mylabris pustulata* could vary with the flower production rate in *S. carolinense* and could favor higher floral-sex ratios biased in favour of higher proportion of female-sterile flowers.

Keywords: Buzz-pollination, female-sterile flowers, florivory, indehiscent berry nectar-less flowers, poricidal anthers.

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Palathoti, S.R. & A.J.S. Raju (2023). Andromonoecy functional through heterostyly and large carpenter bees as principal pollinators in *Solanum carolinense* L. (Solanaceae). *Journal of Threatened Taxa* 15(2): 22686–22694. https://doi.org/10.11609/jott.8287.15.2.22686-22694

Copyright: © Palathoti & Raju 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Self-funded.

Competing interests: The authors declare no competing interests.

Author details: Prof. A.J. Solomon Raju is honorary professor, Department of Environmental Sciences, Andhra University, Visakhapatnam, India. Dr. P. Suvarna Raju is assistant professor, Department of Health, Safety and Environmental Management, International College of Engineering and Management, Muscat, Sultanate of Oman, Oman.

Author contributions: Both authors contributed equally.

Acknowledgements: We thank the Andhra University, Visakhapatnam, for providing physical facilities to carry out this research work

INTRODUCTION

The family Solanaceae has about 100 genera consisting of 2,500 species distributed world over with species diversity centered in America, Australia, and Africa (Olmstead et al. 1999, 2008). Species of this family have enormous importance as food plants the world over. Crops such as potato, tomato, and capsicum in Solanaceae family are important staple vegetables although there are many other species which are important as edible products (Samuels 2009). In India, this family is represented by 29 genera with 116 species, two sub-species, three varieties, and one forma (Kumari 2004). Of these, 12 genera with 39 species are distributed in the Eastern Ghats region (Venkatappa 2011). In this family, *Solanum* with about 1,500 species is one of the largest genera distributed throughout the world (Vorontsova et al. 2013). In India, this genus is represented by 49 species which are distributed throughout the country, of which 17 species occur in the Eastern Ghats region (Venkatappa 2011).

Andromonoecy is more common in Solanaceae family and it is well documented in *Solanum* genus (Vorontsova et al. 2013). In *Solanum* genus, a number of species display andromonoecy and dioecy as functional sexual systems. In vast majority of dioecious species, the female flowers produce pollen-bearing anthers but the pollen is inaperturate, viable and does not produce a pollen tube while male flowers produce pistils with ovules (Martine & Anderson 2006). In andromonoecious species, the staminate flowers produce variously or noticeably reduced pistil because the style is short to place the stigma above the staminal column. As a result, the stigma is unable to receive pollen directly from the pollinating bees but there is a possibility for incidental gravitational pollination from pollen puffed into the air in the space between anthers by the sonicating action of probing bees (Vorontsova et al. 2013). Andromonoecism is functional in species pollinated by bats, bees, flies, hummingbirds, and moths (Bawa & Beach 1981). Heithaus et al. (1974) stated that andromonoecy is evolved to selective pressure for increasing cross-fertilization. Zapata & Arroyo (1978) mentioned that andromonoecism is a result of abortion of non-functional pistils in certain flowers that serve as male or attraction functions before their anthesis. These authors suggested three possibilities as to the significance of pistils in bisexual flowers that largely serve as pollen donors. First, the abortion of pistils could structurally perturb the floral morphology, disrupting the pollination mechanism. Second, the abortion of pistils in many bisexual flowers prior to pollination could restrict the efficacy of selection on progeny acting through control over pollen germination, tube growth, and embryo & fruit abortion. Third, the abortion of pistils may not occur in most hermaphroditic species because it is not possible to predict the fate of flowers as pollen donors or pollen recipients before pollination (Lloyd 1980).

Different authors reported on the sexual system and pollinators of *Solanum carolinense.* It is an andromonoecious species with hermaphrodite and male flowers on the same individual (Bertin 1982). The anthers in staminate and hermaphroditic flowers are of the same size and produce the same quantity of pollen but they display some specialization in each flower sex (Connolly & Anderson 2003). The long-styled flowers serve primarily as pollen recipients while short-styled flowers as pollen donors (Quesada-Aguilar et al. 2008). It is self-incompatible but it is flexible as a part of stable mixed mating system which permits self-fertilization when cross-pollination limits seed production in situations of establishing new populations as a weed (Kariyat et al. 2011). It is pollinated by different bees in different regions of USA (Hardin et al. 1972; Quesada-Aguilar 2001; Connolly & Anderson 2003; Travers et al. 2004; Vallejo-Marin & Rausher 2007). With this backdrop, the intent of the present study is to evaluate whether only long- and short-styled hermaphrodite flower types occur or other hermaphrodite flower types with variation in style length also occur with different sexual functions in *S. carolinense*. Further, the study also aims at providing additional information on its fruiting aspects and florivory. Since there is not even a single report on the sexual system and pollinators of *S. carolinense* from India, this study is an attempt to provide the details of sexual reproduction and fruiting aspects functional through local pollinators and compare the same with the reports published from outside India.

MATERIALS AND METHODS

Flowering season, floral morphology, and biology

Solanum carolinense population growing in the wild pockets of Madhurawada area of Visakhapatnam city (17^{0}49'20.8992"N & 83^{0}21'8.0028"E), Andhra Pradesh, India, was used for the present study during May–December 2021. This plant population was observed for its flowering season, anthesis and anther dehiscence mode, flower visitors and their foraging behavior, pollination, natural fruit, and fruit aspects. The population was followed continuously during the

study period for the flowering intensity levels to classify into initial, peak, and fag end of flowering. Twenty-five just open flowers were used to record the floral details. Anthesis schedule and anther dehiscence timing were recorded by tagging and following 25 marked mature buds in the field. Flowers were classified into five types according to style length and the absence of style and stigma. A total of 211 flowers collected randomly from ten plants were used to calculate the percentage of plants producing each flower type and the production rate of each flower type. Morphological aspects of these flower types are briefly described. Twenty undehisced anthers from each flower type on ten plants were used to determine pollen output and study pollen grain characteristics as per the protocols given in Dafni et al. (2005).

Foraging behavior and pollination

Flowers visitors included exclusively bees and they were listed along with forage sought, foraging schedule and the total number of foraging visited made per day. Their foraging activity pattern during day-time was observed in the field. The hourly foraging visits of each bee species were recorded on four different days during peak flowering phase. The average number of foraging visits made by each bee species at each hour was noted to present the foraging activity pattern of bees. The species were identified by tallying with the reference species collected from the study region and identified by Zoological Survey of India, Calcutta. Further, the same data were used to calculate the percentage of foraging visits of each bee species per day in order to understand the relative foraging activity levels of each bee species. The bees were observed carefully for their foraging behavior such as mode of approach, landing, probing behavior employed for pollen collection and contact with essential organs in effecting pollination.

Florivory

The blister beetle *Mylabris pustulata* (Thunberg, 1821) was found feeding on the flowers. Keeping this in view, a sample of 100 flowers was chosen at the initial, peak and fag-end of flowering phase to record the percentage of flowers fed by this beetle. Further, the floral parts fed by this beetle were recorded to know whether the flowers used by them have any role in fruit set.

Natural fruit set and fruiting ecology

Twenty-five fertilized flowers that showed initial growth of fruit development were tagged and followed to record the duration of fruit development and maturation. Fruit set rate was recorded only in long and semi-long flowers since the other flower types did not initiate and develop fruits. Fifty flowers of each flower type were tagged and followed to record fruit set rate in open-pollinations. Fruit characters were also recorded.

RESULTS

Flowering season and floral morphology

It is a small perennial shrubby weed. The stem and underside of larger leaf veins are covered with prickles. Leaves are petiolate, arranged alternately to each other; they are elliptic to oblong, irregularly lobed and the upper and lower surface is covered with fine hairs. The plant propagates by underground rhizome and seed. The plants emerging from the rhizome appear producing new aerial stalks and foliage with the onset of wet season in June and initiate flowering by late July while those emerging from seed produce full-grown plants by late July and begin flowering by second week of August. The flowering continues without a break until late October and gradually ceases by second week of November (Image 1a). In year-long wet locations, plants display vegetative growth, flowering and fruiting simultaneously or alternately throughout the year. The flowers are produced in terminal and axillary cymes (Image 1b). The flowers are medium-sized, non-tubular, white, odorless and actinomorphic. They are morphologically bisexual but functionally either bisexual or female-sterile. The style length varies but the length of stamens remains unchanged in all flowers borne on the same individual. According to style length, the flowers are classified into four types, long-styled (Image 1d), semi-long-styled (Image 1e), medium-styled (Image 1f), and short-styled ones (Image 1g). Further, another flower type with pistil lacking style and stigma (Image 1h) is also produced along with these four types of flowers in the same individual. All individuals produce long-styled flowers but semi-long-styled flowers are produced only in 75%, medium-styled flowers in 83%, short-styled flowers in 75% and flowering lacking style and stigma in 67% of the total monitored plants (Figure 1). Of the total flowers observed in monitored individuals, 59% are long-styled, 11% semi-long-styled, 10% short-styled, 9% short-styled flowers and 11% flowers lacking both style and stigma (Figure 2). In all flower types, the calyx has five green pointed spiny sepals and is quite inconspicuous. The corolla is rotate bearing five spreading lobes with yellow center and is quite conspicuous. The stamens

Image 1. *Solanum carolinense*: a—Habit – in flowering phase | b—Flowering inflorescence | c—Anthesing bud | d—Long-styled flower | e—Semi-long styled flower | f—Medium-styled flower | g—Short-styled flower | h—Flower lacking style and stigma. ©. A.J. Solomon Raju.

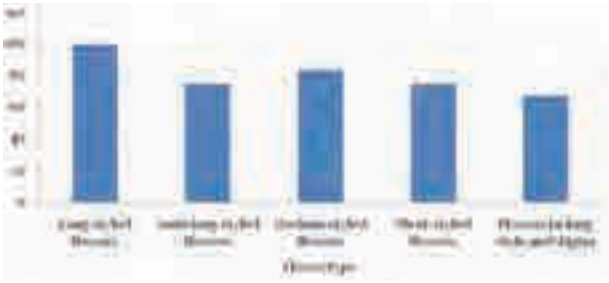


Figure 1. Percentage of plants producing each flower type in *Solanum carolinense*.

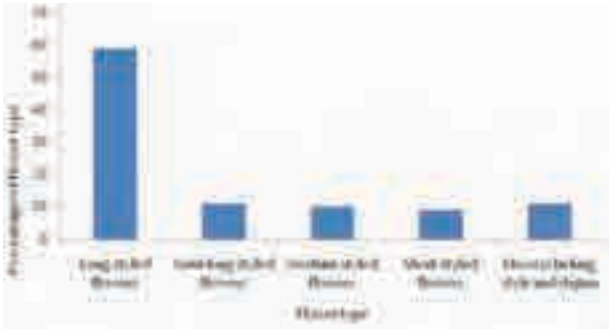


Figure 2. Percentage of flower types produced in *Solanum carolinense*.

are five with short filaments and large, non-adherent yellow anthers inserted on the corolla and form a cone around the pistil; there is no variation in the length of filament and anthers in all flower types. The style is long, extends beyond the length of stamens, it is strikingly sub-capitate. The ovary is bulbous and bears numerous ovules (Image 2b).

Floral biology

The flowers are open daily during 0600-0830 h (Image 1c). The corolla expands and its lobes become flat exposing the anthers as a single unit. All anthers in individual flowers dehisce simultaneously by apical pores. All five flower types produce the same amount of pollen; it is 19,246 ± 346.4 per anther. The pollen grains are dry, powdery, yellow, spheroidal to sub-prolate, tricolporate and 27.39 ± 4 µm in size (Image 2a). The pollen release occurs through apical pores of the anthers when flower foragers exhibit buzzing behavior to collect pollen and in the absence of flower foragers, the pollen remain inside the anthers and is not self-exposed or released. The nectar disc is absent and hence nectar is not produced. As a result, the flowers offer pollen as exclusive reward for the probing insects.

Foraging behavior and pollination

The flowers were visited by five bee species, namely, *Apis cerana*, *Trigona iridipennis*, *Xylocopa latipes, X. pubescens*, and *Nomia* sp. during day time from 0700 to 1700 h (Table 1). These bees showed a gradual increase in foraging activity from morning and until noon and then a gradual decrease towards evening hours (Figure 3). Of these bees, *Xylocopa* bees exhibited buzzing

Image 2. *Solanum carolinense*: a—Pollen grain | b—Ovules | c—*Xylocopa latipes* approaching the flower for pollen collection | d—*X. latipes* vibrating the base of anthers for pollen collection | e & f—*Xylocopa pubescens* vibrating the anthers for pollen collection | g—*Apis cerana* collecting pollen from poricial anthers | h—*Trigona iridipennis* collecting pollen from poricial anthers | i—*Nomia* sp. collecting pollen from poricidal anthers | j—*Mylabris phalerata* feeding on the flowers | k—Fruiting branch | l–n—Fruit developmental stages. ©. A.J. Solomon Raju.

behavior to collect pollen from the poricidal anthers (Image 2c–f). The buzzing length was relatively very less at the fresh flowers and its length increased gradually with a gradual decrease in the amount of pollen in the anthers. Accordingly, the pollen quantity in anthers gradually decreased from morning to evening. These bees upon landing on the anthers, grasped the latter with their hind legs, rotated on the flower to handle each anther separately to collect pollen. In this process, they performed vibrations with their wings by producing audible buzzes. Then, the pollen was released as puffs from the apical pores of the anthers and it is dispersed into the air surrounding the stigma in case of long- and semi-long-styled flowers. Sometimes, the pollen-laden ventral side of the bee body came into contact with the stigma resulting in pollination. Some pollen gradually descended through narrow spaces between the anthers in all other flower types. The flowers that were visited by these bees showed bruise marks on the anthers and these marks were taken as indicators of bee visits that buzz the flowers. Large mass of pollen was visible on the hind legs of the bees visiting the flowers. The other bees, *Apis cerana, Trigiona iridipennis*, and *Nomia* sp. did not show buzzing behavior to handle anthers to collect pollen from apical pores but they simply gathered pollen on and around the rim of the apical pores and in this process, they were able to come in contact with the stigma in long- and semi-long-styled flower types effecting pollination (Image 2g–i). But the contact between the ventral side of the bee body and the stigma in these two flower types was found to be dependent on the posture used by the bees while gathering pollen. All bees were consistent and regular in utilizing the pollen from this plant during its peak flowering season. Only *Xylocopa* bees displayed fidelity to the flowers of this plant throughout its flowering season while all other bees paid visits to its flowers occasionally only. Of the total foraging visits made by bees, *Xylocopa* bees accounted for 54% and all other bees 46% during peak flowering period (Figure 4). Therefore, *Xylocopa* bees were found to be appropriate foragers and hence are the principal pollinators while other bees are only supplementary pollinators for the plant.

Florivory

The common blister beetle, *Mylabris pustulata* (Image 2j) was found feeding on the corolla, stamens, style and stigma (Table 1). Florivory by this beetle stood at 31% during peak flowering phase and at 8–9% in the initial and fag-end of flowering season. This phenomenon

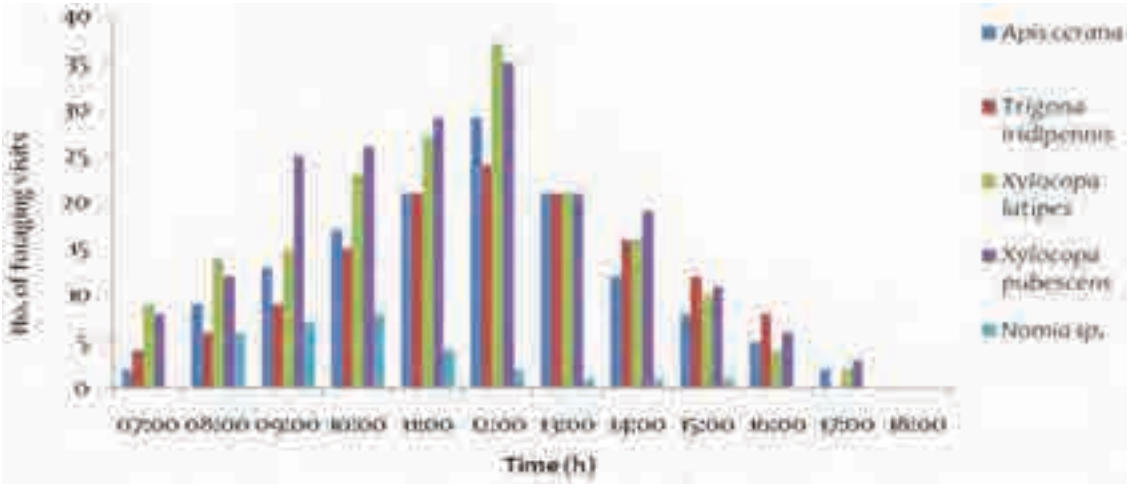


Figure 3. Hourly foraging activity of bees on *Solanum carolinense*.

Table 1. List of flower visitors on *Solanum carolinense*.

Order/ Family	Insect species	Forage sought	Foraging schedule (h)	Total No. of foraging visits/day*
Hymenoptera				
Apidae	*Apis cerana* F.	Pollen	0700-1700	139
	Trigona iridipennis Smith	Pollen	0700-1600	136
	Xylocopa latipes Drury	Pollen	0700-1700	178
	Xylocopa pubescens Spinola	Pollen	0700-1700	195
Halictidae	*Nomia* sp.	Pollen	0800-1500	30
Coleoptera				
Meloidae	*Mylabris phalerata* Pallas	Corolla, stamens, style and stigma	0800-1700	Resident flower feeder

*Approximately 300 flowers on closely spaced plants were used to record foraging visits/day by each pollen- collecting species. The foraging visits indicate mean number of foraging visits made on four clear sunny days during peak flowering days.

appears to have a detrimental effect in the plant for the success of its sexual reproduction.

Natural fruit set and fruiting ecology

Initiation of fruit development occurs as soon as flowers are fertilized and mature and ripe fruits form within a month (Image 2k–n). In open-pollinations, fruit set occurs only in long- and semi-long-styled flower types only. Fruit set is 88% in long-style flower type and 45% in semi-long-styled flower type (Table 2). Fruit is an indehiscent, many-seeded berry; it is dark green when immature and scarlet-orange when mature. The calyx encloses the berry completely throughout the course of its development and maturation. But, the calyx lobes gradually separate and partially unfold exposing the ripe berry.

DISCUSSION

In this species, the role of androecium is different in hermaphrodite and male flowers. In both flower sexes, the anthers are of the same size and produce the same quantity of pollen but display some form of specialization in each flower sex. The anthers of male flowers act primarily as possible near-distance attractors and as pollen donors while hermaphrodite flowers act primarily as pollen recipients and as pollen donors (Connolly & Anderson 2003). In another report, *S. carolinense* is stated to be andromonoecious and functional through long-styled and short-styled flowers; the former type serves primarily as pollen recipient while the latter type as pollen donor (Quesada-Aguilar et al. 2008). *S. carolinense* is self-incompatible but it is flexible as a part of stable mixed mating system which permits self-fertilization when cross-pollination limits seed production

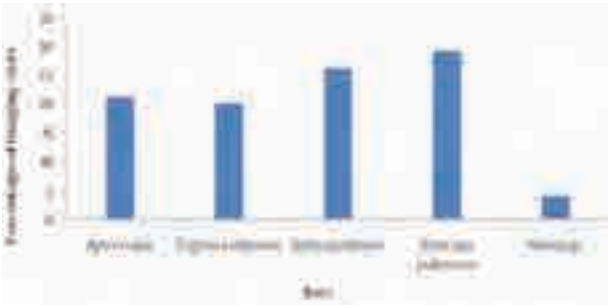


Figure 4. Percentage of foraging visits of bees on *Solanum carolinense*.

Table 2. Fruit set rate in different flower types of *Solanum carolinense*.

Flower type	No. of flowers tagged	No. of flowers set fruit	Fruit set (%)
Long styled	26	23	88
Semi-long-styled	20	9	45
Medium-styled	15	0	0
Short-styled	15	0	0
Ovary lacking style and stigma	10	0	0

in situations of establishing new populations (Kariyat et al. 2011). In the present study also, *S. carolinense* is found to be andromonoecious but this sexual system is functional through heterostyly involving long, semi-long, medium, & short-styled flower types and also another flower type lacking style & stigma completely. All these flower types are present together on the same plant. All individuals produce long-styled flower type while other flower types are not produced by all individuals. The long- and semi- long-styled flowers are functionally co-sexual and produce fruit while the other flower types are functionally male or female-sterile and do not product fruit. The style is placed slightly above the anthers in semi long-styled flowers while it is placed comparatively far above the anthers in long-styled flowers. Such a placement of the style in these flower types facilitates and ensures the occurrence of pollination by specialized pollen collecting bees. In medium- and short-styled flower types, the style is not exposed and enclosed by conical-shaped anthers; there is no scope for contact between the style and pollen collecting bees in these flowers. In flowers lacking style and stigma, the question of pollinator contact with these sex organs does not arise at all. The heterostyly condition functional through andromonoecy appears to have evolved in response to the limitation of nutrients and the production of extra functionally male flowers against functional co-sexual flower types appears to be an indication of resource constraints under which fruit production is most unlikely (Whalen & Costich 1986; Diggle 1991; Meagher 1992). The production of female-sterile flowers is cheaper to produce than perfect flowers and the resources saved by them are not re-allocated to other fitness enhancing functions. The principal morphological trait of female-sterile flowers is pistil reduction which does not increase either pollinator visitation or siring success of open-pollinated flowers (Vallejo-Marin & Rausher 2007). The production of female-sterile flower type completely lacking style and stigma is a functional step in the evolution of perfect male flowers and also an indication of resource constraints for enhancing fruit production. Therefore, the flowers that present style above anthers are functionally co-sexual and fruit producing while the flowers that present style within the anthers or that lack style and stigma are functionally female sterile or male.

In flowering plants, most of the species exhibit longitudinal and poricidal mode of anther dehiscence; in the former mode, pollen is presented along the line of dehiscence and its collection does not require special skills from pollinators while in the latter mode, pollinators require special skills to squeeze the anthers by special buzzes or vibrations in order to collect pollen from the apical pore. In flowers with poricidal anthers present only pollen as the reward and hence pollen collecting insects that exhibit buzzing behavior can only collect this reward while other foragers either visit and subsequently depart from such flowers or do not visit such flowers at all (Buchmann 1983). Different authors (Hardin et al. 1972; Quesada-Aguilar 2001; Connolly & Anderson 2003; Travers et al. 2004; Vallejo-Marin & Rausher 2007; Quesada-Aguilar et al. 2008) reported that *S. carolinense* is pollinated by bees in USA. It is pollinated by pollen-gathering bees which display buzzing behavior, *Lasioglossum* spp., *Augochloropsis metallica*, and *Bombus impatiens.* In the present study, *S. carolinense* flowers display poricidal mode of anther dehiscence and pollen production is copious in poricidal flowers. The carpenter bees employ buzzing or vibration behavior to extract pollen from poricidal anthers by means of vibrations of the wing muscles. Since the pollen is dry and powdery, the carpenter bees collect it with great ease (Buchmann et al. 1989). All other bees recorded on *S. carolinense* do not exhibit buzzing behavior but simply gather pollen from the rim of the apical pores of the anthers. The study shows that there appears to be a positive relationship between the style length and pollen deposition and a negative relationship between the style length and pollen removal in flowers visited by carpenter bees. The study shows that the style

length has a positive relationship with pollen deposition and a negative relationship with pollen removal in flowers visited by carpenter bees. But in flowers visited by other bees, their morphological or behavioral traits do not determine pollen deposition or removal. Quesada-Aguilar et al. (2008) reported similar situation in *S. carolinense* in which the style length has a positive relationship with pollen deposition and a negative relationship with pollen removal in flowers visited by bumble bees. The morphological or behavioral traits of small halictid bees that visit the flowers of *S. carolinense* do not determine pollen deposition or removal. The study indicates that pollinator-specific interactions with flower morphology are important in the maintenance and perfect evolution of andromonoecy in this plant species.

Michael & Christopher (1996) reported that the caterpillars of the moths, *Synanthedon rileyana* Edwards, 1881 and *Manduca sexta* Linnaeus, 1763, and the beetles, *Leptinotarsa junca* Germar, 1824 and *Epitrix fuscula* Crotch, 1873 feed on *S. carolinense*. The beetles reduce fruit production to the extent of 75%. Michael (2007) reported that the weevils, *Trichobaris trinotata* Say, 1832 and *Anthonomus nigrinus* Boheman, 1843 affect or reduce plant growth and fruit set rate, the former bores into the stems while the latter feeds on the flowers. Wise & Hebert (2010) reported that higher levels of florivory and frugivory would favour lower floral-sex ratios biased in favour of lower proportion of male flowers while lower levels of herbivory would favor higher floral sex ratios biased in favour of optimum percentage of male flowers *S. carolinense*. In the present study, florivory by a common blister beetle *Mylabris pustulata* is found to vary with the flowering intensity in *S. carolinense*. However, florivory levels are not high and this situation would favor higher floral-sex ratios biased in favour of higher proportion of female sterile flowers. But, florivory by this beetle could influence the success rate of sexual reproduction.

CONCLUSIONS

In Solanum carolinense, andromonoecious sexual system is functional through heterostyly involving long, semi-long, medium and short-styled flower types, and also through another flower type lacking style and stigma completely. All plants produce long-styled flowers while other flower types are not produced by all individuals. The long- and semi- long-styled flowers are functionally co-sexual and produce fruit while the other flower types are functionally female-sterile and do not product fruit. The position of style in long- and semi-long-styled flowers the style facilities the occurrence of pollination by pollinator bees. *Xylocopa* bees are large-bodied specialist bees which collect pollen from poricidal anthers in this plant species by displaying buzzing behaviour and hence are treated as principal pollinators. The other bees are small-bodied and do not display buzzing behaviour to release pollen from poricidal anthers but they simply collect residual pollen that is available around the rim of the apical pore of the anthers, and hence they act as supplementary pollinators only. The study shows that in *S. carolinense* the style length has a positive relationship with pollen deposition and a negative relationship with pollen removal in flowers visited by *Xylocopa* bees and hence, pollinator-specific interactions with flower morphology are important in the maintenance and perfect evolution of andromonoecy in this plant species. Florivory by *Mylabris pustulata* could vary with the flower production rate in *S. carolinense* during its flowering season and it could favor higher floral-sex ratios biased in favour of higher proportion of female-sterile flowers if there is persistence of florivory.

REFERENCES

Bawa, K.S. & J.H. Beach (1981). Evolution of sexual systems in flowering plants. *Annals of Missouri Botanical Garden* 68: 254–274. https://doi.org/10.2307/2398798.

Bertin, R.I. (1982). The evolution and maintenance of andromonoecy. *Evolutionary Theory* 6: 25–32.

Buchmann, S.L. (1983). Buzz-pollination in angiosperms, pp. 73–113. In: Jones, C.E. & R.J. Little (Eds.). *Handbook of Experimental Pollination Biology*. Van Nostrand Reinhold, New York.

Buchmann, S.L., C.E. Jones & L.J. Colin (1989). Vibratile pollination of *Solanum douglasii* and *S. xanti* (Solanaceae) in Southern California. *Wasmann Journal of Biology* 81: 289–294.

Connolly, B. & G. Anderson (2003). Functional significance of the androecium in staminate and hermaphroditic flowers of *Solanum carolinense* (Solanaceae). *Plant Systematics & Evolution* 240: 235–243.

Dafni, A., P.G. Kevan & B.C. Husband (2005). *Practical Pollination Biology*. Enviroquest Ltd., Ontario, 590 pp.

Diggle, P.K. (1991). Labile sex expression in andromonoecious *Solanum hirtum*: pattern of variation in floral structure. *Canadian Journal of Botany* 69: 2033–2043. https://doi.org/10.1139/b91-256

Elle, E. (1999). Sex allocation and reproductive success in the andromonoecious perennial *Solanum carolinense* (Solanaceae). I. Female success. *American Journal of Botany* 86: 278–286. https://doi.org/10.2307/2656944

Hardin, J., G. Doerksen, H. Herndon, M. Hobson & F. Thomas (1972). Pollination ecology and floral biology of four weedy genera in southwestern Oklahoma. *Southwestern Naturalist* 16: 403–412.

Heithaus, E.R., T.H. Fleming & P.A. Opler (1974). Foraging patterns and resource utilization in seven species of bats in a seasonal tropical forest. *Ecology* 56: 841–854. https://doi.org/10.2307/1936295

Kariyat, R.R., S.R. Scanlon, M.C. Mescher, C.M. De Moraes & A.G.

Stephenson (2011). Inbreeding depression in *Solanum carolinense* (Solanaceae) under field conditions and implications for mating system evolution. *PloS One* 6: e28459. https://doi.org/10.1371/journal.pone.0028459

Kumari, M.R. (2004). *A taxonomic revision of Indian Solanaceae*. Ph.D. Thesis, Bharathiar University, Coimbatore.

Lloyd, D.G. (1980). Sexual strategies in plants. I. An hypothesis of serial adjustment of maternal investment during one reproductive season. *New Phytologist* 86: 69–79. https://doi.org/10.1111/j.1469-8137.1980.tb00780.x

Martine, C.T. & G.J. Anderson (2006). Dioecy, pollination and seed dispersal in Australian spiny *Solanum. Acta Horticulturae* 745: 2.

Meagher, T.R. (1992). The quantitative genetics of sexual dimorphism in *Silene latifolia* (Caryophyllaceae). I. Genetic variation. *Evolution* 46: 445–457. https://doi.org/10.2307/2409863

Michael, J.W. (2007). The herbivores of *Solanum carolinense* (Horsenettle) in Northern Virginia: natural history and damage assessment. *Southeastern Naturalist* 6: 505–522.

Michael, J.W. & F.S. Christopher (1996). Impact of two specialist insect herbivores on reproduction of horse nettle, *Solanum carolinense*. *Oecologia* 108: 328–333. http://doi.org/ 10.1007/BF00334658

Olmstead, R.G., L. Bohs, H. Abdel Migid, E. Santiago-Valentin, V.F. Garcia & S.M. Collier (2008). A molecular phylogeny of the Solanaceae. *Taxon* 57: 1159–1181. https://doi.org/10.1002/tax.574010

Olmstead, R.G., J.A. Sweere, R.E. Spangler, L. Bohs & J.D. Palmer (1999). Phylogeny and provisional classification of the Solanaceae based on chloroplast DNA, pp. 111–137. In: Nee, M., D. Symon, R.N. Lester & J. Jessop (Eds.), *Solanaceae IV: Advances in Biology and Utilization*. Royal Botanic Gardens, Kew.

Quesada-Aguilar, A. (2001). *Flower morphology, gender functionality, and pollinator dynamics in Solanum carolinense: implications for the evolution of andromonoecy.* M.S. Thesis, University of Pittsburgh, Pittsburgh.

Quesada-Aguilar, A., S. Kalisz & A. Tia-Lynn (2008). Flower morphology and pollinator dynamics in *Solanum carolinense* (Solanaceae): implications for the evolution of andromonoecy. *American Journal of Botany* 95: 974–984. http://doi.org/10.3732/ajb.0800106

Samuels, J. (2009). The Solanaceae-novel crops with high potential. *Organic Grower 9*: 32–34.

Travers, S.E., J. Mena-Ali & A.G. Stephenson (2004). Plasticity in the self-incompatibility system of *Solanum carolinense*. *Plant Species Biology* 19: 127–135. https://doi.org/10.1111/j.1442-1984.2004.00109.x

Vallejo-Marin, M. & M.D. Rausher (2007). The role of male flowers in andromonoecious species: energetic costs and siring success in *Solanum carolinense* L. *Evolution* 61: 404–412. https://doi.org/10.1111/j.1558-5646.2007.00031.x

Venkatappa, V. (2011). Solanaceae, pp. 266–310. In: Pullaiah, T., S.S. Rani & S. Karuppasamy (Eds.). *Flora of Eastern Ghats (Stylidaceae to Plantaginaceae).* Regency Publications, Delhi.

Vorontsova, M.S., S. Stern, L. Bohs & S. Knapp (2013). African spiny *Solanum* (Subgenus Leptostemomum, Solanaceae): a thorny phylogenetic tangle. *Botanical Journal of Linnean Society* 173: 176–193. https://doi.org/10.1111/boj.12053

Whalen, M.D. & D.E. Costich (1986). Andromonoecy in *Solanum*, pp. 284–302. In: D'Arcy, W.G. (ed.). *Solanaceae Biology and Systematics*. Columbia University Press, New York.

Wise, M.J. & J.B. Hebert (2010). Herbivores affect natural selection for floral-sex ratio in a field population of horsenettle, *Solanum carolinense*. *Ecology* 91: 937–943. https://doi.org/10.1890/09-1373.1

Zapata, T.R. & M.T.K. Arroyo (1978). Plant reproductive ecology of a secondary deciduous tropical forest in Venezuela. *Biotropica* 10: 221–230.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22695–22717

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

https://doi.org/10.11609/jott.8090.15.2.22695-22717

#8090 | Received 05 July 2022 | Final received 11 December 2023 | Finally accepted 18 February 2023

OPEN ACCESS

COMMUNICATION

An inventory of endemic and near endemic angiosperm flora of Biligiri Rangaswamy Temple Tiger Reserve, peninsular India

J. Jayanthi

Botanical Survey of India, Headquarters, Salt Lake City, Kolkata, West Bengal 700064, India
jayanthi.bsi@gmail.com

Abstract: The Biligiri Rangaswamy Temple (BRT) Tiger Reserve is a biodiverse region of peninsular India that harbors a significant number of endemic and near-endemic angiosperm species. The present documentation reveals a total of 211 endemic taxa conserved in this reserve. Analysis show that the endemic flora is dominated by Western Ghats (57%) elements, followed by Eastern and Western Ghats elements (28%), peninsular endemic elements (9%), and Indian elements (6%). The present study reports two endemic species of Western Ghats *Syzygium densiflorum* (Myrtaceae) and *Meineckia longipes* (Phyllanthaceae) as new distribution records for Karnataka state. The family Orchidaceae harbors the maximum endemic taxa. A majority of endemic taxa are confined to the evergreen forest of the reserve, hence these forests need special attention for conservation.

Keywords: Biligirirangan hills, BRT, diversity, conservation, documentation, Eastern Ghats, evergreen forest, Karnataka, priority, Western Ghats.

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Jayanthi, J. (2023). An inventory of endemic and near endemic angiosperm flora of Biligiri Rangaswamy Temple Tiger Reserve, peninsular India. *Journal of Threatened Taxa* 15(2): 22695–22717. https://doi.org/10.11609/jott.8090.15.2.22695-22717

Copyright: © Jayanthi 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Botanical Survey of India, Ministry of Environment, Forest & Climate Change.

Competing interests: The author declares no competing interests.

Author details: J. Jayanthi, scientist-E, Botanical Survey of India, has been studying the flora of protected areas for the last 15 years. She has completed the angiosperm flora of Great Indian Bustard Wildlife Sanctuary (Maharashtra), Biligiri Rangaswamy Temple Tiger Reserve (Karnataka) and Campbell Bay National Park, Great Nicobar (Andaman & Nicobar Islands).

Acknowledgements: I would like to express my earnest thanks to Dr. A.A. Mao, director, Botanical Survey of India for providing all the facilities and encouragement. My sincere gratitude to the principal chief conservator of forests (Wildlife) & chief wildlife warden, Karnataka and director, BRT Tiger Reserve, Chamrajanagar for granting permission to conduct the field studies and also for providing the map of BRT Tiger Reserve. I would like thank all the range officers and field staff for providing necessary help during the survey. I am thankful to Dr. J.S. Jalal, scientist-E, Botanical Survey of India for providing valuable comments on the manuscript and preparation of map. Finally, I would like to thank the reviewers and subject editor for their constructive comments to improve the manuscript.

INTRODUCTION

Survey and documentation are basic aspects of biodiversity conservation. Cataloguing the species of a particular area can provide baseline data that enable conservation efforts to be effectively targeted (Brummitt et al. 2021). Endemic species help to determine priorities for conservation owing to their limited distribution ranges and vulnerability to disturbance (Morrone 2008). Endemic flora and fauna are considered to be exclusive biological capital of a region or nation (Nayar 1996). The presence of endemic plant species in an area is often considered a measure of stability, allowing prioritization of sites for conservation (Myers et al. 2000).

Peninsular India is bounded by the Western and Eastern Ghats. The Western Ghats comprises of about 7,400 angiosperm species, of which 5,588 are native. Among the native species, 2,253 are endemic, of which 1,273 species are exclusively endemic to the Western Ghats (Nayar et al. 2014), recognized as a global biodiversity hotspot. The Eastern Ghats comprise of about 4,000 angiosperm species (Krishnamurthy et al. 2014) of which 166 are exclusively endemic (Singh et al. 2015). Although these hill ranges have been botanized for a long time and their flora are relatively well known, there are areas with rich floristic diversity that are poorly or sporadically studied, including the Biligirirangan hills.

The Biligirirangan hills are a discontinuous chain of hills running north to south in the Mysore plateau between the Western and Eastern Ghats (Figure 1). An account of the flora of North Coimbatore published by Blatter (1908) based on the notes of C.E.C. Fischer is the first available floristic documentation to include plants from Biligirirangan hills. After more than three decades Barnes (1944) published an account of these hills which included only a particular group of herbaceous plants. Kammathy et al. (1967) published a contribution towards a flora of Biligirirangan hills documenting 825 plant species. Rao & Razi (1981) while studying the flora of Mysore district also made collections from these hills. Later Ramesh (1989) studied the evergreen forests of these hills which included trees and shrubs. None of these studies have mentioned or focused about endemic plants. Therefore, the present study aims to document the endemic flora of the Biligiri Rangaswamy Temple Tiger Reserve due to its unique location often mentioned as a connecting bridge between Western Ghats and Eastern Ghats. This is the first comprehensive documentation available on the endemic flora after notification of these hill ranges as BRT Wildlife Sanctuary in 1972 and as BRT Tiger Reserve in 2011. This documentation will be helpful in conservation & monitoring of endemic species within this reserve, and also contribute to the endemic species database of the country.

MATERIALS AND METHODS

Study area

This work was carried out by the author as part of a project on the flora of BRT Tiger Reserve by the Botanical Survey of India. The BRT Tiger Reserve is situated in the Chamrajanagar district of Karnataka state and lies between 11.727 & 12.140 ^{0}N and 77.007 & 77.269 ^{0}E (Figure 1). The Tiger Reserve (TR) falls under the Kollegal, Yelandur, and Chamrajanagar taluks of the district. The TR is spread over an area of 574.82 km^{2} and managed by different forest department administrative units such as Yelandur range, Kollegal range, Kyathdevaragudi range, Bylore range, and Punajur range. This Tiger Reserve also forms an important wildlife corridor which is contiguous with Malai Mahadeshwar Wildlife Sanctuary in the east, Sathyamangalam Tiger Reserve, and Mudumalai National Park in south, Bandipur & Nagarhole National Park in the west. Apart from this, it is also a part of Nilgiri Biosphere Reserve and the Mysore Elephant Reserve (MoEF&CC 2018). BRT TR is also home for the indigenous Soliga tribe.

The topography of this reserve is highly undulating with elevation ranges 600–1,825 m at Kattaribetta, the highest peak. The BRT receives rainfall from both south-west monsoons from the west coast, and retreating north-east monsoon from the east coast. Rainfall is generally greatest at higher elevations. The mean annual rainfall varies between 620 mm and 1,850 mm. Due to its meteorological and topographical variations, the landscape in BRT TR is heterogeneous with patches of shola grasslands, evergreen forests, moist deciduous forests, dry deciduous forests, scrub forests, and riparian habitats. Presence of diverse ecosystem within a small area is a characteristic feature of this reserve. The forests of BRT TR have been classified as 28.2% of scrub forests, 36.1% dry deciduous, 25% moist deciduous, and 10.7% evergreen forests including shola (Kumara et al. 2012).

Survey and Data collection

Field surveys were conducted at regular intervals every three to six months during the period 2013–2017. Field surveys were organized in different seasons and covered all habitat types in every season. Field data were noted, such as life-form, habitat, elevation, and flowering and fruiting period. Voucher specimens were collected and processed, and herbaria prepared. The

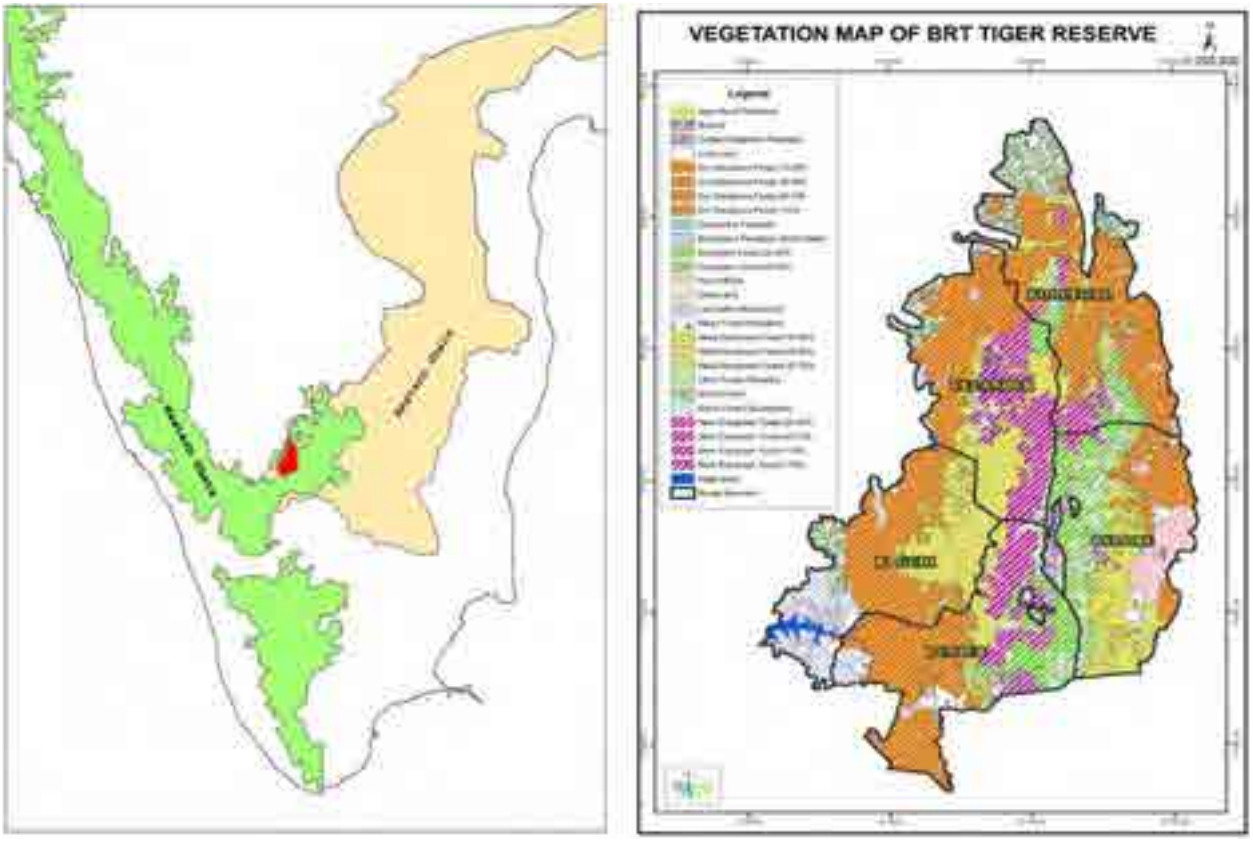


Figure 1. Location of Biligiri Rangaswamy Temple Tiger Reserve in Karnataka, peninsular India (Map source: Karnataka Forest department).

voucher specimens were accessioned and deposited in the Botanical Survey of India (BSI) herbarium. Samples were studied and identified using floras, revisions, checklists such as Blatter (1908), Gamble (1915–1936), Barnes (1944), Kammathy et al. (1967), Rao & Razi (1981), Saldanha (1976), Saldanha (1984), Saldanha (1996), Sharma et al. (1984), Ramesh (2002), Lakshminarasimhan et al. (2019) and online floras, archives, and databases such as Digital flora of Karnataka, Biodiversity Heritage Library (BHL 2022), Digital archives of Botanical Survey of India, Flora of Peninsular India, and through reference against identified herbarium specimens at Botanical Survey of India (BSI), Western Regional Centre, Pune. Apart from own collections, specimens of other collectors were also consulted in different herbaria at Mysore University herbarium, Herbarium of French Institute (HIFP), Pondicherry, University of Agriculture Sciences, Bangalore, Foundation of Revitalisation of Local Health Traditions (FRLH) herbarium, and Ashoka Trust for Research in Ecology and Environment. After identification of species, the endemic species were determined using distributional records from published national, state, district, regional floras, revisionary work, taxonomic accounts, distributional records from published research papers, herbarium reference, and online databases (Nayar 1982; Ahmedullah & Nayar 1986; Venu 2007; Karthikeyan 2009; Jalal & Jayanthi 2012; Jalal et al 2014; Nayar et al. 2014; Singh et al 2015; Jayanthi et al. 2017, 2018; Dash & Mao 2020; Mao & Dash 2020; POWO 2021; WCSP 2021; IPNI 2021; TROPICOS 2021). Species which are strictly confined within the Indian political boundary, Western Ghats, Eastern Ghats, peninsular India or BRT TR is considered as endemic (Table 1). Those species which are found only restricted to BRT TR or found only in few localities in Western Ghats are considered as narrow endemic species. The species which were earlier considered endemic but presently found extended in any one of the countries within Indian subcontinent including Sri Lanka, Bangladesh, Nepal, Pakistan or Myanmar are separately included as near endemic species (Table 2). Photographs of some of the endemic species occurring in BRT TR are provided in Images 1–6.

RESULTS AND DISCUSSION

Taxonomic distribution

The present study resulted in documentation of a total of 211 endemic taxa belonging to 125 genera under 53 families from BRT TR (Table 1). This is almost 15 % of the total flora documented from BRT TR. Of the 211 endemic taxa, 73% were dicotyledonous (154 taxa) and 27% monocotyledonous (57 taxa). The family Orchidaceae is dominant with 39 endemic species, followed by Acanthaceae (23), Rubiaceae (12), Fabaceae (11), Lamiaceae (10), and Lauraceae (10) (Figure 2). These families are also among the 10 dominant families of endemic species in Indian flora as well in the Western Ghats (Singh et al. 2015). Apart from that, about 126 near-endemic species are also documented from BRT TR (Table 2).

Geographical distribution

Among the total endemic taxa documented, 13 are found widely distributed throughout India, 19 are restricted to Peninsular region, 120 are restricted to Western Ghats and 59 are found in both Eastern Ghats (EG) & Western Ghats (WG). In totality, 57 % of the endemic taxa are dominated by WGs elements; 28% of the endemic taxa are shared by EGs & WGs endemic elements. About 9% of the endemic taxa are contributed by Peninsular elements. Only 6% of the Indian endemic taxa are found in BRT Tiger Reserve. This is depicted in Figure 3.

This geographical distribution of endemic flora shows that the BRT TR predominantly composed of Western Ghats endemic elements. About 86% of the Western Ghats endemics in the BRT TR are evergreen and shola forest species occurring in the high rainfall peaks and valleys in BRT TR. Presence of 28% of endemic species common to both Eastern Ghats and Western Ghats could be due to the proximity of BRT towards Eastern Ghats and similar habitats. These common endemic species are mostly of moist deciduous, dry deciduous, and scrub forest species.

Narrow endemics

A few endemic species are found to be confined to only BRT Tiger Reserve. For example, *Barleria morrisiana* is a point endemic species described in 1940, found only in two localities in the dry deciduous forest of BRT TR in Kyathdevaragudi range and Punajur range. Another point endemic species *Amorphophallus mysorensis* described in 1940 is known to occur only in BRT TR, in the moist deciduous forests of Punajur range. This restricted range of distribution may be due to small population of low abundance or subject to under collection and need of more surveys. Even after a lapse of over 80 years these species have so far been recollected only from BRT TR and nowhere else. Another endemic threatened orchid species, *Schoenorchis smeeana* found restricted to few localities of southern Western Ghats is found in BRT TR (Jalal et al. 2014). Another near endemic rare orchid species of southern India, *Vanilla walkerae* is rediscovered from BRT TR after a lapse of more than 100 years (Jayanthi et al. 2018). *Habenaria sahyadrica* a recently described terrestrial orchid from Kerala is also located in BRT TR in the present study (Jayanthi et al. 2017).

Distribution based on vegetation and elevation

The analysis of endemic flora based on elevation distribution in BRT TR showed that 48% (101 spp.) of endemic species are distributed above 1,400 m; 34% (71 spp.) of endemic species occur at 1,000–1,400 m, and 16% (35 spp.) at 600–1,000 m. This shows that evergreen forests which occur above 1,400 m hold most of the endemic species, especially Western Ghats elements. The mid and low elevation regions of BRT TR composed of moist deciduous forests and scrub-dry deciduous forests is dominated by the endemic elements common to WGs & EGs, Peninsular region and Indian region. About 2% (4 spp.) of the endemic species are found in all vegetation types from scrub to evergreen forests. This is depicted in Figure 4.

Life-form distribution

The endemic flora is categorized into different life forms such as trees, shrubs, lianes, climbers, epiphytes, parasitic shrubs and herbs. There are 85 herbs, 35 trees, 39 shrubs (including undershrub), 17 climbers (including herbaceous, woody climbers, lianes or scandent shrubs), 25 epiphytes, and 10 parasitic shrubs documented during the present study (Table 3). Of the total endemic flora, arborescent flora that includes trees, shrubs, lianas, epiphytes, and parasitic shrubs constitutes 50% of which 34% are tree species. The arborescent endemic flora is dominated by Orchidaceae, Rubiaceae, and Lauraceae members. Herbaceous plants contribute 50% of endemic flora which are annuals or perennials with underground bulbs or rhizomatous found during monsoon season and about 51% of them are found in evergreen and shola forests. The herbaceous endemic flora is mostly dominated by Orchidaceae and Poaceae members.

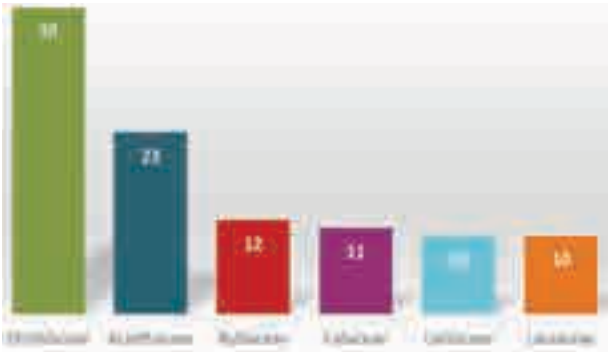


Figure 2. Dominant families of endemic taxa in Biligiri Rangaswamy Temple Tiger Reserve.

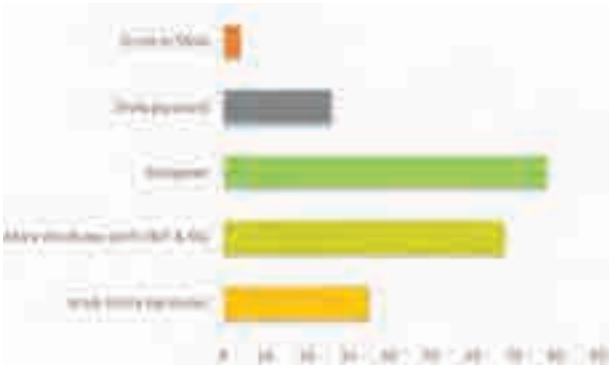


Figure 4. Representation of endemic taxa in different forest types.

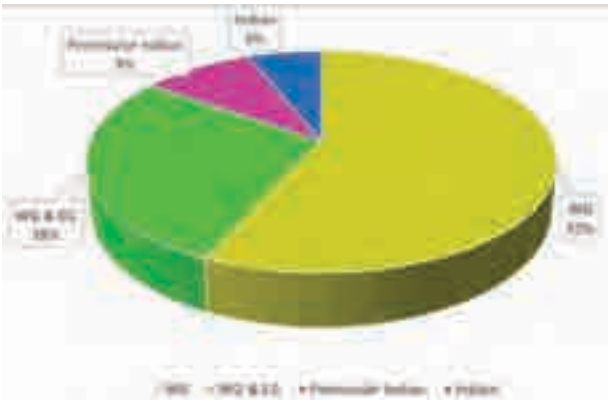


Figure 3. Distribution of endemic taxa based on geographic distribution in Biligiri Rangaswamy Temple Tiger Reserve.

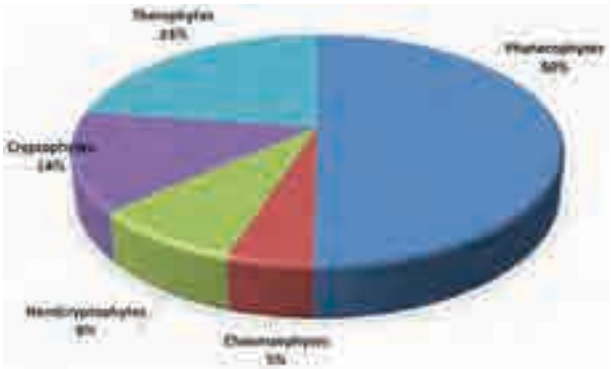


Figure 5. Representation of Raunkiaer's life-form of endemic flora in Biligiri Rangaswamy Temple Tiger Reserve.

Raunkiaer life-form

An analysis based on the Raunkiaer life form classification was also carried out for the endemic flora of BRT Tiger Reserve to determine the biological spectrum of endemic elements which reflect the phytoclimate and adaptation to ecological conditions and prevailing climate of the region. The life form categories were identified according to Raunkiaer (1934) classification. According to this classification, the plant life forms are classified into five main groups such as phanerophytes, chamaephytes, hemicryptophytes, cryptophytes, and therophytes depending on the position and degree of protection of the growth buds of other renewing organs from the ground level in relation to protection during unfavourable seasons. The Raunkiaer life form for BRT is provided in Figure 5. This shows that the endemic flora of BRT TR is dominated by phanerophytes followed by therophytes, hemicryptophytes, cryptophytes, and chamaephytes. Phanerophytes are represented by arborescent group such as trees, shrubs, scandent or woody climbers, epiphytes, and parasitic shrubs. In BRT TR about 51% of the endemic flora (102 taxa) is dominated by phanerophytes and a majority of them are found in evergreen forests. It is to be noted that only 10% of the area of BRT TR holds evergreen forests and hence evergreen forests of BRT should be a high priority conservation zone within this protected area. About 23% of the endemic flora (48 taxa) in BRT TR belongs to therophytes category which are represented by herbaceous plants mainly annuals and a majority are found occurring in shola grassland at higher elevations. Hemicryptophytes, which show reduced stem growth with the shoot apices lying close to the ground surface, are represented by 8% of the flora (18 taxa). Similarly, cryptophytes which comprises of bulbous and rhizomatous plants mainly orchids and gingers comprising about 14 % of the endemic flora (29 taxa). Hemicryptophytes and cryptophytes are mostly found in the scrub, dry deciduous forests, and shola grassland where dry climate prevails and receive moisture only during monsoon period. Only 5% of the endemic flora (10 taxa) belongs to chamaephytes, short stemmed plants that occurs in dry forests or dry habitats. Dominance of phanerophytes over other denotes that BRT TR is

Table 1. List of endemic taxa in the Biligiri Rangaswamy Temple Tiger Reserve.

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
1	Acanthaceae	**Andrographis affinis** Nees	US	September–December	MDF	R.S. Rao 73646
2	Acanthaceae	**Andrographis lineata** Nees	H	June–December	MDF-EGF	Barnes 1944
3	Acanthaceae	**Andrographis neesiana** Wight	H	June	MDF-EGF	Barnes 1944
4	Acanthaceae	**Andrographis serpyllifolia** (Rottler ex Vahl) Wight	H	July	SF-DDF	JJ 194419
5	Acanthaceae	**Asystasia crispata** Benth.	H	March, June–July	MDF-EGF	JJ 194622, JJ 195745
6	Acanthaceae	**Asystasia dalzelliana** Santapau	H	March	MDF	JJ 207003
7	Acanthaceae	**Barleria cuspidata** F.Heyne ex Nees	US	November	SF	JJ 197207
8	Acanthaceae	**Barleria gibsonii** Dalzell	US	September–October	MDF	R.S. Rao 73639
9	Acanthaceae	**Barleria involucrata** var. **elata** (Dalzell) C.B.Clarke	S	September–December	SHEG	Barnes 1944
10	Acanthaceae	**Barleria lawii** T.Anderson	US	September	DDF	JJ 202928
11	Acanthaceae	**Barleria montana** Herb.Madr. ex Nees	US	September	DDF	JJ 194659, JJ 195774, JJ 202863, JJ 202866, JJ 203434
12	Acanthaceae	**Barleria morrisiana** E.Barnes & C.E.C.Fisch.	US	September	DDF	JJ 195731, JJ 203435
13	Acanthaceae	**Barleria prattensis** Santapau	US	October–December	DDF	JJ 194685, JJ 206516
14	Acanthaceae	**Dicliptera cuneata** Nees	US	December	MDF	JJ 203533
15	Acanthaceae	**Justicia micrantha** Wall. ex C.B.Clarke (*Justicia neesii* Ramamoorthy)	H	July–September–December	SF,MDF,EGF	JJ 194417, JJ 203534, JJ 203419
16	Acanthaceae	**Lepidagathis cristata** Willd.	H	November	DDF	JJ 195794
17	Acanthaceae	**Nicoteba nilgherrensis** (Nees) Lindau [*Justicia nilgherrensis* (Nees) Wight ex C.B.Clarke]	H	May–June	SHG	Barnes 1944, Kammathy 1967
18	Acanthaceae	**Strobilanthes barbata** Nees [*Nilgirianthus barbatus* (Nees) Bremek.]	S	October	EGF	JJ 194715
19	Acanthaceae	**Strobilanthes foliosa** (Wight) T.Anderson [*Nilgirianthus foliosus* (Wight) Bremek.]	S	September–October	SHEG	Barnes 1944, Kammathy 1967
20	Acanthaceae	**Strobilanthes lurida** Wight	S	December–April	SHEG	Barnes 1944, Kammathy 1967
21	Acanthaceae	**Strobilanthes meeboldii** Craib [*Nilgirianthus meeboldii* (Craib) Bremek.]	S	March	MDF	JJ 207002
22	Acanthaceae	**Strobilanthes neilgherrensis** Bedd. [*Nilgirianthus neilgherrensis* (Bedd.) Bremek.]	S	September–March	EGF	JJ 197459, JJ 203431
23	Acanthaceae	**Strobilanthes pulneyensis** C.B.Clarke [*Xenacanthus pulneyensis* (C.B.Clarke) Bremek.]	S	September	SHEG	Barnes 1944, Kammathy 1967
24	Amaranthaceae	**Indobanalia thyrsiflora** (Moq.) A.N.Henry & B.Roy. [*Banalia thyrsiflora* Moq.]	H	May	MDF-EGF	Barnes 1944, Kammathy 1967
25	Amaryllidaceae	**Pancratium parvum** Dalzell	H	May–June	SHG	A.S. Rao 79911
26	Annonaceae	**Miliusa nilagirica** Bedd.	T	December–January	EGF	JJ 207025
27	Annonaceae	**Miliusa wightiana** Hook.f. & Thomson	T	December	EGF	JJ 206504
28	Apiaceae	**Pimpinella candolleana** Wight & Arn.	H	September	MDF	R.S.Rao 73537
29	Apiaceae	**Pimpinella wallichiana** (Miq.) Gandhi	H	September–October	MDF-EGF	JJ 194714
30	Apiaceae	**Tetrataenium rigens** (Wall. ex DC.) Manden. [*Heracleum candolleanum* (Wight & Arn.) Gamble]	H	September	MDF	Kammathy 1967
31	Apocynaceae	**Ceropegia hirsuta** Wight & Arn.	C	September	MDF	JJ 203441
32	Apocynaceae	**Ceropegia attenuata** Hook.	C	September	SHG	R.S.Rao 73808
33	Apocynaceae	**Ceropegia fimbriifera** Bedd.	H	June	MDF	Barnes 1944, Kammathy 1967

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
34	Apocynaceae	**Ceropegia pusilla** Wight &Arn.	H	May–September	SHG	Barnes 1944, Kammathy 1967
35	Apocynaceae	**Decalepis hamiltonii** Wight &Arn.	WC	December–March	SF-DDF	JJ 207046
36	Apocynaceae	**Heterostemma beddomei** (Hook.f.) Swarupan. & Mangaly (*Oianthus beddomei* Hook.f.)	WC	February–March	MDF	R.S. Rao 73745
37	Apocynaceae	**Hoya wightii** Hook.f.	E	May	EGF-SHEG	Barnes 1944, Kammathy 1967
38	Apocynaceae	**Vincetoxicum capparidifolium** (Wight & Arn.) Kuntze (*Tylophora capparidifolia* Wight & Arn.)	CS	May	EGF	Barnes 1944
39	Araceae	**Amorphophallus mysorensis** E.Barnes & C.E.C.Fisch. var. **mysorensis**	H	June	MDF	R.H.Beddome No.2159A
40	Araceae	**Arisaema peltatum** C.E.C.Fisch.	H	May–October	SHEG	Barnes 1944, Kammathy 1967
41	Araliaceae	**Heptapleurum capitatum** (Wight &Arn.) Seem. [*Schefflera capitata* (Wight & Arn.) Harms]	S	May–June	EGF	JJ 195717
42	Arecaceae	**Calamus gamblei** Becc.	CS	December–January	EGF	JJ 207060
43	Asparagaceae	**Chlorophytum indicum** (Willd. ex Schult. & Schult.f.) Dress	H	September	DDF	JJ 202877
44	Asparagaceae	**Chlorophytum malabaricum** Baker	H	September	MDF	R.S. Rao 73618
45	Asteraceae	**Anaphalis lawii** Gamble	H	September	SHG	JJ 202970
46	Asteraceae	**Blumea belangeriana** DC.	H	June, December	SHG	JJ 195759, JJ 203547
47	Asteraceae	**Cyanthillium albicans** (DC.) H.Rob. (*Vernonia albicans* DC.)	H	December	DDF	JJ 203566
48	Asteraceae	**Cyanthillium conyzoides** (DC.) H.Rob. (*Vernonia conyzoides* DC.)	H	August–September	SF-DDF	JJ 202872
49	Asteraceae	**Emilia ramulosa** Gamble	H	May–September	DDF	R.S. 73810
50	Asteraceae	**Leucoblepharis subsessilis** Arn. (*Blepharispermum subsessile* DC.)	H	June	MDF	Barnes 1944, Kammathy 1967
51	Asteraceae	**Senecio edgeworthii** Hook.f.	H	August–September	SHG	Barnes 1944, Kammathy 1967
52	Balsaminaceae	**Impatiens balsamina** var. **micrantha** Hook.f.	H	September	SHEG	JJ 202983
53	Balsaminaceae	**Impatiens cuspidata** Wight & Arn. subsp. **cuspidata**	H	May	SHEG	Kammathy 79925
54	Balsaminaceae	**Impatiens fruticosa** Lesch. ex DC.	H	September	SHEG	Barnes 1971
55	Balsaminaceae	**Impatiens goughii** Wight	H	September	SHEG	Barnes 1969
56	Balsaminaceae	**Impatiens scapiflora** B.Heyne ex Wall.	H	September	SHEG	Barnes 1944, Kammathy 1967
57	Bignoniaceae	**Radermachera xylocarpa** (Roxb.) Roxb. ex K.Schum.	T	May–June	MDF	JJ 195990
58	Boraginaceae	**Cordia domestica** Roth	T	May	MDF	JJ 195998
59	Boraginaceae	**Cordia macleodii** (Griff.) Hook.f. & Thomson	T	July	DDF	JJ 194603
60	Boraginaceae	**Cynoglossum meeboldii** Brand	H	April–September	MDF	A.S. Rao 79816
61	Burseraceae	**Boswellia serrata** Roxb.	T	September–March	DDF	A.S. Rao 80115
62	Capparaceae	**Capparis grandiflora** Wall. ex Hook.f. & Thomson	SS	March, July– October	SF	JJ 194509, JJ 195935, JJ 197420
63	Combretaceae	**Terminalia paniculata** B.Heyne ex Roth	T	July	SF,DDF, MDF	JJ 194463, JJ 194552
64	Commelinaceae	**Cyanotis tuberosa** (Roxb.) Schult. &Schult.f.	H	July–October	SF-SHG	JJ 194443, JJ 194575, JJ 194735, JJ 202918
65	Convolvulaceae	**Argyreia cuneata** (Willd.) Ker Gawl.	S	July	SF,DDF, SHG	JJ 194429, JJ 194506
66	Convolvulaceae	**Argyreia sericea** Dalzell & A.Gibson	CS	July–October	SF-EGF	JJ 194466, JJ 195936, JJ 202881, JJ 202936
67	Convolvulaceae	**Argyreia nellygherya** Choisy	C	June	DDF	Barnes 1944
68	Convolvulaceae	**Argyreia pilosa** Wight &Arn.	CS	September–October	DDF	R.S. Rao 73652
69	Crassulaceae	**Kalanchoe bhidei** T.Cooke	H	December	DDF	JJ 203561

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
70	Crassulaceae	**Kalanchoe olivacea** Dalzell	H	March	SHG	JJ 207042
71	Cyperaceae	**Cyperus diaphanus** var. **gracilescens** (Kük.) H.O.Saxena [*Pycreus diaphanus* var. *gracilescens* (Kük.) S.S.Hooper]	H	October	SHG	JJ 194784
72	Dilleniaceae	**Dillenia bracteata** Wight	T	April–August	EGF	JJ 207032
73	Elaeocarpaceae	**Elaeocarpus munroi** (Wight) Mast.	T	February–March	EGF	JJ 197456
74	Eriocaulaceae	**Eriocaulon leucomelas** Steud.	H	December	SHG	JJ 206546
75	Eriocaulaceae	**Eriocaulon margaretae** Fyson	H	April	SHG	A.S. Rao 80401
76	Euphorbiaceae	**Epiprinus mallotiformis** (Müll.Arg.) Croizat	T	October–December	EGF	B.R. Ramesh 1320
77	Euphorbiaceae	**Euphorbia notoptera** Boiss.	H	December	DDF	JJ 203562
78	Fabaceae	**Alysicarpus hamosus** Edgew.	H	December	SHG	JJ 203548
79	Fabaceae	**Alysicarpus racemosus** Benth. [*Desmodiastrum racemosum* var. *rotundifolium* A.Pramanik & Thoth.]	H	December	MDF	JJ 206522
80	Fabaceae	**Alysicarpus roxburghianus** Thoth. & Pramanik	H	December	DDF	JJ 203558
81	Fabaceae	**Crotalaria paniculata** Willd.	US	September–November	SF-DDF	JJ 195770, JJ 202933
82	Fabaceae	**Crotalaria pusilla** Roxb. ex Roth	H	October	SF	JJ 195927
83	Fabaceae	**Dalbergia malabarica** Prain	CS	March	EG	JJ 207069
84	Fabaceae	**Flemingia nilgheriensis** (Benth. ex Baker f.) Wight ex T.Cooke	H	September	SHG	Barnes 1944, Kammathy 1967
85	Fabaceae	**Smithia gracilis** Benth.	H	December	SHG	Barnes 1944, Kammathy 1967
86	Fabaceae	**Vigna vexillata** var. **wightii** (Benth. ex Bedd.) Babu & S.K.Sharma (*Vigna wightii* Benth. ex Bedd.)	C	April	MDF	A.S. Rao 79776, A.S.Rao 80157
87	Fabaceae	**Senna montana** (B.Heyne ex Roth) V.Singh	S	September	SF	JJ 203495
88	Fabaceae	**Tephrosia calophylla** Bedd.	US	June–July	SF	JJ 194636
89	Gentianaceae	**Lomatogonium minus** (Griseb.) Fernald [*Swertia minor* (Griseb.) Knobl.]	H	September	SHG	JJ 203480
90	Gentianaceae	**Swertia corymbosa** (Griseb.) Fielding & Gardner	H	December	SHG	JJ 206508
91	Gentianaceae	**Swertia trichotoma** Wight ex C.B.Clarke	H	October–December	SHG	Barnes 1944, Kammathy 1967
92	Gesneriaceae	**Aeschynanthus perrottetii** A.DC.	E	September–October	SHEG	JJ 194721, JJ 203417
93	Gesneriaceae	**Henckelia incana** (Vahl) Spreng. (*Didymocarpus tomentosus* Wight)	H	October–December	SHEG	R.S. Rao 73794
94	Haloragaceae	**Myriophyllum intermedium** DC.	H	February–March	MDF	Barnes 1944, Kammathy 1967
95	Lamiaceae	**Coleus dysophylloides** (Benth.) A.J.Paton (*Anisochilus dysophylloides* Benth.)	US	September–December	EF	Barnes 1944, Kammathy 1967
96	Lamiaceae	**Isodon nilgherricus** (Benth.) H.Hara (*Plectranthus nilgherricus* Benth.)	H	December	EF	Barnes 1944, Kammathy 1967
97	Lamiaceae	**Leucas eriostoma** Hook.f.	US	March	SHG	JJ 207072
98	Lamiaceae	**Leucas hirta** (B.Heyne ex Roth) Spreng.	H	July	SF	JJ 194407
99	Lamiaceae	**Leucas montana** (Roth) Spreng.	US	April–September	DDF-EGF	R.S. Rao 73783, A.S. Rao 79938
100	Lamiaceae	**Leucas prostrata** (Hook.f.) Gamble	H	April	EGF	Barnes 1944, Kammathy 1967
101	Lamiaceae	**Leucas pubescens** Benth.	H	April–June	MDF	A.S. Rao 79774
102	Lamiaceae	**Pogostemon mollis** Benth.	H	October–December	SHEG	JJ 194727, 203550
103	Lamiaceae	**Scutellaria colebrookeana** Wall. ex Benth.	H	December	SHEG	Barnes 1944, Kammathy 1967
104	Lamiaceae	**Scutellaria wightiana** Benth.	H	March	EGF	JJ 197445
105	Lauraceae	**Actinodaphne bourdillonii** Gamble	T	December	EGF	JJ 206538

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
106	Lauraceae	**Actinodaphne lawsonii** Gamble	T	December	EGF	B.R. Ramesh 1434A
107	Lauraceae	**Beilschmiedia wightii** (Nees) Benth. ex Hook.f.	T	December–March	SHEG	JJ 206544
108	Lauraceae	**Cinnamomum travancoricum** Gamble	T	January–June	EGF	A.S. Rao, 79935
109	Lauraceae	**Cinnamomum wightii** Meisn.	T	March	EGF	JJ 207024
110	Lauraceae	**Cryptocarya beddomei** Gamble	T	March	EGF	JJ 207028
111	Lauraceae	**Litsea floribunda** (Blume) Gamble	T	March–October	SHEG	JJ 207097
112	Lauraceae	**Litsea stocksii** (Meisn.) Hook.f.	T	March	SHEG	JJ 207099
113	Lauraceae	**Litsea wightiana** (Nees) Wall. ex Hook.f.	T	March–September	SHEG	JJ 203407, JJ 207100
114	Lauraceae	**Phoebe wightii** Meisn.	T	March	EGF	JJ 197458, JJ 207029
115	Loranthaceae	**Dendrophthoe memecylifolia** (Wight & Arn.) Danser	PS	October	EGF	JJ 194746
116	Loranthaceae	**Helicanthes elastica** (Desr.) Danser	PS	December–March	MDF-EGF	JJ 203532, JJ 207071
117	Loranthaceae	**Helixanthera intermedia** (Wight) Danser	PS	July	EGF	JJ 194540
118	Loranthaceae	**Helixanthera obtusata** (Wall. ex Wight & Arn.) Danser	PS	March–May	EGF	JJ 195716, JJ 207027
119	Loranthaceae	**Helixanthera wallichiana** (Schult. &Schult.f.) Danser	PS	September	EGF	JJ 203452
120	Loranthaceae	**Macrosolen trigonus** (Wight & Arn.) Tiegh. [*Dendrophthoe trigona* (Wight & Arn.) Danser ex Santapau]	PS	October	SF-DDF	JJ 195940
121	Loranthaceae	**Taxillus heyneanus** (Schult. &Schult.f.) Danser	PS	July	DDF	JJ 194578
122	Loranthaceae	**Taxillus recurvus** (Wall. ex DC.) Tiegh.	PS	April–May, December	MDF-EGF	JJ 195988, JJ 206593
123	Malvaceae	**Grewia orbiculata** Rottler	T	June–July	DDF	JJ 195732, JJ 194639
124	Malvaceae	**Microcos heterotricha** (Mast.) Burret (*Grewia heterotricha* Mast.)	SS	October	DDF	JJ 195929
125	Melastomataceae	**Memecylon lushingtonii** Gamble	S	May–June	SF	JJ 195723
126	Melastomataceae	**Memecylon talbotianum** D.Brandis	T	March	EGF	JJ 207015, JJ 207076
127	Melastomataceae	**Osbeckia brachystemon** Naudin (*Osbeckia cupularis* D.Don ex Wight & Arn.)	H	September	SHG	JJ 203420
128	Melastomataceae	**Osbeckia leschenaultiana** DC.	H	September	SHG	Saldanha 1996
129	Meliaceae	**Naregamia alata** Wight &Arn.	US	March	EGF	JJ 207094
130	Musaceae	**Ensete superbum** (Roxb.) Cheesman	H	June–September	EGF	Barnes 1944
131	Myrtaceae	**Syzygium densiflorum** Wall. ex Wight &Arn.	T	December–March	SHEG	JJ 206543, JJ 207041
132	Myrtaceae	**Syzygium malabaricum** (Bedd.) Gamble	T	April	MDF	JJ 202852
133	Oleaceae	**Ligustrum gamblei** Ramamoorthy (*Ligustrum minii* Raizada)	T	May–June	MDF-EGF	JJ 195753
134	Orchidaceae	**Anoectochilus elatus** Lindl.	H	October	EGF	JJ 195959
135	Orchidaceae	**Bulbophyllum fimbriatum** (Lindl.) Rchb.f. (*Cirrhopetalum fimbriatum* Lindl.)	E	March–April	EGF	JJ 197448
136	Orchidaceae	**Bulbophyllum fusco-purpureum** Wight	E	March–April	EGF-SHEG	JJ 197450
137	Orchidaceae	**Bulbophyllum kaitiense** Rchb.f.	E	June–October	EGF	R.R. Rao 1039
138	Orchidaceae	**Bulbophyllum proudlockii** (King & Pantl.) J.J.Sm. (*Cirrhopetalum proudlockii* King & Pantl.)	E	April	EGF	A.S. Rao 79899
139	Orchidaceae	**Coelogyne nervosa** A.Rich.	E	August	SHEG	JJ 195769
140	Orchidaceae	**Crepidium intermedium** (A. Rich.) Sushil K. Singh, Agrawala & Jalal (*Microstylis stocksii* Hook.f.) [*Malaxis intermedia* (A.Rich.) Seidenf.]	H	June–September	SHG	Barnes 1944, Kammathy 1967
141	Orchidaceae	**Dendrobium aqueum** Lindl.	E	September–October	SHEG	JJ 207149
142	Orchidaceae	**Dendrobium nanum** Hook.f.	E	September–October	SHEG	JJ 207139

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
143	Orchidaceae	**Dendrobium nodosum** Dalzell [*Flickingeria nodosa* (Dalzell) Seidenf.]	E	September	SHEG	JJ 202978
144	Orchidaceae	**Eria exilis** Hook.f.	E	August–September	SHEG	JJ 202964
145	Orchidaceae	**Eria filiformis** (Wight) Rchb.f. [*Porpax filiformis* (Wight) Schuit., Y.P.Ng & H.A.Pedersen] [*Eria dalzellii* (Hook. ex Dalzell) Lindl.]	E	July	EGF	JJ 207130
146	Orchidaceae	**Eria microchilos** (Dalzell) Lindl.	E	October	SHEG	JJ 194739
147	Orchidaceae	**Eria mysorensis** Lindl.	E	August–September	EGF	JJ 202976
148	Orchidaceae	**Eria nana** A.Rich. [*Porpax nana* (A.Rich.) Schuit., Y.P.Ng & H.A.Pedersen]	E	September	SHEG	R.S. Rao 73721, R.S. Rao 73770
149	Orchidaceae	**Eria pauciflora** Wight [*Cylindrolobus pauciflorus* (Wight) Schuit., Y.P.Ng & H.A.Pedersen]	E	September	EGF	Barnes 1944, Kammathy 1967
150	Orchidaceae	**Eria polystachya** A.Rich [*Pinalia polystachya* (A.Rich.) Kuntze]	E	September	EGF	Barnes 1944, Kammathy 1967
151	Orchidaceae	**Eria pseudocalvicaulis** Blatt.	E	August–September	EGF	JJ 203499
152	Orchidaceae	**Eria reticosa** Wight	E	June–July	SHEG	B.R.Ramesh 1490
153	Orchidaceae	**Eulophia pratensis** Lindl. (*Eulophia ramentacea* Wight)	H	December	SHG	Barnes 1944, Kammathy 1967
154	Orchidaceae	**Gastrochilus flabelliformis** (Blatt. & McCann) C.J.Saldanha	E	March	EGF-SHEG	JJ 207138
155	Orchidaceae	**Habenaria brachyphylla** (Lindl.) Aitch.	H	August–September	MDF	JJ 207148
156	Orchidaceae	**Habenaria elliptica** Wight	H	September		R.S. Rao, 73789
157	Orchidaceae	**Habenaria elwesii** Hook.f.	H	August–September	SHG	JJ 207140
158	Orchidaceae	**Habenaria foliosa** A.Rich.	H	September	EGF	JJ 203500
159	Orchidaceae	**Habenaria heyneana** Lindl.	H	September	SHG	JJ 203482
160	Orchidaceae	**Habenaria hollandiana** Santapau	H	September	MDF	R.S. Rao, 73746
161	Orchidaceae	**Habenaria longicornu** Lindl.	H	September	MDF	JJ 203440
162	Orchidaceae	**Habenaria multicaudata** Sedgw.	H	September-October	EGF	JJ 207135
163	Orchidaceae	**Habenaria ovalifolia** Wight	H	September-October	MDF	JJ 195934
164	Orchidaceae	**Habenaria rariflora** A.Rich.	H	September	SHG	R.S. Rao 73788
165	Orchidaceae	**Habenaria sahyadrica** K.M.P.Kumar, Nirmesh, V.B.Sreek. & Kumar	H	December	EGF	JJ 206559
166	Orchidaceae	**Liparis platyphylla** Ridl.	H	September	MDF	Barnes 1944, Kammathy 1967
167	Orchidaceae	**Oberonia chandrasekharanii** V.J.Nair, V.S.Ramach. & R.Ansari	E	September–December	EGF	JJ 202977
168	Orchidaceae	**Oberonia verticillata** Wight	E	September	EGF	Barnes 1944
169	Orchidaceae	**Peristylus stocksii** (Hook.f.) Kraenzl.	E	September	SHG	Barnes 1944
170	Orchidaceae	**Plectoglossa perrottetiana** (A. Rich.) K.Prasad & Venu (*Habenaria perrottetiana* A.Rich.)	H	September	SHG	R.S. Rao, 73786, R.R. Rao 3402
171	Orchidaceae	**Schoenorchis jerdoniana** (Wight) Garay	E	September–June	EGF	Barnes 1944
172	Orchidaceae	**Schoenorchis smeeana** (Rchb.f.) Jalal, Jayanthi & Schuit. [*Schoenorchis latifolia* (C.E.C.Fisch.) C.J.Saldanha] (*Rhynchostylis latifolia*C.E.C.Fisch.) [*Xenikophyton smeeanum* (Rchb.f.) Garay]	E	October–June	EGF-SHEG	JJ 195738, JJ 195943
173	Phyllanthaceae	**Glochidion hohenackeri** (Müll.Arg.) Bedd. var. **hohenackeri** [*Glochidion fagifolium* (Müll.Arg.) Miq. ex Bedd.]	T	April	EGF	A.S.Rao, 79969
174	Phyllanthaceae	**Glochidion hohenackeri** var. **johnstonei** (Hook.f.) Chakrab. & M.Gangop.	T	July	EGF	JJ 194536

	Family	Plant Name	Habit	Flowers	Forest type	Voucher no.
175	Phyllanthaceae	**Meineckia longipes** (Wight) G.L.Webster	S	September–December	EGF	JJ 203456, JJ 206525
176	Phyllanthaceae	**Phyllanthus indofischeri** Bennet	T	March–April	DDF	JJ 197484
177	Phyllanthaceae	**Phyllanthus narayanswamyii** Gamble	US	December	SHEG	JJ 206540
178	Piperaceae	**Piper hookeri** Miq.	CS	July	EGF	JJ 194542
179	Piperaceae	**Piper schmidtii** Hook.f.	CS	April	SHEG	A.S. Rao 79970, A.S. Rao 79977
180	Pittosporaceae	**Pittosporum dasycaulon** Miq.	T	May–June	EGF	JJ 196000
181	Pittosporaceae	**Pittosporum neelgherrense** Wight & Arn.	T	December–February	EGF	R.R. Rao 1805
182	Poaceae	**Aristida stocksii** (Hook.f.) Domin	H	October	SF	JJ 195906
183	Poaceae	**Arthraxon villosus** C.E.C.Fisch.	H	December	EGF	JJ 206567
184	Poaceae	**Capillipedium filiculme** (Hook.f.) Stapf	H	December	SHG	JJ 203556
185	Poaceae	**Isachne setosa** C.E.C.Fisch.	H	October	SHG	JJ 194771
186	Poaceae	**Oropetium roxburghianum** (Schult.) S.M.Phillips	H	December	SHG	JJ 206570
187	Ranunculaceae	**Clematis wightiana** Wall. ex Wight &Arn.	WC	December–February	EGF-SHEG	Kammathy 1967
188	Ranunculaceae	**Ranunculus subpinnatus** Wight &Arn.	H	May	SHG	Blatter 1908
189	Ranunculaceae	**Thalictrum dalzellii** Hook.	H	July–September	SHG	Barnes 1944
190	Rosaceae	**Rubus kasthuriae** Gandhi	CS	May–June	SHEG	Kammathy 1967
191	Rubiaceae	**Gardenia gummifera** L.f.	T	March	DDF	JJ 197403
192	Rubiaceae	**Ixora elongata** B.Heyne ex G.Don	T	May–October	EGF	JJ 194741, JJ 195962
193	Rubiaceae	**Lasianthus coffeoides** Fyson	S	May	EGF	Barnes 1944, Kammathy 1967
194	Rubiaceae	**Mussaenda glabrata** (Hook.f.) Hutch. ex Gamble	S	September	MDF	R.S.Rao, 32944
195	Rubiaceae	**Ophiorrhiza hirsutula** Wight ex Hook.f.		April	EGF	A.S.Rao, 79851
196	Rubiaceae	**Pavetta breviflora** DC.	S	April	SHEG	JJ 202844
197	Rubiaceae	**Pavetta crassicaulis** Bremek.	S	April	EGF	A.S.Rao, 79853
198	Rubiaceae	**Psychotria bisulcata** Wight & Arn.	S	June	SHEG	Barnes 1944
199	Rubiaceae	**Psychotria flavida** Talbot	S	December	SHEG	JJ 206514
200	Rubiaceae	**Psychotria octosulcata** Talbot	S	March	EGF	JJ 207034
201	Rubiaceae	**Psychotria truncata** Wall.	S	March	EGF	JJ 207073
202	Rubiaceae	**Wendlandia thyrsoidea** (Roth) Steud.	T	March	MDF-SHEG	JJ 197279
203	Rutaceae	**Atalantia wightii** Yu.Tanaka	S	March	EGF	JJ 207078
204	Salicaceae	**Flacourtia montana** J.Graham	T	March	MDF-EGF	JJ 197276
205	Santalaceae	**Viscum angulatum** B.Heyne ex DC.	PS	October	SF	JJ 194656
206	Santalaceae	**Viscum subracemosum** Sanjai & N.P.Balakr.	PS	December	SF	JJ 206518
207	Sapindaceae	**Allophylus rheedei** (Wight) Radlk.	T	April	MDF	A.S. Rao 79777
208	Sapotaceae	**Isonandra perrottetiana** A.DC.	T	March	SHEG	JJ 207040, JJ 207077
209	Vitaceae	**Tetrastigma sulcatum** (M.A.Lawson) Gamble	CS	March	MDF	JJ 207005
210	Zingiberaceae	**Curcuma pseudomontana** J.Graham	H	May	EGF	JJ 195953
211	Zingiberaceae	**Zingiber cernuum** Dalzell	H	September	MDF	JJ 202952

C—Climbers | E—Epiphytes | H—Herbs | PS—Parasitic shrubs | S—Shrubs | SS—Scandent shrubs | T—Trees | US—Undershrubs | WC—Woody climbers | SF—Scrub forest | DDF—Dry deciduous forest | MDF—Moist deciduous forest | EGF—Evergreen forest | SHEG—Shola evergreen forest | SHG—Shola grassland.

Table 2. List of near endemic species in the study area Biligiri Rangaswamy Temple Tiger Reserve.

	Family	Plant Name	Habit	Flowering	Voucher no.	Distribution
1	Acanthaceae	**Andrographis alata** (Vahl) Nees	H	March–April	JJ 197483	India, Sri Lanka
2	Acanthaceae	**Asystasia chelonoides** Nees	H	August–September	JJ 202935	India, Sri Lanka
3	Acanthaceae	**Barleria buxifolia** L.	US	December	JJ 206526	India, Sri Lanka
4	Acanthaceae	**Barleria courtallica** Nees	US	March	JJ 197468	India, Sri Lanka
5	Acanthaceae	**Barleria mysorensis** Roth	US	July	JJ 194481	India, Sri Lanka
6	Acanthaceae	**Strobilanthes heyneana** Nees [*Nilgirianthus heyneanus* (Nees) Bremek.]	S	October–December	JJ 206588, JJ 194693	India, Sri Lanka
7	Acanthaceae	**Strobilanthes kunthiana** (Nees) T.Anderson ex Benth. (*Phlebophyllum kunthianum* Nees)	S	December	JJ 203476	India, Myanmar
8	Acanthaceae	**Strobilanthes cordifolia** (Vahl) J.R.I.Wood [*Phlebophyllum spicatum* (Roth) Bremek.]	S	December	JJ 206587	India, Sri Lanka
9	Acanthaceae	**Barleria involucrata** Nees var. **involucrata**	S	September–December	Barnes 1944	India, Sri Lanka
10	Acanthaceae	**Justicia vahliana** Schult. (*Justicia vahlii* Roth)	H	October–December	R.S. Rao 73539	India, Bangladesh, Pakistan
11	Acanthaceae	**Ruellia beddomei** C.B.Clarke	H	September	Barnes 1944	India, Nepal
12	Amaryllidaceae	**Pancratium triflorum** Roxb.	H	October	JJ 207129	India, Bangladesh
13	Anacardiaceae	**Buchanania axillaris** (Desr.) Ramamoorthy	T	November–December	JJ 206597	India, Sri Lanka
14	Annonaceae	**Uvaria narum** (Dunal) Blume	CS	May	JJ 195964	India, Sri Lanka
15	Apiaceae	**Bupleurum ramosissimum** Wight &Arn. (*Bupleurum virgatum* Wight & Arn.)	H	May	Barnes 1944, Kammathy1967	India, Sri Lanka
16	Apocynaceae	**Ceropegia candelabrum** L.	C	September–October	JJ 195933, JJ 202993	India, Sri Lanka
17	Apocynaceae	**Secamone emetica** (Retz.) R.Br. ex Sm.	CS	December–February–March	JJ 202811, JJ 203505, JJ 203510, JJ 207064	India, Sri Lanka
18	Apocynaceae	**Hoya pauciflora** Wight	E	May–June	JJ 195739	India, Sri Lanka
19	Apocynaceae	**Cynanchum tunicatum** (Retz.) Alston	C	December	Barnes 1944	India, Sri Lanka
20	Araceae	**Arisaema barnesii** C.E.C.Fisch.	H	May–October	Barnes 1944	India, Sri Lanka
21	Araceae	**Lagenandra ovata** (L.) Thwaites	H	June	Barnes 1944	India, Sri Lanka
22	Araliaceae	**Heptapleurum stellatum** Gaertn. [*Schefflera stellata* (Gaertn.) Baill.]	CS	May–June	JJ 195987	India, Sri Lanka
23	Arecaceae	**Phoenix loureiroi** var. **pedunculata** (Griff.) Govaerts (*Phoenix humilis* Royle ex Becc. var. *pedunculata* Becc.)	T	May	JJ 195968	India, Pakistan, Nepal Bangladesh
24	Asparagaceae	**Asparagus gonoclados** Baker	H	May	Barnes 1944	India, Sri Lanka
25	Asteraceae	**Anaphalis subdecurrens** Gamble	H	October	JJ 194704	India, Sri Lanka
26	Begoniaceae	**Begonia malabarica** Lam.	H	May–June	R.S. 73708	India, Sri Lanka
27	Burseraceae	**Commiphora caudata** (Wight & Arn.) Engl.	T	December	JJ 206596	India, Sri Lanka
28	Capparaceae	**Capparis divaricata** Lam.	S	October–March	JJ 194650, JJ 197419	India, Sri Lanka
29	Celastraceae	**Elaeodendron glaucum** (Rottb.) Pers. [*Cassine glauca* (Rottb.) Kuntze]	T	September–December	JJ 194630, JJ 197413, JJ 206580	India, Sri Lanka
30	Celastraceae	**Elaeodendron glaucum** (Rottb.) Pers.	T	March, July, December	JJ 194630, JJ 197413, JJ 206580	India, Sri Lanka
31	Celastraceae	**Elaeodendron paniculatum** Wight & Arn.	T	March	JJ 207091	India, Sri Lanka
32	Celastraceae	**Euonymus dichotomus** B.Heyne ex Wall.	T	March–May	Barnes 1944, Kammathy 1967	India, Sri Lanka
33	Combretaceae	**Combretum albidum** G.Don [*Combretum ovalifolium* Roxb. ex G.Don]	SS	March–May	JJ 195971, JJ 197281, JJ 207044	India, Sri Lanka

	Family	Plant Name	Habit	Flowering	Voucher no.	Distribution
34	Combretaceae	**Terminalia anogeissiana** Gere & Boatwr.	T	March–September	JJ 194404	Indian subcontinent
35	Commelinaceae	**Cyanotis villosa** (Spreng.) Schult. & Schult.f.	H	September–December, March	JJ 197469, JJ 203489, JJ 203581	India, Sri Lanka
36	Commelinaceae	**Commelina indehiscens** E.Barnes	H	September	R.S. 73556	India, Sri Lanka
37	Commelinaceae	**Cyanotis fasciculata** (B.Heyne ex Roth) Schult. & Schult.f.	H	September	Barnes 1944	India, Sri Lanka
38	Commelinaceae	**Cyanotis pilosa** Schult. & Schult.f.	H	September	R.S. 73589	India, Sri Lanka
39	Commelinaceae	**Murdannia esculenta** (Wall. ex C.B.Clarke) Abeyw.	H	September	R.S. 73775	India, Sri Lanka
40	Convolvulaceae	**Argyreia elliptica** (Roth) Choisy	CS	September–October	JJ 194681, JJ 202943, JJ 203560	India, Nepal, Sri Lanka
41	Daphniphyllaceae	**Daphniphyllum neilgherrense** (Wight) K.Rosenthal	T	October–December	B.R. Ramesh 1571	India, Sri Lanka
42	Dioscoreaceae	**Dioscorea tomentosa** J.Koenig ex Spreng.	C	August–September	JJ 202927	India, Bangladesh, Sri Lanka
43	Ebenaceae	**Diospyros melanoxylon** Roxb.	T	December–March	JJ 206577, JJ 207090	India, Sri Lanka
44	Eriocaulaceae	**Eriocaulon thwaitesii** Körn.	H	September	JJ 203447	India, Myanmar, Sri Lanka
45	Euphorbiaceae	**Givotia moluccana** (L.) Sreem. (*Givotia rottleriformis* Griff. ex Wight)	T	May–June, September	JJ 195734, JJ 202992	India, Sri Lanka
46	Euphorbiaceae	**Glochidion candolleanum** (Wight &Arn.) Chakrab. & M.Gangop. (*Glochidion arboreum* Wight)	T	September	R.S. 73829	India, Sri Lanka
47	Fabaceae	**Cajanus rugosus** (Wight &Arn.) Maesen (*Atylosia rugosa* Wight &Arn.)	CS	December	JJ 206510	India, Sri Lanka
48	Fabaceae	**Cajanus albicans** (Wight &Arn.) Maesen	C	November	JJ 195775, JJ 197242	India, Sri Lanka
49	Fabaceae	**Crotalaria scabrella** Wight &Arn.	H	March	JJ 207057	India, Sri Lanka
50	Fabaceae	**Dichrostachys cinerea** (L.) Wight & Arn. subsp. **cinerea**	S	March	JJ 202807	India, Sri Lanka
51	Fabaceae	**Hardwickia binata** Roxb.	T	December	JJ 203504	India, Bangladesh
52	Fabaceae	**Smithia bigemina** Dalzell	H	September–December	JJ 206511, JJ 206554	India, Pakistan
53	Fabaceae	**Tephrosia tinctoria** (L.) Pers.	US	October	JJ 194753	India, Sri Lanka
54	Fabaceae	**Dalbergia sissoides** Graham ex Wight & Arn.	T	March–April	JJ 197270, JJ 207085	India, Java
55	Gesneriaceae	**Rhynchoglossum notonianum** (Wall.) B.L.Burtt	H	May & December	Barnes 1944	India, Sri Lanka
56	Hypericaceae	**Hypericum mysurense** Wall. ex Wight & Arn.	S	May–October	JJ 194749, JJ 195984	India, Sri Lanka
57	Lamiaceae	**Endostemon viscosus** (Roth) M.R.Ashby	US	July–October	JJ 194516, JJ 194571, JJ 195911, JJ 202958	India, Sri Lanka
58	Lamiaceae	**Gomphostemma heyneanum** Wall. ex Benth.	US	August–September	JJ 202920	India, Vietnam
59	Lamiaceae	**Coleus divaricatus** A.J.Paton (*Anisochilus paniculatus* Benth.)	H	April	A.S. Rao 80069	India, Sri Lanka
60	Lamiaceae	**Coleus malabaricus** Benth.	H	December	Barnes 1944	India, Sri Lanka
61	Lauraceae	**Cinnamomum sulphuratum** Nees	T	March–June	JJ 195707, JJ 207061	India, Myanmar
62	Liliaceae	**Lilium wallichianum** var. **neilgherrense** (Wight) H.Hara	H	October	JJ 194747, JJ 202979	India, Nepal
63	Loranthaceae	**Helixanthera hookeriana** (Wight &Arn.) Danser	PS	March	JJ 207108	India, Sri Lanka
64	Loranthaceae	**Taxillus courtallensis** (Gamble) Danser	PS	December	JJ 203507	India, Sri Lanka
65	Loranthaceae	**Dendrophthoe neelgherrensis** (Wight &Arn.) Tiegh.	PS	September	Barnes 1944	India, Sri Lanka
66	Magnoliaceae	**Magnolia nilagirica** (Zenker) Figlar	T	March	JJ 197466	India, Sri Lanka

	Family	Plant Name	Habit	Flowering	Voucher no.	Distribution
67	Malvaceae	**Byttneria herbacea** Roxb.	H	July–September	JJ 194570, JJ 202867	India, Bangladesh
68	Malvaceae	**Eriolaena hookeriana** Wight &Arn.	T	September	JJ 203438	India, Sri Lanka
69	Molluginaceae	**Trigastrotheca pentaphylla** (L.) Thulin (*Mollugo pentaphylla* L.)	H	July	JJ 194628	India, Sri Lanka
70	Moraceae	**Dorstenia indica** Wight	H	September	Barnes 1944	India, Sri Lanka
71	Myristicaceae	**Myristica dactyloides** Gaertn.	T	May–June, December	JJ 195718, JJ 206502	India, Bangladesh
72	Oleaceae	**Jasminum angustifolium** (L.) Willd.	CS	July	JJ 194484, JJ 194515	India, Sri Lanka
73	Oleaceae	**Jasminum ritchiei** C.B.Clarke	CS	December	JJ 203506	India, Bhutan
74	Oleaceae	**Ligustrum robustum** subsp. **perrottetii** (A.DC.) de Juana	T	May–June	JJ 195973	India, Laccadive islands
75	Oleaceae	**Jasminum brevilobum** DC.	CS	September	Barnes 1944	India, Vietnam
76	Orchidaceae	**Aerides ringens** (Lindl.) C.E.C.Fisch.	E	July	JJ 194449, JJ 194547	India, Sri Lanka
77	Orchidaceae	**Coelogyne breviscapa** Lindl.	E	March–April	JJ 197478	India, Sri Lanka
78	Orchidaceae	**Coelogyne odoratissima** Lindl.	E	March–April	JJ 197479	India, Sri Lanka
79	Orchidaceae	**Crepidium versicolor** (Lindl.) Sushil K.Singh, Agrawala & Jalal [*Malaxis versicolor* (Lindl.) Sant. & Kapadia]	H	October	JJ 194748	India, Sri Lanka
80	Orchidaceae	**Diplocentrum recurvum** Lindl.	E	May–June	JJ 195767, JJ 195952	India, Sri Lanka
81	Orchidaceae	**Gastrochilus acaulis** (Lindl.) Kuntze [*Saccolabium pulchellum* (Wight) C.E.C.Fisch.]	E	March	JJ 207105	India, Sri Lanka
82	Orchidaceae	**Habenaria longicorniculata** J.Graham	H	September–October	JJ 194732, JJ 202967	India, Sri Lanka
83	Orchidaceae	**Habenaria roxburghii** Nicolson	H	July–September	JJ 194441, JJ 202957	India, Sri Lanka
84	Orchidaceae	**Luisia tenuifolia** Blume	E	July	JJ 194546	India, Sri Lanka
85	Orchidaceae	**Oberonia brunoniana** Wight	E	December	JJ 206598	India, Bangladesh
86	Orchidaceae	**Papilionanthe cylindrica** (Lindl.) Seidenf. (*Aerides cylindrica* Lindl.)	E	March–June	JJ 195706, JJ 197449	India, Sri Lanka
87	Orchidaceae	**Trichoglottis tenera** (Lindl.) Rchb.f.	E	March	JJ 197480	India, Sri Lanka
88	Orchidaceae	**Vanilla walkerae** Wight	C	March–December	JJ 207115	India, Sri Lanka
89	Orchidaceae	**Dendrobium jerdonianum** Wight (*Dendrobium nutans* Lindl.)	E	April–May	Barnes 1944	India, Sri Lanka
90	Orchidaceae	**Habenaria barbata** Wight ex Hook.f.	H	September	Barnes 1944	India, Sri Lanka
91	Orchidaceae	**Liparis atropurpurea** Lindl.	H	September	Barnes 1944	India, Sri Lanka
92	Orchidaceae	**Peristylus spiralis** A.Rich.	H	September	Barnes 1944	India, Sri Lanka
93	Orobanchaceae	**Parasopubia delphiniifolia** (L.) H.-P.Hofm. & Eb.Fisch.	H	October	JJ 195928	India, Sri Lanka
94	Orobanchaceae	**Pedicularis zeylanica** Benth.	H	September	Barnes 1944	India, Sri Lanka
95	Phyllanthaceae	**Glochidion bourdillonii** Gamble	T	February–March	A.S. Rao 80036	India, Bhutan
96	Phyllanthaceae	**Phyllanthus rheedei** Wight	H	July–September	JJ 194430	India, Sri Lanka
97	Poaceae	**Cyrtococcum deccanense** Bor	H	August–September	JJ 202908	India, Sri Lanka
98	Poaceae	**Pseudanthistiria umbellata** (Hack.) Hook.f.	H	December	JJ 206557	India, Sri Lanka
99	Poaceae	**Themeda cymbaria** Hack.	H	March–April	JJ 202846	India, Sri Lanka
100	Poaceae	**Tripogon jacquemontii** Stapf	H	December	JJ 206551	India, Bangladesh
101	Poaceae	**Themeda cymbaria** Hack.	H	September	R.S. Rao 73572	India, Sri Lanka
102	Poaceae	**Tripogon jacquemontii** Stapf	H	April–May	A.S. Rao 80409	India, Bangladesh
103	Primulaceae	**Myrsine wightiana** Wall. ex A.DC. [*Rapanea wightiana* (Wall. ex A.DC.) Mez]	T	May-June	JJ 195710	India, Sri Lanka
104	Ranunculaceae	**Ranunculus wallichianus** Wight & Arn.	H	May	Barnes 1944, Kammathy 1967	India, Sri Lanka
105	Rosaceae	**Rubus fairholmianus** Gardner	CS	March	JJ 207070	India, Sri Lanka

	Family	Plant Name	Habit	Flowering	Voucher no.	Distribution
106	Rubiaceae	**Benkara malabarica** (Lam.) Tirveng.	S	March–September	JJ 194510, JJ 195724, JJ 202808, JJ 202810, JJ 202812, JJ 202937	India, Sri Lanka
107	Rubiaceae	**Gardenia latifolia** Aiton	T	March	JJ 197485	India, Bangladesh
108	Rubiaceae	**Meyna laxiflora** Robyns	T	May–July	JJ 194476, JJ 195945, JJ 197287	India, Bangladesh
109	Rubiaceae	**Mussaenda glabrata** (Hook.f.) Hutch. ex Gamble	S	July	JJ 194548	India, Bangladesh
110	Rubiaceae	**Neanotis monosperma** (Wight & Arn.) W.H.Lewis	H	September	JJ 203457	India, Sri Lanka
111	Rubiaceae	**Psychotria nilgherensis** (Kuntze) Govaerts & Chakrab. [*Psychotria elongata* (Wight) Hook.f.]	S	May–June, September	JJ 195741	India, Sri Lanka
112	Rubiaceae	**Psychotria nigra** (Gaertn.) Alston	S	March	JJ 207038	India, Sri Lanka
113	Rubiaceae	**Ixora pavetta** Andrews	S	July	JJ 194633	India, Bangladesh, Sri Lanka
114	Rubiaceae	**Ixora notoniana** Wall. ex G.Don	S	May	Barnes 1944	India, Sri Lanka
115	Rutaceae	**Chloroxylon swietenia** DC.	T	March–June	JJ 195764, JJ 197404	India, Sri Lanka
116	Rutaceae	**Clausena indica** (Dalzell) Oliv.	T	March–July, December	JJ 194625, JJ 206568, JJ 207079	India, Sri Lanka
117	Rutaceae	**Pleiospermium alatum** (Wall. ex Wight & Arn.) Swingle	T	March–April	JJ 197422	India, Sri Lanka
118	Rutaceae	**Pamburus missionis** (Wall. ex Wight) Swingle	T	March–July	A.S. Rao 80398	India, Sri Lanka
119	Salicaceae	**Casearia thwaitesii** Briq.	T	May	JJ 195712	India, Sri Lanka
120	Salicaceae	**Scolopia crenata** (Wight &Arn.) Clos	T	July	JJ 194522	India, Sri Lanka
121	Santalaceae	**Viscum capitellatum** Sm.	PS	September	R.S. Rao 73760	India, Sri Lanka
122	Sapotaceae	**Madhuca longifolia** var. **latifolia** (Roxb.) A.Chev.	T	March	JJ 203513, JJ 207043	India, Bangladesh
123	Tiliaceae	**Grewia bracteata** B.Heyne ex Roth (*Grewia wightiana* J.R. Drumm.)	T	May	Kammathy 1967	India, Sri Lanka
124	Vitaceae	**Ampelocissus indica** (L.) Planch.	CS	December	JJ 206562	India, Sri Lanka
125	Vitaceae	**Ampelocissus araneosa** (Dalzell) Gamble	CS	July–September	Kammathy 1967	India, Thailand
126	Zingiberaceae	**Meistera acuminata** (Thwaites) Skornick. &M.F.Newman (*Amomum muricatum* Bedd.)	H	May	A.S. Rao 79979	India, Sri Lanka

C—Climbers | E—Epiphytes | H—Herbs | PS—Parasitic shrubs | S—Shrubs | SS—Scandent shrubs | T—Trees | US—Undershrubs | WC—Woody climbers.

predominantly a tropical forest. As, plant life form is the growth form that represents adaptation to specific ecological conditions that reflects climatic adaptability as well as vegetation of that area.

New records for Karnataka

The present study also resulted in documentation of two endemic species of Western Ghats *Syzygium densiflorum* Wall. ex Wight & Arn. (Myrtaceae) and *Meineckia longipes* (Wight) G.L.Webster (Phyllanthaceae) as new distributional records to Karnataka state. *Syzygium densiflorum* and *Meineckia longipes* were so far known to occur in Kerala and Tamil Nadu, and this present report shows their extended distribution to Karnataka.

Threats and Conservation

The endemic flora of BRT TR is vulnerable to anthropogenic pressure and also impacted by other factors. Within its boundary the tiger reserve includes a popular ancient temple 'Biligiri Rangaswamy Temple', coffee plantations in the core zone, settlements of indigenous people 'Soligas', state highways, and ecoresorts of tourism department. The main threats are in the form of invasive alien species, forest fires, and plantations. A study by Barve et al. (2005) revealed that

Table 3. Representation of life-form of endemic flora in Biligiri Rangaswamy Temple Tiger Reserve.

Life form	No. of endemic taxa	Percentage
Trees	35	17%
Shrubs & Under shrubs	39	20%
Herbaceous climbers/ Woody climbers/ Liane/ Scandent shrubs	17	9%
Herbs	85	40%
Epiphytes	25	12%
Parasitic shrubs	10	5%
Total	**211**	**100%**

human induced threats within and around the sanctuary appear to have significantly affected the vegetation composition and structure resulting in thinning of forests. The core area of BRT TR is relatively vulnerable due to the presence of coffee plantations located and also due to the presence of high human densities in the zone. The invasion by weeds such as *Lantana camara* L. and *Chromolaena odorata* (L.) R.M.King & H.Rob. in the dry deciduous to moist deciduous forests is of major concern (Murali & Siddappa 2001). Likewise, presence of another invasive alien weed *Ageratina adenophora* (Spreng.) R.M.King & H.Rob. in the evergreen forests and shola forests causes severe damage to the community composition, species diversity and abundance of native flora including endemic through its allelopathic effects. It is of great concern that majority of the endemic species are concentrated in the evergreen forests necessary steps may be taken to mitigate the effects of invasive weeds and to maintain the health of ecosystem.

Some of the endemic species such as *Andrographis serpyllifolia* and *Lepidagathis cristata* are mostly found growing in the dry deciduous forest and scrub forest areas along the forest borders in the open areas in mud roadsides and sandy-gravely soil along the metal roadsides inside BRT TR. Road expansion or reconstruction of roads will result in dumping and excavation of soils nearby areas which will trample the endemic plants growing along the roadsides. Another threat to the endemic species is the forest fires. Some of the areas in BRT TR especially the dry deciduous forest areas are prone to forest fires. An elegant narrow endemic species, *Barleria morrisiana* is threatened due to this. Similarly, the cultivated trees planted amidst the coffee plantations and other wild trees along the coffee plantations are laden with many endemic orchids. If the trees are removed by natural or unnatural means it will also wipe out the epiphytic species growing along with them.

Recently, in 2018 the Government of India has notified an area to an extent varying from 0.50 km to 6 km from the boundary of BRT TR as an ecosensitive zone. This zone covers a total area of 262.43 sq. km. around the sanctuary. Apart from this, the Forest department has undertaken periodical removal of invasive species such as *Lantana camara*. This should be also expanded to eradication of other major species like *Ageratina adenophora* and *Chromolaena odorata*. Training of local communities, forest department and coffee plantation staff and personnel should be given to identify endemic species for recovery and rehabilitation.

CONCLUSION

The BRT TR is a home to diverse endemic flora that are predominantly Western Ghats elements and confined to the evergreen forests. Presence of 28% of the endemic flora common to Western Ghats and Eastern Ghats elements supports the identification of a unique biogeographical zone which acts as a bridge between the Western and Eastern Ghats. Orchidaceae is the dominant family among the endemic flora of BRT TR, and one of the dominant families of endemic flora of the Western Ghats. The evergreen forests, while comprising only 10% of the total area of BRT TR, shelters a maximum diversity of endemic flora which are vulnerable due to the rapid spread of invasive species. Hence additional focused conservation measures are required for conservation of evergreen forests within BRT TR.

REFERENCES

Ahmedullah, M. & M.P. Nayar (1986). *Endemic Plants of the Indian region—Vol. 1. Peninsular India.* Botanical Survey of India, Calcutta, 262 pp.

Barnes, E. (1944). Notes on the flowering plants of Biligirirangan hills. *Journal of the Bombay Natural History Society* 44(3): 436–459.

Barve, N., M.C. Kiran, G. Vanaraj, N.A. Arvind, D. Rao, R. Uma Shaanker, K.N. Ganeshaiah & J.G. Poulsen (2005). Measuring and mapping threats to a wildlife sanctuary in Southern India. *Conservation Biology* 19(1): 122–130.

BHL (2022). Biodiversity Heritage Library. https://www.biodiversitylibrary.org/. Accessed on 14 April 2022.

Blatter, E. (1908). Contributions to the flora of North Coimbatore (from materials supplied by C.E.C. Fischer). *Journal of the Bombay Natural History Society* 18: 390–429.

Brummitt, N., A.C. Araújo & T. Harris (2021). Areas of plant diversity—What do we know? *Plants People Planet* 3: 33–44.

BSI (2022). Digital archives of Botanical Survey of India. https://archive.bsi.gov.in. Accessed on 25 June 2022.

Gamble, J.S. (1915–1936). *Flora of the Presidency of Madras* (Parts

Image 1. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Andrographis serpyllifolia* | B—*Asystasia crispata* | C—*Asystasia dalzelliana* | D—*Barleria cuspidata* | E—*Barleria lawii* | F—*Barleria montana* | G—*Barleria morrisiana* | H—*Justicia micrantha* | I—*Lepidagathis cristata* | J—*Strobilanthes barbata* | K—*Strobilanthes meeboldii* | L—*Strobilanthes neilgherrensis*. © J. Jayanthi.

Image 2. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Pimpinella wallichiana* | B—*Ceropegia hirsuta* | C—*Heptapleurum capitatum* | D—*Calamus gamblei* | E—*Chlorophytum indicum* | F—*Impatiens balsamina* var | *micrantha*. G—*Radermachera xylocarpa* | H—*Cordia macleodii* | I—*Capparis grandiflora* | J—*Terminalia paniculata* | K—*Cyanotis tuberosa* | L—*Argyreia cuneata*.
© J. Jayanthi.

Image 3. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Argyreia sericea* | B—*Kalanchoe olivacea* | C—*Elaeocarpus munroi* | D— *Euphorbia notoptera* | E—*Crotalaria paniculata* | F—*Crotalaria pusilla* | G—*Senna montana* | H—*Tephrosia calophylla* | I—*Swertia corymbosa* | J—*Aeschynanthus perrottetii* | K—*Leucas eriostoma* | L—*Pogostemon mollis*. © J. Jayanthi.

Image 4. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Scutellaria wightiana* | B—*Actinodaphne bourdillonii* | C—*Beilschmiedia wightii* | D—*Cinnamomum wightii* | E—*Litsea floribunda* | F—*Phoebe wightii* | G—*Dendrophthoe memecylifolia* | H—*Helicanthes elastica* | I—*Helixanthera obtusata* | J—*Helixanthera wallichiana* | K—*Macrosolen trigonus* | L—*Taxillus recurvus*. © J. Jayanthi.

Image 5. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Grewia orbiculata* | B—*Microcos heterotricha* | C—*Memecylon lushingtonii* | D—*Osbeckia brachystemon* | E—*Naregamia alata* | F—*Syzygium densiflorum* | G—*Syzygium malabaricum* | H—*Bulbophyllum fimbriatum* | I—*Bulbophyllum fusco-purpureum* | J—*Habenaria longicornu* | K—*Schoenorchis smeeana* | L—*Glochidion hohenackeri* var. *johnstonei*. © J. Jayanthi.

Image 6. Endemic species occurring in Biligiri Rangaswamy Temple Tiger Reserve: A—*Meineckia longipes* | B—*Phyllanthus indofischeri* | C—*Pittosporum dasycaulon* | D—*Gardenia gummifera* | E—*Ixora elongata* | F—*Pavetta breviflora* | G—*Psychotria flavida* | H—*Psychotria truncata* | I—*Wendlandia thyrsoidea* | J—*Atalantia wightii* | K—*Flacourtia montana* | L—*Isonandra perrottetiana*. © J. Jayanthi.

1–11). Newman & Adlard, London, 2017 pp.

Gaston, K.J. (1991). How large is a species' geographical range? *Oikos* 61: 329–335.

IPNI (2021). The International Plant Name Index. http://www.ipni.org. Accessed on 02 April 2021.

Jalal, J.S. & J. Jayanthi (2012). Endemic orchids of peninsular India: a review. *Journal of Threatened Taxa* 4(15): 3415–3425.

Jalal, J.S., J. Jayanthi & A. Schuiteman (2014). *Xenikophyton* Garay (Orchidaceae — Aeridinae), a new synonym of *Schoenorchis* Reinw. ex Blume. *Kew Bulletin* 69: 9508. https://doi.org/10.1007/s12225-014-9508-y

Jayanthi, J., J.S. Jalal & A.M. Neelima (2017). *Habenaria sahyadrica* (Orchidaceae) – a new distributional record to Karnataka. *Indian Journal of Forestry* 40(1): 77–78.

Jayanthi, J., J.S. Jalal & P.D. Mule (2018). Rediscovery of *Vanilla walkerae* (Orchidaceae) after a lapse of 110 years from Karnataka. *Indian Forester* 114(4): 394–395.

Kammathy, R.V., A.S. Rao & R.S. Rao (1967). A contribution towards a flora of Biligirirangan hills, Mysore state. *Bulletin of the Botanical Survey of India* 9: 206–234.

Karthikeyan, S., M. Sanjappa & S. Moorthy (2009). *Flowering Plants of India: Dicotyledons, Volume 1 (Acanthaceae – Avicenniaceae)*. Botanical Survey of India, Kolkata, 365 pp.

Krishnamurthy, K.V., R. Murugan & K. Ravikumar (2014). *Bioresources of the Eastern Ghats: Their conservation and management*. Bishen Singh Mahendra Pal Singh, Dehradun, 824 pp.

Kumara, H.N., S. Rathnakumar, M.A. Kumar & M. Singh (2012). Estimating Asian elephant, *Elephas maximus*, density through distance sampling in the tropical forests of Biligiri Rangaswamy Temple Tiger Reserve, India. *Tropical Conservation Science* 5(2): 163–172. Available online: www.tropicalconservationscience.org

Lakshminarasimhan, P., S.S. Dash, P. Singh, N.P. Singh, M.K.V. Rao & P.S.N. Rao (2019). *Flora of Karnataka: Monocotyledons, Volume 3*. Botanical Survey of India, Kolkata, 847 pp.

Mao, A.A. & S.S. Dash (2020). *Flowering Plants of India: An Annotated Checklist. Vols. 1–3*. Botanical Survey of India, Kolkata.

MoEF&CC (2018). Ministry of Environment, Forest & Climate Change. Notification, 18 September 2018. *Gazette of India*. Extraordinary. No. 3722.

Morrone, J.J. (2008). Endemism. In: S.E.Jørgensen & B.D. Fath (eds.). *Encyclopedia of Ecology*. Academic Press, 1254–1259. https://doi.org/10.1016/B978-008045405-4.00786-2

Murali, K. & S. Siddappa (2001). Effect of weeds *Lantana camara* and *Chromolaena odorata* growth on the species diversity, regeneration and stem density of tree and shrub layer in BRT sanctuary. *Current Science* 80(5): 675–677.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858. https://doi.org/10.1038/35002501

Nayar, M.P. (1982). Endemic flora of Peninsular India and its significance. *Bulletin of the Botanical Survey of India* 22: 12–23.

Nayar, M.P. (1996). *Hot Spots of Endemic Plants of India, Nepal and Bhutan*. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, 252 pp.

Nayar, T.S., A.R. Beegam & M. Sibi (2014). *Flowering Plants of The Western Ghats, India*. Vol. 1 & 2. Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, 1,683 pp.

Parthasarathy, N., L. Arulpragasan, C. Muthumperumal, S. Raja & M. Rajkumar (2007). Quantitative assessment of plant diversity, bioresource values and conservation of tropical forests of Southern Eastern Ghats, India, pp. 14–18. Procedings of the National Seminar on Conservation of Eastern Ghats.

POWO (2021). Kew Plants of the world online. https://powo.science.kew.org. Accessed on 25 February 2021.

Ramesh, B.R. (2002). Evergreen forests of the Biligirirangan hills, pp. 103–108. In: *Proceedings of the National Seminar on Conservation of Eastern Ghats.* EPTRI, Hyderabad.

Rao, R.R. & B.A. Razi (1981). *A synoptic flora of Mysore District*. Today and Tomorrow's Publishers, New Delhi. 674 pp.

Rao, T.A. & S. Sridhar (2007). *Wild orchids in Karnataka: A pictorial compendium*. Institute of Natural Resources Conservation Education, Research and Training (INCERT), Bangalore, 230 pp.

Raunkiaer, C. (1934). *The Life-forms of plants and statistical plant geography*. Oxford University Press, Oxford. 632 pp.

Saldanha, C.J. (1984). *Flora of Karnataka*. Vol. 1. Oxford and IBH publishing Co., New Delhi, 535 pp.

Saldanha, C.J. (1996). *Flora of Karnataka*. Vol. 2. Oxford and IBH publishing Co., New Delhi, 304 pp.

Saldanha, C.J. & D.H. Nicolson (Eds.) (1976). *Flora of Hassan District, Karnataka, India*. Amerind publishing Co., New Delhi, 923 pp.

Sharma, B.D., N.P. Singh, R.S. Raghavan & U.R. Deshpande (1984). *Flora of Karnataka Analysis.* Botanical Survey of India, Howrah, 394 pp.

Singh, P., K. Karthigeyan, P. Lakshminarasimhan & S.S. Dash (2015). *Endemic Vascular Plants of India*. Botanical Survey of India, Kolkata, 339 pp.

TROPICOS (2021). https://www.tropicos.org/. Accessed on 25 February 2021.

Venu, P. (2007). *Strobilanthes Blume (Acanthaceae) in Peninsular India*. Botanical Survey of India, Kolkata, 216 pp.

WCSP (2021). World Checklist of Selected Plant families (WCSP). https://wcsp.science.kew.org/. Accessed on 25 May 2021.

Young, B.E. (2007). Introduction, pp. 5–7. In: Young, B.E. (ed.). *Endemic species distributions on the east slope of the Andes in Peru and Bolivia*. NatureServe, Arlington, Virginia, USA, 628 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22718–22725
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.8271.15.2.22718-22725
#8271 | Received 24 November 2022 | Finally accepted 28 January 2023
OPEN ACCESS
COMMUNICATION

Multidimensional time-lapse of a relict species *Canarium strictum* Roxb. from a sacred landscape in Pune District, India

Mukul Mahabaleshwarkar [1], Nivedita Ghayal [2], Supriya Mahabaleshwarkar [3] & Vinaya Ghate [4]

[1,1] A. Kulkarni Department of Biodiversity, MES Abasaheb Garware College, Pune, Maharashtra 411004, India.
[2] Department of Botany, MES Abasaheb Garware College, Karve Road, Pune, Maharashtra 411004, India.
[1,3] Indian National Trust for Art and Cultural Heritage (INTACH), Pune Chapter, Kothrud, Pune, Maharashtra 411038, India.
[4] Former senior scientist, Agharkar Research Institute, C-2, New Friends Society, Paud Road, Kothrud, Pune, Maharashtra 411038, India.
[1] mmukul@gmail.com (corresponding author), [2] gnivedita12@gmail.com, [3] supriya.r.g@gmail.com, [4] vsghate@gmail.com

Abstract: The traditional practice of conservation on religious basis along with commercial linkages at a local level is an interesting system from the point of view of its ecological, economical as well as institutional sustainability. Dhoop-rahat, in the Western Ghats region of Bhor Taluka in Pune District, is possibly the only sacred grove dedicated to a religiously important species *Canarium strictum* Roxb. Dhoop (black dammar resin) is traditionally extracted from *C. strictum*. The present study attempts to assess Dhoop-rahat and its surrounding historic sacred landscape with focus on the rare *C. strictum* individuals in the backdrop of changes in the ecological, geographical, socio-cultural, and economical dimensions associated with it, over time. Field and market surveys were conducted and RS-GIS techniques were used in the study. Community conserved Dhoop-rahat sacred grove has two individuals of *C. strictum* along with seven endemic and one IUCN Red Listed species. Successful regeneration of *C. strictum* is not observed. Once commercially harvested from this location, this species is now used only for ritualistic purposes. The two individuals of *C. strictum* have endured the drastic changes in the surrounding vegetation. In the business-as-usual scenario, there is a high risk of losing the last two individuals of *C. strictum* in the region and eventually the grove itself. Newer approaches of conservation by combining community-based traditional ecological knowledge with modern day scientific methods should be applied for protection of this sacred landscape. Long-term periodic monitoring of sacred groves and their surrounding landscape is essential for ensuring their sustainable existence.

Keywords: Black dammar resin, community conservation, dhoop, Dhoop-Rahat, ecological, economical, natural heritage, sambrani, sacred grove, Western Ghats.

स्थानिक व्यावसायिक संबंधों के साथ-साथ धार्मिक आधार पर प्रकृति संवर्धन की पारंपरिक प्रथा पर्यावरणीय, आर्थिक और संस्थात्मक शाश्वतता के दृष्टिकोण से एक दिलचस्प प्रणाली है। पुणे जिले के पश्चिम घाट क्षेत्र में भोर तालुका में धूप-रहाट संभवतः ऐसा एकमात्र पवित्र उपवन है, जो धार्मिक रूप से महत्वपूर्ण प्रजाति *कैनारियम स्ट्रिक्टम* रॉक्सब. को समर्पित है। धूप (काला दमार) पारंपरिक रूप से *सी. स्ट्रिक्टम* पेड़ से निकाला जाता है। यह अध्ययन समय के साथ जुड़े पर्यावरणीय, भौगोलिक, सामाजिक-सांस्कृतिक और आर्थिक आयामों में होनेवाले परिवर्तन की पृष्ठभूमि में दुर्लभ *सी. स्ट्रिक्टम* पेड़ों के साथ धूप-रहाट और इसके आसपास के ऐतिहासिक पवित्र परिदृश्य (लैन्डस्केप) का आकलन करने का प्रयास करता है। इस अध्ययन में फ़ील्ड और मार्केट सर्वेक्षण किए गए और जी.आय.एस. तकनीकों का उपयोग किया गया। समुदाय-संवर्धित धूप-रहाट में सात स्थानिक और एक आय.यू.सी.एन. रेड लिस्ट में सूचीबद्ध प्रजातियों के साथ *सी. स्ट्रिक्टम* के सिर्फ़ दो पेड़ हैं। धूप-रहाट में *सी. स्ट्रिक्टम* का पुनर्जनन नहीं देखा गया है। इस प्रजाति का उपयोग यहाँ अब व्यावसायिक रूप से नहीं होता और केवल कर्मकांडों के लिए किया जाता है। *सी. स्ट्रिक्टम* के यह दो पेड़ आसपास की परिस्थिति और वनस्पति में होनेवाले भारी परिवर्तन के बावजूद भी अबतक जीवित रहे है। अगर ऐसी ही स्थिति रही तो *सी. स्ट्रिक्टम* के इन अंतिम दो पेड़ को और अंततः पवित्र उपवन नष्ट होने की बड़ी जोखिम है। इस पवित्र परिदृश्य के संवर्धन के लिए समुदाय आधारित पारंपरिक पारिस्थितिक ज्ञान को आधुनिक वैज्ञानिक विधियों के साथ जोड़कर संवर्धन की नई संभावनाओं का उपयोग किया जाना चाहिए। पवित्र उपवनों और उनके आसपास के परिदृश्य की दीर्घकालिन आवर्ती देखरेख उनके शाश्वत अस्तित्व को सुनिश्चित करने के लिए आवश्यक है।

Editor: Anonymity requested. **Date of publication:** 26 February 2023 (online & print)

Citation: Mahabaleshwarkar, M., N. Ghayal, S. Mahabaleshwarkar & V. Ghate (2023). Multidimensional time-lapse of a relict species *Canarium strictum* Roxb. from a sacred landscape in Pune District, India. *Journal of Threatened Taxa* 15(2): 22718–22725. https://doi.org/10.11609/jott.8271.15.2.22718-22725

Copyright: © Mahabaleshwarkar et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: This research is part of self-funded doctoral research of Mukul Mahabaleshwarkar.

Competing interests: The authors declare no competing interests.

Author details & Author contributions: See end of this article.

Acknowledgements: Authors are thankful to villagers of Shirgaon and Abhepuri, Dr. Utkarsh Ghate, Dr. Ankur Patwardhan, Prof. Dr. P.B. Buchade, Forest Department (MS) Bhor Division for their support.

INTRODUCTION

In many parts of the world, belief in sacred nature underpins people's land and resource use whilst in pursuit of livelihoods; moreover, traditional cultural and spiritual values provide the context in which environmental stewardship can be nurtured (Robson & Berkes 2010). Nature conservation is an ancient tradition in India. One such significant tradition is of dedicating patches of forests to some deities as sacred groves (Gadgil & Vartak 1981). Similar to tradition of sacred landscapes and sacred forests, worshipping individual species of trees has also been an ancient tradition. The cult of tree worship depicting tree as a representative of gods on earth has its roots deep in the history of mankind (Sane & Ghate 2006). The traditional practice of conservation on religious basis along with commercial linkages at a local level is an interesting system from the point of view of its ecological, economical as well as institutional sustainability (Goturkar-Mahabaleshwarkar & Mahabaleshwarkar 2007).

Dhoop-rahat sacred grove situated in the Western Ghats region of Bhor Taluka in Pune District gets its name from the Sanskrit word 'Dhoop', which refers to offering of incense. Dhoop-rahat is possibly the only sacred grove dedicated to a religiously important species *Canarium strictum* Roxb. *Canarium strictum* is unevenly distributed in Western Ghats and southeastern Asia. It is an indigenous plant species of Eastern and Western Ghats of India (Meena et al. 2012) and is endemic to the western peninsula (Gadgil & Vartak 1976). It occurs as a canopy tree in the moist deciduous and evergreen forests. Information about its conservation status nationally or globally is lacking, though at the level of the region, *C. strictum* has been reported to be a species of conservation concern (Ravikumar & Ved 2000). In Maharashtra it shows a serious population bottleneck (Patwardhan & Vasudeva 2010). The geographical distribution of *C. strictum* in Maharashtra was wider in the past as compared to the present observations. The earlier reports show that the species was distributed in Konkan, hills of Pen, the then Pant Sachiv's country that included present talukas of Maval, Mulshi, Velhe, and Bhor (Dalzell & Gibson 1861) and Matheran (Cooke 1903). In Maharashtra, presently, the species has been recorded from Satara, Kolhapur, Pune and Raigad Districts (Singh & Karthikeyan 2000; Patwardhan & Vasudeva 2010) with Dhoop-rahat sacred grove being the northernmost known location of *C. strictum* in the northern Western Ghats (Kulkarni et al. 2014).

C. strictum has common names such as Black Dammar, Raal Dhoop, Black Dhoop, and Sambrani Dhoop. It is a representative of Burseraceae family, which is known as incense trees family. It exudes a resin called Sambrani or Dammar, which has medicinal and spiritual importance. It is harvested for resin by several indigenous communities in the Indian subcontinent (Varghese 2014). Dhoop has medicinal applications in tribal communities as well as in Siddha and Ayurvedic systems of medicine in treatment of respiratory ailments and rheumatism. Dhoop is also burnt for its insect repellent properties. The species also has commercial use in varnish (Langenheim 2003) and timber.

The only two individuals of *C. strictum* surviving in the Dhoop-rahat were reported first in early 1970s (Gadgil & Vartak 1976). Their unique presence is the only reason for survival of this sacred grove. This species has not shown regeneration in grove as well as in the region. Dhoop-rahat sacred grove, along with three other sacred groves, is part of sacred landscape formed near the origin of River Nira. Ownership and management of these sacred groves are in the hands of different agencies including local community and government departments. An ancient trade route, now a state highway, known as *Varandha Ghat*, connecting Bhor and Mahad in Raigad District of Konkan region, passes through this landscape. Until last decade, it was the only motorable and closest road connecting these two places. Development associated with this connectivity since historic times, influenced the surrounding landscape from time-to-time. Present study attempts to assess this sacred landscape with focus on the existence battle of Dhoop trees and eventually Dhoop-rahat in the backdrop of changes in the ecological, geographical, socio-cultural and economical dimensions associated with it, over time.

MATERIALS AND METHODS

The study area was surveyed for the following dimensions during years 2021 and 2022:

1. Ecological: Field visits were conducted for studying vegetation in the study area. GPS locations of the sacred groves and *C. strictum* trees were recorded using GPS, Garmin e-trex30. Observations on the regeneration of *C. strictum* were noted. Overall health and threatscape of the ecosystem were documented.

2. Geographical: Land ownership and landuse patterns in the sacred landscape and surrounding region were mapped using Google Earth images at different points of time. Geographical changes over the past 30 years were noted with the help of satellite images taken by Landsat

4, 5, 7, and 8. NDVI (Normalized Difference Vegetation Index) was calculated using QGIS software. It was used for calculation of vegetation health. Satellite images from month of March were used so as to avoid cloud cover.

3. Socio-cultural associations: Semi-structured interviews with the local community representatives including *Gurav* (local priest of the deities in the sacred grove) were conducted for understanding levels of awareness about *C. strictum*, occurrence of species in the nearby forests, traditional knowledge associated with the species, usage of the species in past and present and usage of extracted Dhoop in rituals of associated deities.

4. Economical: Survey was conducted in the nearby market places for commercial aspects of Dhoop and history of Dhoop trade in the region. Also, attempt was made to find out if there was any commercial reason for survival of these two individuals.

RESULTS

Geographical / Landscape Dimensions

The sacred landscape is located on the immediate eastern slopes of the Western Ghats, locally known as Rairi Hills. Sacred groves of Dhoop-rahat (18.092N & 73.635E), Janani (also known as Durgadevi) (18.093N & 73.628E) and Waghjai (18.105N & 73.655E) are situated near Bhor-Mahad road, which is part of an ancient trade route connecting historic coastal township of Choul with trade centre of Vijayapura (Karnataka) on Deccan. Sacred groves of Durgadevi and Dhoop-rahat are close to each other and are situated between villages Shirgaon and Abhepuri. As per revenue records of the lands these sacred groves are part of village Abhepuri. The eastern flowing River Nira originates from the first order streams in this landscape and makes its way ahead from Niramai Kund (sacred tank) (18.103N & 73.624E). The ownership and management pattern of this sacred landscape involves multiple stakeholders including a local temple trust, forest and irrigation departments of the government of Maharashtra, and local communities. The landscape is a mosaic of dense forest patches, waterbodies, grazing lands, agricultural fields, and occasional patches of shifting cultivation.

NDVI calculated over the past 30 years at the interval of 10 years from 1991 to 2021 indicates that the dense vegetation patches including reserve forests and sacred groves have remained intact. However, surrounding unprotected vegetation shows degradation as an effect of activities such as construction of dam and road widening during years 2001 and 2011. Slight increase in green cover as seen in NDVI of 2021 can be because of rise of water table due to dam backwaters. This does not represent any addition to the dense forest vegetation (Image 1).

Ecological Dimensions

Plant diversity observed in Dhoop-rahat and Durgadevi sacred groves comprises of 73 species of plants including 32 species of trees, 22 species of shrubs, and lianas and 19 species of herbs, climbers, and ferns. Durgabai sacred grove located at an aerial distance of 800 m and on foot distance of 1,200 m shows similar vegetation pattern except absence of *C. strictum* and presence of invasive plant species. From the vegetation survey at Dhoop-rahat, it was found that the forest is of moist deciduous and semi-evergreen type. The canopy species including old growth trees of *C. strictum*, *Terminalia bellirica, Schleichera oleosa*, and *Holigarna grahamii* form major canopy of the grove. Giant climbers such as *Gnetum ula, Dalbergia horrida, Entada rheedei*, and *Diploclisia glaucescens* were found in the grove. Epiphytic flora includes orchids such as *Eria dalzellii, Aerides maculosum*, and *Dendrobium barbatulum*. Seven endemic species including one IUCN Red List Vulnerable (VU) species (*Curcuma pseudomontana*) were documented from the study area. Invasive plant species were not observed. The forest is dense and forest floor shows deep leaf litter layer. Saplings of different plant species were seen. Seeds of *C. strictum* were found on the forest floor. However, its natural regeneration has not been observed so far. *Canarium strictum* is a canopy species and the two individuals are about 35 m in height and about 5 m in girth. The lowermost 3 m of the trunk shows uneven and globular structures called wood-knots.

Communities in this landscape are dependent on agriculture (mainly rice) for their livelihood and pastoralism for milk and meat requirements. Slash-and-burn shifting cultivation is practiced for cultivating millets like Nachani (Ragi) and Varai (Barnyard millet). As a traditional cultivation practice, the forest patch adjoining the Dhoop-rahat and a part of it were slashed and burned during the years 1985, 1995 and then in the year 2005 for cultivation of Ragi millet, whereas the Dhoop-rahat forest patch having *C. strictum* trees was kept untouched (Image 2). The patch used in the year 1995 was not repeated in the year 2005. In fact, the earlier used patch showed regeneration of forest in the fallow period. Major developments that impacted the landscape include construction of Nira-Deoghar dam and associated infrastructure during the years 1994–2000, widening of roads in the area during the years 2010–

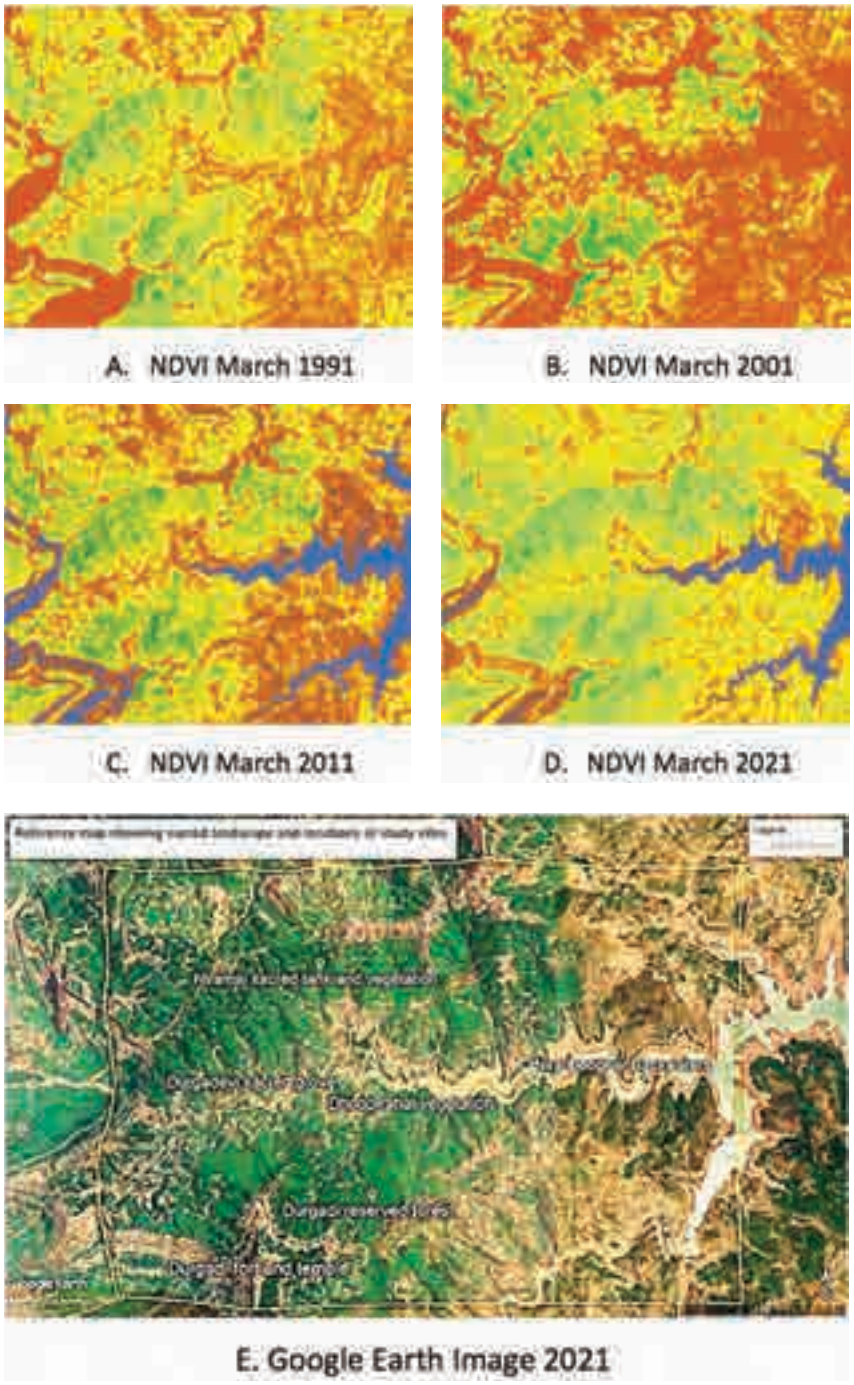


Image 1. Changes in vegetation pattern over time using satellite image processing.

2015 and changes in land ownership from local people to the non-native farmhouse owners.

Vegetation patches of both Dhoop-rahat and Durgadevi sacred groves have been partly lost due to submergence in the dam backwater. Durgadevi grove has been divided because of road passing through it. There is forest clearing at different locations for developmental reasons around this grove. During years 2020 to 2022, maximum number of landslides were observed in the landscape and surroundings (Image 3). Another road construction work on the other side of this grove has further fragmented the grove from surrounding vegetation. Invasive plant species such as *Lantana camara*, *Chromolaena odorata*, and *Cosmos sulphureus*, which were not present earlier, have started appearing along the road side at Durgadevi sacred grove.

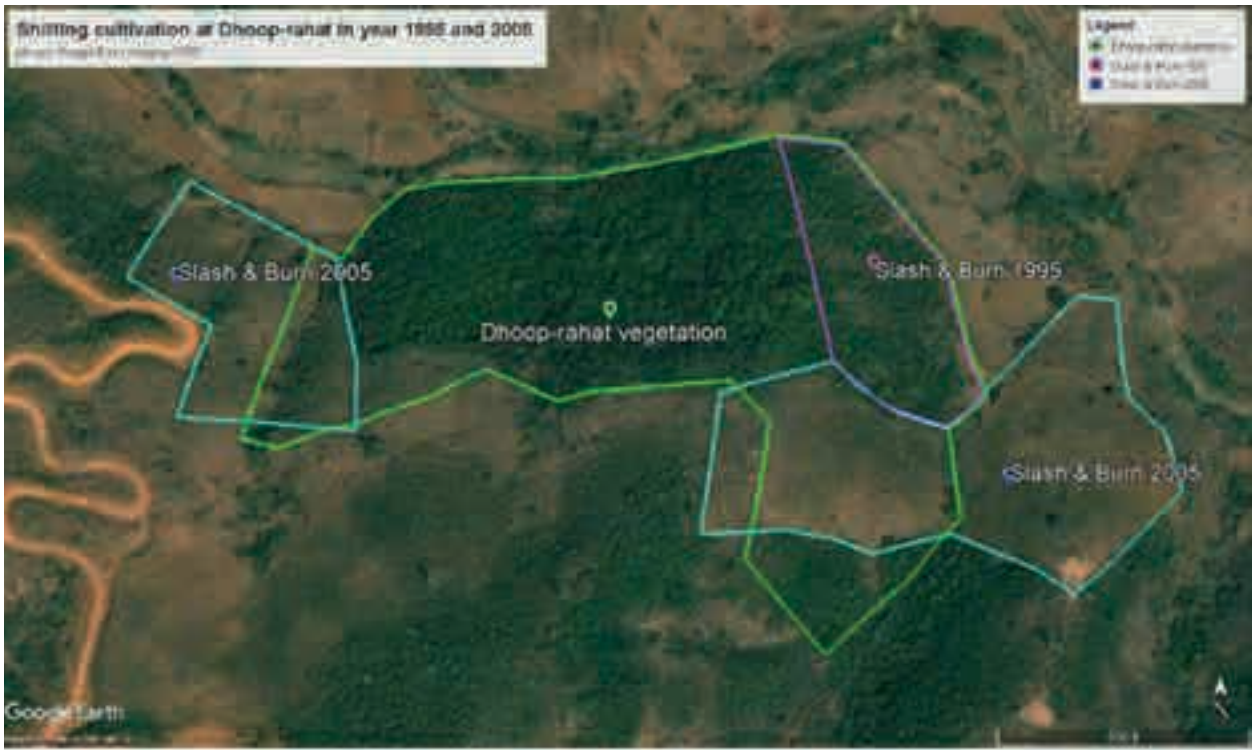


Image 2. Shifting cultivation patches around Dhoop-rahat during years 1995 and 2005.

Waghjai sacred grove in the interiors shows hardly any disturbance due to its inaccessible location.

Socio-cultural Dimension

Dhoop-rahat plays a complimentary role to the Durgadevi sacred grove. These groves in this landscape are not visited often by the local villagers and the forests are left undisturbed except for ritualistic purposes. In earlier times, feelings of fear and respect dominated the association of people with grove and deity. Over time and generations, dilution of such strong feelings has been observed. However, even in present times, during important lifecycle rituals, the deities in the grove are worshipped via simple rituals and are invited for placating and/or seeking blessings. Important decisions related to livelihood practices are taken by the local communities via a practice of 'koul' (Marathi: special permission of the deity) conducted by the Gurav in the grove.

The Dhoop is traditionally extracted from the Dhoop trees from this grove for an annual ritual during the Navaratri festival. The Dhoop-rahat is not dedicated to a particular anthropomorphic deity. The two *C. strictum* individuals in this grove are considered sacred (Image 4). The villagers believe that it is a formless deity and is referred to as 'Dhoopdev' / 'Guptdev' (invisible deity). Access to the Dhoop-rahat and rights of extraction of Dhoop are restricted and Gurav plays a role in decision making regarding the same. The resin is extracted either from natural oozing from fissures of the tree trunk or by making an incision to the tree trunk.

Economical Dimension

Indian black dammar is preferred among incense sticks manufacturers as it is of very good quality. The present market price of Dhoop is Rs. 300 to Rs. 600 per kilogram based on the source and purity. Dhoop from this area used to be extracted in earlier times for commercial purposes. The local markets sold the locally harvested Dhoop in the past. Since the early 1980s extraction of Dhoop from the Dhoop-rahat was stopped for commercial purposes. Restricted extraction is allowed for ritualistic purposes of Durgadevi sacred grove.

DISCUSSION

Certain forest-dwelling communities, often made up of tribal people, offer myriad insights into ways to make sustainable use of forest plants and animals for food and other purposes (Myers 1990). Association of sacredness and sustainable harvesting of Dhoop has resulted in community protection to the rare *C. strictum* individuals and the surrounding vegetation. Earlier records indicate that this species was probably distributed once

Image 3. Landslide observed in the vicinity of Durgadevi sacred grove during 2021.

throughout Western Ghats, but due to developmental activities it now survives only in this particular grove in Pune District. The geographical location of the present study area in the global biodiversity hotspot of Western Ghats makes it a critically important landscape in terms of conservation of biodiversity. Proximity to the ancient trade route also makes it a historically important site. These sacred groves harbour climax vegetation and are home to important endemic and globally and locally rare and vulnerable species of plants and animals. This highlights the significance of groves being vital for conservation and sustenance of biodiversity (Kulkarni et al 2018). Sacred groves are also important for their ecological functions and values. Around the origin of each river in the Indian subcontinent, there is a sacred grove of a small or large dimension (Paranjpye & Paranjpye 1998). Sacred groves in the region protect the headwaters thus safeguarding the origin of river Nira. Many sacred groves are located along the ancient trade routes (active from BCE to 16th CE) through deep forests (Burman 1997). These groves provided shelter and protection to the traders. The offerings they made to the reigning deities of the groves were shared by the villagers (Burman 1997) ensuring safe travel and transport of goods. Proximity to the trade route (possibly overlapping with the ancient incense trade route) of the present landscape had enabled sale of Dhoop extracted from the region. As per interviews with the local knowledgeable individuals and sellers of Dhoop in local markets, locally extracted Dhoop was available for sale in nearby market areas, probably till the time when *C. strictum* trees were abundant in the surrounding landscape. The vegetation community could have been different during that time. An unprecedented pace of development on the northern Western Ghats occurred during the British period due to major interventions like construction of railways, roads,

Image 4. *Canarium strictum* from the sacred grove.

and dams (Gadgil 2011). During the 1940s to 1960s, many forest patches in this region were chopped down for the purpose of coal and timber, resulting in changes in vegetation type and size of the sacred groves. Sacred association of *C. strictum* individuals in Dhoop-rahat could be the reason for their survival, thus making *C. strictum* a relict species in northern Western Ghats region. Ecological surveys conducted in southern India have revealed decreased sizes of *C. strictum* populations, which could lead to still smaller populations over the long term (Meena et al. 2012). Also, seedling fitness decreases as the grove area reduces due to inbreeding among the fewer individuals and accumulation of lethal characters in the smaller groves (Tambat et al. 2005). Occurrence of *C. strictum* seedlings is of prime importance because this tree is very rare in Western Ghats of Maharashtra (Kulkarni & Nipunage 2009). In the present case study seeds of *C. strictum* were observed on forest floor,

however successful regeneration was not observed. Fruits and seeds of *C. strictum* are edible; so monkeys, civets, rodents, and birds like hornbills relish the same. Studies on traditional ecological knowledge of resin harvesters from southern India indicate that regeneration occurs when fruits are eaten and dispersed by giant squirrel, flying squirrel, and civets (Varghese 2014). Population loss of agents of seed dispersal like giant squirrel and flying squirrel due to loss of large canopies, habitat fragmentation, loss of corridors and feeding by langurs could be one of the reasons for unsuccessful regeneration of *C. strictum* in this region. Habitat fragmentation due to increased forest fires, clear-felling for shifting cultivation, construction of private resorts has totally degraded the habitat of seed dispersers like giant squirrels in this region and their populations have drastically reduced (Mehta 2012). The landuse changes in the study area includes increased area under agriculture, shifting cultivation, and watershed. Thus, seed predating rodents like field rats are also negatively impacting regeneration. Further studies in this area can throw light on the ways to encourage natural regeneration of *C. strictum* in northern Western Ghats. Attempts have been made for germination of *C. strictum* using nursery techniques and its reintroduction in wild in other areas of northern Western Ghats. Similar efforts in the study area with the help of local community may help in conservation of the species (Patwardhan & Vasudeva 2010). For successful regeneration of certain species, whether natural or artificial, it requires a number of key parameters to function in synergy so as to form a conducive environment.

The shifting cultivation patches during the fallow period showed regeneration of species like *Strobilanthes callosa*, *Syzygium cumini*, *Memecylon umbellatum*, *Leea indica*, *Carissa carandas*, and *Terminalia* spp. Presence of sun-loving species in the upper, middle, and lower storey of sacred groves in this region indicate large scale felling in the past, recent past, and present period, respectively (Ghate 1994). Clear-felling of part of Dhoop-rahat and surrounding area, in the past, has brought about changes in the vegetation community from evergreen to moist deciduous. The two individuals of *C. strictum* have endured the drastic changes in the surrounding vegetation. In the business-as-usual scenario, there is a high risk of losing the last two individuals of *C. strictum* in the region and eventually the grove itself. The way in which traditional societies perceive and modify the landscape and biodiversity around them, both in space and time to ensure ecosystem stability and resilience, is significant for landuse management (Ramakrishnan 2009). Shifting cultivation using slash-and-burn is one such traditional practice in the study area, which alters the ecosystems at landscape level. Earlier, these alterations were part of a resilient ecosystem. However, on the background of increased developmental pressures and with increased demand of agricultural resources from the growing human population such practice may contribute to threats. Ecological studies indicate forest degradation of overall landscape with original dense climax vegetation surviving in pockets of sacred groves. Association and inter-dependence of the two groves of Durgadevi and Dhoop-rahat by *C. strictum* use for ritualistic purposes indicates the role of culture in connecting and protecting these forest patches. Dhoop harvesting technique, via incisions, used presently is a sustainable method compared to scorching in the past. Ownership and management of Durgadevi sacred grove and Dhoop-rahat involve multiple stakeholders. Diverse landuse types coupled with multiple owners / managers make it a complex system, when it comes to decision making. Biodiversity as well as cultural values of a site and the communities which hold them are dynamic and evolving over generations (Watve & Chavan 2020). The community has taken cognizance of the threat to the *C. strictum* individuals by putting a stop to commercial harvesting of Dhoop. This indicates application of traditional knowledge system along with possible role of environmental awareness in recent times.

So far, community managed sacred groves have been conserved through their vigilance and efforts. However, community aspirations, changing belief systems and developmental pressures are challenging the very existence of these groves. Sacred groves, thus need multidimensional and integrated conservation and management strategies that will be able to appreciate and consider their complexity through systems approach (Mahabaleshwarkar & Ghayal 2020).

RECOMMENDATIONS

Detailed documentation of existing conservation initiatives via traditional practices and monitoring impact of development can be the first step towards conservation of this important landscape. GIS and remote sensing tools can prove useful for documenting and monitoring long term changes in the vegetation health and landuse patterns in the landscape. Further research on harvesting of Dhoop and regeneration of *C. strictum* are needed to ensure sustainability of harvesting practices. For conservation of the rare species *C. strictum*, efforts towards seedling collection from wild, germination and

nurturing saplings can be carried out with community for creating village-level nurseries. Reintroduction of these saplings in the forest and monitoring their growth can help in revival of this species. Conservation of *C. strictum* species and associated cultural aspects are linked to the conservation of the surrounding landscape elements. Formation of a village-level Biodiversity Monitoring Committee can support long term monitoring of vegetation health of the forest. It will also help create and implement local level guidelines for conservation of these sacred groves. A deeper understanding of this link between the conservation of the species and associated historical, geographical, ecological, economic and cultural fabric of the area can open up newer possibilities of conservation by combining traditional ecological knowledge with modern day scientific methods.

REFERENCES

Cooke, T. (1903). *The Flora of the Presidency of Bombay, Vol. 1.* Taylor and Francis, London, 668 pp.

Dalzell, N.A. & A. Gibson (1861). *The Bombay Flora, or, Short descriptions of all the indigenous plants hitherto discovered in or near the Bombay presidency together with a supplement of introduced and naturalised species*. Education Society's Press, Bombay, 738 pp.

Gadgil, M. (2011). *Report of the Western Ghats Ecology Expert Panel*. Project Report No. Part Ip. 522. New Delhi, India: The Ministry of Environment and Forests, Government of India.

Gadgil, M. & V.D. Vartak (1976). The Sacred Groves of Western Ghats in India. *Economic Botany* 30: 152–160. https://doi.org/10.1007/BF02862961

Gadgil, M. & V.D. Vartak (1981). Sacred groves of Maharashtra: an inventory, pp. 279–294. In: Jain, S.K. (ed.). *Glimpses of Indian Ethnobotany*. Oxford University Press, Bombay, xvi + 365 pp.

Ghate, U. (1994). *Selection of Sacred Groves of Western Ghats of Maharashtra for Biodiversity Conservation*pp. Research and Action in Natural Wealth Administration, Pune, 29 pp.

Goturkar-Mahabaleshwarkar, S. & M. Mahabaleshwarkar (2007). Aspiring for resurgence: a case study of Ajeevali; a sacred grove from Western Ghats of India. *Context* IV(I): 31–40.

Kulkarni, A., M.N. Datar, U. Awasarkar & A.S. Upadhye (2014). Northernmost distribution of five tree species to the Western Ghats from the sacred groves of Pune District, Maharashtra, India. *Journal of Threatened Taxa* 6(8): 6093–6100. https://doi.org/10.11609/JoTT.o3644.6093-100

Kulkarni, D.K. & D.S. Nipunage (2009). Floristic diversity and ecological evaluation of 'Dhup-rahat' sacred grove from Pune District. *GEOBIOS* 36: 298–302.

Langenheim, J. (2003). *Plant Resins: Chemistry, Evolution, Ecology, Ethnobotany*. Timber Press, Portland, Oregon, USA, 586 pp.

Mahabaleshwarkar, M. & N. Ghayal (2020). Need for integrated strategies for conservation and management of sacred groves: an overview from Pune District (MS, India), pp. 449–451. In: Perspectives on Biodiversity of India - Proceedings of International Biodiversity Congress (IBC2018), Vol. IV. CISSA, Dehradun, India.

Meena, D., N. Binaibabu & J. Doss (2012). Future prospects for the critically endangered medicinally important species, *Canarium strictum* Roxb. a review. *International Journal of Conservation Science* 3(3): 231–237.

Mehta, P. (2012). Status and Distribution of Malabar Giant Squirrel *Ratufa indica* in Western Ghats of Maharashtra, India. Project Report, Wildlife Research and Conservation Society, Pune, India, 91 pp.

Myers, N. (1990). The non-timber values of tropical forests. *Forestry for Sustainable Development Program* (10): 19.

Paranjpye, V. & A. Paranjpye (1998). River valley cultures at cross-roads, on the threshold of the second millennium, pp. 333–342. In: Chakravarti, K.K. & G.L. Badam (eds.). *Proceedings of a National Seminar, 'River Valley Cultures of India,* IGRMS, Bhopal, India.

Patwardhan, A. & R. Vasudeva (2010). Conservation and Promotion of Endangered Medicinal Plant Species from Western Ghats of India. Project Report. Research and Action in Natural Wealth Administration (RANWA), Pune, 60 pp.

Ramakrishnan, P.S. (2009). *Traditional Ecological Knowledge (TEK).* 1st edition. INTACH, New Delhi, India, 26 pp.

Ravikumar, K. & D.K. Ved (2000). *Illustrated Field Guide-100 Red Listed Medicinal Plants of Conservation Concern in Southern India*. FRLHT, Bangalore, India, 432 pp.

Robson, J.P. & F. Berkes (2010). Sacred nature and community conserved areas, pp. 1–16. In: Sarah, P. & P. Jules (eds.). *Nature and Culture*. Routledge, London, 296 pp. https://doi.org/10.4324/9781849776455

Burman, J.J.R. (1997). Sacred Groves Among the Mahadeo Kolis and the Kunbis of the Western Ghats in Maharashtra. Doctor of Philosophy. Tata Institute of Social Sciences, Deonar, Mumbai.

Sane, H. & V. Ghate (2006). Sacred conservation practices at species level through tree worship. *Ethnobotany* 18: 46–52.

Singh, N.P. & S. Karthikeyan (eds.) (2000). *Flora of Maharashtra State (Dicotyledones).* Vol. 1. Botanical Survey of India, Calcutta, 899 pp.

Tambat, B., G. Rajanikanth, G. Ravikanth, R.Uma Shanker & C.G. Kushalappa (2005). Seedling mortality in two vulnerable tree species in the sacred groves of Western Ghats, South India. *Current Science* 88(3): 350–352.

Varghese, A. (2014). Ecology, Impact and Traditional Knowledge of Resin Harvest on the Wild Dammer Tree - Canarium strictum Roxb. in the Nilgiri Biosphere Reserve, Western Ghats, India. PhD Thesis. University of Hawai'i at MĀnoa, Hawai, 129 pp.

Watve, A. & V. Chavan (2020). Conceptualising framework for local biodiversity heritage sites (LBHS): a bio-cultural model for biodiversity conservation in Maharashtra. *Asian Biotechnology and Development Review* 22(2&3): 61–82.

Author details: Mukul Mahabaleshwarkar (M.Sc., MBA): executive committee member, INTACH Pune Chapter and doctoral fellow at MES Abasaheb Garware College, Pune. Working in the field of environmental research, natural heritage, conservation strategy and policy, farming and sustainability with an interdisciplinary approach. He has authored and contributed to a number of scientific and popular articles in reputed media.

Prof. Dr. Nivedita Ghayal: professor, Department of Botany, MES Abasaheb Garware College Pune. She has academic experience of 32 years and research experience of 20 years. She has published 35 research papers and two book chapters. With her research area as plant physiology, biochemistry, allelopathy and ecology, she is guiding PhD fellows (Environmental Science) of Savitribai Phule Pune University.

Supriya Mahabaleshwarkar: With a master's degree in biodiversity; she is working with INTACH for the last 17 years and is presently Co-convenor, INTACH Pune Chapter. She is working on documentation and conservation of sacred groves, associated natural and cultural heritage. She designs, curates and conducts heritage and environment awareness programs.

Dr. Vinaya Ghate: retired as scientist E and in-charge, Botany Group of Plant Science Division, Agharkar Research Institute, Pune. Floristics, taxonomy, ethnobotany, especially medicinal plants and biodiversity conservation are the areas of her lifelong research interest and passion. She has successfully completed more than 20 in-house research projects in concerned areas and published over 90 research papers.

Author contributions: MM—Conceptualization, research design, background research, field data collection, GIS mapping and analysis, manuscript design and writing. NG—Review and research insights, manuscript checking. SM—Background research, interviews, field data collection, writing and analysis. VG—Past field observation and notes, manuscript checking.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22726-22730

OPEN ACCESS

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

https://doi.org/10.11609/jott.7981.15.2.22726-22730

#7981 | Received 19 April 2022 | Final received 22 December 2022 | Finally accepted 27 January 2023

COMMUNICATION

Rediscovery of *Sewardiella tuberifera* Kash., a long-lost monotypic endemic Indian liverwort

Sapana Pant [1], S.D. Tewari [2], Prachi Joshi [3], Manisha Bhandari [4] & Richa Arya [5]

[1,2,4,5] Department of Botany, Indira Priyadarshini Govt. Girls Post Graduate College of Commerce, Haldwani, Nainital, Uttarakhand 263139, India.

[3] Department of Botany, Govt. PG College Ranikhet, Almora, Uttarakhand 263645, India.

[1] sapanapant2017@gmail.com, [2] shiv.tew@gmail.com (corresponding author), [3] prachi.pragya21@gmail.com, [4] bmannu4@gmail.com, [5] richa.arya.67@gmail.com

Abstract: An extremely rare, long-lost, monotypic endemic, Indian liverwort, *Sewardiella tuberifera* Kash. has recently been recollected after a gap of over three-and-a-half decades from an altogether new location, the Mukteshwar region (2,171 m) of Nainital district in the Kumaun Himalaya, Uttarakhand. The remarkable rediscovery of this monotypic, endemic Himalayan liverwort is a significant finding for the world's bryological treasure. Along with other rare Himalayan monotypic endemics such as *Aitchisoniella himalayensis* Kash. and *Stephensoniella brevipedunculata* Kash., the currently located sporiferous population of *Sewardiella* was discovered persisting in small, dispersed, sparse patches with 5–30 individuals. The currently spotted collection site is being considered a 'bryological hotspot'. As the area develops as a popular ecotourism destination, the original habitat of these hepatics in a lime stone-dominated, south-west facing, unstable sloppy site at Mukteshwar is under constant pressure from several developmental activities. Hence, serious conservation steps are needed to protect this hotspot supporting Himalayan bryophyte jewels. To ensure long term perpetuation and conservation of red-listed hepatic taxa, an attempt is being made to translocate part of the population to ecologically and climatically identical safer site, including a developing 'moss garden' at Lingadhar (Nainital).

Keywords: Endemic, hotspot, rare hepatic, Himalayan liverwort, Kumaun Himalaya, Nainital district, Red List

Hindi: अत्यन्त दुर्लभ, लंबे समय से अप्राप्त, एक प्रतिरूपी, स्थानिक, भारतीय लिवरवर्ट, *सिवारडिऐला टयूबरिफेरा* कश्यप हाल ही में नए स्थान, मुक्तेश्वर (2,171 मीटर) क्षेत्र से साढ़े तीन दशकों के अंतराल के बाद पाया गया है। उत्तराखण्ड के कुमाऊँ हिमालय क्षेत्र में नैनीताल जिले से इस एक प्रतिरूपी, स्थानिक हिमालयी लिवरवर्ट की उल्लेखनीय पुनर्खोज दुनिया के ब्रायोलॉजिकल कोष के लिए एक महत्वपूर्ण अन्वेषण है। *सिवारडिएला* की वर्तमान में बीजाणुजनित आबादी छोटे, बिखरे हुए, विरल पैच (5–30 संख्याओं) में अन्य दुर्लभ हिमालयी एक प्रतिरूपी, स्थानिक हिपेटिक्स जैसे *एचिसोनिएला हिमालयेन्सिस* कश्यप और *स्टीफेन्सोनिएला ब्रेविपेडुनकुलाटा* कश्यप के साथ बनी हुई पाई गई। वर्तमान में चिन्हित किये गए स्थल को एक 'ब्रायोलॉजिकल हॉटस्पाट' माना जा सकता है। मुक्तेश्वर क्षेत्र में चूने के पत्थर के वर्चस्व वाले दक्षिण पश्चिम की ओर अस्थिर ढलान वाले स्थल में इन हिपेटिक्स का मूल निवास स्थान कई विकासात्मक गतिविधियों के कारण लगातार दबाव में है, क्योंकि यह क्षेत्र एक लोकप्रिय ईकोटूरिज्म गंतव्य के रूप में विकसित हो रहा है। इसलिए हिमालयी ब्रायोफाइट रत्नों को आश्रय प्रदान करने वाले इस 'हॉटस्पाट' की सुरक्षा के लिए गंभीर संरक्षण कदम आवश्यक है। दीर्घकालिक स्थायित्व और संरक्षण को सुनिश्चित करने के लिए लाल सूचीबद्ध हेपेटिक टैक्सा की आबादी से एक हिस्से को पारिस्थितिक और जलवायु रूप से समान अन्य सुरक्षित साइट पर स्थानान्तरित करने का प्रयास किया जा रहा है, जिसमें लिंगाधार (नैनीताल) में विकसित किया जा रहा 'मॉस गार्डन' भी शामिल है।

Editor: Afroz Alam, Banasthali Vidyapith, Rajasthan, India.

Date of publication: 26 February 2023 (online & print)

Citation: Pant, S, S.D. Tewari, P. Joshi, M. Bhandari & R. Arya (2023). Rediscovery of *Sewardiella tuberifera* Kash., a long-lost monotypic endemic Indian liverwort. *Journal of Threatened Taxa* 15(2): 22726–22730. https://doi.org/10.11609/jott.7981.15.2.22726-22730

Copyright: © Pant et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: No funding agencies.

Competing interests: The authors declare no competing interests.

Author details & Author contributions: See end of this article.

Acknowledgements: The authors are grateful to Dr. A.K. Asthana senior principal scientist, CSIR-NBRI, Lucknow and Dr. B.S. Kholia, scientist c, BSI Dehradun for providing academic inputs and to the principal Dr. Shashi Purohit, Indira Priyadarshini Government Girls Post Graduate College of Commerce Haldwani, Nainital for furnishing laboratory facilities. We are also thankful to Mr. Ram Lakhan Yadav, block coordinator (GIS Expert), Tonk Rajasthan for preparing/providing the study area map. Our thanks are also to Dr. Saraswati Bisht and research scholars of Bryology Lab, Neha Kohli & Neha Binwal for their help in different ways.

INTRODUCTION

Sewardiella Kash., a monotypic, endemic, and long-lost Indian liverwort genus of the phylum Marchantiophyta, class Jungermanniopsida, family Petalophyllaceae, order Fossombroniales, has been discovered after a long period of time in the Kumaun region of the western Himalaya (Bryophyte Specialist Group 2000). The genus *Sewardiella* is classified as 'Vulnerable' in the IUCN Red List due to its limited distribution in the Indian western Himalaya (Bryophyte Specialist Group 2000). Kashyap (1915) established and described this unusual genus based on a collection from Shimla (Himanchal Pradesh) and Mussoorie (Uttarakhand) in the western Himalayan region. Kashyap (1929) has described the morpho-taxonomic details of a single species as *S. tuberifera*. Occasionally, many workers collected and described *Sewardiella* from different localities of the western Himalaya, India (Pande et al. 1955; Pant 1983; Udar & Srivastava 1983a,b; Tewari & Pant 1984). The mycorrhiza and tuber formation of this liverwort was studied by Chalaud (1932). Pande & Mishra (1937) delineated the life history of this plant, and Mehra (1938) reported 18 numbers of diploid (2x) chromosomes from the archaesporial cell nucleus of this plant. A detailed embryological account of this extraordinary genus *Sewardiella* was provided by Mehra & Khanna (1950). Pande et al. (1955) reported this hepatic as of common occurrence in Nainital and environs. Udar & Srivastava (1983a,b) have also thoroughly described the documentation of rare and endangered liverworts in India, as well as their reproductive biology. Pant (1983) listed this taxon as threatened bryophyte of Kumaun Himalaya. Tewari & Pant (1984) made scanty collections of this plant in a sterile state from the Kumaun region, viz., Suyalbari (1,100 m), Chaubatia (1,820 m), and Dhakuri (2,500 m). Pant et al. (1994) have again stated that this taxon is on the 'red list hepatic'. After 1984, there is no report of the collection of this extremely rare, phylogenetically significant liverwort from any other part of the country. Recently, Singh (2008) marked this taxon as red list endemic hepatics. One of the authors (SDT) has revisited all the earlier mentioned sites, but no traces of its occurrence could be recorded. Due to drastically changing original habitat conditions, it has gradually disappeared from the site of its occurrence over the years. Fortunately, during a recent bryophyte survey and collection in the Kumaun region of the western Himalaya, a new location of this liverwort in a fully fruiting state was discovered in and around the Mukteshwar area of district Nainital (Uttarakhand). The currently encountered poor sporiferous *Sewardiella* population was observed as small, scattered, scanty patches ranging 5–30 individuals in extremely disturbed habitat conditions gripped by rapid urbanization and anthropogenic activities, as well as the enormous mounting pressure of ecotourism. Based on the earlier records as well as the present collection of many interesting Himalayan hepatics like *Aitchisoniella, Stephensoniella, Athalamia, Cryptomitrium*, *Exormotheca*, *Fossombronia, Sewardiella*, and *Haplomitrium* species from the anthropogenically disturbed site at Mukteshwar, this locality may be declared a unique 'bryological hotspot'. Hence, conservation measures are urgently needed to save this hotspot as well as the dwindling hepatic jewels of the Himalaya from unplanned urbanization and developmental activities.

MATERIAL AND METHODS

During the months of April (10 April 2021) to September (26 September 2021), a thorough survey and collection were conducted in and around the Mukteshwar area of district Nainital (29.4727^{0}N & 79.6466^{0}E) within an elevational range of 2,240–2,266 m (Figure 1). Sterile patches of *Sewardiella* were first noticed at the end of September. Fortunately, in the first week of October (2 October 2021–6 October 2021), we were able to collect both sterile and copiously sporiferous thalli of *S. tuberifera* from a south-west facing, sloppy, lime stone hill site. Field as well as microphotographs of both gametophytic and sporophytic parts of the liverwort were taken. The identification was confirmed by Dr. S.D. Tewari based on the earlier collections made from Kumaun region (Tewari & Pant 1984). Underlying substrate pH was measured by means of pH meter. The voucher specimens have been deposited in the herbarium of Botany Department, I.P.G.G.P.G. College of Commerce, Haldwani, Nainital (SP 112, SP 154, SP 187, SP 204, SP 234) and cryptogamic herbarium of National Botanical Research Institute (NBRI), Lucknow (LWG/ SP 154, SP 204/ SD-2).

RESULTS

Taxonomic description

Sewardiella tuberifera Kashyap, New Phytol. 14:5. 1915.

Dioicous, thallose, green, forming scattered patches, when young are generally confused with fern prothallus.

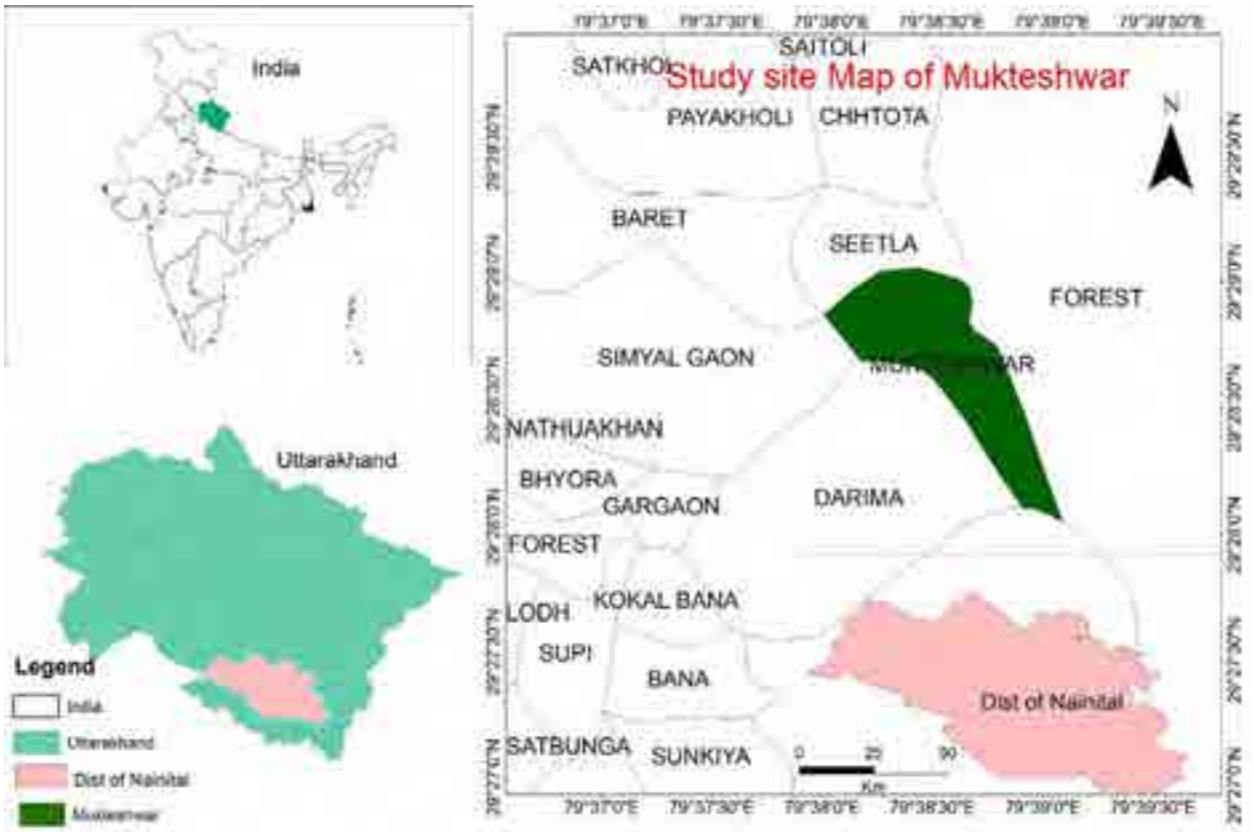


Figure 1. Study site at Mukteshwar (*Source: Bhuvan NRSC).

Thallus winged, 8–9 mm long, 12–13 mm wide, often forked with thick midrib; wings unequal, many layered at base, gradually becoming thin with wavy margin. Lobe cells hexagonal to ovoid, 46.55–53.52 x 26.6 µm towards apex, 133–159.6 x 39.9–53 µm in the middle, 66.5–93.1 x 53.2 µm towards base. Rhizoids abundant on ventral surface, long, hyaline, unicellular. Ventral scales in two rows, minute, red colored, multicellular. Perianth bell shaped, lacerated margin with numerous narrow projections; calyptra thin. Sporophyte one or more in each perianth; foot small, seta dull green, included with in the perianth or slightly exerted, 1.5–1.8 cm long. Capsule, rounded, 1.5–2.0 mm in diameter, at maturity looks like "miniature black plum"; wall 2–3 layered; inner layer with U shaped thickening bands. Spores reticulate - lamellate, 40–48 µm in diameter. Elaters brown, bi - tri spiral, 332–425 µm long, 9.6–10 µm wide at middle (Image 1 A–L).

Specimens examined: India, Western Himalaya, Uttarakhand, Nainital, Mukteshwar, 2,240–2,266 m, (29.4727^{0}N & 79.6466^{0}E) 10 April 21: SP 112, 26 September 2021: SP 154, 2 October 21: SP 187, SP 204, SP 234, leg. S.D. Tewari, Sapana Pant, Manisha Bhandari (Herbarium of Botany Department, Indira Priyadarshini Govt. Girls Post Graduate College of Commerce Haldwani, Nainital).

Distribution: India (Himachal Pradesh, Uttarakhand).

Ecology: Scattered, scanty, sporiferous population of *S. tuberifera* were found to be growing on shady, moist, lime stone (pH 7.1–7.3) dominated south-west facing, sloppy site at Mukteshwar area of District Nainital in association with other thalloid liverworts like *Asterella, Stephensoniella*, *Fossombronia;* hornwort like *Anthoceros*, and mosses like *Anomobryum, Anoectangium, Barbula, Cryptoleptodon, Dicranum, Entodon, Fissidens, Herpetineuron, Hyophila, Pogonatum, Symblepharis*, and *Timiella* species.

DISCUSSION

The 'butterfly-like' morphology of *S. tuberifera*, with a prominent apical tuber, makes this liverwort easily identifiable in the field, even with the naked eye, but it can also be confused with fern prothallus in a sterile state. Still, the fact that the species could not be found in its known locations and habitat conditions in the western Himalaya, where it was once abundant for a

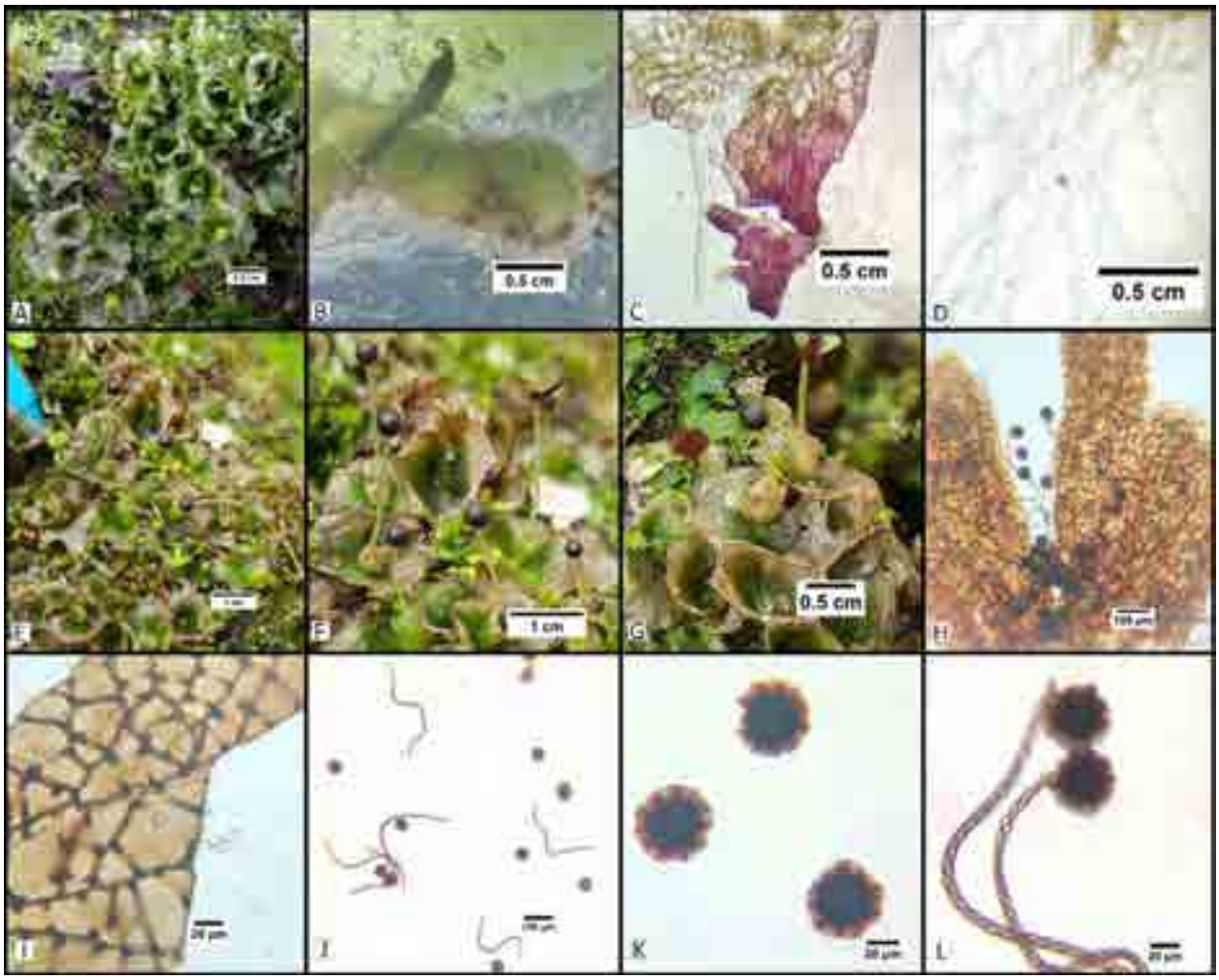


Image 1. *Sewardiella tuberifera* Kash.: A—Thalli | B—Perennating tuber | C—Multicellular scales | D—Unicellular rhizoids | E—Sporiferous patch | F—Mature sporophyte with long seta bearing "miniature black plum" like globose capsule | G—Enlarged sporophyte showing dehisced capsule | H—Inner capsule wall with annular bands | I—Outer capsule wall showing U-shaped bands | J—Spores and elaters | K—Reticulate – lamellate spores | L—bi-trispirate elaters. © Sapana Pant and S.D. Tewari.

long time, is cause for concern and indicates the species' extreme rarity.

CONSERVATION MEASURES

If the lone surviving site of *S. tuberifera* in India, Mukteshwar, is not protected and conserved in time, this fragile liverwort will become extinct. Keeping this in mind, an attempt is being made by us to transplant this liverwort from the highly disturbed site to a relatively undisturbed site with more or less the same topographical habitat conditions (sloppy site). Another attempt is being made to transplant some populations in small patches by creating similar habitat conditions in the recently developed "Moss Garden" at Lingadhar (Nainital), in order to monitor long-term perpetuation and conservation progress. Some of the sporiferous material may be preserved in vitro in the future.

REFERENCES

Bryophyte Specialist Group (2000). *Sewaridiella tuberifera.* The IUCN Red List of Threatened Species 2000 e.T39192A10168752. Accessed on 04 December 2021. https://doi.org/10.2305/IUCN.UK.2000.RLTS.T39192A10168752.en

Kashyap, S.R. (1915). Morphological and biological notes on new and little-known West-Himalayan Liverworts. III. *New Phytologist* 14: 1–18.

Kashyap, S.R. (1929). *Liverworts of the Western Himalayas and the Punjab plain*. I, Lahore, 129 pp.

Chalaud, G. (1932). Mycorhizes et tuberization chez *Sewardiella tuberifera* Kash. *Annales Bryologici* 5: 1–16.

Pande, S.K. & R.N. Mishra (1937). On the morphology of *Sewardiella tuberifera* Kash. Proceeding 24th Indian Science Congress (Hyderabad): 263.

Mehra, P.N. (1938). A study of the chromosome number in some

Indian members of the family Codoniaceae. *Proceedings Indian Academy Sciences* B 8: 1–7.

Mehra, P.N. & A.L. Khanna (1950). Embryology of *Sewardiella tuberifera* Kash. *Botanical Gazette* 112: 31–42.

Pande, S.K., K.P. Srivastava & R.N. Mishra (1955). Studies in Indian Metzgerineae-II. *Sewardiella tuberifera* Kash. *Phytomorphology* 5(1): 57–67.

Udar, R. & S.C. Srivastava (1983a). Rare and endangered liverworts of India, pp. 303–312. In: Jain, S.K. & R.R. Rao (eds.). An Assessment of Threatened Plants of India (Proceedings of Seminar, sept. 14–17, 1981). *Botanical Survey of India, Botanic Gardens, Howrah*, 334 pp.

Udar, R. & S.C. Srivastava (1983b). Reproductive biology of some Indian liverworts. *Phytomorphology* 33: 37–46.

Pant, G. (1983). Threatened bryophytes of Naini Tal, pp. 313–317. In Jain, S.K. & R.R. Rao (eds.). An Assessment of Threatened Plants of India (Proceedings of Seminar, sept. 14–17, 1981). *Botanical Survey of India, Botanic Gardens, Howrah*, 334 pp.

Tewari, S.D. & G. Pant (1984). Present distribution of two rare, monotypic, endemic liverworts, *Stephensoniella brevipedunculata* Kash. and *Sewardiella tuberifera* Kash. in Naini Tal and environs. *Journal Himalayan Research and Development* 3(1): 48–50.

Pant, G., S.D. Tewari & S. Joshi (1994). Vanishing greenery in Kumaon Himalaya: Observations on bryoflora. *Geophytology* 23(2): 253–257.

Singh, D.K. (2008). Red listing of Hepaticae and Anthocerotae in India, pp. 451–458. In: Mohamed, H., B. B. Baki, A. Nasrulhaq- boyce & P.K.Y. Lee (eds.). *Bryology in the new Millennium.* University of Malaya, Kuala Lumpur, 513 pp.

Author details: Sapana Pant, a PhD scholar working under the supervision of Dr S.D. Tewari in the field of bryophyte taxonomy and conservation. She has received Kumaun University gold medal in MSc. Recently she received the "young scientist award" at the 15th Uttarakhand State Science and Technology Congress 2020-22 for the best oral presentation and so far, published eight research papers in national and international journals. Dr S.D. Tewari Professor and former Head of the Department of Botany Govt. Girls PG College of Haldwani. He has 40 years of research experience in the field of bryology with 80 research papers and three books of his credit. Currently, he has been given an opportunity to work as a chief advisor of India's first "Moss Garden" developed at Lingadhar, Nainital. Dr Prachi Joshi, assistant professor Department of Botany Govt. PG. College Ranikhet has 20 years of teaching and research experience. She is specialised in the field of phytosociological studies in bryophytes and angiosperms. She has 20 research papers and one book of his credit. Manisha Bhandari, a research scholar pursuing her PhD work under the supervision of Dr S.D. Tewari. Presently she is working in the field of bryo-systematics and Phytosociological studies of the *Cedrus deodara* forest at Lohaghat. Till now she has published nine research papers and one booklets on bryophyte diversity. Richa Arya currently working as a research student under the supervision of Dr S.D. Tewari and co-supervision of Dr Prachi Joshi. She is engaged in "Bryo-exploratory studies of various Forest Types along an Altitudinal Gradient. So far, she has published three research papers, and one booklet on bryo-diversity.

Author contributions: The main and corresponding authors (S.Pant and S. D.Tewari) collected, identified the samples and finalized the initial draft prepared by co-authors (P Joshi, M. Bhandari and R. Arya).

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22731–22736

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

https://doi.org/10.11609/jott.8353.15.2.22731-22736

#8353 | Received 01 January 2023 | Final received 30 January 2023 | Finally accepted 08 February 2023

OPEN ACCESS

COMMUNICATION

Physcomitrium eurystomum Sendtn. (Funariaceae: Bryophyta) and *Splachnobryum obtusum* (Brid.) Müll. Hal. (Splachnobryaceae: Bryophyta), two rare moss species from the Western Ghats of Kerala

C. Nair Manju [1], P.M. Vineesha [2], B. Mufeed [3] & K.P. Rajesh [4]

[1–3] Department of Botany, University of Calicut, Malappuram District, Kerala 673635, India.
[4] PG & Research Department of Botany, The Zamorins Guruvayurappen College (affiliated to University of Calicut), Kozhikode, Kerala 673014, India.
[1] manjucali@gmail.com (corresponding author), [2] vinishapmohan@gmail.com, [3] mufeednaja@gmail.com, [4] kprajesh.botany@gmail.com

Abstract: *Physcomitrium eurystomum* Sendtn. is a temperate to tropical species, Red Listed in Europe, now collected on the way to Mattupetty from Munnar of Idukki district in the Western Ghats of Kerala. *Splachnobryum obtusum* (Brid.) Müll. Hal. was collected from the lateritic midland of Malappuram district of Kerala. Both these species are of rare occurrence and poorly known in the Western Ghats, hence described in detail with images.

Keywords: Bryological study, conservation, Idukki district, Malappuram district, new records, rare species

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Manju, C.N., P.M. Vineesha, B. Mufeed & K.P. Rajesh (2023). *Physcomitrium eurystomum* Sendtn. (Funariaceae: Bryophyta) and *Splachnobryum obtusum* (Brid.) Müll. Hal. (Splachnobryaceae: Bryophyta), two rare moss species from the Western Ghats of Kerala. *Journal of Threatened Taxa* 15(2): 22731–22736. https://doi.org/10.11609/jott.8353.15.2.22731-22736

Copyright: © Manju et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: DST-SERB-Core Research Grant & University Grants Commission (UGC).

Competing interests: The authors declare no competing interests.

Author details: Dr. Manju C. Nair is working as associate professor of Botany in Calicut University and conducting Bryophyte studies especially on taxonomy and ecology in Western Ghats during the past 23 years. Ms. P.M. Vineesha is working as junior research fellow under the guidance of Dr. Manju C. Nair on the taxonomy and molecular phylogeny of the family Bryaceae in Kerala. Dr. B. Mufeed is working on the DST-SERB CRG project as research associate and doing taxonomic and molecular studies on the *Riccia* of Western Ghats. Dr. K.P. Rajesh is working as assistant professor in the Zamorins Guruvayurappan College and working on the taxonomy and ecology of Angiosperms, Pteridophytes and Bryophytes for the last 26 years.

Author contributions: All authors contributed equally.

Acknowledgements: We thank the authorities of the Department of Botany, University of Calicut and the Zamorins Guruvayurappan College, Kozhikode for the facilities provided. MCN & BM are thankful to the DST-SERB for funding Core Research Grant in the Department of Botany, University of Calicut. VPM is thankful to the University Grants Commission (UGC), New Delhi for the financial assistance under NET-JRF scheme. We are also thankful to the Kerala Forest and Wildlife Department for the permission and support during the collection of Physcomitrium eurystomum from Idukki district; and the Principal, PSMO College, Tirurangadi for permitting to collect *Splachnobryum obtusum* from the campus.

INTRODUCTION

The bryological studies in the Western Ghats intensified during the past two decades and has resulted in the addition of several species to the area, including new species (Nair et al. 2005; Manju et al. 2008; Manju & Rajesh 2012; Daniels et al. 2018; Daniels & Kariyappa 2019; Daniels & Raja 2020; Mufeed et al. 2021; Manjula et al. 2022). Still there are several areas remaining largely unexplored or underexplored. During our recent bryofloristic exploration in the high-altitude regions of Idukki District in the Western Ghats of Kerala, one moss species of Funariaceae was collected, and was identified as *Physcomitrium eurystomum* Sendtn. This is a widely distributed species in the montane temperate and tropical areas of Europe; tropical Africa; southern, southeastern, & southwestern parts of Asia; and northeastern part of Montenegro; but reported as of scattered occurrence (Dierßen 2001; Papp et al. 2013; Porley 2013; Hodgetts 2015; Stešević et al. 2020). Hodgetts et al. (2019) included this species in the European Red List of Mosses, Liverworts, and Hornworts. It is also known to occur in lower Bengal and Assam in northeastern India and Parasnath Wildlife Sanctuary in Jharkhand in central India (Saha & Singh 2020). In the Western Ghats it is, however, known as a sole collection by Rajeevan (1990) from Puliyanmala in Kulamavu area of Idukki District. Since then, it has not been collected or recorded from the Western Ghats. The present collection is on the way to Mattupetty from Munnar, Idukki District, about 70 km away from the first collection by Rajeevan (1990). A detailed account of this rare and poorly collected species from the Western Ghats is being provided here.

The family Splachnobryaceae include two genera, viz., *Koponobryum* Arts and *Splachnobryum* Müll.Hal. (Arts 2001). More than 50 species are known in this family, however, Arts (2001) accepted only 10 valid species, viz.: *Koponobryum bengalense* (Gangulee) Arts, *Splachnobryum aquaticum* Müll. Hal., *S. assamicum* Dixon, *S. crassinervium* Arts, *S. gracile* Besch., *S. limbatum* D.H.Norris & R.H.Zander, *S. novae-guineae* Broth., *S. obtusum* (Brid.) Müll.Hal., *S. oorschotii* M.Fleisch., and *S. wiemansii* M.Fleisch. Among these *Koponobryum bengalense* (Gangulee) Arts was first described by Gangulee (1974) from Calcutta, India as *Splachnobryum bengalense* Gangulee. Later, Arts (2001) established a new genus, *Koponobryum* Arts to accommodate this species due to its unique characteristics such as acute leaf apex, costa reaching the apex in upper stem leaves, the upper lamina cells with one central papilla in contrast to the obtuse leaf apex, costa ending one or more cells below apex in upper stem leaves, and all the lamina cells smooth in *Splachnobryum*. In India, the genus *Splachnobryum* was known with seven species, but Arts (2001) recognized only three valid species—*S. aquaticum* Müll.Hal., *S. assamicum* Dixon, and *S. obtusum* (Brid.) Müll.Hal. (Dixon 1937; Gangulee 1974; Chopra 1975; Tewari & Pant 1989, 1990; Arts 2001; Sahu & Asthana 2022). All other species are treated as synonyms; *S. indicum* Hampe & Müll.Hal. and *S. flaccidum* (Hook.) Müll.Hal. under *S. obtusum., S. procerrimum* under *S. aquaticum* and *S. synoicum* under *S. assamicum. S. pulcherrimum* Dixon et P.de la Varde was treated as invalid due to the absence of description (Blatter & Fernandez 1931). We came across scattered population of *S. obtusum* (Brid.) Müll.Hal. in the lateritic midland of Malappuram District of Kerala. A detailed account of this rare and poorly known species is being provided.

Even though *Splachnobryum obtusum* and *Physcomitrium eurystomum* are mentioned in some literature as reported from Kerala (Manju et al. 2008), the detailed description is lacking. Hence the two species are described in detail with images and its conservation status is discussed.

MATERIAL AND METHODS

Physcomitrium eurystomum was collected during September 2022 from the muddy soil and small rocky stones along land cuttings from Idukki District and *Splachnobryum obtusum* during December 2022 from the lateritic midland terrestrial microhabitat along with *Riccia billardierei* Mont. & Nees from Malappuram District. The voucher specimens are deposited in the Calicut University Herbarium (CALI). Morpho-anatomical analysis of specimens was studied using stereo dissection microscope (Labomed Luxeo 4z and Olympus SZ) and compound microscope (Labomed LX-400, Leica DM 2000 LED, and Olympus CX2LiLED). Measurements of the plant parts and cells were taken with the help of Magnus Analytics MagVision (version: x64, 4.8.15674.20191008) software.

RESULTS

Physcomitrium eurystomum Sendtn., Denkschr. Königl.-Baier. Bot. Ges. Regensburg 3: 142. 1841.-Type: Herb. A.v.Haller, #s.n. (GOET).

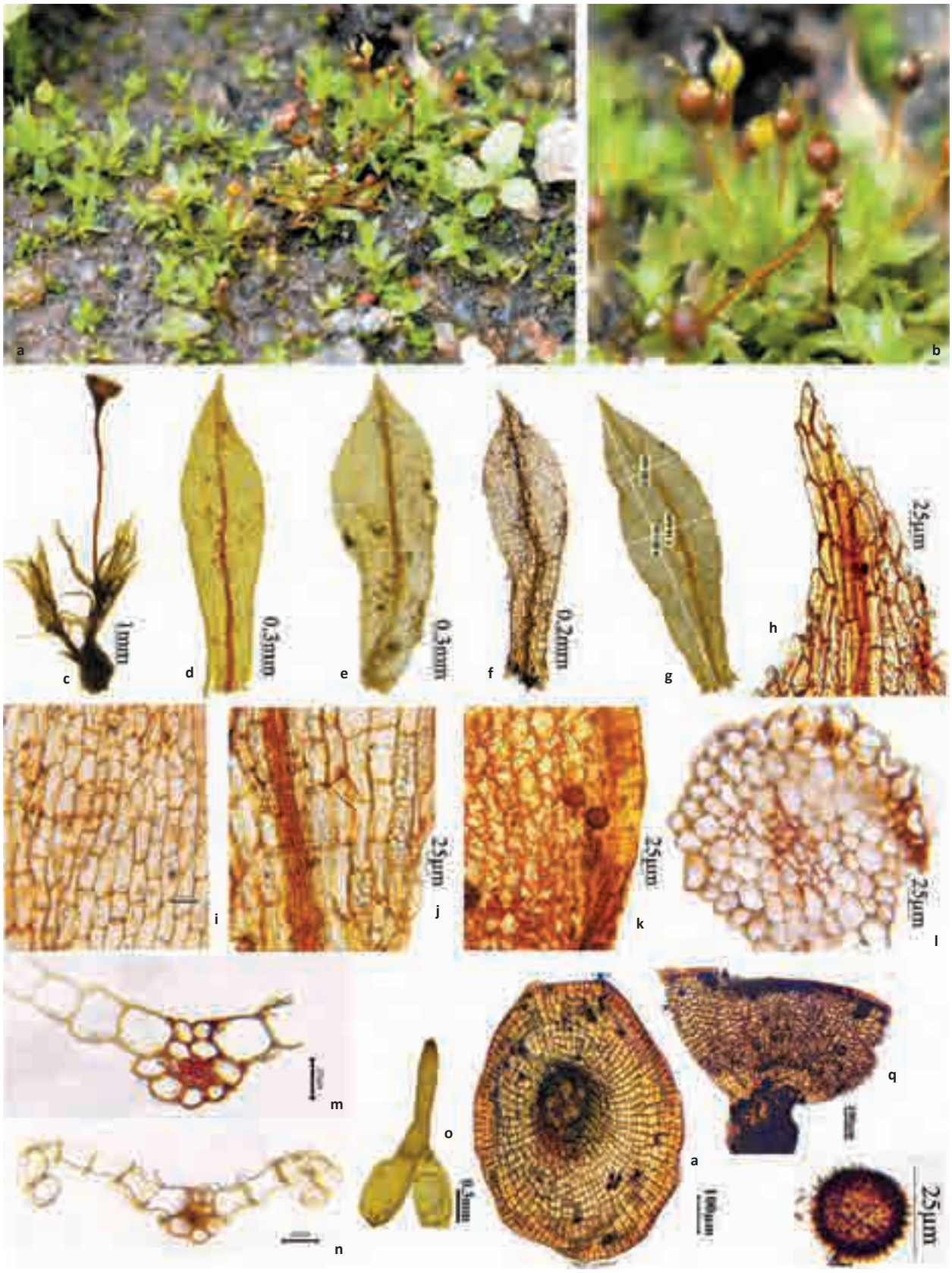


Image 1. ***Physcomitrium eurystomum*** **Sendtn.: a&b—habit with sporophyte | c—single dry plant | d–e—leaves | f—dry leaf | g—perichaetial leaf | h—leaf apex | i—middle cells | j—basal cells | k—capsule wall | l—c.s. of the stem | m&n—c.s. of the leaf | o—calyptra | p—operculum | q—dehisced capsule. © Authors.**

Plants terrestrial, green, erect, gregarious forming small loose mats, short to medium with 3–8 mm high (with sporophyte). Stem slender, ovate in cross section, 0.21–0.25 wide, cells rounded-polygonal, uniseriate thick walled epidermis, epidermal cells 16–24 × 13–21µm, cortex 3 or 4 layered, thin walled cells, 12–33 × 18–40 µm, medullary cells small polygonal, thin-walled, 3–9 × 8–12 µm. Leaves thin erectopatent-erect spreading, arranged in a rosette, lanceolate to spathulate, 3–5 mm long and 0.8–1.5 mm wide, leaf tip acuminate, costa dark brown, stout at the base, gradually tapers towards tip and percurrent. Laminal cells long rectangular at base, 70–85 × 15–27 µm, median cells rectangular, 20–45 × 15–25 µm, apical cells rectangular, 30–43 × 12–20 µm, marginal cells distinct with narrow elongated cells, shorten towards the tip in a single row, dentate from 1/3rd of the leaf, 35–100 × 12–16 µm. Seta slender, pale orange to dark brown, 4–6 mm long, capsule exerted, brown, short-pyriform, symmetrical, short distinct apophyses, turbinate, capsule mouth wider than urn, 1.5–2 mm long and ± 1mm wide, peristome absent, operculum convex with wide rim, shortly rostellate, radiating rows of very short rectangular cells, calyptra papery, more or less transparent, not cucullate, caducus, covering the operculum, ±1.5 mm long, with parallel rows of thin rectangular cells, spores small, brown, globose, 24–28 µm in diameter, spinose-papillose. (Figure 1).

Specimen/s examined: India, Kerala, Idukki Dist., on the way to Mattupetty from Munnar (1,700 m), on land cuttings, Mufeed B., 195009, 1 September 2022 (CALI); Puliyanmala (1,200 m), B. Rajeevan 81007, 26 February 1984 (MH!).

Distribution: India (Northeastern India: Western Himalaya, Punjab & western Rajasthan (Gangulee 1974); Central India: Jharkhand (Saha & Singh 2020); Western Ghats (Kerala- (Rajeevan 1990 & present study)); Austria (ECCB 2016); Belarus (Maslovsky 2005); Belgium (ECCB 2016); the Czech Republic (Kučera & Váňa 2003); Estonia (Ingerpuu et al. 2018); Great Britain (Hodgetts 2011); Germany (ECCB 2016); Hungary (Papp et al. 2010), Netherlands (ECCB 2016); Slovakia (Šoltés et al. 2002); Switzerland (BAFU 2011); Bulgaria, Romania, & Turkey (Sabovljević et al. 2001); Slovenia (Martinčić 2016); Serbia (Papp et al. 2013); and Bulgaria & Slovenia (Sabovljević et al. 2008).

Splachnobryum obtusum (Brid.) Müll.Hal., Verh. K.K. Zool.-Bot. Ges. Wien 19: 504. 1869. *Weissia obtusa* Brid., Muscol. Recent. Suppl. 1: 118. 1806.- Type: Sto. Domingo, leg. Poiteau s.n., s.d. (isotype BM). *Splachnobryum indicum* Hampe & Müll.Hal., Linnaea 37: 174. 1873[1872]. *Splachnobryum flaccidum* (Harv.) Braithw., Grevillea 1(2): 28. 1872.

Plants small, 0.7–15 mm long, pale green or yellowish-green, stems simple, numerous rhizoids arise from the base. Leaves erect to spreading, 0.5–1.0 mm long and 0.3–0.5 mm wide, leaves ovate lanceolate to spathulate, upper leaves longer than the lower, apex broadly rounded or obtuse, costa ending near the apex; leaf margin plane, crenulate at apex with overlapping leaf cells. Leaf cells smooth, thin walled, upper cells shorter, nearly quadrate, 8–12 µm, lower cells long and wider, rectangular, 15–50 µm long, 10–12 µm wide, leaf cells at middle oblong-hexagonal, variable in size and orientation of cells, 28–80 µm long and 15–20 µm wide, rhizoidal tubers not observed as reported; cauline gemmae numerous of different shapes and sizes. Reproductive structures not observed (Figure 2).

Specimen/s examined: India, Kerala, Malappuram Dist., Thirurangadi, PSMO College campus (ca. 37 m) terrestrial on disturbed garden soil, 01 November 2022, K.P. Rajesh 194099c; 21 November 2022 Mufeed & Manju 194097 (CALI).

Distribution: India (Northeastern India & Kerala); Africa; Australia; Cuba; Indonesia; Jamaica; Myanmar; Mexico; Malaya; the Philippines; Papua New Guinea; Thailand; USA; West Indies; and Europe (France, Germany, Hungary, United Kingdom, & Macaronesia) (Arts 2001).

DISCUSSION

The genus *Physcomitrium* is earlier known in the Western Ghats with three well known species, viz., *P. coorgense* Broth., collected from Coorg in Karnataka, *P. immersum* Sull collected from Peechi in Kerala and *P. insigne* Dixon & P.de la Varde a southern Indian endemic species collected from Tamil Nadu. The fourth one, *P. eurystomum* was poorly known, as mentioned by Rajeevan (1990) with a single collection record from Kerala. Since then, it was not collected or recorded from the Western Ghats area by any other workers. In India over these years this species was not well recorded from earlier known areas of its occurrence. In Europe it is distributed in about 22 countries of which 15 countries assessed its status, and included in the Red List (Hodgetts et al. 2019) as VU for Europe or EN for European Union. May be due to its smaller size, and short (ephemeral) life cycle it was not recorded properly from the Western Ghats. Considering these points, it is a potential candidate species for assessing the threat

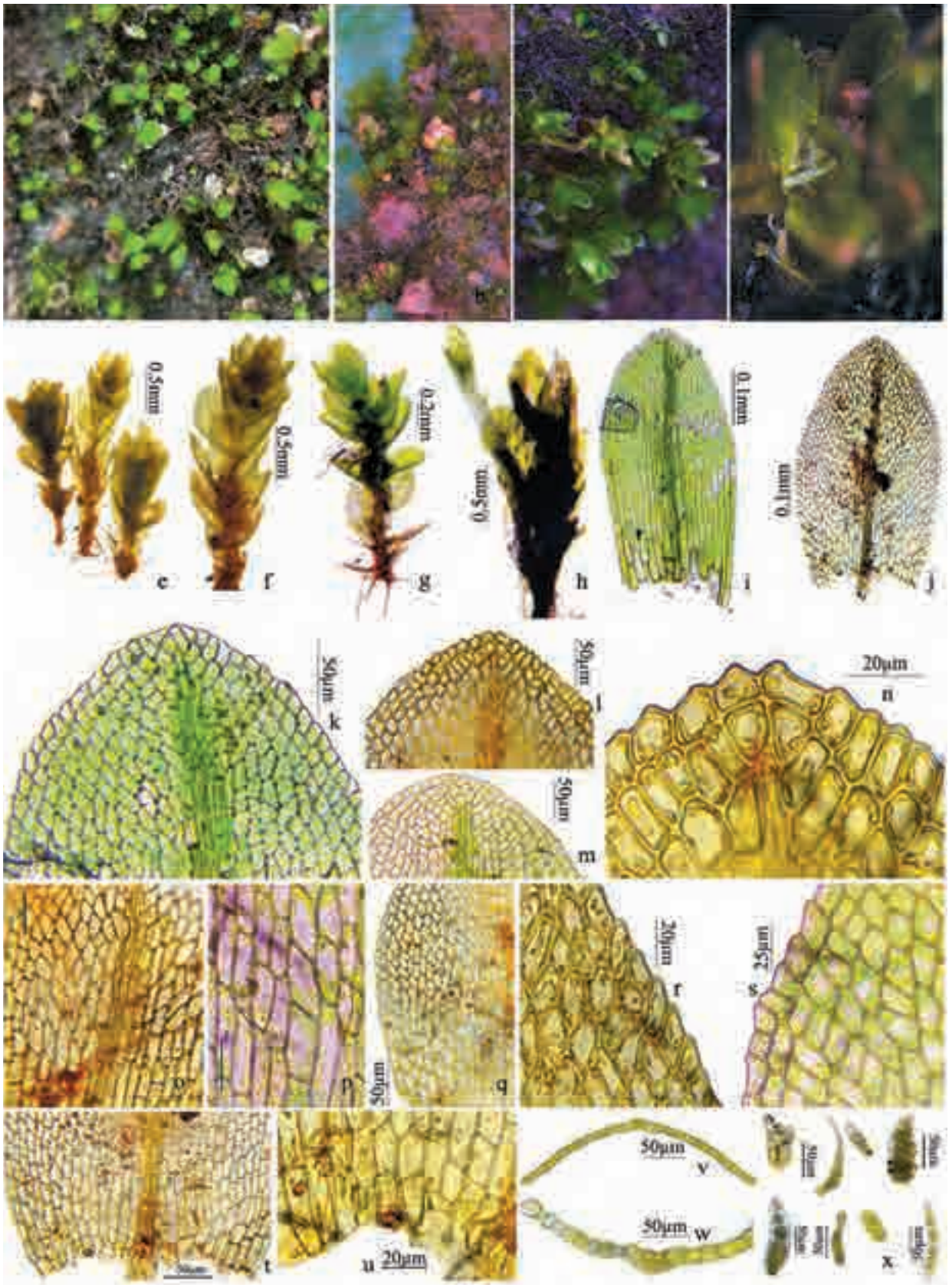


Image 2. ***Splachnobryum obtusum*** **(Brid.) Müll.Hal.: a,b&c—habit | d—habit with gemmae | e,f&g—single habit | h—plants arise from rhizoidal tuber | i—leaves near top | j—leaves near base | k–m—leaf apex | n—leaf cells at tip | o&p—cells at middle | q—leaf marginalv | r&s—marginal cells at mid leaf eenlarged view | t—leaf base | u—basal cells | v&w—c.s. of leaf | x—different types of gemmae. © Authors.**

status in the Western Ghats region or India at large.

The members of *Splachnobryum* are also very small, usually seen in mineral rich soils (Tewari & Pant 1989). The occurrence of *S. obtusum* (Brid.) Müll.Hal. in Kerala was mentioned in some earlier checklist (Manju et al. 2008), based on Rajeevan (1990). However, it is also a poorly known species in Kerala, not collected or recorded frequently. The present record is hence significant.

REFERENCES

Arts, T. (2001). A revision of the Splachnobryaceae (Musci). *Lindbergia* 26(2): 77–96.

BAFU (2011). *Liste der National Prioritären Arten. Arten mit nationaler Priorität für die Erhaltung und Förderung, Stand 2010*. Umwelt-Vollzug 1103. Bundesamt für Umwelt, Bern.

Blatter, E. & J. Fernandez (1931). Waziristan mosses with some new species described by H.N. Dixon. *Journal of Indian Botanical Society* 10: 145–153.

Chopra, R.S. (1975). Taxonomy of Indian mosses. CSIR, New Delhi, India.

Daniels, A.E.D., R. Sreebha & K.C. Kariyappa (2018). *Bryoflora of Indira Gandhi National Park in Anamalai Hills, India*. Bishen Singh Mahendra Pal Singh, 513 pp.

Daniels, A.E.D. & K.C. Kariyappa (2019). *Bryoflora of the Agasthyamalai Biosphere Reserve, Western Ghats, India*. Bishen Singh Mahendra Pal Singh, Dehra Dun, 658 pp.

Daniels, A.E.D. & R.D.A. Raja (2020). *Bryoflora of the Silent Valley National Park, Western Ghats, India.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Dierβen, K. (2001). *Distribution, ecological amplitude and phytosociological characterization of European bryophytes*. Bryophytorum Bibliotheca 56. J. Cramer, Berlin, Stuttgart.

ECCB (2016). European working list of mosses, Version 6.0 (26.ii.2016). Retrieved January, 2019 from https://eccbbryo.nhmus.hu/node/23

Gangulee, H.C. (1974). *Mosses of Eastern India and Adjacent Regions*. vol. II (Fascicle A) Calcutta, India.

Hodgetts, N. (2011). A revised Red List of bryophytes in Britain. Field Bryology 103: 40–49.

Hodgetts, N.G. (2015). *Checklist and country status of European bryophytes – towards a new Red List for Europe*. Irish Wildlife Manuals, No. 84. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Ireland.

Hodgetts, N., M. Cálix, E. Englefield, N. Fettes, M. García Criado, L. Patin, A. Nieto, A. Bergamini, I. Bisang, E. Baisheva, P. Campisi, A. Cogoni, T. Hallingbäck, N. Konstantinova, N. Lockhart, M. Sabovljevic, N. Schnyder, C. Schröck, C. Sérgio, M. Sim Sim, J. Vrba, C.C. Ferreira, O. Afonina, T. Blockeel, H. Blom, S. Caspari, R. Gabriel, C. Garcia, R. Garilleti, J. González Mancebo, I. Goldberg, L. Hedenäs, D. Holyoak, V. Hugonnot, S. Huttunen, M. Ignatov, E. Ignatova, M. Infante, R. Juutinen, T. Kiebacher, H. Köckinger, J. Kučera, N. Lönnell, M. Lüth, A. Martins, O. Maslovsky, B. Papp, R. Porley, G. Rothero, L. Söderström, S. Ştefaˇnuţ, K. Syrjänen, A. Untereiner, J. Váňa, A. Vanderpoorten, K. Vellak, M. Aleffi, J. Bates, N. Bell, M. Brugués, N. Cronberg, J. Denyer, J. Duckett, H.J. During, J. Enroth, V. Fedosov, K.-I. Flatberg, A. Ganeva, P. Gorski, U. Gunnarsson, K. Hassel, H. Hespanhol, M. Hill, R. Hodd, K. Hylander, N. Ingerpuu, S. Laaka-Lindberg, F. Lara, V. Mazimpaka, A. Mežaka, F. Müller, J.D. Orgaz, J. Patiño, S. Pilkington, F. Puche, R.M. Ros, F. Rumsey, J.G. Segarra-Moragues, A. Seneca, A. Stebel, R. Virtanen, H. Weibull, J. Wilbraham & J. Żarnowiec (2019). A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts. IUCN, Brussels, Belgium.

Ingerpuu, N., K. Vellak & L. Ehrlich (2018). Revised Red Data List of Estonian bryophytes. *Folia Cryptogamica Estonica* 55: 97–104.

Kučera, J. & J. Váňa (2003). *Check-and Red List of bryophytes of the Czech Republic. Preslia* 75: 193–222.

Manju C.N. & K.P. Rajesh (2012). Present status of bryophyte diversity in Kerala. *SAMAGRA* 8: 20-27.

Manju C.N., K.P. Rajesh & P.V. Madhusoodanan (2008). Checklist of the Bryophytes of Kerala, India. *Tropical Bryology Research Report* No. 7: 1–24.

Manjula K.M., C.N. Manju & K.P. Rajesh (2022). *Fissidentaceae (Bryophyta) of the Western Ghats, India.* Centre for Research in Indigenous Knowledge Science & Culture, 447 pp.

Martinčić, A. (2016). Updated Red List of bryophytes of Slovenia. *Hacquetia* 15: 107–126.

Maslovsky, O. (2005). Rare and threatened bryophytes and a proposal for an Eastern European Red Book. *Boletín de la Sociedad Española de Briología* 26–27: 47–54.

Mufeed B., C.N. Manju & K.P. Rajesh (2021). *Bryophytes of Anamudi shola National Park in the Western Ghats of Kerala, India*. Centre for Research in Indigenous Knowledge Science & Culture & Malabar Natural History Society, Kozhikode, 455 pp.

Nair, M.C., K.P. Rajesh & P.V. Madhusoodanan (2005). *Bryophytes of Wayanad in Western Ghats*. Malabar Natural History Society, Kozhikode, i–iv+284 pp.

Papp, B., E. Szurdoki, J. Pantović & M. Sabovljević (2013). *Physcomitrium eurystomum* and *Pohlia proligera*, new mosses in the bryophyte flora of Serbia. *Archives of Biological Sciences, Belgrade* 65: 703–706.

Papp, B., P. Erzberger, P. Ódor, Z.S. Hock, P. Szövényi, E. Szurdoki & Z. Tóth (2010). Updated checklist and red list of Hungarian bryophytes. *Studia Botanica Hungarica* 41: 31–59.

Porley, R. (2013). *"Physcomitrium eurystomum*: *Norfolk Bladder." England's Rare Mosses and Liverworts: Their History, Ecology, and Conservation*. Princeton University Press, Princeton, New Jersey; Woodstock, Oxfordshire.

Rajeevan, B. (1990). *Studies on the Bryophyte flora of the Idukki District, Kerala.* Ph.D. Thesis, Bharathiar University, Coimbatore.

Sabovljević, M., A. Ganeva, E. Tsakiri & S. Ştefaˇnuţ (2001). Bryology and bryophyte protection in south-eastern Europe. *Biological Conservation* 101: 73–84.

Sabovljević, M., R. Natcheva, G. Dihoru, E. Tsakiri, S. Dragićević, A. Erdag & B. Papp (2008). Check-list of the mosses of Southeast Europe. *Phytologia Balcanica* 14: 159–196.

Saha, P. & D. Singh (2020). *Physcomitrium eurystomum* (Bryophyta: Funariaceae) - an addition to bryoflora of central India. *Indian Journal of Forestry* 43(4): 341–344.

Sahu, V. & A.K. Asthana (2022). Diversity and distribution of liverworts in some underexplored areas of Manipur. *The Indian Forester* 148(9): 931–937.

Šoltés, R., A. Kubinská & K. Janovicová (2002). Extinction risk to the Bryophytes in Slovakia, reasons and evaluation. *Portugaliae Acta Biologica* 20: 57–63.

Stešević, D., B. Anđić & M. Stanišić-Vujačić (2020). *Physcomitrium eurystomum* Sendtn., a new moss species in the bryophyte flora of Montenegro. *Acta Botanica Croatica* 79(1): 95–97.

Tewari, S.D. & G. Pant (1989). *Splachnobryum procerrimum* Dix. & P. Vard., a little known species from Western Himalaya (India). *Journal of Bryology* 15: 555–557.

Tewari, S.D. & G. Pant (1990). *Splachnobryum synoicum* Robinson new to the Westerm Himalayas (India). *Journal of Bryology* 16(1): 122–124.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22737–22740

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

https://doi.org/10.11609/jott.8171.15.2.22737-22740

#8171 | Received 19 November 2022 | Final received 26 January 2023 | Finally accepted 27 January 2023

OPEN ACCESS

SHORT COMMUNICATION

First record of the Great Seahorse *Hippocampus kelloggi* Jordan & Snyder, 1901 (Actinopterygii: Syngnathiformes: Syngnathidae) from the northwestern coast of Bay of Bengal

Anil Kumar Behera [1], Biswajit Mahari [2] & Amrit Kumar Mishra [3]

[1,2] Department of Marine Sciences, Berhampur University, Odisha 760007, India.
[3] Department of Marine Conservation, Bombay Natural History Society, Hornbill House, Opp. Lions Gate, Mumbai, 400001, India.
[1] anilmarinebio@gmail.com, [2] jitbiswajitmahari00@gmail.com, [3] a.mishra@bnhs.org (corresponding author)

Abstract: This study reports the first occurrence of the Great Seahorse *Hippocampus kelloggi* from the state of Odisha in the eastern coast (Bay of Bengal) of India. The seahorse was captured in a ring net during daily fishing activities. The sample was collected from the Ariyapalli fish landing center and identification was carried out based on the morphometric features of the specimen and the seahorse identification guide. The total length of the juvenile seahorse was 12.5 cm (with a tail length of 6.6 cm (52.8%), trunk length of 3.4 cm (27.2%) and head length of 2.5 cm (20%)). The length of the snout was 1 cm. There were 38 tail rings followed by 11 rings on the trunk of the animal. Both eye and cheek spines were present. Northward migration (~1,300 km) of this species can be a response of extensive fishing activities around the southern coast of India. This calls for increased monitoring of the coast coastal ecosystems of India on the east coast for better conservation and management of the remaining seahorse populations.

Keywords: Conservation, Kellog's Seahorse, migration, monitoring, Vulnerable.

Seahorses belong to the single genus *Hippocampus* are a unique and remarkable group of fishes that have unusual body shapes (e.g., horse-like head structure) and biology (e.g., where males incubate fertilized eggs) inhabiting shallow coastal ecosystems worldwide (Foster & Vincent 2004; Lourie et al. 2004; Zhang & Vincent 2018). The Indo-Pacific region is one of the hotspots of seahorse populations that are distributed across diverse ecosystems such as seagrass, mangroves, macroalgal beds, and coral reefs, while inhabiting the shallow estuaries, lagoons, and subtidal regions up to 15 m depth (Foster & Vincent 2004; Salin et al. 2005; Balasubramanian & Murugan 2017; Li et al. 2021). Around 46 species of seahorse species are reported worldwide with 12 species found in the Indo-Pacific region; eight species as 'Vulnerable' (VU) (*Hippocampus arbourin*, *H. kelloggi*, *H. kuda*, *H. mohnikei*, *H. spinosissimus*, *H. trimaculatus*, *H. fuscus*, and *H. histrix*), four 'Data Deficient' (DD), and one 'Least Concern' (IUCN 2022). Most of the seahorse population in the Indo-Pacific are under decline due to their overexploitation for traditional Chinese medicines (e.g., *Hippocampus capensis, H. kelloggi, H. kuda, H. trimaculatus*, and *H. histrix*) and as ornamental fishes, combined with general destructive fishing and fisheries bycatch (Sreepada et al. 2002; Foster & Vincent 2004; Kavungal & Saravanan 2015; Jeyabaskaran et al. 2018; Zhang & Vincent 2018).

The coastal ecosystems of India inhabit nine out of 12 species of seahorses found in the Indo-Pacific—*Hippocampus trimaculatus* (VU), *H. kuda* (VU), *H. fuscus* (VU), *H. spinosissiums* (VU), *H. kelloggi* (VU), *H. histrix* (VU), *H. mohinekei* (VU), and *H. camelopardalis* (DD)

Editor: R. Ravinesh, Centre for Marine Living Resources and Ecology, Kochi, India. **Date of publication:** 26 February 2023 (online & print)

Citation: Behera, A.K., B. Mahari & A.K. Mishra (2023). First record of the Great Seahorse *Hippocampus kelloggi* Jordan & Snyder, 1901 (Actinopterygii: Syngnathiformes: Syngnathidae) from the northwestern coast of Bay of Bengal. *Journal of Threatened Taxa* 15(2): 22737–22740. https://doi.org/10.11609/jott.8171.15.2.22737-22740

Copyright: © Behera et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: No funding was received for this study.

Competing interests: The authors declare no competing interests.

Acknowledgements: The authors thank Indian Institute of Technology Bhubaneswar for their support in providing laboratory space.

Figure 1. The common occurrence locations of seahorse populations across various states and union territories of India (*). *Hippocampus kelloggi* is recorded from the coast of Odisha (OR*). Andhra Pradesh (AP), Tamil Naidu (TN), Kerala (KL), Karnataka (KA), Goa (GA), Maharashtra (MH), Gujarat (GJ), Daman &Diu (DM), Lakshadweep (LK), and Andaman & Nicobar Islands (AN).

spread across eight states and five union territories (Vaidyanathan & Vincent 2021). However, detailed studies on distribution and diversity of seahorses in India is limited mostly to the Gulf of Mannar and Palk Bay region in the southeastern coast of India (Salin et al. 2005; Balasubramanian & Murugan 2017). Despite the ban on fishing and trading activities on seahorses from 2001 (MoEFCC 2001), clandestine fishing and trading still takes place in India (Sreepada et al. 2002; Kavungal & Saravanan 2015). This creates immense pressure on the seahorse populations that have high dependency on local habitats to maintain their extensive and long-life history traits (Foster & Vincent 2004). For successful maintenance of their population seahorses depend on range extension and migration to new habitats despite being poor swimmers and their dependence on rafting for long-distance dispersal (Teske et al. 2005; Luzzatto et al. 2013). Range extension in seahorses of India has been previously documented for *H. fuscus* from southeastern coast, northwards towards the Chilika lagoon (Mahapatro et al. 2017), and for *H. mohnikei* from the southeastern coast into Mandovi estuary in Goa (Sanaye et al. 2020). *Hippocampus kelloggi* is one of the common seahorse species found along the Coromandel coast with distribution limited only to the southeastern coast of India (Kavungal & Saravanan 2015; Vaidyanathan & Vincent 2021).

Methods

The specimen was collected from Ariyapalli fish landing center (19.30^{0}N & 84.96^{0}E), Ganjam, in the state of Odisha, east coast of India (Figure 1). The seahorse was caught in a ring net (fishing net) on 21 May 2022 during the sample collection for trash fishes along the Ariyapalli fish landing center. All morphometric measurements were recorded using a vernier caliper. The specimen was identified using seahorse identification guide (Lourie et al. 2004), and pictures were taken for photographic evidence.

Results and Discussion

The total length of the *H. kelloggi* specimen in this study was 12.5 cm, that consisted of 52.8% as tail length (6.6 cm), 27.2% as trunk length (3.6 cm), and 20% as head length (2.5 cm) (Table 1). The total number of rings on the seahorse was 49, with the tail consisting of 38 rings and the trunk with 11 rings (Table 1). There was a single spine on the eye and cheek bones (Image 1). The snout length was 1 cm and smaller compared to the head length (Table 1). The total body length (12.5

Image 1. Female *Hippocampus kelloggi* specimen collected from the coast of Odisha, Bay of Bengal. Presence of single eye and cheek spines are identification marks for this species. © Anil Kumar Behera.

cm) of the individual in this study was lower than the average length of the *H. kelloggi* (28 cm), suggesting the captured specimen was a juvenile and not a mature adult that grows up to 28 cm (Lourie et al. 2004).

This incidental catch of *H. kelloggi* from the coast of Odisha could be due to northward migration of the species from the Coromandel coast (i.e., coasts of Andhra Pradesh and Tamil Nadu), where this species is abundant and is under extensive fishing pressure (13 million individuals caught per year), despite the ban of fishing and trading on all species of seahorses in India from 2001 (Vaidyanathan & Vincent 2021). Despite the fact that long-distance migrations in seahorses are not well-understood (Luzzatto et al. 2013), our record of *H. kelloggi* from the coast of Odisha provides evidence that seahorses are able to migrate long-distance (from Palk Bay and Gulf of Mannar region to Ariyapalli in Odisha coast, approx. 1,300 km), adding new information for this vulnerable species of seahorse. However, this migration of seahorses is supported by a unique method known as rafting, where small seahorse species attach themselves to floating substrata (macroalgae, or plastic debris) and are dispersed by ocean currents, such as the east Indian coastal current and north-east and south-west monsoon currents (Teske et al. 2005; Luzzatto et al. 2013). Mostly, this migration in *Hippocampus species* is preferred by juvenile species, which coincides with our specimen of *H. kelloggi* being shorter than a normal adult seahorse. This phenomenon has also been observed for *H. patagonicus* in the southern Atlantic region and, *H. kuda*, *H. fuscus*,

Table 1. Morphometric measurements of the female *Hippocampus kelloggi* recorded from the Ariyapalli coast of Odisha, Bay of Bengal.

Variables	No. / cm
Tail ring (no.)	38
Trunk ring (no.)	11
Head length (cm)	2
Standard length (cm)	12.5
Height (cm)	10.2
Snout length (cm)	1
Tail length (cm)	6.6
Trunk length (cm)	3.4

and *H. capensis* in the Indo-Pacific region (Teske et al. 2005; Luzzatto et al. 2013; Zhang & Vincent 2018).

The occurrence of the threatened Great Seahorse along with previously recorded *H. fuscus* from the Chilika lagoon calls for increase in monitoring of fisheries bycatch from the coast of Odisha. This also calls for trash fish monitoring from fishing activities along the eastern coast of India. Identifying the coastal ecosystems that are potential hotspots and inhabited by these threatened species will create a roadmap for better conservation and management of seahorses and their associated habitats in India (Mishra & Apte 2021; Mishra & Farooq 2022).

References

Balasubramanian, R. & A. Murugan (2017). Length-weight relationship of the Great Seahorse, *Hippocampus kelloggi* (Jordan and Snyder 1902), inhabiting Coromandel Coast, southeast coast of India. *Indian Journal of Geo-Marine Sciences* 46:1193–1197

Foster, S.J. & A.C.J. Vincent (2004). Life history and ecology of seahorses: Implications for conservation and management. *Journal of Fish Biology* 65:1–61. https://doi.org/10.1111/j.0022-1112.2004.00429.x

IUCN (2022). Most threatened species — IUCN Seahorse, Pipefish & Seadragon (www.iucn-seahorse.org).

Jeyabaskaran, R., J. Jayasankar & T.V. Ambrose (2018). Conservation of seagrass beds with special reference to associated species and fishery resources. *Journal of the Marine Biological Association of India* 60: 62–70. https://doi.org/10.6024/jmbai.2018.60.1.2038-10

Kavungal, V. & R. Saravanan (2015). Participatory management for conservation of seahorses in the Gulf of Mannar, South East coast of India BOBLME-2015-Ecology-58. Boblme. https://doi.org/10.13140/RG.2.1.2864.6001

Li, C., M. Olave & Y. Hou, G. Qin, R.F. Schneider, Z. Gao, X. Tu, X. Wang, F. Qi, A. Nater, A.F. Kautt, S. Wan, Y. Zhang, Y. Liu, H. Zhang, B. Zhang, H. Zhang, M. Qu, S. Liu, Z. Chen, J. Zhong, H. Zhang, L. Meng, K. Wang, J. Yin, L. Huang, B. Venkatesh, A. Meyer, X. Lu & Q. Lin (2021). Genome sequences reveal global dispersal routes and suggest convergent genetic adaptations in seahorse evolution. *Nature Communications* 12: 1094. https://doi.org/10.1038/s41467-021-21379-x

Lourie, S.A., S.J. Foster, E.W.T. Cooper & A.C.J. Vincent (2004). *A Guide to the Identification of Seahorses*. University of British Columbia and World Wildlife Fund, Washington D.C.

Luzzatto, D.C., M.L. Estalles, J.M.D. de Astarloa (2013). Rafting seahorses: The presence of juvenile *Hippocampus patagonicus* in floating debris. *Journal of Fish Biology* 83: 677–681. https://doi.org/10.1111/jfb.12196

Mahapatro, D., R.K. Mishra & S. Panda (2017). Range extension of a vulnerable Sea horse *Hippocampus fuscus* (Actinopterygii: Syngnathidae) on the north-eastern Bay of Bengal coast. *Marine Biodiversity Records* 10: 6. https://doi.org/10.1186/s41200-017-0108-z

Mishra, A.K. & D. Apte (2021) The current status of *Halophila beccarii*: An ecologically significant, yet vulnerable seagrass of India. *Ocean Coast Manag* 200: 105484. https://doi.org/10.1016/j.ocecoaman.2020.105484

Mishra, A.K. & S.H. Farooq (2022) Lack of ecological data hinders management of ecologically important saltmarsh ecosystems: A case study of saltmarsh plant *Porterasia coarctata* (Roxb.). *Journal of Environmental Management* 321: 115957. https://doi.org/10.1016/j.jenvman.2022.115957

Salin, K.R., T.M. Yohannan & C.M. Nair (2005). Fisheries and trade of seahorses, *Hippocampus* spp., in southern India. *Fisheries Managemant and Ecology* 12: 269–273. https://doi.org/10.1111/j.1365-2400.2005.00450.x

Sanaye, S.V., R. Khandeparker, A.S. Rayadurga, M.S. Shivaramu, H. Kankonkar, J. Narvekar & M. Gauthankar (2020). Morphological and molecular evidence for first records and range extension of the Japanese Seahorse, *Hippocampus mohnikei* (Bleeker 1853) in a bay-estuarine system of Goa, central west coast of India. *PLoS One* 15:1–22. https://doi.org/10.1371/journal.pone.0220420

Sreepada, R.A., U.M. Desai & S. Naik (2002). The plight of Indian sea horses: need for conservation and management. *Current Science* 82: 377–378.

Teske PR, Hamilton H, Palsbøll, C.K. Choo, H. Gabr, S.A. Lourie, M. Santos, A. Sreepada, M.I. Cherry & C.A. Matthee (2005). Molecular evidence for long-distance colonization in an Indo-Pacific seahorse lineage. *Marine Ecology Progress Series* 286: 249–260.

Vaidyanathan, T. & A.C.J. Vincent (2021). *State of Seahorse Fisheries in India, Nearly Two Decades after they were Banned*. Springer, Netherlands.

Zhang, X. & A.C.J. Vincent (2018). Predicting distributions, habitat preferences and associated conservation implications for a genus of rare fishes, seahorses (*Hippocampus* spp.). *Diversity and Distributions* 24:1005–1017. https://doi.org/10.1111/ddi.12741

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22741–22745

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

https://doi.org/10.11609/jott.7988.15.2.22741-22745

#7988 | Received 25 April 2022 | Final received 16 January 2023 | Finally accepted 29 January 2023

OPEN ACCESS

SHORT COMMUNICATION

Schoenoplectiella erecta (Poir.) Lye ssp. *raynalii* (Schuyler) Beentje (Cyperaceae) – a new record to India from Ossudu Bird Sanctuary, Villupuram District, Tamil Nadu

Chandrasegrane Pradeep [1], Paneerselvam Umamaheswari [2], Natesan Balachandran [3] & Raphael Mathevet [4]

[1–4] Ecology Department, French Institute of Pondicherry, Pondicherry 605001, India.
[2] Department of Botany, Kanchi Mamunivar Government Institute for Postgraduate Studies and Research, Puducherry 605008, India.
[4] UMR 5175 Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), Campus CNRS, 1919 route de Mende, 34293 Montpellier, France.
[1] pradeep.c@ifpindia.org, [2] umamaheswari@ifpindia.org, [3] balachandran.n@ifpindia.org (corresponding author),
[4] raphael.mathevet@ifpindia.org

Abstract: *Schoenoplectiella erecta* subsp. *raynalii* (Cyperaceae) is recorded for the first time from India and Asia. This taxon was collected in Ossudu Bird Sanctuary, Villupuram district of Tamil Nadu, southern India. Detailed description including microscopic study of the glume and nutlets with digital images, morphological characters, habitat, and key characters between the two subspecies are provided.

Keywords: Coromandel coast, India, migratory birds, new record, Pondicherry, wetland.

A new genus *Schoenoplectiella* was established by Lye (2003) with 26 species and it was separated from the genus *Schoenoplectus* (Rchb.) Palla. based on the rbcL suprageneric phylogeny (Muasya et al. 1998) both the genera were differentiated from the heterogeneous and un-natural genus, *Scirpus* L. Characteristically, *Schoenoplectiella* has members that are annuals, rarely perennial, rhizome very short hidden among the culm-bases, prostrate or elongate, glumes entire at apex, and nutlets transversely rugulose to sharply ridged whereas *Schoenoplectus* has perennial, rhizome elongate, creeping or ascending, glumes notched or emargiante or bifid, and nutlets generally smooth (Hayasaka 2012). Currently, the genus has 65 accepted species (POWO 2022) and these are distributed from warm temperate to tropical regions of Africa, America, Asia, and Madagascar (Verloove et al. 2016). In India, 10 species were recorded (Mao & Dash 2020) and only five species are known from Tamil Nadu (Narasimhan & Sheeba 2021).

During recurrent botanical surveys for the last three year (from September 2018 to August 2021) an interesting plant belonging to the genus *Schoenoplectiella* was collected from the shores of the freshwater Lake Ossudu, in Ossudu Bird Sanctuary, a protected area, in Tamil Nadu and Pondicherry regions, southeastern India. On critical microscopic examination and referring to available literatures (Smith 2003; Xanthos & Browning 2015) the collected voucher specimen was identified as *Schoenoplectiella erecta* ssp. *raynalii*. Our identification was confirmed further by comparing the isotype image deposited at K (A.M.Yalala 425–K000416875). Further

Editor: Pankaj Kumar, Department of Plant and Soil Science, Texas Tech University, Lubbock, Texas, USA. **Date of publication:** 26 February 2023 (online & print)

Citation: Pradeep, C., P. Umamaheswari, N. Balachandran & R. Mathevet (2023). *Schoenoplectiella erecta* (Poir.) Lye ssp. raynalii (Schuyler) Beentje (Cyperaceae) – a new record to India from Ossudu Bird Sanctuary, Villupuram District, Tamil Nadu. *Journal of Threatened Taxa* 15(2): 22741–22745. https://doi.org/10.11609/jott.7988.15.2.22741-22745

Copyright: © Pradeep et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: AFD [Project: RUSE].

Competing interests: The authors declare no competing interests.

Acknowledgements: We thank Dr. D. Barboni for a careful review of the manuscript; RUSE AFD, France for the financial support for the survey; the head of forest force and wildlife, Chennai, and district forest officer, Villupuram district, Tamil Nadu granted permission to do botanical survey at Ossudu and Kazuveli wetlands; to the board of trustees, RBG, KEW for the digital image; University of South Florida Herbarium for their digital herbarium image and AURO herbarium for referring the *S. lateriflora* specimens. We also thanks to the anonymous reviewer(s) that shaped this manuscript in better form.

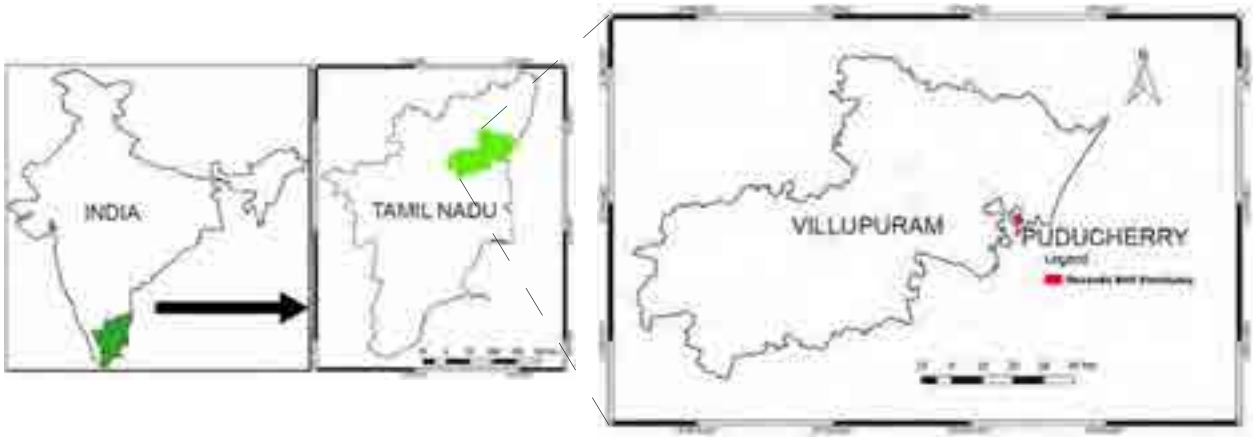


Figure 1. Study area – Ossudu Bird Sanctuary.

perusal of literatures (Cook 1998; Panda et al. 2002; Prasad & Singh 2002; Ansari et al. 2016; Kar et al. 2016; Mao & Dash 2020; Narasimhan & Sheeba 2021) we come to know that this taxon was not yet recorded in Asia, India, and regional floras; however, *Schoenoplectiella erecta* ssp. *erecta* was recorded from northern India. In the Lake Ossudu Bird Sanctuary, three *Schoenoplectiella* species also occur: *S. atriculata* (L.) Lye, *S. lateriflora* (J.F.Gmel.) Lye, and *S. juncoides* (Roxb.) Lye.

Materials and Methods

Botanical exploration and ecological studies were conducted from September 2018 to August 2021 in Ossudu (Figure 1) along the Coromandel Coast, Villupuram district of Tamil Nadu. Ossudu Bird Sanctuary falls in two political boundaries, viz., Union Territory of Pondicherry and Villupuram district of Tamil Nadu. During the survey an unfamiliar sedge was found and collected from the eastern shores of Ossudu Lake and the collected specimen was processed and deposited at Herbarium, French Institute of Pondicherry (HIFP) for further studies. Camera attached light microscope was used to examine the morphological features of glume and nutlets to understand the morphological differences. Recent publications (Mao & Dash 2020; Narasimhan & Sheeba 2021) and consultation of herbaria (Madras Herbarium (MH), Rapinath Herbarium Tiruchirapalli (RHT), Deccan Reginal Centre (DRC), Auroville Herbarium (AURO)) for the occurrence and international datasets (GBIF- the Global Biodiversity Information Facility—https://www.gbif.org, COL- Catalogue of Life—https://www.catalogueoflife.org, POWO- Plants of the World Online—https://powo.science.kew.org/ and USDA-United States Department of Agriculture—https://plants.usda.gov) were referred for the global distribution range of this species.

Results

The inflorescence of *Schoenoplectiella* is capitate or anthellate. The anthella of spikelets are simple to decompound due to the presence of branched or unbranched peduncles with few to numerous sessile spikelets and they are densely crowded. This characteristic feature was recorded in both the inflorescence of *S. lateriflora* and *S. erecta*. On critical examination of the herbarium specimens deposited at AURO (4751, 10317, 11940), *S. lateriflora* was 10–20 cm high with decompound inflorescence, peduncles 3–15 mm high, style 3-branched, achene trigonous whereas *S. erecta* is more than 30 cm high, inflorescence decompound, peduncles 15–65 mm long, secondary peduncles to 8–12 mm long, style 2-branched and nutlet plano-convex.

The two known subspecies, *Schoenoplectiella erecta* ssp. *raynalii* is similar to *S. erecta* ssp. *erecta* but differs by its style and nutlets. Following key can be used to differentiate them:

1. Nutlet biconvex, style 2-fid, slightly wrinkled .... *S. erecta* ssp. *erecta*

1. Nutlet plano-convex, style 3-fid, distinctly rugose ..... *S. erecta* ssp. *raynalii*

Taxonomic treatment

Schoenoplectiella erecta (Poiret) Lye ssp. *raynalii* (Schuyler) Beentje Fl. Trop. E. Africa, Cyperaceae, 34, 2010. (Image 1)

Schoenoplectus erectus (Poiret) Palla *ex* J. Raynal ssp. *raynalii* (Schuyler) Lye, Nordic J. Bot. 3(2): 243. 1983.

Scirpus raynalii Schuyler, Notul. Nat. Acad. Nat. Sci.

Image 1. *Schoenoplectiella erecta* subsp. *raynalii*: A—The present collection | B—Isotype image from KEW | C—inflorescence in close view | D—plant in natural condition | E—dorsal, ventral and lateral view of glumes | F—gynoecium with 3—fid stigma | G—young and matured nutlet. © Balachandran & Uma Maheswari.

Philadelphia 438: 1, figs. 1, 3, 6. 1971.

Type: BOTSWANA, Maun district, 6.2.1964, *Yalala* 425 (K-K000416875!-Isotype-digital image seen)

Description

Annual herbs, culms densely tufted, 30–43 cm (including inflorescence bract), cylindrical, ridged when dry, 1.6–2 mm thick. Leaves 1–3, 2.5–13 cm long, rarely equalling the culm; sheaths brown, 5–9 cm long, ribbed, disintegrating to fibres. Inflorescence, pseudolateral, anthella-decompound in 2–5 pedunculate corymb, primary peduncle 0.5–6 cm long, secondary rachis 8–12 mm long; overtopped by lower bract, involucral bract stem like, erect, 4.5–13 cm long, secondary bract 0.5–4 cm long. Spikelets, in clusters, 1–5, 5–7 × 2–3 mm; green-cream, reddish brown when matured; ovoid-oblong, 3(5) –13(18) × 2–3.5 mm; glume straw-coloured, with brown mosaic, central region often greenish when fresh, ovate-obovate, 2.53.4(5) × 1.5 mm, smooth, mucronate, margins scarious. Perianth absent, stamens 3, style 3-fid. Achenes almost blackish brown when ripe, planoconvex when matured, obovoid, 1.2–1.6 × 1.1–1.5 mm, with sharp ridges along the margins, distinctly and transversely rugose.

Flowering and fruiting: from January–April.

Habitat: Along the shores of the fresh water lake at the elevational range between 30 and 40 m. It was found growing along with *S. lateriflorus* and *S. juncoides* of Cyperaceae, *Persicaria glabra* (Willd.) M.Gomez of Polygonaceae, *Ludwigia perennis* L. of Onagraceae, *Dinebra polystachyos* (R.Br.) E.A.Kellogg of Poaceae, *Aponogeton natans* (L.) Engl. & K.Krause of Aponogetonaceae.

Distribution: Africa, Asia, Australia, Mexico, and South America.

Specimen examined: India, Tamil Nadu, Villupuram district, Ossudu Bird Sanctuary, 11.9577˚ N, 79.7456 ˚ E, 18 m, 8 February 2020, Pradeep & Balachandran 27514 (HIFP!, two sheets).

Conservation status

Considered as 'Least Concern' on the IUCN Red List of Threatened Species (Mesterházy 2020), and in recent days the range of distribution has been extended from Africa, America to Asia, and Australia. Probably the migratory granivorous ducks (Mallards/the whistling ducks) might have played a major role in extending the distribution of this species. This study also proves the report of Kleyheeg et al. (2019) that the granivorous water birds disperse viable seeds of wetland plants over long distance during their migration. The censuses of large flocks of such migratory granivorous wintering or breeding ducks were recorded during this study and previous ones (Perennou 1990; Davidar 2011; Mathevet et al. 2020).

Notes: As per the revision of Hayasaka (2012) and Xanthos & Browning (2015) the subspecies '*raynalii*' could be easily distinguished by having 3-fid stigmas, planoconvex nature of nutlet with distinct rugose surface, while its typical subspecies '*erecta*', has 2-fid stigma, biconvex nutlet with moderate wrinkled surface. The surface of *S. lateriflora* nutlet is otherwise same that of *S. erecta* ssp. *raynalii* but the former species has trigonous nutlet with 2-fid stigmas.

In *Schoenoplectiella*, interspecific natural hybridization exhibits range of variations in plant height, culm width below the inflorescence, shape and length of overtopping inflorescence, glume dimensions at apex, anther crest length, style branch and length, achene dimensions and surface sculpturing were very well studied (Browning 1992; Hayasaka 2012). Meanwhile the variation in the shape of inflorescence was overlooked by previous taxonomic accounts (Ohwi 1944; Koyama 1958). Though, in India we observed that the length of primary and secondary peduncles of the inflorescence is much longer than the (iso)type specimen from KEW image and specimen from the University of South Florida Herbarium (20709).

References

Ansari, R., G. Jeeja & R. Prakashkumar (2016). Aquatic and Wetland Flora of Kerala: Flowering Plants. *Malabar Botanical Garden and Institute for Plant Sciences*, Kozhikode, Kerala, India.

Browning, J. (1992). Studies in Cyperaceae in southern Africa. 20: Changed status of *Schoenoplectus corymbosus* var. *brachyceras* and report of hybrids. *South African Journal of Botany* 58(6): 530–532.

Cook, C. (1998). *Aquatic and Wetland Plants of India*. Oxford University Press, Delhi.

Davidar, P. (2011). Wetland Birds of Pondicherry Region: A pocket field guide. ECOS, Pondicherry, India.

Hayasaka, E. (2012). Delineation of *Schoenoplectiella* Lye (Cyperaceae), a genus newly segregated from *Schoenoplectus* (Rchb.) Palla. *Journal of Japanese Botany* 87(3): 169–186.

Kar, S.K., P.K. Tripathy, S.K. Mohanty, P.K. Acharya & P.C. Panda (2016). Additions to the Flora of Chilika lake and its immediate Neighbourhood. *Journal of Economic and Taxonomic Botany* 40 (3–4): 134–150.

Kleyheeg, E., W. Fledler, K. Safi, J. Waldenstrom, M. Wikelski & M.L. van Toor (2019). A Comprehensive Estimation of Seed Dispersal by Migratory Mallards. *Frontiers in Ecology and Evolution* 7: 1–14.

Koyama, T. (1958). Taxonomic study of the genus *Scirpus* Linn. *Journal of the Faculty of Science, the University of Tokyo, Section* 3(7): 271–366.

Lye, A.L. (2003). *Schoenoplectiella* Lye, gen. nov. (Cyperaceae). *Lidia* 6: 20–29.

Mao, A.A. & S.S. Dash (2020). *Flowering plants of India: An annotated checklist (Monocotyledons)*. Botanical survey of India, Kolkata, 3, 249–300 pp.

Mathevet, R., S. Targowla, G. Venkatasubramanian, M. Anbarashan,

N. Ayyappan & N. Bautès (2020). Wetlands for a sustainable urban future? Insights from Pondicherry. *Journal of Natural Resources* 3(4): 74–93.

Mesterházy, A. (2020). *Schoenoplectiella erecta*. The IUCN Red List of Threatened Species 2020: e.T168941A1255197. Accessed on 25 May 2022. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T168941A1255197.en

Muasya, A.M., D.A. Simpson, M.W. Chase, & A. Culham (1998). An assessment of suprageneric phylogeny in Cyperaceae using rbcL DNA sequences. *Plant Systematics and Evolution* 211(3): 257–271.

Narasimhan, D. & I.J. Sheeba (2021). *Flowering Plants of Tamil Nadu: A Compendium*. Care Earth Trust, Chennai, India, 1,112 pp.

Ohwi, J. (1944). Cyperaceae Japonicae II. A synopsis of the Rhynchosporoideae and Scirpoideae of Japan, including the Kuriles, Saghalin, Korea and Formosa. *Memoirs of the College of Science; Kyoto Imperial University Series* B18: 1–182.

Panda, P.C., A.K. Pattnaik, J. Rath & S.N. Patnaik (2002). Flora of Chilika Lake and its Immediate Neighborhood: A checklist. *Journal of Economic and Taxonomic Botany* 26(1): 1–20.

Perennou, C. (1990). *Peuplements d'oiseaux aquatiques en milieu anthropisé : un exemple. Les plaines de la Cote de Coromandel (Inde du Sud-Est)*. PhD thesis, Lyon, Univ., Lyon I, France.

Prasad, V.P. & N.P. Singh (2002). *Sedges of Karnataka*. Additional Series, 21. Scientific Publishers, Jodhpur.

POWO (2022). https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:77107810-1. Accessed on 7 March 2022.

Smith, S.G. (2003). Cyperaceae. In: Ball, P.W., A.A. Reznick & D.F. Murray (ed.). Flora of North America Vol. 23; http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=10246. Accessed on 9 March 92022.

Verloove, F., A. Mesterhazy & J. Browning (2016). Studies in *Schoenoplectiella* (Cyperaceae) in tropical West Africa. *Phytotaxa* 283(1): 096–100.

Xanthos, M. & J. Browning (2015). Taxonomic re-evaluation of *Schoenoplectiell lateriflora* subsp. *laevinux* (Cyperacee) and a new record for *Schoenoplectiella erecta* subsp. *erecta*. *Kew Bulletin* 70: 36–41.

https://www.gbif.org/occurrence/1503282087. Accessed on 24 February 2022.

https://www.catalogueoflife.org/data/taxon/5L3DV. Accessed on 24 February 2022.

https://plants.usda.gov/home/plantProfile?symbol=SCERR2. Accessed on 9 March 2022.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22746–22748

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

https://doi.org/10.11609/jott.8113.15.2.22746-22748

#8113 | Received 24 July 2022 | Final received 19 August 2022 | Finally accepted 24 January 2023

NOTE

Status of the Sumatran Striped Rabbit *Nesolagus netscheri* in Isau-Isau Wildlife Reserve, South Sumatra Province, Indonesia

Arum Setiawan [1], Muhammad Iqbal [2], Octavia Susilowati [3], Doni Setiawan [4], Martialis Puspito Khristy Maharsi [5] & Indra Yustian [6]

[1,4,6] Department of Biology, Faculty of Science, Sriwijaya University, Jalan Raya Palembang-Prabumulih km 32, Indralaya, Sumatera Selatan 30662, Indonesia.

[2] Biology Programme, Faculty of Science, Sriwijaya University, Palembang 30139, Indonesia.

[3,5] Nature Conservation Agency of South Sumatra Province, Jl. Kol. H. Burlian km 6, Palembang 30961, South Sumatra, Indonesia.

[1] arum.setiawan@unsri.ac.id, [2] kpbsos26@yahoo.com (corresponding author), [3] octavia.susilowati@gmail.com, [4] donisetia@unsri.ac.id, [5] mpkm81@gmail.com, [6] idr_yustian@unsri.ac.id

Classified as Data Deficient on the IUCN Red List, the Sumatran Striped Rabbit *Nesolagus netscheri* is endemic to Sumatra Island of Indonesia and is apparently the rarest lagomorph in the world (Flux 1990; McCarthy et al. 2019). *N. netscheri* normally inhabits montane forest, but was also recorded in lowland forest, at 544–1900 m elevation (McCarthy et al. 2012; Schai-braun & Hacklander 2016). This species has been documented along forests of the Bukit Barisan Mountains, from Gunung Leuser National Park in northern Sumatra to Bukit Barisan National Park in southern Sumatran (McCarthy et al. 2012, 2018). The remaining forests of Bukit Barisan Mountains in South Sumatra Province have been recently reported as important habitat for *N. netscheri* (Setiawan et al. 2018, 2019). Established in 2014 with a total of 16.742 ha, Isau-Isau Wildlife Reserve (formerly known as Isau-Isau Pasemah Wildlife Reserve) is one protected area in South Sumatra Province located in the Bukit Barisan Mountains (Mahanani et al. 2017; Whitten et al. 2000). The Isau-Isau Wildlife Reserve is home for many endangered species of wildlife, particularly *N. netscheri* (Susilowati 2022). In this paper, we report the occurence and review status of *N. netscheri* in Isau-Isau Wildlife Reserve. Due to its rarity and endemicity, the coordinates of specific locations are not shown here.

Our study of *N. netscheri* was conducted in the Wildlife Reserve during various visits from 2018 to 2021. We set camera traps in the potential habitats to detect its occurence. To complement our data, we interviewed as many as possible of the local people to explore their knowledge of *N. netscheri.* There are 24 villages around Isau-Isau Wildlife Reserve (Anonymous 2022), but our study focussed on two villages: Lawang Agung Village (Mulak Ulu Subdistrict, Lahat District) and Tanah Abang Village (Semende Subdistrict, Muara Enim District). Records of *N. netscheri* in Isau-Isau Wildlife Reserve are summarize below:

– A local person c. 70 years old from Lawang Agung Village reported seen *N. netscheri* in 1995 at 23:00 h. He saw an adult *N. netscheri* in the forest when he was hunting a Greater Mouse-deer *Tragulus napu* for food.

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Setiawan, A., M. Iqbal, O. Susilowati, D. Setiawan, M.P.K. Maharsi & I. Yustian (2023). Status of the Sumatran Striped Rabbit *Nesolagus netscheri* in Isau-Isau Wildlife Reserve, South Sumatra Province, Indonesia. *Journal of Threatened Taxa* 15(2): 22746–22748. https://doi.org/10.11609/jott.8113.15.2.22746-22748

Copyright: © Setiawan et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Sriwijaya University, Project funded Number: 023.17.2.677515/2021.

Competing interests: The authors declare no competing interests.

Acknowledgements: We would like to thank Universitas Sriwijaya for funding part of the research through Competitive Grant SP DIPA-023.17.2.677515/2021 in accordance with the Rector's Decree Number 0107.115/UN9/SB3.LP2M.PT/2021.

Image 1. Landscape of Isau-Isau Wildlife Reserve, South Sumatra Province, Indonesia, 18 July 2021. A typical of preference habitat of *Nesolagus netscheri*. © Muhammad Iqbal.

Unfortunately, he forgot the exact date and month of this observation.

– In 2005, a local from Lawang Agung Village reported that he had shot an adult *N. netscheri* in the forest of Isau-Isau Wildlife Reserve. Again, this settler forgot the exact date and month. The habitat is a mix of coffeee plantation and durian trees, bordered with forests. Some herbs are found, and based on interviews with local people, two of them are eaten by *N. Netscheri*: *Elatostema* sp., and *Godonoboea platypus*.

– On 28 December 2018, an adult *N. netscheri* was finally documented in the forest of Isau-Isau Wildlife Reserve at a day-night camera trap set up by the Nature Conservation Agency of South Sumatra Province (Balai Konservasi Sumber Daya Alam Provinsi Sumatera Alam). These photos from a camera trap confirmed the occurence of *N. netscheri* in this conservation area.

– In early January 2020, a local person from Lawang Agung saw an adult *N. netscheri* near his hut. At that time, he was staying in his hut waiting for Durian fruits *Durio zibethinus*, January being a peak season of Durian fruits here.

– On 23 March 2020 at 1119 h, an adult *N. netscheri* was photographed at a camera trap set by the Nature Conservation Agency of South Sumatra Province in the same location where local people reported this species earlier, in January 2020.

– In mid May 2021, a local person from Lawang Agung reported seeing an adult of *N. netscheri* around his garden, located in a coffee plantation bordering with forest. He saw this adult *N. netscheri* in his small chilli farm *Capsicum annuum* at night. It is likely that this rabbit was feeding on leaves of *C. annuum*.

– On 17 September 2021 at 0138 h, an adult *N. netscheri* was documented by a camera of the Department of Biology of Sriwijaya University and Nature Conservation Agency of South Sumatra Province. The location of the camera trap is very close to the location where local people reported this species earlier in January 2020.

– On 9 February 2019, a ranger of Nature Conservation Agency of South Sumatra Province saw one adult with two young *N. netscheri* by day-light where *N. netscheri* had been reported earlier, in January 2020.

Thus, there are eight records of *N. netscheri* documented from Isau-Isau Wildlife Reserve between 1995 and 2022, three from camera traps and five from interviews with local people. It is clear that *N. netscheri* is very rarely encountered here. All records of *N. netscheri* in Isau-Isau Widlife Reserve are from habitat within good canopy cover, or at least near a forest canopy area. Based on the interviews and observations of habitats, *N. netscheri* probably feeds on *Elatostema* sp, *Godonoboea platypus,* and young leaves of Chilli *C. annuum.* The diets of *N. netscheri* have been summarized (Flux 1990; Setiawan et al. 2022), but further information about its diet is still required. In constrast to our previous study on the *N. netscheri* in Gunung Raya Widlife Reserve (Setiawan et al. 2018), our interviews with more than 50 local people who frequent the forests suggest that many of them have never seen this rabbit, and almost none of them are intentionally hunted.

Information from settlers shows that *N. netscheri* is rarely encountered, but camera trap documentations help to confirm its occurence.

The Sumatran Striped Rabbit *N. netscheri* is a protected mammal by Indonesian law (Ministry of Environment and Forestry 2018). Isau-Isau Wildlife Reserve has been justified by its conservation status in protecting *N. netscheri*. Our records of *N. netscheri* in Isau-Isau Wildlife Reserve give strong evidence that this consevation area is important habitat for this species in Sumatra. McCarthy et al. (2019) propose a study to define the distribution of the species on the island, and to develop an estimate of density so that population trends of this rare species may be monitored. To facilitate this conservation action, we recommend that regular patrol undertaken by rangers of the Nature Conservation Agency of South Sumatra Province staff in Isau-Isau Wildlife Reserve should also focus on *N. netscheri*, recording incidental sightings, and collecting information from local people and from camera traps installed in certain areas. This could provide essential information for conserving populations of *N. netscheri* in Sumatra.

Image 2. An adult *Nesolagus netscheri* documented on 17 September 2021: a—Position heading to camera | b—Lateral position move away from camera. © Department of Biology, Sriwijaya University.

References

Anonymous (2022). *Isau Isau*. Downloaded from https://balaiksdasumsel.org/halaman/detail/isau-isau on 18 July 2022. [in Indonesia]

Flux, J.E.C. (1990). The Sumatran rabbit *Nesolagus netscheri*, pp. 137–139. In: Chapman, J.A. & J.E.C. Flux (eds.). *Rabbits, Hares and Pikas: Status Survey and Conservation Action Plan.* IUCN/SSC Lagomorph Specialist Group, Gland.

Mahanani, A.I., W. Nurrudin, M.D. Susanto, Syarifah, O. Susilowati. J. Pitria, T. Kharis & M. Afrina (2017). Buku Informasi Kawasan Konservasi Balai KSDA Sumatera Selatan Prov. Sumatera Selatan & Prov. Kepulauan Bangka Belitung. Balai KSDA Sumatera Selatan, Palembang. [in Indonesia]

McCarthy, J., J. Holden, D. Martyr, & K. McCarthy (2019). *Nesolagus netscheri*. The IUCN Red List of Threatened Species 2019: e.T14662A45178557. Downloaded on 11 March 2022. https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T14662A45178557.en

McCarthy, J.L., J. Holden & D. Martyr (2018). *Nesolagus netscheri* (Schlegel, 1880) Sumatran Striped Rabbit, pp 95–97. In: Smith, A.T., C.H. Johnston, P.C. Alves & K. Hacklander (eds.). *Lagomorphs: Pikas, Rabbits, and Hares of the World.* Johns Hopkins University Press, Baltimore.

McCarthy, J.L., T.K. Fuller, K.P. McCarthy, H.T. Wibisono & M.C. Livolsi (2012). Using camera trap photos and direct sightings to identify possible refugia for the Vulnerable Sumatran striped rabbit *Nesolagus netscheri*. *Oryx* 46: 438–441. https://doi.org/10.1017/S0030605312000051

Ministry of Environment and Forestry (2018). Perubahan Kedua atas Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor P.20/MENLHK/SETJEN/KUM.1/6/2018 tentang jenis tumbuhan dan satwa yang dilindungi (Regulation of Minister of Environment and Forestry of Indonesia No. P.106/MENLHK/SETJEN/KUM.1/12/2018), Ministry of Environment and Forestry, Jakarta, 31 pp. [in Indonesia]

Schai-Braun, S.C. & K. Hackländer (2016). Family Leporidae (Hares and rabbits), pp 62–148. In: Wilson, D.E., T.E. Lacher & R.A. Mittermeier (Eds.). *Handbook of the Mammals of the World. Vol. 6. Lagomorphs and Rodents* I. Lynx Edicions, Barcelona.

Setiawan, A., M. Iqbal, A. Halim, R.F. Saputra, D. Setiawan & I. Yustian (2019). First description of an immature Sumatran striped rabbit (*Nesolagus netscheri*), with special reference to the wildlife trade in South Sumatra. *Mammalia* 84: 250–252. https://doi.org/10.1515/mammalia-2018-0217

Setiawan, A., M. Iqbal, S. Jauhari, J. Zamroni & I. Yustian (2022). First release of a captured Sumatran striped rabbit *Nesolagus netscheri* (Schlegel, 1880) into the wild. *Ecologica Montenegrina* 52: 53–56. https://doi.org/10.37828/em.2022.52.8

Setiawan, A., M. Iqbal, Komarudin, R.F. Saputra, D. Setiawan & I. Yustian (2018). New reports of the presence and ecology of the Sumatran striped rabbit (*Nesolagus netscheri*) in South Sumatra. *Mammalia* 82: 589–591. https://doi.org/10.1515/mammalia-2017-0064

Susilowati, O. (2022). Temuan *Nesolagus netscheri*: Kelinci belang langka di rimba Sriwijaya. Downloaded from https://balaiksdasumsel.org/temuan-nesolagus-netscheri--kelinci-belang-langka-di-rimba-sriwijaya on 21 July 2022. [in Indonesia]

Whitten, T., S.J. Damanik., J. Anwar & N. Hisyam (2000). *The Ecology of Sumatra.* Periplus, Singapore, 512 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22749–22751
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.7985.15.2.22749-22751
#7985 | Received 24 April 2022 | Final received 29 November 2022 | Finally accepted 18 December 2022
OPEN ACCESS
NOTE

Photographic record of the butterfly ray *Gymnura* cf. *poecilura* (Myliobatiformes: Gymnuridae) from the Bhagirathi-Hooghly River in West Bengal, eastern India

Priyankar Chakraborty

Sundarban Tiger Widow Welfare Society (STWWS), Arampur, Gosaba, West Bengal 743370, India.
priyankar.jour@gmail.com

Most elasmobranchs are marine, but some (euryhaline) species occur regularly in estuaries and lower reaches of rivers, and some are obligate freshwater species (Lucifora et al. 2015). Stingrays (some species of Dasyatidae and most of Potamotrygonidae) have been recorded in freshwater habitats (Compagno & Roberts 1982; Weigmann 2016).

Butterfly rays, family Gymnuridae, comprise a single genus *Gymnura* van Hasselt, 1823 and are generally marine, although sometimes found in brackish water areas (McEachran & Carvalho 2002). It includes 12 valid species found in the Indo-Pacific and the Atlantic Oceans (Yokota et al. 2016). Globally, three *Gymnura* species are marginal, and one is brackish marginal (Martin 2005).

Records of elasmobranchs from the freshwater reaches of the Ganges go back centuries. Hamilton (1822) described rays (called "skates") occurring far away from the tidal reaches of the river. At present, rays are a rare bycatch in parts of the freshwater reaches of the Ganges in West Bengal (author pers. obs. 14.vi.2012; 7.i.2018; 22.i.2022).

During a pilot survey of riverine elasmobranchs in West Bengal, eastern India, a fisher showed photographs of a "Shankar Maach" (local name for stingray) that he had caught in a set net. He said he had caught the fish in April 2019 from the Bhagirathi-Hooghly River, a tributary of the Ganga (22.311^{0}N, 88.094^{0}E) near Barkolia village in Howrah district of West Bengal (Figure 1). He stated that the fish weighed about 8.5 kg and had a disc width of about 90 cm (Image 1). The fish was subsequently identified from the photographs as a gymnurid ray based on its unique body shape with a strongly depressed body and pectoral fins extending into a "lozenge-shaped" disc, and as *Gymnura* cf. *poecilura* (Shaw, 1804) based on its long tail with 13 black bands and lack of a dorsal fin (Yokota et al. 2016). The fisher stated that he and his family had eaten the fish. As the species was only recognised from photographs, the specific name is preceded by the qualifier 'cf'.

The nearest marine environment from which gymnurids have been reported is over 100 km away in Digha (Yennawar et al. 2017), and they have also been listed in the mangrove-lined brackish waters of the Sundarbans in southeast West Bengal (Mishra et al. 2019), which is also a considerable distance from the capture site of this study. Therefore, this study reports the first occurrence of Gymnuridae, i.e. *Gymnura* cf. *poecilura*, from the Bhagirathi-Hooghly River in West

Editor: Simon Weigmann, Elasmobranch Research Laboratory, Hamburg, Germany. **Date of publication:** 26 February 2023 (online & print)

Citation: Chakraborty, P. (2023). Photographic record of the butterfly ray *Gymnura* cf. *poecilura* (Myliobatiformes: Gymnuridae) from the Bhagirathi-Hooghly River in West Bengal, eastern India. *Journal of Threatened Taxa* 15(2): 22749–22751. https://doi.org/10.11609/jott.7985.15.2.22749-22751

Copyright: © Chakraborty 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The author has received no financial support for the research, authorship, or publication of this article.

Competing interests: The author declares no competing interests.

Acknowledgements: I would like to thank the fisher who provided me with valuable information and gave me permission to use this information together with the photographs. I would also like to thank the reviewers and editors for their careful review of my manuscript and their insightful remarks and suggestions.

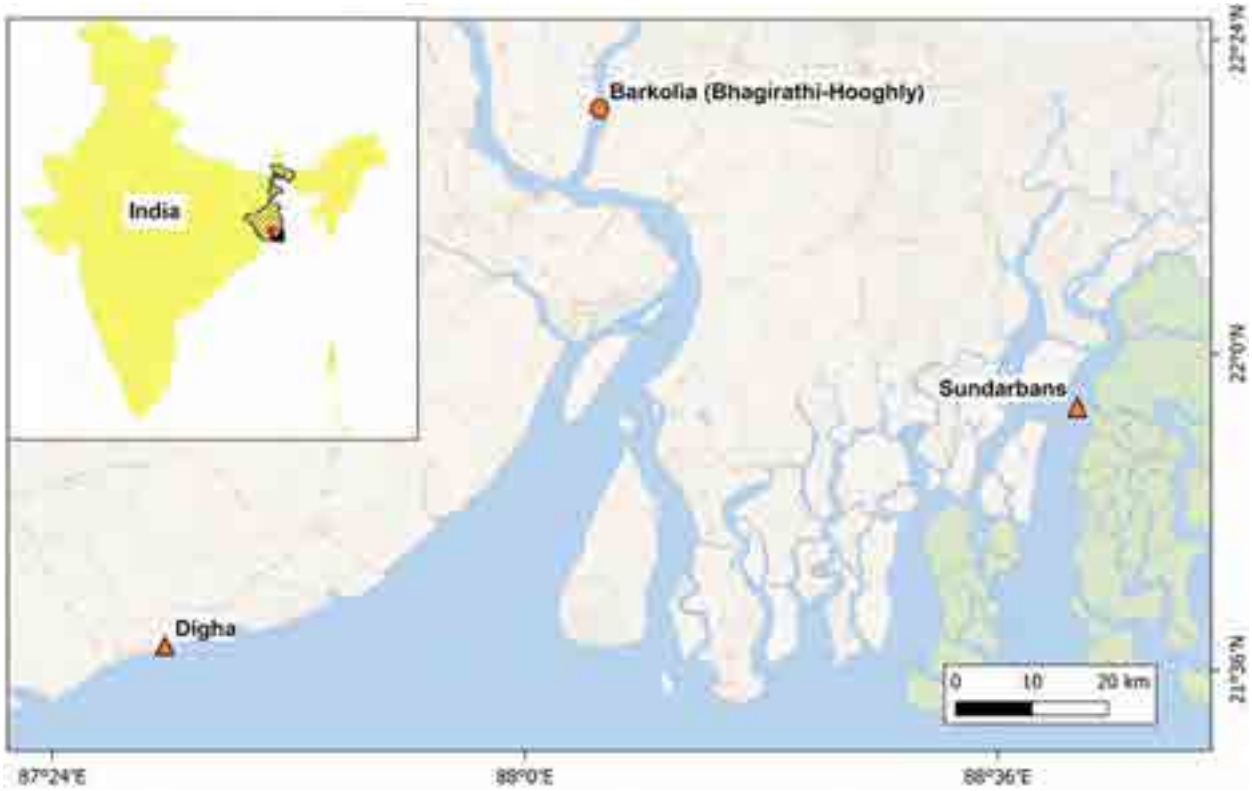


Figure 1. Locations in West Bengal where butterfly rays (Gymnuridae) have been observed. The circle represents the new record described in this study, and the triangles represent previous records. The inset map shows the location of West Bengal (hashed black) in India, and the red dot indicates the collection area of the specimen in this study.

Bengal and India's first Gymnuridae so far inland. A separate species of *Gymnura*, also referred to as *G.* cf. *poecilura*, occurs in the northern Arabian Sea (Muktha et al. 2016). However, it is unlikely that the specimen in this study is *G.* cf. *poecilura* (sensu Muktha et al. 2016), as it was captured from a tributary of the Ganga that flows into the western Bay of Bengal.

Although the identification of the species is based on only two photographs, this evidence is crucial as *G. poecilura* is listed as Vulnerable by the International Union for the Conservation of Nature (IUCN) Red List, and its current population trend is reported to be in decline (Sherman et al. 2021). This study shows how fishers' knowledge can help fill information gaps about rare riverine elasmobranchs.

Thus, this study helps direct future research to document the diversity of elasmobranchs in Indian rivers and to understand how they use their non-marine habitats. It is also important to study the impact of fishing on elasmobranch populations in rivers. This will help to detect any population declines.

References

Compagno, L.J.V. & T.R. Roberts (1982). Freshwater Stingrays (*Dasyatidae*) of Southeast Asia and New Guinea, with description of a new species of *Himantura* and reports of unidentified species. *Environmental Biology of Fishes* 7(4): 321–339. https://doi.org/10.1007/BF00005567

Hamilton, F. (1822). *An Account of the Fishes Found in the River Ganges and its Branches*. Archibald Constable, Edinburgh and Hurst, Robinson, London, 405 pp.

Lucifora, L.O., M.R. de Carvalho, P.M. Kyne & W.T. White (2015). Freshwater sharks and rays. *Current Biology* 25(20): R971–R973. https://doi.org/10.1016/j.cub.2015.06.051

Martin, R.A. (2005). Conservation of freshwater and euryhaline elasmobranchs: a review. *JMBA-Journal of the Marine Biological Association of the United Kingdom* 85(5): 1049–1073.

McEachran, J.D. & M.R. de Carvalho (2002). Gymnuridae: Butterfly rays, pp. 575–577. In: Carpenter, K.E. (ed.). *The Living Marine Resources of the Western Central Atlantic. Volume 1: Introduction, Mollusks, Crustaceans, Hagfishes, Sharks, Batoid fishes and Chimaeras*. FAO, Rome, 599 pp.

Mishra, S.S., K.C. Gopi, L. Kosygin & P.T. Rajan (2019). Ichthyofauna-Fishes, pp. 539–586. In: Chandra, K., K.C. Gopi, S.S. Mishra & C. Raghunathan (eds.). *Faunal Diversity of Mangrove Ecosystem in India*. Zoological Survey of India, India, 735 pp.

Muktha, M., K.V. Akhilesh, S. Sandhya, F. Jasmin, M.A. Jishnudev & S.J. Kizhakudan (2016). Re-description of the longtail butterfly ray, *Gymnura poecilura* (Shaw, 1804) (Gymnuridae: Myliobatiformes) from Bay of Bengal with a neotype designation. *Marine Biodiversity* 48(2): 1085–1096. https://doi:10.1007/s12526-016-0552-8

Image 1. *Gymnura* cf. *poecilura* from the Bhagirathi-Hooghly River in West Bengal, eastern India. a—Anterodorsal view; b—Posterodorsal view. The latter shows the tail with 13 black bands.

Sherman, C.S., K.V. Akhilesh, A.B. Ali, K.K. Bineesh, D. Derrick, Dharmadi, D.A. Ebert, Fahmi, D. Fernando, A.B. Haque, A. Maung, L. Seyha, D. Tanay, D. Tesfamichael, J.A.T. Utzurrum, T. Valinassab, V.Q. Vo & R.R. Yuneni (2021). *Gymnura poecilura*. The IUCN Red List of Threatened Species 2021: e.T60117A124440205. https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T60117A124440205.en Accessed on 02 March 2022.

Weigmann, S. (2016). Annotated checklist of the living sharks, batoids and chimaeras (Chondrichthyes) of the world, with a focus on biogeographical diversity. *Journal of Fish Biology* 88(3): 837–1037. https://doi.org/10.1111/jfb.12874

Yennawar, P., A. Mohapatra & P.C. Tudu (2017). An account of Ichthyofauna of Digha coast, West Bengal. *Records of the Zoological Survey of India* 117(1): 4–21. https://doi.org/10.26515/rzsi/v117/i1/2017/117289

Yokota, L., W.T. White & M.R. de Carvalho (2016). Butterfly Rays: Family Gymnuridae, pp. 511–521. In: Last, P.R., W.T. White, M.R. de Carvalho, B. Séret, M.F.W. Stehmann & G.J.P. Naylor (eds.). *Rays of the World*. CSIRO Publishing, Australia, 790 pp.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22752–22756

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

https://doi.org/10.11609/jott.8158.15.2.22752-22756

#8158 | Received 25 August 2022 | Final received 23 December 2022 | Finally accepted 09 February 2023

NOTE

First report of the fairyfly *Schizophragma mitai* Triapitsyn (Hymenoptera: Mymaridae) from India with notes on *S. indica* Rehmat & Anis

Anandhan Rameshkumar [1], Nazurius Anand [2], Sayan Sardar [3] & Sarfrazul Islam Kazmi [4]

[1–4] Zoological Survey of India, Prani Vigyan Bhawan, New Alipore, Kolkata, West Bengal 700053, India.
[1] drrameshtrichy@gmail.com (corresponding author), [2] anandnazurius30@gmail.com, [3] sardar.sayan830@gmail.com,
[4] kazmizsi@gmail.com

The genus *Schizophragma* Ogloblin, belongs to the *Anagrus* group of genera (Athithya & Manickavasagam 2022) in the family Mymaridae, consists of nine species described worldwide, with seven species occurring in the Nearctic and Neotropical regions in the Western hemisphere (Huber 1987), one species reported from India (Rehmat & Anis 2014) and one from Japan (Triapitsyn 2021). *Schizophragma* is closely related to *Stethynium* Enock but differs by the presence of clava with two segments in females (one in *S. saltensis* Ogloblin), anterior scutellum with single pair of setae, the second phragma notched posteriorly, body colour dark brown and males having simple encapsulated genitalia (Huber 1987). In the present study, *Schizophragma mitai* Triapitsyn is added to the Indian fauna with redescription and notes on *S. indica* Rehmat & Anis have been provided. In addition, illustrations and distribution map (Image 1) have also been provided for the Indian species.

Mymarid specimens included in this study were sorted out from the hymenopteran collections in the National Zoological Collection (NZC), Zoological Survey of India, Kolkata, West Bengal, India. The specimens were collected using a yellow pan trap, dissected and mounted in Canada balsam on a micro slide following the standard protocol given by Noyes (1982). The card mounted specimens were studied using a Nikon SMZ25 stereo zoom microscope and Leica DM1000 compound microscope for studying morphology of slide mounted specimens and measurements. The habitus photographs were obtained using a Nikon DS-Ri2 camera attached to the stereo zoom microscope and processed by the NIS-Elements BR Analysis v5.20.00. Stacking of individual images and processing was done using Adobe Photoshop CS4. Distribution map was prepared using Google Earth Pro based on the coordinates from collection sites. Vouchered specimens have been deposited with their appropriate registration numbers at NZC, Zoological Survey of India, Kolkata.

1. *Schizophragma mitai* Triapitsyn, 2021 (Image 2A–F)

Schizophragma mitai Triapitsyn, 2021: 93, Holotype, female, Japan, Fukuoka (ELKU)

Female: Body length 0.79 mm; body dark brown; antennal pedicel and flagellum pale brown; clava dark brown. Frenum pale brown than anterior scutellum. Fore wing subhyaline except behind venation slightly infuscate; hind wing hyaline. Legs pale brown except

Editor: Anonymity requested. **Date of publication:** 26 February 2023 (online & print)

Citation: Rameshkumar, A., N. Anand, S. Sardar & S.I. Kazmi (2023). First report of the fairyfly *Schizophragma mitai* Triapitsyn (Hymenoptera: Mymaridae) from India with notes on *S. indica* Rehmat & Anis. *Journal of Threatened Taxa* 15(2): 22752–22756. https://doi.org/10.11609/jott.8158.15.2.22752-22756

Copyright: © Rameshkumar et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India that have funded the study resulting in the paper (CRG/2020/006361).

Competing interests: The authors declare no competing interests.

Acknowledgements: We thank the Director, Zoological Survey of India, Kolkata for providing facilities. The authors gratefully acknowledge the Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India (CRG/2020/006361), for the financial support.

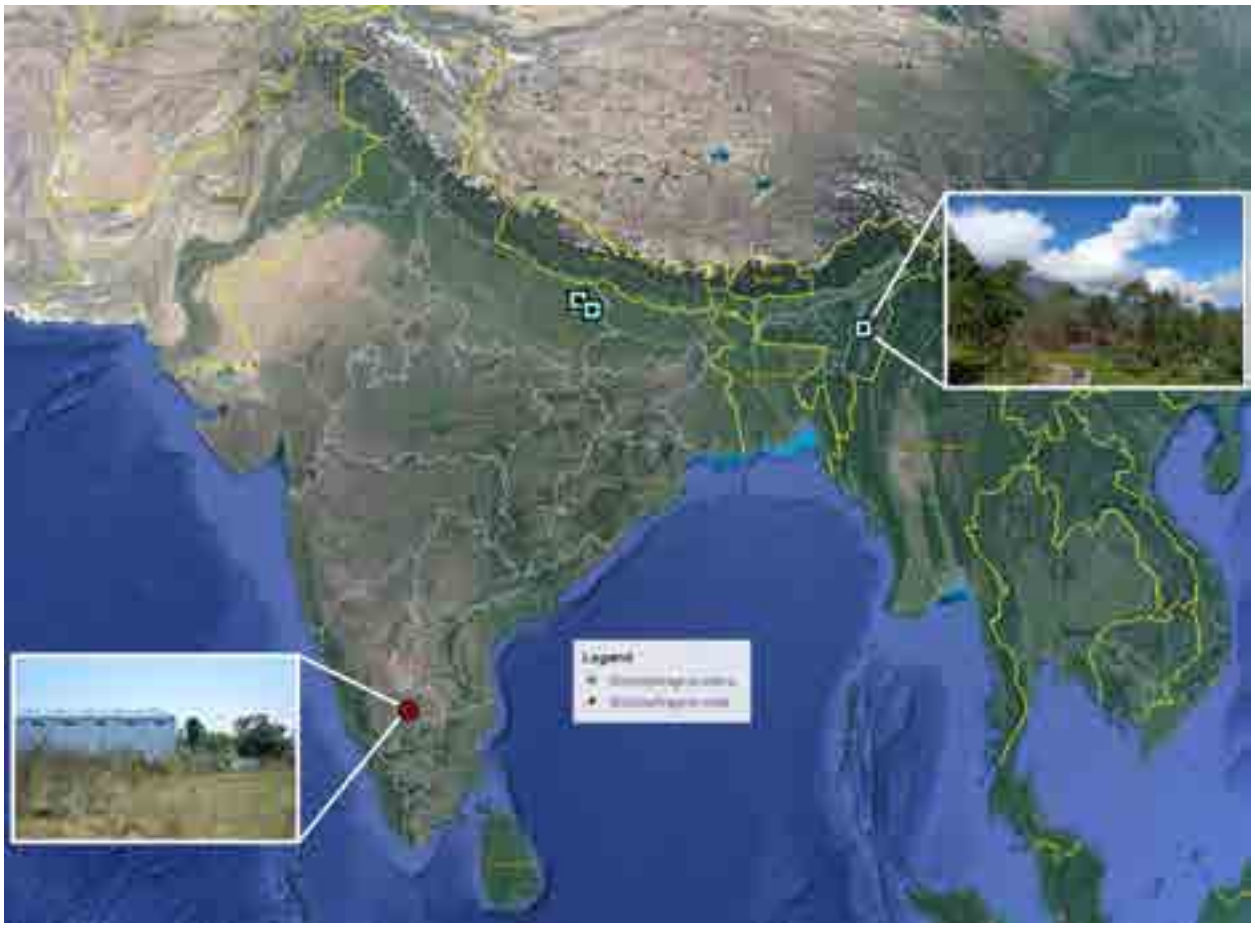


Image 1. Map showing the distribution of *Schizophragma* in India with images of collection sites.

meso & meta coxa and metafemur darker.

Head: Head in frontal view about 1.3× higher than wide; below anterior ocellus with horizontal striation; genae with vertical striation; between torulus and above torulus with polygonal sculpture; sub-torular grooves present; mandible with single tooth. Antennal scape 2.8× as long as wide, with 10-12 transverse ridges extending all way from apex to base; pedicel longer than F1; F4 longer and F5 shortest; mps on F4 (2) and F6 (2); clava 3.7× as long as broad, with longitudinal ridges; clava with seven mps; clava longer than F3-F6 combined.

Mesosoma: Mesosoma 0.8× of metasoma; mesophragma barely notched; mesocutum and scutellum with longitudinal striation. Wings: fore wing 3.3× as long as broad; longest marginal seta 0.4× wing width; distal macrochaeta slightly longer than proximal macrochaeta; hind wing about 14× as long as broad; longest marginal seta 1.8× of wing width.

Metasoma: Ovipositor slightly exserted, 1.8× of metatibia; ovipositor extending anteriorly almost to margin of propodeum.

Measurements (µm): Head width 176; head height 246; pedicel length & width 139:49; antennal segments length: scape 124; pedicel 30; F1 30; F2 31; F3 32; F4 46; F5 19; F6 43; clava length & width 178:48. Fore wing length: width 801:239; hind wing length: width 714:51; mesosoma length: 334; metasoma length 427; longest marginal seta 101; ovipositor length 458; hind tibia length 257.

Material examined: 2 females, India, Karnataka, Virananjipura, 13.1269^{0}N, 77.3622^{0}E, 10.xii.2020, coll. A. Rameshkumar.

Distribution: Japan (Triapitsyn 2021), India: Karnataka (new record).

Comments: The specimens collected from Karnataka are identified as *S. mitai* based on the original description and illustrations provided by Triapitsyn (2021). This species is known only from the Palaearctic region (Japan). Hence, the range of the species is extended to the Oriental region. There is no significant variation observed between original type specimen and Indian material.

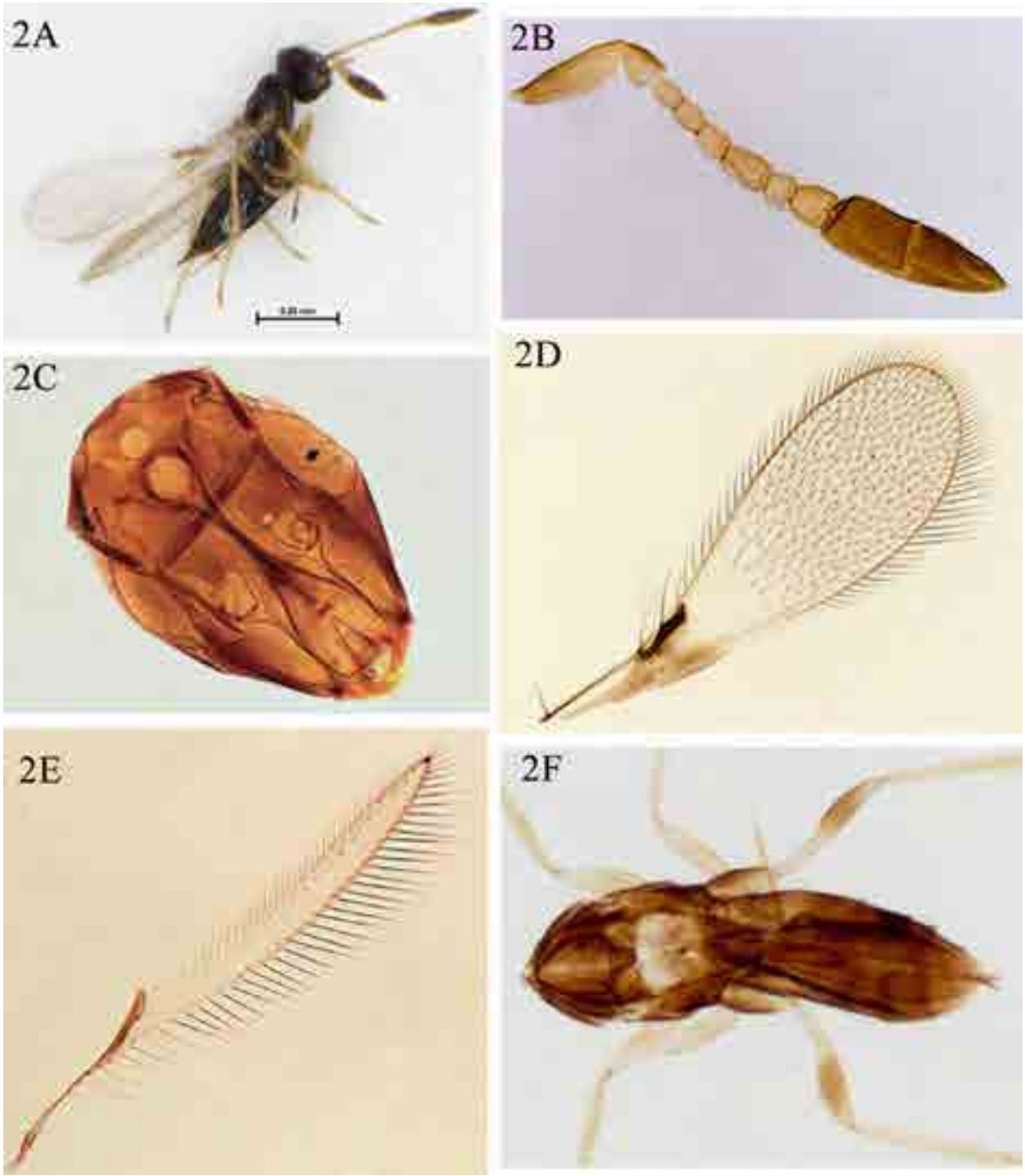


Image 2. ***Schizophragma mitai*** **Triapitsyn, female: A—Habitus | B—Antenna | C—Head frontal view | D—Fore wing | E—Hind wing | F—Meso and metasoma. © Authors.**

2. ***Schizophragma indica*** Rehmat & Anis, 2014 (Image 3A–E)

Schizophragma indica Rehmat & Anis, 2014: 306–311, female. Holotype, female, India, Uttar Pradesh (ZDAMU)

Diagnosis: Female. Length ranges 0.61–0.84 mm (Image 3A). Head dark brown, as long as wide; vertex with fine, rugose and reticulate sculptures (Image 3C); antenna yellowish, scape with 7–8 transverse ridges extending from the apex only up to midway towards base; clava 2 segmented with longitudinal striations, mps on F3(1) and F5(1) (Image 3B); clava with six mps. Wings

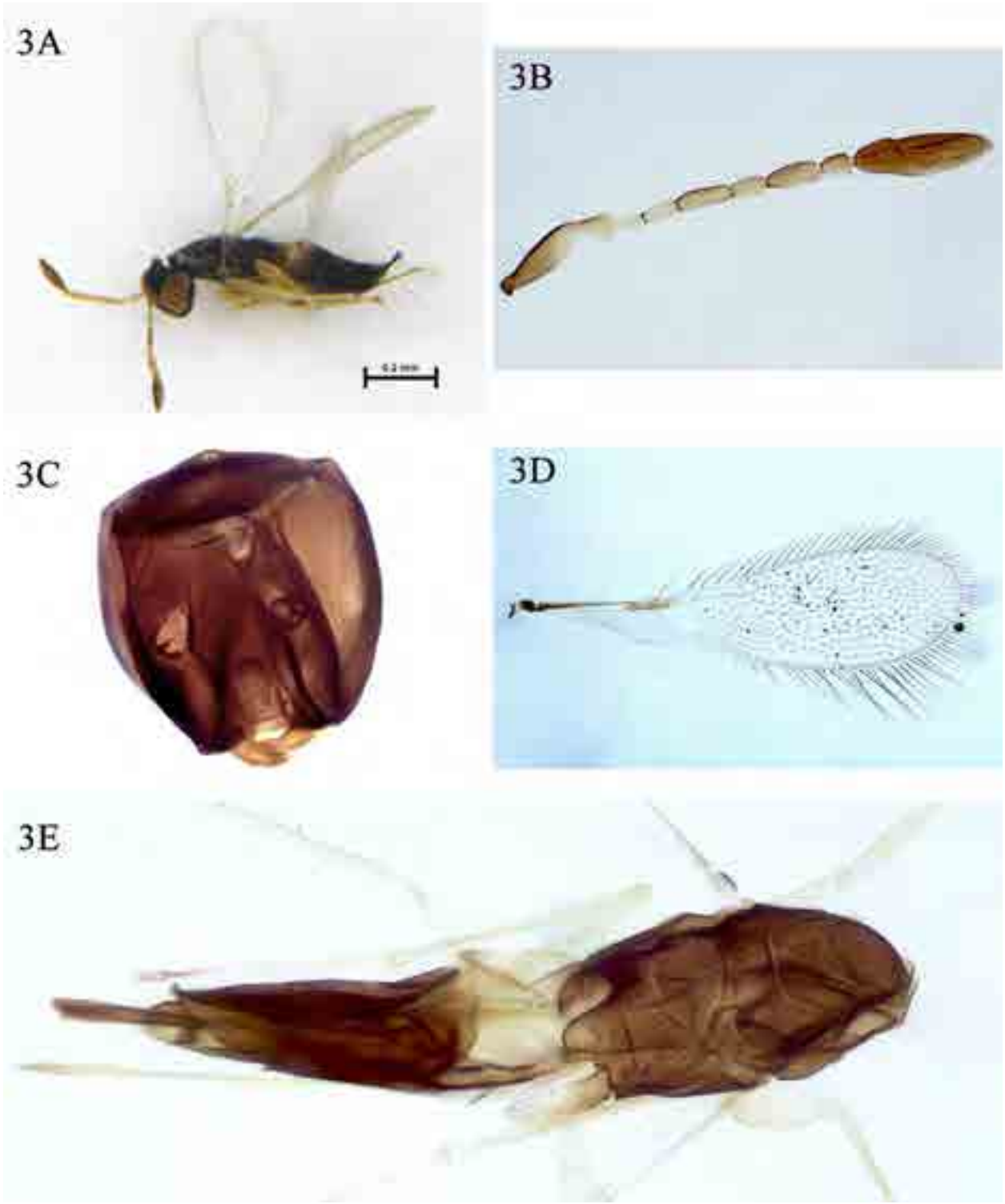


Image 3. *Schizophragma indica* Rehmat & Anis, female: A—Habitus | B—Antenna | C—Head, frontal view | D—Fore wing | E—Meso and metasoma. © Authors.

hyaline (Image 3D); mesosoma dark brown; midlobe of mesoscutum with reticulate sculpture; frenum with lineolate sculpture; mesophragma with deep V-shaped notch. T1 and T2 (partly white), T3–T6 brownish-black; legs light brown; ovipositor shortly exserted from base of metasoma (Image 3E).

Material examined: 8 females, India, Nagaland, Kohima, Basa Khonoma, 25.6453^{0}N, 94.0236^{0}E,

04.xi.2021, coll. A. Rameshkumar.

Distribution: India: Uttar Pradesh (Rehmat & Anis 2014), Nagaland (new record).

Comments: Within the eight specimens collected from Nagaland (Northeastern India) observed, some variations, i.e., size of funicle segments and body colouration, may be due to the habitus and climatic variations.

References

Athithya, A. & S. Manickavasagam (2022). Present status and key to Indian fairyfly genera (Hymenoptera: Mymaridae). *Uttar Pradesh Journal of Zoology* 43(1): 60–70.

Huber, J.T. (1987). Review of *Schizophragma* Ogloblin and the non-Australian species of *Stethynium* Enock (Hymenoptera: Mymaridae). *The Canadian Entomologist* 119: 823–855.

Noyes, J.S. (1982). Collecting and preserving chalcid wasps (Hymenoptera: Chalcidoidea). *Journal of Natural History* 16(3): 315–334.

Rehmat, T. & S.B. Anis (2014). Record of the genus *Schizophragma* Ogloblin (Hymenoptera: Mymaridae) in Oriental region, with description of a new species from India. *Oriental Insects* 48(3–4): 306–311.

Triapitsyn, S.V. (2021). A new subgenus and two new species of Mymaridae (Hymenoptera, Chalcidoidea) from Kyushu, Japan. *Bulletin of the Kyushu University Museum* 18: 87–100.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22757–22760
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.8042.15.2.22757-22760
#8042 | Received 08 June 2022 | Final received 20 December 2022 | Finally accepted 25 January 2023
OPEN ACCESS
NOTE

Occurrence of *Ranunculus sceleratus* L. (Ranunculaceae) from the Nilgiri District, Tamil Nadu, India

J. Shashikanth [1], S.Mugendhiran [2] & Digvijay Verma [3]

[1,2] Center of Medicinal Plants Research in Homoeopathy, 3/126, Indira Nagar, Emerald, The Nilgiri District, Tamil Nadu 643209, India.
[3] Central Council for Research in Homoeopathy, Ministry of AYUSH, Government of India, 61–65, Institutional Areas, Opposite to "D" Block, Janakpuri, New Delhi 110058, India.
[1] jaleshashikanth2000@gmail.com (corresponding author), [2] mugendhiranselvamm@gmail.com, [3] digvijayccrh@gmail.com

The genus *Ranunculus* Linnaeus (Ranunculaceae) consists of herbaceous, annual, and perennial species. The genus is distributed on all continents except Antarctica and the largest number of species occurs in temperate zones of Europe, Asia, North & South America, Australia, New Zealand, and in the alpine regions of New Guinea (Johansson 1998). The genus comprises ca. 600 species (Tamura 1995; Wencai & Gilbert 2001; Horandl et al. 2005; Mabberly 2008; Srivastava 2010). In Asia, the genus is distributed in Japan, Korea, China, India, Nepal, Bhutan, Thailand, Pakistan, Afghanistan, Iran, Mongolia, Egypt, and Syria (Lone & Dar 2016). In India it is almost restricted to eastern and northwestern Himalaya (Rau 1993) and is represented by 21 species and six varieties (Hooker & Thomson 1872). Rau (1993) in Flora of India included 33 species and one variety reported from Indian boundary.

During a recent medicinal plants survey of Udhagamandalam, plant specimens of Nilgiri District belonging to the genus were collected. Critical study of the specimens followed by pertinent literature survey revealed the identity of the specimens as *Ranunculus sceleratus* L. The species was known so far from Himachal Pradesh, Madhya Pradesh, Delhi, Jammu & Kashmir (Srivastava 2010). A further study of existing literature revealed that it was not prior reported from Tamil Nadu. The current distribution of *Ranunculus* in Tamil Nadu is restricted to four species, viz., *Ranunculus muricatus* (it is native to Europe), *R. reniformis* (The species is native of Western Ghats of peninsular India, particularly from Tamil Nadu, Kerala, and Rajasthan), *R. subpinnatus* (native of this species is southern Western Ghats, eastern Himalaya to Assam), and *R. wallichianus* (it is an endemic species to Western Ghats and Sri Lanka) were reported in Tamil Nadu, all reported from The Nilgiris (Hooker & Thomson 1872; Fysen 1915; Gamble 1915; Sharma 1993; Nair & Henry 1983; Srivastava 2010). The present finding from Nilgiri District not only extends its distribution to Tamil Nadu, but also forms an addition to the Ranunculaceae of Tamil Nadu and new record to southern India. As it is reported from Tamil Nadu for the first time, a brief description of the species along with field photographs and notes are provided herewith to facilitate its easy identification. The voucher specimens were deposited and are being maintained at Survey of Medicinal Plants & Collection Unit & Homeopathic Medicinal Plant Research Garden Herbarium (SMPRGH), Emerald, The Nilgiris, Tamil Nadu, India.

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Shashikanth, J., S.Mugendhiran & D. Verma (2023). Occurrence of *Ranunculus sceleratus* L. (Ranunculaceae) from the Nilgiri District, Tamil Nadu, India. *Journal of Threatened Taxa* 15(2): 22757–22760. https://doi.org/10.11609/jott.8042.15.2.22757-22760

Copyright: © Shashikanth et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: CCRH, Ministry of AYUSH, Govt. of India, New Delhi.

Competing interests: The authors declare no competing interests.

Acknowledgements: The authors are grateful to Director General, Central Council for Research in Homoeopathy, Ministry of AYUSH, Govt. of India, New Delhi for facilities and encouragement.

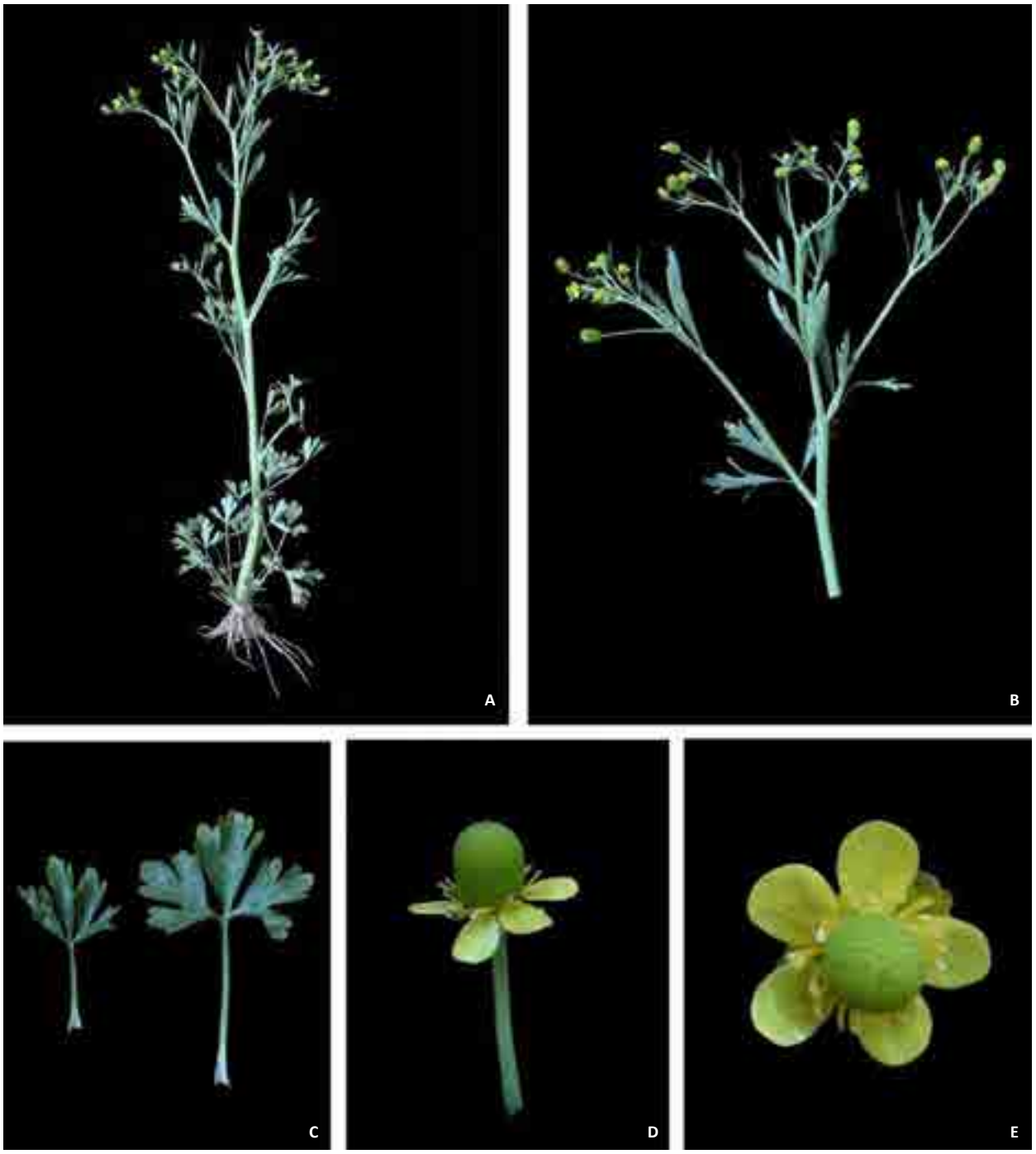


Image 1. *Ranunculus sceleratus* L.: A—habit of the plant | B—a flowering twig | C—leaves | D—a flower: side view | E—a flower: top view.
© J. Shashikanth & S.Mugendhiran.

Taxonomic treatment

Ranunculus sceleratus L., Sp. Pl. 551. 1753; Hook.f. & Thoms in Hook.f., Fl. Brit. India 1: 19. 1872; Rau in Sharma et al., Fl. India 1: 128. 1993; Saini, J. Econ. Taxon. Bot. 29(3): 533. 2005; Maliya & Datt, J. Econ. Taxon. Bot. 34(1): 46. 2010; Srivastava, Taiwania 55(3): 290, f. 33. 2010. (Image 1, 2)

Annual herb, erect, fleshy. Roots fibrous, subequally thick. Stems 10–90 cm high, glabrous or sparsely pubescent; stem stout, branched, hollow, deeply furrowed outside. Radical leaves petiolate, reniform, 2.5–5.0 cm in diam., 3-lobed or 3-partite; segments obovate, bluntly 3– 5-toothed; lateral lobes sometime deeply bilobed again, lobes irregularly shallow crenate;

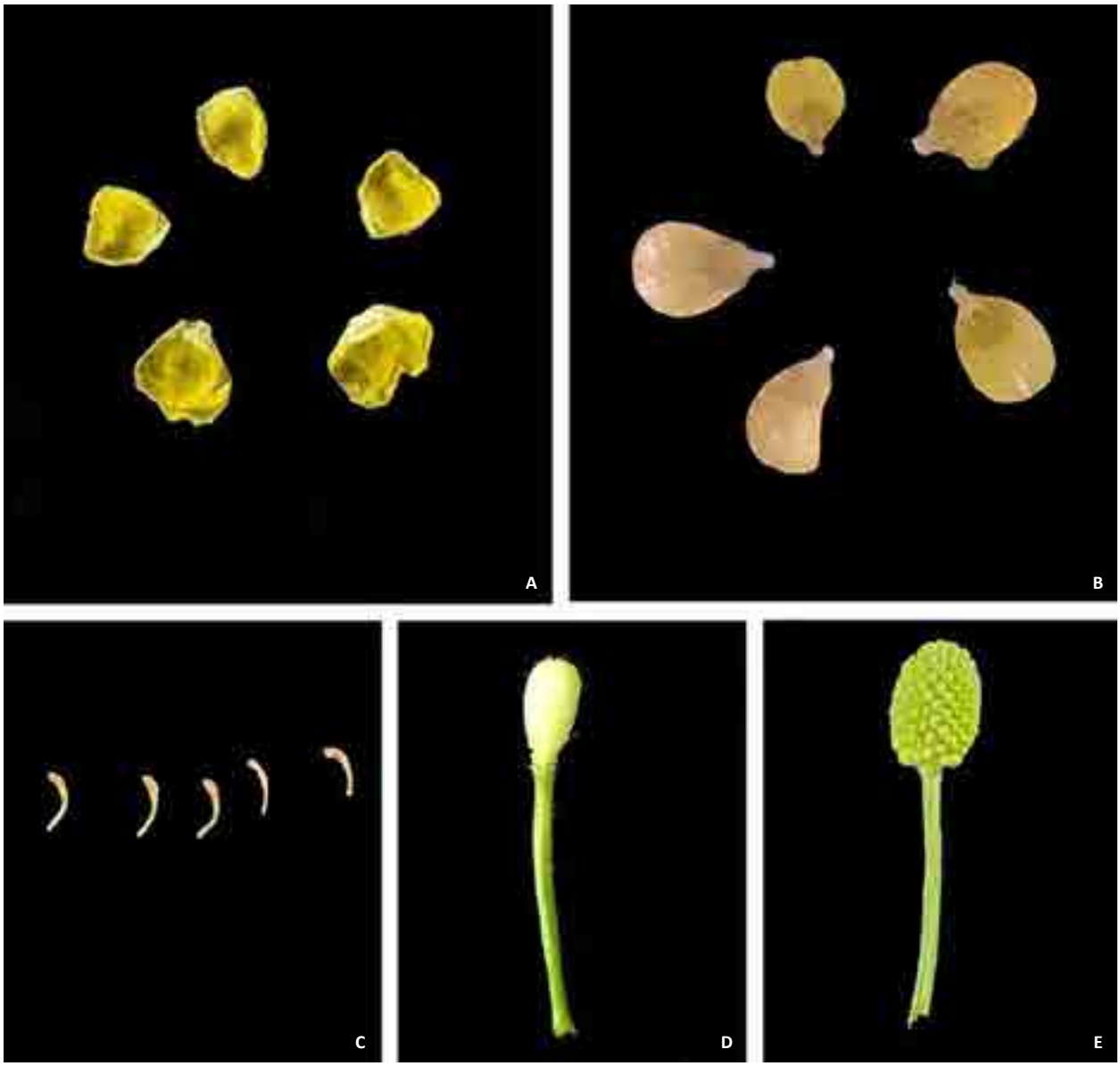


Image 2. *Ranunculus sceleratus* L.: A—dissected sepals of the flowers | B—dissected petals of the flowers | C—dissected anthers of the flowers | D—dissected gynoecium of the flowers | E—a fruit of the plant. © J. Shashikanth & S.Mugendhiran.

petioles 2.5–5.0 cm long, progressively shortened and ultimately sessile in cauline leaves, auricles scarious, 5 mm long; cauline leaves sessile, 3-lobed or 3–5 partite, lobes linear-oblong, entire or deeply crenate or lobulate. Flowers numerous, ca 1 cm in diam., bright yellow, diffusely racemose; pedicel 0.5–1.5 cm, glabrous, Sepals 5, ca 4 mm long, ovate-elliptic, ovate, pubescent outside, reflexed, caduceus. Petals 5, imbricate, shorter or as long as sepals, obovate, 4–6 x 3–4 mm, apex rounded or shallowly notched, claw inconspicuous; nectary pit small, pocket-like without nectary scale. Stamens 10–19; anthers ellipsoid. Aggregate fruit ovoid-cylindrical to cylindrical, 3–11 × 1.5–4 mm; carpels numerous. Achenes small, slightly bilaterally compressed, obliquely obovoid, up to 1.3 mm in diam., beak inconspicuous, glabrous, compressed, smooth to 2- or 3-rugose, somewhat turgid along sutures; arranged in an oblong to shortly cylindrical, 7–8 mm long head; style short, minutely beaked; stigma persistent, ca 0.1 mm.

Flowering & fruiting: Throughout the year.

Distribution: India**:** Northern India, Himalaya, Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal, Assam, Arunachal Pradesh, Manipur (Srivastava 2010), and Tamil Nadu (Present study).

Habitat: Marshes, damp areas stagnant water, and

sewage channels.

Specimen examined: 9440(SMPRGH), 21.i.2020, India, Tamil Nadu, The Nilgiri District, Udhagamandalam, on the way from Ooty bus stand to Mysore road (24.593^{0}N, 86.153^{0}E), 2,275m, coll. J. Shashikanth.

Taxonomic note: *Ranunculus sceleratus* L. is morphologically similar and possibly closely related to *R. sarodous*. Both are annuals, 3-partite leaf blades and reflexed sepals. However, *Ranunculus sceleratus* differ from *R. sardous* in presence of oblanceolate leaf segments, glabrous or sparsely pubescent stem, ovoid-cylindrical to cylindrical aggregated fruits and having numerous achenes. Furthermore petals shorter or as long as sepals, achenes inflated, beak inconspicuous when compared with those of *Ranunculus sardous* (Eun-Mi Sun 2019).

Conservation status: As per Maiz-Tome (2016), the species is Least Concern on the IUCN Red List. In Tamil Nadu as the plant has so far been reported from Udhagamandalam, Nilgiri District only. However, futuristic surveys are recommended to assess its status in different regions in Tamil Nadu. At present, the species is restricted to a very few populations which are under severe threat due to tourism related activities, since Udhagamandalam is one of major tourist destinations in Tamil Nadu. The present populations of *Ranunculus sceleratus* L. is also facing serious threat from human interventions and natural calamities like floods and grazing of street animals.

References

Allen, T.F. (1982). *The Encyclopedic of Pure Materia Medica*. vol. 8. New Delhi: B. Jain Publishers, 1-166pp.

Fysen, P.F. (1915). *The Flora of the South Indian Hill Station*.vol.1 Chennai: Superintendent, Government Press, 1-475pp.

Gamble, J.S. (1915). *Flora of the Presidency of Madras*. Vol. 1. Bishen Singh Mahendra Pal Singh, Dehradun, 577 pp.

Hooker, J.D. & T. Thomson (1872). Ranunculaceae, pp. 16–21. In: Hooker, J.D. (ed.). *The Flora of British India*, *Vol. I*. L. Reeve and Co., London, 740 pp.

Horandl, E., O. Paun, J.T. Johansson, C. Lehnebach, T. Armstrong, L. Chen & P. Lockhart (2005). Phylogenetic relationships and evolutionary traits in *Ranunculus* s.l. (Ranunculaceae) inferred from ITS sequence analysis. *Molecular Phylogenetics and Evolution* 36: 305–327.

Johansson, J.T. (1998). Chloroplast DNA restriction site mapping and the phylogeny of *Ranunculus* (Ranunculaceae). *American Journal of Botany* 213: 1–19.

Lone, F.A. & G.H. Dar (2016). Diversity and distribution of buttercups (*Ranunculus* Linnaeus) in Kashmir Valley of J & K, India. *Pleoine* 10(2): 209–225.

Mabberley, D.J. (2008). *The Plant Book: A Portable Dictionary of Plants, their classification and uses*. Cambridge University Press. Cambridge, UK, 1,021 pp.

Maiz-Tome, L. (2016). *Ranunculus sceleratus*. The IUCN Red List of Threatened Species 2016: e.T164175A1027583. Accessed on 07 February 2023. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T164175A1027583.en

Nair, N.C. & A.N. Henry (1983). *Flora of Tamil Nadu, India, Series 1: Analysis, Vol. 1*. Botanical Survey of India, Howrah, 184 pp.

Rau, M.A. (1993). Ranunculaceae, pp. 113–131. In: Sharma, B.D., N.P. Balakrishnan, R.R. Rao & P.K. Hajra (eds.). *Flora of India, Vol. 1, Ranunculaceae – Barclayaceae.* Botanical Survey of India, Calcutta, 467 pp.

Sharma, B.D., N.P. Balakrishnan, R.R. Rao & P.K. Hajra (1993). *Flora of India,* Vol. 1. Ranunculaceae – Barclayaceae. Botanical Survey of India, Kolkata, 467 pp.

Srivastava, S.K. (2010). Revision of genus *Ranunculus* L. (Ranunculaceae) in India. *Taiwania* 55(3): 273–314.

Sun, E.-M. H.-W. Kim, K.-H. Lee, H. Sookim & D.C. Son (2019). A new record for invasive alien plant *Ranunculus sardous* Crantz (Ranunculaceae) in the Republic of Korea. *Korean Journal of Plant Research* 32(6): 752–757.

Tamura, M. (1995). Angiospermae. Ordnung Ranunculales Fam. Ranunculaceae. II. Systematic Part, pp. 223–519. In: Hiepko, P. (ed.). *Naturlichen Pflanzen familien*, second ed., 17aIV., Duncker & Humblot, Berlin, Germany.

Wencai, W. & M.G. Gilbert (2001). Ranunculus, pp. 391–431. In: Flora China vol. 6, Science press (Beijing), Missouri Botanical Garden Press, St. Louis. http://www.efloras.org

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22761–22763
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.7636.15.2.22761-22763
#7636 | Received 29 August 2021 | Finally accepted 30 January 2023
OPEN ACCESS
NOTE

First report of *Meliola panici* on *Ottochloa nodosa* (Kunth) Dandy (Poaceae)

Gopinathan Nair Gokul [1] & **Jacob Thomas** [2]

[1] Department of Botany, Catholicate College, Makkamkunnu, Pathanamthitta, Kerala 689645, India.
[2] Department of Botany, Mar Thoma College, Tiruvalla 689103, Kerala, India.
[1] gogulgn@gmail.com, [2] jacobnthomas@gmail.com (corresponding author)

Black mildews are ectoparasites forming black colonies on surface of leaves, tender stem, and fruits of host plants (Hansford 1961; Hosagoudar 1996, 2008, 2013; Hongsanan et al. 2015). These fungi are minor plant pathogens and their distribution is reported mostly from tropical parts of the world (Hansford 1961; Hosagoudar 1996, 2008, 2013; Saenz & Taylor 1999; Hongsanan et al. 2015). Black Mildews are host specific and have narrow host range that rarely extend to more than one host family (Zeng et al. 2017). Meliolales are the largest order of black mildew fungi represented by 3,064 epithets listed in Index Fungorum (Jayawardena et al. 2020). This order comprises two families Armatellaceae and Meliolaceae (Hosagoudar 2013; Hongsanan et al. 2015; Zeng et al. 2017; Hyde et al. 2020). *Meliola* is the type genus of the family Meliolaceae. The description of the species *Meliola panici* causing black mildew disease on *Ottochloa nodosa* (Kunth) Dandy is included in this report.

The infected plants were collected from the Konni Forest Division located in the southern part of the Western Ghats in peninsular India. Infection patterns and other characteristics of colonies were noted during collection and photographs were taken. The infected leaves were collected in clean polythene bags and separate field numbers were given to collections from different localities. From the fresh samples, scrapes of surface mycelia taken were treated with 10% KOH for 30 minutes and then mounted in lactophenol in cotton blue. Appropriately dried specimens were used to prepare permanent slides of colonies (Hosagoudar & Kapoor 1985).

Meliola panici Earle, Muchlenbergia 1: 12, 1901; Hansf., Sydowia Beih. 2: 745, 1961; Gupta & Gupta, Indian Phytopath. 58: 390, 1985; Hosag. & Goos, Mycotaxon 42: 136, 1991; Hosag., Meliolales of India, p. 276, 1996; Hosag. & Sabeena, J. Threat. Taxa 6(7): 5971, 2014. (Image 1).

Materials examined: On leaves of *Ottochloa nodosa* (Kunth) Dandy (Poaceae) from Konni Forest Division, Pathanamthitta District, Kerala, India, 9.2281^{0}N, 76.8171^{0}E, 10 February 2019, coll. Gokul G. Nair, MTCHT 271.

Colonies amphigenous, subdense, up to 3 mm in diameter. Mycelium straight to flexuous, branching opposite to irregular at acute to wide angles, loosely reticulate, cells 26–32 × 4–8 µm. Appressoria alternate, straight to curved, antrorse to spreading, 14–20 µm long; stalk cells cylindrical to cuneate, 3–8 µm long; head cells ovate, globose, entire, angular to sublobate, 10–15 × 9–11 µm. Phialides borne on a separate mycelial branch, alternate to opposite, ampulliform, 14–20 ×

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Gokul, G.N. & J. Thomas (2023). First report of *Meliola panici* on *Ottochloa nodosa* (Kunth) Dandy (Poaceae). *Journal of Threatened Taxa* 15(2): 22761–22763. https://doi.org/10.11609/jott.7636.15.2.22761-22763

Copyright: © Gokul & Thomas 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: None.

Competing interests: The authors declare no competing interests.

Acknowledgements: We thank the Department of Botany, Catholicate College, Pathanamthitta and Mar Thoma College, Tiruvalla for providing facilities. Forest Department of Kerala is thankfully acknowledged for granting permission to conduct the field study.

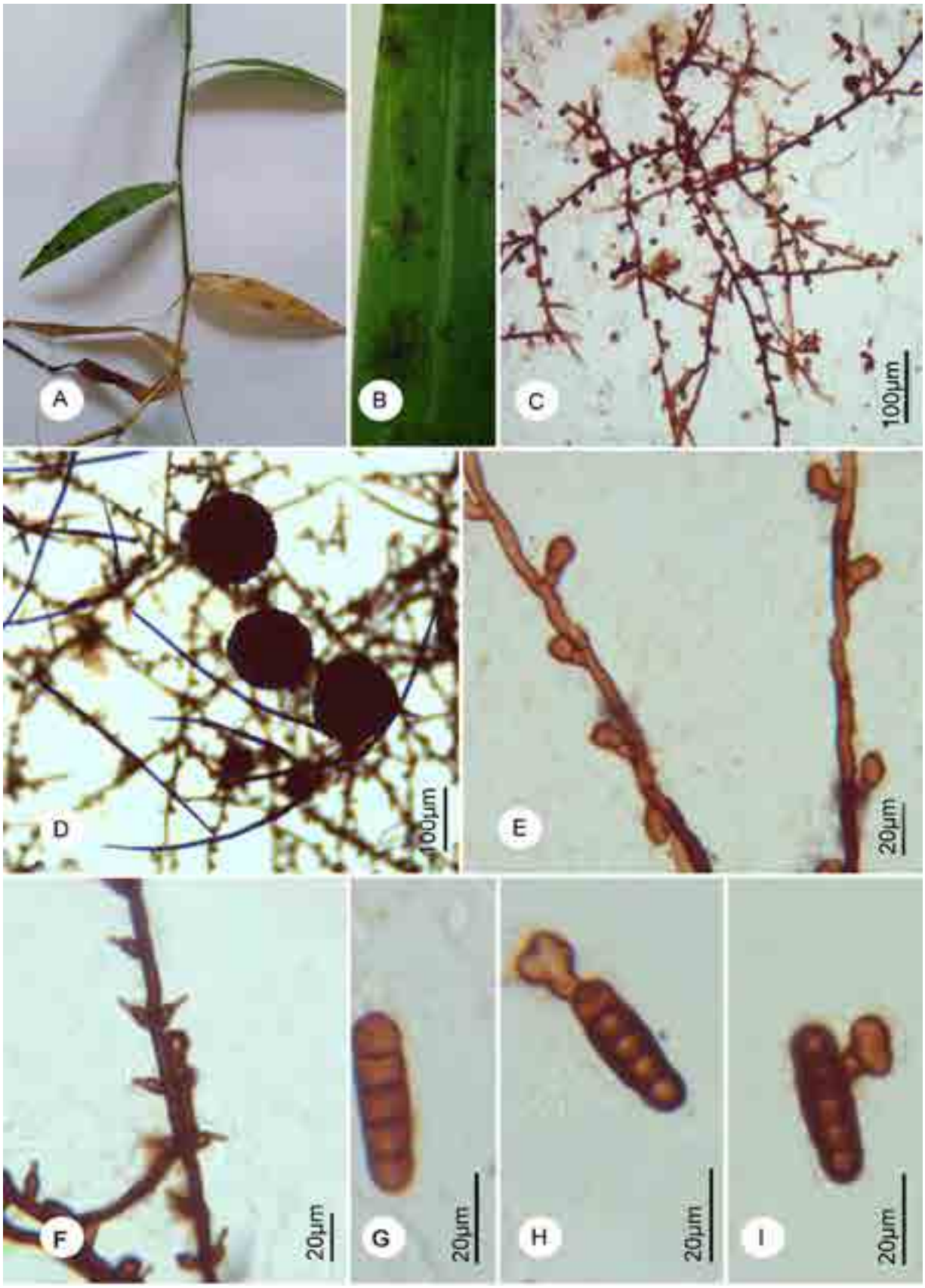


Image 1. ***Meliola panici*****: A—Infected plant | B—Colonies on adaxial surface of leaf | C—Surface mycelium | D—Perithecia and setae | E—Appressoriate Hyphae | F—Hypha with phialides | G—Mature Ascospore | H,I—Germinating ascospores. © G.N. Gokul.**

5–7µm. Mycelial setae numerous, straight, simple, acute to obtuse at the tip, up to 550 µm long. Perithecia mostly grouped, verrucose, up to 158 µm in diameter; ascospores oblong cylindrical, 4-septate, slightly constricted at the septa, 33–42 × 10–14 µm.

Single species of *Asteridiella* and 12 species of *Meliola* were reported infecting members of Poaceae (Hansford 1961). Now 28 species of *Meliola* are known to associate with 39 host plants of the family Poaceae (Hosagoudar 2008, 2013; Hosagoudar & Sabeena 2014; Zeng et al. 2017). *Meliola panici* and its varieties were reported infecting eight species, namely, *Vetiveria zizanioides* (L.) Nash, *Cyrtococcum longipes* (Wight & Arn. ex Hook.f.) A.Camus, *Olyra latifolia* L., *Acroceras munroanum* (Balansa) Henrard (*Panicum latifolium)*, *Setaria palmifolia* (Koenig) Stapf, *Stipa dregeana* Steud., *Uniola virgata* (Poir.) Griseb., and an unidentified species of *Panicum* (Zeng et al. 2017). Based on morphological characteristics and Beeli digital formulae (3111.4223) the present collection is identified as *Meliola panici.* This is the first report of the pathogen growing as a biotrophic associate on *Ottochloa nodosa.*

References

Hansford, C.G. (1961). The Meliolineae. *Sydowia Annales Mycologici, Ser. II, Beihefte* 2: 1–806.

Hongsanan, S., Q. Tian, D. Peršoh, X.Y. Zeng, K.D. Hyde, P. Chomnunti, S. Boonmee, A.H. Bahkali & T.C. Wen (2015). Meliolales. *Fungal Diversity* 74(1): 91–141. https://doi.org/10.1007/s13225-015-0344-7

Hosagoudar, V.B. (1996). *Meliolales of India*, pp. 351–366. Botanical Survey of India, Calcutta.

Hosagoudar, V.B. (2008). *Meliolales of India. Vol. II*, pp. 155–354. Botanical Survey of India, Calcutta.

Hosagoudar, V.B. (2013). Meliolales of India. Vol. III. *Journal of Threatened Taxa* 5(6): 3993–4068. https://doi.org/10.11609/jott.o3307.3993-4068

Hosagoudar, V.B. & A. Sabeena (2014). Foliicolous fungi of Wayanad District in Kerala State, India. *Journal of Threatened Taxa* 6(7): 5909–6052. https://doi.org/10.11609/jott.o3658.5909-6052

Hosagoudar, V.B. & J.N. Kapoor (1985). New technique of mounting meliolaceous fungi. *Indian Phytopathology* 38: 548–549.

Hyde, K.D., C. Norphanphoun, S.S.N. Maharachchikumbura, D.F. Bao, D.J. Bhat, S. Boonmee, D. Bundhun, M.S. Calabon, N. Chaiwan, Y.J. Chen, K.W.T. Chethana, D.Q. Dai, M.C. Dayarathne, B. Devadatha, A.J. Dissanayake, L.S. Dissanayake, M. Doilom, W. Dong, X.L. Fan, I.D. Goonasekara, S. Hongsanan, S.K. Huang, R.S. Jayawardena, R. Jeewon, E.B.G. Jones, A. Karunarathna, S. Konta, V. Kumar, C.G. Lin, J.K. Liu, N. Liu, Y.Z. Lu, J. Luangsa-ard, S. Lumyong, Z.L. Luo, D.S. Marasinghe, E.H.C. McKenzie, A.G.T. Niego, M. Niranjan, R.H. Perera, C. Phukhamsakda, A.R. Rathnayaka, M.C. Samarakoon, S.M.B.C. Samarakoon, V.V. Sarma, I.C. Senanayake, Q.J. Shang, M. Stadler, S. Tibpromma, D.N. Wanasinghe, D.P. Wei, N.N. Wijayawardene, Y.P. Xiao, M.M. Xiang, J. Yang, X.Y. Zeng & S.N. Zhang (2020). Refined families of Sordariomycetes. *Mycosphere* 11(1): 305–1059. https://doi.org/10.5943/mycosphere/11/1/7

Jayawardena, R.S., K.D. Hyde, Y.J. Chen, V. Papp, B. Palla, D. Papp, C.S. Bhunjun, V.G. Hurdeal, C. Senwanna, I.S. Manawasinghe, D.L. Harischandra, A.K. Gautam, S. Avasthi, B. Chuankid, I.D. Goonasekara, S. Hongsanan, X.Y. Zeng, K.K. Liyanage, N. Liu, A. Karunarathna, K.K. Hapuarachchi, T. Luangharn, O. Raspé, R. Brahmanage, M. Doilom, H.B. Lee, L. Mei, R. Jeewon, N. Huanraluek, N. Chaiwan, M. Stadler & Y. Wang (2020). One stop shop IV: taxonomic update with molecular phylogeny for important phytopathogenic genera. *Fungal Diversity* 103: 87–218. https://doi.org/10.1007/s13225-020-00460-8

Saenz, G.S. & J.W. Taylor (1999). Phylogenetic relationships of *Meliola* and *Meliolina* inferred from nuclear small subunit rRNA sequences. *Mycological Research* 103(8): 1049–1056.

Zeng, X.Y., J.J. Zhao, S. Hongsanan, P. Chomnunti, S. Boonmee & T.C. Wen (2017). A checklist for identifying Meliolales species. *Mycosphere* 8(1): 218–359. https://doi.org/10.5943/mycosphere/8/1/16

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22764–22766

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

https://doi.org/10.11609/jott.8303.15.2.22764-22766

#8303 | Received 04 December 2022 | Final received 13 January 2023 | Finally accepted 10 February 2023

OPEN ACCESS

NOTE

New record of an usneoied lichen *Usnea hirta* (L.) Weber ex F.H.Wigg. from India

K.S. Vinayaka [1], Archana R. Mesta [2] & N. Rajeshwari [3]

[1] Department of Botany, Shri Venkataraman Swamy College, Vidyagiri, Bantwala, Dakshina Kannad, Karnataka 574211, India.
[2,3] Department of Botany, Sahyadri Science College, Shimoga, Karnataka 577201, India.
[1] ks.vinayaka@gmail.com (corresponding author), [2] archu.mesta@gmail.com, [3] rajeshwaribabu02@gmail.com

Lichens are the first members of the barren rocky regions to colonize and are good forest health indicators in the tropical forest regions of the world. Western Himalaya and Western Ghats are lichen hotspots in the country (Upreti et al. 2005). *Usnea* is one the largest fruticose genera of lichen forming fungi around the world within the family Parmeliaceae (Lucking et al. 2016). The genus *Usnea* is widely distributed in tropical and subtropical regions of the world (Stevens 2004; Clerc 2006; Galloway 2007; Hinds & Hinds 2007; Herrera 2016; Ohmura et al. 2017). Among the usneoid lichens, the genus *Usnea* was segregated into five subgenera (Motyka 1938). About 300 *Usnea* species were reported from all over the world Ohmura (2012) and 57 species are known from India (Shukla et al. 2014). *Usnea* species which are primarily saxicolous have restricted distribution patterns compared to corticolous species (Clerc & Herrera-Campos 1997). The genus *Usnea* can be described by fruticose thallus with cartilaginous central axis. The species of *Usnea* are differentiated on the basis of pigmentation on cortex and medulla, branching types, density of branches, and different morphological parts.

The present study is based on the lichens collected from different parts of Karnataka during 2008–2020. The lichens were collected from different altitudes and all types of substrata such as barks, twigs, and rocks. The collected samples were taken to the laboratory, air dried, and stored in the lichen herbarium of Kumadvathi First Grade College and Sri Venkataramana Swamy College, Karnataka. The voucher specimen was submitted to NBRI, Lucknow (LWG). Ecological parameters such as temperature, humidity, altitude, latitude were noted at the place of collection. The morphological characters were noted down. The anatomical characters studied with the help of binocular microscope. The chemical tests (K, C, KC, P, I test, and TLC in solvent system A) were carried out to identify the secondary metabolites present in it (White & James 1985; Orange 2001). The pH of the bark was estimated by the procedure of Kricke (2002) using digital pH meter (Multi-Parameter PTTestrTM 35 Oakton, USA). The identification of *Usnea* was done on the basis of morphological, anatomical, and chemical characters (Awasthi 2007; Ohmura 2012).

***Usnea hirta* (L.) F.H.Wigg.**

Collection: Karnataka, Chikkamagaluru,Mullayanagiri (13.6433^{0}N & 73.9840^{0}E) on the twigs of *Hypericum mysurense* at an altitude of 1,780m. Average temperature

Editor: Anonymity requested.

Date of publication: 26 February 2023 (online & print)

Citation: Vinayaka, K.S., Archana R. Mesta & N. Rajeshwari (2023). New record of an usneoied lichen *Usnea hirta* (L.) Weber ex F.H.Wigg. from India. *Journal of Threatened Taxa* 15(2): 22764–22766. https://doi.org/10.11609/jott.8303.15.2.22764-22766

Copyright: © Vinayaka et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: None.

Competing interests: The authors declare no competing interests.

Acknowledgements: We are thankful to management and principal of SVS College, Bantwal and Sahyadri Science College Shimoga for providing the facilities. We also thankful to Karnataka Forest Department for permission and Dr. S. Nayaka, NBRI for encouragement to carry out the study.

Figure 1. Study locality of *Usnea hirta* in India.

is 24°C and humidity 90–92%.

Voucher No: LHKFGC0015

Description: Thallus fruticose, corticolous, branching sympodial, main branches stiff, segments terete to strongly ridged, thallus erect and shrubby, 5–7cm long, light to dark brown in color, absence of papillae, cortex single layered, central axis solid, pseudocyphellae and soredia absent, isidia present, apothecia not found.

Ecology: Ramicolous, collected from the shola forests of Mullayanagiri on the twigs of *Hypericum mysurense* with smooth bark with pH 6.36±0.3

Chemistry (Colour Test): Medulla K-, P-, I-, C-, KC-

Chemicals: Norstictic acid, usnic acid, and murolic acid

Distribution: Europe, North America (South California, Arizona), Philippines, Australia, eastern Africa, India (Western Ghats).

Image 1. A—*Usnea hirta* (L.) Weber ex F.H.Wigg. | B—thallus section (scale =10 µm). © Vinayaka KS.

References

Awasthi, D.D. (2007). *A Compendium of the Macrolichens from India, Nepal and Sri Lanka*. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.

Clerc, P. & M.A. Herrera-Campos (1997). Saxicolous species of *Usnea* subgenus *Usnea* (Lichenized Ascomycetes) in North America. *The Bryologist* 119: 361–416.

Clerc, P. (2006). Synopsis of *Usnea* (lichenized Ascomycetes) from the Azores with additional information on the species in Macaronesia. *Lichenologist* 38: 191–212.

Galloway, D. (2007). Flora of New Zealand Lichens. Revised Second Edition Including Lichen-Forming and Lichenicolous Fungi. Volumes 1 and 2. Manaaki Whenua Press, Lincoln, New Zealand, 2261 pp.

Herrera-Campos, M.A. (2016). *Usnea* in Mexico. *Bibliotheca Lichenologica* 110: 505–620.

Hinds, J.W. & P.L. Hinds (2007). *The Macrolichens of New England*. In: Memoirs of the New York Botanical Garden No. 96. New York Botanical Garden Press, Bronx, 584 pp.

Kricke, R. (2002). Measuring bark pH, pp. 333–336. In: Nimis, P.L., C. Scheidegger & P.A. Woolseley (eds.). *Monitoring with Lichens-Monitoring Lichens*. Academic Publishers, Netherlands,

Lucking, R., B.P. Hodkinson & S.D. Leavitt (2016). The classification of lichenized fungi in the Ascomycota and Basidiomycota – approaching one thousand genera. *The Bryologist* 119: 361–416.

Motyka, J. (1938). Lichenum generis *Usnea* studium monographicum. *Pars systematica* (Vol. 2). Leopoldi.

Differences with other *Usnea* species

	Papillae	Isidia	Apothecia	Medulla	Secondary metabolites
U. hirta	-	+	Not found	Dense	Usnic acid and norstictic acid
U. ghattensis	+	-	Terminal	Loose	Only usnic acid

Key to *Usnea* species of Karnataka

1. Central axis solid 2
2. a. Thallus dichotomously branched up to the apices.....3
   b. Thallus sympodially branched 4
3. Thallus surface with anuular, irregular cracks and dot like to linear pseudocyphellae ..... ***U. rigidula***
4. Branching sympodial or subsympodial, with secondary branches, thallus erect bushy 5
5. a. Thallus with pseudocyphellae 6
   b. Thallus lacking pseudocyphellae and red pigment absent 10
6. a. Thallus pseudocyphellate, isidiate but lacking soredia ... 7
   b. Thallus pseudocyphellate lacking both soredia and isidia. 9
7. Cortex single layered and much branched 8
8. a. Thallus surface tuberculate, lacking papillae, five different chemical strains present ..... ***U. undulata***
   b. Central axis thick, medulla compact and thin ..... ***U. hirta***
9. Cortex single layered, lacking tubercles, medulla K-, thallus stiff, lateral branches dense, apically blackish ..... ***U. ghattensis***
10. a. Thallus with apothecia 11
    b. Thallus lacking apothecia 16
11. Lacking soredia and isidia, cortex single layered 12
12. a. Thallus surface papillate and tuberculate 13
    b. Thallus surface lacking papilla and tubercule 14
13. Thallus yellow to yellowish brown, branches somewhat inflated, medulla K+ red ..... ***U. orientalis***
14. Thallus large, not sub subcoralloid, central axis circular in cross section 15
15. Lateral spinules and fibrils rigid, dense, ± uniform in length ..... ***U. luridorufa***
16. Medulla K+ red (norstictic/salazinic acid) 17
17. Thallus both isidiate and sorediate, inflated in apical region, smooth to maculate, stictic acid complex in medulla ..... ***U. leucospilodea***

Image 2. TLC of *Usnea hirta*. 1—*Parmelinella wallichiana* | 2—*Usnea ghattensis* | 3—*U.hirta)*

Ohmura, Y. (2012). A synopsis of lichen genus *Usnea* (Parmeliaceae, Ascomycota) in Taiwan. *Bulletin of the National Museum of Nature and Science, Tokyo* 48: 91–103.

Ohmura, Y., I. Skirina & F. Skirin (2017). Contribution to the knowledge of the genus *Usnea* (Parmeliaceae, Ascomycota) in southern far East Russia. *Bulletin of the National Museum of Nature and Science* 43(1): 1–10.

Orange, A., P.W. James & F.J. White (2001). *Microchemical Methods for the Identification of Lichens*. British Lichen Society, 101 pp.

Shukla, P., D.K. Upreti & L.M. Tewari (2014). Lichen genus *Usnea* (Parmeliaceae, Ascomycota) in Uttarakhand, India. *Current Research in Environmental and Applied Mycology* 4(2): 188–201.

Stevens, G.N. (2004). Usneaceae, pp. 78–98 & 107–115. In: McCarthy, P.M. & K. Mallett (eds.). *Flora of Australia Vol. 56A, Lichens 4*.

Upreti, D.K., P.K. Divakar & S. Nayaka (2005). Commercial and Ethnic use of lichens in India. *Economic Botany* 59: 269.

White, F.J. & P.W. James (1985). A new guide to the microchemical technique for the identification of lichen substances. *British Lichen Society Bulletin* 57: 1–41.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2023 | 15(2): 22767–22770
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.8222.15.2.22767-22770
#8222 | Received 07 October 2022 | Finally accepted 24 January 2023
OPEN ACCESS
NOTE

On the occurrence of two species of rare cyanobacterial genus *Petalonema* M.J.Berkeley ex Wolle, 1887 (Cyanophyceae: Nostocales: Scytonemataceae) from eastern Himalaya, India

Jai Prakash Keshri [1], Narendra Nath Koley [2] & Jay Mal [3]

[1,2,3] Phycology Laboratory, CAS in Botany, The University of Burdwan, Golapbag, West Bengal 713104, India.
[1] keshrijp@gmail.com (corresponding author), [2] narendranathkoley444@gmail.com, [3] jaymal8942@gmail.com

Petalonema M.J.Berkeley ex Wolle is a rare genus of Scytonemaceae known for its unique features. It is a filamentous genus growing mostly in subaerophytic situations forming mats. The genus could be easily identified due to its lamellated funnel shaped sheath divergent at ends, although not clear in all species (Geitler 1932; Desikachary 1959; Komárek 2013). The sheath is mostly coloured and very distinct. The trichome is uniseriate having barrel shaped cells sometimes constricted at junction points. Heterocysts are solitary and oval to spherical in shape and located variously, mostly at the base of the branches. Akinetes have not been recorded but reproduction by hormogonia formation and distintegration is well known (Komárek 2013; Guiry & Guiry 2022).

The systematic position of the genus was in matter of debate for sometime (Komárek & Anagnostidis 1989; Taton et al. 2006; Kukk et al. 2001; Uher 2010; Komárek 2013; Mares et al. 2015; Maree et al. 2018) but it is now almost settled. Komárek & Anagnostidis (1989) placed it under Microchaetaceae due to its heteropolar growth but Kukk et al. (2001) on the basis their observations on bipolar growth of hormogonia confirmed its closeness to *Scytonema*, that was further confirmed on the basis of molecular studies (Mares et al. 2015). Now its placement in Scytonemataceae is established.

During the systematic investigation on the algal diversity of eastern Himalaya and its foothills, the authors recorded two unique species of *Petalonema*: *Petalonema alatum* (Borzì ex Bornet & Flahault) Wolle & *Petalonema velutinum* Migula.

The samples were collected from the habitat by scrapping the mats with help of scalpel, preserved in 4% formalin solution and stored in amber colour bottles. Geographical location were recorded at the time of collection by a GPS device (GPS MAP 78S, GARMIN). Standard procedure was followed for permanent slide preparation. The samples were studied under Olympus GB compound microscope and images of the samples were taken using Zeiss Axioscope A1 microscope with Axiocam 504 model digital camera. The specimens are deposited in the Algae Herbarium of Department of Botany, the University of Burdwan (BURD).

Petalonema alatum (Borzì ex Bornet & Flahault) Wolle

Komárek, Süβwasserflora von Mitteleuropa. Cyanoprokaryota: 3rd part: Heterocystous genera. 19: p.

Editor: Anonymity requested. **Date of publication:** 26 February 2023 (online & print)

Citation: Keshri, J.P., N.N. Koley & J. Mal (2023). On the occurrence of two species of rare cyanobacterial genus *Petalonema* M.J.Berkeley ex Wolle, 1887 (Cyanophyceae: Nostocales: Scytonemataceae) from eastern Himalaya, India. *Journal of Threatened Taxa* 15(2): 22767–22770. https://doi.org/10.11609/jott.8222.15.2.22767-22770

Copyright: © Keshri et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: 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: The authors are grateful to Ministry of Environment Forest & Climate Change for funding under AICOPTAX programme (No. F. No. 2018/15/2015-CS (Tax) dated 18th January 2018); & HOD, CAS in Botany, The University of Burdwan, for laboratory facilities.

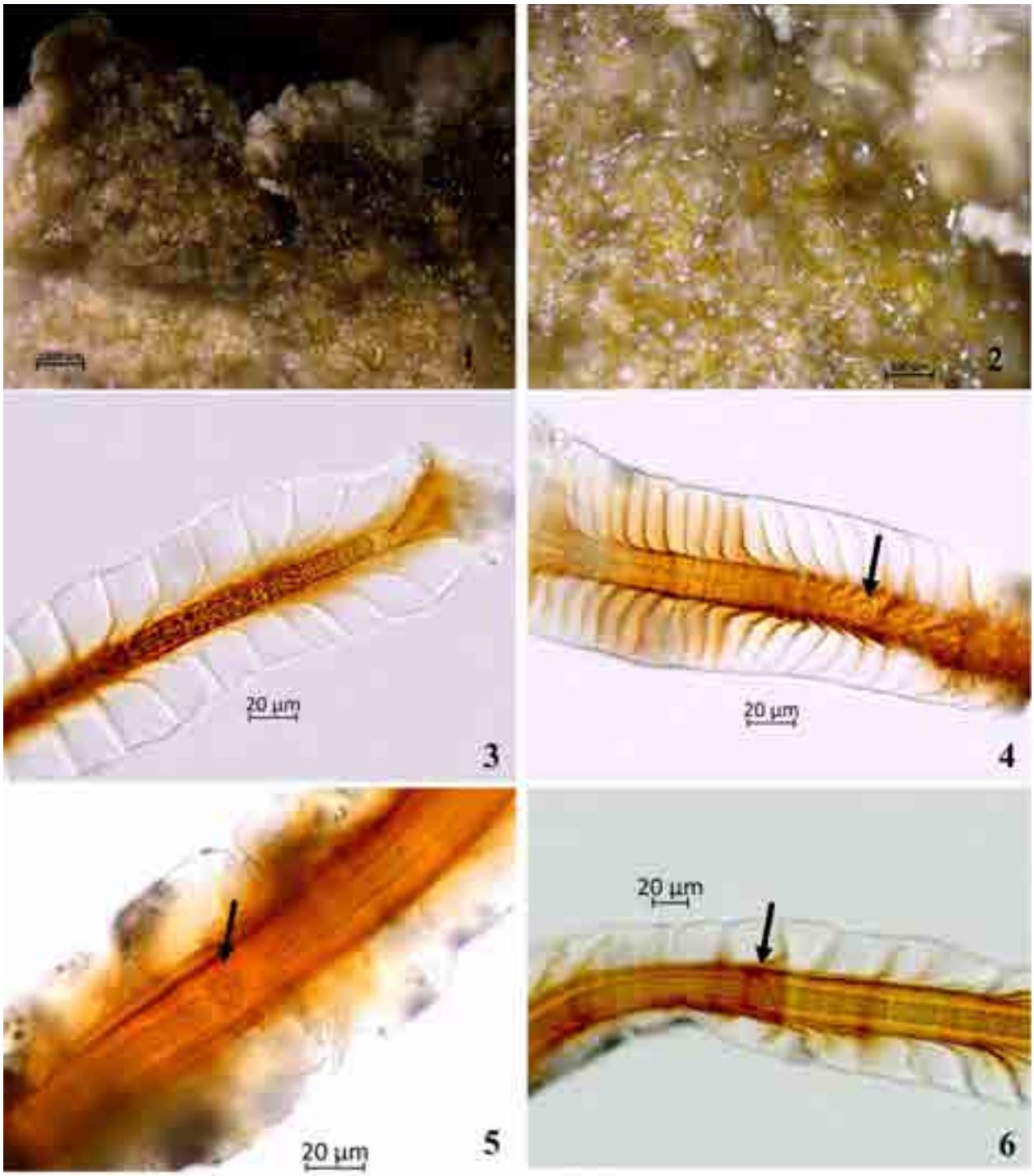


Image 1. *Petalonema alatum*: 1–2—showing the habitat | 3—showing the filament | 4–6—showing the heterocysts (arrows indicate the heterocyst). © Jai Prakash Keshri.

146, f. 139. 2013]. (Image 1)

Thallus forming thick calcareous mats (up to 1 cm thick) under dripping wet rocks; filaments slightly erected, sheath distinctly lamellated with divergent lamellations ending in funnels, colourless, yellowish-brown, golden yellow, distinctly brown to dark tan coloured adjoin the main trichome where a clear layer of dark brown sheath is noticed; trichome cylindrical constricted at cross walls 12.60–16.34 µm broad; heterocysts always intercalary globose to barrel shaped always singh 13.59–16.66 µm broad and 7.13–13.15 µm long.

Ecological notes: Rajabhat khawa, Alipurduar, India;

26.5829^{0}N, 89.4604^{0}E; growing on wet rocks; collection no. MoEF/JPK/243; 25 September 2019.

Distribution in India: Tamil Nadu. This is the first report of the species from eastern Himalaya.

Petalonema velutinum Migula

Komárek, Süβwasserflora von Mitteleuropa. Cyanoprokaryota: 3rd part: Heterocystous genera. 19: p. 148, f. 142. 2013. (Image 2)

Thallus mat forming growing on wet rocks among *Trentepohlia* mats, deep brown in colouration; filaments coalescing, branches mostly in pairs; sheath gelatinous yellowish to reddish-brown in colouration, distinctly lamellated, lamellation divergent but not always distinctly demarcated as in *P. alatum*; trichome 5.57–10.37 µm in diameter, distinctly constricted at cross walls; cells 5.57–10.37 µm wide, and 5.95–8.14 µm long, spherical to slightly elongate, ovate in shape; heterocysts intercalary always, solitary, 10.37 µm wide and 4.84 µm long more or less rectangular and broader than long.

Ecological notes: On the rocks near Relli River, Kalimpong, West Bengal, India; 27.0864^{0}N, 88.8211^{0}E; collection no. MoEF/JPK/224; 23 September 2019.

Distribution in India: First report from India (Eastern Himalaya, West Bengal).

So far *Petalonema alatum* Berkeley ex Kirchner 1898 has been reported from Tamil Nadu (Desikachary 1959). *Petalonema densum* A. Braun ex Migula was recorded from Karnataka (Desikachary 1959), Madhya Pradesh, and Maharashtra (Gupta 2012). R.K. Gupta (2001) has described a new species *P. striato-theca* from Tiuni, Dehradun (Uttrakhand). So far no species of this genus has been reported from eastern Himalaya. Occurrence of these two species from eastern Himalaya is therefore new record for both the species including new record for *Petalonema velutinum* Migula from the Indian subcontinent.

References

Desikachary, T.V. (1959). *Cyanophyta*. ICAR, New Delhi, 686 pp.

Geitler, N.L. (1932). Cyanophyceae. In Raberhorst's Kryptogamenflora von Deutschland, Österreich and der Schweiz, 14, Germany, 1196 pp.

Guiry, M.D. & G.M. Guiry (2022). *AlgaeBase*. National University of Ireland, Galway. https://www.algaebase.org. Accessed 29 September 2022.

Gupta, P. (2012). *Algae of India 1. A Checklist of Cyanoprokaryota (Cyanophyceae).* Botanical Survey of India, Ministry of Environment & Forests, Kolkata, India, 160 pp.

Gupta, R.K. (2001). A new species of *Petalonema* Berk. from Dehradun, India. *Indian Journal of Forestry* 24(4): 500–502.

Komárek, J. & K. Anagnostidis (1989). Modern approach to the classification system of cyanophytes 4. Nostocales. *Algological Studies* 56: 247–345.

Komárek, J. (2013). *Süßwasserflora von Mitteleuropa (Freshwater Flora of Central Europe) Band 19/3 Cyanoprokaryota 3. Teil Heterocystous genera.* Springer Spektrum, Germany, 1130 pp.

Kukk, E., G. Hallfors & A. Niemi (2001). *Scytonema alatum* (Carmichael) Borzi (Nostocophyceae, Nostocales) in a lake in Kuusamo, NE Finland Archiv für. *Hydrobiologie* 140: 47–61.

Maree, L., S.J. van Vuuren, A. Levanets & J. Taylor (2018). First record of cyanobacterium *Petalonema alatum* (Borzi ex Bornet & Flahault) Correns (Cyanobacteria, Scytonemataceae) in Africa. *Checklist* 14(5): 827–832.

Mares, J., Y. Lara, I. Dadáková, T. Hauer, B. Uher, A. Wilmottle & J. Kastovsky (2015). Phylogenetic analysis of cultivation resistant terrestrial cyanobacteria with massive sheaths (*Stogonema* sp. and *Petalonema alatum*, Nostocales, Cyanobacteria) using single-cell and filament sequencing of environmental samples. *Journal of Phycology* 51: 288–297.

Taton, A., S. Grubisic, D. Ertz, D.A. Hodgson, R. Pecardi, N. Biondi, M.R. Tredici, M. Mainini, D. Losi, F. Marinelli & A. Wilnaotte (2006). Polyphasic study of Antarctic cyanobacterial strains. *Journal of Phycology* 42: 1257–1270. https://doi.org/10.1111/j.1529-8817.2006.00278.x

Uher, B. (2010). Cyanobacterium *Petalonema alatum* Berk. ex Kirch.-species variability & diversity. *Fottea* 10(1): 83–92.

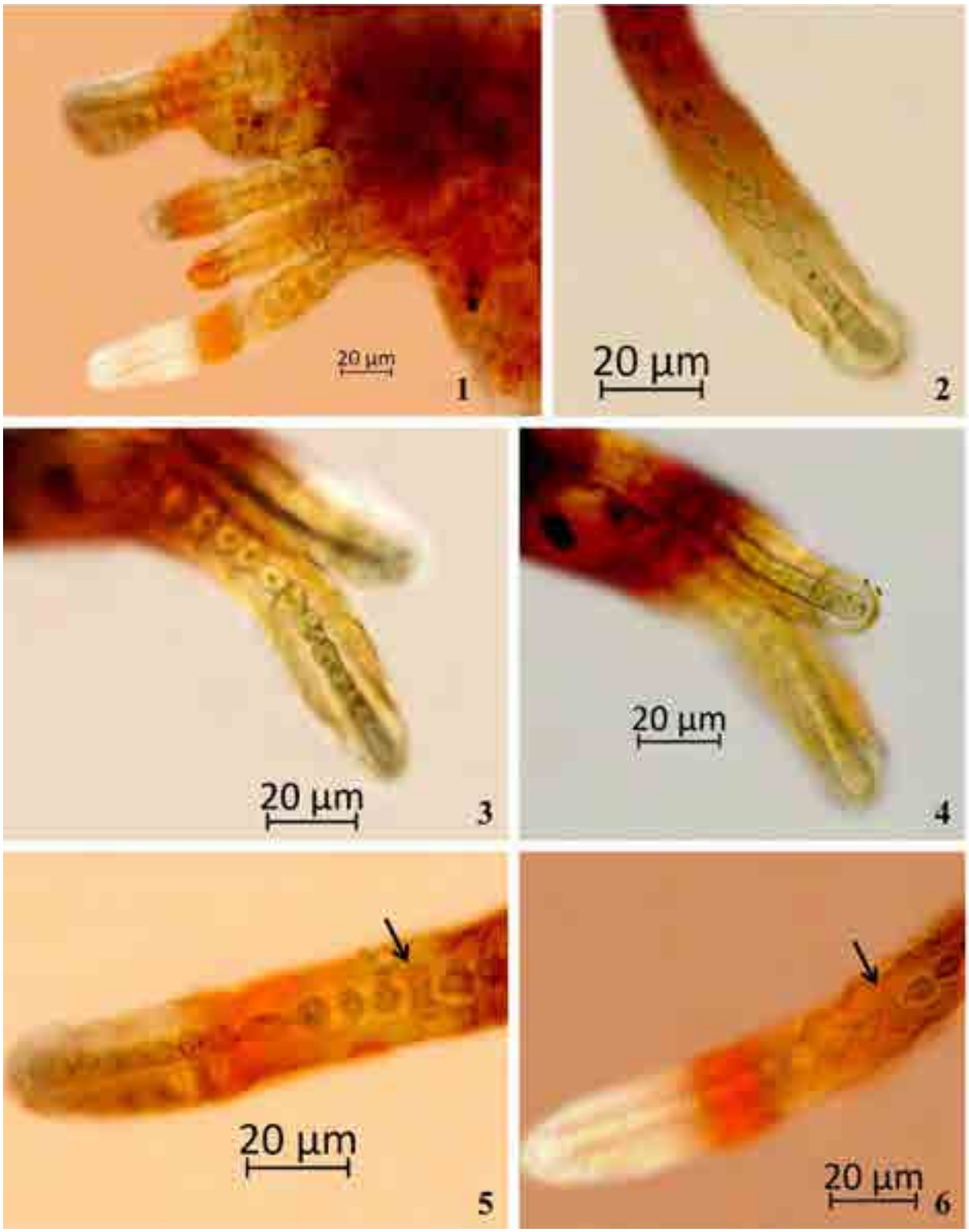


Image 2. ***Petalonema velutinu:*** **1—showing the cluster of filaments | 2–4—showing the filaments | 5–6—showing the heterocysts (arrows indicate the heterocyst). © Jai Prakash Keshri.**

Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
Dr. John Noyes, Natural History Museum, London, UK
Dr. Albert G. Orr, Griffith University, Nathan, Australia
Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
Dr. Nancy van der Poorten, Toronto, Canada
Dr. Kareen Schnabel, NIWA, Wellington, New Zealand
Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
Dr. K.A. Subramanian, Zoological Survey of India, New Alipore, Kolkata, India
Dr. P.M. Sureshan, Zoological Survey of India, Kozhikode, Kerala, India
Dr. R. Varatharajan, Manipur University, Imphal, Manipur, India
Dr. Eduard Vives, Museu de Ciències Naturals de Barcelona, Terrassa, Spain
Dr. James Young, Hong Kong Lepidopterists' Society, Hong Kong
Dr. R. Sundararaj, Institute of Wood Science & Technology, Bengaluru, India
Dr. M. Nithyanandan, Environmental Department, La Ala Al Kuwait Real Estate. Co. K.S.C., Kuwait
Dr. Himender Bharti, Punjabi University, Punjab, India
Mr. Purnendu Roy, London, UK
Dr. Saito Motoki, The Butterfly Society of Japan, Tokyo, Japan
Dr. Sanjay Sondhi, TITLI TRUST, Kalpavriksh, Dehradun, India
Dr. Nguyen Thi Phuong Lien, Vietnam Academy of Science and Technology, Hanoi, Vietnam
Dr. Nitin Kulkarni, Tropical Research Institute, Jabalpur, India
Dr. Robin Wen Jiang Ngiam, National Parks Board, Singapore
Dr. Lional Monod, Natural History Museum of Geneva, Genève, Switzerland.
Dr. Asheesh Shivam, Nehru Gram Bharti University, Allahabad, India
Dr. Rosana Moreira da Rocha, Universidade Federal do Paraná, Curitiba, Brasil
Dr. Kurt R. Arnold, North Dakota State University, Saxony, Germany
Dr. James M. Carpenter, American Museum of Natural History, New York, USA
Dr. David M. Claborn, Missouri State University, Springfield, USA
Dr. Kareen Schnabel, Marine Biologist, Wellington, New Zealand
Dr. Amazonas Chagas Júnior, Universidade Federal de Mato Grosso, Cuiabá, Brasil
Mr. Monsoon Jyoti Gogoi, Assam University, Silchar, Assam, India
Dr. Heo Chong Chin, Universiti Teknologi MARA (UiTM), Selangor, Malaysia
Dr. R.J. Shiel, University of Adelaide, SA 5005, Australia
Dr. Siddharth Kulkarni, The George Washington University, Washington, USA
Dr. Priyadarsanan Dharma Rajan, ATREE, Bengaluru, India
Dr. Phil Alderslade, CSIRO Marine And Atmospheric Research, Hobart, Australia
Dr. John E.N. Veron, Coral Reef Research, Townsville, Australia
Dr. Daniel Whitmore, State Museum of Natural History Stuttgart, Rosenstein, Germany.
Dr. Yu-Feng Hsu, National Taiwan Normal University, Taipei City, Taiwan
Dr. Keith V. Wolfe, Antioch, California, USA
Dr. Siddharth Kulkarni, The Hormiga Lab, The George Washington University, Washington, D.C., USA
Dr. Tomas Ditrich, Faculty of Education, University of South Bohemia in Ceske Budejovice, Czech Republic
Dr. Mihaly Foldvari, Natural History Museum, University of Oslo, Norway
Dr. V.P. Uniyal, Wildlife Institute of India, Dehradun, Uttarakhand 248001, India
Dr. John T.D. Caleb, Zoological Survey of India, Kolkata, West Bengal, India
Dr. Priyadarsanan Dharma Rajan, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Bangalore, Karnataka, India

Fishes

Dr. Neelesh Dahanukar, IISER, Pune, Maharashtra, India
Dr. Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, México
Dr. Heok Hee Ng, National University of Singapore, Science Drive, Singapore
Dr. Rajeev Raghavan, St. Albert's College, Kochi, Kerala, India
Dr. Robert D. Sluka, Chiltern Gateway Project, A Rocha UK, Southall, Middlesex, UK
Dr. E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India
Dr. Davor Zanella, University of Zagreb, Zagreb, Croatia
Dr. A. Biju Kumar, University of Kerala, Thiruvananthapuram, Kerala, India
Dr. Akhilesh K.V., ICAR-Central Marine Fisheries Research Institute, Mumbai Research Centre, Mumbai, Maharashtra, India
Dr. J.A. Johnson, Wildlife Institute of India, Dehradun, Uttarakhand, India
Dr. R. Ravinesh, Gujarat Institute of Desert Ecology, Gujarat, India

Amphibians

Dr. Sushil K. Dutta, Indian Institute of Science, Bengaluru, Karnataka, India
Dr. Annemarie Ohler, Muséum national d'Histoire naturelle, Paris, France

Reptiles

Dr. Gernot Vogel, Heidelberg, Germany
Dr. Raju Vyas, Vadodara, Gujarat, India
Dr. Pritpal S. Soorae, Environment Agency, Abu Dubai, UAE.
Prof. Dr. Wayne J. Fuller, Near East University, Mersin, Turkey
Prof. Chandrashekher U. Rivonker, Goa University, Taleigao Plateau, Goa. India
Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

Birds

Dr. Hem Sagar Baral, Charles Sturt University, NSW Australia
Mr. H. Byju, Coimbatore, Tamil Nadu, India
Dr. Chris Bowden, Royal Society for the Protection of Birds, Sandy, UK
Dr. Priya Davidar, Pondicherry University, Kalapet, Puducherry, India
Dr. J.W. Duckworth, IUCN SSC, Bath, UK
Dr. Rajah Jayapal, SACON, Coimbatore, Tamil Nadu, India
Dr. Rajiv S. Kalsi, M.L.N. College, Yamuna Nagar, Haryana, India
Dr. V. Santharam, Rishi Valley Education Centre, Chittoor Dt., Andhra Pradesh, India
Dr. S. Balachandran, Bombay Natural History Society, Mumbai, India
Mr. J. Praveen, Bengaluru, India
Dr. C. Srinivasulu, Osmania University, Hyderabad, India
Dr. K.S. Gopi Sundar, International Crane Foundation, Baraboo, USA
Dr. Gombobaatar Sundev, Professor of Ornithology, Ulaanbaatar, Mongolia
Prof. Reuven Yosef, International Birding & Research Centre, Eilat, Israel
Dr. Taej Mundkur, Wetlands International, Wageningen, The Netherlands
Dr. Carol Inskipp, Bishop Auckland Co., Durham, UK
Dr. Tim Inskipp, Bishop Auckland Co., Durham, UK
Dr. V. Gokula, National College, Tiruchirappalli, Tamil Nadu, India
Dr. Arkady Lelej, Russian Academy of Sciences, Vladivostok, Russia
Dr. Simon Dowell, Science Director, Chester Zoo, UK
Dr. Mário Gabriel Santiago dos Santos, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real, Portugal
Dr. Grant Connette, Smithsonian Institution, Royal, VA, USA
Dr. M. Zafar-ul Islam, Prince Saud Al Faisal Wildlife Research Center, Taif, Saudi Arabia

Mammals

Dr. Giovanni Amori, CNR - Institute of Ecosystem Studies, Rome, Italy
Dr. Anwaruddin Chowdhury, Guwahati, India
Dr. David Mallon, Zoological Society of London, UK
Dr. Shomita Mukherjee, SACON, Coimbatore, Tamil Nadu, India
Dr. Angie Appel, Wild Cat Network, Germany
Dr. P.O. Nameer, Kerala Agricultural University, Thrissur, Kerala, India
Dr. Ian Redmond, UNEP Convention on Migratory Species, Lansdown, UK
Dr. Heidi S. Riddle, Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA
Dr. Karin Schwartz, George Mason University, Fairfax, Virginia.
Dr. Lala A.K. Singh, Bhubaneswar, Orissa, India
Dr. Mewa Singh, Mysore University, Mysore, India
Dr. Paul Racey, University of Exeter, Devon, UK
Dr. Honnavalli N. Kumara, SACON, Anaikatty P.O., Coimbatore, Tamil Nadu, India
Dr. Nishith Dharaiya, HNG University, Patan, Gujarat, India
Dr. Spartaco Gippoliti, Socio Onorario Società Italiana per la Storia della Fauna "Giuseppe Altobello", Rome, Italy
Dr. Justus Joshua, Green Future Foundation, Tiruchirapalli, Tamil Nadu, India
Dr. H. Raghuram, The American College, Madurai, Tamil Nadu, India
Dr. Paul Bates, Harison Institute, Kent, UK
Dr. Jim Sanderson, Small Wild Cat Conservation Foundation, Hartford, USA
Dr. Dan Challender, University of Kent, Canterbury, UK
Dr. David Mallon, Manchester Metropolitan University, Derbyshire, UK
Dr. Brian L. Cypher, California State University-Stanislaus, Bakersfield, CA
Dr. S.S. Talmale, Zoological Survey of India, Pune, Maharashtra, India
Prof. Karan Bahadur Shah, Budhanilakantha Municipality, Kathmandu, Nepal
Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraja, Indonesia
Dr. Hemanta Kafley, Wildlife Sciences, Tarleton State University, Texas, USA

Other Disciplines

Dr. Aniruddha Belsare, Columbia MO 65203, USA (Veterinary)
Dr. Mandar S. Paingankar, University of Pune, Pune, Maharashtra, India (Molecular)
Dr. Jack Tordoff, Critical Ecosystem Partnership Fund, Arlington, USA (Communities)
Dr. Ulrike Streicher, University of Oregon, Eugene, USA (Veterinary)
Dr. Hari Balasubramanian, EcoAdvisors, Nova Scotia, Canada (Communities)
Dr. Rayanna Hellem Santos Bezerra, Universidade Federal de Sergipe, São Cristóvão, Brazil
Dr. Jamie R. Wood, Landcare Research, Canterbury, New Zealand
Dr. Wendy Collinson-Jonker, Endangered Wildlife Trust, Gauteng, South Africa
Dr. Rajeshkumar G. Jani, Anand Agricultural University, Anand, Gujarat, India
Dr. O.N. Tiwari, Senior Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India
Dr. L.D. Singla, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India
Dr. Rupika S. Rajakaruna, University of Peradeniya, Peradeniya, Sri Lanka
Dr. Bahar Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2019–2021
Due to pausity of space, the list of reviewers for 2018–2020 is available online.

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

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

www.threatenedtaxa.org

OPEN ACCESS

The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under Creative Commons Attribution 4.0 International License unless otherwise mentioned. JoTT allows allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

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

February 2023 | Vol. 15 | No. 2 | Pages: 22559–22770
Date of Publication: 26 February 2023 (Online & Print)
DOI: 10.11609/jott.2023.15.2.22559-22770

Publisher & Host

Threatened Taxa