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Cover: Rajendran's Shieldtail Snake *Uropeltis rajendranai*, a new species described in this issue from Bodhamalai, southern Eastern Ghats, India. © S.R. Ganesh

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Do wildlife crimes against less charismatic species go unnoticed? A case study of Golden Jackal *Canis aureus* Linnaeus, 1758 poaching and trade in India

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Abstract: Wildlife crimes pertaining to lesser-known species do not usually garner adequate focus or interest by enforcement and conservation agencies. Additionally, illegal wildlife trade fuelled by religious beliefs in sorcery and superstition is an oft-neglected field of research. To draw attention to these two broad issues, we provide a baseline analysis of open-source reports on Golden Jackal *Canis aureus* poaching and trade in India. We highlight the pervasiveness of an active local and transnational 'jackal horn' trade, which is severely under-reported and insufficiently researched. News reports and government seizure data reveal that, between 2013 and 2019, 126 skins, eight tails, more than 370 'jackal horns', 16 skulls and two live jackals have been seized. The demand for the illusionary 'jackal horn' appears to be driven by extensive online endorsement and unsubstantiated claims made by religious practitioners, targeted primarily at south Asian markets. This preliminary study is an urgent call for concerted efforts to monitor the illegal trafficking and trade of this common species, with a particular focus on the demand and supply chains.

Keywords: *Canis aureus*, carnivores, 'jackal horn', management, illegal wildlife trade, poaching, wildlife trafficking.

Tamil abstract: குறைவாக அறியப்பட்ட இனங்கள் தொடர்பான வனவிலங்கு குற்றங்கள் வழக்கமாக அமலாக்கம் மற்றும் பாதுகாப்பு நிறுவனங்களால் போதுமான கவனம் அல்லது ஆர்வத்தை பெறுவதில்லை. கூடுதலாக, சூனியம் மற்றும் மூடநம்பிக்கை ஆகியவற்றில் மத நம்பிக்கைகளால் தூண்டப்பட்ட சட்டவிரோத வனவிலங்கு வர்த்தகம் என்பது பெரும்பாலும் புறக்கணிக்கப்பட்ட ஆராய்ச்சித் துறையாகும். இந்த இரண்டு பரந்த பிரச்சினைகளுக்கும் கவனத்தை ஈர்க்க, இந்தியாவில் குள்ளநரி (கேனிஸ் ஆரியஸ்) வேட்டையாடுதல் மற்றும் வர்த்தகம் குறித்து திறந்த மூல அறிக்கைகளின் அடிப்படையில் ஒரு பகுப்பாய்வை நாங்கள் வழங்குகிறோம். செயலில் உள்ள உள்ளூர் மற்றும் நாடுகடந்த 'குள்ளநரி கொம்பு' வர்த்தகத்தின் பரவலான தன்மையை நாங்கள் முன்னிலைப்படுத்துகிறோம். இது கடுமையாக அறிக்கை செய்யப்படாதது மற்றும் போதுமான அளவு ஆராய்ச்சி செய்யப்படவில்லை. 2013 மற்றும் 2019 க்கு இடையில், 126 தோல்கள், 8 வால்கள், 370 க்கும் மேற்பட்ட 'குள்ளநரி கொம்புகள்', 16 மண்டை ஓடுகள் மற்றும் 2 நேரடி குள்ளநரிகள் பறிமுதல் செய்யப்பட்டுள்ளதாக செய்தி அறிக்கைகள் மற்றும் அரசு கைப்பற்றப்பட்ட தகவல்கள் தெரிவிக்கின்றன. மாயையான 'குள்ளநரி கொம்பு'க்கான கோரிக்கை விரிவான ஆன்லைன் ஒப்புதல் மற்றும் மத பயிற்சியாளர்களால் ஆதாரமற்ற கூற்றுக்கள், முக்கியமாக தெற்காசிய சந்தைகளை இலக்காகக் கொண்டது. இந்த பூர்வாங்க ஆய்வு இந்த பொதுவான உயிரினத்தின் சட்டவிரோத கடத்தல் மற்றும் வர்த்தகத்தை கண்காணிப்பதற்கான ஒருங்கிணைந்த முயற்சிக்கான அவசர அழைப்பாகும். மேலும் அதன் தேவை மற்றும் விநியோக சங்கிலிகளில் ஒரு குறிப்பிட்ட கவனத்தை செலுத்துகிறது.

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INTRODUCTION

The marginalization of less charismatic species is evident in the lack of conservation funding and public discourse in preventing their illegal poaching and trade (Sigouin et al. 2017). Conservation efforts to combat poaching are generally focused on large, charismatic species or species that face immediate extinction threats. Illegal trade of relatively abundant species, whose populations are not considered to face imminent declines, however, may comprise a significant portion of wildlife seizure data (Scheffers et al. 2019). For example, digital monitoring of illegal wildlife trade in the United States revealed that non-threatened species, which included deer, elk, moose and bear were frequently confiscated, although these species were not typically the focus of organizations controlling illegal wildlife trade (Hansen et al. 2012). This presents a paradox. While anti-poaching efforts focus inadequately on common species, unsustainable hunting or poaching could in fact accelerate the decline of less charismatic species and result in local extinctions (e.g., local extinction of the African Civet in several areas in Ghana driven by unsustainable bush meat hunting; Ryan & Attuquayefio 2000; Damania et al. 2005). Additionally, the pursuit of a common target species could lead to the 'opportunistic exploitation' of a higher value rare species. The basis of this suggestion is that targeting a widespread species, while also earning profits through opportunistic encounters with higher valued species, is more profitable than targeting higher valued species alone (Branch et al. 2013). Therefore, monitoring common or relatively widespread species in illegal wildlife trade networks fulfills the dual role of preventing an abundant species from spiralling into decline and reducing poaching pressure on rare species.

An oft-overlooked aspect of illegal wildlife trade is one that is rooted in local religious practices. Wildlife may be utilized as sacrificial offerings (e.g., sea turtle sacrifice by Balinese Hindus in Indonesia; Jensen 2009), ornaments (e.g., birds-of-paradise feathers for traditional outfits in Papua New Guinea; Van den Bergh et al. 2013), food in festivals or ceremonies (e.g., consumption of barking deer and wild pig meat during the Morum festival in north-east India; Hilaluddin et al. 2005), products for sorcery practice (e.g., Demidoff's Bushbaby skull in West Africa; Djagoun et al. 2018) and in similar superstitious practices (e.g., Indian Star Tortoise in India; D'Cruz et al. 2015). An investigation of outdoor markets and religious shops in northern Brazil revealed that the wildlife trade for religious purposes involved an extensive commercial network of collectors, distributors and shop owners, where priests of the Candomblé religion directed traders and customers about the type of animal and their body parts used for specific religious ceremonies (Alves et al. 2012).

In India, conservation bias towards charismatic species echoes amongst policy makers, with many holding the view that large, charismatic wildlife are the primary target species for poaching or illegal trade (Niraj et al. 2009). In contrast, illegal wildlife trade in the country constitutes a significant portion of lesser-known, less charismatic and common species that are traded in diverse markets as exotic pets, wild meat, traditional medicine, sorcery and superstitious practices, perfumes, souvenirs, ornaments and even for the manufacture of painting and shaving products, among other reasons (Sahajpal et al. 2009; Aiyadurai 2011; Mendiratta et al. 2017; Sharma et al. 2019). The demand for products used in superstitious or religious practices surpasses state and national boundaries, giving rise to widespread and diverse consumer groups. The evidence-base for this trade, unfortunately, is limited and ambiguous. This is typified by the local and international trade in monitor lizard *Varanus* spp. genital parts, driven by belief in sorcery, superstition and traditional medicine. The body part is sold in local markets and online platforms with the Hindi name 'hatha jodi', which is also the name for the root of *Martynia annua*, a rare medicinal plant. The masked biological origin, and shared nomenclature with a plant that is valued as traditional medicine, most likely facilitates the trade while evading detection by enforcement authorities (Bhattacharya & Koch 2018; Rajpoot et al. 2018; Sharma et al. 2019). Additionally, the use of e-commerce platforms for wildlife-derived products (compared to previous 'word-of-mouth' approaches; Ahmed 2010) presents a definitive shift by sorcery practitioners to reach a much wider clientele. Illegal, small-scale wildlife markets benefit from online legal markets by the legal protection provided by these companies, and as a means to expand business opportunities in a relatively risk-free cyber space (Lavorgna 2014).

Poaching of the Golden Jackal *Canis aureus* in India exemplifies two broad issues discussed above: (i) the marginalization of less-charismatic species in terms of conservation efforts, and (ii) illegal trade of common species for religious practices. The Golden Jackal is listed under the Least Concern category of the IUCN Red List because of its large global distribution and purported stable populations. In India, hunting and trade of jackals is a punishable offence; it is protected under Schedule II of the Wild Life Protection Act (1972) and Appendix III of

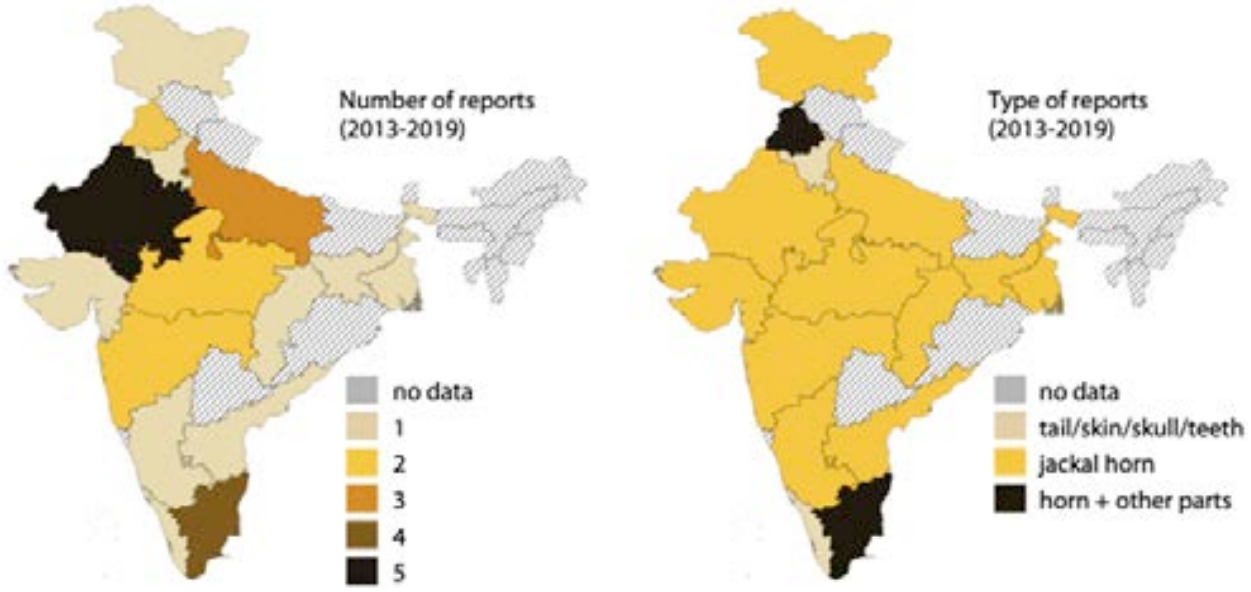

Figure 1. State-wise numbers of media reports or advertisements (2013–2019) featuring sale, trade or seizure of jackal body parts.
Note: Jammu-Kashmir was a State during the study period; now split into Union Territories.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). To provide baseline information on the severely under-reported issue of illegal poaching and trade of jackals, we examined multiple forms of internet-based media which include advertisements, social media posts, blog articles, news reports and peer-reviewed articles. We compiled data on illegal hunting, sale of jackal body parts, trade, and seizure reports by enforcement agencies, from 2013 to 2019. Key findings based on the analysis of online media posts and reports are presented in this article.

SUBSISTENCE HUNTING, POACHING, AND TRADE

Our review of open-source reports showed that jackal meat is consumed by several communities in the north-eastern states, and parts of western, central and southern India (Borah & Prasad 2016). Jackal body parts such as head, skin, tail and teeth find use in traditional and cultural practices in southern India, and jackal organs are believed to have medicinal properties in central India. Poaching and trade of skin, teeth, tail and hair have been documented in media reports from several Indian states (Figure 1). Our analysis of media reports revealed that 126 skins, eight tails, and two live jackals were seized by the Wildlife Crime Control Bureau of India (WCCB) between 2013 and 2019 (see Supplementary Material).

A more pervasive threat is likely from poaching of jackals for 'siyar singhi'—a talisman extracted from the jackal's skull—translating to 'jackal horn' in English. A jackal's skull does not have a true horn; the 'siyar singhi' is either a protrusion or deformity behind the jackal's sagittal crest, or in many cases, a tuft of hair from a jackal or any domestic animal (dog, pig, or goat), stuck together in the shape of a ball. Some images on the Internet also show the dewclaw of jackals/foxes/dogs marketed as 'jackal horn'. The sale of 'jackal horn' appears to be commonplace in Indian trade markets, as evidenced by advertisements on social media and popular online retail outlets. Regional names for 'jackal horn' include 'siyar singhi' or 'gidar singhi' in Hindi, Urdu, and Punjabi, and 'nari kombu' in Tamil, Kannada, and Telugu. Between 2013 and 2019, the WCCB seized more than 370 'jackal horns' and 16 skulls. These seizures usually happen during anti-trafficking operations targeted at 'hatha jodi' (dried copulatory organ of monitor lizard *Varanus* spp.) trade (Bhattacharya & Koch 2018; Sharma et al. 2019). The demand for 'jackal horns' appears to be driven by superstitious beliefs, strengthened by online propaganda, perpetuated by traders of ritualistic worship materials, astrologers, and sorcery or 'black magic' practitioners of Hindu, Muslim, and Sikh religious groups (see Supplementary Material).

ONLINE ENDORSEMENT AND TRADE OF 'JACKAL HORNS'

We found that verified accounts on YouTube endorse the purported magical powers of 'jackal horns', with

several tutorials demonstrating how the product is stored or used. These parts are often sold in pairs, claiming to be a male and a female. Online advertisements and videos show the widespread presence of an internet-based market for jackal parts, with local, regional, and international stakeholders. The demand from sorcery practitioners of the southern Asian diaspora perhaps fuels the trade. Based on evidence from social media posts and e-commerce platforms, we believe that Pakistan may be a source-country (besides India) for the 'siyar singhi' trade (see Supplementary Material). We found that online retailers based in the UK, USA, Germany, and Singapore also list 'jackal horns' for sale on their websites. Some reports indicate that sellers procure the product from local hunters, while others suggest 'jackal horns' are part of a much wider international trade. These open markets raise serious concerns about the prevalence of organised crime networks transporting and distributing jackal products across international borders. There is some evidence that jackals may be poached by planting crude bombs or trapped in leg-hold traps. The jackal trade issue discussed here is, therefore, problematic, both, from the ecological and animal welfare perspectives.

KEY CHALLENGES AND RECOMMENDATIONS

Limited only to publicly accessible reports and social media articles, our exploratory research underscores the paucity of comprehensive data or academic analyses of seizures related to jackal parts. Absence of detailed information such as the quantity, modus operandi, transit modes, transit routes, and potential destinations, impedes our understanding of the scale of harvest and components of the demand–supply chain. The biases associated with English media news reports further add to the problem; levels of public interest and awareness may influence locations and accuracy in such reporting. Furthermore, those states in India that actively enforce poaching and wildlife trafficking laws may be overrepresented in the media. Understanding the extent of local and transnational trade in jackal parts and combating the trade will require ground-based investigations and collaborations between source and destination countries. This will largely depend on political will, or the lack of it.

As preliminary efforts in this direction, we strongly recommend that State Forest Departments confiscate jackal parts that may be encountered while targeting the larger illegal trade market for superstitious ritualistic products, which often include monitor lizards, musk pods (from Himalayan Musk Deer *Moschus chrysogaster*), pangolin scales, leopard parts, snake bones, owls, corals and other species (see Supplementary Material). Animal parts seized during such raids should be sent for laboratory-based genetic analysis to help ascertain species identity. Protocols in the identification, screening and documentation of 'jackal horn' trade need to be developed for the Police, Forest officials and enforcement agencies that regulate wildlife trade. Given the trans-boundary nature of the trade, Customs officials deputed at international transit points need to be trained in identification of these products. E-commerce portals such as Amazon, Facebook, eBay, and possibly YouTube must incorporate a stricter screening of posts that involve illegal trade of wild animal parts through their websites. These measures would also go a long way in meeting the Convention of Biological Diversity post-2020 global commitments that stress on the importance of maintaining transparency in wildlife trade flows between countries (IUCN 2019).

CONCLUSION

Knowledge of Golden Jackal poaching and trade in India is severely lacking due to its 'common' status, lack of public awareness and its prevalence in the lesser-known wildlife market driven by superstitious and religious practices. Through our exploratory analysis, we draw attention to the widespread poaching and trade of jackal body parts in India, largely driven by superstitious belief. We highlight the prevalence of the 'jackal horn'- a talisman extracted from the jackal's skull that is widely advertised on social media and e-commerce platforms. News reports and government seizure data reveal that the 'jackal horn' trade is possibly part of the larger wildlife trade for sorcery products that similarly targets monitor lizards, pangolins, leopards, musk deer, owls and several marine species. At present, critical knowledge gaps impede effective detection and prevention of jackal poaching crimes. Future investigations will need to focus on periodic monitoring of the species to further our understanding of trends in wildlife trade and trafficking of jackals in India and beyond.

Supplementary Material (Appendix 1–4)

Information on poaching and trade news reports and seizure reports. Requests for archived news articles, images and videos may be directed to the corresponding author.

REFERENCES

Ahmed, A. (2010). Imperilled custodians of the night: a study of the illegal trade, trapping and utilization of owls in India. Traffic India/WWF India, 76pp. https://www.traffic.org/site/assets/files/3160/imperilled-custodians-of-the-night-1.pdf

Aiyadurai, A. (2011). Wildlife hunting and conservation in northeast India: a need for an interdisciplinary understanding. *International Journal of Galliformes Conservation* 2: 61–73.

Alves, R.R., I.L. Rosa, N.A. Léo Neto & R. Voeks (2012). Animals for the gods: magical and religious faunal use and trade in Brazil. *Human Ecology* 40(5): 751–780. https://doi.org/10.1007/s10745-012-9516-1

Bhattacharya, S. & A. Koch (2018). Hatha jodi: an illegal trade of misused scientific facts. *Biawak* 12(2): 97–99. Retrieved from http://varanidae.org/biawak

Borah, M.P. & S.B. Prasad (2016). Ethnozoological remedial uses by the indigenous inhabitants in adjoining areas of the Pobitora Wildlife Sanctuary, Assam, India. *International Journal of Pharmacy and Pharmaceutical Sciences* 8(4): 90–96.

Branch, T.A., A.S. Lobo & S.W. Purcell (2013). Opportunistic exploitation: an overlooked pathway to extinction. *Trends in Ecology and Evolution* 28(7): 409–413. https://doi.org/10.1016/j.tree.2013.03.003

Damania, R., E.J. Milner-Gulland & D.J. Crookes (2005). A bioeconomic analysis of bushmeat hunting. *Proceedings of the Royal Society B: Biological Sciences* 272(1560): 259–266. https://doi.org/10.1098/rspb.2004.2945

D'Cruze, N., S. Bhagat, T. Morrison, J. Schmidt-Burbach, D.W. Macdonald & A. Mookerjee (2015). A star attraction: the illegal trade in Indian Star Tortoises. *Nature Conservation* 13: 1–19. https://doi.org/10.3897/natureconservation.13.5625

Djagoun, C.A., E.A. Sogbohossou, B. Kassa, H.A. Akpona, I.O. Amahowe, J. Djagoun & B. Sinsin (2018). Trade in primate species for medicinal purposes: implications for conservation. *TRAFFIC Bulletin* 30(2). 48–56.

Hansen, A.L.S., A. Li, D. Joly, S. Mekaru & J.S. Brownstein (2012). Digital surveillance: a novel approach to monitoring the illegal wildlife trade. *PLoS ONE* 7(12). https://doi.org/10.1371/journal.pone.0051156

Hilaluddin, K.R. & D. Ghose (2005). Conservation implications of wild animal biomass extractions in Northeast India. *Animal Biodiversity and Conservation* 28: 169–179.

IUCN (International Union for the Conservation of Nature) (2019). IUCN's views on the structure of the Post 2020 Global Biodiversity Framework. https://www.iucn.org/sites/dev/files/iucn_position_paper_oewg-1_-_22_august_2019.pdf. Accessed on September 2, 2019.

Jensen, A. (2009). Shifting Focus: Redefining the goals of sea turtle consumption and protection in Bali. *Independent Study Project (ISP) Collection* 753. Retrieved from https://digitalcollections.sit.edu/isp_collection/753/

Lavorgna, A. (2014). Wildlife trafficking in the Internet age. *Crime science* 3: 5. https://doi.org/10.1186/s40163-014-0005-2

Mendiratta, U., V. Sheel & S. Singh (2017). Enforcement seizures reveal large-scale illegal trade in India's tortoises and freshwater turtles. *Biological Conservation* 207: 100–105. https://doi.org/10.1016/j.biocon.2017.01.023

Niraj, S.K., P. R. Krausman & V. Dayal (2012). A stakeholder perspective into wildlife policy in India. *Journal of Wildlife Management* 76(1): 10–18.

Rajpoot, A., V.P. Kumar, A. Bahuguna, T. Singh, S. Joshi & D. Kumar (2018). Wildlife forensics in battle against veneration frauds in Uttarakhand, India: identification of protected Indian monitor lizard in items available in the local market under the name of Hatha Jodi. *Mitochondrial DNA Part B* 3(2): 925–932. https://doi.org/10.1080/23802359.2018.1501284

Ryan, J. & D. Attuquayefio (2000). Mammal fauna of the Muni-Pomadze Ramsar site, Ghana. *Biodiversity and Conservation* 9: 541–560. https://doi.org/10.1023/A:1008964000018

Sahajpal, V., S.P. Goyal, R. Raza & R. Jayapal (2009). Identification of mongoose (genus: Herpestes) species from hair through band pattern studies using discriminate functional analysis (DFA) and microscopic examination. *Science & Justice* 49(3): 205–209. https://doi.org/10.1016/j.scijus.2008.09.002

Scheffers, B.R., B.F. Oliveira, I. Lamb & D.P. Edwards (2019). Global wildlife trade across the tree of life. *Science* 366: 71–76. https://doi.org/10.1126/science.aav5327

Sigouin, A., M. Pinedo-Vasquez, N. Robert, C. Poole, B. Horne & T.M. Lee (2017). Priorities for the trade of less charismatic freshwater turtle and tortoise species. *Journal of Applied Ecology* 345–350. https://doi.org/10.1111/1365-2664.12797

Van den Bergh, M.O., K. Kusters & A.J. Dietz (2013). Destructive attraction: factors that influence hunting pressure on the Blue Bird-of-paradise *Paradisaea rudolphi*. *Bird Conservation International* 23(2): 221–231. https://doi.org/10.1017/s0959270913000233

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Author contributions: MMC and AS conceived the idea, MMC and AB compiled the data, all authors critically evaluated and validated the data and finally MMC, AS, and SS processed the data for publication. All authors contributed towards writing the manuscript.

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Supplementary Table 1: Golden Jackal Trade and Trafficking: 'Jackal horn'/ 'Siyar singhi'.

	Month/ Year	Location	State	Remarks	Source	Web Source Link
1	Oct-18	Durg	Chhattisgarh	325 'jackal horns' and other items seized, one arrest made	Facebook	https://www.facebook.com/WCCBHQ/photos/pcb.2181416092106197/2181411855439954/?type=3&theater
2	Nov-15	Not available	Andhra Pradesh	Facebook seller of 'jackal horn' and other wildlife products	Facebook	https://www.facebook.com/photo.php?fbid=1586701538219113&set=pcb.1586701611552439&type=3&theater
3	Jun-16	Not available	Punjab & Chhattisgarh	Endorsing use of 'jackal horn' in black magic	Facebook	https://www.facebook.com/1534636733511969/photos/a.1535697460072563/1543731165935859/?type=3&theater
4	Oct-16	Bangalore	Karnataka	Endorsing use of 'jackal horn' in black magic	Facebook	https://www.facebook.com/onlineloveproblemssolutions/photos/basw.AbpqMf_skvD4bbEuB1ybEb6jbUBIVvc0ZL6nBhxZO5iOShJgpSHlHlUIKGqF7ia7ZfoSJhmQ1BrL6cTgAO10SHrgGy-0kDCiiQAU-BdQpWkwjphxDiOIPSv1heClyZ_tOHK1_TmAzeRbjZLckjThRF-ix8LQYVRsOtwfL268Dl3 Dzw.1416645638621343.1020219052761 9169.1545053349136974.1133217456799838.568560056656679 .720365731399512.1545054829136826.568556543323697.5575 68107755874/1133217456799838/?type=1&opaqueCursor=Abqo Wt17_VpHrqCX1MaIIy4wYHH0hidEKPgq9x_kfgwVFJQLBzjgHDcznf3B vY7ookat4F62DzpuHiRrGJ1xZqyyr8VY_-isn9A7OiZbeY9xw6UH1XFy4 bZA4gJ0Nmbdyl7gFsF5n6d6taW32sOPpxSmBfoArNpEtA6bsKWIrRD jNCLSRerlD_wIlg8lo2KeRaI_TXvCXcQyJqH1FpcDudQ2MGxZpEbZ3R_ txk3GvBkRhhskQHW76aABOzm-YkaVbcRwie2KKeeXTl5khXTWn1VXHS37 6p66LZntvn_f8pasBULuCYESZThYL8iIBoJ2uck4PXHf7Wae950QbmPWIIuj uL2bx9MBExC0BJoePa7MIjSR_8Ul3EmKZXCW7z-WDnceok8SvKlLM_RgIY-YrX_ILduSuRnluIoY_R0zlchPal2_Ake07yzK11PaKT8CRcDd6g_IY-My_IH dFcNP9jmeX9Xrt0XyMgEDdYLzs3qCeznHaOCrd4M2qPB6Gza16eGjmJl XrBdmfk-Wh627gVzJTcSqulafidqqCV7s60fbtSZ0zi7PJUTLFc74jJJBn9An Bc-9LE6ok-KVhcUZuw1qQQoBr87TwjLHZTyeKtmYSMZIvgcjovDidP8AIHAf qAOpsE_2ZMz_LtFXzKSULnYlG-PEBFn3F_9Si5ET6-HcLzT8nxp1mv60QZJJY-Gp1oY&theater
5	Jul-18	Delhi	NCT of Delhi	Amazon seller	Amazon	https://www.amazon.com/craftslook-siyar-singhi-gidar-Singhi/dp/B00VL9NFCY
6	Jun-16	Jodhpur	Rajasthan	Trade India seller	Trade India	https://www.tradeindia.com/fp3394158/Siyar-Singhi.html
7	Dec-18	Kolkata	West Bengal	Online shop: Rs 4000	Fortune Teller India	https://fortunetellerindia.com/product/siyar-singhi/
8	May-18	Navi Mumbai	Maharashtra	Online shop: Rs 4100	WhiteAuraVastu Store	https://www.whiteauravastustore.com/product/siyar-singhi/
9	Mar-18	Delhi	NCT of Delhi	Product discontinued, sold for Rs 5700	Shop Clues	https://www.shopclues.com/sidha-and-original-siyar-singhi-singi-gidar-singhi.html
10	Jan-18	Mumbai	Maharashtra	Rs 1484 for 'jackal horn' and hatha jodi	Abel Store	http://abelestore.com/home-decor-furnishings/original-hatha-jodi-siyar-singhi-combo/p-7002726-70837448739-cat.html (Page no longer exists)
11	Jan-18	Delhi	NCT of Delhi	An account of an astrologer from Delhi	Blogpost	http://craftsman-saqib.blogspot.com/2012/01/gider-singhi-siyar-singhi-or-jackals.html
12	Aug-15	Delhi	NCT of Delhi	Endorsing use of 'jackal horn' in black magic	Wordpress	https://kamakhyavashikaranservices.wordpress.com/tag/siyar-singhi-price-in-delhi/ (Page no longer exists)
14	Feb-18	Meerut	Uttar Pradesh	16 'jackal horns' and other wildlife products seized from a tantric shop	Times of India	https://timesofindia.indiatimes.com/city/meerut/in-major-haul-body-parts-of-endangered-species-recovered-in-meerut/articleshow/63100788.cms
15	2018	Morabadi	Jharkhand	Online shop: Rs 4150	Tantra Astro	http://www.tantraastro.com/product/100-original-sidha-siyar-singi-jackal-horn/?fbclid=IwAR1H8XgsNT8DIf2DrR3JnVfuMYqOUa8GnlYX0zE9A7AmZWJuJbjOoQiaAB4 (Page no longer exists)
16	Jun-17	Noida	Uttar Pradesh	27 'jackal horns' and other wildlife products seized	Times of India-Noida	https://timesofindia.indiatimes.com/city/noida/lizard-genitalia-sold-as-rare-root-arrest-in-noida-after-interpol-alert/articleshow/59279141.cms
17	Jan-19	Dhanmandi, Udaipur	Rajasthan	4 shops raided; 'jackal horns' and other wildlife products seized	Udaipur Times	https://udaipurtimes.com/pooja-product-sellers-arrested-selling-wild-life-products/
18	Sep-18	Not available	Jammu and Kashmir	Explanation of 'jackal horn' by astrologers	YouTube	https://www.youtube.com/watch?v=6LgQlvotguw
19	Aug-17	Indore	Madhya Pradesh	Jackal horn' and hatha jodi seized from a company- Shubh Bhakti	The Indian Express	https://indianexpress.com/article/india/four-e-commerce-firms-including-snapdeal-get-notice-for-selling-animal-parts-4792899/
21	Sep-18	Bhilwara	Rajasthan	Jackal horn' and other wildlife products seized, two arrested	Wildlife Crime Control Bureau, Government of India	http://wccb.gov.in/Content/NewsDetail.aspx?news_id=1229 (Page no longer exists)
22	Jun-17	Allahabad	Uttar Pradesh	Jackal horn' sold by tantriks during Mahakumbh, 2013	Shodhganga	http://shodhganga.inflibnet.ac.in/bitstream/10603/38763/12/12_chapter%205.pdf
23	Sep-18	Jaipur	Rajasthan	Endorsing use of 'jackal horn' in black magic	YouTube	https://www.youtube.com/watch?v=yHnWkexnt-U
24	Nov-17	Not available	Rajasthan	Customer's account	YouTube	https://www.youtube.com/watch?v=lZ5S4vcr9cM
25	Jul-15	Vellore	Tamil Nadu	3 jackal heads seized; jackal heads sold during 'Girivalam' festival	Times of India-Chennai	https://timesofindia.indiatimes.com/city/chennai/Headhunters-on-loose-jackals-on-run/articleshow/48106934.cms
26	Jan-15	Samayapuram	Tamil Nadu	12 jackal skulls seized	The Hindu	https://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/jackal-skulls-seized/article6773951.ece?fbclid=IwAR0ynPOTpqmyPR1_RhfS1jpsGiTUFQeIGHRMxsh5TdeDmBJO58qTYd_VQ28
27	Jun-17	Ahmedabad	Gujarat	24 'jackal horns' and other wildlife products seized	Wildlife Crime Control Bureau, Government of India	http://wccb.gov.in/Content/SpecialOperations.aspx

Supplementary Table 2. Illegal endorsement of 'Jackal horn'/ 'Siyar singhi' on YouTube.

	Month/ Year	Remarks	Source	Web source Link
1	Apr-19	Tantric practitioner describes uses of 'jackal horn' and how to activate it	YouTube	https://www.youtube.com/watch?v=1qIwo-tqRQM&t=2s
2	Sep-17	Tantric practitioner describes uses and storage of 'jackal horn'	YouTube	https://www.youtube.com/watch?v=l_1b3sCsYQE&t=62s
3	Jan-18	Tantric practitioner describes uses and storage of 'jackal horn'	YouTube	https://www.youtube.com/watch?v=tC4i7YAaFMQ
4	May-18	Tantric practitioner describes uses and storage of 'jackal horn'	YouTube	https://www.youtube.com/watch?v=aHxD4x4boyc&t=124s
5	Jan-18	Tantric practitioner describes how the original 'jackal horn' male and female pair look	YouTube	https://www.youtube.com/watch?v=XkU7pZ_EOyY&t=403s
6	Jun-17	Tantric practitioner claims that the jackal itself sheds the 'horn' from its head	YouTube	https://www.youtube.com/watch?v=GtD8R9Deyi0&t=89s
7	Jul-18	Tantric practitioner describes and uses and storage of 'jackal horn'	YouTube	https://www.youtube.com/watch?v=vqvu2rBxN-s
8	Feb-19	Tantric practitioner demonstrates the storage of 'jackal horns' using a "fresh" pair	YouTube	https://www.youtube.com/watch?v=FBjpGViCPuo&t=435s
9	Feb-19	Tantric practitioner shows the skeletal structure of an animal and claims it is derived from jackal	YouTube	https://www.youtube.com/watch?v=GmaiCGO0Ovs&t=215s
10	Dec-18	Seller describes uses of 'jackal horn' and alerts viewers of fake ones	YouTube	https://www.youtube.com/watch?v=mE9X2gFB6QM&t=197s
11	Jan-19	Seller claims to give a live demonstration of the removal of the 'horn' from a jackal via video call	YouTube	https://www.youtube.com/watch?v=j_39-fP-5GA&t=335s
12	Mar-16	Seller claims to provide details of a 'DNA test' to prove the authenticity of the 'jackal horn'	YouTube	https://www.youtube.com/watch?v=JSwripSFwxM
13	Sep-18	Use of 'jackal horn' in combination with hatha jodi in tantric practice	YouTube	https://www.youtube.com/watch?v=WcEyatHGf2k&t=7s
14	Jan-18	Use of 'jackal horn' in combination with hatha jodi in tantric practice	YouTube	https://www.youtube.com/watch?v=2_954O77ox4&t=1s

Supplementary Table 3. Details of trade and trafficking of golden jackal body parts in India.

	Month/ Year	Location	State	Remarks	Source	Web Source Link
1	Dec-14	Tiruttani	Tamil Nadu	8 jackal tails seized; each tail was priced at Rs. 300	The Hindu- Chennai	https://www.thehindu.com/news/cities/chennai/jackal-tails-seized-in-tiruttani/article6665863.ece
2	Oct-16	Periyar TR	Kerala/ Tamil Nadu	14 jackal skins seized	Wildlife Trust of India	https://www.wti.org.in/news/wti-study-provides-intelligence-for-covert-operation-leads-to-seizure-of-14-jackal-skins-in-periyar/
3	Jan-18	Ropar	Punjab	112 jackal skins and poaching traps seized	Times of India-Chandigarh	https://timesofindia.indiatimes.com/city/chandigarh/5-snakes-necklaces-of-birds-claws-recovered-in-ropar-raids/articleshow/62465494.cms?fbclid=IwAR0GKQFsU9mlpc6SiRLDuZdt2sRAl9QDM8eyHEHBkAASPYNVuhOZuCl-IrA
4	Feb-19	Rohtak	Haryana	1 jackal killed with a trap and spear	Wildlife Crime Control Bureau, Government of India	http://wccb.gov.in/Content/SeizuresofWCCB.aspx
5	Dec-17	Trichy	Tamil Nadu	Traps set for jackals to sell off nails and teeth	Times of India- Trichy	https://timesofindia.indiatimes.com/city/trichy/2-dogs-killed-for-trade-in-fox-teeth-nails/articleshow/62214778.cms
6	Jun-19	Hyderabad	Telangana	1 live jackal rescued from bird trade market	Times of India-Hyderabad	https://timesofindia.indiatimes.com/city/hyderabad/34-protected-birds-jackal-rescued-from-murgi-chowk/articleshow/69949714.cms
7	July-19	Kurukshetra	Haryana	1 jackal seized along with jungle cat and monitor lizards	Facebook	https://www.facebook.com/WCCBHQ/photos/a.193786712312763/2358458097735328/?type=3&theater

Supplementary Table 4. Evidences of jackal hunting as a source of bush-meat.

	Month/ Year	Location	State	Remarks	Source	Web Source Link
1	Nov-16	Mangrol	Gujarat	Caught and kept in captivity for meat	Facebook	https://www.facebook.com/krunal.trivedi.94/posts/1167339343331316
2	Jul-16	East Midnapore	West Bengal	Hunted by local communities during Jyeshtha Amavasya	Mongabay	https://news.mongabay.com/2016/07/5000-wild-animals-killed-in-west-bengal-india-on-world-environment-day/
3	Jan-17	Rajgarh	Madhya Pradesh	Hunted; leg-hold traps, head, meat and hair seized	Times of India-Bhopal	https://timesofindia.indiatimes.com/city/bhopal/jackals-poached-for-meat-in-madhya-pradesh/articleshow/56674933.cms

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REVIEW

Hazards of wind turbines on avifauna - a preliminary appraisal within the Indian context

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Abstract: Wind farms are substantial sources of renewable energy in India; however, their spread across the country potentially present new hazards to local and migratory birds. This study explored the risk of electrocution and collision of birds with wind turbines close to eco-sensitive zones in India, including Bakkhali, a UNESCO World Heritage site. Geographic information system and remote sensing technology were used. The results indicate vulnerability of local bird species such as barn owl, Indian Scops Owl, Blue Rock Pigeon, Asian Koel, House Crow, Common Sandpiper, Common Snipe, Ruddy Shelduck, Lesser Whistling Duck, Cattle Egret, Great Egret, and Pond Herons, as well as migratory species such as Bar-headed Goose, Red-crested Pochard, and American Black Duck. Modification of wind turbine design and location were considered determinant factors to reduce risk of bird collisions.

Keywords: Biodiversity, birds, geographic information system, remote sensing, transect chart.

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Author contribution: TS collected the data and has full access to all data used in this study. HD and SS are responsible for data analyses. All authors equally contributed in manuscript writing. AK and SS provided critical inputs on results interpretation, modification, and approved it for submission.

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INTRODUCTION

Wind energy is touted as an eco-friendly and sustainable alternative to fossil fuel (Nazir et al. 2019). As fossil fuel sources are more and more limited, increase in wind energy production has been growing over the last decade (Morinha et al. 2014). The global wind energy council (GWEC) has predicted a 17-fold increase in generation of wind energy by 2030 (Lu et al. 2009). Such expansion in wind energy production poses serious threats to flying vertebrates (Peron et al. 2013; Singh et al. 2015). Birds and bats often collide with rotor blades of wind turbines (WTs) and associated structures such as meteorological towers and power lines (Barclay et al. 2007; Zimmerling et al. 2013; Korner-Nievergelt et al. 2013; Ferreira et al. 2015; Beston et al. 2016; Anoop et al. 2018). Mortality of birds and bats due to such collisions has been frequently reported from the USA, Canada (Johnson 2005; Arnett et al 2008; Loss et al. 2013, Smales et al. 2013; Erickson et al. 2014; Marques et al. 2014), Europe (Bach & Rahmel 2004; Dürr & Bach 2004; Welling et al. 2018), Australia (Hull et al. 2013), New Zealand (Powlesland 2009), India (Pande et al. 2013; Kumar et al. 2019), and many other countries. WTs were initially installed in coastal areas (Larsen & Guillemette 2007; Larsen & Guillemette 2007), then subsequently extended to inland agricultural areas (Rydell et al. 2010) and ecologically sensitive areas such as hills and mountains (Aschwanden et al. 2018).

Several factors have been identified as contributing to collision of birds and bats with WTs. These include morphology of birds, sensorial perception, phonology, behavior, habit richness or abundance, landscape, flight path, food availability, weather, turbine type, lightening, among others (Marques et al. 2014). Hull et al. (2013) identified key morphological, behavioural, and ecological features that make birds prone to collision. These include the ability of birds to detect and avoid moving turbine blades, mode of flight and foraging strategies. Pescador et al. (2019) observed that abundance of potential prey makes predator birds prone to collision with WTs. In an offshore wind park in Denmark, Larsen & Guillemette (2007) observed visibility conditions as a major factor for collision of birds with WTs. Plonczkier & Simms (2012) also pointed out visibility conditions as the major factor for collision and associated mortality of birds at offshore wind farms in England. As a result, nocturnal migrants face a high risk of collision with WTs (Aschwanden et al. 2018). De Lucas et al. (2012) indicated a link between wind conditions, topography, and flight behaviour as factors associated with mortality of griffon vultures within and between wind farms. In Hokkaido, Japan, Kitano et al. (2013) observed highest fatality of birds at the turbines on a costal cliff where the rotor zones of wind turbines overlapped the frequent flight paths of large birds. Pande et al. (2013) used collision index (CI) to measure avian seasonal collision rate due to WT and noted that maximum collision risk with raptors occurred predominantly during monsoon periods. In Germany, Lehnert et al. (2014) observed that both local and migratory bats were vulnerable to WTs, and fatalities varied with age and sex. Studying *Alauda arvensis* in northern Portugal, Morinha et al. (2014) found a sex biased mortality. Mortality of birds and bats was also found to vary with turbine hub height (Everaert et al. 2006; Rothery et al. 2009). Also, the modern wind turbine towers are much taller than in the past, putting more risks to birds and bats (Welling et al. 2018).

In recent articles, wetland birds have been reported as most susceptible to collision with WT in Turkey and Netherlands (Graff et al. 2016; Arikan & Turan 2017). Similar susceptibility of collision of wetland birds with WT near freshwater bodies have been found in Taiwan (Lin 2017). The Black Shag *Phalacrocorax carbo* and Cattle Egret *Bubulcus ibis* are the only species of water birds of New Zealand that often face fatal injury after collision with WT (Powlesland 2009). There is possibility that other species of water birds may also be affected. The IUCN Red List reveals a steady and continuing deterioration; according to the World's birds report 2018, one in eight bird species are threatened with extinction (www.birdlife.org). Therefore, it is necessary to prevent fatalities of birds from WTs.

Risk of collision of birds from WTs have not been explored in India aside from sporadic attempts in Gujarat (Kumar et al. 2019) and the Western Ghats (Pande et al. 2013). India is the fourth largest producer of wind energy, with an installed capacity of 32.85GW at the end of 2017. Tamil Nadu, Maharashtra, Gujarat, Rajasthan, Karnataka, and Andhra Pradesh are the leading states in the generation of wind energy in India (Chaurasiya et al. 2019). India has four biodiversity hotspots, namely: (1) the Western Ghats, (2) the eastern Himalaya, (3) the Indo-Burma region, and (4) the Sunda Islands. India is also the home to 12.6% of all avian species found in the world. Huge amount of anthropogenic activities including collision of avifauna with WT, however, have put many birds in India at a high risk of extinction (Chitale et al. 2014). This has forced the necessity to explore risk of collision of avifauna from WT in India. The main objective of this study was to investigate the collision risk of avian species, and loss of habitat due to

allocation of WT in India.

METHODS

Study Area

This study considered three geographically distinct locations, namely: (i) Gujarat and its adjoining areas (68.245–75.061^{0}E and 23.770–17.093^{0}N) in the western part of India; (ii) Tamil Nadu and its adjoining areas (76.018–81.967^{0}E and 9.358–17.461^{0}N) in the southern part of India, and (iii) Bakkhali, South 24-Parganas, West Bengal (88.231–88.288^{0}E and 21.511–21.563^{0}N) located in the eastern part of India (location 3). For the first two locations we used secondary data however, we used GIS technique to identify nearby ecologically sensitive areas in these two locations and attempted to explain the collision of birds in these areas. In the third location (Bakkhali), which is situated 125km south of Kolkata in Sunderban Biosphere Reserve (Figure 1), extensive fieldwork was conducted to collect primary data on death and injuries of birds due to collision with WT of Frezerganj Wind Farm, near Bakkhali during the period February 2017 to January 2018. We interacted with local people living around WTs through printed questionnaires, and collected carcasses of 15 bird species from this location. These species included Barn Owl, Indian Scops Owl, Blue Rock Pigeon, Asian Koel, House Crow, Common Sandpiper, Common Snipe, Ruddy Shelduck, Lesser Whistling Duck, Cattle Egret, Great Egret, Indian Pond Heron, Bar-headed Goose, Red-crested Pochard, American Black Duck from this location. WTs present in Bakkhali have been presented in Figure 2.

Remote Sensing and Geographical Information System Techniques

Remote sensing (RS) and geographic information system (GIS) technology were used to identify whether actual positions of WTs caused any obstacle to bird's movement. With the help of RS and GIS technique, it is easy to prepare the map without coming into physical contact with the object under study (Effat 2014). Satellite image of the Indian subcontinent was downloaded from Google Earth Pro followed by georeferencing by GIS (TNTmips) Software. WT locations were identified and digitized on raster map (Wald and Ranchin 1995). GIS map was drawn to establish relationship between WT areas and the bird species of various ecologically sensitive areas such as national park, biosphere reserve, and biodiversity hotspot region. Seasonal wind direction was taken into consideration to assessing the bird migration direction because wind direction sometime influenced their path (Kemp et al. 2010). The map of these ecologically sensitive areas and location of WTs were downloaded and digitized on raster maps of the Indian subcontinent to generate a complete vector map

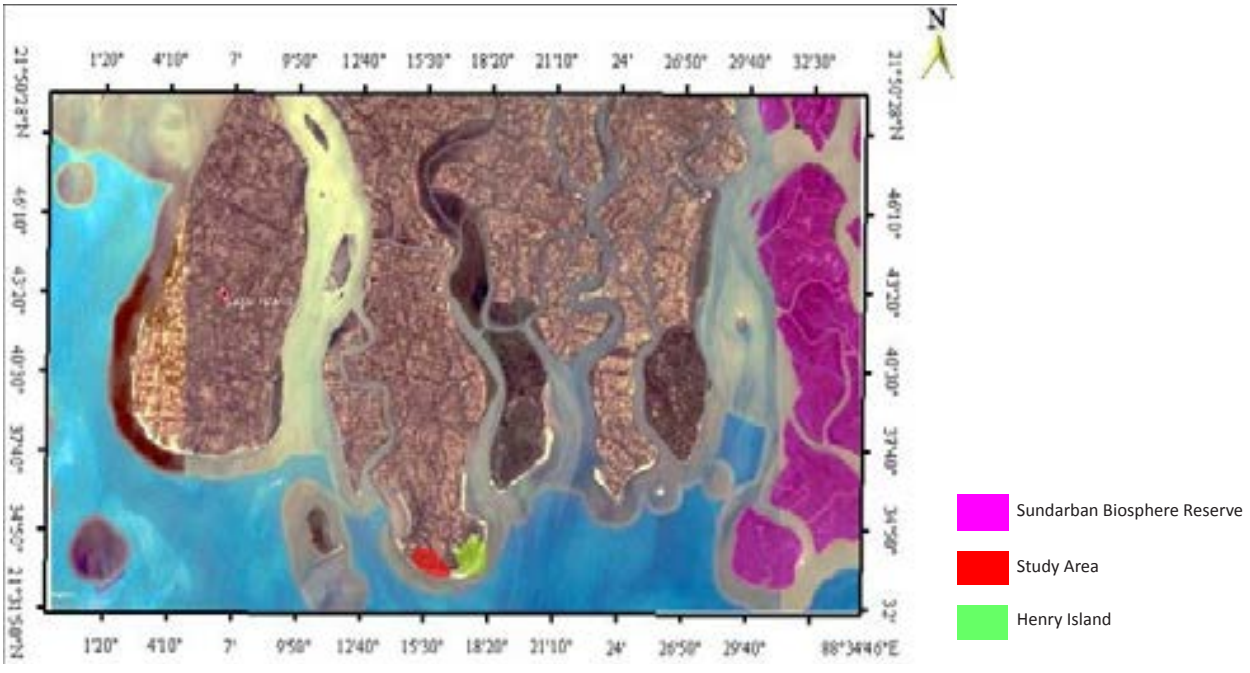


Figure 1. Geographic information system for field study area at Frezerganj Wind Farm, Bakkhali (South 24-Parganas; West Bengal; 87.916–94.051^{0}E and 21.552–25.533^{0}N)

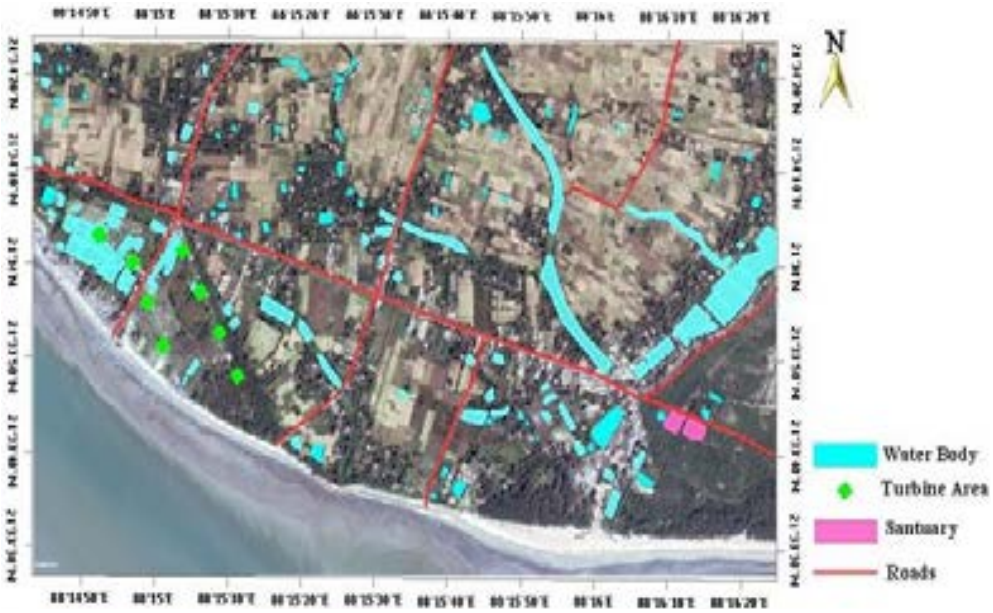


Figure 2. Exact location of wind farms in the study area at Location-3 near Bakhkali (www.google.com/earth/)

of intersection between bird habitat area and location of WTs. B-spline curve (Origin Lab), the natural way to represent a continuous curve from a set of discrete points, was used to represent collision data collected from the Bakkhali (Eilers & Marx 1996; Cao & Wang 2008).

Transect Chart

Transect charts were used to assess collision of bird with WT (Xie et al. 2015; Roeleke et al. 2016; Sivakumar & Ghosh 2017; Tucker et al. 2018). A transect represents a line following a route along which observations are considered. Transect chart is a geographic tool which demonstrates the changes and interdependency of human characteristics on physical object from one place to another (Jcngsma et al. 1989). In this study, we used the line transect method to illustrate a particular gradient or linear pattern along which birds' location and WTs are intersected based on the latitude and longitude of that location. This tool can potentially illustrate collision risk of birds with WTs location (Saha et al. 2019). At first, a GIS map was made for three study areas by incorporating WTs location in that area (TNTmips). Then, latitude, longitude, and altitude were measured of those areas. Altitude was identified from Google Earth Pro. Then horizontal transect lines were drawn between those latitudes and longitudes. From the GIS map location of WTs, national park, biosphere reserve, biodiversity hotspot, and habitat of 15 bird species were transferred to the edge of the screen from one end of transect line to the other. The x-axis represented horizontal distance covered by transects. In this way, we tried to demonstrate whether biosphere reserve, biodiversity hotspots or any national parks are in the area of influence of installed WTs.

RESULTS

Figure 3 represents GIS and RS mapping of seasonal wind movement, WTs locations and key biodiversity areas. It demonstrates that WTs are installed near national parks, biosphere reserves & biodiversity hotspots, and thus can potentially interrupt the natural movement of birds. This figure also identifies the direction of monsoon winds in summer and winter, which fall along the path of movements of some local and migratory birds. Distributions of 15 bird species found in location-3 have been presented in Figure 4. Figures 5a–c present data of collision of birds with WT generated from location 3. These figures reflect seasonal variation in collision. The dead and wounded birds included Barn Owl, Indian Scops Owl, Rock Pigeon, Asian Koel, House Crow, Common Sandpiper, Common Snipe, Great Egret, Ruddy Shelduck, Lesser Whistling Duck, Cattle Egret, Indian Pond Heron, and migratory bird species such as Bar-headed Goose, Red-crested Pochard, and American Black Duck (Table 1). The transect charts were used to visualize the location of WTs along a transect line to inspect whether their loci intersected birds' movement

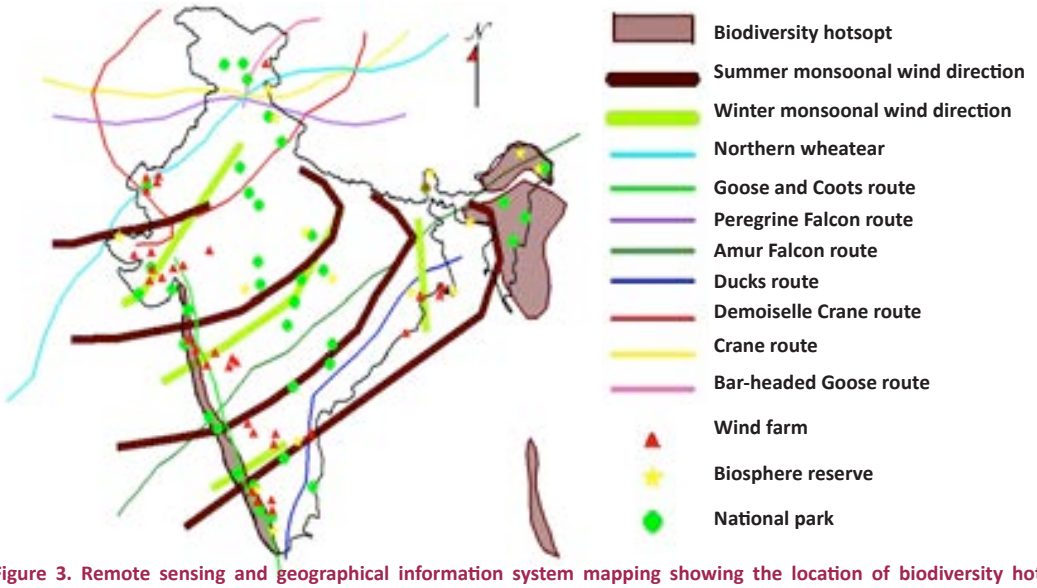


Figure 3. Remote sensing and geographical information system mapping showing the location of biodiversity hotspots, national parks, biosphere reserves, seasonal wind directions, wind farms, and migration rout of some bird species in India (www.microimages.com/products/tntmips. html).

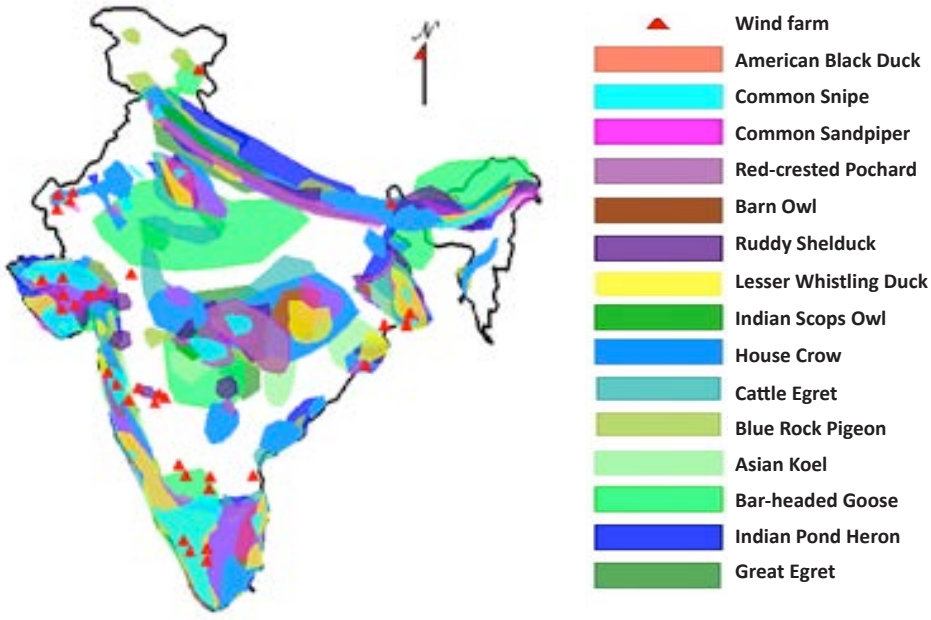


Figure 4. Remote sensing and geographical information system mapping showing the distribution mapping of fifteen bird species considered in this study (https://ebird.org/).

directly in Gujarat (Figure 6a), Tamil Nadu (Figure 6b), and Bakkhali (Figure 6c).

DISCUSSION

The IUCN Red List status of the birds sampled from location-3 (Bakkhali) is listed in Table 1. All these birds belong to IUCN category 'Least Concern'. Bakkhali is also home to Spoon-billed Sandpiper, a 'Critically Endangered' species. Further observations are required to assess if this bird species is vulnerable to WTs installed

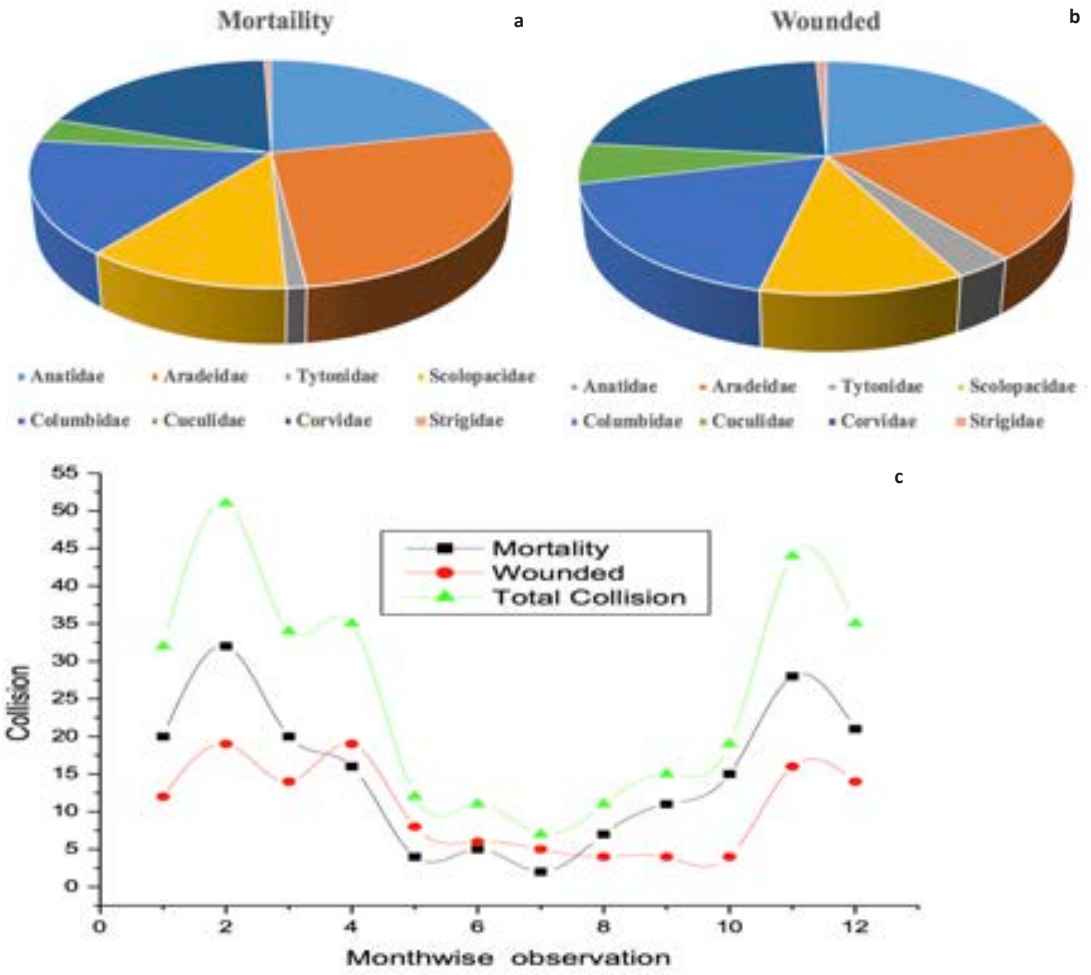


Figure 5. Records of collision of birds near Bakkhali (South 24-Parganas; West Bengal): a—family wise wounded | b—family wise mortality | c—monthwise observation between February 2017 and January 2018.

in this area.

The casualty of birds found in location-3 may be attributed to seasonal variation in concentration of migratory birds as well as seasonal variation in food habits of local birds. The probability of collision of birds with WT, however, cannot be concluded from the raster map alone. This study reveals maximum mortality of Cattle Egret, Indian Pond Heron, and Great Egret (Ardeidae) in location-3 followed by Common Sandpiper, Common Snipe (Scolopacidae), Bar-headed Goose, Red-crested Pochard, Lesser Whistling Duck, American Black Duck, Ruddy Shelduck (Anatidae), Rock Pigeon (Columbidae), and House Crow (Corvidae). Barn Owl, Asian Koel, and Indian Scops Owl were the least affected species of birds. Maximum number of species killed or wounded by WT belonged to the family Anatidae with five species, followed by the family Ardeidae with three species, Scolopacidae with two species, and Tytonodae, Columbidae, Cuculidae, Strigidae & Corvidae with one species each (Table 1, Figure 5a,b).

The birds belonging to the families Ardeidae and Anatidae are mostly water birds (such as Indian Pond Heron) and are abundant in this location. Wetlands of southern part of West Bengal are the preferred habitats for many birds, including the Bar-headed Goose and Red-crested Pochard that migrate annually from trans Himalayan region during December–January (Majumder et al. 2007). There are sporadic evidences from Turkey and Netherlands also that wetland birds are susceptible to collision with WTs (Krigsveld et al. 2009; Arikan et al. 2017), probably because of affinity of the migratory birds to wetlands. Habitat association (Thaxter et al. 2017) and abundance appeared to be key factors behind collision of the birds of the family Ardeidae and Anatidae in Bakkhali.

Kumar et al. (2019) observed several bird species around Kutch District (part of Location-1, Gujarat) between October 2011 and July 2014, and found

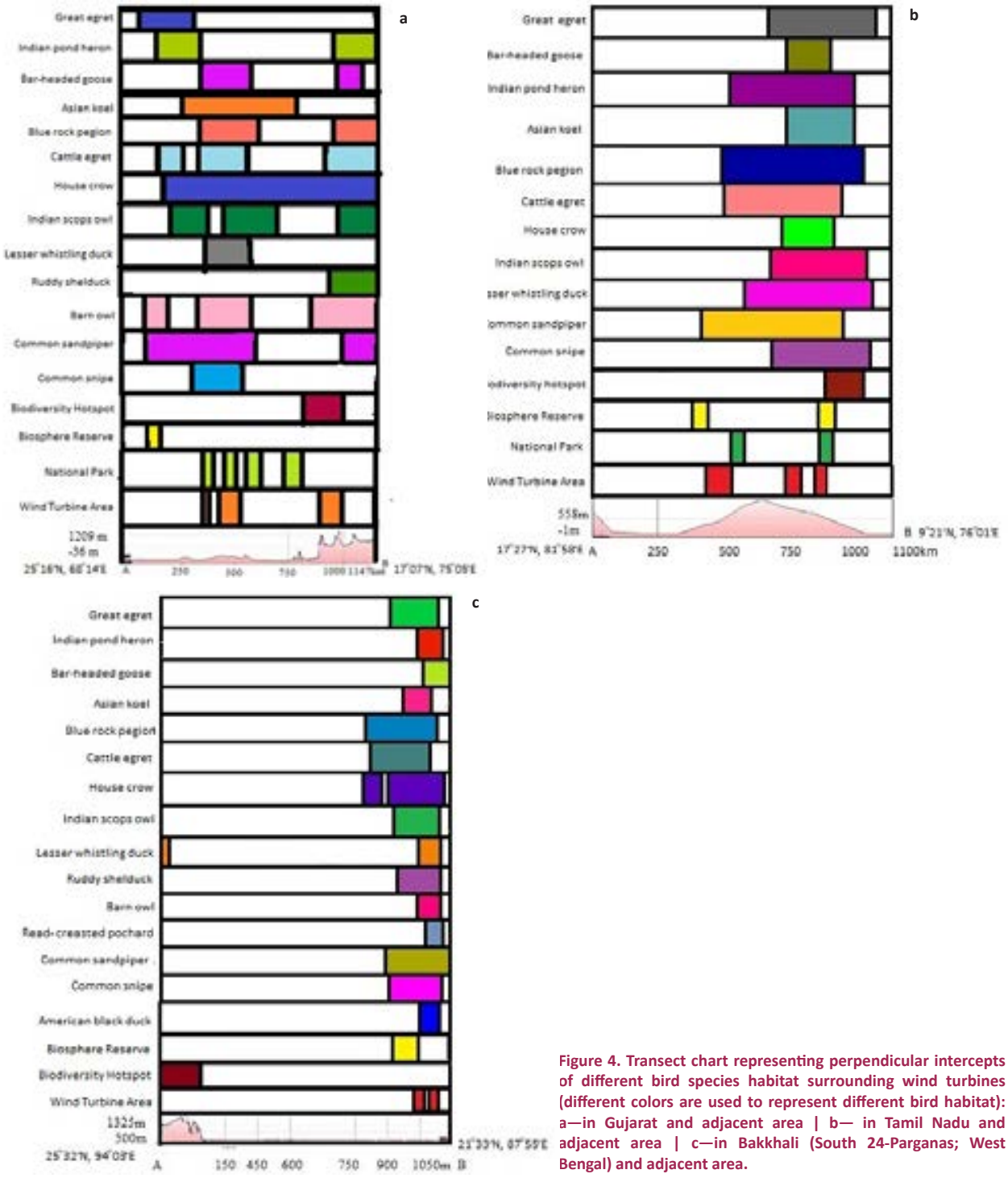


Figure 4. Transect chart representing perpendicular intercepts of different bird species habitat surrounding wind turbines (different colors are used to represent different bird habitat): a—in Gujarat and adjacent area | b— in Tamil Nadu and adjacent area | c—in Bakkhali (South 24-Parganas; West Bengal) and adjacent area.

carcasses of 47 birds belonging to 11 species. Since a few national parks are situated in this area (Figure 3), many more species are at risk from the WTs. Pande et al. (2013) observed 89 species of birds, from July 2008 to June 2010 in Bhambarwadi Wind Farm Plateau in northern Western Ghats, out of which 27 birds were under risk by rotor blades. During this period, the authors found 12 dead birds belonging to seven different species, *viz.,* Black Kite *Milvus migrans*, Bonelli's Eagle *Aquila fasciata*, Changeable Hawk Eagle *Nisaetus cirrhatus*, Red-rumped Swallow *Cecropis daurica*, Dusky Crag-martin *Ptyonoprogne concolor*, Slaty-legged Crake *Rallin aeurizonoides,* and Common Crow. These birds, however, are not depicted in Figures 6a–6c, which

Table 1. IUCN status of the bird species collision found in location -3 (www.iucnredlist.org)

Family	Name	Scientific name	IUCN status
Anatidae	Bar-headed Goose	*Anser indicus*	Least Concern
	Red-crested Pochard	*Netta rufina*	Least Concern
	Lesser Whistling Duck	*Dendrocygna javanica*	Least Concern
	American Black Duck	*Anas rubripes*	Least Concern
	Ruddy Shelduck	*Tadoma ferruginea*	Least Concern
Ardeidae	Cattle Egret	*Bubulcus ibis*	Least Concern
	Indian Pond Heron	*Ardeola grayii*	Least Concern
	Great Egret	*Ardae alba*	Least Concern
Tytonidae	Barn Owl	*Tyto alba*	Least Concern
Strigidae	Indian Scops Owl	*Otus bakkamoena*	Least Concern
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Least Concern
	Common Snipe	*Gallinago gallinago*	Least Concern
Columbidae	Rock Pigeon	*Columba livia*	Least Concern
Cuculidae	Asian Koel	*Eudynamys scolopaceus*	Least Concern
Corvidae	House Crow	*Corvus splendens*	Least Concern

consider only 15 birds whose carcasses are recorded from location-3. Western Ghats is a biodiversity hotspot region and is home to many birds, which are vulnerable to collision with WTs installed in this region. Another 'Critically Endangered' species of bird, the Great Indian Bustard (Dasgupta 2017) is found mostly in Rajasthan, a state with high wind energy installations.

In India, more than 95% of the wind power capacity is installed in the two southern states, Tamil Nadu & Karnataka and three western states, Gujarat, Rajasthan & Maharashtra (Chaurasiya et al. 2019). Since many wildlife protected areas are situated in these states, there is possibility of overlap of home range of the local and migratory birds and the WT installations.

4.1 Mitigation Measures

Bose et al. (2018) used ecological niche factor analysis (ENFA) to identify overlaps collision niche between species of birds, which are susceptible to injuries from WTs. Wind energy is a dominant renewable energy source in India, and there is possibility of expansion of the WT installation capacities in many other states including within ecologically sensitive areas. Therefore, it is necessary to develop environmentally sustainable planning at wind turbine installations to prevent collision of birds with WTs. Since birds that migrate during the day have a lower risk of colliding with WTs (Nichols et al. 2018), restriction of WTs during daytime may be an effective measure to reduce collision probabilities. Temporary shutdown during high risk period has also been recommended by a few authors (Marques et al. 2014; May 2015). Visual approaches to alert birds by painting wind turbine blades with conspicuous and contrast colors or using ultraviolet reflective paint on rotor blades for UV-sensitive species and using pulsating lights or other wavelengths may also reduce fatalities (Arnet & May 2016). Although use of bio-acoustic sound and electromagnetic signals have been found effective for some species of birds and bats (Marques et al. 2014; May et al. 2015), effectiveness of radar as a potential measure to deter birds and bats is questionable (Arnett et al. 2008).

CONCLUSIONS

We examined distribution of bird species across India and possibility of their collision with WTs. From digitization on raster maps, this study demonstrates that wind farms in India are located along the ecologically sensitive zones like national parks, biosphere reserves, biodiversity hotspots, and coastal areas. Transect charts ensure the possibility of collision of birds with WTs in these areas. Bakkhali is located in Sundarban Biosphere Reserve, an ecologically sensitive zone and a UNESCO World Heritage site. This study reveals that 12 local and three migratory species of birds in Bakkhali are vulnerable to collision with wind turbines. There is utmost urgency to modify design of wind turbines to save these birds from collision. Further studies are required to assess accurate causes of bird fatalities near wind farms in India, detailed assessment of the most affected local and migratory species of birds, their dependency with other species, and implementation of additional & complementary measures to protect birds from wind turbines. As a future extension, one needs to conduct risk analysis through robust statistical analysis.

REFERENCES

Arnett, E.B. & R. F. May (2016). Mitigating wind energy impacts on wildlife: approaches for multiple taxa. *Human Wildlife Interactions* 10(1):28–41. https://doi.org/10.26077/1jeg-7r13

Aschwanden, J., H. Stark, D. Peter, T. Steuri, B. Schmid & F. Liechti

(2018). Bird collisions at wind turbines in a mountainous area related to bird movement intensities measured by radar. *Biological Conservation* 220: 228–236. https://doi.org/10.1016/j.biocon.2018.01.005

Arikan, K. & S.L. Turan (2017). Estimation of bird fatalities caused by wind turbines in Turkey. *Fresenius Environmental Bulletin* 26(11): 6543–6550.

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J.Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski & R.D. Tankersley (2008). Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management* 72: 61–78. https://doi.org/10.2193/2007-221

Anoop, V., P.R. Arun & R. Jayapal (2018). Do Black-naped Hares *Lepus nigricollis* (Mammalia: Lagomorpha: Leporidae) have synanthropic association with wind farms? *Journal of Threatened Taxa* 10(7): 11925–11927. http://doi.org/10.11609/jott.3411.10.7.11925-11927

Bach, L. & U. Rahmel (2004). Summary of wind turbine impacts on bats—assessment of a conflict. *Bremer BeiträgefürNaturkunde und Naturschutz* 7: 245–252.

Barclay, R.M., E.F. Baerwald & J.C. Gruver (2007). Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology 85*(3): 381–387. https://doi.org/10.1139/Z07-011

Bose, A., T. Dürr, R.A. Klenke & K. Henle (2018). Collision sensitive niche profile of the worst affected bird-groups at wind turbine structures in the Federal State of Brandenburg, Germany. *Scientific Reports* 8(1): 3777. https://doi.org/10.1038/s41598-018-22178-z

Beston, J.A., J.E. Diffendorfer, S.R. Loss & D.H. Johnson (2016). Prioritizing avian species for their risk of population-level consequences from wind energy development. *PloS One* 11(3): e0150813. https://doi.org/10.1371/journal.pone.0150813

Cao, J. & G. Wang (2008). The structure of uniform B-spline curves with parameters, *Progress in Natural Science* 18(3): 303–308. https://doi.org/10.1016/j.pnsc.2007.09.005

Chitale, V.S., M.D. Behera,& P.S. Roy (2014). Future of endemic flora of biodiversity hotspots in India. *PloS One* 9(12): e115264. https://doi.org/10.1371/journal.pone.0115264

Chaurasiya, P.K., V. Warudkar & S Ahmed (2019). Wind energy development and policy in India: A review. *Energy Strategy Reviews* 24: 342–357. https://doi.org/10.1016/j.esr.2019.04.010

Dasgupta, S. (2017). Critically Endangered Great Indian Bustards burn up on power lines. Date of download 17-05-2018. https://india.mongabay.com/2017/12/27/video-critically-endangered-great-indian-bustards-burn-up-on-power-lines/

De Lucas, M., M. Ferrer & G.F. Janss (2012). Using wind tunnels to predict bird mortality in wind farms: the case of griffon vultures. *PloS One* 7(11): e48092. https://doi.org/10.1371/journal.pone.0048092

Dürr, T. & L. Bach (2004). Bat deaths and wind turbines: a review of current knowledge, and of the information available in the database for Germany. *Bremer Beiträge für Naturkunde und Naturschutz* 7: 253–264.

Eilers, P.H. & B.D. Marx (1996). Flexible smoothing with B-splines and penalties. *Statistical Science* 1: 89–102. https://doi.10.1214/ss/1038425655

Effat, H.A. (2014). Spatial modeling of optimum zones for wind farms using remote sensing and geographic information system, application in the Red Sea, Egypt. *Journal of Geographic Information System* 6: 358–374. https://doi.org/10.4236/jgis.2014.64032

Erickson, W.P., M.M. Wolfe, K.J. Bay, D.H. Johnson & J.L. Gehring (2014). A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. *PLoS One* 9(9): e107491. https://doi.org/10.1371/journal.pone.0107491

Everaert, J. & E.W. Stienen (2006). Impact of wind turbines on birds in Zeebrugge (Belgium). *Biodiversity and Conservation* 16: 3345–3359. https://doi.org/10.1007/s10531-006-9082-1

Ferreira, D., C. Freixo, J. Cabral, R. Santos & M. Santos (2015). Do habitat characteristics determine mortality risk for bats at wind farms? Modelling susceptible species activity patterns and anticipating possible mortality events. *Ecological Informatics* 28: 7–18. https://doi.org/10.1016/j.ecoinf.2015.04.001

Graff, B.J., J.A. Jenks, J.D. Stafford, K.C. Jensen & T.W. Grovenburg (2016). Assessing spring direct mortality to avifauna from wind energy facilities in the Dakotas. *Journal of Wildlife Management* 80(4): 736–745. https://doi.org/10.1002/jwmg.1051

Hull, C.L., E.M. Stark, S. Peruzzo & C.C. Sims (2013). Avian collisions at two wind farms in Tasmania, Australia: taxonomic and ecological characteristics of colliders versus non colliders. *New Zealand Journal of Zoology* 40(1): 47–62. https://doi.10.1080/03014223.2012.757243

Jcngsma, D., J.M. Woodside, W. Huson, S. Suparka & D. Kadarisman (1989). Geophysics and tentative late cenozoic seismic stratigraphy of the Banda arc-Australian continent collision zone along three transects. *Netherlands Journal of Sea Research* 24(2/3): 205–229. https://doi.org/10.1016/0077-7579(89)90150-6

Johnson, G.D. (2005). A review of bat mortality at wind-energy developments in the United States. *Bat Research News* 46: 45–49.

Kemp, M.U., J. Shamoun-Baranes, H. van Gasteren, W. Bouten & E.E. van Loon (2010). Can wind help explain seasonal differences in avian migration speed? *Journal of Avian Biology* 41: 672–677. https://doi.org/10.1111/j.1600-048X.2010.05053.x

Kitano, M. & S. Shiraki (2013). Estimation of bird fatalities at wind farms with complex topography and vegetation in Hokkaido, Japan. *Wildlife Society Bulletin 37*(1): 41–48. https://doi.org/10.1002/wsb.255

Korner-Nievergelt, F., R. Brinkmann, I. Niermann & O. Behr (2013). Estimating bat and bird mortality occurring at wind energy turbines from covariates and carcass searches using mixture models. *PloS One* 8(7): p.e67997. https://doi.10.1371/journal.pone.0067997

Krijgsveld, K.L., K. Akershoek, F. Schenk, F. Dijk & S. Dirksen (2009). Collision risk of birds with modern large wind turbines. *Ardea 97*(3): 357–366. https://doi.org/10.5253/078.097.0311

Kumar, S.R., V.K. Anoop, P.R. Arun, R. Jayapal & A.M. Ali (2019). Avian mortalities from two wind farms at Kutch, Gujarat and Davangere, Karnataka, India. *Currrent Science* 116(9): 1587–1592. https://doi.10.18520/cs/v116/i9/1587-1592

Larsen, J.K. & M. Guillemette (2017). Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk. *Journal of Applied Ecology* 44: 516–522. https://doi.org/10.1111/j.1365-2664.2007.01303.x

Lehnert, L.S., S. Kramer-Schadt, S. Schönborn, O. Lindecke, I. Niermann & C.C. Voigt (2014). Wind farm facilities in Germany kill noctule bats from near and far. *PloS One* 9(8): p.e103106. https://doi.10.1371/journal.pone.0103106

Lin, S.C. (2017). A survey and study of tower kills and wind turbine kills. *Applied Ecology and Environmental Research 15*(1): 589–607. https://doi.10.15666/aeer/1501_589607

Loss, S.R., T. Will & P.P. Marra (2013). Estimates of bird collision mortality at wind facilities in the contiguous United States. *Biological Conservation 168*: 201–209. https://doi.org/10.1016/j.biocon.2013.10.007

Lu, X., M.B. McElroy & J. Kiviluoma (2009). Global potential for wind-generated electricity. *Proceedings of the National Academy of Sciences 106*(27): 10933–10938. https://doi.org/10.1073/pnas.0904101106

Mazumdar, S., K. Mookherjee & G.K. Saha (2007). Migratory water birds of wetlands of southern West Bengal, India. *Indian Birds* 3(2): 42–45.

Marques, A.T., H. Batalha, S. Rodrigues, H. Costa, M.J.R. Pereira, C. Fonseca, M. Mascarenhas & J. Bernardino (2014). Understanding bird collisions at wind farms: An updated review on the causes and possible mitigation strategies. *Biological Conservation* 179: 40–52. https://doi.org/10.1016/j.biocon.2014.08.017

May, R.F. (2015). A unifying framework for the underlying mechanisms of avian avoidance of wind turbines. *Biological Conservation* 190: 179–187. https://doi.org/10.1016/j.biocon.2015.06.004

Morinha, F., P. Travassos, F. Seixas, A. Martins, R. Bastos, D. Carvalho,

P. Magalhães, M. Santos, E. Bastos & J.A. Cabral (2014). Differential mortality of birds killed at wind farms in Northern Portugal. *Bird Study* 61(2): 255–259. https://doi.org/10.1080/00063657.2014.883357

Nazir, M.S., A.J. Mahdi, M. Bilal, H.M. Sohai, N. Ali & Iqbal (2019). Environmental impact and pollution-related challenges of renewable wind energy paradigm – A review. *Science of the Total Environment* 683: 436–444. https://doi.org/10.1016/j.scitotenv.2019.05.274

Nichols, K.S., T. Homayoun, J. Eckles & R.B. Blair (2018). Bird-building collision risk: an assessment of the collision risk of birds with buildings by phylogeny and behavior using two citizen science datasets. *PLoS One* 13(8): e0201558. https://doi.10.1371/journal.pone.0201558

Pande, S., A. Padhye, P. Deshpande, A. Ponkshe, P. Pandit, A. Pawashe, S. Pednekar & R. Pandit (2013). Avian collision threat assessment at Bhambarwadi Wind Farm Plateau in northern Western Ghats, India. *Journal of Threatened Taxa* 5(1): 3504–3515. https://doi.10.11609/JoTT.o3096.210

Péron, G., J.E. Hines, J.D. Nichols, W.L. Kendall, K.A. Peters & D.S. Mizrahi (2013). Estimation of bird and bat mortality at wind-power farms with superpopulation models. *Journal of Applied Ecology* 50(4): 902–911. https://doi.org/10.1111/1365-2664.12100

Pescador, M., J.I.G. Ramírez & S.J. Peris (2019). Effectiveness of a mitigation measure for the Lesser Kestrel (*Falco naumanni*) in wind farms in Spain. *Journal of Environmental Management* 231: 919–925. https://doi.org/10.1016/j.jenvman.2018.10.094

Plonczkier, P. & I.C. Simms (2012). Radar monitoring of migrating Pink-footed Geese: behavioural responses to offshore wind farm development. *Journal of Applied Ecology* 49: 1187–1194. https://doi.org/10.1111/j.1365-2664.2012.02181.x

Powlesland, R. (2009). Impact of wind farms on birds: a review. *Science for Conservation* 289: 5–41. Retrieved on 03/05/2018 from www.doc.govt.nz/Documents/science-and-technical/sfc289entire.pdf

Roeleke, M., T. Blohm, S. Kramer-Schadt, Y. Yovel & C.C.Voigt (2016). Habitat use of bats in relation to wind turbines revealed by GPS tracking. *Scientific Reports* 6: 28961. https://doi.10.1038/srep28961

Rothery, P., I. Newton & B. Little (2009). Observations of seabirds at offshore wind turbines near Blyth in northeast England. *Bird Study* 56(1): 1–14. https://doi.org/10.1080/00063650802648093

Saha, S., G.C. Paul, & T.K. Hembram (2019). Classification of terrain based on geo-environmental parameters and their relationship with land use/land cover in Bansloi River basin, eastern India: RS-GIS approach. *Applied Geomatics* 12: 55–71: https://doi.org/10.1007/s12518-019-00277-4

Singh, K., E.D. Baker & M.A. Lackner (2015). Curtailing wind turbine operations to reduce avian mortality. *Renewable Energy* 78: 351–356. https://doi.org/10.1016/j.renene.2014.12.064

Rydell J., L. Bach, M. Dubourg-Savage, M. Green, L. Rodrigues & A. Hedenström (2010). Bat mortality at wind turbines in northwestern Europe. *Acta Chiropterologica* 12(2): 261–274. https://doi.10.3161/150811010X537846

Sivakumar, R. & S. Ghosh (2017). Determination of threshold energy for the development of seismic energy anomaly model through integrated geotectonic and geoinformatics approach. *Natural Hazards* 86(2): 711–740. https://doi.10.1007/s11069-016-2713-2

Smales, I., S. Muir, C. Meredith & R. Baird (2013). A description of the biosis model to assess risk of bird collisions with wind turbines. *Wildlife Society Bulletin 37*(1): 59–65 https://doi.org/10.1002/wsb.257

Thaxter C.B., G.M. Buchanan, J. Carr, S.H. Butchart, T. Newbold, R.E. Green, J.A. Tobias, W.B. Foden, S. O'Brien, J.W. Pearce-Higgins (2017). Bird and bat species' global vulnerability to collision mortality at wind farms revealed through a trait-based assessment. *Proceedings of the Royal Society B: Biological Sciences* 284(1862): 20170829. https://doi.org/10.1098/rspb.2017.0829

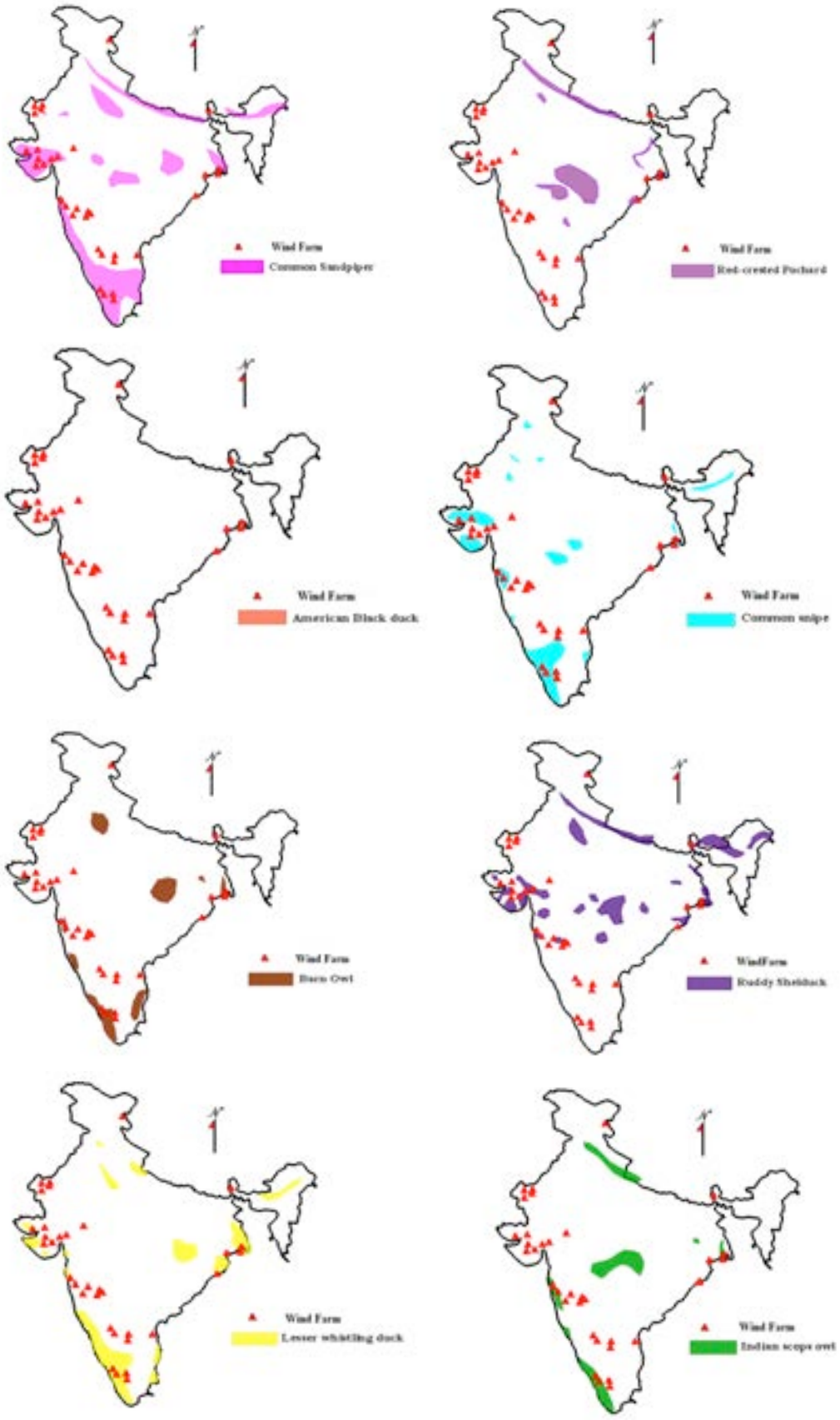
Tucker, M.A., K. Böhning-Gaese, W.F. Fagan, J. M. Fryxell, B. Van Moorter, S.C. Alberts, A.H. Ali, A.M. Allen, N. Attias, T. Avgar & H .Bartlam-Brooks (2018). Moving in the anthropocene: global reductions in terrestrial mammalian movements. *Science* 359(6374): 466–469. https://doi.10.1126/science.aam9712

Xie, H., G. Yao & G Liu (2015). Spatial evaluation of the ecological importance based on GIS for environmental management: a case study in Xingguo county of China. *Ecological Indicators* 51: 3–12. https://doi.org/10.1016/j.ecolind.2014.08.042

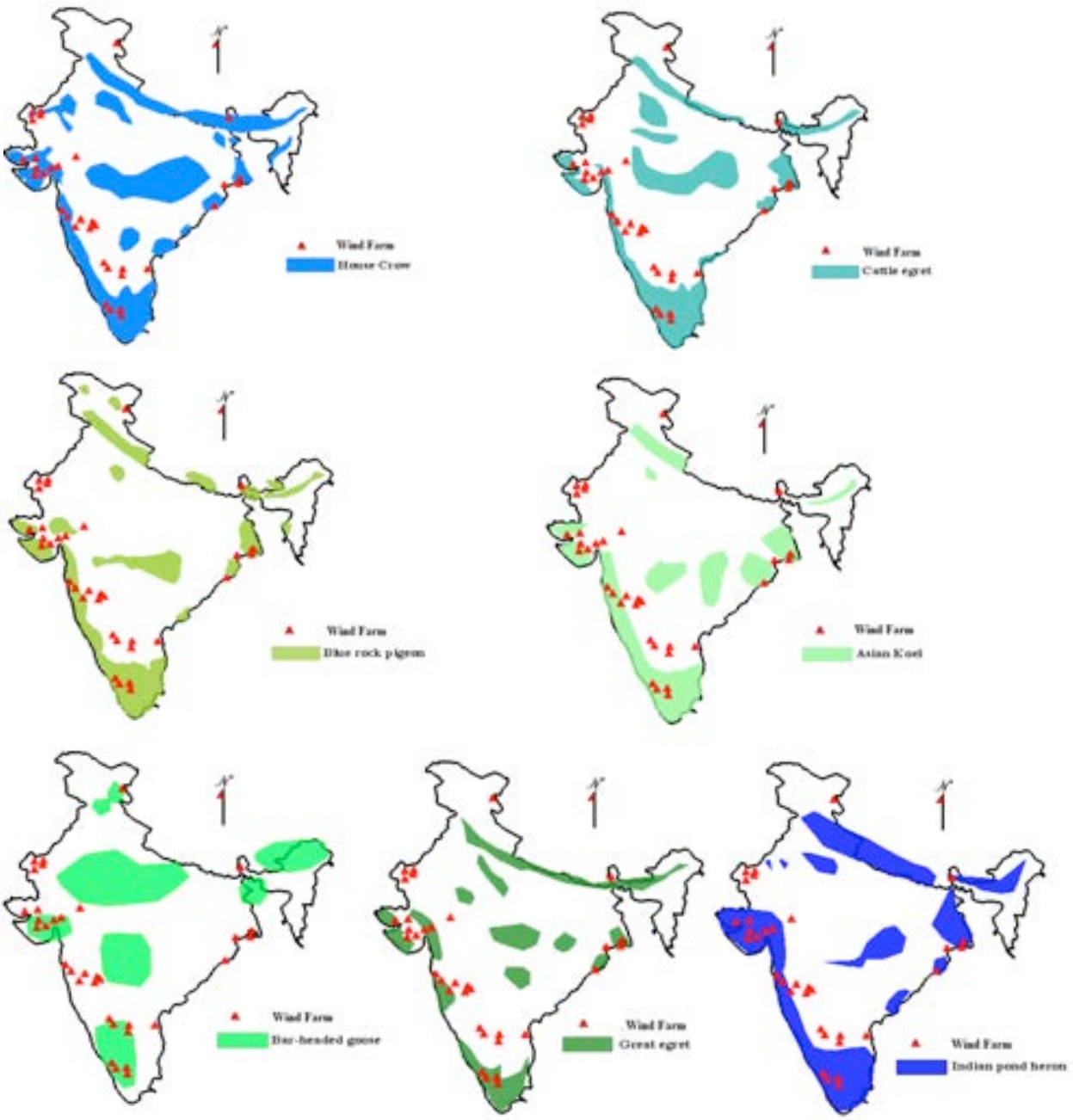
Wald, L. & T. Ranchin (1995). Fusion of images and raster-maps of different spatial resolutions by encrustation: an improved approach. *Computers, Environment and Urban Systems* 19(2): 77–87. https://doi.org/10.1016/0198-9715(95)00014-Y

Wellig, S.D., S. Nussle, D. Miltner, O. Kohle, O. Glaizot, V. Braunisch, M.K. Obrist & R. Arlettaz (2018). Mitigating the negative impacts of tall wind turbines on bats: *vertical activity profiles and relationships to wind speed*. *PLoS One* 13(3): e0192493. https://doi.org/10.1371/journal.pone.0192493

Zimmerling, J.R., A. Pomeroy, M. d'Entremont & C.M. Francis (2013). Canadian estimate of bird mortality due to collisions and direct habitat loss associated with wind turbine developments. *Avian Conservation and Ecology* 8(2): 10. https://doi.org/10.5751/ACE-00609-080210



Appendix 1. Home ranges for fifteen birds considered in this study (continued on next page...)



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COMMUNICATION

Analysis of stereotypic behaviour and enhanced management in captive Northern Giraffe *Giraffa camelopardalis* housed at Zoological Garden Alipore, Kolkata

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Abstract: In the wild, giraffes live complex social lives exhibiting fission-fusion social systems. They have sophisticated communication which likely forms a crucial component regulating subgroup dynamics. They spend a large part of their day browsing and traveling over large distances. In captivity, lack of continuous browsing opportunities and limited space can lead to various abnormal and stereotypic behaviours. These stereotypic behaviours can have cascading detrimental health consequences. A behavioural analysis of stereotypic behaviours in giraffes under human care was conducted to evaluate sources of variation within a population and provide management recommendations. The aim of this investigation was threefold: 1. to examine current behaviour of giraffes in Zoological Garden Alipore, Kolkata to advise on their enhanced management; 2. to highlight any behavioural abnormalities and recommend enrichment mechanisms; and 3. to compare the observed stereotypic behaviours with behaviour described in other zoological institutions and in the wild to provide a focal trajectory in the development of guidelines. Four individuals (two adult males, one adult female, and one male calf) were observed outdoors for seven days, three times a day for 30 minutes by instantaneous scan sampling method. During the observation period, the giraffe exhibited oral stereotypy more than any other behaviour recorded, though this was recorded disproportionally between individuals. The giraffe spent a larger amount of time exhibiting oral stereotypy compared to feeding/foraging activities. The study suggests incorporating diet and feeding strategies with provision of natural browse as well as offering enrichment methods to increase the foraging time using various time-engaged feeding devices to mitigate the observed abnormal stereotypic behaviour. Additionally, recommendations are made for expanding the size of the open enclosure to meet guidelines by the Central Zoo Authority, as a minimum.

Keywords: Animal welfare, behavioural abnormalities, enrichment, Giraffe, stereotypy.

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Author details: TUSHAR KULKARNI has undertaken collaborative work with Zoological Garden Alipore, Kolkata, India and with West Bengal Zoo Authority (WBZA), West Bengal, India, on giraffe behaviour studies, education and genetic studies of giraffe at Zoological Garden Alipore. He has also associated with Giraffe Conservation Foundation (GCF), Namibia, for a number of years and have collaborated on a range of giraffe conservation and management initiatives. He has presented the current work at International Giraffid Conference held at Brookfield zoo, Chicago, USA, in May 2016.

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INTRODUCTION

Giraffes *Giraffa* spp. are tallest of the land mammals, largest of the ruminants, and are mega herbivores. Over the past decade the first-ever comprehensive DNA sampling and analysis (genomic, nuclear, and mitochondrial) from all major natural populations of giraffe was undertaken throughout their range in Africa. As a result, an update to the traditional taxonomy now exists. This study revealed that there are four distinct species of giraffe and likely five subspecies (Fennessy et al. 2016; Winter et al. 2018). The four species are Masai Giraffe *G. tippelskirchi*, Northern Giraffe *G. camelopardalis*, Reticulated Giraffe *G. reticulata*, and Southern Giraffe *G. giraffa*. Nubian giraffe *G. c. camelopardalis*, Kordofan Giraffe *G. c. antiquorum* and West African Giraffe *G. c. peralta* are the three subspecies of the Northern Giraffe, while Angolan Giraffe *G. g. angolensis*, and South African Giraffe *G. g. giraffa* fall under the Southern Giraffe. Rothschild's Giraffe is genetically identical to the Nubian Giraffe, and thus subsumed into it (Winter et al. 2018). Based on this research, we refer to the updated giraffe taxonomy of four species.

The pursuit of forage constitutes a large portion of the daily activities of giraffe (Dagg & Foster 1976) with studies suggesting that wild giraffe spend approximately 51–59% of the day feeding/foraging (Fennessy 2004). Giraffes move constantly while feeding due to spatially heterogeneous distribution of forage and the protection mechanisms of browse plants (EAZA 2006). As such, daily foraging and rumination times make up a large proportion of their activities. Food and energy intake, therefore, remains distributed over the whole day for giraffe due to their specialized feeding ecology. Pellew (1984) observed wild Masai Giraffe in Serengeti National Park, Tanzania and 96% of feeding was on trees or shrubs, with *Acacia* species most frequently consumed during the wet season. Removal of *Acacia* leaves is difficult because most species have thorns (Dagg & Foster 1976; Pellew 1984) or stinging ants (Dagg & Foster 1976), and giraffes must use their tongues to remove the tree's leaves (Dagg & Foster 1976).

As giraffes have evolved to use their prehensile tongues to remove leaves from trees, oral stereotypies like non-food object licking behaviours likely result from a captive environment that does not provide ample opportunities to satiate this need (Sato & Takagaki 1991; Kolter 1995; Koene & Visser 1996; Baxter & Plowman 2001; Fernandez et al. 2008). Although giraffes rarely exhibit stereotypic behaviours in the wild (Veasey et al. 1996) other studies of giraffe under human care suggest that 79.1 % of captive giraffe in surveyed zoos (Bashaw et al. 2001) with reported prevalence of tongue playing stereotypic behaviours reached as high as 25% of total observed behaviours (Koene & Visser 1996).

Giraffe are foregut fermenters (Mertens 2007). Captive giraffe are often fed diets too high in starch and sugars (as are found in sugar-rich produce), and the reduced fiber could cause explosive fermentation in the foregut, increasing the risk of occurrence of rumen acidosis among giraffe (EAZA 2006). Rumen acidosis contributes to several physiological and behavioural problems in captive giraffes including oral stereotypy (EAZA 2006). A fully grown giraffe with maintenance requirements (including moderate locomotion levels) consumes about 8.5–12 kg of dry matter (DM) per day on a captive diet (1.2–1.3 % of body weight) (EAZA 2006). Lintzenich & Ward (1997) recommend 60–70 % of forage in diets for giraffes. Hofmann (1973) classifies the giraffe as browsers. Browse closely resembles their natural food and food acquisition patterns. Also, being ruminants, a considerable proportion of tongue movement occurs during rumination. In captive settings, lack of browse or opportunities to browse to induce rumination do not promote natural tongue manipulation and could lead to increase in oral stereotypies (Schaub et al. 2004; Hummel et al. 2006; Duggan et al. 2015). In zoological institutions, therefore, a major task for giraffe husbandry is to simulate the feeding and foraging behaviours, as lack of behavioural foundations representing natural behavioural ecology can lead to behavioural pathologies (e.g., oral stereotypies or pacing), and impaired health (e.g., rumen acidosis).

Enclosure space has a profound influence on the behavioural activity budget of the giraffes housed in it (Garry 2012). Giraffe naturally have a mean home range size of 282km^2 (du Toit 1990) and have been found to cope well in restricted captive conditions; however, enclosures too restrictive due to space constraints for group size and density of animals have also been correlated with increased stereotypic licking in giraffes, okapi, horses (Redbo et al. 1998; Bashaw et al. 2007). The Central Zoo Authority (CZA), Ministry of Environment and Forests, Government of India prescribes minimum size of outdoor enclosure of 1,500m^2 for housing two giraffes (Bonal et al. 2014).

This study was conducted with a threefold objective. Firstly, to examine current behaviour of Northern Giraffes in Zoological Garden Alipore, Kolkata to advise on their enhanced management. Secondly, to highlight any behavioural abnormalities and recommend enrichment

mechanisms. And lastly, to compare the observed stereotypic behaviours with behaviour described in other zoological institutions and in the wild to provide a focal trajectory in the development of guidelines.

MATERIALS AND METHODS

To characterize stereotypical behaviour in captive giraffe, behavioural observations were conducted at the Zoological Garden Alipore, Kolkata, India. The giraffe enclosure housed seven individuals, consisting of three adult males, two adult females, and two calves (a male and a female). The outdoor enclosure was 20m x 20m in width (400m^2) (Figure 1), with an indoor facility that contained the feeding and drinking area. The feeding and drinking area was not visible during the observation sessions, although the giraffes had open access day and night to both areas. Therefore, observations on feeding and drinking behaviour could not be included in the study.

The food offered to the giraffe at Zoological Garden Alipore included higher proportions of concentrates and sugar-rich produce (in the form of fruits and vegetables). No browse was offered as a part of the diet. The feed was offered in open feeders and was accessible to all giraffes equally. The proportion of concentrates and produce a single giraffe would eat was not estimated. The giraffe were fed twice a day at 08.00 and 15.00 h, making them susceptible to large amounts of starch and sugar loads in the rumen at any one time.

For the study, four giraffe were selected as a sample of the herd (Table 1).

The four giraffe representing different ages and sexes; the dominant male, the subordinate male, a female and

Table 1. Details of subjects involved in the observational study at Zoological Garden Alipore, India.

Giraffe	Identity code	Age	Description
Dominant male	B1	14 years	Dominant bull and sire of calf (C)
Subordinate male	B2	13 years	Second largest bull
Female	F	4 years	Dam of calf (C)
Calf	C	1.5 months	Male calf

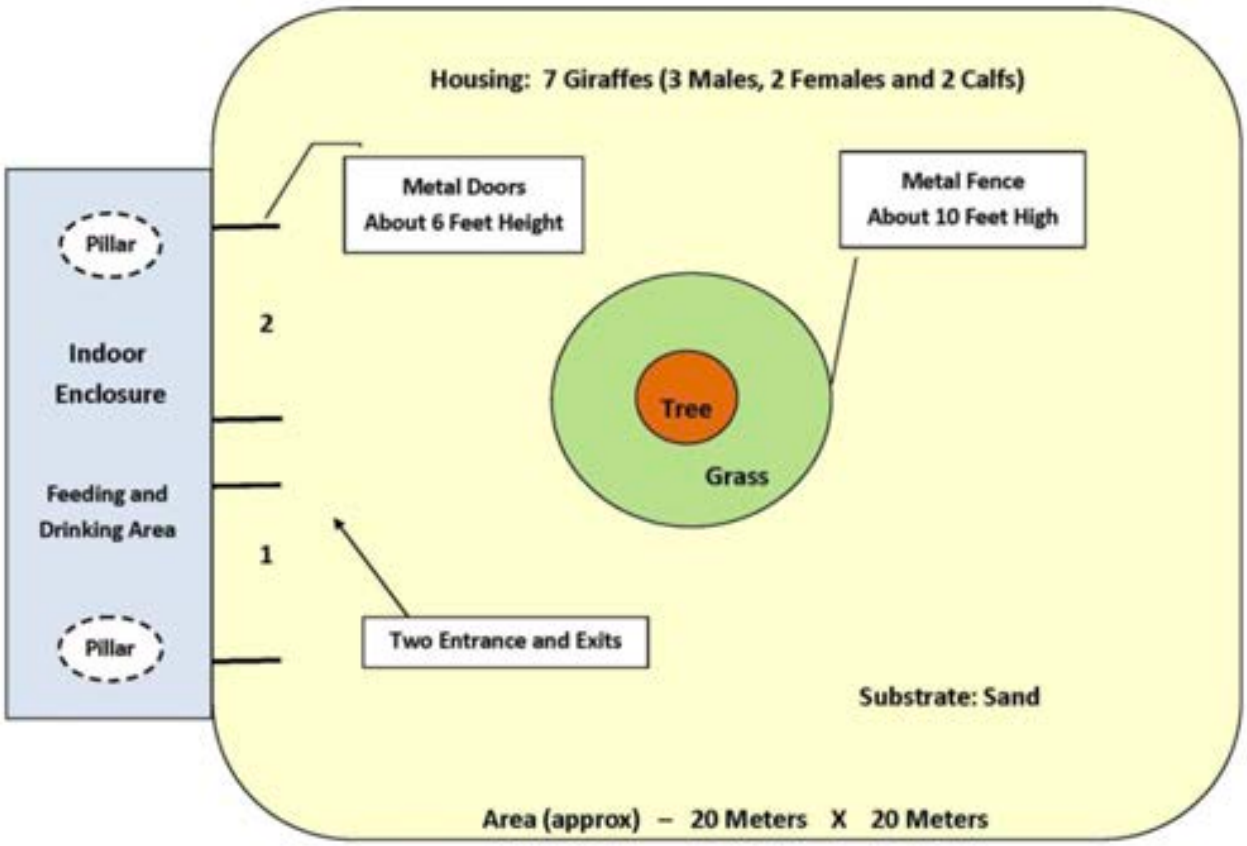

Figure 1. Layout of the Giraffe Enclosure at Zoological Garden Alipore, India.

Table 2. Giraffe behaviour categories and descriptions recorded.

	Behaviour	Description of behaviours collected
1	Resting	Subject is standing motionless, eyelids go down or remain half closed, or is laying on the ground, either neck held up right or low to the ground
2	Ruminating	Subject regurgitates food to the mouth and chews it again while standing motionless, sitting on the ground or moving from one place to another
3	Self grooming	Subject is nibbling, licking itself, appearing to clean itself while in standing position or sitting on the ground
4	Walking	Subject is moving from one place to another at a normal walking pace
5	Galloping	Subject is moving from one place to another in a three beat gait e.g. canter, faster than a walk
6	Reaching out for food	Subject in standing or in splaying position is trying to reach the leaves of trees outside the enclosure by sticking out the tongue through the gaps of the metal netted fence
7	Sniffing / Tasting soil or grass	Subject is splaying and sniffing or tasting the soil, or nibbling grass at the edges inside the enclosure
8	Vigilant	Subject is observing the visitors or focusing on visitor activity
9	Interaction with others	Subject is interacting with another individual e.g. touching nose, mouth, back, tail, licking / biting mane, bumping rump
10	Licking stereotypy	Subject is indulging in invariant and repetitive licking of walls, metal doors, metal fence, etc., along with tongue playing
11	Suckling	Subject (calf) suckling or trying to suckle the mother
12	Out of sight	Subject is inside the indoor facility and not visible
13	Others	Any other behaviours that are not listed above

the youngest calf (male), were observed for seven days from 24–31 October 2015, using instantaneous scan sampling method. Observations could not be done on Thursday, 29 October 2015 as the zoo remains closed on Thursdays. Behaviours were recorded every two minutes during each 30-minute session, three-times a day at 09.00, 13.00 and 17.00 h. A total of 84 observations were recorded, resulting in 1,260 data points.

The behaviours were categorized into an ethogram of 13 headings based on overall observed behaviour patterns (Table 2).

The average counts into an ethogram across the group were computed and aggregated into half-hourly blocks of time. To test if the observed levels of oral stereotypy at Zoological Garden Alipore were different than previously reported values in the wild and in other zoos, a series of one-sample t-tests were conducted. To assess if observed prevalence of stereotypic behaviour was greater than the null model of 0 in the wild, a series of one-sample t-tests were used comparing the observed prevalence of stereotypy for each individual's behavioural observations to 0 to account for the assumption that giraffe do not exhibit stereotypic behaviour in the wild (Bashaw et al. 2001). To assess if observed prevalence of stereotypic behaviour was different than previously reported studies, a series of one-sample t-test was conducted, comparing the observed prevalence of stereotypy for each individual's behavioural observations to 0.25 to account for the reported prevalence of stereotypic tongue playing reported by Koene & Vissner (1996). To evaluate differences in stereotypic behaviours across age and sex classes over time, a linear mixed effects model was developed using proportion of time exhibiting stereotypic behaviour as the response variable. Age/sex class and time of day time of day were used as the fixed effects and individual identity as a random effect. To account for proportional data, arcsine was used to transform the response variable.

RESULTS

Examination of behaviour

Figure 2 represents the behaviours recorded among all four giraffes during the total observation period at Zoological Garden Alipore (see Table 1 for identification of individuals).

During the week-long period, the giraffe primarily exhibited four behaviours: licking stereotypy, ruminating, walking, and resting more than any other behaviour recorded. The remainder of the recorded behaviours were observed less than 5% each of the total time observed.

Behavioural abnormalities (Licking stereotypy)

Licking stereotypy (LS) was observed among the giraffe accounting for 25% of the total observations, peaking in the evenings (39%). LS was observed in all four giraffe, but disproportionally among the individuals.

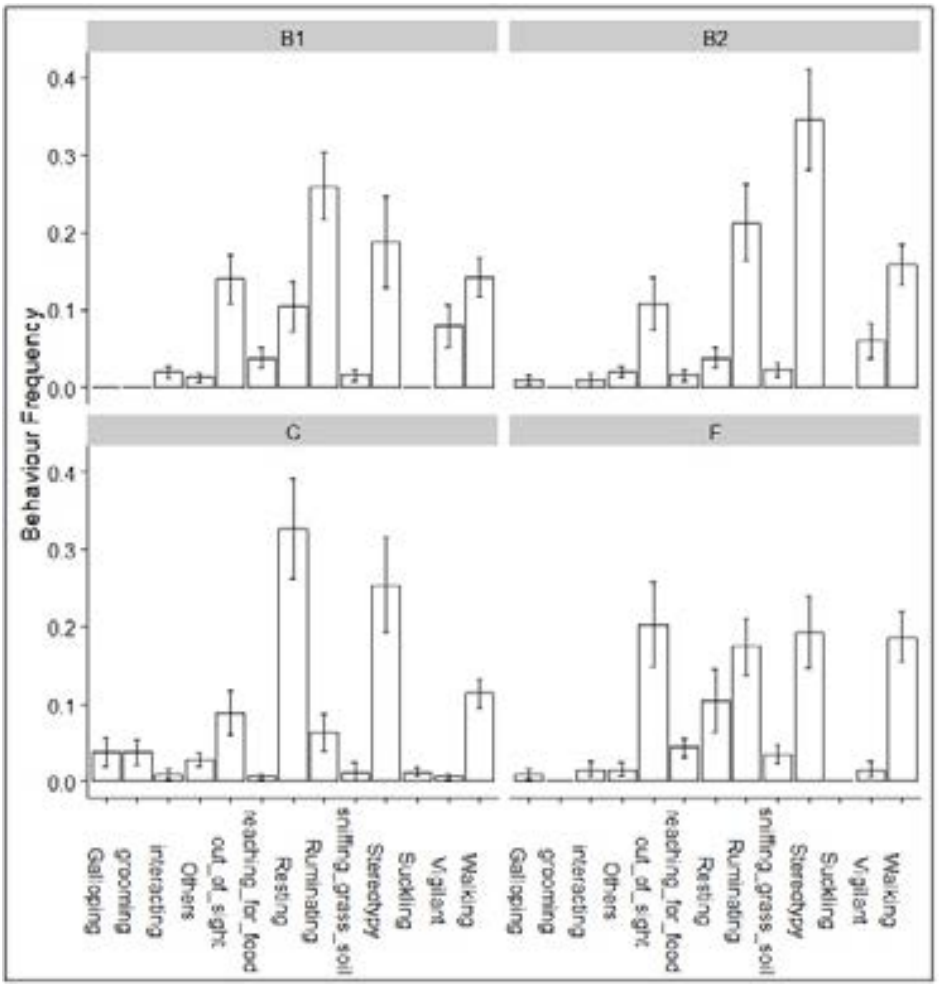

Figure 2. Behaviour among all four giraffe during total observation period at Zoological Garden Alipore.

The subordinate male (B2) was recorded 35% of time engaged in LS, compared to 26% for the calf (C), 20% for female (F) and 19% for the dominant male (B1). All captive giraffes consistently exhibited significantly higher proportion of stereotypic behaviour than giraffe in the wild (Veasey et al. 1996). These findings were consistent across all individuals of different age and sex classes, including: B1 ($t=3.10$, $df=20$, $p<0.01$),B2 ($t=5.13$, $df=20$, $p<0.01$), C ($t=4.052$, $df=20$, $p<0.01$), and F ($t=4.07$, $df=20$, $p<0.01$) (Figure 3). No significant difference was found in the proportion of observed stereotypic behaviour and reported values of 0.25 from other zoological collection. This finding was true for all observed giraffe: B1 ($t=-1.04$, $df=20$, $p=0.31$), B2 ($t=1.42$, $df=20$, $p=0.17$), C ($t=0.06$, $df=20$, $p=0.95$), and F ($t=-1.18$, $df=20$, $p=0.25$).

In evaluating the mixed effects model to test for the effect of time of day on the proportion of stereotypic behaviour, a significant effect of time of day on proportion of stereotypic behaviour was found with the highest proportions observed during evening observation periods. Although the observed calf displayed an inverse temporal relationship with the highest proportion of stereotypic behaviours observed during the morning periods, the temporal effect was strong enough such that this relationship did not significantly vary across giraffe identity.

DISCUSSION

The daily behaviours of the group of giraffe studied in this investigation was markedly different than the daily behaviours of their wild conspecifics. In particular, the amount of time spent indulging in oral stereotypical behaviours. Oral stereotypy, which was observed highest among all the behaviours in this study, is predominantly a giraffe behaviour observed in captivity as a result of diet, feeding method (foraging), appetitive behaviour, enclosure space, complexity of the environment and enrichment (Veasey et al. 1996; Mason & Mendl 1997).

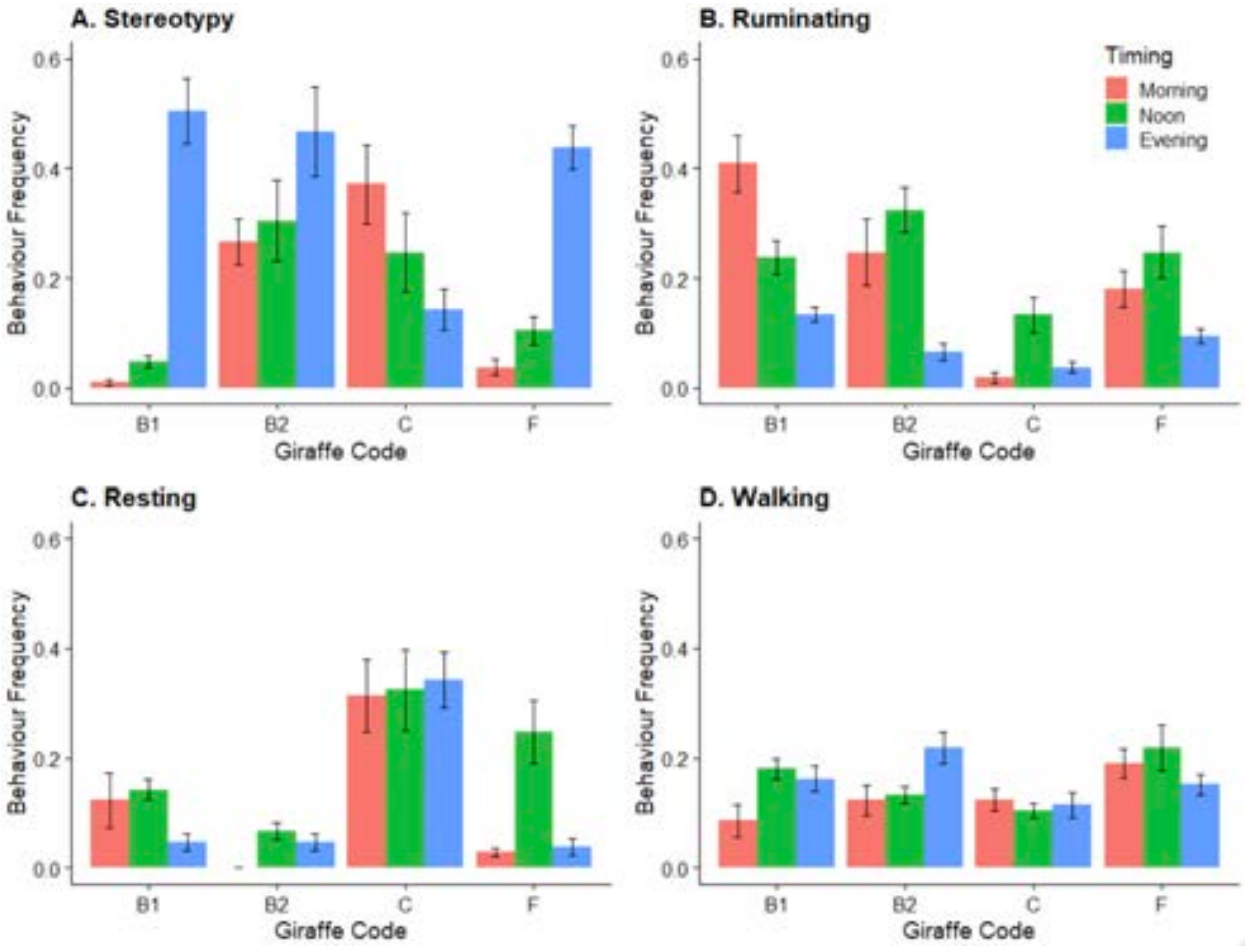

Figure 3. Behaviour across half-hourly blocks among all four giraffe during total observation at Zoological Garden Alipore.

The giraffes at the zoo were observed to perform stereotypical non-food object licking behaviours such as licking the enclosure doors, walls, and fence, which has been associated as a coping technique for captive animals in suboptimal environments (Mason 1991). Stereotypic behaviours are reported to have diminishing effects on the welfare of animals which perform them (Mason & Latham 2004; Mason et al. 2007).

Diet and feeding

Stereotypies in captive herbivores who are fed on diets largely consisting of concentrated feeds, presented in limited time and space, are often a result from a lack of opportunity to fulfill their innate motivation to perform foraging, consumption and digestive behaviour patterns (Appleby & Lawrence 1987; Terlouw et al. 1991). This in turn is detrimental to their welfare. The giraffe at Zoological Garden Alipore were fed higher proportions of sugar-rich produce (commercial fruits and vegetables) and concentrates, and no browse. Sugar-rich produce contain nutritionally very fast fermenting sugars and starch and are low in plant fiber. Bergeron et al. (2006) suggests the hypothesis of occurrence of oral-stereotypic behaviours in captive ungulates having diets deficient in fiber, stating that the animals don't fill their gut and thus are not satisfied. Additionally, these feeds induce little chewing and hence little saliva production. In such cases oral stereotypy is suggested to benefit gut health by generating saliva which helps to rectify gastrointestinal pH (Bergeron et al. 2006). Intake of high proportion of concentrates can induce a rapid or even 'explosive' fermentation in the rumen, increasing the risk of occurrence rumen acidosis. Rumen acidosis could contribute to several problems in captive giraffes including oral stereotypy (EAZA 2006). By lowering the concentrations of sugar-rich produce and increasing the concentration of fiber in giraffe diet, Zoological Garden Alipore should be able to minimize the observed oral disturbances, and also a number of health problems associated with unhealthy rumens. It is recommended

that the zoo should restrict sugar-rich produce to very small quantities and special purposes like training or medication (EAZA 2006). Concentrates should be fed restrictively to minimize the fermentation effects for overcoming the observed oral stereotypy.

Feeding duration and schedule have been linked to the performance of stereotypic behaviour (Bashaw et al. 2001). In the wild, higher frequency of feeding behaviour occurs in the early morning and late afternoon but occurs throughout the day (Fennessy 2004). The observed giraffe exhibited oral stereotypy throughout the day but increased in oral stereotypy behaviour in the evening, post feeding times. The giraffe were offered meals only twice in a day resulting in peaks of energy intake during feeding hours. In the wild, however, energy intake remains distributed over the whole day because of their specialized feeding ecology. By increasing the number of meals offered, the energy intake can be prorated throughout the day. This will, in turn, lower the incidence of rapid microbial fermentation in the rumen and reduce the acidosis-induced tongue play, which the giraffe demonstrated through the oral stereotype behaviour. It is, therefore, recommended that the giraffe are fed at least three separate meals daily (EAZA 2006), with fresh browse or lucerne available at all times to guarantee additional fiber and reduced oral stereotypic behaviour.

The disproportionately observed LS behaviour among the individuals can be correlated with the incongruous feeding pattern adopted by the zoo as they desegregate the amounts of food consumed by individual giraffe. The giraffe are fed in feeders equally accessible to the entire herd, and as such, the proportion of food intake by an individual giraffe could not be measured. Allowing equal access to feeders can also spur dominant individuals to monopolize the feed stations and consume more. It is, therefore, recommended that the zoo provide separate feeders for each individual giraffe. This will enable to monitor food and energy intake by each individual and also prohibit dominant individual(s) from monopolizing a feed station and consuming too much concentrates or sugar-rich feed.

The diet of the giraffe lacked provision of browse: nontoxic, palatable tree branches and trimmings, closely resembling the natural food of giraffe. In the wild, browsing requires extensive use of their long prehensile tongues which is difficult to replicate in captivity if giraffe are fed more food concentrates that are thornless and relatively easy to process. A resultant LS behaviour was observed as the giraffe had inadequate opportunity for use of their long prehensile tongues in their natural feeding repertoire (Sato & Takagaki 1991) thus consuming food rapidly. The importance of browse for both the nutritional value and the behavioural well-being of animals cannot be overstated and natural browse should be provided to the greatest possible extent, i.e., 40–60 pounds of browse per individual each day (Burgess 2004; EAZA 2006; Miller & Fowler 2012). Giraffe are highly efficient in processing foliage, and as such, browse should not be considered enrichment, but a formal requirement of their diet. Only browse that has been approved for use with giraffe should be fed. A well-developed logistics, either by contacts with the local forestry department, i.e., Department of Forests, Govt. of West Bengal, or by a browse plantation (Höllerl et al. 2006) is recommended to ensure year-round supply of sufficient browse for giraffe at Zoological Garden Alipore.

Enclosure Space

In the wild, large herbivorous species have to walk long distances between feeding patches (du Toit & Yetman 2005). For giraffe, energy consumptive activity like walking is strongly biphasic with increased movements occurring post-dawn/early morning and pre-dusk/early evening, as compared to hottest period of the day (midday) (Fennessy 2004). Additionally giraffe are the only species to ruminate whilst walking (du Toit & Yetman 2005). Spatial limitations due to smaller enclosure caused eradication of the need to walk, and the giraffe were not observed to: walk, ruminate whilst walking for any long time periods.

It has been proposed that enclosure size influences the proportion of abnormal behaviour exhibited by confined animals (Maple 1979; Macedonia 1987; Kirkwood 1998). This appears very likely given the nature of giraffe movements in the wild who often have large home ranges (Baxter & Plowman 2001). In captivity, smaller enclosures limit opportunity to move and exercise due to inadequate space. Reduced opportunity to exercise may lead to decreased periods of sleep and increased time available for undesirable behaviour (Bashaw et al. 2001). Also, enclosures that are restrictive due to too large group size and density can have a negative impact on the animal's well-being (Garry 2012). The giraffe in the Zoological Garden Alipore were housed in a small enclosure space (400m^2), far too restrictive for the group of seven. CZA prescribes minimum size of outdoor enclosure of 1,500m^2 for housing two giraffe (Bonal et al. 2014), extrapolated to a minimum size of 5,250m^2 which is recommended. This is a significant difference. CZA also states that the enclosure for all the species displayed or kept in a zoo shall be of such size that all animals get adequate space

for free movement and exercise and no animal is unduly dominated or harassed by any other animal (Bonal et al. 2014). It is, therefore, recommended that Zoological Garden Alipore should expand the enclosure to meet the guidelines by CZA as a minimum. Allowing greater access to exhibit space may also reduce the observed oral stereotypic behaviour and allow a more natural activity cycle (Forthman 1998).

Enrichment

Providing opportunities for an animal to engage in its environment is an integral part of the daily husbandry routine, and is as important to an animal's care as diet and clean living quarters (Macphee & Mellen 2000). The existing giraffe enclosure at Zoological Garden Alipore was deficient in environmental complexity, lacking natural browse, and feeding and behavioural enrichments, leaving excess free time which giraffe appear to have filled by performing oral-stereotypic behaviours. In the wild giraffe prefer to rest in microhabitats, such as under trees within the riparian woodland, allowing shade and wind to optimise heat loss or gain (Fennessy 2004). In captive environments, it is presumed that rumination is suppressed when giraffes cannot rest or relax (EAZA 2006). It is recommended that Zoological Garden Alipore provides special resting places in the outdoor enclosure, not too close to visitors or other busy places, to encourage the giraffe to lay down, rest, and ruminate (EAZA 2006).

In the wild giraffe use their prehensile tongues to remove small leaves from thorny plants, pluck off pods and flowers. Giraffe at the Zoological Garden Alipore are

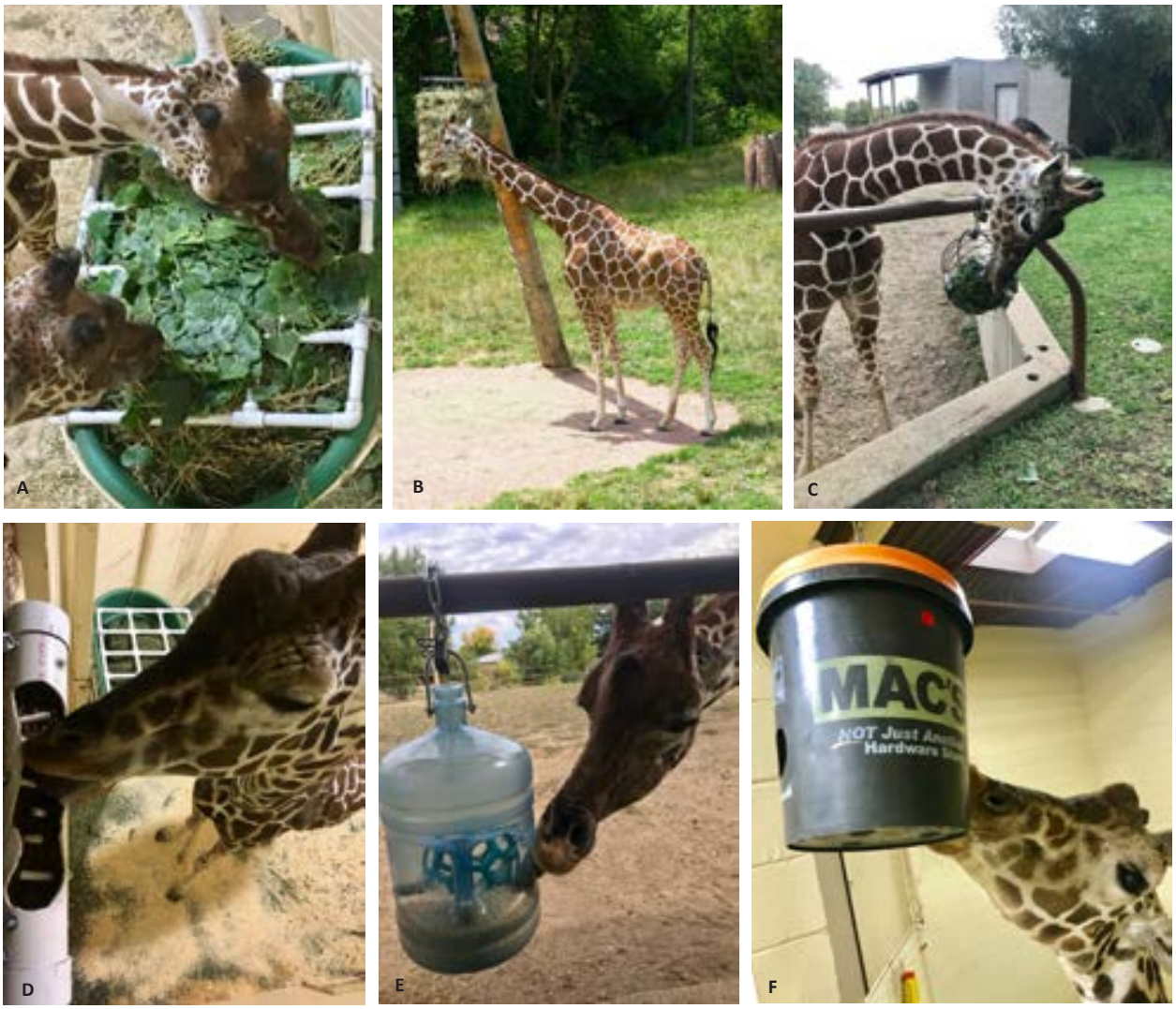

Image 1. Enrichment Devices. A—closed-topped feeder | B—hay rack | C—browse ball | D—puzzle feeder | E— puzzle feeder (treat jar) | F—puzzle feeder (tongue puzzle bucket). Photo credits: A,C,D,E,F—Allison Suda & Chelsea Mihalick, Roosevelt Park Zoo, ND, USA; B—Cory Fagg, Fort Wayne Children's Zoo, IN, USA.

only offered food in open feeders and take mouthfuls without much tongue effort. As a result, their need for a certain amount of tongue movement was not met and they used their tongues for movements other than feeding, e.g., non-food stereotype object licking behaviours (EAZA 2006). Hence food presentation for giraffe in captivity should offer challenges to display increased tongue movements, encouraging the individuals to elicit more natural feeding behaviours. As compared to their wild conspecifics in the wild, the goal for captive giraffe should be to spend up to 60% of their time engaged in feeding or foraging activities (Fennessy 2004). Therefore, providing enrichment methods to increase time-engaged feeding for giraffe is strongly recommended. Closed-topped feeders (Bashaw et al. 2001) (Image 1), are recommended instead of traditional rack or trough-style feeders. These feeders require the giraffe to employ their prehensile tongue in obtaining food and increase feeding bout duration. Browse devices like hay racks, browse balls and puzzle feeders (Image 1) are recommended as they encourage giraffe to use their tongues to pull out the food, increasing their feeding durations and foraging time (Burgess 2004; EAZA 2006).

These devices are preferably spaced throughout the enclosure and rotated either on a schedule or randomly to provide more stimulation for the giraffe. Placing them at different heights also allows for foraging opportunities for all giraffe and encourages them to utilise all areas of the enclosure. CZA state that the timing of distribution of food, placement of food and way of distribution of food to the animals should be regulated in such a manner that the animals get maximum opportunity to express natural instincts and skills and behaviour related to feeding (Bonal et al. 2014).

CONCLUSION

The giraffe in Zoological Garden Alipore, India lack continuous feeding stimulation and a balanced proportion of forage and concentrates. The facility lacked methods to monitor proportions of individual food intake and availability of browse. The outdoor enclosure did not meet the minimum size prescription advised by CZA and also lacked any feeding and behavioural enrichments. The combined effect of these limitations clearly causes the giraffe to exhibit predominant stereotypic licking behaviour. Other impacts on their welfare were not observed in the short study period but will likely result from the cumulative effects and limitations described above.

By increasing proportions of fiber in the diet and using a combination of different forages along with browse, the zoo will be able to reach the feeding goals for the giraffe. Expanding the outer enclosure to 5,250m^2 for the existing herd of seven giraffe can emphatically influence the need for free movement and exercise. Introducing enrichment methods to improve the feeding behaviours (longer and more feeding periods resulting in longer rumination) and positively changing the animal's environment would encourage eliciting the animal's natural behavioural repertoire to achieve improvements in the observed oral disturbance pattern.

REFERENCES

Appleby, M.C. & A.B. Lawrence (1987). Food restriction as a cause of stereotypic behaviour in tethered gilts. *Animal Science* 45: 103–110. https://doi.org/10.1017/S0003356100036680

Bashaw, M.J., L. Tarou, T. Maki & T. Maple (2001). A survey assessment of variables related to stereotypy in captive giraffe and okapi. *Journal of Applied Animal Science Behavior* 73: 235–247. https://doi.org/10.1016/S0168-1591(01)00137-X

Bashaw, M.J., M.A. Bloomsmith, L.M. Terry & F.B. Bercovitch (2007). The structure of social relationships among captive female giraffe (*Giraffa camelopardalis*). *Journal of Comparative Psychology* 121: 46-53. https://doi.org/10.1037/0735-7036.121.1.46

Baxter, E. & A.B. Plowman (2001). The effect of increasing dietary fibre on feeding rumination and oral stereotypies in captive giraffes (*Giraffa camelopardalis*). *Animal Welfare* 10: 281–290.

Bergeron, R., A.J. Badnell-Waters, S. Lambton & G. Mason (2006). Stereotypic Oral Behaviour in Captive Ungulates: Foraging, Diet and Gastrointestinal Function, pp. 19–57. In: Mason G. & J. Rushen (eds.). *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare, 2nd Edition*. CABI, Wallingford, 384pp. https://doi.org/10.1079/9780851990040.0019

Bonal, B.S., I. Dhamija, B.R. Sharma, S.C. Sharma & B.K. Gupta (eds.) (2014). *Zoos in India-legislation, policy, guidelines & strategy, 5th revision.* Central Zoo Authority (Statutory Body under the Ministry of Environment, Forests and Climate Change, Govt. of India), India, 271pp.

Burgess, A. (eds.). (2004). *The Giraffe Husbandry Resource Manual. AZA Antelope and Giraffe Taxon Advisory Group*. Disney's Animal Kingdom, Orlando, FL, 184pp.

Dagg, A.I. & J.B. Foster (1976). *The Giraffe: Its Biology, Behavior and Ecology.* Van Nostrand Reinhold Company, New York, 210pp.

du Toit, J.T. (1990). Home range-body mass relations: a field study on African Browsing ruminants. *Oecologia* 85: 301–303. https://doi.org/10.1007/BF00319416

du Toit, J.T. & C.A. Yetman (2005). Effects of body size on the diurnal activity budgets of African browsing ruminants. *Oecologia* 2: 317–325. https://doi.org/10.1007/s00442-004-1789-7

Duggan, G., C.C. Burn & M. Clauss (2015). Nocturnal behavior in captive giraffe (*Giraffa camelopardalis*)—a pilot study. *Zoo Biology* 35: 14–18. https://doi.org/10.1002/zoo.21248

EAZA Giraffe EEPs (2006). EAZA Husbandry and Management Guidelines for *Giraffa camelopardalis*. *Burgers' Zoo*, Arnhem, 132pp.

Fennessy, J.T. (2004). Ecology of the desert-dwelling giraffe *Giraffa camelopardalis angolensis* in northwestern Namibia. PhD Thesis. University of Sydney, Sydney, NSW, Australia, xvi+265pp.

Fennessy, J., T. Bidon, F. Reuss, V. Kumar, P. Elkan, M.A. Nilsson, M. Vamberger, U. Fritz & A. Janke (2016). Multi-locus analyses reveal four giraffe species instead of one. *Current Biology* 26: 2543–2549. https://doi.org/10.1016/j.cub.2016.07.036

Fernandez, L.T., M.J. Bashaw, R.L. Sartor, N.R. Bouwens & T.S. Maki (2008). Tongue twisters: feeding enrichment to reduce oral stereotypy in giraffe (*Giraffa camelopardalis*). *Zoo Biology* 27: 200–212. https://doi.org/10.1002/zoo.20180

Forthman, D.L. (1998). Toward optimal care for confined ungulates, pp. 236–261. In: Shepherdson, D.J., J. D. Mellen & M. Hutchins (eds.). *Second Nature: Environmental Enrichment for Captive Animals.* Smithsonian Institution Press, Washington, DC, 376pp.

Garry, S. (2012). Analyses of captive behaviour and enclosure use in Rothschild's giraffes (*Giraffa camelopardalis rothschildi*) housed at Paignton Zoo Environmental Park. *The Plymouth Student Scientist* 5: 4–30.

Hofmann, R.R. (1973). *The ruminant stomach. East African Monographs in Biology Vol. II.* East African Literature Bureau, Nairobi, 354pp.

Höllerl, S., B. Stimm, J. Hummel & M. Clauss (2006). Browse provision for captive herbivores. Design and management of a browse plantation, pp. 211–212. In: Andrea, F., M. Clauss, K. Eulenberger, J-M. Hatt, I. Hume, G. P. J. Janssens & J. Nijboer (eds.). *Zoo Animal Nutrition, Vol. 3*. Filander Verlag, Fürth.

Hummel, J., M. Clauss, E. Baxter, E.J. Flach & K. Johansen (2006). The influence of roughage intake on the occurrence of oral disturbances in captive giraffids, pp. 235–252. In: Fidgett, A., M. Clauss, K. Eulenberger, J.-M. Hatt, I. Hume, G Janssens & J. Nijboer (eds.). *Zoo Animal Nutrition Vol. 3.* Filander Verlag, Fürth.

Kirkwood, J.K. (1998). Design for the accommodation for wild animals: How do we know when we have got it right? In: Plowman A.B. & P.M.C. Stevens (eds.). Proceedings of the 5th International Zoo Design Conference. Paignton, England.

Koene, P. & E.K. Visser (1996). Tongue playing behavior in captive giraffes, pp. 106–111. *In: 1st International Symposium on Physiology and Ethology of Wild and Zoo Animals.* Klima, Berlin.

Kolter, L. (1995). Control of behavior and the development of disturbed behavior patterns, pp. 248–256. In: Ganslosser, U., J.K. Hodges & W. Kaumanns W (eds.). *Research and captive propagation*. Filander Verlang, Fürth, Germany, 338pp.

Lintzenich, B.A. & A.M. Ward (1997). Hay and pellet ratios: considerations in feeding ungulates. In: *Nutrition Advisory Handbook, Fact Sheet* 006.

Macedonia, J.M. (1987). Effects of housing differences upon activity budgets in captive sifakas (*Propithecus verreauxi). Zoo Biology* 6: 55–67. https://doi.org/10.1002/zoo.1430060107

MacPhee, M. & J, Mellen (2000). Framework for planning, documenting, and evaluating enrichment programs (and the director's, curator's, and keeper's roles in the process), pp. 221–225. In: AAZPA Annual Conference Proceedings. American Association of Zoological Parks and Aquariums, Wheeling, WV.

Maple, T.L. (1979). Great apes in captivity: The good, the bad and the ugly, pp. 239–273. In: Maple T.L., J. Erwin & G. Mitchell (eds.). *Captivity and behavior: Primates in breeding colonies, laboratories and zoos*. Van Nostrand Reinhold, New York, 286pp.

Mason, G.J. (1991). Stereotypies: a critical review. *Animal Behaviour* 41: 1015–1037. https://doi.org/10.1016/S0003-3472(05)80640-2

Mason, G.J. & M. Mendl (1997). Do the stereotypies of pigs, chickens and mink reflect adaptive species differences in the control of foraging? *Applied Animal Behaviour Science* 53: 45–58. https://doi.org/10.1016/S0168-1591(96)01150-1

Mason, G.J. & N. Latham (2004). Can't stop, won't stop: is stereotypy a reliable animal welfare indicator. *Animal Welfare* 13: 57–69.

Mason, G., R. Clubb, N. Latham & S. Vickery (2007). Why and how should we use environmental enrichment to tackle stereotypic behavior? *Applied Animal Behavior Science* 102: 163–188. https://doi.org/10.1016/j.applanim.2006.05.041

Mertens, D.R. (2007). Digestibility and intake chapter: 32. In: Barnes, R.F, C.J. Nelson, K.J. Moore & M. Collins (eds.). *Forages, The Science of Grassland Agriculture, 6th edition, Vol. 2.* Blackwell Publishing, U.K., 808pp.

Miller, R.E. & M.E. Fowler (eds.) (2012). *Fowler's Zoo and Wild Animal Medicine, Volumes 6, 7 & 8.* Saunders, USA, 688pp. https://doi.org/10.1016/C2009-0-63976-3

Pellew, R.A. (1984). The feeding ecology of a selective browser, the giraffe (*Giraffa camelopardalis tippelskirchi*). *Journal of Zoology* 202: 57–81. https://doi.org/10.1111/j.1469-7998.1984.tb04288.x

Redbo, I., P. Redbo-Torstensson, F.O. Odberg, A. Hedendahl & J. Holm (1998). Factors affecting behavioral disturbances in racehorses. *Animal Science* 66: 475–48. https://doi.org/10.1017/S1357729800009644

Sato, S. & I. Takagaki (1991). Tongue-playing in captive giraffe, pp. 22–29. In: *22nd International Ethological Conference.* Kyoto: Otani University.

Schaub, D., M. Clauss, E.J. Flach, H.R. Wettstein, C. Tack & J.-M. Hatt (2004). *Influence of physical and chemical composition of diet on oral stereotypies in captive giraffes (Giraffa camelopardalis). Proceedings of the European Association of Zoo and Wildlife Veterinarians* 5: 27–28. https://doi.org/10.5167/uzh-3550

Terlouw E.M.C., A.B. Lawrence & A.W. Illius (1991). Influences of feeding level and physical restriction on the development of stereotypies in sows. *Animal Behaviour* 42: 981–991. https://doi.org/10.1016/S0003-3472(05)80151-4

Veasey, J.S., N.K. Waran & R.J. Young (1996). On comparing the behaviour of zoo housed animals with their wild conspecifics as a welfare indicator, using the Giraffe (*Giraffa camelopardalis*) as a model. *Animal Welfare* 5: 139–153.

Winter, S., J. Fennessy & A. Janke (2018). Limited introgression supports division of giraffe into four species. *Ecology and Evolution* 8: 10156–10165. https://doi.org/10.1002/ece3.4490

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COMMUNICATION

A new species of shieldtail snake (Reptilia: Squamata: Uropeltidae) from Kolli Hill complex, southern Eastern Ghats, peninsular India

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Abstract: We describe a new species of shieldtail (uropeltid) snake, *Uropeltis rajendrani* sp. nov., from the Kolli Hill complex of the southern Eastern Ghats in Tamil Nadu, India. The new species belongs to the *U. ceylanica* group and is differentiated from related species in having 16–17:16–17:15–16 dorsal scale rows; 145–158 ventral scales; 8–11 pairs of subcaudals; dorsum uniform brown, anteriorly powdered with yellow mottling; venter brown, scales outlined with yellow. This endemic species with a restricted range is known only from atop Kolli Hill complex, inhabiting higher elevation (> 900m) evergreen forests, where it is the only known member of this genus.

Keywords: Allopatric species, endemism, isolated massif, *Uropeltis rajendrani* sp. nov., Western Ghats.

Abbreviations: CESS—Centre for Ecological Sciences / Snakes; CSPT—Chennai Snake Park Trust; BNHS—Bombay Natural History Society; MAD—Madras Government Museum Chennai.

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Author contribution: SRG conceived and diagnosed the new species and led the manuscript writing. NSA conducted the field surveys and roadkill specimen collections, examined the type specimens and scored morphological details. SRG diagnosed the new species against the comparative materials' morphology that he had gathered. Both the authors equally contributed in fine tuning and refining the draft and approved the final version.

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INTRODUCTION

Subterranean animals often top the list of undocumented and little-known fauna. Small, unassuming, burrowing snakes such as the shieldtail snakes of the family Uropeltidae Müller, 1832 deservedly fall in the list of under-researched animals. This is the only snake family endemic to the Indian subcontinent (McDiarmid et al. 1999; Wallach et al. 2014) and is surmised to be an evolutionary radiation (Bossuyt et al. 2004; Ganesh 2015). Pyron et al. (2016) provided the latest treatment to this group, decades after a previous detailed study by Rajendran (1985). This family consists of seven genera, of which the genus *Uropeltis* (type genus) is the most diverse and widespread in the Indian peninsula (Beddome 1886; Rajendran 1985; Whitaker & Captain 2004; Pyron et al. 2016).

Until recently, the distribution of the whole genus as such remained unclear, as new studies found that it is restricted to the Indian peninsula and is absent from Sri Lanka (Pyron et al. 2013, 2016). The alpha-taxonomy of the earliest described species in this genus—*Uropeltis ceylanica* Cuvier, 1829—is still unsettled and obscure. Gower et al. (2008) and Ganesh et al. (2014) partly resolved the taxonomic complexities in this species complex by reviving subjective junior synonyms as valid taxa, thereby uncovering cryptic diversity in this group. Just a year ago, a new species of *Uropeltis* was discovered (Jins et al. 2018). In this work, we describe a new *Uropeltis* from one of the emerging centers of herpetofaunal endemism – the southern Eastern Ghats (Aengals & Ganesh 2013; Ganesh & Arumugam 2016; Ganesh et al. 2018).

MATERIALS AND METHODS

This paper is based on the examination of three preserved specimens as well as five wild, uncollected topotypic specimens of the species in question, documented in the field (also see Ganesh & Arumugam 2016). All photos were taken using Nikon D 7000 and Canon Power Shot SX-130-IS model high resolution digital cameras. We recorded morphological details like scalation, measurements and colour patterns with the help of a magnifying hand lens (5X optical zoom). The type series comprises solely road kills that were later identified to be of this new species. We measured the preserved specimens using Mitutoyo dial vernier calipers (LC 0.1mm) except for snout-vent length that was measured with a standard measuring tape (LC 1mm). We followed Smith (1943) for definition and terminology of morphological characters, except for ventral scales for which Gower & Ablett (2006) counting method was followed. Where damaged, the adjacent coastal scale rows were used as proxies for counting ventral scales in the two paratypes. We provide comparisons and differential diagnosis based on our series of preserved voucher specimens in collections at various museums (see Appendix 1) and also on our perusal of original description papers and subsequent taxonomic treatises (see literature cited).

TAXONOMY

Uropeltis rajendrani sp. nov.
(Image 1a–k)

urn:lsid:zoobank.org:act:B86EB241-587F-46CD-8EC0-783370465334

Uropeltis cf. *ceylanica* (*nec* Cuvier, 1829) – Ganesh & Arumugam 2016

Holotype: BNHS 3559 an adult male, August 2019, a relatively undamaged specimen found dead on a road, in Bodhamalai, Tamil Nadu State, India, coll. N.S. Achyuthan & N.V. Srikanthan.

Paratypes: BNHS 3560 and BNHS 3561, trampled adults, found dead on a road. Same data as of holotype.

Etymology: Named in honour of Dr. Maria Viswasam Rajendran (2 Nov 1916–6 Aug 1993), 'MVR' for short, for his exhaustive studies on shieldtail snakes in Tamil Nadu, next only to Richard Henry Beddome and Frank Wall. Not only was he a professor of zoology at the St. Joseph's College Palayamkottai (Tirunelveli, Tamil Nadu) but also the director of the Madras (now Chennai) Snake Park (Chennai, Tamil Nadu) during the early 1980s.

Common name: Rajendran's Shieldtail snake.

Type locality: Bodhamalai Hills near Salem and Namakkal District border, overlooking Panamarathupatti Town (11.535˚N 78.221˚E; 1,070m), Tamil Nadu State, peninsular India.

Diagnosis: A species of *Uropeltis* from the Kolli Hill complex, characterized by having the following combination of characters: (1) caudal shield truncate, with a distinct thickened circumscribed concave disc; (2) part of rostral visible from above not distinctly longer than its distance from frontal; (3) rostral scale partially separating nasal scales; (4) snout obtusely rounded; (5) eye diameter 3/4th that of ocular shield; (6) dorsal scale rows 16–17:16–17:15–16; (7) ventral scales 145–158; (8) subcaudal scales 8–11 pairs; (9) dorsum deep brown, unpatterned, anteriorly with a few yellow speckles; (10)

Figure 1. Map of southern India showing the type locality and the general distribution range of *Uropeltis rajendrani* sp. nov.

venter yellow, each scale edged with brown.

Description of holotype

Measurements (in mm, on the left side): Snout-vent length 221mm; tail length 13mm; head length 7.60mm; head width 3.85mm; head depth 3.09mm; body width 5.92mm; vertical eye-diameter 0.45 mm; horizontal eye-diameter 0.41mm; eye-lip distance 0.45mm; eye-nostril distance 1.37mm; eye-rostrum distance 2.29mm; interocular distance 2.32mm; internarial distance 1.15mm; snout-parietal distance 6.10mm; posterior end of rostral to posterior end of parietal distance 4.75mm; tail shield length 8.17mm; tail shield width 3.95mm; tail shield depth 2.60mm; parietal scale length 1.70mm; parietal scale width 1.12mm; frontal scale length 2.4mm; frontal scale width 1.32mm; ocular scale length 1.72mm; prefrontal scale length 1.45mm; midbody ventral scale width 2.50mm; midbody basal coastal scale width 1.23mm.

Scalation: Rostral visible from above, smaller than nasal, not completely separating nasals; nasals in contact with one another posteriorly, prefrontals subequal in size to nasal and ocular scales, not in contact with rostral; nostril piercing nasal scales; nasal scales divided by rostral anteriorly but in contact with each other posteriorly; prefrontals subequal to frontal, slightly larger than nasals and oculars; frontal longer than broad, smaller than parietal; parietals large, largest of all head scales; supralabials 4, 4 (left, right), 1st and 2nd ones small, 3rd below eye, 4th the largest; infralabials 3,4 (left, right), elongate, 1st pair slightly curved anteriorly; mental scale small, subequal to 1st infralabial, but as wide as long; body scales imbricate, cycloid; dorsally around body in 17:16:16 rows (one head length after neck: at midbody: one head length before vent); ventrals 148, angulate laterally; cloacal scale divided, each part larger than a dorsal scale; subcaudals 11 pairs + 1 terminal scale; tail shield distinctly truncate above, concave, clearly circumscribed and ridged; covered with bi- and tri-carinate thickened scales; 11 scales across the length and 5 across the width of the tail shield.

Colouration: Dorsum deep brown, rather uniform and unpatterned for the most part, except near neck where it is speckled with yellow spots; venter rich brown each ventral scale and abutting rows of last coastal scales more or less fully bordered with yellow outlines, giving an overall brown-mottled appearance; a pair of yellow stripes extending from last supralabial scale till the anterior 1/3rd of the body, across the first blotch near the neck; cloacal scale and subcaudal scales orange with

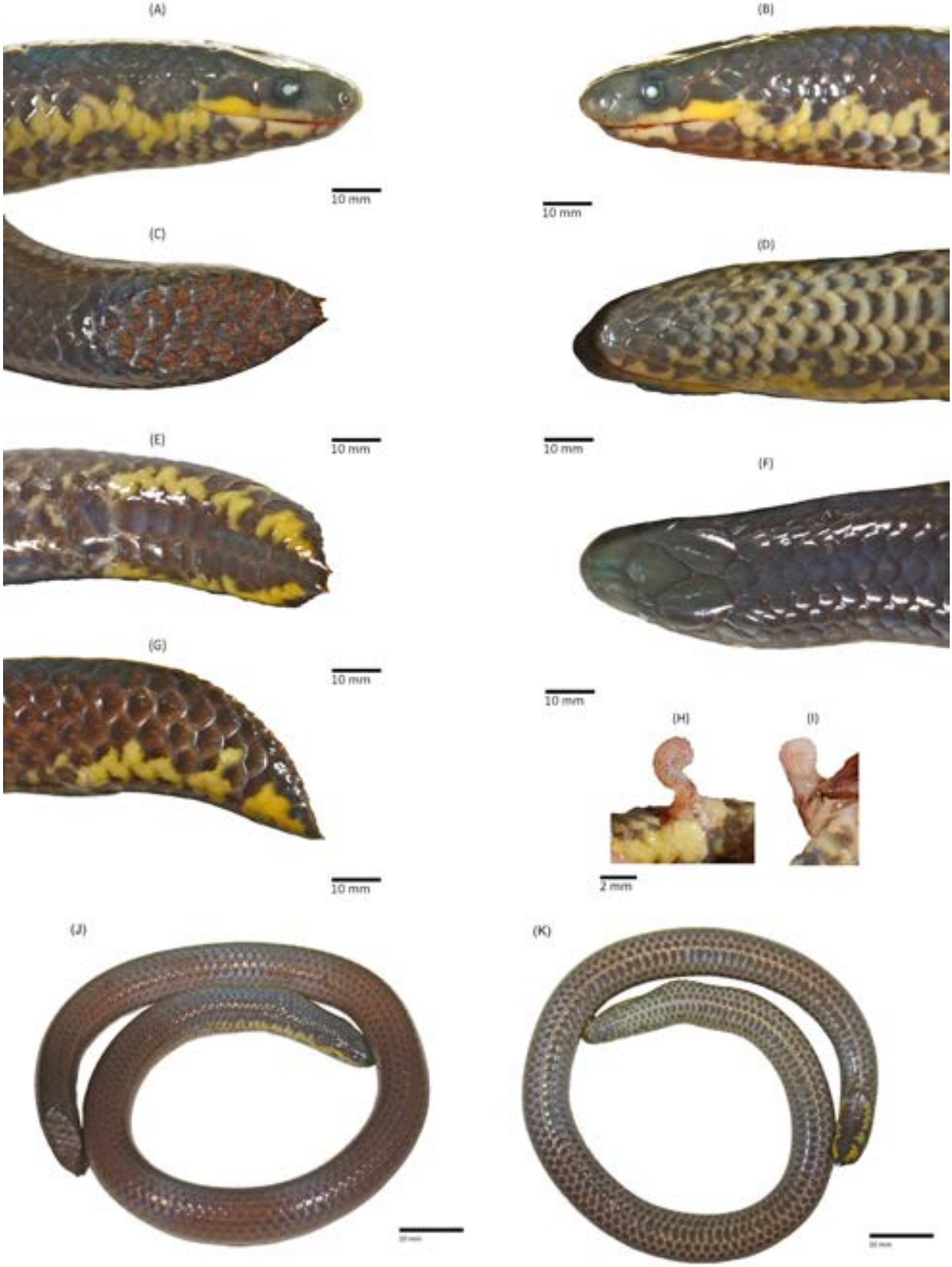

Image 1. Profile close-ups of head and tail shield in lateral, dorsal and ventral views (A–I) and entire, dorsal and ventral views (J–K) of BNHS 3359, holotype of *Uropeltis rajendrani* sp. nov. © N.S. Achyuthan.

smaller blackish-brown spots.

Hemipenis: Everted; organ short (3mm), and fairly stout (1.92mm); extending up to 2nd subcaudal scales; unilobed, not forked at tip; lobe head (2.00mm) wider than pedicel (1.37mm), sulcal lip rounded, spinose with tiny flounces, pedicel in asulcate view plain and smooth; in sulcate view, sulcus spermaticus feebly visible as a reddish groove, extending down to the base from the lobe head.

Dentition: Maxillary (upper jaw) teeth – 8/8 (L/R); Dentary (lower jaw) teeth – 10/9 (L/R). No diastema visible; all teeth present in sockets; teeth apparently equal in size and shape.

Variation: Paratypes (n=2) are topotypic specimens that were more damaged road kills than the holotype, permitting fewer variables to be scored. In general, agreeing with the holotype and showing the following intraspecific variation: dorsal scale rows: 17:16:16; ventrals: 145, 147; subcaudals: 11 pairs; snout-vent length: 163, 183mm, tail length: 12, 13.5mm; body width: 7.07, 7.74 mm (trampled specimens); head length: 7.84, 7.79mm; head width: 5.83, 5.91mm; interocular distance: 2.05, 2.14mm; internarial distance: 2.04, 1.89mm.

Field observations (also see Ganesh & Arumugam 2016): The new species was sighted in and around the type locality and in other parts of the higher slopes (> 900m) with adequate vegetation cover of Kolli Hill complex of Salem and Namakkal. This species has previously been sighted from Semmedu, Solakkadu, Kuzhivalavu, Seekuparai, Thenur Nadu, Selur Nadu, Gundur Nadu settlements (see Ganesh & Arumugam 2016). This is a burrowing snake, like all others of its family and resting individuals have been observed under fallen logs, rocks and stones and have also been dug out during active searches. It is active during night time when the individuals forage out on to land, but was once sighted outside soil surface at 11.00h in a closed canopy forest on a rainy day. A young one (SVL: 70mm) was sighted in July. The new species inhabits evergreen and semi-evergreen forests covering the hill tops and, also, marginally cultivated habitats such as coffee and cardamom plantations. It has never been recorded within other modified monocultures such as pineapple, tapioca, eucalyptus, and silver oak (Ganesh & Arumugam 2016). The new species is regularly killed by vehicular traffic on the ghat roads as attested by the type specimens that are comprised of road kills, especially during the monsoons (June–September). This is a potentially threatened species as its entire geographic range that covers only a single hill range, is outside any protected area network and is undergoing a continual onslaught of anthropogenic pressures resulting in population declines (see Ganesh & Arumugam 2015).

Comparisons and Differential diagnosis: The new species is here compared with all 24 recognized species of *Uropeltis* (see Pyron et al. 2016; Jins et al. 2018). By having a thickened, circumscribed, concave caudal disc *Uropeltis rajendrani* sp. nov. clearly differs from the following 14 species: *U. bhupathyi, U. ellioti, U. nitida, U. grandis, U. aculate, U. dindigalensis, U. beddomei, U. macroryncha, U. woodmasoni, U. broughami, U. aculate, U. petersi, U. liura*, and *U. pulneyensis*. Further, *Uropeltis rajendrani* sp. nov. also differs from the remaining congeners (after Gower et al. 2008; Ganesh et al. 2014) with a thickened, circumscribed, caudal shield categorized under Smith's (1943) Group II A & B as follows (only opposing suite of character states listed): *U. arcticeps* (southern Western Ghats): dorsal scales lacking a clearly defined yellow scale border; ventral scale counts much lower (127–128); *U. bicatenata* (northern Western Ghats): yellowish scalloping chain-like pattern across both sides of the body; *U. broughami* (southern Western Ghats): 19 midbody scale rows; rostral scale much produced and ridged with a dorsal keel; dorsum brown with distinct small, yellow-black-edged transverse ocelli; ventral scale counts higher (181–230); *U. ceylanica* s. auct. (Western Ghats): anterior dorsum without distinct yellow spots; venter lacking a clearly defined brownish scale border; ventral scale counts much lower (119–146; 130 in holotype – Gower et al. 2008); *U. macrolepis* complex (northern Western Ghats): 15 midbody scale rows; lower ventral scale counts (128–140); dorsum blackish-brown with yellow broken spots forming zig-zag crossbars or annuli or a pair of distinct, thick, yellowish-orange paravertebral stripes extending across most of the body except near neck, where there are two large orange spots; *U. madurensis* (southern Western Ghats): dorsal scales with a clearly defined yellow scale border; *U. myhendrae* (southern Western Ghats): dorsum with brownish-black body, each scale with yellowish posterior border forming more or less complete band or annuli; part of rostral visible from above distinctly longer than its distance from frontal; ventral scales comparatively lower (139–156); *U. phipsoni* (northern Western Ghats): a pair of yellowish lateral streaks along both sides of the body; part of rostral visible from above distinctly longer than its distance from the frontal; ventral scales comparatively lower (138–157); *U. rubromaculata* (southern Western Ghats): presence of two large red caudal spots; much higher ventral counts (127–136); *U. rubrolineata* (southern Western Ghats): presence

Image 2. Live uncollected topotypes (adult and juvenile), view of forest cover at the type locality – the Kolli Hill complex, southern Eastern Ghats, Tamil Nadu. © S.R. Ganesh.

of two ventrolateral red stripes; much higher ventral counts (165–172); *U. shorttii* (southern Eastern Ghats, allopatric): dorsal body brownish or bluish-black, with distinct yellowish annuli or crossbars; ventral counts comparatively lower (141–156).

DISCUSSION

Uropeltis rajendrani sp. nov. is the 25th species in the genus *Uropeltis* to be described. It is the second recently described species in this genus (after *U. bhupathyi* Jins et al., 2018) as well as from this hill complex (after *Rhinophis goweri* Aengals & Ganesh, 2013). This finding of undocumented diversity of uropeltid snakes from the southern Eastern Ghats is in agreement with the discovery of *R. goweri* by Aengals & Ganesh (2013) and the revival of *U. shorttii* (Beddome, 1863) by Ganesh et al. (2014). The new species is sympatric with *R. goweri* and is allopatric with *U. shorttii* that is endemic to a northerly massif—the Shevaroys (see Ganesh et al. 2014; Ganesh & Arumugam 2016). Taxonomically, this population was discovered only recently and has been previously referred to as *Uropeltis* cf. *ceylanica* by Ganesh & Arumugam (2016). This is in contrast with description of *U. bhupathyi* as it is a long-known taxon, but misrepresented as *U. ellioti* sensu lato (see Jins et al. 2018).

Massifs in the southern Eastern Ghats contain disjunct, elevated (1,400m) hill ranges. This provides an ideal setting for the evolution of a distinct assemblage of hill forest herpetofauna in the upper reaches, as has been discovered by Ganesh & Arumugam (2016) and Ganesh et al. (2018). Precisely, the Kolli Hill complex, is an emerging center of reptile endemism as exemplified by the finding of other range-restricted reptiles such as the new geckoes *Hemiphyllodactylus kolliensis* and *Hemidactylus kolliensis* (see Agarwal et al. 2019a,b),

apart from the pioneering discovery of *Rhinophis goweri* by Aengals & Ganesh (2013) previously, from the same general area. *Uropeltis rajendrani* sp. nov. thus joins an increasing array of point-endemic vertebrates restricted to the Kolli massif complex. This new discovery underscores the need for research and conservation attention to the Kolli Hill complex, and the southern Eastern Ghats in general.

REFERENCES

Aengals, R. & S.R. Ganesh (2013). *Rhinophis goweri* — A new species of shieldtail snake from the southern Eastern Ghats, India. *Russian Journal of Herpetology* 20(1): 61–65.

Agarwal, I., A.M. Bauer, V.B. Giri & A. Khandekar (2019). An expanded ND2 phylogeny of the brookii and prashadi groups with the description of three new Indian *Hemidactylus* Oken (Squamata: Gekkonidae). *Zootaxa* 4619(3): 431–458.

Agarwal, I., A. Khandekar, V.B. Giri, U. Ramakrishnan & K.P. Karanth (2019). The hills are alive with geckos! A radiation of a dozen species on sky islands across peninsular India (Squamata: Gekkonidae, *Hemiphyllodactylus*) with the description of three new species. *Organisms Diversity & Evolution* 19: 341–361. https://doi.org/10.1007/s13127-019-00392-5

Beddome, R.H. (1886). An account of the earth-snakes of the peninsula of India and Ceylon. *Annals and Magazines of Natural History* 17(5): 3–33.

Ganesh, S.R. & M. Arumugam (2015). Microhabitat use and abundance estimates of understorey herpetofauna in the highlands of southern Eastern Ghats, India, with observations on roadkill mortalities. *Asian Journal of Conservation Biology* 4: 143–150.

Ganesh, S.R. & M. Arumugam (2016). Species richness of montane herpetofauna of southern Eastern Ghats, India: a historical resume and a descriptive checklist. *Russian Journal of Herpetology* 23(1): 7–24.

Ganesh, S.R., R. Aengals & E. Ramanujam (2014). Taxonomic reassessment of two Indian shieldtail snakes in the *Uropeltis ceylanicus* species group (Reptilia: Uropeltidae). *Journal of Threatened Taxa* 6(1): 5305–5314. https://doi.org/10.11609/JoTT.o3636.5305-14

Ganesh, S.R., A. Kalaimani, P. Karthik, N. Baskaran, R. Nagarajan & S.R. Chandramouli (2018). Herpetofauna of southern Eastern Ghats, India – II from Western Ghats to Coromandel Coast. *Asian Journal of Conservation Biology* 7(1): 28–45.

Ganesh, S.R. (2015). Shieldtail snakes (Reptilia: Uropeltidae) – the Darwin's finches of south Indian snake fauna? pp: 13–24. In: Kannan, P. (Ed.). *Manual on identification and preparation of keys of snakes with special reference to their venomous nature in India*. Proceedings by Govt. Arts College, Udhagamandalam, Tamil Nadu, India, 42pp.

Gower, D.J. & J.D. Ablett (2006). Counting ventral scales in Asian anilioid snakes. *The Herpetological Journal* 16: 259–263.

Gower, D.J., A. Captain & S.S. Thakur (2008). On the taxonomic status of *Uropeltis bicatenata* (Günther) (Reptilia: Serpentes: Uropeltidae). *Hamadryad* 33(1): 64–82.

Jins, V.J., F.L. Sampaio & D.J. Gower (2018). A new species of *Uropeltis* Cuvier, 1829 (Serpentes: Uropeltidae) from the Anaikatty Hills of the Western Ghats of India. *Zootaxa* 4415(3): 401–422.

McDiarmid, R.W., J.A. Campbell & T.A. Toure (1999). *Snake Species of the World: A Taxonomic and Geographic Reference*. The Herpetologists' League, Washington DC, 511pp.

Pyron, R.A., H.D. Kandambi, C.R. Hendry, V. Pushpamal, F.T. Burbrink & R. Somaweera (2013). Genus-level phylogeny of snakes reveals the origins of species richness in Sri Lanka. *Molecular Phylogenetics and Evolution* 66(3): 969–978.

Pyron R.A., S.R. Ganesh, A. Sayyed, V. Sharma, V. Wallach & R. Somaweera (2016). A catalogue and systematic overview of the shield-tailed snakes (Serpentes: Uropeltidae). *Zoosystema* 38(4): 453–506.

Rajendran, M.V. (1985). *Studies in uropeltid snakes*. Madurai Kamaraj University, Madurai, India, 132pp.

Smith, M.A. (1943). *Fauna of British India including Ceylon and Burma. Vol–III Serpentes*. Taylor & Francis, London, 583pp.

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

Whitaker, R. & A. Captain (2004). *Snakes of India – The Field Guide*. Draco Books, Chengelpet, South India, 481pp.

Appendix 1. List of preserved voucher specimens studied

Uropeltis ceylanica: MAD no number from Perambikulam; another unnumbered specimen from Cochin; MAD 1938 from Attikan (Mysore) E. Barne's collection, from ca. 1,500m, in June 1938; more unnumbered specimens, from Nilgiris, Cochin and Travancore; CESS 092 from Pakshipathalam, Bramgiri, Kannur District, Kerala; CESS 281, from Coorg, Madikeri District, Karnataka.
Uropeltis dindigalensis: MAD no number from Sirumalai, Madura District.
Uropeltis ellioti: CESS 079, from Chemmunji, Peppara WS, Trivandrum District, Kerala; CSPT/S-81 from Shevaroys, Salem District, Tamil Nadu.
Uropeltis grandis: MAD no number from Anamalai, Coimbatore District.
Uropeltis liura: CSPT/S-3, 2 e.g., from Madurai Hills, Madurai District, Tamil Nadu.
Uropeltis maculata: CESS186 from Anaimudi Shola NP, Idukki District, Kerala; MAD no number from Anamalai, Coimbatore District.
Uropeltis madurensis: CSPT/S-6, 1 e.g. from High Wavys, Theni District, Tamil Nadu.
Uropeltis myhendrae: CSPT/S-5, 1 e.g. from Vannathipparai, Kanyakumari District, Tamil Nadu.
Uropeltis nitida: CESS408 from Nelliampathy RF, Palghat District, Kerala.
Uropeltis* cf. *ocellata: MAD no number from Perambikulam; more unnumbered specimens from Cochin and Kodaikanal, Palni Hills.
Uropeltis petersi: CSPT/S-7a 1 e.g. from Kodaikanal, Dindigul District, Tamil Nadu.
Uropeltis pulneyensis: MAD 1929 6 e.g., collected by E. Barnes, during April-May, from 1,800–2,040 m, Kodaikanal, Palni hills; CSPT/S-4a, 1 e.g. from Kodaikanal, Dindigul District, Tamil Nadu.
Uropeltis rubromaculata: MAD no number from Anamalai, Coimbatore district; CSPT/S-7 from Anaimalai, Coimbatore district, Tamil Nadu; CESS 322, from Anaimalai WLS, Tirupur District, Tamil Nadu.
Uropeltis shorttii: CSPT/S-80, 2 e.g. from Shevaroy Hills, Salem District, Tamil Nadu.
Uropeltis woodmasoni: CSPT/S-4, 1 e.g. from Anaimalai, Coimbatore District, Tamil Nadu.

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COMMUNICATION

The insect fauna of Tenompok Forest Reserve in Sabah, Malaysia

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Abstract: The insect fauna in Tenompok Forest Reserve, adjacent to Mount Kinabalu in Sabah was surveyed. Nocturnal insect diversity was moderately high, compared to other forest reserves surveyed earlier. Species richness, however, was moderate, with an average of 73 species from 84 individuals recorded from a 1m^2 area of the light-trapping cloth. At least 20 Bornean endemic insect species were recorded from this rapid biodiversity assessment, which include 19 moth species and one beetle species. The endemics and other insects of conservation interest recorded during the survey provide salient information to enhance the conservation effort of this forest which connects Kinabalu Park and the Crocker Range Park. Such information provides inputs towards recommendations on high conservation value (HCV) of the area that would be incorporated in the formulation of the forest management plan. Issues affecting the insect fauna and recommendations on insect diversity enhancement and conservation are highlighted in this paper.

Keywords: Biodiversity conservation, diversity, Heart of Borneo, insect fauna, Tenompok Forest Reserve.

Malay abstract: Satu tinjauan fauna serangga telah dijalankan di Hutan Simpan Tenompok, berhampiran dengan Gunung Kinabalu di Sabah. Kepelbagaian serangga malam adalah sederhana tinggi berbanding dengan hutan-hutan simpan lain yang telah dikaji sebelum ini. Walau bagaimanapun, kekayaan spesies adalah sederhana, dengan purata 73 spesies dari 84 individu yang telah direkodkan dari 1m2 kain putih perangkap cahaya. Sekurang-kurangnya 20 spesies serangga endemik kepada Borneo telah direkodkan dari penilaian kepelbagaian pantas ini, yang merangkumi 19 spesies rama-rama dan satu spesies kumbang. Spesies endemik serta serangga berkepentingan konservasi yang lain memberikan maklumat yang boleh membantu dalam mempertingkatkan usaha konservasi hutan ini, yang menghubungkan Taman Kinabalu dan Taman Banjaran Crocker. Maklumat sebegini membekalkan input terhadap rekomendasi untuk kawasan konservasi bernilai tinggi dalam penyediaan pelan pengurusan hutan. Isu-isu berkaitan dengan fauna serangga serta rekomendasi untuk konservasi dan peningkatan kepelbagaian serangga turut diketengahkan dalam penerbitan ini.

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Author contribution: AYCC and VP participated in the survey. SB is an expert on beetles and other montane insects. He contributed significantly in identification.

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INTRODUCTION

The Malaysian state of Sabah in Borneo is known for its remarkable biodiversity and iconic wildlife species (Oldfield 2014), including insects (Chung et al. 2015). These are the natural treasures that need to be protected and conserved, as stipulated in the Sabah Biodiversity Strategy 2012–2022 (Anon. 2012). This strategy is in line with the National Policy on Biological Diversity (Anon. 2016) that seeks to conserve Malaysia's biodiversity and to ensure that its components are utilised in a sustainable manner for continued progress and socio-economic development. In line with this strategy, the Sabah Forestry Department has been in the forefront in implementing biodiversity conservation programmes under the Heart of Borneo (HoB) Initiative. The HoB initiative is a 'three countries – one vision' responsibility, which is to protect and conserve the rich biodiversity within this area. It is a voluntary transboundary cooperation aimed at conserving and managing the ecologically inter-connected highlands of Borneo and parts of the adjacent foothills and lowland rainforests, which straddle the borders of three ASEAN countries, covering an area of approximately 2,00,000km^2 (Anon. 2013).

Insect numbers are declining globally (Basset & Lamarre 2019). Hence, much attention should be given to this group of living organisms. Within the HoB initiative, biodiversity documentation has been extensively carried out in Sabah, encompassing insect diversity as well, e.g., Chung et al. (2013, 2016a,b), since much is still unknown about the insect fauna compared to the large and more charismatic animals (Anon. 2012). Despite their small size in comparison with other wildlife, they are ecologically important in the functioning of the tropical ecosystems because of their high species richness and abundance (Hill & Abang 2005).

This scientific survey was carried out on 5–9 September 2016, with the base camp located at Kg. Kilimu in Ranau. The objectives of this study were to document the insect fauna of Tenompok Forest Reserve (FR) under the HoB Initiative, and to investigate issues affecting insect diversity, as well as to provide recommendations that would contribute towards biodiversity conservation of the study area. Research findings from this study would enhance this area as a Class I FR to promote the connectivity between Kinabalu Park (KP) and Crocker Range Park (CRP) under the Ecolinc Kinabalu project. This project is a connectivity conservation effort initiated by Sabah Parks to improve ecological connectivity between KP and CRP. Although KP and CRP reside on the same range, the parks are physically separated from each other; their boundaries are separated by a distance of approximately 10km at the closest point. Forest fragmentation that occurs within these two protected areas due to uncontrolled deforestation and expansion of agriculture and human activities has been an issue.

MATERIALS & METHODS

Study area

Tenompok FR (Figure 1 and Image 1) is a Class I Protection FR and is situated adjacent to Mount Kinabalu (4,095m) (Image 2), the tallest mountain in Malaysia. It is located beside the Kota Kinabalu-Ranau highway, approximately 92km east of Kota Kinabalu and 19km west of Ranau. With an area of 1,984ha the forest reserve is under the jurisdiction of the Ranau District Forestry Officer. It is surrounded by villages ('kampung' in Malay and often used as 'Kg.' before the name of the village), namely Kg. Bundu Tuhan in the east, Kg. Torolobou and Kg. Toboh in the south, Kg. Kiau in the north, and Kg. Tiong in the west.

The forest is mountainous, (1,040–1,650 m), with slope amplitudes in excess of 300m and normally greater than 25°. The soil associations in this reserve are mainly Croker and Trusmadi, based on the soil classification in Sabah (Acres et al. 1975). The reserve is a water catchment area for Kg. Bundu Tuhan and many other villages. Several rivers flow from this reserve, namely Liodan, Kenipir, Terleboh, Luminanap, Kuriau, Kipalapok and Tomis. The vegetation type of the reserve is largely lower montane forest.

Insect sampling methods

Light trap was used to sample nocturnal insects while sweep nets and forceps were used to sample diurnal insects.

Light trap

The trap consists of a vertical white sheet (2 X 2 m) illuminated by a 250W mercury-lithium bulb. It was powered by a portable Yamaha generator. The trap was set up in an open area facing the forest reserve, from 19.00 to 21.00 h. A GPS (Model: Garmin GPSMAP 60CSx) was used to determine the coordinates of each sampling site. Temperature and relative humidity were taken with a digital hygrometer from Extech Instruments (model no. 445702). The details of each trapping position are given in Table 1.

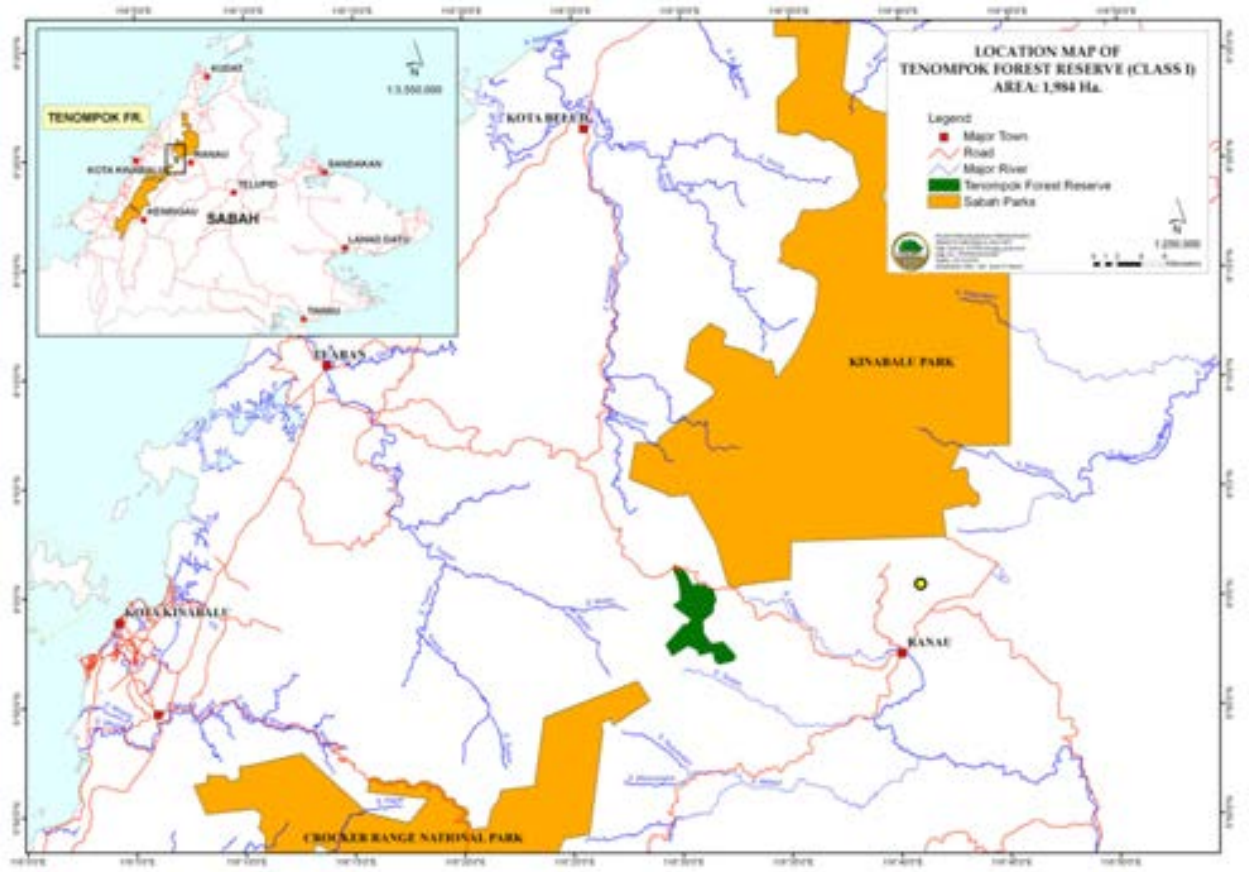

Figure 1. Location of Tenompok Forest Reserve in Sabah (inset) and the reserve (green colour) between Kinabalu Park and Crocker Range Park, and the location of the base camp (yellow dot), near Ranau.

Image 1. Tenompok FR, as viewed from Panataran at the entrance of Kinabalu Park.

To evaluate diversity of the sampling area, insect species and individuals (≥ 5mm) within the 1 X 1 m^2 at the centre of the white cloth were enumerated from 20.30 to 21.00 h. This is a rapid biodiversity assessment method because by the end of the sampling time, morphospecies and individual numbers can be obtained. The data was used to calculate diversity indices. This method is simple, fast and can be carried out by non-insect specialists. To avoid compounding human error, the same staff was assigned to count the species and individual numbers throughout the sampling period. Light trapping was conducted within the compound of the Tenompok nursery (approximately 0.5 acre) but facing different positions of the forest on different nights. The term 'position' is used here rather than site because of the limited space within the nursery and the authors acknowledge that these positions may not be independent of one another. There were no other suitable sites for setting up the light trap in other parts of the forest due to logistical difficulties and safety reasons at night.

Sweep net and manual collection

Sweep nets were used to collect flying insects while other insects were sampled using fine forceps. Butterflies were put in triangle papers while other specimens were

Image 2. Mt. Kinabalu, as viewed from Kg. Bundu Tuhan, located beside Tenompok FR.

Table 1. Light-trapping positions at the nursery of Tenompok FR.

Sampling position	Coordinates	Elevation (m)	Temp. (°C)	Humidity (%)	Sampling date	Remarks
A	6.0205°N 116.499°E	1326	17.9	88	6 Sep	Cloudy
B	6.020°N 116.499°E	1329	18.0	90	7 Sep	Cloudy
C	6.020°N 116.499°E	1334	17.9	91	8 Sep	Cloudy and misty

put in vials with 75% ethanol solution. Sampling was conducted along the trails established previously and also old skid trails. Details of the daytime sampling sites are listed in Table 2.

Table 2. Daytime sampling sites in Tenompok FR from 5 to 9 September 2016.

Sampling site	Starting point coordinates	Elevation (m)
1 -- (Along the forest trail at Tenompok nursery)	6.020°N 116.499°E	1327–1404
2 -- (Along the view point trail at Tenompok nursery)	6.020°N 116.499°E	1327–1397
3 -- (Along the trail at Kg Bundu Tuhan)	5.962°N 116.537°E	1224–1461

Insect specimens and identification

In this survey, focus was given to certain insect groups, i.e., butterflies, moths, and beetles. Other insects were recorded when encountered but without any concerted effort. Only insects with conservation interest and potential indicator insect species were sampled, so as to minimize the workload at the laboratory in preparing the specimens for identification. This is also one of the best practices adopted to minimize stress and disturbance to biodiversity, as pointed out by Costello et al. (2016) and Didham et al. (2019) on field work ethics in biological research. Photographs were taken with DSLR Nikon D800E and Nikon Coolpix cameras to facilitate identification. Common insects were not sampled but photographs were taken for record purposes. Some insect photos were not taken on the white sheet (on purpose) after the enumeration was conducted.

Selected specimens were dry-mounted and sorted to family and some to the genus and species level. The specimens sampled from this survey are deposited at the Forest Research Centre, Sepilok, Sabah. Dry-mounted specimens were identified based on the FRC Entomology Collection and various reference materials, e.g., Otsuka (1988, 2001) and Kirton (2014) for butterflies; Holloway (1983, 1985, 1986, 1987, 1988, 1989, 1993, 1996, 1997, 1998, 1999, 2001, 2003, 2005, 2008, 2009, 2011), Robinson et al. (1994), and Sutton et al. (2015) for moths; Fujita (2010), Makihara (1999), and Tung (1983) for beetles; Orr (2003) and Tang et al. (2010) for dragonflies. Some other insects were identified based on Hill & Abang (2005).

Diversity indices

The diversity indices, namely Shannon Wiener, Simpson, and Fisher Alpha were calculated through a diversity analysis software by Seaby & Henderson (2007), based on Magurran (2004) and Southwood & Henderson (2000). Merits and limitations of diversity measurements are provided by Beck & Schwanghart (2010). Knowing that biodiversity is a multifaceted phenomenon and the existence of various methods in diversity measurements, we used the same few indices that were also applied in the past insect surveys

throughout Sabah, for comparison purposes.

Shannon Wiener Index (H')

This index is calculated in the following way:

$H' = -\sum p_i \ln p_i$

where p_i is the proportion of individuals found in species i. For a well-sampled community, we can estimate this proportion as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community. Since by definition the p_is will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why we take the inverse of the sum. Typical values are generally between 1.5 and 3.5 in most ecological studies. The Shannon index increases as both the richness and the evenness of the community increase.

Simpson Index (D)

This index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species:

$D_s = \sum p_i^2$

where again p_i is the proportion of individuals found in species i. For a finite community, this is

$D = \sum n_i(n_i - 1)/N(N - 1)$

D is a measure of dominance, so as D increases, diversity (in the sense of evenness) decreases. Thus, Simpson's index is usually reported as its complement 1-D (or sometimes 1/D or –lnD). In Seaby & Henderson (2007), it is reported as 1/D, which is also known as Simpson's reciprocal index. It is heavily weighted towards the most abundant species in the sample while less sensitive to species richness (Magurran 1988). Hence, the value will be low if there is a very abundant species.

Fisher Alpha Index (S)

This is a parametric index of diversity that assumes that the abundance of species follows the log series distribution:

$\alpha x, \alpha x^2/2, \alpha x^3/3, \ldots \alpha x^n/n$

where each term gives the number of species predicted to have 1,2,3,....n individuals in the sample. The index is the alpha parameter. This is a useful index, which has been widely used. It is estimated by an iterative procedure that may take an appreciable amount of time with large data sets.

Insect fauna in conservation implications

Within ecological science, there has been a large focus on whether a reduction in the diversity of the entities of organisms – biodiversity – is impacting ecological process and ecological services. Various studies have highlighted that there is indeed a positive relationship between diversity and functioning in terms of biomass production and some other functions (Balvanera et al. 2006; Cardinale et al. 2006; Isbell et al. 2011). Biodiversity conservation should focus on ecosystem function, rather than on a particular species, that could serve as a framework for addressing the current urgent conservation challenges (Peh & Lewis 2012). In this study, it is hoped that the documentation of insect fauna would provide an impetus for biodiversity conservation of Tenompok FR as insects are ecologically important in the functioning of the ecosystem.

RESULTS AND DISCUSSION

Overall insect diversity

The nocturnal insect diversity was moderately high, as shown in Table 3. The mean Shannon Index was 4.2 while Simpson index was 206.5 and Fisher alpha index was 260.2. Species number and abundance, however, were moderate, with an average of 77 species and 84 individuals recorded within a $1m^2$ light-trapping cloth.

During light-trapping, the temperature was cold, between 17°C and 18°C with relatively high humidity, between 88% and 91% (Table 1). The distribution of insect species from the light-trapping positions is reflected in the species-rank abundance curves in Figure 2. Position C recorded the most species (85), as indicated with the long tail graph, and the Shannon's index of 4.37 was the highest among the three positions. Position C also shows the steepest curve, with six specimens from one interesting moth species, *Areas galactina*. This was the most prominent species throughout the three nights of light-trapping.

When the nocturnal insect richness is compared with other forest reserves, Tenompok FR (in red) appeared to be moderate as it is ranked 8th of the 19 sites in Sabah (Figure 3a). In terms of nocturnal insect diversity, it is moderately high (ranked 5th of the 19 sites) and almost comparable to many other montane forest reserves sampled previously, such as Bukit Hampuan FR and Crocker Range FR (Figure 3b).

Many Bornean endemic species were recorded from Tenompok FR during the survey, as listed in Table 4. The endemics included 19 moth species (Image 3) and one beetle species (Image 4). This information provides input towards recommendations on High Conservation

Table 3. Insect diversity within a 1 x 1 m² of the light-trapping cloth, as sampled in Tenompok FR.

	Sampling position	Species	Ind.	Shannon	Simpson	Fisher Alpha
1	A	77	93	4.26	178.3	210.1
2	B	56	64	3.98	224	214.3
3	C	85	96	4.37	217.1	356.2
	Mean	73±15	84±18	4.2±0.2	206.5±24.6	260.2±83.2

Values (HCV) of the area, namely HCV 1 as stipulated in HCVRN (2013). From the past insect surveys under the HoB programme in Sabah, Crocker Range FR recorded the highest number of endemics with 27 species (Chung 2016a), followed by Bukit Hampuan FR with 19 species (Chung 2013). Hence, Tenompok FR recorded the second highest number of endemics. All the three forest reserves are located between 1,300 to 2,000 m within the Crocker Range, which indicate that the montane forest is a haven for endemic insect species. Merckx et al. (2015) reported that tropical mountains are hot spots of biodiversity and endemism.

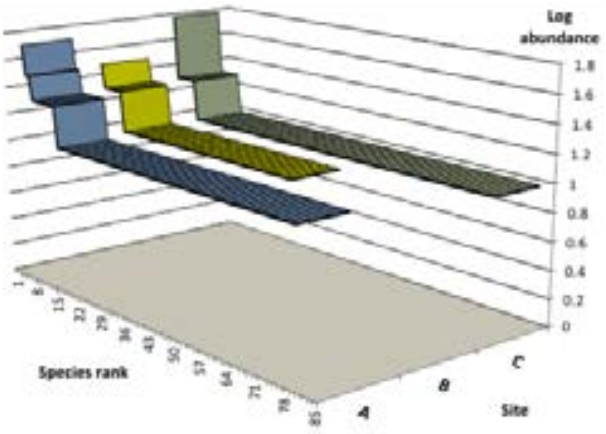

Figure 2. Species-rank abundance curves of the light-trapping in Tenompok FR.

Butterflies (Lepidoptera)

At least 13 butterfly species were recorded, as listed in Appendix 1. Most of the butterflies were recorded at Sg. Liden in Kg. Bundu Tuhan, at the fringe of the forest reserve. Among the interesting butterflies sighted were

Table 4. Bornean endemic insect species from Tenompok FR during the survey. The photographs of moth and beetle species are shown in Figures 6 and 7, respectively.

	Species	Author	Order	Family
1	*Odontolabis leuthneri*	Boileau	Coleoptera	Lucanidae
2	*Amata prepuncta*	Holloway	Lepidoptera	Erebidae
3	*Auriculoceryx pterodactyliformis*	Holloway	Lepidoptera	Erebidae
4	*Metaemene albigrisea*	Holloway	Lepidoptera	Erebidae
5	*Cyana cruentata*	Talbot	Lepidoptera	Erebidae
6	*Cyana saulia*	Swinhoe	Lepidoptera	Erebidae
7	*Garudina macrolatana*	Holloway	Lepidoptera	Erebidae
8	*Lyclene mesilaulinea*	Holloway	Lepidoptera	Erebidae
9	*Monosyntaxis trimaculata*	Hampson	Lepidoptera	Erebidae
10	*Spilosoma groganae*	Holloway	Lepidoptera	Erebidae
11	*Asota kinabaluensis*	Rothschild	Lepidoptera	Erebidae
12	*Ozola submontana*	Holloway	Lepidoptera	Geometridae
13	*Plutodes evaginata*	Holloway	Lepidoptera	Geometridae
14	*Problepsis borneamagna*	Holloway	Lepidoptera	Geometridae
15	*Spaniocentra apatelloides*	Holloway	Lepidoptera	Geometridae
16	*Buzara saikehi*	Holloway	Lepidoptera	Noctuidae
17	*Mudaria magniplaga*	Walker	Lepidoptera	Noctuidae
18	*Manoba coadei*	Holloway	Lepidoptera	Nolidae
19	*Tyana marina*	Warren	Lepidoptera	Nolidae
20	*Panacra psaltria*	Jordan	Lepidoptera	Sphingidae

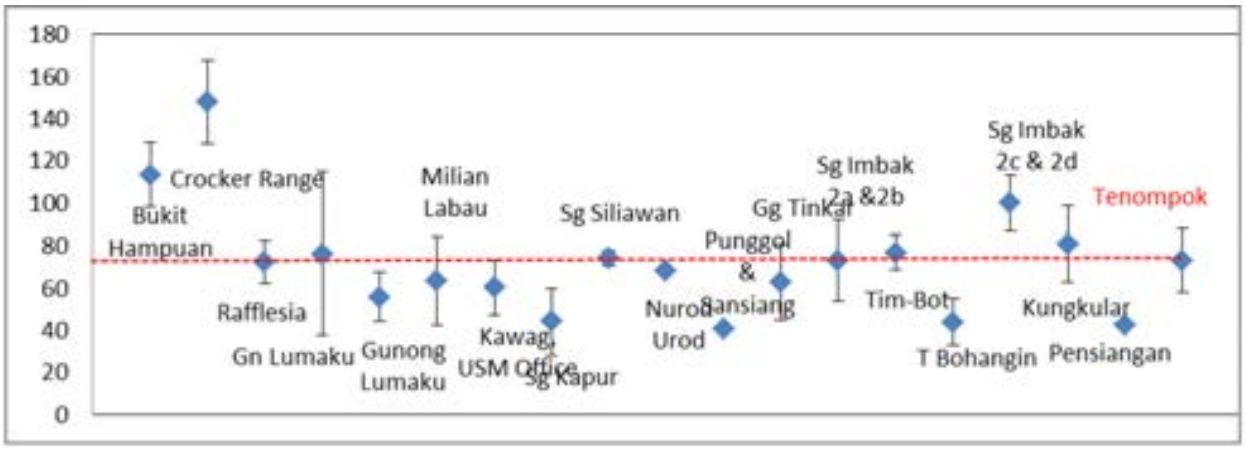

Figure 3a. Species number (±standard deviation) within one metre squared cloth as assessed through light-trapping in various forest reserves in Sabah.

Figure 3b. Shannon index (±standard deviation) within one metre squared cloth as assessed through light-trapping in various forest reserves in Sabah.

the Rajah Brooke's Birdwing *Trogonoptera brookiana* which is the national butterfly of Malaysia and the Golden Birdwing *Troides amphrysus*, a flagship species of Sabah (Otsuka 2001).

Moths (Lepidoptera)

Some 102 moth species were recorded during this study (Appendix 2). A total of 19 endemic species were documented (Image 3), which represents 19% of the moths recorded during the survey. In terms of percentage, more endemic moths were recorded in Crocker Range FR (Chung 2016a) and Bukit Hampuan FR (Chung 2013), with 33% and 23% respectively. In this paper, all Arctiidae and Lymantriidae moths are classified under Erebidae based on DNA analyses by Zahiri et al. (2010 & 2011) and taxonomic changes highlighted by Holloway (2011).

Beetles (Coleoptera)

At least nine species of macro beetles were documented (Appendix 3). One Bornean endemic species was recorded, namely *Odontolabis leuthneri* (Image 4) of the telodonte form (Fujita 2010). This stag beetle was sighted during day time at 1,600m. A large long-horned beetle, *Batocera tigris*, (about 65mm) was attracted to the light trap at the Tenompok nursery. It is a rare beetle in Borneo although it is known to be distributed in Peninsular Malaysia, Thailand, Sumatra, Java and Borneo. Quite a number of the soldier beetles, *Mimopolemius* sp. of the family Cantharidae were sighted while trekking along the trail at Kg. Bundu Tuhan.

Other insects

At least 17 other insect species were recorded which include termites, bugs, fig wasps, honeybees, ants, night wasps, praying mantis, dragonflies, damselflies and

Amata prepuncta
(Erebidae, Arctiinae)

Auriculoceryx pterodactyliformis
(Erebidae, Arctiinae)

Cyana cruentata
(Erebidae, Arctiinae)

Cyana saulia
(Erebidae, Arctiinae)

Garudina macrolatana
(Erebidae, Arctiinae)

Lyclene mesilaulinea
(Erebidae, Arctiinae)

Monosyntaxis trimaculata
(Erebidae, Arctiinae)

Spilosoma groganae
(Erebidae, Arctiinae)

Asota kinabaluensis
(Erebidae)

Metaemene albigrisea
(Erebidae, Boletobiinae)

Ozola submontana
(Geometridae)

Plutodes evaginata
(Geometridae)

Problepsis borneamagna
(Geometridae)

Spaniocentra apatelloides
(Geometridae)

Buzara saikehi
(Noctuidae)

Mudaria magniplaga
(Noctuidae)

Manoba coadei
(Nolidae)

Tyana marina
(Nolidae)

Panacra psaltria
(Sphingidae)

Image 3. Bornean endemic moths from Tenompok FR. © A.Y.C. Chung.

Image 4. Bornean endemic Stag Beetle *Odontolabis leuthneri* (telodonte form).

crickets. They are listed in Appendix 4.

Further pertinent observations on selected insects during the survey

Tiger Moth *Areas galactina* (Lepidoptera: Erebidae: Arctiinae)

This was the commonest moth species encountered during the three nights of light-trapping at the Tenompok FR nursery. It is a spectacular species because of its vibrant colours and interesting pattern (Image 5a & b). According to Holloway (1988), this insect cannot be confused with any other; the reticulate black markings of the forewings and the black spots on patagia and tegulae distinguish it from *Spilosoma* of the *ericsoni* group. The length of the forewings is 32–35 mm for male and 40–42 mm for female. It is distributed from northern India and southern China to Sundaland and the Philippines. Although widely distributed, it is not commonly encountered, normally found between 1,200m and 2,000m. In this survey, it was recorded from 1,300m. Although it is predominantly a montane species, it has been recorded in the lowland forest, such as Danum Valley (AYC Chung, unpublished data). There has been no information documented on the host plants.

Tiger Moth *Amerila* spp. (Lepidoptera: Erebidae: Arctiinae)

Two species of *Amerila* were recorded during the survey, namely *Amerila astreus* (Image 6a) and *Amerila omissa* (Image 6b–d). Like that of *Areas galactina*, both species are spectacular, with strikingly pink legs. Both were attracted to the light trap at the Tenompok FR nursery. They are similar externally in appearance except for the dorsal part of the abdomen. In *A. astreus*, it is entirely pink but only apically so in *A. omissa*. One of the interesting defense mechanisms that was observed

Image 5a. *Areas galactina* in resting position.

Image 5b. *Areas galactina* exposing its strikingly-coloured hind wings.

Image 6a. *Amerila astreus* with pink abdomen.

Image 6b. *Amerila omissa* with pink abdomen at the apical end.

Image 6c. The underside of *Amerila omissa*, with striking pinkish legs.

Image 6d. When alarmed, the moth produces yellow froth at the thorax.

during the survey was the secretion of acrid smelling yellow froth from the cervical glands at the anterior of the thorax when the moth was disturbed.

Carton ball-like termite nests (Termitidae: Nasutitermitinae)

While trekking along the trail (Sampling Site 3) from Kg Bundu Tuhan, at least 10 ball-like termite nests were sighted from 1,300 to 1,461 m. They were found on tree trunks (Image 7a) or hanging on tree branches (Image 7b), some of which were about the size of a football. The nests were constructed from soil and litter, mixed with termite saliva. This is interesting because it was rarely observed in previous surveys in other forest reserves, e.g., Chung et al. (2013, 2016a,b). The termites belong to the Nasutiterminae group because of their pointed-nose soldiers. They were observed carrying their food back to the nest openly in an organized manner (Image 7c).

Issues indirectly affecting insect diversity

Among many of the forest reserves in Sabah, Tenompok FR is considered one of those that is well-protected, with active participation from the local communities. The reserve is a source of water supply for many of the adjacent villages. Hence, the local communities have formed a committee to monitor and take care of the resources in the reserve. Sign boards were put up to warn trespassers into the reserve (Image 8). During the survey, a few villagers joined the researchers, indicating that they were keen to know more about the resources in the reserve.

Tenompok FR is located between Kinabalu Park and the Crocker Range Park. Hence, the reserve is important as a corridor connecting the two park areas, especially for wildlife movement. It is a stepping stone approach for movement of birds and insects, and the adverse impacts on inbreeding and decline in genetic diversity can be reduced. Staff from Sabah Parks and the Ecolinc project

Image 7a. The carton ball-like termite nest on a tree trunk in Tenompok FR.

Image 7b. The nest, hanging from a branch, could reach the size of a football.

Image 7c. The termites carrying their food back to the nest openly in an organized trail.

also participated in this survey to enhance their info on this area. The Ecolinc project was initiated some eight years ago under the EU-REDD+ programme to promote and enhance awareness to the local communities on forest connectivity and related activities on climate change and sustainable forest management. ECOLINC is the acronym for ECOlogical Linkage (conserving Sabah's heritage, empowering INdigenous Communities).

Although the forest is considered well-protected, the survey team also spotted a few animal traps in the forest. Among them was a pangolin trap at the base of a big tree (Image 9a). A few tree trunks were partly burnt previously, presumably to harvest honey from the stingless bees (Image 9b).

It is important for the local communities to work hand-in-hand with the relevant departments and agencies to tackle various issues pertaining to forest biodiversity which could indirectly affect insect population (Nilus et al. 2013). As shown in this brief study, relatively high diversity of insects and many endemic species were recorded. Hence, it is important to continue to protect the forest for its interesting biodiversity, in line with the goals of the Sabah Biodiversity Strategy (Anon. 2012), guided by the National Policy on Biodiversity.

Impediments in insect fauna study

Impediments to identification are one of the major reasons why insect data are not the prime focus in conservation, as the group is perceived too big and unwieldy to use. Misidentification potentially lead to overestimating or underestimating species richness, and these problems can extremely compromise research

Image 8. A signage put up by the villagers to warn trespassers.

involving diversity. Poor taxonomy can jeopardize the understanding of ecological patterns since they are based on richness and measurement of species turnover between sites, respectively.

For biodiversity conservation, taxonomy is important, primarily because in order to protect a taxon it is essential know it first, and secondly, because no conservation action can protect undescribed species. In this study, the enumeration on nocturnal insect diversity was based on morphospecies. Photographs of insects were taken and identification was based on various publications and the scientific reference collection at the Forest Research Centre, Sepilok. Various experts on certain insect groups also provided input in the identification of insects in this study.

CONCLUSION

From this study, the nocturnal insect diversity in Tenompok FR was moderately high when compared to other forest reserves surveyed earlier. Many endemic species were recorded in this montane forest.

The pioneer data from this rapid biodiversity assessment will serve as baseline information for other research work in future. Local university students could use these data for comparative study for long-term monitoring on the insect diversity status of Tenompok FR. The endemics and insect species with conservation interest recorded during the survey provide salient information to enhance the conservation of this forest as a Class I FR. Such information can also be used in promoting nature tourism in Tenompok which is located adjacent to the touristic Kinabalu Park and Crocker Range Park.

Issues, such as poaching and encroachment may indirectly affect the insect fauna. Relevant agencies would have to work hand-in-hand to tackle the issues

Image 9a. An old pangolin trap at the base of a big tree.

Image 9b. A tree trunk that had been set ablaze, presumably for the stingless bee honey.

with the local communities. Public awareness and environmental education would have to be enhanced among the villagers and their children who are living adjacent to the reserve to instill on them the importance of biodiversity conservation.

REFERENCES

Acres, B.P., R.P. Bower, P.A. Burrough, C.J. Folland, M.S. Kalsi, P. Thomas & P.S. Wright (1975). *The soils of Sabah. Volume 1. Classification and description.* Land Resources Study 20. Land Resources Division, Ministry of Overseas Development, Tolworth Tower, Surbiton, Surrey, England.

Anon. (2012). *Sabah Biodiversity Strategy 2012–2022*. Sabah State Government, Universiti Malaysia Sabah & Japan International Cooperation Agency (JICA).

Anon. (2013). *Strategic Plan of Action (Sabah), the Heart of Borneo Initiative (2014–2020).* Sabah Forestry Department & WWF-Malaysia, 92pp.

Anon. (2016). *National Policy on Biodiversity*. https://www.mybis.gov.my/pb/590 (Date accessed: 3 January, 2020).

Balvanera, P., A.B. Pfisterer, N. Buchmann, J.-H. He, T. Nakashizuka, D. Raffaelli & B. Schmid (2006). Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecology Letters* 9: 1146–1156.

Basset, Y. & G.P.A. Lamarre (2019). Toward a world that values insects. *Science* **364(6447): 1230–1231.**

Beck, J. & W. Schwanghart (2010). Comparing measures of species diversity from incomplete inventories: an update. *Methods in Ecology and Evolution* **1: 38–44.**

Cardinale, B.J., D.S. Srivastava, J.E. Duffy, J.P. Wright, A.L. Downing, M. Sankaran & C. Jouseau (2006). Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature* (443): 989–992.

Chung, A.Y.C., S.K.F. Chew, R. Majapun & R. Nilus (2013). Insect diversity of Bukit Hampuan Forest Reserve, Sabah, Malaysia. *Journal of Threatened Taxa* 5(10): 4461–4473.

Chung, A.Y.C., R. Nilus & F. Kugan (2015). Sabah's rainforests: a treasure trove of fascinating insects. Paper presented at the International Conference on Rainforest Ecology, Diversity and Conservation in Borneo, Kota Kinabalu, Sabah. 9–11 June 2015.

Chung, A.Y.C., S. Bosuang, R. Majapun & R. Nilus (2016a). Diversity and geographical ranges of insects in Crocker Range Forest Reserve, Sabah, Malaysia. *Journal of Tropical Biology & Conservation* 13: 135–155.

Chung, A.Y.C., E. Khoo, R. Nilus, M.A.F. Suis & J.B. Sugau (2016b). An insect survey in Kungkular Forest Reserve, Tenom, Sabah. *Sepilok Bulletin* 23 & 24: 37–50.

Costello, M.J., K.H. Beard, R.T. Corlett, G.S. Cumming, V. Devictor, R. Loyola, B. Maas, A.J. Miller-Rushing, R. Pakeman & R.B. Primack (2016). Field work ethics in biological research. *Biological conservation* 203: 268–271.

Didham, R.K., S.R. Leather & Y. Basset (2019). Ethics in entomology. *Antenna* 43(3): 124–125.

Fujita, H. (2010). *The lucanid beetles of the world*. Mushi-Sha's Iconographic Series of Insects 6. Tokyo, Japan.

HCVRN (2013). High Conservation Value Resource Network – common guidance for HCV identification for high conservation values. The Proforest Initiative, Oxford, UK, 74pp.

Hill, D. & F. Abang (2005). *The insects of Borneo (including South-east and East Asia)*. Universiti Malaysia Sarawak. 435 pp.

Holloway, J.D. (1983). Moths of Borneo (part 4): family Notodontidae *Malayan Nature Journal* 37: 1–107.

Holloway, J.D. (1985). Moths of Borneo (part 14): Family Noctuidae: subfamilies Euteliinae, Stictopterinae, Plusiinae, Pantheinae *Malayan Nature Journal* 38: 157–317.

Holloway, J.D. (1986). Moths of Borneo (part 1): key to families: families Cossidae, Metarbelidae, Ratardidae, Dudgeoneidae, Epipyropidae and Limacodidae. *Malayan Nature Journal* 40: 1–166.

Holloway, J.D. (1987). *The moths of Borneo (part 3): superfamily Bombycoidea: families Lasiocampidae, Eupterotidae, Bombycidae, Brahmaeidae, Saturniidae, Sphingidae*. Southdene Sdn. Bhd., Kuala Lumpur, 199pp.

Holloway, J.D. (1988). *The moths of Borneo (part 6): family Arctiidae, subfamilies Syntominae, Euchromiinae, Arctiinae; Noctuidae misplaced in Arctiidae (*Camptoloma*, Aganainae).* Southdene Sdn. Bhd., Kuala Lumpur, 101pp.

Holloway, J.D. (1989). *The moths of Borneo (part 12): family Noctuidae, trifine subfamilies: Noctuinae, Heliothinae, Hadeninae, Acronictinae, Amphipyrinae, Agaristinae*. Southdene Sdn. Bhd., Kuala Lumpur, 226pp.

Holloway, J.D. (1993). *The moths of Borneo (part 11): family Geometridae, subfamily Ennominae*. Southdene Sdn. Bhd., Kuala Lumpur, 309pp.

Holloway, J.D. (1996). The moths of Borneo (part 9): family Geometridae, subfamilies Oenochrominae, Desmobathrinae and Geometrinae. *Malayan Nature Journal* 49: 147–326.

Holloway, J.D. (1997). The moths of Borneo (part 10): family Geometridae, subfamilies Sterrhinae & Larentiinae. *Malayan Nature Journal* 51: 1–242.

Holloway, J.D. (1998). The moths of Borneo (part 8): families Castniidae, Callidulidae, Drepanidae & Uraniidae. *Malayan Nature Journal* 52: 1–155.

Holloway, J.D. (1999). The moths of Borneo (part 5): family Lymantriidae. *Malayan Nature Journal* 53: 1–188.

Holloway, J.D. (2001). *The moths of Borneo (part 7): family Arctiidae, subfamily Lithosiinae.* Southdene Sdn. Bhd., Kuala Lumpur, 486pp.

Holloway, J.D. (2003). *The moths of Borneo (part 18): family Nolidae.* Southdene Sdn. Bhd., Kuala Lumpur, 279pp.

Holloway, J.D. (2005). The moths of Borneo: family Noctuidae, subfamily Catocalinae. *Malayan Nature Journal* 58(1–4): 1–529.

Holloway, J.D. (2008). The moths of Borneo: family Noctuidae, subfamilies Rivulinae, Phytometrinae, Herminiinae, Hypeninae and Hypenodinae. *Malayan Nature Journal* 60(1–4): 1–268.

Holloway, J.D. (2009). The moths of Borneo (part 13): family Noctuidae, subfamily Pantheinae (part), Bagisarinae, Acontiinae, Aediinae, Eustrotiinae, Bryophilinae, Araeopteroninae, Aventiinae, Eublemminae and further miscellaneous genera. *Malayan Nature Journal* 62(1&2): 1–240.

Holloway, J.D. (2011). The moths of Borneo: families Phaudidae, Himantopteridae and Zygaenidae; revised and annotated checklist. *Malayan Nature Journal* 63(1–2): 1–548.

Isbell, F., V. Calcagno, A. Hector, J. Connolly, S. Harpole, P.B. Reich, M. Scherer-Lorenzen, B. Schmid, D. Tilman, J. van Ruijven, A. Weigelt, B.J. Wilsey, E.S. Zavaleta & M. Loreau (2011). High plant diversity is needed to maintain ecosystem services. *Nature* (199): 202.

Kirton, L.G. (2014). *A naturalist's guide to the butterflies of Peninsular Malaysia, Singapore and Thailand*. John Beaufoy Publ. Ltd., UK & FRIM, Malaysia, 176pp.

Magurran, A.E. (1988). *Ecological Diversity and its Measurement*. Croom Helm, London, 178pp.

Magurran, A.E. (2004). *Measuring Biological Diversity*. Blackwell, UK.

Makihara, H. (1999). Atlas of longicorn beetles in Bukit Soeharto Education Forest, Mulawarman University, East Kalimantan, Indonesia. *PUSREHUT Special Publication No. 7.* Mulawarman University & JICA, 140pp.

Merckx, V.S., K.P. Hendriks, K.K. Beentjes, C.B. Mennes, L.E. Becking, K.T. Peijnenburg , A. Afendy, N. Arumugam, H. de Boer, A. Biun, M.M. Buang, P.P. Chen, A.Y.C. Chung, R. Dow, F.A. Feijen, H. Feijen, C. Feijen-van Soest, J. Geml, R. Geurts, B. Gravendeel, P. Hovenkamp, P. Imbun, I. Ipor, S.B. Janssens, M. Jocqué, H. Kappes, E. Khoo, P. Koomen, F. Lens, R.J. Majapun, L.N. Neupane, N. Nieser, J.T. Pereira, H. Rahman, S. Sabran, A. Sawang, R.M. Schwallier, P.S. Shim, H. Smit, N. Sol, M. Spait, M. Stech, F. Stokvis, J.B. Sugau, M. Suleiman, S. Sumail, D.C. Thomas, J. van Tol, F.Y. Tuh, B.E. Yahya, J. Nais, R. Repin, M. Lakim & M. Schilthuizen (2015). Evolution of endemism on a young tropical mountain. *Nature* 524: 347–350.

Nilus, R., J.T. Pereira, A.Y.C. Chung, J.B. Sugau, S. Sabran, C. Prudente & F. Kugan (2013). Inventory of biodiversity in the Heart of Borneo (HoB), Sabah. Paper presented at the International Conference on Heart of Borneo's Natural Capital: Unleashing their Potential for Sustainable Growth in Sabah. 11–12 November, 2013, Kota Kinabalu, Sabah.

Oldfield, M. (2014). *The green heart of Sabah*. Scubazoo Publications & Sabah Forestry Department, 255pp.

Orr, A.G. (2003). *A guide to the dragonflies of Borneo: their identification and biology*. Natural History Publications (Borneo), Kota Kinabalu, 195pp.

Otsuka, K. (1988). *Butterflies of Borneo.* Vol. I. Tobishima Corporation, Tokyo, Japan, 61pp.

Otsuka, K. (2001). *A field guide to the butterflies of Borneo and South East Asia*. Hornbill Books, 224pp.

Peh, K.S.-H. & S.L. Lewis (2012). Conservation implications of recent advances in biodiversity-functioning research. *Biological Conservation* 151: 26–31.

Robinson, G.S., K.R. Tuck & M. Shaffer (1994). *A field guide to smaller moths of South-east Asia.* The Natural History Museum, London & Malaysian Nature Society, 309pp.

Seaby, R.M.H. & P.A. Henderson (2007). Species Diversity & Richness version 4.1.2. Pisces Conservation Ltd., Lymington, UK.

Southwood, T.R.E. & P.A. Henderson (2000). *Ecological methods*. Blackwell, UK, 565pp.

Sutton, S., H. Barlow & T. Whitaker (2015). *A preliminary guide to pyralids of Borneo (part 1)*. Natural History Publications (Borneo) & Southdene Sdn. Bhd., Kuala Lumpur, 89pp.

Tang, H.B., L.K. Wang, & M. Hamalainen (2010). *A photographic guide to the dragonflies of Singapore*. The Raffles Museum of Biodiversity Research, Singapore, 222pp.

Tung, V.W–Y. (1983). *Common Malaysian beetles*. Longman, Kuala Lumpur, 142pp.

Zahiri, R., I.J. Kitching, J.D. Lafontaine, M. Mutanen, L. Kaila, J.D. Holloway & N. Wahlberg (2010). A new molecular phylogeny offers hope for a stable family level classification of Noctuoidea (Lepidoptera). *Zoologica Scripta* 2010: 1–16.

Zahiri, R., J.D. Holloway, I.J. Kitching, J.D. Lafontaine, M. Mutanen, & N. Wahlberg (2011). Molecular phylogenetics of Erebidae (Lepidoptera, Noctuoidea). *Systematic Entomology* 37(1): 102–124. https://doi.org/10.1111/j.1365-3113.2011.00607.x

Appendix 1. Butterflies recorded from Tenompok FR, Sabah (5–9 September 2016).

	Species	Author	Family	Photo no. (TEN) *
1	*Graphium sarpedon sarpedon*	Linnaeus	Papilionidae	0432
2	*Trogonoptera brookiana brookiana*	Wallace	Papilionidae	Spotted
3	*Troides amphrysus flavicollis*	Druce	Papilionidae	Spotted
4	*Troides* sp.		Papilionidae	Spotted
5	*Eurema blanda blanda*	Boisduval	Pieridae	0182
6	*Cethosia hypsea hypsea*	Doubleday	Nymphalidae	0018
7	*Euploea mulciber portia*	Fruhstorfer	Nymphalidae	0180
8	*Junonia orithya metion*	Fruhstorfer	Nymphalidae	0437
9	*Mycalesis* sp.		Nymphalidae	0362
10	*Neptis duryodana duryodana*	Moore	Nymphalidae	0184
11	*Ypthima pandocus sertorius*	Fruhstorfer	Nymphalidae	0015
12	*Sinthusa* sp.		Lycaenidae	0158
13	*Potanthus* sp.		Hesperiidae	0409

Appendix 2. Selected moths recorded from Tenompok FR, Sabah (5–9 September 2016).

	Species	Author	Family	Photo no. (TEN) *	Remarks
1	*Penicillifera apicalis*	Walker	Bombycidae	0453	
2	*Arthroschista hilaralis*	Walker	Crambidae	0512	
3	*Dichocrocis zebralis*	Moore	Crambidae	0124	
4	*Fritillerynnis clathraria*	Warren	Crambidae	0255, 0107	
5	*Heortia vitessoides*	Moore	Crambidae	0469, 0473	
6	*Nevrina procopia*	Stoll	Crambidae	0463	
7	*Pitama hermesalis*	Walker	Crambidae	0095	
8	*Rhimphalea* sp.		Crambidae	0083	
9	*Syllepte iophanes*	Meyrick	Crambidae	0112	
10	*Syllepte* sp.		Crambidae	0133	
11	*Xanthomelaena* sp.		Crambidae	0261	
12	*Oreta* sp.		Drepanidae	0263	
13	*Tridrepana flava*	Moore	Drepanidae	0126	
14	*Asota heliconia*	Linnaeus	Erebidae	0488	
15	*Asota kinabaluensis*	Rothschild	Erebidae	0259	Endemic

	Species	Author	Family	Photo no. (TEN) *	Remarks
16	*Asota* nr *producta*	Butler	Erebidae	0511	
17	*Nyctemera muelleri*	Vollenhoven	Erebidae	0456, 0458	
18	*Nyctemera* sp.		Erebidae	0321	Day flying
19	*Amata prepuncta*	Holloway	Erebidae (Arctiinae)	0264	Endemic
20	*Amerila astreus*	Drury	Erebidae (Arctiinae)	0478	
21	*Amerila omissa*	Rothschild	Erebidae (Arctiinae)	0502, 0523	
22	*Areas galactina*	Hoeven	Erebidae (Arctiinae)	0052, 0065	
23	*Asura fulguritis*	Hampson	Erebidae (Arctiinae)	0125	
24	*Auriculoceryx pterodactyliformis*	Holloway	Erebidae (Arctiinae)	0243, 0256	Endemic
25	*Barsine lineatus*	Walker	Erebidae (Arctiinae)	0108	
26	*Barsine roseororatus*	Butler	Erebidae (Arctiinae)	0241	
27	*Creatonotos transiens*	Walker	Erebidae (Arctiinae)	0091	
28	*Cyana cruentata*	Talbot	Erebidae (Arctiinae)	0238	Endemic
29	*Cyana pudens*	Walker	Erebidae (Arctiinae)	0481	
30	*Cyana saulia*	Swinhoe	Erebidae (Arctiinae)	0111	Endemic
31	*Eilema* sp.		Erebidae (Arctiinae)	0480	
32	*Eugoa trifasciata*	Snellen	Erebidae (Arctiinae)	0239	
33	*Garudina macrolatana*	Holloway	Erebidae (Arctiinae)	0454	Endemic
34	*Lyclene angulifera*	Holloway	Erebidae (Arctiinae)	0240	
35	*Lyclene mesilaulinea*	Holloway	Erebidae (Arctiinae)	0092, 0265	Endemic
36	*Monosyntaxis trimaculata*	Hampson	Erebidae (Arctiinae)	0234	Endemic
37	*Padenia obliquifascia*	Rothschild	Erebidae (Arctiinae)	0484	
38	*Spilosoma groganae*	Holloway	Erebidae (Arctiinae)	0066, 0260	Endemic
39	*Metaemene albigrisea*	Holloway	Erebidae (Boletobiinae)	0125	Endemic
40	*Metaemene* sp.		Erebidae (Boletobiinae)	0250	
41	*Arctornis* sp.		Erebidae (Lymantriinae)	0075	
42	*Nygmia amplior*	Collenette	Erebidae (Lymantriinae)	0110	
43	*Nygmia* nr *atereta*	Collenette	Erebidae (Lymantriinae)	0088	
44	*Nygmia* nr *atrisignata*	Swinhoe	Erebidae (Lymantriinae)	0268	
45	*Nygmia peperites*	Collenette	Erebidae (Lymantriinae)	0081	
46	*Eupterote asclepiades*	Felder	Eupterotidae	0524	
47	*Eupterote naessigi*	Holloway	Eupterotidae	0134	
48	*Eupterote* sp.		Eupterotidae	0086	
49	*Dichomeris* sp.		Gelechiidae	0487	
50	*Chloroglyphica xeromeris*	Prout	Geometridae	0262	
51	*Cleora* sp. 1		Geometridae	0270	
52	*Cleora* sp. 2		Geometridae	0272	
53	*Comostola pyrrhogona*	Walker	Geometridae	0094	
54	*Comostola subtiliaria*	Bremer	Geometridae	0069	
55	*Dooabia plana*	Prout	Geometridae	0132	
56	*Eucyclodes* sp.		Geometridae	0076	
57	*Hypephyra brunneiplaga*	Swinhoe	Geometridae	0105	
58	*Hypochrosis hyadaria*	Guenée	Geometridae	0093	

	Species	Author	Family	Photo no. (TEN) *	Remarks
59	*Hyposidra apioleuca*	Prout	Geometridae	0507	
60	*Omiza lycoraria*	Guenée	Geometridae	0121	
61	*Ornithospila bipunctata*	Prout	Geometridae	0465, 0468	
62	*Ozola liwana*	Sommerer	Geometridae	0115	
63	*Ozola submontana*	Holloway	Geometridae	0067	Endemic
64	*Pachyodes* sp.		Geometridae	0097	
65	*Perixera* sp.		Geometridae	0116	
66	*Pingasa* sp.		Geometridae	0257	
67	*Plutodes evaginata*	Holloway	Geometridae	0489, 0129	Endemic
68	*Problepsis borneamagna*	Holloway	Geometridae	0452	Endemic
69	*Protuliocnemis biplagiata*	Moore	Geometridae	0074	
70	*Ruttellerona* sp.		Geometridae	0127	
71	*Spaniocentra apatelloides*	Holloway	Geometridae	0096	Endemic
72	*Thinopteryx crocopterata*	Kollar	Geometridae	0087	
73	*Tristeirometa* sp.		Geometridae	0119	
74	*Trabala hantu*	Roepke	Lasiocampidae	0522	
75	*Scopelodes unicolor*	Westwood	Limacodidae	0106	
76	Unidentified		Noctuidae	0123	
77	*Buzara saikehi*	Bremer	Noctuidae	0073	Endemic
78	*Catocala macula*	Hampson	Noctuidae	0118, 0131	
79	*Daddala lucilla*	Butler	Noctuidae	0251	
80	*Daddala* sp.		Noctuidae	0244	
81	*Episparis costistriga*	Walker	Noctuidae	0077	
82	*Hamodes propitia*	Guérin-Méneville	Noctuidae	0117	
83	*Hypopyra ossigeroides*	Holloway	Noctuidae	0113	
84	*Mudaria magniplaga*	Walker	Noctuidae	0128	Endemic
85	*Ochrotrigona praetextata*	Hering	Noctuidae	0476	
86	*Psimada quadripennis*	Walker	Noctuidae	0252	
87	*Rema* sp.		Noctuidae	0269	
88	*Rusicada nigritarsis*	Walker	Noctuidae	0509	
89	*Rusicada* sp.		Noctuidae	0271	
90	Unidentified		Noctuidae?	0254	
91	*Blenina* sp.		Nolidae	0090	
92	*Clethrophora angulipennis*	Prout	Nolidae	0485	
93	*Hylophilodes* nr *dubia*	Prout	Nolidae	0483	
94	*Manoba coadei*	Holloway	Nolidae	0273	Endemic
95	*Tyana marina*	Warren	Nolidae	0510	Endemic
96	*Acosmeryx shervillii*	Boisduval	Sphingidae	0089	
97	*Hippotion rosetta*	Swinhoe	Sphingidae	0245	
98	*Panacra psaltria*	Jordan	Sphingidae	0464	Endemic
99	*Theretra boisduvali*	Bugnion	Sphingidae	0508	
100	*Theretra latreillei*	MacLeay	Sphingidae	0246	
101	*Dysaethria quadricaudata*	Walker	Uraniidae	0482	
102	*Dysaethria* sp.		Uraniidae	0267	

Appendix 3. Beetles recorded from Tenompok FR, Sabah (5–9 September 2016).

	Species	Author	Family	Photo no. (TEN) *	Remarks
1	*Mimopolemius* sp. 1		Cantharidae	0104	
2	*Mimopolemius* sp. 2		Cantharidae	0304	
3	*Batocera tigris*	Voet	Cerambycidae	0175, 0174	Rare (1,400m)
4	Unidentified		Chrysomelidae	0048, 0043	
5	*Eumorphus* sp.		Endomychidae	9977	
6	*Eulichas* sp.		Eulichadidae	0275	
7	Unidentified		Lampyridae	0049	Bioluminescent larva
8	*Odontolabis leuthneri*	Boileau	Lucanidae	0209	Endemic (1,600m)
9	*Aceraius* sp.		Passalidae	0072	

Appendix 4. Other insects recorded from Tenompok FR, Sabah (5–9 September 2016).

	Species	Author	Order	Family	Photo no. (TEN)*	Remarks
1	*Bulbitermes* sp.		Blattodea	Termitidae	0343	
2	*Hospitalitermes* sp.		Blattodea	Termitidae	0336, 0365, 0373, 0386	
3	Unidentified 1		Hemiptera		9969	
4	Unidentified 2		Hemiptera		9972	
5	Unidentified 3		Hemiptera		0358	
6	*Blastophaga* sp.		Hymenoptera	Agaonidae	0324	Fig wasps
7	*Apis cerana*	Fabricius	Hymenoptera	Apidae	0156	
8	*Dolichoderus* sp.		Hymenoptera	Formicidae	9974, 9967	
9	*Myrmicaria* sp.		Hymenoptera	Formicidae	0022	
10	*Provespa anomala*	De Saussure	Hymenoptera	Vespidae	0078, 0253	
11	Unidentifed		Mantodea	Mantidae	9983	
12	*Vestalis* sp.		Odonata	Calopterygidae	0423	
13	*Euphaea* sp.		Odonata	Euphaeidae	0414	
14	*Orthetrum glaucum*	Brauer	Odonata	Libellulidae	0434	
15	*Orthetrum testaceum*	Burmeister	Odonata	Libellulidae	0433	
16	*Nisitrus vittatus*	de Haan	Orthoptera	Gryllidae	0012	
17	*Mecopoda* sp.		Orthoptera	Tettigoniidae	0417	

*Note: TEN 0000 is the photo code for Tenompok FR insects. All photographs were taken by the first author and are kept in the Forest Research Centre of the Sabah Forestry Department.

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COMMUNICATION

Tiger beetles (Coleoptera: Cicindelinae) of Davao Region, Mindanao, Philippines

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Abstract: An assessment of tiger beetles in select mountains of Davao region including Mt. Hamiguitan (MHRWS), Marilog District (MD), Davao City (DC), Sta. Cruz Davao del Sur (SCD), and Davao de Oro (DO) is herein presented. Materials were collected between December 2017 and February 2019 through a combination of opportunistic and standard light trapping methods. Twenty-two species belonging to 9 genera were recorded with 64% endemic in the Philippines. Nine (9) species are recorded from MHRWS, 6 from MD, 8 from DC, 5 SCD, and 14 from DO (formerly Compostela Valley Province). Tiger beetles showed consistent habitat preferences particularly riparian species which includes the genera Calomera, Thopeutica, Therates, Prothyma, Cylindera, and Heptodonta. Strictly arboreal species include Tricondyla, Therates, and Neocollyris. Strict epigeic species include but not limited to the genera Calomera, Tricondyla, Thopeutica, Cylindera, Heptodonta, Neocollyris, and Prothyma. Endemic species such as *Heptodonta lumawigi* (Wiesner, 1980), *Thopeutica (Thopeutica) anichtchenkoi* (Wiesner 2015), *Thopeutica (Thopeutica) milanae* (Wiesner, 1992), *Thopeutica (Thopeutica) rolandmuelleri* Cassola, 2000 and *Thopeutica petertaylori* (Medina, Cabras, Wiesner, 2019) prefers a more intact forests while others such as *Cylindera (Ifasina) discreta elaphroides* (Dokhtouroff 1882), *Calomera mindanaoensis* (Cassola, 2000) and *Necollyris* sp. could tolerate disturbed secondary forest even agricultural lands. New distribution record for *Heptodonta lumawigi* (Wiesner, 1980) and *Thopeutica (Thopeutica) milanae* (Wiesner, 1992) for Marilog District were also recorded. Ecological data and conservation status of tiger beetles are also presented. Conservation actions are deemed necessary in the remaining green spaces in Davao City that hosts tiger beetle fauna should also be conducted.

Keywords: Conservation, davao region, diversity, Philippines.

Filipino abstract: Pag-lista sa tanan tiger beetles gikan sa mga bukid sa rehiyon sa Davao, apil ang Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS), distrito sa Marilog, Sta. Cruz Davao del Sur, ug Davao de Oro (sa una probinsya sa Compostela Valley) gipahigayon sa mga bulan sa Desyembre 2017 ug Pebrero 2019 ginamit ang opportunistic ug light trapping nga mga pamaagi. Baynte dos ka mga species ilalum sa syam ka mga genera ang na lista diin 64% ang makita lamang sa Pilipinas. Syam ka mga species ang na lista gikan sa MHRWS, unom gikan sa distrito sa Marilog, walo gikan sa nagka lain-lain green nga mga lugar sa syudad sa Davao, lima gikan Sta. Cruz, ug katorse gikan sa Davao de Oro. Ang mga tiger beetles nagpakita ug specific nga pinuy-anan, partikularmente mga species namuyo duol sa sapa sama sa Calomera, ug mga species sa sapa jud mismo makita sama sa Thopeutica, Therates, Prothyma, and Cylindera. Mga species makita ibabaw sa kahoy sama sa Tricondyla ug Neocollyris. Ang uban species sama sa *Heptodonda lumawigi* (Wiesner, 1980), *Thopeutica (Thopeutica) anichtchenkoi* (Wiesner, 2015), *Thopeutica (Thopeutica) milanae* ()Wiesner, 1992), *Thopeutica (Thopeutica) rollandmuelleri* Cassola 2000, ug *Thopeutica (Thopeutica) petertaylori* (Medina, Cabras, Wiesner, 2019) nagapamili ug baga nga lasang. Sa laing bahin, *Cylindera (Ifasina) discreta elaphroides* (Dokhtouroff, 1882), *Calomera mindanaoensis* (Cassola, 2000), ug *Necollyris* sp. maka agwanta ug medyo guba na nga lugar, ug gamay nga lasang. Naay duha ka mga species, *Heptodonta lumawigi* (Wiesner, 1980) ug *Thopeutica (Thopeutica) milanae* (Wiesner,1992) na lista sa unang higayon sa distrito sa Marilog. Gipakita usab ang status sa nahibilin nga mga tiger beetles gikan sa rehiyon sa Davao. Ang presyensa sa mga tiger beetles sa mga green nga mga lugar sa syudad sa Davao nagpamatuod nga aduna pa gayud nahibilin nga species sa lugar nga angay natong ampingan ug protektahan.

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INTRODUCTION

The tiger beetles are predatory beetles recognized by their lengthy legs, prominent sickle mandibles, 11 segmented filiform antennae, and a pair of conspicuous large compound eyes (Pearson 1998). Their size ranges from 6mm to the extent of 45mm (Pearson 1998). Recent revisions of Lopez-Lopez & Vogler (2017) and a comprehensive molecular phylogeny of tiger beetles of Gough et al. (2018) placed the taxon into a separate family Cicindilidae. Among the insect taxa, tiger beetles are a bioindicators of biodiversity (Pearson & Cassola 1992) and information can be gathered by analyzing their habitat specificity, presence of endemic species, and a possible translation of patterns to related taxa (Nose 1990; Morgan et al. 2000).

The Philippines is home to a high number of unique species of Cicindilinae. In 1992, Wiesner recorded 94 species of Cicindelid in the Philippines. Between 1990 and 2000, Cassola & Pearson (2000) listed 130 tiger beetles wherein 111 are endemic, making the Philippines the fifth in terms of the absolute number of tiger beetles, and ranked third based on endemism behind Madagascar and Australia. More recently, Cabras et al. (2016) listed a total of 155 tiger beetle species and 18 subspecies, of which 130 are endemic in the Philippines. Additionally, six new species were added by Dheurle (2016), Zettel & Pangantihon (2017), Zettel & Wiesner (2018), raising the list to 161 tiger beetles in the Philippines.

Consequently, tiger beetle studies in the Philippines are still scant mostly focusing on taxonomy with very few faunistic data (Wiesner 1980, 1988a, 1988b, 1989, 1992a, 1992b, 2015; Bogenberger 1988; Naviaux 1992, 2002; Cassola 2000, 2011; Cassola & Ward 2004; Cassola & Zettel 2006; Deuve 2015; Dheurle 2015; Cabras et al. 2016). In Mindanao, only Davao de Oro (formerly Compostela Valley) and Davao Oriental Province, particularly in Mainit Hot Spring Protected Landscape (MHSPL) and Mati Protected Landscape, have published data on tiger beetle fauna (Cabras et al. 2016). This paper presents the list of tiger beetles in Mt. Hamiguitan Range Wildlife Sanctuary Davao Oriental, Sta. Cruz Davao del Sur, green spaces of Davao City, and upland forests of Marilog District Davao City. Notes on their ecology and conservation status, which are an essential reference for conservation and monitoring purposes, are also presented.

MATERIALS AND METHODS

Collection of tiger beetles was done using opportunistic sampling and light trapping for Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS) Davao Oriental [6^{0}44’08.000”N, 126^{0}8’33.810”E], Sta. Cruz Davao del Sur [6^{0}52’27.000”N, 125^{0}22’04.320”E], green spaces and lowland forest of Davao City [7^{0}03’56.540”N, 125^{0}35’36.910”E], mountain forests of Marilog District [7^{0}26’31.070”N, 125^{0}15’23.310”E] (Figure 1) from December 2017 to February 2019. Additional data from Davao de Oro [7021’21.080”N, 126011’00.220”E] is also included (Cabras et al. 2016b).

The daily collection was conducted using insect net and light trapping for nocturnal sampling from 18.00h to 22.00h. Collected specimens were killed using ethyl acetate and placed in 90% ethanol. Species identification was made by examining morphological characters were observed under Luxeo 4D and Nikon SMZ745T stereomicroscopes. Stacked digital habitus images were taken with Nikon D5300 digital camera and Sigma 18-250. All images were then stacked and processed using a licensed version of the software Photoshop CS6Portable with reference to taxonomic keys and published articles of Wiesner (1980, 1988a, 1988b, 1989, 1992a, 1992b, 2015), Cassola (2000, 2011), Cassola & Ward (2004), and Cabras et al. (2016).

RESULTS AND DISCUSSION

A total of 22 species belonging to nine genera were collected in all sampling sites (Table 1). Nine species were recorded from MHRWS, six from the mountain forests of Marilog District Davao City, eight from the urban green spaces of Davao City, five from Sta. Cruz Davao del Sur, and 14 species from Davao de Oro. Of the 22 species, nine (41%) are Philippine endemic, five (23%) are Mindanao endemic, four (18%) are distributed to Southeast Asia, and two (9%) are Oriental species. Five (23%) species are threatened according to the latest DENR Administrative Order (2017) https://www.philippineplants.org/dao-2017-11.pdf, while the other seventeen (77%) species are Data Deficient.

The most widespread species shared by almost all areas include *Calomera mindanaoensis* (Cassola, 2000), *Cylindera (Ifasina) discreta elaphroides* (Dokhtouroff, 1882), *Neocollyris (Heterocollyris) similior* (Horn, 1893), *Therates fasciatus fasciatus* (Fabricius, 1801), *Therates fulvipennis everetti* (Bates, 1878), and *Tricondyla (Tricondyla) aptera punctipennis* (Chevrolat, 1841)

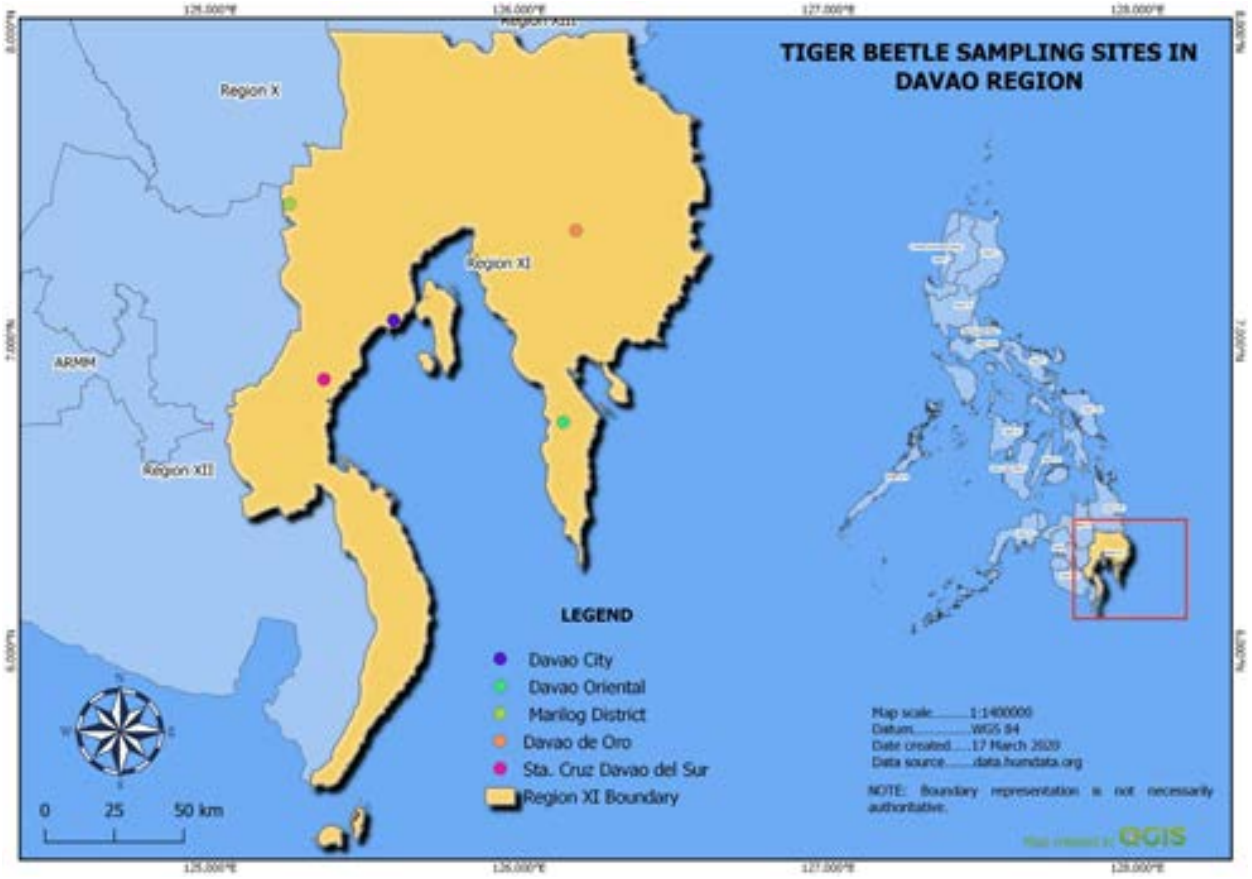

Figure 1. Sampling sites in Davao Region.

(Image 1). The genus *Cylindera* is the most speciose with four species recorded, followed by *Therates, Tricondyla*, and *Thopeutica* with three species each. The genera *Calomera* and *Neocollyris* were represented by two species, while the rest of the genera, viz., *Heptodonta* and *Prothyma* with one species each, and *Thopeutica* with three species. Cabras et al. (2016) enumerated five subspecies of *Therates fasciatus*, of which two subspecies are found in the Davao Region. Two out of three species of *Calomera* in Mindanao are also recorded in Davao Region, namely *Calomera mindanaoensis* (Cassola, 2000) and *Calomera lacrymosa* (Dejean, 1825). Two of the recently described *Thopeutica* from Mindanao were also recorded in Davao Region, namely *Thopeutica (Thopeutica) anichtchenkoi* (Wiesner, 2015) and *Thopeutica (Thopeutica) rolandmuelleri* Cassola, 2000. A new species of *Thopeutica* was also discovered in Compostela Valley, awaiting description. *Thopeutica (Thopeutica) milanae* (Wiesner, 1992) was also recorded for the first time in Davao Region, specifically in the mountain forests of Marilog District. It was initially known to be endemic in Leyte. Moreover, additional specimens were recorded for Samar and Mindanao by Cassola & Ward (2004) and Cabras et al. (2016).

Most species of tiger beetles are matched to a specific environmental condition, which makes the diversity of the fauna strongly determined by the availability and variety of suitable habitats (Willis 1967; Knisley 1984). In general, tiger beetles preferred river edges, water beaches, dunes, sandy flats, woodland paths, grasslands, and areas with dirt roads, trails, sandpits, and spoil deposits (Knisley 2011). The difference in habitats including physical parameters such as soil characteristics, plant composition, and the presence of bare patches of the ground determine their composition since these species need bare spots of the field as a habitat requirement both for adults and larvae (Dreisig 1980). For adults, the presence of sunlight is an essential physical factor in maintaining their high body temperature to enhance speed and effectiveness in catching their prey. Majority of the tiger beetles captured during day time were collected in open spaces where sunlight can penetrate and near river edges and cliffs. Species like *Heptodonta lumawigi* (Wiesner, 1980), *Thopeutica* (*Thopeutica*) *anichtchenkoi* (Wiesner, 2015), *Thopeutica* (*Thopeutica*) *milanae* (Wiesner,

Table1. List of tiger beetles in Davao Region with their geographic distribution and conservation status. MH—Mt. Hamiguitan Range Wildlife Sanctuary | MD—Marilog District | DC—Davao City | SCDDS—Sta. Cruz, Davao del Sur | CVP—Compostela Valley Province | PE—Philippine Endemic | O—Oriental region | ME—Mindanao Endemic | SE—Southeast Asia | OTS—Other Threatened Species | DD—Data Deficient.

Species	MH	MD	DC	SCDS	CVP	GD	CS
Calomera lacrymosa (Dejean, 1825)					√	PE	OTS
Calomera mindanaoensis (Cassola, 2000)	√		√	√	√	PE	OTS
Cylindera (*Ifasina*) *mouthiezi* (Dheurle, 2015)					√	ME	DD
Cylindera (*Ifasina*) *discreta elaphroides* (Dokhtouroff, 1882)	√		√		√	PE	DD
Cylindera viduata (Fabricius, 1801)				√		O	DD
Cylindera (Eugrapha) excisa (Schaum, 1862)					√	SE	DD
Heptodonta lumawigi (Wiesner, 1980)		√				PE	OTS
Lophyra striolata (Illiger, 1800)				√		O	OTS
Neocollyris (*Heterocollyris*) *similior* (Horn, 1893)	√		√		√	ME	DD
Neocollyris sp.			√	√		-	DD
Prothyma (*Symplecthyma*) *heteromallicollis heteromallicollis* (Horn, 1909)	√		√			ME	DD
Therates coracinus coracinus (Erichson, 1834)					√	SE	OTS
Therates fasciatus fasciatus (Fabricius, 1801)	√	√	√		√	SE	DD
Therates fasciatus quadrimaculatus (Horn, 1895)	√	√				PE	DD
Therates fulvipennis everetti (Bates,1878)	√	√	√		√	PE	DD
Thopeutica (*Thopeutica*) *anichtchenkoi* (Wiesner, 2015)					√	ME	DD
Thopeutica (*Thopeutica*) *milanae* (Wiesner, 1992)		√				PE	DD
Thopeutica (*Thopeutica*) *rolandmuelleri* Cassola, 2000					√	ME	DD
Thopeutica (*Thopeutica*) *petertaylori* (Medina, Cabras, Wiesner, 2019)					√		
Tricondyla (*Stenotricondyla*) *cavifrons* (Schaum, 1862)	√			√		PE	DD
Tricondyla (*Tricondyla*) *elongata* (Horn, 1906)					√	PE	DD
Tricondyla (*Tricondyla*) *aptera punctipennis* (Chevrolat, 1841)	√	√	√		√	SE	DD

1992), *Thopeutica* (*Thopeutica*) *rolandmuelleri* Cassola, 2000, and *Thopeutica* sp. are habitat-specific and prefer a more intact forest habitat. Few species like *Cylindera (Ifasina) discreta elaphroides* (Dokhtouroff, 1882) and *Calomera mindanaoensis* (Cassola, 2000), can thrive in relatively disturbed habitats. Both were collected in the University of Mindanao campus and remaining green spaces in Bago Gallera as well as a mixed agricultural farm in Matina Pangi Davao City, Philippines.

Riparian species of tiger beetles include *Calomera mindanaoensis* (Cassola, 2000), *Calomera lacrymosa* (Dejean, 1825), *Cylindera* (*Ifasina*) *mouthiezi* (Dheurle, 2015), *Cylindera* (*Ifasina*) *discreta elaphroides* (Dokhtouroff, 1882), *Cylindera viduata* (Fabricius, 1801), *Cylindera* (*Eugrapha*) *excisa* (Schaum, 1862), *Heptodonta lumawigi* (Wiesner, 1980), *Lophyra striolata* (Illiger, 1800), *Prothyma* (*Symplecthyma*) *heteromallicollis heteromallicollis* (Horn, 1909), *Therates coracinus coracinus* (Erichson, 1834), *Therates fasciatus fasciatus* (Fabricius, 1801), *Therates fasciatus quadrimaculatus* (Horn, 1895), *Therates fulvipennis everetti* (Bates, 1878), *Thopeutica* (*Thopeutica*) *anichtchenkoi* (Wiesner, 2015), *Thopeutica* (*Thopeutica*) *milanae* (Wiesner, 1992), *Thopeutica* (*Thopeutica*) *rolandmuelleri* (Cassola, 2000), and *Thopeutica* sp. were collected in open riparian ecosystem or at least a few meters away from the river bank. Arboreal species such as *Tricondyla* and *Neocollyris* were mostly captured on shrubs' branches and tree trunks, considering the genus *Tricondyla* (Latreille, 1822) is a tree-dwelling species. Because of this, most species are found on tree trunks or the ground, going from one tree to another. *Tricondyla* (*Stenotricondyla*) *cavifrons* (Schaum, 1862) and *Tricondyla* (*Tricondyla*) *aptera punctipennis* (Chevrolat, 1841) as well as *Neocollyris* (*Heterocollyris*) *similior* (Horn, 1893) and *Neocollyris* sp. prefers mixed agricultural to secondary forests ecosystem with shaded areas.

Species such as *Heptodonta lumawigi* (Wiesner, 1980), *Thopeutica* (*Thopeutica*) *milanae* (Wiesner, 1992), and *Prothyma* (*Symplecthyma*) *heteromallicollis*

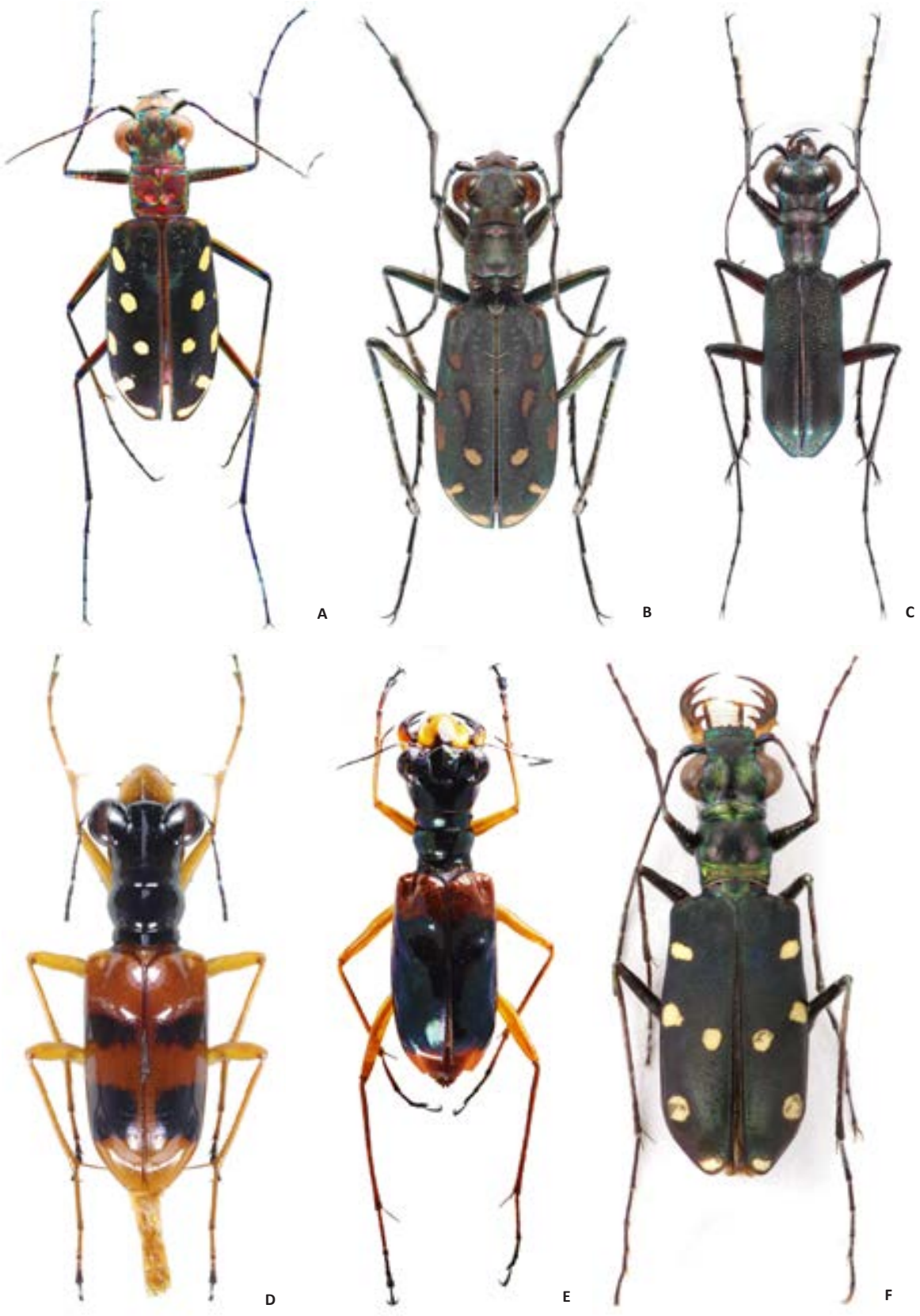

Image 1. Tiger beetles in Davao region: A—*Calomera mindanaoensis* (Cassola, 2000) | B— *Calomera lacrymosa* (Dejean, 1825) | C - *Heptodonta lumawigi* (Wiesner, 1980) | D —*Therates fasciatus quadrimaculatus* Horn 1895 | E— *Therates fulvipennis everetti* (Bates 1878) | F—*Thopeutica petertaylori* (Medina, Cabras, Wiesner, 2019). © A,D - H. Ramillano | B,C,E - C. Torrejos & R. Cabras | F - J. Wiesner.

Image 2. Tiger beetles in their natural habitat. A—*Heptodonta lumawigi* (Wiesner, 1980) | B—*Thopeutica* (*Thopeutica*) *milanae* (Wiesner, 1992) | C—*Calomera mindanaoensis* (Cassola, 2000) | D—*Therates fulvipennis everetti* (Bates, 1878). © A. Cabras.

heteromallicollis (Horn, 1909) were observed on steeply sloping areas near creeks and rivers (Image 2B,C). *Heptodonta lumawigi* (Wiesner, 1980) seemed to favor sloping creeks but also collected along with the road cuts in open spaces (Image 2A). The high preference of this species to inhabit intact forest habitat might be one of the reasons why this species is recorded under threatened species. *Heptodonta lumawigi* (Wiesner, 1980) was first believed to be endemic to Panay when Wiesner recorded it in 1980. New specimens, however, were recorded by Cassola (2000) in Mt. Parker, South Cotabato, listing the species as widely spread in the Philippines. This is also the first time that *H. lumawigi* is recorded in the forest of Marilog District, Davao City. The species under the genus *Therates*, on the other hand, are commonly found near the rivers, usually in the leaves of shrubs and ferns. At times, two species of *Therates* can co-exist in the same riverine are such as *Therates fulvipennis everetti* (Bates, 1878) and *Therates fasciatus fasciatus* (Fabricius, 1801). All species of *Therates* share the same habitat type, shrubs in relatively disturbed secondary forests system, and shaded riverine sandy areas (Image 2D).

The remaining green spaces of Davao City harbors eight species a testament of the importance of keeping the green spaces within urban areas for species to thrive and continue living. It is interesting to note that *Cylindera* (*Ifasina*) *discreta elaphroides* (Dokhtouroff, 1882) is documented both within the campus of the University of Mindanao Matina and in the secondary forests of Bago Gallera. *Neocollyris* sp. and *Calomera mindanaoensis* (Cassola, 2000) were captured in Shrine Hills, Matina, and in the agricultural ecosystem in Matina Pangi, respectively. Cassola & Ward (2004) observed different species of tiger beetles have various adaptations to the changing environment. Similar findings were observed by Cabras et al. (2016). The present list if more numerous compared to tiger beetle fauna in Calanasan Apayao Province which (Medina et al., 2020) which is dominated by old growth secondary forests. The other five species of tiger beetles from Davao City, viz., *Prothyma* (*Symplecthyma*) *heteromallicollis heteromallicollis* (Horn, 1909), *Tricondyla aptera punctipennis* (Chevrolat, 1841), *Neocollyris* (*Heterocollyris*) *similior* (Horn, 1893), *Therates fasciatus quadrimaculatus* (Horn, 1895), and *Therates fulvipennis everetti* (Bates, 1878) were documented in a pristine lowland secondary forests in Calinan and Baguio districts.

Image 3. Tiger beetle habitat in Mt. Hamiguitan and Marilog districts. A—Habitat of *Thopeutica* (*Thopeutica*) *milinae* (Wiesner, 1992) | B—Habitat of *Tricondyla* species | C—Habitat of *Therates* species | D—Habitat of *Prothyma* (*Symplecthyma*) *heteromallicollis heteromallicollis* (Horn, 1909). © M.N.D. Medina.

CONCLUSION & RECOMMENDATION

Davao Region hosts a good number of tiger beetles with 22 species record with 64% endemism (Table 1). Five (23%) are listed as threatened species, which calls for immediate conservation efforts. The astonishing number of tiger beetles in the remaining green spaces of Davao City is a testament to the importance of keeping the urban that houses tiger beetles and other animal species. Tiger beetles of Davao Region show consistent habitat preferences to forested and riverine ecosystems. In the face of deforestation and conversion of forest habitats, tiger beetles, which are linked with forested habitats, are highly at risk of extinction. This calls for more expeditions and inventories to assess extant populations leading towards conservation.

REFERENCES

Bogenberger, J.M. (1988). Two new species of tiger beetles from Palawan (Coleoptera: Cicindilidae). *Mitteilunger der Muncher Entomologischen Gesellschaft* 78: 109–114.

Cabras, A., E. Cabigas & J. Wiesner (2016a). Updated checklist of Tiger Beetles in the Philippines (Coleoptera, Carabidae, Cicindelinae) (131th. Contribution towards the knowledge of Cicindelinae). *Lambillionea* 116(3): 188–201.

Cabras, A., M.N. Medina & J. Wiesner (2016b). Tiger beetles (Coleoptera: Carabidae: Cicindelinae) of Compostella Valley Provinxe, Mindanao Island, Philippines. *Biotropia*, 23: 137–143.

Cassola, F. (2000). Studies on Tiger Beetles. CII. The Cicindelidae Collected by Roland A. Muller in the Philippine Islands, with Description of Three New Species (Coleoptera, Cicindelidae). *Zoologische Mededelingen, Leiden* 73(33): 491–509.

Cassola, F. (2011). Studies on Tiger Beetles CLXXXIX. A New Calomera Species from Mindanao, Philippines. *Spixiana* 34: 129–131.

Cassola, F. & D.L. Pearson (2000). Global Patterns Of Tiger Beetle Species Richness (Coleoptera: Cicindelidae): Their Use In Conservation Planning. *Biological Conservation* 95: 197–208.

Cassola, F. & R.D. Ward (2004). Systematics And Zoogeography Of The Philippine Species Of The Genus Thopeutica Chaudoir, 1861. *Ann Mus Ciy Stor Nat Genova* 96: 1–32.

Deuve, T. (2015). Deux nouvelles Cicindeles des Philippines et du Mozambique (Coleoptera: Caraboidea). *Coleopteres* 21(8): 99–104.

Dheurle, C. (2015). *Cylindera (Ifasina) mouthiezi*, nouvelle espece des Philippines (Coleoptera: Cicindilidae). *L'Entomologiste* 71(2): 123–124.

Dheurle, C. (2016). Une nouvelle espèce de Cylindera Westwood, 1831 de l'île de Samar aux Philippines est décrite et illustrée. *L'Entomologiste* 72(6): 401–403.

Dreisig, H. (1980). Daily activity, thermoregulation and water loss in the tiger beetle. *Cicindela hybrida* 44: 376 –389.

Gough, H., Duran, D., Kawahara, A., & E. Toussaint (2018). A comprehensive molecular phylogeny of tiger beetles (Coleoptera, Carabidae, Cicindilinae). *Systematic Entomology* 1–17. https://doi.org/10.1111/syen.12324

Knisley, C.B. (1984). Ecological Distribution of Tiger Beetles (Coleoptera: Cicindilinae) in Colfax Country, New Mexico. *Southwestern Naturalist* 93–104.

Knisley, C.B. (2011). Anthropogenic disturbances and rare tiger beetle habitats: benefits, risks, and implications for conservation. *Terrestrial Arthropod Reviews* 4: 41–61.

Lopez-Lopez, A., & A.P. Vogler (2017). The Mitogenome Phylogeny Of Adephaga (Coleoptera). *Molecular Phylogenetics and Evolution* 114: 116–174.

Medina, M.N.D., A. Cabras, & J. Wiesner (2019). *Thopeutica petertaylori*, a new tiger beetle species from Mindanao, Philippines. *Insecta Mundi* 0733: 1-5

Medina, M.N.D., A.A. Cabras, J. Ibanez, G.Opiso, & R.J.T. Villanueva (2020). Annotated list of tiger beetles (Coleoptera: Cicindelidae) in Calanasan, Apayao Province, Luzon, Philippines. *Checklist* 16(1): 37–45. https://doi.org/10.15560/16.1.37

Morgan, M., C.B. Knisley & A.P. Vogler (2000). New Taxonomic Status of the Endangered Tiger Beetle Cicindela limbata albissima (Coleoptera: Cicindelidae): Evidence from mtDNA. *Annals of Entomological Society of America* 93(5): 1108–1115.

Naviaux, R. (1992). Diagnose de quatre Neocollyris nouveaux des Philippines et du Vietnam (Col. Cicindilidae). *Bulletin de la Société entomologique de France* 97(1): 42.

Naviaux, R. (2002). Les Tricondylina (Coleoptera, Cicindilidae). Revision des genres *Tricondyla* Latreille et *Derocrania* Chaudoir et descriptions de nouveaux taxons. Memoires de la SEF 5: 1–106.

Nose, R.F. (1990). Indicators For Monitoring Biodiversity: A Hierarchal Approach. *Conservation Biology* 4: 355–364.

Pearson, D.L. (1998). Biology of Tiger Beetles. *Annual Review Entomology*, 33: 123–147.

Pearson, D.L. & F. Cassola (1992). World-wide Species Richness Patterns Of Tiger Beetles (Coleoptera: Cicindelidae): Indicator Taxon For Biodiversity And Conservation Studies. *Conservation Biology* 6: 376–391.

Wiesner, J. (1980). Beintrag zur Kenntnis der philippinischen Cicindeliae (Coleoptera). *Mitteilungen der Minchner Entomologischen Gesellschaft* 70: 119–127.

Wiesner, J. (1988a). Die Gattung Therates Latr. und ihre Arten. 15. Beitrag zur Kenntnis der Cicindelidae (Coleoptera). *Mitteilungen der Münchner Entomologischen Gesellschaft* 78: 5–107.

Wiesner, J. (1988b). Eine neue Cylindera von den Philippinen (Coleoptera: Cicindelidae). 16. Beitrag zur Kenntnis der Cicindelidae. *Entomologische Zeitschrift* 98: 153–5.

Wiesner, J. (1989). Beiträge zur Kenntnis der philippinischen Cicindelidae (II) (Coleoptera). 22. Beitrag zur Kenntnis der Cicindelidae. *Entomologische Zeitschrift* 99: 237–8.

Wiesner, J. (1992). Verzeichnis der Sandlaufkäfer der Welt (Coleoptera: Cicindelidae). *Erna Bauer; Keltern*, 364.

Wiesner, J. (1992a). Eine neue Thopeutica von den Philippinen (Coleoptera: Cicindelidae). 26.Beitrag zur Kenntnis der Cicindelida. *Entomologische Zeitschrift* 102: 128–30.

Wiesner, J. (1992b). Verzeichnis der Sandlaufkäfer der Welt. Checklist of the Tiger Beetles of the World. *Verlag Erna Bauer, Keltern*, 1–364.

Wiesner, J. (2015). Two new Thopeutica species from the Philippines (Coleoptera: Carabidae: Cicindelinae). 122. Contribution towards the knowledge of Cicindelinae. *Mitteilungen des Internationalen Entomologischen Vereins* 40(1/2): 1–8.

Willis, H.L. (1967). Bionomics and zoogeography of tiger beetles of saline habitats in the central United States (Coleoptera: Cicindilinae). *University of Kansas Science Bulletin* 47: 145–313.

Zettel, H. & C.V. Pangantihon (2017). Two New Tiger Beetle Species Of The Therates Fasciatus Group (Coleoptera: Carabidae: Cicindelinae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen* 69: 95–104.

Zettel, H., & J. Wiesner (2018). *Cylindera* (*Conidera*) *mindoroana* sp. n. (Coleoptera: Cicindelidae), a new tiger beetle species from the Philippines. *Insecta Mundi* 0632: 1–10.

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Author contribution: MNM—confirmed species identification, re-drafted the manuscript, provide data analyses; AC—provided the photos of specimens, habitats, and photos of tiger beetles in the wild; HR—drafted the manuscript, provide literatures; RJV—provided additional materials, peer reviewed the manuscript.

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COMMUNICATION

An assessment of the conservation status of a presumed extinct tree species *Wendlandia angustifolia* Wight ex. Hook.f. in southern Western Ghats, India

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Abstract: In this study, we carried out an assessment of IUCN conservation status of *Wendlandia angustifolia* Wight ex. Hook.f. (Rubiaceae), based on field data on populations and distribution status of this species that is narrowly endemic to southern Western Ghats. This species was earlier presumed to be extinct, however, our data suggests that it should be assigned to the Endangered (EN) category based on the IUCN Red List criteria.

Keywords: Conservation assessment, endemic plant, endangered category, Rubiaceae, *Wendlandia angustifolia*.

Tamil abstract: [illegible]

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Author contribution: CM conducted field works, data collection, data analysis, interpretation and prepared the manuscript. PB provided technical inputs and guidance for data collection, LR provided the primary location of the species, herbarium details, and helped in confirming the identity of the species.

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INTRODUCTION

A species unique to a defined geographic unit such as an island/nation or habitat type and not found elsewhere is known as an endemic species. Physical, climatic, and biological factors influence endemism (Chitale et al. 2014). According to Lavergne et al. (2004) some common traits have been observed among the endemic species such as inhabiting microhabitats, producing fewer flowers and seeds, and having lower fecundity than their widespread congeners. Endemic species are poor competitors, and least tolerant to environmental stress (Lavergne et al. 2004). Species with a narrow distribution range and/or fewer individuals are considered to be the most prone to extinction due to changing climatic conditions and competition from alien species (Chitale et al. 2014). Endemic species have long been targets for conservation efforts, because they are not found anywhere else in the world and if lost from their native habitat they are lost forever (Chitale et al. 2014). Myers et al. (2000) opined that conservation of endemic species could result in conservation of species rich landscapes. Assessing present and future distribution of endemic species would form crucial contribution for their conservation planning and management.

India is one of the mega diversity countries with a wide range of topography, climate and habitat. India has a total of 18,532 flowering plant species of which 23.2% are endemic (Singh & Dash 2017). The Western Ghats (along with Sri Lanka) is one of the four designated biodiversity hotspots in India on account of its high degree of endemism and loss of primary forest cover. Of the 2,116 endemic flowering plants recorded in the Western Ghats, 410 are distributed in the state of Tamil Nadu (Singh et al. 2015). Many of these species are rapidly disappearing due to increases in human population, urbanization, habitat fragmentation and the increased dependency of the world's population on limited natural resources (Woodruff 2001). Accordingly global, regional, national and local lists of threatened species have proliferated over the past four decades (Burton 2003). The first step to initiate conservation action for endangered organisms is to identify the populations of species that are in decline or are facing the risk of extinction (Caughley 1994; Brook et al. 2006). The present study was carried out to assess the population status of *Wendlandia angustifolia*, a narrow endemic and extinct category (IUCN 2012; version 3.1) tree species distributed in the southern Western Ghats, India.

MATERIALS AND METHODS

Study area

The study was conducted in Kalakad-Mundanthurai Tiger Reserve (KMTR), in the southern Western Ghats which is part of the Agasthiamalai Biosphere Reserve. KMTR represents a wide variation in the topographical, geo-morphological, edaphic and climatic features, and thus supports a wide range of forest types. The vegetation type varies from thorny shrub jungle to lush evergreen forests and montane grass-lands. Eleven major forest types are present here, out of which the Tirunelveli semi-evergreen forests are unique in the area. KMTR partly comprises a large contiguous tract of around 400km^2 of wet evergreen forest.

Sampling and assessment

The population status and distribution of *Wendlandia angustifolia* in the stream habitat of Tamirabarani River basin was ascertained along Karaiyar, Servalar and Manimuthar rivers. Field surveys were carried out in Mundanthurai range that lies between 8.566–8.716 ^{0}N and 77.266–77.433 ^{0}E. Quadrats measuring 0.1ha area (31.7×31.7m) were established along the river banks to assess the population of this species. Contiguous plots (each includes five number of quadrats) were established along 1.5km stretch for each stream. The number of individuals in each quadrat was enumerated along with their location, height, girth, phenological status and associated species. Geographical coordinates were recorded using Global Positioning System (Garmin eTrex 30x). Height and girth were measured by a measuring tape. Phenological status such as presence of flowers and fruits were observed by periodic field visits. Various growth categories were fixed based on the height and girth classes. A majority of the individuals are less than minimum measurable threshold of 1.3m height from the rooting point. Hence height classes have been incorporated to include those plant individuals which are less than 1.3m height. Individuals which have grown less than 1m height are capable of producing flowers and fruits and hence considered as adults. Girth class was categorised as saplings (<10cm gbh), recruits (10–20 cm gbh) and established (>20cm gbh) individuals. In the height categories, the above mentioned saplings were further classified into seedlings (<1m) and saplings (1–2 m), the corresponding girth classes are mentioned as height class ranges between 1.2–3.5 m as recruits and 1.3–6.5 m as established individuals.

The species was further evaluated as per IUCN Red List criteria, version 3.1 (IUCN 2012). We used the

minimum convex polygon method to calculate the range size as an estimate of its extent of occurrence (EOO). Area of occupancy (AOO) of the species within the grid is studied taking into account of the terrain features with respect to altitude. The EOO and AOO values were calculated by using the GEOCAT software developed by Kew with the standard cell width of 2km (Bachman et al. 2011). Formal thresholds based on population size and geographic range were used for categorization.

RESULTS AND DISCUSSION

History and characteristic features of endemic tree species

Wendlandia angustifolia is a small tree belonging to the family Rubiaceae. This plant species usually grows on rock crevices at low to medium altitude in riparian forests. It was first collected from the Courtalam Hills, Western Ghats by Robert Wight and described by Hooker (1882) in his Flora of British India. The species was re-collected from Kannikatti area in 1917 by Rangachari and after that no collection was made for about 81 years. Viswanathan et al. (2000) re-collected the species from Inchikuzhi area of KMTR in 1988. Gamble (1921) stated that this species was found in the Deccan forests of Kadapa and Western Ghats of Tinnevelly. The distribution in Kadapa forest, however, was reported by Gamble based on the Beddome collections (Coll. No. RHB 1880) available at Madras Herbarium (MH). The distribution of this species in Kadapa forest seems doubtful, as there is no re-collection from the Kadapa forests since Beddome's collection. Beddome has extensively explored the Western Ghats during the period 1880. We presume that the location details could be wrongly labeled as Kadapa forests with collection number 1880 and it could have been collected from Western Ghats in the year 1880. This species is assessed as Extinct (Ex) in the Red List Assessment by the World Conservation Monitoring Centre (1998). Deb & Maiti in Nayar & Sastry (1987) analyzed the species and suggested that this species is presumed extinct. They also suggested that efforts should be made to relocate the species from the river beds at low altitudes and introduce in botanic gardens for its conservation.

Nomenclature

Wendlandia angustifolia Wight ex. Hook.f., Fl. Brit. India. 3: 40. 1880. Gamble, Fl. Madras 588. 1921 (repr. ed. 2. 415. 1957); Deb & Maiti in Nayar & Sastry, Red Data Book Indian Pl. 1: 348. 1987.

Specimens examined: Tamil Nadu: Tirunelveli District: Courtallum, R. Wight, s.n., (Barcode No. K000030922); Courtallum, R. Wight 1334 (Barcode No. K000030921) both are at Kew Herbarium (K); Mundanthurai, 16.iii.1917, Rangachari 14623; Kannikatti, 19.iii.1917, Rangachari 14663 (MH); Inchikuzhi, 1000 m, 16.ii.1998, M.B. Viswanathan, E. Harrison Premkumar & N. Ramesh 1641; Inchikuzhi, 1,000m, 24.v.1998, M.B. Viswanathan, E. Harrison Premkumar & N. Ramesh 2010 (SPKCESH); Ambalam, Aruvipuram River bank, 29.iv.1990, R. Gopalan 93319 (MH); Papanasam, Near Sorimuthu Ayyanar Temple, 04.iii.2011, L. Rasingam, 3101 (BSID).Karaiyar 224m, 05.xii.2016, C. Muthumperumal 3201; Servalar, 218m, 07.xii.2016, C. Muthumperumal 3202;Inchikuzhi, 625m, 19.i.2017, C. Muthumperumal 3203; Kandamparai, 283m, 22.ii.2017, C. Muthumperumal 3204; Inchikuzhi, 617m 01.iii.2017, C. Muthumperumal 3205 (SACONH-Herbarium of Sálim Ali Centre for Ornithology and Natural History).

Species description

Wendlandia angustifolia is a small tree with slender branches, growing up to 5m height. Leaves are ternately whorled; linear-lanceolate, attenuate at base, entire at margin, acute at apex, 4–11 x 0.5–1.8 cm, coriaceous; lateral nerves 6–8 pairs; petioles up to 1cm long; stipules triangular-ovate, subulate or cuspidate at apex. Inflorescence at terminal branches in panicles; panicles slender, pyramidal, leafy below; flowers densely crowded; bracts ligulate, hastate at base, acuminate at apex. Calyx tube turbinate, glabrous, about 1.5mm long, lobes cuspidate, about 1mm long, subulate. Corolla tube slender, about 5mm long; lobes almost orbicular, small. Stamens exserted, filaments short; anthers dorsifixed, linear, about 1mm long. Style about 6mm long, exserted; stigma bifid. Fruits globose, 2mm across, rugose and many seeded; seeds brown, irregular, oblong-trigonous.

This species is distinct from other known species by its glabrous stem, ternately-whorled, linear-lanceolate leaves and glabrous calyx tube with subulate lobes. Further, the habitat of the species is very distinct, as it grows only on rocky riverbeds, whereas be congeners grows along the stream banks as well as other forest types.

Species distribution

A total of 1,091 individuals were enumerated in 9.3ha area (93 quadrats of 0.1ha) sampled. This species was present in seven out of 11 streams surveyed (Figure 1). Among the seven streams explored, Inchikuli had a higher number of individuals (398), followed by Moolakasam (190), Baana tirtam (178), Kandampaarai (139), Pambar

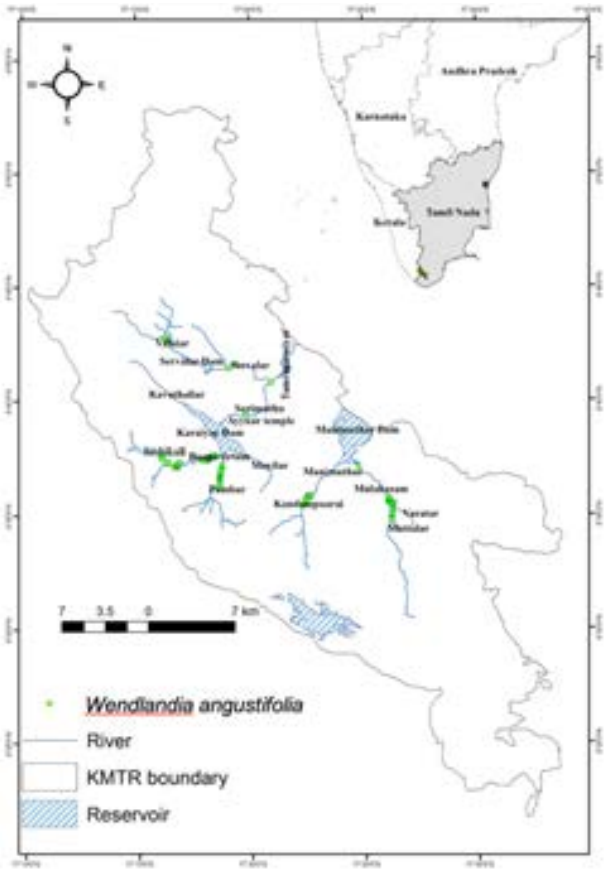

Figure 1. The distribution of *Wendlandia angustifolia* in different streams of Thamirabarani River basin, Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats.

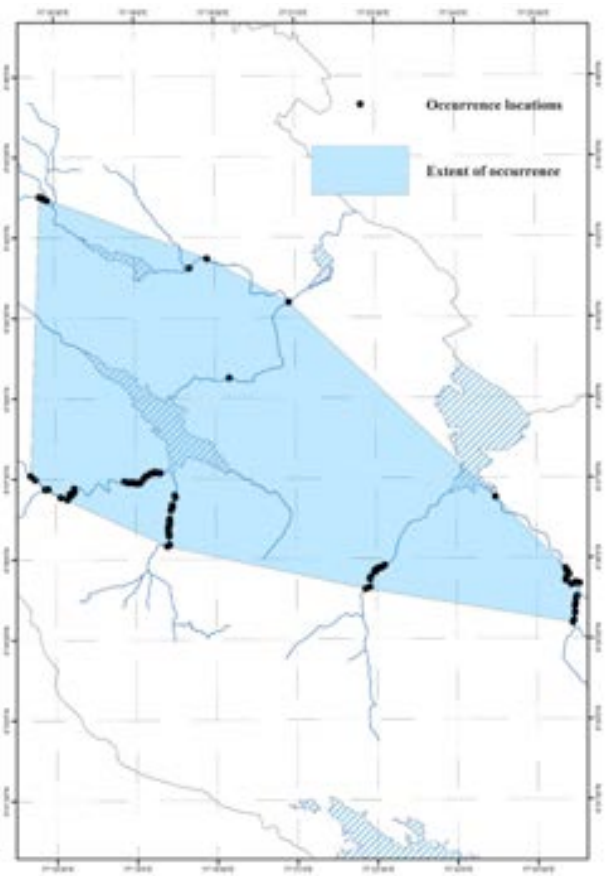

Figure 2. Minimum convex polygon of *Wendlandia angustifolia* in Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats.

(105) and less number of individuals were recorded in Varattar (47) and Servalar (34) (Table 1; Figure 3). The major associating taxa are *Syzygium zeylanicum* var. *lineare*, *Syzygium cumini*, *Garcinia gummi-gutta*, *Pongamia pinnata*, and *Phyllanthus singampattianus*.

Growth category

Growth categories of tree individuals were classified into both girth and height classes. Among the 1,091 individuals recorded in the study site, the girth categories show the occurrence of 862 saplings (<10cm gbh), 175 recruits (10-20cm gbh) and 54 established >20cm gbh) individuals (Figure 4a). In the height class categories, saplings were further classified into seedlings 648 (<1m) and saplings 214 (1m-2m). About 175 recruits fall in the ranges of 1.2–3.5 m height class whereas 54 established individuals fall between the ranges of of 1.3–6.5 m height (Figure 4b). Almost all individuals growing along the water course area are impacted by water flow. Hence, even the matured individuals were recognized in stunted growth form. Individuals recorded on river banks attained a reasonable girth. Individuals that attained height ≥1.3m and girth ≥5cm gbh were considered as adults. They are matured enough to produce flowers and fruits even in the dwarf condition. This species produced new leaves in December, flower buds in January, full blooming in February–March and seeds developed during April–May (Image 1).

Assessment of conservation status

This is the first attempt to assess the population of *W. angustifolia*, a narrow endemic tree species which has been presumed Extinct from the original distribution range in southern Western Ghats, India as per the recent IUCN category (Ver. 3.1; 2012). This species is distributed in the eastern slopes of southern most Western Ghats and grow in gentle rocky beds in rivers and river banks. Moreover this species is found in semi-shade condition and distributed between the elevation ranges of 250m to 720m. As this species occurs in river course area, we observed the flood force impacting the growth of the individuals leaving only a stunted growth.

Table 1. Population assessment of *Wendlandia angustifolia* in different stream habitats in Tamirabarani River basin, Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats.

Name of the reservoir	Name of the stream	Elevation range (m)	Number of quadrats sampled	Area sampled (ha)	Number of individuals recorded
Karaiyar dam	Inchikuliar	617–717	15	1.5	398
	Baanatirtam	354–439	18	1.8	178
	Pambar	286–424	15	1.5	105
	Varattar	436–452	03	0.3	47
Servalar dam	Vaalaiyar	268–309	05	0.5	34
Manimuthar dam	Kandampaaraiar	250–390	17	1.7	139
	Moolakasamar	380–453	20	2.0	190
		Total	**93**	**9.3**	**1091**

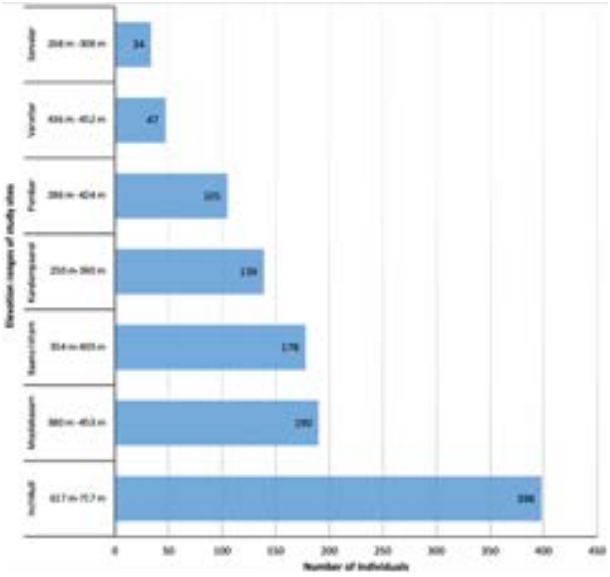

Figure 3. Population distribution of *Wendlandia angustifolia* in different streams (elevation ranges in meter) in Tamirabarani River basin, Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats.

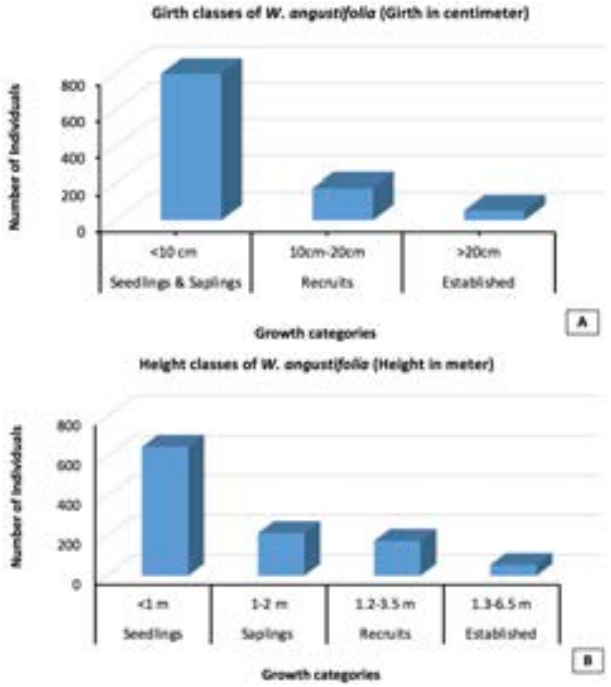

Figure 4. Different growth categories on (A) girth classes and (B) corresponding height class ranges of *Wendlandia angustifolia* in Tamirabarani river basin, Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats.

The geographic range of *W. angustifolia* was quantified using two metrics, extent of occurrence (EOO) and area of occupancy (AOO), both of which can be used for assessments under criterion B (restricted range species) as recommended by IUCN. EOO which is calculated by constructing the minimum convex polygon (convex hull) around known occurrences using the GEOCAT software developed by Kew with the standard cell width of 2km (Bachman et al. 2011). AOO is also calculated with the same tools by overlaying a grid and interpreting known occurrences as occupied grid cells. The sum of occupied grid cells equates to the AOO value. The EOO of *W. angustifolia* was estimated to be 143 km^2 and distributed in five major streams indicated in Figure 1 and 2. As per IUCN Sub-criteria "B1-a" the species qualifies to Endangered category, as this species is distributed in ≤ 5 locations. Among the 7 localities assessed the number of individuals had extreme fluctuation which is clearly indicated in table 1. Hence the Sub-criteria"B1-c" also supporting that this plant under endangered category. The AOO of *W. angustifolia* was 60 km^2 (Figure 2) and since this estimate is less than 500 km^2 and hence this species qualifies for Endangered category (B2). Among the 1,091 individuals recorded during the present study, 293 were adults. Individuals which have grown ≥1.3m height and girth ≥ 5cm gbh were considered as adults.

Image 1. Population assessment of *Wendlandia angustifolia* in Inchikuli at Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats. Phenology: a—leafing in December | b—flower buds in January | c—full blooming in February–March | d—fruiting in April–May.

These individuals are capable of producing flowers and fruits in appropriate season of the year. Hence the number of adult individuals is less than 2500, the species quantifies for Endangered category. Moreover number of mature individuals in majority of subpopulations were ≤ 250 individuals [C2 (ai)] and percentage of mature individuals in one subpopulation is 95–100 % [C2 (aii)] also fit for Endangered category.

Final assessment: Based on field observations and population assessment of *W. angustifolia* it is stated that this species is Endangered [EN B1ac(i–iv)+2ac(i–iv); C2a(i,ii)] and not Extinct.

CONCLUSION

W. angustifolia is a habitat and altitude specific species which is reported from seven tributaries of the river Tamirabarani, Kalakad-Mundanthurai Tiger Reserve, southern Western Ghats, India. The current assessment shows that this narrow endemic tree species qualifies for the Endangered (EN) category. It is recommended that this species should be regularly monitored in all the tributaries of river Tamirabarani and further explorations in the neighborhood habitats are suggested. There is an immense need to implement a restoration program to conserve this narrow endemic tree species.

REFERENCES

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. (version XX). https://doi.org/10.3897/zookeys.150.2109

Brook, B.W., L.W. Traill & C.J.A. Bradshaw (2006). Minimum viable population size and global extinction risk are unrelated. *Ecology Letters* 9: 375–382. https://doi.org/10.1111/j.1461-0248.2006.00883.x

Burton, J.A. (2003). The context of Red Data Books, with a complete bibliography of the IUCN publications. In: H.H. de Iongh, O.S. Bánki, W. Bergmans and M.J. van der Werff ten Bosch (eds), *The Harmonization of Red Lists for Threatened Species in Europe*, pp. 291–300. Proceedings of an International Seminar 27 and 28 November 2002. The Netherlands Commission for International Protection, Mededelingen No. 38, Leiden. https://core.ac.uk/download/pdf/15603428.pdf

Caughley, G. (1994). Directions in conservation biology. *Journal of Animal Ecology* 63:215–244. http://www.journalofanimalecology.org/SpringboardWebApp/userfiles/jane/file/Caughley%201989%20JAE%2063_%20215-244.pdf

Chitale, V.S., M.D. Behera & P.S. Roy (2014). Future of endemic flora of biodiversity hotspots in India. *PLOS ONE* 9(12): e115264. https://doi.org/10.1371/journal.pone.0115264

Gamble, J.S. (1921).*The Flora of the Presidency Madras*, Vol. 2. Adlard & Son, Limited, London.

Hooker, J.D. (1882). Rubiaceae, pp. 14–219. In: Hooker, J.D. (ed.). *Flora of British India* - Vol. 3. L. Reeve & Co., London.

IUCN. (2012). IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN, iv+32pp.

Lavergne, S., J.D. Thompson, E. Garnier & M. Debussche (2004). The biology and ecology of narrow endemic and widespread plants: a comparative study of trait variation in 20 congeneric pairs. *Oikos* 107: 505–518. https://doi.org/10.1111/j.0030-1299.2004.13423.x

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. Da Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858. https://doi.org/10.1038/35002501

Nayar, M.P. & A.R.K. Sastry (1987). *Red data book of Indian plants*. Vol. 1. Botanical Survey of India, Calcutta, 348pp.

Singh, P. & S. S. Dash (2017). *Plant Discoveries 2017*. Botanical Survey of India, Kolkata, 135pp.

Singh P., K. Karthigeyan, P. Lakshminarasimhan & S.S. Dash (2015). *Endemic Vascular Plants of India*. Botanical Survey of India. Kolkata, 355pp.

Viswanathan, M.B., E.H. Premkumar & N. Ramesh (2000). Rediscovery of *Wendlandia angustifolia* Wight ex Hook.f. (Rubiaceae), from Tamil Nadu, A species presumed extinct. *Journal of Bombay Natural History Society* 97(2): 311–313.

Woodruff, D.S. (2001). Declines of biomes and biotas and the future of evolution. *Proceeding of the National Academy of Sciences of the United States of America* 98: 5471–5476. https://doi.org/10.1073/pnas.101093798

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SHORT COMMUNICATION

Additional morphological notes on the male of *Icius alboterminus* (Caleb, 2014) (Aranei: Salticidae) with new distribution records from India

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Abstract: This paper includes additional detailed characters and new distribution records of the male of *Icius alboterminus* (Caleb, 2014) from India. A detailed morphological description based on scanning electron microscopic (SEM) images and illustrations of the reproductive organ are provided.

Keywords: Additional characters, Gujarat, jumping spider, new records, taxonomy.

Abbreviations: ALE—anterior lateral eye | AME—anterior median eye | AS—anterior spinnerets | CMS—clypeal marginal scale | CP—cheliceral pit | E—embolus | OLS—opisthosomal leaf-like scales | OS—ordinary setae | LS—larger leaf-like scale | MS—minute prosomal scales | OS—ordinary setae | PLE—posterior lateral eye | PME—posterior median eye | POS—posterior spinnerets | PS—plumose setae | PSS—plumose setae of spinnerets | RTA—retrolateral tibial apophysis | SCP—scattered papillae | SD—sperm duct | SP—setae on protuberance | SSB—setae on stout base | TB—tegular bump | I–IV—1st to 4th legs.

Several new salticid species were described recently from India (Caleb 2014; Prajapati et al. 2016, 2018; Sanap et al. 2017; Caleb 2017). All three Indian species of the genus *Icius* Simon, 1876—*Icius alboterminus* (Caleb, 2014), *Icius kumariae* Caleb, 2017 and *Icius vikrambatrai* Prajapati, Malamel, Sudhikumar & Sebastian, 2018—were described within a span of five years (Caleb 2014, 2017; Prajapati et al. 2018). Of these, *I. alboterminus* (Caleb, 2014) was originally described under the genus *Phintella* Strand in Bösenberg & Strand, 1906 and was recently transferred to *Icius* (Caleb 2017). In the present paper, we provide additional and previously undescribed morphological characters for the male of *I. alboterminus* from Gujarat. The species has been reported only from its type locality in Chennai, Tamil Nadu (Caleb 2014) and the current record in Gujarat extends its distribution by about 1,560km from the type locality.

Materials and Methods

Samples were hand collected and preserved in 70% ethyl alcohol. The specimens were studied under a Dewinter Zoomstar-II stereomicroscope. All measurements are in millimeters (mm). Length of the palp and leg segments are given as follows: total (femur, patella, tibia, metatarsus (except palp), tarsus). B/W drawings were made by means of a drawing apparatus attached to the Dewinter Zoomstar-II microscope. Scanning Electron Microscopic (SEM) images were

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Competing interests: The authors declare no competing interests.

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taken by means of a ZEISS EVO 18 Scanning Electron Microscope. The studied specimens are in the personal collection of Dhruv Prajapati (GJSP).

Taxonomy

Icius Simon, 1876

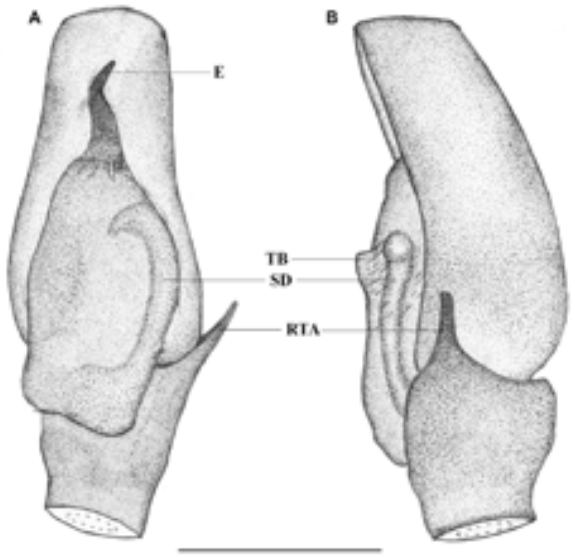
Type species: *Icius hamatus* C.L. Koch, 1846.

Icius alboterminus (Caleb, 2014)

Images 1A–H, 2A–H, 3A–D; Figures 1A–B, 2

Specimens examined: GJSP90243A, 1 male, 2.v.2019, India, Gujarat, Jamnagar, Khijadiya Bird Sanctuary (22.523N, 70.139E), 7m, from foliage, coll. D.A. Prajapati; GJSP90243B, 2 males, 8.v.2019, India, Gujarat, Kheda, Pariej wetland (70.139N, 72.610E), 20m, from foliage, coll. D.A. Prajapati; GJSP90243C 1 male, 9.v.2019, India, Gujarat, Anand, Kanewal wetland (72.610N, 72.539E), 9m, from foliage, coll. D.A. Prajapati.

Male of *Icius alboterminus* can be easily distnguished from all other *Icius* species by the dorsal abdominal pattern (see Fig. 1 in Caleb 2014); claw-shaped embolus



Figures 1A–B. *Icius alboterminus* (Caleb, 2014), male from Pariej wetland in Gujarat, India: A—left palp, ventral view; B—same, retrolateral view. Scale bar: 0.2mm (A–B). © Dhruv Prajapati.

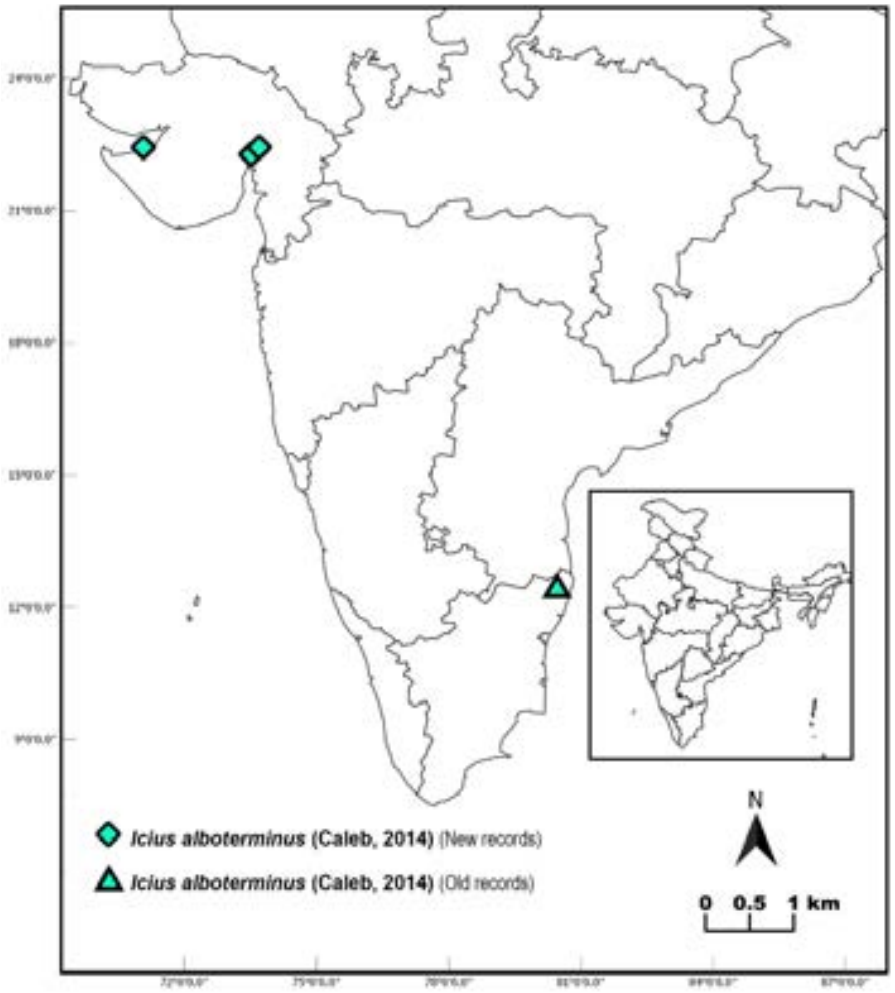
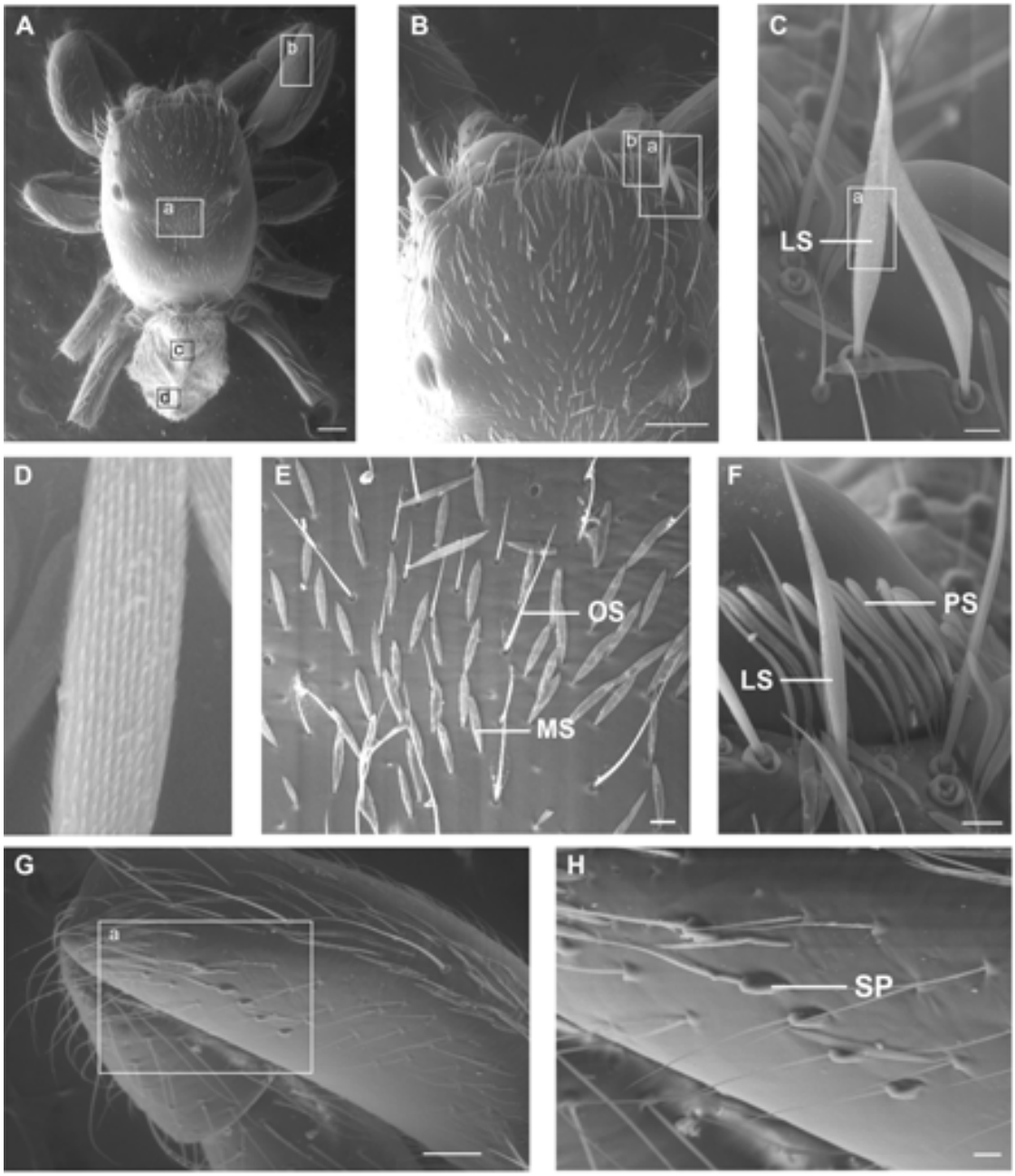


Figure 2. Distributional records of *Icius alboterminus* (Caleb, 2014) (squares indicate new records and triangle indicate previous record) from India.

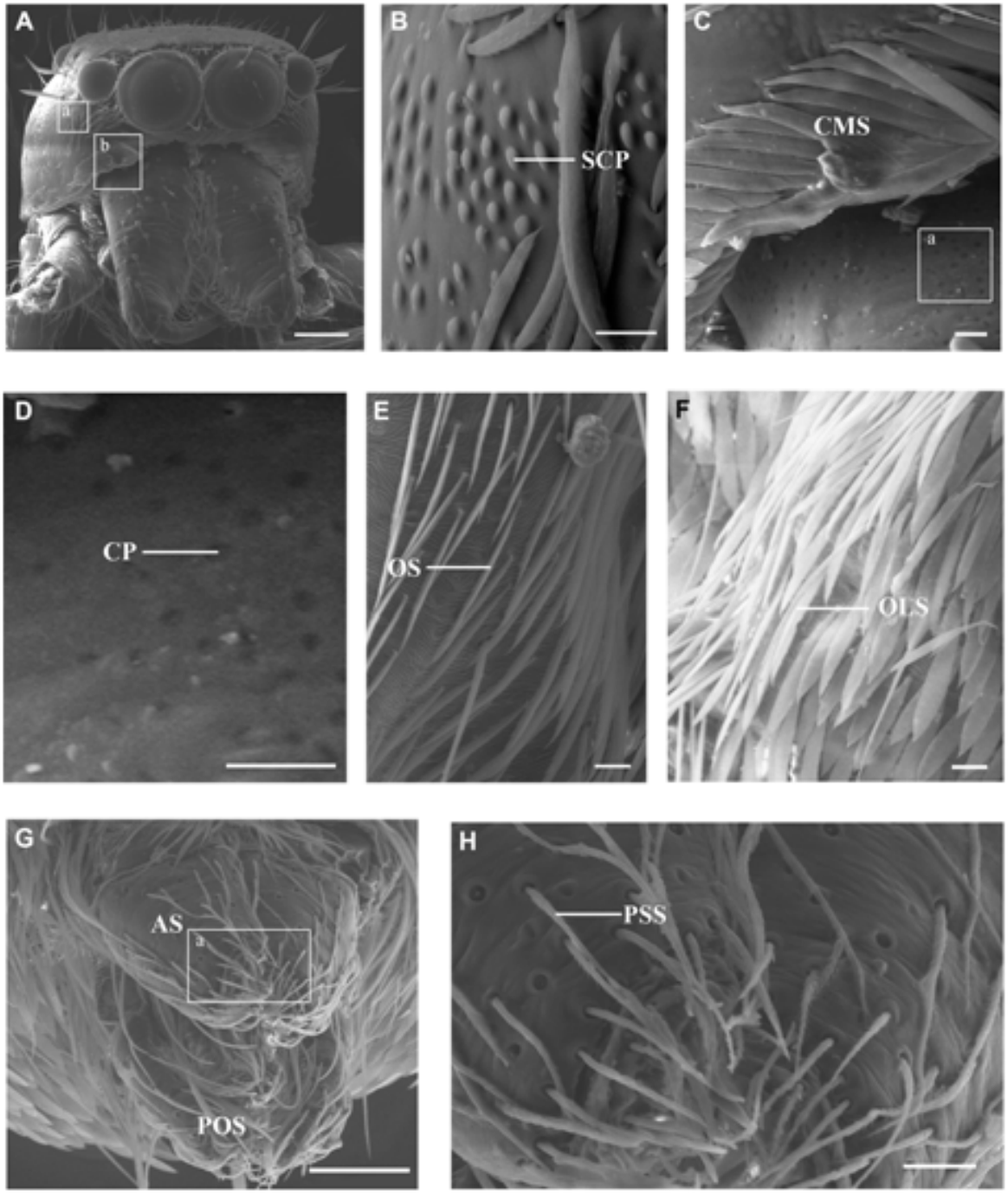


Images 1 A–H. Scanning electronic microscopic (SEM) images of *Icius alboterminus* (Caleb, 2014), male from Pariej wetland in Gujarat, India: A—body, dorsal view | B—cephalic region, dorsal view | C—enlarged portion of Image B(a) showing leaf-like scales | D—enlarged portion of Image C(a) showing details of leaf-like scale | E—enlarged portion of Image A(a) | F—enlarged view of Image B(b) | G—femur I (left), enlarged view of Image A(b) | H—enlarged view of Image G(a). Insets of A(c & d) are shown in Image 2E & 2F. Scale bars: 0.02mm (A–B), 0.002mm (C–F), 0.01 (G), 0.001 (H). © Dhruv Prajapati & R. D. Kamboj.

directed at 2 O'clock position (Images 3A–B, Figure 1A) (slightly bent in *I. kumariae* and *I. vikrambatrai*, see figs 10, 11, 16 in Caleb 2017; figs 6, 7 in Prajapati et al. 2018); RTA with narrow tip directed at 1 o'clock position in ventral view (Image 3A, Figure 1A) (branched in *I. kumariae*, see figs 10, 11, 16, 17 in Caleb (2017); tridentate in *I. vikrambatrai*, see figs 5, 14, 15 in Prajapati et al. (2018)). For diagnosis of female see Caleb (2014).

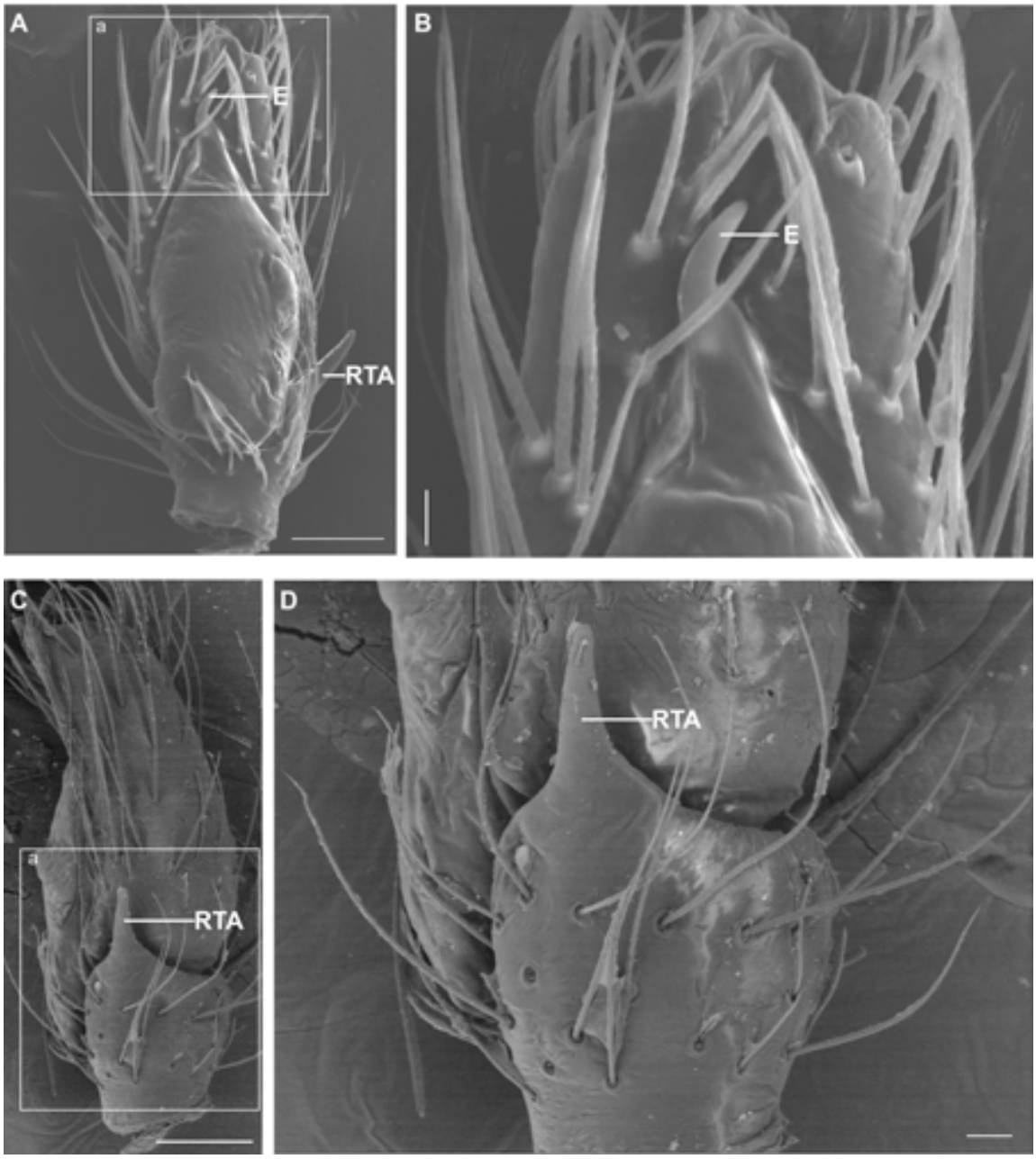
Description

Male (Images 1A–H, 2A–H): Prosoma pear-shaped, blackish-brown, with a thin white marginal stripe of uniform thickness; anterio-lateral sides of prosoma with whitish minute leaf-like scales. Cephalic region blackish,



Images 2 A–H. Scanning electronic microscopic (SEM) images of *Icius alboterminus* (Caleb, 2014), male from Pariej wetland in Gujarat, India: A—prosoma, frontal view | B—enlarged view of Image A(a) | C—enlarged view of Image A(b) | D—enlarged view of Image C(a) | E—enlarged view of Image 1A(c) | F—enlarged view of Image 1A(d) | G—spinnerets, ventral view | H—enlarged view of Image G(a). Scale bars: 0.02mm (2A), 0.002mm (2B–F, H), 0.01mm (G). © Dhruv Prajapati & R. D. Kamboj.

with scattered pale yellowish minute leaf-like scales and ordinary setae (Image 1E); eyes encircled by minute orange yellowish plumose setae (Image 1F), six leaf-like scales (with ribbed surface) located between ALEs and PLEs on either sides (Images 1A–1D, 1F), scattered papillae visible on lateral sides of cephalic region, near ALEs (Images 2A–B). Clypeus margin with whitish leaf-like scales (Images 2A, 2C). Clypeus, chelicerae, endites, labium and sternum brownish. Chelicerae with one promarginal and one retromarginal teeth and with 18–20 small setae dorsally with stout base (Image 2A); apical region of chelicerae with several pits (Images



Images 3A–D. Scanning electronic microscopic (SEM) images of *Icius alboterminus* (Caleb, 2014), male from Pariej wetland in Gujarat, India: A—left palp, ventral view | B—enlarged view of Image A(a) showing embolus | C—left palp, retrolateral view | D—enlarged view of Image C(a) showing magnified view of RTA. Scale bars: 0.01mm (A, C), 0.002 (B, D). © Dhruv Prajapati & R. D. Kamboj.

2C–D); fangs medium sized, yellowish-brown. Leg I blackish-brown, legs II–IV yellowish-brown with black blotches; antero-prolateral region of femur I with eight setae on protuberance distributed in two rows (five in first row and three in second row) (Images 1A, 1G–H). Opisthosoma oval, covered with ordinary setae and leaf-like scales (Images 2E–F), brownish anteriorly and blackish brown at posterior end; one anterior and two antero-lateral white dots on each side of abdominal margin, two white dots on mid-anterior region of abdomen, two on medio-lateral abdominal margin and single white dot above spinnerets. Spinnerets blackish, covered with plumose setae (Images 2G–H). Body length 2.59. Prosoma length 1.23, width (at the middle) 0.93, height (at the middle) 0.51. Opisthosoma length 1.36, width (at the middle) 0.93, height (at the middle) 0.78. Eye diameter: ALE 0.17, AME 0.24, PLE 0.11, PME 0.06. Eye interdistances: AME–AME 0.02, AME–ALE 0.01,

ALE–ALE 0.52, ALE–PME 0.23, PLE–PLE 0.61, PME–PME 0.59, PME–PLE 0.16. Clypeus height at ALE 0.23, at AME 0.009. Chelicera length 0.46. Measurements of palp and legs. Palp 1.02 (0.38, 0.11, 0.15, 0.38), I 2.30 (0.64, 0.41, 0.52, 0.39, 0.34), II 1.90 (0.57, 0.32, 0.40, 0.32, 0.29), III 2.06 (0.59, 0.30, 0.45, 0.39, 0.33), IV 2.48 (0.76, 0.35, 0.54, 0.47, 0.36). Leg formula: 4132. Palp (Images 3A–D, Figures 1A–B): embolus short and resembles the "claw" of a raptor; embolic tip narrowed and directed at 1 o' clock position ventrally (Images 3A–B, Figure 1A). Bulb protruded posteriorly (not prominent in Caleb 2014; see Figs 9–10 in Caleb 2014) (Images 3A, 3C, Figure 1A). Tegular bump can be seen from retrolateral view (Images 3C, Figure 1B). RTA simple, broad at the base and narrow at its blunt tip (a spiniform tip is shown in the original illustration; see figs 9–10 in Caleb 2014) (Images 3A, 3C–D, Figures 1A–B). Distribution: *Icius alboterminus* is endemic to India and known from the following localities:

Gujarat: Khijadiya Bird Sanctuary in Jamnagar District; Pariej wetland in Kheda District; Kanewal wetland in Anand district (new records) (Figure 2).

Tamil Nadu: Thirumullaivoyal in Chennai (holotype) (Figure 2).

Discussion

Newly collected specimens from Gujarat have a slightly prominent posterior protrusion of the bulb, which is not significant as seen in illustrations given by Caleb (2014). This may be due to the change in angle of view or may be considered as an intraspecific variation but more specimens need to be examined to confirm this assumption.

All the collected specimens were from vegetation near wetlands which may indicate its preference to habitats associated with water bodies. The type locality of the species is also near a suburban lake (Araabath Lake) which may define its preferred habitat (Caleb 2014). The new localities are Khijadiya Bird Sanctuary, Pariej wetland and Kanewal wetland. Habitat of all these localities are almost similar which include vegetation belonging to *Prosopis* sp., *Ipomoea* sp., *Azadiracta indica*, *Achyranthes aspera*, *Cressa cretica*, *Aeluropus lagopoides*, *Sueada* sp. and *Calotropis procera*. Since many states have similar habitat, *I. alboterminus* might also be found in states such as Karnataka, Maharashtra, Rajasthan, Madhya Pradesh. This case might be similar as *Chrysilla volupe* (Karsch, 1879), which was earlier known from Sri Lanka and later from Bhutan but no records were there in India. Later many specimens were collected and recorded from India (Caleb et al. 2018).

References

Bösenberg, W. & E. Strand (1906). Japanische Spinnen. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 30: 93–422.

Caleb, J.T.D. (2014). A new species of *Phintella* Strand (Araneae: Salticidae) from India. *Munis Entomology and Zoology* 9(2): 605–608.

Caleb, J.T.D. (2017). Jumping spiders of the genus *Icius* Simon, 1876 (Araneae: Salticidae) from India, with a description of a new species. *Arthropoda Selecta* 26(4): 323–327. https://doi.org/10.15298/arthsel.26.4.07

Caleb, J.T.D., R.V. Sanap, K.G. Patel, P.P. Sudhin, K.S. Nafin & A.V. Sudhikumar (2018). First description of the female of *Chrysilla volupe* (Karsch, 1879) (Araneae: Salticidae: Chrysillini) from India, with notes on the species' distribution and life history. *Arthropoda Selecta* 27(2): 143–153. https://doi.org/10.15298/arthsel. 27.2.06

Koch, C.L. (1846). *Die Arachniden*. J. L. Lotzbeck, Nürnberg, Dreizehnter Band, pp. 1–234, pl. 433–468 (f. 1078–1271); Vierzehnter Band, pp. 1–88, pl. 467–480 (f. 1272–1342). https://doi.org/10.5962/bhl.title.43744

Prajapati, D.A., P.S. Murthappa, P.M. Sankaran & P.A. Sebastian (2016). Two new species of *Stenaelurillus* Simon, 1886 from India (Araneae: Salticidae: Aelurillina). *Zootaxa* 4171(2): 321–334. https://doi.org/10.11646/zootaxa.4171.2.5

Prajapati, D.A., J.J. Malamel, A.V. Sudhikumar & P.A. Sebastian (2018). A new species of the jumping spider genus *Icius* Simon, 1876 from India (Aranei: Salticidae: Chrysillini). *Arthropoda Selecta* 27(4): 330–334. https://doi.org/10.15298/arthsel. 27.4.08

Sanap, R.V., A. Joglekar, D.A. Prajapati & J.T.D. Caleb (2017). Two new species of *Langelurillus* Próchniewicz, 1994 from India (Araneae: Salticidae: Aelurillina). *Zootaxa* 4318(1): 135–146. https://doi.org/10.11646/zootaxa.4318.1.6

Simon, E. (1876). *Les arachnides de France*, *vol. 3*, Paris, 364pp.

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SHORT COMMUNICATION

Three moss families (Bryopsida: Calymperaceae, Hyopterygiaceae, & Pterobryaceae): new distribution records to bryoflora of Andhra Pradesh, India

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Abstract: Our investigation of the bryoflora of Andhra Pradesh carried out during 2015–19 resulted in three new records of moss families: Calymparaceae, Hypopterygiaceae, and Pterobryaceae represented by *Calymperes tenerum*, *Hypopterygium* tamarisci, and *Pterobryopsis acuminata,* respectively.

Keywords: Bryophyte, Mosses, new records.

Part of bryophyte inventory during June 2016 to September 2018 in the state of Andhra Pradesh, we collected curious moss plant specimens from different forest localities of Andhra Pradesh. After critical study, we identified the specimens collected from the hill tops of Sadasiva Kona, Chittoor District belonging to *Calymperes tenerum* Mull.Hal. (Calymperaceae, Dicranales, Bryopsida); those collected from hills of Galikonda near Sunkarimetta, Visakhapatnam District as *Hypopterygium tamarisci* (Sw.) Brid. ex Müll.Hal. (Hypopterygiaceae, Hookeriales, Bryopsida) and those from the valleys of Vantamamidi near Lambasingi, Visakhapatnam District as *Pterobryopsis acuminata* (Hook.) M. Fleisch. (Pterobryaceae, Hypnales, Bryopsida).

Calymperaceae comprises 19 genera and 1,051 species worldwide (The Plant List 2013), of which seven genera and 44 species are represented in India; *Calymperes* comprising 342 species are represented by 19 in India (Dandotiya et al. 2011; Alam 2015). Hypopterigiaceae comprises five genera and 33 species (The Plant List 2013), of which four genera and 13 species are represented in India; *Hypopterygium* comprising 27 species is represented by five species in India (Dandotiya et al. 2011). Pterobryaceae comprises 41 genera and 393 species (The Plant List 2013), of which eight genera and 27 species are recorded from India; *Pterobryopsis* comprises 52 species, represented by 12 species in India (Dandotiya et al. 2011).

Perusal of updated literature on bryoflora of Andhra Pradesh (Rani et al. 2014) revealed that till date, representatives of the families Calymperaceae, Hypopterygiaceae, and Pterobryaceae have not been reported from the state of Andhra Pradesh and hence the present collection forms new distribution records of these three families, genera and species for the state.

Materials and Methods

The plant materials were collected by using sharp knife and brought to the laboratory in labeled zip lock

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Competing interests: The authors declare no competing interests.

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polythene cover, air dried at room temperature and preserved in brown paper packets (12×18 cm) with detailed label (10×17cm). Critical examination of the collected specimens were done by using temporary slides, and plant parts were separated by using micro forceps (Varin) VR-15 curved, VR-11straight with fine sharp edges. Slides were observed under light microscope (Olympus CH20i), and measurements were taken by using ocular micro meter (Erma) 19mm, 100 segments in 1cm. Field photographs were taken by using Nikon D3300; microscopic photographs were taken by using Moto g3 turboequipped with 13MP camera, 4x wide digital zoom. Different dimensions were measured and identifications were done using standard bryofloras. Description, phenology, distribution, voucher specimen information, microscopic photographs, and illustrations are provided for all the three species. Distribution pertaining to the world is adopted from the Tropicos website (Mussorie Botanical Garden 2019). Voucher specimens are deposited in the Sri Krishnadevaraya University Herbarium, Ananthapuramu (SKU). Abbreviations used for collectors are: AS (Ananthaneni Sreenath), BR (B. Ravi Prasad Rao).

Taxonomic treatment

Calymperes tenerum Mull.Hal. in Linnaea 37: 174. 1872: Bureshi in Rec. Bot. Surv. India 13(1): 32. 1931; Foreau in J. Bombay Nat. Hist. Soc. 61: 223; 1964 Gungulee, Moss. E. India 1(2): 600. 1971; W.D. Reese & Mohamed in Bryologist 88: 106. 1985; Ellis in J. Bryol. 15:712. 1989; Daniels, Bryophytes of Southern W. Ghats 56–57.2003.

Plants small, tufted or forming mats up to 3–7 mm high, green to dark green-colored. Stem usually notbranching, very short, without central stand. Leaves curled when dry, erect to spreading when moist; dimorphic. Gemmiferous leaves obovate-lanceolate 1.6–2.8 × 0.6–1.2 mm., non-gemmiferus leaves obovate to oblong ligulate, 1.1–2.1 × 0.7–1.2 mm; leaf cells unipapillose at apex and middle, papilla reducing towards base, apical cells 6–14 × 4–12 µm; hexagonal to quadrate, basal cells 14–43 × 6–8 µm, quadrate, elongate and cancellinae 9–13 rows in side of costa at base; 40–90 × 40–45 µm. Costa smooth on back side, 70–80 µm wide, finely toothed at apex, percurrent to excurrent in non gemmiferous leaves, excurrent in gemmiferous leaves. Gemmae green, radiating stellate, clustered at costal apex, and 130–180 × 33–54 µm with shinytransparent margins and cells having thick chlorophyll. Capsulesnot seen. Microscopic Photographs & Illustrations for the species (Image 1; Figure 1)

Habitat: Corticolous on *Alphonsea sclerocarpa* (Annonaceae) and found associated with *Frullania udarii* V. Nath & Ajit P. Singh. (Frullaniaceae). Also found on soil covered rock substratum near the host tree.

Specimens examined: 53330-B (SKU) 24.ii.2017, 13.734^{0}N & 79.590^{0}E, 508m, Sadasivakona hill top, Chittoor District, Andhra Pradesh, India, coll. Boyina Ravi Prasad Rao & Ananthaneni Sreenath.

Distribution: Aldabra, Australia (northern Queensland) (Fife & De Lange 2009)**,** Benin Bioko, Brazil, Chagos Archipelago, China, Comoros, Democratic Republic of the Congo, Ghana, Hawaiian Island, India (Andhra Pradesh, Kerala, Tamil Nadu, lower Bengal, southwestern Himalaya), Indonesia, Ivory Coast, Kenya, Madagascar, Malaysia, Maldives, Mauritius, New Zealand, Nigeria, Papua New Guinea, Pacific Islands (Hawaii, Fiji, Tonga Group, Cook Islands, Society Islands, Marquesas, New Caledonia) Philippines, Reunion, Rodrigues, Seychelles, South Africa, Sri Lanka, Tanzania, and United States (Florida).

Hypopterigium tamarisci (Sw.) Bird. ex Mull. Hal.; Syn. Musc. Frond. 2: 8. 1850; *Hypopterygium tenellum*Mull. Hal., Bot. Zeitung (Berlin) 12: 557. 1854; R.S. Chopra, Tax. Indian moss. 397. 1975; Daniels, Bryophytes of Southern W. Ghats 123–124. 2003.

Plants small to medium-sized, main stem to 5cm long creeping, secondary stem erect, dendroid to 2.5cm high, yellowish-green to dark green above and reddish-brown below by dese tomentose. Leaves complanate, asymmetric, arranged in 3 rows, 2 lateral rows and 1 ventral row; lateral leaves ovate-abovate to 0.7–1.1 × 0.5–0.67 mm, acute to short acuminate, finally toothed at apex, entire below at margin, bordered by two rows of limbidium, linear elongated cells, hylane to 50–145 x 6–11 µm; leaf apical, middle and basal cells are same in size shape, rhomboid-rhomboid hexagonal to 20–36 × 10–22 µm and some cells slightly larger near at costa base to 30–42 × 12–22 µm. Costa single, more or less ½ of the leaf length, ending much below the apex. Ventral leaves orbicular-cordate to 0.43–0.47 × 0.4–0.5 mm; apex acuminate, faintly toothed to entire at margin with border of limbidium, linear elongate hyaline cells similar to lateral leaves. Costa more are less ½ of the leaf length, sometimes percurent, just below the leaf tip or whole length of the leaf. Gemmae present as axillary buds. Sporophyte not seen in this specimens. Microscopic photographs and illustrations for the species (Image 2, A–G; Figure 2, A–G)

Habitat: Racophilous on wet tocks near aquatic areas, found associated with *Hetiroscyphus hylanus*

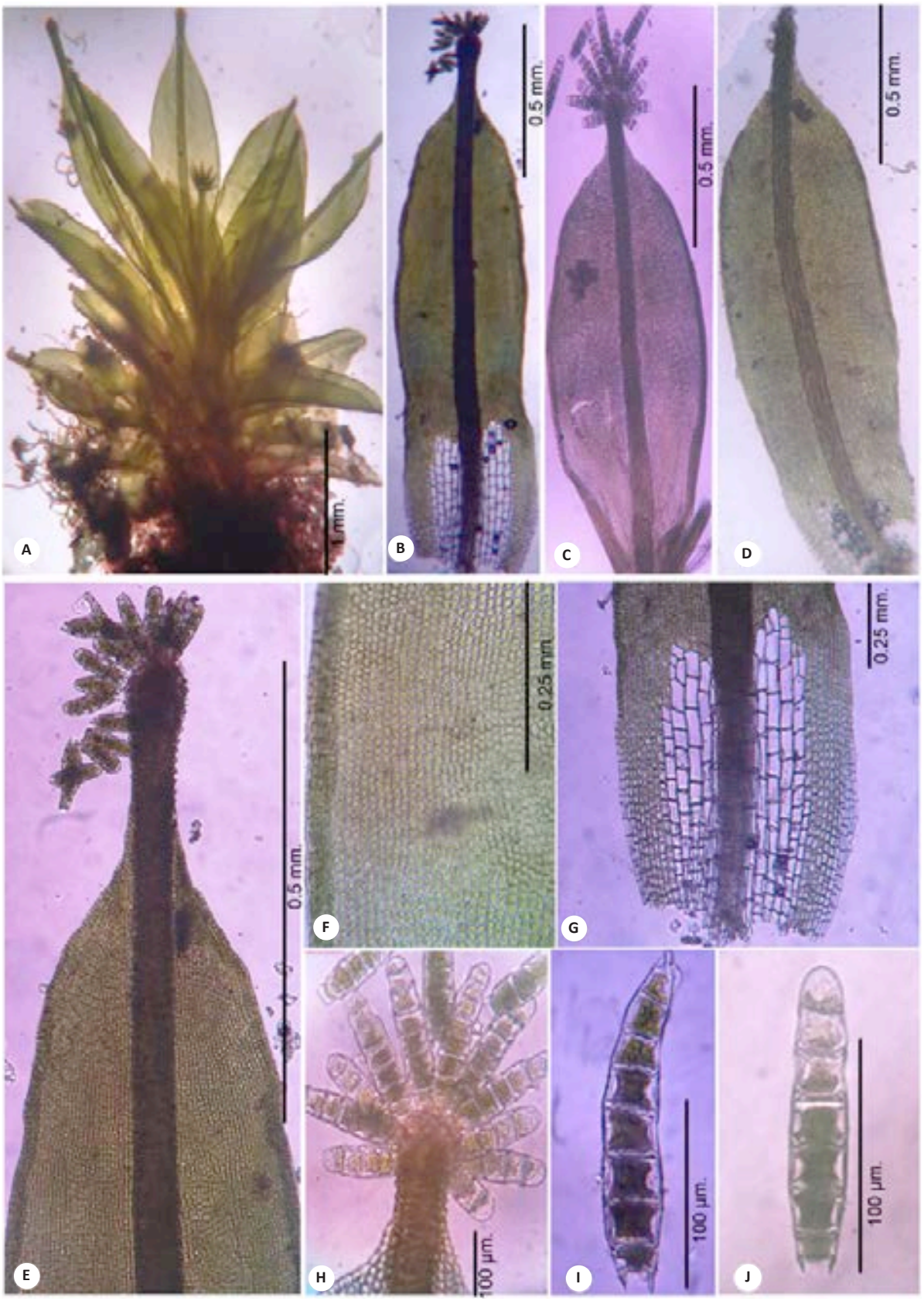

Image 1. ***Calymperes temerum*** **Mull.Hall.**
A—Plant | B & C—Gemmiferous leaves | D—Non gemmiferous leaf | E—Leaf Apical cells | F—Leaf Middle cells | G—Leaf basal cells with cacellinae cells | H—Gemmiferous Leaf tip | I & J—Gemmae. © Ananthaneni Sreenath & B.R.P. Rao.

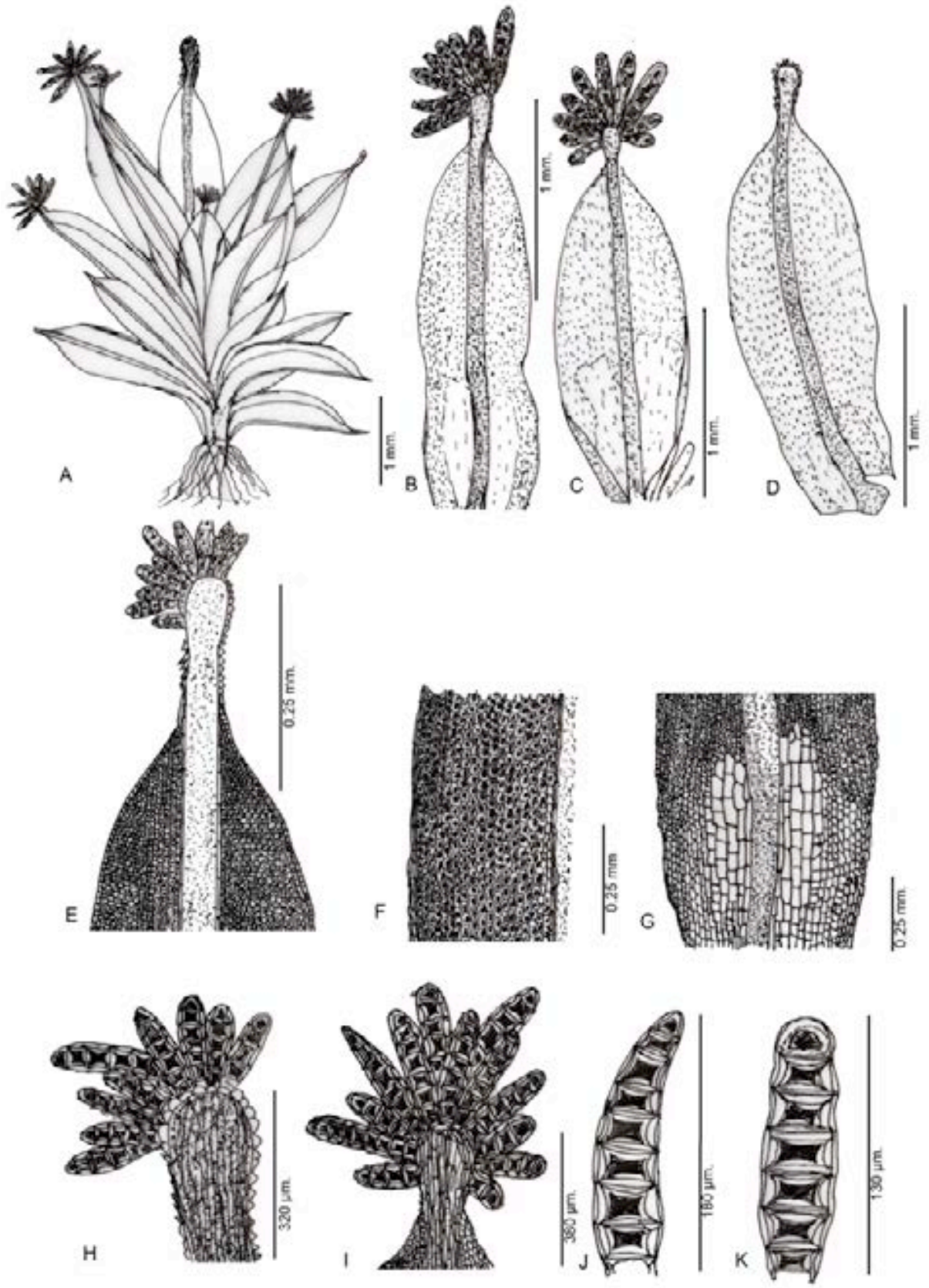

Figure 1. ***Calymperes tenerum*** **Mull.Hall.**
A—Plant | B & C—Gemmiferous leaves | D—Non gemmiferous leaf | E—Leaf Apical cells | F—Leaf Middle cells | G—Leaf basal cells with cacellinae cells | H & I—Gemmiferous Leaf tips | J & K—Gemmae.

(Geocaliaceae) and *Fissidens* sp. (Fissidentaceae).

Specimens examined: 55201-A (SKU) 21.x.2018, 18.360^{0}N & 83.041^{0}E, 1,280m, Galikonda, on the way of Ananthagiri to Sunkarimetta, 1.5km near Galikonda view point from Ananthagiri, Visakhapatnam District, Andhra Pradesh, India, coll. Boyina Ravi Prasad Rao & Ananthaneni Sreenath.

Distribution: Belize, Bioko, Brazil, Burundi, Cameron, Caribbean, Comoros, Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, India (Andhra Pradesh, Kerala and Tamil Nadu), Kenya, Madagascar, Malawi, Mascarene Islands, Mauritius, Mexico, Reunion, Rwanda, Sao Tome, South Africa, Tanzania, Uganda, Zimbabwe.

Note: Although Dandotiya et al. (2011) treated *Hypopterigium tamarisci* (Sw.) Bird. ex Mull. Hal. and *H. tenellum* Mull. Hal. separately, the Plant List (2013) treated the latter as synonym to the former based on Tropicos data.

Pterobryopsis acuminata (Hook.) M. Fleisch. Hedwigia 45: 59. 1905; Gangulee, Mosses of Eastern India 2(5): 1273. 1976; Manju, Eco-systematic studies on bryophytes of Wayanad 259. 2005.

Plants small to medium-sized, main stem to 6cm long creeping, secondary stem sub erect, dendroid, pinnate to 4cm high, secondary branches to 5–7 mm, light yellowish to brown when dry, green to dark green when moist and dark brown below. Leaves concave, densely lamellose, spirally arranged, stem leaves, branch leaves slightly differentiated in shape and shape, stem leaves cordate, orbicular-ovate to 1.28–1.5 × 0.8–0.9 mm; branch leaves ovate to 1.2–1.6 × 0.58–0.64 mm, acute to short acuminate, finally denticulate but not at apex; leaf cells are same in stem and branch leaves; leaf apical, middle, basal and alar cells slightly, differentiated in size, shape; leaf cells thick walled elongated, basal and middle cells to 50–60 × 10–12 µm, apical cells 26–30 × 0.7–10 µm and alar cells differentiated with other all leaf cells, quadrangular to 10–12 × 0.7–1 µm. stem attachment cells transparent and base reddish-brown to golden brown in color. Costa more than ½ of the leaf length, single, ending much below the leaf tip, costa end simple or sometimes furcate. Gemmae absent some. Sporophyte not seen in this specimen. Microscopic photographs and illustrations for the species (Image 2, H–N; Figure 2, H–M)

Habitat: Corticolous on old, wet tree trunks of branching base, found associated with *Stereophyllum* sp. (Plageotheciaceae) and *Erythrodontium julacium* (Erythrodontaceae).

Specimens examined: 53900–B 13.xii.2017, 17.825^{0}N & 82.618^{0}E, 800m, interior forest of Vantamamidi near Lambasingi, Visakhapatnam District, Andhra Pradesh, India, coll. Boyina Ravi Prasad Rao & Ananthaneni Sreenath.

Distribution: India (Andhra Pradesh, Tamil Nadu, Kerala, Khasia Hills and Sikkim), Indo-Burma, and China.

Discussion

Bryophytes are an important component of plant biomass especially in forests and play a vital role in soil development, nutrient biogeochemical cycling and ecological succession (Frego 2007). Studies on bryophytes are, however, sparse owing to the difficulty in their identification, availability of less literature and as well as high-costs for explorations. Only a few studies are there on bryoflora of Andhra Pradesh and most of the bryophytes of the state were recorded in the past three decades from the state. Past studies on bryoflora of Andhra Pradesh includes: Rao et al. (1999); Sowghandika (2010); Rani et al. (2011a,b, 2012, 2014); Sowghandika et al. (2011); Pullaiah et al. (2012). Perusal of literature (Rani et al. 2014; Manjula & Manju 2016; Pande et al. 2019) revealed the records of 101 taxa (99 species) belonging to 36 families. Owing to the presence of diversified bryophyte habitats in the state and consequently anticipated much more diversity, we explored the state for the past three years intensively. The present records of three bryophyte species are part of the result of this exploration.

Calymperaceae is distinct in Bryopsida with gemmiferous leaftips. *Calymperes tenerum* Mull.Hal., an acrocarpous moss is distributed South America, Africa, southern and southeastern Asia, Pacific Islands; in India, the species is having discontinuous distribution: in southern peninsular India, southwestern Himalaya and lower Bengal; we could locate it only in one place of Andhra Pradesh. Hypopterygiaceae, characterized by plants with dendroid habit are pleurocarpous mosses. *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hall. are distributed in Brazil, Bioko, Mexico, central America, Africa, Indian Ocean Islands, and southeastern Asia; in India, the species is known only from southern peninsular India states; and currently recorded only from one locality in Andhra Pradesh. Pterobryaceae characterized by concave shaped leaves are pleurocarpous mosses. *Pterobryopsis acuminata* (Hook.) M. Fleisch. is recorded only from Indo-Burma, China, and India; in India the species is known from the Eastern Ghats, Kerala, and northeastern India and presently recorded only from one locality in Andhra Pradesh. All the three species reported as new records to states are not falling in any threatened categories (IUCN 2001).

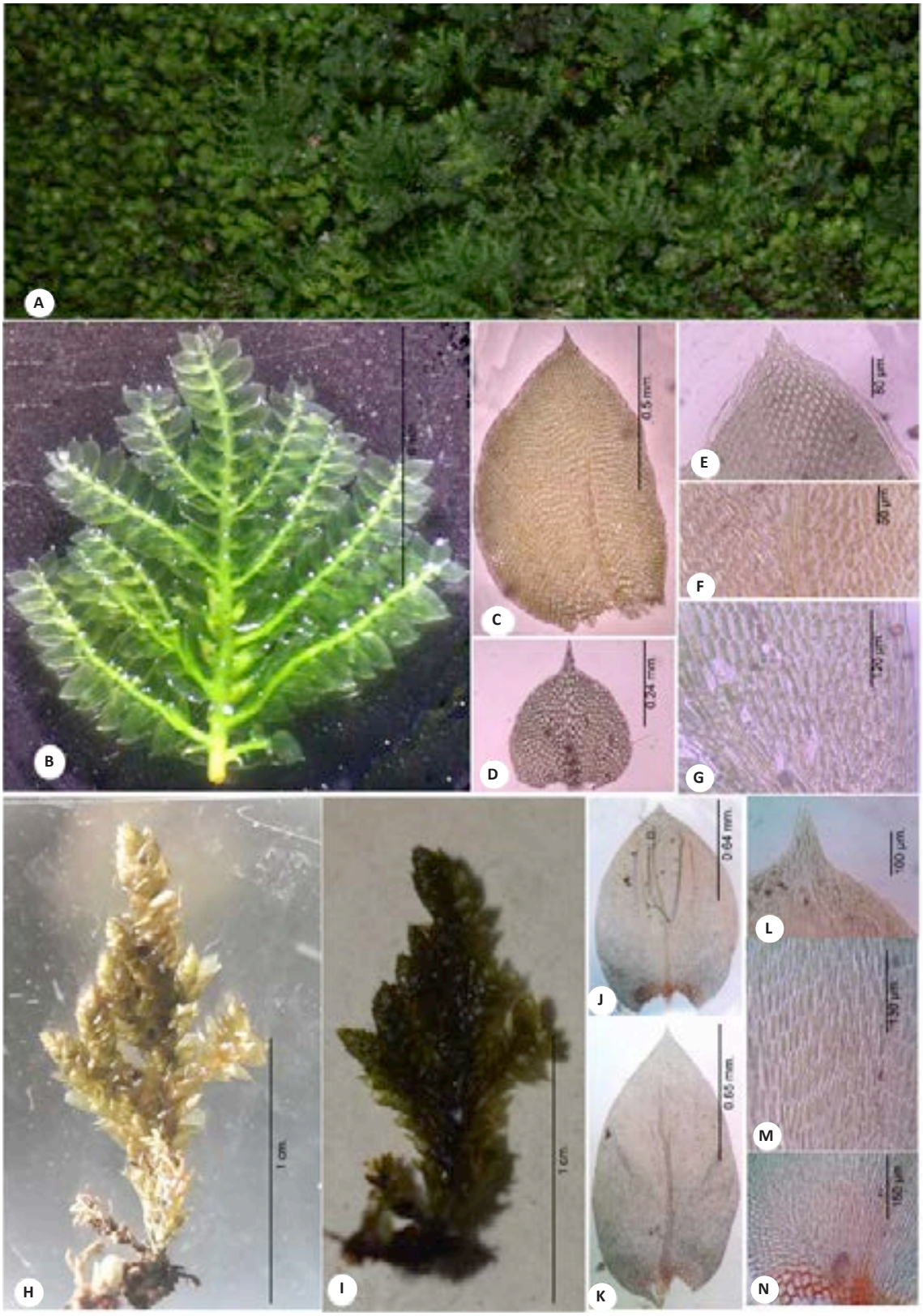

Image 2. A–G: *Hypopterigium tamarisci* (Sw.) Bird. ex Mull. Hal.: A—Single branch | B—Elongated view of apical portion | C—Lateral leaf | D—Ventral leaf | E—Leaf apical cells | F—Leaf middle cells | G—Leaf basal cells.
H–N: *Pterobryopsis acuminata* (Hook) M. Fleisch.: H—Dry plant | I—Wet plant | J—Stem leaf | K—Branch leaf | L—Leaf apical cells | M—Leaf middle cells | N—Leaf basal and alar cells.

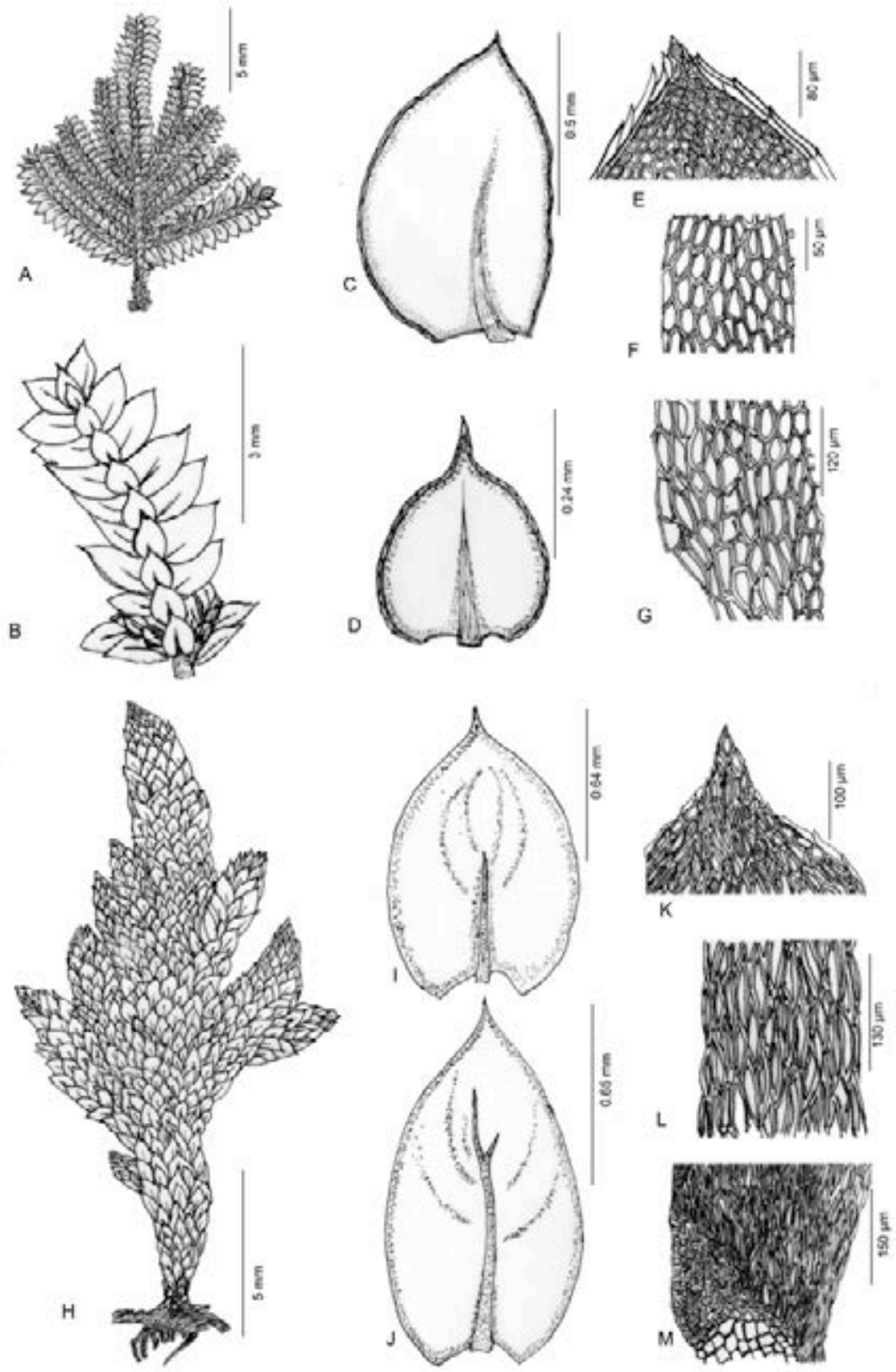

Figure 2. A – G: *Hypopterigium tamarisci* (Sw.) Bird. ex Mull. Hal.
A—Natural habit with single branch | B—Apical portion of plant elongated view | C—Lateral leaf | D—Ventral leaf | E—Leaf apical cells | F—Leaf middle cells | G—Leaf basal cells
H–M: *Pterobryopsis acuminata* (Hook) M. Fleisch.
H—Single branch | I—Stem leaf | J—Branch leaf | K—Leaf apical cells | L—Leaf middle cells | M—Leaf basal and alar cells.

References

Alam, A. (2015). *Moss Flora of India. An Updated Summary of Taxa*. GRIN Publisher, Germany, 195pp.

Bureshi, P. (1931). A census of Indian mosses with analytical key to genera. *Records Botanical Survey of in India* 13(1): 1–135pp.

Chopra, R.S. (1975). *Taxonomy of Indian mosses*, CSIR publications & Information directorate, New Delhi, 397–398pp.

Dandotiya, D.H., Govindapyari, S. Suman & P.L. Uniyal (2011). Check list of the Bryophytes of India, *Archive for Bryology* 88: 1–126.

Daniels, A.E.D (2003). Studies on Bryoflora of southern Western Ghats, Tamil Nadu, India. PhD Thesis. Department of Botany, Manonmaniam Sundaranar University, vi+370pp.

Ellis, L.T. (1989). A taxonomic revision of Calymperes in Southern India and neighbouring islands. *Journal of Bryology* 15: 697–737. https://doi.org/10.1179/jbr.1989.15.4.697

Fife, A.J. & P.J. De Lange (2009) *Calymperes tenerum* Mull. Hal. (Calymperaceae) on the Chatham Islands, New Zealand. *Australasian Bryological Newsletter* 57: 14–16.

Foreau, G. (1964). Some south Indian mosses. *Journal of the Bombay Natural History Society* 61: 223–226.

Frego, K.A. (2007). Bryophytes as potential indicators of forest integrity. *Forest Ecology and Management* 242: 65–75.

Gungulee, H.C. (1969–1972). *Mosses of Eastern India and adjacent regions, a monograph*,Vol-1 (Fasc. 1-3) Calcutta, xix+830pp.

IUCN (2001). IUCN Red List Categories and Criteria: Version 3.1. Prepared by the IUCN Species Survival Commission. IUCN, Gland and Cambridge, 32pp. http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf

Manju, C.N. (2005). Eco-systematic studies on bryophytes of Wayanad, Kerala, PhD Thesis. Department of Botany, University of Calicut. li+456pp.

Manjula, K.M. & C.N. Manju (2016). Genus *Fissidens* Hedw. (Fissidentaceae; Bryophyta) from Eastern Ghats of Andhra Pradesh, India. *Cryptogam Biodiversity and Assessment* 1(2): 1–15.

Missouri Botanical Garden (2019). Missouri botanical garden. http://www.tropicos.org. (Accessed on 8 August 2019).

Pande, P., P. Srivastava & A.K. Astana (2019). Addition of two pleurocarpous mosses to the Bryoflora of South India. *Indian Journal of Forestry* 42(1): 99–103.

Pullaiah, T., A.S.V. Kumar, S.S. Rani & M. Sowghandhika (2012). Bryophyte Diversity in Guntur district, Andhra Pradesh. *Journal of the Indian Botanical Society* 91(1–3): 264–271.

Rao, R.S., S. Sudhakar & P. Venkanna (1999). *Flora of East Godavari District*. The Indian National Trust for Art and Culture Heritage (INTACH), Andhra Pradesh State Chapter, Hyderabad, xi+947pp.

Reese, W.D. & M.A.H. Mohamed (1985). A synopsis of *Calymperes* (Musci: Calymperaceae) in Malaysia and adjacent regions. *The Bryologist* 88: 98–109.

Rani, S.S., T. Pullaiah, D. Ramanjaneyulu & M. Sowghandika (2011). Bryophyte diversity in Kurnool District, Andhra Pradesh. *Journal of Economic and Taxonomic Botany* 36(3): 674–679.

Rani, S.S., M. Sowghandhika, B. Suseela, K.S. Nagesh & T. Pullaiah (2011). Additions to the bryoflora of southern peninsular India. *Journal of the Indian Botanical Society* 90(1&2): 75–79.

Rani, S.S., M. Sowghandhika, T.V.K. Kumar & T. Pullaiah (2012). Bryophyte Diversity in East Godavari district, Andhra Pradesh. *Journal of Plant Science Research* 28(1): 101–109.

Rani, S.S., M. Sowghandhika, K.S. Nagesh, B. Suseela & T. Pullaiah (2014). *Bryophytes of Andhra Pradesh*. Bishen Singh Mahendra Pal Singh, Dehra Dun, iii+279pp.

Sowghandika, M. (2010). Bryophytes in Visakhapatnam District, Andhra Pradesh. PhD Thesis. Department of Botany, Sri Krishnadevaraya University, ix+220pp.

Sowghandika, M., S.S. Rani, B. Susheela & T. Pullaiah (2011). Musci in Visakhaptnam district of Andhra Pradesh. *Journal of Economic and Taxonomic Botany* 35: 516–528.

The Plant List (2013). http://www.theplatlist.org. Accessed on 08 August 2019.

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NOTE

Mating behavior of the Yellow-throated Marten *Martes flavigula* (Mammalia: Carnivora: Mustelidae)

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Martes flavigula Boddaert, 1785, commonly known as the Himalayan Yellow–throated Marten, is the biggest marten in the old world and has distinctive blends of black, white, golden-yellow and brown, comparatively brief fur and lengthy tail. It is differentiated from eight other known races of the species by the lack of a bare skin above the hind foot plantar pad, a big hair mat between the forefoot plantar and carpal pads, and its longer, luxuriant winter coat (Pocock 1941).

Yellow-throated Marten has a broad distribution in tropical Asia (including the Greater Sundas) and expands to the Palaearctic north-east (Corbet & Hill 1992). It is frequently said to be a voracious predator. For example, Pocock (1941: 336) cited local reports given to J.M.D. Mackenzie (in Wroughton 1916) that "three or four will attack an unarmed man". There is, however, no specific verifiable proof to support such extreme reports although Yellow-throated Marten is known, however, to feed on a broad range of vertebrates, invertebrates, fruit, honey, and food waste both on the ground and in trees (Heptner et al. 1967; Parr & Duckworth 2007; Zhou et al. 2011).

It is listed as Least Concern on the IUCN Red List due to its wide distribution, evidently relatively stable population, occurs in a number of protected areas, and no major threats (Abramov et al. 2008). But in India, this species is regarded threatened. Yellow-throated Marten is under protection in the Indian Wildlife Protection Act 1972 Schedule II (Part II).

The species occurs in the Himalaya of Afghanistan, Pakistan, India, Nepal, and Bhutan, the Korean peninsula, southern China, Taiwan, and eastern Russia. The southern range of Yellow-throated Marten stretches across Bangladesh, Myanmar, Thailand, the Malay Peninsula, Laos, Cambodia, and Vietnam (Chutipong et al. 2016). In northeastern India, it has been reported in Arunachal Pradesh, Manipur, Himalayan regiion in West Bengal, and Assam. In the Sunda Shelf it occurs in Borneo, Sumatra, and Java (Proulx et al. 2005).

The Yellow-throated Marten has comprehensive and temporary home-ranges. In a single, 24 hour cycle, it patrols the land actively, and is known to cover 10–20 km. It hunts mainly on the ground, but can skillfully climb trees, jumping between branches 8–9 meters away (Heptner & Sludskii 2002). It restricts its operations to treetops after snowfall till March. Estrus cycle takes place twice a year from mid-February to late March and from late June to early August. The males fight each other for

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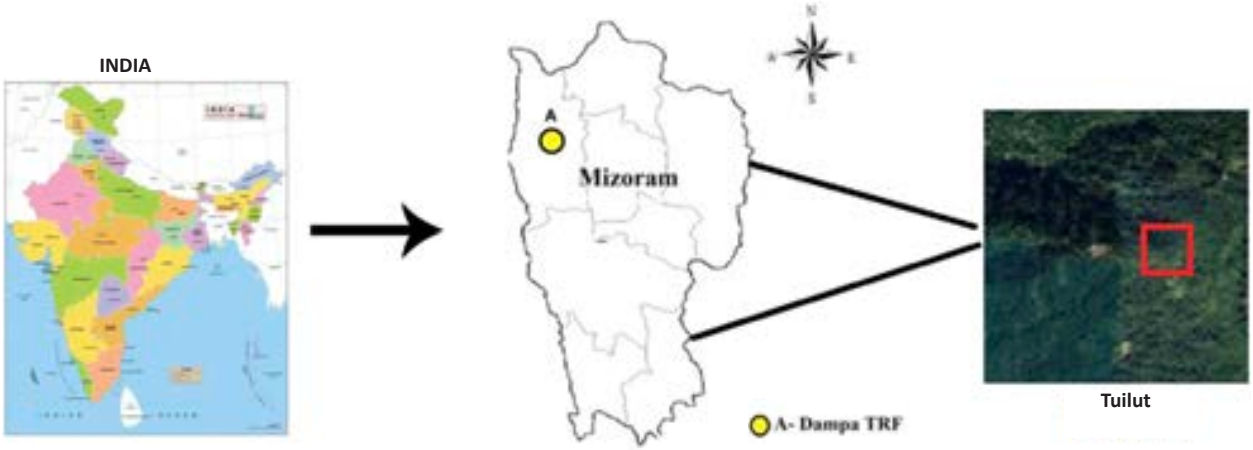

Figure 1. Map of study area.

access to female during these phases. Typically, litters consist of two or three kits and rarely four (Heptner & Sludskii 2002). No previous observation is available on mating behaviour of Yellow-throated Marten in India, and this is a first report.

The present opportunistic study was carried out in Dampa Tiger Reserve (DTR) on mating behaviour of *Martes flavigula* during November 2018 during an ongoing primate survey on transect line at Tuilut anti-poaching camp of Teirei range. DTR covers 500Km2 as core and 488Km2 as buffer area. Its geographical location is measured 23.341^{0}N and 92.127^{0}E, 800–1100 m. Annual rainfall of the area is 2,000–2,500 mm and the minimum temperature is 3.5^{o}C and the maximum temperature is 35^{o}C.

Natural vegetation on the upper slopes of the reserve is tropical type with evergreen at lesser altitudes. The forest is widely split into three kinds: tropical moist deciduous, tropical wet evergreen, and subtropical montane (Champion & Seth 1968; Forest Survey of India 2002) (Figure 1). The map was extracted from Google images as well as Google Earth pro (v.6.0).

Using a video camera (Sony HXR-MC1500P), the mating behaviour was registered on 25 November 2018 for around four minutes. The video was recorded slowly to determine the frequency of mating behaviour during winter. The information was recorded over a time scale of three minutes. One episode of mating was consisted of three minute duration.The three minutes duration was split into six intervals of 30 second each. Mating was classified into unsuccessful and successful category. These categories were recorded in each interval during mating (Thurman & Broghammer 2001; Gupta & Pati 1992).

On 25 November 2018 at 05:35h, two martens were observed mating on *Sterculia villosa* tree (locally named Khau-pui) (Image 1). The plant height was about 23m and the girth at breast height (GBH) was 117m. We recorded the activities from a distance of about 15–20 m.

During mating, the copulation was observed 14 times (36, 41, 48, 62, 70, 77, 85, 92, 107, 127, 145, 151, 194, 196 secs) successively (Supplementary Video 1–3). During mating, female was on her stomach (Image 2), and facing her head forward. The male did not look around and laid over the female (Figure 2). We observed four consecutive couplating rhythms between 60 sec to 90 sec followed by three time during 30 sec to 60 sec, two consecutive coupling rhythms were noted between 120 sec to 210 sec and no copulation was observed between 0 sec to 30 sec (Figure 3). During the copulation, an interruption (Image 3 and Supplementary Video 1–3) from another male *Martes flavigula* was recorded.

The initiation of mating is a complex behaviour in Yellow-throated Martin that depends on the temporal and spatial orientation of mating individuals. Pre-mating orientation is essential, for mate selection and sucessesful copulation (Rymer et al. 2007). Breeding pattern in martens vary on spatial changes. In the northern hemisphere, females were found active during February to September (Pearson & Baldwin 1953; Nellis & Everard 1983) and in the southern hemisphere female breeds actively during August to February (Gorman 1976). Khan (2008) stated that Small Asian Mongooses breed primarily in Bangladesh from March to July, but it is not evident whether females breed when offspring are there in the group. A recent incidence of mating of Indian Grey Mongooses *H. edwardsii* was reoprted in an open place and the individuals immediately vanished into the nearby bushes (Murali et al. 2012).

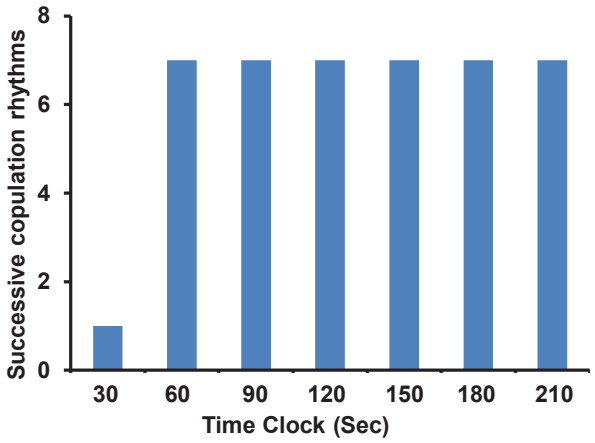

Figure 2. Copulation pattern of *Martes flavigula* at differenttime intervals.

Image 1. Mating behavior of Yellow-throated Marten *Martes flavigula* was observed on the tree, namely *Sterculia villosa* (locally named Khau-pui).

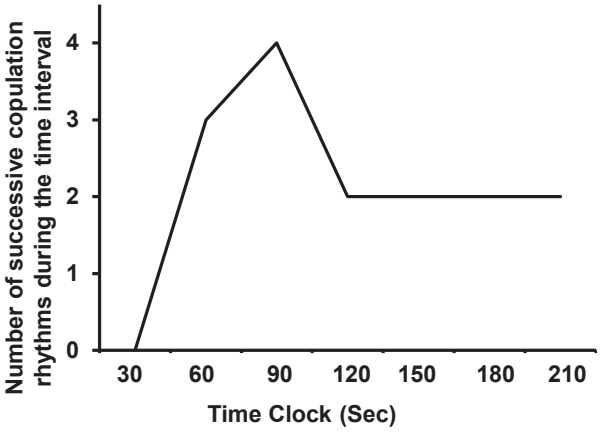

Figure 3. Consecutive couplings of *Martes flavigula* at different time intervals.

Image 2. Copulation, of *Martes flavigula* on *Sterculia villosa* tree.

References

Abramov, A., R.J. Timmins, S. Robertson, B. Long, Z. Than & J.W. Duckworth (2008). *Martes flavigula*, In. IUCN 2011. IUCN Red list of Threatened Species. Version 2011. 2. www.iucnredlist.org.

Borah, J. & K. Deka (2011). An observation of Common Palm Civet *Paradoxurus hermaphroditus* mating. *Small Carnivore Conservation* 44: 32–33.

Champion, S.H. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Government of India Press, Delhi, 600pp.

Chutipong, W., J.W. Duckworth, R.J. Timmins, A. Choudhury, A.V. Abramov, S. Roberton, B. Long, H. Rahman, A. Hearn, V. Dinets & D.H.A. Willcox (2016). *Martes flavigula*. The IUCN Red List of Threatened Species 2016: e.T41649A45212973. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41649A45212973.en

Corbet, G.B. & J.E. Hill (1992). *Mammals of the Indomalayan Region*, A Systematic Review. Oxford University Press, Oxford, U.K.

Duckworth, J.W. (1997). Small carnivores in Laos: a status review with notes on ecology, behaviour and conservation. *Small Carnivore Conservation* 16: 1–21.

Forest Survey of India (2002). State Forest Report. Ministry of Environment & Forest. Govt of India, Dehradun.

Grassman Jr, L.I. (1998). Movements and fruit selection of two

Image 3. Coupling activity of *Martes flavigula* interrupted by another male.

Supplementary Video 1. Video shows copulation of *Martes flavigula* and interruption by another male.

Supplementary Video 2. Copulation of *Martes flavigula*.

Supplementary Video 3. Copulation of *Martes flavigula*.

Paradoxurinae species in a dry evergreen forest in southern Thailand. *Small Carnivore Conservation* 19: 25–29.

Groman, M.L. (1976). Seasonal changes in the reproductive pattern of feral *Herpestes auropunctatus* (Carnivora: Viverridae). *The Fijian Islands Journal of Zoology* 178(2): 237–246.

Gupta, S. & A.K. Pati (1992). Data analysis methodology in chronobiological studies. *Journal of Parasitology and Applied Animal Biology* 1: 153–163.

Heptner & Sludskii (2002). *Mammals of the Soviet Union*, *Vol. II*, *Part 1b*, Carnivores (Mustelidae and Procyonidae). Washington, DC: Smithsonian Institution Libraries and National Science Foundation, 844pp.

Heptner, V.G., N.P. Naumov, P.B. Yurgenson, A.A. Sludskii, A.F. Chirkova & A.G. Banninkov (1967). *Mammals of the Soviet Union, 2, Part 1. Sea cows and carnivores*. Vysshaya Shkola, Moscow, Russia. (In Russian.), 466pp.

Jia, Z.Y., E.K. Duan, Z.G. Jiang & Z.W. Wang (2002). Copulatory plugs in Masked Palm Civets: prevention of semen leakage, sperm storage, or chastity enhancement? *Journal of Mammalogy* 83: 1035–1038.

Murali, K.C., S. Ramachandran & P. Mutthulingam (2012). An observation of Indian Grey Mongoose *Herpestes edwardsii* mating. *Small Carnivore Conservation* 47: 75–76.

Nellis, D.W. & C.O.R. Everard (1983). The biology of the mongoose in the Caribbean. *Studies on the fauna of Curacao and other Caribbean Islands* 64(1): 1–162.

Parr, J.W.K. & J.W. Duckworth (2007). Notes on diet, habituation and sociality of Yellow-throated Marten *Martes flavigula*. *Small Carnivore Conservation* 36: 27–29.

Pearson, O.P. & P.H. Baldwin (1953). Reproduction and age structure of a mongoose population in Hawaii. *Journal of Mammalogy* 34(4): 436–447.

Pocock, R.I. (1941). *Fauna of British India: Mammals. Vol. 2.* Taylor and Francis, London, 463PP.

Proulx, G., K. Aubry, J. Birks, S. Buskirk, C. Fortin, H. Frost, W. Krohn, L. Mayo, V. Monakhov, D. Payer & M. Saeki (2005). "World Distribution and Status of the Genus *Martes* in 2000", pp. 21–76. In: *Martens and Fishers (Martes) in Human-altered Environments*. Springer, Boston, MA.

Rabinowitz, A. (1991). Behaviour and movements of sympatric civet species in Huai Kha Khaeng Wildlife Sanctuary. *Thailand Jounal of Zoology London* 223: 281–298.

Rymer, J., A.L. Bauernfeind, S. Brown & T.L. Page (2007). Circadian rhythms in the mating behavior of the Cockroach, *Leucophaea maderae*. *Journal of Biological Rhythms* 22(1): 43–57.

Than, Z., H. Saw, P. Tha, M. Myint, A.J. Lynam, T.L. Kyaw & J.W. Duckworth (2008). Status and distribution of small carnivores in Myanmar. *Small Carnivore Conservation* 38: 2–28.

Thurman, C.L. & A.M. Broghammer (2001). Locomotor activity of the Fiddler Crab, *Uca subcylindrica* (Stimpson), under artificial illumination. *Biological Rhythm Research* 32: 85–99.

Timmins, R.J. & J.W. Duckworth (2013). *A Survey of Gibbons and Other Wildlife in the Bokeo Section of Nam Kan National Protected Area, Lao PDR*. Fauna & Flora International, Cambridge, U.K., 64pp.

Wroughton, R.C. (1916). Bombay Natural History Society's mammal survey of India, Burma and Ceylon. N° 25. Chin Hills. *Journal of the Bombay Natural History Society* 24: 758–773.

Zhou, Y.B., C. Newman, C.D. Buesching, A. Zalewski, Y. Kaneko, D.W. Macdonald & Z.Q. Xie (2011). Diet of an opportunistically frugivorous carnivore, *Martes flavigula*, in subtropical forest. *Journal of Mammalogy* 92: 611–619.

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NOTE

New to Myanmar: the Rosy Starling *Pastor roseus* (Aves: Passeriformes: Sturnidae) in the Hkakabo Razi Landscape

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Rosy Starlings *Pastor roseus* primarily breed in Europe and central Asia (Diniarsih et al. 2016) and winter mainly in India and Sri Lanka (BirdLife International 2019), but small numbers regularly reach the Thai-Malay Peninsula (Wells 2010), mainly between October and February (Diniarsih et al. 2016). Additionally, reports show single records from Java and Bali (Diniarsih et al. 2016), but not yet from Myanmar. The species is also a rare, but more or less annual, non-breeding visitor to Thailand (Treesucon & Limparungpatthanakij 2018).

On 20 September 2018, we observed a distinct looking starling (Image 1) in the afternoon in Naung Mung, Kachin State, Myanmar. Although the crest of this bird is not prominent in the picture, its head, hood, wings, and tail are black and the remaining plumage is pale pink. The eye is black while the bill is thick, pale orange with a pale yellow base and a grey culmen. We identified it as a Rosy Starling individual with adult plumage (Image 1) and recorded the species, probably the same individual, two more times at the same place until 26 September 2018 (Figure 1). We recorded an individual of the same species in February 2017, but were unable to take a photographic record during this previous observation. The place where we observed the Rosy Starling is on the outskirts of Naung Mung Village, an open and flat area with bushes and a few trees in the riparian area along a small creek (elevation is approximately 540m). The climatic condition of Naung Mung is tropical to subtropical and the average temperature is around 15°C (6–35 °C) while the annual rainfall is 1,700mm (Du Sar No pers. com). The bird rested on a power cable in Naung Mung and foraged in Taw Gway (Hog Plum, *Spondias pinnata*) and Minbaw trees (Fish Tail Palm, *Caryota* sp.). The Rosy Starling accompanied a mixed-species flock of Vinous-breasted Myna *Acridotheres burmannicus* and Red-vented Bulbul *Pycnonotus cafer*.

Our observation is the first record of *P. roseus* for Myanmar and confirms that this species occurs in the Hkakabo Razi Landscape, Myanmar (Figure 1). Although many ornithological expeditions were conducted previously by us and others to the Hkakabo Razi Landscape since 2001, and the occurrence of this species has been postulated, Rosy Starlings were not mentioned or recorded so far (Dumbacher et al. 2011; Rappole et al. 2011; Rasmussen et al. 2011; Renner &

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Figure 1. Naung Mung, Kachin State where the Rosy Starling was recorded. Map by Nay Myo Hlaing.

Image 1. Rosy Starling *Pastor roseus* resting on a tree in Naung Mung Village, Kachin State, Myanmar, 20 September 2018.

Rappole 2011; Renner et al. 2015, 2018; Suarez-Rubio et al. 2016). Rosy Starlings typically move in flocks or large aggregations, but we have only observed individuals of this species twice in the Hkakabo Razi Landscape. We therefore, suggest that *P. roseus* be added as a passage or vagrant species to Myanmar's bird species list.

References

BirdLife International (2019). Species factsheet: *Pastor roseus*. IUCN Red List for birds.

Diniarsih, S., S. Jones, J. Setiyono & R. Noske (2016). Rosy Starling *Pastor roseus*: a new species for Indonesia. *Kukila* 19: 60–64

Dumbacher, J.P., J.R. Miller, M.E. Flannery & Yang Xiaojun (2011). Avifauna of the Gaoligong Shan Mountains of western China: a hotspot of avian species diversity, pp. 30–63 In: Renner, S.C. & J.H. Rappole (eds). *Ornithological Monographs*. American Ornithologists' Union, Washington, D.C., 166pp.

Rappole, J.H., Thein Aung, P.C. Rasmussen & S.C. Renner (2011). Ornithological exploration in the southeastern sub-Himalayan region of Myanmar, pp. 10–29 In: Renner, S.C. & J.H. Rappole (eds.). *Ornithological Monographs*. American Ornithologists' Union, Washington, DC.

Rasmussen, P.C., Thein Aung & J.H. Rappole (2011). The breeding avifauna of the Sub-Himalayan zone of Northern Kachin State, Myanmar, pp. 95–108. In: Renner, S.C. & J.H. Rappole (eds). *Ornithological Monographs*. American Ornithologists' Union, Washington, DC., 166pp.

Renner, S.C., & J.H. Rappole (2011). Bird diversity, biogeographic patterns, and endemism of the eastern Himalayas and southeastern Sub-Himalayan Mountains, pp. 153–166. In: Morrison, M.L. (ed.). *Ornithological Monographs*. American Ornithologists' Union, Washington, DC., 166pp.

Renner, S.C., J.H. Rappole, M. Kyaw, C.M. Milensky & M. Päckert (2018). Genetic confirmation of the species status of *Jabouilleia naungmungensis*. *Journal of Ornithology* 159: 63–71. https://doi.org/10.1007/s10336-017-1493-0

Renner, S.C., J.H. Rappole, C.M. Milensky, Myint Aung, Nay Myo Shwe & Thein Aung (2015). Avifauna of the southeastern Himalayan mountains and neighboring Myanmar hill country. *Bonn Zoological Bulletin - Supplementum* 62: 1–75

Suarez-Rubio, M., Thein Aung, Sai Sein Lin Oo, Nay Myo Shwe, Nay Myo Hlaing, Kyaw Myo Naing, Tun Oo, Mie Mie Sein, & S.C. Renner (2016). Nonbreeding bird communities along an urban-rural gradient of a tropical city in central Myanmar. *Tropical Conservation Science* 9: 1–9. https://doi.org/10.1177/1940082916675961

Treesucon, U. & W. Limparungpatthanakij (2018). *Birds of Thailand*. Lynx Ediciones and BirdLife International. Barcelona, Cambridge, 452pp.

Wells, D.R. (2010). *The Birds of the Thai-Malay Peninsula - Vol. 2*. Bloomsbury Publishing, 848pp.

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NOTE

New records of *Heloderma alvarezi* (Wiegmann, 1829) (Sauria: Helodermatidae) on the coast of Oaxaca and increases to its distribution in Mexico

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In Mexico, the genus *Heloderma* is composed of five broad-ranging species: (i) the Gila Monster *H. suspectum* distributed in the Mohave Desert of extreme Nevada, southwestern Utah, extreme southeastern California and northwestern Arizona, and throughout the Sonoran Desert region in Arizona and Sonora, Mexico, as well as into the Chihuahuan Desert of southeastern Arizona and southwestern New Mexico (Campbell & Lamar 2004; Beck 2005); (ii) the Rio Fuerte Beaded Lizard *H. exasperatum* inhabits the foothills of the Sierra Madre Occidental, in the transition area between the drainage bains of Rio Mayo and Rio Fuerte and the Sonoran-Sinaloan subtropical dry forest in southern Sonora, extreme western Chihuahua, and northern Sinaloa (Campbell & Lamar 2004; Beck 2005); (iii) the Mexican Beaded Lizard *H. horridum* is found primarily in dry forest habitats from southern Sinaloa southward to Oaxaca and inland into the states of Mexico and Morelos (Bogert & del Campo 1956; Campbell & Lamar 2004; Beck 2005); (iv) the Chiapan Beaded Lizard *H. alvarezi* inhabits dry forests in the Central Depression of central Chiapas and the Rio Lagartero Depression in extreme western Guatemala (Campbell & Lamar 2004; Beck 2005); and (v) the Guatemalan Beaded Lizard *H. charlesbogerti* that inhabits the Rio Motagua Valley in the Atlantic slope of eastern Guatemala (Campbell & Vannini 1988).

The beaded lizard is known coloquially as 'escorpión' and is well known to local inhabitants, yet its natural history is surrounded by mystery, notoriety and misconception (Reiserer et al. 2013; Domínguez-Vega et al. 2018), principally because these animals can pass up to 95% of their lives hidden in shelters underground, which makes it difficult to detect them. Moreover, they maintain a low population (Beck & Jennings 2003; Domínguez-Vega et al. 2018). Furthermore, it is the only group which bears venom-transmitting teeth

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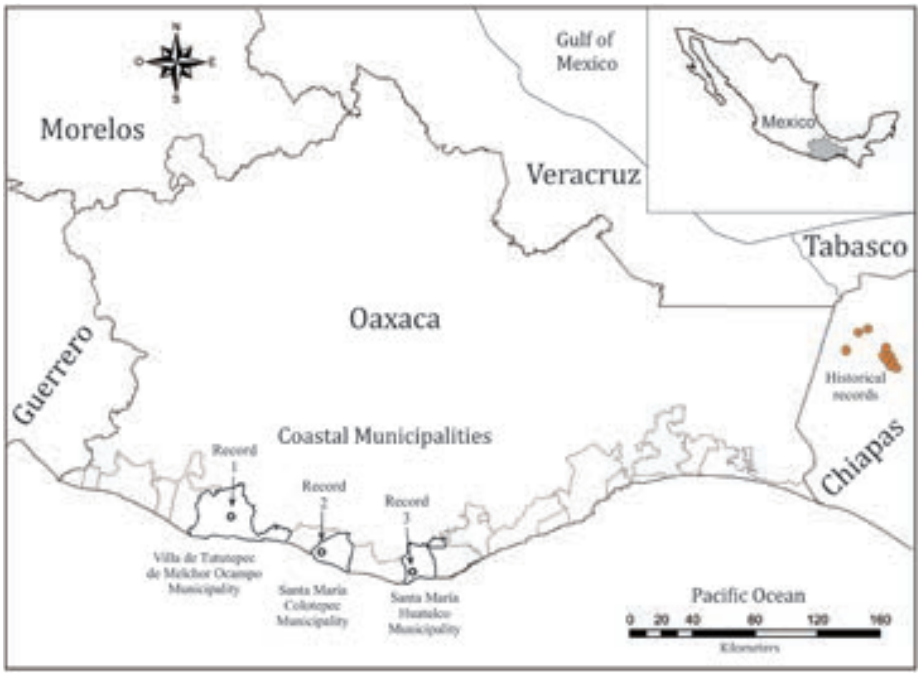

Figure 1. Location of photographic records of *Heloderma alvarezi* along the coast of Oaxaca; and historic published records (orange circles) in Chiapas State.

with a deep venom groove in the rostral carina (Fry et al. 2006). Although bites by the lizards are extremely rare, envenomation is known to produce severe local pain, dizziness, diaphoresis, vomiting, paresthesia, and hypotension (Ariano-Sánchez 2006). Consequently, the lizard is frequently slaughtered when encountered by humans (Beck 2005; Domínguez-Vega et al. 2017).

Herein, we provide three new records and a significant extension on the distribution of *H. alvarezi* about different encounters between humans while performing their activities and the species during its movement along the central coast of Oaxaca, Mexico, particularly in three different municipalities (Figure 1).

The first observation ocurred on 04 July 2017, when a lizard was held in captivity in the town of Santa Rosa de Lima, municipality of Villa de Tututepec de Melchor Ocampo. This animal was used as an exhibition specimen to decrease the fear of this species in the town. We were prohibited from measuring it, weighing it or determining its sex; however, to the naked eye this individual presented good body condition (Image 1a). According to the people in charge of the lizard, it came from the upper zone, close to the municipality.

The second observation ocurred on 10 October 2019 at 17.15 h. An adult female *H. alvarezi* was found and captured by people who were cleaning a field in a locality known as 'El Porvernir' in the Municipality of Santa María Colotepec, Oaxaca. Due to their fear of the creature, people caught the lizard in order to slaughter it, but then they reflected on the situation and reported it to the Universidad del Mar in the city of Puerto Escondido. The individual was measured (total length: 670mm), photographed (Image 1b) and then traslocated and released into the Natural Protected Area El Gavilán in San Francisco Cozoaltepec, municipality of Santa María Tonameca, Oaxaca, to ensure that the individual would not be harmed.

Most recently, the third observation ocurred on 03 November 2019 at 18.20h, between the boundaries of the Universidad del Mar campus Huatulco and Huatulco National Park, in the Municipality of Santa María Huatulco. A single juvenile was found walking near a road and was later photographed on a tree (Image 2c). It was not manipulated in order to avoid causing it unnecessary stress.

The identification of these lizards was possible because this taxon is unique among the beaded lizards in that it undergoes an ontogenetic increase in melanism (Bogert & del Campo 1956; Beck 2005). Also distinctive is that yellow banding on the tail, a characteristic typical of the other species of beaded lizards, is esentially absent in adults of *H. alvarezi* (Bogert & del Campo 1956; Beck 2005). Although Bogert & del Campo (1956) and Beck (2005) explain that black individuals are uncommon, there is recent photographic evidence of black individuals on the coast of Oaxaca. Neonates and

Image 1. ***Heloderma alvarezi*** **in: a—Villa de Tututepec de Melchor Ocampo municipality | b—Santa María Colotepec municipality | c—Santa María Huatulco municipality.**

juveniles often are distinctly marked with yellow spots and bands on the tail, but the color pattern of adults gradually transforms to an almost uniform dark brown or gray coloration.

Heloderma alvarezi was described as inhabiting dry tropical forest in the Central Depression (Río Grijalva Depression) of central Chiapas and the Río Lagartero Depression in extreme western Guatemala (Campbell & Lamar 2004; Beck 2005; Köhler 2008; Johnson et al. 2010; Wilson et al. 2010). Nontheless, Álvarez del Toro (1983 in Campbell & Vannini 1988) indicated the probabiliy of sympatry areas between *H. horridum* and *H. alvarezi* in the region between the Isthmus of Tehuatepec (Oaxaca) and Cintalapa (Chiapas); however, up to this point, the literature on integration between these two species is inconclusive (Reiserer et al. 2013), and therefore, the most recent herpetofauna list in Oaxaca does not include *H. alvarezi's* presence in the State. Sánchez de la Vega et al. (2012) provided, however, the photographic record of *H. horridum* in the Municipality of San Pedro Mixtepec, and previous records were made of this species in Jamiltepec and the Isthmus of Tehuantepec (Bogert & del Campo 1956).

Helodermatid lizards are listed as "threatened" under Mexican law (NOM-059-SEMARNAT-2010, SEMARNAT 2010) and assessed as 'Vulnerable' by the Red List of International Union for Conservation of Nature (IUCN). The main threat to beaded lizards populations is primarily the deforestation of dry tropical forests for agriculture, cattle ranching, and the burgeoning human population (Janzen 1988; Myer et al. 2000; Williams-Linera & Lorea 2009; Pennington et al. 2006; Domínguez-Vega et al. 2012), as well as, an escalation of droughts and fires (Beck 2005; Miles et al. 2006). Additionally, anthropogenic pressure is a threat.

These three photographic records represent the most northeastern (NE) geographic records of *H. alvarezi,* and it increases the distribution of the species approximately 359km for the record 3, 405km for record 2, and 470km for record 1 to the northeast from the previously closest reported localities of Cintalapa and Ocozocoautla, Chiapas. It is neccesary to gather more records on the

distribution of this Mexican species to amend the lack of information about this. In conclusion, our records of this species increase the number of reptiles present in Oaxaca to 448 species, if we considered the recent contributions made by Carbajal-Marquez et al. (2020).

References

Ariano-Sánchez, D. (2006). The Guatemalan beaded lizard: endangered inhabitant of a unique ecosystem. *Iguana* 13: 179–183.

Beck, D.D. (2005). *Biology of Gila monsters and Beaded lizards*. University of California Press, Berkeley, California, USA, 247pp.

Beck, D.D. & R. Jennings (2003). Habitat use by Gila monsters: the importance of shelters. *Herpetological Monographs* 17: 111–129.

Bogert, C.M. & R.M. del Campo (1956). The Gila monster and its allies: the relationships, habits, and behaviour of the lizards of the family Helodermatidae. *Bulletin of the America Museum of Natural History* 109: 1–238.

Campbell, J.A. & W.W. Lamar (2004). The venomous reptiles of the Western Hemisphere (2 volumes). Comstock Publishing Associates, Cornell University Press, Ithaca, New York, USA, 528pp.

Campbell, J.A. & J.P. Vannini (1988). A new subspecies of beaded lizard, *Heloderma horridum*, from the Motagua Valley of Guatemala. *Journal of Herpetology* 22: 457–468.

Domínguez-Vega, H., O. Monroy-Vilchis, C.J. Balderas-Valdivia, C.M. Gienger & D. Ariano-Sánchez (2012). Predicting the potential distribution of the beaded lizard and identification of priority areas for conservation. *Journal of Nature Conservation* 20: 247–253. https://doi.org/10.1016/j.jnc.2012.04.003

Domínguez-Vega, H., O. Monroy-Vilchis, J. Majarrez & C.J. Balderas-Valdivia (2017). Aversive hunting and sight frequency ecology of Beaded lizards (Squamata: Helodermatidae). *Perspective in Ecology and Conservation* 15: 47–51. https://doi.org/10.1016/j.pecon.2016.11.003

Domínguez-Vega, H., C.J. Balderas-Valdivia, J. Manjarrez & O. Monroy-Vilchis (2018). Conociendo al lagarto escorpión: leyendas, realidad y potencial de una rareza biológica. *Ciencia ergo-sum* 25(2): 1–8. https://doi.org/10.30878/ces.v25n2a10

Fry, B.G., N. Vidal, J.A. Norman, F.J. Vonk, H. Scheib, S.F.R. Ramjan, S. Kuruppu, K. Fung, S.B. Hedges, M. Richardson, W.C. Hodgson, V. Ignjatovic, R. Summerhayes & E. Kochva (2006). Early evolution of the venom system in lizards and snakes. *Nature* 439: 584–588.

Janzen, D.H. (1988). Tropical dry forest: the most endangered major tropical ecosystem. pp. 130–137. In: Wilson, E.O. (ed.). *Biodiversity*. National Academy Press, Washington, D. C., USA, 538pp.

Johnson, J.D., V. Mata-Silva & L.D. Wilson (2010). Geographic distribution and conservation of the herpetofauna of southeastern Mexico, pp. 322–369 In: Wilson, L.D., J. Townsend & J.D. Jonhnson (eds.). *Conservation of mesoamerican amphibians and reptiles* Eagle Mountain Publishing, LC., Eagle Mountain, Utah, United States.

Köhler, G. (2008) *Reptiles of Central America*. Herpeton, Offenbach, Germany, xvii+812pp.

Miles, L., A.C. Newton, D.S. DeFries, C. Ravilious, I. May, S. Blyth, V. Kapos & J.E. Gordon (2006). A global overview of the conservation status of tropical dry forests. *Journal of Biogeography* 33: 491–505.

Pennington, R.T., G.P. Lewis & J.A. Ratter (2006). *Neotropical savannas and seasonally dry forests: Plant diversity, biogeography, and Conservation*. CRC Press, Boca Ratón, Florida, USA, 508pp.

Reiserer, R.S., G.W.S. Schuett & D. Beck (2013). Taxonomic reassessment and conservation status of the beaded lizard, *Heloderma horridum* (Squamata: Helodermatidae). *Amphibian & Reptile Conservation* 7(1): 74–96.

Sánchez de la Vega, G., A.B. Silva, J.G. Grajales & V.M. Silva (2012). Geographic distribution. *Heloderma horridum* (Mexican beaded lizard). Mexico: Oaxaca. *Herpetological Review* 43: 102.

SEMARNAT (2010). Norma Oficial Mexicana NOM-059-SEMARNAT-2010, que determina las especies de flora y fauna silvestres, terrestres y acuáticas, endémicas, amenazadas, en peligro de extinción y sujetas a protección especial. Órgano del Gobierno Constitucional de los Estados, Gobierno Federal, México.

Williams-Linera, G. & F. Lorea (2009). Tree species diversity driven by environmental and anthropogenic factors in tropical dry forest fragments in central Veracruz, Mexico. *Biodiversity and Conservation* 18: 3269–3293.

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NOTE

Description of a new subspecies of the genus *Microcerotermes* Silvestri, 1901 (Amitermitinae: Termitidae: Isoptera) and the first record of another termite species from Meghalaya, India

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Abbreviations: HL—Head length; HLM—Head length with mandible; HW—Head width; LL—Labrum length; LW—Labrum width; ML—Mandible length; PL—Pronotum length; PW—Pronotum width; PoL—Postmentum length; PoW—Postmentum width; PoWW—Postmentum width at waist; Post L—Postclypeus length; Post W—Postclypeus width; TBL—Total body length.

Microcerotermes is a cosmotropical genus occurring in all the zoogeographical regions except Nearctic region with around 148 living species (Chhotani 1997; Krishna et al. 2013). In the Oriental region, this genus is widely distributed in almost all the countries of the region and equally well distributed in the Ethiopian region too (Chhotani 1997). According to Chhotani (1997), the oriental region comprises 42 species under the genus *Microcerotermes* with 29 species from the Indian region. The northeastern part of India, which harbors 76 species of termites, comprises four species of the genus *Microcerotermes* out of which one is endemic to the region (Bose 1999). But, from Meghalaya, one of the states of northeastern India, there was no earlier report of the genus. On the other hand, the genus *Reticulitermes* is palaearctic in distribution which is extended in the colder parts of Indian region with around 60 species in total. The Indian region comprises of five species with two species reported from the state of Meghalaya (Bose 1999).

In our recent study on the termite fauna of Megyalaya, we identified the genus *Microcerotermes* for the first time with the description of a new subspecies due to its characteristic differences from the nominate species. The subterranean termite species *Reticulitermes chinensis* is also a new record from the state and the morphometrics of which is also revised here.

The specimens studied were collected from different parts of Meghalaya and were preserved in 80% alcohol. Measurements of the specimens were done using Leica stereo zoom microscope S8AP0 and the identification was done based on available literature and taxonomic keys (Roonwal & Chhotani 1989; Chhotani 1997). All the samples studied are deposited in the national repository of the Zoological Survey of India, North Eastern Regional Centre, Shillong, Meghalaya.

ZooBank: urn:lsid:zoobank.org:pub:AAF00A11-DE35-4663-9572-729AE91F19C0

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Family: Termitidae
Subfamily: Amitermitinae
***Microcerotermes labioangulatus wahkdaitensis* ssp. nov.**
(Image 1 A–E)

urn:lsid:zoobank.org:act:F63C9179-D913-4F96-9F81-A434C0027635

Type materials studied

Holotype: Voucher No. IV/ISOP/ERS/4424, one ex. soldier, 22.ii.2019, Wahkdait area, East Khasi Hills, Meghalaya, India, 25.208^{0}N & 91.990^{0}E, 388m, coll. Khirod Sankar Das & party.

Paratype: Voucher No. IV/ISOP/ERS/4425, one ex. soldier and 24 exs. workers, same information as in Holotype.

Other materials studied: Voucher No. IV/ISOP/ERS/4426, 11 exs. soldiers and three exs. workers, 24.iv.2019, Wahkdait area, East Khasi Hills, Meghalaya, India, 25.208^{0}N & 91.989^{0}E, 388m, coll. Khirod Sankar Das & party.

Description

Soldier (Image 1, A–C): Head-capsule yellowish-brown to deep brown; antennae yellowish-brown; mandibles dark reddish-brown; body straw in color. Head sparsely and body moderately hairy. Head-capsule long, rectangular, sides almost parallel. Antennae with 13 segments; segment 3 shortest, 4 longer than 5 or sub equal to 5. Labrum pentagonal; antero-lateral corners angulated and anterior margin somewhat pointed at middle; broader than long. Mandibles strongly curved like a scathye and apically pointed and incurved; mandible length less than the half of the head-length; inner margin coarsely serrated in basal half. Postmentum club-shaped, a little narrowed at waist behind middle. Pronotum saddle-shaped.

Worker (Image 1, D–E): Head-capsule and antennae yellowish; body paler than head. Head moderately and body densely hairy. Head-capsule subsquarish. Fontanelle indistinct. Antennae 13 segmented; segment 3 shortest, 5 longer than 4 or sub equal to 4. Postclypeus swollen, hairy; length a little more than half of width. Pronotum saddle-shaped; anterior margin with a distinct notch, posterior margin weakly emarginated.

Diagnosis: The morphometrics (Table 1) of this new subspecies is very close to that of the species *Microcerotermes labioangulatus* but shows striking differences in the taxonomic characters with high importance (Chhotani 1997). In this subspecies, the length of the mandible is less than the half of the head length (without mandible) whereas in case of *M. labioangulatus* the length of mandibles is more than the half of the head length. The mandible length and the head length (without mandible) index is also less than that of the *M. labioangulatus*. On the other hand, the antennal segments of soldiers have shown slight differences as segment two is slightly longer than segment four and segment four is subequal to or slightly longer than segment five whereas in *M. labioangulatus*, segment

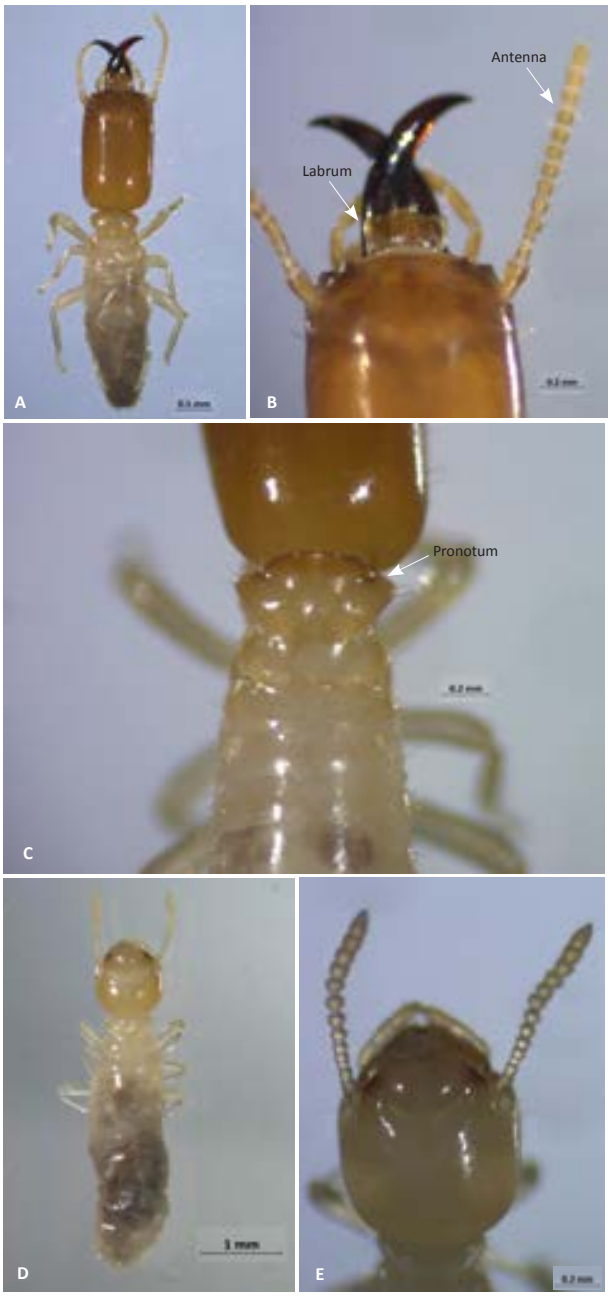

Image 1. Soldier and worker of *Microcerotermes labioangulatus wahkdaitensis* ssp. nov.: A—soldier | B—head of soldier showing antenna and labrum | C—pronotum of soldier | D—worker | E—head of worker showing the antennal segments. © Authors.

Table 1. Morphometrics (in mm) of soldiers (n=13) and workers (n=27) of *Microcerotermes labioangulatus wahkdaitensis* ssp. nov.

Characters	Soldiers		Workers
	Holotype	Size ranges	Size ranges
TBL	5.6	5.00–5.65	3.80–5.10
HLM	2.55	2.45–2.75	–
HL	1.75	1.75–1.85	0.85–1.05
HW	1.00	1.00–1.10	0.88–1.13
HW/HL	0.57	0.57–0.60	–
ML	0.80	0.75–0.95	–
ML/HL	0.48	0.40–0.54	–
PL	0.43	0.40–0.45	0.25–0.38
PW	0.73	0.73	0.50–0.68
PoL	1.00	1.00–1.10	–
PoW	0.33	0.30–0.35	–
PoWW	0.18	0.18	–
LL	0.25	0.18–0.25	–
LW	0.43	0.35–0.43	–
Post L	–	–	0.28–0.33
Post W	–	–	0.43–0.55

four is longer than segment five. In case of workers too, segment five is longer than or subequal to four whereas in *M. labioangulatus*, segment four is longer than five. The total body length of the smaller workers also found to be less than the lower range of *M. labioangulatus*. Further, this subspecies also showed some similarities in the structure of labrum and head with the soldiers of *M. pakistanicus* which is also reported from India. But, can be separated clearly based on the differences of head length, mandible length, mandible and head length index, postmentum length, pronotum length and width of soldiers and the total body length, pronotum length and width of the workers of both the species (Chhotani 1997).

Etymology: This subspecies is named after its type locality which is Wahkdait area near Pynursla, East Khasi Hills, Meghalaya.

Distribution: Wahkdait, East Khasi Hills, Meghalaya, India.

Family: Rhinotermitidae

Subfamily: Heterotermitinae

***Reticulitermes chinensis* Snyder, 1923**

Materials examined- Voucher No. IV/ISOP/ERS/4427, 23 exs. soldiers and 20 exs. workers, 25.vii.2019, NEHU Campus, Shillong, Meghalaya, India, 25.613^{0}N & 91.900^{0}E, 1,413m, coll. Khirod Sankar Das.

Description

Soldier (Image 2, A–B): TBL 5.90-7.10 mm; head-capsule sub rectangular, longer than wide, length

Image 2. Soldier and workers (major) of *Reticulitermes chinensis* Snyder, 1923: A—soldier | B—head of soldier showing labrum | C—worker with 16 antennal segments | D—worker with 17 antennal segments | E—worker with 18 antennal segments. © Authors.

Table 2. Revised morphometrics (in mm) of *Reticulitermes chinensis* Snyder, 1923.

Reticulitermes chinensis Snyder, 1923			
Characters	**Soldiers (n=23)**	**Workers minor**	**Workers major (n=20)**
TBL	5.90–6.70	3.50–4.00	4. 80–5.15
HLM	2.85–3.15	–	–
HL	1.90–2.15	1.05–1.07	1.00–1.30
HW	1.10–1.20	1.17–1.22	1.07–1.45
HW/ HL	0.52–0.60	–	–
ML	0.95–1.05	–	–
ML/ HL	0.47–0.51	–	–
PL	0.55–0.60	0.42–0.50	0.42–0.45
PW	0.90–0.95	0.77–0.85	0.77–0.85
PoL	1.45–1.60	–	–
PoW	0.45–0.50	–	–
PoWW	0.18	–	–
Antennal segments	16 or 17 or 18 segmented. In 16 and 17, 3rd or 4th is shortest. In 18 segmented, 4th is shortest.	15 segmented. 4th segment is shortest.	16 or 17 or 18 segmented. In 16 and 18 Segmented, 4th is shortest. In 17 segmented, 3rd segment is shortest.

1.83–2.27; HW 1.08–1.32 mm. Antennae with 16, 17 or 18 segmented; segment 3 shortest in 16 and 17 segmented one and segment 4 shortest in 18 segmented one. Labrum oval, longer than broad, usually broadest near the base; sides convex with hyaline margin and converging into thin and sharply pointed tip having two long bristles. ML 0.95–1.22 mm; left mandible with 3–4 crenulations arid a basal projection. PoL 1.30–1.50; PoW 0.43–0.52; PoWW 0.12–0.15 mm. Pronotum flat, narrower than head; length 0.50–0.55, width 0.82–0.95.

Workers: Dimorphic: Worker minor: TBL 3.50–4.00 mm, HL 1.05–1.07, HW 1.17–1.22 mm. Antennae 15 segmented, segment 2 longer than 3, 4 shortest. Mandibles typically *Reticulitermes*-type. Pronotum flat, length 0.42–0.50 mm, width 0.77–0.85 mm (Adapted from Roonwal & Chhotani 1989).

Worker major (Image 2, C–E): TBL 4.80–5.15 mm, HL 1.00–1.30, HW 1.07–1.45 mm. Antennae 16–18 segmented, segment 4 is shortest in 16 and 18 segmented one and segment 3 is shortest in 17 segmented one. Pronotum flat, length 0.42–0.50 mm and width 0.77–0.85 mm.

Redescription: The morphometrics of *R. chinensis* from the study area show variation in comparison to the descriptions in available literature (Roonwal & Chhotani 1989). Variation among the individuals of *R. chinensis* may be because of their inclined nature toward variation or because of the climatic condition of the study area which is usually colder (Average maximum temperature 12^0C in Winter and 25^0C in Summer). The HLM, HW/ HL, and ML/HL index of the soldier castes are provided here based on this study. Here, the upper ranges of the PL, PoL, and PoWW have been found slightly more than the ranges reported earlier. In case of the workers, the TBL, HL, HW were found to be greatly varied than the range in available literature. The antennae of the worker individuals also vary significantly which were found to be 16, 17 or 18 segmented. In case of 16 and 18 segmented one, segment 4 is shortest and in 17 segmented one, segment 3 is shortest. We did not get workers with 15 segmented antenna from the study area. Based on the morphometrics of *R. chinensis* from the samples studied by us and the descriptions by Roonwal & Chhotani (1989), we designate the workers as worker major and worker minor and revise the morphometrics for the species through this communication (Table 2).

Distribution: China and India (Arunachal Pradesh, Assam, and Meghalaya).

The description of the new subspecies of the genus *Microcerotermes* forms the first report of the genus from Meghalaya, India, which revealed the probability of more new discoveries of termite species from the state. Furthermore, the revised morphometrics of *Reticulitermes chinensis* will definitely help future workers in correct identification of the species from the study area.

References

Bose, G. (1999). *Termite fauna of North Eastern India.* Records of the Zoological Survey of India, Occasional paper, 171.

Chhotani, O.B. (1997). *The Fauna of India and the Adjacent Countries. Isoptera (Termites): (Family Termitidae) - Vol. 2*. Zoological Survey of India, Calcutta, xx+800pp.

Krishna, K., Grimaldi, A. David, V. Krishna & M.S. Engel (2013). "*Treatise on the Isoptera of the World*". Bulletin of the American Museum of Natural History no. 377 (http://digitallibrary.amnh.org/dspace/ handle/2246/6430).

Roonwal, M.L. & O.B. Chhotani (1989). *The Fauna of India and the Adajcent Countries: Isoptera (Termites) - Vol. 1*. Zoological Survey of India, Calcutta, viii+672pp.

Silvestri, F. (1901). Nota preliminare sui Termitidi Sud-Americani. *Bollettino dei Musei di Zoologia e Anatomia comparata, Torinno* 16(398): 1–8.

Snyder, T.E. (1923). A new *Reticultitermes* from the orient. *Journal of the Washington Academy of Sciences* 13(6): 107–109.

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NOTE

A new record of the hoverfly genus *Dasysyrphus* Enderlein, 1938 (Insecta: Diptera: Syrphidae) from India

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The distribution of *Dasysyrphus* Enderlein, 1938 is rare with only four species known out of 355 syrphid species in India (Mitra et al. 2008; Ghorpade 2014; Shah et al. 2014). *Dasysyrphus* is characterized by the presence of distinct abdominal tergites, characteristic longitudinal marginal grooves present along the abdominal tergites (McAlpine et al. 1981). Here we report *Dasysyrphus albostriatus* (Fallen, 1817) for the first time from India (Pape & Evenhuis 2018).

The species was collected from Recong Peo of Kinnaur District, Himachal Pradesh, during a survey in the state of Himachal Pradesh in the year 2018. Kinnaur is in the northeast corner of Himachal Pradesh, about 235km from Shimla, having the three high mountains ranges, i.e., Zanskar, Greater Himalaya, and Dhauladhar, and enclosing valleys of Sutlej, Spiti, Baspa and their tributaries (31°05'–32°05'N & 77°45'–79°00'E). Survey was conducted in the month of April 2018.

Syrphid flies were collected from the field during daytime by using insect sweep nets, malaise trap, and pan traps. The collected samples were narcotized by using ethyl-acetate and stored for further study in insect envelopes in the field. The specimens were later carried back to the laboratory, mounted with insect pins and stored in insect cabinets.

Identification of the fly specimens was done using the keys of Brunetti (1923), Vockeroth (1992) and Thomson (2013) keeping in mind the recent nomenclatural changes (Pape & Evenhuis 2018) . After identification, the specimens were deposited in the designated repository of national zoological collection, Diptera section, Zoological Survey of India, Kolkata.

The 3D maps used here were generated using ARC GIS software Version 10.1. The photograph of habitus and insect body and parts were taken by using Leica Microscope M205A, where 0.32x Acrolense was used for habitus photography and PLANAPO 1.0X lense was used for the photography of body parts.

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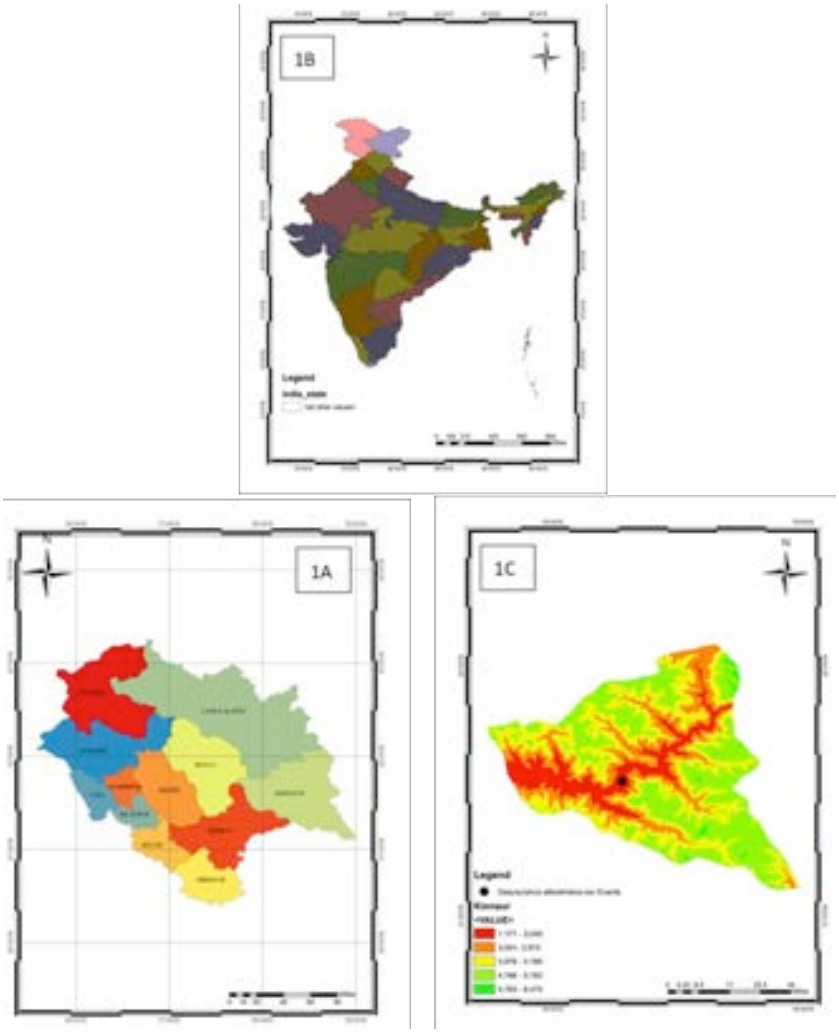

Figure 1. 3D GIS Map: a—India | b—Himachal Pradesh | c—Collection locality of species in Kinnaur District.

Systematic Account

Subfamily Syrphinae

Tribe Syrphini

Genus *Dasysyrphus* Enderlein, 1938

1938. *Dasysyrphus* Enderlein, *Sber. Ges. Naturf. Freunde Berl.* 1937: 208

The genera *Dasysyrphus* is described by Enderlein in the year 1938. He has described the genera based on the taxonomic characters of the species *Scaeva albostriata*.

Diagnosis: Frons black with purinose areas, face slightly broadened with distinct median stripe. Scutellum dull yellow to brown in colour. Ventral scutellar fringe well developed. Upper and lower katepisternal patches narrowly to broadly join posteriorly. Abdomen narrowly to broadly oval and convex. Sternites yellow with distinct black bands. Wing membrane entirely trichose (McAlpine et al. 1981)

Key to species of the genus *Dasysyrphus* Enderlein, 1938.

***Dasysyrphus albostriatus* (Fallen, 1817)**
(Image 1A–F)

1817. *Dasysyrphus albostriatus*, Fallen, *Syrphici Sveciae*: 42

Taxonomic history: *Dasysyrphus albostriatus*is a species with distributional affinity towards Palearctic region. This species has been described in the year 1817 by Fallen. The type locality was Scania of Sweden. Three species namely *Syrphus carinthiacus* Latzel, 1876, *Syrphus confusus* Egger, 1860 and *Syrphus nigrum* Brown, 1971 has been synonymised with this *Dasysyrphus albostriatus* later on.

Type location: Sweden, Scania. This species is thus the first record from India as well as from the oriental region.

Material examined: 18870/H6 , 18871/H6, 18872/H6, 18873/H6 and 18874/H6, five males, 12.iv.2018, Recong Peo, Kinnaur District, 2,220m, 31.539 N, 78.276 E, coll: J Sengupta. Syrphid flies were collected by

Image 1. A—Dorsal view of head | B—Dorsal view of thorax | C—Habitus | D—Dorsal view of abdomen | E—Dorsal view of hind leg | F—Lateral view of wing of *Dasysyrphus albostriatus*. © Jayita Sengupta.

sweeping insect nets in agricultural field by the collector (Figure 1a–c).

Diagnosis: Presence of large shinning black antennal prominence; distinct black median stripe enclosing the central bump. Occiput grey with yellowish-white uninterrupted fringe. Dorsum of thorax consists of black conspicuous stripes. Pleurae shinning dark grey, scutellum brownish-yellow in color with wholly long black pubescence. Abdominal tergites distinct. Moderate sized yellow oval spot on 2nd segment while sinuate narrow yellow band of uniform length on 3rd and 4th segment. Basal half of anterior and hind femora and whole hind tibiae more or less blackish. Wing grayish with orange colored halters.

Distribution: India: Himachal Pradesh: Kinnaur: Recong Peo (new record); Sweden (Pape & Evenhuis 2018).

Remarks: *Dasysyrphus albostriatus* has been reported feeding on larvae of Lepidoptera (Krpač et al. 2009). Adults are also known as beneficial pollinator (Laska et al. 2013). Therefore, both the larvae as well as adults are economically important from agricultural viewpoint.

Discussion: Hoverfly research in India is quite

Key to species of the genus *Dasysyrphus* Enderlein, 1938

1. Frons with white hairs, femoral 1 & 2 entirely yellow .... *pandu* Ghorpade, 1994
- Frons with black hairs, femora 1 & 2 yellow with basal part half blackish 2

2. Hind tibia black on basal one half or more .... *darada* Ghorpade, 1994
- Hind tibia yellow on basal one half 3

3. Tergum 5 yellow only on posterior margin 4
- Tergum 5 yellow on posterior and lateral margins .... *rossi* Ghorpade, 1994

4. No obvious stripes at thoracic region .... *orsua* (Walker, 1852)
- Two definite greyish stripes on anterior part of thorax .... *albostriatus* (Fallen, 1817)

enriched with a research history over the past 110 years. The research on Indian hoverflies has always preferred the taxonomic aspect during pre-independence era (Fabricius 1805; Brunetti 1923; Bhatia & Shaffi 1933) whereas in post-independence period, the research interest has been shifted more towards economic and agricultural aspects (Coe 1964; Nayar 1968; Hippa 1974; Biswas et al. 1975; Kohli et al. 1988). During the last decade research has focused on both taxonomy as well as the field of agricultural, ecological and economical studies (Mitra & Parui 2002, 2012; Mukherjee et al. 2006, 2007; Parui et al. 2006; Ghorpade 2007, 2009, 2012, 2014; Mitra 2010; Shah et al. 2014; Sengupta et al. 2017, 2019, Wachkoo et al. 2019). Recently one genus and one species have been reported newly from India (Wachkoo et al. 2019) thereby updating the hoverflies taxon list with 70 genera and 356 species currently from India.

References

Bhatia, H.L. & M. Shaffi (1933). Life histories of some Indian Syrphidae. *Indian Journal of Agricultural Science* 2: 543–570.

Biswas, S., A.R. Lahiri & A.K. Ghosh (1975). A preliminary study of the Insect fauna of Meghalaya. Diptera, Syrphidae: eleven new records and notes on other species. *Proceedings of the Zoological Society, Calcutta* 27: 23–27.

Brunetti, E. (1923). Family Syrphidae, pp. 23–340, 409–415. In: *The Fauna of British India, Diptera, Vol.* 3. Published by Taylor and Francis, Red Lion Court, Fleet Street, 449pp.

Coe, R.L. (1964). Diptera from Nepal, Syrphidae. *Bulletin of the British Museum, Natural History* (*Entomology*) 15: 255–290.

Fabricius, J.C. (1805). Systema antliatorum: secundum ordines, genera, species, adiectis synonymis, locis, observationibus, descriptionibus. Brunsvigae, Apud Carolum Reichard, 373pp.

Ghorpade, K.D. (1994). Diagnostic keys to new and known genera and species of Indian subcontinent Syrphini (Diptera, Syrphidae). *Colemania* 3: 1–15.

Ghorpade, K. (2007). The genus *Agnisyrphus* Ghorpadé (Diptera—Syrphidae), peculiar to the Oriental Region, with notes on phylogeny, evohistory and panbiogeography. *Colemania* 14: 1–35.

Ghorpade, K. (2009). Some nomenclatural notes on Indian subregion Syrphini (Diptera-Syrphidae). *Colemania* 15: 3–13.

Ghorpade, K. (2012). Notes on Nomenclature taxonomy and phylogeny of genus *Chrysotoxum* Meigen (Diptera-Syrphidae) in Oriental region. *Colemania* 32: 1–4.

Ghorpade, K. (2014). An updated Check-list of the Hover-flies (Diptera-Syrphidae) recorded in the Indian subcontinent. *Colemania* 44: 1–30.

Hippa, H. (1974). On the taxonomy of the Celonese and southern Indian species of the genus *Xylota* Meigen (Diptera, Syrphidae). *Annales entomologici fennici* 40(2): 56–60.

Kohli, V.K., V.C. Kapoor & S.K. Gupta (1988). On one new genus and nine species of syrphid flies (Diptera: Syrphidae) from India. *Journal of Insect Science* 1(2): 113–127.

Krpač, V.T., A. Vujić, S. Šimić, S. Radenković & S. Lazarevska (2009). Revision of the genus *Dasysyrphus* Enderlein, 1938 (Diptera: Syrphidae) in the fauna of Macedonia. *Kragujevac Journal of Science* 31: 103–108.

Laska, P., L. Mazanek & V. Bicik (2013). Key to adults and larvae of the genera of European Syrphinae (Diptera, Syrphidae). *Acta Musei Silesiae, Scientiae Naturales* 62(3): 193–206.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth & D.M. Wood (1981). Manual of Nearctic Diptera. Volume 1. *Manual of Nearctic Diptera* 1(27): 222–224

Mitra, B. & P. Parui (2002). Diptera flower visitors in Jessore Sloth Bear and Balaram Ambaji Wildlife Sanctuaries, north Gujarat. *Bionotes* 4(2): 45.

Mitra, B., M. Mukherjee & D. Banerjee (2008). A check-list of hover-flies (Diptera: Syrphidae) of Eastern Himalayas. *Records of the Zoological Survey of India, Occasional Paper* 284: 1–47.

Mitra, B. (2010). Diversity of flower-visiting flies (Insecta: Diptera) in India and their role in pollination. *Records of the Zoological Survey of India* 110(2): 95–107.

Mitra, B. & P. Parui (2012). Diversity of True Flies (Diptera: Insecta) in the Bhibhutibhusan Wildlife Sanctuary. *Records of the Zoological Survey of India* 112(2): 57–64.

Mukherjee, M., P. Parui & B. Mitra (2006). Insecta: Diptera: Syrphidae. *Zoological Survey of India, Fauna of Arunachal Pradesh*, *State Fauna Series* 13(2): 331–354.

Mukherjee, M., P. Parui & B. Mitra (2007). Insecta: Diptera: Syrphidae. *Zoological Survey of India, Fauna of Andhra Pradesh, State Fauna Series* 5(3): 479–490.

Nayar, J.L. (1968). A contribution to our knowledge of high altitude Syrphidae (Cyclorrhapha: Diptera) from NW Himalaya, Part I – Subfamily Syrphinae. *Agra University Journal of Research* (*Science*) 16: 121–131.

Pape, T. & N.L. Evenhuis (2018). Systema Dipterorum, Version 1.5.67 records. http://www.diptera.org/, accessed on 14/05/2018.

Parui, P., B. Mitra, & R.M. Sharma (2006). Diptera Fauna of Punjab and Himachal Shiwalik Hills. *Records of the Zoological Survey of India* 106(1): 83–108.

Sengupta, J., A. Naskar, A. Maity, S. Hazra, N.K. Sarkar & D. Banerjee (2017). Hover flies (Diptera: Syrphidae) from Darjeeling Himalaya – a part of Indo-Burmese Hotspot. *Indian Journal of Entomology* 79(3): 336–353. https://doi.org/10.5958/0974-8172.2017.00065.7

Sengupta, J., A. Naskar, A. Maity, S. Homechaudhuri & D. Banerjee (2019). A short taxonomic account of dipteran flies from the Renuka Wetland and adjacent Sanctuary, Himachal Pradesh, India. *Munis Entomology & Zoology* 14(1): 224–231.

Shah, M.G., U. Ja & A.A. Wachkoo (2014). A checklist of Hoverflies (Diptera: Syrphidae) in the Western Himalaya, India. *Acta Zoologica Academiae Scientiarum Hungaricae* 60(4): 283–305.

Wachkoo, A.A., V.J. Steenis, Z.A. Rather, J. Sengupta & D. Banerjee (2019). First record of the genus *Spilomyia* (Diptera, Syrphidae) from the Oriental region. *Turkish Journal of Zoology* 43: 239–242. https://doi.org/10.3906/zoo-1811-27

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NOTE

First record of Banded Lineblue *Prosotas aluta* Druce, 1873 (Insecta: Lepidoptera: Lycaenidae) from Bangladesh

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Butterfly diversity in Bangladesh is very rich and may exceed 400 species (Chowdhury & Hossain 2013), but the exact number is not known till date. Baksha & Choudhury (1983, 1985) reported 33 species comprising of 17 pierids and 16 papilionids. Larsen (2004) annotated a checklist of 236 species. Ahmad et al. (2009) compiled 148 species in Encyclopedia of Bangladesh. Chowdhury & Hossain (2013) documented a photographic field guide with 225 species of butterflies from Bangladesh. IUCN Bangladesh (2015) stated status of 305 species of butterflies. There is no other more comprehensive list of butterflies available in Bangladesh. Habib et al. (2016), however, recorded 146 species of butterfly from Kaptai National Park (KNP) including *Prosotas dubiosa*. Hitherto, five species under the genus *Prosotas*: *bhutea, dubiosa, lutea, nora,* and *pia* have been previously recorded from Bangladesh (Chowdhury & Hossain 2013; Larsen 2004). *P. aluta* is reported from India, Myanmar, Malaysia, Philippine, Thailand, Indonesia, Singapore, Vietnam, China, Nepal, and Bhutan but not in Bangladesh until this report (Evans 1932; Cassidy 1990; Hirowatari 1992; Huang & Xue 2004; Kehimkar 2013; Khew 2014; Monastyrskii & Devyatkin 2016). Though, new records of butterflies are being added in the existing list, there is still an opportunity to explore new habitats and discover around 200–250 species of butterflies in the country.

The Kaptai National Park (KNP) situated at Kaptai Upazila (sub-district) in Rangamati District falls between the Karnaphuly River and Kaptai mountain ranges (22.5^{0}N and 92.33^{0}E) (Figure 1). It is about 57km north of Chattogram (Chittagong) City and 12km south of Rangamati Town comprising an area of 54.64km^2 (5,464ha, 13,502acres). The park was previously known as Sitapahar Reserve and was declared a national park in 1999. It comprises two forest ranges: Kaptai and Karnaphuli. The KNP is sub-tropical mixed evergreen forest decked with hills, streams, valleys and plain lands. The area in the landscape context is very good, but disturbed by shifting cultivation, secondary plantation and human settlement. Nonetheless, the KNP is very rich in flora and fauna. The area is known as a butterfly hotspot in Bangladesh (Habib et al. 2016).

The survey was conducted on butterfly diversity twice a month from January 2017 to December 2018. As the study was carried out on butterfly diversity hence emphasis was given on sunny periods of the day, when

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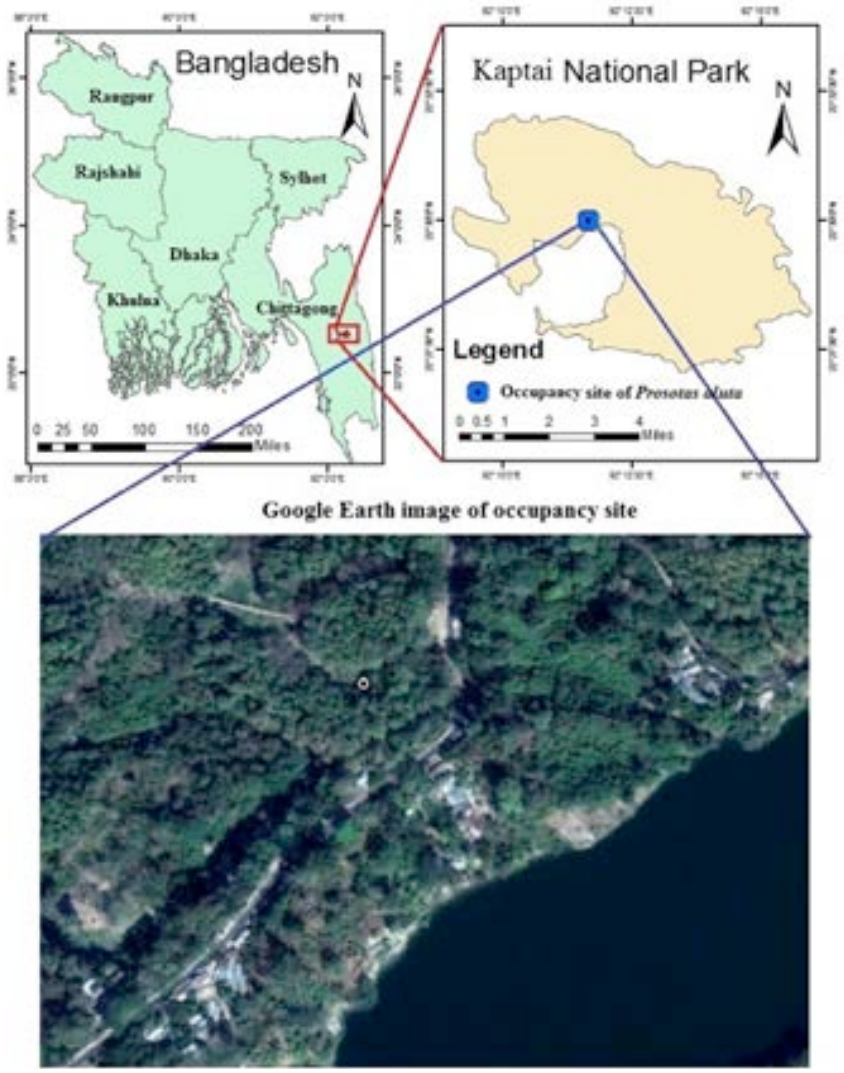

Figure 1. The area in KNP, Bangladesh where *Prosotas aluta* was recorded during the present survey.

butterflies are more active. Butterflies were searched for through the existing roads, trails, streams and bridle paths.

The observed butterfly was photographed but the specimen neither killed nor collected. So, the specimen was identified based on photographic document following the keys developed by Bingham (1907) and field guides (Chowdhury & Hossain 2013; Kehimkar 2013).

An individual of *Prosotas aluta* (Image 1) was found at about 11:50AM (GMT+6) on 07 September 2018 in a hill stream named 'Baro Chara' (22.501^{0}N & 92.184^{0}E, 9m). The butterfly was puddling on small hilly rocks and sandy clay. The observed individual is characterized by the tail in the hind wing like other lycaenid butterflies (Kehimkar 2013). Moreover, shiny silky brown cilia, brown tails with white tip, black head and antennae, bluish thorax and abdomen indicate that the photographed specimen is a species under the genus *Prosotas* (Bingham 1907). The specimen is also characterized with dark brown under wings, spaces between discal lines filled with dark bands in both wings, and discal band and end cell band joined together to form a black discal area in the underside of hind wing (Kehimkar 2013). In addition, sub-basal and discal bands in the underside of hind wing inwardly and outwardly edged with slender white lines and discal band greatly broad in the middle (Bingham 1907).

Previously the species was recorded from Cachar and Khasi Hills (Parsons & Cantlie 1948) of India which is close to Bangladesh. So, Larsen (2004) listed the species in a possible checklist of butterflies in Bangladesh. The species has also been recorded from the Baghmara National Park of Garo Hills in Meghalya (Kunte et al. 2012) and from Jeypore-Dehing Forest in Assam of India (Gogoi 2013). Subsequently, the species has been recorded from the Kaptai National Park of Bangladesh (aerial distance: ~266km from Cachar, ~330Km from Garo Hills, ~367km

Image 2. Underwing image of *Prosotas aluta* while puddling in Kaptai National Park.

from Khasi Hills and ~575km from Jeypore-Dehing Forest). The northeastern region (greater Sylhet) of Bangladesh also comprises some mixed evergreen forested areas similar to KNP. In addition, the northeastern part is closer to the Cachar, Garo Hills, Khasi Hills and Jeypore-Dehing Forest (aerial distance: ~112km, ~124km, ~164km and ~413km respectively). So, the species may also be found in the northeastern mixed evergreen forests of Bangladesh. The record of *Prosotas aluta*, however, confirms its existence in Bangladesh after the compilation of butterflies by Larsen (2004) and Red List of Threatened Species (butterfly) by IUCN Bangladesh (2015).

References

Ahmad, M., S.M.H. Kabir, A.T.A. Ahmed, A.K.A. Rahman, Z.U. Ahmed, Z.N.T. Begum, M.A. Hassan & M. Khondker (eds.) (2009). *Encyclopedia of Flora and Fauna of Bangladesh,* Vol. 21(III). Asiatic Society of Bangladesh, Dhaka, 460pp.

Baksha, M.W. & J.H. Chowdhury (1983). Entomo-fauna in the forest of Bangladesh. I. Pieridae: Lepidoptera. *University Journal of Zoology* 4: 53–60.

Baksha, M.W. & J.H. Chowdhury (1985). Entomo-fauna in the forest of Bangladesh. II. Papilionidae: Lepidoptera. *University Journal of Zoology* 4: 1–7.

Bingham, C.T. (1907). *The Fauna of British India, Including Ceylon and Burma II.* Tailor and Francis Ltd, London, 480pp.

Cassidy, A.C. (1990). On *Nacaduba* and allied genera (Lepidoptera, Lycaenidae) from the Sulawesi Region. *Tyô to Ga* 41(4): 227–241.

Chowdhury, S.H. & M. Hossain (2013). *Butterflies of Bangladesh-A Pictorial Handbook* (Revised and enlarged version), Skylark Printers, Dhaka, 260pp.

Evans, W.H. (1932). *The Identification of Indian Butterflies.* Bombay Natural History Society, Mumbai, 454pp.

Gogoi, M.J. (2013). A preliminary checklist of butterflies recorded from Jeypore-Dehing Forest, eastern Assam, India. *Journal of Threatened Taxa* 5(2): 3684–3696. https://doi.org/10.11609/JoTT.o3022.3684-96

Habib, M.S., N. Rima, F. Akter, M.S. Islam & M.M. Hossain (2016). Checklist of butterfly fauna of Kaptai National Park in Bangladesh. *Journal of Taxonomy and Biodiversity Research* 7: 19–28.

Hirowatari, T. (1992). A generic classification of the tribe Polyommatini of the Oriental and Australian regions (Lepidoptera, Lycaenidae, Polyommatinae). *Bulletin of the University of Osaka Prefecture* Series B, 44: 1–102.

Huang, H. & Y.P. Xue (2004). A contribution to the butterfly fauna of southern Yunan. *Neue Entomologische Nachrichten* 57: 135–154.

IUCN Bangladesh (2015). *Red List of Bangladesh Volume 7: Butterflies.* IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, 400pp.

Kehimkar, I. (2013). *The Book of Indian Butterflies.* Bombay Natural History Society, Mumbai, 497pp.

Khew, S.K. (2014). New Record of a 4th *Prosotas* in Singapore: Discovery of *Prosotas aluta nanda*. In: Butterflies of Singapore: A tribute to nature's flying jewels. http://butterflycircle.blogspot.com/2014/01/new-record-of-4th-prosotas-species.html downloaded on 02 January 2019.

Kunte, K., S. Sondhi, B.M. Sangma, R. Lovalekar, K. Tokekar, & G. Agavekar (2012). Butterflies of the Garo Hills of Meghalya, northeastern India: their diversity and conservation. *Journal of Threatened Taxa* 4(10): 2933–2992. https://doi.org/10.11609/JoTT.o2945.2933-92

Larsen, T.B. (2004). *Butterflies of Bangladesh- An Annotated Checklist*. IUCN Bangladesh Country Office, Dhaka, 104pp.

Monastyrskii, A.L. & A.L. Devyatkin (2016). *Butterflies of Vietnam: An Illustrated Checklist.* Planoroma Media, Hanoi, 95pp.

Parsons, R.E. & K. Cantlie (1948). The butterflies of the Khasi and Jaintia hills, Assam. *Journal of the Bombay Natural History Society* 47: 498–522.

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NOTE

Notes on *Ptilomera agriodes* (Hemiptera: Heteroptera: Gerridae) from Eastern Ghats, India

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Freshwater Hemiptera commonly known as aquatic bugs are widely distributed in the aquatic ecosystem. There are 325 species belonging to 84 genera and 18 families reported from India (Basu & Subramanian 2017). The aquatic bug belongs to the suborder Heteroptera (true bugs), in which infra order Gerromorpha are semi-aquatic bugs living on the surface water. Gerromorpha include eight families, viz.: Gerridae, Veliidae, Hydrometridae, Hebridae, Hermatobatidae, Paraphrynoveliidae, Macroveliidae, and Mesoveliidae (Damgaard 2008). Family Gerridae has 26 genera and 93 species in India (Basu & Subramanian 2017), in which genus *Ptilomera* are large water striders distributed in the aquatic habitats. Globally, there are 57 species belonging to the genus *Ptilomera*, in which only six species were documented from India (Jehamalar et al. 2017): *Ptilomera agriodes* Schmidt, 1926; *P. assamensis* Hungerford & Matsuda, 1965; *P. laticaudata* (Hardwicke, 1823); *P. occidentalis* Zettel, 2003; *P. tigrina* Uhler, 1860, and *P. nagalanda* Jehamalar & Chandra, 2017.

Among this *P. agriodes* was originally described from Tiruchirappalli and Tharangambadi, in the state of Tamil Nadu. Later it was reported from Chhattisgarh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharastra, Odisha, and Rajasthan by various workers (Thirumalai 2002; Thirumalai et al. 2007; Jehamalar & Chandra 2013; Basu et al. 2015; Jehamalar et al. (2017). Earlier, Basu et al. (2015) reported *P. agriodes* only from Devkund waterfall, Mayurbhanj District, Odisha region of Eastern Ghats. The present study documents *P. agriodes* extended distribution from different parts of Eastern Ghats regions like Andhra Pradesh, Odisha, Telangana and Tamil Nadu.

P. agriodes was collected from the different streams of Eastern Ghats (Table 1, Figure 1). The specimens were collected by hand-operated insect-nets and preserved in 10% formalin and labeled. After sorting, the specimens were observed under stereo zoom microscope (Olympus SZX10). The specimens are deposited at the National Zoological Collection, FBRC/ZSI, Hyderabad.

Material examined: 16 males, 4 females Exs, FBRC/ZSI/INS/1062, Mallela Theertham waterfall, 20.ix.2018; 3 male, 1 female Exs, FBRC/ZSI/INS/1063, Chinthapaka, Challagadda stream, 10.ix.2018; 8 males, 7 females Exs, FBRC/ZSI/INS/1064, Thatiguda waterfall, 10.ix.2018; 3 males, 1 female Exs, FBRC/ZSI/INS/1065, Dharmattam waterfall, 11.ix.2018; 4 males, 11 females Exs, FBRC/ZSI/INS/1066, Yerravaram waterfall, 03.ix.2018;

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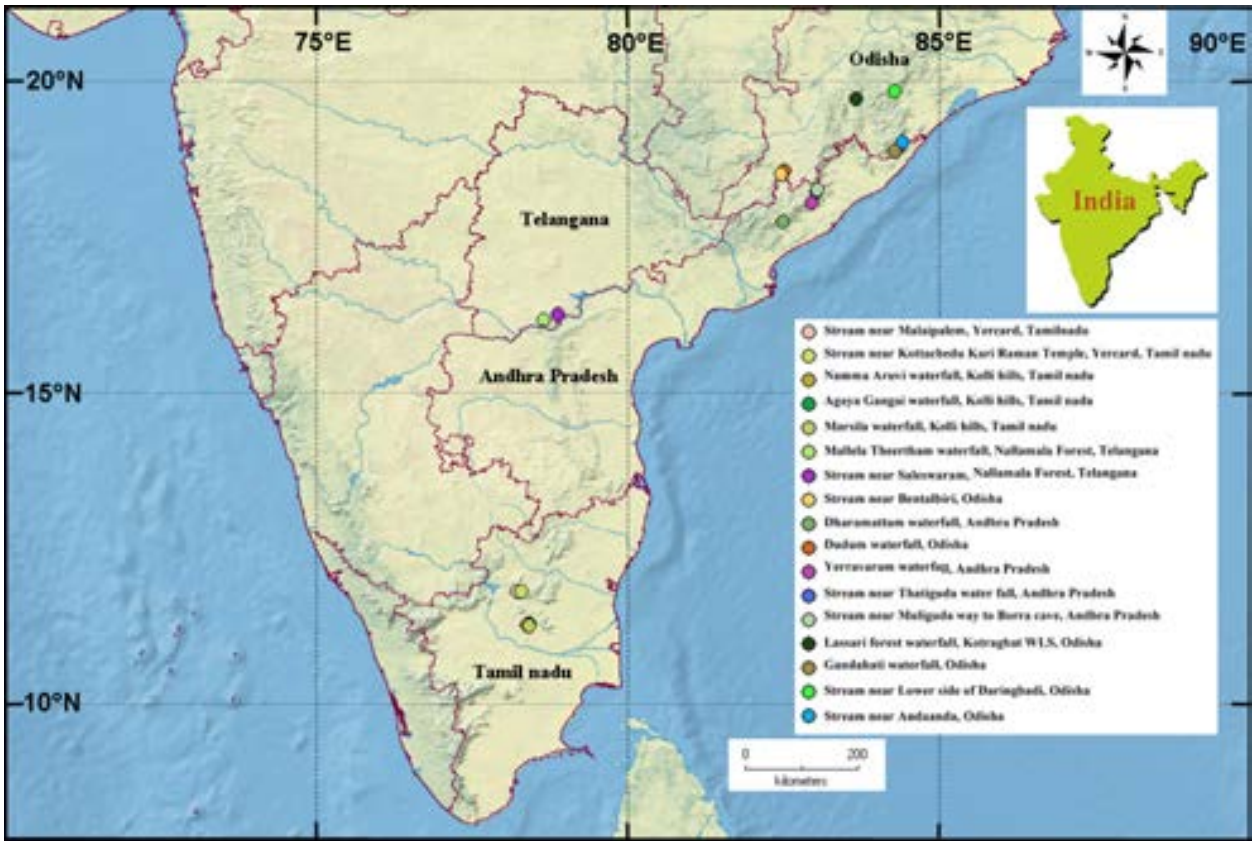

Figure 1. Distribution of *Ptilomera agriodes* from Eastern Ghats, India.

Table 1. Collections location of *Ptilomera agriodes* from different parts of Eastern Ghat regions, India.

	Locations	District	State	Latitude (N)	Longitude (E)
1	Challagadda stream	Vishakhapatnam	Andhra Pradesh	18.054	82.947
2	Stream near Thatiguda waterfall	Vishakhapatnam	Andhra Pradesh	18.226	83.007
3	Stream near Muliguda, way to Borra cave	Vishakhapatnam	Andhra Pradesh	18.263	83.031
4	Dharamattam waterfall	Vishakhapatnam	Andhra Pradesh	17.712	82.478
5	Yerravaram waterfall	Vishakhapatnam	Andhra Pradesh	17.754	82.476
6	Stream near Bentalbiri	Koraput	Odisha	18.568	82.499
7	Dudum waterfall	Koraput	Odisha	18.519	82.454
8	Lassari forest waterfall	Kandhamal	Odisha	19.717	83.656
9	Stream near lower side of Daringbadi	Kandhamal	Odisha	19.849	84.272
10	Gandahati waterfall	Ganjam	Odisha	18.890	84.270
11	Stream near Andaanda	Ganjam	Odisha	19.031	84.388
12	Marsila waterfall	Nammakal	Tamil Nadu	11.308	78.394
13	Stream near Malaipalem	Salem	Tamil Nadu	11.822	78.214
14	Namma Aruvi waterfall	Nammakal	Tamil Nadu	11.289	78.365
15	Agaya Gangai waterfall	Nammkal	Tamil Nadu	11.267	78.395
16	Stream near Kottachedu, Kari Raman Temple	Salem	Tamil Nadu	11.831	78.272
17	Mallela Theertham waterfall, Nallamala Forest	Mahabubnagar	Telangana	16.266	78.856
18	Saleswaram	Mahabubnagar	Telangana	16.189	78.639

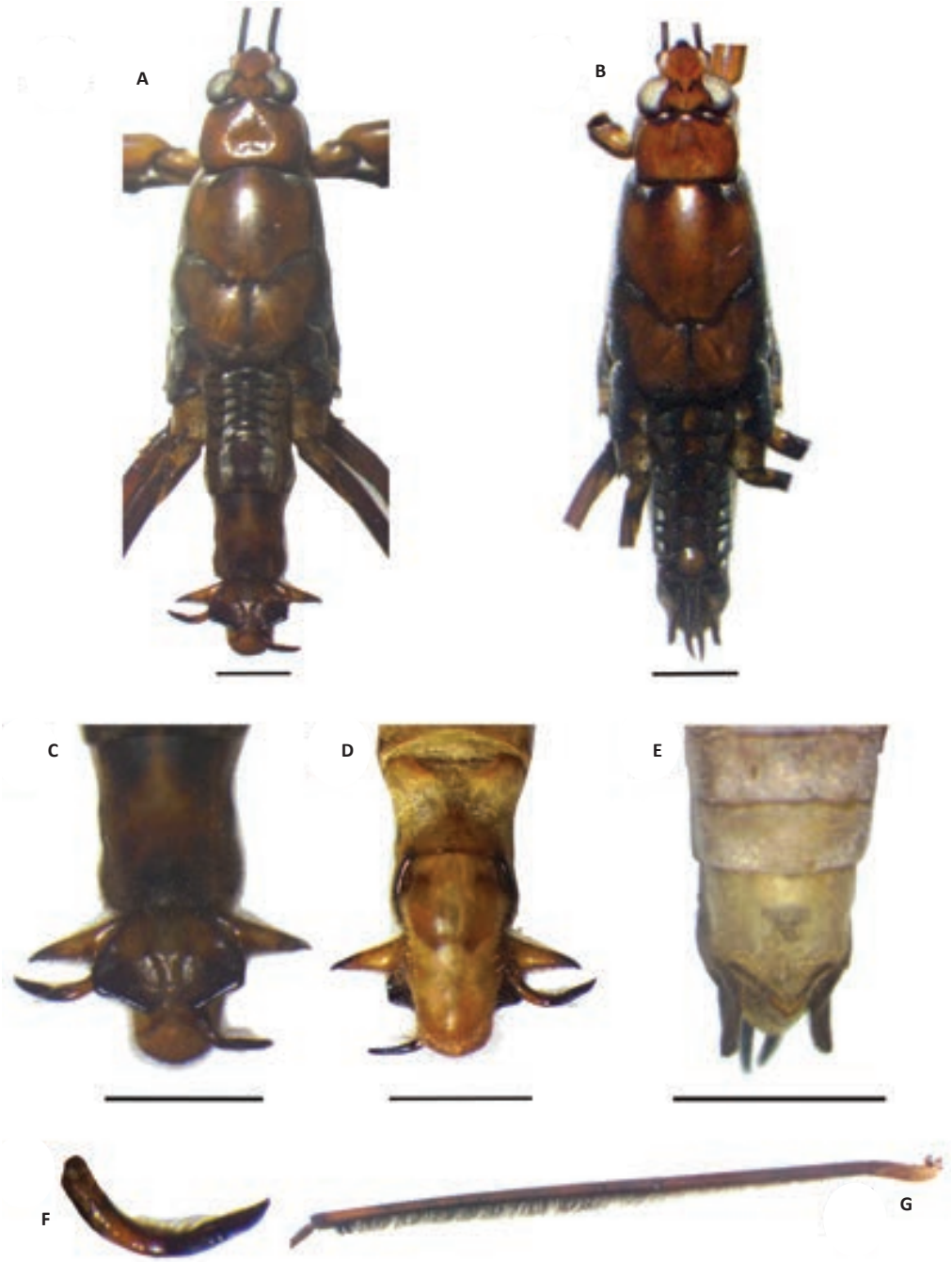

Image 1 . *Ptilomera agriodes* (Schmidt, 1926): A—male | B—female | C—male abdominal dorsal view | D—male abdominal ventral view | E—female abdominal ventral view | F—paramere | G—male femur | Scale = 1mm. © A. Narahari.

13males, 8females Exs, FBRC/ZSI/INS/1067, Stream at Saraiguda,way to Borra caves, 05.ix.2018;8 males, 4 females Exs, FBRC/ZSI/INS/1132, Marsila waterfall, 06.i.2019; 3 males, 10 females Exs, FBRC/ZSI/INS/1133, Malai Palem waterfall, 08.i.2019; 3 males, 2 females Exs, FBRC/ZSI/INS/1318, Saleswaram, 28.xii.2018; 4 males, 2 females Exs, FBRC/ZSI/INS/1407, Namma Aruvi waterfall,06.i.2019; 6 males, 8 females Exs, FBRC/ZSI/INS/1413, Agaya Gangai waterfall, 6.i.2019; 9 males, 5 females Exs, FBRC/ZSI/INS/1540, Near Nagalru waterfall, 08.i.2019; 39 males, 35 females Exs, FBRC/ZSI/INS/1132, Kottachedu Kari Raman Temple, 07.i.2019; 1 male Exs, FBRC/ZSI/INS/1687, Gandahati waterfall, 25.xi.2019; 4 males, 4 females Exs, FBRC/ZSI/INS/1714, Stream near Bentalbiri, 29.xii.2019; 2 males, 1 female Exs, FBRC/ZSI/INS/1711, Dudum waterfall, 29.xii.2019; 1 male, 6

females Exs, FBRC/ZSI/INS/1712, Lassari forest waterfall, 03.i.2020; 3 males, 6 females Exs, FBRC/ZSI/INS/1709, Stream near Kasipatnam, 27.xii.2019; 1 male Exs, FBRC/ZSI/INS/1710, Stream near Daringbadi, 04.i.2020; 4 males, 13 females Exs, FBRC/ZSI/INS/1707, Stream near Andaanda, 05.i.2020.

Diagnostic features: Body length of the male is 13–14 mm; Female 11–12 mm. Surface of the body is dark brown to yellow brown in color. Eyes are large reddish-brown to black and broadly rounded. First antennal segment is larger than combining length 2–4. Rostrum is short, male mid femur fringe of black setae. Length of male abdomen 6mm, paramere curved and contains setae. Hind legs are longer than body length; spine-like lateral process of the pygophore extended well the lateral process of the proctiger. The posteromedian margin of the proctiger is bisinuate.

References

Basu, S., G. Thirumalai, K.A. Subramanian & G.K. Saha (2015). New records of aquatic and semi aquatic Heteroptera (Insecta: Hemiptera) from West Bengal and Odisha. *Records of the Zoological Survey of India* 115(Part 2): 191–201.

Basu, S. & K.A. Subramanian (2017). Insecta: Hemiptera (Aquatic Bugs) (Chapter 23), pp. 357–378. In: Chandra, K., K.C. Gopi, D.V. Rao, K. Valarmathi & J.R.B. Alfrad (eds.). *Current Status of Freshwater Faunal Diversity in India.* Published by Zoological Survey of India, Kolkata.

Damgaard, J. (2008). Phylogeny of the semiaquatic bugs (Hemiptera-Heteroptera, Gerromorpha). *Insect Systematics & Evolution* 39(4): 431–460.

Jehamalar, E.E & K. Chandra (2013). On a collection of aquatic and semi-aquatic bugs (Hemiptera: Heteroptera) from Chhattisgarh, India. *Records of the Zoological Survey of India* 113(Part 1): 183–195.

Jehamalar E.E., K. Chandra, S. Basu & C. Selvakumar (2017). Review of *Ptilomera (Ptilomera)* (Hemiptera: Heteroptera: Gerridae) from India with description of a new species. *Zootaxa* 4370(5): 501–518.

Thirumalai, G. (2002). A checklist of Gerromorpha (Hemiptera) from India. *Records of the Zoological Survey of India* 100 (1–2): 55–97.

Thirumalai, G., R.M. Sharma & K. Chandra (2007). A checklist of aquatic and semiaquatic Hemiptera (Insecta) of Madhya Pradesh. *Records of the Zoological Survey of India* 107(Part–4): 71–91.

Threatened Taxa

Erratum

Citation: Schaffer, N.E., M. Agil & Z.Z. Zainuddin (2020). Ramifications of reproductive diseases on the recovery of the Sumatran Rhinoceros *Dicerorhinus sumatrensis* (Mammalia: Perissodactyla: Rhinocerotidae). *Journal of Threatened Taxa* 12(3): 15279–15288. https://doi.org/10.11609/jott.5390.12.3.15279-15288

Page #15281,

Table 1. line Stud Book #40 last box in row reads: N. Schaffer P. Kretzschmar Should read: N. Schaffer T. Hildebrandt

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NOTE

Didymocarpus bhutanicus W.T. Wang (Gesneriaceae): a new addition to the herbs of India

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Didymocarpus bhutanicus W.T. Wang (Gesneriaceae), an uncommon mossy herb species from the eastern Himalaya is reported here as a new record for Indian flora. The species was earlier known only from Bhutan and listed as 'Least Concern' in the IUCN Red List (Bhutan Endemic Flowering Plants Workshop 2017). A detailed description along with an image of the habitat and a photo showing a dissected flower is provided. A comparison with its most similar allied species, *Didymocarpus oblongus* Wall. ex D.Don, is also provided for easy identification (Table 1).

Didymocarpus Wall., with 60 species worldwide, is mainly distributed in Nepal, Bhutan, northeastern India, Myanmar, southern China, Vietnam, Laos, Cambodia, Thailand, and the Malay peninsula. It is represented by 23 species in India, mainly restricted to the northeastern regions (Moller et al. 2016). The taxonomy and delimitation of *Didymocarpus* has varied considerably from time to time (Burtt 1998; Weber et al. 2000, 2011; Möller et al. 2011; Möller & Clark 2013; Li et al. 2016) and the circumscription of its members have also been subjected to various changes based on molecular phylogenetic studies and morphological revisions (Xu et al. 2019). Recent studies reveal the need for taxonomic rearrangement of the members, particularly those in northeastern India and in southeastern Asia (Weber & Burtt 1998; Möller et al. 2016).

During a floristic and ecological study in Sikkim in July 2019, under the auspices of the project entitled 'Biodiversity Assessment through Long Term Monitoring Plots in Indian Himalayan Landscape' an isolated population of an interesting species of *Didymocarpus* Wall. was discovered near Radong, East District, Sikkim (Figure 1). Through a survey of literature (Wang 1983; Wang et al. 1998; Weber et al. 2000; Hilliard 2001) and a comparison of herbarium specimens at ARUN, BSHC, CAL, we identified the plants as *Didymocarpus bhutanicus* W.T. Wang, a species hitherto not reported from India. A detailed description of *D. bhutanicus* along with a field photograph (Image 1), locality map (Figure. 1) and notes are provided. The presence of *D. bhutanicus* in Sikkim also establishes an eastward extension of its range.

Macro and micro morphology of dissected floral parts were observed using an Olympus stereo-zoom dissecting microscope (Olympus SZ61). Photographs were taken in the field with a Sony HX 400V Camera. The

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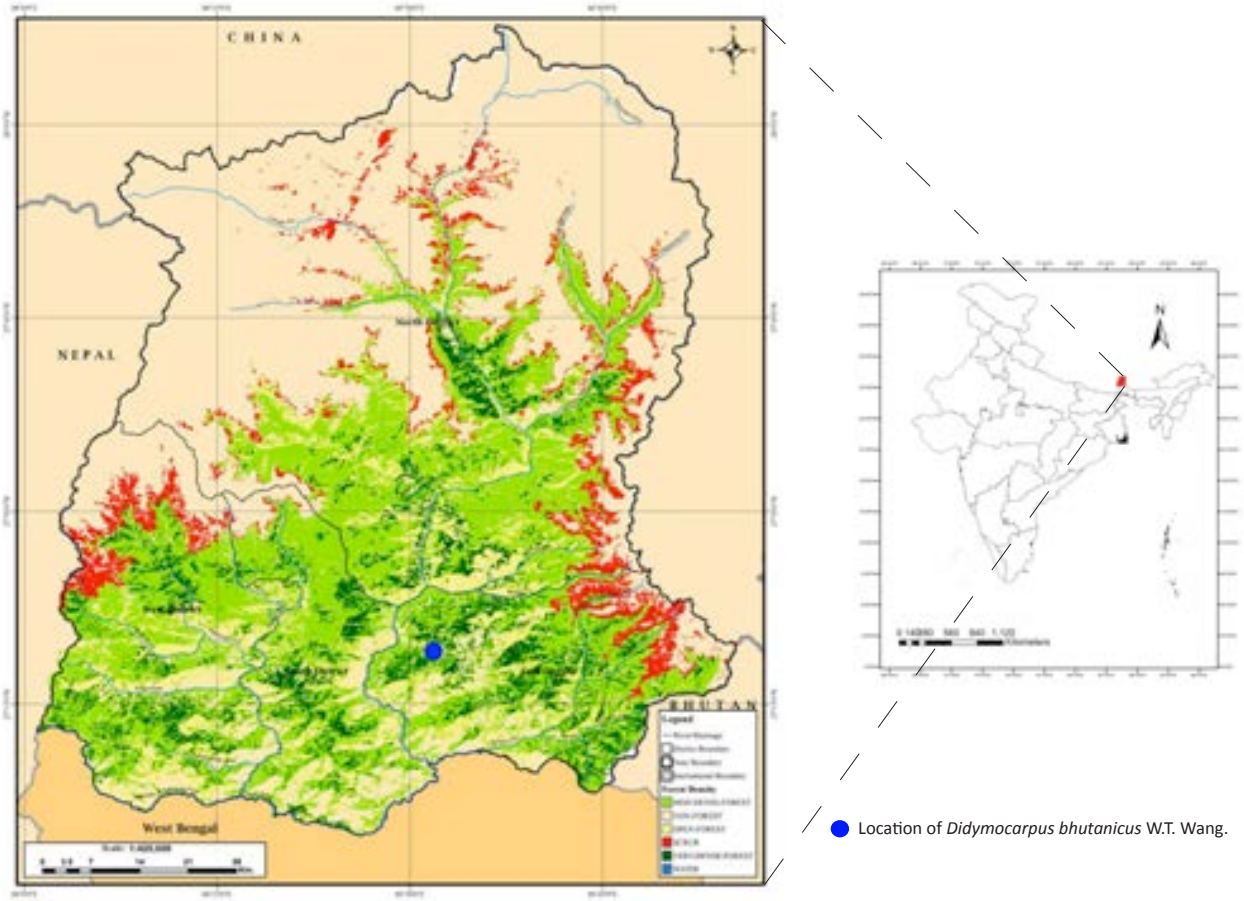

Figure 1. Location of *Didymocarpus bhutanicus* W.T. Wang near Rakdong area, East District, Sikkim.

coloured photo plate was made using Adobe Photoshop CS3; the locality map was created by using Arc Map (ver. 10.1) and Google Earth Pro.

***Didymocarpus bhutanicus* W.T. Wang,**

Bull. Bot. Res., Harbin 3(4): 46. 1983.

Type: E. Bhutan, Trashi Yangsi Chu, Tobrang, 2,600m, on mossy stones, in dense mixed forest, 5 July 1949, F. Ludlow, G. Sherriff and J.H. Hicks n. 20840 (Holotype, TI) (digital image!).

Herbs, erect, perennial. Roots woody, fibrous. Stem erect, 9–12 cm long, spreading, light brownish puberulous. Leaves 4, sub-verticillate, distal on stem; petiole 1.4–2.8 cm long; lamina herbaceous, slight unequally oblong or narrowly oval, 3.5–12 × 2.6–5 cm, base obliquely cuneate or obliquely rounded, margin double toothed, apex acute to acuminate, abaxially puberulous, adaxially glabrous or appressed puberulous, midvein prominent, lateral veins 5–7 pairs. Inflorescences cymes, axillary, peduncle 7.5–9.5 cm long, 2 or 3 times branched, distally spreading puberulous, ca. 6–10 flowered; bracts opposite, rounded-oval, 7.5–8 × 7–9 mm. Flowers: calyx campanulate, ca. 5mm long, light pink, glabrous, 5–lobed, lobes 1.4–2.1 mm long, obtuse; corolla pink or pale lilac, 1.7–2 cm long, glabrous, tube cylindrical, lower lip suborbicular, 8.5–9 mm long, 9–10 mm wide, 3-lobed; stamens inserted 2.3–3.5 mm above base of corolla, anthers oval, dorsifixed, glabrous; ovary lanceolate 2–3.8 mm long, stigma disciform. Capsule 1.8–2.3 cm long.

Flowering and fruiting: July–August.

Habitat and ecology: In wet moss-covered rocky crevices; 2,000–2,300 m. Main associated species: *Caulokaempferia sikkimensis* (King ex Baker) K. Larsen, *Impatiens purpurea* Hand.-Mazz., *Lycopodium japonicum* Thunb., *Adiantum incisum* Forssk.

Distribution: Bhutan; India (Sikkim).

Conservation status: Least Concern (Bhutan Endemic Flowering Plants Workshop 2017).

Specimen examined: 95701, 01.vii.2019, India, Sikkim, East District, near Rakdong, 27.385^{0}N & 88.528^{0}E, 2,100m, coll. S. Lahiri & M. Das (CAL!) (Image 2).

Notes: *Didymocarpus bhutanicus* is morphologically similar to *D. oblongus* Wall. ex D.Don. Both species

Image 1. ***Didymocarpus bhutanicus*** **W.T. Wang: A—habitat | B_adaxial surface of leaf | C—abaxial surface of leaf | D—inflorescence | E—calyx | F—corolla | G—corolla split to show stamen | H—pistil | I—capsules. @ Subhajit Lahiri.**

Image 2. Herbarium sheet of *Didymocarpus bhutanicus* (CAL! 95701).

occur between 1,500 and 3,000 m elevation. Both have well-developed stems and a pink corolla. *Didymocarpus bhutanicus* can be differentiated from *D. oblongus* by the longer peduncle, larger flowers and longer petiole. The leaves are rounded and densely puberulous to villous in *D. oblongus*; *D. bhutanica* has oblique, rounder leaves glabrous on the adaxial surface.

References

Bhutan Endemic Flowering Plants Workshop (2017). *Didymocarpus bhutanicus*. *The IUCN Red List of Threatened Species* 2017: e.T83604887A84447396. Downloaded on 20 February 2020. https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T83604887A84447396.en

Burtt, B.L. (1998). Taxonomic history of *Didymocarpus* and *Henckelia* (Gesneriaceae). *Beiträge zur Biologie der Pflanzen, Breslau* 70: 365–375.

Hilliard, O.M. (2001). Gesneriaceae, pp. 1308–1315 In: Grierson, A.J.C. & D.G. Long (eds.). *Flora of Bhutan*, Vol. 2. Part 3. Royal Botanic Garden Edinburgh, UK & the Roal Government of Bhutan, Bhutan, 1675pp.

IUCN (2017). The IUCN Red List of Threatened Species. Available online at https://www.iucnredlist.org. Accessed on 25 November 2019.

Li, J.M., W.J. Sun, Y. Chang & W.G. Yang (2016). Systematic position of *Gyrocheilos* and some odd species of *Didymocarpus* (Gesneriaceae) inferred from molecular data, with reference to pollen and other morphological characters. *Journal of Systematics and Evolution* 54(2): 113–122.

Möller, M., A. Forrest, Y.G. Wei & A. Weber (2011). A molecular phylogenetic assessment of the advanced Asiatic and Malesian didymocarpoid Gesneriaceae with focus on non-monophyletic and monotypic genera. *Plant Systematics and Evolution* 292(3–4): 223–248.

Möller, M. & J.L. Clark (2013). The state of molecular phylogenetic work in the family Gesneriaceae: a review. *Selbyana* 31(2): 95–125.

Möller, M., Y.G. Wei, F. Wen, J.L. Clark & A. Weber (2016). You win some you lose some: updated generic delineations and classification of Gesneriaceae - implications for the family in China. *Guihaia* 36: 44–60.

Wang, W.T. (1983). Four new Gesneriaceous species from Asia. *Bulletin of Botanical Research* 3(4): 45–50

Wang, W.T., K.Y. Pan, Z.U. Li, A.L. Weitzman & L.E. Skog (1998). Gesneriaceae. pp 349–358. In. Wu, Z.Y. & P.H. Raven (eds.). *Flora of China*, Vol. 18. Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis, 450pp.

Weber, A. & B.L. Burtt (1998). Remodeling of *Didymocarpus* and associated genera (Gesneriaceae). *Beitrage zur Biologie der Pflanzen Breslau* 70: 293–363.

Weber, A., V.L. Burtt & E. Vitek (2000). Materials for a revision of *Didymocarpus* (Gesneriaceae). *Annalen des Naturhistorischen Museums in Wien* 102: 441–475.

Weber, A., Y.G. Wei, C. Puglisi, F. Wen, V. Mayer & M. Möller (2011). A new definition of the genus *Petrocodon* (Gesneriaceae). *Phytotaxa* 23 (1): 49–67. https://doi.org/10.11646/phytotaxa.23.1.3

Xu, W.J., W.H. Qin, Z.Q. Wang, Z.L. Li, L.F. Fu, X. Hong (2019). A new variety of *Didymocarpus* (Gesneriaceae) from Guangdong, China. *PhytoKeys* 128: 33–38. https://doi.org/10.3897/phytokeys.128.35

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NOTE

Rediscovery of *Epilobium trichophyllum* Hausskn.: a rare and endemic plant from Sikkim Himalaya, India

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Epilobium trichophyllum Hausskn. was described in 1879 based on J.D. Hooker & Thomson collection from Lachung Valley, Sikkim in July 1849. Simultaneously, in the same year C.B. Clarke (1879) had described *Epilobium origanifolium* var. *villosum* based on another specimen from the same collection housed at K. Haussknecht (1884); later Raven (1962) treated both the names as conspecific. The species is characterized by the presence of densely villous hairs throughout the plant. Since its original collection in 1849, this species has never been recollected until Aswal & Mehrotra (1994) reported it from Lahaul-Spiti, Himachal Pradesh based on their collection [Aswal 6780 (CDRI- Central Drug Research Institute, Lucknow)]. Later, Srivastava & Shukla (2015) reported this species from the cold desert area of western Himalaya based on the same collection of Aswal. During the present study, in order to confirm the identity of the specimen reported as *Epilobium trichophyllum* by Aswal & Mehrotra (1994), image of [Aswal 6780 (CDRI) was examined. Closer examination revealed that the specimen has morphological characteristics similar to *Epilobum amurense* Hausskn., and not *E. trichophyllum* as identified by them. The image was compared with the type specimen image of *E. trichophyllum* and observed as remarkably different (Image 1–2, Table 1). The dense villous hairs were not found throughout the cold desert specimen to determine this as *E. trichophyllum*. Thus, its occurrence report from western Himalaya can be excluded. Despite its report from Lahul-Spiti in 1994, the species was mentioned as presumably extinct and endemic to Sikkim in the treatment of family Onagraceae by Paul (1998).

During the revisionary studies on the family Onagraceae for Flora of Sikkim, the authors came across few unidentified specimens of *Epilobium* collected from Sikkim and housed at herbarium of Botanical Survey of India, Sikkim Himalayan Regional Centre (BSHC). The specimen Pradhan & Giri 29191 collected in 2006 from Zema-1 (Lachen to Thangu) composed of two specimens representing two species of *Epilobium*. Upon critical study and comparison with type images, one of them [29191A (Image 3)] was identified as *E. trichophyllum* by virtue of the presence of villous hairs throughout the plant. The other specimen (29191B) could be identified as *Epilobium sikkimense* Hausskn. (Table 1). Both the species are quite similar in appearance and can easily be mistaken for each other. Thus, the specimen (29191A) represents the second report of the species after a gap of 157 years. The locality of the present collection is not too far away from the type locality and also shares

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Table 1. Comparative morphology of *Epilobium trichophyllum*, *E. sikkimense*, and *E. amurense*.

Species	*E. trichophyllum*	*E. sikkimense* [D.L.Biate & S.K. Rai 39431 (BSHC)]	*E. amurense* [D.L. Biate & S.K. Rai 39421 (BSHC)]
Habit	Small herbs, with short leafy soboles	Herbs erect, often clumped, with thick fleshy soboles that leave brown basal scales	Herbs erect, with short leafy soboles or rosettes
Stem	Stem approximately 10 cm tall, densely villous throughout	Stems 7–25 cm tall, simple to moderately branched, subglabrous except for 2(–4) raised strigillose lines decurrent from petioles, or sometimes appressed stiffly hairy and glandular all around	Stem 18–45 cm tall, simple or sparsely branched, upper stem with appressed stiff hairs, often with glandular hairs, with two raised lines decurrent from margin of petioles below, or rarely subglabrous
Leaves	Leaves opposite, ovate, 1–1.8 x 0.5–1 cm, crowded at base, villous on both sides, margin serrulate, base rounded, apex subacute, lower leaves oblong-ovate, entire	Leaves opposite, ovate to elliptic or oblong-lanceolate, 1.5–3 x 0.5–1.5 cm, sessile and clasping above or petiolate below, glabrous except for sparsely appressed stiffly hairy on midvein and margins, margin serrulate, base cuneate or rounded, apex sub-obtuse to acute	Leaves ovate to lanceolate, 3–6 x 1–1.6 cm, subsessile to shortly petiolate below, sparsely appressed stiffly hairy on veins and margins, margin serrulate, base rounded to attenuate, apex acute
Flowers	Flowers suberect. Petals pink. Stigma clavate/ capitate	Flowers nodding to suberect. Petals pink to rose-purple. Stigma capitate, entire	Flowers suberect. Petals white to rose purple. Stigma subcapitate
Fruit	Capsule ca. 3cm, densely villous	Capsules 5–9 cm, sparsely appressed stiffly hairs and glandular	Capsules 3.5–7 cm, appressed stiffly hairy.

similar phyto-climatic conditions. Both these localities are subjected to thorough floristic survey by Botanical Survey of India and other institutes during last five decades, but this species was not reported in any of these surveys indicating its rarity. One could argue that its short life span, small plant size and high similarity with *E. sikkimense* might be the reason for it being excluded from earlier reports. Thus, the present report carries lots of significance and will definitely change the approach of the field botanists while going for a floristic trip to these localities in future.

A brief description, taxonomic history, distribution map (prepared in Arc-GIS) and photograph of the specimens have been provided to facilitate easy identification. Its threat status has been assessed as per IUCN criteria.

Taxonomy

Epilobium trichophyllum Hausskn. in Oesterr. Bot. Z. 29:53. 1879; P.H. Raven in Bull. Brit. Mus. (Nat.Hist.), Bot. 2(2): 374. 1962; P. Hoch in Fl. Bhutan 2(1):320. 1991; T.K. Paul in Bull. Bot. Surv. India 40 (1-4): 15. 1998. *Epilobium origanifolium* var. *villosum* C.B. Clarke in Hook, f., Fl. Brit. India 2: 586. 1879.

Small herbs, with short leafy soboles, stem approximately 10cm tall, densely villous throughout. Leaves ovate, 1–1.8 x 0.5–1 cm, crowded at base, opposite above, villous on both sides, margin serrulate, base rounded, apex subacute, lower leaves oblong-ovate, entire. Flowers suberect, petals pink, stigma clavate/ capitate. Capsule *ca*. 3cm, densely villous. Seeds not seen (Image 3).

Flowering and Fruiting: July.

Image 1. Herbarium specimen Aswal 6780 (CDRI)

Distribution: India, Sikkim (3,000–3,600 m), endemic.

Specimen examined: 29191A (BSHC!), 15.vii.2006, Sikkim, North District, Lachen to Thangu (Zema-1), 27.774^{0}N & 88.713^{0}E, 3,536m, coll. Pradhan & Giri.

Image 2. The holotype and isotype of *Epilobium trichophyllum*.

Image 3. *Epilobium trichophyllum* [Pradhan & Giri 29191A (BSHC)].

Threat status assessment: The species is so far known only from two localities of alpine forest in Sikkim. One of these is based on a 170 year old historical report and none of these records provide any information on the population size. Being an annual herb, its generation length can be estimated as one year. The collectors of the present specimen revealed (pers. comm.) the sub population is nearly 30–40 matured individuals. The extent of occurrence (EOO) can be calculated as 50km^2 and the area of occupancy (AOO) can be estimated as 8km^2 (Criterion B) by taking the minimum grid size of 2 × 2 km (Image 4). Although this species is not known for its economic potential or trade, the habitat was subjected to severe natural calamities (landslides, avalanches) in the past causing damage to many indigenous species. Quality of habitat is currently degrading due to intense tourism and developmental activities. Further, the species being highly confined in its distribution at higher elevation of Sikkim is also under threat as such species are known to be more vulnerable to the effect of climate change. Therefore, the threat status of this species as per IUCN (2013) guidelines can be assessed as 'Critically Endangered' [CRB1ab(iii)+2ab(iii); C2a(i); D]. Habitat management and more intense survey is recommended for conservation of this species.

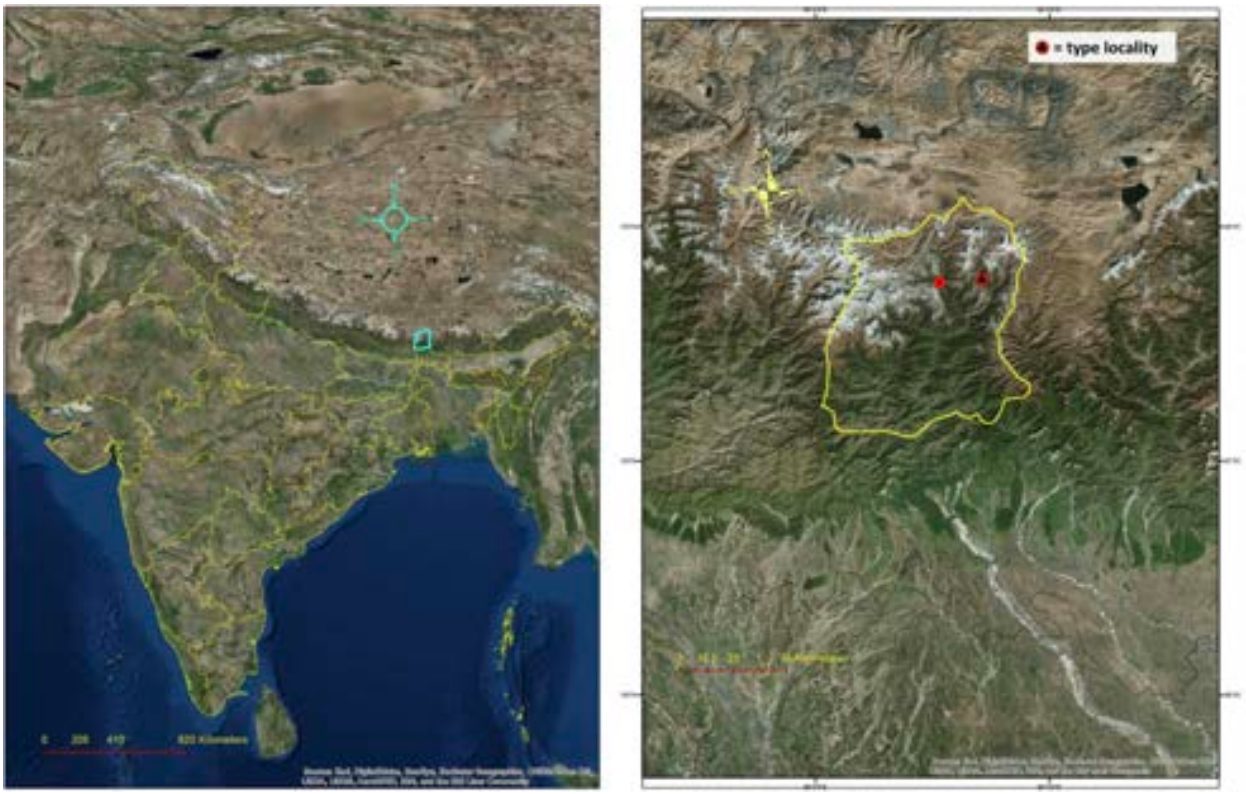

Image 4. Distribution map of *Epilobium trichophyllum*.

References

Aswal, B.S. & B.N. Mehrotra (1994). *Flora of Lahaul-Spiti*(*A Cold Desert in North-West Himalaya*). Bishen Singh and Mahendra Pal Singh, Dehradun, 268pp.

Clarke, C.B. (1879). Onagraceae, pp. 582–590. In: Hooker, J.D. (eds.). *The Flora of British India*. Vol.2. L. Reev & Co., London, 586pp.

Hoch, P.C. (1991). Family Onagraceae, pp. 309–323.In: Grierson, A.J. C. & D.G. Long (eds.) *Flora of Bhutan* 2(1): 309–323. Royal Botanic Garden, Edinburgh, 320pp.

Haussknecht, H.C. (1884). *Monographie der Gattung Epilobium*. Jena, viii+318pp.

IUCN (2013). Guidelines for Using the IUCN Red List Categories and Criteria. Version 10. Prepared by the Standards and Petitions Subcommittee. Accessed on: 09/01/2019. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Paul, T.K. (1998). A conspectus of the family Onagraceae in India. *Bulletin of the Botanical Survey of India* 40(1–4): 1–22.

Raven, P.H. (1962). The genus *Epilobium* in the Himalayan region. *Bulletin of the British Museum (Natural History)* 2(12): 327

Srivastava, S.K., & A.N. Shukla (2015). *Flora of Cold Desert: Western Himalaya, India*. Botanical Survey of India, Kolkata, 264pp.

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NOTE

Additions of woody climbers (Lianas) to the flora of Manipur, India

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Manipur, one of the northeastern states of India, is a predominantly hilly and forest dominated state with an area of 22,327km^2. Out of the total geographical area, 17,477km^2 is under forest cover which constitutes about 78% of the total area of the state. The state shares an international boundary with Myanmar (Anonymous 2009). Due to diverse phytogeography and varied climatic conditions, the state has provided suitable habitats for the growth of luxuriant floral elements. The total floral richness and abundance are also evidenced by the diversity of lianas in the state.

To explore the liana diversity of the state, a study has been carried out since 2013. During field explorations, the first author collected many woody climbers (lianas) from the study area of which five were found uncommon ones. After critical morpho-taxonomic examination of all the specimens, scrutiny of relevant literature (Hooker 1875–83; Kanjilal et al. 1934–39; Fang & Staples 1995; Chang et al. 1996; Chen & Turland 2007; Chen et al. 2007; Quang et al. 2013; eFlora 2017) and matching of specimens housed in herbaria of Botanical Survey of India (BSI), Eastern Regional Centre, Shillong (ASSAM) and Central National Herbarium (CNH), Howrah (CAL), the species were identified as *Ampelopsis rubifolia* (Wall.) Planch. (Vitaceae), *Argyreia wallichii* Choisy (Convolvulaceae), *Combretum sundaicum* Miq. (Combretaceae), *Jasminum lanceolaria* Roxb. (Oleaceae), and *Tetrastigma obovatum* Gagnep. (Vitaceae). The identities of all the five species were further confirmed consulting the digitized images of type specimens at Royal Botanic Gardens, Kew, London (K) (www.apps.kew.org).

The perusal of relevant literature (Deb 1957, 1961; Chaudhuri & Naithani 1985; Singh et al. 2000) revealed that these species were not so far known from Manipur; hence, this report constitutes five new distribution records and additions of woody climbers to the state of Manipur.

The specimens were preserved following standard herbarium methods (Jain & Rao 1977) and deposited in ASSAM and the Herbarium of Department of Life Science & Bioinformatics, Assam University, Silchar. Detailed taxonomic description, illustration, and photographs are provided for easy identification of the species. In the treatment, families are arranged alphabetically and again species are arranged alphabetically within a family where the family contains more than one species.

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Family: Combretaceae

1. *Combretum sundaicum* Miq., Fl. Ned. Ind., Eerste Bijv. 2: 327. 1861; C.B. Clarke in Hook.f., Fl. Brit. India 2: 458–459. 1878; Kanjilal et al., Fl. Assam 2: 256. 1938; Jie &Turland in Wu et al., Fl. China 13: 316–320. 2007. (Fig. 1; Image 1).

Large woody climber. Stems terete, glabrous; young branchlets short brown pubescent. Leaves simple, opposite; petioles 0.1–0.7 cm long, glabrous. Leaf blades broadly elliptic-ovate, 7–17 × 4–12 cm, obtuse-subacute at base, acute-acuminate at apex, entire at margins, thinly coriaceous, densely scaly at both surfaces; scales minute, yellow at abaxial surface, white at adaxial surface; lateral veins 7–8 pairs. Inflorescences apical to axillary, compound dichasium, c. 5–13 cm long, usually grouped at apex of branchlets forming a panicle, densely villous at axes, inconspicuously scaly; hemispheric capitula composed of apically condensed flower-bearing spikes, c. 0.8–1.3 cm long; bracts linear, caducous; buds ovate, acute at apex. Calyx tube infundibuliform, c. 0.7–1.2 cm long, glabrous at abaxial surface, yellow scaly, ring of densely coarse hairs at adaxial surface, 4-lobed; lobes broadly triangular-deltoid, c. 2 mm long, shortly acute-acuminate at apex. Petals 4, white, obovate-oblong, c. 0.2 × 0.1 cm, obtuse-rounded at apex. Stamens 8, exserted, c. 6 mm long; anthers ellipsoid, c. 1 mm long. Ovary superior, c. 3 mm long; styles terete, c. 8 mm long. Fruit not found.

Flowering: June–July.

Habitat: The species grows in shady areas along roadsides and hilly slopes between 1,000–1,126 m.

Specimen examined: #94641, 4.vii.2014, India, Manipur, Noney District, Charoi Chakotlong II, 24.752^{0}N & 93.616^{0}E, c. 1,126.90m, coll. L.M. Chanu 25359, ASSAM (Image 6).

Distribution: India (Assam, Manipur, Sikkim), Borneo, Java, peninsular Malaysia, Singapore, Sumatra, Thailand, Vietnam (http://www.catalogueoflife.org), (https://www.indiabiodiversity.org).

Image 1. *Combretum sundaicum* Miq.

Figure 1. *Combretum sundaicum* Miq.: a—flowering twig | b— bud | c—calyx | d—calyx throat with rims of hairs | e—calyx lobe (adaxial view) | f—calyx lobe (abaxial view) | g—floret | h—petal (adaxial view) | i—petal (abaxial view) | j—androecium | k—gynoecium | l—ovary.

Family: Convolvulaceae

2. *Argyreia wallichii* Choisy, Mém. Soc. Phys. Genève 6: 422. 1833; C.B. Clarke in Hook.f., Fl. Brit. India 4: 187. 1883; Kanjilal et al., Fl. Assam 3: 342. 1939; Rhui-cheng & Staples in Wu et al., Fl. China 16: 316. 1995. (Fig. 2; Image 2).

Woody climber, extensively large. Stems terete, pale greenish; young branchlets short white tomentose. Leaves compound, opposite; petioles 5–13 cm long. Leaf blades broadly ovate-cordate, 11–24 × 8–19 cm, cordate at the base, acute at apex, entire at margins, pale greenish, densely white tomentose at abaxial surface, glabrous at adaxial surface with sparsely strigose hairs along midrib; lateral veins 10–17 pairs, prominent at base adaxially. Inflorescences terminal-

axillary, capitate cymes, many flowered; peduncles up to 2cm long, pubescent. Outer bracts persistent, ovate-elliptic, 3–3.5 × 2–2.5 cm, greyish pubescent at abaxial surface, glabrous and nerved at adaxial surface, entire at margins. Inner bracts persistent, ovate-elliptic, 2–2.5 × 1–1.5 cm, pubescent at abaxial surface, glabrous at adaxial surface and nerved. Corolla and androecium not seen. Ovary globose to ovate-elliptic, glabrous, obtuse at apex; styles c. 1 cm long. Fruits not seen.

Flowering: October–November.

Habitat: The species was found in a deforested area at an elevation of c. 1,000m and climbing on *Pinus* sp.

Specimen examined: #94637, 3.xi.2013, India, Manipur, Chandel District, Chakpi karong Sub-division, Gohok Village, 24.207^{0}N & 93.900^{0}E, coll. L.M. Chanu 25324, ASSAM (Image 7).

Distribution: India (Sikkim, Manipur, West Bengal (Darjeeling)), Bhutan, China, Myanmar, northern Thailand (http://www.catalogueoflife.org).

Family: Oleaceae

3. *Jasminum lanceolaria* Roxb., Fl. Ind. 1: 98. 1820; C.B. Clarke in Hook.f., Fl. Brit. India 3: 601. 1882. Mei-Chen et al. in Wu et al., Fl. China 15: 314. 1996. Quang et al., *J. Biol.* 35(4): 431. 2013; Kanjilal et al., Fl. Assam 3: 232. 1939. *Jasminum lanceolaria* var. *puberulum* Hemsl., *J. Linn. Soc., Bot.* 26: 78. 1889. (Fig. 3; Image 3).

Woody climber. Stems terete; young branchlets smooth, greenish. Leaves opposite, 3-foliolate, sometimes reduced to single at the base of inflorescences; petioles 1–3 cm long, glabrous; petiolules 2–4.5 cm long, glabrous. Leaflets elliptic-ovate, coriaceous, cuneate-rounded at base, acute-acuminate at apex, entire at margins; nerve obscure, 5–8 pairs of lateral nerves; terminal leaflets larger than lateral leaflets, 6–12 × 3–4 cm; lateral leaflets 6–10 × 2.5–3.5 cm. Inflorescences compound, terminal-axillary, pedunculate trichotomous cymes, many flowered, 7–12 cm long. Bracts linear, 1–5 × 1–2 mm; bracteoles linear, c. 1 × 0.5 mm long, serrate at margins. Flowers fragrant, white, pentamerous; pedicels 0–1.2 cm long, glabrous. Calyx tubular, glabrous, 2–5 × 2 mm wide; lobes minutely dentate, c. 0.5 mm long. Corolla white, hypocrateriform; tubes 2–3 × 0.2–0.3 cm wide; 5-lobed, lobes oblong-lanceolate, 1–1.3 × 0.4–0.5 cm. Stamens 2; filament short, attached to throat; anthers c. 0.6 cm. Ovary c. 0.1 cm long, styles terete, c. 0.5 cm long; stigma c. 0.3 cm long. Fruits not seen.

Habitat: Grows in moist forests at an altitude of c. 782m.

Flowering: April–May.

Image 2. *Argyreia wallichii* Choisy. Inset: persistent bracts.

Figure 2. *Argyreia wallichii* Choisy: a—flowering twig | b - outer bract (adaxial view) | c—outer bract (abaxial view) | d—inner bract | e—outer and inner bracts arrangement | f—gynoecium.

Specimen examined: #94638, 7.iv.2014, India, Manipur, Chandel District, Chakpi karong Sub-division, Khubung Khunou, 24.198^{0}N & 93.908^{0}E, coll. L.M. Chanu 25337, ASSAM (Image 8).

Distribution: India (Andaman Island, Assam, eastern

Image 3. *Jasminum lanceolaria* Roxb.

Figure 3. *Jasminum lanceolaria* Roxb.: a—flowering twig | b—bud | c—floret | d—bract (abaxial view) | e—bract (adaxial view) | f—bracteole (abaxial view) | g—bracteole (adaxial view) | h—calyx | i—corolla showing epipetalous stamens | j—stamen (abaxial view) | k—stamen (adaxial view) | l—gynoecium | m—ovary.

Himalaya, Manipur), Bangladesh, China, Japan, Malaya, Myanmar, Taiwan, Thailand, Vietnam (http://www.catalogueoflife.org).

Family: Vitaceae

4. *Ampelopsis rubifolia* (Wall.) Planch., Monogr. Phan. 5: 463. 1887; Chen in Wu et al., Fl. China 12: 183. 2007. *Vitis rubifolia* Wall., Fl. Ind., ed. 1820 2: 480 1824. M.A. Lawson in Hook.f., Fl. Brit. India 1: 663. 1875; Kanjilal et al., Fl. Assam 1(1): 302. 1934. (Fig. 4; Image 4).

Large woody climber. Stems angular, glabrous; young branchlets slender, surface covered with densely rusty ferruginous pilose hairs; tendrils anti-folius, bifurcate. Leaves compound, bipinnate, rarely 3-foliolate, c. 22 cm long; petioles 5–11 cm long, densely curly pilose; terminal leaflets petiolules c. 2–3 cm long; lateral leaflets petiolules c. 0.2–0.5 cm long, densely curly pilose. Leaflets ovate-elliptic, 4–11 × 2.5–6.5 cm, sub-truncate at base, acute-acuminate at apex, serrate at margins, pubescent at abaxial surface, glabrous at adaxial surface; 5–7 pairs of lateral nerves. Inflorescences leaf-opposed, umbellate cymes, c. 11cm long, pseudo-terminal, densely curly ferruginous pilose; peduncles 5–8 cm long, densely rusty ferruginous pilose. Flowers pale greenish, c. 0.3cm long; pedicels 1–0.2 cm long, densely rusty ferruginous pilose; buds ovoid, c. 0.3 cm long, rounded at apex, rusty ferruginous pilose abaxially. Calyx cupular, 0.2–0.3 × 0.1–0.2 cm, rusty pilose at abaxial surface; 5-lobed, lobes apex slightly sub-truncate, densely rusty ferruginous pilose abaxially. Petals c. 0.2cm long, 5-lobed, elliptic-ovate, pubescent at abaxial surface. Stamens 5, c. 1.5mm long; anthers ovate, c. 0.5mm long, dorsifixed. Disc cupular. Ovary adnate to disc; styles short, conical; stigmas capitate. Fruits not seen.

Habitat: The species grows along roadsides and hill slopes at an elevation of c. 880m. It forms a large canopy on tree species *viz*. *Acacia* sp. and *Pinus* sp. Associated other species recorded was *Millettia pachycarpa* Benth. (Leguminosae: Papilionoideae).

Flowering: Mid April–June.

Specimen examined: #94639, 29.vi.2016, India, Manipur, Chandel District, Beru Anthi, 24.331^{0}N & 94.975^{0}E, coll. L.M. Chanu 25441, ASSAM (Image 9).

Distribution: India (Assam, Manipur, Meghalaya, Mizoram), Bangladesh, China (http://efloraindia.nic.in, http://www.catalogueoflife.org).

5. *Tetrastigma obovatum* (M.A. Lawson) Gagnep., Notul. Syst. (Paris) 1(9): 266–267. 1910; Teng in Wu et al., Fl. China 12: 202. 2007; *Vitis obovata* M.A. Lawson in

Image 4. *Ampelopsis rubifolia* (Wall.) Planch.

Figure 4. *Ampelopsis rubifolia* (Wall.) Planch.: a—flowering twig | b—inflorescence | c—bud | d—floret | e—corolla (adaxial view) | f—calyx | g—androecium | h—stamen | i—gynoecium.

Hook.f. Fl. Brit. India 1(3): 658–659. 1875; Kanjilal et al., Fl. Assam 1(1): 298. 1934; Deb, Fl. Tripura 1: 415. 1981. (Fig. 5; Image 5).

Large woody climber. Stems flattened; young branchlets terete, densely hirsute; tendrils anti-folius, unbranched. Leaves palmately 5-foliolate; petioles 10–15 cm long, densely hirsute; petiolules 1–2 cm long, densely hirsute. Leaflets ovate, obovate-elliptic, hirsute at abaxial surface, adaxially glabrous with sparsely pilose hairs at veins, membranous, serrate at margins; lateral nerves 6–8 pairs, distinct; terminal leaflets obovate-elliptic, 15–20 × 7–9 cm, cuneate at base, acuminate at apex, serrate at margins; lateral leaflets elliptic-ovate, 11–18 × 4.5–8.5 cm, asymmetric at base, acuminate at apex, serrate at margins. Flowers not seen. Infructescences axillary, umbelliform, dichasium. Fruits berry, globose, smooth, 1.8–2 cm, 2–4 seeded. Seeds ellipsoid, c. 1cm long, plano-convex, rostrate at base, retuse at apex with transverse line on both surfaces, ventrally furrowed, up to apex.

Habitat: Grows in moist and shady areas at an elevation of 790–1,340 m.

Fruiting: June–July.

Specimens examined: #94640, 15.vi.2014, India, Manipur, Imphal West District, Orchid Preservation Centre, Khonghampat, 24.892^{0}N & 93.898^{0}E, c. 793 m, coll. L.M. Chanu 25348, ASSAM; #94642, 04.vii.2014, India, Manipur, Churachandpur District, Ngariyan Hill, 24.611^{0}N & 93.688^{0}E, c. 1,340m, coll. L.M. Chanu 25363, ASSAM (Image 10).

Distribution: India (Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim), Bangladesh, China, Myanmar, Thailand, Vietnam (http://www.catalogueoflife.org).

Notes: As per IUCN (2019), threat status of these five species has not been assessed. No ecological studies were also conducted for enumeration of their abundance in the study area in this present study, however, field observations made in the entire state during the last six years showed that *Ampelopsis rubifolia*, *Argyreia wallichii*, *Combretum sundaicum*, and *Jasminum lanceolaria* were rare in the state and were recorded only from hill regions of Manipur. The first author could recognize only one population of each of these four species in the field. In contrast, *Tetrastigma obovatum* was found common throughout and seen growing abundantly in different localities in the state, both in hilly and valley districts. Deforestation of timber-yielding plants might have had a devastating impact on the overall population status of lianas in the state as this curious growth form is fully

Image 5. ***Tetrastigma obovatum*** **(M.A. Lawson) Gagnep.**

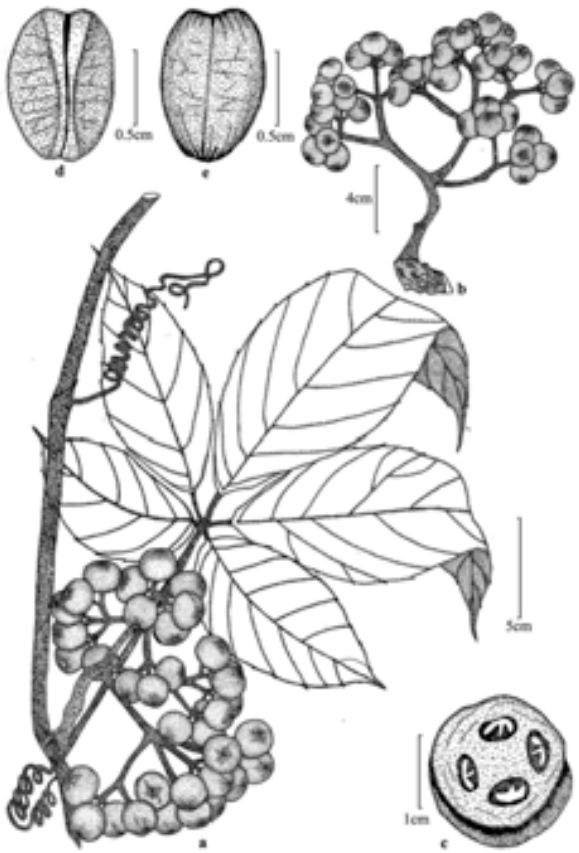

Figure 5. ***Tetrastigma obovatum*** **(M.A. Lawson) Gagnep.: a—fruiting twig | b—fruit | c—tranverse section of fruit | d—seed (adaxial view) | e—seed (abaxial view).**

dependent upon their supporting trees for their climbing mechanisms. Therefore, to preserve these lianas, in situ conservation of overall habitat should be prioritized.

References

Anonymous (2009). Manipur. India State Forest Report 2009. http://www.fsi.nic.in, accessed on 15 July 2018.

Catalogue of Life (2017). Catalogue of Life: 2017 Annual Checklist. http://www.catalogueoflife.org, accessed on 15 October 2018.

Chang, M., Q. Lian-qing & P.S. Green (1996). Oleaceae, pp. 272–319. In: Wu, Z., P.H. Raven & D. Hong (eds.). Flora of China. Vol. 15. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, USA.

Chaudhuri, A.B. & H.B. Naithani (1985). *Lianas, Climber and Shrubby Climbers*, Part III. National Book Distributors, Dehra Dun, India, 133pp.

Chen, Z., H. Ren & J. Wen (2007). Vitaceae, pp. 173–222. In: Wu, Z., P.H. Raven & D. Hong (eds), Flora of China. Vol. 12. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, USA.

Chen, J. & N.J. Turland (2007). Combretaceae, pp. 316–320. In: Wu, Z., P.H. Raven & D. Hong (eds.). Flora of China. Vol. 13. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, USA.

Deb, D.B. (1957). Studies of the Flora of Manipur. *Bulletin of the Botanical Society of Bengal* 11(1): 15–24.

Deb, D.B. (1961). Dicotyledonous plants of Manipur Territory. *Bulletin of the Botanical Society of Bengal* 3(3&4): 253–350.

eFlora (2017). eFlora of India, Botanical Survey of India. http://www.efloraindia.nic.in, accessed on 15 October 2018.

Fang, R. & G. Staples (1995). Convolvulaceae, pp. 271–325. In: Wu, Z., P.H. Raven & D. Hong (eds.). Flora of China. Vol. 16. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, USA.

Hooker, J.D. (1875–1883). *The Flora of British India*, Vols. 1–4, pp. 658–663; pp. 458–459; p. 601; p. 187. L. Reeve & Co. Ltd., London.

India Biodiversity Portal (2018). India Biodiversity Portal. https://www.indiabiodiversity.org, accessed on 15 October 2018.

IUCN (2019). The IUCN Red List of Threatened Species. Version 2019 – 3. http://www.iucnredlist.org, accessed on 16 December 2019.

Jain, S.K. & R.R. Rao (1977). *Handbook of Field and Herbarium methods*. Today and Tomorrow's Printers and Publishers, New Delhi, 157pp.

Kanjilal, U.N., P.C. Kanjilal, A. Das, N.L. Bor & R.N. De (1934–1939). *Flora of Assam*, Vols. 1–3, pp. 298–302; p. 256; pp. 232–342. National Book Distributors, Dehra Dun, India.

Kew Herbarium Catalogue (2002). Kew Herbarium Catalogue: 2002 Kew Herbarium digital collection. http://www.apps.kew.org, accessed on 28 February 2019.

Quang, B.H, T.T.P. Anh & V.T. Chinh (2013). Study on the Section *Trifoliolata* DC. (*Jasminum* L. - Oleaceae Juss.) in Vietnam. *Journal of Biology* 35(4): 429–434.

Singh, N.P., A.S. Chauhan & M.S. Mondal (2000). *Flora of Manipur*. Vol. 1. (Ranunculaceae–Asteraceae). Botanical Survey of India, Kolkata, 555pp.

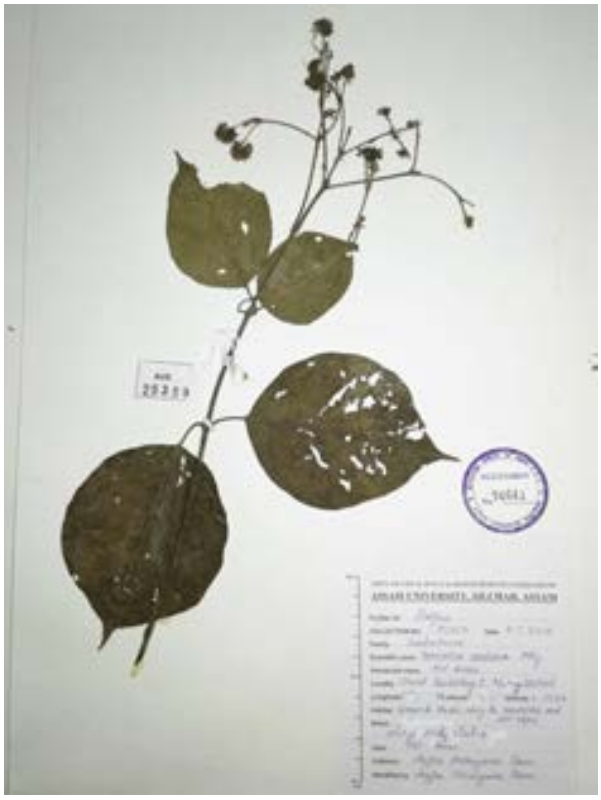

Image 6. *Combretum sundaicum* Miq. [#94641]

Image 7. *Argyreia wallichii* Choisy. [#94637]

Image 8. *Jasminum lanceolaria* Roxb. [#94638]

Image 9. *Ampelopsis rubifolia* (Wall.) Planch. [#94639]

Image 10. *Tetrastigma obovatum* (M.A. Lawson) Gagnep. [#94640] & [#94642]

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NOTE

Molecular characterization of stinkhorn fungus *Aseroë coccinea* Imazeki et Yoshimi ex Kasuya 2007 (Basidiomycota: Agaricomycetes: Phallales) from India

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The fungal family Phallaceae, commonly known as stinkhorn mushrooms, is a member of order Phallales in the division Basidiomycota. Although the *Dictionary of fungi* (Kirk et al. 2008) recognized 77 species under 21 genera, subsequent description of a new genus (Cabral et al. 2012), new species (Gogoi & Parkash 2015; Trierveiler-Pereira et al. 2017) and new distributional records (Gogoi & Parkash 2014; Kour et al. 2016) points to knowledge gap regarding the diversity and distribution of members within Phallaceae. One of the interesting genera of Phallaceae is the pantropical *Aseroë*, which is morphologically characterized as having a fruiting body consisting of pseudo-stipe that is partly covered at the top by a disc from the margin of which spring numerous, long, acute, fundamentally paired arms, which adopt a horizontal position at maturity; its gleba is located on the upper surface of the disc and adaxial faces of the arms (Dring 1980). While describing the species *A. coccinea*, Kasuya (2007) considered four valid species within the genus, namely, *A. arachnoidea*, *A. coccinea*, *A. floriformis* and *A. rubra*, however, recent phylogenetic studies (Cabral et al. 2012; Trierveiler-Pereira et al. 2014) suggested that *Aseroë* is not monophyletic and *A. arachnoidea* was transferred to *Lysurus* (Trierveiler-Pereira et al. 2014), while *A. floriformis* was transferred to *Abrachium* (Cabral et al. 2012). While there is no issue regarding the generic status of the name bearing type *Aseroë rubra*, generic status of *A. coccinea* has not been assessed using molecular methods.

In India, there are reports of *Lysurus arachnoideus* and *A. rubra* (Narasimhan 1932; Iyengar & Krishnamurthy 1954; Vasudeva 1962; Mohanan 2011a,b; Pradhan et al. 2012), however, there are no records of *A. coccinea*. In fact, to our knowledge, there are no reports of *A. coccinea* from anywhere outside its type locality in Japan. In the current communication, we provide the first report of *A. coccinea* from northern Western Ghats of India and provide its phylogenetic placement based on nuclear internal transcribed spacer region.

Six specimens of *A. coccinea* were observed at Khandobacha Mal (18.252ºN, 73.674ºE, 830m), at the base of Rajgad fort, Pune, India. Two specimens were collected in a clean bottle. A small piece of stipe from each specimen was preserved in absolute ethanol for

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Image 1. *Aseroë coccinea* from northern Western Ghats. (a–d) Basidiome of *Aseroë coccinea*: a & b—same individual from side and top view, respectively | e—cross section of arm showing a single chamber | f—basidiospores. © Vivek Bobade.

genetic study, while the specimens were dried for long term preservation. One of the collected specimens is deposited in the culture collection of Ajrekar Mycological Herbarium (AMH), National Fungal Culture Collection of India (NFCCI & FIS), Biodiversity and Palaeobiology Group, MACS-Agharkar Research Institute, Pune, India, under the accession number AMH 9967.

DNA was extracted from two specimens using QIAamp DNA Mini Kit following manufacturer's protocol. The nuclear gene encoding small-subunit ribosomal RNA (18S rRNA) was amplified using the primer pair A (5'-CCA ACC TGG TTG ATC CTG CCA GT-3') and B (5'-GAT CCT TCT GCA GGT TCA CCT AC-3') (Berger et al. 1998). The internal transcribed spacer (ITS) region in the nuclear ribosomal repeat unit was amplified using primer pair ITS1f (5'-CTT GGT CAT TTA GAG CGA AGT A-3') (Gardes & Bruns 1993) and ITS4 (5'-TCC TCC GCT TAT TGA TAT GC-3') (White et al. 1990), which included partial 18S, complete ITS1, complete 5.8S, complete ITS2 and partial 28S. Protocol for PCR amplification, PCR product purification and DNA sequencing follow Suranse et al. (2017) with the annealing temperature 55ºC for 18S and 50ºC for ITS. Sequences generated as a part of this study are deposited in GenBank under the accession numbers MK543504–MK543505 for 18S and MK541641–MK541642 for ITS.

Since limited genetic data were available for 18S gene, genetic analysis was performed only for ITS region.

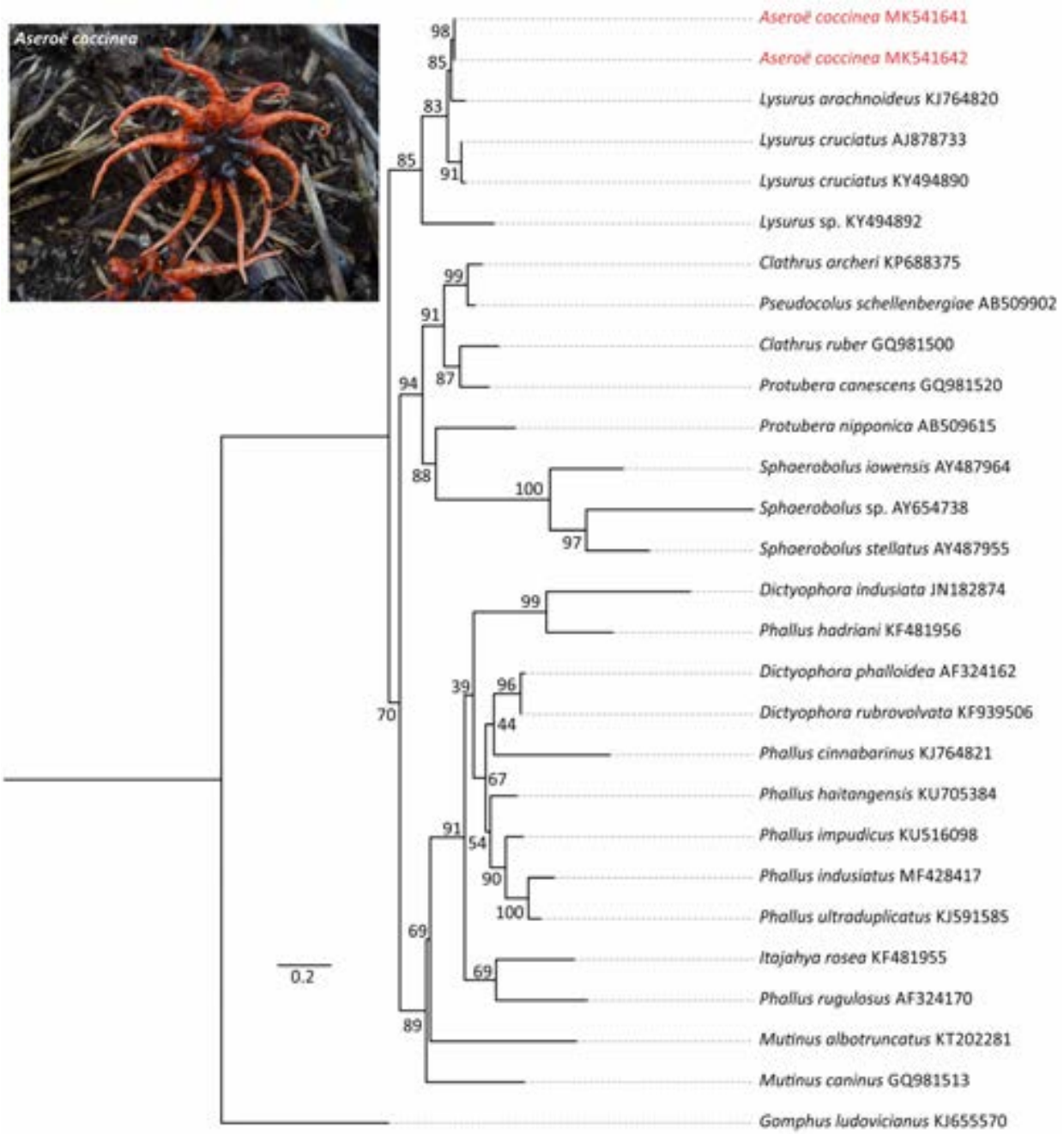

Figure 1. Maximum likelihood tree based on internal transcribed spacer region including 5.8S ribosomal RNA gene using the best nucleotide substitution model TNe+I+G4. *Gomphus ludovicianus* is used as an outgroup. Values along the nodes are percentage bootstrap based on 1000 replicates. GenBank accession numbers are provided after the species names.

Additional ITS sequences for Phallales were downloaded from NCBI database (https://www.ncbi.nlm.nih.gov/). *Gomphus ludovicianus* (Gomphales: Gomphaceae) was used as an outgroup following Trierveiler-Pereira et al. (2014). Sequences were aligned using MUSCLE (Edgar 2004) implemented in MEGA 7 (Kumar et al. 2016). Model for nucleotide substitution pattern was determined using ModelFinder (Kalyaanamoorthy et al. 2014) based on Bayesian Information Criterion (Schwarz 1978) and was used for constructing maximum likelihood tree in IQTree (Nguyen et al. 2015) with ultrafast bootstrap (Hoang et al. 2018) support for 1000 iterations. Phylogenetic tree was viewed and edited in FigTree (Rambaut 2009). Raw genetic p distance was calculated using MEGA 7 (Kumar et al. 2016).

Six fruiting bodies of *A. coccinea* were found

growing on donkey dung in dry deciduous forest floor at Khandobacha Mal. Basidiomes of four specimens are shown in Image 1a–d. Observed specimens showed following morphology. Basidiome terrestrial, gastrocarpic appearance, approximately 30–60 mm in height; gleba horizontally expanded, origin at the base of the arms, and at the top of the stipe covering the disc at the upper surface of receptacle, olivaceous green to dark green in color, mucoid, granular; receptacle white in color, cylindrical, spongy, hollow with single chamber, at the apex flattened to form a disc, about 10–12 mm in diameter; arms arise from the tip of receptacle, 25–50 mm in length, single arms arise from the margin of horizontal discoid portion, diameter at the base 5 mm in the middle 3mm and at the tip less than 1mm, single chambered (Image 1e), nonbifurcating, 9 (n = 1), 11 (n = 4) or 13 (n = 1) arms, it diameter at the base about 5mm, in the middle about 3mm, at the tip less than 1mm, red color on the dorsal surface, pale red to white ventrally, at maturity the arms are fully expanded; basidiospores hyaline (Image 1f), cylindrical or elongated in shape, mean spore dimensions were 4.4 (sd 0.3) × 1.9 (sd 0.2) µm , average spore quotient (length/width) of 2.4 (sd 0.2); spread gregarious as well as solitary; saprophytic, growing on donkey dung among the grasses close to the ground (epigeal).

Morphologically, the species closely resembles the original description of *A. coccinea* (see Kasuya 2007) except for the number of arms that varied from 9–13 in our specimens as appose to 7–9 arms reported in the original description. Further, the specimens we observed were slightly larger than the type of *A. coccinea*. The specimens in our collection differ from *A. rubra* in having nonbifurcating and single chambered arms versus bifurcating and several chambered arms in *A. rubra* (Kasuya 2007; Hemmes & Desjardin 2009). Further, the specimens in our collection differs from morphologically closely related species *Lysurus arachnoideus* in having dorsally reddish arms versus white arms in *L. arachnoideus* (Kasuya 2007; Hemmes & Desjardin 2009) and basidiospores larger and ellipsoid to cylindrical (Image 1f) 3.6–5.0 × 1.5–2.4 µm versus 2.5–3.5× 1.5 µm in *L. arachnoideus* (Kasuya 2007).

Our communication provides the first report of *A. coccinea* from northern Western Ghats of India and first report of this species under this nomen from outside its type locality in Japan. It is essential to note, however, that the earlier report of *L. arachnoideus* (as *Aseroë arachnoidea*) from Karnataka by Narasimhan (1932) needs a critical evaluation. Description of anomalous specimen of *L. arachnoideus* by Narasimhan (1932) with red colored arms has a close resemblance with the description of *A. coccinea* from our study. In fact, while describing the species *A. coccinea*, Kasuya (2007) pointed out that the description of Indian specimens provided by Narasimhan (1932) shares some characters with *A. coccinea*. We believe that the species collected by Narasimhan (1932) is same as the species in our collection, indicating that *A. coccinea* is distributed in both Maharashtra and Karnataka part of the Western Ghats. One notable difference among the specimens studied by Narasimhan (1932), type studied by Kasuya (2007) and our observation is the size of the fruiting bodies. Type studied by Kasuya (2007) is a small specimen as compared to the specimens we studied from northern Western Ghats, while the specimen dimensions provided by Narasimhan (1932) are very large. For instance, Kasuya (2007) reports the length of arm as 4 to 10 mm, we report it as 25–50 mm, while Narasimhan (1932) reports it as 38 to 40 mm. Because the number of specimens studied in all three studies are limited the variation in the size cannot be explained at the moment.

Genetically, *A. coccinea* from our study is sister taxon to *L. arachnoideus* (Figure 1). Nevertheless, the two species are separated by a raw genetic distance of 5.4%. This result is not very surprising, because even in the original description of *A. coccinea*, Kasuya (2007) pointed out close resemblance between the two species. The fact is, however, that *A. coccinea* is nested within the well supported *Lysurus* clade, suggests that the species needs to be transferred to the genus. In the current communication, we refrain from transferring *A. coccinea* to *Lysurus* because of two reasons, (1) there is need for detailed taxonomic study of the group, preferably including the material from the type locality, for delimiting the generic boundary for *Aseroë* by studying its type species *A. rubra* from throughout its distributional range and reassessment of *A. coccinea*, and (2) taxonomic sampling for the genetic analysis in our study is not adequate because of limited information available on 18S and ITS markers of family Phallaceae. Nevertheless, we make the data available for two genetic markers, 18S and ITS region, of specimens from our study, which can facilitate further comparative genetic studies on this group.

Our report of *A. coccinea*, along with its genetic information, suggests that there is a need for more exploratory surveys for understanding diversity, distribution and taxonomy of Phallales of India.

References

Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Goggin, R. Slocombe, M.A. Ragan, A.D. Hyatt, K.R. McDonald & H.B. Hines (1998). Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Science* 95: 9031–9036. https://doi.org/10.1073/pnas.95.15.9031

Cabral, T.S., P. Marinho, B.T. Goto & I.G. Baseia (2012). *Abrachium*, a new genus in the Clathraceae, and *Itajahya* reassessed. *Mycotaxon* 119: 419–429. https://doi.org/10.5248/119.419

Dring, D.M. (1980). Contributions towards a rational arrangement of the Clathraceae. *Kew Bulletin* 35: 1–96. https://doi.org/10.2307/4117008

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

Gardes, M. & T.D. Bruns (1993). ITS primers with enhanced specificity for basidiomycetes-application to the identification of mycorrhizae and rusts. *Molecular Ecology* 2: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Gogoi, G. & V. Parkash (2015). *Lysurus habungianus* sp. nov. (Phallaceae)-A new stinkhorn fungus from India. *Current Research in Environmental and Applied Mycology* 5: 248–255. https://doi.org/10.5943/cream/5/3/7

Gogoi, G. & V. Parkash (2014). Some new records of stinkhorns (Phallaceae) from Hollongapar Gibbon Wildlife Sanctuary, Assam, India. *Journal of Mycology* 490847: 1–8. http://dx.doi.org/10.1155/2014/490847

Hemmes, D.E. & D.E. Desjardin (2009). Stinkhorns of the Hawaiian Islands. *Fungi* 2: 8–10.

Hoang, D.T., O. Chernomor, A. von Haeseler, B.Q. Minh & L.S. Vinh (2018). UFBoot2: Improving the ultrafast bootstrap approximation. *Molecular Biology and Evolution* 35: 518–522. https://doi.org/10.1093/molbev/msx281

Iyengar, M.O.P. & V. Krishnamurthy (1954). A note on *Aseroe rubra* (La Bill) Fries var. *zeylanica* (Berk.) Ed. Fischer from South India. *Lloydia* 17: 257–262.

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

Kasuya, T. (2007). Validation of *Aseroë coccinea* (Phallales, Phallaceae). *Mycoscience* 48: 309–311. https://doi.org/10.1007/S10267-007-0370-8

Kirk, P.M., P.F. Cannon, D.W. Minter & J.A. Stalpers (2008). *Dictionary of the Fungi*. 10th ed. CABI, Wallingford, UK, 784pp.

Kour, H., R. Yangdol, S. Kumar & Y.P. Sharma (2016). Three species of *Phallus* (Basidiomycota: Agaricomycetes: Phallaceae) from Jammu & Kashmir, India. *Journal of Threatened Taxa* 8: 8403–8409. http://dx.doi.org/10.11609/jott.2173.8.1.8403-8409

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

Mohanan, C. (2011a). *Biodiversity of Terricolous and Lignicolous Macrofungi of the Western Ghats, Kerala*. Final Technical Report: F. No. 23/15/2006–RE, Kerala Forest Research Institute, Kerala, 389pp.

Mohanan, C. (2011b). *Macrofungi of Kerala*. Kerala Forest Research Institute, Peechi, Kerala, India, 670pp.

Narasimhan, M.J. (1932). The Phalloideae of Mysore. *Journal of Indian Botanical Society* 11: 248–254.

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

Pradhan, P., A.K. Dutta, S. Giri, N. Chakraborty, A. Roy & K. Acharya (2012). Phallales of West Bengal, India, I. Clathraceae: *Aseroe* and *Clathrus*. *Science and Culture* 78: 444–447.

Rambaut, A. (2009). FigTree, ver 1.4.3. Available online at: http://tree.bio.ed.ac.uk/software/figtree. Accessed on 1 January 2019.

Schwarz, G. (1978). Estimating the dimension of a model. *Annals of Statistics* 6: 461–464.

Sursane, V., N.S. Sawant, S. Paripatyadar, K. Krutha, M.S. Paingankar, A.D. Padhye, D.B. Bastawade & N. Dahanukar (2017). First molecular phylogeny of scorpions of the family Buthidae from India. *Mitochondrial DNA Part A* 28: 606–611. https://doi.org/10.3109/24701394.2016.1149830

Trierveiler-Pereira, L., R.M.B. da Silveira & K. Hosaka (2014). Multigene phylogeny of the Phallales (Phallomycetidae, Agaricomycetes) focusing on some previously unrepresented genera. *Mycologia* 106: 904–911. https://doi.org/10.3852/13-188

Trierveiler-Pereira, L., A.A. De Meijer, M.A. Reck, K. Hosaka & R.M.B. Da Silveira (2017). *Phallus aureolatus* (Phallaceae, Agaricomycetes), a new species from the Brazilian Atlantic Forest. *Phytotaxa* 327: 223–236. http://dx.doi.org/10.11646/phytotaxa.327.3.2

Vasudeva, R.S. (1962). *Fungi of India*. Supplement 1. Indian Council of Agricultural Research, New Delhi, 206pp.

White, T.J., T. Bruns, S. Lee & J. Taylor (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics, pp. 315–322. In: Innis, M.A., D.H. Gelfand, J.J. Sninsky & T.J. White (eds.). *PCR Protocols: A Guide to Methods and Applications*, Academic Press, New York, 482pp.

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