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Cover: *Euphaea pseudodispar* shot at Kalindi River, Thirunelly, Wayanad district, Kerala. © Muneer P.K.

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ARTICLE

Identification of confiscated pangolin for conservation purposes through molecular approach

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Abstract: Over the past decade, the pangolin has emerged as one of the most prominent illegally traded mammals, and high extraction rates of *Manis javanica* from Indonesia have become a world concern. With the rise of the illegal trade, tools for uncovering the origins of pangolins for law enforcement are needed. Use of genetic markers for species and population identification has become a versatile tool in law enforcement efforts related to illegal wildlife trade and the management of endangered species. This study aims to uncover the origin of confiscated pangolins via a molecular approach using COI mtDNA markers. Forty-eight samples came from confiscated pangolins in Jakarta, Surabaya, Jember, Pangkalan Bun, Medan, Lampung, Riau, and Palembang, as well as four samples from the wild population in Riau, Pangkalan Bun, and East Java. Grouping using phylogenetic trees showed two groups with a bootstrap value of 90% based on wild samples. The first group consists of Sumatra and Kalimantan populations, while the second group consists of a Javan population. From a total of 44 confiscated samples, 12 were identified as Javan, nine from Kalimantan, and 23 from Sumatra. Genetic distance value (d) among individuals was d= 0.012 ± 0.002, with haplotype diversity (Hd) 0.864 ± 0.0444. The analysis of molecular variance (AMOVA) shows a clear genetic difference among populations (75%) and within populations (25%). The results showed that animals confiscated in one location may come from several different populations. These results can be used to track the flow of the pangolin trade in Indonesia, and support conservation management for the release of confiscated animals.

Keywords: COI, confiscated, illegal wildlife trade, *Manis javanica*, Pangolin, population.

Indonesian Abstrak: Dalam dekade terakhir, trenggiling telah menjadi salah satu mamalia yang paling menonjol diperdagangkan, dan tingginya tingkat ekstraksi *Manis javanica* dari Indonesia telah menjadi perhatian dunia. Dengan maraknya perdagangan ilegal, diperlukan alat untuk mengungkap asal usul trenggiling untuk penegakan hukum. Penggunaan penanda genetik untuk identifikasi spesies dan populasi telah menjadi teknik yang umum dalam upaya penegakan hukum terkait perdagangan satwa liar ilegal dan pengelolaan spesies yang terancam punah. Penelitian ini bertujuan untuk mengungkap asal usul trenggiling sitaan melalui pendekatan molekuler menggunakan penanda mtDNA COI. Empat puluh delapan sampel berasal dari trenggiling sitaan di Jakarta, Surabaya, Jember, Pangkalan Bun, Medan, Lampung, Riau, dan Palembang, serta empat sampel dari populasi liar di Riau, Pangkalan Bun, dan Jawa Timur. Pengelompokan menggunakan pohon filogenetik menunjukkan dua kelompok dengan nilai bootstrap 90% berdasarkan sampel liar. Kelompok pertama terdiri dari populasi Sumatera dan Kalimantan, sedangkan kelompok kedua terdiri dari populasi Jawa. Dari total 44 sampel yang disita, 12 di antaranya berasal dari Jawa, sembilan dari Kalimantan, dan 23 dari Sumatera. Nilai jarak genetik (d) antar individu adalah d= 0,012 ± 0,002, dengan keragaman haplotipe (Hd) 0,864 ± 0,0444. Analisis varians molekuler (AMOVA) menunjukkan perbedaan genetik yang jelas antara populasi (75%) dan dalam populasi (25%). Hasil penelitian menunjukkan bahwa satwa yang disita di satu lokasi dapat berasal dari beberapa populasi yang berbeda. Hasil ini dapat digunakan untuk melacak arus perdagangan trenggiling di Indonesia, dan mendukung manajemen konservasi untuk pelepasan hewan sitaan.

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INTRODUCTION

There are eight extant pangolin species (*Manis* sp.) distributed in Asia and Africa. Four species are known In Asia: *Manis pendactyla* in China, *M. crassicaudata* in India, and two in southeastern Asia, the Sunda pangolin (*M. javanica*) also occurring in Indonesia apart from other southeastern countries, and *M. culionensis* in the Philippines (Feiler 1998; Gaubert & Antunes 2005; Gaubert et al. 2018; Kumar et al. 2018). In Indonesia, the Sunda Pangolin is one of several species listed as protected under the Minister of Environment and Forestry Regulation Number P.106 of 2018 concerning protected plant and animal. Under the International Union for Conservation of Nature (IUCN), this species is 'Critically Endangered', while CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) list Sunda Pangolin in Appendix I since 2016. In Indonesia, pangolins can be found in Sumatra, Java, Kalimantan, and other surrounding islands. Over the past decade, pangolins have emerged as one of the world's highest illegally traded mammal species surpassing other iconic species such as tigers, rhinos, and elephants (Kumar et al. 2018a).

The illegal trade in the eastern Asian and southeastern Asian markets was primarily driven by the demand for pangolin scales that were allegedly used by Traditional Chinese Medicine (TCM) and as accessories/ornaments, for spiritual and ritualistic purposes (Boakye et al. 2004; Challender 2011; Mahmood et al. 2012; Kumar et al. 2018 Xing et al. 2020). Scales of pangolins are the most valuable part, followed by meat (Li & Wang 1999; Pantel & Chin 2009; Challender 2011). The decline of the pangolin population in mainland Indo-China region due to excessive utilization caused traders to expand the range of pangolin search to all types in southeastern Asia, such as Indonesia, Malaysia, and India, as well as Africa. Factors responsible for pangolin population vulnerability are a low reproduction rate, predation, habitat loss, and poaching.

The level of poaching and illegal trade of pangolin in Indonesia is in stark contrast to the biological data, information, and studies on pangolins. Until now, the population, reproduction, most of the biological information of this species in nature are unknown. In contrast, the rapid decline in the population will undoubtedly continue every year, mainly due to hunting and habitat loss. Pangolins are particularly vulnerable to over exploitation because they are easy to hunt and have a slow reproductive rate (Yang et al. 2007; Challender 2011). Large-scale commercial harvesting and international trade have been going on since the early 20th century. Dammerman (1929) in Vincent (2015) reported the export of several tonnes of Sunda Pangolin scales from Indonesia on the island of Java to China in the period 1925–1929 involving at least 4,000–10,000 pangolins per year, even though the species is legally protected. Likewise, for the period 1958–1964, Harrisson & Loh (1965) in Vincent (2015) documented export licenses of more than 60,000 kg of pangolin scales which most likely came from Indonesian Borneo (Kalimantan) through Malaysia from Sarawak to Singapore and Hong Kong. Furthermore, data obtained from press and law enforcement authorities have shown that around 30,000 pangolins were caught in southeastern Asia between 2000 and 2007 (Chin & Pantel 2009 in Mahmood et al. 2012), indicating that *M. javanica* was mainly from Indonesia. The high hunting rate for Sunda Pangolins can be seen from the description of the results of confiscations from 2012 to 2015, where there were 45 confiscations: 12 in 2012, 10 in 2013, 17 in 2014, and seven in 2015. Sumatra is the location where most seizures occurred, with 21 confiscations totaling 4,046 individuals; Java had 14 confiscations with 6,736 individuals, and Kalimantan region seven with 793 pangolins destined for China (Vincent 2015). Data from tirto.id states that between 1999 and 2017, at least 192,567 pangolins were involved in illegal trade. Moreover, it estimated that the actual number is much higher due to many confiscation data not adequately recorded.

One of the main problems for law enforcement in the illegal wildlife trade of pangolins is the lack of information regarding the origin of confiscated pangolins (national and transboundary), since they can only be visually identified as Sunda Pangolin. This data is crucial for surveillance and conservation management to protect this species from extinction, e.g., choosing the right location to release confiscated animals. A DNA-based approach to species and population identification may prove to be a powerful tool for wildlife law enforcement agencies (Ogden et al. 2009; Zhang et al. 2015; Rajpoot et al. 2016). Genetic profiling of Indonesian Pangolin using mitochondria (mtDNA) reveals the genetic structure of the Sunda Pangolin population based on cytochrome b gene and control region (D-loop) (Kumar et al. 2018a; Wirdateti & Semiadi 2013, 2017). Nevertheless, this study is only conducted on a small part of the mtDNA gene, while mtDNA using a single marker is prone to bias (Ballard & Whitclok 2004). Recently, a whole-genome sequence of Sunda Pangolin originating from Malaysia provides a genome infrastructure for genetic research related to conservation and management (Cho

et al. 2016), providing broader insight into genome conservation to reveal possible illegal trade routes and mixing of pangolin lineages in southeastern Asia (Nash et al. 2017). In the present study, we conducted identification of confiscated Sunda pangolins using COI genes to provide information for their management and conservation.

MATERIALS AND METHODS

Sample Collection

A total of 48 samples were taken from confiscated (44) and wild pangolin (4) in several places (Java, Sumatra, and Kalimantan; Table 1). DNA materials were collected as tissue from meats, and scales, and were preserved in absolute ethanol. Wild samples are taken from scales of dead pangolins found in their natural habitat. Confiscated samples were collected in 2008 from Medan, from Kalimantan in 2013 (Pangkalan Bun), from Java in 2010 and 2014 (Jember, Jakarta, and Surabaya), from Sumatra in 2014 and 2018 (Lampung, Riau, and Palembang; Figure 1). Wild samples were acquired from Central Kalimantan, Riau, and East Java. Some of these samples (26 samples originating from 2013 and 2014 confiscation) had been analyzed using Cytochrome b (Wirdateti et al. 2013).

DNA Amplification

Total genome DNA was extracted using Qiagen Dneasy Blood and Tissue Kit Mini Stool (Qiagen) for tissue samples. For scale samples, and tissue with low yields, we extracted DNA using conventional phenol-chloroform (Kocher et al. 1989). This study used the COI gene mtDNA as a marker to determine the population origin of the confiscated pangolins by using a specific primer on Sunda Pangolin as long as 870 bp. The primer was designed as follows COI Treng F: TGGAAACTGACTAGTGCCCC; COI Treng R: GCTCCCATGGAGAGAACGTA. Primers were designed using a sequence template from COI Pangolin. The primers were designed using Primers3 (v.0.4.0) and Pick primers tools.

The amplification uses 30 µl polymerase chain reactions (PCR) containing 1 µl DNA template, 17 µl PCR mix reaction (FirstBase, Singapore), 2.5 µl primer F and R respectively, and distilled water (MQ) up to 30 µl. PCR reaction started with a 3-min denaturation at 95°C, followed by 35 cycles of denaturation at 94°C for 30 seconds, annealing at 56°C for 45 seconds and extension at 72°C for 30 seconds. The final incubation was at 72°C for 10 min.

Sequencing

PCR products were sequenced using the same forward and reverse primer as in amplification at FirstBase, Singapore using the Sanger method. PCR products were purified using the kit SureClean Plus (Bioline USA Inc.) according to the manufacturer's manual and sequenced using BigDye Terminator v3.1 Cycle Sequencing Kit DNA Analyzer (Applied Biosystems) following Vendor's protocol.

Remark: confiscated confiscated & wild wild

Figure 1. Sampling on Sumatra, Java, and Kalimantan 2008–2018, confiscated (n = 44), wild (n = 4). Maps of sample locality.

Table 1. List of samples used in this study.

	Catalog number	Year	Type	Sample location
1	MZBR. T01 (1352)	2018	Confiscated	KSDA Lampung
2	MZBR. T02 (1355)	2018	Confiscated	KSDA Lampung
3	MZBR. T03 (1353)	2018	Confiscated	KSDA Lampung
4	MZBR. T04 (1354)	2018	Confiscated	KSDA Lampung
5	MZBR. T05 (1359)	2018	Confiscated	KSDA Lampung
6	MZBR. T06 (1360)	2018	Confiscated	KSDA Lampung
7	MZBR. T07 (1361)	2018	Confiscated	KSDA Lampung
8	MZBR. T08 (1363)	2018	Confiscated	KSDA Lampung
9	MZBR. T09 (1356)	2018	Confiscated	KSDA Lampung
10	MZBR. T10 (1367)	2018	Confiscated	KSDA Lampung
11	MZBR. T11 (1322)	2018	Confiscated	KSDA Lampung
12	MZBR. T12 (1340)	2018	Confiscated	KSDA Lampung
13	MZBR. T13 (1421)	2018	Confiscated	Palembang Market
14	MZBR. T14 (1334)	2018	Confiscated	KSDA Lampung
15	MZBR.1038	2012	Confiscated	KSDA Bogor 1
16	MZBR. T15 (1341)	2018	Confiscated	KSDA Lampung
17	MZBR. T16 (1418)	2018	Confiscated	Palembang Market
18	MZBR.17 (1420)	2018	Confiscated	Palembang Market
19	MZBR.18 (1416)	2018	Confiscated	Palembang Market
20	MZBR.19 (1422)	2018	Confiscated	Palembang Market
21	MZBR.1034	2012	Confiscated	KSDA Bogor 1
22	MZBR.20 (1423)	2018	Wild	Zamrud National Park
23	MZBR.1036	2012	Confiscated	KSDA Bogor 1
24	MZBR.21 (1424)	2018	Wild	Zamrud National Park
25	MZBR.22 (1417)	2018	Confiscated	Palembang Market
26	MZBR.1040	2012	Confiscated	KSDA Bogor 1
27	MZBR.1165	2013	Confiscated	Pangkalanbun, Central Kalimantan
28	MZBR.0270	2008	Confiscated	Sukabumi, West Java
29	MZBR.1180	2014	Confiscated	Jember, East Java
30	MZBR.0273	2008	Confiscated	Medan, North Sumatra
31	MZBR.1181	2014	Confiscated	Jember, East Java
32	MZBR.1030	2012	Confiscated	Tegal Alur, Jakarta
33	MZBR.0272	2008	Confiscated	Medan, North Sumatra
34	MZBR.1182	2014	Confiscated	Jember, East Java
35	MZBR.1183	2014	Confiscated	Jember, East Java
36	MZBR.1179	2014	Wild	Jember, East Java wild
37	MZBR.0276	2008	Confiscated	Medan, North Sumatra
38	MZBR.1166	2013	Confiscated	Pangkalanbun, Central Kalimantan
39	MZBR.1057	2012	Confiscated	Tanggamus, Lampung
40	MZBR.1069	2012	Confiscated	Surabaya, East Java
41	MZBR.1070	2012	Confiscated	Surabaya, East Java
42	MZBR.1071	2012	Confiscated	Surabaya, East Java
43	MZBR.1072	2012	Confiscated	Surabaya, East Java
44	MZBR.1157	2013	Confiscated	Pangkalanbun, Central Kalimantan
45	MZBR.1163	2013	wild	Pangkalanbun, Central Kalimantan
46	MZBR.1164	2013	Confiscated	Pangkalanbun, Central Kalimantan
47	MZBR.0275	2008	Confiscated	Medan, North Sumatra
48	MZBR.1162	2013	Confiscated	Pangkalan Bun, Central Kalimantan

Data Analysis

All nucleotide sequence results were stored in a database using BioEdit software. The complement sequence between the forward primer and the reverse was edited with Chromas Pro software. All sequences were compared with the NCBI Genbank BLAST Database (www.ncbi.nlm.nih.gov/BLAST). DNA alignment was done using Clustal X (Thompson et al. 1997), and data analysis was conducted using MEGA 6.0 software (Tamura et al. 2013) and DNaSP ver. 5.0 (Librado & Rozas 2009). The MEGA 6.0 calculates the genetic distance and site variations among 48 samples, and the phylogenetic trees were used to determine each confiscated pangolins' position based on the wild samples data. The analysis of DNA polymorphism includes the calculation of haplotype (h), haplotype diversity (Hd), and diversity of the nucleotides (π) using the DNaSP ver 5.0 software. Identification of Sunda pangolin was conducted using comparisons of Asian pangolin species, *M. pendactyla* (China), *M. crassicaudata* (India), and *M. culionensis* (Philippines) in GeneBank NCBI (NCBI Reference Sequence: NC_016008.1; NC_036434.1; and NC_036433.1, respectively). The phylogenetic tree formed was constructed using ML (Maximum Likehood) methods with bootstrap precision of 5,000.

For the selection of the best-fit model of nucleotide substitution using Bayesian inference (BAY) was conducted with the software IQ-TREE 1.6.12 (Nguyen L et al. 2015). The best-fitting of nucleotide substitution model for gene was determined with jModelTest v.2.1.6 (Kalyaanamoorth et al. 2017) selected by the Bayesian Information Criterion (BIC). The nucleotide frequencies for COI: A = 0.2509, C = 0.2915, G = 0.185, T = 0.2726; proportion of invariable sites I = 0.7542. The result was shown in FigTree v1.4.4 (Rambaut 2018). Bootstrap percentages (BP) were computed using 5,000 replicates.

The analysis of molecular variance (AMOVA) (Excoffier et al. 1992) was conducted to investigate the hierarchical structure of mitochondrial marker variation to test the significance of the three pangolin populations using Arlequin v.3.5. 2.2 (Exocoffier & Lisher 2010). The significance of this structure was tested with 20,000 random permutations to test the significance of the three pangolin populations (Weir & Cockerham 1984). AMOVA was performed by grouping samples according to their geographical location according to our result from the previous analysis (MEGA). We calculated genetic differentiation among pangolin populations as pairwise fixation indices (Fst) in Arlequin. We used the pairwise FST values distances as the input data and 200 permutations were performed to determine the level of significance.

RESULTS

A. Genetic Variations

The COI fragment from all samples was 866 bp long obtained using COI primer Treg F and COI Treg R designed from a sequence available on the GenBank NCBI. Only four samples had known origins: the wild samples obtained from Central Kalimantan (Pangkalan Bun), East Java (Jember), and Sumatra (Riau), while the other 44 samples came from the confiscated, market, and private collection with unknown origin. The use of wild samples is essential as a comparison to provide information of the unknown sample's origin. Nucleotide blast in GeneBank NCBI revealed similarities (homology) sequence of 98.75 % to 99.75% for all samples with Sunda Pangolin (*M. javanica*). Furthermore, the genetic variation analysis of several parameters for the identification of confiscated samples can be seen in Tables 2 and 3.

The results of polymorphic sites based on variations in nucleotide sites (V), singleton base (difference of one base) (S), informative sites (P), and genetic distance (d) show differences from each population of Sumatra, Java, and Kalimantan (Table 2, Table 3). Overall sequence alignment along 866 nucleotides from 48 samples contained of 54 variation sites (V), 16 singleton variation sites (S), and 38 informative sites (P). Genetic distance between individuals d = 0.012 ± 0.002 (1.2% ± 0.2%), which is formed from base mutations or site variations in the 866 bp nucleotide sequence. The use of Cyt b on *M. javanica* (Sunda Pangolin) showed higher variations of 83 site variations, 20 singletone variation sites (S), and 226 conserved sites with a sequence length of 331 bp nucleotide. (Kumar et al. 2018a). Results of analysis of 20 sequences along 373 nt Cyt-b mtDNA showed 32 site variations, 21 sites informative, and 11 singleton sites from confiscated samples (Wirdateti et al. 2013). While the identification of confiscated pangolin species in Africa using the COI gene showed, the genetic distance (d) was from 0.001 to 0.055 (0.1% to 5%) among all species with *M. javanica* and *P. tricuspis* (Mwale et al. 2017).

DNA polymorphism analysis based on site variations showed 21 haplotypes (h) from the entire study sample with haplotype diversity Hd = 0.864 ± 0.0444. Nucleotide diversity (Pi) was Π = 0.01138 ± 0.00140, with the average nucleotide difference between individuals (k) = 9,801. This value gives the genetic distance between confiscated pangolin individuals of about 1.1%, indicating pangolins are in the same species but different populations.

To strengthen the quality of this study, we calculated the analysis data using AMOVA and Statistic test (Fst) to

Table 2. Genetic variation using mtDNA COI markers in 48 pangolin samples.

Parameter	Total samples (Confiscated, Wild)	Java	Sumatra	Kalimantan
	n = 48	N = 13	n = 25	n = 10
Polymorphic sites				
Variable (polymorphic) sites Singleton variable sites Parsimony informative sites Genetic distance (d)	54 16 38 d = 0.012 ± 0.002	23 8 15 0.006± 0.001	14 9 5 0.002 ± 0.001	7 7 - 0.003 ± 0.001
DNA Polymorphism				
Haplotype (h): Haplotype diversity Hd Variance of Hd Nucleotide diversity, Pi: Average of nucleotide differences, k	h = 21 Hd = 0.864 ± 0.0444 V = 0.00195 Π = 0.01138 ± 0.00140 K = 9.801	9 0.00812± +/- 0.00458 11.647268	8 0.00256± +/- 0.00163 2.869185	4 0.00336± +/- 0.00217 3.301497

Table 3. Genetic distance between and within population.

	Population	Between population (d ± SE)			Within population (d ± SE)
		1	2	3	
1.	Java		0.005	0.004	0.006 ± 0.001
2.	Kalimantan	0.024		0.001	0.003 ± 0.001
3.	Sumatra	0.023	0.004		0.002 ± 0.001

get strengthening the quality of the study, we calculated the analysis data using AMOVA and the statistic test (Fst).

The results of AMOVA for total populations are shown in Table 3. The AMOVA for three populations shows a significant Fixation Index Fst value of 0.7525, indicating that at least the pair-wise populations reveals significant heterogeneity ($p < 0.05$) (Table 4).

We found significant genetic differentiation (pairwise Fst) among population and within population base on localities pangolin samples. And statistic test with distance method are show values of pairwise Fst calculated between populations are genetically distinct (Table 5). The values of Fst between Java and Sumatra (0.81201); Java and Kalimantan (0.75713); Kalimantan and Sumatra (0.33619). Comparisons of pairs of these populations are significant ($p = 0.000$).

B. Phylogeny

The phylogeny tree was formed using the MEGA 6.0 program (Kumar et al. 2015) with the ML (Maximum Likelihood) method with a bootstrap of 5000, as shown in Figure 2. As a comparison, other species from Asia, *M. pendactyla, M. culionensis*, and *M. crassicaudata* from the NCBI GeneBank sequence (NCBI Reference Sequence: NC_016008.1; NC_036434.1; and NC_0364333.1) were used. Phylogenetic analysis was used to identify confiscated pangolins based on samples of pangolins from the wild (Figure 2). From 44 confiscated pangolins and four wild samples, two main groups with a bootstrap value of 90% were formed, representing the Sumatra-Kalimantan population and the Java population.

The phylogeny tree shows that the first group being represented by, Sumatra and Kalimantan, came from four populations: Population 1 representing the Sumatra, and populations 2, 3, and 4 representing the Kalimantan. This grouping is based on the wild sample of each population. Wild sample from Zamrud National Park in Riau (MZBR 1423; 1424) representing Sumatra, and the Pangkalan Bun wild sample (MZBR 1163) representing the population of Kalimantan. This first group shows no clear differences between the populations of Sumatra and Kalimantan with a low genetic distance d = 0.004 ± 0.001 (Table 3), and low bootstrap value (30%). In contrast, the Javan population is clearly separated from the Sumatran and Kalimantan groups based on the wild samples from Jember (MZBR 1179), and it was showed high genetic distance from Sumatra and Java (d = 0.024 ± 0.005 with Kalimantan; d = 0.023 ± 0.004 with Sumatra) than the Sumatra and Kalimantan (Table 3). Based on this grouping, 44 confiscated samples were identified as 12 samples from the Java population, 23 samples from Sumatra, and nine samples estimated to be from Kalimantan. Each population variation site (polymorphic sites) can be seen in Table 2. The population of Java has a fairly high diversity compared to Sumatra and Kalimantan. As many as 23 sites varied (different nucleotides) from 13 samples in the Java population; in the Sumatran population, from 25 samples, only 14 sites were varied, while in the Kalimantan population from 10 samples, only seven site variations were found. The result indicates that populations with high nucleotide

Table 4. Analysis of molecular variance (AMOVA) based on sequences of cytochrome c oxidase subunit I (COI) of pangolin populations from Java, Sumatra, and Kalimantan.

Source of variation	Sum of squares	d.f.	Variance components	Percentage of variation	Fixation index (FST)
Among populations	2	166.210	5.53432 Va	75.25	0.75254* (p <0.05)
Within populations	45	81.894	1.81986 Vb	24.75	
Total	47	248.104	7.35418		

Table 5. Pairwise Fst calculated among pairs of pangolin population from Java, Sumatra, and Kalimantan based on sequences of cytochrome c oxidase subunit I (COI).

	1	2	3
1. JAVA	0.00000		
2. SUMATRA	0.81201	0.00000	
3. KALIMANTAN	0.75713	0.33619	0.00000

differences (site variations) in the sequence range provides high haplotype diversity on the confiscated pangolins population being tested in this study. The analysis results show that the genetic diversity in the Java population is quite high, namely nine haplotypes from 13 individuals. In comparison, the Sumatran population has eight haplotypes from 25 individuals, and Kalimantan has four haplotypes from 10 individuals or 21 haplotypes were formed in this confiscated sample (Figure 3). Besides high haplotypes, higher genetic diversity in the Javan population was also indicated by a higher genetic distance (d = 0.006 ± 0.001) than the Sumatran and Kalimantan populations (d = 0.003 ± 0.001; d = 0.002 ± 0.001). However, the haplotype diversity of the confiscated samples was still quite high (Hd = 0.864 ± 0.0444). Haplotypes can identify the origin of the population from confiscated samples based on on-site variations and groupings in the phylogeny tree. Individuals who share the same haplotype can provide information on the origin of confiscated pangolins, trade routes, assist in controlling and monitoring hunting sites, and policymaking on conservation directions.

The phylogeny using Bayesian (BAY):

These three populations are clustered into two distinct groups; the first group includes the Java population; the second one includes the other two populations. The second group seemingly came from either Sumatra population or Kalimantan (Borneo) population.

We included the posterior probabilities obtained by BAY in the tree obtained by ML and supported by bootstrap values (Figure 4). The TN+F+I (Tamura Nei, parameter F: Nucleotide Frequencies; I: Invariance Sites) model nucleotide substitution was selected as the best-fit model according to BIC (Bayesian Information Criterion scores and weights) of evolution for all gene fragments using JModeltest (Kalyaanamoorthy et al. 2017). The nucleotide frequencies for COI: A = 0.2509, C = 0.2915, G = 0.185, T = 0.2726; proportion of invariable sites I = 0.7542. This topology is almost similar to the NJ tree in the MEGA Program, where Kalimantan and Sumatra are in one group (Figure 5).

DISCUSSION

To see the position of the Sunda Pangolin species, other Asian pangolin species *M. pendactyla, M. culionensis* and *M. crassicaudata* were used as a comparison. The results showed that all samples used in this research belonged to the *M. javanica* species group. The results of the analysis showed that *M. javanica* was separated from *M. culionensis* (Philippines) by a genetic distance (d) of 3.6%, and from *M. crassicaudata* (India) by a genetic distance (d) of 14.4%, the separation between these two species had a high bootstrap value (93%). The genetic distance (d = 3.6%) between *M. javanica* and *M. culionensis* indicates that the two species are closely related. This result is also supported by the results of previous studies, which stated that the Palawan Pangolin *M. culionensis* (Philippines) is often considered a subspecies of *M. javanica*; the species was later raised to the species level based on morphological differences with *M. javanica* (Feiler 1998; dan Antunes 2005). Likewise, Gaudin et al. 2009 (Gaubert et al. 2018) stated that the thick-tailed pangolin, the Sunda and Palawan pangolins (*M. javanica* and *M. culionensis*) are sister species. The Chinese Pangolin species are located in population 4 or one clade with the Sunda Pangolin in the phylogenetic tree (Figure 2). Meanwhile, another sample in population 4 came from confiscated in Medan, Jakarta, Lampung, and Palembang. The other studies on both species using the same COI marker showed the

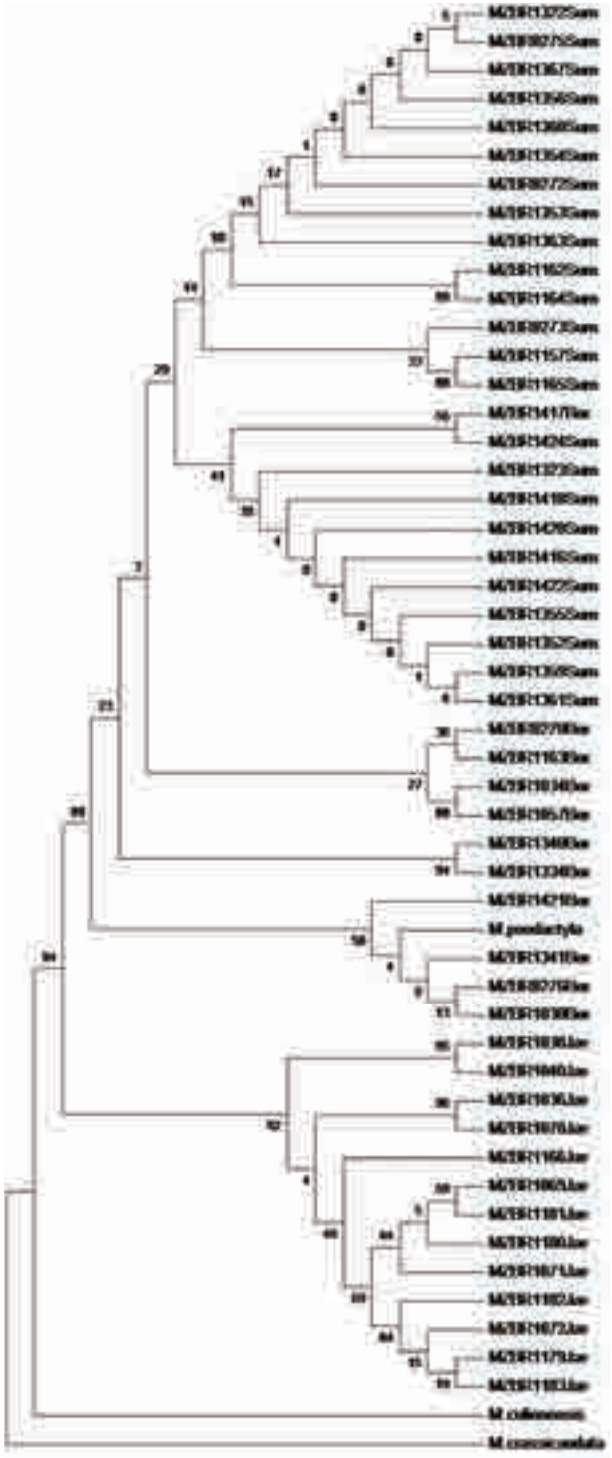

Figure 2. Phylogenetic tree of the 48 samples using the maximum likelihood (ML) method with the Kimura 2-parameter model. Sum—Sumatrae | Bor—Borneo (Kalimantan) | Jav—Java.

separation between *M. pentadactyla* and *M. javanica* in the phylogenetic tree (dan Antunes 2015; Hassanin et al. 2015). So, the presence of *M. pendactyla* in subgroup 4 (Kalimantan), possibly indicates that the sample from NCBI is not *M. pendactyla*, or the confiscated sample is of unknown origin.

The confiscated pangolins are identified as Sunda Pangolin with a genetic distance of d = 0.012 ± 0.002 (1.2%), and nucleotide diversity Π = 0.01138 ± 0.00140, which indicated the value of differences within one species. However, the use of the mtDNA COI gene in this species has not shown a clear separation between the Sumatran and Kalimantan populations, as shown in the phylogenetic tree, while the Javan population is clearly genetically separated (Figure 2). Based on the group formed, the location of the confiscation does not always indicate the origin place of the pangolin. It can be seen that several confiscated samples from central Kalimantan (Pangkalan Bun) were in the same group as Sumatra (1165, 1164, 1157, etc. Table 1.), while confiscated samples from Sumatra (Medan 270, Lampung 057) and Jakarta (1034, 1030) were in the same group as Kalimantan (wild). The same result can also be seen in the one Kalimantan confiscated sample (1166) clustered in the Javan group. Previous research using mtDNA (mitochondria) levels also showed that some samples from Medan, Kalimantan were clustered with the Javan population, then, confiscated samples from Sumatra and Java were clustered in the Kalimantan population (Nash et al. 2017). The grouping of each individual also gave the same results as the haplotype phylogeny, which gave a clear difference in the Java population, with nine haplotypes from 13 individuals with a bootstrap value of 99% (Figure 3, Table 2). Zhang et al. (2015) revealed that the analysis of confiscated scales using multiple levels of mitochondrial DNA also gave an unclear separation in the population of *M. javanica* species. The results above can illustrate that the illegal trade of pangolin in Indonesia is run through several routes, namely Sumatra, Java, and Kalimantan.

AMOVA analysis with genetic structure testing showed significant genetic differentiation (pairwise Fst) among pangolin populations. Although the phylogenetic tree shows several genealogical branches or geographic clusters, the results of cluster analysis, sequence statistics, and AMOVA indicate a significant division between these three populations. The cluster analysis suggests that these three populations can be clustered into two groups, one includes Java populations, and the second population includes Kalimantan and Sumatra. Fst values between the Java population and Sumatra, between the Java and Kalimantan populations, and between the Sumatra and Kalimantan populations show significant genetic differences (Table 4), indicating that at least two populations exist of pangolins in

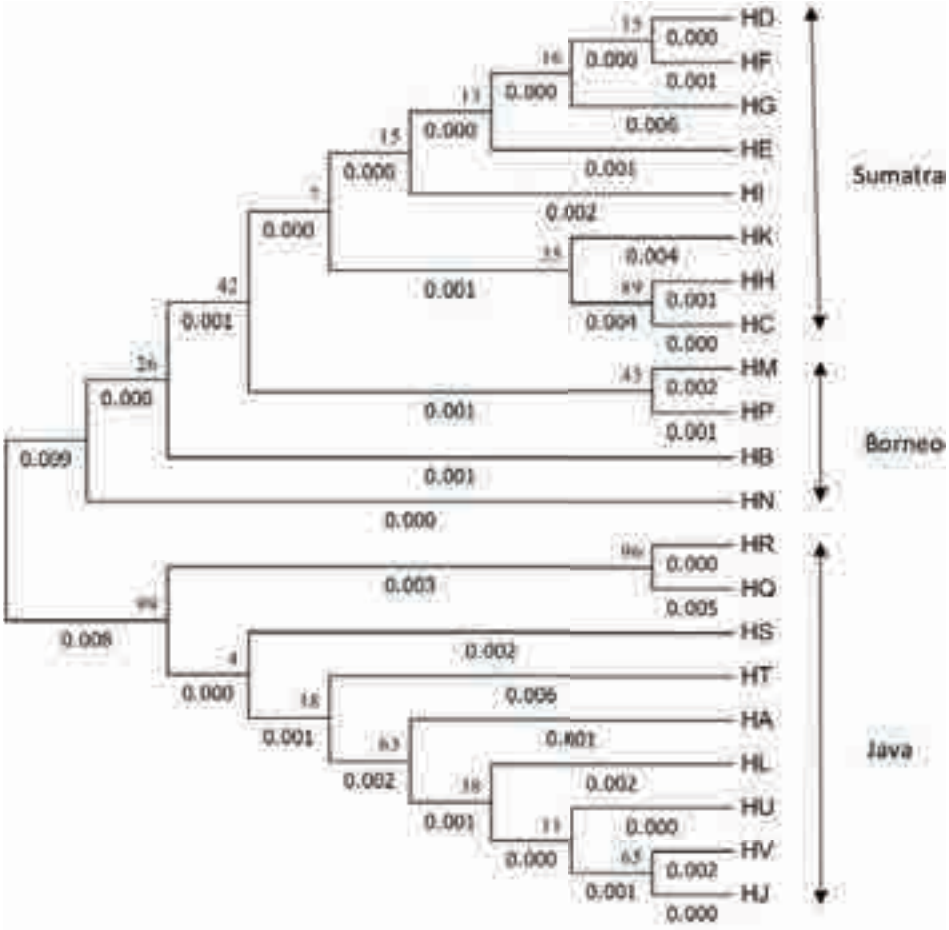

Figure 3. Reconstruction of 21 haplotypes spread using the maximum likelihood method with the Kimura 2-parameter model.

Indonesia. The AMOVA results show that among the population percentage of variance is 75.25%, and within a population is 24.75%, and the Fixation index (Fst) value is 0.7525 which indicates a significance ($p< 0.005$) (Table 4). A considerable Fst value indicates a genetic structure with a high degree of variation between populations, and each population is geographically separated where the allele frequencies are different. While within the population shows a small diversity value in the genetic structure, the possibility of mating or breeding is high among the population due to the low effective population size (Ne). If Fst is small, it means that allele frequencies in each population are the same; if it is large, the allele frequencies are different (Hosinger & Weir 2019).

The sample size that is not large enough or irregular or small will affect the genetic structure. The FSt statistic test showed significant results both between populations and within populations. Based on the comparison of pairs of population sample test, the Java and Sumatra populations gave a higher value (Fst = 0.812, $p <0.001$) than Java and Kalimantan (Fst = 0.757, $p <0.001$), and the lowest values were Sumatra and Kalimantan (Fst = 0.336, $p <0.001$) (Table 5). The FSt values above indicate a robust genetic structure for the Javan population, with high differentiation with Sumatra and Kalimantan. The amount of genetic differentiation among populations has a predictable relationship with the rate of evolutionary processes (migration, mutation, and drift). Large populations with a lot of migration tend to show little differentiation, whereas small populations with little migration tend to be highly differentiated (Wright 1931). The results of other studies also showed that the intraspecific p-distance in *M. javanica* and *P. tricupis* was higher (COI: 0.037 to 0.030) than African pangolins, which averaged between 0.001–0.055. It has a higher maximum intraspecific divergence indicating a geographic sub-structure (Mwale et al. 2016).

Like the previous analysis, the results of the statistical distance test through Alerquin, showed that the populations of Sumatra and Kalimantan were closer and also shown in the BI phylogram tree. Bootstrapping does not support the separation of the two populations,

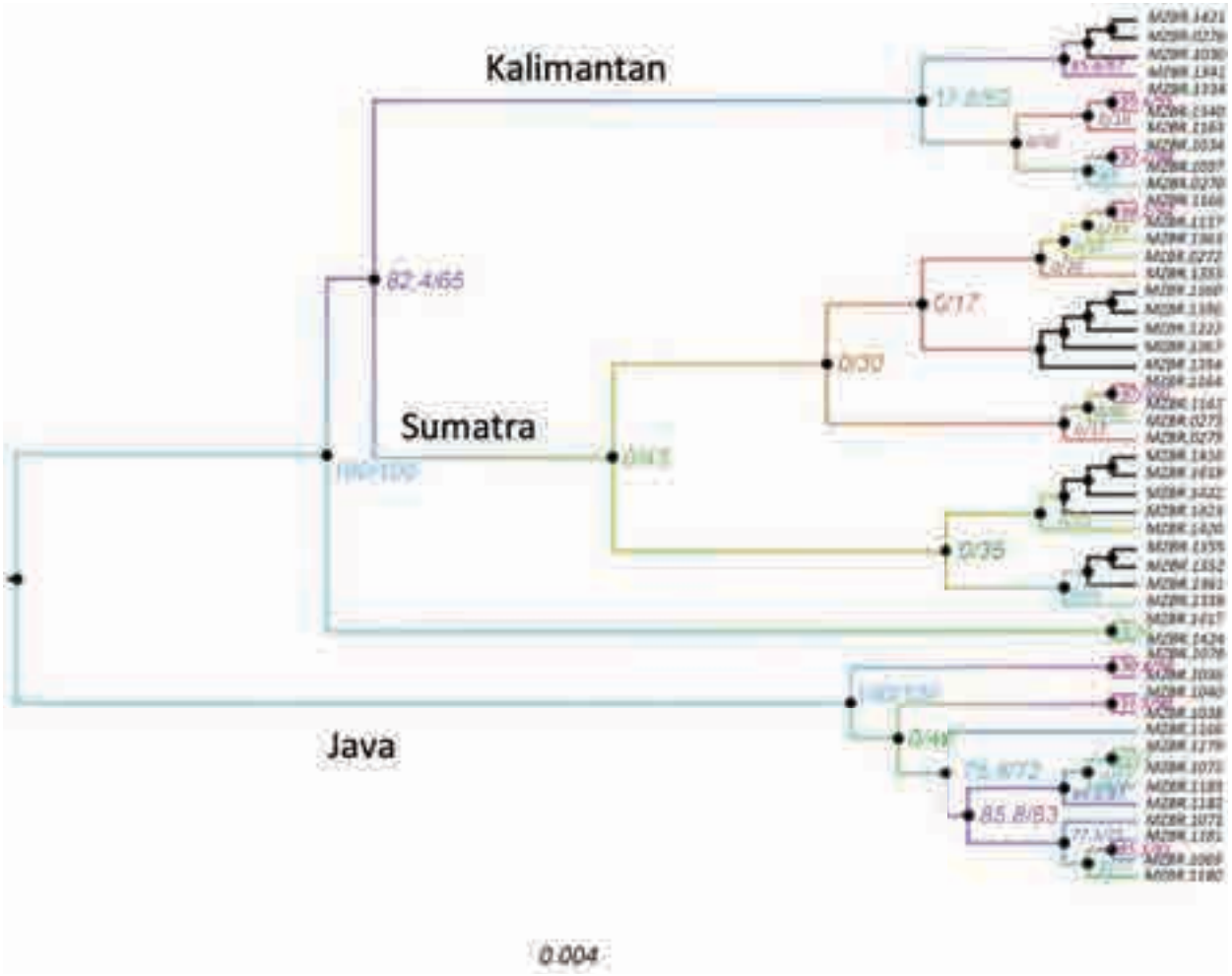

Figure 4. Maximum likelihood phylogram of three population of the species pangolin based on a concatenated sequence dataset of 866 bps of cytochrome c oxidase subunit I (COI). The numbers near the nodes represent the bootstrap support values from the maximum likelihood analysis and the posterior probabilities from the Bayesian inference.

namely node 82, following the Kalimantan population to be a sub-population, and this result is also shown from different haplotypes or no shared or nested haplotypes. In contrast, the genetic structure of the Javan population shows that the population is separated from the other two populations through Bayesian analysis with nodes 100 bootstrap, AMOVA and Fst statistical tests, with high distance values. The sample size that is not large enough also affects gene flow (Nm) in genetic structure (not shown), these results indicate a significant difference in the Java population (7,025; p <0.001) than in Sumatra (2,220, p <0.001) and Kalimantan (2,911. P <0.001). Test Differentiation Based on Haplotype Frequencies (Raymond & Rousset 1995) was significant between populations (p <0.05). The strong and significant genetic structure indicates substantial limitations on genetic and demographic connectivity (Hedgecock et al. 2007) among pangolin populations in Indonesia.

The Bayesian inference phylogenetic analysis results can be seen from the phylogram (Figure 4) using the IQ Tree program. The value at each branch point node is the result of the bootstrap support value in supporting topological credibility. Some results of bootstrap on several nodes/branch points have unsupported values with indistinguishable branches (polytomy) so that the position of external nodes or individuals may be incorrect. The Bayesian Inference (BI) phylogenetic results are not much different from the previous analysis, namely MEGA in terms of population divergence on valid bootstrap support (Hoang et al. 2017). The Java population still represents a separate group from Sumatra and Kalimantan with valid bootstrap support of 100 and the position of the Kalimantan population from Sumatra. However, the sample numbers MZBR 1417 and 1424 were separated from Sumatra and Kalimantan with a bootstrap of 100,

while the Kalimantan population was separated from Sumatra by a bootstrap of 82. The bootstrap node value of 82 did not support the phylogenetic tree in BI. A phylogenetic tree has supporting nodes with a bootstrap value of 95 for Bayesian values (Huelsenback & Hilis 1993). The branching or divergence of each individual in the population seems to show better resolution and description, although a very valid bootstrap value has not supported it for several nodes. Although it doesn't produce a valid bootstrap support value, the topology with a better resolution may be due to the Effective population size (Ne), which is analyzed heuristically to minimize polytomy. The advantages of Bayesian Inference (BI) resolution over MEGA can be caused by complex parameters in BI, the use of the MCMC (Monte Carlo Markov Chain) numerical algorithm, and prior and posterior distributions.

The Java population represents a monophyletic group with the same common ancestor and lineages and forms a natural group with a valid bootstrap support value of 100. Although the AMOVA data clearly shows the population structure, this result cannot be clearly explained by the separation of the Sumatran and Kalimantan populations.

The results above show that mitochondrial COI markers in this study have not provided sensitive information for each population or intra-species. But a DNA-based approach to species and population identification may prove to be a powerful tool for wildlife law enforcement agencies (Ogden et al. 2009; Zhang et al. 2015; Rajpoot et al. 2016). Several experts have used mitochondrial markers as validation for species identification, including cytochrome b (Cyt b), 12S ribosomal RNA (12S rRNA), 16S ribosomal RNA (16S rRNA), and Cytochrome oxidase subunit I (COI) genes which are routinely used for species identification in wildlife forensics (DeSalle et al. 1993; Hsieh et al. 2001; Guha & Kashyap 2006; Alacs et al.2009; Kumar et al. 2016, 2018). Likewise, for the identification of confiscated pangolins, the use of several mitochondrial COI, cyt b genes, and D-loop can distinguish several confiscated species, namely *P. tricuspis, P. tetradactyla, S. gigantea, S. temminckii, M. javanica*, and *M. pentadactyla* with high bootstrap values >70%, and the distance between all species was around 0.100–0.188 for COI and 0.10–0.20 for Cyt b, and 0.048–0.125 for the D-loop (Mwale et al. 2017). Thus, COI, Cyt b, and D-loop markers were more effectively used for identification or as inter-species markers.

Reports of high extraction rate of pangolins from Indonesia have become a concern to the world. However, counter measures and origin of these pangolins is not clearly understood. One of the main problems of pangolin confiscation in Indonesia is identifying the source and distribution of these confiscated pangolins; there is no data on the genetic distribution map of Sunda Pangolin in Indonesia. A distribution map will help the conservation of pangolin by allowing stakeholders to monitor the population and prevent its illegal trade. The latest report states that about 30% of the proportion of pangolin confiscated in Sumatra came from Kalimantan (Nash et al. 2017). Identification using one or two genes certainly cannot reveal the origin of the pangolin in the same species (intraspecies). This study is only conducted on a small fraction of mtDNA genes, mtDNA as a single marker, is prone to bias (Ballard & Whitclok 2004). With this argument, it is necessary to reveal the whole genome mtDNA and approximately 15,000 bp nucleotides as genetic markers for identification at the population level, especially for Indonesian pangolin. The data can be used as a baseline for mapping Indonesian pangolin genetic diversity to assist the conservation and handling of confiscated animals. The main problem with confiscated pangolin is that life confiscated animals will be released back into the wild as soon as possible; in many cases, these animals have been released back to the nearby confiscation area or region the pangolin while the pangolin itself might not come from the same population. This will undoubtedly affect each population's gene pool, as the results of this study show that there are pretty clear differences between Sumatra, Kalimantan, and Java populations. In this regard, the information provided by this research is essential for policymakers and stakeholders to better understand the management and conservation of pangolins.

CONCLUSION

The use of COI gene markers in this study has not been able to provide effective information on confiscated samples based on population origin, especially between Sumatran and Kalimantan, owing to low genetic distances. However, it can provide a clear separation between Sumatran and Kalimantan populations with Java populations based on phylogenetic trees and a higher genetic distance values, and the Javan population had a stronger genetic structure than the other two populations. Based on the distribution of haplotypes from confiscated samples can identify the origin of confiscated pangolin from Java, Sumatra, and Kalimantan populations. Even though genetic

distances and nucleotide differences between Sumatra and Kalimantan are very low, they can be distinguished from the haplotype type. This study's findings showed that the seized material came from several organized hunting locations from illegal traders in the range of pangolin distribution areas, as shown that samples from one confiscation location originated from more than one population. Further analysis is required with the addition of wild samples with known geographical origin as a comparison reference. Policymakers can apply this information to release live pangolin, manage and supervise wild pangolins, and carry out effective law enforcement.

REFERENCES

Alacs, E.A., A. Georges, N.N. FitzSimmons & J. Robertson (2009). DNA detective: a review of molecular approaches to wildlife forensics. *Forensic Science, Medicine, and Pathology* 6: 180–194. https://doi.org/10.1007/s12024-009-9131-7

Ballar, J.W.O. & M.C. Whitlock (2004). The incomplete natural history of mitochondria. *Molecular Ecology* 13(4): 729–744

Boakye, M., D. Pietersen, D.A. Kotze, D. Dalton & R. Jansen (2004). Ethno medicinal use of African pangolins by traditional medical practitioners in Sierra Leone. *Journal of Ethnobiology and Ethnomedicine* 10: 76.

Challender, D.W.S., S.R. Harrop & D.C. MacMillan (2015). Understanding markets to conserve trade-threatened species in CITES. *Biological Conservation* 187: 249–259. https://doi.org/10.1016/j.biocon.2015.04.015

Challender, D.W.S. (2011). Asian pangolins: increasing affluence driving hunting pressure. *TRAFFIC Bulletin* 23: 92–93.

Choo, S.W., M. Rayko, T.K. Tan, R. Hari, A. Komissarov, W.Y. Wee, A.A. Yurchenko, S. Kliver, G. Tamazian, A. Antunes, R.K. Wilson, WC. Warren, KP. Koepfli, P. Minx, K. Krasheninnikova, A. Kotze, DL. Dalton, E. Vermaak, I.C. Paterson, P. Dobrynin, F.T. Sitam, J.J. Rovie-Ryan, W.E. Johnson, A.M. Yusoff, S.J. Luo, K.V. Karuppannan, G. Fang, D. Zheng, M.B. Gerstein, L. Lipovich, S.J. O'Brien & G.J. Wong (2016). Pangolin genomes and the evolution of mammalian scales and immunity. *Genome Research* 26: 1312–1322.

DeSalle, R., A.L. Williams & M. George (1993). Isolation and characterization of animal mitochondrial DNA. *Methods in Enzymology* 224: 176–204.

Excoffier, L. & H.E. Lischer (2010). Arlequin suite ver 3.5: a new series of programs to perform population genetics analyses under Linux and windows. *Molecular Ecology Resources* 10: 564–567.

Feiler, A. (1998). Das Philippinen-Schuppentier, *Manis culionensis* ELERA, 1915, eine fast vergessene Art (Mammalia: Pholidota: Manidae). *Zoologische Abhandlungen (Staatliches Museum fürTierkunde Dresden)* 50: 161–164.

Gaubert, P. & A. Antunes (2015). What's behind these scales? Comments to "The complete mitochondrial genome of Temminck's ground pangolin (Smutsiatemminckii; Smuts, 1832) and phylogenetic position of the Pholidota (Weber, 1904). *Gene* 563: 06-108.

Gaubert, P., A. Antunes, H. Meng, L. Miao, S. Peigne, F. Justy, F Njiokou, S. Dufour, E. Danquah, J. Alahakoon, E. Verheyen, W.T. Stanley, S.J. O'Brien, W.E. Johnnson & S.J. Luo. (2018). The complete phylogeny of pangolin: Scaling up resources for the molecular tracing of the most trafficked mammals on earth. *Journal of Heredity* 109(4): 347–359

Gaubert, P. & A. Antunes (2005). Assessing the taxonomic status of the Palawan Pangolin *Manis culionensis* (Pholidota) using discrete morphological characters. *Journal of Mammalogy* 86: 1068–1074

Gerstein, L., S.J. Lipovich, O'Brien & G.J. Wong (2016). Pangolin genomes and the evolution of mammalian scales and immunity**.** *Genome Research* 26: 1312–1322.

Guha, S. & V.K. Kashyap (2006). Molecular identification of lizard by RAPD and FINS of mitochondrial 16S rRNA gene. *Legal Medicine* 8: 5–10.

Hassanin, A., J.P. Hugot & B.J. van Vuuren (2015). Comparison of mitochondrial genome sequences of pangolins (Mammalia, Pholidota). *Comptes Rendus Biologies* 338: 260–265.

Hedgecock, D., S. Launey, A. Pudovkin, Y. Naciri & S. Lapegue. (2007). Small effective number 667 of parents (nb) inferred for a naturally spawned cohort of juvenile European flat oysters Ostrea 668 edulis. *Marine Biology* 150: 1173–1182

Hoang, D.T., C. Olga, V.h. Arndt, Q.M. Bui & V. Le Sy (2018). UFBoot2: Improving the Ultrafast Bootstrap Approximation. *Molecular Biology and Evolution* 35: 518–522.

Hsieh, H.M., H.L. Chiang, L.C. Tsai, N.E. Huang, A. Linacre & L.C. Lee (2001). Cytochrome b gene for species identification of the conservation animals. *Forensic Science International* 122: 7–18.

Huelsenbeck, J.P. & D.M. Hillis (1993). Success of Phylogenetic methods in the four-taxon case. *Systematic Biology* 42(3): 247-264

Kalyaanamoorthy, S., B.Q. Minh, T.K.F Wong, V.H. Arndt & S.J. Lars (2017). ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* 14: 587–589.

Kocher, T.D., W.K. Thomas, A. Meyer, S.V. Edwards, S. Pääbo, F.X. Villablanca & A.C. Wilson (1989). Dynamics of mitochondrial DNA evolution in animals: Amplification and Sequencing with Conserved Primers. *Proceedings of the National Academy of Sciences USA* 86: 6196– 6200. https://doi.org/10.1073/pnas.86.16.6196

Kumar, V.P., A. Rajpoot, M. Thakur, M. Shukla, D. Kumar & S.P. Goyal (2016). Illegal trade of Indian pangolin (*Manis crassicaudata*): genetic study from scales based on mitochondrial genes. *Egyptian Journal of Forensic Sciences* 6: 524–534.

Kumar, V.P., A. Rajpoot, M. Shukla, P. Nigam & S.P. Goyal (2018a). Inferring the molecular affinity of Indian pangolin with extant Manidae species based on mitochondrial genes: a wildlife forensic perspective. *Mitochondrial DNA Part B: Resources* 3(2): 640–644.

Kumar, V.P., A. Rajpoot, A. Shrivastav, K. Kumar, P. Nigam, A. Madhanraj & S.P. Goyal (2018). Phylogenetic relationship and molecular dating of Indian Pangolins (*Manis crassicaudata*) with other extant Pangolins species based on complete cytochrome b mitochondrial gene. *Mitochondria Part A*. 29:1–6.

Li, H. & H. Wang (1999). Wildlife trade in Yunnan Province, China, at the border with Vietnam. *TRAFFIC Bulletin* 18: 21–30.

Librado, P.J.R. & J. Rozas (2009). DnaSP v5: A Software for Comprehensive Analysis of DNA Polymorphism Data. *Bioinformatics* 25(11): 1451-2.

Mahmood, T., R. Hussain, N. Irshad, F. Akrim & M.S. Nadeem (2012). Illegal mass killing of Indian pangolin (*Manis crassicaudata*) on Potohar Region, Pakistan. *Pakistan Journal of Zoology* 44: 1457–1461.

Mwale, M., D.L. Dalton, R. Jansen, M.D. Bruyn, D. Pietersen, P.S. Mokgokong & A. Kotze (2017). Forensic application of DNA barcoding for identification of illegally traded African pangolin scales. *Genome* 60: 272–284.

Nash, H.C., Wirdateti, G.W. Low, S.W. Choo, J.L. Chong, G. Semiadi, R. Hari, M.H. Sulaiman, S.T. Turvey, T.A. Evans & F.E. Rheind (2018). Conservation genomics reveals possible illegal trade routes and admixture across pangolin lineages in Southeast Asia. *Conservation Genetics* 19: 1083–1095

Nijman, V. (2015). Pangolin seizure data reported in the Indonesian media. *TRAFFIC Bulletin* 27(2): 43–46.

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.

Ogden, R., N. Dawnay & R. McEwing (2009). Wildlife DNA forensics - bridging the gap between conservation genetics and law

enforcement. *Endangered Species Research* 9: 179–195.

Pantel. S. & S.Y. Chin (2009) In: Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia. TRAFFIC Southeast Asia. Petaling Jaya, Selangor

Posada, D. & T.R. Buckley (2004). Model selection and model averaging in phylogenetics: advantages of Akaike information criterion and Bayesian approaches over likelihood ratio tests. *Systematic Biology* 53: 793–808.

Raymond, M and F. Rousset (1995). An Test Exact Test for Population differentiation. *Evolution* 49(6): 1280–1283.

Rajpoot, A., K.P. Kumar, A. Bahuguna & D. Kumar (2016). Forensically informative nucleotide sequencing (FINS) for the first time authentication of Indian Varanus species: implication in wildlife forensics and conservation. *Mitochondria DNA Part A.* 27: 1–9.

Tamura, K., G. Stecher, D. Peterson, A. Filipski & S. Kumar (2013). MEGA 6: Molecular Evolutionary Genetics Analysis Version 6.0. *Molecular Biology Evolution* 30(12): 2725–2729.

Thomson, J.D., T.J. Gibson, F. Plewniak, F. Jeanmougin & D.G. Higgins (1997). The Clustal_X Windows Interface: Flexible Strategies for Mutiple Sequence Alignment Aided by Quality Analysis. *Nucleid Acids Research* 25(24): 4876–4882.

Wei, B. & C. Cockerham (1984). Estimating F-statistics for the analysis of population structure. *Evolution* 38: 1358–1370. http://www.jstor.org/stable/2408641

Wirdateti, G.S. (2017). Genetic variation of confiscated pangolins of Sumatra, Java, and Kalimantan based on control region mitochondrial DNA. *Jurnal Veteriner* 18(2): 181–191

Wirdateti, G.S. & Yulianto (2013). IdentifikasiTrenggiling (*Manis javanica*) MenggunakanPenanda Cytochrome B Mitokondria DNA (Identification Of Pangolin (*Manis javanica* Desmarest, 1822) Using Cytochrome B mtDNA Marker). *Jurnal Veteriner* 14(4): 467–474.

Wright, S. (1931). Evolution in Mendelian populations. *Genetics* 16: 97–159.

Xing, S., T.C. Bonebrake, W. Cheng, M. Zhang, G. Ades, D. Shaw & Y. Zhou (2020). Chapter 14 - Meat and medicine: historic and contemporary use in Asia, pp. 227–239. In: Challender, DW.S., H.C. Nash & C. Waterman (eds.), Pangolins. Academic Press.

Yang, C.W., S. Chen, C. Chang, M.F. Lin, E. Block, R. Lorentsen, J.S.C. Chin & E.S. Dierenfeld (2007). History and husbandry of pangolins in captivity. *Zoo Biology* 26: 223–230.

Zhang, H., M.P. Miller, F. Yang, H.K. Chan, P. Gaubert, G. Ades & G.A. Fischer (2015). Molecular tracing of confiscated pangolin scales for conservation and illegal trade monitoring in Southeast Asia. *Global Ecology and Conservation* 4: 414–422.

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COMMUNICATION

The trade of Saiga Antelope horn for traditional medicine in Thailand

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Abstract: Demand for Saiga Antelope *Saiga tatarica* horn products in Southeast Asia, due to their perceived medicinal value, has drastically impacted the conservation of this species. At the same time, poor understanding of the dynamics of this trade in parts of Southeast Asia continues to impede regulation and conservation efforts. Here we examine the trade of Saiga horn products in Thailand through a rapid physical and online market survey, and via an analysis of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) trade data. We found an active local trade in Saiga horn products in Thailand, with both physical market surveys and online surveys showing predominantly two forms of Saiga horn products in the market, i.e., cooling water and horn shavings (mostly sold as pre-packaged boiling kits). These products are commercially marketed as staple household medicines. Greater scrutiny, monitoring and research is urgently needed to understand how the use of Saiga horn is being regulated in Thailand including the number of licensed traders, potential stockpiles and management of these. Traditional medicine outlets and online sales of commercial Saiga horn products also requires attention. As a non-native species, the Saiga Antelope is not protected in Thailand which makes it difficult for enforcement authorities to prevent illegal trade of Saiga horn products within the country. Thailand is currently revising its wildlife laws with the intention of addressing the protection of non-native and CITES-listed species. Considering the widespread use of Saiga horn in Thailand, we recommend that Saiga Antelope be included in the revised species protection lists to enable enforcement action against trade in illegally sourced Saiga horn products.

Keywords: CITES, illegal wildlife trade, species conservation, species protection, wildlife legislation, wildlife trade, wildlife trafficking.

Thai: ความต้องการของผลิตภัณฑ์ที่ทำมาจากกุย หรือ ไซกา (*Saiga tatarica*) ในทวีปเอเชียตะวันออกเฉียงใต้ ที่มีค่านิยมและความเชื่อว่ามีคุณค่าเป็นยารักษา ได้ส่งผลกระทบอย่างมากต่อประชากรและการอนุรักษ์สัตว์ชนิดนี้ ในเวลาเดียวกันข้อมูลที่มี ณ เวลาปัจจุบัน และความเข้าใจเกี่ยวกับลักษณะตลาดที่มีการขายผลิตภัณฑ์ในทวีปนี้ ก็ยังขาดแคลนเช่นกัน ทำให้ยังคงเป็นอุปสรรคต่อการจัดการและความพยายามในการอนุรักษ์
การวิจัยนี้ได้มีการตรวจสอบลักษณะของตลาดที่ขายผลิตภัณฑ์ที่ทำมาจากกุยในประเทศไทย (หรือที่เรียกว่า เหล่งเอี๊ยง) ผ่านการสำรวจตลาดทางกายภาพและออนไลน์อย่างรวบรัด และการวิเคราะห์ข้อมูลการค้าของทางไซเตส Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES) หรืออนุสัญญาว่าด้วยการค้าระหว่างประเทศ ซึ่งชนิดสัตว์ป่าและพืชป่าที่ใกล้จะสูญพันธุ์
ผลการวิจัยทั้งในตลาดทางกายภาพและออนไลน์ พบว่าในตลาดท้องถิ่นมีการขายผลิตภัณฑ์ที่ทำมาจากเขากุยเป็นจำนวนมาก ซึ่งสองรูปแบบหลักจะเป็นยาน้ำหรือเครื่องดื่มเพื่อลดความร้อนในร่างกาย และ เขากุยที่ขายเป็นชุดสมุนไพรพร้อมต้ม ซึ่งผลิตภัณฑ์เหล่านี้ถูกขายในเชิงพาณิชย์เป็นยาสามัญประจำบ้าน การคิดตาม ตรวจสอบ และหาข้อมูลเพิ่มเติมจึงเป็นสิ่งที่จำเป็นอย่างยิ่ง เพื่อที่จะเพื่อทำความเข้าใจตลาดการขายผลิตภัณฑ์เขากุยในไทย รวมถึง รวมถึงจำนวนผู้ค้าที่ได้รับอนุญาต คลังการเก็บสินค้า และการจัดการในร้านยา ร้านยาจีนแผนโบราณและร้านค้าออนไลน์ เนื่องจาก กุย ไม่ได้เป็นสัตว์ท้องถิ่นในประเทศไทย จึงไม่ได้อยู่ในการควบคุมได้พระราชบัญญัติสงวนและคุ้มครองสัตว์ป่า
จึงทำให้การมีความยากในการบังคับใช้กฎหมายหรือควบคุมการขายในประเทศ ดังนั้นในโอกาสที่มีการปรับปรุงพระราชบัญญัติสงวนและคุ้มครองสัตว์ป่าที่ เพื่อรวมสัตว์ที่ไม่ได้เป็นสัตว์ท้องถิ่นในไทยและสัตว์ไซเตส จึงควรรวม กุย ไซกา (*Saiga tatarica*) ด้วยเพื่อเป็นยกระดับการปกป้องและควบคุมการค้าขายผลิตภัณฑ์กุยที่มาจากแหล่งผิดกฎหมาย

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Author contributions: LG conceptualised the study, collected CITES trade data and searched for seizure data in English, analysed and interpreted the data set and wrote the manuscript; PS conducted the physical market and online surveys and searched for seizure data in local language (Thai); CRS conceptualised and obtained funding for the study and reviewed the manuscript.

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INTRODUCTION

The use of wildlife in traditional medicine is controversial as it has been associated with species extinction (Byard 2016; Van Uhm 2019; Wong 2019; D'Cruze et al. 2020). Wild plants and animals are crucial resources in a variety of traditional medicinal remedies that range from general health benefits such as the common cold to more severe conditions such as liver ailments and cancer (Costa-Neto 2005). It has been estimated that 80% of the world's population relies on wildlife based traditional medicinal remedies (Lee et al. 2014). This is particularly evident in developing countries, as it is often more affordable in comparison to modern medicine, and in remote areas, it can be the only form of medicine available (Sofowora 1996; Soewu et al. 2012; Alves & Rosa 2013). Commercialisation of the industry however has also made it a mainstream form of medicine in a globalised world which has triggered over exploitation of a vast and varied range of species and undermined the value and reputation of the industry/practice (Lee et al. 2014; Peng & Chen 2021). Traditional Chinese medicine (TCM), in particular, is a multibillion-dollar industry that is expanding through China's Belt and Road Initiative (Wong 2019; Hinsley et al. 2020). Species prized for the value of their parts regardless of their efficacy in TCM remedies are continually threatened by illegal hunting/poaching, to supply illegal and unsustainable trade (Alves et al. 2010, 2013; Nijman & Shepherd 2015; Nijman & Bergin 2017; Gomez & Shepherd 2019; Van Uhm 2019; Wong & Krishnasamy 2019).

Among the species drastically impacted by the TCM industry is the Saiga Antelope *Saiga tatarica* (Milner-Gulland et al. 2001; Mallon 2008; Doughty et al. 2019; Roberts et al. 2021). The global population of the species has declined by over 95% since the early 1990s largely due to hunting and exploitation for the TCM trade in Asia (Milner-Gulland et al. 2001; Mallon 2008; IUCN SSC Antelope Specialist Group 2018). Saiga populations have stabilised or increased in parts of their range through various conservation measures, signifying their ability to rapidly recover but disease outbreaks and persistent trade driven impacts continue to threaten their recovery (Milner-Gulland et al. 2020). Trade of the species predominantly revolves around the use of their horns in TCM remedies that treat fevers, liver ailments, and epilepsy (Zang 1990; Li et al. 2007). Only males carry horns, and overhunting has led to a skewed sex ratio and reproductive collapse, further contributing to population decline (Milner-Gulland et al. 2003). Exacerbating the issue are the massive die-offs from disease and the effects of changing climatic conditions. For example, hemorrhagic septicemia attributable to the bacterium *Pasteurella multocida* led to a 2015 mass die-off of some 200,000 animals in central Kazakhstan in 2015 (Frankfurt Zoological Society et al. 2016; Saiga Conservation Alliance 2017; Kock et al. 2018; Fereidouni et al. 2019).

Historically, hunting and trade of Saiga for horns, meat and skins were legally allowed in parts of its range. However, the increasing demand of horns for the TCM trade in Asia led to conservation concerns, and in 1995 the species was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to regulate international commercial trade in Saiga parts and derivatives. Continued declines led to a hunting ban in all range States, implemented during different periods since the 1990s (Theng et al. 2017). A proposal to transfer *Saiga* spp. from Appendix II to Appendix I of CITES, which would have banned trade for primarily commercial purposes, was presented at the 18th meeting of the Conference of the Parties in Geneva in 2019 but was not adopted. Instead, the CITES Parties accepted an amended proposal that retained *Saiga* on Appendix II subject to a zero-export quota for wild specimens traded for commercial purposes (Milner-Gulland et al. 2020). Specimens in trade must be accompanied by a valid export permit, or by a certificate of pre-Convention status for specimens/stocks harvested prior to 1995, when the species was first listed on CITES (Milner-Gulland et al. 2020). Information is lacking or dated on current stockpiles of horns and derivatives harvested before the adoption of the zero quota or before the species was listed, inadvertently creating a loophole exploited by traders to launder illegally obtained horns (Meibom et al. 2010; EIA 2019; Milner-Gulland et al. 2020). However non-range states with existing stock are still permitted to trade in Saiga horn and derivatives (Milner-Gulland et al. 2020) which still leaves room for the laundering of wild-sourced horns. Despite protection measures in place for the species, illegal harvesting of Saiga horn persists due to continuing demand for its use in TCM in Asia.

Today, only five fragmented populations exist: one in Kalmykia, Russia (5,000–6,000 individuals), three populations in Kazakhstan (~154,600), and one in western Mongolia (~5,000 individuals) (IUCN SSC Antelope Specialist Group 2018). Populations in China and Ukraine are considered extinct, while migrating populations are no longer seen in Turkmenistan and those reaching Uzbekistan have declined. The IUCN Red List of Threatened Species (hereafter the IUCN Red List)

has assessed Saiga Antelope as Critically Endangered since 2002. This assessment treats Saiga Antelopes as a single species with two sub-species: *S.t. tatarica* found in Russia and Kazakhstan; and *S.t. mongolica* (equivalent to *S. borealis*) found in western Mongolia (IUCN SSC Antelope Specialist Group 2018). However, the Convention on Migratory Species (CMS) and CITES recognise them as two separate species, separating the single population of Mongolia (*S. borealis*) from other populations (*S. tatarica*).

Demand for Saiga horn has been reported to be significant in Southeast Asia (Meibom et al. 2010) yet there is a lack of research on the level of trade in the region aside from Singapore and Malaysia (Meibom et al. 2010; Theng et al. 2017; Doughty et al. 2019; Gomez & Krishnasamy 2019). Here we examine the sale of Saiga horn in TCM markets in Bangkok, Thailand. Based on records in the CITES Trade Database, Thailand is the third largest importer of Saiga horn products in Southeast Asia after Singapore and Malaysia. Thai-Chinese constitute the largest minority group in Thailand (West 2009). They first arrived in the country in the Sukhothai period, mid-13th century (Chaitiang & Sornsakdanuphap 2021) and since then the use of TCM has gained widespread acceptance in Thailand. In 2000, Thailand's Ministry of Public Health issued a notification on "Permission to persons to practise the healing arts with traditional Chinese medicine according to Section 31 of the Practice of Healing Arts Act B.E. 2542 (1999)", legally acknowledging the use of TCM for public health.

METHODS

In order to assess the trade of Saiga horn in Thailand, we conducted rapid physical market and online surveys and extracted trade data from the CITES Trade Database. We assumed that products observed/advertised for sale in physical and online markets were genuine. No products were purchased during this study for further testing. We also attempted to obtain seizure data (useful for understanding illegal trade dynamics such as trafficking routes, origins and onward destinations) for Saiga horn or derivatives in Thailand, both in the public domain and in government records, but no reported seizures were found.

Physical market surveys were undertaken in Bangkok on 23 September and 10 December 2020. The area surveyed was confined to Bangkok's 'Chinatown' area which is located along Yaowarat Road and Charoen Krung Road in the district of Samphanthawong. It is the main area where Chinese businesses including medicine outlets are located and features bilingual signs in Chinese and Thai. Prior to initiating surveys, TCM outlets were identified on Google Maps using the search term "ร้านยาจีน (Raan Ya Jeen)" meaning "Chinese Pharmacy". This included contemporary pharmacies and traditional Chinese apothecaries. Surveys commenced at 1000 h and ended at 1300 h each day; and all outlets open during this time were surveyed. A total of 10 TCM outlets were visited, i.e., six contemporary pharmacies selling mainly modern medicines and four traditional Chinese apothecaries, selling mainly TCMs. These outlets were Thai-Chinese owned, and local researchers inquired about the product by its Chinese name, in Thai language. Researchers gathered information on type of Saiga horn products for sale and availability, stated uses, quantities and price. It should be noted that COVID-19 restrictions affected accessibility to TCM outlets in the area (with many closed permanently or temporarily during the survey period/time), resulting in fewer outlets being visited than would have otherwise been possible.

Online market surveys were undertaken on 13 October and 13 December 2020, using Google search and the top two e-commerce platforms in Thailand—Lazada and Shopee (Anonymous 2020). Two key search terms were used: (a) Kao–gui (เขากุย) which directly translates to Saiga horn, sold in a liquid infusion marketed as 'cooling water'; (b) Leng Yiang (เหล่งเอียง), a term derived from the original "Ling Yang", used most often for horn shavings. In a few instances, the term for "Deer Antler" (เขากวางอ่อน) was used interchangeably to describe Saiga horn shavings. All Saiga horn products that appeared for sale on the first two pages of google and e-commerce platforms were recorded including prices. There were three main types of online 'sellers' observed which we differentiate as: direct producers (companies that produce and sell their own Saiga horn products); online pharmacies; and "health and wellness" product sellers. All prices were in Thai Baht and have been converted at a rate of 30 Baht per USD 1 (the exchange rate as of 30 January 2021).

Data from the CITES Trade Database (trade.cites.org) were extracted in April 2021, covering the period 1995–2019 (the most current available data).

RESULTS

Physical market surveys

Every TCM outlet visited (n = 10) stocked at least one and/or two types of Saiga horn product, i.e., cooling

water (n = 2), horn shavings (n = 5), both (n = 3) (Image 1). Horn shavings were either sold individually or mixed with herbs prepared as a "pre-packaged/ready-made boiling kit". The price for horn shavings ranged from USD 20 to USD 32 per ready–made package. The price varied depending on the quantities of Saiga horn and other ingredients. Ready–made packages also included three herbal ingredients considered to have cooling properties, including bamboo leaves (*Lophatherum* sp.), Ophiopogon roots (*Ophiopogonis* sp.), and Medulla Junci.

Whole Saiga horns were not observed for sale in any of the 10 TCM outlets visited.

Online market surveys

There were three main types of Saiga horn products for sale online, i.e., cooling water, horn shavings and pills. Both cooling water and pills were being advertised as 'staple household medicines' used to relieve ulcers and fevers in children. The price for cooling water ranged USD 1–1.50 per bottle, while the price for pills was USD 5 per bottle (100 x 500 mg pills). Saiga horn shavings were being sold by weight or as pre-packaged ready-made boiling kits that included other medicinal herbs. The price per weight of Saiga horn was either USD 18/50 g or USD 19/37 g, while the price for ready-made boiling kits ranged from USD 10/kit to USD 30/kit, perhaps due to varying quantities of Saiga horn and combinations of herbal ingredients used.

Horn shavings were being advertised as having cooling-remedial properties, suitable for reducing swelling and targeted specially for pre- and post-surgery care (e.g., cosmetic surgery) and chemotherapy patients.

Based on the Google search, we found three prominent Thai-based herbal medicine companies that produce Saiga horn products (registered under the Thai Food and Drug Administration), one of which offered both cooling water and pills, while the other two only offered cooling water. Only one of the three companies specifically indicated the amount of Saiga horn in each 240 cc bottle of cooling water which was 60mg of Saiga horn in addition to other herbal ingredients. Saiga horn shavings were offered by at least six traditional Thai-Chinese pharmacies (with an online shop interface).

On e-commerce platforms a total of 75 listings for Saiga horn were found during the survey period, 39 on Shopee and 36 on Lazada. Of these, 80% were for cooling water and 20% were for Saiga horn shavings. Cooling water products observed for sale were of the same three Thai brands found on the Google search, and one additional brand originating from Malaysia. Shavings were most commonly offered for sale in pre-packaged/ready–made kits (Images 2–3). The products listed for sale on the e-commerce platforms mostly originated from Thailand, predominantly from Bangkok. The original traditional Chinese name for Saiga horn "Ling Yang" was more frequently used on Shopee and Lazada in comparison to the search terms used in this study suggesting that these e-commerce sites cater to a wider range of target consumers including non-Thais,

Image 1. Type of products containing Saiga Antelope horn available in TCM shops in Bangkok: a—cooling water | b—Saiga horn shavings with other herbs prepared as a ready-made boiling kit. © P. Siriwat.

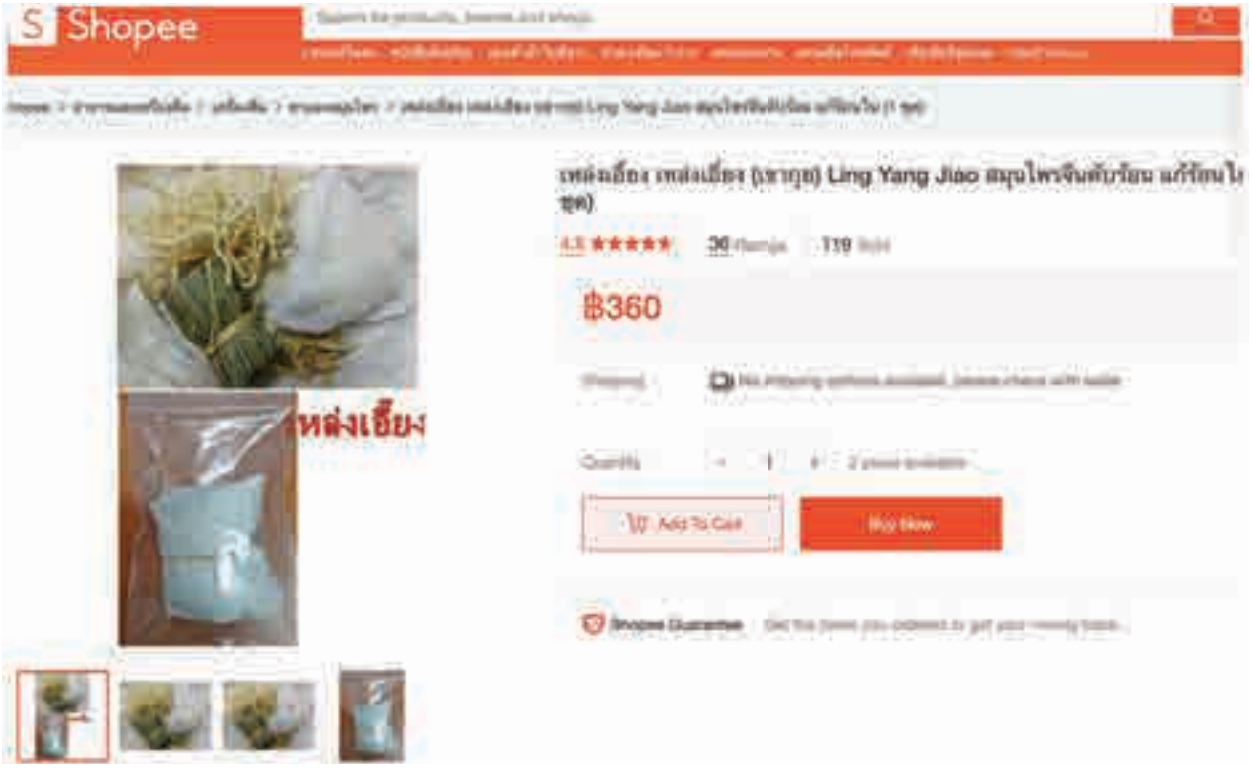

Image 2. Saiga horn shavings pre–packaged into a ready-made boiling kit for sale (~USD 12) on Shopee.

Image 3. Another type of pre–packaged ready–made boiling kit containing Saiga horn shavings for sale (~USD 18) on Shopee.

as opposed to the traditional Thai-Chinese pharmacies catering specifically to local Thai consumers ("Lin Yang" was not a term used on the Thai pharmacy websites). Sellers that offered health and wellness items were found to offer Saiga horn products as a post-surgery relief, whereas online pharmacies generally to not advertise in this way.

Thailand's role in the international trade in Saiga Antelope products according to the CITES Trade Data

Between 1996 and 2018, 16 records of Saiga horn imports into Thailand were listed on the CITES Trade Database (Table 1). The majority of imports (15 records) were reported as medicine/derivatives amounting to 11.16 kg. Japan was the main country of export (69%) of medicines/derivatives to Thailand, followed by China (25%), although China exported larger quantities in comparison (Table 1). There was one import of 2,700 kg of horns from Russia in 1996. Exports from Japan were reported as pre-convention stocks (i.e., source code O) while exports from China and Russia were reported as wild-sourced (i.e., source code W).

There was only one export/re-export record of Saiga horn derivatives (n = 5) from Thailand to New Zealand. This was reported as source code 'I' which refers to a seized or confiscated item. In this case, it could be referring to an illegal shipment that was seized in New Zealand (possible due to a lack of a valid export permit) or it could be referring to a shipment of previously seized items that can be legally exported with a valid CITES permit.

DISCUSSION

We found an active local trade in Saiga horn products in Thailand, occurring in Bangkok's Chinatown and on online platforms. Two main types of products were openly available: cooling water and shavings, the latter often observed in pre-packaged boiling kits. The Saiga horn is marketed as a staple household medicine. It is also being targeted for post-surgical care, especially in relation to cosmetic surgery for which there is a substantial market in Thailand. Cooling water products have been observed on sale throughout the country, not only in 'Chinatown areas' and not only in TCM outlets (M. Phassaraudomsak, pers. comm. to L. Gomez on 5 August 2021). It appears that Saiga horn products are being commercially produced in Thailand, yet overall trade dynamics including source and scale remain unknown. However, given the lack of any recent reported imports, and the prevalent availability of Saiga horn products, it is likely that either some of these products are illegally sourced from outside Thailand, or that the Thai Management Authority has not reported trade into Thailand to the CITES Secretariat. It is also possible that some of these products may not contain Saiga horn and testing of these products would confirm this.

According to CITES trade data, Thailand has imported Saiga horn and derivatives from China, Japan, and Russia. Both China and Russia have been implicated in the poaching and illegal trade of Saiga horns (Li et al. 2007; Meibom et al. 2010; WWF 2020), while Japan is one of the biggest importers of Saiga horn products, predominantly importing from China. CITES trade data shows that Thailand imported about 2,711 kg of Saiga horns and medicine/derivatives over a 23 year period (1996–2018). The bulk of this came from the 1996 import of 2,700 kg of horns from Russia mentioned above. This was the only record of export from Russia, probably because Russia instituted a commercial hunting ban in 1997 (although hunting was also banned from 1987 to 1989 and again from 1992 to 1996), and because CITES Notification 2001/043, issued in 2001 and still in effect, recommended suspension of imports of Saiga horn from Russia and Kazakhstan until the two countries complied with recommendations that included implementation of a regional conservation strategy for the species (Milner-Gulland et al. 2020). According to Meibom et al. (2010), Russia had a stockpile of only 1,500 kg horns in 1995

Table 1. Import of Saiga Antelope horns into Thailand between 1996 and 2018.

Country	Exporter reported quantities (kg)[1]													
	1996	2001	2003	2005	2006	2008	2010	2012	2013	2014	2015	2016	2017	2018
China									2.09	2.61		2.61	2.61	
Japan		0.15	110[2]	0.12	0.12	0.12	0.12	0.12		0.12	0.12		0.12	0.25
Russia	2700[3]													

[1]—All imports were of 'medicine/derivatives' with the exception of that from Russia, which was the only import of 'horns' reported; no importer reported quantities were listed | [2]—one import record described as derivatives but no unit (i.e., g, kg) was mentioned | [3]—only record of 'horns' imported into Thailand | Source: CITES Trade Database.

and Saiga Antelope continued to be poached to supply illegal demand. Aside from this massive import, Japan and China were the two main exporters of Saiga horn derivatives/medicine to Thailand amounting to 11.16 kg. China is one of the biggest consumers and exporters of Saiga horn and derivatives (Li et al. 2007; EIA 2019; WWF 2020). In 2006, China, Japan, Malaysia, South Korea, and Singapore reportedly had a combined stockpile of approximately 130 tons of Saiga horn. It was estimated this would be exhausted between 2016 and 2021 (EIA 2019). Trade in Saiga horns nonetheless continues, and illegally sourced horns continue to enter the market (EIA 2019; Van Uhm 2019; WWF 2020). Regular Saiga horn seizures in China and range States support this conclusion (EIA 2019; des Bois 2019, 2020a,b,c,d, 2021; Xinhua 2021). The most recent seizures occurred in: May 2021, when Chinese Customs authorities confiscated 200 Saiga horns smuggled from Russia (Xinhua 2021a); and December 2021 when Chinese customs officers in the Shandong Province confiscated six Saiga horns from two inbound parcels which were labelled as gifts (Xinhua 2021b). From 2015 to 2019, a minimum of 3,752 Saiga horns were seized in Russia and Kazakhstan (WWF 2020). Without current stockpile data, efforts to track source of products in trade remains difficult and undermines conservation efforts for these species.

This study reveals the existence of illegal trade in Saiga horn products in Thailand. Online market surveys show a Malaysian brand of Saiga horn product for sale, though no export records from Malaysia were found in the CITES Trade Database. Malaysia has been previously implicated in the illegal export of Saiga horn products, though the volume and significance of this trade was unknown (Meibom et al. 2010). Recent surveys of TCM outlets in Peninsular Malaysia revealed a substantial trade in Saiga horn products, though discrepancies in trade data and lack of information on stocks in the country made it impossible to determine to what extent legal stocks were permitted in domestic trade (Gomez & Krishnasamy 2019). CITES trade data also include at least one seizure record that potentially links Thailand to illegal re-export of Saiga horn derivatives to New Zealand. We could not find any record of seizures of Saiga horn in Thailand, and this may be a sign of low enforcement or perhaps weaknesses in the law prior to 2019. Saiga Antelope is not native to Thailand, and so was not listed as a protected species under its national wildlife law, the Wild Animal Reservation and Protection Act B.E.2535 (WARPA 1992). This law was amended in 2019 (Wildlife Conservation and Protection Act B.E. 2562 (WARPA 2019)) and now includes a new category, 'controlled wild animal', which is defined as "wildlife which is afforded protection under CITES and any other wild animal necessitating appropriate control measures as provided under the new Act". Listing as 'controlled wild animal' would mean the possession, import, export and re-export, as well as trade (including online trade, publicising and advertisement) is regulated through a permitting system. Violations of the law are liable to imprisonment and fines amounting to: for Illegal possession of 'controlled wildlife' – up to one year in prison and/or a fine not exceeding BHT 100K (>USD 3,000); illegal import or export of 'controlled wildlife' – up to ten years in prison and/or a fine not exceeding BHT1mil (>USD 30,000); Illegal trade of 'controlled wildlife' – up to four years in prison and/or a fine of up to BTH 400K (>USD 12,000). Prior to 2019, however, there was a major loophole in the law that hindered enforcement action against local trade of non-native species once they had been smuggled into the country as they were not protected after import (UNODC 2017). The 'controlled wild animal' list will reportedly be issued 2022 year-end under a Notification of the Minister. It remains unclear whether all CITES-listed species will be included. A current draft of the list does include the Saiga Antelope and if finalised could remove this loophole for the species.

CONCLUSION AND RECOMMENDATIONS

Thailand appears to be an important market for Saiga horn products. It is likely there is a mixture of both legally and illegally sourced Saiga horns in the market, partially due to the possible availability of pre-convention stock and partially due to loopholes in Thailand's national legislation. Greater scrutiny, monitoring and research is urgently needed to understand how the use of Saiga horn is being regulated in Thailand including the number of licensed traders, potential stockpile and management as well as the monitoring of traditional medicine outlets and online sale of commercial Saiga horn products. The addition of Saiga Antelope to the 'controlled wild animal' list is certainly warranted if it is to empower and enable enforcement in preventing the illegal trade of a Critically Endangered species.

REFERENCES

Alves, R.R., W.M. Souto & R.R. Barboza (2010). Primates in traditional folk medicine: a world overview. *Mammal Review* 40(2): 155–180.

Alves, R.R.N., W.L.S. Vieira, G.G. Santana, K.S. Vieira & P.F.G.P. Montenegro (2013). Herpetofauna used in traditional folk medicine: conservation implications, pp. 109–133. In: Alves, R. & I. Rosa (eds).

Animals in Traditional Folk Medicine. Springer, Berlin, Germany, 492 pp.

Anonmyous (2020). Top 10 eCommerce marketplaces in Thailand. https://www.vinculumgroup.com/top-ecommerce-marketplaces-thailand/. Electronic version accessed 1 June 2021.

Byard, R.W. (2016). Traditional medicines and species extinction: another side to forensic wildlife investigation. *Forensic Science, Medicine, and Pathology* 2016(12): 125–127. https://doi.org/10.1007/s12024-016-9742-8

C4ADS (2020). Tipping the scales: exposing the growing trade of African pangolins into China's traditional medicine industry. https://static1.squarespace.com/static/566ef8b4d8af107232d5358a/t/5f63b35ea44ed56361a512c4/1600369515449/Tipping+the+Scales.pdf. Downloaded on 5 October 2020.

Chaitiang, N. & J. Sornsakdanuphap (2021). Traditional Chinese medicine law with Thai health system. *Public Health Policy and Laws Journal* 7(1): 121–138.

D'Cruze, N., J. Green, A. Elwin & J. Schmidt–Burbach (2020). Trading tactics: time to rethink the global trade in wildlife. *Animals* (Basel) 10(12): e2456. https://doi.org/10.3390/ ani10122456

des Bois, R. (2019). On the trail n°24. https://robindesbois.org/wp-content/uploads/ON_THE_TRAIL_24.pdf. Electronic version accessed 3 March 2021.

des Bois, R. (2020a). On the trail n°28, the defaunation bulletin. Robin des Bois, with the support of the Brigitte Bardot Foundation, the Franz Weber Foundation and of the Ministry of Ecological and Solidarity Transition, France, 138 pp. https://www.robindesbois.org/wp-content/uploads/ON_THE_TRAIL_28.pdf. Electronic version accessed 3 March 2021.

des Bois, R. (2020b). On the trail n°27. https://www.robindesbois.org/wp-content/uploads/ON_THE_TRAIL_27.pdf. Electronic version accessed 3 March 2021.

des Bois, R. (2020c). On the trail n°26. https://robindesbois.org/wp-content/uploads/ON_THE_TRAIL_26.pdf. Electronic version accessed 3 March 2021.

des Bois, R. (2020d). On the trail n°25. https://robindesbois.org/wp-content/uploads/ON_THE_TRAIL_25.pdf. Electronic version accessed 3 March 2021.

des Bois, R. (2021). On the trail n°29, the defaunation bulletin. Robin des Bois, with the support of the Brigitte Bardot Foundation, the Franz Weber Foundation and of the Ministry of Ecological and Solidarity Transition, France, 182 pp. https://www.robindesbois.org/wp-content/uploads/ON_THE_TRAIL_29.pdf. Electronic version accessed 3 March 2021.

Doughty, H., D. Veríssimo, R.C.Q. Tan, J.S.H. Lee, L.R. Carrasco, L.R., K. Oliver & E.J. Milner-Gulland (2019). Correction: Saiga horn user characteristics, motivations, and purchasing behaviour in Singapore. *PloS one* 14(12): e0226721. https://doi.org/10.1371/journal.pone.0226721

EIA (2019). Transfer Saiga Antelope to Appendix I. https://content.eia-global.org/posts/documents/000/000/920/original/Saiga_Briefing_Final.pdf?1565646513. Electronic version accessed 1 June 2021.

EIA (2020). Smoke and mirrors: China's complicity in the global illegal pangolin trade. https://eia-international.org/wp-content/uploads/EIA-Smoke-and-Mirrors-2020-FINAL.pdf. Electronic version accessed 14 October 2020.

Fereidouni, S., G.L. Freimanis, M. Orynbayev, P. Ribeca, J. Flannery, D.P. King, S. Zuther, M. Beer, D. Höper, A. Kydyrmanov, K. Karamendin, & R. Kock (2019). Mass die-off of Saiga Antelopes, Kazakhstan, 2015. *Emerging Infectious Diseases* 25(6): 1169–1176. https://doi.org/10.3201/eid2506.180990

Frankfurt Zoological Society, Royal Society for the Protection of Birds, Flora and Fauna International, Altyn Dala Conservation Initiative & Convention on Migratory Species (2016). Signs of hope for Saiga Antelope after mass die-off in 2015. Saiga Antelope: Memorandum of Understanding concerning Conservation, Restoration and Sustainable Use of the Saiga Antelope. 15 June 2016. http://www.cms.int/saiga/en/news/ signs-hope-saiga-antelope-after-mass-die-2015. Electronic version accessed 1 June 2021.

Gomez, L. & K. Krishnasamy (2019). A rapid assessment of the trade in Saiga Antelope horn in Peninsular Malaysia. *TRAFFIC Bulletin* 31: 35–38.

Gomez, L. & C.R. Shepherd (2019). Bearly on the radar–an analysis of seizures of bears in Indonesia. *European Journal of Wildlife Research* 65(6): 1–8.

Heinrich, S., T.A. Wittmann, T.A. Prowse, J.V. Ross, S. Delean, C.R. Shepherd & P. Cassey (2016). Where did all the pangolins go? International CITES trade in pangolin species. *Global Ecology and Conservation* 8: 241–253.

Hinsley, A., E.J. Milner-Gulland, R. Cooney, A. Timoshyna, X.D. Ruan & T.M. Lee (2020). Building sustainability into the belt and road initiative traditional Chinese medicine trade. *Nature Sustainability* 3(2): 96–100.

Ingram, D.J., L. Coad, K.A. Abernethy, F. Maisels, E.J. Stokes, K.S. Bobo & J.P. Scharlemann (2018). Assessing Africa-wide pangolin exploitation by scaling local data. *Conservation Letters* 11(2): e12389.

IUCN SSC Antelope Specialist Group (2018). *Saiga tatarica*. The IUCN Red List of Threatened Species 2018: e.T19832A50194357. Downloaded on 1 June 2021. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T19832A50194357.en

Kock, R.A., M. Orynbayev, S. Robinson, S. Zuther, N.J. Singh, W. Beauvais, E.R. Morgan, A. Kerimbayev, S. Khomenko, H.M. Martineau, R. Rystaeva, Z. Omarova, S.W.F. Hawotte, J. Radoux & E.J. Milner-Gulland (2018). Saigas on the brink: Multidisciplinary analysis of the factors influencing mass mortality events. *Science Advances* 4(1): eaao2314. https://doi.org/10.1126/sciadv.aao2314

Li, L., Z. Yao & E.L. Bennett (2007). Report of a survey on Saiga horn in markets in China. https://global.wcs.org/Resources/Publications/Publications-Search-II/ctl/view/mid/13340/pubid/DMX1201700000.aspx. Electronic version accessed 1 June 2021.

Mallon, D.P. (2008). *Saiga tatarica*. The IUCN Red List of Threatened Species 2008: e.T19832A9021682. Downloaded on 24 August 2018. https://doi.org/10.2305/IUCN.UK.2008.RLTS.T19832A9021682.en

Meibom, S., A. Vaisman, S.H. Neo Liang, J. Ng & H. Xu (2010). Saiga Antelope trade: global trends with a focus on South-East Asia. TRAFFIC project report to the CITES Secretariat. TRAFFIC Europe, Brussels, Belgium.

Milner-Gulland, E.J., M.V. Kholodova, A. Bekenov, O.M. Bukreeva, I.A. Grachev, L. Amgalan & A.A. Lushchekina (2001). Dramatic decline in Saiga Antelope populations. *Oryx* 35: 340–345.

Milner-Gulland, E.J., O.M. Bukreeva, T. Coulson, A.A. Lushchekina, M.V. Kholodova, A.B. Bekenov & I.A. Grachev (2003). Reproductive collapse in Saiga Antelope harems. *Nature* 422(6928): 135.

Milner-Gulland, E.J., P. Hughes, E. Bykova, B. Buuveibaatar, B. Chimeddorj, T. Karimova, A.A. Lushchekina, A. Salemgareyev, S. von Meibom & S. Zuther (2020). The sustainable use of Saiga Antelopes: perspectives and prospects. Report to the Bundesamt für Naturschutz and the UN Convention on Migratory Species, 116 pp.

Nijman, V. & C.R. Shepherd (2015). Adding up the numbers. TRAFFIC Southeast Asia, Petaling Jaya, Selangor.

Nijman, V. & D. Bergin (2017). Reptiles traded in markets for medicinal purposes in contemporary Morocco. *Contributions to Zoology* 86(1): 39–50. https://doi. org/10.1163/18759866-08601003

Roberts, D.L., K. Mun & E.J. Milner-Gulland (2021). A systematic survey of online trade: trade in Saiga Antelope horn on Russian-language websites. *Oryx*: 1–8.

Saiga Conservation Alliance (2017). Help save Mongolia's Saigas. http://saigaconservation.org/2017/02/08/help-save-mongolias-saigas/. Electronic version accessed 24 February 2017.

Theng, M., J.A. Glikman & E.J. Milner-Gulland (2017). Exploring Saiga horn consumption in Singapore. *Oryx*: 1–8. https://doi.org/10.1017/S0030605317001624

UNODC (2017). Criminal justice response to wildlife crime in Thailand. United Nations Office on Drugs and Crime, **51pp.** https://data.opendevelopmentmekong.net/dataset/608b5d67-11a8-4892-

b0ac-9ed7d3452188/resource/d59bd8a3-8010-4577-9d72-dbdf31d07db0/download/thai_assessment_13_16_may_2017.pdf. Electronic version accessed 1 June 2021.

Van Uhm, D.P. (2019). Chinese wildlife trafficking networks along the silk road pp 114–133. In: T. Wing Lo, Dina Siegel, Sharon Kwok (eds). *Organized crime and corruption across borders.* Routledge, London, 294pp.

WAP (2020). Cruel cures: the industry behind bear bile production and how to end it. https://www.dropbox.com/s/2kzpdkfjn4vh347/Bear%20Bile%20Re-port_Cruel%20Cures_FINAL_compressed.pdf?dl=0. Electronic version accessed 13 July 2020.

West, B.A. (2009). Encyclopaedia of the peoples of Asia and Oceania. Facts on File, p 794. ISBN 978-1438119137

Wong, R.W. (2019). The illegal wildlife trade in China: understanding the distribution networks. Springer, Switzerland, 181pp. https://doi.org/10.1007/978-3-030-13666-6

Wong, R. & K. Krishnasamy (2019). Skin and bones unresolved: an analysis of tiger seizures from 2000–2018. TRAFFIC, Petaling Jaya, Selangor.

WWF (2020). Wildlife trade in the Russian Federation. https://wwf.ru/en/resources/publications/booklets/kommercheskiy-oborot-dikikh-zhivotnykh-v-rossiyskoy-federatsii-2020/. Electronic version accessed 1 June 2021.

Xinhua (2021). Wildlife smuggling busted in China's Heilongjiang. https://www.bignewsnetwork.com/news/269546384/wildlife-smuggling-busted-in-chinas-heilongjiang. Electronic version accessed 19 May 2021.

Zang, Z. (1990). A textual research on the history of lingyang. *Nanjing Chinese Medical College Magazine* 6: 57–59.

Zhang, L. & F. Yin (2014). Wildlife consumption and conservation awareness in China: a long way to go. *Biodiversity Conservation* 23: 2371–2381.

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COMMUNICATION

The occurrence of Indochinese Serow *Capricornis sumatraensis* in Virachey National Park, northeastern Cambodia

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Abstract: The Mainland Serow *Capricornis sumatraensis* is an under-studied, enigmatic rupicarin in the family Bovidae that lives in remote parts of the interior of Cambodia's mountain ranges, most of which border neighboring countries. Their population status in Cambodia is unclear but thought to be in decline. Our records stem from steep forested areas and never in open meadows or clearings. Our fairly robust camera trap records, including direct observations, suggest that Virachey National Park in the northeastern corner of the country might be the species' last best chance for survival in the wild in Cambodia.

Keywords: Bovidae, camera-trapping, Indochina, Mainland Serow, poaching, threats.

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Author contributions: GM and KP collected data in the field and wrote the manuscript; TS permitted the trek, reviewed data, and assisted with all organizational aspects of the expedition.

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INTRODUCTION

Not much is known of the life habits and ecology of the four serow species, which are found from the Indonesian island of Sumatra, across mainland southeastern Asia and the Himalaya, and on the islands of Japan and Taiwan. The status of the Serow in Cambodia has long been poorly understood, and their behavior is not well known (Lovari et al. 2020). In this paper we describe the Mainland Serow *Capricornis sumatraensis* (which some refer to as a sub-species called Indochinese Serow *Capricornis sumatraensis milneedwardsii*) records from Cambodia's Virachey National Park (VNP), in the northeastern corner of the country. This region is mountainous and forested, with peaks reaching up to 1,500 m, and is characteristic of the serow's preferred habitat (Mori et al. 2019; Phan et al. 2020). The only other regions of Cambodia that are confirmed to hold serow are the Cardamom Mountains in the southwestern corner of the country (N. Marx pers. comm. 2021), and Ko Seima Wildlife Sanctuary (Griffin 2019)—all locations with mountains that reach over 1,000 m. It is possible that serow occur in the Dangrek Mountains that serve as the northern boundary between Cambodia and Thailand, but border tensions and intensive illegal logging operations have deterred most researchers from entering the area. The last serow of the Phnom Tnout Wildlife Sanctuary in Preah Vihear province was snared in 2008 (N. Marx pers. comm. 2021), but there are anecdotal reports that some serow persist on the Phnom Tbeng plateau, also in Preah Vihear province in the north of the country. Overall, the serow occurs in the high mountainous segments that in places separate Cambodia from Thailand, Laos, and Vietnam, and their numbers are in decline due to hunting and habitat loss.

Although there has been a debate regarding the classification of the serow species, in particular whether the Mainland and Indochinese Serows are separate species, it is distinct from the Sumatran Serow *Capricornis sumatraensis*, we regard the species found in VNP and throughout Cambodia as well as in Thailand, Laos, and Vietnam, as belonging to *Capricornis sumatraensis* or Mainland Serow, which is consistent with the recent classification by Mori et al. (2019). Other serow species, such as Japanese Serow *Capricornis crispus,* Taiwan Serow *Capricornis swinhoei,* and the Myanmar-China Red Serow *Capricornus rubidus* are clearly different in appearance. It is not within the scope of this paper to attempt a clarification of the classification of the species and sub-species.

We found Mainland Serow at many of our high elevation camera stations, and a young specimen was observed and photographed by a park ranger in the Yak Yeuk Grasslands area of VNP wandering alone in a rocky and semi-forested section of the meadows in 2018 (S. Leam pers comm. 2021). Interestingly, we never camera-trapped serow at any of our open grassland camera stations, but only in the high mountains in closed forest canopy, many days' walk from the nearest village, so the ranger sighting might be an anomaly. In the Khmer language, the species is called "sat kɛh" (សត្វកែ), which correlates with Indochinese Serow, and that is also what our guides and porters call them. Recent DNA analysis has determined that outside of Japan and Taiwan, serows belong to the same species *Capricornis sumatraensis* (Mori et al. 2019). Visibly, there is little or nothing to distinguish between serows from Sumatra or mainland southeastern Asia, while the species from Japan and Taiwan are distinctly different. We have camera-trapped serows in Sumatra, Thailand, and Cambodia, and can see no discernible difference between them.

Serows appear to be in decline because of hunting for its horns and meat for Asian pharmacopeia, evident by the photographs which have appeared in the conservation NGO Wildlife Alliance's monthly reports. This paper attempts to help fill that knowledge gap by noting the serow distribution in VNP.

Study site

VNP is located in northeastern Cambodia along the mountainous international borders with Laos and Vietnam. The park covers an area of 3,325 km². Most of Cambodia is very flat, which is unsuitable terrain for all serow species, as they prefer mountainous habitats (Francis 2019; Phan et al. 2020). Several extensive grasslands dot VNP, and the park is extremely hilly and cut by deep river valleys. Access to its remote points near the border with Laos was, until quite recently, very difficult, but motorbike tracks blazed for selective logging have made access easier, something which may spur additional hunting in previously difficult to reach regions of VNP.

Our three study sites in the park were chosen due to their distance from villages and their apparent high quality forest cover based on satellite imagery. Many of the mountains which form the wild and unmarked border between VNP (Cambodia) and Laos are steep, heavily forested, and reach up to and over 1,000 m, making it prime serow habitat. Our three study areas are known as the Veal Thom Grasslands, Yak Yeuk Grasslands, and T'buen Mountain.

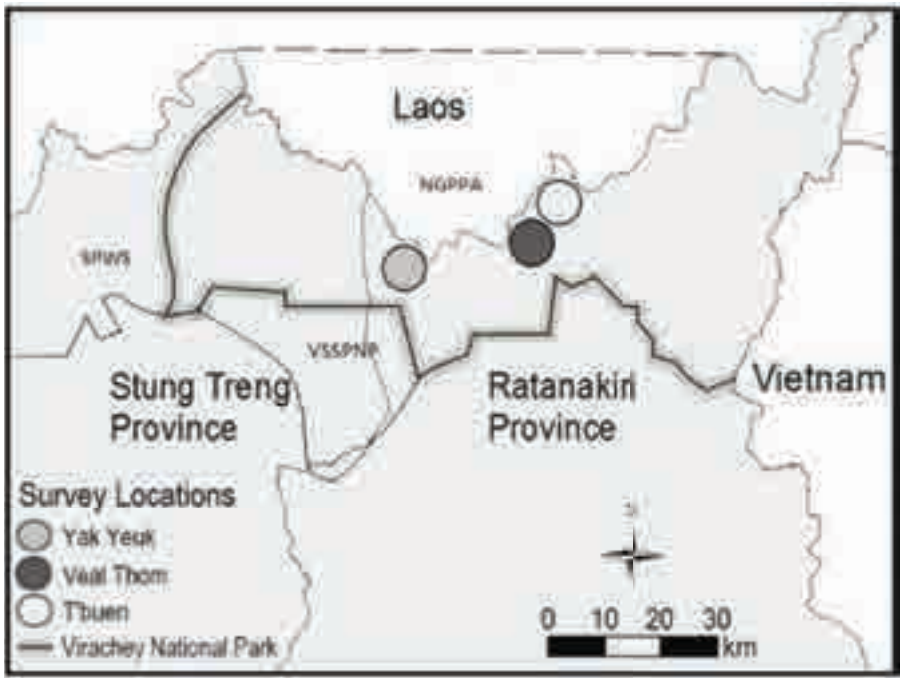

Figure 1. Our three study areas in VNP showing occurrence of serow positions.

MATERIALS AND METHODS

This was a broad wildlife survey, where camera traps were placed in a variety of habitats. Cameras were set along forest paths, ridge lines, game trails, basaltic clearings, streams, and wallows in order to maximize effort and the chances of encountering different species. We also relied heavily on the knowledge of the park rangers and our guides for camera placement. Cameras were often placed in locations where signs of wildlife were observed. Due to our camera deployment methodology, some species may be either over or underrepresented. Site selection, often being on or near game trails, may have influenced our capture rate of serow.

Camera trap stations, with one camera per site, were set approximately 20–100 cm above the ground, depending on slope and vegetation. All camera traps were set to be active for 24 hours each day, and to record time, date, and temperature when triggered. Camera traps from our three study areas were set for a combined total of 299,400 hours or 12,475 camera trap nights. Out of 36 camera traps, 32 were set to photograph mode, recording three pictures for every trigger event, at various time intervals, ranging from 30 seconds to five minutes. Camera traps at wallows or areas that showed signs of foraging were set at longer time intervals to minimize the number of redundant photographs. Camera traps on game trails were set at shorter intervals to maximize the number of records. The four camera traps set to video recorded for one minute and restart after 1-minute interval if motion was detected; the video would therefore record until the animal had left the area. Encounters were defined as a single or series of photographs separated by more than 30 minutes at the same camera trap location. Coordinates and altitudes were recorded directly from a Garmin GPSMAP altimeter and a base-map of Cambodia that was purchased from Aruna Technologies in Phnom Penh. We used Bushnell HD Trophy Cams, Reconyx Rapidfire, Browning Strikeforce Pro XD, and Covert camera traps. Several camera traps malfunctioned, and five were lost to theft or damaged by poachers. Camera trap data were recorded and organized in MS Excel.

Serows in protected areas adjacent to VNP

Serows have never been detected in the Siem Pang Wildlife Sanctuary due west of VNP (J. Eames pers comm. 2021), likely due to the flatter terrain. Direct observations of serow were made by community patrols in Vuen Sai-Siem Pang National Park, which is adjacent to VNP to the south, but they were not recorded in camera traps (V. Audibert pers comm. 2021), possibly suggesting that VNP is a regional stronghold for the species, along with other habitats which form a kind of semi-circular mountainous international barrier around Cambodia; it

is these mountainous barriers which serve as the habitat and likely final redoubt for the serow in Cambodia. We recorded serow on the ridge line of Phnom Haling-Halang, which serves as a natural boundary between Cambodia and Laos. The name of the Lao area adjacent to VNP to the north is Nam Ghong Provincial Protected Area (NGPPA), so it is plausible that serows are found in this region of Laos because it contains a similar topography to VNP.

RESULTS

We recorded a total of 126 independent encounters, for an encounter rate of 1.01 over a period 12,475 camera trap nights (Table 1).

Serow triggered 24/36 (67%) of our camera trap stations and were present in all three survey areas. Of the three survey areas, the Veal Thom area had the highest number of independent encounters and encounter rate (1.35), where it appeared on 12 of 22 camera traps. Many of the encounters are likely the same individual, feeding or moving past a given camera, as distinguishing characteristics were often difficult to identify.

Sun Bears *Helarctos malayanus* were seen at altitudes ranging 490–1,420 m and appeared at elevations over 1,000 m in 62% of camera-trap occurrences (13 of 21). They were camera-trapped in evergreen, semi-evergreen, mixed deciduous, and mixed-bamboo forest; in forested grassland corridors, along riversides, & mud wallows; and were frequently encountered on well-traveled game trails. They were often captured in our stream-placed cameras. Most individuals encountered appeared to be in good health and none had evidence of snaring. All individuals photographed, except for a mother and juvenile pair, were solitary.

DISCUSSION

Serows were detected at all hours of the day. In several photos they were pictured resting on the ground, while in others they are seen feeding, crossing swift streams, walking on boulders, or running. Similar to our records in Sumatra, serows seemed unperturbed by camera traps and often spent extensive amounts of time feeding in front of them, sometimes triggering several dozen photographs. Our VNP records, however, are encouraging, as serow appear on many of our camera stations, including some with young, and a direct observation (also photographed) a young individual by itself.

Serows are in decline in the Cardamom Mountains in the south-west of the country (N. Marx pers comm. 2021), and due to their habitat requirements—steep, heavily forested mountains—it is difficult to surmise that they are found anywhere else in Cambodia outside of what is likely a very small population in Ko Seima Wildlife Sanctuary in Mondulkiri province. To the best of our

Table 1. Serow encounter rates recorded in Virachey National Park. Encounter rate was calculated as independent encounters/100 camera trap nights. Encounter rates at each survey location; Yak Yeuk, Veal Thom and T'buen are represented as YY, VT, Tb, respectively.

Common name	Species	Total encounters	Encounter rate (YY, VT, Tb)	Total encounter rate
Mainland Serow	*Capricornis sumatraensis*	126	0.45, 1.35, 0.42	1.01

Number of encounters (YY, VT, Tb) of *C. sumatraensis* = 10, 106, 10
Total camera trap nights = 12,475.
Total camera trap nights per area (YY, VT, Tb) = 2,242, 7,865, 2,368

Image 1. Serow with a large mane in the T'buen Mountain area in old growth forest at 1,150 m.

Image 2. Serow with young in forest corridor in Phnom Veal Thom Grasslands.

Image 4. Side view of a Serow, north of the Veal Thom Grasslands in Virachey, NP, Cambodia.

knowledge, no recent records stem from Bokor National Park or from Phnom Kulen National Park—two locations with montane forest which could possibly support serow. Also to the best of our knowledge no recent records stem from the Dangrek Mountain chain on the Cambodian side. This scarcity of knowledge is mainly due to a tense military standoff between Thailand and Cambodia and the illicit trade in Siamese Rosewood in which Khmers illegally cross into Thailand to poach the highly sought-after hardwood, often resulting in violent confrontations between Thai security forces and Cambodian loggers (Stokes 2017). All border areas between Cambodia and Thailand are now off-limits due to the fast spread of Covid-19 in Thailand, so it will be some time before any information can be gathered from the Cambodian side of the Dangrek mountains and other mountainous border areas. Therefore, it is very likely that VNP represents the greatest stronghold for the species in Cambodia.

Elsewhere in the region, limited data from Thailand's National Parks website pinpoints Indochinese Serow occurrence in the Dangrek Mountains right on the Thailand-Cambodian border (www.thainationalparks.com), but just how up-to-date and accurate this information is, is open to question. Across Thailand, serow appear to be widespread and abundant (T. Redford pers. comm. 2021), and we camera trapped them in Khlong Saeng Wildlife Sanctuary in southern Thailand in 2014 during a short pilot survey. Their status in Laos is unclear, though very heavy hunting and particularly snaring pressures are prevalent throughout the country (DeBuys 2015), as is from neighboring Vietnam, which would indicate population declines, possibly very drastic. However, there is a semi-wild rescue center for them at Phong Nha Ké Báng National Park (Tri pers. comm. 2021)

Image 3. A young Serow seen alone in rocky and hilly, semi-forested area of the Yak Yeuk Grasslands in Virachey NP, Cambodia, which had previously been set on fire by local hunters. This photograph was a direct observation by a park ranger and not recorded via camera trap.

which offers some hope for the species in Vietnam; their status in wild throughout the rest of the country is not well known, but likely in steep decline.

The serow's main predators in VNP are dholes *Cuon alpinus*, Clouded Leopards *Neofelis nebulosa*, and humans, with the latter likely representing by far the most serious threat, as Cambodia is in the midst of a snaring epidemic (Gray et al. 2018). A recent study targeted at VNP's wild cats found that Clouded Leopards are still present in VNP (McCann et al. 2020). Dholes were also detected in that survey, but a study on Dhole diet and prey selection noted that serow represented just 6% of Dholes consumed biomass in Cambodia, perhaps due to the serow's preference for steep terrain,

making it more difficult for dholes to hunt them (Kamler et al. 2020).

Overall, the Mainland or Sumatra Serow is an understudied bovine deserving more directed conservation attention, or it could soon go the way of the Saola *Pseudoryx nghetinhensis* of the Annamite Mountains of Laos and Vietnam—becoming extremely rare, and possibly extinct. As such, VNP offers one of its last best hopes for survival in the wild, especially in Indochina (Cambodia, Laos, and Vietnam). It is probably not too late to turn the situation around for serows in Cambodia, but as stated previously they do not garner significant conservation attention. We hope that this publication can help raise an alarm and bring attention and conservation management for the species where it still occurs.

REFERENCES

DeBuys, W (2015). *The Last Unicorn: A Search for One of the Earth's Rarest Creatures*. Little, Brown and Company, New York, 385 pp.

Francis, C.M. (2008). *A Field Guide to the Mammals of South-east Asia*. New Holland, London, 392 pp.

Gray, T.E., A.C. Hughes, W.F. Laurance, B. Long, A.J. Lynam, H. O'Kelly, W.J. Ripple, T. Seng, L. Scotson & N.M. Wilkison (2018). The wildlife snaring crisis: an insidious and pervasive threat to biodiversity in Southeast Asia. *Biodiversity Conservation* 27: 1031–1037. https://doi.org/10.1007/s10531-017-1450-5

Griffin, O. (2019). The Biodiversity of Keo Siema Wildlife Sanctuary. WCS Cambodia.

Kamler, J., A. Bousa, S. Rostro-Garcia & A. Caragiulo (2020). Diet and prey selection of dholes in evergreen and deciduous forests of Southeast Asia. *Journal of Wildlife Management* 84(7): 1396–1405. https://doi.org/10.1002/jwmg.21931

Lovari, S., E. Mori & E.L. Procaccio (2020). On the behavioral biology of the Mainland Serow: a comparative study. *Animals* 10: 1669. https://doi.org/10.3390/ani10091669

McCann, G., K. Pawlowski & T. Soukhon (2020). The standard four in Virachey National Park, northeastern Cambodia. *CATnews* 71: 9–13.

Mori, E., L. Novari & S. Lovari (2019). Reclassification of the Serows and gorals: the end of a never ending story? *Mammal Review* 49(3): 256–262.

Phan, T.D., S. Nijhawan, S. Li & L. Xiao (2020). *Capricornis sumatraensis*. The IUCN Red List of Threatened Species 2020: e.T162916735A162916910. Downloaded on 11 October 2021. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T162916735A162916910.en

Stokes, D. (2017). No let-up in Thailand's relentless, violent Siamese rosewood poaching. Downloaded on 15 October 2021. https://news.mongabay.com/2017/01/no-let-up-in-thailands-relentless-violent-siamese-rosewood-poaching/

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COMMUNICATION

Attitudes and perceptions of people about the Capped Langur *Trachypithecus pileatus* (Mammalia: Primates: Cercopithecidae): a preliminary study in Barail Wildlife Sanctuary, India

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Abstract: Conservation of any species needs the support and cooperation of local people. In order to understand the attitudes and perceptions of the locals about the Capped Langur, the present study was carried out around Barail Wildlife Sanctuary in Assam. The study was carried out through a questionnaire, semi-structured interviews, and interaction with forest staff & local experts to assess the perception of present threats and conservation problems. A total of 400 respondents were interviewed during the study periods. The results reveal that a majority of respondents supported Capped Langur conservation. Habitat loss and fragmentation was considered a major threat (47%), followed by human exploitation (22%), developmental activities (17%), agricultural extension (8%), and hunting & teasing (6%). Knowledge concerning Capped Langurs and perceptions of threats varied considerably among respondents. Increased awareness among local people is suggested to motivate them towards conservation. Benefit sharing and promotion of value-added services through skill development could also be highly rewarding.

Keywords: Assam, conservation, northeastern India, threats.

Bengali: উদ্ভিদ হোক, কিম্বা প্রাণী, যে কোনো প্রজাতির সংরক্ষণের জন্য স্থানীয় লোকদের সহযোগিতা অত্যন্ত প্রয়োজন। টুপিওয়ালা বানর (কেপড ল্যাঙ্গুর) সম্পর্কে স্থানীয়দের ধারণা এবং মনোভাব বোঝার জন্য এই গবেষণাটি আসামের বড়াইল বন্যপ্রাণী অভয়ারণ্যে করা হয়েছিল। এদের সংরক্ষণের প্রয়োজনীয়তা কি এবং বড়াইল পাহাড় অঞ্চলে বানরগুলোর টিকে থাকতে গিয়ে কি কি সমস্যার মুখোমুখি হচ্ছে, এসব নিরীক্ষণ করার জন্য একটি প্রশ্নমালা তৈরি করে বনকর্মী এবং স্থানীয় লোকদের সাক্ষাৎকারের মধ্য দিয়ে এই গবেষণার ভিত তৈরি করা হয়েছিল। মোট ৪০০ লোকের সাক্ষাৎকার নেওয়া হয়েছিল। দেখা গেলো যে বেশিরভাগ উত্তরদাতাই টুপিওয়ালা বানরের সংরক্ষণকে সমর্থন করছেন। প্রায় ৪৭% উত্তরদাতা মনে করেন বাসস্থানের অবক্ষয় বানর প্রজাতিটির সংরক্ষণের প্রধান অন্তরায়, ২২% এর মতে বানরের প্রতি মানুষের বৈরী আচরন, ১৭% এর মতে তাদের বাসস্থানের আশপাশ অঞ্চলে বিভিন্ন উন্নয়নমূলক কর্মযজ্ঞ, ৪%-র মতে এলাকাতে কৃষি সম্প্রসারণ, এবং ৬%-র মতে নির্বিচার বানর নিধন, এ সবই হচ্ছে প্রজাতিটির সংরক্ষণের অন্তরায়। স্থানীয়দের ভাষ্য মতে, সাধারন জনগণের মধ্যে টুপিওয়ালা তথা অন্যান্য সব বানর প্রজাতির সংরক্ষণের প্রয়োজনীয়তার উপর সচেতনতা বৃদ্ধির যথেষ্ট প্রয়োজন রয়েছে, যাতে করে সবাই বানর সংরক্ষণের প্রতি উদ্বুদ্ধ হন।

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Author contributions: RAB & PC designed the study; RAB, ASC, & NRT collected the data while RAB analyzed the data, RAB wrote the first manuscript and all authors revised the manuscript.

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INTRODUCTION

Primates play an fundamntal role in the forest ecosystem as seed dispersers and predators, and they are dependent on primary forest habitats (Chapman & Onderdonk 1998; Kays & Allison 2001). Habitat fragmentation, quality of habitat, and anthropogenic factors affect primate diversity and abundance across their distribution (Rylands 1987; Chapman & Peres 2001; Pyritz et al. 2010). It has been recorded that some primates respond to these challenges by emigration, crowding, and altered sex ratios, while others continue to thrive in the same area by adjusting to anthropogenic threats (Baranga 2004; Martins 2005; Rode et al. 2006; Schwitzer et al. 2011). In disturbed, degraded or fragmented habitats, animals also face loss of roosting sites, reduced food resources, diminished escape cover, altered and migratory routes (Kumar & Solanki 2004; Malhi et al. 2008). They are likely to become more prone to natural disasters such as hurricanes, floods, and seasonal droughts (Malhi et al. 2008; Alho & Silva 2012).

Capped Langur *Trachypithecus pileatus* (Image 1) is a folivorous primate occurring in the northeastern states of India, Bangladesh, northwestern Myanmar, Bhutan, and southern China (Das et al. 2020). They live in multi-female groups, rarely with more than one male (Stanford 1991; Mukherjee et al. 1995). The species occurs in different habitats including bamboo stands, plantations, and tea gardens (Choudhury 1989, 1996; Raman et al. 1995). Their population is on the decline mainly due to habitat loss and forest degradation (Srivastava et al. 2001; Das et al. 2020). Human population explosion, forest degradation by logging, tea garden extension, fuel wood collection, and other construction activities affect the healthy survival of Capped Langurs in Assam.

The present study was carried out in Barail Wildlife Sanctuary (BWS), which is the only protected area in southern Assam, northeastern India. It is situated in the Barail Hill range on the transitional zone between the Indo-Burmese and Indo-Chinese subregions and surrounded by tea gardens from the southern side. Although some scattered studies have been carried out on wildlife of this sanctuary, to date no study was taken up on Capped Langurs. The wildlife sanctuary is a safe home for many primates, including an 'Endangered' species, the Western Hoolock Gibbon *Hoolock hoolock*; four 'Vulnerable' species including Bengal Slow Loris *Nycticebus bengalensis*, Capped Langur, Stump-tailed Macaque *Macaca arctoides*, and Northern Pig-tailed Macaque *Macaca leonina* (Choudhury 2013; Talukdar et al. 2018). Besides, Assamese Macaque *Macaca assamensis*, a 'Near Threatened' species, and Rhesus Macaque *Macaca mulatta*, a 'Least Concern' species also occur in the sanctuary. The present study was done to develop a clear understanding of conflict of the Capped Langur with the people of the fringe villages and threats that affect the survival of the species. Here, we document the results of a questionnaire survey on the Capped Langur in BWS. This work presents ongoing problems for the species and suggests some effective measures for conservation in the region.

Image 1. Capped Langur *Trachypithecus pileatus* in Barail Wildlife Sanctuary. © Rofik Ahmed Barbhuiya

METHODS

Study area

The Barail Wildlife Sanctuary is located in the Barak Valley area of southern Assam districts. The area comprises of fourteen reserve forests, out of which Barail Reserve forest and North Cachar Reserve forests have been converted into BWS. It is a newly declared sanctuary formed in 2004 through a gazette notification of the Government of Assam (vide no. FRW-12/2001/pt/4, dated 19 June 2004).

It is a major catchment area and watershed zone for Barak valley. It covers a total area of 326.24 km^2 and is located at the 92.766–92.866 °E & 24.966–25.966 °N. The North Cachar part of the sanctuary is located at 92.27–92.78 °E & 25.12– 25.18 °N (Figure 1). The forests occupy the outlying ranges of hills that project out from the main ranges of the Jaintia Hills and North Cachar Hills and undulate at the base. The highest point in the

Figure 1. Map of India highlighting the state Assam and the study area.

BWS is Nemotha Peak with an altitude of 1,105 m. The southern slopes are steeper than the northern slopes. The elevation ranges from 55 to more than 1,800 m and annual rainfall ranges 2,500–4,000 mm. The temperature is a minimum of 9 °C in winter and highest 37 °C in summer, and humidity varies from 62% to 83%. The administrative control of the BWS is under the Southern Assam Forest Circle, Silchar, Assam.

The sanctuary includes several rivulets—Jatinga, Daloo, Kayong, Gumra, and Boleswar—all of which drain into Barak, the main river basin of the valley. Vegetation of the sanctuary is a mix of tropical moist evergreen, semi-evergreen, and deciduous forests which supports a wide diversity of wildlife. The Sanctuary harbors 19 species of mammals including seven species of primates, 250 species of avifauna, 23 species of amphibians, and 43 species of reptiles which are globally threatened (Choudhury 2013; Talukdar et al. 2021). The plant diversity of BWS comprises of 81 tree species, eight species of bamboo, and several species of herbs & shrubs.

Data collection

A preliminary survey was conducted from November 2016 to December 2018. The survey was carried out by a set of close ended questionnaire. The questions were designed as per Mutanga (2015), Mir et al. (2015), Choudhury et al. (2019), and Talukdar & Choudhury (2020) with slight modifications. The samples were taken within the range of two kilometers from the sanctuary, considering that the Capped Langurs do not usually come out to the fringe villages. A pilot survey was carried out on a sample of 50 people, giving special preference to the forest staff, village headman, hunters, and local experts. Before interviewing the respondents, a pre-test was conducted among a few respondents to assess their level of understanding of the questionnaire. A total of 400 respondents were selected from all the villages irrespective of their community. The sample size was realistic as the pilot survey suggested homogeneous responses.

The study was done in two phases. In the first phase, the photograph of the species was shown to the respondents to identify if they have seen it. Only those respondents who knew the species were selected for the next phase, i.e., feedback collection. For obtaining feedback, preference was given to the senior-most family member, who was expected to have an idea about the past as well as the present status of the species, and all their perceptions were recorded based on the questionnaire set for this. After this, the respondents were asked about the threats faced by the Capped Langur in BWS, community responses for them, and the problems caused by the species. The ideal reason for assessing the trends of species over time and threats were noted in the field record book as short forms, for example, Habitat loss and fragmentation 'HF', Developmental activities 'DA', and Hunting & Teasing 'HT'. Collected data were combined as per the objectives of study and perceptions of people were used for population trend analysis. Data were analyzed through SPSS version 20 and the chi-square test was applied to understand the significance level.

RESULTS

Perceptions

Results reveal that the local people are aware of the species. Most respondents think that the population of Capped Langur was decreasing (46.7%), while 30.3% respondents believe that the population was increasing, whereas 23% people did not know whether it was increasing or decreasing, and these varied significantly (Table 1). All the respondents are regular visitors of the sanctuary (as they harvest firewood and practice 'jhum' (slash and burn cultivation). The majority of the respondents (59%) expressed that agricultural crops (like jhum cultivation) in fringe areas and inside the sanctuary are not damaged by the langur, whereas 26.3% of respondents were neutral, and 14.7% said that they do cause damage to the crops There was a significant difference in people's perception. (χ^2 = 126.52, df = 2, P <0.001). Large numbers of respondents (58.2%) feel that the species should be conserved, 36% were neutral, and a small segment (5.8%) did not speak in favor of conservation (χ^2 = 166.65, df = 2, P <0.001). Most respondents (68.3%) are not well aware of the species conservation status. Only 23.5% of respondents knew that it is a legally protected animal and 8.2% thought it is not legally protected and the difference was significant (χ^2 = 233.41, df = 2, P <0.001).

A total of 49.5% respondents reported that the species is good for the sanctuary, whereas 41.2% of respondents were not interested, and only 9.3% clearly expressed it was not good to have the langur (χ^2 = 108.49, df = 2, P <0.001). A good number of respondents (53.8%) shared that they enjoy to watch the species, but 43% respondents were silent and only 3.2% said no (χ^2 = 169.84, df = 2, P <0.001).

When the respondents were interviewed to know the species relation with regards to human health, the maximum response (70.2%) was 'do not know', whereas the remaining 10.3% and 19.5% said 'Yes' and 'No' respectively (χ^2 = 250.45, df = 2, P <0.001). Most of the respondents (57.2%) said that the species is important for balancing the ecosystem whereas 35.8% of respondents did not know about it and only 7% of people said that they had no role (χ^2 = 152.56, df = 2, P <0.001).

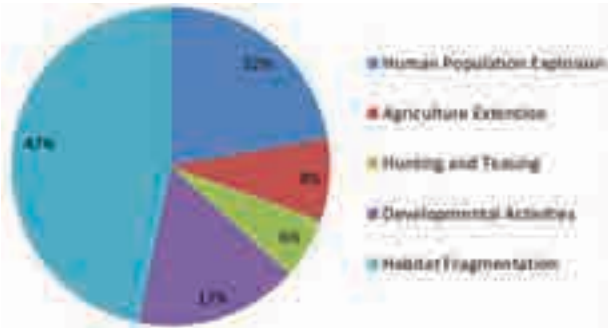

Figure 2. Perceptions of people about threats faced by the species.

Threats to the Capped Langur in Barail Wildlife Sanctuary

It was found that most people were well aware of the threats to the Capped Langur (Figure 2). The majority of respondents (47%) informed that habitat loss and fragmentation are significant threats to the species and its population decline. Another section of the respondents stated that human exploitation (22%) was the second most important factor due to wood collection for fuel and house construction by the people in the fringe villages. Developmental activities (17%) like road constructions and sand & stone collection from the rivers of the sanctuary were affecting their habitats. A few of the respondents thought that agriculture extensions (8%) through the practice of jhum inside the

Table 1. Perception of people about various questions and its calculated value.

	Question	Category			χ^2	p
1	Do you think the number of Capped Langur has been increasing in BWS?	Yes	No	Neutral	35.56	0.001
		121 (30.3%)	187 (46.7)	92 (23%)		
2	Do you think Capped Langurs are harmful for Agricultural crops?	59 (14.7%)	236 (59%)	105 (26.3)	126.52	0.001
3	Is it important to conserve Capped Langur in BWS?	233 (58.2%)	23 (5.8%)	144 (36%)	166.65	0.001
4	Are Capped Langurs legally protected animal?	94 (23.5%)	33 (8.2%)	273 (68.3%)	233.41	0.001
5	Do you think Capped Langur is good for BWS and local people?	198 (49.5%)	37 (9.3%)	165 (41.2%)	108.49	0.001
6	Do you think Capped Langur has the recreational value?	215 (53.8%)	13 (3.2%)	172 (43%)	169.84	0.001
7	Is it good for human health?	41 (10.3%)	78 (19.5%)	281 (70.2%)	250.45	0.001
8	Do you think Capped Langur balance the ecosystem?	229 (57.2%)	28 (7%)	143 (35.8%)	152.56	0.001

Image 2. Threats in the Barail Wildlife Sanctuary: A—Rice cultivation in fringe area | B—Betel Nut plantation by local inhabitants | C—After interaction with the local people | D—Tea plantation in fringe areas of the BWS.

sanctuary was also a reason for habitat destruction. The remaining respondents indicated that hunting & teasing (6%) affected the survival of the species in the sanctuary.

DISCUSSION

Most people believed that the population of the Capped Langur was declining. Many of them opined that these langurs were now not as frequently seen as in the past decades. Villagers regularly roam in the buffer areas of the sanctuary, where they had witnessed a deterioration of forest cover due to increase in timber logging, firewood collection, and jhum practices. Thus, the langurs might have shifted to their traditional forage areas in the core of BWS to good quality forests, and hence their reported perceptions. The Capped Langurs sometimes come to the fringe areas, especially in the morning hours to forage on crops and hence a few of the respondents reported loss of crops to langurs, while the majority of the respondents did not experience similar incidents. Respondents opined that they drove away the animals during the onset of jhum cultivation so as to minimize crop loss and show a strong ability to adapt to living close to human settlements. Large core areas of the sanctuary are sufficient to fulfill the needs of the Capped Langur. From most of the respondents, positive attitudes were documented on the conservation of the langur. A few of the respondents experienced conflict and thus had negative attitude towards conservation of the species thinking that it would cause loss to their shifting cultivation practices. The percentage of respondents (36%) who kept silent on conservation of the species is not negligible and they need to be sensitized to increase cooperation for conservation.

Although most of the respondents have a low educational background, they believe that the species was important for the forest. Only a small fraction of the respondents knew that these langurs were legally protected, but the majority of the respondents had no knowledge about the conservation status of the species. This reflects the need for awareness for the species. None of the respondents reported that the death of langurs happens because of conflict or demand for their meat.

Habitat loss and fragmentation are the main threats for the Capped Langur in the sanctuary (Image 2). Jhum cultivation and large-scale harvesting of forest resources in the form of firewood collection from the sanctuary are also major reasons for the reduction the habitat. Although tea and rubber plantations within reserve forests are the major factors for the destruction of natural habitats in southern Assam (Talukdar et al. 2018), the local people in BWS have destroyed the habitat by jhum and fuelwood collection. Jhum cultivation is one of the biggest threats for wildlife including primates in northeastern states (Johnsingh 1985; Katti 1992; Choudhury 1996). It is done by tribal communities for planting several crops, fruits, and betel nut. Jhum cultivation leads to soil erosion and landslides ultimately damaging large forest covers through the creation of canopy gaps and depletion of food (Choudhury 2013). Increasing land for monoculture activities especially betel nut plantation in human settlement fringe areas of the sanctuary is another major threat. It was found that local people collect timber yielding plants for house and furniture construction and also for selling them to support their livelihood. Commercial mining of stone creates landslide in Jatingah River and other small riverbanks within the sanctuary. These are the major factors that affect survival of wildlife including primates (Fahrig 1997; Srivastava 2006). Habitat loss causes reduction in population size in particular forest areas and ultimately increases the chances for some species to become locally extinct (Burkey 1995).

Road construction and a railway line inside the sanctuary are also threats for the Capped Langur. There is regular railway line repairing due to damages of its track especially in monsoon season after introducing the new broad-gauge line in 2015. Also, National Highway 27 is under construction inside the sanctuary and NH 54 also traverses through the western boundary of the sanctuary. A considerable number of landslide incidences take place in these tracts every year between

April and September. Once the construction of NH 27 is over, it will cause hindrance for the free movement of animals, especially Capped Langurs as they prefer to use tree canopy for travel. This aspect deserves the sincere attention of conservationists.

The increasing human population is another major threat to wild animals in the BWS. A rising population entails increasing consumption of food, water, and fuel (Ehrlich & Anne 1970; Cincotta & Engelman 2000). This leads to reducing the habitat of wildlife inside the sanctuary (Figure 3). Extension of agricultural land, especially monoculture activities, consumes the natural forests in human settlement areas near or fringe villages of the sanctuary. People residing inside the sanctuary especially tribal people have started practicing Betel Nut *Areca catechu* and Pan *Piper betel* plantation (Figure 3). Both have good market value as these are consumed by the locals as a mouth freshener and psycho stimulant i.e., creates a sense of well-being and decreases depression.

REFERENCES

Alho, C.J.R. & J.S.V. Silva (2012). Effects of severe floods and droughts on wildlife of the Pantanal wetland (Brazil)- a review. *Animals* 2: 591–610. https://doi.org/10.3390/ani2040591

Baranga, D. (2004). Red tail monkey groups in forest patches outside the protected area systems in Kampla Area. *African Journal of Ecology* 42: 78–83. https://doi.org/10.1111/j.1365-2028.2004.00465.x

Burkey, T.V. (1995). Extinction rates in archipelagoes: implications for populations in fragmented habitats. *Conservation Biology* 9: 527–541.

Chapman, C.A. & C.A. Peres (2001). Primate conservation in the new millennium: role of scientists. *Evolutionary Anthropology* 10: 16–33. https://doi.org/10.1002/1520-6505(2001)10:1<16::AID-EVAN1010>3.0.CO;2-O

Chapman, C.A. & D.A. Onderdonk (1998). Forests without primates: Primate/Plant codependency. *American Journal of Primatology* 45: 127–141. https://doi.org/10.1002/(SICI)1098-2345(1998)45:1<127::AID-AJP9>3.0.CO;2-Y

Choudhury, A. (1989). Ecology of the Capped Langur in Assam, India. *Folia Primatologica* 52: 88–92. https://doi.org/10.1159/000156385

Choudhury, A. (1996). Primates in Assam - status and conservation. *Tigerpaper* 23: 14–17.

Choudhury, A. (2013). The Mammals of North-East India, 1st ed. Gibbon Books, Rhino Foundation, Guwahati, India, 432 pp.

Choudhury, A.S., R.A. Barbhuiya & P. Choudhury (2019). Understanding people's perception and attitudes towards mammalian fauna using qualitative data: a case study in Barail Wildlife Sanctuary, India. *Journal of Threatened Taxa* 11(15): 14979–14988. https://doi.org/10.11609/jott.5283.11.15.14979-14988

Cincotta, R.P. & R. Engelman (2000). *Nature's Place; Human Population and the Future of Biological Diversity*. Population Action International, Washington DC, 80 pp.

Das, J., D. Chetry, A. Choudhury & W. Bleisch (2020). *Trachypithecus pileatus* (errata version published in 2021). The IUCN Red List of Threatened Species 2020: e.T22041A196580469. Accessed on 04 June 2022. https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T22041A196580469.en

Ehrlich, P.R. & H. Anne (1970). *Population, Resources, Environment - Issues in Human Ecology*. W.H. Freeman and Company, 383 pp.

Fahrig, L. (1997). Relative effects of habitat loss and fragmentation on population extinction. *The Journal of Wildlife Management* 61(3): 603–610. https://doi.org/10.2307/3802168

Johnsingh, A.J.T. (1985). Understand, assist, protect and conserve. *India Magazine* 5: 64–71.

Katti, M. (1992). Nightmare in Dreamland. *Hornbill* 4: 4–9.

Kays, R.W. & A. Allison (2001). Arboreal tropical forest vertebrates: current knowledge and research trends. *Plant Ecology* 153: 109–120. https://doi.org/10.1007/978-94-017-3606-0_9

Kumar, A. & G.S. Solanki (2004). A rare feeding observation on water lilies *(Nymphaeaalba)* by capped langur *(Trachypithecus pileatus)*. *Folia Primatologica* 75: 157–159. https://doi.org/10.1159/000078306

Malhi, Y., J.T. Roberts, R.A. Betts, T.J. Killeen, W. Li & C.A. Nobre (2008). Climate change, deforestation and the fate of the Amazon. *Science* 319: 169–172. https://doi.org/10.1126/science.1146961

Martins, M.M. (2005). Density of primates in four semi-deciduous forest fragments of Sao Paulo, Brazil. *Biodiversity Conservation* 14: 2321–2329.

Mir, R.A., S.K. Jain, A.K. Saraf & A. Goswami (2015). Accuracy assessment and trend analysis of MODIS-s derived data on snow-covered areas in the Sutlej basin, Western Himalayas. *International Journal of Remote Sensing* 36(15): 3837–3858. https://doi.org/10.1080/01431161.2015.1070320

Mukherjee, R.P., S. Chaudhuri & A. Murmu (1995). Population survey of South-Asian non-human primates in and around Darjeeling. *Primate Report* 41: 23–32.

Mutanga, C.N., S. Vengesayi, E. Gandiwa & N. Muboko (2015). Community perceptions of wildlife conservation and tourism: A case study of communities adjacent to four protected areas in Zimbabwe. *Tropical Conservation Science* 8(2): 564–582. https://doi.org/10.1177/194008291500800218

Pyritz, L.W., A.B.S. Buntge, K.H. Sebastian & M. Kessler (2010). Effects of habitat structure and fragmentation on diversity and abundance of primates in tropical deciduous forests in Bolivia. *International Journal of Primatology* 31: 796–812. https://doi.org/10.1007/s10764-010-9429-z

Raman, T.R.S., C. Mishra & A.J.T. Johnsingh (1995). Survey of primates in Mizoram, north-east, India. *Primate Conservation* 16: 59–62.

Rode, K.D., C.A. Chapman, L.R. McDowell & C. Stickler (2006). Nutritional correlates of population density across habitats and logging intensities in Red tail monkeys *(Cercopithecus ascanius)*. *Biotropica* 38: 625–634. https://doi.org/10.1111/j.1744-7429.2006.00183.x

Rylands, A.B. (1987). Primate Communities in Amazonian forests: their habitats and food resources. *Experientia* 43: 265–279.

Schwitzer, C., L. Glatt, K.A.I. Nekaris & J.U. Ganzhorn (2011). Responses of animals to habitat alteration: on overview focusing on primates. *Endangered Species Research* 14: 31–38. https://doi.org/10.3354/esr00334

Srivastava, A. (2006). Conservation of threatened primates of north-east India. *Primate Conservation* 20: 107–113. https://doi.org/10.1896/0898-6207.20.1.107

Srivastava, A., J, Das, J. Biswas, P. Bujarbarua, P. Sarkar, I.S. Bernstein & S.M. Mohnot (2001). Primate population decline in response to habitat loss: Borajan Reserve Forest of Assam, India. *Primates* 42(4): 401–406. https://doi.org/10.1007/BF02629631

Stanford, C.B. (1991). The capped langur in Bangladesh: Behavioural ecology and reproductive tactics. *Contributions to Primatology* 26: 1–179.

Talukdar, N.R. & P. Choudhury (2020). Attitudes and Perceptions of the Local People on Human–Elephant Conflict in the Patharia Hills Reserve Forest of Assam, India. *Proceedings of the Zoological Society* 73: 380–391. https://doi.org/10.1007/s12595-020-00343-5

Talukdar, N.R., B. Singh & P. Choudhury (2018) Conservation status of some endangered mammals in Barak Valley, Northeast India. *Journal of Asia-Pacific Biodiversity* 11: 167–172. https://doi.org/10.1016/j.japb.2018.01.011

Talukdar, N.R., P. Choudhury, R.A. Barbhuiya, F. Ahmad, D. Daolagupu & J.B. Baishya (2021). Mammals of northeastern India: an updated checklist. *Journal of Threatened Taxa* 13(4): 18059–18098. https://doi.org/10.11609/jott.6010.13.4.18059-18098

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COMMUNICATION

Feather characteristics of Common Myna *Acridotheres tristis* (Passeriformes: Sturnidae) from India

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Abstract: The systematic study of feather microstructure supports species identification, which is important in cases of illegally traded birds and bird-aircraft strikes. Our study focused on morphometric, macro- and micro-characters of feathers of Common Myna *Acridotheres tristis* from India. Among macro-characters, silver-colored filoplume feathers with pale black pigmentation on the barbs are specific for *A. tristis*. Morphometric measurements revealed that primary contour feathers (10.8±0.100 cm) were the longest and bristle feathers (1.26±0.051 cm) the shortest among all feathers. The longest (average) barb is found in primary contour feathers (1.875±0.123 cm), and the shortest in filoplume feathers (0.288±0.017 cm). We observed 3 types of nodal structures, and elongated prongs in bristle and filoplume feathers are significant characteristics of *A. tristis*. These insights into feather microstructures of *A. tristis* will aid species identification using plumology.

Keywords: Micro-structure, macro-structure, morphometry, plumology, Sturnidae.

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Author contributions: S.D.R. collected the sample; R.P.S., G.Q. and P.P. conceived the idea and supervised the research; R.P.S., and P.P. generated the funds for the study. S.D.R, G.Q., P.D. and R.P.S. standardized the methodology; S.D.R. generated the data. S.D.R., G.Q. and R.P.S. wrote the manuscript and analyzed the data. All the authors reviewed the manuscript.

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INTRODUCTION

Feathers cover the body of birds (Gill 2007) and support their survival in a wide range of climatic conditions (Lovette & Fitzpatrick 2016). The study of the microscopic structures of feathers and their systematic description (i.e., plumology) has provided a useful tool in studies of bird evolution (Chandler 1916; Dove 1997), paleontology, archeology, ecology (e.g., examining feeding habits using prey remains) and in the forensic examination of bird strikes (Dove 1997), where feather microstructures support the identification of avian species (Chandler 1916; Lei et al. 2002; Dey et al. 2021). In India only a few recent plumology studies (Dey et al. 2021; Ray et al. 2021) have been reported.

The Common Myna *Acridotheres tristis* belongs to the family Sturnidae, and is widely distributed across the Indian subcontinent. It is a medium-sized (~25 cm) bird, with no distinct sexual dimorphism (Ali & Ripley 1987; Kannan & James 2020). It is one of the world's most invasive species as per IUCN (Lowe et al. 2004), and according to Ahmed (2001), *A. tristis* is among the top five most traded avian species in Indian pet markets and in the illegal pet/avian trade (Ahmed 1997, 2013). *A. tristis* is sold at a high price in both domestic and international illegal pet markets as Hill Myna *Gracula religiosa* by disguising its appearance with slight morphological modifications (Ahmed 1997). Without detailed examination it is difficult to distinguish these species (Ahmed, 1997; Lei et al. 2002), and the high demand for *G. religiosa* in the pet trade has put pressure on population of *A. tristis*. Plumology can be used to identify these birds from their feather microstructures (Dove 1997; Lei et al. 2002; Lee et al. 2016; Dey et al. 2021; Ray et al. 2021).

In the present study, we have focused on the systematic approach to document qualitative and quantitative feather characteristics of *A. tristis* useful for identifying species-specific feather signatures. We describe specific microstructures present in both pennaceous and plumulaceous barbs that can be used as baseline data for future plumology studies in India.

METHODS

Feathers from a specimen of *A. tristis* (26.60°N; 93.47°E) were collected during a road-kill survey in September 2019 from adjacent road-stretches of Kaziranga National Park, Assam, India (Figure 1). Permissions were obtained for the collection of avian biological samples from the office of the Principal Chief Conservator of Forests, Assam Forest Department (Ref. no. WL/FG.31/Pt/Technical Committee/2018) and office order (No. 258, date: 11/01/2019) and Assam State Biodiversity Board (Ref. no: ABB/Permission/2012/82). Feathers from the collected individuals were sampled, and macro characteristics, microstructures and morphometric measurements were documented following methods described by Chandler (1916), Dove (1997), and Dey et al. (2021).

Nine different types of pennaceous and plumulaceus feathers were sampled from five different body locations (Image 1) as follows:

1. Primary contour feathers and secondary contour feathers were collected from the right wing;
2. Tail contour feathers were collected from the tail region;
3. Body contour, semiplume, down and powder down feathers were collected from dorsal, ventral, and tail regions.
4. Modified contour feathers known as bristle feathers were collected from specific locations near the eyes and beak.
5. Filoplume feathers, which are filamentous in structure, were retrieved from the right wing.

For primary contour, secondary contour, tail contour, body contour, semiplume, down and powder down types of feathers, two numbers from each type from their respective locations were retrieved for the study. Due to the location specificity, five each of bristle and filoplume feathers were collected. A total of 38 different feathers were studied to document macro characteristics and microstructures.

Based on morphometric measurements of rachis, the feathers were divided into three different regions, proximal, intermediate and distal, except for powder down and bristle feathers (Dey et al. 2021). Because of the absence of proper rachis, the powder down and bristle feathers were not divided into the three regions. From each region, five barbs were sampled for slide preparation. Five each of bristle and filoplume feathers were whole-mounted on slides. The slides were prepared using the dry mount method (Ray et al. 2021; Dey et al. 2021).

Feather macro characters were observed by focusing on three main characters: colour, pattern and texture. Morphometric characters were measured from feathers' photographs for calamus length, vane length and rachis length using imageJ software. The feather microstructures were observed and documented using LaboMed Lx 500 compound light microscope. Slides

Figure 1. Geotag location of road-killed Common Myna.

were observed under 4X, 10X and 40X magnification for different characters, including presence of sub-pennaceous region, presence of villi, shape of villi, presence of nodes, shape of nodes, presence of hooklets, presence of prongs, size of prongs, presence of ventral teeth, shape of internodes, pigmentation on nodes, internodes, and ramus.

RESULTS

Feather macro characters

The feather macro characters documented for *A. tristis* are presented in Table 1. Feather color varied from black and white to dark brown to pale white and brown, even dark brown with a tinge of white. Only filoplume feathers showed a silvery appearance with pale black colored barbs at the tip. The texture of feathers varied. Flight contour feathers (primary contour, secondary contour and tail contour feathers) and bristles that represent modified contour feathers were firmly rigid, body contour feathers irrespective of their location were semi-rigid, and semiplume, down and powder down feathers were soft and fluffy.

Feather morphometry

Calamus length, vane length and rachis length of the nine different types of feathers were measured (Table 2). The primary contour feather from the wing was the longest; the average length for the calamus was 1.45±0.050 cm, vane length 9.35±0.050 cm and rachis 10.8±0.100 cm. Bristles were the shortest feathers, with an average calamus length of 0.26±0.024 cm, average vane length of 1±0.032 cm and average rachis length of 1.26±0.051 cm. The vane and rachis length was not measured for powder down due to the absence of rachis. As there was no quill present in filoplume, only the feather and barb lengths were measured.

The average length of barbs was measured. The longest feather type i.e. primary contour feathers followed with the longest barbs measured as 1.875±0.123 cm while the barbs of filoplume feathers measured as the shortest with 0.288±0.017 cm.

Feather microstructures

The barbs from the nine different feather types of *A. tristis* were dry-mounted onto slides to observe different microstructures (Table 3) under the microscope that included elongated barbules, distinct nodes, internodes, sub-pennaceous region, villi, prongs, hooklets, ventral teeth, pigmentation and other focused microstructures, elaborated below.

Sub-pennaceous region: The barbs of all the feathers showed the absence of a sub-pennaceous region in both pennaceous and plumulaceous barbules in all feather types.

Table 1. Feather macro-characteristics.

	Feather type	Feather location	Color	Pattern	Texture
1	Primary contour feather	Wing	Black and white	No Pattern	Rigid
2	Secondary contour feather	Wing	Dark brown	No Pattern	Rigid
3	Tail contour feather	Tail	Dark brown with white tinge	No Pattern	Rigid
4	Body Contour	Dorsal	Pale brown	No Pattern	Semi-rigid
5	Body Contour	Ventral	Pale brown	No Pattern	Semi-rigid
6	Semiplume	Dorsal	Pale brown	No Pattern	Soft and fluffy
7	Semiplume	Ventral	Pale brown	No Pattern	Soft and fluffy
8	Semiplume	Tail	White	No Pattern	Soft and fluffy
9	Down	Dorsal	Pale brown	No Pattern	Soft and fluffy
10	Down	Ventral	Pale white	No Pattern	Soft and fluffy
11	Down	Tail	Pale white	No Pattern	Soft and fluffy
12	Powder Down	Dorsal	White	No Pattern	Soft and fluffy
13	Powder Down	Ventral	White	No Pattern	Soft and fluffy
14	Powder Down	Tail	White	No Pattern	Soft and fluffy
15	Bristle	Near Eye and Beak	Black	No Pattern	Rigid
16	Filoplume	Wings	Silver	No Pattern	Soft

Table 2. Feather morphometric measurements.

	Feather type	Feather location	Length (in cm)			
			Calamus ± S.E.	Vane ± S.E.	Rachis ± S.E.	Barb ± S.E.
1	Primary contour feather	Wing	1.45±0.050	9.35±0.050	10.8±0.100	1.875±0.123
2	Secondary contour feather	Wing	1.35±0.050	7.80±0.000	9.25±0.050	1.821±0.111
3	Tail contour feather	Tail	0.8±0.100	7.3±0.100	8.25±0.050	1.637±0.079
4	Body contour	Dorsal	0.2±0.000	3.85±0.050	4.25±0.050	1.391±0.026
5	Body contour	Ventral	0.35±0.050	4.85±0.050	5.25±0.050	1.646±0.043
6	Semiplume	Dorsal	0.35±0.050	3.40±0.100	3.80±0.100	1.532±0.033
7	Semiplume	Ventral	0.45±0.050	4.51±0.395	4.58±0.425	1.901±0.037
8	Semiplume	Tail	0.45±0.050	4.95±0.150	5.50±0.100	1.034±0.024
9	Down	Dorsal	0.25±0.050	3.15±0.050	3.45±0.050	1.415±0.068
10	Down	Ventral	0.3±0.000	3.45±0.050	3.70±0.100	1.604±0.064
11	Down	Tail	0.2±0.000	3.25±0.050	3.45±0.050	1.078±0.057
12	Powder down	Dorsal	0.2±0.000	N/A	N/A	1.2799±0.046
13	Powder down	Ventral	0.25±0.050	N/A	N/A	1.032±0.043
14	Powder down	Tail	0.25±0.050	N/A	N/A	0.765±0.028
15	Bristle	Near Eye and Beak	0.26±0.024	1±0.032	1.26±0.051	0.316±0.008
16	Filoplume	Wings	N/A	N/A	1.94±0.262	0.288±0.017

Villi: Villi are the unique diagnostic microstructural characteristic of passerine birds that extend out from the basal cell of the barbules, only present in the basal cell region of the plumulaceous barbs. The shape of villi was either knobbed or pointed, but sometimes both were present in the basal cells forming finger-like structures (Image 2A–B).

Nodes and their shape: The barbules of all feathers

had nodes that were swollen, with three different shapes: plain nodes (Image 2C–D), plain pronged nodes (Image 2E–F) and quadrilobed nodes (Image 2G–H). The plumulaceous barbs have all three node types, which were absent in pennaceous barbs. The quadrilobed nodes were mainly present in the proximal region of barbules (Image 2), while the distal region had plain nodes either with prongs or without prongs. These nodes were present in all the different feather types, except in powder down, bristle and filoplume feathers.

Internode shape: The region between two nodes is the internode, which is straight in shape and present in the barbules of plumulaceous barbs (Image 2C–H).

Prongs and their size: Prongs are present only on the swollen nodes. Nodes with small prongs were present in the plumulaceous barbs of primary contour, secondary contour, tail contour, body contour, semiplume and down feathers. On the nodes of the bristle (Image 2I–J) and filoplume (Image 3K–L) feathers, elongated and large-sized prongs are present. Prongs were totally absent in powder down feathers.

Hooklets: Distinct hooklets were present in pennaceous barbs of primary contour, secondary contour and tail contour feathers, and were present after the basal cells of the barbules (Image 3M–N). Hooklets were completely absent in all plumulaceous barbs of *A. tristis*.

Ventral teeth: Pennaceous barbs had ventral teeth at the end of basal cells that were less broadened (Image 3O–P).

Image 1. Common Myna with locations of feathers sampled. ©Rajesh Kumar.

Table 3. Feather microstructures.

	Feather type	Feather location	Vilii		Vilii shape	Nodes	Node shape	Prongs	Prong size	Hooklets	Ventral teeth	Internode shape	Pigmentation		
			0/1		KNB/PNT	0/1	2,3,4	0/1	S/L	0/1	0/1	STR/KNK	Nodes	Internodes	Ramus
1	Wing Feather	Right Wing	1		KNB, PNT	1	2, 3	1	S	1	1	STR	6	5	6
2	Tail Contour	Tail	1		KNB, PNT	1	2, 3	1	S	1	1	STR	6	5	6
3	Body Contour	Dorsal & Ventral	1		KNB, PNT	1	2,3,4	1	S	1	0	STR	6	5	5, 6
4	Semiplume	Dorsal, Ventral & Tail	1		KNB, PNT	1	2,3,4	1	S	0	0	STR	6,5	5	5,6
5	Down	Dorsal, Ventral & Tail	1		KNB, PNT	1	2,3,4	1	S	0	0	STR	6	5	5, 6
6	Powder Down	Dorsal, Ventral & Tail	1		KNB, PNT	1	3	0	NA	0	0	STR	5,6	5	6
7	Bristle	Near eye and beak	1		KNB,PNT	1	2	1	L	0	0	STR	6	5	6
8	Filoplume	Wings	0		NA	1	2	1	L	0	0	STR	5	5	5, 6

0—Absent | 1—Present | KNB—Knobbed | PNT—Pointed | 2—Plain pronged node | 3—Plain unpronged node | 4—Quadrilobed node | S—Small | L—Large | STR—Straight | KNK—Kinked | 5—Patchy pigmentation | 6—Dark pigmentation | NA—Not applicable.

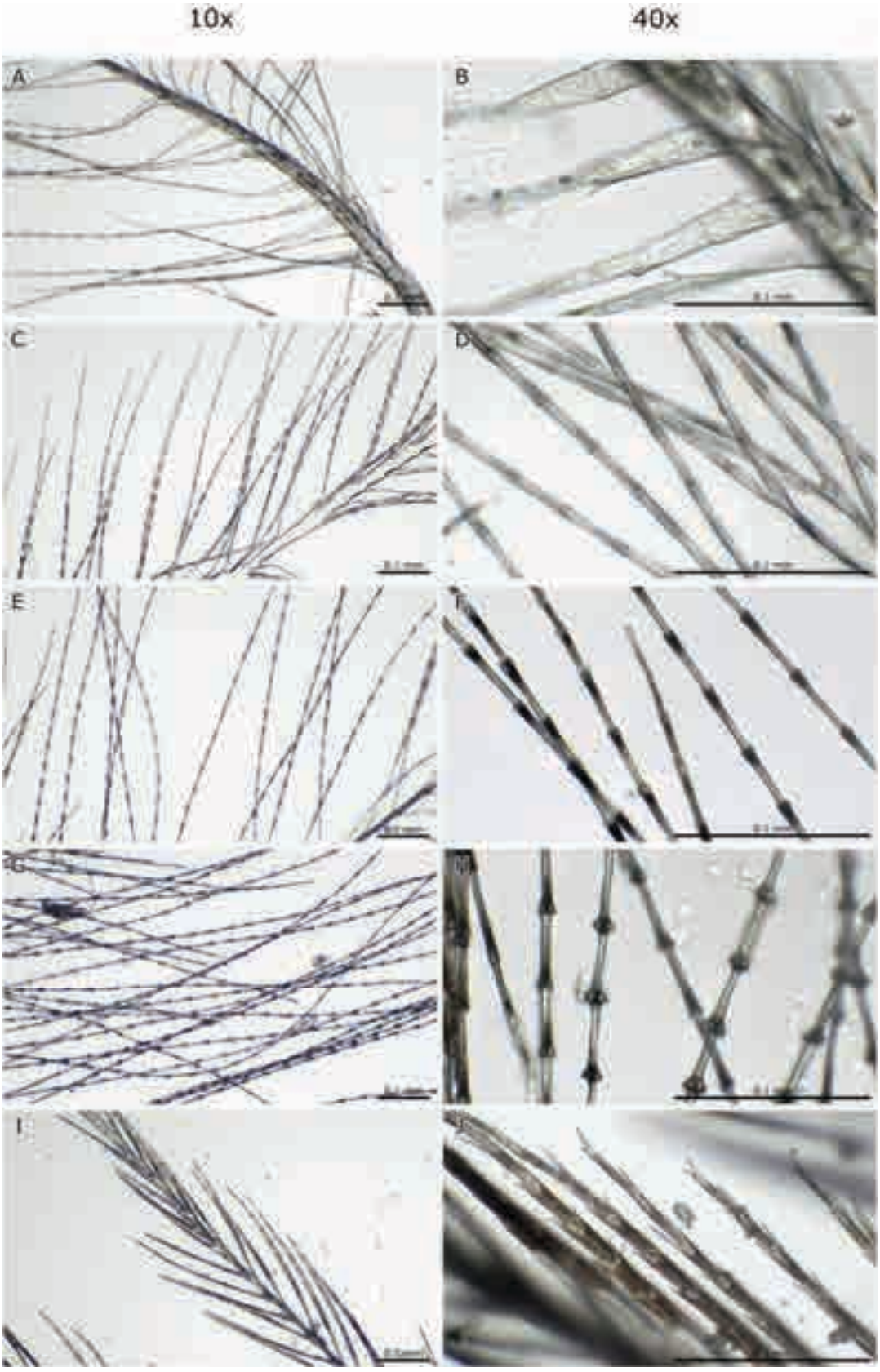

Image 2. Feather microstructures of *A. tristis*. A—Villi at 10X | B—Villi at 40X | C—Plain unpronged nodes at 10X | D—Plain unpronged nodes at 40X | E—Plain pronged nodes at 10X | F—Plain pronged nodes at 40X | G—Quadrilobed nodes at 10X | H—Quadrilobed nodes at 40X | I—Elongated prongs on bristle feathers barbs at 10X | J—Elongated prongs at bristle feathers barbs at 40X. © Swapna Devi Ray.

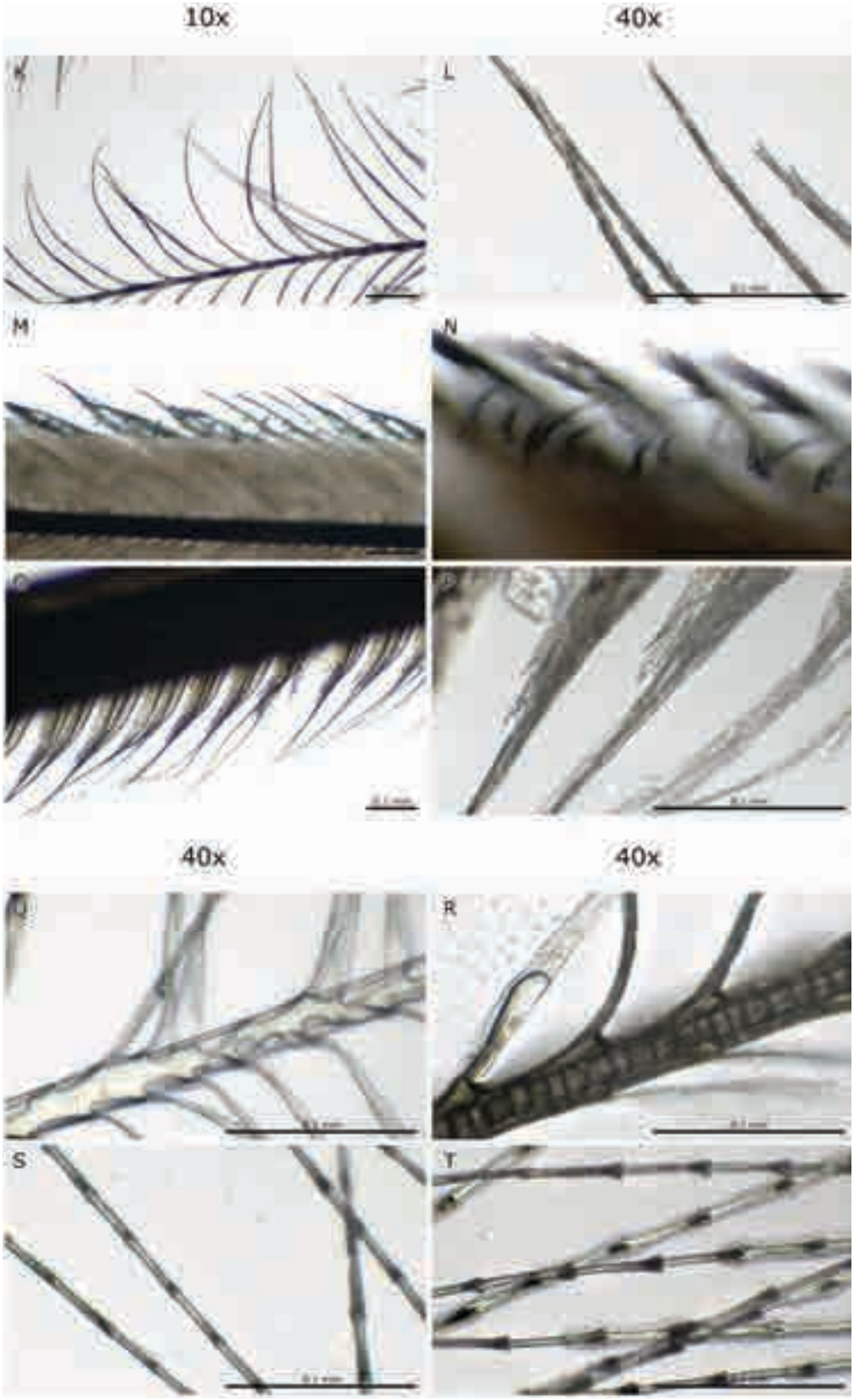

Image 3. Feather microstructures of Common Myna (*A. tristis*): K—Elongated prongs on filoplume feathers at 10X | L—Elongated prongs on filoplume feathers at 40X | M—Hooklets at 10X | N—Hooklets at 40X | O—Ventral teeth at 10X | P—Ventral teeth at 40X | Q—Patchy pigmentation on ramus 40X | R—Dark pigmentation on ramus at 40X | S—Patchy pigmentation on nodes at 40X | T—Dark pigmentation on nodes at 40X. © Swapna Devi Ray.

Pigmentation: Dark pigmentation was mainly present on the nodes where internodes mostly had patchy pigmentation. However, in the semiplume and powder down feathers, nodes had both types of pigmentation (Image 3S–T). Ramus was present with both patchy (Image 3Q) and dark pigmentation (Image 3R).

DISCUSSION

In this study we have documented feather macro-characters, morphometry and microstructures of *A. tristis*. The colour and texture of feathers mainly depends on their location in the body, and also their functional aspects (Ray et al. 2021). According to Chandler (1916), colour is the most important characteristic in species identification, and we observed silver-colored filoplume feathers with pale black pigmentation on the barbs as a specific character of *A. tristis*. It must be noted, however, that it is difficult to retrieve filoplume feathers due to their location and almost transparent nature. Except for the filoplume feathers, we recorded varying colors specific to feather types.

The texture of feathers is known to vary based on their body location and functions, such as flight, thermoregulation, signaling and protection (Lovette & Fitzpatrick 2016). The texture of the feathers of *A. tristis* mainly comprised of three types: rigid, semi-rigid, and soft and fluffy, associated with flight, protection and thermoregulation respectively. While macro characteristics and morphometric measurements tend to vary according to bird age and sex, the measurements are species-specific (Dove 2000; Lee et al. 2015). Data on feather morphometry can also provide clues about physical size (Lee et al. 2015). The present study provides ranges for feather morphometry of *A. tristis* that can be used for these purposes.

Several studies have examined the variation of diagnostic feather features among species, and among different feathers (Chandler 1916; Dey 1966; Robertson et al. 1984; Brom 1991; Dove 2000; Dove & Peurach 2002; Lee et al. 2015; Dey et al. 2021; Ray et al. 2021). These studies illustrate that the feather microstructures of a species remain the same irrespective of individual variation (Dove 1997; Lee et al. 2015; Ray et al. 2021). To identify passerine birds, Chandler (1916) stated that the pennaceous barbs would contain three to four hooklets, while Lee et al. (2015) observed the presence of the broadened shape of ventral teeth in *A. tristis.* However, Lee et al. (2015) cautioned that these microstructures cannot be used as an exclusive character for the identification of species, while Dove (2000) suggested that pigmentation patterns provide diagnostic clues for determining species groups. From our study of *A. tristis* feathers, we observed that there is no particular uniform pigmentation pattern present in nodes, internodes, and ramus. However, the presence of dark and patchy pigmentation on different shapes of nodes can be used as a micro character for the identification of *A. tristis*. Also from this study we report three microstructures that can be used in the identification of *A. tristis* species: (i) the presence of finger-like villi that are distinctively knobbed and pointed on the border of the basal cells, (ii) the presence of all three types of nodes: quadrilobed, pronged and plain, and (iii) the presence of sharply pointed pronged nodes on bristle and filoplume feathers.

CONCLUSION

Plumology uses feather macro characters, morphometry, and microstructures to aid the identification of order, family and species of birds. During our study we used a systematic approach towards identification of *A. tristis*. Macro-characters including filoplume feathers helped to identify this as a passerine species, while examination of microstructures including finger-like projection of villi, the presence of three node types and the presence of elongated prongs on the nodes of bristle and filoplume feathers were identified as specific to *A. tristis*. This study provides feather morphometry measurements for future reference as a baseline for the identification of *A. tristis* from India.

REFERENCES

Ali, S. & S.D. Ripley (1987). *Handbook of the birds of India and Pakistan. Vol. 5.* Oxford University Press, Bombay, 278 pp.

Ahmed, A. (1997). *Live Bird Trade in Northern India.* TRAFFIC India, New Delhi, 104pp.

Ahmed, A. (2001). *Fraudulence in Indian live bird trade: An identification monograph for control of illegal trade.* TRAFFIC India, New Delhi, 24 pp.

Ahmed A. (2013). 'WILDLIFE ON SALE': An insight into the Sonepur Mela, Bihar. *TRAFFIC POST* 17: 16.

Brom, T. (1991). The diagnostic and phylogentic significance of feather structures. PhD Thesis. Universiteit van Amsterdam, Instituutvoor Taxonomische Zoölogie, University of Amsterdam, viii+277 pp.

Chandler, A.C. (1916). *A study of Feathers, with reference to their taxonomic significance.* University of California Press, Berkeley, 274 pp.

Day, M.G. (1966). Identification of hair and feather remains in the gut and faeces of stoats and weasels. *Journal of Zoology* 148(2): 201–217. https://doi.org/10.1111/j.1469-7998.1966.tb02948.x

Dove, C.J. (1997). Quantification of Microscopic Feather Characters Used in the Identification of North American Plovers. *The Condor* 99(1): 47–57.

Dove, C.J. (2000). A Descriptive and Phylogenetic Analysis of Plumulaceous Feather Characters in Charadriiformes. *Ornithological Monograph* 51: 1–163.

Dove, C.J. & S.C. Peurach (2002). Microscopic Analysis of Feather and Hair Fragments Associated with Human Mummified Remains from Kagamil Island, Alaska. To the Aleutians and Beyond-The Anthropology of William S. Laughlin. *Ethnographical Series* 20: 51–62.

Dey, P., S.D. Ray, S.K. Sharma, P. Pramod & R.P. Singh (2021). Identification of a unique barb from the dorsal body contour feathers of the Indian Pitta *Pitta brachyura* (Aves: Passeriformes: Pittidae). *Journal of Threatened Taxa* 13(8): 19029–19039. https://doi.org/10.11609/jott.6362.13.8.19029-19039

Gill, F.B. (2007). *Ornithology*. Third Edition, W.H. Freeman and Company, New York City, 725 pp.

Kannan, R. & D.A. James (2020). Common Myna (*Acridotheres tristis*), version 1.0. In; Billerman, S.M. (ed.). Birds of the World. Cornell Lab of Ornithology, USA. https://doi.org/10.2173/bow.commyn.01

Lei, F.M., Y.H. Qu, Y.L. Gan, A. Gebauer & M. Kaiser (2002). The feather microstructure of Passerine sparrows in China. *Journal für Ornithologie* 143(2): 205–212.

Lowe, S., M. Browne, S. Boudjelas & M. De Poorter (2004). *100 of the World's Worst Invasive Alien Species – A Selection from the Global Invasive Species Database.* Invasive Species Specialist Group (Species Survival Commission) of the World Conservation Union (IUCN), 12 pp.

Lee, J., S.D. Sarre, L. Joseph & J. Robertson (2016). Microscopic characteristics of the plumulaceous feathers of Australian birds: a preliminary analysis of taxonomic discrimination for forensic purposes. *Australian Journal of Forensic Sciences* 48(4): 421–444. https://doi.org/10.1080/00450618.2015.107603

Lovette, I.J. & J.W. Fitzpatrick (Eds.). (2016). *Handbook of Bird Biology.* John Wiley & Sons, UK, 716 pp.

Robertson, J., C. Harkin & J. Govan (1984). The identification of bird feathers. Scheme for feather examination. *Journal of the Forensic Science Society* 24(2): 85–98. https://doi.org/10.1016/S0015-7368(84)72301-2

Robertson, G.R. (2002). Birds of a feather stick: microscopic feather residues on stone artifacts from Deep Creek Shelter, New South Wales, pp. 175–182. Proceedings of the 2001 Australian Archaeological Assoc Annual Conference, Tempus, Anthropology Museum, The University of Queensland.

Ray, S.D., P. Dey, N. Islam, S.K.S. Sharma, P. Pramod & R.P. Singh (2021). Comparative study of Yellow-billed Babbler (*Turdoides affinis*) feather reveals uniformity in their microstructure among individuals. *Journal of Experimental Biology and Agricultural Sciences* 9(1): 51–64. https://doi.org/10.18006/2021.9(1).51.64

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COMMUNICATION

Population and distribution of Wattled Crane *Bugeranus carunculatus*, Gmelin, 1989 at lake Tana area, Ethiopia

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Abstract: The Wattled Crane is listed as Vulnerable on the IUCN Red List, and isolated population occurs in Ethiopia. This study was conducted in Chimba wetlands, Lake Tana area from October–2013 to December–2014. The objectives were to understand the distribution and population status of the Wattled crane and assess the vegetation characteristics and threats of the ecological units. The population size and density of cranes in the study area was determined from weekly counts carried out in equal-sized sampling units. The total survey area was divided into square grids, and each of them was 1.23 square km wide/size. A total of 10 grid squares, which have an area of 12.32 square km were considered for density analysis. Although the total area of the study was 208.2 km^2, unsuitable habitats, such as forest or farmlands were excluded. Counts of cranes were made at known sites. The density was calculated as the average number of cranes counted per unit area. A total of 32 cranes were recorded. The density of cranes in the study area is 2.6 per km^2. Cranes were located in Addis Amba, Dehena Mesenta, Latamba, and Legdia local administrative areas. The number recorded in each area varied, the largest (17) was recorded in Latamba Kebele and the fewest (2) in Legdia. The dominant vegetation type of Chimba wetlands is emergent macrophyte. However, the papyrus bed represents about 10% of the wetland. Species of vegetation other than papyrus bed is represented by a 20 quadrat study. A total of 26 macrophyte species belonging to 10 families were recorded. Intensive cultivation, draining of the wetland, habitat degradation, overgrazing of the wetland, overharvesting of papyrus, invasive species, and over-flooding are the major threats of wetlands.

Keywords: Blue Nile, conservation, density, ecological units, egg, habitat destruction, macrophytes, nesting site, threats, wetlands.

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Author contributions: The authors have conducted the project and collected data in the field at various times. Both authors have participated in organizing and analyzing the data. The second author participated in shaping and commenting the manuscript while the first author write the draft paper.

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INTRODUCTION

Cranes (family Gruidae) are among the world's most threatened birds. Of the six species occurring in Africa, Wattled Cranes are listed as 'Vulnerable' on the IUCN Red List. Isolated populations occur in Ethiopia and South Africa, which are not considered different subspecies (Beilfuss et al. 2007; BirdLife International 2020). Wattled Cranes range across 11 countries from Ethiopia to South Africa, the majority occurring in the extensive flood plain systems of southern Africa's large river delta (especially the Kafue, Okavango, and Zambezi). They are also found in smaller wetlands throughout their range.

The status and distribution of the Wattled Crane is of particular conservation concern because of the species' life history traits (e.g., delayed sexual maturity and low reproductive output) and specialized habitat requirements (Johnsgard 1983). Wattled Cranes are the most wetland-dependent of all Africa's cranes (Meine & Archibald 1996). When hydrological conditions are not satisfactory at a particular location due to drought, flooding, or inappropriate water management, most Wattled Cranes fail to initiate nesting (Douthwaite 1974; Konrad 1981). The availability of the Wattled Crane's main food source, underground tubers of spike rushes (*Eleocharis* spp.), water lilies (*Nymphaea* spp.) and various sedge species (especially *Cyperus* spp.), is also negatively affected by disruption in the regular annual cycle of flooding and drying (Beilfuss 2000).

Three populations of the Wattled Crane are recognized. The core population occurs in southern central Africa on the primary floodplains and dambos of the upper Congo, Zambezi, and Okavango river basins. More isolated populations occur in Ethiopia and South Africa, with the Ethiopian population likely to be a distinct subspecies (Jones 2003). However, this isolated population presently is not considered as a separate subspecies (Beilfuss et al. 2007).

The total population of the species was 13,000–15,000 in 1974–1994. However, it declined to 8,000 in 2004, with the highest population residing in Zambia (4,500). The population and distribution of Wattled Cranes in Ethiopia is poorly known. A survey report in 2004 estimated less than 200 birds (Beilfuss et al. 2007). However, a recent survey in 2017 suggested that a total of 366 were recorded because additional survey sites were added (Zelelew et al. 2020).

The three species of cranes found in Ethiopia; Wattled Crane, Eurasian Crane and the Black Crowned Crane occur in different sites of the Lake area (Francis & Aynalem 2007; Aynalem et al. 2011). Wetlands of Chimba, Yiganda, Gorgora and the Fogera wetland plain are the major locations for the cranes. Past records show that the Wattled Cranes occurred over a large range and different habitats in Ethiopia (Urban & Walkinshaw 1967). However, recent studies showed that they are distributed in the central, southern, and northwestern parts of the country (Zelelew et al. 2020). Chimba wetlands are the breeding grounds of the Wattled Crane (Aynalem et al. 2011). Although these sites are known for breeding and foraging, total population estimate of the species is still not known. Therefore, baseline information on the distribution, population of the species, the vegetation characteristics of the wetlands, and threats to the species can provide a starting point for future monitoring, conservation planning, and developing management intervention. Therefore, the objectives of this study were to determine the distribution, population estimate, and assess the vegetation characteristics of the wetlands, and the threats of ecological unit conservation targets.

MATERIALS AND METHODS

Study area

The study was conducted in the lake Tana area of Ethiopia. The southwestern part of the lake, particularly the wetlands situated along the Gilgel Abay River, was the main focus of the study (Figure 1). Lake Tana is the largest lake in Ethiopia, ca. 68 km wide and ca. 73 km long, and is the source of the Blue Nile. About 83 wetland bird species have been recorded here and their total population around Lake Tana is likely to exceed 100,000 individuals seasonally (Francis & Aynalem 2007).

Chimba wetlands are situated along the Gilgel Abay River. It is bounded by 13 local administrative Kebeles (small districts that have at least 2,000 households), whereas the wetland itself covers four Kebeles: Latamba, Legdia, Addis Amba, Dehena, and Mesenta. Seasonal flooding occurs during the rainy season, June–September. Conventional farming is practiced in the area. Chimba wetlands harbor an enormous number of resident and migratory bird populations. It is home to the largest Black Crowned Crane population of Ethiopia next to the Gambela wetland flood plains (Zelelew et al. 2020). It is also the only place where extensive papyrus beds remain in the Lake Tana area.

The study area is situated within the temperate, cool sub-humid highland agro-ecological zone (Sime & Solomon 2017). The elevation of Chimba wetland area varies from 1,790–1,812 m. The mean annual rainfall at

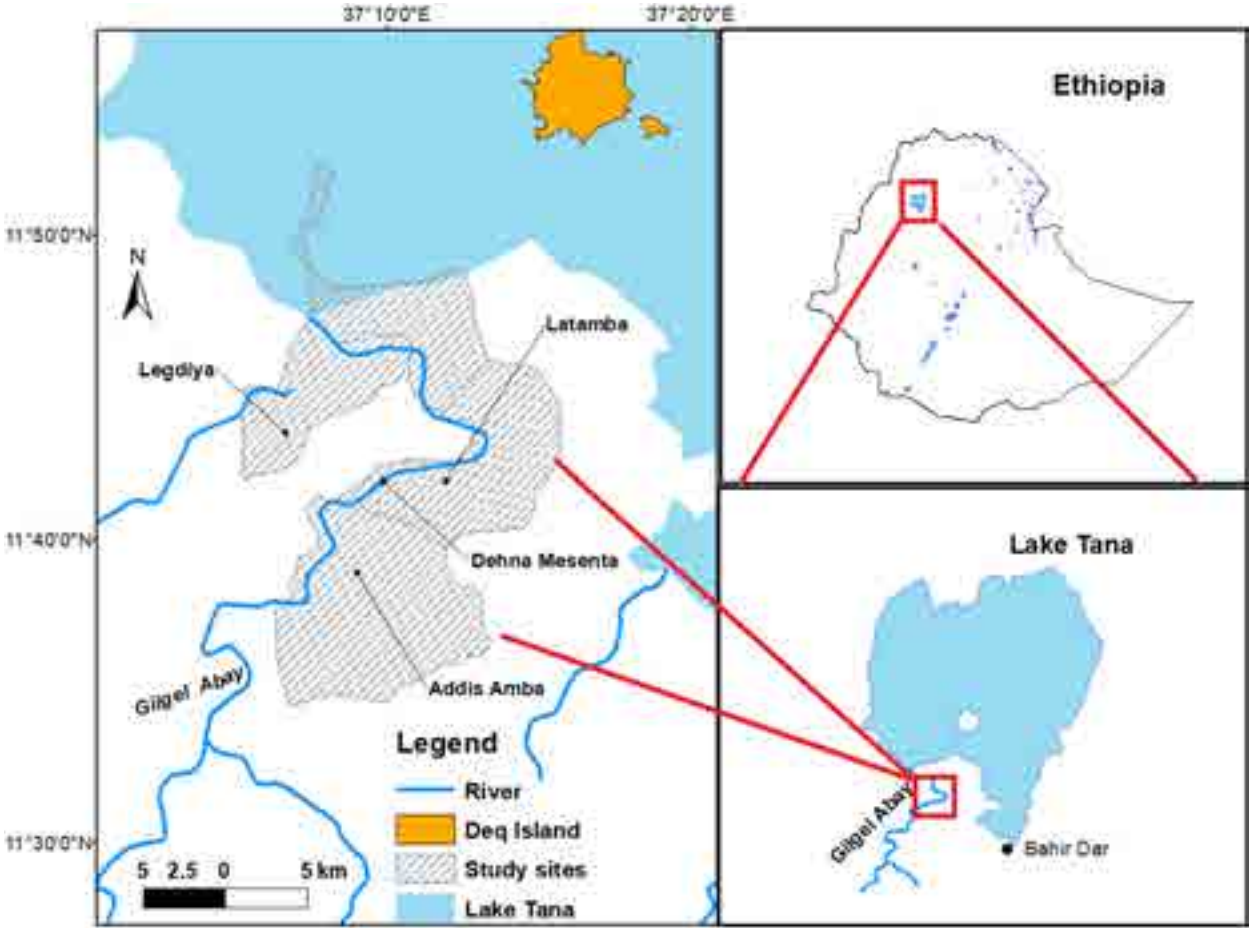

Figure 1. Study area, Chimba wetlands, and southwestern parts of Lake Tana.

Bahir Dar station is 1,439 mm. The rainfall in the area has a unimodal peak extending from May–October followed by the dry season from November–April. Ninety five percent of the annual rainfall occurs during the wet season (May–October).

The geographical coordinates where Wattled Crane occurs was recorded and mapped using ArcGIS 9.3 Software to show where the species are concentrating. Single species count method was employed. The typical feature of the habitat was determined (Bibby et al. 1992; Sutherland 1996; Lloyd et al. 1998).

Distribution and population

The population size and density of cranes in Lake Tana area was assessed from 10 October 2013 to 30 December 2014. The study area was divided into 1.23 km squares based on the size of the wetland and transferred to a GIS map during field work. Weekly counts of cranes were made in 10 grid squares selected systemically where cranes reside (Krebs 1978).

Search for cranes started from 0800 h up to 1800 h since the survey area was spread out and inaccessible. Ground surveys were done by walking and a car was used to reach the study areas.

Breeding pairs (territorial pairs) and non-breeding ones (in this case family groups) were searched for by a person walking along the edge of the wetland and stopping frequently to scan using binoculars and spotting scope for birds. When nests were encountered the distance from the observer and the approximate coordinates of the nests were recorded by indicating the position relative to the grid map. Additional information such as crane roosting site, foraging places, nesting sites and any local movement of cranes from the local people was recorded while surveying the birds.

The population size and density of cranes in the study area was determined from weekly counts carried out in equal-sized sampling units as described by Joly (1969). These sampling units using *x* and *y* coordinates a 'go to' function in the GPS was practiced in the field to find the exact place. A total sampled area of 12.32 km^2 where cranes occur was considered. However, the total area of

the study was 208.2 km^2. Areas that were covered by unsuitable habitat, such as forest or farm land, were excluded. Counts of cranes were made at known sites.

The population density (R, birds/square km), was estimated using the following equation,

$$R = \sum y / \sum z$$

where, *y* is the number of birds in a quadrat and *z* is the area of the quadrat. The population size (Y) for each survey period was calculated from the average number of birds counted in each quadrat.

Vegetation

Macrophytes were collected at each sampling site using one by one meter quadrat sampling method. A total of 20 quadrats were collected. The quadrats were laid along a diagonal line with an interval of 50 m. Papyrus were excluded for sampling since the vegetation cover is distinct and known (10% cover). The collected unknown specimens were identified to the species or genus level at the Addis Ababa University Herbarium. The proportion of macrophyte cover per sampled area was estimated.

Materials

Observations were carried out with the aid of Nikon 12 x 25 © binoculars and 20–60x Swarovski Telescope. GPS eTrex® model 2004 was used to apply 'Go to' function, which was used to find the specified selected quadrat, and also to limit the transect length. Grid map was used during the actual field work. Sony '16' optical lens digital camera and Leica professional camera were utilized to take pictures of the habitat components, features, and the macrophytes.

Threats

Threat types for each ecological unit were listed out during field observation. Then each threat type was evaluated based on their "severity" and "scope", and their conservation priority was also evaluated by "ranking" them as very high, high, medium and low. The ecological units' such as wetlands, indigenous trees, macrophytes, shrubs and some wild animals' were the conservation targets in the area. Their conservation status of these ecological units were evaluated based on the threat types that are listed out already. And hence to indicate the degree of threat severity, a "severity" index was assigned for each threat. A very high level was given for the total eliminated ecological unit in the area, high for seriously degraded, and medium for moderately degraded and low for slightly impaired ecological components. Whereas, for the "scope", which shows the extent of damage of the area, spatially: very high evaluation was given for 75% prevalence of the threat, high for 50–75 % widespread threats, medium for the threats that are localized in limited spots, and low for very localized spread. Based on this evaluation, a threat matrix table was developed to provide priority of management action to conserve which ecological unit.

RESULTS

Distribution and population

A total of 30 adults and two juvenile Wattled Cranes were recorded in the sampled area (Image 1). The density of Wattled Cranes in the study area is 2.6/ km^2.

Cranes were observed in four Kebele's areas (Legdia, Latamba, Dehena Mesenta, and Addis Amba). The number of Wattled Cranes recorded in each Kebele was: Addis Amba, five; Legdia, two; Dehena Mesenta, eight; and Latamba, 17. All places are nesting sites for the species. However, Latamba Kebele was a very important site for Wattled Crane nesting sites because the nesting area is larger than the others.

Lam Gebya, Basha Dangela at Latamba Kebele, and Addis Amba area are nesting sites that are far apart from each other. During the study period, two nests were identified. The nesting sites were located where disturbance from people were less. The average water depth where the nests are built was about 60 cm. The nesting materials were mainly sedge plants cut from the surrounding area. However, no chick was observed. But, for the first time, one egg that weighed 213.7 g was measured during October 2014.

Vegetation characteristics

The dominant vegetation type of Chimba wetlands are the emergent macrophytes and papyrus bed. A total of 26 macrophytes belonging to 10 families were recorded (Table 1). However, the major macrophytes were: *Cyperus rotundus, C. papyrus, Echinochloa colona, E. stagnina, Hygrophila schulli, Ipomoea aquatic, Leersia hexandra, Ludwigia stolonifera, Nymphaea nouchali, Oryza longistamina, Perscaria senegalensis, Potamogeton thunbergii*, and *Sacciolepis africana*.

The papyrus bed represents about 10% of the wetland area and is located around 'Achifi Gott' and 'Lamm Gebya' in Latamba Kebele and Dhana Mesenta area. The proportion of macrophytes other than papyrus was estimated in the sample quadrat (Figure 2).

Image 1. Sampled area Wattled Cranes in Chimba wetland. © Shimelis Aynalem Zelelew, 2014.

Table 1. List of macrophytes in Chimba wetlands (Local status), Lake Tana area, 2014.

Family	Species	Growth habit	Status	Remark
Acanthaceae	*Dyschoriste radicans* Nees	Herb	LC	Weed
	Dyschoriste sp.	Herb	LC	Weed
	Hygrophila schulli (Hamilt.) MR. & S.M. Almeida	Herb	LC	Weed
Ceratophyllaceae	*Ceratophyllum demersum*	Submerged		
Convolvulaceae	*Ipomoea aquatic* Forssk.	Emergent	LC	Aquatic floater
Cyperaceae	*Cyperus papyrus* L.	Aquatic	LC	Emergent
	Cyperus longus L.		LC	Emergent
	Cyperus macrostachyos	Sedge	LC	Emergent
	Cyperus dives		LC	Emergent
	Cyperus rotundus			
Menyanthaceae	*Nymphoides indica* (L.) O.Kunze	Water herb		Float leaves
	Nymphaea lotus	Water herb		Float leaves
	Nymphaea nouchali var. caerulea	Water herb		Float leaves
Onagraceae	*Ludwigia stolonifera* (Guilt L. & Perl'.) Raven	Creeper		Aquatic
	Ludwigia sp.			
Poaceae	*Hyperrhenia rufa* Staps	Grass	LC	Terrestrial
	Andropogon gayanus Kunth.	Grass		Terrestrial
	Snowdenia polystachya Pilg	Grass		
	Echinochloa colona (L.) Link	Aqu.Grass		Aquatic
	Echinochloa stagnina (Retz.) P. Beauv.	Aqu.Grass		Aquatic
	Leersia hexandra SW.	Aquatic		
	Sacciolepis africana CE. Hubb. & Snowden			
	Oryza longistaminata A. Chev. & Roehr.	Aquatic		
	Eleusine africana	Semi aquatic		Edge part of wetland
	Phragmites australis. (Cav.) Trin. ex Steud.	Aquatic		
Pollygonaceae	*Persicaria senegalensis* (Meisn.) Sojak	Aquatic	LC	Creeper
Potamogetonanceae	*Potamogeton thunbergii* Cham. & Schlecht.	Submerging		
Typhaceae	*Typha latifolia*	Aquatic		

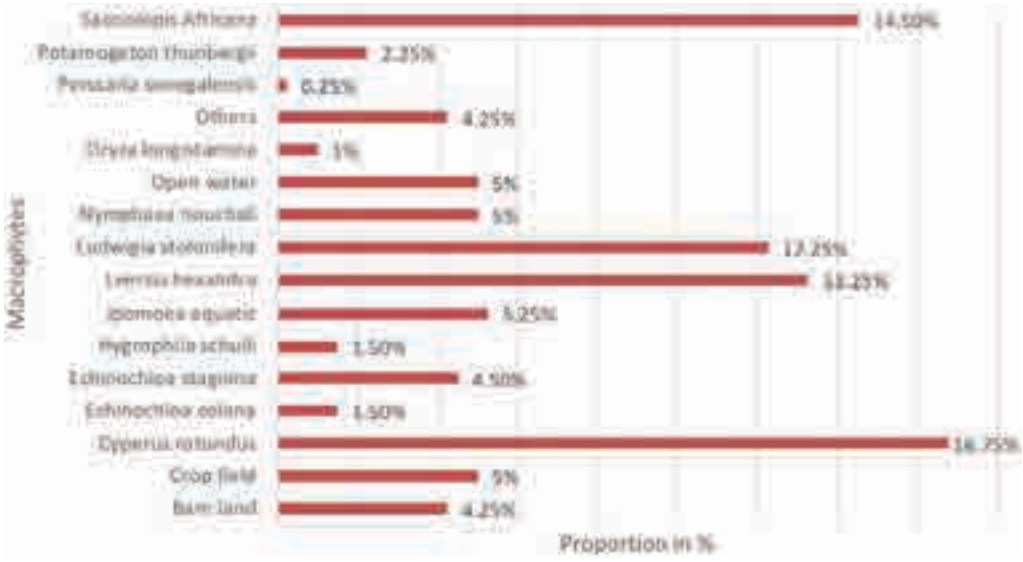

Figure 2. Relative proportion of macrophytes, except papyrus in Chimba wetlands, 2014

Image 2. Pumping water for Khat C. edulis cultivation at Chimba wetland Lam Gebya area. © Shimelis Aynalem Zelelew, 2013.

Ecological unit conservation targets threats

The ecological unit conservation targets were identified as: wetlands, riverine habitat, indigenous trees (like fig trees, *Sezigum gunensie*, *Millettia ferruginea*, *Mimousops kummel*), macrophytes (like some of them C*yprus papyrus*), fishes, some primate species (Grivet Monkey and Common Baboons), mammals (Water Buck), birds (like cranes, water birds, passerine birds), and amphibians and reptiles (Table 2). The threats that are potentially of harm to these ecological units are listed out (Table 2).

As observed in the study area, water is drained for Khat *Catha edulis* cultivation (Image 2). Expansion of this activity has affected the wetland ecosystem as the wetland dries fast before the next rain. The presence of a large cattle population has also degraded the nesting sites of cranes. Bare land is created around the wetland (Image 3). The flood also results in sediment accumulation. This has affected Wattled Crane feeding and nesting sites. Some wetland vegetation is being rooted out due to intensive cultivation.

Seasonal flooding during the wet season and water shortage during the dry season and self-removal of wet biomass were observed. Overgrazing, wetland draining, habitat fragmentation, and farming have affected the natural ecological process, which have impacts on breeding and feeding sites of cranes. This creates competition for habitat, reduction of breeding grounds leading to decrease in the viable population, and ecosystem destruction. Encroachment of agriculture on wetlands and overgrazing have affected the papyrus bed that is important for breeding and feeding sites of birds, reptiles, amphibians, and fishes as well. Since the area is a communal land, there is no proper management activity.

Table 2. Ecological unit conservation targets, threat. and ecological levels.

	Ecological unit conservation targets	Threats	Severity	Scope	Ranking	Ecological level
1	Wetlands and Gilgel Abay riverine habitat	Habitat degradation	High	V. High	V. High	Ecosystem
		Draining of wetland	Medium	Low	Low	Ecosystem
		Over grazing	Medium	V. high	V. high	Ecosystem
		Cultivation and encroachment	Medium	High	High	Ecosystem
		Vegetation removal	High	Medium	high	Ecosystem
		Flooding	High	High	High	Ecosystem
		Invasive species	Medium	High	Medium	Ecosystem
2	Indigenous trees macrophyte and shrubs	Deforestation	High	V. High	V. High	Community
		Overgrazing	High	V. High	V. High	Community
		Agriculture encroachment	High	V. High	V. High	Community
		Sedimentation	High	Medium	High	Community
		Invasive species	Medium	Medium	Medium	Community
3	Fig trees, *Sezigum gunensie* , *Millettia ferruginea, Mimousops kummel* , *Cyprus papyrus*	Deforestation	V. High	V. High	V. High	Species
		Charcoal making	Medium	Medium	Medium	Species
		Construction	Medium	Low	Low	Species
		Lumber production	Medium	Low	Low	Species
		Burning (intentional)	Low	Low	Low	Species
4	Fish	Overfishing	Medium	Low	Low	Species
		Habitat loss	High	Low	Medium	Species
		Water Channelization	Medium	Low	Low	Species
		Wetland degradation	High	Medium	Medium	Species
5	Primate species Grivet Monkey and Common Baboons; Water Buck	Habitat degradation	V. High	V. High	V. High	Species
		Killing (to remove them)	Low	Low	Low	Species
		Grazing competition	Low	Low	Medium	Species
6	Birds (cranes, water birds, passerine birds)	Wetland degradation	High	V. High	V. High	Species
		Vegetation removal	High	High	V. High	Species
		Overgrazing	High	V. High	V. High	Species
		Breeding and feeding site loss	High	High	V. High	Species
7	Amphibians and reptiles	Wetland degradation	V. High	High	High	Species
		Killing (to remove them)	High	High	High	Species
		Food shortage	V. High	V. High	V. High	Species
		Breeding and feeding sites loss	V. High	V. High	V. High	Species
		Decreased water flow	Medium	Medium	High	Species

Image 3. Siltation after flooding in Chimba wetland adjacent to Gilgel Abay River. © Shimelis Aynalem Zelelew, 2013.

DISCUSSION

The occurrence of 32 individuals of Wattled Cranes showed that the population has increased compared to 27 recorded in 2009 (Aynalem et al. 2011). It could be even more since inaccessibility and the limited position available to view the majority area of the breeding wetlands could underestimate the number of breeding nests recorded and also the number of juveniles. In addition to this factor, delayed sexual maturity and low reproductive output and specialized habitat requirements could account for low number of population (Johnsgard 1983). Particularly, when hydrological conditions are not satisfactory at a particular location due to drought, flooding, or inappropriate water management, most Wattled Cranes fail to initiate nesting (Douthwaite 1974; Konrad 1981). The lack of availability of the Wattled Crane's main food source, underground tubers of spike rushes (*Eleocharis* spp.), water lilies (*Nymphaea* spp.), and various sedge species (especially *Cyperus* spp.), also affects the annual cycle of flooding and drying (Beilfuss 2000).

Wattled Cranes are distributed in the extensive wetland areas of Legdia, Latamba, Dehena Mesenta and Addis Amba Kebele. The distribution of cranes and the number of individuals/population is related to the presence of secure habitats, nesting and feeding sites. Several of the Wattled Cranes were located around their nesting sites because most cranes need undisturbed nesting sites, except the Indian Sarus Crane (*Grus antigone*), which is highly tolerant of human activity. Wild cranes generally nest in isolated places where the risk of predation is minimal (Archibald & Meine 1996; Claire et al. 1996; Bento et al. 2007; Sundra 2009); but studies carried out on nest success of Greater Sandhill Cranes at Malheur National Wildlife Refugia, Oregon showed that nest concealment has no relationship with nest success (Ivey 2007). However, in the breeding grounds of Wattled Crane at Lake Tana, nests were built in secure and inaccessible places. This kind of behavior accounted for fewer number of nesting sites at Chimba area though there is more than 208 ha of papyrus bed. Similarly, the breeding and nesting sites have been repeatedly used by the species since the beginning of 2008 at Lake Tana area (Aynalem et al. 2011). This indicates that Wattled Cranes are loyal to their nesting sites. Unless they are disturbed, nesting site consistency has been also reported by Bento et al. (2007) in the Marromeu complex of the Zambezi Delta.

Papyrus swamp is an important habitat supporting a wide diversity of species such as Sitatunga Antelope *Tragelaphus spekei* and African Python *Python sebae* (Aynalem & Mengitu 2017); several birds with restricted distribution, including the Papyrus Lesser Swamp Warbler *Acrocephalus glacilirostris* at Chimba wetlands. They provide breeding and feeding ground for numerous species of fish, and also grazing of large herbivores (Aynalem 2017).

The two major threats to wetlands in the area are habitat destruction through agricultural development and over-exploitation (Aynalem 2017). This has affected Wattled Crane feeding and nesting sites. Some wetland vegetation is being rooted out due to intensive cultivation, because private lands are not clearly demarcated from communal ones.

Apart from major biodiversity and ecological ecosystem services, a wide range of regulatory ecosystem services are provided by Papyrus swamps. The services include water, carbon and nitrogen cycles and buffering capacity for sediment and nutrient loads, as well as services of benefit to communities, including biofuel, drinking water, building materials, and flood control (Maltby 1986).

Seasonal flooding during the wet season and water shortages during the dry season and self-removal of wet biomass were observed. Overgrazing, wetland draining, habitat fragmentation, and farming have affected the natural ecological process. These practices have affected the breeding and feeding sites of cranes. This creates habitat competition, reduction of breeding grounds leading to decrease in viable population, and ecosystem destruction. Encroachment of agriculture on wetlands and overgrazing have affected the papyrus bed that is important for breeding and feeding sites of birds, reptiles, amphibians and fishes as well; this phenomenon was described in developing countries (Dugan 1990). Since the area is a communal land, there is no proper management activity.

Threats on the ecological setup of wetlands arose from two major directions. First, from natural processes, which could affect the normal functioning of natural processes derived from natural forces such as seasonal flooding during the wet season and water shortage during the dry season. This phenomenon is linked to the Inter Tropical Convergent Zone (ITCZ) location of the area (Mohamed et al. 2005). The ITCZ is characterized by a low-pressure zone at the meeting point between the dry northeasterly and moist southwesterly winds, and is the major reason for a rainfall season in the area. Bahir Dar annual rainfall records show there are pronounced periods of wetter and drier fluctuations. The early period (1966–1977) was comparatively

wet (average 1,661 mm), but this was followed by a dry period (1978–1987) with an annual average of 1,239 mm. The driest year in the record was 1983, with an annual rainfall of 895 mm. The wettest year was 1973, when the total rainfall was 2,036 mm. The mean and median of the annual series rainfall were 1,439 mm and 1,468 mm, respectively. Seventy percent of the annual rainfall was above 1,300 mm and 80% was above 1,200 mm. Self-removal of wet biomass could also account as a threat. Overgrazing, wetland draining, habitat fragmentation, and farming have also impacted the area. This phenomenon leads to competition, reduction of breeding grounds, and then decrease of viable population. In Chimba area, encroachment of agriculture on wetlands and overgrazing are affecting the papyrus bed.

Wattled Cranes are flagship species requiring extensive wetlands for feeding, breeding and resting. Chimba wetlands are the only areas that support these life processes for this globally threatened species. Since the area is free grazing land, community based sustainable utilization management must be implemented to save this threatened species and other life forms as well.

REFERENCES

Archibald, G.W. & C. Meine (1996). Ecology, Status, and Conservation, pp. 263–292. In: Ellis, D.H., G.H. Gee & M.C. Mirande (eds.). *Cranes: Their Biology, Husbandry, and Conservation*. Department of the Interior, National Biological Service and Washington, DC, and the International Crane Foundation, Baraboo, Wisconsin, xii+318pp.

Aynalem, S. (2017). Birds of Lake Tana Sub-Basin, pp. 179–206. In: Stave, K., G. Goshu & S. Aynalem (eds.). *Social and Ecological System Dynamics: Characteristics, Trends, and Integration in the Lake Tana Basin, Ethiopia.* Springer International Publishing, Switzerland, 645 pp.

Aynalem, S., G. Nowald & W. Schroder (2011). Observation on the biology and ecology of cranes: Wattled Cranes (*Bugeranus carunculatus*), Black Crowned Cranes (*Balearica pavonina*), and Eurasian Cranes (*grus grus*) at Lake Tana, Ethiopia. INDWA. *Journal of African Crane Research and Conservationist* 7: 1–12.

Beilfuss, R. (2000). Piecing together the story of an African floodplain: water, wetlands, and Wattled Cranes. *ICF Bugle* 26: 1–3.

Beilfuss, R., T. Dodman & E.K. Urban (2007). The status of cranes in Africa in 2005. *Ostrich* 78: 175–184.

Bento, C.B., R.D. Beilfuss & P.A.R. Hockey (2007). Distribution, structure and simulation modeling of the Wattled Crane population in the Marromeu Complex of the Zambezi Delta, Mozambique. *Ostrich* 78: 185–193.

Bibby, C.J., N.B. Collar, M.J. Crosby, M.F. Heath, C. Imboden, T.H. Jonston, A.J. Long, A.J. Satterfield & S.J. Thirgood (1992). *Putting Biodiversity on the Map: Priority Areas for Global Conservation*. Barrington Press, Cambridge, 239 pp.

Birdlife International (2020). Species factsheet: *Bugeranus carunculatus*. Downloaded from http://www.birdlife.org on 31 May 2020**.**

Claire, M.M, F.G George, B. Ann & W. Peter (1996). Egg and semen production, 45–58 pp. **In:** Ellis DH, Gee GH and Mirande MC (eds.). *Cranes: Their Biology, Husbandry, and Conservation*. Department of the Interior, National Biological Service, Washington, DC, and the International Crane Foundation, Baraboo, Wisconsin, xii+318pp.

Douthwaite, R.J. (1974). An endangered population of Wattled Cranes. *Biological Conservation* 6: 134–142.

Dugan, P.J. (ed.) (1990). Wetland Conservation: A Review of Current Issues and Required Action. IUCN, Gland, 192pp.

Francis, I.S. & S. Aynalem (2007). Bird surveys around Bahir Dar-Lake Tana. Important Bird Areas Report, Ethiopia. 93 pp.

Ivey, G.L. (2007). Factors Influencing Nest Success of Greater Sandhill Cranes at Malheur National Wildlife Refuge, Oregon. M.Sc. Thesis. Oregon State University, Oregon, 48pp.

Johnsgard, P.A. (1983). *Cranes of the World*. Indiana University Press, Bloomington. 316 pp.

Joly, G. (1969). Sampling methods for aerial census of wildlife populations. *East African Agricultural and Forestry Journal* 34: 50–55.

Konrad, P.M. (1981). Status and ecology of Wattled Crane in Africa, pp. 220–237. **In:** Lewis, J.C. & H. Masatomi (eds.). *Crane Research around the World. Proceedings of the International Crane Symposium at Sapporo, Japan*. International Council for Bird Preservation, Sapporo.

Krebs, C.J. (1978). *Ecology: experimental analysis of distribution and abundance of animals*. 2nd ed. Harper and Row, New York, 688 pp.

Lloyd, H., A. Cahill, M. Jones & S. Marsden (1998). Estimating Bird Densities Using Distance Sampling, pp. 35–52. In: Bibby, C., M. Jones & S. Marseden (eds). *Expedition field techniques, Bird surveys*. Royal Geographical Society with the Institute of British Geography, London, 134pp.

Maltby, E. (1986). Waterlogged Wealth: Why waste the world's wet places? International Institute for Environment and Development and Earth scan, London, 200 pp.

Meine, C.D. & G.W. Archibald (1996). The Cranes: Status Survey and Conservation Action Plan. IUCN, Gland, 293 pp.

Mohamed, Y.A., B.J.J.M. van den Hurk, H.H.G. Savenije & W.G.M. Bastiaanssen (2005). Hydroclimatology of the Nile: results from a regional climate model. *Hydrology and Earth System Science* 9: 263–278. https://doi.org/10.5194/hess-9-263-2005

Sundra, K.S.G. (2009). Are rice paddies suboptimal breeding habitat for Sarus Cranes in Uttar Pradesh, India? *The Condor* 111(4): 611–623.

Sime E. & B. Solomon (2017). Hydrology of Lake Tana Basin, pp. 117–126. In: Stave, K., G. Goshu & S. Aynalem (eds.). *Social and Ecological System Dynamics: Characteristics, Trends, and Integration in the Lake Tana Basin, Ethiopia.* Springer International Publishing, Switzerland, 645 pp.

Sutherland, W.J. (1996). *Ecological Census Techniques*: *A handbook*. Cambridge University Press, London. 336 pp.

Urban, E.K. & L.H. Walkinshaw (1967). The Wattled Crane in Ethiopia. *Auk*. 84: 263–264.

Zelelew, S.A., N. Günter, A. George, T. Hadis, A. Abebayehu, M. Kerryn & G.M. Tariku (2020). Distribution and population estimates of four crane species in Ethiopia: a global crane hotspot facing increasing threats. *Scopus: Journal of East African Ornithology* 40(2): 1–17.

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COMMUNICATION

Waterbird assemblage along Punatsangchhu River, Punakha and Wangdue Phodrang, Bhutan

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Abstract: Crossing Bhutan is one of the shortest transits, and Bhutan holds the main breeding refuge/habitats for many Central Asian migratory birds. Our study assessed the community structure of waterbirds along the Punatsangchhu River basin, located towards the western part of Bhutan. The study determined the species composition, habitat use and preference of waterbirds, together with the different habitats present. Furthermore, the study examined the potential drivers of habitat fragmentation along the river. The entire study area was classified into five different habitats: dam, dredged area, farmland, urban, and pristine. The Cummings method of habitat assessment for high gradient river and streams was used to assess the habitat variables such as bank stability, vegetative protection and the riparian vegetation zone along the river and the association with the diversity of aquatic birds. A questionnaire survey was also used to evaluate the degree of threats caused by human disturbances. Among the five habitats, the dam area recorded the highest diversity (H` = 2.13) against their total count of 103 (8.7%) and the least diversity was recorded from farmland area (H` = 1.1) against their total count of 282 (23.8%) birds. Most waterbirds preferred an open area with shallow river depth. Habitats with emergent vegetation negatively correlated with the waterbird species composition. The study also recorded one Vulnerable species *Aythya ferina*, one Near Threatened species *Vanellus duvaucelii*, and one Endangered species *Haliaeetus leucoryphus*. Punatsangchhu is a major habitat to both resident and migratory waterbirds which stop here enroute from the Palaearctic and Indo-Malayan Region corroborating the need for habitat conservation and management regimes in the basin.

Keywords: Avifauna, dam, diversity, dredged area, farmland, habitat, pristine, threats, town.

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Author contributions: N—conceived and designed the research from the initial stage. He was also actively involved in collection of data from the field. In addition, he analyzed the data and wrote the first draft of manuscript. UD—supervised the study. He assisted in developing research framework and proposal since the initial stage. As a corresponding author, he also performed the analysis using statistical tool R and reviewed the manuscript after getting comments from reviewers.

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INTRODUCTION

Waterbirds are the most visible visitors to wetlands, and they are also useful bio-indicators and models for investigating a number of environmental issues (Datta 2011). Wetland avifauna serve as indicators of wetland quality, as well as criteria for evaluating restoration success and regional biodiversity (Kumar & Gupta 2009). They account for roughly 10% of all bird species globally and are frequently employed as surrogate indicators of water quality, chemical contamination, prey availability, and vegetation characteristics in wetland ecosystems (Datta 2011).

Bhutan is home to 753 (Tshultrium & Wangchuk 2021) different bird species, with 137 (UWICER 2014) being waterbirds. Bhutan is also the pivotal transit and nesting place for many Central Asian migratory birds. Bhutan considers its resident waterbirds, as well as wintering and passage migrating waterbirds, to be national treasures, and has enacted legislation to safeguard them. "Waterfowl" is defined by the Ramsar Convention as species of birds that are ecologically dependent on wetlands, and "Waterbird" is defined as synonymous with "waterfowl" to apply the Convention (Mundkur & Nagy 2012). Effective conservation and management of wetlands biodiversity involves data on species status and threats to inform decision-making (Stephenson et al. 2020). Therefore, diversity of waterbirds in Bhutan needs more documentation to bring out further conservation strategies.

In Bhutan, winter migratory waterbirds have been found in abundance in along Punatsangchhu basin (Spierenburg 2005). Numerous birders in the country consider Punatsangchhu, the expanse between Punakha and Wangdue Phodrang, a central stopover home for many waterbirds and any instability in the area due to anthropogenic activities would impede the migration of the bird species enroute through Bhutan (Nidup et al. 2020). Large numbers of migratory waterbirds such as Ruddy Shelduck, Common Pochard, Northern Pintail and others, rely on the Punatsangchhu basin for their survival (Ghemiray 2016).

Human actions leading to habitat fragmentation and loss are constantly threatening biodiversity around the world (Gayk & Lindsay 2012). Human activities have encroached on waterbird habitats, putting them at a greater risk. The feeding area of aquatic birds, particularly migrating birds, are rapidly diminishing owing to numerous development activities and poor water quality (Tshering 2010). Many birds have been harmed as a result of sand mining and other contemporary developmental activities such as hydropower construction. Forests, grasslands, and wetlands are being degraded or lost across the region as a result of overexploitation, and bird populations are under threat (BirdLife 2004). The direct effects of habitat transformation provide biologists with the opportunity to investigate the impacts of habitat size, quality, habitat isolation, and the effects of edges and disturbances on gene flow, populations, species, communities and ecosystems (Fukami & Wardle 2005; Laurance 2008). In addition, birds are suitable for the examination of changes in response to habitat disturbance and loss because they are reliable indicators of broader biodiversity trends (Barlow et al. 2007). Therefore, this study aimed to determine the waterbird composition, assess habitat use and preference of waterbirds along with the different habitats along the river. Furthermore, the study examined the potential drivers of habitat fragmentation of waterbirds along the Punatsangchhu.

MATERIALS AND METHODS

Study Area

The study was conducted in the Punatsangchhu River (27.4620 N–89.9010 E and 27.5790 N –89.8670 E) flowing across the two districts: Punakha and Wangdue Phodrang located towards the western part of the country at an altitude ranging 1,200–4,800 m (Figure 1). The river basin is the longest and widest, extending from the extreme north of Gasa with an elevation of 6,500 m to the extreme south of Dagana with an elevation of 200 m covering four districts in Bhutan (Tobgay 2017).

The study site was located at Mochhu River and along the basin where the river is still much less fast-flowing and where there are the greatest number of agriculture fields and also a mixture of grassland and small area of pine forest along the Punatsangchhu Hydroelectric Project and Authority 1 (PHPA 1). The area is also under constant disturbance with large area of sand under extraction and also the place where two mega-hydropower projects are under construction (Dorji & Nidup 2016). The river course was dominated by the presence of rocks and boulders with fast flowing waters in the upper stretches, mainly of cobbles, pebbles, sand and silt (Haq et al. 2021) along the middle stretches and exposed rocks and boulders towards the lower stretches of the basin.

Sampling Design

The study area covered a total distance of 15 km

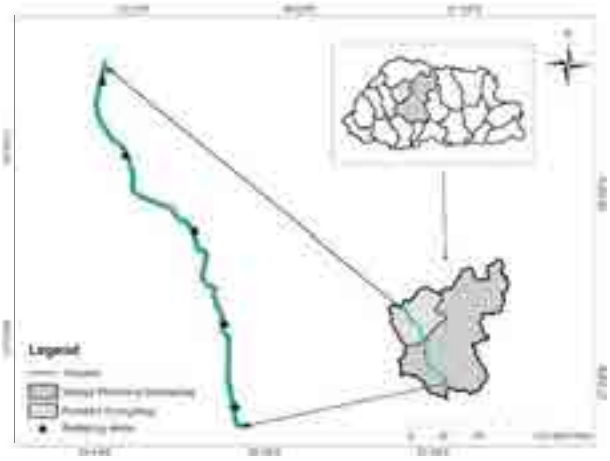

Figure 1. Location of the study area with five different habitats along the Punatsangchhu River basin, covering two districts of Punakha and Wangdue Phodrang, Bhutan.

along the Punatsangchhu river basin. Stratified random sampling was carried out at the study site which composed of five strata, namely, dam, dredged area, farmland, urban, and pristine habitats. The sampling was carried out to stratify the study site into five habitats; one, under undisturbed natural habitat (Rimchu area) and four other strata from the disturbed habitat that are settlement area (Khuruthang town), along the farmland above the Punakha *dzong* up to Zomlingthang area, area of sand extraction (dredged area) and hydropower area respectively. Each habitat covered a distance of 3 km. The transect was laid out systematically in five different habitats along with a total of 10 point counts at a distance of 300 m (Bibby et al. 2000) between each of the point count station. The starting point was laid out randomly at convenience. Overall, a total of 50 point count stations was laid out (Dorji & Nidup 2016). The data were collected from November 2020 to early May 2021 in the winter, post- winter, and spring seasons.

Bird Survey

Birds were recorded by locating transects along a predefined route within a defined survey unit using the line transect method (Burnham et al. 1980). Then the point count approach (Bibby et al. 2000) was used to sample the birds along the designated transects. The birds were counted by strolling along the river concomitantly, halting every 300 m (Bibby et al. 2000) to survey the region within a 50 m radial distance from the observer considering the location as plot center.

At each location, a time of 15 minutes was spent observing, identifying and recording the waterbirds. Owing to the conspicuous activities of birds, the observation period was from 0630 h to 1030 h in the morning, and 1500 h to 1700 h in the afternoon. The observation period began around 30 minutes after sunrise and extended until mid-morning (Bibby et al. 1998). The line transects were put along any riverfront that was accessible and easy to assess for the survey. This was also done to account for the birds that use various features of riparian ecosystems. For identification of the birds, reference guides of Inskipp et al. (2004) and UWICER (2014) were used.

Habitat Assessment

A variation of the line-intercept method (Cummings & Smith 2000) was used to assess the percentage of the riverbank, bank-side open area, shrub cover and canopy cover. Three transects of 30 m each running parallel to each other and perpendicular to the river course, with the middle transect passing through the center of the point count station were laid out. Transects were spaced 10 m away from each other. The lengths of the transect line intercepted by the river-bank, open area, shrub cover and canopy cover were measured (Pasang 2017).

Potential Threats of Habitat Fragmentation

A snowball sampling method was used for preliminary surveys to document risks, including anthropogenic activities, and to provide disturbance scores at each primary sampling site based on Shenoy et al. (2006). A questionnaire survey initially included the forest officials from the Wangdue Forest Division possessing keen interests in birds along the Punatsangchhu River and following the snowball method, the interviewees' recommendations were traced and surveyed. Based on the factors affecting the activity of waterbird communities, anthropogenic disturbances were assigned a score of one, two, or three. A score of three indicated the most severe disturbance while a score of two indicated mild disturbance. Disturbance by visitors was deemed to have the least harmful impact on waterbird communities and was given a score of one (Shenoy et al. 2006).

Data Analysis

The data were analyzed using MS Excel and R software (Oksanen et al. 2018). Descriptive statistics were used to check the summary such as mean, standard deviation, maximum, minimum, and range of the data generated. A Shapiro Wilks test was used to test the normality of the data.

Kruskal-Wallis *H* test was performed to evaluate the habitat comparison. The post-hoc Dunnets test

was performed to further test the difference in the distribution of waterbirds. Spearman's correlation was used to evaluate the association between diversity indices within plots with the habitat assessment scores of the environmental variables. Principal component analysis (PCA) was used to analyze the potential drivers of habitat fragmentation from the environmental variables (Andrade et al. 2018). The principal components were selected based on their eigen value higher than 1 and explained data showed 70–80 % of proportions of variance.

Dendrogram through a hierarchical clustering, was extracted from the *GGdendro package* following Ward's (1963) clustering criterion and using Bray Curtis on standardized data. The similarity distance at 0.5 (50%) by (Gonzalez-Gajardo et al. 2009) was taken to distinguish the habitat plots into groups of similar characteristics.

Measurement of diversity

Diversity of aquatic birds was determined by Shannon's diversity index *H'*

Shannon's diversity index *(H')* = $H' = \Sigma\ Pi * LnPi$

Where:

S = total number of species in the sample

Pi = proportion of individuals belonging to an i^{th} species in a plot or an area

1n = natural logarithm

Measurement of species richness

Species richness index (Mg) was used as a simple measure of species richness.

Mg = (S – 1) / Log N

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

Measurement of species evenness

$E_H = H`/ LN$ (n)

Where n = total number of species recorded

Spearman's correlation was used to evaluate the association between diversity indexes between each plot with the habitat assessment scores of the environmental variables.

r values vary between -1 and +1

r value near 1 indicates strong correlation and near 0 no correlation

RESULTS

Species Composition and Abundance

A total count of 1,186 individuals in 11 families was recorded along the Punatsangchhu River basin adjoining the Mochhu River (Table 1). The bird species belonged to the families: Anatidae, Muscicapidae, Motacillidae, Cinclidae, Scolopacidae, Phalacrocoracidae, Charadriidae, Ibidorhynchidae, Alcedinidae, Accipitridae, and Turdidae. The highest number of species was recorded in Anatidae (27.3%, n = 9) which consists of ducks, followed by Muscicapidae (18.2%, n = 6) and Charadriidae (12.1%, n = 4). Along the Punatsangchhu River all duck species were spotted in open water area characterized mainly by sandy banks, and less dense and dry vegetation along the banks. Motacillidae and Alcedinidae recorded three each (9.09%, n = 3) followed by Scolopacidae and Phalacrocoracidae (6.1%, n = 2). Cinclidae, Ibidorhynchidae, Accipitridae, and Turdidae constituted of one species each (3.0%, n = 1).

Among the five habitats, the dam area recorded the highest diversity (*H`* = 2.13) with an abundance of 103, while the least diversity was recorded from the farmland area (*H`* = 1.10) with their total count of 282 birds (Figure 2). The highest numbers of waterbirds species and abundance were recorded along the dredged area with species richness (*SR* = 7.56). The dredged area was more open compared to other habitats and had patches of sand where the birds were found resting. Birds from the Anatidae family could be found in huge flocks either dabbling across the river or resting along the riverside. Some species of diving ducks were seen diving into the river for a period of five to ten seconds for fishing.

Habitat Preference

Habitat heterogeneity and their conditions significantly influence the waterbirds species composition and the diversity indices (H (4) = 31.64, p = 0.00). Most of the waterbirds preferred the dredged area (Median (Mdn)) (Mdn = 18.00) compared to the urban (Mdn = 10.50), farmland (Mdn = 8.00), dam (Mdn = 7.50) and pristine (Mdn = 4.50) habitats.

Post-hoc Dunn's test using a Bonferroni-adjusted alpha level of 0.025(0.05/2) showed a significant influence in the waterbird assemblage and population between farmland and the dredged area (p = 0.008), pristine area and dam (p = 0.001), pristine area and dredged area (p = 0.00), town and farmland (p = 0.02), and town and pristine habitats (p = 0.00). The difference in the waterbird distribution was mainly attributed to pristine habitat, which was an undisturbed habitat

Table 1. Checklist of waterbirds species encountered during the study.

	Family	Common name	Scientific name	IUCN Red List category
1	Anatidae	Ruddy Shelduck	*Anas ferruginea*	Least Concern
2		Mallard	*Anas platyrhynchos*	Least Concern
3		Gadwall	*Anas strepera*	Least Concern
4		Common Merganser	*Mergus merganser*	Least Concern
5		Common Shelduck	*Tadorna tadorna*	Least Concern
6		Common Pochard	*Aythya ferina*	Vulnerable
7		Red-crested Pochard	*Rhodonessa rufina*	Least Concern
8		Eurasian Wigeon	*Anas penelope*	Least Concern
9		Northern Pintail	*Anas acuta*	Least Concern
10	Muscicapidae	Little Forktail	*Enicurus scouleri*	Least Concern
11		Slaty-backed Forktail	*Enicurus immaculatus*	Least Concern
12		Black-backed Forktail	*Enicurus schistaceus*	Least Concern
13		Hodgson Redstart	*Phoenicurus hodgsoni*	Least Concern
14		White-capped Water Redstart	*Chaimarrornis leucocephalus*	Least Concern
15		Plumbeous Water Redstart	*Rhyacornis fuliginosus*	Least Concern
16	Motacillidae	White Wagtail	*Motacilla alba*	Least Concern
17		White-browed Wagtail	*Motacilla maderaspatensis*	Least Concern
18		Grey Wagtail	*Motacilla cinerea*	Least Concern
19	Cinclidae	Brown Dipper	*Cinclus pallasii*	Least Concern
20	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Least Concern
21		Marsh Sandpiper	*Tringa stagnatilis*	Least Concern
22	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger*	Least Concern
23		Great Cormorant	*Phalacrocorax carbo*	Least Concern
24	Charadriidae	River Lapwing	*Vanellus duvaucelii*	Near Threatened
25		Yellow-wattled Lapwing	*Vanellus malabaricus*	Least Concern
26		Red-wattled Lapwing	*Vanellus indicus*	Least Concern
27		Long-billed Plover	*Charadrius placidus* J.E.	Least Concern
28	Ibidorhynchidae	Ibisbill	*Ibidorhyncha struthersii*	Least Concern
29	Alcedinidae	Crested Kingfisher	*Halcyon smyrnensis*	Least Concern
30		Common Kingfisher	*Alcedo atthis*	Least Concern
31		White-throated Kingfisher	*Megaceryle lugubris*	Least Concern
32	Accipitridae	Palla's Fish Eagle	*Haliaeetus leucoryphus*	Endangered
33	Turdidae	Blue Whistling Thrush	*Myiophonus caeruleus*	Least Concern

with relatively higher diversity (H` = 2.03) compared to other habitats. The four other habitats were categorized as disturbed habitats although each of these has its characteristic features to attract a number of species and waterbird population.

Relationship between Waterbird Composition with Physical Parameter

A dissimilarity distance at 0.5 (50%) was taken to distinguish the data into four groups (Figure 3) as follows:

Group I Transition Zone

The first cluster is one of the major parts of the ecosystem and is characterized by 38% of the plots from town and 31% each from dredged area and farmland. The cluster area is named the bio-geographical transition zone. The study area of river comprises shallow water, sandy bank and open area, which favored maximum assemblage of waterbirds including both residents and migratory waterbirds. The area throughout saw more than 23 m^2 flock of migratory Ruddy Shelduck *Anas*

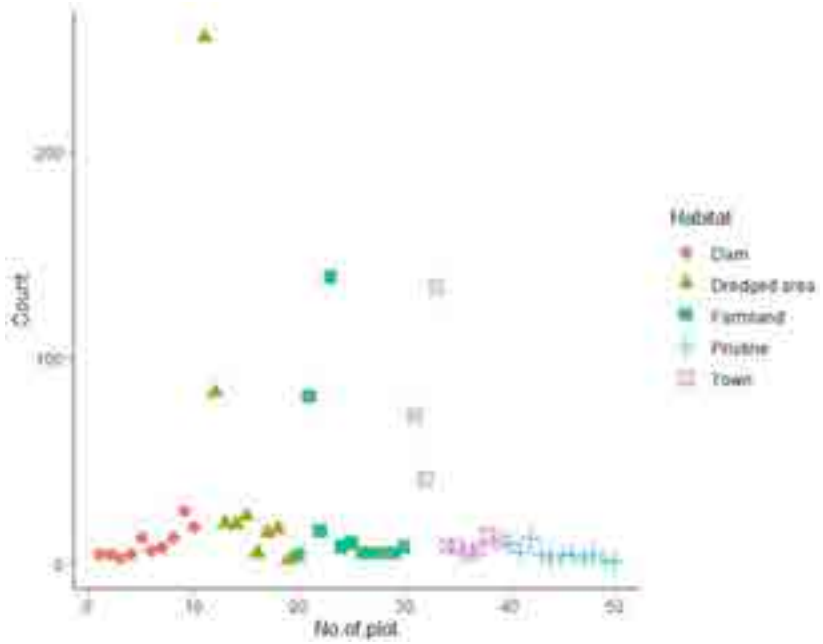

Figure 2. Distribution of waterbirds abundance along each habitat. The graph denotes the counts per plot in each transects line of five different habitats.

ferruginea, River Lapwing *Vanellus duvaucelii*, White Wagtail *Motacilla alba*, Common Merganser *Mergus merganser*, and Little Cormorant *Phalacrocorax niger*. Common Sandpiper *Actitis hypoleucos* was found in every plot throughout the stretch of the habitats.

Group II Dam Zone

The second cluster grouped all the plots from the dam area. All of the plots (P) ranging from P1 to P10 were designated from the dam habitat and hence, the name of the zone. The zone had all the plots falling under a high gradient and fast-flowing river. The abundant species found were Little Forktail *Enicurus scouleri*, Slaty-backed Forktail *Enicurus immaculatus* Hodgson, White-capped Water-Redstart *Chaimarrornis leucocephalus*, and Plumbeous Water Redstart *Rhyacornis fuliginosus*. In contrast, there was a shallow depth of water pools from P6 to P9, due to serious habitat degradation, and the Anatidae species were not found to prefer this area.

Group III Human Interaction Zone

Plots (P11, P12, P23, and P34) falling under three strata: dredged area, farmland, and urban were grouped. The plots shared similar characteristics of being under constant touch with anthropogenic activities and human settlements. All the plots categorized under the group reported the presence of waterbirds species such as Great Cormorant *Phalacrocorax carbo* and Plumbeous Water Red-start *Rhyacornis fuliginosus* along both the banks of the river throughout the stretch in these three habitats. This group indicated a major disturbance to waterbirds' habitat due to vigorous developmental and anthropogenic activities.

Group IV Undisturbed Zone

This cluster consisted of all the plots belonging to the pristine habitat. Since all the plots have been reported from pristine habitat, the zone was named the undisturbed zone. Throughout the plots, there was high canopy cover and very minimal disturbance from the development activities. Waterbird species recorded include Brown Dipper *Cinclus pallasii* and Blue Whistling Thrush *Myiophonus caeruleus*.

Relationship between the Waterbird Composition and Habitat Parameters

Spearman's rho correlation was used to determine the association between the waterbird count and the environmental variables of the right bank (RB) of the river (Figure 4a, b). The bank sides were attributed in a way that was against the flow of the river. The correlation test found no significant association between the waterbird count and elevation (r_s = -1.60, p = 0.28). Conversely, the waterbird counts along the RB showed a significant association with environmental variables: bank stability (BS) (r_s = -0.34, p = 0.01), vegetative protective (VP) (r_s = -0.29, p = 0.03) and riparian vegetation zone (RVZ) (r_s = -0.48, p = 0.00).

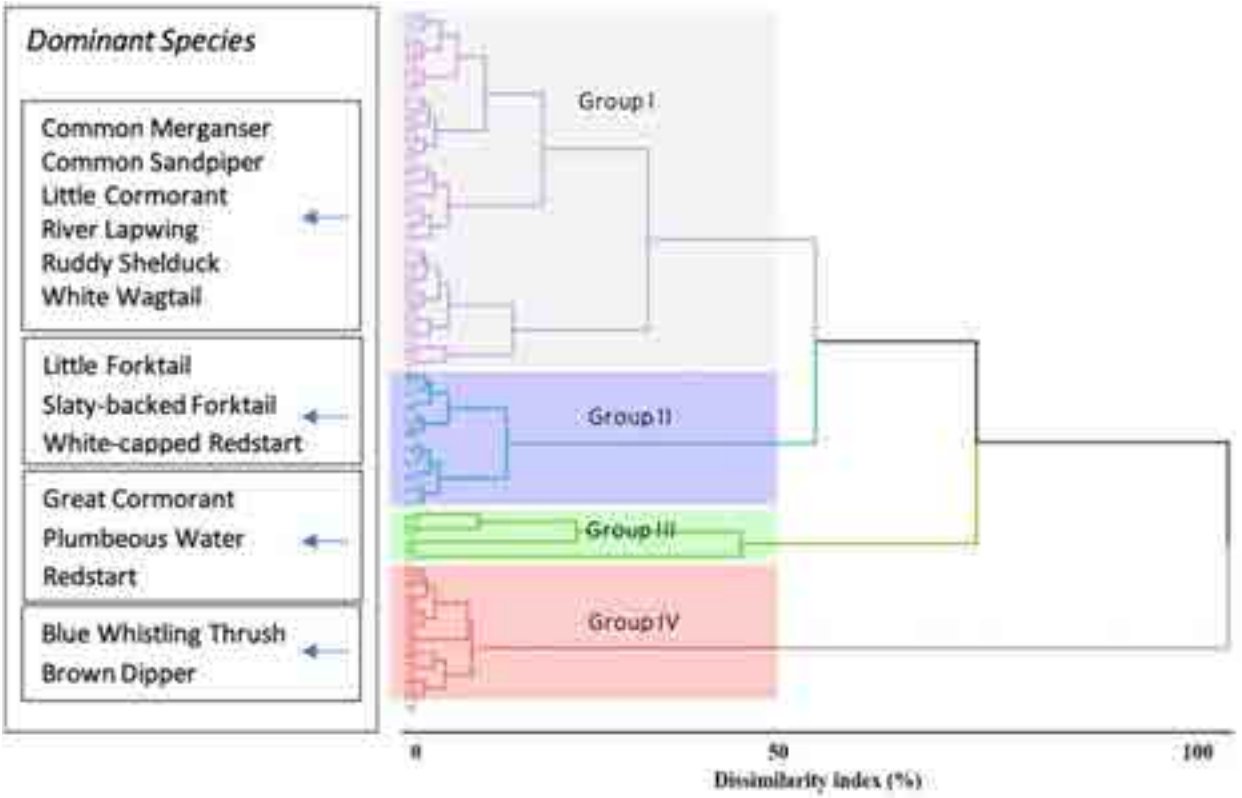

Figure 3. A dissimilarity distance at 0.5 (50%) showing the grouping of similar plots.

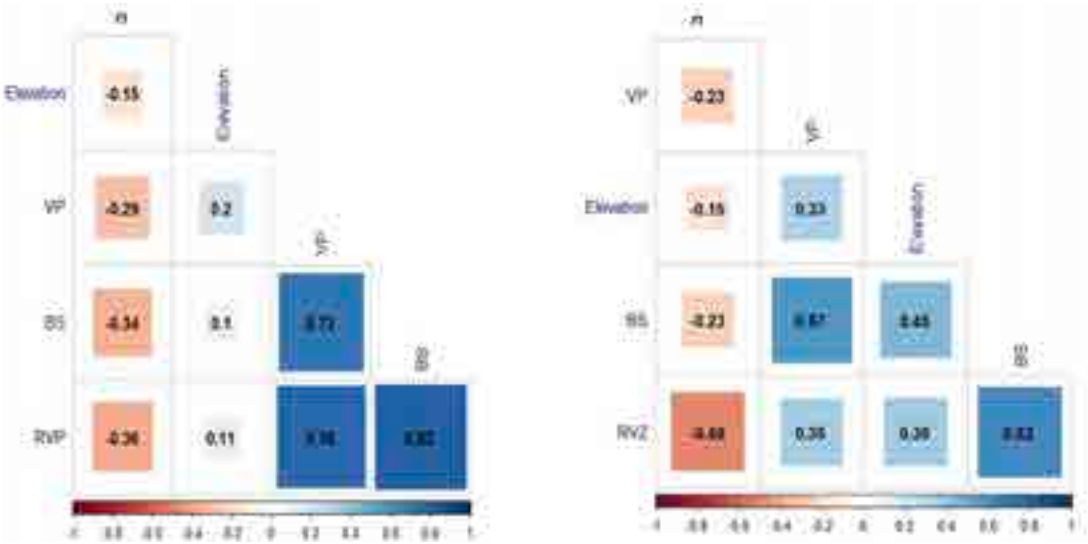

Figure 4. a—correlation along RB | b—correlation along LB

Throughout the habitat, the national highway passing through the region, human settlements, farmlands, and the dredged area sites were situated toward the RB of the river. The national highway connecting the Gasa-Punakha Road passed along the RB of the river. The major portion of Khuruthang town was also established along with the RB of Punatsangchhu River where all of the sewerage drains were observed to run into the river. The farmland of Zomlingthang village was also along the RB of the river.

The BS and VP were interfered with anthropogenic activities which were constantly decreasing the stability

Table 2. Correlation coefficient in each principal component. The table shows the 10 anthropogenic activities that deduced four principal components used as an explanatory variable for analysis.

	EF	RC	WP	D	M	SE	CRC	IF	TEX	FD	SD	Cumulative proportion (*CP*)	Proportion of Variance (*V*)
PC1	-0.24	-0.26	0.03	0.22	0.03	-0.43	0.3	-0.47	-0.35	-0.41	1.11	0.29	0.29
PC2	0.73	-0.1	0.03	-0.11	-0.34	-0.14	0.03	0.147	0.02	-0.5	0.85	0.46	0.17
PC3	0.01	-0.06	-0.40	-0.11	-0.05	0.16	-0.70	-0.19	-0.48	-0.12	0.80	0.62	0.15
PC4	-0.09	-0.52	-0.36	-0.46	-0.12	0.37	0.46	0.04	-0.09	0.05	0.74	0.74	0.13

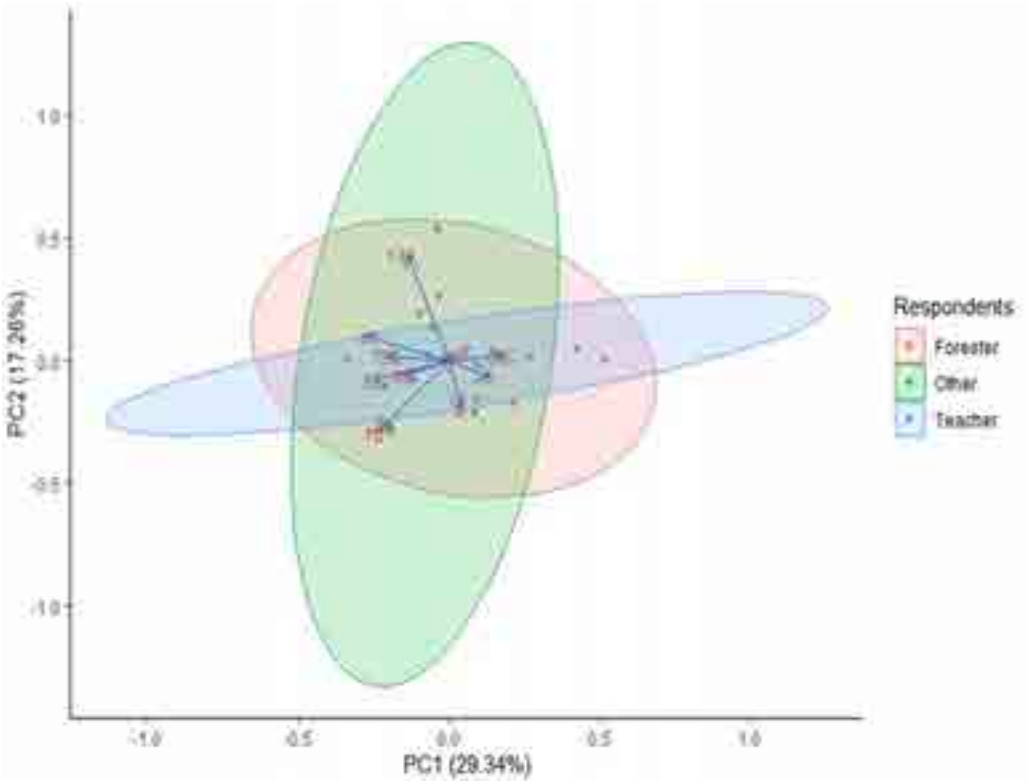

Figure 5. Principal component analysis bi-plot for potential drivers that lead to habitat degradation based on 10 different anthropogenic activities. The PCA biplot shows the categories of respondents and directions values of impact scores used as an explanatory variable for analysis.

of BS and VP hence, directly affecting the waterbird assemblage. The RB of the bank throughout the study area was covered with bushes of *Desmodium* sp., *Phyllanthus officinale*, *Artemisia vulgaris*, a mixed stand of *Ficus semicordata*, *Pinus roxburghii*, and *Macaranga* sp. Although the percentage coverage varied from plot to plot along the habitat, the composition of waterbirds did not depend on it. It can also be seen that most of the waterbirds were found along the riverside feeding near the river and bank.

Similarly, Spearman's rho correlation coefficient was used to determine the association between the waterbird count and environmental variables of the left bank (LB) side of the river. There was no significant association between the count and the environmental variables: elevation (r_s = -0.160, p = 0.283), BS (r_s = -231, p = 0.105), and VP (r_s = -0.223, p = 0.102). Elevation, BS, and VP do not influence the waterbird's assemblage and distribution.

On the other hand, the correlation reported a significant association between the waterbird count and RVZ (r_s = -0.487, p = 0.000, N = 50). The LB of the river was mostly covered with Riparian Vegetation (RV) and the correlogram showed a moderate correlation corroborating the influence of assemblage by RVZ cover. With the increase in the canopy cover and presence of thick vegetation along the riparian zone, the waterbirds assemblage decreased.

Relationship with Waterbirds and Anthropogenic Activities

PCA was conducted for 10 parameters considering the various anthropogenic activities as a potential threat to habitat degradation. The activities listed are: change in the river course (CRC), damming (D), electric fencing (EF), fire disturbance (FD), illegal fishing (IF), mining (M), road construction (RC), sand extraction (SE), town expansion (TE) and water pollution (WP). Reduction to four Principal Components accounted for 74.70% of the anthropogenic activities from the total number of respondents. The resulting components that had an eigenvalue summed to >1 was selected to represent the original variation in the environmental data (Kaiser 1960).

The PC1 showed a weak positive correlation with 40% of anthropogenic activities such as (WP, D, M, and CRC) and 60% of activities (EF, RC, SE, IF, TEX) showing a negative correlation with the PC1 (Table 2). Similarly, a 50% positive correlation (EF, WP, CRC, IF, TEX) and 50% negative correlation (RC, D, M, and SE) were found with the PC2. In addition, PC3 showed a positive correlation with 30% (EF, RC, and SE) of the anthropogenic activities and a 70% negative correlation (WP, D, M, CRC, IF, TEX, and FD). PC4 showed a 40% positive correlation (SE, CRC, IF, and FD) and a 60% negative correlation with (EF, RC, WP, D, M, and TEX).

According to the bi-plot (Figure 4), D, CRC, WP, and M were highly correlated to one another. All of the above activities were all related to impacts on the river which will further affect the waterbird habitat. Anthropogenic activities such as FD, RC, and TEX were associated with the environment nearby the waterbird's habitat. The groups were highly correlated with each other concerning habitat degradation from the impact of nearby settlements and activities. The next group of activities was SE and IF which directly disturbed the river and therefore, affected the feeding and habitat of waterbirds. Activity such as EF had a negative correlation with the rest of the anthropogenic activities depicting a weak effect on the waterbird community.

DISCUSSIONS

Punatsangchhu is one of the biggest rivers, and the basin is a significant habitat in Bhutan for resident and migrant waterbirds (Nidup et al. 2020). Large numbers of winter migratory waterbirds in Bhutan have been found in this location (Spierenburg 2005). The most abundant species reported were under the family Anatidae. From the Kurichhu basin, which has similar characteristics, Dorji & Nidup (2016) also reported up to eight Anatidae species. Changthang Wildlife Sanctuary in Ladakh reported up to 34% of the bird's species belonging to the Anatidae (Jamwal et al. 2020). The high number of Anatidae may be due to the presence of passage migratory species inhabiting different habitats (Dorji & Nidup 2016). The study area was an open wetland that could have attracted a greater number of dabbling birds.

One main cause of the decline in waterbird population is the increase in anthropogenic land-use which reduce habitat availability at stopover and wintering sites (Page & Gill 1994). The bird assemblages are affected by various factors such as food availability, the size of the wetland (Paracuellos 2006), and the abiotic changes in the wetlands (Jaksic 2004; Lagos et al. 2008). Not only the birds but all organisms, belonging to the plant and the animal communities, are affected by the physical characteristics of the environment (Gillings et al. 2008).

The variation in the distribution of waterbirds in different habitats is attributed to prime habitat preference: "Each species may have a different habitat preference and feed throughout this habitat on all kinds of food, or all the species may share the entire habitat with each species feeding on a variety of food in the different situation within the habitat" (Onoja et al. 2011). Many studies have demonstrated the importance of habitat heterogeneity in wetland bird richness and abundance (Gonzalez-Gajardo et al. 2009).

Open areas are of utmost importance for bird populations as these areas provide better visibility for vigilance against predators and free movement for food procurement (Elafri et al. 2017). Open water provides optimum feeding and resting conditions to waterbirds and the least impact of human disturbances (Elafari et al. 2017).

The river gradient along the study area was characterized by fast-flowing and running river, where species such as Plumbeous Water Redstart, White-capped Water Redstart, Little Forktail, White Wagtail, and Blue Whistling Thrush of Muscicapidae family were widespread (Dorji & Nidup 2016). This could be attributed to the river being pristine and fast-flowing, where the Muscicapidae are widespread (Tyler & Ormerod 1993). Plumbeous Water Redstart is the most widespread species found along fast-flowing rivers and streams, dam areas, and pristine habitat and is also a common altitudinal migrant, ranging 350–4,270 m (Tyler & Ormerod 1993; Inskipp et al. 2004).

Brown Dippers were mostly spotted along the rapidly flowing river. When foraging, Brown Dipper mainly

catches prey from submerged rocks or the slowing river-bed, whereas Little Forktail picks prey from spray-drenched rocks at a waterfall or from the hygropetric area of rocks (Tyler & Ormerod 1993). Diving waterbirds with long necks, bills, and legs can feed in deeper habitats than smaller taxa, and their access to foraging is limited by the minimum water depth (Ma et al. 2010).

A bio-geographical transition zone is an area where physical features, environmental conditions, and ecological factors forms mixture and co-occurrence of two or more biotic components but also constrain their distribution further into one another (Ferro & Morrone 2014). Habitat choice of birds is primarily influenced by the availability of food (Collin 1998), suitable nesting sites, and the presence of potential predators (Martin 1993). Waterfowl migrate from their Palearctic breeding grounds and accumulate in different wetland bodies of the valley at the arrival of winter (Ali 1979). Birds such as the Common Sandpiper *Actitis hypoleucos* prefer stone, gravel, rocky, muddy, or sandbanks along rivers during the breeding season (Snow & Perrins 1998).

Higher canopy cover saw a significantly lower diversity of waterbirds (Tobgay 2017). Along with the river segments with high canopy cover, the waterbirds were sighted in lesser numbers of individuals (Passang 2017). Bird diversity negatively correlated with canopy density (Daniels 1991). Tall emergent vegetation, open shore, and canopy appeared to be primary habitat elements affecting waterbirds' presence. All waterbirds were negatively associated with tall emergent vegetation (Traut 2003). Waterbirds were recorded significantly less in the plots with a high percentage of canopy cover (Tena et al. 2007). A smaller number of waterbirds species was found along the river segments with high canopy cover (Passang 2017). However, ecological studies show that lower altitude has more bird species than higher altitude while some species are restricted to certain zones and others occur throughout a range of altitudes (Jankowski et al. 2009).

Regardless of their importance, global waterbirds populations are declining (Wetlands International 2012). One main cause of the decline is the increase in anthropogenic landuse, reducing habitat availability at stopover and wintering sites (Page & Gill 1994). While the implications and Conservation Action Plans (CAP) are prepared by the government and NGOs RSPN, only one has been prepared in Bhutan for river birds. This CAP is for the globally Critically Endangered White Bellied Heron *Ardea insignis*, there are several other waterbirds species occurring in the river that are missing from the list under the IUCN Red List criteria. These species are: Common Pochard *Aythya ferina*, Palla's Fish Eagle *Haliaeetus leucoryphus* and River Lapwing *Vanellus duvaucelii*. A CAPs for these waterbirds are important too and should be considered before we declare it to be just too late for the same.

REFERENCES

Ali, S. (1979). *The Book of Indian Birds*. The Bombay Natural History Society, India, 466 pp.

Andrade, R., H.L. Bateman, J. Franklin & D. Allen (2018). Waterbird community composition, abundance, and diversity along urban gradient. *Landscape and Urban Planning* 170(2018): 103–111.

Barlow, J., Gardner, T. A., Araújo, I. S., Ávila-Pires, T. C., Bonaldo, A. B., Costa, J. E., Esposito, M. C., Ferreira, L. V., Hawes, J., Hernandez, M. I. M., Hoogmoed, M. S., Leite, R. N., Man-Hung, N. F., Malcolm, J. R., Martins, M. B., Mestre, L. A. M., Miranda-Santos, R., Nunes-Gutjahr, A. L., Overal, W. L., Parry, L., Peters, S. L., Ribeiro-Junior, M. A., Silva, M. N. F., Silva Motta, C. & Peres, C. A. (2007). Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. *Proceedings of the National Academy of Sciences;* 104(47):18555–18560.

Bibby, C.J., N.D. Burgess, D.A. Hill & S.H. Mustoe (2000). *Bird census techniques*, pp. 33–34. Academic Press, London.

BirdLife. (2004). *Important Bird Areas in Asia; Key sites for conservation*. BirdLife International.UK, pp 297

Burnham K. P., D. R. Anderson & J. L. Aake (1980). Estimation of density from line transects sampling from biological populations. *Wildlife Monographs* 72:3-202.

Cummings, J. & D. Smith (2000). The line-intercept method: A tool for introductory plant ecology laboratories. *Proceedings of the 22nd Workshop/Conference of the Association for Biology Laboratory Education*, 22: 234-246.

Daniels, R.J.R. (1991). Practical methods for studying bird vegetation associations in the forests of the Western Ghats. Proceedings of workshop on "Medicinal plants conservation areas of tropical forest" held on 26–29 April, 1991 at Kemmangundi, Chickmagalur: 21–28.

Datta, T. (2011). Human interference and avifaunal diversity of two wetlands of Jalpaiguri, West Bengal, India. *Journal of Threatened Taxa* 3(12): 2253–2262. https://doi.org/10.11609/JOTT.O2739.2253-62

Dorji, T. (2015). *Waterbird diversity and their habitat use along Nyera Ama chu and its tributary in Thrimshing, Tashigang* (unpublished BSc dissertation). College of Natural resources, Lobesa, pp 53.

Dorji, Y. & T. Nidup (2016). Aquatic Avifauna Composition and Diversity along Hydropower Dam Gradient: A case study of Kurichhu dam in Mongar, Bhutan (Unpublished manuscript). . Accessed on 15 May 2021. https://www.researchgate.net/publication/308522394_Aquatic_Avifauna_Composition_and_Diversity_along_Hydropower_Dam_Gradient_A_case_study_of_Kurichhu_dam_in_Mongar_Bhutan

Elafri, A., A.M. Belhamra & M. Huhamd (2017). Comparing habitat preferences of a set of waterbird species wintering in the coastal wetlands of North Africa: implication for management. *Ekologia* 36(2): 158–171. https://doi.org/10.1515/eko-2017-0014

Ferro, I. & J.J. Morrone (2014). Biogeographical transition zones: a search for conceptual synthesis. *Biological Journal of the Linnean Society* 113: 1–12. https://doi.org/10.1111/bij.12333

Fukami, T. & D. Wardle (2005). Long-term ecological dynamics: reciprocal insights from natural and anthropogenic gradients. *Proceeding of the Royal Botanical Society* 272: 2105–2115. https://doi:10.1098/rspb.2005.3277

Gayk, Z. G., & Lindsay, A. R. (2012). Winter microhabitat foraging preference of sympatric boreal and black-capped chickadees in Michigan's Upper Peninsula. *The Wilson Journal of Ornithology*

124(4): 820-824.

Ghemiray, D.K. (2016). Assessment of habitat usage by White bellied Heron (*Ardea insignis*) at Burichhu nesting site. B.Sc. Thesis, College of Natural Resources, Lobesa, Punakha, Bhutan.

Gillings, S., M.W. Andrew, J.C. Greg, A.V. Juliet & J.F. Robert (2008). Distribution and abundance of birds and their habitats within the lowland farmland of Britain in winter, Bird Study. *Bird Study* 55(1): 8–22.

Haq, I.U., B.A. Bhat, K. Ahmad & A.R. Rahmani (2021). Population status and distribution of Ibisbill *Ibidorhyncha struthersii* (Vigors 1832) (Aves: Charadriiformes: Ibidorhynchidae) in Kashmir Valley, India. *Journal of Threatened Taxa* 13(6): 18614–18617. https://doi.org/10.11609/jott.6632.13.6.18614-18617

Inskipp, C., T. Inskipp & R. Grimmett (2004). *Birds of Bhutan*. Timeless Books, New Delhi, 192 pp.

Jaksic, F. (2004). El Ninõ effects on avian ecology: lesson learned from the southeastern Pacific. *Ornitologia Neotropical* 15: 61–72.

Jamwal, P.S., S. Shrotriya & J. Takpa (2020). The pattern of waterbird diversity of the Trans Himalayan wetland in Changthang Wildlife Sanctuary, Ladakh, India. *Journal of Threatened Taxa* 12(1): 15129–15139. https://doi.org/10.11609/jott.5122.12.1.15129-15139

Jankowski, J.E., A.L. Ciecka, N.Y. Meyer & K.N. Rabenold (2009). Beta diversity along environmental gradient: implications of habitat specialization in tropical montane landscapes. *Journal of Animal Ecology* 78: 315–327. https://doi.org/10.1111/j.1365-2656.2008.01487.x

Kaiser, H.F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological measurement* 20:141-151.

Kumar, P. & S.K. Gupta (2009). Diversity and Abundance of Wetland Birds around Kurukshetra, India. *Our Nature* 7(1): 212–217.

Lagos, N.A, P. Paolini, E. Jaramillo, C. Lovengreen, C. Duarte & H. Contreras (2008). Environmental processes, water quality degradation, and decline of waterbird populations in the Rio cruces wetland, Chile. *Wetlands* 28: 938–950. https://doi.org/10.1672/07-119.1

Laurance, W.F. (2008). Theory meets reality in fragmented forests. *Animal Conservation* 11(5): 364–365. https://doi.org/10.1111/j.1469-1795.2008.00206.x

Ma, Z., Y. Cai, B. Li & B. Chen (2010). Managing Wetland Habitats for Waterbirds: An International Perspective. Coastal Ecosystems Research Station of Yangtze River Estuary, People's Republic of China. *Wetlands* 30: 15–27. https://doi.org/10.1007/s13157-009-0001-6

Melles, S., S. Glenn & K. Martin (2003). Urban bird diversity and landscape complexity: Species-environment associations along a multiscale habitat gradient. *Conservation Ecology* 7(1): 5–15. https://www.ecologyandsociety.org/vol7/iss1/art5/

Mundkur, T. & Nagy, S. (2012). *Waterbird Population Estimates* 5th edition. Wageningen, The Netherlands: Wetland International.

Nidup, S., Gyeltshen & T. Tobgay (2020). An account of a first record of the Common Goldeneye *Bucephala clangula* Linnaues, 1758 (Aves: Anseriformes: Anatidae) in Bhutan. *Journal of Threatened Taxa* 12(3): 15823–15384. https://doi.org/10.11609/jott.5323.12.3.15382-15384

Oksanen, J., F.G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P.R. Minchin, R.B. O'Hara, G.L. Simpson, P. Sloymos, M. Henry, H. Stevens, E. Szoecs & H. Wagner (2018). Vegan: Community Ecology Package. R package version 2.4.6. https://CRAN.R project.org/package=vegan

Omotoriogun, T.C., J.D. Onoja, T. Tende & S. Manu (2011). Density and Diversity of Birds in the Wetlands of Yankari Game Reserve, Bauchi, Nigeria. *Journal of Wetlands Ecology* 5: 48–58. https://doi.org/10.3126/jowe.v5i0.4778

Page, G.W. & R.E. Gill (1994). Shorebirds in western north America: Late 1800 to late 1900. *Studies in Avian Biology* 15: 147–160.

Paracuellos, M. (2006). How can habitat selection affect the use of a wetland complex by waterbirds? *Biodiversity and Conservation* 15: 4569–4582. https://doi.org/10.1007/s10531-005-5820-z

Pasang (2018). Diversity of waterbird and their correlation with riparian habitat variable along Bindu River, Tashichhoeling (Sipsoo), Bhutan. Journal of the Bhutan Ecological Society (3): 45–55.

Sebastian-Gonzalez, E. & A.J. Green (2014). Habitat use by waterbirds in relation to pond size, water depth, and isolation. *Restoration Ecology* 22(3): 311–318. https://doi.org/10.1111/rec.12078

Snow, D.W. & C.M. Perrins (1998). *The birds of the Western Palearctic*. Oxford University Press, Oxford, 1051 pp.

Spierenburg, P. (2005). *Birds in Bhutan: Status and Distribution.* Oriental Bird Club, Bedford, 383 pp.

Stephenson, P.J., Ntiamoa-Baidu, Y. & Simiaka, J. P., (2020). The use of Traditional and Modern Tools for Monitoring Wetlands Biodiversity in Africa: Challenges and Opportunities. *Frontiers in Environmental Science* 8: 61. https://doi:10.3389/fenvs.2020.00061

Tena, A.G., A. Saura & L. Britons (2007). Effects of forest composition and structure on bird species richness in a Mediterranean context: Implications for forest ecosystem management. *Forest Ecology and Management* 242: 470–476. https://doi.org/10.1016/j.foreco.2007.01.080

Tobgay, T. (2017). First record of Oriental Pratincole. *Birding ASIA* 27: 120–121.

Traut, A.H. (2003). Urban lakes and waterbirds: Effects of the development on distribution and behavior. MSc Thesis. University of Florida, pp13

Tshultrium & T. Wangchuk (2021). A *Pictorial Guide to Birds and Butterflies of Bhutan.* P.T. Printing and Publishing House, Thimphu, pp 238

Tyler, S.J. & S.J. Ormerod (1993). The Ecology of River Birds in Nepal. *Forktail* 9: 59–82.

UWICER (2014). *Pictorial Guide for waterbirds in Bhutan.* Ugyen Wangchuck Institute for Conservation and Environmental Research. Lami Goenpa, Bumthang, Bhutan.

Ward, Jr. & H. Joe (1963). Hierarchical Grouping to Optimize an Objective Function. *Journal of the American Statistical Association* 58(308): 236–244.

Wetlands International (2012). *Waterbird Population Estimates*. Wetlands International. Downloaded on 29 April 2020.

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COMMUNICATION

Freshwater fishes of the Chimmony Wildlife Sanctuary, Western Ghats, India

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Abstract: The fish diversity of Chimmony Wildlife Sanctuary in the Western Ghats of Kerala was studied between January 2018 and December 2020. The ichthyofauna comprised of 40 species belonging to 11 Orders, 17 Families, and 29 genera, of which 35% are endemic to the Western Ghats region, and two are endemic to the state of Kerala. Cyprinids were the most dominant family, represented by 19 species belonging to three genera, followed by family Channidae (3 species) and loaches belonging to the family Nemacheilidae (3 species). Of the 40 species, one (*Mesonemachelius herrei*) belonged to the 'Critically Endangered' (CR), one species is listed as 'Vulnerable' (VU), and four 'Near Threatened' (NT) category and on the IUCN Red List. Results are presented in the form of a primary checklist of the freshwater fish fauna of the Chimmony Wildlife Sanctuary, together with remarks on their threats and conservation requirements.

Keywords: Checklist, diversity, endemic species, ichthyofauna, Kerala.

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Author contributions: Both of the authors were involved in field survey, documentation, literature review and manuscript preparation, editing and finalizing the manuscript.

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INTRODUCTION

India's Western Ghats mountain ranges feature a high level of ecological variety and endemicity in terrestrial fauna, and are listed as a global biodiversity hotspot (Myers et al. 2000). Around 320 species belonging to 11 orders, 35 families, and 112 genera are known from this region, of which more than 60% are endemic (Dahanukar & Raghavan 2013). The Chimmony Wildlife Sanctuary (Chimmony WS) covering a catchment area of 85.06 km^2 is an IUCN category IV protected area located on the western slopes of the Nelliyampathi Hills in Thrissur district of Kerala, India (IUCN 2020). This protected area falls between 10.38° & 10.48° N and 76.43° & 76.55° E (Figure 1). The sanctuary, which is bordered on the east by the Parambikulam Wildlife Sanctuary and on the west by the Peechi-Vazhani Wildlife Sanctuary, was established as a wildlife sanctuary in August 1984.

The vegetation of Chimmony WS comprises a mix of evergreen, damp teak, and wet mixed deciduous trees and except the watershed area, the whole area is considered as a core zone of the sanctuary (Thomas et al. 2000a). The Chimmony Dam on the Chimmony River provides means of subsistence fishing from the reservoir, specially permitted to tribal communities. Much research has been conducted on the fish fauna of Kerala's wildlife sanctuaries and reserved forests, including the Aralam WS (Shaji et al. 1995), Neyyar WS, Idukki WS (Thomas et al. 2000b), Parambikulam WS (Biju et al. 1999), Karimpuzha WS (Baby et al. 2010), Periyar Tiger Reserve (Radhakrishnan & Kurup 2010), and Achankovil Reserve Forest (Baby et al. 2011). Thampy et al. (2021) recorded a total of 136 fish species belonging to 13 orders, 29 families and 69 genera from the upper-catchment of Kabini River in Wayanad, an indication of high diversity of upper catchment areas of Kerala Rivers.

The only previous study of ichthyodiversity and fishery resources of Chimmony WS is that of Thomas et al. (2000a), conducted by visiting two sites within the sanctuary. A thorough exploratory study of the protected area's freshwater habitats covering all seasons would reveal a more comprehensive assessment of fish diversity and abundance in the area, and this was the aim of the present study. Identification of major threats to fish fauna and providing suggestions on suitable conservation strategies were the other main objectives.

MATERIALS AND METHODS

Based on elevation gradients and topographical variations of the habitat, sampling was carried out from 23 sampling sites of Chimmony WS (Fig. 1; Table 1). To understand the seasonal variation, sampling was carried out during pre-monsoon, monsoon, and post monsoon periods from January 2018 to December 2020. Gillnets, cast nets, and scoop nets with different mesh sizes were operated for catching fish from all sampling sites. Personal expertise of tribal fishermen was utilised in fishing gear selection and sample collection methodology. All the fish caught were identified and photographed live. Specimens collected through a detailed survey of the reservoir's

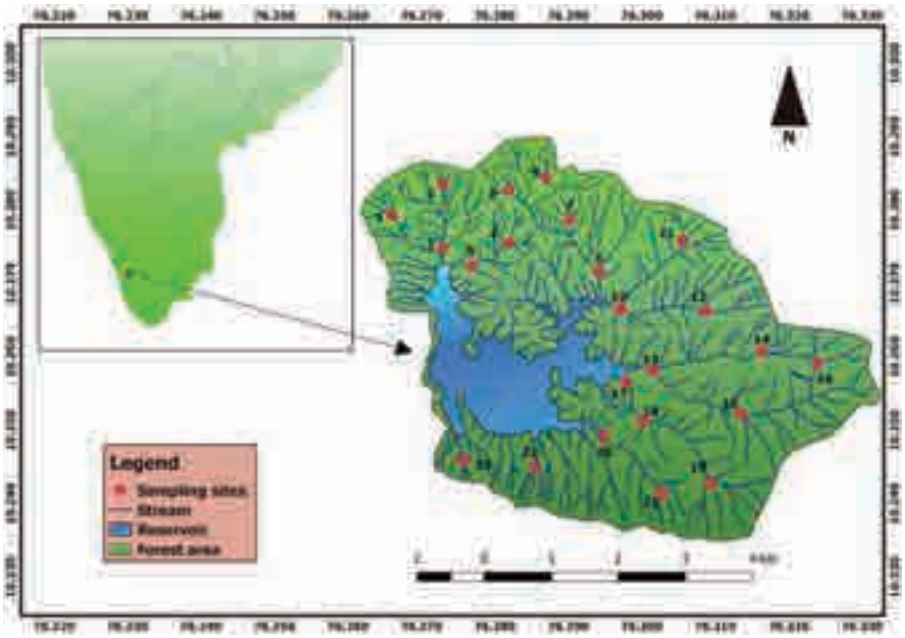

Figure 1. Map of Chimmony Wildlife Sanctuary. Red markings denote different sampling stations in the study area.

Table 1. Sampling sites, their co-ordinates, and elevation.

	Sampling sites	Longitude (°E)	Latitude (°N)	Elevation (m)
1	Cheenikuzhi	76.2716	10.2805	550
2	Ponmudi	76.2817	10.2824	444
3	Virakuthodu	76.2758	10.2743	90
4	Nellipara	76.2836	10.2751	168
5	Mukkomkodal	76.2818	10.2732	165
6	Kodakallu	76.2954	10.2716	142
7	Thekkallu	76.2948	10.2753	322
8	Vedivachankallu	76.2858	10.2818	527
9	Mangalamkavu	76.2918	10.283	566
10	Anaporu	76.3005	10.2702	118
11	Moongamadu	76.3057	10.2748	435
12	Vellimudi	76.3117	10.2701	419
13	Mulapara	76.3041	10.2614	157
14	Muramadukuthu	76.3145	10.2622	669
15	Chaurala	76.315	10.2539	333
16	Karimadakallu	76.3247	10.2619	752
17	Payampara	76.3021	10.2556	121
18	Karandanpara	76.3044	10.2535	239
19	Pundimudi	76.3122	10.2452	404
20	Kallichembara	76.2951	10.2532	80
21	Pandipetti	76.3041	10.245	429
22	Poomala	76.2927	10.2508	297
23	Ettakombanmala	76.2811	10.2519	232

tribal fishery were supplemented. Fish samples were fixed in 5% formaldehyde, and those for genetic analysis were directly fixed in 99% ethanol. Fish identification was confirmed using the available literature (Jayaram 1981, 1999). Voucher specimens were deposited in the Department of Fisheries Resource Management, Kerala University of Fisheries and Ocean studies, Kochi, Kerala, India. Checklist of fishes collected during the present study was prepared following Nelson et al. (2016) and Fricke et al. (2021). Personal interviews and discussions with focus groups including field staff of the Kerala State Forest and Wildlife Department and tribal fishermen were conducted to understand the changes that took place in the habitat and abundance of fishes. Views of tribal fishermen regarding the present threats to the system were recorded to understand the status of diversity of the wildlife sanctuary.

RESULTS

A total of 40 fish species belonging to 10 orders, 17 families, and 26 genera were recorded from the Chimmony WS, with results presented in Table 2. Order Cypriniformes dominated with 19 species (47 %) under three families (Cyprinidae, Nemacheilidae, Cobitidae), followed by Siluriformes (10%) and Anabantiformes (10%) with four species each. IUCN status and population trend of species recorded are shown in Table 2. A majority of fish species found in the study region are classified as 'Least Concern' (IUCN 2020) as per IUCN Red List of Threatened Species. However, one species *Mesonemachelius herrei* has been listed as 'Critically Endangered' (CR), one species is listed as 'Vulnerable' (VU), and four as 'Near Threatened' (NT). Additionally, one species was listed as 'Data deficient' (DD) (Figure 2), and two species *Oreochromis niloticus* and *Gibelion catla* were exotic. According to the IUCN Red List, the population trend for *Mesonoemacheilus herrei, Aplocheilus lineatus,* and *Clarias dussumieri* is known to be decreasing, while the population trend for an additional 11 species are stable. The population trend for the other species recorded from the wildlife sanctuary is currently not known (Figure 3). Species richness of the study area was inversely proportional to the elevation of the sampling site. *Garra mullya* was recorded from all the sampling sites, but loaches and *Gara mullya* were the only fish species recorded from habitats situated at an elevation above 700 m (Figure 4). Out of the 40 species, 36 were recorded from the elevation below 300 m. *Dawkinsia filamentosa, Channa gachua, Garra mullya, Devario malabaricus, Haludaria melanampyx, Rasbora dandia, Mesonoemacheilus triangularis, Mystus armatus, and Ompok malabaricus* were distributed throughout the Chimmony WS other than high elevation sites.

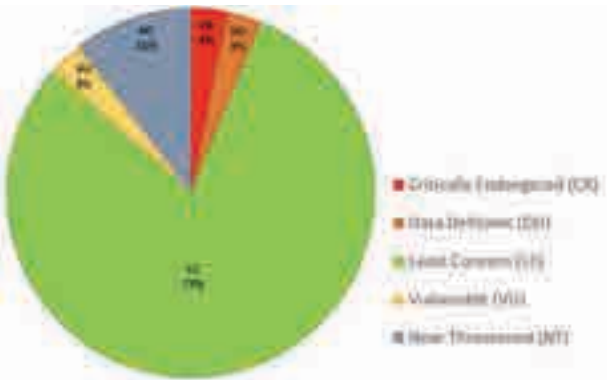

Figure 2. IUCN Red List threat status of fish collected from Chimmony Wildlife Sanctuary.

Table 2: List of fish collected from Chimmony Wildlife Sanctuary and their IUCN status, population trend and distribution at different sampling sites.

Order/family	Scientific name	Authority	IUCN Red List status	Sampling sites	Elevation range	Population trend	Voucher no.
Anabantiformes							
Anabantidae	*Anabas testudineus*	Bloch, 1792	LC	10,17,20	80–120	Stable	KUFOS.FV.2019.1002
Channidae	*Channa gachua*	Hamilton, 1822	LC	3,4,5,6,7,10,12,13 ,15,18,20,22,23	80–450	Unknown	KUFOS.FV.2019.1007
	Channa striata	Bloch, 1793	LC	17,20	80–120	Stable	KUFOS.FV.2019.1009
	Channa pseudomarulius	Hamilton, 1822	LC	20	80	Unknown	KUFOS.FV.2019.1008
Anguilliformes							
Anguillidae	*Anguilla bengalensis*	Gray, 1831	NT	5,10,17,18	80–240	Unknown	KUFOS.FV.2019.1003
	Anguilla bicolor	McClelland, 1844	NT	5,13,22	150–310	Unknown	KUFOS.FV.2019.1004
Beloniformes							
Belonidae	*Xenentodon cancila*	Hamilton, 1822	LC	17,20	80–120	Unknown	KUFOS.FV.2019.1040
Cichliformes							
Cichlidae	*Pseudetroplus maculatus*	Bloch, 1795	LC	10,13,17,20	80–160	Stable	KUFOS.FV.2019.1033
	Oreochromis niloticus *	Linnaeus, 1758		17	120	Unknown	KUFOS.FV.2019.1029
Clupeiformes							
Clupeidae	*Dayella malabarica*	Day, 1873	LC	10,13,17,20	80–150	Unknown	KUFOS.FV.2019.1013
Cypriniformes							
Cobitidae	*Lepidocephalichthys thermalis*	Valenciennes, 1846	LC	3,5,6,10,13, 17,18,20	80–250	Stable	KUFOS.FV.2019.1021
Cyprinidae	*Amblypharyngodon melettinus*	Valenciennes, 1844	LC	10,13,17,20	80–150	Unknown	KUFOS.FV.2019.1001
	Gibelion catla *	Hamilton, 1822		17	120	Unknown	KUFOS.FV.2019.1020
	Cyprinus carpio	Linnaeus, 1758	VU	13	150	Unknown	KUFOS.FV.2019.1010
	Labeo dussumieri	Valenciennes, 1842	LC	10,20	80–120	Unknown	KUFOS.FV.2019.1018
	Dawkinsia filamentosa	Valenciennes, 1844	LC	3,5,6,10,13,17, 18,20,22,23	80–165	Unknown	KUFOS.FV.2019.1012
	Devario malabaricus	Jerdon, 1849	LC	3,5,6,7,10,12, 13, 15,17,18,20, 22,23	80–450	Stable	KUFOS.FV.2019.1014
	Garra mullya	Sykes, 1839	LC	1,2,3,4,5,6,7,8, 9,10, 11,12,13,14,15, 16,17,18, 19,20,21,22,23	80–750	Stable	KUFOS.FV.2019.1015
	Hypselobarbus kurali	Menon & Rema Devi, 1995	LC	17	120	Unknown	KUFOS.FV.2019.1019
	Haludaria melanampyx	Jerdon, 1849	LC	3,5,6,7,10,12,13, 15,17,18,20,22,23	80–420	Unknown	KUFOS.FV.2019.1017
	Pethia punctata	Day, 1865	LC	3,5,6,10,13,17, 20,22	80–150	Stable	KUFOS.FV.2019.1032
	Puntius mahecola	Valenciennes, 1844	DD	5,6,10,13,18, 20,22	80–150	Unknown	KUFOS.FV.2019.1035
	Puntius parrah	Day, 1865	LC	10,13,17,20	80–150	Unknown	KUFOS.FV.2019.1036
	Puntius vittatus	Day, 1865	LC	3,10,13,17,20	80–150	Unknown	KUFOS.FV.2019.1037

	Rasbora dandia	Valenciennes, 1844	LC	3,5,6,7,10,12,13, 15,17,18,20,22,23	80–420	Stable	KUFOS.FV.2019.1038
	Systomus sarana	Hamilton, 1822	LC	3,5,6,10,13,17,18, 20, 22,23	80–300	Unknown	KUFOS.FV.2019.1039
Nemacheilidae	*Mesonoemacheilus herrei*	Nalbant & Banarescu, 1982	CR	11,12,14,15,16,19	400–750	Decreasing	KUFOS.FV.2019.1023
	Mesonoemacheilus triangularis	Day, 1865	LC	1,2,4,7,8,9,11,12, 14, 15,16, 18,19,20, 21	80–750	Stable	KUFOS.FV.2019.1024
	Mesonoemacheilus guentheri	Day, 1865	LC	1,2,4,9,11,12,14, 15, 16,19,21	150–750	Stable	KUFOS.FV.2019.1025
Cyprinodontiformes							
Aplocheilidae	*Aplocheilus lineatus*	Valenciennes, 1846	LC	5,10,17,18,20	80–160	Decreasing	KUFOS.FV.2019.1006
Gobiformes	*Aplocheilus blockii*	Arnold, 1911	LC	5,17,18	80–160	Unknown	KUFOS.FV.2019.1005
Gobidae	*Glossogobius giuris*	Hamilton, 1822	LC	3,5,10,17,18,20	80–230	Unknown	KUFOS.FV.2019.1016
Oxudercidae	*Pseudogobiopsis oligactis*	Bleeker, 1875	LC	10,13,17,20	80–160	Unknown	KUFOS.FV.2019.1034
Incertae sedis under Ovalenteria							
Ambassidae	*Parambassis dayi*	Bleeker, 1874	LC	3,5,10,17,18,20	80–160	Stable	KUFOS.FV.2019.1030
	Parambassis thomassi	Day, 1870	LC	3,5,6,10,13,17,18, 20,22	80–150	Unknown	KUFOS.FV.2019.1031
Siluriformes							
Bagridae	*Mystus armatus*	Day, 1865	LC	3,5,6,10,13,15, 17,18, 20,22,23	80–350	Unknown	KUFOS.FV.2019.1026
	Mystus malabaricus	Jerdon, 1849	NT	3,13,17,20,22	80–160	Unknown	KUFOS.FV.2019.1027
Clariidae	*Clarias dussumieri*	Valenciennes, 1840	NT	10,13,17,20	80–150	Decreasing	KUFOS.FV.2019.1011
Siluridae	*Ompok malabaricus*	Valenciennes, 1840	LC	3,4,5,6,10,12,13, 15,17, 18,20,22,23	80–420	Unknown	KUFOS.FV.2019.1028
Synbranchiformes							
Mastacembelidae	*Mastacembelus armatus*	Lacepede, 1800	LC	5,10,17,18	120–250	Stable	KUFOS.FV.2019.1022

LC—Least Concern | NT—Near Threatened | CR—Critically Endangered | DD—Data Deficient | VU—Vulnerable | *—Exotic.

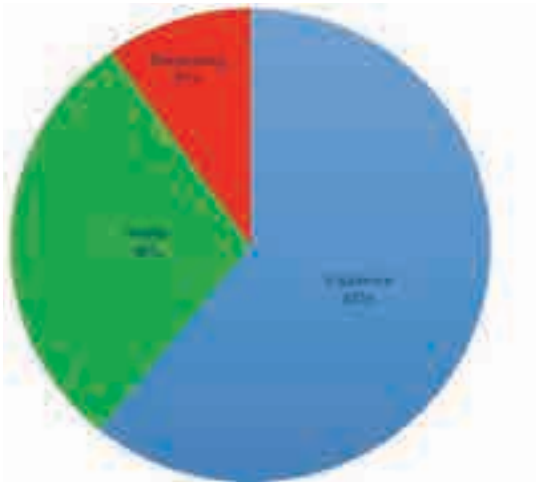

Figure 3. IUCN Red List population trend of fish collected from Chimmony Wildlife Sanctuary.

DISCUSSION

Results of the present study revealed the existence of 40 species within the Chimmony WS (Table 2). Thomas et al. (2000a) examined the fish diversity of Chimmony and Peechi WS, and recorded 37 species, with Chimmony WS harbouring 34 species belonging to 15 families, whereas Peechi Wildlife Sanctuary had 33 species belonging to 15 families. Their research was conducted by visiting only two sites within Chimmony WS. The present study carried out a thorough exploratory survey of the protected area's freshwater habitats over multiple seasons to better assess fish diversity and abundance, and our findings indicate that the ichthyo-diversity of Chimmony WS is somewhat greater than previously reported.

A comparative statement of the results of studies on

Image 1. *Amblypharyngodon melettinus*

Image 2. *Anguilla bicolor*

Image 3. *Aplochelius lineatus*

Image 4. *Channa gachua*

Image 5. *Clarias dussumieri*

Image 6. *Dawkinsia filamentosa*

Image 7. *Devario malabaricus*

Image 8. *Garra mullya*

Image 9. *Haludaria melanampyx*

Image 11. *Lepidocephalichthys thermalis*

Image 13. *Mesonoemacheilus guentheri*

Image 15. *Mystus armatus*

Image 10. *Hypselobarbus kurali*

Image 12. *Mastacembelus armatus*

Image 14. *Mesonoemacheilus triangularis*

Image 16. *Pethia punctata*

Image 17. *Pseudetroplus maculatus*

Image 18. *Pseudogobiopsis oligactis*

Image 20. *Puntius vittatus*

Image 22. *Systomus sarana*

Image 19. *Puntius mahecola*

Image 21. *Puntius parrah*

Image 23. *Rasbora dandia*

Image 24. *Xenentodon cancila*

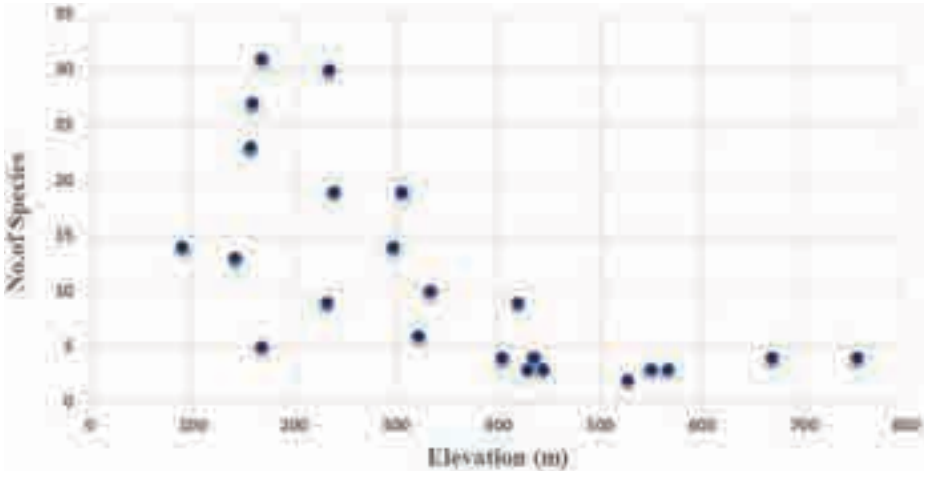

Figure 4. Elevation based fish species richness in Chimmony Wildlife Sanctuary.

Table 3. Studies on fish fauna of Kerala's wildlife sanctuaries and reserved forests.

Area of study	Number of species recorded	Author
Aralam Wildlife Sanctuary	33	Shaji et al. 1995
Neyyar Wildlife Sanctuary	38	Thomas et al. 2000b
Parambikulam Wildlife Sanctuary	40	Biju et al. 1999
Idukki Wildlife Sanctuary	40	Thomas et al. 2000b
Karimpuzha Wildlife Sanctuary	43	Baby et al. 2010
Achankovil Reserve Forest	46	Baby et al. 2011
Periyar Tiger Reserve	54	Radhakrishnan & Kurup 2010
Chimmony Wildlife Sanctuary	40	Present study

fish fauna of Kerala's wildlife sanctuaries and reserved forests is presented in Table 3. The results of the present study are in agreement with findings of the earlier studies conducted on the fish fauna of Kerala's wildlife sanctuaries and reserved forests. Baby et al. (2010), Radhakrishnan & Kurup (2010), and Baby et al. (2011) recorded higher numbers of species than the present study. This indicates that topography habitats, elevation of sites and differences in hydrological parameters and vegetation play major roles in the distribution and abundance of fish in the upper reaches of the river.

Present study collected information on the habitat, ichthyofauna and fishery of the Chimmony WS, and the compiled results of responses indicate that illegal fishing methods practiced in the area will have harmful effects on habitat and ichthyofauna diversity. The Kerala State Forest Department has banned fishing inside the sanctuary's limits, but illegal fishing in the upper reaches of the river is still prevalent and destructive fishing practices pose a major threat to the sanctuary's fish diversity. Indiscriminate capture of adult individuals during their yearly spawning migration (locally known as 'Ootha') is another illegal practice that has drastic effects on the fish population. Stream bank alteration and loss of riparian vegetation due to human-induced disturbance and local firewood collection resulted in deterioration of habitat. Most protected area staff working with the forest department were not familiar with freshwater habitats, ichthyofaunal diversity and the concept of conservation of fishery resources. Preliminary training of forest staff on ichthyofaunal diversity, sustainable fisheries and informed habitat management is needed. Comprehensive multi-disciplinary research, outreach and capacity building of the diversity, distribution, ecology, and threats to fish and other aquatic species inhabiting in the Chimmony WS is also highly recommended.

REFERENCES

Baby, F., J. Tharian, A. Ali & R. Raghavan (2010). A checklist of freshwater fishes of the New Amarambalam Reserve Forest (NARF), Kerala, India. *Journal of Threatened Taxa* 2(12): 1330–1333. https://doi.org/10.11609/jott.o2497.1330-3

Baby, F., J. Tharian, S. Philip, A. Ali & R. Raghavan (2011). Checklist of the fishes of the Achankovil forests, Kerala, India with notes on the range extension of an endemic cyprinid *Puntius chalakkudiensis*. *Journal of Threatened Taxa* 3(7): 1936–1941. https://doi.org/10.11609/jott.o2674.1936-41

Biju, C.R., K.R. Thomas & C.R. Ajithkumar (1999). Fishes of Parambikulam Wildlife Sanctuary, Palakkad District, Kerala. *India. Journal of the Bombay Natural History Society* 96: 82–87.

Dahanukar, N. & R. Raghavan (2013). Freshwater fishes of Western Ghats: Checklist MIN-Newsletter of IUCN SSC/WI, FFCNSA 1: 6–16.

Fricke, R., W.N. Eschmeyer & R. van der Laan (eds) (2020). Eschmeyer's catalogue of fishes: genera, species, references. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Electronic version accessed on 02 August 2021.

IUCN (2020). The IUCN Red List of Threatened Species. Version 2015.1. <http://www.iucnredlist.org>. Downloaded on 26.04.2020.

Jayaram, K.C. (1981). *Freshwater Fishes of India - A Handbook*. Zoological survey of India, Calcutta, 482 pp.

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

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853–858. https://doi.org/10.1038/35002501

Nelson, J., T. Grande & M. Wilson (2016). Fishes of the World, fifth edition. John Wiley & Sons, Hoboken, New Jersey, xlii+707 pp. https://doi.org/10.1002/9781119174844

Radhakrishnan, K.V. & B.M. Kurup (2010). Ichthyodiversity of Periyar Tiger Reserve, Kerala, India. *Journal of Threatened Taxa* 2(10): 1192–1198. https://doi.org/10.11609/jott.o2350.1192-8

Shaji, C.P., P.S. Easa & S.C. Basha (1995). Fresh water fish diversity in Aralam Wildlife Sanctuary, Kerala, South India. *Journal of the Bombay Natural History Society* 92: 360–363.

Thampy, D.R., M.R. Sethu, M.B. Paul & C.P. Shaji (2021). Ichthyofaunal diversity in the upper-catchment of Kabini River in Wayanad part of Western Ghats, India. *Journal of Threatened Taxa* 13(2): 17651–17669. https://doi.org/10.11609/jott.6159.13.2.17651-17669

Thomas, K.R., C.R. Biju & C.R. Ajithkumar (2000a). Fishes of Chimmony and Peechi-Vazhani wildlife sanctuaries, Kerala, *India. Journal of the Bombay Natural History Society* 97: 289–292.

Thomas, K.R., C.R. Biju & C.R. Ajithkumar (2000b). Fish fauna of Idukki and Neyyar wildlife sanctuaries, Southern Kerala, *India. Journal of the Bombay Natural History Society* 97: 443–446.

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COMMUNICATION

Butterflies of Eravikulam National Park and its environs in the Western Ghats of Kerala, India

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Abstract: The Eravikulam National Park (ENP) holds the largest remaining pristine patches of southern montane wet temperate forests and southern montane wet temperate grasslands of peninsular India. The study shows that ENP harbours 198 species of butterflies, constituting 60.73% of the butterflies recorded from Kerala and 59.10% of butterflies observed in Western Ghats (WG). Thirty-five species of butterflies seen in ENP have some level of endemicity associated with them and 22 of them (52.38%) are strictly endemic to WG. Twenty-seven species are under the schedules of Indian Wildlife Act 1972 (WPA) and its amendments. This National Park has montane grassland-Shola dependent super-endemics like *Neptis palnica* and *Telinga davisoni*. ENP also holds *Parantica nilgiriensis* a Near Threatened species and another 11 Western Ghats endemics, namely, *Telinga davisoni, T. oculus*, *Ypthima chenu, Y. ypthimoides*, *Arnetta mercara*, *Baracus hampsoni*, *B. subditus*, *Thoressa astigmata*, *T. evershedi*, *Oriens concinna*, and *Caltoris canaraica*, which are primary grass feeders. Eravikulam, on the Anamalai–High Range–Palni landscape, lies on a major path of the return migration of butterflies to Western Ghats before the north-east monsoons. Although well-protected, the ENP has anthropogenic pressures from tea estates surrounding it, mammal-oriented management practices like controlled burning of primary grasslands, and natural forest fires, that can significantly affect the invertebrate fauna especially montane grassland shola-dependent butterflies.

Keywords: Checklist, Endemic, grasslands, IUCN, Lepidoptera, shola, WPA.

Abbreviations: ENP—Eravikulam National Park | KFD—Kerala Forest Department | MWD—Munnar Wildlife Division | TNHS—Travancore Nature History Society | IUCN—The International Union for Conservation of Nature | WG—Western Ghats | WPA—Indian Wildlife (Protection) Act 1972.

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Author contributions: KS worked on the primary concept of this paper, did field surveys and drafted the Manuscript. TA helped with field surveys and editing of MS. EK shared filed data and made comments on the MS. BK helped with field surveys and made edits on the MS.

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INTRODUCTION

The Eravikulam National Park (ENP), was established in 1978. ENP with an area of 97 km^2, is located in the High Ranges (Kannan Devan Hills) of the Munnar landscape of southern Western Ghats (WG) in the Devikulam Taluk of Idukki district, Kerala State (Image 1) between 10.08–10.33 °N & 77.00–77.16 °E. The elevation ranges from 1,200 m on the slopes to 2,695 m at the summit of Anamudi, the highest point in peninsular India. The boundaries of the park extend into Anamalai Tiger Reserve in Tamil Nadu, Chinnar Wildlife Sanctuary, and Marayur forest division in the north & east, Mankulam & Munnar forest divisions in the south, and the Anamudi reserve forest under Munnar Forest Division in the west (Anonymous 2012). The terrain is undulating with vegetation mainly of montane wet temperate forests (sholas) and primary grasslands. Annual rainfall varies from 2,000 mm to 5,000 mm, with a short three-month dry season. The major fraction (up to 60%) of precipitation is received from the south-west monsoons. The temperature varies from 10.88±6.55 ^{0}C to 23.42±1.3 ^{0}C. Frost is a common phenomenon in winter (December–February). ENP is regionally important as a perennial catchment area for east-flowing tributaries of River Pambar, west-flowing tributaries of rivers Periyar and Chalakkudy (Nair 1991; Anonymous 2012). The ENP has good biodiversity with 132 species of birds, 20 species of amphibians, 13 species of reptiles, four species of fish, and 101 species of butterflies (Anonymous 2012). The major vegetation types of the ENP are the southern montane wet temperate forests, southern montane wet temperate grasslands, southern sub-tropical broad-leaved hill forest, southern west coast evergreen forest, and southern tropical moist deciduous forests (Image 2) (Anonymous 2012). The last two forest types are seen along the western and eastern boundaries respectively (Anonymous 2012). The ENP holds the last remaining undisturbed patches of southern montane wet temperate forests and southern montane wet temperate grasslands of Peninsular India (Nair 1991).

Previous works on butterfly diversity of ENP are very few. Ferguson (1891), was probably the first naturalist to work on butterflies of Munnar and the adjoining Pirmed (Peermedu) Plateau. The records from High Range of Munnar of the following species may be seen in his work on butterflies of Travancore: '*Rohana cambia* Moore' [*Rohana parisatis atacinus* Fruhstorfer, 1913, Black Prince], '*Argynnis niphe* Linnaeus' [*Argynnis castetsi* (Oberthür, 1891), Palni Fritillary], '*Colias nilagiriensis* Felder' [*Colias nilagiriensis* Felder & Felder, 1859, Nilgiri Clouded Yellow], '*Catophaga galena* Felder' [*Appias wardii* (Moore, 1884), Sahyadri /Lesser/ Ward's Albatross], and '*Ismene jaina* Moore' [*Burara jaina fergusonii* (de Nicéville, [1893]), Sahyadri Orange Awlet]. G.F. Hampson (1888) paid occasional visits to Anamalais, Mudis Hills, and Nelliampathies during his stay in Wayanad-Nilgiris but his major work was on the northern slopes of Nilgiris. No other historical works are specifically available for ENP, though some works are traceable from the adjoining landscapes bordering it. Evans (1910), compiled the first-ever checklist for Palnis and Kodaikanal on the eastern side of the High Range and listed 191 species. In Evans (1910), J. Evershed added a note in on the migration of butterflies in the Palnis landscape. Ugarte & Rodricks (1960) added 54 species to Evans (1910) list, and later Ghorpadé & Kunte (2010), updated the Palni checklist with a compilation of records from 1910 to 1960 and mentioned 310 species. Mathew et al. (2001) though worked on sholas of Idukki, namely, the Mannavan Shola (Anamudi Shola National Park) of the High Range landscape, with 66 species, no mention of the ENP was found. Palot (2012) reported migration of the Indian Dark Cerulean *Jamides bochus bochus* (Stoll, [1782]) from ENP. Sreekumar et al. (2018), based on a 4-month study provided a preliminary checklist of ENP with 85 species. The management plan of ENP published by the Kerala Forest Department has 101 species mentioned (Anonymous 2012). However, recent systematic surveys by Travancore Nature History Society (TNHS), Munnar Wildlife Division (MWD), and Kerala Forest Department (KFD) have revealed 88 species with some additions (Kalesh 2019). In this paper, we critically evaluate all the available published peer-reviewed records of butterflies from ENP including survey reports. A final checklist of butterflies from ENP is provided in light of our fieldwork since the year 2000.

MATERIALS AND METHODS

This paper is a critical compilation of the field data of the authors including distribution, larval host and migration, recorded over the last two decades from ENP. The previous literature on butterflies of the region and the adjoining landscapes Ferguson (1891), Hampson (1888), Evans (1910), Ugarte & Rodricks (1960), Ghorpadé & Kunte (2010), Palot (2012), Sreekumar et al. (2018), and (Kalesh 2019) were reviewed. The data logged in the management plan published by the KFD (Anonymous 2012) was also consulted, as well as the

Image 1. Map of Eravikulam National Park.

reports submitted by TNHS to MWD, KFD on faunal survey of MWD done in 2016, 2018, 2020, and 2021. In addition, the field data of the authors from previous visits to the region was also added. The standard transect methodology (3 km in 3 hours) was employed in field surveys with strategically placed basecamps covering all habitats and elevational gradients of ENP. The core region was assessed in Anamudi, Eravikulam, Poovar, Varattukulam, Rajamalai, Kolukkan, Meenthotty, and Bhadrakali Shola. The boundaries were assessed by visiting Njandala, Pothumala, Chinna-Poovar, Vaguvarai, Lakkam, and Pettimudi. Occasional visits were done to wetter evergreen Edamalayar & Valparai slopes on the western and northern side and eastern dry slopes of Marayur & Chinnar. For all calculation purposes, the butterflies recorded inside the ENP only were considered. The general taxonomic placement and checklists follow Evans (1932 & 1949), Wynter-Blyth (1957), Larsen (1987–88), Gaonkar (1996), Nitin et al. (2018), Kunte et al. (2022), and Sadasivan & Sengupta (2022, in press). Geographical divisions and landscapes follow Sankar (2013) with necessary modifications. The population status was determined in the ENP based on transect data with status as Very Common (VC) if seen in >75% transects, Common (C) if seen in 50–75%, Not Rare (NR) if is seen in 25–50% transects, Rare (R) in case seen in 5–25%, and Very Rare (VR) if seen in <5% of the transects. Doubtful records and stragglers are mentioned in the discussion part of each family. Detailed analysis of transects with biodiversity indices and

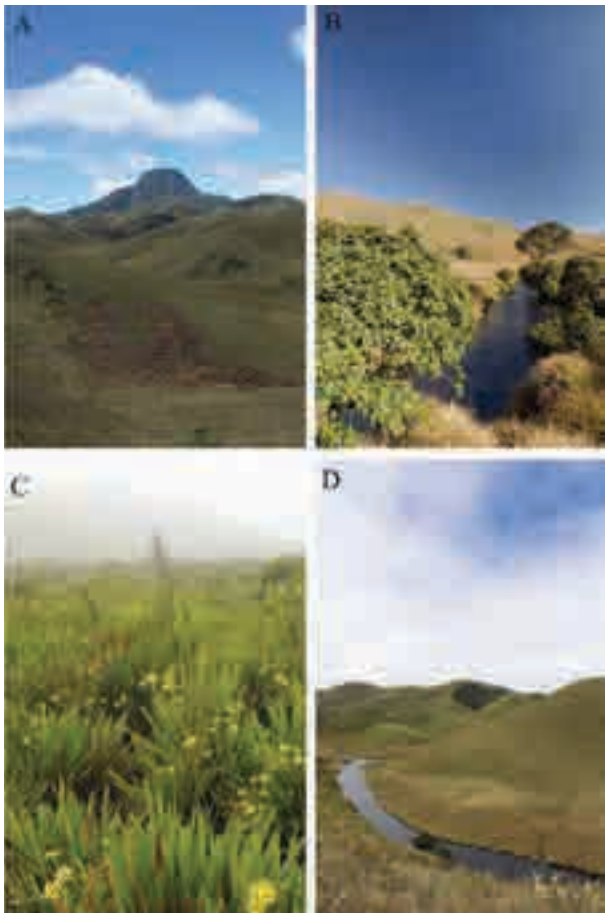

Image 2. Habitats shots of Eravikulam National Park: A—Southern montane wet temperate grasslands of Eravikulam near Anamudi peak | B—Riparian patches of grasses and *Rhododendron* trees | C—*Garnotia* grass patches in marshes and steam sides | D—Southern montane wet temperate forests (Sholas) and grasslands. © Kalesh Sadasivan.

conservation values shall be published elsewhere. The Red List status is derived from the IUCN site http://www.iucnredlist.org (IUCN 2021), based on global population assessments. Species with distribution restricted to habitats and subunits of a single landscape are referred to as super-endemics. The Palani Sailor *Neptis palnica* Eliot, 1969 from High Ranges of southern Western Ghats and Palini Bushbrown *Telinga davisoni* (Moore, [1891]) from Anjanad valley-Palani region of southern Western Ghats are known only from specific subregions inside the of the Munnar landscape and hence are examples of super-endemics (Image 3).

RESULTS AND DISCUSSION

Based on our field work we found 198 valid species records for ENP from our work. Western Ghats has 335 species and Kerala state has 326 species as per the latest estimates (Sadasivan & Sengupta, in press 2022). Thus, ENP harbours 60.73% of butterflies of Kerala and 59.10% species of butterflies seen in the WG.

Fourteen species of family Papilionidae were recorded out of the 19 (73.69%) species seen in Kerala and WG. The commonest of them was *Graphium teredon* (Felder & Felder, 1865). None of the endemic papilionids were recorded during the present study. The largest butterfly and the south Indian endemic *Troides minos* (Cramer, [1779]) was occasionally seen in the western boundaries. *Papilio dravidarum* Wood-Mason, 1880, and *Pachliopta pandiyana* (Moore, 1881) are mentioned in the management plan, but we have no records of this WG endemic, which may be seen in the wetter western slopes. *Papilio paris tamilana* Moore, 1881 is occasionally seen in the sholas and sub-tropical forests on the west, while *Papilio crino* Fabricius, 1793 was a very rare straggler from the eastern slopes.

Twenty-five species of Pierids were observed inside the ENP out of the 32 (78.13%) species in Kerala and 34 (73.53%)species in WG. *Colias nilagiriensis* Felder & Felder, 1859, and *Appias wardii* (Moore, 1884) were the WG endemics seen in the ENP. *Catopsilia pomona pomona* (Fabricius, 1775) and *Appias* (*Catophaga*) *albina swinhoei* (Moore, 1905) were the commonest species followed by *Eurema laeta laeta* (Boisduval, 1836) and *Eurema brigitta rubella* (Wallace, 1867) in our observation. *Eurema* (*Terias*) *nilgiriensis* (Yata, 1990), *Prioneris sita* (Felder & Felder, 1865), *Appias libythea* (Fabricius, 1775), and *Pareronia hippia* (Fabricius, 1787) are possible stragglers from the low evergreen side on the west (<1,000 m), while *Colotis fausta fulvia* (Wallace, 1867) is occasionally encountered on the western slopes, and *Pareronia hippia* (Fabricius, 1787) on the eastern slopes. However, there are no confirmed records of these species inside the ENP.

Nymphalidae had the highest number of butterflies in ENP with 70 species recorded of the 97 (72.16%) in Kerala and 100 (70%) in WG. Amongst the subfamilies of Nymphalidae, Satyrinae topped the numbers with 20 species followed by Limenitidinae (14 species) and Nymphalinae 10 (species). This is not surprising as the major part of the landscape is covered in grass (Poaceae), the larval hostplant of most Satyrines. *Ypthima ypthimoides* (Moore, 1881), *Lethe rohria neelgheriensis* (Guérin-Méneville, 1843), *Ypthima baldus baldus* (Fabricius, 1775), and *Ypthima huebneri* Kirby, 1871 were the most common Satyrines encountered. *Ochlandra* sp. dependent species like *Zipaetis saitis* Hewitson, 1863 and *Parantirrhoea marshalli* Wood-

Mason, 1881 are yet to be found in the ENP but may be seen in the lower western slopes, while the dry species *Ypthima ceylonica* Hewitson, 1865, may occur on the eastern slopes. *Telinga davisoni* (Moore, [1891]) *Telinga oculus* Marshall, 1881, *Ypthima ypthimoides* (Moore, 1881), and *Ypthima chenu* (Guérin-Méneville, 1843) are grassland depended endemic Satyrines. Of these, *Telinga davisoni* (Moore, [1891]) is endemic to the landscape and Palnis. *Argynnis castetsi* (Oberthür, 1891), *Neptis palnica* Eliot, 1969 and *Parantica nilgiriensis* (Moore, 1877) are montane temperate shola Nymphalid endemics. *Charaxes psaphon imna* Butler, 1870, *Charaxes schreiber wardii* (Moore, 1896), *Idea malabarica* (Moore, 1877), *Kallima horsfieldii* Kollar, [1844], *Cethosia mahratta* Moore, 1872, and *Dophla evelina laudabilis* Swinhoe, 1890, are reported on the western lower slopes, but not inside the ENP, while *Byblia ilithyia* (Drury, [1773]) and *Symphaedra nais* (Forster, 1771) are rare stragglers of the eastern dry Chinnar slopes.

Of the two species of Riodinidae seen in Kerala and WG, only one species—*Abisara echerius prunosa* Moore, 1879—has been recorded from ENP.

Of the 100 species of Lycaenidae in WG and 97 in Kerala, 42 species have been reported from ENP. *Celatoxia albidisca* (Moore, [1884]) is the only endemic species of lycaenid recorded here. Polyommatinae subfamily had 31 taxa, the maximum number of species, Theclinae had only nine, Miletinae had one species, while Curetinae was unrepresented. Interestingly none of the three dependent species from tribe *Arhopalini* were recorded. *Azanus jesous gamra* (Lederer, 1855) and *Azanus ubaldus* (Stoll, [1782]) are dryland species seen on the eastern slopes, but till now not recorded inside ENP. *Freyeria putli* (Kollar, [1844]) was a common species. *Creon cleobis cleobis* (Godart, [1824]), the sole representative of tribe Iolaini -was not rare on the shola edges.

Forty-six species of Hesperiidae were noted inside ENP, out of the 82 species seen in Kerala (56.09%) and WG (56.09%). Eight endemics were noted, they were primary grass feeders like *Arnetta mercara* Evans, 1932, *Baracus hampsoni* Elwes & Edwards, 1897, *Baracus subditus* Moore, [1884], and *Oriens concinna* (Elwes & Edwards, 1897). Some Bamboo and *Calamus* sp. feeding butterflies like *Thoressa evershedi* (Evans, 1910), *Caltoris canaraica* (Moore, [1884]), *Thoressa astigmata* (Swinhoe, 1890), and *Quedara basiflava* (de Nicéville, [1889]), were recorded occasionally from the western slopes. Sreekumar et al. (2018) reported *Tagiades litigiosa litigiosa* Möschler, 1878, and *Gerosis bhagava bhagava* (Moore, [1866]), both low-midland species from ENP. But, based on our field data these records are doubtful, and are possibly stragglers to high elevations, hence records of these are highly unlikely inside ENP, although these may be found on the western and eastern slopes at lower elevations.

Table 1. Summary of comparison of Western Ghats (WG), Kerala, and Eravikulam National Park (ENP) with respect to butterfly families, endemic status, IUCN Red List status, and legal protection under Indian Wildlife Protection Act 1972.

Family-wise statistics			
Family	**WG**	**Kerala**	**ENP**
Papilionidae	19	19	14
Pieridae	34	32	25
Nymphalidae	100	97	70
Riodinidae	2	2	1
Lycaenidae	98	94	42
Hesperiidae	82	82	46
Total	335	326	198
Endemic species			
Family	**WG**	**Kerala**	**ENP**
Papilionidae	4	4	2
Pieridae	3	3	3
Nymphalidae	18	18	8
Riodinidae	0	0	0
Lycaenidae	5	5	1
Hesperiidae	12	12	8
Total	42	42	22
IUCN Red List status			
Red List Category	**WG**	**Kerala**	**ENP**
Least Concern	20	20	17
Lower Risk/Near Threatened	2	2	1
Total	22	22	18
WPA 1972 legal status			
Schedules	**WG**	**Kerala**	**ENP**
Schedule I	6	6	3
Schedule I,II	1	1	1
Schedule II	45	44	18
Schedule IV	11	11	5
Total	63	62	27

Endemicity

Thirty-five species of butterflies from ENP had some kind of endemicity associated with them (Table 2). Twenty-two (52.38%) were strictly endemic to WG. Two papilionids, three pierids, eight nymphalids, one lycaenid, and eight hesperiids of ENP are endemic to the WG.

Table 2. Family-wise list of endemic species and their known distribution.

	Scientific name — Common name	Endemicity
1	*Troides minos* (Cramer, [1779]) — Sahyadri Birdwing	WG and SI
2	*Pachliopta pandiyana* (Moore, 1881) — Malabar Rose	WG
3	*Pachliopta hector* (Linnaeus, 1758) — Crimson Rose	PI and SL
4	*Graphium teredon* (Felder & Felder, 1865) — Narrow-banded Bluebottle	SI
5	*Papilio dravidarum* Wood-Mason, 1880 — Malabar Raven	WG
6	*Eurema* (*Terias*) *nilgiriensis* (Yata, 1990) — Sahyadri Grass Yellow	WG
7	*Colias nilagiriensis* Felder & Felder, 1859 — Nilgiri Clouded Yellow	WG
8	*Prioneris sita* (Felder & Felder, 1865) — Painted Sawtooth	SI and SL
9	*Appias wardii* (Moore, 1884) — Sahyadri Albatross / Ward's Albatross	WG
10	*Lethe drypetis todara* Moore, 1881 — Dakhan Treebrown	SI and SL
11	*Mycalesis patnia junonia* Butler, 1868 — Malabar Glad-eye Bushbrown	SI
12	*Mycalesis subdita* Moore, 1892 — Tamil Bushbrown	SI and SL
13	*Telinga davisoni* (Moore, [1891]) — Palni Bushbrown	WG
14	*Telinga oculus* Marshall, 1881 — Red-disc Bushbrown	WG
15	*Ypthima ceylonica* Hewitson, 1865 — White Four-ring	PI and SL
16	*Ypthima chenu* (Guérin-Méneville, 1843) — Nilgiri Four-ring	WG
17	*Ypthima ypthimoides* (Moore, 1881) — Palni Four-ring	WG
18	*Cethosia mahratta* Moore, 1872 — Sahyadri Lacewing	WG
19	*Argynnis castetsi* (Oberthür, 1891) — Palni Fritillary	WG
20	*Cirrochroa thais thais* (Fabricius, 1787) — Sahyadri Yeoman	SI and SL
21	*Neptis palnica* Eliot, 1969 — Palni/ Creamy Sailer	WG
22	*Parantica nilgiriensis* (Moore, 1877) — Nilgiri Tiger	WG
23	*Celatoxia albidisca* (Moore, [1884]) — White-disc Hedge Blue	WG
24	*Ionolyce helicon viola* (Moore, 1877) — Sri Lankan Pointed Lineblue	WG and SL
25	*Cigaritis schistacea* (Moore, [1881]) — Plumbeous Silverline	PI and SL
26	*Celaenorrhinus fusca* (Hampson, 1888) — Dusky Spotted Flat	PI
27	*Arnetta mercara* Evans, 1932 — Coorg Forest Bob	WG
28	*Baracus hampsoni* Elwes & Edwards, 1897 — Malabar Hedge Hopper	WG
29	*Baracus subditus* Moore, [1884] — Yellow-striped Hedge Hopper	WG
30	*Quedara basiflava* (de Nicéville, [1889]) — Yellow-base Flitter	WG
31	*Thoressa astigmata* (Swinhoe, 1890) — Unbranded Ace	WG
32	*Thoressa evershedi* (Evans, 1910) — Travancore Tawny Ace	WG
33	*Oriens concinna* (Elwes & Edwards, 1897) — Sahyadri Dartlet	WG
34	*Potanthus diana* (Evans, 1932) — Chinese Dart	PI
35	*Caltoris canaraica* (Moore, [1884]) — Karwar Swift	WG

WG—Western Ghats | PI—Peninsular India | SL—Sri Lanka | SI—Southern India.

IUCN Red List

Eighteen species are under the Red List of IUCN, in accordance with the global population status. Except for *Parantica nilgiriensis* in the Near Threatened category, all others are under Least Concern. In addition *Pachliopta pandiyana* (Moore, 1881) and *Byblia ilithyia* (Drury, [1773]) are stragglers to the ENP under the Least Concern category (Table 3).

WPA 1972

Twenty-seven species from ENP were under the schedules of WPA and its amendments. Two species are in schedule I, one in both schedule I&II, 17 under schedule II, and four under schedule IV (Table 4). Of them *Charaxes schreiber wardii* (Moore, 1896), *Dophla evelina laudabilis* Swinhoe, 1890, *Prioneris sita* (Felder & Felder, 1865), and *Appias libythea* (Fabricius, 1775) were stragglers.

Butterfly Migration in ENP

Eravikulam falls in the main migration path of Anamalai–High Range–Palni landscape. The major passage is the return migration before the northeast monsoons towards the Western Ghats. The major family of this migration is the nymphalids, though the process starts with the pierids. There are two paths followed by the migrants, one is from the Amaravati Valley through Marayur gap and the other is from Palnis. The butterflies ascend into the ENP plateau through the Olikudi, and similar valleys on the eastern slopes of Marayur and Chinnar, passing through Poovar and descend into Valparai and Edamalayar valleys, finally dispersing into the lower Periyar landscape. Major component of the migration are danaines like *Tirumala septentrionis dravidarum* Fruhstorfer, 1899, *Euploea core core* (Cramer, [1780]), *Tirumala limniace exoticus* (Gmelin, 1790), *Danaus chrysippus chrysippus* (Linnaeus, 1758), and *Euploea sylvester coreta* (Godart, 1819). The pierid component is *Catopsilia pomona pomona* (Fabricius, 1775), *Appias (Catophaga) albina* swinhoei (Moore, 1905), and *Appias wardii* (Moore, 1884). Lycaenids like *Jamides bochus bochus* (Stoll, [1782]) & *Lampides boeticus* (Linnaeus, 1767) and hesperiids like *Pelopidas agna agna* (Moore, [1866]) & *Pelopidas mathias mathias* (Fabricius, 1798) also migrate. The onward migration from Western Ghats to Tamil Nadu plains and the Eastern Ghats is less striking and obvious. List of migrating butterflies is given in Table 5.

Image 3. Some interesting butterflies of Eravikulam National Park: A—*Argynnis castetsi* (Oberthür, 1891) Palni Fritillary | B—*Telinga davisoni* (Moore, [1891]) Palni Bushbrown | C—*Neptis palnica* Eliot, 1969 Palni Sailer | D—*Telinga oculus* Marshall, 1881 Red-disc Bushbrown | E—*Parantica nilgiriensis* (Moore, 1877) Nilgiri Tiger | F—*Celatoxia albidisca* (Moore, [1884]) White-disc Hedge Blue | G—*Baracus subditus* Moore, [1884] Yellow-striped Hedge Hoppe | H—*Oriens concinna* (Elwes & Edwards, 1897) Sahyadri Dartlet | I—*Caltoris canaraica* (Moore, [1884]) Karwar Swift | J—*Colias nilagiriensis* Felder & Felder, 1859 Nilgiri Clouded Yellow. © A-B, D-J—Kalesh Sadasivan & C—Preeti Y.

Table 3. List of species in ENP under Red List of IUCN.

	Scientific name — Common name	IUCN Red List status*
1	*Troides minos* (Cramer, [1779]) — Sahyadri Birdwing	LC
2	*Pachliopta pandiyana* (Moore, 1881) — Malabar Rose	LC
3	*Pachliopta aristolochiae aristolochiae* (Fabricius, 1775) — Indian Common Rose	LC
4	*Pachliopta hector* (Linnaeus, 1758) — Crimson Rose	LC
5	*Eurema* (*Terias*) *andersoni shimai* Yata & Gaonkar, 1999 — Sahyadri One-spot Grass Yellow	LC
6	*Eurema brigitta rubella* (Wallace, 1867) — Small Grass Yellow	LC
7	*Belenois aurota aurota* (Fabricius, 1793) — Indian Pioneer	LC
8	*Melanitis leda leda* (Linnaeus, 1758) — Oriental Common Evening Brown	LC
9	*Rohana parisatis atacinus* Fruhstorfer, 1913 — Sahyadri Black Prince	LC
10	*Byblia ilithyia* (Drury, [1773]) — Joker	LC
11	*Junonia almana almana* (Linnaeus, 1758) — Oriental Peacock Pansy	LC
12	*Junonia hierta hierta* (Fabricius, 1798) — Oriental Yellow Pansy	LC
13	*Vanessa cardui* (Linnaeus, 1758) — Painted Lady	LC
14	*Euploea core core* (Cramer, [1780]) — Indian Common Crow	LC
15	*Parantica nilgiriensis* (Moore, 1877) — Nilgiri Tiger	NT
16	*Zizula hylax hylax* (Fabricius, 1775) — Indian Tiny Grass Blue	LC
17	*Cheritra freja butleri* Cowan, 1965 — Sahyadri Common Imperial	LC
18	*Pelopidas mathias mathias* (Fabricius, 1798) — Dakhan Small Branded Swift	LC

* LC—Least Concern | NT—Near Threatened.

Table 4. List of species in ENP under WPA 1972.

	Scientific name — Common name	WPA 1972 Schedule
1	*Pachliopta hector* (Linnaeus, 1758) — Crimson Rose	I
2	*Eurema* (*Terias*) *andersoni shimai* Yata & Gaonkar, 1999 — Sahyadri One-spot Grass Yellow	II
3	*Prioneris sita* (Felder & Felder, 1865) — Painted Sawtooth	IV
4	*Cepora nadina remba* (Moore, [1858]) — Sahyadri Lesser Gull	II
5	*Appias* (*Hiposcritia*) *indra shiva* (Swinhoe, 1885) — Sahyadri Plain Puffin	II
6	*Appias libythea* (Fabricius, 1775) — Western Striped Albatross	IV
7	*Appias wardii* (Moore, 1884) — Sahyadri Albatross / Ward's Albatross	II
8	*Melanitis zitenius gokala* Moore, 1857 — Sahyadri Great Evening Brown	II
9	*Mycalesis anaxias anaxias* Hewitson, 1862 — Sahyadri White-bar Bushbrown	II
10	*Charaxes schreiber wardii* (Moore, 1896) — Sahyadri Blue Nawab	I
11	*Libythea laius lepitoides* Moore, 1903 — Sahyadri Lobed Beak	II
12	*Dophla evelina laudabilis* Swinhoe, 1890 — Sahyadri Redspot Duke	II
13	*Tanaecia lepidea miyana* (Fruhstorfer, 1913) — Peninsular Grey Count	II
14	*Athyma ranga karwara* (Fruhstorfer, 1906) — Karwar Blackvein Sergeant	II
15	*Neptis nata hampsoni* Moore, 1899 — Sahyadri Clear Sailer	II
16	*Neptis palnica* Eliot, 1969 — Palni/ Creamy Sailer	II
17	*Parthenos sylvia virens* Moore, 1877 — Sahyadri Clipper	II
18	*Hypolimnas misippus* (Linnaeus, 1764) — Danaid Eggfly	I,II
19	*Euchrysops cnejus cnejus* (Fabricius, 1798) — Oriental Gram Blue	II
20	*Lampides boeticus* (Linnaeus, 1767) — Pea Blue	II
21	*Nacaduba pactolus continentalis* Fruhstorfer, 1916 — Continental Large Four-Lineblue	II
22	*Prosotas noreia hampsonii* (de Nicéville, 1885) — Indian White-tipped Lineblue	I
23	*Tarucus ananda* (de Nicéville, [1883]) — Dark Pierrot	IV
24	*Cigaritis lohita lazularia* (Moore, 1881) — Tamil Long-banded Silverline	II
25	*Catapaecilma major callone* (Fruhstorfer, 1915) — Sahyadri Common Tinsel	II
26	*Oriens concinna* (Elwes & Edwards, 1897) — Sahyadri Dartlet	IV
27	*Pelopidas subochracea subochracea* (Moore, 1878) — Bengal Large Branded Swift	IV

CONCLUSIONS

This paper critically summarises the butterfly fauna of ENP. A total of 198 species of butterflies were recorded from ENP including point endemics like *Neptis palnica* Eliot, 1969, and *Telinga davisoni* (Moore, [1891]) found only in this landscape. These are montane grassland-shola depended species. Moreover, ENP also holds *Parantica nilgiriensis* (Moore, 1877) a Near Threatened species, and another 11 Western Ghat endemics namely: Palni Bushbrown *Telinga davisoni* (Moore, [1891]), Red-disc Bushbrown *Telinga oculus* Marshall, 1881, Nilgiri Four-ring *Ypthima chenu* (Guérin-Méneville, 1843), Palni Four-ring *Ypthima ypthimoides* (Moore, 1881), Coorg Forest Bob *Arnetta mercara* Evans, 1932, Malabar Hedge Hopper *Baracus hampsoni* Elwes & Edwards, 1897, Yellow-striped Hedge Hopper *Baracus subditus* Moore, [1884], Unbranded Ace *Thoressa astigmata* (Swinhoe, 1890), Travancore Tawny Ace *Thoressa evershedi* (Evans, 1910), Sahyadri Dartlet *Oriens concinna* (Elwes & Edwards, 1897), and Karwar Swift *Caltoris canaraica* (Moore, [1884]), which are primary grass (Poaceae) feeders.

During the field work we observed that even though well-protected, the ENP is facing pressures from forest/grassland fires, anthropogenic effects like use of pesticides and invasive flora from tea estates on

Table 5. List of migratory butterflies of Eravikulam National Park.

	Family	Tribe	Taxon
1	Papilionidae	Papilioninae	*Pachliopta aristolochiae aristolochiae* (Fabricius, 1775)
2	Papilionidae	Papilioninae	*Pachliopta hector* (Linnaeus, 1758)
3	Papilionidae	Papilioninae	*Papilio demoleus demoleus* Linnaeus, 1758
4	Papilionidae	Papilioninae	*Papilio polytes romulus* Cramer, [1775]
5	Pieridae	Coliadinae	*Catopsilia pomona pomona* (Fabricius, 1775)
6	Pieridae	Coliadinae	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758)
7	Pieridae	Pierinae	*Cepora nerissa phryne* (Fabricius, 1775)
8	Pieridae	Pierinae	*Belenois aurota aurota* (Fabricius, 1793)
9	Pieridae	Pierinae	*Appias* (*Catophaga*) *albina swinhoei* (Moore, 1905)
10	Pieridae	Pierinae	*Appias* (*Hiposcritia*) *indra shiva* (Swinhoe, 1885)
11	Pieridae	Pierinae	*Appias wardii* (Moore, 1884)
12	Nymphalidae	Nymphalinae	*Hypolimnas bolina jacintha* (Drury, 1773)
13	Nymphalidae	Nymphalinae	*Hypolimnas misippus* (Linnaeus, 1764)
14	Nymphalidae	Nymphalinae	*Junonia almana almana* (Linnaeus, 1758)
15	Nymphalidae	Nymphalinae	*Junonia hierta hierta* (Fabricius, 1798)
16	Nymphalidae	Nymphalinae	*Junonia lemonias lemonias* (Linnaeus, 1758)
17	Nymphalidae	Nymphalinae	*Junonia orithya* Butler, 1885
18	Nymphalidae	Nymphalinae	*Vanessa cardui* (Linnaeus, 1758)
19	Nymphalidae	Danainae	*Danaus chrysippus chrysippus* (Linnaeus, 1758)
20	Nymphalidae	Danainae	*Danaus genutia genutia* (Cramer, [1779])
21	Nymphalidae	Danainae	*Euploea core core* (Cramer, [1780])
22	Nymphalidae	Danainae	*Euploea sylvester coreta* (Godart, 1819)
23	Nymphalidae	Danainae	*Parantica aglea aglea* (Stoll, [1782])
24	Nymphalidae	Danainae	*Tirumala limniace exoticus* (Gmelin, 1790)
25	Nymphalidae	Danainae	*Tirumala septentrionis dravidarum* Fruhstorfer, 1899
26	Lycaenidae	Polyommatinae	*Jamides bochus bochus* (Stoll, [1782])
27	Lycaenidae	Polyommatinae	*Lampides boeticus* (Linnaeus, 1767)
28	Hesperiidae	Hesperiinae	*Pelopidas agna agna* (Moore, [1866])
29	Hesperiidae	Hesperiinae	*Pelopidas mathias mathias* (Fabricius, 1798)

its borders. Invasive alien species from tea estates like Eucalyptus and Wattle colonise the fringes of ENP, must be systematically removed. The tourism zone is highly vulnerable due to the constant human and vehicular movement during the dry season. There is marginal grazing in and around the boundary of the National Park. Fire is the most alarming threat to the shola grassland ecosystem (Anonymous 2012).

In addition, the Nilgiri Tahr, *Nilgiritragus hylocrius* (Ogilby, 1838) (the flagship-mammal) oriented forest management practices, like controlled burning of primary grasslands, significantly affect the invertebrate fauna like grasshoppers (Bhaskar et al. 2019), and hence herb/grass feeding butterflies. ENP being the last patch of undisturbed montane shola-grasslands of peninsular India, needs urgent changes in management practices for survival of grassland and shola-dependent endemic invertebrate species.

REFERENCES

Anonymous (2012). Management Plan of Eravikulam National Park 2012–13 to 2022–23. Kerala Forests and Wildlife Department, 107 pp.

Bhaskar, D., P. Easa, S. Ashtamoorthy, J. Skejo & A. Hochkirch (2019). Large scale burning for a threatened ungulate in a biodiversity hotspot is detrimental for grasshoppers (Orthoptera: Caelifera). *Biodiversity and Conservation* 28: 3221–3237. https://doi.org/10.1007/s10531-019-01816-6

Evans, W.H. (1910). A List of the Butterflies of the Palni Hills with descriptions of two new species. *Journal of the Bombay Natural History Society* 20: 380–392.

Evans, W.H. (1927).*The Identification of Indian butterflies.* Bombay Natural History Society, Madras, xii+302 pp.

Evans, W.H. (1949). *A catalogue of the Hesperiidae from Europe, Asia, and Australia in the British Museum (Natural History).* British Museum of Natural History, London, 502 pp.

Ferguson, H.S. (1891). A list of the butterflies of Travancore. *Journal of the Bombay Natural History Society* 6: 438–448.

Gaonkar, H. (1996). Butterflies of the Western Ghats, India (including Sri Lanka: A Biodiversity Assessment of a Threatened Mountain System). Technical report to Centre for Ecological Sciences, Indian Institute of Science, Bangalore, 51 pp.

Ghorpadé, K. & K. Kunte (2010). Butterflies (Lepidoptera—Rhopalocera) of the Palni Hills, southern Western Ghats in peninsular India: an updated review, with an appreciation of Brigadier W.H. Evans. *Colemania* 23: 1–19.

Hampson, G.F. (1888). The butterflies of the Nilgiri district, south India. *Journal of the Asiatic Society of Bengal* 47: 346–368.

Palot, M.J. (2012). A note on the migration of Dark Cerulean *Jamides bochus* (Stoll) (Lepidoptera: Lycaenidae) in Eravikulam National Park, Idukki District, Kerala, India. *Journal of Threatened Taxa* 4(14): 3373–3374. https://doi.org/10.11609/JoTT.o3244.3373-4

Kalesh, S. (2019). Report on faunal survey of Munnar Wildlife Division 2018. Munnar Wildlife Division and TNHS, Submitted to Kerala Forest and Wildlife Department, 59 pp.

Kunte, K., S. Sondhi & P. Roy (2022). *Butterflies of India, vol 3.28*. Indian Foundation for Butterflies. https://www.ifoundbutterflies.org. (Accessed online 15 January 2022)

Larsen, T.B. (1987). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 84(1): 26–54, 84(2): 291–316, 84(3):560–584.

Larsen, T.B. (1988). The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 85(1): 26–43.

Mathew G., K. Mohanadas & C.M. Brijesh (2001). Insect fauna of the

Appendix I. Checklist of Butterflies of Eravikulam National Park and Its Environs, Kerala (*POP-Population status as VC–Very Common, C–Common, NR–Not Rare, R– Rare, VR–Very Rare and S–Stragglers, **END– Endemicity as WG–Western Ghats, PI–Peninsular India, SL– Sri Lanka, SI–South India, +IUCN –IUCN Red List Status, #WPA–Indian Wildlife Protection Act Schedule as Sch.)

	Scientific name — Common name	Pop*	End**	IUCN+	WPA#
Papilionidae					
1	*Troides minos* (Cramer, [1779]) — Sahyadri Birdwing	R	WG & SI	LC	
2	*Pachliopta pandiyana* (Moore, 1881) — Malabar Rose	VR	WG	LC	
3	*Pachliopta aristolochiae aristolochiae* (Fabricius, 1775) — Indian Common Rose	R		LC	
4	*Pachliopta hector* (Linnaeus, 1758) — Crimson Rose	C	PI & SL	LC	Sch I
5	*Graphium agamemnon menides* (Fruhstorfer, 1904) — Dakhan Tailed Jay	R			
6	*Graphium doson eleius* (Felder & Felder, 1864) — Dakhan Common Jay	R			
7	*Graphium nomius nomius* (Esper, 1799)– Indian Spot Swordtail	VR			
8	*Graphium teredon* (Felder & Felder, 1865) — Narrow-banded Bluebottle	C	SI		
9	*Papilio demoleus demoleus* Linnaeus, 1758 — Northern Lime Swallowtail	C			
10	*Papilio dravidarum* Wood-Mason, 1880 — Malabar Raven	VR	WG		
11	*Papilio helenus daksha* Hampson, 1888 — Sahyadri Red Helen	NR			
12	*Papilio polymnestor polymnestor* Cramer, [1775] — Indian Blue Mormon	NR			
13	*Papilio polytes romulus* Cramer, [1775] — Indian Common Mormon	C			
14	*Papilio paris tamilana* Moore, 1881 — Sahyadri Paris Peacock	R			
Pieridae					
15	*Catopsilia pomonapomona* (Fabricius, 1775) — Oriental Lemon Emigrant	C			
16	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758) — Oriental Mottled Emigrant	R			
17	*Eurema andersoni shimai* Yata & Gaonkar, 1999 — Sahyadri One-spot Grass Yellow	VR		LC	Sch II
18	*Eurema nilgiriensis* (Yata, 1990) — Sahyadri Grass Yellow	VR	WG		
19	*Eurema blanda silhetana* (Wallace, 1867) — Sylhet Three-spot Grass Yellow	NR			
20	*Euremahecabe hecabe* (Linnaeus, 1758) — Oriental Common Grass Yellow	NR			
21	*Eurema laeta laeta* (Boisduval, 1836) — Indian Spotless Grass Yellow	C			
22	*Eurema brigitta rubella* (Wallace, 1867) — Small Grass Yellow	C		LC	
23	*Colias nilagiriensis* Felder & Felder, 1859 — Nilgiri Clouded Yellow	NR	WG		
24	*Delias eucharis* (Drury, 1773) — Indian Jezebel	R			
25	*Prioneris sita* (Felder & Felder, 1865) — Painted Sawtooth	VR	SI & SL		Sch IV
26	*Pieris canidia canis* Evans, 1912 — Sahyadri Cabbage White	VC			
27	*Cepora nadina remba* (Moore, [1858]) — Sahyadri Lesser Gull	VR			Sch II
28	*Cepora nerissa phryne* (Fabricius, 1775) — Dakhan Common Gull	R			
29	*Belenois aurota aurota* (Fabricius, 1793) — Indian Pioneer	R		LC	
30	*Appias* (*Catophaga*) *albina swinhoei* (Moore, 1905) — Sahyadri Common Albatross	C			
31	*Appias* (*Hiposcritia*) *indra shiva* (Swinhoe, 1885) — Sahyadri Plain Puffin	NR			Sch II
32	*Appias lalage lalage* (Doubleday, 1842) — Himalayan Spot Puffin	VR			
33	*Appias libythea* (Fabricius, 1775) — Western Striped Albatross	R			Sch IV
34	*Appias wardii* (Moore, 1884) — Sahyadri Albatross / Ward's Albatross	R	WG		Sch II
35	*Leptosia nina nina* (Fabricius, 1793) — Oriental Psyche	R			
36	*Colotis fausta fulvia* (Wallace, 1867) — Dakhan Large Salmon Arab	S			
37	*Ixias pyrene sesia* (Fabricius, 1777) — Dakhan Yellow Orange-tip	R			
38	*Pareronia hippia* (Fabricius, 1787) — Common Wanderer	R			
39	*Hebomoia glaucippe australis* Butler, 1898 — Sahyadri Great Orange-tip	NR			
Nymphalidae					
40	*Melanitis leda leda* (Linnaeus, 1758) — Oriental Common Evening Brown	C		LC	

	Scientific name — Common name	Pop*	End**	IUCN+	WPA#
41	*Melanitis phedima varaha* Moore, 1857 — Sahyadri Dark Evening Brown	NR			
42	*Melanitis zitenius gokala* Moore, 1857 — Sahyadri Great Evening Brown	R			Sch II
43	*Lethe drypetis todara* Moore, 1881 — Dakhan Treebrown	R	SI & SL		
44	*Lethe europa europa* (Fabricius, 1775) — Dakhan Bamboo Treebrown	R			
45	*Lethe rohria neelgheriensis* (Guérin-Méneville, 1843) — Common Treebrown	C			
46	*Mycalesis anaxias anaxias* Hewitson, 1862 — Sahyadri White-bar Bushbrown	NR			Sch II
47	*Mycalesis patnia junonia* Butler, 1868 — Malabar Glad-eye Bushbrown	C	SI		
48	*Mycalesis mineus polydecta* (Cramer, [1777]) —Dakhan Dark-branded Bushbrown	C			
49	*Mycalesis perseus tabitha* (Fabricius, 1793) — Dakhan Common Bushbrown	C			
50	*Mycalesis subdita* Moore, 1892 — Tamil Bushbrown	NR	SI & SL		
51	*Mycalesis visala visala* Moore, [1858] — Indian Long-branded Bushbrown	NR			
52	*Orsotriaena medus mandata* (Moore, 1857) — Sahyadri Medus Brown	R			
53	*Telinga davisoni* (Moore, [1891]) — Palni Bushbrown	R	WG		
54	*Telinga oculus* Marshall, 1881 — Red-disc Bushbrown	NR	WG		
55	*Ypthima baldus baldus* (Fabricius, 1775) — Common Five-ring	C			
56	*Ypthima ceylonica* Hewitson, 1865 — White Four-ring	S	PI & SL		
57	*Ypthima chenu* (Guérin-Méneville, 1843) — Nilgiri Four-ring	NR	WG		
58	*Ypthima huebneri* Kirby, 1871 — Common Four-ring	VC			
59	*Ypthima ypthimoides* (Moore, 1881) — Palni Four-ring	C	WG		
60	*Rohana parisatis atacinus* Fruhstorfer, 1913 — Sahyadri Black Prince	NR		LC	
61	*Ariadne ariadne indica* (Moore, 1884) — Indian Angled Castor	R			
62	*Ariadne merione merione* (Cramer, [1777]) — Dakhan Common Castor	R			
63	*Byblia ilithyia* (Drury, [1773]) — Joker	S		LC	
64	*Charaxes bharata* Felder & Felder, [1867] — Indian Nawab	VR			
65	*Charaxes psaphon imna* Butler, 1870 — Indian Plain Tawny Rajah	S			
66	*Charaxes schreiber wardii* (Moore, 1896) — Sahyadri Blue Nawab	S			Sch I
67	*Cyrestis thyodamas indica* Evans, 1924 — Common Map	NR			
68	*Acraea terpsicore* (Linnaeus, 1758) — Tawny Coster	R			
69	*Cethosia mahratta* Moore, 1872 — Sahyadri Lacewing	VR	WG		
70	*Argynnis castetsi* (Oberthür, 1891) — Palni Fritillary	C	WG		
71	*Cirrochroa thais thais* (Fabricius, 1787) — Sahyadri Yeoman	NR	SI & SL		
72	*Cupha erymanthis maja* Fruhstorfer, 1898 — Sahyadri Rustic	C			
73	*Phalanta phalantha phalantha* (Drury, [1773]) — Oriental Common Leopard	R			
74	*Vindula erota saloma* de Nicéville, 1886 — Sahyadri Cruiser	C			
75	*Libythea laius lepitoides* Moore, 1903 — Sahyadri Lobed Beak	R			Sch II
76	*Libythea myrrha rama* Moore, 1872 — Sri Lankan Club Beak	C			
77	*Dophla evelina laudabilis* Swinhoe, 1890 — Sahyadri Redspot Duke	S			Sch II
78	*Symphaedra nais* (Forster, 1771) — Baronet	S			
79	*Tanaecia lepidea miyana* (Fruhstorfer, 1913) — Peninsular Grey Count	R			Sch II
80	*Athyma inara* Westwood, 1850 — Color Sergeant	R			
81	*Athyma perius perius* (Linnaeus, 1758) — Oriental Common Sergeant	R			
82	*Athyma ranga karwara* (Fruhstorfer, 1906) — Karwar Blackvein Sergeant	R			Sch II
83	*Athyma selenophora kanara* (Evans, 1924) — Staff Sergeant	R			
84	*Moduza procris procris* Fruhstorfer, 1906 — Sahyadri Commander	C			
85	*Neptis clinia kallaura* Moore, 1881 — Sahyadri Sullied Sailer	R			

	Scientific name — Common name	Pop*	End**	IUCN+	WPA#
86	*Neptis hylas varmona* Moore, 1872 — Indian Common Sailer	R			
87	*Neptis jumbah nalanda* Fruhstorfer, 1908 — Nalanda Chestnut-streaked Sailer	R			
88	*Neptis nata hampsoni* Moore, 1899 — Sahyadri Clear Sailer	VR			Sch II
89	*Neptis palnica* Eliot, 1969 — Palni/Creamy Sailer	R	WG		Sch II
90	*Parthenos sylvia virens* Moore, 1877 — Sahyadri Clipper	R			Sch II
91	*Hypolimnas bolina jacintha* (Drury, 1773) — Oriental Great Eggfly	C			
92	*Hypolimnas misippus* (Linnaeus, 1764) — Danaid Eggfly	NR			Sch I,II
93	*Junonia almana almana* (Linnaeus, 1758) — Oriental Peacock Pansy	R		LC	
94	*Junonia hierta hierta* (Fabricius, 1798) — Oriental Yellow Pansy	C		LC	
95	*Junonia iphita iphita* (Cramer, [1779]) — Chocolate Pansy	C			
96	*Junonia lemonias lemonias* (Linnaeus, 1758) — Chinese Lemon Pansy	C			
97	*Junonia orithya* Butler, 1885 — Pale Blue Pansy	C			
98	*Kaniska canace viridis* Evans, 1924 — Sahyadri Blue Admiral	NR			
99	*Vanessa indica pholoe* (Fruhstorfer, 1912) — Sahyadri Red Admiral	NR			
100	*Vanessa cardui* (Linnaeus, 1758) — Painted Lady	NR		LC	
101	*Danaus chrysippus chrysippus* (Linnaeus, 1758) — Oriental Plain Tiger	C			
102	*Danaus genutia genutia* (Cramer, [1779]) — Oriental Striped Tiger	C			
103	*Euploea core core* (Cramer, [1780]) — Indian Common Crow	C		LC	
104	*Euploea klugii kollari* Felder & Felder, [1865] — Brown King Crow	VR			
105	*Euploea sylvester coreta* (Godart, 1819) — Double-branded Black Crow	NR			
106	*Parantica aglea aglea* (Stoll, [1782]) — Coromandel Glassy Tiger	C			
107	*Parantica nilgiriensis* (Moore, 1877) — Nilgiri Tiger	R	WG	NT	
108	*Tirumala limniace exoticus* (Gmelin, 1790) — Oriental Blue Tiger	VC			
109	*Tirumala septentrionis dravidarum* Fruhstorfer, 1899 — Dakhan Dark Blue Tiger	VC			
Riodinidae					
110	*Abisara echerius prunosa* Moore, 1879 — Lankan Plum Judy	NR			
Lycaenidae					
111	*Spalgis epius epius* (Westwood, 1852) — Oriental Apefly	E			
112	*Anthene lycaenina lycaenina* (Felder, 1868) — Dakhan Pointed Ciliate Blue	R			
113	*Acytolepis puspa felderi* Toxopeus, 1927 — Malabar Common Hedge Blue	R			
114	*Caleta decidia* (Hewitson, 1876) — Angled Pierrot	R			
115	*Castalius rosimon rosimon* (Fabricius, 1775) — Continental Common Pierrot	NR			
116	*Catochrysops strabo strabo* (Fabricius, 1793) — Oriental Forget-me-not	R			
117	*Celatoxia albidisca* (Moore, [1884]) — White-disc Hedge Blue	NR	WG		
118	*Celastrina lavendularis lavenduris* (Moore, 1877) — Sri Lankan Plain Hedge Blue	NR			
119	*Chilades lajus lajus* (Stoll, [1780]) — Indian Lime Blue	NR			
120	*Chilades pandava pandava* (Horsfield, [1829]) — Oriental Plains Cupid	C			
121	*Euchrysops cnejus cnejus* (Fabricius, 1798) — Oriental Gram Blue	C			Sch II
122	*Everes lacturnus syntala* Cantlie, 1963 — Dakhan Cupid	R			
123	*Freyeria putli* (Kollar, [1844]) — Oriental Grass Jewel	C			
124	*Ionolyce helicon viola* (Moore, 1877) — Sri Lankan Pointed Lineblue	VR	WG & SL		
125	*Jamides alectoeurysaces* (Fruhstorfer, 1916) — Himalayan Metallic Cerulean	R			
126	*Jamides bochus bochus* (Stoll, [1782]) — Indian Dark Cerulean	C			
127	*Jamides celeno celeno* (Cramer, [1775]) — Oriental Common Cerulean	VC			
128	*Lampides boeticus* (Linnaeus, 1767) — Pea Blue	C			Sch II

	Scientific name — Common name	Pop*	End**	IUCN*	WPA#
129	*Leptotes plinius plinius* (Fabricius, 1793) — Asian Zebra Blue	R			
130	*Megisba malaya thwaitesi* (Moore, [1881]) — Tailless Malayan	VR			
131	*Nacaduba kurava canaraica* Toxopeus, 1927 — Karwar Transparent 6-Lineblue	C			
132	*Nacaduba Pactolus continentalis* Fruhstorfer, 1916 — Continental Large 4-Lineblue	VR			Sch II
133	*Petrelaea dana* (de Nicéville, [1884]) — Dingy Lineblue	VR			
134	*Prosotas dubiosa indica* (Evans, [1925]) — Indian Tailless Lineblue	R			
135	*Prosotas nora ardates* (Moore, [1875]) — Indian Common Lineblue	R			
136	*Prosotas noreia hampsonii* (de Nicéville, 1885) — Indian White-tipped Lineblue	R			Sch I
137	*Pseudozizeeria maha ossa* (Swinhoe, 1885) — Dakhan Pale Grass Blue	NR			
138	*Talicada nyseus nyseus* (Guérin-Méneville, 1843) — Indian Red Pierrot	R			
139	*Tarucus ananda* (de Nicéville, [1883]) — Dark Pierrot	R			Sch IV
140	*Udara akasa mavisa* (Fruhstorfer, 1917) — Sahyadri White Hedge Blue	C			
141	*Zizeeria karsandra* (Moore, 1865) — Dark Grass Blue	C			
142	*Zizina otis indica* (Murray, 1874) — Indian Lesser Grass Blue	C			
143	*Zizula hylax hylax* (Fabricius, 1775) — Indian Tiny Grass Blue	VC		LC	
144	*Iraota timoleon arsaces* Fruhstorfer, 1907 — Dakhan Silverstreak Blue	R			
145	*Cigaritis lohita lazularia* (Moore, 1881) — Tamil Long-banded Silverline	NR			Sch II
146	*Cigaritis schistacea* (Moore, [1881]) — Plumbeous Silverline	NR	PI & SL		
147	*Cigaritis vulcanus* (Fabricius, 1775) — Common Silverline	NR			
148	*Catapaecilma major callone* (Fruhstorfer, 1915) — Sahyadri Common Tinsel	R			Sch II
149	*Cheritra freja butleri* Cowan, 1965 — Sahyadri Common Imperial	R		LC	
150	*Deudorix epijarbas epijarbas* (Moore, 1857) — Oriental Cornelian	R			
151	*Rapala iarbus sorya* (Kollar, [1844]) — Indian Red Flash	R			
152	*Creon cleobis cleobis* (Godart, [1824]) — Bengal Broad-tail Royal	NR			
Hesperiidae					
153	*Badamia exclamationis* (Fabricius, 1775) — Brown Awl	NR			
154	*Burara gomata kanara* (Evans, 1926) — Sahyadri Pale Green Awlet	VR			
155	*Burara jaina fergusonii* (de Nicéville, [1893]) — Sahyadri Orange Awlet	R			
156	*Choaspes benjaminii benjaminii* (Guérin-Méneville, 1843) — Sahyadri Indian Awlking	NR			
157	*Hasora chromus chromus* (Cramer, [1780]) — Oriental Common Banded Awl	R			
158	*Hasora taminatus taminatus* (Hübner, 1818) — Lankan White-banded Awl	NR			
159	*Celaenorrhinus fusca* (Hampson, 1888) — Dusky Spotted Flat	C	PI		
160	*Pseudocoladenia dan dan* (Fabricius, 1787) — Sahyadri Fulvous Pied Flat	NR			
161	*Coladenia indrani indra* Evans, 1926 — Dakhan Tricolor Pied Flat	R			
162	*Gerosis bhagava bhagava* (Moore, [1866]) — Bengal Yellow-breasted Flat	S			
163	*Tagiades gana silvia* Evans, 1934 — Dakhan Suffused Snow Flat	VR			
164	*Tagiades japetus obscurus* Mabille, 1877 — Dravidian Common Snow Flat	NR			
165	*Tagiades litigiosa litigiosa* Möschler, 1878 — Sylhet Water Snow Flat	VR			
166	*Spialia galba* (Fabricius, 1793) — Indian Grizzled Skipper	R			
167	*Aeromachus dubius dubius* Elwes & Edwards, 1897 — Sahyadri Dingy Scrub Hopper	C			
168	*Aeromachus pygmaeus* (Fabricius, 1775) — Pygmy Scrub Hopper	NR			
169	*Arnetta mercara* Evans, 1932 — Coorg Forest Bob	NR	WG		
170	*Baracus hampsoni* Elwes & Edwards, 1897 — Malabar Hedge Hopper	NR	WG		
171	*Baracus subditus* Moore, [1884] — Yellow-striped Hedge Hopper	C	WG		
172	*Erionota torus* Evans, 1941 — Rounded Palm-Redeye	R			

	Scientific name — Common name	Pop*	End**	IUCN+	WPA#
173	*Iambrix salsala luteipalpis* (Plötz, 1886) — Southern Chestnut Bob	C			
174	*Notocrypta paralysos mangla* Evans, 1949 — Sahyadri Common Banded Demon	NR			
175	*Quedara basiflava* (de Nicéville, [1889]) — Yellow-base Flitter	VR	WG		
176	*Salanoemia sala* (Hewitson, [1866]) — Maculate Lancer	VR			
177	*Suastus gremius gremius* (Fabricius, 1798) — Indian Palm Bob	VR			
178	*Suastus minuta bipunctus* Swinhoe, 1894 — Sahyadri Small Palm Bob	VR			
179	*Thoressa astigmata* (Swinhoe, 1890) — Unbranded Ace	VR	WG		
180	*Thoressa evershedi* (Evans, 1910) — Travancore Tawny Ace	NR	WG		
181	*Udaspes folus* (Cramer, [1775]) — Grass Demon	NR			
182	*Cephrenes acalle oceanica* (Mabille, 1904) — Variable Plain Palm-Dart	VR			
183	*Oriens concinna* (Elwes & Edwards, 1897) — Sahyadri Dartlet	NR	WG		Sch IV
184	*Oriens goloides* (Moore, [1881]) — Smaller Dartlet	NR			
185	*Potanthus diana* (Evans, 1932) — Chinese Dart	NR	PI		
186	*Potanthus pallidus* (Evans, 1932) — Pale Dart	NR			
187	*Potanthus palnia palnia* (Evans, 1914) — Palni Dart	C			
188	*Potanthus pava pava* (Fruhstorfer, 1911) — Yellow Dart	VR			
189	*Taractrocera ceramas* (Hewitson, 1868) — Incomplete Tawny-spotted Grass Dart	C			
190	*Telicota bambusae bambusae* (Moore, 1878) — Oriental Dark Palm-Dart	R			
191	*Telicota colon colon* (Fabricius, 1775) — Indian Pale Palm-Dart	R			
192	*Borbo bevani* (Moore, 1878) — Lesser Rice Swift	NR			
193	*Borbo cinnara* (Wallace, 1866) — Rice Swift	R			
194	*Caltoris canaraica* (Moore, [1884]) — Karwar Swift	NR	WG		
195	*Caltoris kumara kumara* (Moore, 1878) — Sahyadri Blank Swift	NR			
196	*Pelopidas agna agna* (Moore, [1866]) — Bengal Obscure Branded Swift	NR			
197	*Pelopidas mathias mathias* (Fabricius, 1798) — Dakhan Small Branded Swift	R		LC	
198	*Pelopidas subochracea subochracea* (Moore, 1878) — Bengal Large Branded Swift	C			Sch IV

sholas of Idukki and Wayanad districts, pp. 317–339. In: Nair, K.K.N., S.K. Khanduri & K. Balasubramanian (eds.). *Shola Forests of Kerala*. Kerala Forest Department and Kerala Forest Research Institute, 453 pp.

Nair, S.C. (1991). The southern Western Ghats: a biodiversity conservation plan. Studies in Ecology and Sustainable Development–4. Indian National Trust for Art and Cultural heritage, New Delhi, 92 pp.

Nitin, R., V.C. Balakrishnan, P.V. Churi, S. Kalesh, S. Prakash & K. Kunte (2018). Larval host plants of the butterflies of the Western Ghats, India. *Journal of Threatened Taxa* 10(4): 11495–11550. http://doi.org/10.11609/jott.3104.10.4.11495-11550

Sadasivan, K & A. Sengupta (2022). The butterflies of Western Ghats–their status and distribution. *Journal of the Bombay Natural History Society* (in press).

Sankar, S. (2013). Landscape units: A biogeographical approach to the assessment and conservation of biodiversity in the Western Ghats of Kerala, Western Ghats. Proceedings of the National seminar on Western Ghats Biogeography, Biodiversity & Conservation. UGC Sponsored Three Day National Seminar 14th, 15th And 16th Of February 2013. Department of Botany NSS College, Manjeri, Malappuram, Kerala, pp. 15–30.

Sreekumar, E.R., S. Nikhil, K.G. Ajay & P.O. Nameer (2018). Diversity and endemism of butterflies of montane forests of Eravikulam National Park in the Western Ghats, India. *Journal of Threatened Taxa* 10(9): 12235–12246. https://doi.org/10.11609/jott.4201.10.9.12235-12246

Ugarte, E. & L. Rodricks (1960). Butterflies of the Palni Hills: a complementary list. *Journal of the Bombay Natural History Society* 57(2): 270–277.

Wynter-Blyth, M.A. (1957). *Butterflies of Indian Region*. Bombay Natural History Society, Mumbai, 523 pp.

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COMMUNICATION

The dragonflies and damselflies (Insecta: Odonata) of Shendurney Wildlife Sanctuary, southern Western Ghats, India

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Abstract: The odonate diversity of Shendurney Wildlife Sanctuary, southern Western Ghats (WG) of Kerala state, is discussed in this paper. A total of 181 species belonging to 87 genera and 14 families have been compiled for Kerala and this includes 68 Western Ghats endemics. A total of 116 species of odonates including 33 endemics were recorded for the region. A total of 41 damselflies (Zygoptera) and 75 dragonflies (Anisoptera) were recorded for the sanctuary. Shendurney thus harbours 56.04 % of WG and 64.08 % of the odonate diversity of Kerala. In addition, this includes 48.52% of Kerala and 41.25 % of endemic odonates of Western Ghats. About 29% of all the species recorded for the Shendurney are endemic to WG. With respect to IUCN Red List of Threatened Species, one species is 'Endangered', three 'Vulnerable', two 'Near Threatened', 84 'Least Concern', 20 'Data Deficient', and six species whose IUCN Red List status was not assessed. Family Libellulidae (41 species) dominated the odonate diversity, followed by Coenagrionidae (15 species) and Gomphidae (13 species). Regarding the occurrence status, we found that 11 species were Very Common, 42 species were found to be Common, 34 species Not Rare, 10 species were Rare, and 19 species were Very Rare inside the sanctuary. None of the species listed is protected under the Indian Wildlife Protection Act 1972.

Keywords: Anisoptera, checklist, endemicity, IUCN Red List, Kerala, Zygoptera.

Abbreviations: IUCN—The International Union for Conservation of Nature | RF—Reserve Forest | TIES—Tropical Institute of Ecological Sciences | TNHS—Travancore Nature History Society | TORG—TNHS Odonate Research Group | TR—Tiger Reserve | WG—Western Ghats | WS—Wildlife Sanctuary.

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Author contributions: KS planned and executed the fieldwork and surveys, laid the concept and wrote the manuscript. VPN edited the drafts and did fieldwork. AS helped with the drafts and fieldwork.

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INTRODUCTION

The Shendurney Wildlife Sanctuary (8.80–8.95 N, 77.07–77.27 E), with an area of 171 km^2 is located in the northern aspect of the Agasthyamalai hills of the southern Western Ghats and lies in the catchment of the Parappar Dam (Thenmalai) constructed across the west-flowing Kallada River (Image 1). The Achankovil gap separates this region from the Pandalam hills, which is the southernmost extension of the Annamalai Hills Complex. The Kuttalam (Courtallam) reserve forest lies to the north-east of the sanctuary. The state boundary of Kerala with Tamil Nadu delineates its eastern border. On the southeastern side lies the Papanasam RF and Mundanthurai region of the Kalakkad-Mundanthurai TR in Tamil Nadu. The southern boundary lies along the border of the Thiruvananthapuram Forest Division where Kulathupuzha and Yerur RFs lie in contiguity with the sanctuary. A narrow stretch of reserved forest tract of the Paruthipally range separates it from Peppara WS in the south (Nair 1991). Much of the terrain of the region is undulating, with valleys and high hills. The altitude ranges from 100 m at the base of the hill to 1,550 m on top of Alwarkurichi, the highest peak. The weather is hot and humid with 2,500–5,000 mm of rainfall received during both the monsoons (Nair 1991). The temperature varies from 16 ˚C to 35 ˚C (Mathew et al. 2004). Most of the region is accessible from strategically located base camps for biodiversity assessments. The Shendurney WS has good floral diversity (Subramanian 1995). The vegetation types found here are the west-coast tropical evergreen, southern hilltop tropical evergreen, west-coast tropical semi-evergreen, and southern subtropical hill forests, southern moist mixed deciduous forests, *Ochlandra* reed brakes, myristica swamp forest, and grasslands (Chandrashekaran 1962). Shendurney was relatively unexplored as far as odonates were concerned. There are no published papers on the odonate fauna of the sanctuary and the only available literature are the survey reports submitted by the TNHS to Shendurney WS from 2011 to 2021.

MATERIALS AND METHODS

Eight basecamps at different elevations and habitats were used to assess the odonate diversity of the 171 km^2 sanctuary (Image 1). The entire sanctuary was systematically covered by using six base camps; located at Darbhakulam, Idimuzhangan, Kallar, Kattalapara, Pandimotta, Rockwood, Rosemala, and Umayar. Transects were laid considering the location of water bodies at the basecamps. A standard transect length of 3 km, 3 m wide was covered in 3 hours and odonates were documented by a three-member team. Each station was covered using 30 such transects that were analysed for presence or absence data. The paper is based majorly on the field data from monthly visits to Shendurney WS since the year 2000. In addition, the consolidated report of systematic surveys done twice a year (May and December) in the sanctuary from 2010 to 2022 by TNHS, Trivandrum submitted to Shendurney WS, Kerala Forest Department (Sadasivan et al. 2021), was also consulted.

The odonates were field-observed and photographed as far as possible with special consideration to the prothorax and anal appendages. With a valid research permit, few of the confusing species were caught, field-observed under loupe magnification (ZEISS EyeMag Pro 5x450 mm Carl Zeiss Meditec Inc.) and released. Photographs of interesting odonates and dead specimens in the field were taken with Canon EOS 70D DSLR fitted with a 180 mm macro lens and MPE 65 f 2.8 1–5x Lens (Canon Inc., Japan). Photographs of interesting odonates are included (Images 3–6).

The basic taxonomy of odonates follows Fraser (1933,

Image 1. Map of Shendurney WS with study locations. Based on Apple Maps, Copyright © 2012–2020 Apple Inc.

1934, 1936) and is updated as per Kalkman et al. (2020). The current Odonata checklist and distribution for Kerala follows Subramanian & Babu (2017), Subramanian et al. (2018), Paulson et al. (2021), and Nair et al. (2021). The occurrence status is based on transect data with status as Very Common (VC) if seen in >75% transects, Common (C) if seen in 50–75%, Not Rare (NR) is seen in 25–25% transects, Rare (R) in a case seen in 5–25%, and Very Rare (VR) is seen in <5% of the transects. The conservation status as per the IUCN Red List of Threatened Species is derived from the IUCN site http://www.iucnredlist.org (IUCN 2021). We define the occurrence status of a species as 'Locally Common' when it is commonly seen only in a particular location, habitat, station or elevation, but is rare when the transect or distribution data from the whole sanctuary is considered.

RESULTS AND DISCUSSION

A total of 116 species of odonates including 32 endemics were recorded for the Shendurney region, while the current checklist of odonates of WG is at 207 species with 80 endemics and that of Kerala state is 181 species (87 genera, 14 families) and 68 WG (Nair et al. 2021) (see Appendix 1). A total of 116 species of odonates including 32 endemics were recorded from Shendurney WS. Rao & Lahiri (1982) recorded 23 species from Silent Valley and New Amarambalam RF; Emiliyamma & Radhakrishnan (2000, 2014) reported 39 species from Parambikukam WS, Mathavan & Miller (1989) had reported 36 species from Periyar TR, Gnanakumar et al. (2012) had reported 55 species from Chimmony WS; Adarsh et al. (2015) gave a checklist of 48 species from Chinnar, and 82 species were observed from Thattaekkad bird sanctuary and its environs by Varghese et al. (2014). Palot & Kiran (2016) reported 93 species from Aaralam WS. Thus, it is to be noted that Shendurney WS has the highest species diversity of odonates amongst protected areas in Kerala state known as of present.

We observed 41 damselflies (Zygoptera) and 75 dragonflies (Anisoptera) from the sanctuary (Figure 1B). Family Libellulidae dominated the odonate diversity with 41 species, it was followed by Coenagrionidae (15 species) and Gomphidae (13 species) (Figure 1B).

The species diversity was highest at Kattalapara (88 species), followed by Darbhakulam (72) and then Umayar (69 species) (Figure 2A). The lowest numbers were at Pandimotta (35 species), but this station had some rare and endemic species (see Appendix I). The

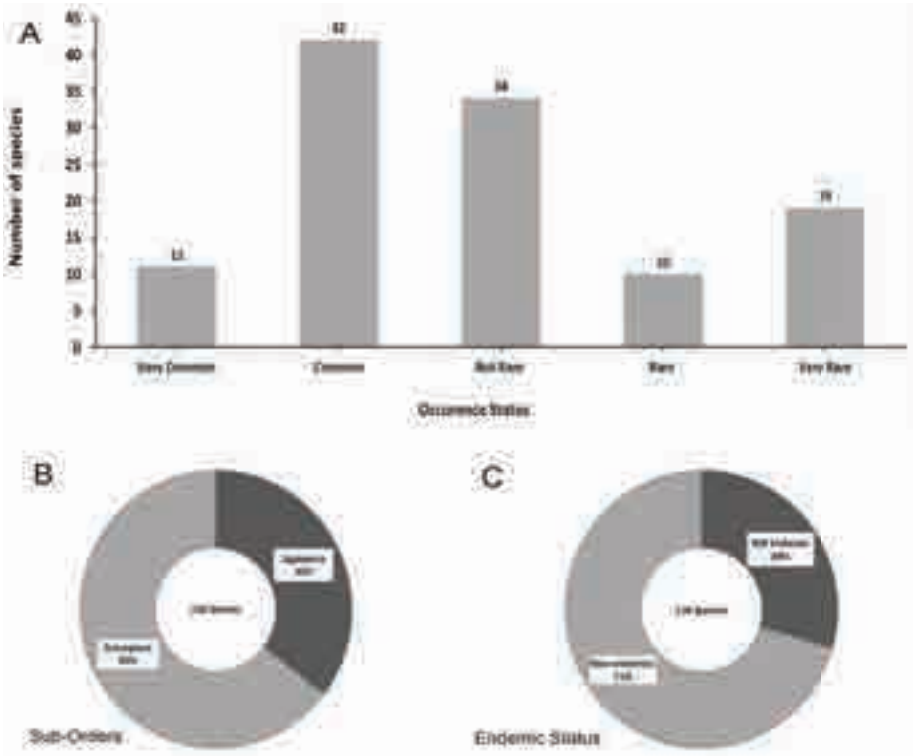

Figure 1. A—The Occurrence status of odonates of Shendurney WS | B—The percentage composition of Zygoptera (Damselflies) and Anisoptera (Dragonflies) at Shendurney WS | C—The percentage composition of endemics and non-endemic odonates at Shendurney WS.

Table 1. Details of base camps selected for the assessment in Shendurney Wildlife Sanctuary.

	Station	Elevation (m)	Major habitat/forest types
1	Darbhakulam	200–800	West-coast tropical evergreen, tropical semi-evergreen, Ochlandra reed patches, riparian forests, secondary forests, and cultivation
2	Idimuzhangan	100–250	West-coast tropical evergreen, southern moist mixed deciduous, Ochlandrareed patches, riparian vegetation, Myristica swamps, secondary forests, Ochlandrareed patches, and plantations
3	Kattalapara	100–500	West-coast tropical evergreen forest, west-coast semi-evergreen forest, moist mixed deciduous forest, Myristica swamp, Ochlandra patches
4	Kallar	500–1000	West-coast tropical evergreen forest, west-coast semi-evergreen forest, monoculture plantation, southern hilltop tropical evergreen forest, Ochlandra patches
5	Pandimotta	1000–1500	Southern hilltop tropical evergreen forest, southern sub-tropical hill forest, Ochlandra brakes
6	Rockwood	250–600	West-coast tropical evergreen, tropical semi-evergreen, and abandoned plantations
7	Rosemala	100–600	West-coast tropical evergreen, tropical semi-evergreen, Ochlandra reed patches, riparian forests, secondary forests, and cultivation
8	Umayar	100–500	West-coast tropical evergreen, tropical semi-evergreen, secondary forests, Ochlandra reed patches, and riparian patches

sanctuary has a good number of interesting records as stated below. *Elattoneura tetrica* (Laidlaw, 1917) was recorded from Kattalapara. *Vestalis submontana* Fraser, 1934, was locally common in the higher reaches of the mountains above 800 m (Image 3A). *Euphaea cardinalis* (Fraser, 1924) was usually seen confined to small streams of the hills (Image 3F), and *Euphaea fraseri* (Laidlaw, 1920) was generally restricted to low elevations (Image 3E); though they are occasionally found together after monsoons in low altitudes. *Chlorogomphus xanthoptera* (Fraser, 1919) is the sole member of Chlorogomphidae and was recorded only at high elevations at Pandimotta (Image 5B). The notable gomphids that were seen in the high elevations were *Asiagomphus nilgiricus* Laidlaw, 1922 (Image 5F), and *Heliogomphus promelas* (Selys, 1873), while *Acrogomphus fraseri* Laidlaw, 1925 (Image 5D), *Burmagomphus pyramidalis* Laidlaw, 1922, *Burmagomphus laidlawi* Fraser, 1924 (Image 5E), and

Table 2. Endemic odonates of the Western Ghats, reported from Shendurney Wildlife Sanctuary.

	Family	Scientific name
1	Chlorocyphidae	*Calocypha laidlawi* (Fraser, 1924)
2	Coenagrionidae	*Aciagrion approximans krishna* Fraser, 1921*
3	Coenagrionidae	*Agriocnemis keralensis* Peters, 1981
4	Coenagrionidae	*Pseudagrion indicum* Fraser, 1924
5	Euphaeidae	*Euphaea cardinalis* (Fraser, 1924)
6	Euphaeidae	*Euphaea fraseri* (Laidlaw, 1920)
7	Platycnemididae	*Caconeura risi* (Fraser, 1931)
8	Platycnemididae	*Elattoneura tetrica* (Laidlaw, 1917)
9	Platycnemididae	*Esme mudiensis* Fraser, 1931
10	Platystictidae	*Indosticta deccanensis* Laidlaw, 1915
11	Platystictidae	*Protosticta cyanofemora* Joshi, Subramanian, Babu & Kunte, 2020
12	Platystictidae	*Protosticta gravelyi* Laidlaw, 1915
13	Platystictidae	*Protosticta rufostigma* Kimmins, 1958
14	Platystictidae	*Protosticta sanguinostigma* Fraser, 1922
15	Chlorogomphidae	*Chlorogomphus xanthoptera* (Fraser, 1919)
16	Gomphidae	*Acrogomphus fraseri* Laidlaw, 1925
17	Gomphidae	*Asiagomphus nilgiricus* Laidlaw, 1922
18	Gomphidae	*Burmagomphus pyramidalis* Laidlaw, 1922
19	Gomphidae	*Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019
20	Gomphidae	*Gomphidia kodaguensis* Fraser, 1923
21	Gomphidae	*Macrogomphus wynaadicus* Fraser, 1924
22	Gomphidae	*Merogomphus tamaracherriensis* Fraser, 1931
23	Gomphidae	*Melligomphus acinaces* (Laidlaw, 1922)
24	Libellulidae	*Epithemis mariae* (Laidlaw, 1915)
25	Macromiidae	*Macromia ellisoni* Fraser, 1924
26	Macromiidae	*Macromia irata* Fraser, 1924
27	Genera insertae sedis	*Idionyx corona* Fraser, 1921
28	Genera insertae sedis	*Idionyx galeata* Fraser, 1924
29	Genera insertae sedis	*Idionyx minima* Fraser, 1931
30	Genera insertae sedis	*Idionyx saffronata* Fraser, 1924
31	Genera insertae sedis	*Idionyx travancorensis* Fraser, 1931
32	Genera insertae sedis	*Idionyx gomantakensis* Subramanian, Rangnekar & Nayak, 2013
33	Genera insertae sedis	*Macromidia donaldi donaldi* (Fraser, 1924)

*subspecies is endemic to WG (Kalkman et al. 2020).

Melligomphus acinaces (Laidlaw, 1922) (Image 5C) were generally seen in mid-elevations (500–1,000 m). *Orthetrum triangulare triangulare* (Selys, 1878) is a locally Common species above 800 m. Three species, *Calocypha laidlawi* (Fraser, 1924) (Image 3B). *Epithemis mariae* (Laidlaw, 1915) (Image 6D), and *Lyriothemis*

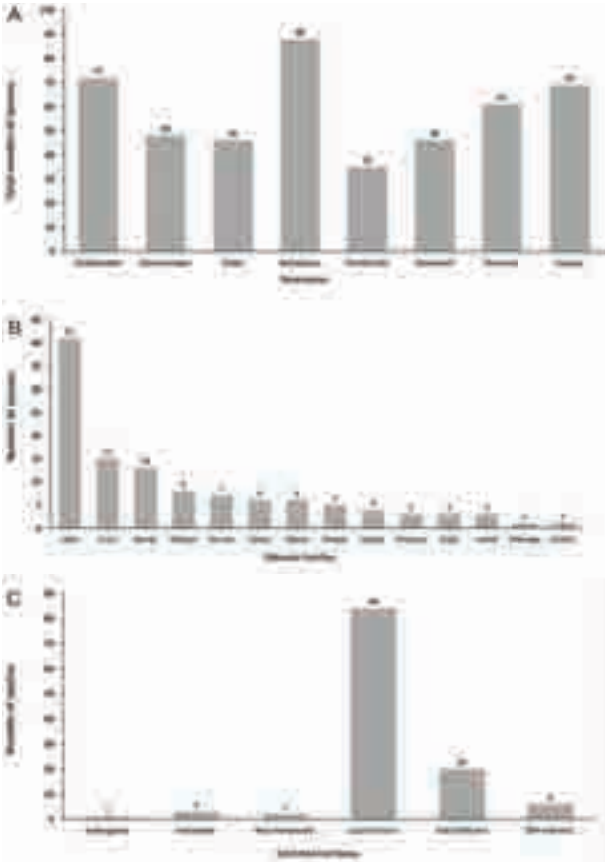

Figure 2. A—Odonate diversity across base camps at Shendurney WS | B—The diversity of different odonate families at Shendurney WS | C—IUCN Red List species composition of odonates at Shendurney WS. (Aeshn—Aeshnidae | Calopt—Calopterygidae | Chlorocy—Chlorocyphidae | Chlorogo—Chlorogomphidae | Coen—Coenagrionidae | Cordul—Corduliidae | Euph—Euphaeidae | Gen ins—Genera insertae sedis | Gomp—Gomphidae | Lestid—Lestidae | Libel—Libellulidae | Macro—Macromiidae | Platycn—Platycnemididae | Platyst—Platystictidae).

tricolor Ris, 1919 (Image 6B) were seen in lower elevations. *Epithemis mariae* and *Lyriothemis tricolor* were mostly seen around Myristica swamps while the latter was a tree-hole breeder. *Lyriothemis* males were seen guarding the water-filled tree holes at Kattalapara, Umayar, and Rosemala. *Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019 (Image 5H), and *Cyclogomphus heterostylus* Selys, 1854 were generally seen in the foothills. *Pantala flavescens* (Fabricius, 1798) was the commonest migratory species, while *Anax ephippiger* (Burmeister, 1839) was not uncommon at Umayar during the first half of the year, before the south-west monsoon. We observed that the species in the genera *Macromia* and *Idionyx* found in Shendurney WS were forest insects. While the former preferred large streams, the latter and *Macromidia* were confined to smaller streams and rocky edges of large streams. *Macromia* was represented by *M. cingulata* Rambur, 1842, *M. ellisoni* Fraser, 1924 (Image 6F), *M. flavocolorata* Fraser, 1924 (Image 6E), and *M. irata* Fraser, 1924 (Image 6C). The distribution of *M. irata* was interesting in the fact that it was observed foraging on the edges of Myristica swamps, while others were riverine insects preferring open waters. Six species of *Idionyx* are seen in the sanctuary. Of them, *I. saffronata* Fraser, 1924 and *I. travancorensis* Fraser, 1931, are the commonest and seen in huge swarms in clearings on hills hawking insects at dusk. *I. galeata* Fraser, 1924, *I. corona* Fraser, 1921 (Image 6G), and *I. minima* Fraser, 1931 are much rarer compared to the others in our observation. *I. gomantakensis* Subramanian et al., 2013 (Image 6H), was seen in the vicinity of Myristica swamps at Kattalapara. *Macromidia donaldi donaldi* (Fraser, 1924) is a low to mid-elevation species seen at the edges of large streams. *Lestes concinnus* Hagen in Selys, 1862 is occasionally seen in the low elevations of Umayar and Kattalapara. *Protosticta cyanofemora* Joshi et al., 2020 (Image 4E), and *Protosticta rufostigma* Kimmins, 1958 (Image 4C) were recorded above 800 m from Pandimotta. *Indosticta deccanensis* Laidlaw, 1915 (Image 4B), was recorded from Darbhakulam and Rockwood.

Occurrence Status

Regarding the occurrence status, we found that according to our working definition, 11 species were Very Common, 42 species were found to be Common, 34 species Not Rare, 10 species were Rare and 19 species were Very Rare (Figure 2A). The most common species seen in the region with respect to numbers were *Pantala flavescens* (Fabricius, 1798), *Brachythemis contaminata* (Fabricius, 1793), *Ceriagrion coromandelianum* (Fabricius, 1798), and *Diplacodes trivialis* (Rambur, 1842). The rarest of the species were *Idionyx galeata*, *Protosticta cyanofemora, Cyclogomphus flavoannulatus, Epophthalmia frontalis binocellata* Fraser, 1936, and *Idionyx gomantakensis.*

Endemic Status

We found 33 species from the Shendurney region which were strictly endemic to Western Ghats (Table 2). Thus, about 29 percent of the odonates of the Shendurney are Western Ghats endemics (Figure 12C).

Status as per IUCN Red List of Threatened Species

With respect to the IUCN Red List of Threatened Species, there was one 'Endangered' species, three 'Vulnerable', two 'Near Threatened', 84 'Least Concern', 20 'Data Deficient', and six species whose IUCN status was not available (Figure 2C). *Idionyx galeata*, reported from

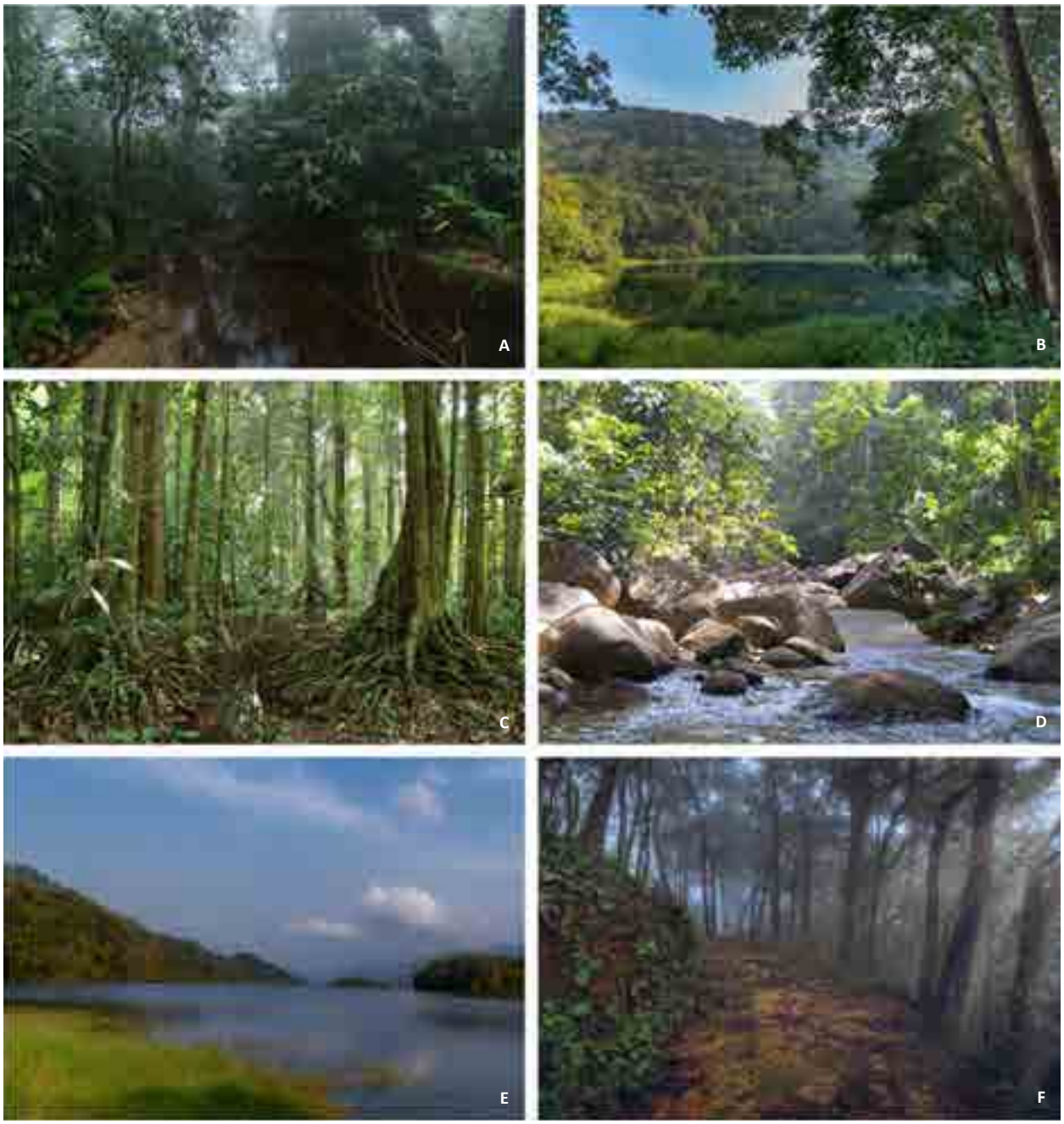

Image 2. Major habitats Shendurney WS: A—Southern Subtropical Hill Forests | B—West Coast Tropical Evergreen | C—Myristica Swamp Forests | D—West Coast Tropical Semievergreen | E—Southern Moist Mixed Deciduous Forests | F—Southern Hilltop Tropical Evergreen Forests. Photo © A & F—Raghuram | C—Ajithkumar | B, D & E—Kalesh Sadasivan.

Pandimotta is an Endangered and very rare dragonfly. *Heliogomphus promelas* is a Near Threatened and rare gomphid that was recorded in the montane swamps of subtropical jungles at 1,200 m from Pandimotta. *Indothemis carnatica* another Near Threatened species was seen at Kattalapara. Three species are under the Vulnerable category – *Indosticta deccanensis, Protosticta sanguinostigma* Fraser, 1922 (Image 4F), and *Chlorogomphus xanthoptera.* Six species whose status needs to be assessed are *Protosticta cyanofemora, Paplopleura sexmaculata* (Fabricius, 1787)*, Idionyx gomantakensis*, *Vestalis submontana, Cyclogomphus flavoannulatus,* and *Merogomphus tamaracherriensis* Fraser, 1931 (Image 5G).

Image 3. A—*Vestalis submontana* Fraser, 1934 © Kalesh Sadasivan | B—*Calocypha laidlawi* (Fraser, 1924) © K. Baiju | C—*Agriocnemis keralensis* Peters, 1981 © Vinayan P. Nair | D—*Aciagrion approximans krishna* Fraser, 1921 © Kalesh Sadasivan | E—*Euphaea fraseri* (Laidlaw,1920) © Kalesh Sadasivan | F—*Euphaea cardinalis* (Fraser, 1924) © Kalesh Sadasivan | G—*Caconeura risi* (Fraser, 1931) © Kalesh Sadasivan | H—*Esme mudiensis* Fraser, 1931 © Kalesh Sadasivan.

Image 4. A—*Pseudagrion indicum* Fraser, 1924 © Vinayan P. Nair | B—*Indosticta deccanensis* Laidlaw, 1915 © Abraham Samuel | C—*Protosticta rufostigma* Kimmins 1958 © Kalesh Sadasivan | D—*Protosticta gravelyi* Laidlaw, 1915 © Kalesh Sadasivan | E—*Protosticta cyanofemora* Joshi et al., 2020 © Kalesh Sadasivan | F—*Protosticta sanguinostigma* Fraser, 1922 © Kalesh Sadasivan | G—*Onychargia atrocyana* (Selys, 1865) © Abraham Samuel | H—*Prodasineura verticalis annandalei* (Fraser, 1921) © Kalesh Sadasivan.

Image 5. A—*Macrogomphus wynaadicus* Fraser, 1924 © Kalesh Sadasivan | B—*Chlorogomphus xanthoptera* (Fraser, 1919) © Kalesh Sadasivan | C—*Melligomphus acinaces* (Laidlaw, 1922) © Kalesh Sadasivan | D—*Acrogomphus fraseri* Laidlaw, 1925 © Toms Augustine | E—*Burmagomphus laidlawi* Fraser, 1924 © Kalesh Sadasivan | F—*Asiagomphus nilgiricus* Laidlaw, 1922 © Kalesh Sadasivan | G—*Merogomphus tamaracherriensis* Fraser, 1931 © Vinayan P. Nair | H—*Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019 © Kalesh Sadasivan.

Image 6. A—*Rhyothemis triangularis* Kirby, 1889) © Vinayan P. Nair | B—*Lyriothemis tricolor* Ris, 1919 © Kalesh Sadasivan | C—*Macromia irata* Fraser, 1924 © Kalesh Sadasivan | D—*Epithemis mariae* (Laidlaw, 1915) © Kalesh Sadasivan | E—*Macromia flavocolorata* Fraser, 1924 © Kalesh Sadasivan | F—*Macromia ellisoni* Fraser, 1924 © Kalesh Sadasivan | G—*Idionyx corona* Fraser, 1921 © Kalesh Sadasivan | H—*Idionyx gomantakensis* Subramanian, Rangnekar & Nayak, 2013 © Kalesh Sadasivan.

CONCLUSION

Shendurney WS has the highest number of species reported for any protected area in Kerala especially considering the small area of 171 km^2. The odonate fauna of Shendurney is rich and harbours 56.04% of WG and 64.08% of the odonate diversity of Kerala. In addition, this includes 48.52% of Kerala and 41.25% of endemic odonates of Western Ghats. About 29% of all the odonates recorded from Shendurney are endemic to WG. None of the species is protected under the Indian Wildlife Protection Act 1972. Myristica swamps of Kattalapara and Umayar and the subtropical hill forests of Pandimotta are unique habitats harbouring endemic and rare odonates. Seasonal changes in odonate diversity and population dynamics with respect to the monsoons need to be elucidated with further studies.

REFERENCES

Adarsh, C.K., R. Arunraj & P.O. Nameer (2015). Odonata (Insecta) diversity of Chinnar Wildlife Sanctuary, The Southern Western Ghats, India. *Journal of Threatened Taxa* 7(2): 6910–6919. https://doi.org/10.11609/JoTT.o3771.6010-19

Chandrashekaran, C. (1962). Forest types of Kerala State, *Indian Forester* 88: 660–847.

Emiliyamma, K.G & C. Radhakrishnan (2000). Odonata (Insecta) of Parambikulam Wildlife Sanctuary, Kerala, India. *Records of the Zoological Survey of India* 98(1): 157–167.

Emiliyamma, K.G & C. Radhakrishnan (2014). Additional records of Odonata (Insecta) from Parambikulam Wildlife Sanctuary, Kerala, India. *Records of the Zoological Survey of India* 114(3): 365–369.

Fraser, F.C. (1933). *Fauna of British India, including Ceylon and Burma, Odonata,* Vol I. Taylor & Francis group, London, 436 pp.

Fraser, F.C. (1934). *Fauna of British India, including Ceylon and Burma, Odonata,* Vol II. Taylor & Francis group, London, 442 pp.

Fraser, F.C. (1936). *Fauna of British India, including Ceylon and Burma, Odonata,* Vol III. Taylor & Francis group, London, 461 pp.

Gnanakumar, M., B.R. Ansil, P.O. Nameer & S. Das (2012). Checklist of odonates of Chimmony Wildlife Sanctuary. *Malabar Trogon* 10(1 & 2): 5–8.

IUCN (2021). The IUCN Red List of Threatened Species. Version 2021-1. https://www.iucnredlist.org Downloaded on 03 June 2021.

Kalkman, V.J., R. Babu, M. Bedjanic, K.Coniff, T. Gyeltshen, M.K. Khan, K.A. Subramanian, A. Zia & A.G. Orr (2020). Checklist of the dragonflies and damselflies (Insecta: Odonata) of Bangladesh, Bhutan, India, Nepal, Pakistan, and Srilanka. *Zootaxa* 4849(1): 1–84. https://doi.org/10.11646/zootaxa.4849.1.1.

Mathavan, S. & P.L. Miller (1989). A collection of dragonflies (Odonata) made in the Periyar National Park, Kerala, South India, in January 1988. International Odonatological Society, Bilthoven (Rapid communications, supplements), no.10, 10 pp.

Nair, S.C. (1991). The southern Western Ghats: a biodiversity conservation plan. Indian National Trust for Art and Cultural Heritage, New Delhi, 91 pp.

Nair, V.P., K.A. Samuel, M.J. Palot & K. Sadasivan (2021). The Dragonflies and Damselflies (Odonata) of Kerala- Status and distribution. *Entomon* 46(3): 185–238. https://doi.org/10.33307/entomon.v46i3.609

Mathew, G., C. Rashmi, C.M. Brijesh & R.S.M. Shamsudeen (2004). Insect fauna of Shendurney Wildlife Sanctuary, Kerala. *Zoos' Print Journal* 19(1): 1321–1327. https://doi.org/10.11609/JoTT.ZPJ.19.1.1321-7

Palot, M.J. & C.G. Kiran (2016). Dragonfly survey of Aralam Wildlife Sanctuary, Kannur district, Kerala– A report. *Malabar Trogon* 14(1 –3): 44–46.

Paulson, D., M. Schorr & C. Deliry (2021). World Odonata List. https://www.pugetsound.edu/academics/academicresources/slater–museum/ biodiversity – resources/dragonflies/world odonata–list2/ (accessed 2 June, 2021)

Rao, K.R. & A.R. Lahiri (1982). First records of Odonata (Arthropoda: Insecta) from Silent Valley and New Amarambalam reserve forests. *Journal of the Bombay Natural History Society* 79: 557–562.

Sadasivan, K., R. Iyer & K. Jayakumar (2021). Shendurney Wildlife Sanctuary, Annual Faunal Survey report 2021, submitted to Shendurney Wildlife Sanctuary, Kerala Forests, and Wildlife Department, 73 pp.

Subramanian, K.N. (1995). *Flora of Thenmala (& its Environs)*. International Book Distributors, 516 pp.

Subramanian, K.A. & R. Babu (2017). A checklist of Odonata (Insecta) of India, Version 3.0. pp 1–51. www.zsi.gov.in (accessed 2 Dec. 2020)

Subramanian, K.A., K.G. Emiliyamma, R. Babu, C. Radhakrishnan & S.S. Talmale (2018). *Atlas of Odonata (Insecta) of Western Ghats, India*. Zoological Survey of India, Kolkata, 417 pp.

Varghese, A.P., P.R. Nikesh & J. Mathew (2014). Odonata (Insecta) diversity of Salim Ali Bird Sanctuary and its adjacent areas in Thattekkad, Kerala, India. *Journal of Threatened Taxa* 6(6): 5887–5893. https://doi.org/10.11609/JoTT.o3395.5887-93

Appendix I. List of Odonates of Shendurney Wildlife Sanctuary.

	Scientific name	ST	EN	RL	DR	ID	KL	KT	PM	RK	RM	UM
Sub-Order Zygoptera												
Family Calopterygidae												
1	*Neurobasis chinensis* (Linnaeus, 1758)	C	–	LC	√	√	√	√	–	√	√	√
2	*Vestalis apicalis* Selys, 1873	C	–	LC	√	√	√	√	–	√	√	√
3	*Vestalis gracilis* (Rambur, 1842)	C	–	LC	√	√	√	√	–	√	√	√
4	*Vestalis submontana* Fraser, 1934	NR	–	NA	–	–	–	–	√	–	–	–
Family Chlorocyphidae												
5	*Calocypha laidlawi* (Fraser, 1924)	NR	√	DD	–	–	–	√	–	√	–	–
6	*Heliocypha bisignata* (Hagen in Selys, 1853)	C	–	LC	√	√	√	√	–	√	√	√
7	*Libellago indica* (Fraser, 1928)	C	–	LC	√	√	√	√	–	√	√	√
Family Coenagrionidae												
8	*Aciagrion approximans krishna* Fraser, 1921*	NR	√	LC	–	–	–	–	√	–	–	–
9	*Aciagrion occidentale* Laidlaw, 1919	C	–	LC	√	√	√	√	–	√	√	√
10	*Agriocnemis keralensis* Peters, 1981	C	√	LC	–	–	–	√	–	–	–	–
11	*Agriocnemis pieris* Laidlaw, 1919	C	–	LC	√	√	–	√	–	–	–	√
12	*Agriocnemis pygmaea* (Rambur, 1842)	C	–	LC	√	√	–	√	–	–	√	√
13	*Agriocnemis splendidissima* Laidlaw, 1919	VR	–	LC	–	–	–	√	–	–	√	–
14	*Ceriagrion cerinorubellum* (Brauer, 1865)	C	–	LC	–	√	√	√	–	√	√	√
15	*Ceriagrion coromandelianum* (Fabricius, 1798)	VC	–	LC	√	√	√	√	–	√	√	√
16	*Ischnura rubilio* Selys, 1876	C	–	LC	√	√	√	√	√	√	√	√
17	*Ischnura senegalensis* (Rambur, 1842)	NR	–	LC	√	√	–	√	–	√	√	√
18	*Pseudagrion decorum* (Rambur, 1842)	R	–	LC	–	–	–	√	–	√	–	√
19	*Pseudagrion indicum* Fraser, 1924	NR	√	LC	√	–	–	√	–	–	–	–
20	*Pseudagrion malabaricum* Fraser, 1924	C	–	LC	–	–	–	√	–	–	–	–
21	*Pseudagrion microcephalum* (Rambur, 1872)	C	–	LC	√	–	–	√	–	√	–	–
22	*Pseudagrion rubriceps* (Selys, 1876)	C	–	LC	√	–	–	√	–	–	√	√
Family Euphaeidae												
23	*Dysphaea ethela* Fraser, 1924	R	–	DD	–	–	–	√	–	–	√	√
24	*Euphaea cardinalis* (Fraser, 1924)	R	√	LC	–	–	–	–	√	–	–	–
25	*Euphaea fraseri* (Laidlaw,1920)	C	√	LC	√	–	√	√	–	√	√	–
Family Lestidae												
26	*Lestes concinnus* Hagen in Selys, 1862	NR	–	DD	√	√	√	√	–	–	–	√
27	*Lestes elatus* Hagen in Selys, 1862	VC	–	LC	√	√	√	√	√	√	√	√
28	*Lestes praemorsus decipiens* Kirby, 1893	R	–	LC	√	–	–	–	√	–	–	–
Family Platycnemididae												
29	*Caconeura ramburi* (Fraser, 1922)	C	–	DD	√	–	√	–	√	√	–	–
30	*Caconeura risi* (Fraser, 1931)	VC	√	DD	√	√	√	√	–	–	√	√
31	*Copera marginipes* (Rambur, 1842)	VC	–	LC	√	–	–	√	–	–	√	√
32	*Copera vittata* (Selys, 1863)	VC	–	LC	√	√	√	√	–	√	√	√
33	*Elattoneura tetrica* (Laidlaw, 1917)	R	√	LC	–	–	–	√	–	–	–	–
34	*Esme mudiensis* Fraser, 1931	NR	√	DD	√	–	–	–	√	√	–	–
35	*Onychargia atrocyana* (Selys, 1865)	NR	–	LC	√	–	–	√	–	–	√	–
36	*Prodasineura verticalis annandalei* (Fraser, 1921)	C	–	LC	√	√	–	√	–	√	√	√
Family Platystictidae												
37	*Indosticta deccanensis* Laidlaw, 1915	VR	√	VL	√	–	–	–	–	√	–	–

	Scientific name	ST	EN	RL	DR	ID	KL	KT	PM	RK	RM	UM
38	*Protosticta cyanofemora* Joshi, Subramanian, Babu & Kunte, 2020	VR	√	NA	–	–	–	–	√	–	–	–
39	*Protosticta gravelyi Laidlaw, 1915*	C	√	LC	√	√	√	√	–	√	√	√
40	*Protosticta rufostigma* Kimmins 1958	NR	√	DD	–	–	–	–	√	–	–	–
41	*Protosticta sanguinostigma* Fraser, 1922	C	√	VL	√	–	–	–	√	√	–	–
Sub-Order Anisoptera												
Family Aeshnidae												
42	*Anaciaeschna martini* Selys, 1897	VR	–	LC	–	–	–	–	√	–	–	–
43	*Anax ephippiger* (Burmeister, 1839)	C	–	LC	√	–	–	–	√	–	–	√
44	*Anax guttatus* (Burmeister, 1839)	VR	–	LC	√	–	–	–	–	–	–	–
45	*Anax immaculifrons* (Rambur,1842)	C	–	LC	√	√	√	√	√	√	√	√
46	*Gynacantha millardi* Fraser,1920	R	–	LC	√	–	–	√	–	√	√	√
47	*Gynacantha dravida* Lieftinck,1960	C	–	DD	√	√	√	√	–	–	√	√
Family Chlorogomphidae												
48	*Chlorogomphus xanthoptera* (Fraser, 1919)	R	√	VL	–	–	–	–	√	–	–	–
Family Corduliidae												
49	*Hemicordulia asiatica* (Selys, 1878*)*	C	–	LC	–	–	–	√	–	–	√	–
Family Gomphidae												
50	*Acrogomphus fraseri* Laidlaw, 1925	NR	√	DD	√	–	√	√	–	√	√	√
51	*Asiagomphus nilgiricus* Laidlaw, 1922	NR	√	DD	–	–	√	√	–	–	–	–
52	*Burmagomphus laidlawi* Fraser, 1924	NR	–	DD	–	–	–	–	√	–	–	–
53	*Burmagomphus pyramidalis* Laidlaw, 1922	NR	√	LC	–	–	–	–	√	–	–	–
54	*Cyclogomphus flavoannulatus* Rangnekar, Dharwadkar, Kalesh & Subramanian, 2019	VR	√	NA	–	–	–	√	–	–	–	–
55	*Cyclogomphus heterostylus* Selys,1854	VR	–	DD	–	–	–	√	–	–	–	–
56	*Gomphidia kodaguensis* Fraser, 1923	NR	√	DD	–	–	√	√	–	–	√	√
57	*Heliogomphus promelas* (Selys, 1873)	R	–	NT	–	–	–	–	√	–	–	–
58	*Ictinogomphus rapax* (Rambur, 1842)	C	–	LC	√	√	√	√	–	–	√	√
59	*Macrogomphus wynaadicus* Fraser, 1924	NR	√	DD	√	–	√	√	–	–	√	–
60	*Merogomphus tamaracherriensis* Fraser, 1931	NR	√	NA	–	–	–	–	√	–	–	–
61	*Melligomphus acinaces* (Laidlaw, 1922)	R	√	DD	–	–	√	√	–	–		–
62	*Paragomphus lineatus* (Selys,1850)	C	–	LC	–	√	√	√	–	√	√	√
Family Libellulidae												
63	*Acisoma panorpoides* Rambur, 1842	C	–	LC	√	√	–	√	–	–	√	√
64	*Aethriamanta brevipennis* (Rambur, 1842)	NR	–	LC	√	√	–	√	–	–	√	√
65	*Brachydiplax chalybea* Brauer, 1868	C	–	LC	√	√	–	√	–	–	√	√
66	*Brachydiplax sobrina* (Rambur, 1842)	NR	–	LC	√	–	–	√	–	–	–	–
67	*Brachythemis contaminata* (Fabricius, 1793)	VC	–	LC	√	√	–	√	–	–	√	√
68	*Bradinopyga geminata* (Rambur, 1842)	VC	–	LC	–	–	√	√	–	√	√	√
69	*Cratilla lineata calverti* (Forster, 1903)	C	–	LC	√	√	√	√	√	√	√	√
70	*Crocothemis servilia* (Drury, 1770)	NR	–	LC	–	–	–	√	–	–	√	√
71	*Diplacodes nebulosa* (Fabricius, 1793)	VR	–	LC	–	–	–	√	–	–	–	√
72	*Diplacodes trivialis* (Rambur, 1842)	VC	–	LC	√	√	√	√	√	√	√	√
73	*Epithemis mariae* (Laidlaw, 1915)	NR	√	LC	√	–	–	√	–	√	–	√
74	*Hydrobasileus croceus* (Brauer, 1867)	NR	–	LC	√	√	√	√	–	–	√	√
75	*Hylaeothemis apicalis* Fraser, 1924	NR	–	DD	√	√	√	√	√	√	√	√
76	*Indothemis carnatica* (Fabricius, 1798)	VR	–	NT	√	–	–	–	–	–	–	–
77	*Lathrecista asiatica* (Fabricius, 1798)	C	–	LC	√	√	√	√	–	–	√	√

	Scientific name	ST	EN	RL	DR	ID	KL	KT	PM	RK	RM	UM
78	*Lyriothemis tricolor* Ris, 1919	VR	–	LC	–	–	√	√	–	–	–	√
79	*Neurothemis fulvia* (Drury, 1773)	C	–	LC	√	–	–	√	–	–	√	√
80	*Neurothemis tullia* (Drury, 1773)	NR	–	LC	√	√	–	√	–	–	√	–
81	*Onychothemis testacea ceylanica* Ris, 1912	NR	–	LC	√	–	√	√	–	–	–	√
82	*Orthetrum chrysis* (Selys, 1891)	C	–	LC	√	√	√	√	–	√	√	√
83	*Orthetrum triangulare triangulare* (Selys, 1878)	NR	–	LC	–	–	–	–	√	√	–	–
84	*Orthetrum glaucum* (Brauer, 1865)	C	–	LC	√	√	√	√	√	√	√	√
85	*Orthetrum luzonicum* (Brauer, 1868)	C	–	LC	√	√	√	√	√	√	√	√
86	*Orthetrum pruinosum neglectum* (Rambur, 1842)	C	–	LC	√	√	√	√	√	√	√	√
87	*Orthetrum sabina sabina* (Drury, 1770)	VC	–	LC	√	√	√	√	√	√	√	√
88	*Paplopleura sexmaculata* (Fabricius, 1787)	NR	–	NA	√	√	√	√	–	–	√	√
89	*Pantala flavescens* (Fabricius, 1798)	VC	–	LC	√	√	√	√	√	√	√	√
90	*Potamarcha congener* (Rambur, 1842)	NR	–	LC	√	√	–	√	–	–	–	√
91	*Rhodothemis rufa* (Rambur, 1842)	C	–	LC	–	–	–	√	–	–	–	√
92	*Rhyothemis triangularis* Kirby, 1889	R	–	LC	–	–	–	√	–	–	–	–
93	*Rhyothemis variegata variegata* (Linnaeus, 1763)	C	–	LC	√	√	√	√	–	–	√	√
94	*Tetrathemis platyptera* Selys, 1878	NR	–	LC	√	–	–	√	–	√	–	√
95	*Tholymis tillarga* (Fabricius, 1798)	C	–	LC	√	√	√	√	–	–	√	√
96	*Tramea basilaris* (Palisot de Beauvois, 1805)	C	–	LC	√	√	√	√	–	–	√	√
97	*Tramea limbata* (Desjardins, 1832)	NR	–	LC	√	–	–	√	–	√	–	√
98	*Trithemis aurora* (Burmeister, 1839)	VC	–	LC	√	–	√	√	–	–	√	√
99	*Trithemis pallidinervis* (Kirby, 1889)	C	–	LC	–	√	–	√	–	√	–	√
100	*Trithemis festiva* (Rambur, 1842)	C	–	LC	√	√	√	√	–	√	√	√
101	*Urothemis signata* (Rambur, 1842)	VR	–	LC	–	–	–	√	–	–	–	√
102	*Zygonyx iris malabarica* Fraser, 1926	NR	–	LC	√	√	√	√	–	√	√	√
103	*Zyxomma petiolatum* Rambur, 1842	C	–	LC	–	√	–	√	–	√	√	√
Family Macromiidae												
104	*Epophthalmia vittata vittata* Burmeister, 1839	C	–	LC	√	–	–	√	–	–	–	√
105	*Epophthalmia frontalis binocellata* Fraser, 1936	VR	–	LC	√	–	–	–	–	–	–	√
106	*Macromia cingulata* Rambur, 1842	VR	–	LC	√	–	–	–	√	√	–	–
107	*Macromia ellisoni* Fraser, 1924	VR	√	LC	–	–	–	–	√	–	–	–
108	*Macromia flavocolorata* Fraser, 1924	VR	–	LC	–	√	–	√	–	–	√	√
109	*Macromia irata* Fraser, 1924	NR	√	LC	–	–	–	√	–	–	√	–
Genera Insertae Sedis												
110	*Idionyx corona* Fraser, 1921	VR	√	DD	–	–	–	–	√	√	–	–
111	*Idionyx galeata* Fraser, 1924	VR	√	EN	–	–	–	–	√	–	–	–
112	*Idionyx minima* Fraser, 1931	NR	√	DD	–	–	–	–	√	–	–	–
113	*Idionyx saffronata* Fraser, 1924	NR	√	DD	–	–	–	–	√	–	–	–
114	*Idionyx travancorensis* Fraser, 1931	NR	√	DD	√	–	–	–	√	–	–	–
115	*Idionyx gomantakensis* Subramanian, Rangnekar & Nayak, 2013	VR	√	NA	√	–	–	√	–	–	–	–
116	*Macromidia donaldi donaldi* (Fraser, 1924)	VR	√	LC	–	–	–	√	–	–	√	–
	TOTAL 116 species		33		72	48	46	88	35	46	61	69

*—The subspecies is endemic to WG (Kalkman et al. 2020) | ST—Occurrence status | EN—Taxon endemic status with respect to WG | RL—IUCN Red List Data | DR—Darbhakulam | ID—Idimuzhangan | KL—Kallar | KT—Kattalapara | PM—Pandimotta | RK—Rockwood | RM—Rosemala | UM—Umayar.

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COMMUNICATION

A pioneering study on the spider fauna (Arachnida: Araneae) of Sagar District, Madhya Pradesh, India

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Abstract: The present investigations were carried out to elucidate the spider fauna of the Sagar district of Madhya Pradesh. A total of 1,505 spider specimens were documented from various sites of the study area. A total of 74 species grouped under 58 genera and 22 families are reported. The family Araneidae was the most common, accounting for 31% of the overall population followed by Salticidae, which accounted for 15% of the overall population. Spiders belonging to seven guild structures were identified which were then classified on the basis of their dietary habits. Further research is needed to analyze the behavior, biology and web patterns of these ubiquitous creatures.

Keywords: Agroforestry, Araneidae, forest habitat, guild structure, orb weavers, Salticidae, spider diversity.

मध्य प्रदेश के सागर जिले के मकड़ी के जीवों को स्पष्ट करने के लिए वर्तमान जांच की गई। अध्ययन क्षेत्र के विभिन्न स्थलों से कुल 1,505 मकड़ी के नमूनों का दस्तावेजीकरण किया गया। कुल 74 प्रजातियों को 58 पीढ़ी या जेनरा और 22 परिवारों के अंतर्गत वर्गीकृत किया गया है। परिवार अरानिडे सबसे आम था, कुल आबादी का 31% हिस्सा साल्टिसीडे के बाद था, जो कुल आबादी का 15% था। सात गिल्ड संरचनाओं से संबंधित मकड़ियों की पहचान की गई थी, जिन्हें बाद में उनकी आहार संबंधी आदतों के आधार पर वर्गीकृत किया गया था। इन सर्वव्यापी प्राणियों के व्यवहार, जीव विज्ञान और वेब पैटर्न का विश्लेषण करने के लिए और अधिक शोध की आवश्यकता है।

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Author contributions: TRS did majority of the collection of spiders from different study sites of Sagar district. She photographed and identified spiders in the laboratory. She prepared the manuscript and data analysis. JA helped in writing, compilation and data analysis of this paper.

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INTRODUCTION

Spiders are remarkable primitive arthropods of the class Arachnida that live in every ecosystem on the planet, from Arctic islands to dry desert regions (Foelix 2011). They are members of the order Araneae, which are commonly known as spiders. Spiders can play an essential role in managing the populations of terrestrial arthropods. Because of their small body size, quick reproduction period, and great sensitivity to temperature and moisture changes, they are good biological monitors of ecosystem changes and habitat adjustments (Napiórkowska et al. 2021). Spiders are not only ecologically significant, but also commercially beneficial (Koneri & Nangoy 2017). Spider silk and venom have become essential industrial commodities, particularly in the pharmaceutical industry. They are also beneficial in decreasing the negative effects of pesticide and insecticide overdoses (Jose et al. 2018).

British explorers began studying spiders in India in the latter half of the 19th century and taxonomists from India carried on the work (Siliwal et al. 2005). Presently, about 50,040 spider species classified into 4,250 genera and 131 families are described worldwide (WSC 2022) and India has 1,904 spider species classified under 490 genera and 60 families (Caleb & Sankaran 2022). The spider fauna of Madhya Pradesh was studied by various workers beginning from Tikader (1980, 1982a,b), Tikader & Malhotra (1980), and Gajbe (1987–2003) in which they described several species from the families Thomisidae, Philodromidae, Lycosidae, Araneidae, and Gnaphosidae. Patil et al. (2013, 2016) studied spiders from Rani Veerangana Durgawati Wildlife Sanctuary and from the Nauradehi Wildlife Sanctuary, respectively. However, there is no information available so far on the spider fauna of Sagar district in Madhya Pradesh and thus the present work was carried out.

MATERIALS AND METHODS

Study area

Sagar district is located in the north central region of Madhya Pradesh and covers an area of 10,252 km^2. It lies between 23.16–24.45 °N & 78.06–79.35 °E (Figure 1). The major part of the district is enclosed by the Deccan trap lava flows and Vindhayan sandstones in the eastern region (Pareta & Pareta 2013). The climate is quite harsh, with maximum temperatures of 45 ^{0}C in summer and minimum temperatures of 6 ^{0}C in winter. The annual rainfall ranges 1,050–1,100 mm. It has a total forest area of 2,75,924.38 ha, with 1,91,607.32 ha of reserved forests and 84,317.06 ha of protected forests (ISFR 2019).

Sampling sites

Three different habitats were selected: forest (Malthone, Dhana 1 and Shahgarh range), agricultural (Patheriya Jat, Rajaua, Deori) and agroforestry (Rehli, Dhana 2, and Rahatgarh). The surveys were conducted during October 2017 to October 2021. A total of 42 quadrates with 20m x 20m dimensions were established in selected sites of the district.

Collection

Spider specimens were collected by active visual searching, vegetation beating, net sweeping, and hand picking following Sørensen et al. (2002). All surveys were conducted from 8000 h to 1200 h, with an opportunistic night time survey conducted as well. Spiders were collected and photographed with a DSLR camera (Canon

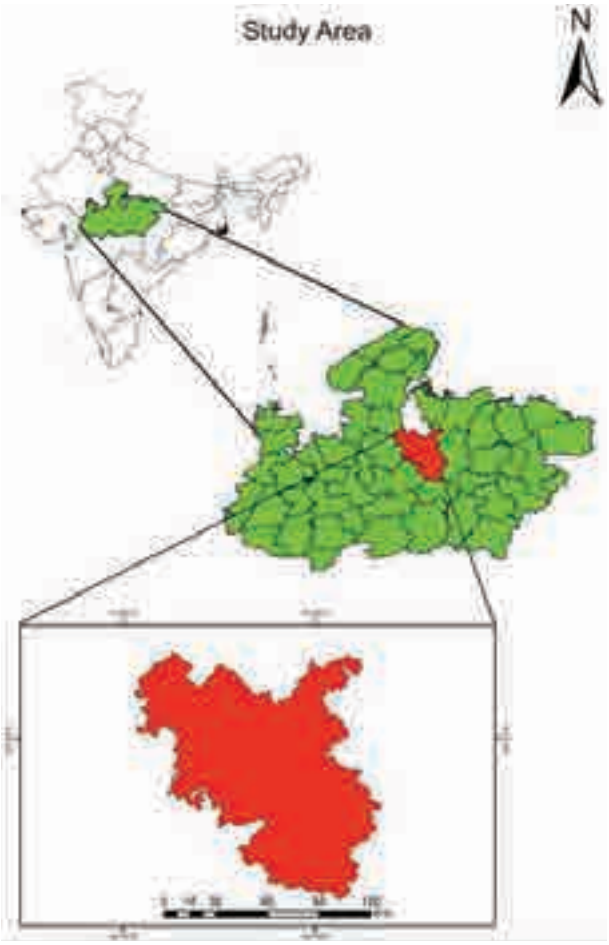

Figure 1. Map of Sagar District (Madhya Pradesh).

EOS 200D) before being put back into their natural environment. The collected specimens were preserved in 30 ml glass vials in 70% ethyl alcohol with proper labeling.

Identification

The preserved specimens were examined under a Quasmo SZB-47A stereomicroscope. Spiders were recognized to the family, genus, and species levels using existing literatures and standard taxonomic keys provided by Pocock (1900); Gravely (1921a,b, 1924, 1931); Tikader (1977, 1980, 1982a); Tikader & Malhotra (1980); Tikader & Biswas (1981); Majumder & Tikader (1991); Gajbe (2004, 2007, 2008); Caleb (2016). The spider guild categorization was based on the dietary habits and ecological traits of the respective families (Höfer & Brescovit 2001).

RESULTS

The Sagar district, Madhya Pradesh is home to a variety of spider species. During the entire study period 1,505 specimens were collected from the study area belonging to 74 species under 22 families (Table 1; Images 1–69). The number of families, genera, species, number of individuals and percentage of number of individuals in particular families are enlisted in Table 2. Araneidae was the dominant family with 19 species from nine genera, followed by Salticidae with 14 species from 13 genera. The seven different guild types include orb-web builders, sheet web weavers, space builders, stalkers, foliage hunters, ambushers, and ground runners (Figure 2). Orb weavers (14 species) made up the most common feeding guild, accounting for 630 spider specimens (42%) of the overall population, followed by stalkers 373 spiders, 19 species (25%), space builders, 197 spiders, four species (13%), sheet web weavers, 132 spiders, one species (9%), foliage runners 95 spiders, six species (6%), ambushers 48 spiders, eight species (3%) and ground runners with 30 spiders, six species (2%) (Figure 2). During the survey, more spiders were seen in forest and agroforestry habitats than in agriculture habitat. Abundance of spiders was high in 2020 and 2021 (Figure 3).

DISCUSSION

In the present investigations 22 families have been reported from different sites of Sagar district. Gajbe (2007), Patil et al. (2013), and Patil et al. (2016) in their studies reported 24, 7, and 12 families respectively from Jabalpur and nearby places. Gajbe & Gajbe (2004) reported that most spiders which live on the ground or in plants have some form of camouflage. Some of the noteworthy examples of mimics seen in the present study are the ant-mimicking spiders of genus *Myrmaplata,* spiders of genus *Cyclosa* resembling trash, *Tetragnatha* species resembling twigs or reed tips, while *Hersilia* camouflage themselves perfectly with the surroundings. Analyzing the spider diversity patterns in Sagar district environment provides valuable information which can be used to validate the ecosystem's balance. The present study was undertaken with the objective to document the spider fauna of Sagar district and prepare the first

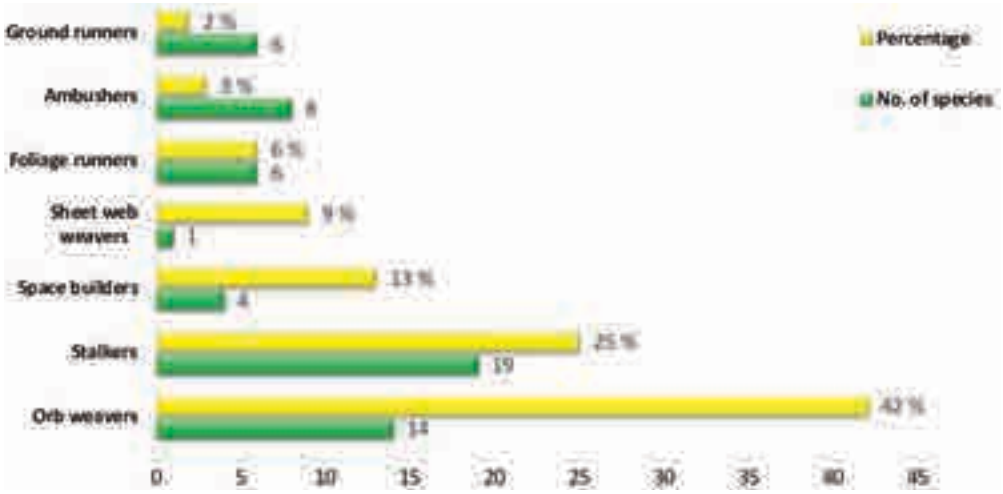

Figure 2. Guild structure and percentile distribution of guilds of spiders of Sagar district, Madhya Pradesh.

Table 1. Checklist of spiders from Sagar district, Madhya Pradesh, India.

	Scientific name	Guild
	Araneidae	
1	*Argiope aemula* (Walckenaer, 1841)	Orb weavers
2	*Argiope anasuja* Thorell, 1887	Orb weavers
3	*Bijoaraneus mitificus* (Simon, 1886)	Orb weavers
4	*Cyclosa bifida* (Doleschall, 1859)	Orb weavers
5	*Cyclosa hexatuberculata* Tikader, 1982	Orb weavers
6	*Cyclosa insulana* (Costa, 1834)	Orb weavers
7	*Cyrtophora cicatrosa* (Stoliczka, 1869)	Orb weavers
8	*Eriovixia excelsa* (Simon, 1889)	Orb weavers
9	*Gasteracantha kuhli* C. L. Koch, 1837	Orb weavers
10	*Gasteracantha* sp.	Orb weavers
11	*Neoscona mukerjei* Tikader, 1980	Orb weavers
12	*Neoscona nautica* (L. Koch, 1875)	Orb weavers
13	*Neoscona* sp. 1	Orb weavers
14	*Neoscona* sp. 2	Orb weavers
15	*Neoscona theisi* (Walckenaer, 1841)	Orb weavers
16	*Neoscona vigilans* (Blackwall, 1865)	Orb weavers
17	*Nephila pilipes* (Fabricius, 1793)	Orb weavers
18	*Nephila* sp.	Orb weavers
19	*Parawixia dehaani* (Doleschall, 1859)	Orb weavers
	Cheirancanthiidae	
20	*Cheiracanthium melanostomum* (Thorell, 1895)	Foliage runners
	Clubionidae	
21	*Clubiona drassodes* O. Pickard-Cambridge, 1874	Foliage runners
	Corinnidae	
22	*Castianeira* sp.	Foliage runners
23	*Castianeira zetes* Simon, 1897	Foliage runners
	Dictynidae	
24	*Nigma* sp.	Stalkers
	Eresidae	
25	*Stegodyphus sarasinorum* Karsch, 1892	Sheet weavers
	Gnaphosidae	
26	*Drassodes carinivulvus* Caporiacco, 1934	Ground runners
27	*Poecilochroa* sp.	Ground runners
	Hersiliidae	
28	*Hersilia savignyi* Lucas, 1836	Ambushers
	Lycosidae	
29	*Hippasa fabreae* Gajbe & Gajbe, 1999	Ground runners
30	*Lycosa shaktae* Bhandari & Gajbe, 2001	Ground runners
31	*Pardosa* sp.	Ground runners
	Oecobiidae	
32	*Oecobius putus* O. Pickard-Cambridge, 1876	Space builders
	Oxyopidae	
33	*Hamataliwa* sp.	Stalkers
34	*Oxyopes birmanicus* Thorell, 1887	Stalkers
35	*Oxyopes javanus* Thorell, 1887	Stalkers
36	*Oxyopes shweta* Tikader, 1970	Stalkers
37	*Peucetia viridana* (Stoliczka, 1869)	Stalkers

	Scientific name	Guild
	Pisauridae	
38	*Perenethis venusta* L. Koch, 1878	Ambushers
	Philodromidae	
39	*Tibellus elongatus* Tikader, 1960	Ambushers
	Pholcidae	
40	*Artema atlanta* Walckenaer, 1837	Space builders
41	*Crossopriza lyoni* (Blackwall, 1867)	Space builders
42	*Pholcus phalangioides* (Fuesslin, 1775)	Space builders
	Prodidomidae	
43	*Zimiris doriae* Simon, 1882	Ground runners
	Salticidae	
44	*Carrhotus* sp.	Stalkers
45	*Epocilla* sp.	Stalkers
46	*Harmochirus* sp.	Stalkers
47	*Hasarius adansoni* (Audouin, 1826)	Stalkers
48	*Menemerus bivittatus* (Dufour, 1831)	Stalkers
49	*Myrmaplata plataleoides* O. Pickard-Cambridge, 1869	Stalkers
50	*Plexippus paykulli* (Audouin, 1826)	Stalkers
51	*Plexippus petersi* (Karsch, 1878)	Stalkers
52	*Portia* sp.	Stalkers
53	*Rhene flavicomans* Simon, 1902	Stalkers
54	*Siler semiglaucus* (Simon, 1901)	Stalkers
55	*Stenaelurillus* sp.	Stalkers
56	*Telamonia dimidiata* (Simon, 1899)	Stalkers
57	*Thyene* sp.	Stalkers
	Scytodidae	
58	*Scytodes pallida* Doleschall, 1859	Stalkers
	Sparassidae	
59	*Gnathopalystes kochi* (Simon, 1880)	Foliage runners
60	*Heteropoda venatoria* (Linnaeus, 1767)	Foliage runners
61	*Olios milleti* (Pocock, 1901)	Foliage runners
	Tetragnathidae	
62	*Guizygiella indica* (Tikader & Bal, 1980)	Orb weavers
63	*Leucauge decorata* (Blackwall, 1864)	Orb weavers
64	*Tetragnatha mandibulata* Walckenaer, 1841	Orb weavers
65	*Tetragnatha* sp.	Orb weavers
	Theridiidae	
66	*Nesticodes rufipes* (Lucas, 1846)	Space builders
	Thomisidae	
67	*Camaricus formosus* Thorell, 1887	Ambushers
68	*Henriksenia* sp.	Ambushers
69	*Indoxysticus minutus* (Tikader, 1960)	Ambushers
70	*Runcinia insecta (*L. Koch, 1875*)*	Ambushers
71	*Thomisus lobosus* Tikader, 1965	Ambushers
	Uloboridae	
72	*Uloborus* sp. 1	Orb weavers
73	*Uloborus* sp. 2	Orb weavers
74	*Zosis geniculata* (Olivier, 1789)	Orb weavers

Table 2. Diversity and abundance of spiders in Sagar district, Madhya Pradesh, India.

	Family	Number of genera	Number of species	No. of Individuals	Percentile distribution of families of spiders of Sagar district, Madhya Pradesh.
1	Araneidae	9	19	472	31
2	Cheirancanthiidae	1	1	14	1
3	Clubionidae	1	1	15	1
4	Corinnidae	1	2	11	1
5	Dictynidae	1	1	11	1
6	Eresidae	1	1	132	9
7	Gnaphosidae	2	2	9	1
8	Hersiliidae	1	1	9	1
9	Lycosidae	3	3	13	1
10	Oecobiidae	1	1	55	4
11	Oxyopidae	3	5	129	9
12	Pisauridae	1	1	8	1
13	Philodromidae	1	1	9	1
14	Pholcidae	3	3	106	7
15	Prodidomidae	1	1	8	1
16	Salticidae	13	14	220	15
17	Scytodidae	1	1	13	1
18	Sparassidae	3	3	55	4
19	Tetragnathidae	3	4	97	6
20	Theridiidae	1	1	36	2
21	Thomisidae	5	5	22	1
22	Uloboridae	2	3	61	4

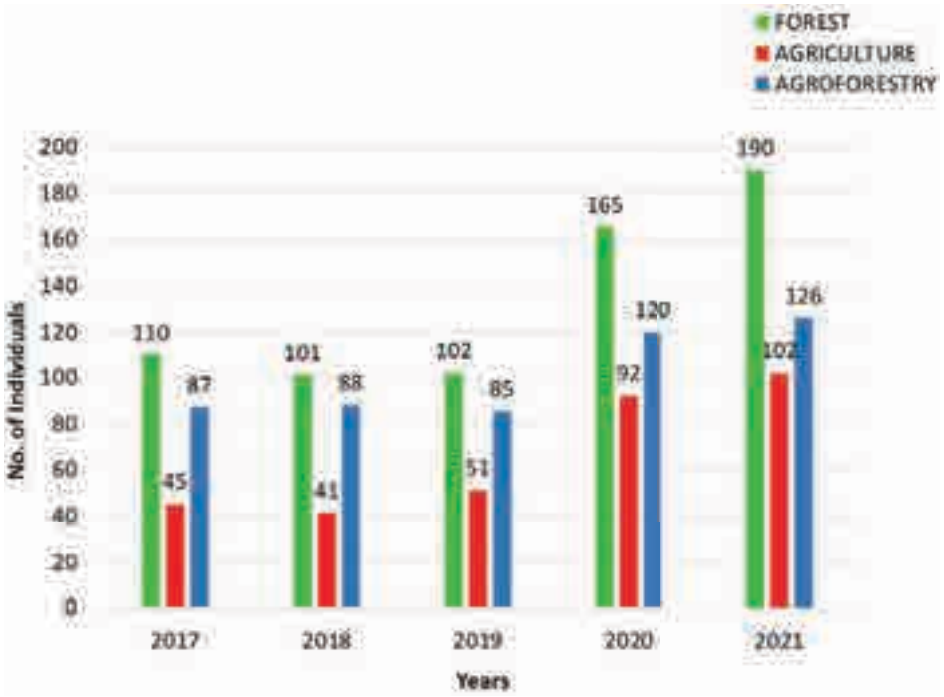

Figure 3. Abundance distribution of spiders from 2017 to 2021 of Sagar district, Madhya Pradesh.

Image 1–12. Spiders of Sagar district, Madhya Pradesh: 1—*Bijoaraneus mitificus* | 2—*Argiope aemula* | 3—*Argiope anasuja* | 4—*Cyclosa bifida* | 5—*Cyclosa hexatuberculata* | 6—*Cyclosa insulana* | 7—*Cyrtophora cicatrosa* | 8—*Eriovixia excelsa* | 9—*Gasteracantha kuhli* | 10—*Neoscona mukerjei* | 11—*Neoscona nautica* | 12—*Neoscona* sp. © Tanmaya Rani Sethy.

Image 13–24. Spiders of Sagar district, Madhya Pradesh: 13—*Neoscona* sp. | 14—*Neoscona theisi* | 15—*Neoscona vigilans* | 16—*Nephila pilipes* | 17—*Parawixia dehaani* | 18—*Cheiracanthium melanostomum* | 19—*Clubiona drassodes* | 20—*Castianeira* sp. | 21—*Castianeira zetes* | 22—*Nigma* sp. | 23—*Stegodyphus sarasinorum* | 24—*Drassodes carinivulvus.* © Tanmaya Rani Sethy.

Image 25–36. Spiders of Sagar district, Madhya Pradesh: 25—*Poecilochroa* sp. | 26—*Zimiris doriae* | 27—*Hersilia savignyi* | 28—*Hippasa fabreae* | 29—*Lycosa shaktae* | 30—*Pardosa* sp. | 31—*Oecobius putus* | 32—*Hamataliwa* sp. | 33—*Oxyopes birmanicus* | 34—*Oxyopes javanus* | 35—*Oxyopes shweta* | 36—*Peucetia viridana*. © Tanmaya Rani Sethy.

Image 37–48. Spiders of Sagar district, Madhya Pradesh: 37—*Tibellus elongatus* | 38—*Artema atlanta* | 39—*Crossopriza lyoni* | 40—*Pholcus phalangioides* | 41—*Carrhotus* sp. | 42—*Epocilla* sp. | 43—*Harmochirus* sp. | 44—*Hasarius adansoni* | 45—*Thyene* sp. | 46—*Menemerus bivittatus* | 47—*Myrmaplata plataleoides* | 48—*Plexippus paykulli*. © Tanmaya Rani Sethy.

Image 49–60. Spiders of Sagar district, Madhya Pradesh: 49—*Plexippus petersi* | 50—*Rhene flavicomans* | 51—*Siler semiglaucus* | 52—*Stenaelurillus* sp. | 53—*Telamonia dimidiata* | 54—*Scytodes pallida* | 55—*Gnathopalystes kochi* | 56—*Heteropoda venatoria* | 57—*Leucauge decorata* | 58—*Tetragnatha mandibulata* | 59—*Tetragnatha* sp. | 60—*Guizygiella indica*. © Tanmaya Rani Sethy.

Image 61–69. Spiders of Sagar district, Madhya Pradesh: 61—*Nesticodes rufipes* | 62—*Camaricus formosus* | 63—*Thomisus lobosus* | 64—*Indoxysticus minutus* | 65—*Runcinia insecta* | 66—*Henriksenia* sp. | 67—*Uloborus* sp. | 68—*Uloborus* sp. | 69—*Zosis geniculata*. © Tanmaya Rani Sethy.

spider checklist of this area thus, providing a baseline data of spiders that live in the forest, agricultural and agroforest habitats. Spiders however, face risks such as habitat loss due to laterite mining, pollution, and changes in land use practices. Further research needs to be carried out to ensure efficient conservation of spiders.

REFERENCES

Caleb, J.T.D. & P.M. Sankaran (2022). Araneae of India. Version 2022, online at http://www.indianspiders.in Accessed on 26 April 2022.

Caleb, J.T.D. (2016). Taxonomic notes on some ant-mimicking jumping spiders (Araneae: Salticidae) from India. *Arthropoda Selecta* 25(4): 403–420. https://doi.org/10.15298/arthsel.25.4.09

Foelix, R.F. (2011). *Biology of Spiders*. Oxford University Press, New York, 287 pp.

Gajbe, P. (2003). Checklists of spiders (Arachnid: Araneae) of Madhya Pradesh and Chattisgarh. *Zoo's Print Journal* 18(10): 1223–1226. https//doi.org/10.11609/JoTT.ZPJ.18.10.1223-6

Gajbe, P.U. (2004). Spiders of Jabalpur, Madhya Pradesh (Arachnida:

Araneae). *Records of the Zoological Survey of India, Occasional Paper* 227: 1–154.

Gajbe, U.A. (1987). A new *Scopodes* spider from India (Araneae: Gnaphosidae). *Bulletin of the Zoological Survey of India* 8: 285–287. https//doi.org/10.1080/00222933.2018.1478998

Gajbe, U.A. (1988). On a collection of spiders of the family Gnaphosidae from India (Araneae: Arachnida). *Records of Zoological Survey of India* 85(1): 59–74.

Gajbe, U.A. (2007). Fauna of Madhya Pradesh (including Chhattisgarh): State Fauna Series Part-1. Zoological Survey of India, 564 pp.

Gajbe, U.A. (2008). *Fauna of India and the adjacent countries: Spider (Arachnida: Araneae: Oxyopidae) Vol 3.* Zoological Survey of India Kolkata, 137 pp.

Gajbe, U.A. & P. Gajbe (2004). A new species of *Chorizopes* spider (Araneae: Araneidae) from Jabalpur, Madhya Pradesh, India. *Records of the Zoological Survey of India* 102(3–4): 117–119.

Gravely, F.H. (1921a). The spiders and scorpions of Barkuda Island. *Records of the Indian Museum* Calcutta 22: 399–421.

Gravely, F.H. (1921b). Some Indian spiders of the subfamily Tetragnathidae. *Records of the Indian Museum Calcutta* 22: 423–459.

Gravely, F.H. (1924). Some Indian spiders of the family Lycosidae. *Records of the Indian Museum Calcutta* 26: 587–613.

Gravely, F.H. (1931). Some Indian spiders of the families Ctenidae, Sparassidae, Selenopidae and Clubionidae. *Records of the Indian Museum Calcutta* 33: 211–282.

Höfer, H. & A.D. Brescovit (2001). Species and guild structure of a Neotropical spider assemblage (Araneae) from Reserva Ducke, Amazonas, Brazil. *Andrias* 15: 99–119.

ISFR (2019). India State of Forest Report. Forest Survey of India, Dehradun, Ministry of Environment, Forests and Climate Change, Government of India. https://www.fsi.nic.in/fores t-report-2019.

Jose, A.C., P.P. Sudhin, P.M. Prasad & K.A. Sreejith (2018). Spider Diversity in Kavvayi River Basin, Kerala, Southern India. *Current World Environment* 13(1): 100–112. https://doi.org/10.12944/CWE.13.1.10

Koneri, R. & M.J. Nangoy (2017). The Distribution and Diversity of Spiders (Arachnida: Aranae) In Sahendaruman Mountain, Sangihe Islands, North Sulawesi, Indonesia. *Applied Ecology and Environmental Research* 15(3): 797–808. https//doi.org/10.15666/aeer/1503_797808

Majumder, S.C. & B.K. Tikader (1991). Studies on some spiders of the family Clubionidae from India. *Records of the Zoological Survey of India, Occasional Paper* 102: 1–175.

Napiórkowska, T., J. Templin, P. Grodzicki & J. Kobak (2021). Thermal preferences of two spider species: an orb-web weaver and a synanthropic funnel-web weaver. *The European Zoological Journal* 88(1): 824–836. https://doi.org/10.1080/24750263.2021.1950223

Pareta, K. & U. Pareta (2013). Geological investigation of Rahatgarh waterfall of Sagar (MP) through the field survey and satellite remote sensing techniques. *International Journal of Geology* 5(3): 72–79.

Patil, S.R., B. Rita & C. Kailash (2016). Preliminary investigation on spider fauna (Arachnida: Araneae) of Nauradehi Wildlife Sanctuary, Madhya Pradesh, India. *Indian Forester* 142(7): 697–701.

Patil, S.R., S. Sambath & R. Bhandari (2013). Preliminary investigation on spiders (Arachnida: Araneae) in Rani Veerangana Durgawati wildlife sanctuary, Damoh, Madhya Pradesh, India. *Indian Forester* 139(10): 943–946.

Pocock, R.I. (1900). *The fauna of British India, including Ceylon and Burma. Arachnida*. W.T. Blanford (First). Taylor & Francis, London, 279pp.

Siliwal, M., S. Molur & B.K. Biswas (2005). Indian spiders (Arachnida: Araneae): updated checklist 2005. *Zoos' Print Journal* 20(10): 1999–2049. https//doi.org/10.11609/JoTT.ZPJ.1283.1999-2049

Sørensen, L.L., J.A. Coddington & N. Scharff (2002). Inventorying and estimating subcanopy spider diversity using semiquantitative sampling methods in an Afromontane Forest. *Environmental Entomology* 31(2): 319–330. https//doi.org/10.1603/0046-225X-31.2.319

Tikader, B.K. (1977). Studies on spider fauna of Andaman and Nicobar Islands, Indian Ocean. *Records of the Zoological Survey of India* 72(1–4): 153–212.

Tikader, B.K. (1980). Family Thomisidae. Fauna of India (Araneae) Vol. 1 (Part 1) (Thomisidae (Crab-Spiders)). Zoological Survey of India, Calcutta, 247pp.

Tikader, B.K. (1982a). Family Araneidae (=Argiopidae), typical orb-weavers, pp. 1–293. *Fauna of India, Spiders: Araneae, Vol 2.* Zoological Survey of India, Calcutta, 565 pp.

Tikader, B.K. (1982b). Family Gnaphosidae, pp. 295–536. In: *Fauna of India, Spiders: Araneae, Vol 2*. Zoological Survey of India, Calcutta, 565 pp.

Tikader, B.K. & B. Biswas (1981). Spider fauna of Calcutta and vicinity: Part-I. *Records of the Zoological Survey of India, Occasional Paper* 30: 1–149.

Tikader , B.K. & M.S. Malhotra (1980). *The Fauna of India, Vol. 1 (Part 2 (Lycosidae (Wolf-Spiders)).* Zoological Survey of India, Calcutta, 448 pp.

World Spider Catalog (2022). World Spider Catalog. Version 23.0. Natural History Museum Bern, online at http://wsc.nmbe.ch. Accessed on 29 April 2022. https://orcid.org/10.24436/2

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COMMUNICATION

Taxonomy and threat assessment of *Lagotis kunawurensis* Rupr. (Plantaginaceae), an endemic medicinal plant species of the Himalaya, India

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Abstract: *Lagotis kunawurensis* Rupr. (Plantaginaceae), a rare plant species endemic to the Himalaya, is reported here after a gap of 50 years from Ladakh. This species has often been taxonomically misidentified and confused with *Picrorhiza kurroa,* an important medicinal plant of the Himalaya. The present study clarifies the taxonomy of *L. kunawurensis* by providing description and photo illustrations of diagnostic characters which will aid its proper field identification. Furthermore, the threat assessment of *L. kunawurensis* using the IUCN Red List of Threatened Species has been conducted based on the available occurrence records, and the species currently falls under the 'Near Threatened' category. This species is used for medicinal purposes by locals in the study area. As the species is simultaneously experiencing various kinds of threats and the known distribution range is relatively smaller, it is right time to develop conservation strategies for the sustainable utilization of this endemic medicinal plant species of the Himalaya.

Keywords: Biogeography, conservation, Ladakh, medicinal plant, *Picrorhiza kurroa*, status, uses.

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Author contributions: AHG, TAB and AAK conceived the project idea; AHG, TAB, NR and SB collected the data. AHG, AAK, RA and ZAR analyzed and compiled the data; AHG and AAK wrote the manuscript, while all other authors provided editorial advices and contributed to finalize the manuscript.

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INTRODUCTION

Plants are crucial for the existence of life (Isbell et al. 2011). However, in recent times, plants are subjected to various threats such as habitat loss, over-exploitation, pollution, illicit trade (Tali et al. 2014; Ganie et al. 2019), and increasing stresses associated with climate change (Urban 2015; Hamid et al. 2020). These anthropogenic pressures on plant diversity are predicted to push Earth beyond the tipping points (Steffen et al. 2015; Bachman et al. 2017). In response to such grave concerns, the Target 2 of Convention on Biological Diversity (CBD) has called for assessment of threat status at regional, national, and global level to identify plant species which need immediate conservation. Empirical evaluation of threat status of biodiversity has emerged as an area of immediate research focus (Agnihotri et al. 2107; Tali et al. 2018; Ganie et al. 2019). Designation of current threat status of a species is crucial in assessing the risk of extinction, development of conservation policy, and drawing public attention towards these species, as well as their declining habitats (Burton 2003; Tali et al. 2018; Ganie et al. 2019).

The Himalaya, one of the global biodiversity hotspots, harbors about 10,000 plant species of which >3,100 are endemic to the region (Chitale et al. 2014). The Indian Himalayan region is rich in biodiversity, including prized medicinal plants (Tali et al. 2019; Dar & Khuroo 2020; Ganie et al. 2020). The genus *Lagotis* J. Gaertn. (Family: Plantaginaceae) has several species endemic to the Himalayan region (Stewart 1972; Lu 1992; Li et al. 2014). Four species of *Lagotis* have been recorded from the Himalaya (Stewart 1972) and two: *L. cashmeriana* (Royle) Rupr. and *L. kunawurensis* Rupr. are narrow endemic to the region. Stewart (1972) has recorded *L. kunawurensis* from Ladakh, Trans-Himalayan region in India; however, since then no other researcher (Kachroo et al. 1977; Polunin & Stainton 1984; Klimeš & Dickoré 2006; Behera et al. 2014) has reported this species from Ladakh. Recently, while carrying out botanical surveys to document the flora of Ladakh, specimens of a typical *Lagotis* species were collected from Sapi La, Kargil (Ladakh). After critical study of its morphological features, the species was identified as *Lagotis kunawurensis* Rupr. (Stewart 1972; Polunin & Stainton 1984). The later researchers, most likely, have taxonomically confused *L. kunawurensis* with *Picrorhiza kurroa,* another important medicinal plant of the Himalaya (*Lagotis kunawurensis*- efloraindia https://sites.google.com/site/efloraofindia/species/mz/p/plantaginaceae/lagotis/lagotiskunawurensis).

In an era of biodiversity crisis, the correct taxonomic identification and scientific information on the occurrence and population status of endemic species is urgently needed to undertake threat assessment, and thereafter develop appropriate conservation strategies (Chitale et al. 2104; Tali et al. 2018; Khuroo et al. 2020). In the backdrop of *L. kunawurensis* being a narrow endemic species, the present study aimed to resolve its taxonomic confusion and also for the first time undertake an empirical assessment of its threat status across the Himalaya based on IUCN Red List criteria (IUCN 2012).

MATERIALS AND METHODS

Study area

The Himalaya, covering an area of about 329,109.22 km^2, is located between 25.065–35.082 °N & 73.013–97.041 °E, along the northern boundary of India (Chitale et al. 2014). The climate is sub-alpine-temperate in western Himalaya, while it is sub-tropical to temperate in eastern Himalaya; whereas annual temperature and precipitation is on average 5 °C and 1,200 mm in western Himalaya, it is 10 °C and 3,500 mm in eastern Himalaya, respectively. The wide elevation gradient in the Himalaya ranging from 500–8,800 m results in a variety of ecosystems within short distances, from alluvial grasslands and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid-hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the treeline (Chitale et al. 2014).

The Trans-Himalayan region of Ladakh, the collection site of the present study, is located at the northwestern boundary of India between 21.095–37.083 °N & 72.066–78.041 °E. This region possesses a wide altitudinal gradient, land with diverse geological formations, resulting in the rich diversity of alpine and cold-desert flora (Nüsser & Dickorè 2002). The collection site namely, Sapi La is located in district Kargil of Ladakh at an altitude of 4,375 m, at 34.036 °N & 76.019 °E, and situated about 70 km towards the southwestern side of Kargil township.

Taxonomy

Standard herbarium methods (Bridson & Forman 1992) were used during collection, processing and preparation of the herbarium specimens. Voucher specimens have been deposited at the University of Kashmir Herbarium (KASH). Besides, an ethno-botanical survey was conducted in the study area to document the traditional use of this plant species. The survey usually started with the interview of elderly and experienced

members, locally known as 'Amchi' to collect information regarding medicinal uses of this plant species.

Record of operative threats

The operative threats (both direct and indirect) to plant species and their habitats were assessed during different seasons of the year at regular intervals of time following Ganie et al. (2019).

Threat assessment

Occurrence records for *Lagotis kunawurensis* were obtained from the Global Biodiversity Information Facility database (GBIF 2018) using the 'gbif' function from the 'dismo' package (https://CRAN.R-project.org/package=dismo) (Hijmans et al. 2017) and supplemented with the occurrence records from India Biodiversity Portal (IBP 2018), herbarium records (BSD, KASH) and field surveys.

Adopting the IUCN Red List Categories and Criteria, version 3.1 (IUCN 2012), we assessed the current threat status of the species based on the Criterion B; it takes into account the geographic range size as well as evidence of diminishing or fragmenting populations (Gaston & Fuller 2009; Cosiaux et al. 2018). The Criterion B is appropriate for assigning conservation status even when data is scarce and the geographic distribution of a species is known from only a few georeferenced herbarium records (Cosiaux et al. 2018). We used the ConR package (https://CRAN.R-project.org/package=ConR) (Dauby et al. 2017) implemented in R software (https://www.R-project.org/; R Core Team 2018) to calculate extent of occurrence (EOO) and area of occupancy (AOO) based on the occurrence records of the species. EOO was calculated by constructing a minimum convex polygon around all the known occurrences while AOO was estimated as the sum of occupied cells after superimposing the grid with cells of desired size (Dauby et al. 2017; Cosiaux et al. 2018; Lughadha et al. 2018). During the present study, the minimum AOO was estimated based on a standard grid cell of size 2 x 2 km (IUCN 2017). In addition, we also calculated the number of 'locations', as defined by IUCN (2017), with respect to the various types of threats, so that a single 'location' may involve more than one adjacent sub-populations.

RESULTS

Taxonomic description

***Lagotis kunawurensis* Rupr., Sert. Tianschan. 64 1869.**

Synonyms: *Gymnandra kunawurensis* Royle ex Benth., Scroph. ind. 47, 1835.

Lagotis glauca var. *kunawurensis* (Royle) Hook. f., Fl. Brit. Ind. 5, 569, 1885

Plant herbaceous up to 23 cm tall; roots many, fibrous; basal leaves obovate-oblanceolate, with cuneate leaf base, dentate-denticulate margin and acute-rounded leaf apex, 6-8 cm long and 1.5–2.2 cm broad, petiolate, petiole creamy with reddish tinge, 6–8 cm in length; stem leaves ovate, sessile, 2–3 cm long and 1–1.5 cm broad; inflorescence spike, flowers pale mauve or blue, numerous; calyx spathe-like; corolla tube slender, zygomorphic, bracts numerous, overlapping; stamens 2, filament as long as corolla or shorter; anthers reniform, black in colour; ovary 2 locular, superior; stigma capitate, bilobed (Image 1).

Specimens examined: India, Ladakh, Kargil: Sapi La, 03 August 2017, Tariq, Aijaz, & Khuroo 1000129; 23 July 2019, Aijaz & Nazima 110991 (KASH); Himachal Pradesh, Lahaul: Rohtang pass, 04 August 1994, Murti & Singh 102923 (BSD).

Identification aid: In western Himalaya, there is a confusion regarding the identification between *Lagotis kunawurensis* and *Picrorhiza kurroa* (https://sites.google.com/site/efloraofindia/species/mz/p/plantaginaceae/lagotis/lagotiskunawurensis), therefore the comparison of the diagnostic characters between these two species is provided to facilitate their correct taxonomic identification (Table 1).

Flowering period: July–August.

Ecological note: The species grows in the cold desert alpine areas which experience high speed winds and also prone to landslides. Also, the species is over-exploited for local use by herbal healers and whole plant along with roots is extracted. During the present study, the species was recorded only at one site (i.e., Sapi La) in the

Table 1. Comparison of diagnostic characters between *Lagotis kunawurensis* and *Picrorhiza kurroa*.

Diagnostic characters	Species	
	Lagotis kunawurensis	***Picrorhiza kurroa***
Leaf a. Type b. Shape	Both basal and stem leaves present Basal leaves obovate-oblanceolate Stem leaves ovate, sessile	Only stem leaves present Absent Stem leaves spathulate to narrow elliptical with winged leaf stalk
Inflorescence a. Type b. Size	Spike Up to 15–20 cm long	Cylindrical head Up to 10 cm long
Flower a. Colour b. Stamens	Pale mauve or blue Short, not exerted	Purplish-blue Long, exerted

Image 1. *Lagotis kunawurensis* Rupr.: A—Habitat (Scale = 0.1mm) | B—Habit (Scale = 1mm) | C—Fibrous roots (Scale = 1.5 mm) | D—Inflorescence –spike (Scale = 6 mm) | E—Zygomorphic pale blue flowers (Scale = 8 cm) | F—Numerous overlapping bracts (Scale = 9 mm) | G—Obovate-lanceolate basal leaves (Scale = 6 mm) | H—Leaf with denticulate margins and acute-rounded leaf apices (Scale = 2 cm) | I—Sessile stem leaves (Scale = 8 mm). © Aijaz Hassan.

entire Ladakh region. The number of mature individuals at the collection site was about 250 individuals, thus represented by a small population size.

Distribution

Global: Pakistan (Deosai, Baltistan); India (Drass, Rusi La, Sapi La and Zanskar in Ladakh, Jhow, Kunawur, Phalloot in Himachal Pradesh, Uttarakhand, and Sikkim); Nepal (Mechi, Gandaki Zone, Sagarmatha Zone, Koshi Zone, Thorung La, Manang, Karnali. Suli Gad); Bhutan (Catalogue of life-https://www.catalogueoflife.org)

During the present study, the plant species was collected from Sapi La (4370 m.; 34.036 °N and 76.019 °E), in Kargil district of Ladakh, India (Figure 1).

Ethno-medicinal uses

The plant species, in particular roots, are used against abdomen cramps, inflammation, and brown phlegm. The plant is also used as liver tonic and to treat different types of fevers in the collection site of the present study.

Threat status

Empirical evaluation of the threat status revealed that the extent of occurrence (EOO) and area of occupancy (AOO) for *L. kunawurensis* is 2,78,896 km^2 and 88 km^2 respectively (Figure 1). Furthermore, the species is recorded from 24 unique localities, representing a total of 19 sub-populations from 20 different locations (sensu IUCN 2012) which are more than 10 locations that represent the upper most limits for the 'Vulnerable' (VU) category under sub-criterion 'a'. Therefore, *L. kunawurensis* is assigned under IUCN category of Near Threatened (NT) according to criterion B.

DISCUSSION

After Stewart (1972), *Lagotis kunawurensis* has not been reported from the Ladakh region (Kachroo et al. 1977; Polunin & Stainton, 1984; Klimeš & Dickoré, 2006; Behera et al. 2014), therefore the authenticity of its presence in this region was doubtful. However, the present study clearly demonstrates distribution of *L. kunawurensis* in the region. The species has been confused with similar-looking *Picrorhiza kurroa,* another important medicinal plant that grows in Ladakh. A detailed taxonomic description and photo illustrations of diagnostic characters, as worked out in the present study, will facilitate its easier field identification, which is crucial for its conservation and sustainable use.

The present study has revealed that *L. kunawurensis* is currently Near Threatened (NT). Being narrow endemic to the Himalaya, rare distribution at high altitudes and smaller population size in the region makes the species highly vulnerable to contemporary land-use and climate changes (Rana et al. 2017). Ladakh region is recently experiencing climate change, which can impact both floral and faunal diversity of the region (Barrett & Bosek 2018). As *L. kunawurensis* is a narrow endemic species, thus considered more prone to extinction due to changing climate (Muthumperumal et al. 2020). In Ladakh, the species is mostly extracted by 'Amchis' (local herbal healers) for preparation of traditional medicine. Overexploitation for local use poses a serious threat to valuable wild medicinal plant species, and in turn endangers their habitats as well (Ganie et al. 2019). The medicinally important plant species is overharvested, in most cases illegally, from their wild habitats for trade in the national and international markets. This poses one of the biggest threats to the plant species (Ganie & Tali 2013). Worryingly, the species is extracted as a whole along with roots, that hinders its sexual (seeds) and/or asexual (rootstock) reproduction and which in turn results in reduction of population size and distribution (Tali et al. 2014). The species grows in landslide prone areas in the study area. Landslides are one of the major factors of habitat fragmentation (Dar & Naqshi 2002) and also play a major role in making the plant species vulnerable to local extirpation (Ganie et al. 2019). The landslides can lead to the competitive advantage for growth of other ruderal species due to changes brought

Figure 1. Result of the threat assessment for Lagotis kunawurensis. Blue dots represent the occurrence records for the target species, grey polygon the convex hull used for calculation of extent of occurrence (EOO). The inset (upper right black text) summarizes all the information calculated by the *IUCN.eval* function.

in physico-chemical properties of the soil, which in turn can render the natural habitat of endemic species unfavorable, and lead to their population decline (Tali et al. 2014; Ganie et al. 2019). If these threats continue to operate unchecked, the species is highly susceptible to become threatened in near future. To focus conservation action at a regional scale, it becomes necessary to prioritize these species in their natural distributional range (Nori et al. 2016).

Therefore, in an era of rapid land-use change and climate crisis, the results from present study have wide relevance in devising successful conservation strategies for this endemic species in high-altitude habitats of the Himalaya. Looking ahead, the present study can serve as an early warning for undertaking urgent efforts to conserve this important endemic medicinal plant species.

REFRENCES

Agnihotri, P., T. Husain, P.A. Shirke, O.P. Sidhu, H. Singh, V. Dixit, A.A. Khuroo, D.V Amla & C.S. Nautiyal (2017). Climate Change-driven Shifts in Elevation and Ecophysiological Traits of Himalayan Plants during the Past Century. *Current Science* 112(3): 595–601.

Bachman, S.P., E.M.N. Lughadha & M.C. Rivers (2017). Quantifying progress toward a conservation assessment for all plants. *Conservation Biology* 32(3): 516–524

Barrett, K & K. Bosak (2018). The Role of Place in Adapting to Climate Change: A Case Study from Ladakh, Western Himalayas. *Sustainability* 10(4): 898. https://doi.org/10.3390/su10040898

Behera, M.D., S. Martin & P.S. Roy (2014). Biodiversity of Kargil Cold Desert in Ladakh Himalaya, pp. 253–274. In: Nakano S., T. Yahara, T. Nakashizuka (eds.). *Integrative Observation and Assessment, Ecological Research Monograph*. Springer, Japan, xv+431 pp. https://doi.org/10.1007/978-4-431-54783-9

Bridson, D. & L. Forman (1998). *The herbarium handbook*, *3rd ed*. Kew, Royal Botanic Gardens, London, 320 pp.

Burton, J.A. (2003). The context of red data books, with a complete bibliography of the IUCN publications 291–300. In: De Iongh, H., O.S. B´anki, W. Bergmans, M.J. Van derWerff ten Bosch (eds). *The Harmonization of Red Lists for Threatened Species in Europe*. The Netherlands Commission for International Nature Protection, Leiden, 332 pp.

Catalogue of life. https://www.catalogueoflife.org. Accessed on 10 April 2020.

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

Cosiaux, A., L.M. Gardiner, F.W. Stauffer, S.P. Bachman, B. Sonké, W.J Baker & T.L.P. Couvreur (2018). Low extinction risk for an important plant resource: conservation assessments of continental African palms (Arecaceae/Palmae). *Biological Conservation* 221: 323–33.

Dar, G.H. & A.A. Khuroo (2020). *Biodiversity of the Himalaya: Jammu and Kashmir State*. Springer Nature, Singapore, 1,100 pp.

Dar, G.H. & A.R. Naqshi (2002). Plant resources of Kashmir: Diversity, utilizationand conservation, pp. 109–122. In: Pandit, A.K. (Ed.). *Natural resources of Western Himalaya*, Valley Book House, Srinagar, Kashmir.

Dauby, G., T. Stévart, V. Droissart, A. Cosiaux, V. Deblauwe, M. Simo-Droissart, M.S.M. Sosef, P.P.I.I. Lowry, G.E. Schatz, R.E. Gereau & T.L.P. Couvreur (2017). ConR: An R package to assist large-scale multispecies preliminary conservation assessments using distribution data. *Ecology and Evolution* 7: 11292–11303. https://CRAN.R-project.org/package=ConR

Efloraindia https://sites.google.com/site/efloraofindia/species/mz/p/plantaginaceae/lagotis/lagotiskunawurensis. Accessed on 10 April 2020.

Ganie, A.H & B.A. Tali (2013). Vanishing medicinal plants of Kashmir Himalaya. India's endangered. (Available online). http://indiasendangered.com/vanishing-medicinal-plants-of-kashmir-himalaya/.

Ganie, A.H., B.A. Tali, A.A. Khuroo, Z.A. Reshi & I.A. Nawchoo (2019). Impact assessment of anthropogenic threats to high-valued medicinal plants of Kashmir Himalaya, India. *Journal of Nature Conservation* 50: 125715. https://doi.org/10.1016/j.jnc.2019.125715

Ganie, A.H., B.A. Tali, A.A. Khuroo, I.A. Nawchoo, Z.A. Reshi & G.H. Dar (2020). Diversity in medicinal and aromatic flora of the Kashmir Himalaya, pp. 545–564. In: Dar G. & Khuroo A. (eds). *Biodiversity of the Himalaya: Jammu and Kashmir State*. Springer, Singapore, xxiii+1,100 pp.

Gaston, K.J. & R.A. Fuller. (2009). The sizes of species' geographic ranges. *Journal of Applied Ecology* 46: 1–9.

GBIF (2018). Global Biodiversity Information Facility database. https://www.gbif.org/ Accessed 21 March 2020.

Hamid, M., A.A Khuroo, A.H. Malik, R. Ahmad, C.P. Singh, J. Dolezal & S.M. Haq (2020). Early evidence of shifts in alpine summit vegetation: A case study from Kashmir Himalaya. *Frontiers in Plant Science* 11: 421.

Hijmans, R.J., S. Phillips, J. Leathwick & J. Elith (2017). dismo: *Species Distribution Modeling*. R package version 1.1-4. https://CRAN.R-project.org/package=dismo

IBP (2018). India Biodiversity Portal. https://indiabiodiversity.org/. Accessed 21 March 2020.

Isbell, F., V. Calcagno, A. Hector, J. Connolly, W.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* 477: 199–202. https://doi.org/10.1038/nature10282

IUCN (2012). IUCN Red List Categories and Criteria: Version 3.1. 2nd edition. IUCN Species Survival Commission, Gland, Switzerland and Cambridge, UK, 32 pp.

IUCN (2017). Guidelines for Using the IUCN Red List Categories and Criteria. Version 13.http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Kachroo, P., B.L. Sapru & U. Dhar (1977). *Flora of Ladakh. An Ecological and Taxonomical Appraisal*. Bishen Singh Mahender Pal Singh, Dehra Dun, 172 pp.

Khuroo, A.A., G. Mehraj, I. Muzafar, I. Rashid & G.H. Dar (2020). Biodiversity conservation in Jammu and Kashmir state: current status and future challenges, pp. 1049–1076. In: Dar H.S. & A.A Khuroo (eds). *Biodiversity of the Himalaya: Jammu and Kashmir State*. Springer, Singapore, xxiii+1,100 pp.

Klimeš, L. & W.B. Dickoré (2006). *Flora of Ladakh (Jammu and Kashmir, India)-a preliminary checklist*. http://www.butbn.cas.cz/klimes. Accessed 3 February 2020.

Li, G.D., C. Kim, H.G. Zha & Z. Zhou (2014). Molecular phylogeny and biogeography of the arctic-alpine genus *Lagotis* (Plantaginaceae). *Taxon* 63(1): 103–115.

Lu, X.F. (1992). A study of *Lagotis* Gaertn. (Scrophulariaceae) in the Qinghai-Tibet Plateau. *Acta Biologica Plateau Sin* 11: 187–198.

Lughadha, N.E., B.E. Walker, C. Canteiro, H. Chadburn, A.P. Davis, S. Hargreaves, E.J. Lucas, A. Schuiteman, E. Williams, S.P. Bachman, D. Baines, A. Barker, A.P. Budden, J. Carretero, J.J. Clarkson, A. Roberts & M.C. Rivers (2018). The use and misuse of herbarium specimens in evaluating plant extinction risks. *Philosophical Transactions of the Royal Society B* 374(1763): 20170402. https://doi.org/10.1098/rstb.2017.0402

Muthumperumal, C., P. Balasubramanian & L. Rasingam (2020). An

assessment of the conservation status of a presumed extinct tree species *Wendlandia angustifolia* Wight ex. Hook.f. in southern Western Ghats, India. *Journal of Threatened Taxa* 12(4): 15468–15474. https://doi.org/10.11609/jott.5148.12.4.15468-15474

Nori, J., R. Torres, J.N. Lescano, J.M. Cordier, E. Maria, M.E. Periago & D. Baldo (2016). Protected areas and spatial conservation priorities for endemic vertebrates of the Gran Chaco, one of the most threatened ecoregions of the world. *Diversity and Distributions* 22(12): 1212–1219.

Nüsser, M. & W.B. Dickorè (2002). A tangle in the triangle: Vegetation map of the Eastern Hindukush (Chitral, northern Pakistan). *Erdkundle* 56(1): 37–59

Polunin, O & A. Stainton (1984). *Flowers of the Himalaya*. Oxford University Press, Delhi, 295 pp.

R Core Team (2018). R: *A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Rana, S.K., H.K. Rana & S.K. Ghimire, K.K. Srestha & S. Ranjitkar (2017). Predicting the impact of climate change on the distribution of two threatened Himalayan medicinal plants of Liliaceae in Nepal. *Journal of Mountain Science* 14(3): 558–570.

Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney & C. Ludwig (2015). The trajectory of the Anthropocene: the great acceleration. *The Anthropocene Review* 2: 81–98.

Stewart, R.R. (1972). *Flora of West Pakistan: An annonated catalogue of the vascular plants of West Pakistan and Kashmir.* Fakhri Press, Karachi, Pakistan, 450 pp.

Tali, B.A., A.A. Khuroo, I.A. Nawchoo & A.H. Ganie (2018). Prioritizing conservation of medicinal flora in the Himalayan biodiversity hotspot: An integrated ecological and socio-economic approach. *Environmental Conservation* 46(2): 147–154. https://doi.org/10.1017/S0376892918000425

Tali, B.A., A.H. Ganie, I.A. Nawchoo, A.A. Wani & Z.A. Reshi (2014). Assessment of threat status of selected endemic medicinal plants using IUCN regional guidelines: A case study from Kashmir Himalaya. *Journal for Nature Conservation* 23: 80–89.

Tali, B.A., A.A. Khuroo, A.H. Ganie & A.A. Nawchoo (2019). Diversity, distribution and traditional uses of medicinal plants in Jammu and Kashmir (J&K) state of Indian Himalayas. *Journal of Herbal Medicine* 17: 100280. https://doi.org/10.1016/j.hermed.2019.100280

Urban, M.C. (2015). Accelerating extinction risk from climate change. *Science* 348: 571–573.

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OPEN ACCESS

COMMUNICATION

The study of algal diversity from fresh water bodies of Chimmony Wildlife Sanctuary, Kerala, India

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Abstract: The algal diversity of the freshwater ecosystem is very significant because they are the primary energy producers in the food web. The study for the algal diversity was conducted at Chimmony Wildlife Sanctuary, Thrissur, Kerala, India, from selected sampling sites (Pookoyil thodu, Kidakkapara thodu, Viraku thodu, Nellipara thodu, Anaporu thodu, Kodakallu thodu, Odan thodu, Mullapara thodu, Payampara thodu, Chimmony dam). The identified algal species belong to four different classes: Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae. Sixty-one algal species were identified, represented by 37 genera, 22 families, and 14 orders. Among the four, Chlorophyceae was the dominant class.

Keywords: Biodiversity, Chlorophyceae, conservation, Cyanophyceae, Euglenineae, freshwater, Rhodophyceae, taxonomy, Thrissur.

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Author contributions: JJ did the experimental design, field data collection and the data analysis. JX has supervised the work and preparation of final manuscript.

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INTRODUCTION

Algae are the most abundant aquatic organisms present in the freshwater ecosystem. Algae were responsible for the beginning of multicellular life on our planet and could be the key to our future survival. They are an essential source for producing fine chemicals, natural pigments, vitamins, polysaccharides, bioflocculants, and growth promoters. Algae are also a significant producers of oxygen than plants (Rai et al. 2000).

The freshwater ecosystems are mainly categorized into two types: lotic and lentic. The rivers, streams, waterfalls, canals fall into the lotic type, and the stagnant waters like pools, lakes, reservoirs and paddy fields fall into the lentic type. The freshwater algal diversity varies from unicellular phytoplankton to colonial and much larger multicellular algae. The algal biodiversity depends upon the physicochemical parameters of the water bodies. In the food chain of aquatic ecosystems, algae are the primary producers, making them very important. So the conservation and knowledge about algal biodiversity are necessary for maintaining a healthy aquatic ecosystem.

The information regarding species diversity is an essential component to realize life in its fullness and conserve it for future generations (Pandey 1995). Therefore, there is a strong demand for research on biodiversity in developing countries (Briji 2005; Tessy & Sreekumar 2017). Generally, the taxonomy is considered an outdated science that cannot keep up with the present biodiversity crisis (De Clerck et al. 2013). But for the future development in biodiversity research, systematics and taxonomy are important (Koen & Segers 2005).

The study of biodiversity as the present one opens new opportunities to understand the different algal forms in their respective natural habitat. The large algal species in the freshwater ecosystem depict its diversity. In the current scenario, hardly a few genera are used in the industry, giving a broad scope for other potential obtainable algae. Even though plenty of literature is available on fresh water algal diversity of Kerala, there is no published record available on the algal diversity of Chimmony Wildlife Sanctuary. Hence the study.

MATERIALS AND METHODS

Study area

The study was conducted in Chimmony Wildlife Sanctuary (CWS; Figure 1), which is situated in the Thrissur District of Kerala state. It belongs to Mukundapuram taluk and within geographical limits of 10.40° & 10.48° E and 76.41° & 76.56° N. CWS has an area extent of 85.067 km^2 and water spread area of 10.1 km^2. The sanctuary consists of more than 250 streams, which drains into the Chimmony Reservoir (George 2012; Velayudhan et al.

Figure 1. Location of sampling sites in Chimmony Wildlife Sanctuary.

2021). In this study, 10 different streams were selected to study the algal flora (Table 1).

Sampling

The algal samples were collected from 10 different stations using forceps, scalpel, and blade. The collections were made from the surface level, the underside of rocks, mucilage masses attached to dripping rocks, and tree trunks. 4% formalin solution was used for preservation. The collected specimens were observed under a microscope by preparing wet mounts within 48 hours. The algal specimens were identified using standard literature, monographs and research papers (Ralfs 1848; Turner 1892; Desikachary 1959; Randhawa 1959; Prescott 1961; Pal & Kundu 1962; Ramanathan 1964; Philipose 1967; Hindak 1977; Hirose et al. 1977; Hindak 1984; West & West 1904; Kouwets & Coesel 1984; Prasad & Misra 1992; Wolowski 1998; Wotowski & Hindak 2005).

RESULTS

In the study conducted in CWS, 61 algal species were recorded, which belongs to four different classes (Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae). These species are represented by 37 genera, 22 families, and 14 orders (Table 2). The class Chlorophyceae represents 33 taxa under 22 genera, the class Euglenineae represents seven taxa under four genera, the class Rhodophyceae represents one taxa under one genera, and the class Cyanophyceae represents 20 taxa under 10 genera.

Class: Chlorophyceae
Order: Volvocales
Family: Chlamydomonadaceae
Genus: *Chlamydomonas* Ehrenberg

1. *Chlamydomonas globosa* Snow (Image 1)

Prescott, 1961, p.71, pl.1, figs. 8,9

The cells are globose, enclosed in a hyaline, gelatinous sheath. The cell is 3–5 µm in diameter and 5–10 µm long. The cell consists of a parietal cup-shaped chloroplast with basal pyrenoid and a contractile vacuole at the anterior end. The cell is covered with a smooth membrane and two flagella at the anterior end. The pigment spot is small and inconspicuous.

Family: Volvocaceae
Genus: *Gonium* Mueller

2. *Gonium pectorale* Mueller (Image 2)

Prescott, 1961, p. 75, pl.1, fig. 22

The colony consists of 16 ellipsoid to subspherical cells arranged in a flat quadrangular plate. This quadrangular plate consists of four inner cells covered by 12 marginal cells. The anterior ends of marginal cells were projecting outwards. Each cell is enclosed in an individual sheath and the cells are 5–20 µm in diameter.

Order: Tetrasporales
Family: Tetrasporaceae
Genus: *Tetraspora* Link

3. *Tetraspora gelatinosa* (Vauch.) Desvaux (Image 3)

Prescott, 1961, p. 88, pl.5, figs. 3,4

The thallus is a macroscopic attached floating cylindrical sac where each cell are irregularly arranged. The thallus is globular and bullate, in which spherical cells are arranged in a tetrad manner. The thallus is covered in a thick mucilaginous sheath, and the cells are 6–10 µm in diameter.

Order: Chlorococcales
Family: Chlorococcaceae
Genus: *Chlorococcum* Fries

4. *Chlorococcum humicola* (Naeg.) Rabenhorst (Image 4,5)

Prescott, 1961, p. 212, pl.45, fig. 1

The colony is unicellular, non-motile, with spherical cells in various small clumps. Each cells consist of a completely filled spherical chloroplast with a single pyrenoid. The cell is 7–10 µm in diameter.

Family: Selenastraceae
Genus: *Monoraphidium* Komarkova - Legnerova

5. *Monoraphidium griffithii* (Berkeley) Komarekova - Legnerova (Image 6)

Table 1. Latitude and Longitude of sampling sites

	Sampling sites	Latitude (E) and Longitude (N)
1	Pookoyil thodu	10.4600, 76.4744
2	Kidakkapara thodu	10.4641, 76.4658
3	Viraku thodu	10.4497, 76.4444
4	Nellipara thodu	10.4458, 76.4638
5	Anaporu thodu	10.4300, 76.5069
6	Kodakallu thodu	10.4388, 76.5141
7	Odan thodu	10.4522, 76.5047
8	Mullapara thodu	10.4558, 76.4983
9	Payampara thodu	10.4544, 76.4913
10	Chimmony dam	10.4605, 76.4722

Table 2. Algal species identified from Chimmony Wildlife Sanctuary.

	Class	Order	Family	Genus	Species
1	Chlorophyceae	Volvocales	Chlamydomonadaceae	*Chlamydomonas*	*globosa* Snow
2			Volvocaceae	*Gonium*	*pectorale* Mueller
3		Tetrasporales	Tetrasporaceae	*Tetraspora*	*gelatinosa* (Vauch.) Desvaux
4		Chlorococcales	Chlorococcaceae	*Chlorococcum*	*humicola* (Naeg.) Rabenhorst
5			Selenastraceae	*Monoraphidium*	*griffithii* (Berkeley) Komarekova - Legnerova
6					*indicum* Hindak
7			Scenedesmaceae	*Scenedesmus*	*quadricauda* var. *maximus* West & West
8		Ulotrichales	Ulothrichaceae	*Ulothrix*	*aequalis* Kuetzing
9		Cladophorales	Cladophoraceae	*Pithophora*	*oedogonia* (Mont.) Wittrock
10		Chaetophorales	Trentepohliaceae	*Trentepohlia*	*aurea* (L.) Martius
11		Oedogoniales	Oedogoniaceae	*Oedogonium*	*areschougii* Wittrock
12					*croasdaleae* Jao
13		Zygnematales	Zygnemataceae	*Mougeotia*	*scalaris* Hassall
14				*Zygnema*	*carinatum* Taft
15				*Spirogyra*	*acanthophora* (Skuja) Czurda
16					*condensata* (Vauch.) Kuetzing
17					*decimina* (Mueller) Kuetzing
18					*fuellebornei* Schmidle
19					*micropunctata* Transeau
20					*novaeangliae* Transeau
21					*rhizobrachialis* Jao
22			Mesotaeniaceae	*Cylindrocystis*	*brebissonii* (Ralfs) De Bary
23				*Netrium*	*digitus* (Ehrbg.) Itzigs. & Rothe
24			Desmediaceae	*Actinotaenium*	*silvae-nigrae* (Rabanus) Kouwets & Coesel
25				*Closterium*	*ehrenbergii meneghinii* var. ehrenbergii
26					*moniliferum* Ehrenberg ex Ralfs
27					*tumidulum* Gay
28				*Cosmarium*	*botrytis* Meneg
29					*subtumidum* Nordst
30				*Micrasterias*	*radians* Turn var. *bogoriensis* (Breb) G.S West
31				*Pleurotaenium*	*trabecula* (Ehrbg) Nag
32				*Staurastrum*	*zonatum* Borges var. *majus* Presc.
33		Charales	Characeae	*Nitella*	*furcata* (Roxburgh *apud* Bruzelius) Agardh
34	Euglenineae	Euglenales	Astasiaceae	*Euglena*	*elastica* Prescott
35					*minuta* Prescott
36				*Phacus*	*curvicauda* Swirenko
37					*obolus* Pochmann
38					*orbicularis* var. *caudatus* Skzortzow
39				*Lepocinclis*	*acus* (Muller) marin and Melkonian
40				*Trachelomonas*	*hispida* var. *papillata* Skvortzow
41	Rhodophyceae	Batrachospermales	Batrachospermaceae	*Sheathia*	*boryana* (Sirodot) Salomaki & M.L.Vis

	Class	Order	Family	Genus	Species
42	Cyanophyceae	Chroococcales	Chroococcaceae	*Aphanocapsa*	*pulchra* (Kutz) Rabenh
43				*Microcystis*	*aeruginosa* Kutz.
44		Nostocales	Microchaetaceae	*Microchaete*	*uberrima* Carter, N
45			Oscillatoriaceae	*Oscillatoria*	*limosa* Agardh ex Gomont
46					*subbrevis* Schmidle
47					*vizagapattensis* Rao, C. B
48				*Phormidium*	*abronema* Skuja
49					*hansgirgi* Schmidle
50					*microtomum* Skuja
51					*molle* (Kutz.) Gomont
52					*retzii* (Ag.) Gomont
53					*truncicola* Ghose
54					*usterii* Schmidle
55			Nostocaceae	*Anabaena*	*anomala* Fritsch
56					*sphaerica* Bornet et Flahault
57				*Cylindrospermum*	*stagnale* (Kutz.) Born.et Flah
58			Rivulariaceae	*Gloeotrichia*	*echinulata* (J. E. Smith) P. Richter
59				*Scytonema*	*ocellatum* Lyngbye ex Born. et Flah
60					*rivulare* Borzi ex Born. et Flah
61		Stigonematales	Nostochopsidaceae	*Nostochopsis*	*lobatus* Wood em. Geitler

Hindak, 1984, p. 219, pl. 79, figs. 5,8

The cell is straight and fusiform, having a tapering from the centre towards the pointed ends. The cell is 45–50 µm long and 2–3 µm broad.

6. *Monoraphidium indicum* Hindak (Image 7)

Hindak, 1977, p.105, pl.44

The cells are very thin and are accurately curved. The cell has a tapering towards the end and it is pointed. The cell is 40–45 µm long and 1.5–2 µm broad.

Family: Scenedesmaceae

Genus: *Scenedesmus* Meyen

7. *Scenedesmus quadricauda* var. *maximus* West & West (Image 8)

M. T Philipose, 1967, p. 283, fig. 187 g

The colonies are usually four-celled with much larger cells. The cell is 25–30 µm long and 10–11 µm in diameter. The spines are 25–35 µm long.

Order: Ulotrichales

Family: Ulothrichaceae

Genus: *Ulothrix* Kuetzing

8. *Ulothrix aequalis* Kuetzing (Image 9)

K.R Ramanathan, 1964, p.36, pl.9 I-L

The thallus is non-branching, filamentous with cylindrical cells. The cells are 12–14 µm broad and 24–28 µm long. The cells consist of a striated cell wall, girdle shaped broad chloroplast covering half of the wall surface with one or more pyrenoids.

Order: Cladophorales

Family: Cladophoraceae

Genus: *Pithophora* Wittrock

9. *Pithophora oedogonia* (Mont.) Wittrock (Image 10, 11; Image 12, 13)

Prescott, 1961, p.140, pl.22, figs. 7–10

The filaments are slender 50–60 µm in diameter with solitary branching. Each cell are cylindrical and long. The akinetes are cylindrical and slightly swollen and acuminate at the terminal. Akinetes are 55–140 µm in diameter and 90–350µm long.

Order: Chaetophorales

Family: Trentepohliaceae

Genus: *Trentepohlia* Martius

10. *Trentepohlia aurea* (L.) Martius (Image 14,15,16)

Prescott, 1961, p.133, pl.67, figs. 6–9

The cells are rusty-brown in colour sometimes the thallus shows yellow colour in shaded regions. The cells are slightly swollen but slightly reduced in diameter towards apices. The cell has a smooth wall, and it is 4–10

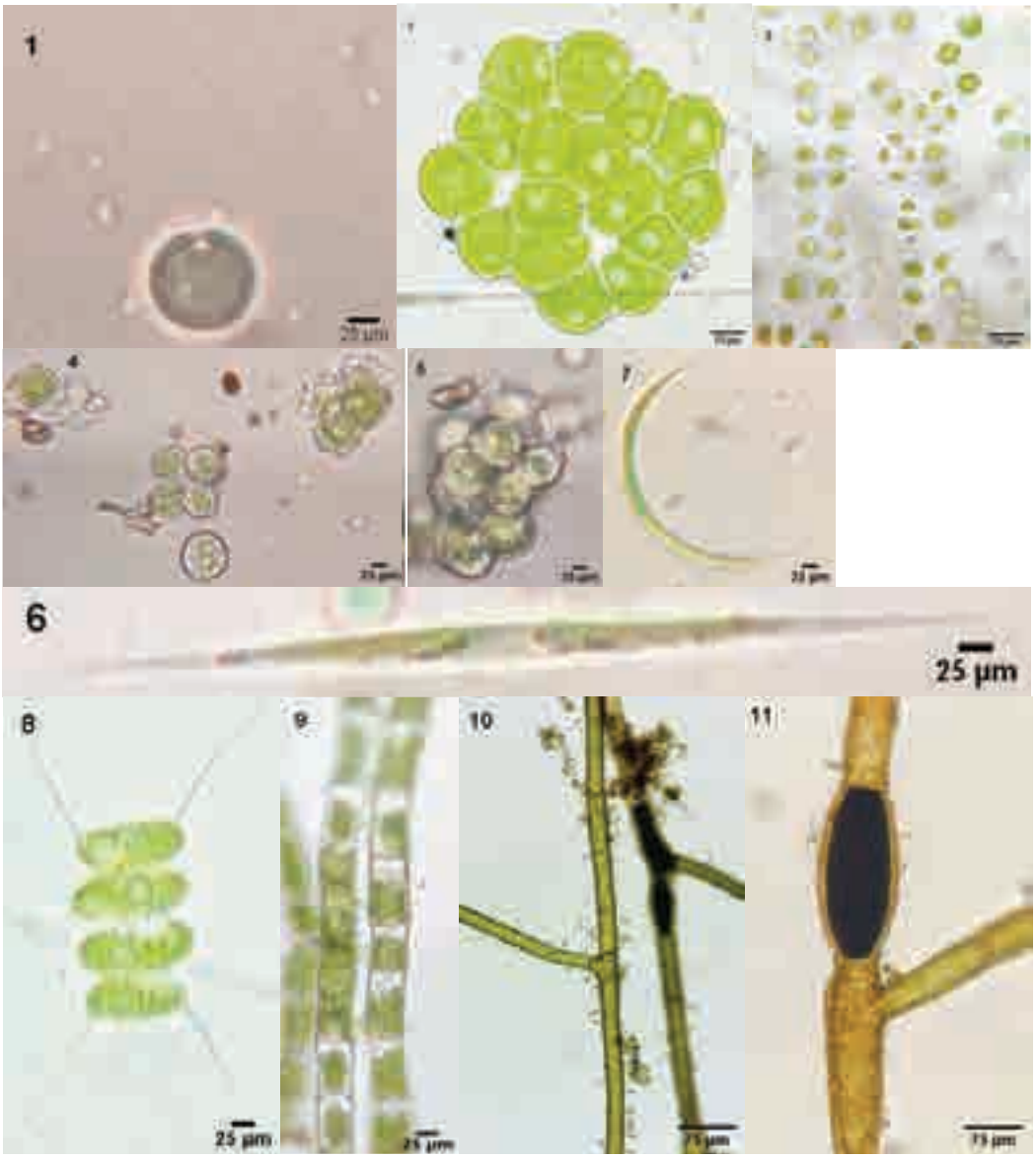

Image 1–11. 1—*Chlamydomonas globosa* | 2—*Gonium pectorale* | 3—*Tetraspora gelatinosa* | 4, 5—*Chlorococcum humicola*| 6—*Monoraphidium griffithii* | 7—*Monoraphidium indicum* | 8—*Scenedesmus quadricauda* var. *maximus* | 9—*Ulothrix aequalis* | 10, 11—*Pithophora oedogonia*. (© Joel Jose)

µm in diameter. The sporangia are generally terminal on curved cells with 15–20 µm in diameter. The gametangia are not frequently observed, and they will be the same size as the sporangia.

Order: Oedogoniales
Family: Oedogoniaceae
Genus: *Oedogonium* Link

11. *Oedogonium areschougii* Wittrock (Image 17)
Prescott, 1961, p. 204

The filament is nannandrous & gynandrosporous. The filaments are cylindrical in shape with a 10–12 µm diameter and 35–28 µm long. The oogonia is pyriform globose shaped and operculate with 30-35µm diameter and 36–40 µm long. The smooth-walled oospore is not completely filled inside the oogonia. The diameter of the oospore is 23–25 µm. The dwarf males are unicellular attached near or on the oogonia with 6–7 µm diameter and 13–15 µm long.

12. *Oedogonium croasdaleae* Jao (Image 18, 19)
Prescott, 1961, p.204, pl.41, fig. 11

The filament is nannandrous and gynandrosporous. The vegetative cells are cylindrical 25–30 µm in diameter

and 150–200 µm long. The oogonia are two in a series, 60–70 µm in diameter and 80–113 µm long. The dwarf males are 9–17 µm in diameter and 48–55 µm long.

Order: Zygnematales
Family: Zygnemataceae
Genus: *Mougeotia* C.A. Agardh

13. *Mougeotia scalaris* Hassall (Image 20)
Prescott, 1961, p. 304, pl.71, figs. 6,7

The filaments are 14–20 µm in diameter and 34–182 µm long. The chloroplast consists of 4–6 pyrenoids. The zygospores are globose to ovate with smooth walls and formed in the tube due to scalariform conjugation. The zygospore measures up to 30–35 µm in length and 26–30 µm in diameter.

Genus: *Zygnema* Agardh

14. *Zygnema carinatum* Taft (Image 21)
Randhawa 1959, p.225, fig. 160

The filaments are greenish and unbranched. The cells are rectangular to square in shape. Presence of two star-shaped chloroplasts. The cell is 11–15 µm long and 10 µm broad. The scalariform conjugation results in the formation of globose shaped zygospore in the tube. The globose zygospore is formed at the right angle of the tube, and it measures 13–16 µm in length and 15–20 µm in breadth.

Genus: *Spirogyra* Link

15. *Spirogyra acanthophora* (Skuja) Czurda (Image 22)
Randhawa, 1959, p.376, fig. 413

The filaments are 300–328 µm long and 60–65 µm wide. The zygospores are 37–42 µm in diameter and 50–62 µm in length.

16. *Spirogyra condensata* (Vauch.) Kuetzing (Image 3: 23)
Prescott, 1961, p. 312, pl.72, figs. 5,6

The filaments are 111–153 µm long and 40–53 µm wide. Smooth walled zygospores were formed due to conjugation, and it measures up to 35–37 µm in diameter and 52–60 µm in length.

17. *Spirogyra decimina* (Mueller) Kuetzing (Image 24, 25)
Prescott, 1961, p. 313

The filaments are 130–133 µm long and 20–24 µm wide. Presence of two chloroplasts. The zygospores are cylindrical to ovate with a smooth wall that measures up to 32–38 µm in diameter to 30–35 µm in length.

18. *Spirogyra fuellebornei* Schmidle (Image 26)
Randhawa. 1959. P. 316, fig. 291

The filaments are long and cylindrical having 238–376 µm long and 26–31 µm broad. Presence of two chloroplast, having 3–4 turns in a cell. The zygospores are 30–39 µm in diameter and 58–65 µm in length.

19. *Spirogyra micropunctata* Transeau (Image 27)
Prescott, 1961, p. 317, pl.73, fig. 9

The filaments are 243–300 µm long and 29–35 µm wide. The scalariform conjugation produces an ellipsoidal zygospore, which measures up to 35–40 µm in diameter and 60–72 µm long.

20. *Spirogyra novaeangliae* Transeau (Image 28)
Prescott, 1961, p. 318, pl.75, figs. 1-3

The filaments are 200–230 µm long and 58µm wide. The zygospore is ovate to ellipsoidal. The zygospore exhibits a brown colour which measures up to 50–60 µm in diameter and 85–90 µm in length.

21. *Spirogyra rhizobrachialis* Jao (Image 3: 29)
Prescott, 1961, p. 320, pl.76, figs. 1, 2

The filaments are 43–50 µm in diameter and 120–211 µm long. Presence of two crenate and deeply toothed chloroplast. The fertile cylindrical cells form zygospores through conjugation. The zygospore is ellipsoidal brown, which measures up to 40–50 µm in diameter and 111 µm in length.

Family: Mesotaeniaceae
Genus: *Cylindrocystis* De Bary

22. *Cylindrocystis brebissonii* (Ralfs) De Bary (Image 30, 31)
W. West & G.S. West, 1904, pl. 4, figs. 23–32, pl.5, fig. 10

The cells are cylindrical with round apices. The chloroplast consists of a few large radiating prolongations. The cell body is 35–40 µm long and 22–28 µm in broad.

Genus: *Netrium* (Nageli) Itzigsohn & Rothe in Rabenhorst

23. *Netrium digitus* (Ehrbg.) Itzigs. & Rothe (Image 32)
W. West & G. S. West, 1904, pl. 6, fig. 14–16

The cell is generally large and elliptic to oblong in shape. The cell is gradually attenuated from the centre towards the apices, which is rounded and truncated. The chloroplast is axile with deeply notched free margins. The cell body is 150–160 µm long and 40–45 µm in diameter.

Image 12–21. 12, 13—*Pithophora oedogonia* | 14, 15, 16—*Trentepohlia aurea* | 17—*Oedogonium areschougii* | 18, 19—*Oedogonium croasdaleae* | 20—*Mougeotia scalaris* | 21—*Zygnema carinatum*. (© Joel Jose)

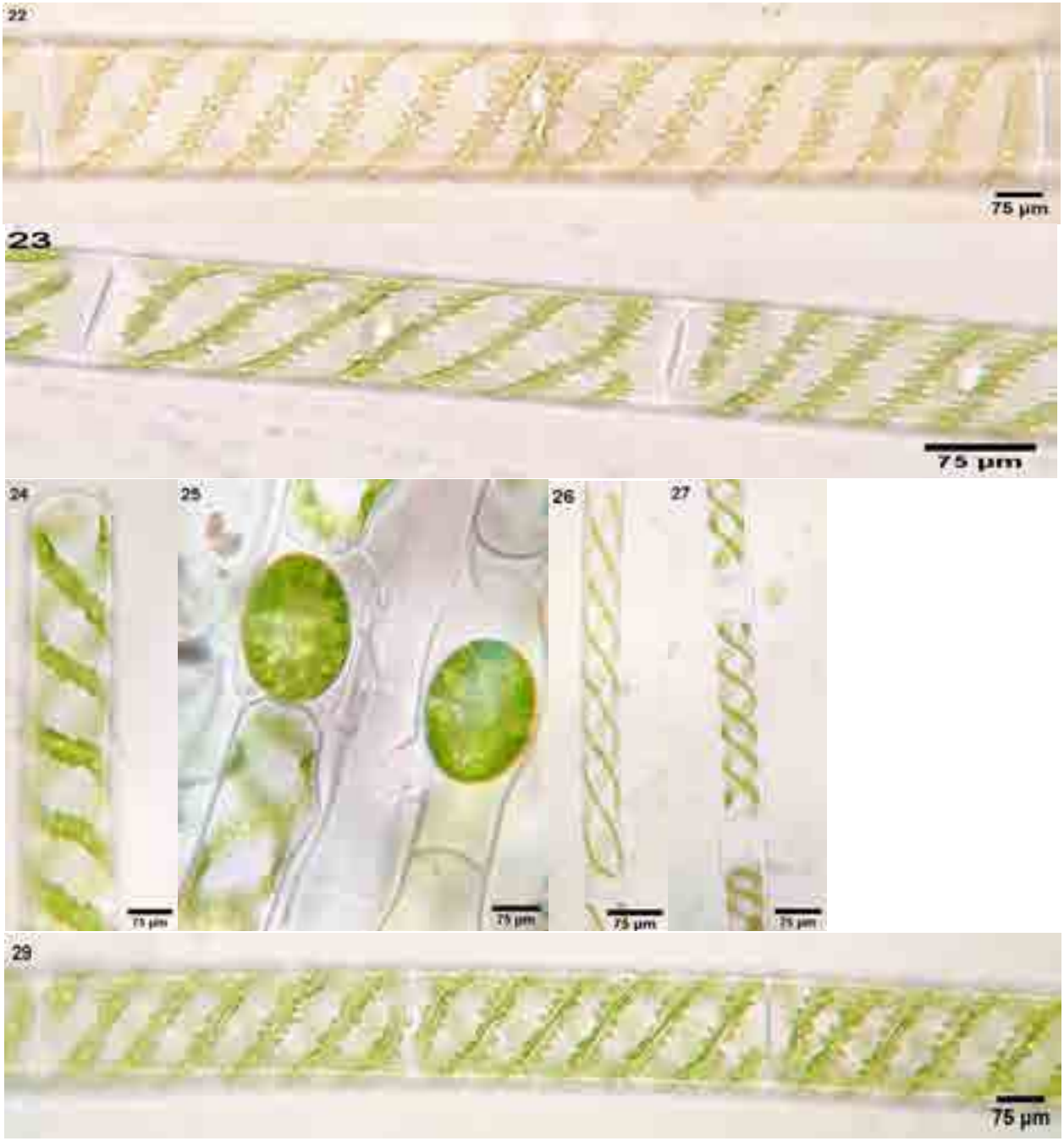

Image 22–29. 22—*Spirogyra acanthophora* | 23—*Spirogyra condensata* | 24, 25—*Spirogyra decimina* | 26—*Spirogyra fuellebornei* | 27—*Spirogyra micropunctata* | 29—*Spirogyra rhizobrachialis*. (© Joel Jose)

Family: Desmediaceae

Genus: *Actinotaenium* (Nageli) Teiling

24. *Actinotaenium silvae-nigrae* (Rabanus) Kouwets & Coesel (Image 33)

Kouwets & Coesel, 1984, p. 555–562, fig. 23

The cell is cylindrical with broadly rounded ends with a smooth cell wall. The cell is 60–65 µm long and 20–25 µm wide.

Genus: *Closterium* Nitzsch ex Ralfs

25. *Closterium ehrenbergii Meneghinii* var. *Ehrenbergii* (Image 34)

Hirose, H, et al., 1977

The cell body is large and bulged at the centre with a smooth cell wall. The chloroplasts consist of 4–7 laminae with many scattered pyrenoids. The cell body is 250–890 µm long and 50–165 µm wide.

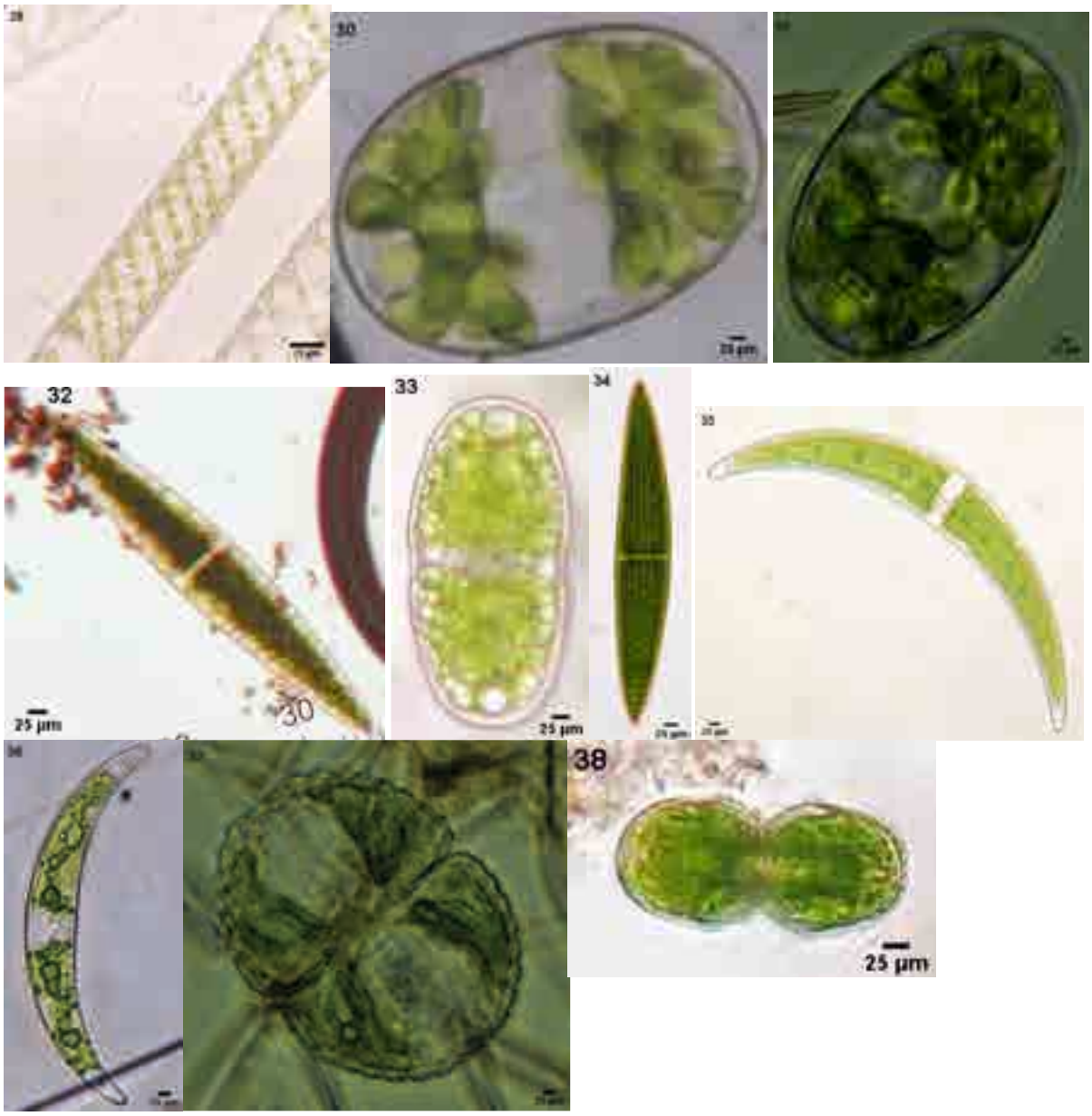

Image 28–38. 28—*Spirogyra novaeangliae* | 30, 31—*Cylindrocystis brebissonii* | 32—*Netrium digitus* | 33—*Actinotaenium silvae-nigrae* | 34—*Closterium ehrenbergii* | 35—*Closterium moniliferum* | 36—*Closterium tumidulum* | 37—*Cosmarium botrytis* | 38—*Cosmarium subtumidum*. (© Joel Jose)

26. *Closterium moniliferum* Ehrenberg ex Ralfs (Image 35)

Prasad & Misra, 1992, p. 113, pl. 12, fig. 4.

The cell is curved with rounded apices. The chloroplast consists of 7–10 pyrenoids arranged in a median series. The cell is 140–155 µm long and 7–20 µm broad.

27. *Closterium tumidulum* Gay (Image 36)

Turner, 1892, p.19, pl.1, fig. 20

The cell is small and curved with an acute tip. The cell is 90–100 µm long and 10–15 µm broad.

Genus: *Cosmarium* Ralfs

28. *Cosmarium botrytis* Meneg (Image 37)

Ralfs, 1848, p.99, pl. 16, fig. 1

The cell has denticulate margins with a deeply constricted linear notch at the centre. The cell is 54.1–77.6 µm long and 40.6–60.6 µm broad.

29. *Cosmarium subtumidum* Nordst (Image 38)

Prescott, 1961, p. 70, pl. 29, figs. 12, 13

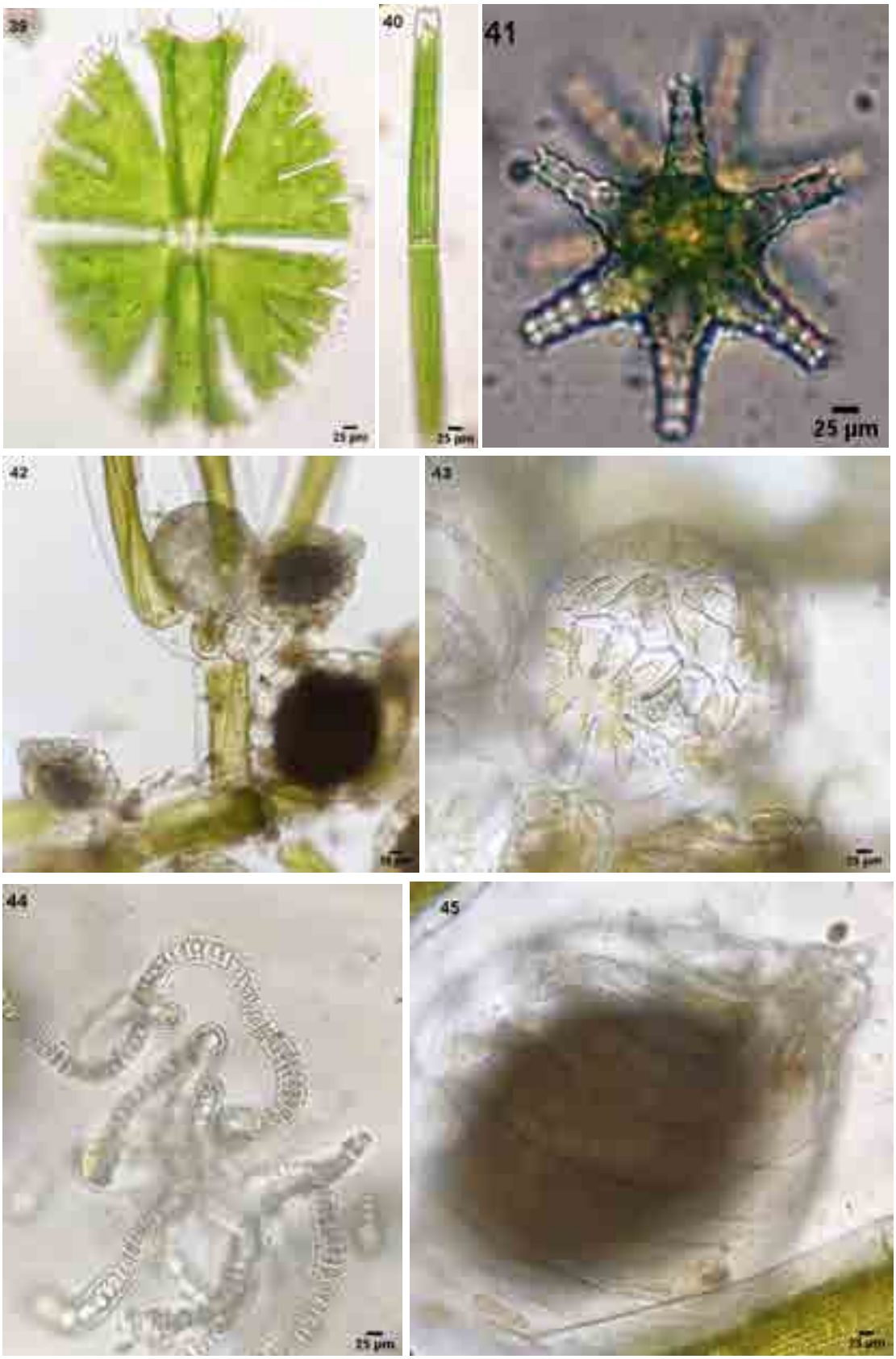

Image 39–45. 39—*Micrasterias radians* var. *bogoriensis* | 40—*Pleurotaenium trabecula* | 41—*Staurastrum zonatum* var. *majus* | 42–45—*Nitella furcata*. (© Joel Jose)

The cell body is 30–43 µm long, 14–19 µm wide and isthmus is 12–14 µm.

Genus: *Micrasterias* C. Agardh

30. *Micrasterias radians* Turn var. *bogoriensis* (Breb) G.S. West (Image 39)

Prescott, 1961, p.51, pl.23, figs. 2, 3

The cell body is 121–206 µm long, 126–170 µm wide and the isthmus is 14–17 µm wide

Genus: *Pleurotaenium* Nageli

31. *Pleurotaenium trabecula* (Ehrbg) Nag (Image 40)

Prescott, 1961, p. 18, pl. 3, fig. 4

The cylindrical cell body is 400–434 µm long and 30–40 µm in diameter. The cell is constricted at the centre, with a slight bulge at the base semi cell. The chloroplast is elongated with 3–4 laminae.

Genus: *Staurastrum* (Meyen) Ralphs

32. *Staurastrum zonatum* Borges var. *majus* Presc. (Image 41)

Prescott, 1961, p.119, pl. 46, fig. 8

The semi cells consist of five long dentate ends with rings of granules and the apex biundulate with some tiny teeth. The cell body is 40–70 µm long, 81–90 µm wide and the isthmus is 13–16 µm.

Order: Charales

Family: Characeae

Genus: *Nitella* C. Agardh

33. *Nitella furcata* (Roxburgh apud Bruzelius) Agardh (Image 42–45)

B.P. Pal et al., 1962, p.62, figs. 76-79

The plant is monoecious. The stem is 600–1,000 µm thick and antheridia is terminal, which is 200–250 µm in diameter. The oogonia are 1–2, together, which are 230–240 µm long and 210–310 µm in diameter. Spiral cells showing 7–8 convolutions and the coronula are 70–100 µm high and 70 µm at the base.

Class: Euglenineae

Order: Euglenales

Family: Astasiaceae

Genus: *Euglena* Ehrenberg

34. *Euglena elastica* Prescott (Image 46)

Prescott, 1962, p. 392, pl.86, figs. 10–12

The cells have the potential to change shape regularly, when in motion. Usually the cells are spindle-shaped but often swollen in the mid-region and slightly tapered to the apices. The cell consists of many irregularly ovoid-shaped chloroplasts. The cell is 10–11 µm in diameter and 80–90 µm long.

35. *Euglena minuta* Prescott (Image 47)

Prescott, 1962, p. 393, pl.85, figs. 23, 25

The cells are highly active, which are fusiform to pyriform in shape. The smooth membraned cell consists of one plate-like chloroplast with a pyrenoid. The cell is 14–16 µm long and 2–6 µm broad.

Genus: *Phacus* Dujardin

36. *Phacus curvicauda* Swirenko (Image 48)

Prescott, 1962, p.399, pl.87, fig. 14, pl.88, fig.21

The cells are ovoid and slightly spiral, which causes the caudus to curve slightly to the left. The cell consists of numerous ovoid chloroplasts. The cell is 40–48 µm in diameter and 48–60 µm long.

37. *Phacus obolus* Pochmann (Image 49)

Wolowski, 1998, p.78, figs. 270–272

The cells are broadly oval and slightly narrower at the anterior end with straight, conical cauda at the posterior end. The cell consists of numerous ovoid-globular chloroplasts. Cells are 34–42 µm long and 22–35 µm broad

38. *Phacus orbicularis* var. *caudatus* Skzortzow (Image 50)

Prescott, 1962, p.401, pl.87, fig. 12, pl.88, fig.15

Cells are ovoid with a long, straight , sharply pointed caudus. 1–2 paramylon bodies are present. Cells are 38–41 µm in diameter and 50–70 µm long.

Genus: *Lepocinclis* Perty

39. *Lepocinclis acus* (Muller) Marin & Melkonian (Image 51)

Wotowski & Hindak, 2005, p. 28, figs. 5–8 The cells are long, elongate, thin and spindle-shaped, gradually tapering to apices which forms a sharp tail. Numerous disc-shaped chloroplasts are present, and two paramylon bodies are present. The cells are 10–12 µm diameter and 150 µm long.

Genus: *Trachelomonas* Ehrenberg

40. *Trachelomonas hispida* var. *papillata* Skvortzow (Image 52)

Prescott, 1962, p. 414, pl. 84, fig. 7

The cell is 25–30 µm in diameter and 35–40 µm long. The wall is brown smooth except for a few minute spines near the flagellum aperture.

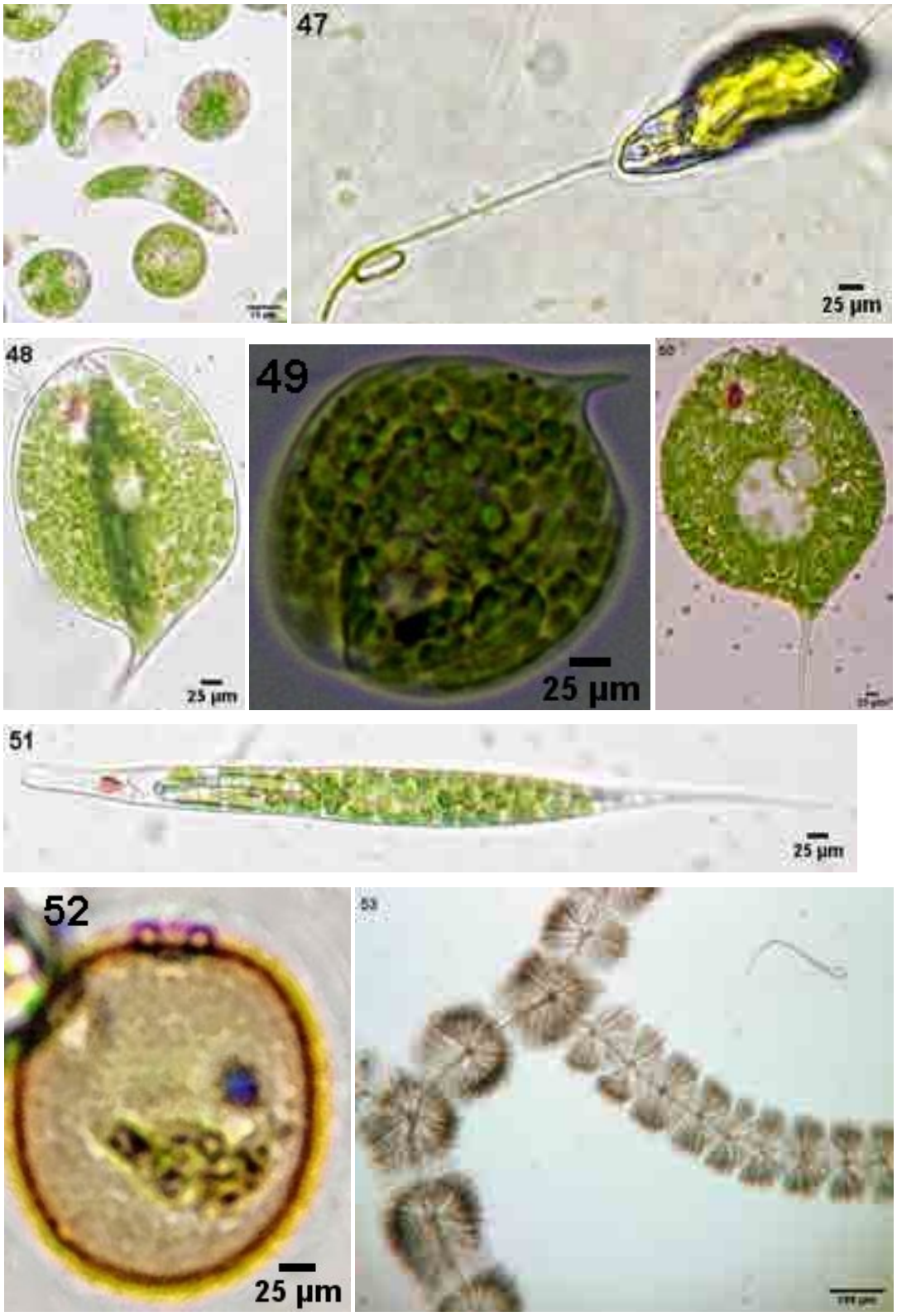

Image 46–53. 46—*Euglena elastica* | 47—*Euglena minuta* | 48—*Phacus curvicauda* | 49—*Phacus obolus* | 50—*Phacus orbicularis* var. *caudatus* | 51—*Lepocinclis acus* | 52—*Trachelomonas hispida* var. *papillata* | 53—*Sheathia boryana*. (© Joel Jose).

Class: Rhodophyceae
Order: Batrachospermales
Family: Batrachospermaceae
Genus: *Batrachospermum* Roth

41. *Sheathia boryana* (Sirodot) Salomaki & M.L.Vis (Image 53; Image 54)

Prescott, 1962, p.567, pl. 136, fig. 4; Sheath & Hymes, 1980, p.1306, figs. 31–36; John & Francis, 2013, p. 237.

The plant is 5–9 cm high and has a highly mucilaginous thallus, which is brown to green. The central axes are 90–105 µm wide, and glomeruli are ellipsoidal to globular. The lateral branches have short internodes. The carpogonia are 4–5 µm wide at the basal portion and 25–30 µm long. The trichogyne are elongate, club-shaped and embrace the carpogonia. The carposporophyte is globular and scattered close to the periphery. The carposporophyte measures 14–150 µm in diameter.

Class: Cyanophyceae
Order: Chroococcales
Family: Chroococcaceae
Genus: *Aphanocapsa* Nag

42. *Aphanocapsa pulchra* (Kutz) Rabenh (Image 55)

T.V. Desikachary, 1959, p.132, pl. 21, fig. 2

The thallus is gelatinous and blue-green. The cells are spherical, loosely arranged in single or sometimes doubles with individual sheaths. The cells are 6–7 µm in diameter.

Genus: *Microcystis* Kutzing

43. *Microcystis aeruginosa* Kutz. (Image 56)

T.V Desikachary, 1959, p. 93, pl. 17, fig. 1, 2, 6

The colonies are free-floating and attaining a macroscopic size with a mucilaginous envelope. The cells in the colony are spherical with distinct hyaline colonial mucilage. The colonies are light brown and round with 5–7 µm in diameter. Gas vacuoles are present.

Order: Nostocales
Family: Microchaetaceae
Genus: *Microchaete* Thuret

44. *Microchaete uberrima* Carter, N (Image 57, 58)

T.V. Desikachary, 1959, p.511, pl. 104, figs. 5-7, 10, 13, 16, 18

The trichomes were long up to 4 mm, with cylindrical cells having a firm sheath. The filaments were 10–15 µm broad with intercalary heterocyst.

Family: Oscillatoriaceae
Genus: *Oscillatoria* Vaucher

45. *Oscillatoria limosa* Agardh ex Gomont (Image 59)

T.V. Desikachary, 1959, p.206, pl. 42, fig.11

The thallus is blue-green with a straight trichome that is slightly constricted. The trichomes are 12–13 µm broad and 2–4 µm long.

46. *Oscillatoria subbrevis* Schmidle (Image 60, 61)

T. V. Desikachary, 1959, p.207, pl. 37, fig. 2, pl. 40, fig. 1

The trichomes are single, straight and not attenuated with round cell, calyptra absent. The trichome is 5–6 µm broad, and the cells are 3–4 µm long. The trichomes are blue-green, and they exhibit an oscillating movement at the apex.

47. *Oscillatoria vizagapattensis* Rao, C.B. (Image 62)

T.V. Desikachary, 1959, p.205, pl. 39, figs. 16, 18.

The cells are much shorter than the broad and form a broadly rounded cap with a slightly thickened outer wall. The trichome is blue-green in colour and 8–10 µm broad.

Genus: *Phormidium* Kutz.

48. *Phormidium abronema* Skuja (Image 64)

T.V. Desikachary, 1959, p.257.

The thallus is blackish-green to light bluish. The trichomes consist of the hyaline mucilaginous sheath. The cells are cylindrical or barrel-shaped. The trichome is 3–4 µm broad and 16–17 µm long.

49. *Phormidium hansgirgi* Schmidle (Image 63; Image 65)

T.V. Desikachary, 1959, p.272, pl. 43, fig. 20

The filaments are straight with a very thin mucilaginous sheath. The trichomes are cylindrical and not capitate. The hormogones are short. The trichomes are 12–14 µm broad and 2–3 µm long.

50. *Phormidium microtomum* Skuja (Image 66)

T.V. Desikachary, 1959, p.257, pl. 43, fig. 16, 17

The trichomes are greyish-brown, straight with a thin colourless sheath. The ends of trichomes are attenuated, and cells are well constricted at the cross wall. The trichome is 6–8 µm broad with apical rounded hyaline calyptra.

51. *Phormidium molle* (Kutz.) Gomont (Image 67)

T.V. Desikachary, 1959, p.255, pl. 59, fig. 8

The trichomes are thin, straight, constricted at

cross walls and not attenuated at the ends. The cells are quadrate or barrel-shaped with rounded ends and calyptra absent. The trichome is 2–3 µm broad and 8–7 µm long.

52. *Phormidium retzii* (Ag.) Gomont (Image 68)

T.V. Desikachary, 1959, p.268, pl. 44, figs. 13-15

The filaments are straight with a thin mucilaginous sheath. The trichomes are blue-green with a thin sheath. The ends are not attenuated and not capitate. The trichomes are 11–13 µm broad and 8–10 µm long.

53. *Phormidium truncicola* Ghose (Image 70)

T.V. Desikachary, 1959, p.258, pl. 59, fig. 9

The trichomes consist of thin membrane and are constricted at cross walls. The calyptra is absent. The trichomes are 6–8 µm broad and 2–3 µm long.

54. *Phormidium usterii* Schmidle (Image 69)

T.V. Desikachary, 1959, p.257.

Trichomes with thin mucilaginous sheath. The cells are shorter than broad with short rectangular cells with broadly round ends. The trichome is 3–4 µm broad and 5–6 µm long.

Family: Nostocaceae

Genus: *Anabaena* Bory de Bornet & Flahault

55. *Anabaena anomala* Fritsch (Image 71)

T.V. Desikachary, 1959, p.398, pl. 73, fig. 2

The thallus is thin and gelatinous. The cells are spherical, and apical cells are rounded. The trichome is blue-green, consisting of densely or irregularly aggregated rounded cells. The cell is 2–5 µm in diameter.

56. *Anabaena sphaerica* Bornet et Flahault (Image 72)

T.V. Desikachary, 1959, p.393, pl. 71, fig. 8

Gelatinous thin sheath present, Trichomes are pale blue-green in colour. Cells are barrel-shaped and 2–7 µm long. End cells are rounded. Heterocysts are 9–11 µm broad and 13–17 µm long with a smooth yellow outer wall.

Genus: *Cylindrospermum* Kutz

57. *Cylindrospermum stagnale* (Kutz.) Born.et Flah (Image 73, 74)

T.V. Desikachary, 1959, p.363, pl. 65, fig. 9

The thallus is blue-green with a mucilaginous sheath. The cells are constricted at the cross wall and nearly quadrant to cylindrical with spherical or oblong heterocyst. The trichomes are cylindrical and 2–5 µm broad.

Family: Rivulariaceae

Genus: *Gloeotrichia* Ag.

58. *Gloeotrichia echinulata* (J. E. Smith) P. Richter (Image 75, 76)

Prescott, 1962, p.557, pl. 134, figs. 1,2

The colonies are tiny macroscopic and opaque at the centre and translucent at the periphery. The colonies are free-floating, spherical and covered in a gelatinous sheath. The trichomes radiate from a common centre and are tapered from basal heterocyst to a fine hair-like end. The cells are cylindrical to barrel-shaped 6–9 µm wide, and the cells are joined end to end to form long chains.

Genus: *Scytonema* Ag.

59. *Scytonema ocellatum Lyngbye ex Born. et Flah* (Image 77)

T.V Desikachary, 1959, p.467, pl.92, fig.3

The thallus is cushion-like, brownish to reddish with false branching. The trichomes are covered in a firm mucilaginous sheath. The filaments are 11–15 µm broad.

60. *Scytonema rivulare Borzi ex Born. et Flah* (Image 78)

T.V Desikachary, 1959, p.452, pl.100, fig.2

The thallus is broad, with a thick mucilaginous sheath. The thallus is brownish to reddish with false branching. The cells are shorter than broad and 30 µm broad.

Order: Stigonematales

Family: Nostochopsidaceae

Genus: *Nostochopsis* Wood em. Geitler

61. *Nostochopsis lobatus Wood em. Geitler* (Image 79; Image 80, 81)

T.V. Desikachary, 1959, p.570, pl. 120, figs. 1-8

The thallus is irregularly lobed, blue-green with a thick mucilaginous matrix. The cells are barrel-shaped. The heterocyst are mostly lateral, spherical to ellipsoidal. The trichomes are 5–9 µm wide and 6–10 µm long.

DISCUSSION

The freshwater ecosystem holds the most biodiversity among all other ecosystem. The study of freshwater habitat is significant as it occupies only 0.5% of the earth surface, but is equally crucial because they are the cheapest natural source for domestic and industrial purposes (Norton et al. 1996).

The present study portraits the algal diversity of CWS. In our study, Chlorophyceae and Cyanophyceae

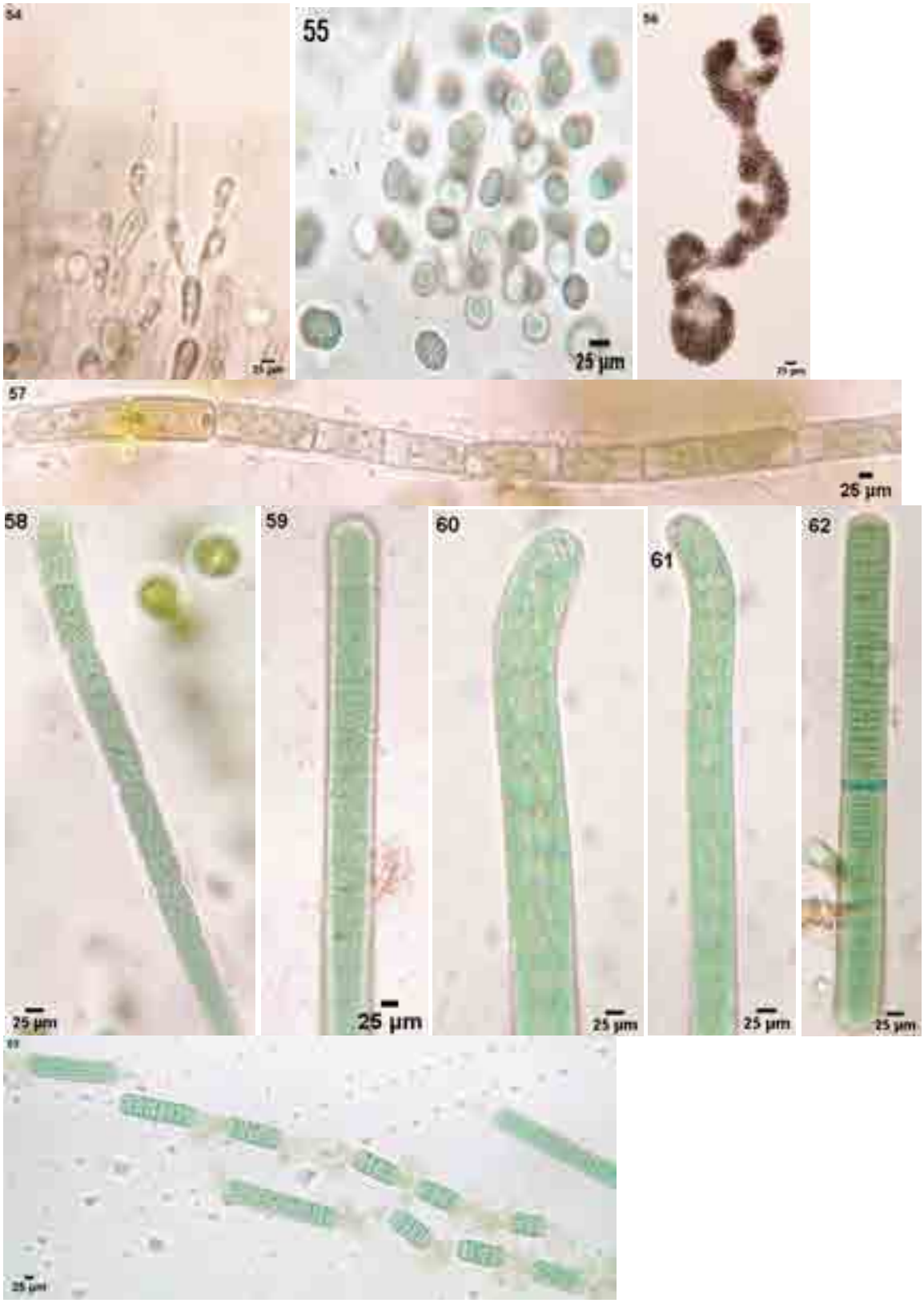

Image 54–63. 54—*Sheathia boryana* | 55—*Aphanocapsa pulchra* | 56—*Microcystis aeruginosa* | 57, 58—*Microchaete uberrima* | 59—*Oscillatoria limosa* | 60, 61—*Oscillatoria subbrevis* | 62—*Oscillatoria vizagapattensis* | 63—*Phormidium hansgirgi*. (© Joel Jose)

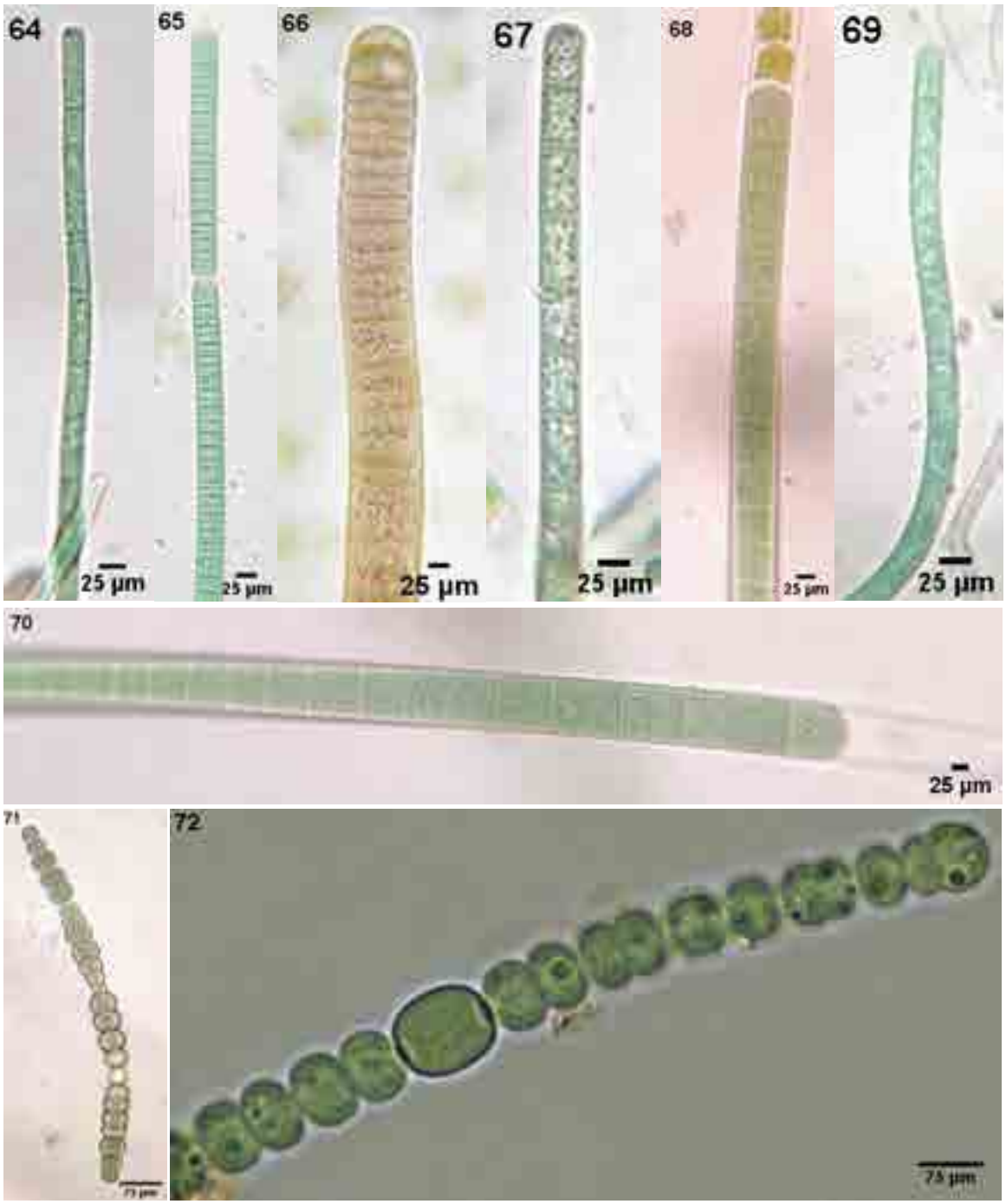

Image 64–72. 64—*Phormidium abronema* | 65—*Phormidium hansgirgi* | 66—*Phormidium microtomum* | 67—*Phormidium molle* | 68—*Phormidium retzii* | 69—*Phormidium usterii* | 70—*Phormidium truncicola* | 71—*Anabaena anomala* | 72—*Anabaena sphaerica*. (© Joel Jose)

algae were dominant. The preliminary study conducted in Kannam River, Kannur, Kerala for the diversity of algae has reported 40 algal species of which Chlorophyceae was dominant, followed by Cyanophycea (Girish et al. 2018). The algal population of Pennar River, Kottayam, has reported 61 algal species were Chlorophyceae was dominant (Joseph & Claramma 2010). In our study also, more algae were reported from the order Zygnematales, and *Spirogyra* was the most common genus. The algal species from order Nostocales of Cyanophyceae was dominant. A similar type of diversity was observed in the Gundur lake of Tamil Nadu. Out of 87 algal species reported from Gundur Lake, 37 species were Cyanophyta (Vijayan et al. 2014). The algae from Chlorophyceae and

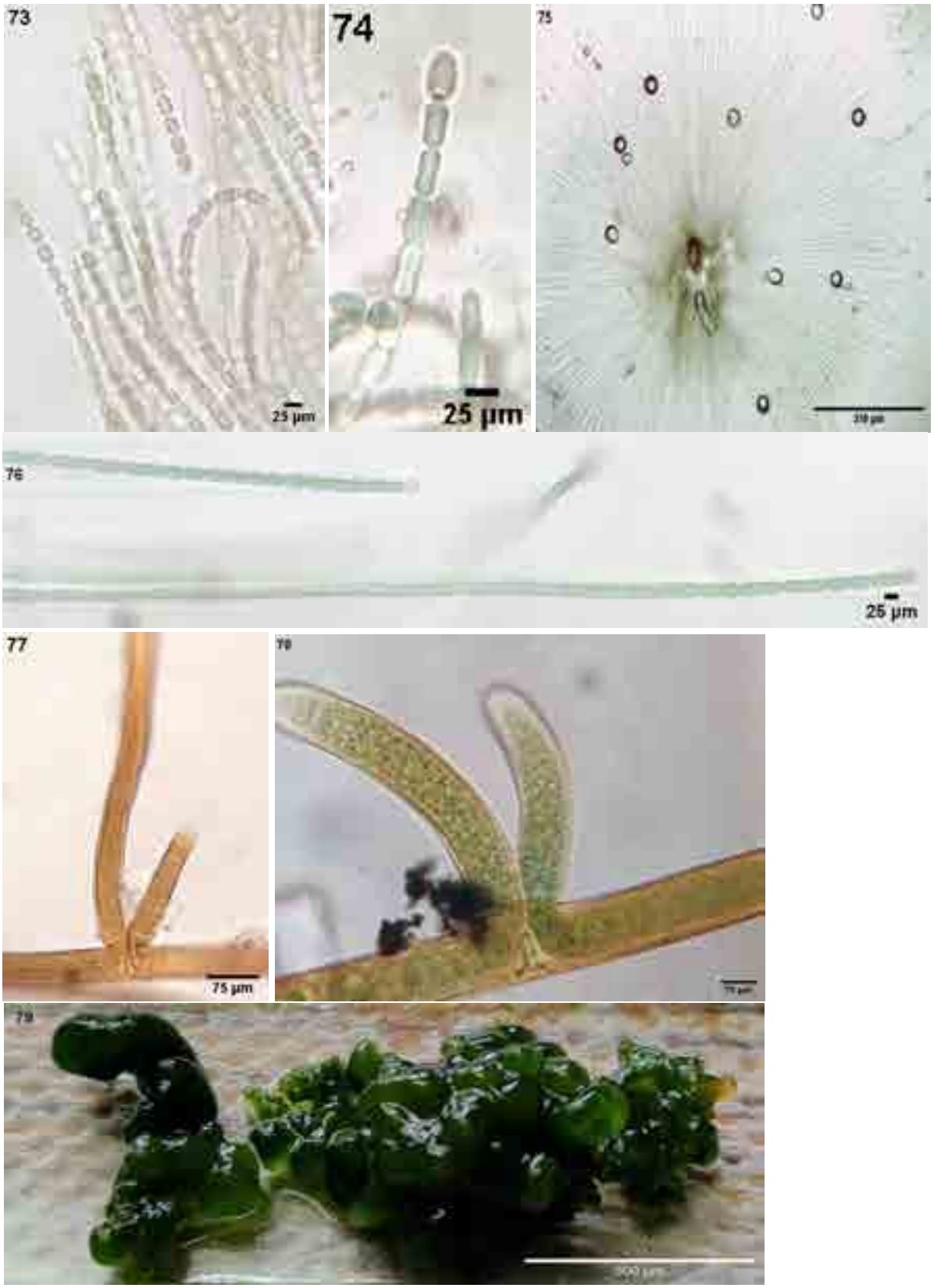

Image 73–79. 73, 74—*Cylindrospermum stagnale* | 75, 76—*Gloeotrichia echinulata* | 77—*Scytonema ocellatum* | 78—*Scytonema rivulare* | 79—*Nostochopsis lobatus*. (© Joel Jose)

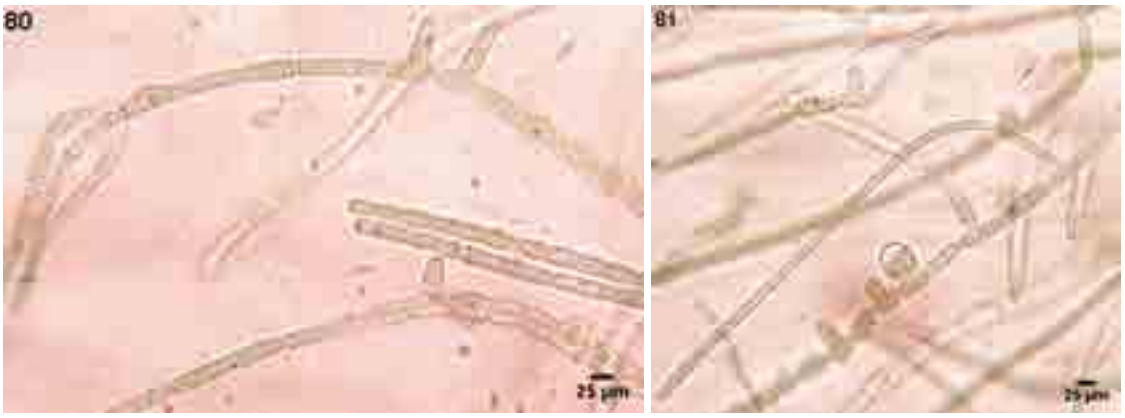

Image 80–81. 80, 81—*Nostochopsis lobatus*. (© Joel Jose)

Cyanophyceae were dominant in species composition compared to other classes.

CONCLUSION

Overall, the biodiversity study conducted in Chimmony Wildlife Sanctuary shows a good presence of algae. The study also revealed that *Spirogyra* was dominant from Chlorophyceae, *Phacus* was dominant from Euglenineae, and *Phormidium* was dominant from Cyanophyceae. The algal diversity directly depends on season and the physicochemical parameters of the freshwater ecosystem. Therefore, extensive seasonal studies are required for acquiring more knowledge about algal diversity.

REFERENCES

Briji, G. (2005). Relevance and policy dimensions of research on biodiversity in freshwater ecosystems: a developing country perspective. *Hydrobiologia* 542(2): 19–21. https://doi.org/10.1007/s10750-005-0890-1

De Clerck, O., M.D. Guiry, F. Leliaert, Y. Samyn & H. Verbruggen. (2013). Algal Taxonomy: A Road to Nowhere? *Journal of Phycology* 49(2): 215–225. https://doi.org/10.1111/jpy.12020

Desikachary, T.V. (1959). *Cyanophyta*. Indian Council of Agricultural Research, New Delhi, 686 pp.

Girish, K.E., K.V. Thanzeeha, K. Sasikala, G. Pradeepkumar, K.K. Sivadasan & J.V. Abdul (2018). A preliminary study on the diversity of planktonic algae of Kaanam river, Kannur, Kerala, India. *Phykos* 48(2): 13–16.

George, V.J. (2012). Management Plan Chimmony Wildlife Sanctuary. Kerala Forest Department, 107 pp.

Hindak, F. (1977). Studies on the Chlorococcal Algae (Chlorophyceae) - I. Veda Publishing house of the Slovak Academy of Sciences, Bratislava, 190 pp.

Hindak, F. (1984). Studies on the Chlorococcal Algae (Chlorophyceae) - III. Veda Publishing house of the Slovak Academy of Sciences, Bratislava, 299 pp.

Hirose, H., K. Akiyama, K. Ioriya, H. Imahori, S. Kasaki, H. Kumano, Kobayashi, E. Takahashi, K. Tsumura, M. Hirano & T. Yamagishi (1977). *Illustration of the Japanese freshwater algae*. Uohida Rokakauho, Tokyo, Japan, 933 pp.

John, J. & M.S. Francis (2013). An Illustrated algal flora of Kerala, vol. I – Idukki district. Green Carmel Scientific Books, Cochin, 279 pp.

Joseph, P.V & J. Claramma (2010). Bacterial, fungal and algal population of Pennar river: a fresh water wet land in Kottayam district, Kerala. *Asian Journal of Chemistry* 22(6): 4286–4290.

Koen, M. & H. Segers (2005). Taxonomy and systematics in biodiversity research. *Hydrobiologia* 542 (4):27–31. https://doi.org/10.1007/s10750-005-0892-z

Kouwets, F.A.C. & P.F.M. Coesel (1984). Taxonomic revision of the Conjugatophycean family Peniaceae on the basis of cell wall ultrastructure. *Journal of Phycology* 20(4): 555–562. https://doi.org/10.1111/j.0022-3646.1984.00555.x

Norton, T.A., M. Melkonian & R.A. Andersen (1996). Algal biodiversity. *Phycologia* 35(4): 308–326. https://doi.org/10.2216/i0031-8884-35-4-308.1

Pal, B.P. & B.C. Kundu (1962). *Charophyta*. Indian Council of Agricultural Research, New Delhi, 130 pp.

Pandey, A.K. (1995). Conservation of biodiversity: Present status and future strategy, pp. 44–51. In: Pandey, A.K. (eds.). *Taxonomy and Biodiversity*. CBS Publishers and distributors, New Delhi, 232 pp.

Philipose, M.T. (1967). *Chlorococcales*. Indian Council of Agricultural Research, New Delhi, 365 pp.

Prasad, B.N. & P.K. Misra (1992). *Fresh water algal flora of Andaman & Nicobar Islands. Vol. II*. Bishen Singh Mahindhra Pal Singh, Dehra Dun, 284 pp.

Prescott, G.W. (1961). *Algae of the Western Great Lakes Area*. Cranbrook Institute of Science, New York, 977 pp.

Rai, L.C., D.K Har, H.M. Frieder & J.S. Carl (2000). Services of algae to the environment. *Journal of Microbiology and Biotechnology* 10(1): 36–119.

Ralfs, J. (1848). *The British Desmidieae*. The drawings by Edward Jenner. Benham & Reeve, London, 266 pp.

Ramanathan, K.R. (1964). *Ulotrichales*. Indian Council of Agricultural Research, New Delhi, 188 pp.

Randhawa, M.S. (1959). *Zygnemaceae*. Indian Council of Agricultural Research, New Delhi, 478 pp.

Sheath, R.G. & B.J. Hymes (1980). A preliminary investigation of the freshwater red algae in streams of southern Ontario, Canada. *Canadian Journal of Botany* 58: 1295–1318. https://doi.org/10.1139/b80-161

Tessy, P.P. & R. Sreekumar (2017). Seasonal and spatial distribution of freshwater diatoms from Thrissur Kole lands (part of Vembanad - Kol , Ramsar site), Kerala. *Phykos* 47(2): 129–134.

Turner, W.B. (1892). The fresh water algae (principally Desmidieae)

of East India. *Kongl. Svenska Vetenskaps–Akademiens Handlingar* 25(5): 1–187.

Velayudhan, A., A. Mohanarangan, G. Chandy & S. Biju (2021). Does the size of the butterfly enhance detection? Factors influencing butterfly detection in species inventory surveys. *Journal of Threatened Taxa* 13(3): 17950–17962. https://doi.org/10.11609/jott.6596.13.3.17950-17962

Vijayan, D., K. Manivannam, S. Santhoshkumar, D. Pandiaraj, M.M. Imran, N. Thajuddin, K. Kala & M.H.M. Ilyas (2014). Depiction of Microalgal Diversity in Gundur Lake, Tiruchirappalli District, Tamil Nadu, South India. *Asian Journal of Biological Sciences* 7(3): 111–121. https://doi.org/10.3923/ajbs.2014.111.121

West, W. & G.S. West (1904). *A Monograph of the British Desmidiaceae*. The Ray Society, London, 311 pp.

Wolowski, K. (1998). *Taxonomic and environmental studies on Euglenophytes of the Krakow- Czestochowa upland (South Poland)*. Polish Academy of Sciences, Krakow, 192 pp.

Wotowski, K. & F. Hindak (2005). Atlas of Euglenophytes. VEDA, Publishing House of the Slovak Academy of Sciences, Czechia, 136 pp.

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REVIEW

A checklist of herpetofauna of Telangana state, India

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Abstract: A checklist of herpetofauna of Telangana, India including accepted English name, scientific name along with authority, Telugu and vernacular name, IUCN, Indian Wildlife Protection Act and CITES status, and endemicity is presented in this paper. The herpetofauna diversity of Telangana is represented by 98 species including 16 species of amphibians belonging to four families, one species of crocodile, six species of testudines, 35 species of saurians and 40 species of snakes. Three species—*Hemidactylus flavicaudus*, *H. xericolus*, and *H. aemulus*—are endemic to Telangana.

Keywords: Amphibia, Crocodylia, Ophidia, Reptilia, Sauria, Squamata, Testudines.

తెలంగాణ రాష్ట్రంలో ఉన్న 98 జాతులు ఉభయచరాలు మరియు సరీసృపాల జాబితా ఈ పేపర్‌లో అందించబడింది. వేరొక జాతి యొక్క సాంకేతిక పేరు, పేరు రచయిత, మొదటి వివరణ సంవత్సరం, ఆంగ్ల పేరు, తెలుగు పేరు, IUCN వర్గం, భారతీయ వన్యప్రాణి (సంరక్షణ) చట్టం, 1972 వర్గం, CITES వర్గం మరియు స్థానికత ఇందులో అందించబడింది. ఈ వైపిధ్యంలో నాలుగు కుటుంబాలకు చెందిన 16 రకాల ఉభయచరాలు, ఒక జాతి మొసలి, ఆరు రకాల తాబేళ్లు, 35 రకాల బల్లులు మరియు 40 రకాల పాములు ఉన్నాయి. హెమిడాక్టిలస్ ఫ్లావికాడస్, హెమిడాక్టిలస్ జెరికోలస్ మరియు హెమిడాక్టిలస్ ఎములస్ అనే మూడు జాతులు బల్లులు తెలంగాణ రాష్ట్రంలో మాత్రమే కనిపిస్తాయి.

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INTRODUCTION

The herpetofaunal diversity of Telangana is in the process of being documented (Khartade et al. 2019; Dinesh et al. 2021; Narayana & Bharat 2021) and due to unavailability of a comprehensive database many doubtful species are finding place in various checklists being published from time to time. Through this short communication we aim to provide a checklist of amphibian and reptilian species currently known from Telangana published literature and personal observations.

Telangana State (15.835–19.917 ^{O}N, 77.238–81.307 ^{O}E; 150–900 m), located in the Deccan Plateau in the south central part of peninsular India, was part of the erstwhile united Andhra Pradesh (1956–2014). Before that it contributed to the major land area of the Hyderabad State (1948–1956) and the state of Hyderabad (1724–1948). It encompasses an area of 1,22,077 km^2. Two major rivers, Godavari and Krishna, along with their major and minor tributaries flow through the state (Prasad & Srinivasulu 2021).

Earlier known works on amphibians and reptiles of the region roughly corresponding to present day Telangana State include the historical works that documented list of herpetofauna in Madras Presidency, Bombay Presidency, and Central Provinces. Stoliczka (1871, 1872) described a species of leaf-toed gecko based on specimens collected by W.T. Blanford from Godavari River basin near Bhadrachalam (in erstwhile Madras Presidency).

Predominant works in Telangana region of erstwhile united 'Andhra Pradesh' include that of Sharma (1969, 1971), Sanyal et al. (1993), Sarkar et al. (1993), Chanda (2002), Srinivasulu (2003), Srinivasulu & Srinivasulu (2010, 2012a,b, 2013a,b), Rao et al. (2005), Srinivasulu et al. (2006, 2009, 2011), Srinivasulu & Das (2008), Seetharamaraju et al. (2008, 2011), Mahony (2009), Datta-Roy et al. (2012), Seetharamaraju & Srinivasulu (2013), and Narayana et al. (2014).

Other works published after the formation of Telangana State include those of Srinivasulu et al. (2014, 2016), Visvanathan (2015), Seetharamaraju (2015), Kumar & Srinivasulu (2015), Kumar et al. (2015, 2017a,b, 2022), Visvanathan et al. (2017), Srinivasulu (2017), Mirza et al. (2017), Narayana et al. (2017, 2018), Kumar (2018), Mohan et al. (2018), Prasad et al. (2018), Anne & Visvanathan (2018), Seetharamaraju et al. (2019), Ganesh et al. (2020), Lajmi et al. (2020), Narayana & Sandeep (2021), and Choure et al. (2021).

Four species of geckoes—*Hemidactylus treutleri* Mahony, 2009; *H. flavicaudus* Lajmi et al., 2020; *H. xericolus* Lajmi et al., 2020; and *H. aemulus* Kumar et al., 2022—were described from Telangana. Mahony (2009) described Treutler's Gecko *H. treutleri* based on type specimens collected from Golconda fort, Hyderabad; Lajmi et al. (2020) described *H. flavicaudus* and *H. xericolus* based on types collected from Guddeguda, Mahbubnagar district, and Marriguda, Nalgonda district, respectively; while Kumar et al. (2022) described *H. aemulus* from Chandanapalli and Chaya Someshwara Temple, Nalgonda District.

In recent years, attempts to document the herpetofauna diversity of Telangana were done by Khartade et al. (2019), Dinesh et al. (2021), and Narayana & Bharath (2021). The present work updates the information on taxonomy and reports species missed in the earlier literature.

METHODS

For the present checklist, we researched and critically analysed all published (both peer-reviewed and non-peer-reviewed) literature, online databases (including iNaturalist, India Biodiversity Portal, HerpMapper) and also relied on field surveys conducted since 1995 in various parts of Telangana State (Srinivasulu 2003; Srinivasulu et al. 2006, 2009, 2011, 2014, 2016; Seetharamaraju et al. 2008, 2011, 2019; Srinivasulu & Das 2008; Srinivasulu & Srinivasulu 2010; Seetharamaraju & Srinivasulu 2013; Kumar & Srinivasulu 2015; Kumar et al. 2015, 2017a,b; Seetharamaraju 2015; Kumar 2018). We confirmed the species identities by consulting standard references (Daniel 2002; Das 2002; Whitaker & Captain 2004), incorporating further updates by more recent literature (Deepak et al. 2016, 2018, 2021; Lajmi et al. 2016; Ganesh et al. 2017; Mirza & Patel 2018; Pal et al. 2018; Mallik et al. 2020, 2021; Bisht et al. 2021; Gowande et al. 2021; Bandara et al. 2022). We have also provided explanation for deletion of the taxa earlier reported in literature, and appeal to future workers to collect voucher specimens or photographs to report additions to the herpetofauna diversity of Telangana.

RESULTS AND DISCUSSION

In this checklist, 98 species of herpetofauna including 17 species of amphibians and 81 species of reptiles are listed (Table 1; Images 1 to 72) as being present in Telangana. The amphibian diversity is represented by

Table 1. Checklist of herpetofauna of Telangana State, India.

	English name	Species	Authority	Telugu name	Vernacular name	IUCN	IWPA	CITES
I. Order Anura								
1. Family Bufonidae								
1	Asian Common Toad	*Duttaphrynus melanostictus*	(Schneider, 1799)	సామాన్య కప్ప	Samanya Kappa	LC	-	-
2	Schneider's Toad[1]	*Duttaphrynus scaber* [IN,SL]	(Schneider, 1799)	స్నేకనైడర్స కప్ప	Schneiders Kappa	LC	-	-
3	Deccan Toad	*Duttaphrynus peninsularis*	(Rao, 1920)	పాలరాతి కప్ప	Palarati Kappa	LC	-	-
4	Günther's Toad[2]	*Duttaphrynus hololius* [PI]	(Günther, 1876)	గుంతర్స కప్ప	Gunthers Kappa	DD	-	-
2. Family Dicroglossidae								
5	Indian Skipper Frog	*Euphlyctis cyanophlyctis*	(Schneider, 1799)	చీరుమ కప్ప	Cheruvu Kappa	NE	-	-
6	Orissa Cricket Frog[3]	*Fejervarya orissaensis* [SA]	(Dutta, 1997)	ఒడిషా వరి నేను కప్ప	Odisha Vari Senu Kappa	LC	-	-
7	Common Indian Cricket Frog	*Minervarya agricola* [SA]	(Jerdon, 1853)	సామాన్య క్రికెట్ కప్ప	Samanya Cricket Kappa	LC	-	-
8	Jerdon's Bullfrog	*Hoplobatrachus crassus* [SA]	(Jerdon, 1854)	జరడన్స కప్ప	Jerdon's Kappa	LC	Sch. IV	-
9	Indian Bullfrog	*Hoplobatrachus tigerinus* [SA]	(Daudin, 1803)	గందరు కప్ప	Gandru Kappa	LC	Sch. IV	App. II
10	Indian Burrowing Frog	*Sphaerotheca breviceps* [SA]	(Schneider, 1799)	బొరయలు కప్ప	Boriyalu Kappa	LC	-	-
3. Family Microhylidae								
11	Ornate Narrow-mouth Frog	*Microhyla ornata* [SA]	(Duméril & Bibron, 1841)	అలంకృత చిన్న కప్ప	Alankrita Chinna Kappa	LC	-	-
12	Red Narrow-mouth Frog	*Microhyla rubra* [IN]	(Jerdon, 1854)	ఏరుపు చిన్న కప్ప	Erupu Chinna Kappa	LC	-	-
13	Sri Lankan Painted Frog	*Uperodon taprobanicus* [SA]	(Parker, 1934)	చితీరించిన గలిబుడుగా కప్ప	Chitrinchina Galibuduga Kappa	LC	-	-
14	Variegated Ramanella	*Uperodon variegatus* [SA]	(Stoliczka, 1872)	రంగురంగుల గలిబుడుగా కప్ప	Rangurangula Galibuduga Kappa	LC	-	-
15	Indian Balloon Frog	*Uperodon globulosus* [SA]	(Günther, 1864)	సామాన్య గలిబుడుగా కప్ప	Samanya Galibuduga Kappa	LC	-	-
16	Marbled Balloon Frog	*Uperodon systoma* [SA]	(Schneider, 1799)	పాలరాతి గలిబుడుగా కప్ప	Palarati Galibuduga Kappa	LC	-	-
4. Family Rhacophoridae								
17	Indian Tree Frog	*Polypedates maculatus* [SA]	(Gray, 1830)	సున్నం కప్ప	Sunnam Kappa	LC	-	-
II. Order Crocodylia								
1. Family Crocodylidae								
18	Mugger Crocodile	*Crocodylus palustris*	Lesson, 1831	మొసలి	Mosali	VU	Sch. I (Part II)	App. I
III. Order Testudines								
1. Family Testudinidae								
19	Indian Star Tortoise	*Geochelone elegans* [IN,SL]	(Schoepff, 1795)	నక్షత్ర తాబేలు	Nakshatra Tabelu	VU	Sch. IV	App. I
2. Family Geomydidae								
20	Indian Tent Turtle	*Pangshura tentoria* [BD,IN]	(Gray, 1834)	సామాన్య డేరా తాబేలు	Samanya Dera Tabelu	LC	Sch. IV	App. II

	English name	Species	Authority	Telugu name	Vernacular name	IUCN	IWPA	CITES
21	Indian Black Turtle	*Melanochelys trijuga*	(Schweigger, 1812)	నియే తాబేలు	Nuiye Tabelu	NT	Sch. IV	App. II
3. Family Trionychidae								
22	Indian Flap-shelled Turtle	*Lissemys punctata* [SA]	(Bonnaterre, 1789)	రెక్క□పిచ్చ తాబేలు	Rekka-chippa Tabelu	LC	Sch. I (Part II)	App. II
23	Ganges Soft-shelled Turtle[4]	*Nilssonia gangetica* [BD,IN,PK]	(Cuvier, 1825)	గంగమ్మ మెత్తని□పిచ్చ తాబేలు	Gangamma Mettani-chippa Tabelu	VU	Sch. I (Part II)	App. I
24	Leith's Soft-shelled Turtle[5]	*Nilssonia leithii* [IN]	(Gray, 1872)	లేతన్ మెత్తని□పిచ్చ తాబేలు	Leiths Mettani-chippa Tabelu	VU	Sch. IV	App. II
IV. Order Squamata								
Sauria (Lacertilia)								
1. Family Agamidae								
25	Forest Calotes[6]	*Monilesaurus* cf. *rouxii* [IN]	Dumeril & Bibron, 1837	అడవి తొండ	Adavi Thonda	LC	-	-
26	Common Garden Lizard	*Calotes vultuosus*	(Harlan, 1825)	సామాన్య తొండ	Samanya Thonda	NE	-	-
27	Blanford's Rock Agama	*Psammophilus blanfordanus* [IN]	(Stoliczka, 1871)	చిన్న బోలీస్ తొండ	Chinna Polees Thonda	LC	-	-
28	Peninsular Rock Agama	*Psammophilus dorsalis* [PI]	(Gray, 1831)	బోలీస్ తొండ	Polees Thonda	LC	-	-
29	Spiny-headed Fan-throated Lizard	*Sitana spinaecephalus* [IN]	Deepak, Vyas & Giri, 2016	సీతమ్మ తొండ	Sitamma Thonda	NE	-	-
30	Nagarjunasagar Fan-throated Lizard[7]	*Sitana thondalu* [AP,TS]	Deepak, Khandekar, Chaitanya & Karanth, 2018	నాగార్జునసాగర్ తొండ	Nagarjunasagar Thonda	NE		
2. Family Chamaeleonidae								
31	Indian Chameleon	*Chamaeleo zeylanicus* [IN, SL]	Laurenti, 1768	ఊసరవల్లి	Ursaravalli	LC	Sch. II (Part I)	App. II
3. Family Gekkonidae								
32	Emulous leaf-toed gecko	*Hemidactylus aemulus* [TS]	Kumar, Srinivasulu & Srinivasulu, 2022	ఏములున్ రాతి బల్లి	Emulus Rathi Balli	NE	-	-
33	Mahbubnagar Yellow-tailed Brookish Gecko	*Hemidactylus flavicaudus* [TS]	Lajmi, Giri, Singh & Agarwal, 2020	మహబూబ్‌నగర్ పశుపుతోకగల బల్లి	Mahbubnagar Pasuputhokagala Balli	NE	-	-
34	Yellow-bellied House Gecko	*Hemidactylus flaviviridis*	Rüppell, 1835	పసుపురంగు ఇంటి బల్లి	Pasupurangu Inti Balli	NE	-	-
35	Common House Gecko	*Hemidactylus frenatus*	Duméril & Bibron, 1836	సామాన్య ఇంటి బల్లి	Samanya Inti Balli	LC	-	-
36	Giant Leaf-toed Gecko	*Hemidactylus giganteus* [PI]	Stoliczka, 1871	పెద్ద రాతి బల్లి	Pedda Rathi Balli	LC	-	-
37	Gleadow's House Gecko	*Hemidactylus* cf. *gleadowi* [IN,PK]	Murray, 1884	గలేడోన్ బల్లి	Gleadows Balli	NE	-	-
38	Graceful Leaf-toed Gecko	*Hemidactylus gracilis* [IN]	Blanford, 1870	అందమైయాన బల్లి	Andamaiyana Balli	LC	-	-
39	Kanger Valley Rock Gecko[8]	*Hemidactylus kangerensis* [CG,TS]	Mirza, Bhosale & Patil, 2017	కాంగెర్ లోయ బల్లి	Kanger Loya Balli	NE	-	-
40	Leschenault's Leaf-toed Gecko	*Hemidactylus leschenaultii*	Duméril & Bibron, 1836	లేసేనాలటస్ బల్లి	Leschenaults Balli	NE	-	-
41	Murray's House Gecko	*Hemidactylus murrayi*	Gleadow, 1887	ముర్రేస్ బల్లి	Murrays Balli	NE	-	-
42	Spotted House Gecko	*Hemidactylus parvimaculatus*	Deraniyagala, 1953	చుక్కల బల్లి	Chukala Balli	NE	-	-
43	Reticulated Leaf-toed Gecko[9]	*Hemidactylus reticulatus* [PI]	Beddome, 1870	సన్న□చారల బల్లి	Sana-Charala Balli	LC	-	-
44	Saxatile Leaf-toed Gecko	*Hemidactylus saxicolus* [TS,KAR]	Kumar, Srinivasulu & Srinivasulu, 2022	నాకేషాటయిల్ రాతి బల్లి	Saxatile Rathi Balli	NE	-	-

	English name	Species	Authority	Telugu name	Vernacular name	IUCN	IWPA	CITES
45	Treutler's Gecko	*Hemidactylus treutleri* [PI]	Mahony, 2009	తీరుతలరీస బల్లి	Treutlers Balli	LC	-	-
46	Termite Hill Gecko	*Hemidactylus triedrus* [IN,PK,SL]	(Daudin, 1802)	చెడ్డలపుట్ట బల్లి	Chedalaputta Balli	NE	-	-
47	Nalgonda Yellow-tailed Brookish Gecko	*Hemidactylus xericolus* [TS]	Lajmi, Giri, Singh & Agarwal, 2020	నాలగొండ పశుపుతోకగల బల్లి	Nalgonda Pasuputhokagala Balli	NE		
4. Family Lacertidae								
48	Leschenault's Snake-eyed Lizard	*Ophisops leschenaultii* [IN,SL]	(Milne-Edwards, 1829)	లేనేనాలటన్ పాము□కనులా బల్లి	Leschenaults Pamu-kanula Balli	LC	-	-
49	Jerdon's Snake-eye Lizard[10]	*Ophisops jerdonii* [AF,IN,PK]	Blyth, 1853	జరడన్స పాము□కనులా బల్లి	Jerdons Pamu-kanula Balli	LC	-	-
50	Lesser Snake-eyed Lizard[11]	*Ophisops nictans* [IN,SL]	Arnold, 1989	చిన్న పాము□కనులా బల్లి	Chinna Pamu-kanula Balli	NE	-	-
5. Family Scincidae								
51	White-spotted Supple Skink	*Riopa albopunctata*	Gray, 1846	తెళ□మచ్చలా నలికీర	Tella-machhala Nalikiri	NE	-	-
52	Günther's Writhing Skink[12]	*Riopa guentheri* [PI]	(Peters, 1879)	గుంతరీస నలికీర	Gunthers Nalikiri	LC	-	-
53	Common Spotted Supple Skink	*Riopa punctata*	(Linnaeus, 1758)	నలికీర	Nalikiri	NE	-	-
54	Allapalli Skink[13]	*Eutropis allapallensis* [PI]	(Schmidt, 1926)	ఆళ్లపల్లి పాలపింది	Allapally Palapinde	LC	-	-
55	Ashwamedha Scrub Forest Skink[14]	*Eutropis ashwamedhi* [AP,TS]	(Sharma, 1969)	ఆశ్వమేధుని పాలపింది	Ashwamedhuni Palapinde	VU	-	-
56	Common Grass Skink	*Eutropis carinata* [SA]	(Schneider, 1801)	పాలపింది	Palapinde	LC	-	-
57	Bronze Skink	*Eutropis macularia*	(Blyth, 1853)	మచ్చమచ్చల పాలపింది	Machamachala Palapinde	NE	-	-
58	Nagarjunasagar Grass Skink[15]	*Eutropis nagarjunensis* [AP,TS]	(Sharma, 1969)	నాగార్జునసాగర్ పాలపింది	Nagarjunasagar Palapinde	NT	-	-
6. Family Varanidae								
59	Common Monitor Lizard	*Varanus bengalensis*	(Daudin, 1802)	మదుము	Vudumu	LC	Sch. I (Part II)	App. I
Ophidia (Serpentes)								
7. Family Typhlophidae								
60	Beaked Worm Snake	*Grypotyphlops acutus* [PI]	(Duméril & Bibron, 1844)	ఎడ్డూముక్కీకూ పాము	Eddhumukku Paamu	LC	Sch. IV	-
61	Brahminy Worm Snake	*Indotyphlops braminus*	(Daudin, 1803)	గుడ్డి పాము	Guddi Paamu	NE	Sch. IV	-
8. Family Pythonidae								
62	Indian Rock Python	*Python molurus* [SA]	(Linnaeus, 1758)	కొండచిలువ	Konda Chiluva	NE	Sch. I (Part II)	App. I
9. Family Boidae								
63	Common Sand Boa	*Eryx conicus* [SA]	(Schneider, 1801)	మట్టి పాము	Matti Paamu	NE	Sch. IV	App. II
64	Red Sand Boa	*Eryx johnii*	(Russell, 1801)	రెండుముతుల పాము	Rendumoothula Paamu	NE	Sch. IV	App. II
10. Family Colubridae								
65	Indian Vine Snake	*Ahaetulla oxyrhynca* [IN]	(Bell, 1825)	పసరిక	Pasarika	NE	Sch. IV	-
66	Yellow-green Cat Snake[16]	*Boiga flaviviridis* [IN]	Vogel & Ganesh, 2013	పసుపుపచ్చ పిల్లి□కన్ను పాము	Pasupupaccha Pilli-kannu Paamu	NE	Sch. IV	-

	English name	Species	Authority	Telugu name	Vernacular name	IUCN	IWPA	CITES
67	Forsten's Cat Snake[17]	*Boiga forsteni* [IN,SL]	(Duméril et al., 1854)	ఫోర‌స్టెన్ పిల్లి□కన్ను పాము	Forsten Pilli-kannu Paamu	LC	Sch. IV	-
68	Common Cat Snake	*Boiga trigonata*	(Schneider, 1802)	సామాన్య పిల్లి□కన్ను పాము	Samanya Pilli-kannu Paamu	LC	Sch. IV	-
69	Indian Egg-eating Snake[18]	*Boiga westermanni* [BD,IN,NP]	(Reinhardt, 1863)	గుడ్డు□తిని పాము	Guddu-thine Paamu	NE	Sch. I (Part II)	App. II
70	Common Trinket Snake	*Coelognathus helena* [SA]	(Daudin, 1803)	మెగారేకుల పోద	Megarekula Poda	NE	Sch. IV	-
71	Indian Smooth Snake[19]	*Wallophis brachyurus* [IN]	(Günther, 1866)	మెత్తని పాము	Mettani Paamu	NE	Sch. IV	-
72	Common Bronzeback Snake	*Dendrelaphis tristis* [SA]	(Daudin, 1803)	చెత్తీరిక	Chettirika	NE	Sch. IV	-
73	Slender Wolf Snake[20]	*Lycodon fasciolatus* [SA]	(Shaw, 1802)	సన్న కట్ల పాము	Sanna Katla Paamu	NE	Sch. IV	-
74	Common Wolf Snake	*Lycodon aulicus*	(Linnaeus, 1758)	చిన్న కట్ల పాము	Chinna Katla Paamu	NE	Sch. IV	-
75	Yellow-collared Wolf Snake[21]	*Lycodon flavicollis* [PI]	Mukherjee & Bhupathy, 2007	పసుపు మేడ చిన్న కట్ల పాము	Pasupumeda Chinna Katla Paamu	NE	Sch. IV	-
76	Yellow-spotted Wolf Snake[22]	*Lycodon flavomaculatus* [PI]	Wall, 1907	పసుపుమచ్చల చిన్న కట్ల పాము	Pasupumachala Chinna Katla Paamu	LC	Sch. IV	-
77	Bridal Snake[23]	*Lycodon nympha* [IN,SL]	(Daudin, 1803)	వనదేవత పాము	Vanadevatha Paamu	NE	Sch. IV	-
78	Barred Wolf Snake	*Lycodon striatus*	(Shaw, 1802)	చారల కట్ల పాము	Charala Kalta Paamu	NE	Sch. IV	-
79	Streaked Kukri Snake	*Oligodon taeniolatus*	(Jerdon, 1853)	సామాన్య కుకీరి పాము	Chinna Kukri Paamu	NE	Sch. IV	-
80	Russell's Kukri Snake[24]	*Oligodon russellius* [IN]	(Daudin, 1803)	రసెల్స కుకీరి పాము	Russells Kukri Paamu	LC	Sch. IV	-
81	Nagarjunsagar Racer[25]	*Platyceps bholanathi* [PI]	(Sharma, 1976)	నాగార్జునసాగర్ పాము	Nagarjunasagar Paamu	DD	Sch. IV	-
82	Banded Racer	*Platyceps plinii* [SA]	(Merrem, 1820)	శ్వేత నాగు	Shwetha Naagu	NE	Sch. IV	-
83	Indian Rat Snake	*Ptyas mucosa*	(Linnaeus, 1758)	జెర్రిగొడ్డు	Jerri Goddu	NE	Sch. II (Part II)	App. II
84	Dumeril's Black-headed Snake[26]	*Sibynophis subpunctatus* [BD,IN,SL]	(Duméril, Bibron & Duméril, 1854)	చిన్న నలాతల పాము	Chinna Nalathala Paamu	NE	Sch. IV	-
11. Family Natricidae								
85	Buff-striped Keelback	*Amphiesma stolatum*	(Linnaeus, 1758)	వాన కోయిలా	Vaana Koyila	NE	Sch. IV	-
86	Olive Keelback[27]	*Atretium schistosum* [SA]	(Daudin, 1803)	వాన పాము	Vaana Paamu	LC	Sch. II (Part II)	App. III
87	Checkered Keelback	*Fowlea piscator*	(Schneider, 1799)	నీరుకట్టే పాము	Neerukatte Paamu	NE	Sch. II (Part II)	App. III
88	Green Keelback	*Rhabdophis plumbicolor*	(Cantor, 1839)	వనప పాము	Vanapa Paamu	NE	Sch. IV	-
12. Family Psammophidae								
89	Indian Sand Snake[28]	*Psammophis condanarus*	(Merrem, 1820)	ఇసుక పాము	Isuka Paamu	LC	-	-
90	Stout Sand Snake[29]	*Psammophis longifrons* [MH,TS]	Boulenger, 1890	బొడ్డు ఇసుక పాము	Boddu Isuka Paamu	LC	-	-
13. Family Elapidae								
91	Common Indian Krait	*Bungarus caeruleus* [IN,PK,SL]	(Schneider, 1801)	కట్ల పాము	Katla Paamu	NE	Sch. IV	-
92	Banded Krait[30]	*Bungarus fasciatus*	(Schneider, 1801)	బంగారు కట్ల పాము	Bangaru Katla Paamu	LC	Sch. IV	-
93	Slender Coral Snake[31]	*Calliophis melanurus* [SA]	(Shaw, 1802)	సనని పగడపు పాము	Sanani Padagapu Paamu	NE	Sch. IV	-

	English name	Species	Authority	Telugu name	Vernacular name	IUCN	IWPA	CITES
94	Spectacled Cobra	*Naja naja* [SA]	(Linnaeus, 1758)	నాగు పాము	Naagu Paamu	NE	Sch. II (Part II)	App. II
14. Family Viperidae								
95	Russell's Viper	*Daboia russelii* [SA]	(Shaw & Nodder, 1797)	రక్త పింజర	Raktha Pinjara	NE	Sch. II (Part II)	App. III
96	Saw-scaled Viper	*Echis carinatus*	(Schneider, 1801)	చిన్న పింజర	Chinna Pinjara	NE	Sch. IV	-
97	Bamboo Pit Viper	*Trimeresurus gramineus* [PI]	(Shaw, 1802)	వెదురు పాము	Veduru Paamu	LC	Sch. IV	-
15. Family Uropeltidae								
98	Elliot's Shieldtail Snake[32]	*Uropeltis ellioti* [PI]	(Gray, 1858)	ఎలియట్స్ మన్ను పాము	Elliots Mannu Paamu	LC	Sch. IV	-

Key: *Vernacular names are those expressly coined anew by the authors of this paper and they are not necessarily what is there in common dialect in Telangana State | DD—Data Deficient | LC—Least Concern | NE—Not Evaluated | VU—Vulnerable | AF—Afghanistan | BD—Bangladesh | IN—India | NP—Nepal | PK—Pakistan | SL—Sri Lanka | PI—Peninsular India | SA—Southern Asia | AP—Andhra Pradesh | CG—Chhattisgarh | KAR—Karnataka | MH—Maharashtra | TS—Telangana | Sch.—Schedule | App.—Appendix.

[1]Known from Hyderabad, Karimnagar, Komaram Bheem Asifabad, Medak, Medchal-Malkajgiri, Nagarkurnool, Nalgonda, Nirmal, Nizamabad and Sangareddy districts (C. Srinivasulu & G.C. Kumar pers. obs.)
[2]Known from Medchal-Malkajgiri and Nalgonda districts (Ganesh et al. 2020)
[3]Due to recent taxonomic changes, species identification needs to be resolved; perhaps more species might be present in Telangana State
[4]Known historically from Nagarjunasagar dam area in Nalgonda district (Sharma 1971)
[5]Known historically from Nagarjunasagar dam area in Nalgonda district (Sharma 1971)
[6]Known from Nirmal district, Nagarkurnool district and Nalgonda district (C. Srinivasulu pers. obs.)
[7]Known from Nagarjunasagar dam area in Nalgonda district (M. Seetharamaraju & G.C. Kumar pers. obs.)
[8]Known from Khammam Fort, Khammam district (Mirza et al. 2017)
[9]Known from Hyderabad, Nalgonda, and Warangal Urban districts (Kumar et al. 2015)
[10]Known from Warangal Urban district (G.C. Kumar pers. obs.)
[11]Known from Adilabad district (Agarwal et al. 2018)
[12]Known from Nalgonda and Adilabad districts (Javed et al. 2010)
[13]Known from Adilabad, Komaram Bheem Asifabad and Nirmal districts (C. Srinivasulu & G.C. Kumar pers. obs.)
[14]Known historically from Nagarjunasagar dam area in Nalgonda district (Srinivasulu et al. 2016)
[15]Known from Nagarkurnool, Nalgonda, Ranga Reddy, and Wanaparthy districts (Narayana et al. 2017)
[16]Known from Jangaon district (Choure et al. 2021)
[17]Known from Bhadradri Kothagudem, Jayashankar Bhupalapally, Nagarkurnool, and Warangal Rural districts (G.C. Kumar, A. Visvanath & C. Srinivasulu pers. obs.)
[18]Known from Mancherial, Ranga Reddy, Sangareddy and Vikarabad districts (Mohan et al. 2018)
[19]Known from a single record near Vikarabad, Vikarabad district (A. Visvanath pers. obs. June 2016)
[20]Known from Hyderabad, Medchal-Malkajgiri, Ranga Reddy, and Sangareddy districts (A. Visvanath pers. comm., G.C. Kumar pers. obs.)
[21]Known from Hyderabad, Medchal-Malkajgiri, Peddapalli, Ranga Reddy, Sangareddy, and Wanaparthy districts (A. Visvanath pers. comm., C. Srinivasulu pers. obs.)
[22]Known from Neredgonda, near Kuntala, Adilabad district (G.C. Kumar pers. obs.) and Belgaon, Jainath mandal, Adilabad (Anne & Visvanathan 2018)
[23]Known from Adilabad, Hyderabad, and Medchal-Malkajgiri districts (Whitaker & Captain 2004; C. Srinivasulu & M. Seetharamaraju pers. obs.)
[24]Known from Hyderabad, Mancherial, Medchal-Malkajgiri, Nagarkurnool, Nirmal, Nizamabad, Peddapalli, Ranga Reddy, and Wanaparthy districts (Seetharamaraju et al. 2011, C. Srinivasulu & M. Seetharamaraju pers. obs .)
[25]Known from Hyderabad, Kamareddy, Medchal-Malkajgiri, Nalgonda, Ranga Reddy, and Sangareddy districts (Narayana & Sandeep 2021)
[26]Known from Kamareddy, Komaram Bheem Asifabad, Medchal-Malkajgiri, Nagarkurnool, and Ranga Reddy districts (Kumar et al. 2017a)
[27]Known from Kamareddy, Hyderabad, Medchal-Malkajgiri, Nalgonda, and Sangareddy districts (C. Srinivasulu & M. Seetharamaraju pers. obs.)
[28]Known from Nallamala Hills, Nagarkurnool and near Koppole, Nalgonda district (C. Srinivasulu pers. obs.)
[29]Known from Medchal-Malkajgiri and Ranga Reddy districts (Visvanathan et al. 2017)
[30]Known from Jayashankar Bhupalapally and Mulugu districts (Srinivasulu et al. 2009)
[31]Known from Nalgonda district (Seetharamaraju et al. 2019)
[32]Known from Egalapenta in Nallamala Hills in Nagarkurnool district (S. Sadashivaiah pers. comm. April 2021)

Table 2. Species names removed from the final list of herpetofauna known from Telangana State, India.

Class	Family	Species	Reason	Reference
Amphibia	Dicroglossidae	*Euphlyctis hexadactylus* (Lesson, 1834)	This species is known only from the wetlands of coastal plains of India	Frost (2022)
		Fejervarya limnocharis (Gravenhorst, 1829)	This species is now restricted to southeastern Asia; populations from Indian subcontinent assigned to this nomen represent other species	Frost (2022) Ganesh et al. (2017)
		Sphaerotheca dobsonii (Boulenger, 1882)	This species is now restricted to Western Ghats, India	Dahanukar et al. (2017), Prasad et al. (2019)
		Sphaerotheca rolandae (Dubois, 1983)	This species is now restricted to Sri Lanka	Prasad et al. (2019)
Reptilia	Agamidae	*Sitana ponticeriana* Cuvier, 1829	This species is now restricted to Tamil Nadu, Andhra Pradesh, and Odisha, India	Deepak et al. (2018)
		Draco dussumieri A.M.C. Duméril & Bibron, 1837	This species is not present in Telangana. Narayana & Bharath (2021) inadvertently included this in their checklist.	
	Gekkonidae	*Hemidactylus brookii* Gray, 1845	This species is now restricted to southeastern Asia; populations from the Indian subcontinent assigned to this nomen have been reassigned to other available nomen or have been provided new nomen	Lajmi et al. (2016)
	Colubridae	*Ahaetulla nasuta* (Lacépède, 1789)	This species is now restricted to Sri Lanka	Mallik et al. (2020)
		Argyrogena fasciolata (Shaw, 1802)	Due to taxonomic revision, this species has been assigned to the genus *Lycodon*, hence currently accepted as *Lycodon fasciolata* (Shaw, 1802). However, its presence in Telangana needs to be confirmed. Earlier records assigned to A. fasciolata (Shaw, 1802) is now assigned to *Platyceps plinii* (Merrem, 1820)	Deepak et al. (2021)
		Chrysopelea ornata (Shaw, 1802)	Known from a single record from a commercial timber depot in Hyderabad; a case of accidental introduction through timber transportation	
	Homalopsidae	*Enhydris enhydris* (Schneider, 1799)	In Indian subcontinent, this species is known from the large wetlands of coastal plains in Eastern India north of Krishna river in Andhra Pradesh through Nepal and northeastern India, and northern Sri Lanka	Karns et al. (2010)

four species belonging to family Bufonidae, six species to Microhylidae, five species to Dicroglossidae, and one species to Rhacophoridae. The reptilian diversity is represented by one species belonging to one family Crocodylidae in order Crocodylia, six species in three families: Testudinidae, Geomydidae & Trionychidae, in order Testudines, 72 species in 15 families in order Squamata. Among the squamates, 33 species belonging to six families are saurids, while 39 species belonging to nine families are serpents.

Among the amphibians, two species are endemic to India (with one to peninsular India), 11 species endemic to South Asia (one species from India and Sri Lanka, rest from more than two countries in South Asia). Among the reptiles, three species of reptiles (*Hemidactylus flavicaudus* Lajmi, Giri, Singh & Agarwal, 2020; *H. xericolus* Lajmi, Giri, Singh & Agarwal, 2020; and *H. aemulus* Kumar, Srinivasulu & Srinivasulu, 2022) are endemic to Telangana State, 27 species are endemic to India (with 19 from peninsular India), 26 species endemic to southern Asia (seven species from at least two countries, five species from three countries, and rest from more than three countries in southern Asia). One species of snake, the Ornate Flying Snake *Chrysopelea ornata*, was discovered in a timber depot in Hyderabad in July 2017 and is thought to have been inadvertently transported to the urban ecosystem by a timber truck.

As per the IUCN Red List database, the amphibian diversity of Telangana includes 14 Least Concern species, one species—*Duttaphrynus hololius*—as Data Deficient, and one species—*Euphlyctis cyanophlyctis*—is Not Evaluated. Amongst the reptiles, five species—*Crocodylus palustris*, *Geochelone elegans*, *Nilssonia gangetica*, *N. leithii*, and *Eutropis ashwamedhi*—are listed as Vulnerable. Two species—*Melanochelys trijuga* and *Eutropis nagarjunensis*—are Near Threatened, while one species—*Platyceps bholanathi*—is Data Deficient. As many as 26 species are of Least Concern, and 44 species are yet to be evaluated.

Among amphibians, only two species—*Hoplobatrachus crassus* and *H. tigerinus*—are included in Schedule IV of Indian Wildlife (Protection) Act, 1972. The latter species is also included in Appendix III of CITES. Among reptiles, six species are included in Schedule I, six species are included in Schedule II, and 35 species are included in Schedule IV of Indian Wildlife (Protection) Act, 1972. As many as 18 species are included in CITES list—five species in Appendix I, 10 species in Appendix II, and three species in Appendix III.

While compiling this list we have detected 10 species

that have been included in earlier lists that we have removed due to taxonomic reasons and/or distribution mismatch (Table 2). Furthermore, we have not included two species—*Minervarya syhadrensis* Annandale, 1919 and *Microhyla nilpharmariensis* Howlader, Nair, Gopalan & Merilä, 2015—included in the recent lists by Dinesh et al. (2021), and Narayana & Bharath (2021) due to lack of voucher specimen-based record of the presence of the species in Telangana. These works included those taxa that are considered to have wide distribution range according to Garg et al. (2018) and Phuge et al. (2020).

REFERENCES

Agarwal, I., A. Khandekar, U. Ramakrishnan, R. Vyas & V.B. Giri (2018). Two new species of the *Ophisops microlepis* (Squamata: Lacertidae) complex from northwestern India with a key to Indian *Ophisops*. *Journal of Natural History* 52(13–16): 819–847. https://doi.org/10.1080/00222933.2018.1436203

Anne, S. & A.C. Visvanathan (2018). Yellow-spotted Wolf Snake: New locality record of *Lycodon flavomaculatus* Wall, 1907 from Telangana, India. *Zoo's Print* 33(4): 12–14.

Bandara, S.K., S.R. Ganesh, A.S. Kanishka, A.D. Danushka, V.R. Sharma, P.D. Campbell, I. Ineich, G. Vogel & A.T. Amarasinghe (2022). Taxonomic composition of the *Oligodon arnensis* (Shaw 1802) species complex (Squamata: Colubridae) with the description of a new species from India. *Herpetologica* 78(1): 51–73.

Bisht, K., S. Garg, A. Sarmah, S. Sengupta & S.D. Biju (2021). Lost, forgotten, and overlooked: systematic reassessment of two lesser-known toad species (Anura, Bufonidae) from peninsular India and another wide-ranging northern species. *Zoosystematics and Evolution* 97: 451.

Chanda, S.K. (2002). *Hand Book of Indian Amphibians*. Zoological Survey of India, Kolkata, 335 pp.

Choure, G., A. Komanduri, P. Choure & H.T. Lalremsanga (2021). First record of the Yellow-green Cat Snake, *Boiga flaviviridis* Vogel & Ganesh, 2013 (Reptilia: Squamata: Colubridae) from Telangana, India. *Reptiles & Amphibians* 28(2): 238–239.

Dahanukar, N., S. Sulakhe & A.D. Padhye (2017). Identity of *Sphaerotheca pluvialis* (Jerdon, 1853) and other available names among the burrowing frogs (Anura: Dicroglossidae) of South Asia. *Journal of Threatened Taxa* 9(6): 10269–10285. https://doi.org/10.11609/jott.3358.9.6.10269-10285

Daniel, J.C. (2002). *The Book of Indian Reptiles and Amphibians*. Bombay Natural History Society, Oxford University Press, Mumbai, India, 238 pp.

Das, I. (2002). *A Photographic Guide to Snakes and other Reptiles of India*. New Holland, Ralph Curtis Publishers, United Kingdom, 144 pp.

Datta-Roy, A., M. Singh, C. Srinivasulu & P. Karanth (2012). Phylogeny of the Asian *Eutropis* (Squamata: Scincidae) reveals an 'into India' endemic Indian radiation. *Molecular Phylogenetics and Evolution* 63: 817–824.

Deepak, V., V.B. Giri, M. Asif, S.K. Dutta, R. Vyas, A.M. Zambre, H. Bhosale & K.P. Karanth (2016). Systematics and phylogeny of *Sitana* (Reptilia: Agamidae) of Peninsular India, with the description of one new genus and five new species. *Contributions to Zoology* 85(1): 67–111.

Deepak, V., A. Khandekar, R. Chaitanya & P. Karanth (2018). Descriptions of two new endemic and cryptic species of *Sitana* Cuvier, 1829 from peninsular India. *Zootaxa* 4434(2): 327–365.

Deepak, V., S. Narayanan, P.P. Mohapatra, S.K. Dutta, G. Melvinselvan, A. Khan, K. Mahlow & F. Tillack (2021). Revealing two centuries of confusion: new insights on nomenclature and systematic position of *Argyrogena fasciolata* (Shaw, 1802) (auctt.), with description of a new species from India (Reptilia: Squamata: Colubridae). *Vertebrate Zoology* 71: 253–316. https://doi.org/10.3897/vz.71.e64345

Dinesh, K.P., B.L. Narayana & B. Bharath (2021). Amphibia, pp. 327–339. In: Chandra, K., D. Jaiswal, C. Raghunathan, S.S. Jadhav & M. Karuthapandi (eds.). *Current Status of Faunal Diversity in Telangana*. Zoological Survey of India, Kolkata, India, xix+394 pp.

Frost, D.R. (2022). Amphibian Species of the World: an Online Reference. Version 6.1 (20.08.2020). Electronic Database accessible at https://amphibiansoftheworld.amnh.org/index.php. American Museum of Natural History, New York, USA. https://doi.org/10.5531/db.vz.0001

Ganesh, S.R., S.K. Dutta & S.R. Chandramouli (2017). On the taxonomy and nomenclature of common Indian Cricket Frog *Rana agricola* Jerdon, 1853 (Amphibia: Dicroglossidae). *Asian Journal of Conservation Biology* 6(2): 107–113.

Ganesh, S.R., S. Brihadesh, B.L. Narayana, S. Hussain & G.C. Kumar (2020). A contribution on morphology and distribution of the Rock Toad *Duttaphrynus hololius* (Günther, 1876) with first report on deformity, calling and breeding behaviours (Amphibia: Anura: Bufonidae). *Asian Journal of Conservation Biology* 9(1): 71–78.

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

Garg, S., A. Das, R.G. Kamei & S.D. Biju (2018b). Delineating *Microhyla ornata* (Anura, Microhylidae): mitochondrial DNA barcodes resolve century-old taxonomic misidentification. *Mitochondrial DNA, Part B: Resources* 3: 856–561. https://doi.org/10.1080/23802359.2018.1501286

Gowande, G., S. Pal, D. Jablonski, R. Masroor, P.U. Phansalkar, P. Dsouza, A. Jayarajan & K. Shanker (2021) Molecular phylogenetics and taxonomic reassessment of the widespread agamid lizard *Calotes versicolor* (Daudin, 1802) (Squamata, Agamidae) across South Asia. *Vertebrate Zoology* 71: 669–696. https://doi.org/10.3897/vz.71.e62787

Javed, S.M.M., M. Seetharamaraju, K.T. Rao, F. Tampal & C. Srinivasulu (2010). Distribution of *Lygosoma guentheri* (Peter, 1879) (Reptilia: Scincidae) in Andhra Pradesh, India. *Journal of Threatened Taxa* 2(4): 837–840. https://doi.org/10.11609/JoTT.o2092.837-40

Karns, D., V. Lukoschek, J. Osterhage, J. Murphy & H. Voris (2010). Phylogeny and biogeography of the *Enhydris* clade (Serpentes: Homalopsidae). *Zootaxa* 2452: 18–30. https://doi.org/10.11646/zootaxa.2452.1.2

Khartade, K.S., C. Srinivasulu, C.S. Reddy, D. Jaiswal, D. Ramaiyan, F. Tampal, G. Sailu, J. Swamy, Karuthapandi, L. Rasingam, S.S. Jadhav & V.V. Rao (2019). *Telangana State Biodiversity Field Guide*. Telangana State Biodiversity Board, Hyderabad, Telangana, India, xvii+293 pp.

Kumar, G.C. & C. Srinivasulu (2015). A two-tailed Indian Giant Leaf-toed Gecko (*Hemidactylus giganteus*). *Taprobanica* 7(4): 263–265.

Kumar, G.C. (2018). Diversity, systematics and phylogeny of gekkotans in Godavari river basin, Telangana. PhD Thesis submitted to Osmania University, Hyderabad.

Kumar, G.C., C. Srinivasulu & K.K. Prasad (2017a). First records of the Dumeril's Black-headed Snake *Sibynophis subpunctatus* Dumeril, Bibron and Dumeril, 1854 (Reptilia: Colubridae) from Telangana State, India. *Checklist* 13(5): 577–580.

Kumar, G.C., C. Srinivasulu & K.K. Prasad (2017b). New locality records of Leschenault's Snake eye, *Ophisops leschenaultii* (Sauria: Lacertidae) (Milne-Edwards, 1829) from Telangana State, with notes on the species' natural history. *IRCF Reptiles and Amphibians* 24(1): 51–54.

Kumar, G.C., C. Srinivasulu & M. Seetharamaraju (2015). On the distribution of the Reticulate leaf-toed gecko *Hemidactylus reticulatus* (Beddome, 1870) (Reptilia: Gekkonidae) from Telangana and Andhra Pradesh, India. *Taprobanica* 7(4): 272–274.

Lajmi, A., V.B. Giri & K.P. Karanth (2016). Molecular data in conjunction

Image 1. *Duttaphrynus melanostictus*

Image 2. *Duttaphrynus peninsularis*

Image 3. *Duttaphrynus hololius*

Image 4. *Euphlyctis cyanophlyctis*

Image 5. *Minervarya agricola*

Image 6. *Hoplobatrachus tigerinus*

Image 7. *Sphaerotheca breviceps*

Image 8. *Microhyla ornata*

Image 9. *Microhyla rubra*

Image 10. *Uperodon taprobanicus*

Image 11. *Uperodon systoma*

Image 12. *Polypedates maculatus*

Image 13. *Crocodylus palustris*

Image 14. *Geochelone elegans*

Image 15. *Melanochelys trijuga*

Image 16. *Lissemys punctata*

Image 19. *Sitana spinaecephalus*

Image 22. *Hemidactylus flaviviridis*

Image 25. *Hemidactylus gleadowi*

Image 28. *Hemidactylus parvimaculatus*

Image 17. *Calotes vultuosus*

Image 20. *Chamaeleo zeylanica*

Image 23. *Hemidactylus frenatus*

Image 26. *Hemidactylus gracilis*

Image 18. *Psammophilus blanfordanus*

Image 21. *Hemidactylus aemulus*

Image 24. *Hemidactylus giganteus*

Image 27. Hemidactylus leschenaultii (© G. Chethan Kumar)

Image 29. *Hemidactylus reticulatus*

Image 30. *Hemidactylus treutleri*

Image 33. *Riopa punctata*

Image 36. *Eutropis nagarjunensis*

Image 39. *Grypotyphlops acutus*

Image 31. *Hemidactylus triedrus*

Image 34. *Eutropis ashwamedhi*

Image 37. *Indotyphlops braminus*

Image 40. *Eryx conicus*

Image 32. *Ophisops leschenaultii*

Image 35. *Eutropis carinata*

Image 38. *Varanus bengalenis*

Image 41. *Python molurus*

Image 42. *Eryx johnii*

Image 43. *Ahaetulla oxyrhynca*

Image 44. *Boiga trigonata*

Image 45. *Boiga westermanni*

Image 46. *Coelognathus helena*

Image 47. *Lycodon flavicollis*

Image 48. *Dendrelaphis tristis*

Image 49. *Lycodon fascioltaus*

Image 50. *Oligodon russellius*

Image 51. *Lycodon nympha*

Image 52. *Lycodon striatus*

Image 53. *Daboia russelii*

Image 54. *Oligodon taeniolatus*

Image 55. *Naja naja*

Image 56. *Platyceps bholanathi*

Image 59. *Sibynophis subpunctatus*

Image 62. *Fowlea piscator*

Image 65. *Psammophis longifrons*

Image 68. *Uropeltis ellioti*

Image 57. *Platyceps plinii*

Image 60. *Amphiesma stolatum*

Image 63. *Rhabdophis plumbicolor*

Image 66. *Bungarus caeruleus*

Image 58. *Ptyas mucosa*

Image 61. *Atretium schistosum*

Image 64. *Calliophis melanurus*

Image 67. *Echis carinatus*

with morphology help resolve the *Hemidactylus brookii* complex (Squamata: Gekkonidae). *Organisms, Diversity and Evolution* 16: 659–677. https://doi.org/10.1007/s13127-016-0271-9

Lajmi, A., V.B. Giri, T. Singh & I. Agarwal (2020). Two new species of yellow-tailed *Hemidactylus* Goldfuss, 1820 (Squamata: Gekkonidae) from rocky outcrops on the Telangana Plateau, India. *Zootaxa* 4895(4): 483–504. https://doi.org/10.11646/zootaxa.4895.4.2

Mahony, S. (2009). A new species of gecko of the genus *Hemidactylus* (Reptilia: Gekkonidae) from Andhra Pradesh, India. *Russian Journal of Herpetology* 16(1): 27–34.

Mallik, A.K., A.N. Srikanthan, S. Pal, P.M. D'souza, K. Shanker & S.R. Ganesh (2020). Disentangling vines: a study of morphological crypsis and genetic divergence in vine snakes (Squamata: Colubridae: *Ahaetulla*) with the description of five new species from Peninsular India. *Zootaxa* 4874(1): 1–62. https://doi.org/10.11646/zootaxa.4874.1.1

Mallik, A.K., A.N. Srikanthan, S.R. Ganesh, S.P. Vijayakumar, P.D. Campbell, A. Malhotra & K. Shanker (2021). Resolving pitfalls in pit viper systematics–A multi-criteria approach to species delimitation in pit vipers (Reptilia, Viperidae, *Craspedocephalus*) of Peninsular India reveals cryptic diversity. *Vertebrate Zoology* 71: 577–619.

Mirza, Z.A., H. Bhosale & R. Patil (2017). A new large species of gecko of the genus *Hemidactylus* Oken, 1817 (Reptilia: Sauria: Gekkonidae) from the Eastern Ghats, India. *Comptes Rendus Biologies* 340: 11–12. https://doi.org/10.1016/j.crvi.2017.09.003

Mirza, Z.A., H. Bhosale & R. Patil (2017). A new large species of gecko of the genus *Hemidactylus* Oken, 1817 (Reptilia: Sauria: Gekkonidae) from the Eastern Ghats, India. *Comptes Rendus Biologies* 340(11–12): 531–540.

Mirza, Z.A. & H. Patel (2018). Back from the dead! Resurrection and revalidation of the Indian endemic snake genus *Wallophis* Werner, 1929 (Squamata: Colubridae) insights from molecular data. *Mitochondrial DNA Part A* 29(3): 331–334.

Mohan, A.V., A.C. Visvanathan & K. Vasudevan (2018). Phylogeny and conservation status of the Indian egg-eater snake, *Elachistodon westermanni* Reinhardt, 1863 (Serpentes, Colubridae). *Amphibia-Reptilia* 2018: 317–324. https://doi.org/10.1163/15685381-17000201

Narayana, B.L. & B. Bharath (2021). Reptilia, pp. 341–366. In: Chandra, K., D. Jaiswal, C. Raghunathan, S.S. Jadhav & M. Karuthapandi (eds.). *Current Status of Faunal Diversity in Telangana*. Zoological Survey of India, Kolkata, India, xix+394 pp.

Narayana, B.L. & M. Sandeep (2021). Recent records of the Nagarjunasagar Racer, *Platyceps bholanathi* (Sharma 1976), from Telangana, India. *Reptiles & Amphibians* 28(1): 89–90.

Narayana, B.L., G. Surender & V.V. Rao (2014). *Hemidactylus treutleri* from Eastern Ghats, Andhra Pradesh, India. *Taprobanica* 6: 55.

Narayana, B.L., G.C. Kumar, B. Naresh & V.V. Rao (2017). Distribution of an endemic Skink (Sharma, 1969) (Reptilia: Scincidae) with notes on its natural history and behavior *Eutropis nagarjunensis* in Eastern Ghats, India. *Journal of the Bombay Natural History Society* 114: 44–47. https://doi.org/10.17087/jbnhs/2017/v114/109359

Narayana, B.L., M. Sandeep & S. Dogra (2018). A new locality record for the Yellow-collared Wolfsnake, *Lycodon flavicollis* Mukherjee and Bhupathy 2007, from Hyderabad, Telangana, India. *Reptiles & Amphibians* 25(1): 55–56.

Pal, S., S. P. Vijayakumar, K. Shanker, A. Jayarajan & V. Deepak (2018). A systematic revision of *Calotes* Cuvier, 1817 (Squamata: Agamidae) from the Western Ghats adds two genera and reveals two new species. *Zootaxa* 4482(3): 401–450.

Phuge, S., A.B. Patil, R. Pandit, N.U. Kulkarni, B.H. Chennakeshavamurthy, P. Deepak & K.P. Dinesh (2020). Importance of genetic data in resolving cryptic species: A century old problem of understanding the distribution of *Minervarya syhadrensis* Annandale 1919, (Anura: Dicroglossidae). *Zootaxa* 4869: 451–492. https://doi.org/10.11646/zootaxa.4869.4.1

Prasad, K.K., C. Srinivasulu, A. Srinivasulu, G.R.K. Rao & C. Shivaiah (2018). Reassessment of status and spatial analysis of the distribution of *Crocodylus palustris* in Manjeera Wildlife Sanctuary, Telangana State, India. *Herpetological Conservation and Biology* 13(3): 569–575.

Prasad, V.K., K.P. Dinesh, A. Das, P. Swamy, A.D. Shinde & J.B. Vishnu (2019). A new species of *Sphaerotheca* Gunther, 1859 (Amphibia: Anura: Dicroglossidae) from the agro ecosystems of Chota Nagpur Plateau, India. *Records of the Zoological Survey of India* 119: 197–210.

Rao, K.T., H.V. Ghate, M. Sudhakar, S.M. Javed & I.S.R. Krishna (2005). Herpetofauna of Nallamalai Hills with eleven new records for the region including ten new records for Andhra Pradesh. *Zoo's Print Journal* 20(1): 1737–1740. https://dx.doi.org/10.11609/JoTT.ZPJ.1232.1737-40

Sanyal, D.P., B.D. Gupta & N.C. Gayen (1993). *Reptilia*. 1–63 pp. In: Ghosh, A.K. (ed). *State Fauna Series 5. Fauna of Andhra Pradesh, Part I*. Zoological Survey of India, Calcutta, vi+334 pp.

Sarkar, A.K., P.K. Chandra & S. Ray (1993). *Amphibia*. 65–87 pp. Ghosh, A.K. (ed). *State Fauna Series 5. Fauna of Andhra Pradesh, Part I*. Zoological Survey of India, Calcutta, vi+334 pp.

Seetharamaraju, M. & C. Srinivasulu (2013). Discovery and description of male specimen of *Coluber bholanathi* Sharma, 1976 (Reptilia: Colubridae) from Hyderabad, India. *Taprobanica* 5(1): 32–35.

Seetharamaraju, M. (2015). Taxonomy, Diversity, Distribution and Ecology of snakes in Telangana State. PhD Thesis submitted to Osmania University, Hyderabad, India.

Seetharamaraju, M., C. Srinivasulu & B. Srinivasulu (2011). New records of *Oligodon taeniolatus* (Jerdon, 1853) (Reptilia: Colubridae) in Andhra Pradesh, India. *Herpetology Notes* 4: 421–423.

Seetharamaraju, M., G.C. Kumar & C. Srinivasulu (2019). Notes on rare slender coral snake *Calliophis melanurus* (Shaw, 1802) (Serpentes: Elapidae: Calliophinae) from Telangana State, India. *Sauria* 41(2): 50–54.

Seetharamaraju, M., R. Sreekar, P. Venkateshwarlu & C. Srinivasulu (2008). Notes on the eggs and hatchlings of Striped Keelback *Amphiesma stolatum* (Linnaeus, 1758). *Cobra* 2(4): 20–21.

Sharma, R.C. (1969). Two new lizards of the genera *Mabuya* Fitzinger and *Riopa* Gray (Scincidae) from India. *Bulletin of Systematic Zoology, Calcutta* 1(2): 71–75.

Sharma, R.C. (1971). The reptile fauna of the Nagarjunasagar Dam area (Andhra Pradesh, India). *Records of the Zoological Survey of India* 63(1–4): 77–93.

Srinivasulu, C. (2003). Reptiles of Kawal Wildlife Sanctuary, Andhra Pradesh. *Reptile Rap* 5: 2.

Srinivasulu, C. (2017). Threatened Taxa of Telangana State. Telangana State Biodiversity Board and Osmania University, Hyderabad, Telangana State, India, viii+212 pp.

Srinivasulu, C. & B. Srinivasulu (2010). Herpetofauna, pp. 99–112. In: *Limnological and Faunistic Studies of Pocharam Lake, Nizamabad-Medak District, Andhra Pradesh*. Wetland Ecosystem Series 13. Zoological Survey of India, Kolkata, iv+181 pp.

Srinivasulu, C. & B. Srinivasulu (2012a). Biodiversity of Andhra Pradesh - A Profile. Biodiversity Research and Conservation Society, Hyderabad; Osmania University, Hyderabad; and Zoo Outreach Organization, Coimbatore, 46 pp.

Srinivasulu, C. & B. Srinivasulu (2012b). Glimpses of Biodiversity of Greater Hyderabad. Greater Hyderabad Municipal Corporation, Hyderabad; Osmania University, Hyderabad; and Zoo Outreach Organization, Coimbatore, 86 pp.

Srinivasulu, C. & B. Srinivasulu (2013a). *Hemidactylus gracilis.* The IUCN Red List of Threatened Species 2013: e.T194108A2299467. Accessed on 20 March 2021. https://doi.org/10.2305/IUCN.UK.2013-1.RLTS.T194108A2299467.en

Srinivasulu, C. & B. Srinivasulu (2013b). *Hemidactylus reticulatus*. The IUCN Red List of Threatened Species 2013: e.T172713A1373112. Accessed on 20 March 2021. https://doi.org/10.2305/IUCN.UK.2013-1.RLTS.T172713A1373112.en

Srinivasulu, C. & I. Das (2008). The herpetofauna of Nallamala Hills, Eastern Ghats, India: an annotated checklist, with remarks on nomenclature, taxonomy, habitat use, adaptive types and biogeography. *Asiatic Herpetological Research* 11: 110–131.

Srinivasulu, C., B. Srinivasulu & C.A.N. Rao (2006). Reptilian fauna of Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh. *Records of the Zoological Survey of India* 106(3): 97–122.

Srinivasulu, C., B. Srinivasulu, A. Srinivasulu & M. Seetharamaraju (2016). No longer supple? Molecular phylogeny suggests generic reassignment of *Lygosoma ashwamedhi* (Sharma, 1969) (Reptilia: Scincidae). *Zootaxa* 4127(1): 135–148.

Srinivasulu, C., B. Srinivasulu, M. Seetharamaraju, R. Sreekar & H. Kaur (2011). Reptiles of Andhra Pradesh. *Paryavaranam* 5(3): 2–7.

Srinivasulu, C., D. Venkateshwarlu & M. Seetharamaraju (2009). Rediscovery of the Banded Krait *Bungarus fasciatus* (Schneider 1801) (Serpentes: Elapidae) from Warangal district, Andhra Pradesh, India. *Journal of Threatened Taxa* 1(6): 353–354. https://doi.org/10.11609/JoTT.o1986.353-4

Srinivasulu, C., G.C. Kumar & B. Srinivasulu (2014). New site records and updated distribution of Treutler's gecko *Hemidactylus treutleri* Mahony, 2009 (Sauria: Gekkonidae) from peninsular India. *Herpetology Notes* 7: 679–682.

Stoliczka, F. (1871). Notes on new or little known Indian lizards. *Proceedings of the Asiatic Society of Bengal* 1871: 192–195.

Stoliczka, F. (1872). Notes on various new or little known Indian lizards. *Journal of the Asiatic Society of Bengal*, 41: 86–135, pls. II–V.

Visvanathan, A.C. (2015). Natural history notes on *Elachistodon westermanni* Reinhardt, 1863. *Hamadryad* 37: 132–136.

Visvanathan, A.C., S. Anne & A.K. Kolli (2017). New locality records of the Stout Sand Snake *Psammophis longifrons* Boulenger, 1890 (Reptilia: Squamata: Lamprophiidae) in Telangana, India. *Journal of Threatened Taxa* 9(11): 10968–10970. https://doi.org/10.11609/jott.3449.9.11.10968-10970

Vogel, G. & S. R. Ganesh (2013). A new species of cat snake (Reptilia: Serpentes: Colubridae: *Boiga*) from dry forests of eastern peninsular India. *Zootaxa* 3637(2): 158–168.

Whitaker, R. & A. Captain (2004). *Snakes of India: The Field Guide*. Draco Books, Chennai, 500 pp.

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VIEWPOINT

Comments on "The Dragonflies and Damselflies (Odonata) of Kerala – Status and Distribution"

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Abstract: This is a rejoinder to the article "The Dragonflies and Damselflies (Odonata) of Kerala – Status and Distribution". In the said paper, certain species are of doubtful occurrence in Kerala and the Western Ghats. First reports of certain species which were available in open-access biodiversity portals and published articles in peer-reviewed journals were ignored. Additions to the checklists have been made without conducting taxonomic investigations, or in one case, even presenting a photograph. These shortcomings will lead to confusion and misunderstanding among odonatologists and naturalists in the region.

Keywords: Biodiversity documentation, checklist, insecta, rejoinder, research ethics, Western Ghats.

We would like to commend Nair et al. (2021) for attempting to compile checklists of Odonata species recorded from the Western Ghats and within the political boundaries of Kerala state. Regional checklists form the baseline of biodiversity documentation and are crucial for conservation planning. However, in the said paper, certain species are of doubtful occurrence in Kerala and the Western Ghats. First reports of certain species which were available in open-access biodiversity portals and published articles in peer-reviewed journals were ignored. Additions to the checklists have been made without conducting taxonomic investigations, or in one case, even presenting a photograph. These shortcomings will lead to confusion and misunderstanding among odonatologists and naturalists in the region. The missteps in the paper can be discussed under four heads:

1. Misappropriation of first records

a. *Platylestes platystylus* (Rambur, 1842) was recorded for the first time from Kerala by Rison Thumboor in 2018 from Thrissur district. This record is available in the Global Biodiversity Information Facility (Ueda 2021). There are also published records of the species from the state (Emiliyamma et al. 2020; Rison & Chandran 2020; Chandran et al. 2021), but these records were ignored by the authors.

b. *Pseudagrion australasiae* Selys, 1876 was also recorded for the first time from the state by Rison Thumboor from Thrissur district. This record is also available in the Global Biodiversity Information Facility (India Biodiversity Portal 2021). In this case also, published records of the species (Chandran et al. 2020, 2021) were ignored.

2. Addition of species in the checklist without presenting the results of taxonomic examination

a. *Crocothemis erythraea* (Brullé, 1832)

This species is common in southern Europe and throughout Africa. It also occurs across western Asia as far as southern China (Clausnitzer 2013). It is known to occur within Indian limits

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(Subramanian & Babu 2017), but has not been recorded from the Western Ghats (Subramanian et al. 2018). The authors claim to have recorded this species from Munnar, Kerala and have provided a photograph as evidence. However, *C. erythraea* very closely resembles *Crocothemis servilia* (Drury, 1773), a species seen commonly throughout Kerala. Hence, it is unwise to include it in the checklist of Kerala or the Western Ghats without proper taxonomic examination of specimens.

b. *Zygonyx torridus* (Kirby, 1889)

This species is widespread across many African countries, parts of Europe and Asia (Dow et al. 2016). In the Western Ghats, it has been recorded only from Karnataka state (Subramanian et al. 2018). The authors claim to have recorded the species from Kerala without presenting any photographic evidence of it.

c. *Tramea virginia* Rambur, 1842

This species is known to occur in parts of India and many southeastern Asian countries (Dow 2020). In the Western Ghats, there are records from Maharashtra and Tamil Nadu (Subramanian et al. 2018). The authors have added the species to the checklist of Kerala based on a published record (Sharma et al. 2007) and provide no further evidence for its occurrence in Kerala. It has to be noted that in the paper cited by the authors, no taxonomic description or photograph of *T. virginia* is given.

3. Extralimital species added in the checklist of Kerala without presenting any evidence

a. *Heliogomphus kalarensis* Fraser, 1934

This species is known only from the type specimen, a male, collected by Fraser from Kalar, at the foot of Mettupalayam Ghat (Fraser 1934). The location clearly falls in Tamil Nadu. The authors have added it to the checklist of Kerala without presenting any evidence.

b. *Macromia flavicincta* Selys, 1874

This species is endemic to India and has been recorded only from Maharashtra and West Bengal (Subramanian et al. 2018). The authors have included the species in the checklist of Kerala without presenting any evidence.

c. *Idionyx nadganiensis* Fraser, 1924

This species is known only from two female specimens collected by Fraser (1936). The type locality is mentioned as "Nilgiri Wynaad" and the geographical locations mentioned as its range probably fall outside the present political boundaries of Kerala (Fraser 1924). It should be noted that the boundaries between Kerala and the neighbouring states were redrawn after independence and also during the reorganisation of states. Keeping these caveats in mind, Subramanian et al. (2018) chose to show its distribution only in Tamil Nadu. Again, the authors have included this species in the checklist of Kerala without presenting any evidence of its occurrence here.

d. *Idionyx periyashola* Fraser, 1939

This species is also known only from the type specimen and the type locality is uncertain (Subramanian 2011). Subramanian et al. (2018) show its distribution only in the state of Tamil Nadu. The authors have chosen to include it in the checklist of Kerala without giving any evidence of its occurrence here.

4. Other errors/omissions

a. *Bradinopyga konkanensis* Joshi & Sawant, 2020

This species, described recently from Maharashtra, has been recorded from Kidoor in Kasaragod district of Kerala (Haneef et al. 2021). Its identity was confirmed in the paper by diagnosing its wing venation and structure of secondary genitalia of a male specimen. Even though the authors have referred this paper, the species has not been included in the list. The authors state that the species "has not been authentically reported from Kerala."

b. *Idionyx minima* Fraser, 1931

The photograph presented as of *Idionyx minima* (Figure 5E) is actually of a female *Macromidia donaldi* (Fraser, 1924). In the case of *I. minima*, the abdomen is black and unmarked (Fraser 1931). A close inspection of the photograph given reveals a yellow mid-dorsal stripe on the individual's abdomen characteristic of *M. donaldi*.

c. *Indolestes pulcherrrimus* (Fraser, 1924) and *Indothemis limbata* (Selys, 1891)

Even though Muneer P.K. has been credited with the records of these two species, a published record of which he is the first author has not been cited (Munner & Chandran 2020). Presenting these records as published for the first time is misleading.

Citizen scientists contribute their observations to open-access biodiversity portals such as iNaturalist and India Biodiversity Portal with the hope that their contributions would further research and aid in the conservation of species and their habitats. It is with this purpose in mind that the observations are pooled into the Global Biodiversity Information Facility (GBIF). Only 'research grade' observations of iNaturalist and 'publication grade' observations of India Biodiversity Portal are sourced into GBIF, which enhances the authenticity of such records. If the authors are of the opinion that these records are insufficient, they should have at least considered papers already published in peer-reviewed journals before claiming their own observations as first records. The misappropriation of such records is unacceptable. Further, considering the fact that odonates are insects, any new record from the region should be backed with detailed taxonomic examination. If specimens are not available for such study, detailed photographs showing taxonomic features are necessary to establish the presence of the species in the region. Even though the authors have included photographs of many common species such as *Pantala flavescens* (Fabricius, 1798) and *Urothemis signata* (Rambur, 1842), they have not presented photographs of species such as *M. flavicincta* and *Z. torridus* which they claim as new records.

The comments provided above need to be considered before the checklists prepared by Nair et al. (2021) are used by biodiversity managers, researchers, and interested public. It will be beneficial if the authors address the issues pointed out and publish a corrigendum.

References

Chandran, A.V., A. Wilson & S.K. Jose (2020). Odonates of Irinjalakuda ponds of central Kerala, India. BugsRAll. *Zoo's Print* 35(10): 26–33. https://www.zoosprint.zooreach.org/index.php/zp/article/view/7142/6474

Chandran A.V., S.K. Jose & S.V. Gopalan (2021). Dragonflies and damselflies (Insecta: Odonata) of the Kole Wetlands, central Kerala, India. *Journal of Threatened Taxa* 13(3): 17963–17971. https://doi.org/10.11609/jott.5885.13.3.17963-17971

Clausnitzer, V. (2016). *Crocothemis erythraea*. The IUCN Red List of Threatened Species 2016: e.T59859A83846274. Downloaded on 26 April 2022. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T59859A83846274.en

Dow, R.A., J.P. Boudot, V. Clausnitzer, F. Suhling, S. Ferreira, K.D.B. Dijkstra, W. Schneider & B. Samraoui (2016). *Zygonyx torridus*. The IUCN Red List of Threatened Species 2016: e.T60078A83877723. Downloaded on 26 April 2022. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T60078A83877723.en

Dow, R.A. (2020). *Tramea virginia*. The IUCN Red List of Threatened Species 2020: e.T163702A138282735. Downloaded on 26 April 2022. https://doi.org/10.2305/IUCN.UK.2020-1.RLTS.T163702A138282735.en

Emiliyamma, K.G., M.J. Palot & C. Charesh (2020). A new species of *Platylestes* Selys (Odonata: Zygoptera: Lestidae) from the coastal area of Kannur District, Kerala, India. *Journal of Threatened Taxa* 12(13): 16854–16860. https://doi.org/10.11609/jott.5209.12.13.16854-16860

Fraser, F.C. (1924). A survey of the Odonata fauna of western India with special remarks on the genera *Macromia* and *Idionyx* and description of thirty new species. *Records of the Indian Museum* 26(5): 423–522.

Fraser, F.C. (1931). Addition to the survey of the Odonata (dragonfly) fauna of Western India, with descriptions of nine new species. *Records of the Indian Museum* 33: 443–474.

Fraser, F.C. (1934). *Fauna of British India, including Ceylon and Burma.* Odonata, Vol II. Taylor & Francis group, London, 398 pp.

Fraser, F.C. (1936). *Fauna of British India, including Ceylon and Burma*. Odonata, Vol III. Taylor & Francis group, London, 461 pp.

Haneef, M., B.R.S. Crasta & A.V. Chandran (2021). Reportof *Bradinopyga konkanensis* Joshi & Sawant, 2020 (Insecta :Odonata) from Kerala, India. *Journal of Threatened Taxa* 13(8): 19173–19176. https://doi.org/10.11609/jott.6484.13.8. 19173-19176

India Biodiversity Portal (2022). India Biodiversity Portal publication grade dataset. Occurrence dataset https://doi.org/10.15468/rs5upd. Accessed via GBIF.org on 27 October 2021. https://www.gbif.org/occurrence/2598676526

Muneer, P.K. & A.V. Chandran (2020). A preliminary study of Odonate diversity in Wayanad Wildlife Sanctuary. Report submitted to Kerala Forests & Wildlife Department, 42 pp. https://www.ferns.org.in/resources/wyd-wls-odonate-2020.pdf?fbclid=IwAR18pCIiU3ECrn8flgftt0CF3729xyhTE-uktrt8qEkHSNy3wAok717TDhY

Nair, V.P., K.A. Samuel, M.J. Palot & K. Sadasivan (2021). The Dragonflies and Damselflies (Odonata) of Kerala – Status and Distribution. *Entomon* 46(3): 185–238. https://doi.org/10.33307/entomon.v46i3.609

Rison, K.J. & A.V. Chandran (2020). Observations of the damselfly *Platylestes* cf. *platystylus* Rambur, 1842 (Insecta: Odonata: Zygoptera: Lestidae) from peninsular India. Journal of Threatened Taxa 12(10): 16392–16395. https://doi.org/10.11609/jott.5834.12.10.16392-16395.

Sharma, G., R. Sundararaj & L.R. Karibasvaraja (2007). Species diversity of Odonata in the selected provenances of sandal in Southern India. *Zoo's Print* 22(7): 2765–2767.

Subramanian, K.A. (2011). *Idionyx periyashola*. The IUCN Red List of Threatened Species 2011: e.T175193A7120124. Downloaded on 26 April 2022. https://doi.org/10.2305/IUCN.UK.2011-1.RLTS.T175193A7120124.en

Subramanian, K.A. & R. Babu (2017). *A checklist of Odonata (Insecta) of India.* Version 3.0. pp 1–51. Accessed on 20 April 2022. https://zsi.gov.in/WriteReadData/userfiles/file/Checklist/Odonata%20V3.pdf

Subramanian, K.A., K.G. Emiliyamma, R. Babu, C. Radhakrishnan & S.S. Talmale (2018). *Atlas of Odonata (Insecta) of Western Ghats*, India. Zoological Survey of India, Kolkata.

Ueda, K. (2021). iNaturalist Research-grade Observations. iNaturalist.org. Occurrence dataset https://doi.org/10.15468/ab3s5x accessed via GBIF.org on 27 October 2021. https://www.gbif.org/occurrence/2465188586

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SHORT COMMUNICATION

Landings of IUCN Red Listed finfishes at Chetlat Island of Lakshadweep, southeastern Arabian Sea

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Abstract: The Lakshadweep Islands are well-known for their abundant fishery resources. Present study primarily focused on the systematic representation of IUCN (International Union for Conservation of Nature) Red Listed marine finfish landings of Chetlat Island of Lakshadweep archipelago (India). Monthly collections were carried out from September 2019 to February 2020 from the study area. A list of finfishes along with their scientific name, common name, family, and present conservation status was prepared. As per the IUCN Red List, out of 41 fish species identified, one species is 'Endangered' (EN), two species are 'Near Threatened' (NT), four species are 'Vulnerable' (VU), one species 'Data Deficient' (DD), 29 species 'Least Concern' (LC), and four species are 'Not Evaluated' (NE) categories. Information on the conservation status of fishes plays a significant role in fisheries science since it forms the basis for managing marine fishery resources.

Keywords: Conservation status, fisheries, island, India, marine fishes.

India is home to a diverse range of flora and fauna and is considered as one of the world's richest biodiversity countries. Fisheries contribute significantly to India's national economy (1.21% of total gross domestic product (GDP) and 5.3% of agricultural GDP) and bestow livelihoods to about 10 million people (Infantina et al. 2016). Fishery resources in India are one of the most diversified and most significant natural resources in the world with respect to the abundance of fish species. Marine ecosystems are currently facing an intensified loss of species and populations due to increasing anthropogenic activities, with unknown consequences (Worm et al. 2006). There is a significant alarm about the increasing human interference on marine biodiversity in recent years (Costello et al 2010; Nihal et al. 2021). Since the 1950s, the International Union for Conservation of Nature (IUCN) has issued lists of endangered species, which have been compiled as Red Data Books and Red Lists (Butchart et al. 2005). The IUCN Red List (2017) categorized the species into nine groups based on their population size, rate of decline, geographic distribution area, degree of population, and distribution fragmentation. These include Extinct (EX), Extinct in the wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not

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Evaluated (NE). The islands of Lakshadweep form India's smallest Union Territory and are typical atolls formed by the perpetual deposition of corals (Tripathy 2002). The archipelago of Lakshadweep, located in the southern Arabian Sea, encompasses 36 islands that make up a group of India's major coral reef complex (Vyshnavi et al. 2020). Fisheries support thousands of fisherman families in and around the island's coastal settlements. The atolls offers a network of habitats for a variety of fish species, both resident and migratory. It forms a model marine system where differentiation of ecologically sensitive and vulnerable regions is challenging due to dependence on its resources. As our knowledge on marine biodiversity is yet inadequate to guide our actions, a careful approach, such as establishing marine reserves, may be required (Tripathy 2002). The fisheries in the Lakshadweep Islands have always been sustainable and subsistence oriented. Tuna and needlefish account for around 95% of the total commercial fisheries in the Lakshadweep Islands, where fishing is the primary source of income (Vinay et al. 2017). These fishes have traditionally been caught with troll line, pole and line, handline and drift gillnet. Knowledge regarding the condition of threatened species biodiversity is critical for protecting species in the wild from extinction and conserving them via good management so they can continue to exist in their natural habitat (Pimm et al. 2015). The ability to tackle biodiversity management and conservation is highly dependent on a thorough understanding of the taxonomy of the flora and fauna that make up biodiversity (Joshi et al. 2016). We have carried out a survey of IUCN Red Listed species of various species landed, and the findings of the same are depicted in this manuscript.

Materials and Methods

Chetlat is an atoll within the Lakshadweep archipelago in the Arabian Sea, off the west coast of India. It is 56 km north of Amini and 432 km (233 nautical miles) west of Kochi. It is located between 11.68 & 11.71 N and 72.68 & 72.71 E and covers an area of 1.40 km^2 (Fig 1). The samples were taken every month from fisherman during September 2019 to February 2020 from the study area. The collected fish species were identified using standard references and keys (Misra 1952; Ebert & Mostarda 2013; Froese & Pauly 2021). A Canon IXUS 190 digital camera was used to acquire the fish photographs. During the auction, fish samples were chosen at random from each mound. All of the samples were rinsed thoroughly with tap water, and preserved in 10% formaldehyde for subsequent analysis in the laboratory. The data on the conservation status of the collected fishes were ascertained according to their IUCN Red List status (IUCN Red List 2017). The data regarding gears used for catching different fishes were obtained from local fishermen.

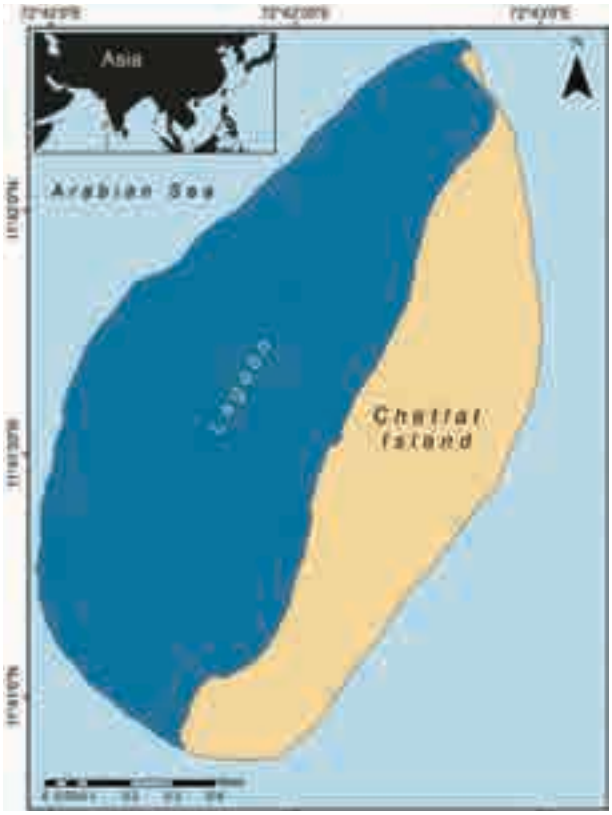

Figure 1. Map depicting the study area.

Results

During the present study, 654 marine fishes belonging to 41 distinct fish species under 20 different families were identified. The Red List status of all identified species was examined, and 41 of them were found to be listed under the 2017 IUCN Red List. The detailed information on species name, family, common name, and IUCN status is given in Table 1. Scombridae was the most represented, out of 20 families, with seven fish species. Lutjanidae was second most represented with four species belonging under it. Belonidae and Carcharhinidae were represented by three species from each family. Two species were represented by each of the following families including Istiophoridae, Carangidae, Serranidae, Lethrinidae, Dasyatidae, Acanthuridae, Spratelloididae, and Mullidae. Only one species from the families of Xiphiidae, Sphyraenidae, Coryphaenidae, Exocoetidae, Hemiramphidae, Alopiidae, Gerreidae, and Pinguipedidae was recorded. Out of the 41 fish species

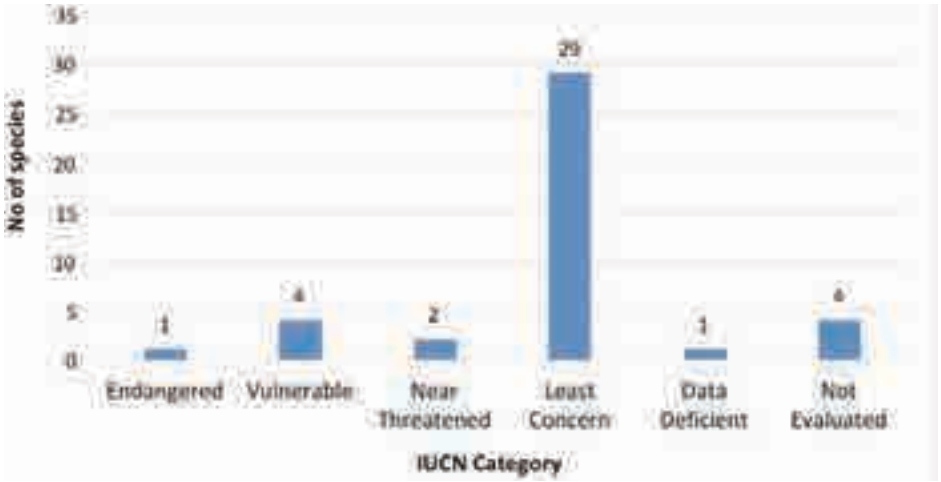

Figure 2. Fish species representatives of IUCN categories.

sampled, one species was 'Endangered', four species were 'Vulnerable', two species were 'Near Threatened', 29 species were 'Least Concern', one species was 'Data Deficient', and four species were 'Not Evaluated' as per the IUCN Red List (Figure 2). The scombroid fishes collected were caught using the gears including pole & line and hook & line. The fishes belonging to the family Carcharhinidae and Carangidae were caught using hook & line. Handlines, gill nets and cast nets were used to catch the fishes coming under the families of Lethrinidae and Lutjanidae. Seine nets were used to catch belonids.

Discussion

The fish diversity in Chetlat was studied using visual examination and descriptive statistics. Tuna, needle fish, sword fish, wahoo, trevally, grouper, sharks, dolphin fish, half beak, sailfish, red snapper, marlins, unicorn fish, emperor fish, goat fish, sting ray, carangids, and perches were among the most common landings in the study area. Scombridae constituted the major catch out of the fishes sampled. The islanders' major source of income is tuna fishing, which takes place for roughly six months, from October to April and forms the major resource (Vinay et al. 2017). Tunas are highly migratory, effective epipelagic predators found more prevalent in the Indian exclusive economic zone's oceanic island regions, particularly Lakshadweep (Kumar et al. 2020). Among the fishes identified, *Alopias pelagicus* (pelagic thresher) constitutes the only fish coming under endangered category as per IUCN status. The pelagic thresher is abundantly captured in gill nets and longlines, and is especially abundant in tuna fisheries. It has been found that intense exploitation would be unsustainable considering the pelagic thresher's vulnerability (Camhi 2008). *Carcharhinus limbatus* and *Scoliodon laticaudus* belong to the 'Near Threatened' category possibly due to the recent population decline documented across its range and hence there is a pressing need for monitoring and regulation (Antony et al. 2014; Smart et al. 2017; Haque et al. 2019). Unsustainable development activities, a rise in human population, overexploitation, and climate change substantially influences the biodiversity of the island (KSCSTE 2013). Overexploitation of these species for food is a primary concern, which has resulted in dramatic population decrease. Anthropogenic interventions have disastrous consequences for island biodiversity. Therefore, conservationists and policymakers must pay close attention (Bijukumar et al. 2015). In 2020, 164,000 tonnes of fishes were landed in Lakshadweep, a 28 percent decrease from the previous year (of 22,929 tonnes) following the same trend of decline as in the preceding year 2018–2019 (CMFRI 2019; 2020). This could be attributed by the improper management and overexploitation of fishery resources. Understanding a region's fish diversity is regarded as critical not only for management but also for conservation and sustainable utilization of fishery resources (Nihal et al. 2021). Proper utilisation of fish discards at the landing centre for fish meal and fertilizer production purposes would prevent the depletion of such resources in the near future. Insular ecosystem rich in endemism is more susceptible to species depletion due to its small population being restricted to live in specific habitats (Andrades et al. 2018). Previous studies on the conservation status of fishes are scanty in Lakshadweep, particularly in Chetlat Island. Covid scenario might be also considered as a reason for the reduction in fish catch correlated

Table 1. List of species recorded from the study area with common name, family and present conservation status.

	Species	Common name	Family	IUCN Red List status
1	*Ablennes hians* (Valenciennes, 1846)	Flat Needlefish	Belonidae	LC
2	*Acanthocybium solandri* (Cuvier, 1832)	Wahoo	Scombridae	LC
3	*Alopias pelagicus* Nakamura, 1935	Pelagic Thresher	Alopiidae	EN
4	*Aprion virescens* Valenciennes, 1830	Green Jobfish	Lutjanidae	LC
5	*Auxis thazard* (Lacepede, 1800)	Frigate Tuna	Scombridae	LC
6	*Belone belone* (Linnaeus, 1760)	Garfish	Belonidae	LC
7	*Caranx ignobilis* (Forsskal, 1775)	Giant Trevally	Carangidae	LC
8	*Carcharhinus limbatus* (Valenciennes, 1839)	Blacktip Shark	Carcharhinidae	NT
9	*Coryphaena hippurus* Linnaeus, 1758	Common Dolphinfish	Coryphaenidae	LC
10	*Elagatis bipinnulata* (Quoy & Gaimard, 1825)	Rainbow Runner	Carangidae	LC
11	*Epinephelus erythrurus* (Valenciennes, 1828)	Cloudy Grouper	Serranidae	LC
12	*Epinephelus fasciatus* (Forsskal, 1775)	Blacktip Grouper	Serranidae	LC
13	*Euthynnus affinis* (Cantor, 1849)	Kawakawa	Scombridae	LC
14	*Exocoetus volitans* Linnaeus, 1758	Tropical Two-wing Flyingfish	Exocoetidae	LC
15	*Gerres microphthalmus* Iwatsuki, Kimura & Yoshino, 2002	Small-eyed Whipfin Mojarra	Gerreidae	NE
16	*Gymnosarda unicolor* (Ruppell, 1836)	Dogtooth Tuna	Scombridae	LC
17	*Hemiramphus far* (Forsskal, 1775)	Black-barred Halfbeak	Hemiramphidae	NE
18	*Istiophorus platypterus* (Shaw, 1792)	Indo-Pacific Sailfish	Istiophoridae	LC
19	*Katsuwonus pelamis* (Linnaeus, 1758)	Skipjack Tuna	Scombridae	LC
20	*Lethrinus lentjan* (Lacepede, 1802)	Pink Ear Emperor	Lethrinidae	LC
21	*Lutjanus bohar* (Forsskal, 1775)	Two-spot Red Snapper	Lutjanidae	LC
22	*Lutjanus gibbus* (Forsskal, 1775)	Humpback Red Snapper	Lutjanidae	LC
23	*Lutjanus rivulatus* (Cuvier, 1828)	Blubberlip Snapper	Lutjanidae	LC
24	*Makaira nigricans* Lacepede, 1802	Blue Marlin	Istiophoridae	VU
25	*Monotaxis heterodon* (Bleeker, 1854)	Redfin Emperor	Lethrinidae	LC
26	*Naso hexacanthus* (Bleeker, 1855)	Sleek Unicornfish	Acanthuridae	LC
27	*Naso tonganus* (Valenciennes, 1835)	Bulbnose unicornfish	Acanthuridae	LC
28	*Neotrygon kuhlii* (Muller & Henle, 1841)	Blue-spotted Stingray	Dasyatidae	DD
29	*Parapercis millepunctata* (Gunther, 1860)	Black-dotted Sand Perch	Pinguipedidae	NE
30	*Parupeneus indicus* (Shaw, 1803)	Indian Goatfish	Mullidae	LC
31	*Parupeneus macronemus* (Lacepede, 1801)	Long-barbel Goatfish	Mullidae	LC
32	*Rhizoprionodon acutus* (Ruppell, 1837)	Milk Shark	Carcharhinidae	VU
33	*Scoliodon laticaudus* Muller & Henle, 1838	Spadenose Shark	Carcharhinidae	NT
34	*Sphyraena jello* Cuvier, 1829	Pickhandle Barracuda	Sphyraenidae	NE in India
35	*Spratelloides delicatulus* (Bennett, 1832)	Delicate Round Herring	Spratelloididae	LC
36	*Spratelloides gracilis* (Temminck & Schlegel, 1846)	Silver-stripe Round Herring	Spratelloididae	LC
37	*Taeniurops meyeni* (Muller & Henle, 1841)	Round Ribbontail Ray	Dasyatidae	VU
38	*Thunnus albacares* (Bonnaterre, 1788)	Yellowfin Tuna	Scombridae	LC
39	*Thunnus obesus* (Lowe, 1839)	Bigeye Tuna	Scombridae	VU
40	*Tylosurus crocodilus* (Peron & Lesueur, 1821)	Hound Needlefish	Belonidae	LC
41	*Xiphias gladius* Linnaeus, 1758	Swordfish	Xiphiidae	LC

EN—Endangered | VU—Vulnerable | NT—Near Threatened | LC—Least Concern | DD—Data Deficient | NE—Not Evaluated.

with the smaller number of fishing days. In light of the above findings, the current study aims to offer a well-documented checklist of major finfishes in Chetlat waters, its diversity, species composition and IUCN status. Conservation and management plans must be developed to ensure the future of island ecosystem. The baseline data on fish distribution and diversity will aid in the design of successful conservation strategies for insular ecosystems such as Chetlat atoll.

Reference

Andrades, R., J.A. Reis-Filho, R.M. Macieira, T.Giarrizzo & J.C. Joyeux (2018). Endemic fish species structuring oceanic intertidal reef assemblages. *Scientific Reports* 8(1): 10791. https://doi.org/10.1038/s41598-018-29088-0

Kumar, K.V.A., K.P. Deepa, M.M.M. Rafeeq, G.S. Renjima, H. Manjebrayakath, B.R. Smitha & M. Sudhakar (2020). Near reef abundance and on–offshore distribution of tuna larvae around Minicoy Island in Lakshadweep Sea, India. *Marine Biology Research* 16(2): 77–92. https://doi.org/10.1080/17451000.2019.1704018

Antoni, L., P.L. Luque, K. Naghshpour & E.A. Saillant (2014). Polymorphic microsatellite markers for the Yellowfin tuna (*Thunnus albacares*). *Conservation Genetics Resources* 6(3): 609–611. https://doi.org/10.1007/s12686-014-0152-5

Bijukumar, A., R. Ravinesh, A.R. Arathi & K.K. Idreesbabu (2015). On the molluscan fauna of Lakshadweep included in various schedules of Wildlife (Protection) Act of India. *Journal of Threatened Taxa* 7(6): 7253–7268. https://doi.org/10.11609/JoTT.o4140.7253-68

Butchart, S.H., A.J. Stattersfield, J. Baillie, L.A. Bennun, S.N. Stuart, H.R. Akçakaya & G.M. Mace (2005). Using Red List Indices to measure progress towards the 2010 target and beyond. *Philosophical Transactions of the Royal Society B: Biological Sciences* 360(1454): 255–268. https://doi.org/10.1098/rstb.2004.1583

Camhi, M. D. (2008). Conservation status of pelagic elasmobranchs, pp. 397–417. In: Camhi, M.D., E.K. Pikitch & E.A. Babcock (eds.). *Sharks of the Open Ocean: Biology, Fisheries and Conservation*. Blackwell Publishing Ltd., 502 pp. https://doi.org/10.1002/9781444302516

Costello, M.J., M. Coll, R. Danovaro, P. Halpin, H. Ojaveer & P. Miloslavich (2010). A census of marine biodiversity knowledge, resources, and future challenges. *PloS one* 5(8): e12110. https://doi.org/10.1371/journal.pone.0012110

CMFRI (2019). CMFRI Annual Report 2018–19. Accessed on 5 December 2021. http://eprints.cmfri.org.in/id/eprint/13922

CMFRI (2020). CMFRI Annual Report 2019–20. Accessed on 5 December 2021. http://eprints.cmfri.org.in/id/eprint/15458

Ebert, D.A. & E. Mostarda (2013). *Identification guide to the deep-sea cartilaginous fishes of the Indian Ocean*. FAO, Rome, 76 pp.

Froese, R. & D. Pauly (2021). Fish Base. Accessed on 12 August 2021. http://www.fishbase.org/identification/classlist.php

Haque, A.B., S.A. Das & A.R. Biswas (2019). DNA analysis of elasmobranch products originating from Bangladesh reveals unregulated elasmobranch fishery and trade on species of global conservation concern. *PloS one* 14(9): e0222273. https://doi.org/10.1371/journal.pone.0222273

Infantina, J.A., R. Jayaraman, T. Umamaheswari, B.S. Viswanatha & L. Ranjith (2016). Governance of marine fisheries in India: Special reference to Tamil Nadu. *Indian Journal of Geo Marine Sciences* 45(10): 1225–1233. http://nopr.niscair.res.in/handle/123456789/35706

IUCN (2017). The IUCN Red List of Threatened Species. Version 2017-3. http://www.iucnredlist.org

Joshi, K.K., M.P. Sreeram, P.U. Zacharia, E.M. Abdussamad, M. Varghese, O.M.M.J.H. Mohammed & M.S. Varsha (2016). Check list of fishes of the Gulf of Mannar ecosystem, Tamil Nadu, India. *Journal of the Marine Biological Association of India* 58(1): 34–54. http://mbai.org.in/php/journaldload.php?id=2386&bkid=115

KSCSTE (2013). State of Environment Report for Lakshadweep. Kerala State Council for Science, Technology and Environment, Thiruvananthapuram, Kerala, 400 pp.

Misra, K.S. (1952). An aid to the identification of fishes of India, Burma and Ceylon. I. Elasmobranchii and Holocephali. *Records of the Indian Museum* 49(1): 89–137.

Nihal, D., N.M. Naseem, A.A. Kasim & M. Prabhakaran (2021). Anthropogenic Interventions in the Coastal Environment–A Serious Threat to Insular Ecosystem in Kadmat Island, Lakshadweep, Southwest Coast of India. *International Journal of Ecology and Environmental Sciences* 47(1): 71–75.

Pimm, S.L., C.N. Jenkins, R. Abell, T.M. Brooks, J.L Gittleman, L.N. Joppa & J.O. Sexton (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science* 344(6187): 1246752. https://doi.org/10.1126/science.1246752

Smart, J.J., A. Chin, A.J. Tobin, W.T. White, B. Kumasi & C.A. Simpfendorfer (2017). Stochastic demographic analyses of the Silvertip Shark (*Carcharhinus albimarginatus*) and the Common Blacktip Shark (*Carcharhinus limbatus*) from the Indo-Pacific. *Fisheries Research* 191: 95–107. https://doi.org/10.1016/j.fishres.2017.03.002

Tripathy, B. (2002). Marine biodiversity of Lakshadweep: An overview. *Kachappa* 7: 14–19.

Vinay, A., V. Ramasubramanian, M. Krishnan, N.R. Kumar & A.E. Ayoob (2017). Economic analysis of tuna pole and line fisheries in Lakshadweep. Indian Journal of Geo Marine Sciences 46(5): 947–957. http://nopr.niscair.res.in/handle/123456789/41663

Vyshnavi, P., A. Samad, N. Venkatesan & E.J. Avital (2020). A review on the energy prospects of Indian remote islands and preliminary assessment of marine current energy potential. *Journal of Physics: Conference Series* 1716(1): 012007.

Worm, B., E.B. Barbier, N. Beaumont, J.E. Duffy, C. Folke, B.S. Halpern & R. Watson (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science* 314(5800): 787–790. https://doi.org/10.1126/science.1132294

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SHORT COMMUNICATION

First report of the termite *Glyptotermes ceylonicus* (Blattodea: Isoptera: Kalotermitidae) from India: an example of discontinuous distribution

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Abstract: We report *Glyptotermes ceylonicus* (Holmgren, 1911), an endemic Sri Lankan termite, for the first time from India. *Glyptotermes* show a high degree of endemism throughout the world. Record of this species from the current location indicates a wide distribution of this species in southern India, in the past, before the complete separation of Sri Lanka from India. The current distribution of *Glyptotermes ceylonicus* is also an example of discontinuous distribution. Pictorial illustrations of the morphologically important parts and revised key for the Indian species are provided.

Keywords: Dichotomous key, diversity, endemism, southern India.

Glyptotermes ceylonicus is a species of damp wood termite endemic to the high elevations of Sri Lanka. Holmgren (1911) described *G. ceylonicus* from Peradeniya, Ceylon. *Glyptotermes* is a highly endemic genus of the family Kalotermitidae. Krishna et al. (2013), reported 456 species from this family, including 127 species of *Glyptotermes.* Two more species were introduced into the genus recently, making a total of 129 *Glyptotermes* species worldwide. In India, eight of the 13 species of *Glyptotermes* species reported are endemic (Thakur et al. 2010; Amina & Rajmohana 2016; Sengupta et al. 2019). Three species of *Glyptotermes—ceylonicus* Holmgren (1911), *dilatatus* (Bugnion & Popoff 1910), and *minutes* Kemner 1932—reported from Sri Lanka are endemic to the area (Sri Lanka). None of the Indian species of *Glyptotermes* were reported from Sri Lanka. Likewise, none of the Sri Lankan species of *Glyptotermes* were reported from India. The total termite species reported from Kerala is 67, which belongs to three families and 30 genera (Mathew & Ipe 2018).

Materials and Methods

Termites were collected from Pinnakkanadu, Kottayam district of Kerala State, located in southern India. The study area is situated between 9.64°N and 76.76°E at an altitude of 97.536 m. The collection was made from the core of a rotten wood of *Hevea brasiliensis* Müll.Arg, 1857, with high moisture content. The periphery of the wood was severely infected with *Heterotermes indicola* (Wasmann, 1902). The specimens were collected using an aspirator and preserved in 80% alcohol. Voucher specimens were deposited in the Zoological Survey of India (ZSI) Western Ghats Regional Centre Specimen Repository with register number ZSI/WGRC/I.R.-INV.17975. Measurements were

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made in 80% alcohol under a stereo zoom microscope, Labomed Luxeo 4D binocular microscope with attached camera and pixel pro software at magnification of 8–35X. Morphological terminology, measurements and indices for describing soldiers, workers and imago follow Roonwal & Chhotani (1989) and Sands (1998). Mandibles, antennae, and labrum of the imago, soldier and worker caste were mounted on a glass slide for examining diagnostic characters. Photographs were taken using Labomed Luxeo 4D binocular microscope with an attached camera.

Systematics

Family Kalotermitidae Froggatt, 1897

Genus *Glyptotermes* Froggatt, 1897

Glyptotermes ceylonicus (Holmgren, 1911)

Materials examined

CMSZMAI-111, Soldier-10, Imago-5, worker-10. 08.10.2018, Pinnakkanadu, Kottayam, Kerala, India, 9.63°N and 76.76°E, 97.536 m, coll. Jobin Mathew.

Diagnosis

Soldier: (Image 1, Table 1). Head-capsule brownish yellow, frons reddish-brown with an inclination angle of about 70°. Labrum and antennae pale yellow. Mandibles black, body and legs straw yellow. Head sparsely and body moderately hairy. Mandibles with short hairs at basal humps. Head-capsule sub-rectangular, length a little less than twice width. Antennae with 12 segments, segment three shortest. Mandibles thick, stout, and short, broadly narrowed at tips. Left mandible with two large and broad marginal teeth. First marginal situated at about one-fourth from the distal tip or closer to tip, second marginal broader and situated medially or just below first postmentum long, club-shaped, widest anteriorly at one fourth, waist long and narrow, minimum width of waist less than half to about half of maximum width.

Imago: (Image 2, Table 2). Head brown, paler in front. Pronotum paler than head. Abdomen brownish above paler below. Wings iridescent, with brownish anterior veins. Head thick, almost quadrately oval. Eyes and ocelli are small, ocelli separated from the eyes by their diameter or a little more. Clypeus short. Antenna 13 segmented, distinctly thickened distally. Segment two is almost as long as three.

Pseudoworker: (Image 3, Table 3). Head-capsule pale yellow, antennae, labrum, legs and body paler. Head and body moderately hairy. Head-capsule subcircular, a little broader than its length to base of mandibles. Eyes

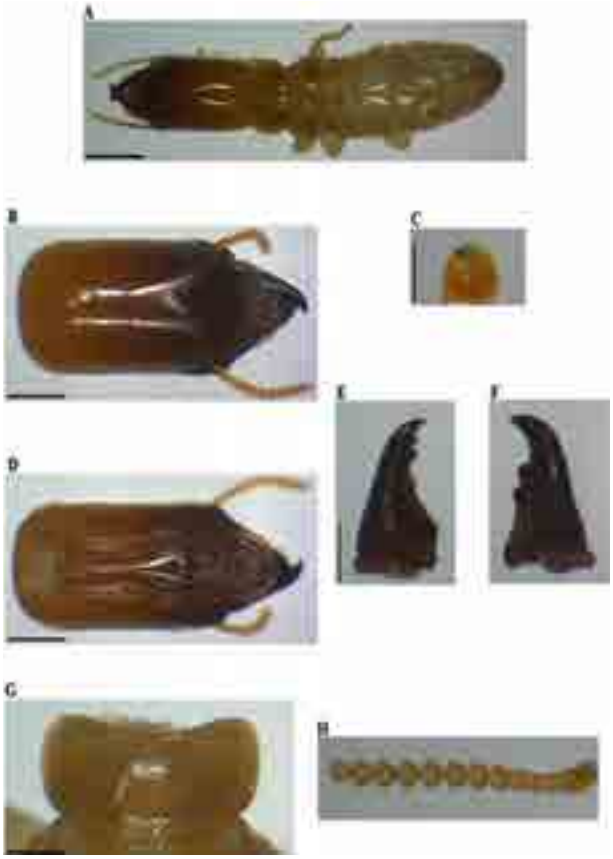

Image 1A–H. *Glyptotermes ceylonicus*: A—Soldier | B—Head dorsal view | C—Labrum | D—Head ventral view showing postmentum | E—Left mandible | F—Right mandible | G—Pronotum | H—Antennae. Scale bars: A—1 mm | B—0.75 mm | C—0.25 mm | D—0.75 mm | E—0.4 mm | F—0.4 mm | G—0.75 mm. © Authors.

translucent and round. Ocelli absent. Antennae with 13 segments, segment three shortest. Labrum broadly tongue-shaped, hairy near anterior margin and on body. Mandibles typically *Glyptotermes*-type.

Biology

Glyptotermes ceylonicus is a rare species in Sri Lanka and India. It is reported from dead, decaying logs and branches of *Hevea, Acacia*, and *Artocarpus integrifolia* Linn.f. 1782. In Sri Lanka, it is found at an altitude between 460–610 m. In India, it is reported at 97.536 m. The nest is in the form of longitudinal galleries. The galleries and chambers contain a small round heap of faecal matter.

Distribution

Sri Lanka: Chilaw, Hewaheta, Elpitiya, Kurunegala, Pasara, and Peradeniya.

India: Kottayam (new record)

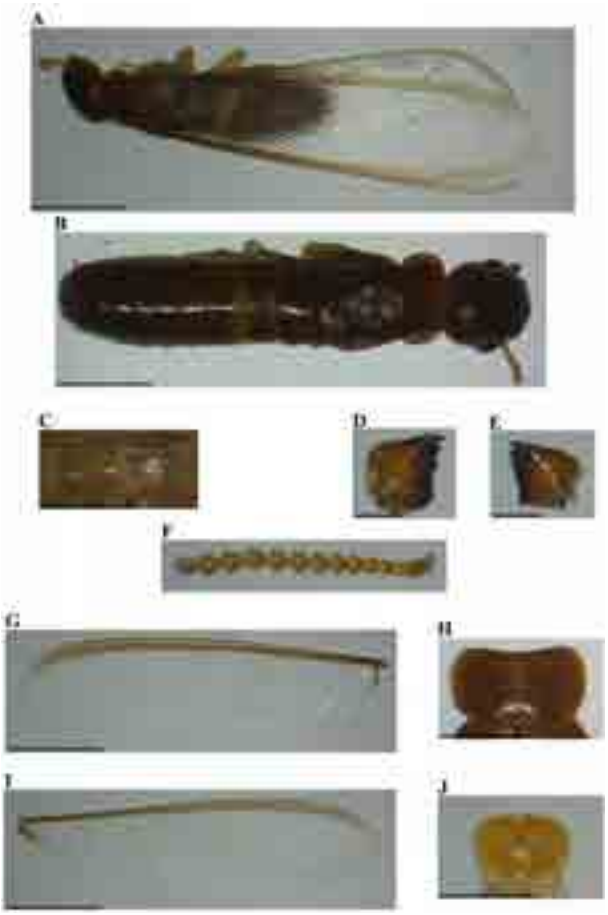

Image 2A–J. *Glyptotermes ceylonicus*: A—Imago with wing | B—Imago without wing | C—postmentum | D—Left mandible | E—Right mandible | F—Antennae | G—Fore wing | H—Pronotum | I—Hind wing | J—Labrum. Scale bars: A—1 mm | B—1 mm | C—0.25 mm | D—0.5 mm | E—0.5 mm | G—2 mm | H—0.75 mm | I—2 mm | J—0.3 mm. © Authors.

Image 3A–F. *Glyptotermes ceylonicus*: A—Worker | B—Pronotum | C—Labrum | D—Antennae | E—Left mandible | F—Right mandible. Scale bars: A—1 mm | B—0.5 mm | C—0.3 mm | E—0.25 mm | F—0.25 mm. © Authors.

Discussion

Kalotermitidae is a monophyletic lineage (Inward et al. 2007); it contains lower termites that evolved during the Cretaceous period. Three species of Kalotermitidae are preserved in Miocene amber from the Dominican Republic, which belong to the living genera *Cryptotermes, Glyptotermes*, and *Incisitermes* (Rohr et al. 1986). The higher distribution and abundance of *Glyptotermes* in the Neotropical (34.2%) and Indo-Malayan (31.5%) regions suggest, the genus had its origin in either of these regions. They got dispersed in the late Jurassic or early Cretaceous to the Australian and Papuan regions and dispersed through the Bering land bridge (Emerson 1952, 1955) or they originated in southern landmass when they were contiguous and dispersed before landmass drifted apart according to Warner's hypothesis (Chhotani 1970). Either of the two theories gives an insight into the reason behind the peculiar distribution.

Studies show that East Gondwana, including India, split from West Gondwana between 165 and 150 million years ago (Krutzsch 1989; McLoughlin 2001; Briggs 2003). The collision of the Deccan plate (comprising India, Sri Lanka, and Seychelles) with Laurasia during the Eocene between 55 and 40 million years ago led to the rise of the Himalayan chain (Partridge 1997; Willis & McElwain 2002). The tropical climate of this region supports the development of the tropical biome in southeastern Asia. Sri Lanka was probably connected to India until 6,000 years ago, with a continuous stretch of tropical rain forest, which permitted the exchange of fauna of these regions. Later, Sri Lanka separated from the Indian mainland due to rise in sea levels (McLoughlin 2001).

Roonwal & Chottani (1989) conducted extensive studies on the termite fauna of the Indian subcontinent and reported 12 species of *Glyptotermes.* Thakur et al. (2010), introduced a new species, *Glyptotermes roonwali,* from northern India. Amina & Rajmohana (2016), introduced a new species, *Glyptotermes chiraharitae,*

Table 1. Measurements of soldier cast of *Glyptotermes ceylonicus*.

Characters	Present study		Roonwal & Chhotani (1989)
	Range	Mean	
Total body Length	7.00–7.3 1	7.15	6.5–10.4
Head Length to the base of mandible	2.11–2.19	2.15	2.67–3.00
Head Width	1.37–1.4	1.38	1.5–1.67
Mandible Length	0.97–1.00	0.98	0.90–1.00
Labrum Length	0.35–0.38	0.36	-
Labrum Width	0.34–0.35	0.345	-
Pronotum Length	1.72–1.75	1.73	-
Pronotum Width	1.32–1.38	1.35	-
Postmentum Length	1.92–1.95	1.93	1.90–2.33
Postmentum Width Maximum	0.49–0.58	0.53	0.5–0.6
Postmentum Width Minimum	0.2–0.23	0.21	0.23
Antenna segments	12	-	12

Table 2. Measurements of imago cast of *Glyptotermes ceylonicus*.

Characters	Present study		Roonwal & Chhotani (1989)
	Range	Mean	
Total Length with wings	8.5–9.63	9.06	8.5–11.0
Total Length without wings	4.8–5.77	5.28	4.7–6.0
Head Length	1.47–1.49	1.48	1.33–1.52
Head Width	1.24–1.29	1.26	1.15–1.30
Labrum Length	0.31–0.33	0.32	-
Labrum Width	0.29–0.31	0.30	-
Pronotum Length	0.61–0.66	0.63	-
Pronotum Width	1.06–1.09	1.07	-
Diameter of the eye	0.27–0.30	0.28	-
Diameter of Ocellus	0.09–0.11	0.10	-
Antenna segments	13	-	13–14

from southern India in 2016, and the presence of two Glyptotermes species were revalidated by Rituparna et al. (2019) in 2019. Currently, a total of 17 *Glyptotermes* species are reported from the Indian region. Earlier it was thought that *Glyptotermes ceylonicus* was restricted to Sri Lanka. This is not a very common species and was earlier reported from Chilaw, Hewaheta, Elpitiya, Kurunegala, Pasara, and Peradeniya at an elevation of 460–610 m (Hemachandra et al. 2012). This species

Table 3. Measurements of pseudo-worker cast of *Glyptotermes ceylonicus*.

Characters	Present study		Roonwal & Chhotani (1989)
	Range	Mean	
Total body Length	7.94–8.6	7.15	7.9–8.6
Head Length to the base of mandible	1.30–1.42	1.36	1.40
Head Width	1.45–1.5	1.47	1.5
Labrum Length	0.46–0.48	0.47	0.47
Labrum Width	0.39–0.42	0.40	0.43
Pronotum Length	0.57–0.62	0.59	-
Pronotum Width	1.09–1.14	1.11	-
Antenna segments	13	-	13

prefers to feed on dead, decaying logs and branches of *Hevea, Acacia*, and *Artocarpus integrifolia* with high water content (Roonwal & Chhotani 1989). Through the present study, we report *Glyptotermes ceylonicus* for the first time in India. The population is found in the western part of Western Ghats, 500 km (aerial distance) away from the currently known location, at an elevation of 97.536 m. The species may have been widely distributed in southern India before the separation of Sri Lanka from India. Invasion through traded goods is thin because artificial transport of this rare species is difficult (Chhotani 1970). These family of termites are obscure in nature, except *Paraneotermes simplicicornis*, which exclusively dwells in woody structures (Thakur et al. 2010), resulting in under-exploration. Another reason for the absence of this species from the area between Sri Lanka and current location might be due to the extinction in the intermediate areas due to the influence of anthropogenic factors (Basu et al. 1996). Amina et al. (2013) reported Sri Lankan termite *Hospitalitermes monoceros* (Konig, 1779) from Chinnar Wildlife Sanctuary, Western Ghats, Kerala. This also supports our view that many termites are distributed in southern India and Sri Lanka and later dwindled to narrow geographical areas. The present documentation of *Glyptotermes ceylonicus* is an example of discontinuous distribution.

References

Amina, P. & K. Rajmohana (2016). *Glyptotermes chiraharitae* n. sp., a new dampwood termite species (Isoptera: Kalotermitidae) from India. *Zoosystema* 38(3): 309–316. https://doi.org/10.5252/z2016n3a2

Amina, P., K. Rajmohana, C. Bijoy, C. Radhakrishnan & N. Saha (2013). First record of the Srilankan Processional Termite, *Hospitalitermes monoceros* (Konig) (Termitidae: Nasutitermitinae) from India. *Halteres* 4: 48–52.

Revised key to the indian species of *Glyptotermes* (based on soldier caste)
(Froggatt 1897; Thakur et al. 2010; Amina & Rajmohana 2016; Rituparna et al. 2019)

1. Large species; frons sharply inclined in front at an angle of more than 65° 2
— Small species; frons gradually inclined in front at an angle of 45–50 ° 5

2. Head much longer (1.7–1.85 times) than wide, left mandible with four marginal teeth 3
— Head not much longer (a little more than 1.5 times) than wide left mandible with three marginal teeth 4

3. Head length to base of mandible 3.20–3.50 mm, head width 1.90–2.05 mm). Antennae 14–15 segmented; mandibles long (1.48–1.58 mm) ..... *Glyptotermes tikaderi* Chhotani & Bose, 1985
— Head length to base of mandibles 2.67–3.00 mm, headwidth 1.50–1.67 mm; antennae 12-segmented; mandibles shorter (0.90–1.00 mm) ..... *G. ceylonicus* (Holmgren, 1911)

4. Antennae 14 segmented; labrum subsquare, broader than long; postmentum long (1.78 mm), waist much narrower, postmentum contraction index 0.42; small species ..... *G. taruni* Bose, 1999
— Antennae 12 segmented; labrum tongue shaped, longer than wide; postmentum not much long (1.48–1.70 mm), waist comparatively wider, postmentum contraction index 0.47–0.52; large species ..... *G. chiraharitae* Amina & Rajmohana, 2016

5. Head capsule large and wide (head length to base of mandibles 1.93–2.27 mm, head width 1.25–1.40 mm); antennae 12–14 segmented ..... *G. teknafensis* Akhtar, 1975
— Head capsule small and narrow (head length to base of mandibles 1.18–1.73 mm, head width 0.88–1.20 mm); antennae 8–12 segmented 6

6. Head width less than 1.00 mm 7
— Head width more than 1.00 mm 10

7. Ocelli absent; antennae 10–11 segmented ..... *G. ukhiaensis* Akhtar, 1975
— Ocelli present; antennae 8–12 segmented 8

8. Epicranial suture faintly visible; antennae 9–10 segmented ..... *G. caudomunitus* Kemner, 1932
— Epicranial suture distinct; antennae 8–12 segmented 9

9. Mandibles basally bumped at outer margins; antennae 8–10 segmented ..... *G. tripurensis* Thakur, 1975
— Mandibles with a weak basal bump; antennae 11–12 segmented ..... *G. roonwali* Thakur et al. 2010

10. Antero-lateral corners of head sharply pointed in font 11
— Antero-lateral corners of head rounded and not pointed in font 13

11. Mandibles with prominent basal hump; antennae 9–11 segmented ..... *G. coorgensis* (Holmgren & Holmgren, 1917)
— Mandibles with weaker basal humps; antennae 11–12 segmented 12

12. Margin between 2nd and 3rd marginal teeth of left mandible not sharp and roundly incurved; postmentum narrow at waist (width at waist 0.16–0.20 mm) ..... *G. sensarmai* Maiti, 1976
— Margin between 2nd and 3rd marginal teeth of left mandible, not continuous, but with angular cutting edges; postmentum comparatively wider at waist (0.19–0.29 mm) ..... *G. brevicaudatus* Haviland, 1898

13. Head comparatively wide (head width index 0.67–0.77); epicranial suture incomplete; postmentum wide (maximum width of postmentum 0.40–0.43 mm) ..... *G. almorensis* Gardner, 1945
— Head comparatively narrow (head width index 0.59–0.66); epicranial suture complete; postmentum narrow (maximum width of postmentum 0.30–0.37 mm) ..... *G. nicobarensis* Maiti & Chakraborty, 1981

Basu, P., E. Blanchart & M. Lepage (1996). Termite (Isoptera) community in the Western Ghats, South India: influence of anthropogenic disturbance of natural vegetation. *European Journal of Soil Biology* 32(3): 113–21.

Briggs, J.C. (2003). The biogeographic and tectonic history of India. *Journal of Biogeography* 30: 381–388. https://doi.org/10.1046/j.1365-2699.2003.00809.x

Chhotani, O.B. (1970). Revision of the genus Glyptotermes Froggatt (Kalotermitidae, Isoptera, Insecta) from the Indian Region. *Records of the Zoological Survey of India* 68(1/4): 109–159.

Emerson, **A.E. (1952)**. The Neotropical genera *Procornitermes* and *Cornitermes* (Isoptera, Termitidae). *Bulletin of the American Museum of Natural History* 99(8): 475–539.

Emerson, A.E. (1955). Geographical origins and dispersions of termite genera. *Fieldiana: Zoology* 37: 465–521. https://doi.org/10.5962/bhl.title.2783

Froggatt W.W. (1897). Australian Termitidae. Part II. *Proceedings of the Linnean Society of New South Wales* 21: 510–552. https://doi.org/10.5962/bhl.part.8483

Hemachandra, I.I., J.P. Edirisinghe, W.A.I.P.A. Karunaratne & C.V.S. Gunetilleke (2012). An annotated checklist of termites (Isoptera) of Sri Lanka.MAB Checklist and Handbook Series Publication No. 24. National Science Foundation of Sri Lanka, Colombo, 29 pp.

Holmgren, N. (1911). Ceylon-Termite gesammelt von Prof. K. Escherisch, nebste iner synoptischen tibersicht tiber alle bisjetzt von Ceylon und den angrenzenden Festland bekannten Termitenarten, pp. 183–212. In: *Termiten lebena Uf Ceylon, u.s. w.* (by K. Escherisch). Systematischer Anhang: Termiten und Termitophilen von Ceylon.

Inward, D. J., A.P. Vogler & P. Eggleton (2007). A comprehensive phylogenetic analysis of termites (Isoptera) illuminates key aspects of their evolutionary biology. *Molecular phylogenetics and evolution* 44(3): 953–967.

Krishna, K., D.A. Grimaldi, V. Krishna & M.S. Engel (2013).Treatise on the Isoptera of the world. *Bulletin of the American Museum of Natural History* B377(1): 2282–2310. https://digitallibrary.amnh.org/handle/2246/6430

Krutzsch, W. (1989). Paleogeography and historical phytogeography (paleochorology) in the Neophyticum. *Plant Systematics and*

Evolution 162: 5–61. https://doi.org/10.1007/BF00936909

Mathew, J. & C. Ipe (2018). New species of termite *Pericapritermes travancorensis* sp. nov. (Isoptera: Termitidae: Termitinae) from India. *Journal of Threatened Taxa* 10(11): 12582–12588. https://doi.org/10.11609/jott.3389.10.11.12582-12588

Mcloughlin, S. (2001). The breakup history of Gondwana and its impact on pre-Cenozoic floristic provincialism. *Australian Journal of Botany* 48: 271–300. https://doi.org/10.1071/BT00023

Partridge, T.C. (1997). Late Neogene uplift in eastern and southern Africa and its paleoclimatic implications, pp. 63–86. In: Ruddiman, W.F. (eds.). *Tectonic Uplift and Climate Change*. Springer, Boston, xxi+535 pp. https://doi.org/10.1007/978-1-4615-5935-1_4

Rohr, D.M., J. Boucot, A.J. Miller & M. Abbott (1986). Oldest termite nest from the Upper Cretaceous of west Texas. *Geology (Boulder)* 14(1): 87–88. https://doi.org/10.1130/0091-7613(1986)14<87:OTNFTU>2.0.CO;2

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

Sands, W.A. (1998). *The Identification of Worker Castes of Termite Genera from Soils of Africa and the Middle East*. CAB International, Wallingford, 500 pp. https://doi.org/10.1017/S0007485399000413

Sengupta, R., K. Rajmohana, A. Poovoli, J. Basak & B. Baraik (2019). Revalidation of the presence of Glyptotermes brevicaudatus (Haviland) and Glyptotermes caudomunitus Kemner in India (Isoptera: Kalotermitidae). *Oriental Insects* 53(4): 588–598.

Thakur, R.K., T. Vivek & K. Sachin (2010). Glyptotermes roonwali (Isoptera: Kalotermitidae), a new species from India. *Entomon* 35(2): 111–119.

Wasmann, E. (1902). Termiten, Termitophilen und Myrmekophilen, gesammelt auf Ceylon von Dr W Horn, 1899, mitandernostindischen Material bearbeitet. Beitragezur Kenntnis der Myrmekophilen und der Termitophilen. *Zoologische Jahrbücher (Syst.)* 17(1): 99–164.

Willis, J.K. & J.C. Mcelwain (2002). The evolution of plants. *Annals of Botany* 90(5): 678–679. https://doi.org/10.1093/aob/mcf232

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SHORT COMMUNICATION

Authentic report of the emesine bug *Gardena melinarthrum* Dohrn, 1860 (Hemiptera: Heteroptera: Reduviidae) from India

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Abstract: An emesine bug, *Gardena melinarthrum* Dohrn, 1860, is reported from two areas in India—Kerala and Assam. Both, macropterous and apterous forms are found in India. This is the first illustrated report of this assassin bug from India.

Keywords: Assam, assassin bug, Emesinae, Emesini, Kerala, species distribution.

Two macropterous males collected from Kerala and one apterous female of thread-legged bug (Emesinae), collected from Assam (Guwahati), were identified as *Gardena melinarthrum* Dohrn, 1860 based on the identification keys in Wygodzinsky (1966). *Gardena melinarthrum* is the type species of the genus *Gardena* Dohrn, 1860 by monotypy (Capriles 1990). Wygodzinsky (1966) provided the taxonomic account with numerous line drawings of the diagnostic characters, along with information on the distribution of the species. Capriles (1990) also listed this species and its synonyms.

Dohrn (1860) described *Gardena melinarthrum* from an apterous specimen collected in Ceylon (=Sri Lanka). McAtee & Malloch (1926) reported the species from the Philippines by describing a new form as *Gardena melinarthrum* var. *femoralis* McAtee & Malloch, 1926 and simultaneously also synonymized Dohrn's another species, *Gardena semperi* Dohrn, 1863 as a winged male of *G. melinarthrum*. Wygodzinsky (1966) illustrated brachypterous form known from other localities (e.g., Taiwan, Philippines, Java, Australia) and synonymized *G. m. femoralis* with *G. melinarthrum*. Ishikawa (2005) provided a brief redescription, supplemented with photographs of the species (including macropterous form, from Japan), along with illustrations of diagnostic characters, distribution records and synonyms; according to this paper, *G. melinarthrum* is distributed in Japan, Taiwan, China, Sri Lanka, the Philippines, Indonesia, Malaysia, and Australia. Recently, Rédei & Tsai (2010) have also provided information on diagnosis and distribution of this species. None of the above cited papers mention India as a locality for this species. Though original descriptions of the species are available (Dohrn 1860), the whereabouts of the type material collected from Sri Lanka remain unknown, as per Wygodzinsky (1966).

Wygodzinsky (1966) provided a detailed description

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of the genus *Gardena* as well as of the tribe Emesini to which it belongs; he further divided this genus into four species groups, the *melinarthrum*, *brevicollis*, *longimana*, and *pipara* groups, based on morphology of fore legs (especially the extent of spineless portion of fore femur) and the characters of male genitalia. *Gardena melinarthrum* obviously belongs to the nominotypical group. Members of the *melinarthrum* group show a length variation from 18.5 mm to 25.0 mm (Wygodzinsky 1966).

Ambrose (2006) published a checklist of Reduviidae of India but did not include this species; subsequently, Mukherjee & Saha (2017) published a paper claiming that they were presenting the first record of *G. melinarthrum* from West Bengal, India. However, Mukherjee & Saha (2017) mentioned the size of their apterous specimens to be: male 10 mm and female 15.37 mm. Based on the body size alone it appears that the specimens reported by Mukherjee & Saha (2017) belong to another species. In addition, the fore tibia in *G. melinarthrum* is less than half the length of fore femur, while, Mukherjee & Saha's image (their Fig. 3) shows a much longer fore tibia (the lengths provided by the authors are: fore femur 2.80 mm and fore tibia 1.68 mm (implying that the tibia is longer than half length of femur); in addition, the first long spine of posteroventral series of fore femur also seems closer to the base of femur (unlike what is observed in true *G. melinarthrum*). In any case, male genitalia of the specimen reported by Mukherjee & Saha (2017) must be studied to resolve the identity issue; hence, till such a time the previous record of *G. melinarthrum* from West Bengal, India must be considered doubtful. Thus, it is imperative to state that there is no reliable previous record of *G. melinarthrum* from India, although the finding of a Sri Lankan species in India is always likely, as mentioned earlier (Sarode et al. 2018).

In this work we are presenting morphological details along with the illustrations of macropterous male (based on two specimens), and one apterous form. Since diagnostic characters of the genus as well this species, along with illustrations are already provided by the earlier authors cited above, we are only giving photographic illustrations and relevant characters as a brief redescription here.

Reduviidae, Emesinae, Emesini.
***Gardena* Dohrn, 1860**
***Gardena melinarthrum* Dohrn, 1860, p. 214.**
***Gardena semperi* Dohrn, 1863, p. 64**
***Gardena melinarthrum* var. *femoralis* McAtee & Malloch, 1925, p. 136.**

Winged form from Kerala:

Colouration and vestiture: Overall colour reddish brown in dorsal aspect, posterior lobe of pronotum and distal half of abdomen darker (Image 1A,B; Image 2A). Head dark brown, slightly darker ventrally and covered by short, grey adpressed setae all over, a distinct shining 'V' mark in front of transverse sulcus is devoid of setae; all antennal segments dark brown, III and IV antennomeres appearing pale because of dense grey setae. First two antennomeres with long, erect but sparsely distributed grey setae. Eyes black; labium pale brown (Image 2B,C). Overall legs brown; fore coxae slightly darker than fore femora. In fore femora spiniform processes of postero-ventral series with pale bases and black spines while antero-ventral series consists of thin black setae. Mid and hind femora brown but blackish-brown sub apically, apex cream. Mid and hind tibiae brown but with basal cream area followed by dark brown area. Tarsal segments dark brown and hairy. Both mid and hind femora as well as tibia covered with fine, greyish microchaetae with only a few macrochaetae. Fore and hind wings pale brown; prosternum pale brown, meso and metasternum dark brown to black (Image 3D; Image 4 A,B). Mid and hind coxae and trochanters dark brown, shining due to sparse setae. Meso and meta sternum are dull because of dense cover of grey setae. Prosternum

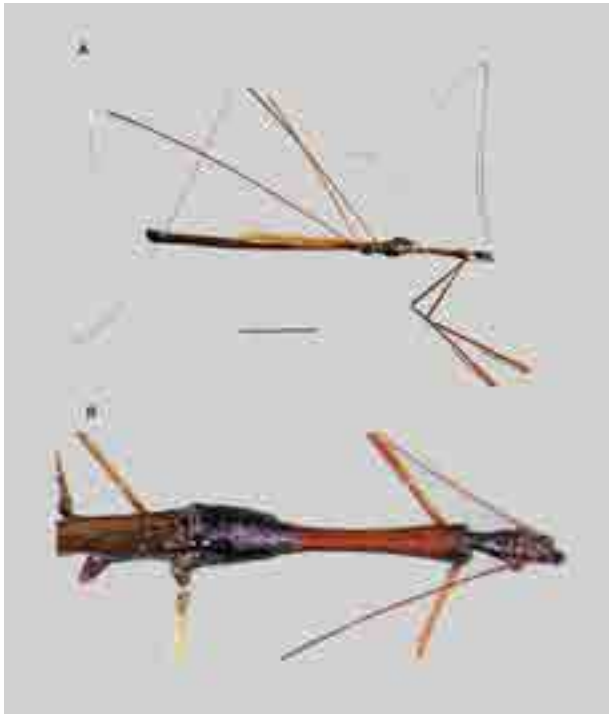

Image 1. *Gardena melinarthrum* from Kerala: A—lateral view (scale 5 mm) | B—dorsal view, anterior half. © H.V. Ghate.

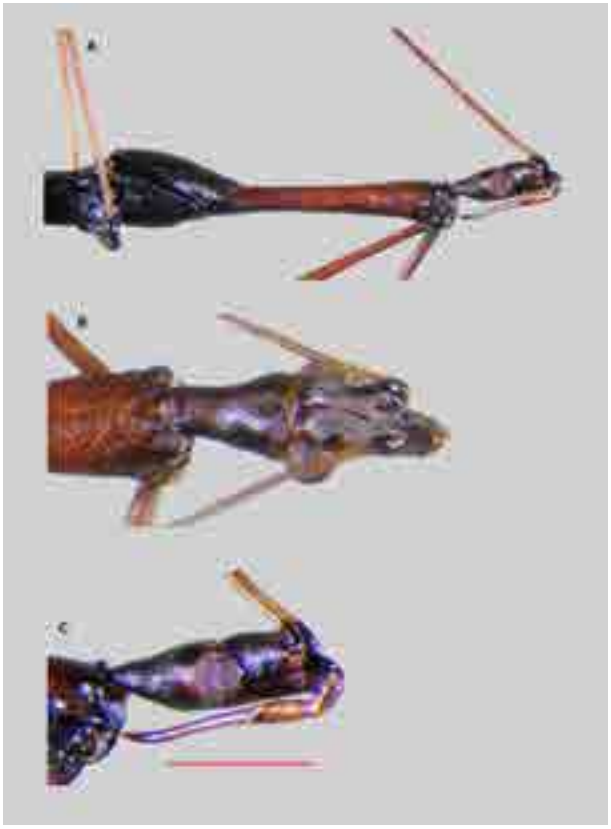

Image 2. *Gardena melinarthrum* from Kerala, male: A—anterior half in lateral view | B—head, dorsal view; C—head, lateral view. © H.V. Ghate.

Image 3. *Gardena melinarthrum* from Kerala, male: A & B—pronotum anterior and posterior lobe, respectively, in dorsal view | C—forewing | D—head and thorax, ventral view. © H.V. Ghate.

also has moderately dense cover of very fine setae, hence there is mild shining (Image 3D). Fore legs more setose than mid and hind legs.

Dorsally, abdomen dark brown along entire length, all abdominal tergites finely sculptured, with fine setae. Abdomen ventrally dark brown to black, sub shining from fifth segment to pygophore, whereas segments two to four dull; setae on pygophore slightly longer. Spiracles slightly elevated, their rims shining. Connexivum of moderate width, pale brown in anterior half and dark brown in posterior half.

Structure: Head elongate, fusiform, anteocular slightly longer than postocular (without neck). Eyes globular, of moderate size, occupying one third of head length, lower margin of eye not reaching ventral margin of head; transverse sulcus more or less straight not passing beyond posterior margin of eye. Anteocular part with distinct, short, median sulcus that ends at tip of 'V' like shining area. Antenniferrous tubercles situated nearly in middle of anteocular area. Clypeus and mandibular plates slightly sloping. Labium bent between visible segments I and II, visible segment I very short, visible segment III longest. Postocular part of head distinctly narrowed in to neck (Image 2B,C; Image 4A).

Thorax with long pronotum; anterior lobe of pronotum much longer than posterior lobe and distinctly narrowed posteriorly, with a median shallow longitudinal depression, its surface sparsely granular (Image 1B, Image 2A; Image 3A); posterior lobe situated at an angle and about twice as wide as middle of anterior lobe, distinctly rugulose, sub shining, with humeral angles slightly elevated and button-like (Image 3B). Scutellum and metanotum without spines. Prosternum with its posterior margin round. Mesosternum rectangular, with a slight depression in distal part. Metasternum narrower than mesosternum, with an indistinct carina in between coxae (Image 3D; Image 4B). Fore and hind wings short, reaching only posterior border of fourth abdominal segment (Image 1). Both wings narrow and elongate; forewing with typical venation (Image 3C).

Fore legs extremely slender, coxae more than half

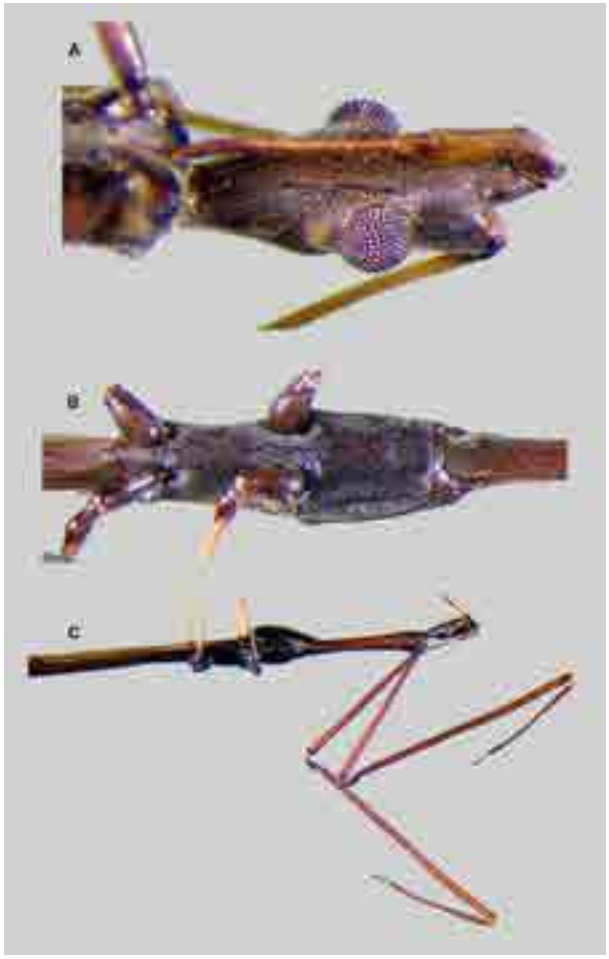

Image 4. *Gardena melinarthrum* from Kerala, male: A—head, ventral view | B—meso- and metasternum | C—anterior half with fore legs, lateral view. © H.V. Ghate.

as long as femur, while tibia less than half as long as femur (Image 4C). Femur with postero-ventral series of spines that begins at about one third length of femur from base, first femoral spiniform process about 0.27 mm long (including basal tubercle) and its distance from base of femur 2.75 mm (i.e., the first spine is situated at about 10 times the length of the first spiniform process itself) (Image 5A). There are 12 long spiniform processes each with pale base and black spine. Extreme apical region there with only small black denticles; antero-ventral series composed of very fine setae without any conspicuous base. Fore tibia with long setae underneath, interspersed with short black and blunt denticles (Image 5B). Hind femora passing tip of abdomen (see Image 1A).

Abdomen narrow, parallel sided; connexivum narrow. Seventh tergite narrowed posteriorly, tongue shaped, set at an angle from body and nearly covering pygophore from dorsal side; eighth sternite partly visible laterally (Image 5C). Pygophore (detached) cup like, laterally

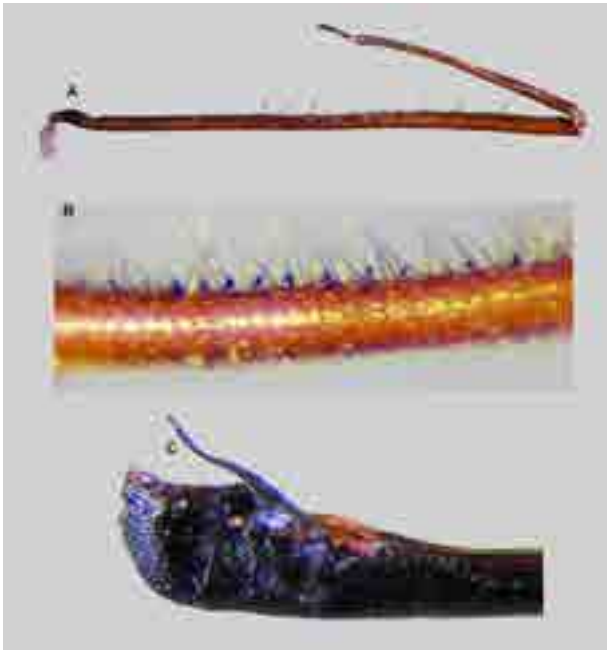

Image 5. *Gardena melinarthrum* from Kerala, male: A—fore leg details | B—fore tibia showing black tubercles and setae on under surface | C—pygophore in situ, lateral view. © H.V. Ghate.

slightly compressed, with distinct posterosuperior spine and two moderately broad parameres, visible laterally on each side (Image 6A,B). Parameres as in Image 6E. Phallus symmetrical, with short but stout articulatory apparatus, basal plate struts fused into a sclerite. Phallotheca with moderately sclerotized areas ventrolaterally (Image 6C); endosoma with two elongate processes bearing numerous spiny projections (Image 6D).

Material examined: Two winged males from Kerala and one apterous female from Guwahati, Assam. Preserved at Modern College at present.

Measurements (in mm): Males from Kerala (leg. S. Hiremath, 10 May 2018, loc. Vellayani) (n = 2): total body length 24.0/23.0. Total length of head 1.75/1.75, length of anteocular part 0.50/0.45, of postocular part 0.50/0.50, eye diameter 0.37/0.37. Antenna: length of segment I 14.0/14.0, of segment II 11.5/11.4, of segment III 0.50/0.50, of segment IV 2.70/NA. Labium: Length of visible segment I 0.18/0.20, of visible segment II 0.56/0.55, of visible segment III 1.1/1.0. Length of anterior lobe of pronotum 3.13/3.15, of posterior lobe 2.0/2.0. Length of fore coxa 4.5/4.5, of fore femur 7.0/6.95, of fore tibia 3.4/3.20, of fore tarsus 0.60/0.50; of mid coxa 0.60/0.60, of mid femur 15.0/15.0, of mid tibia 21.0/20.0, of mid tarsus with claw 0.50/0.50; of hind coxa 0.60 /0.58, hind femur 25.0/- hind tibia -/-, hind tarsus with claw -/-. Forewing 10.0/10.0.

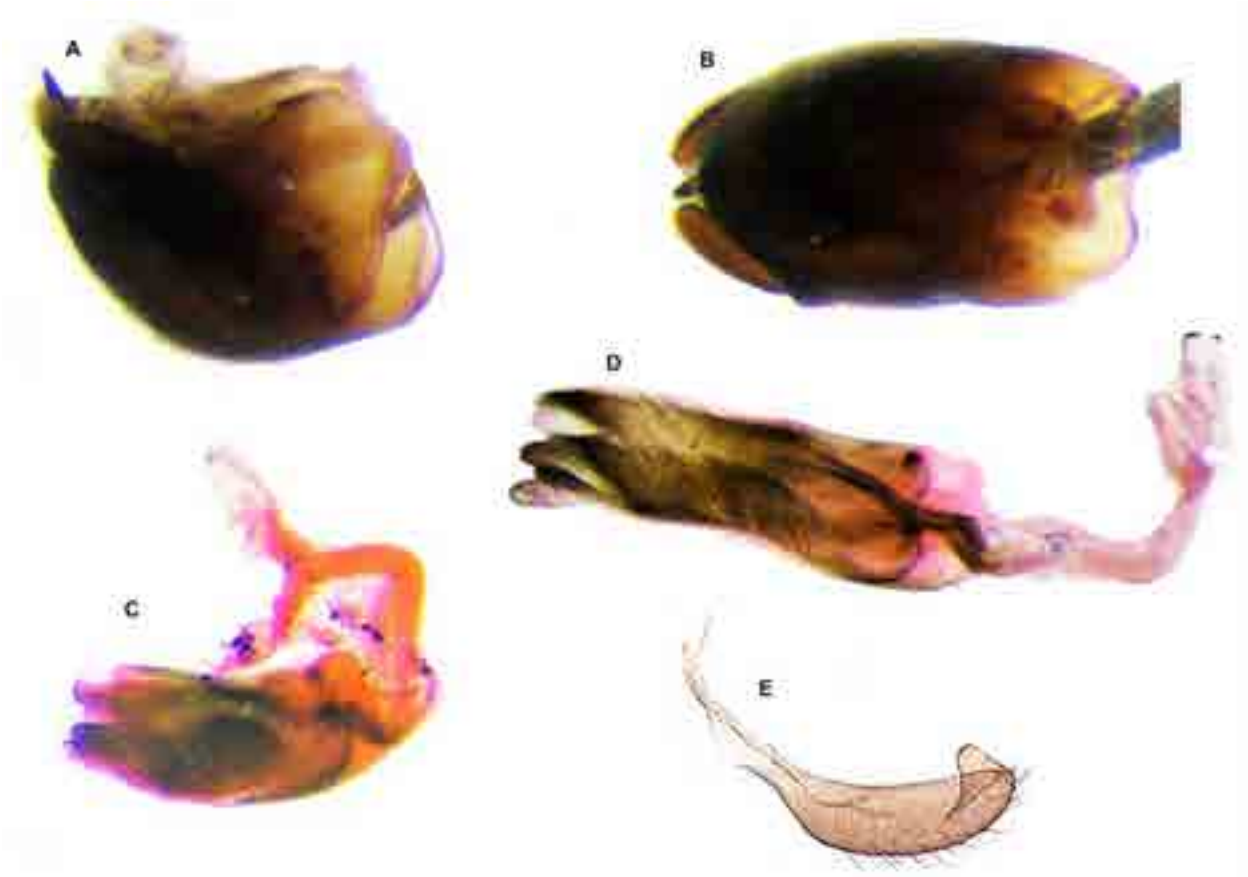

Image 6. *Gardena melinarthrum* from Kerala, male: A & B—pygophore in lateral and dorsal view, respectively | C & D—phallus in repose and everted | E—Paramere. © H.V. Ghate.

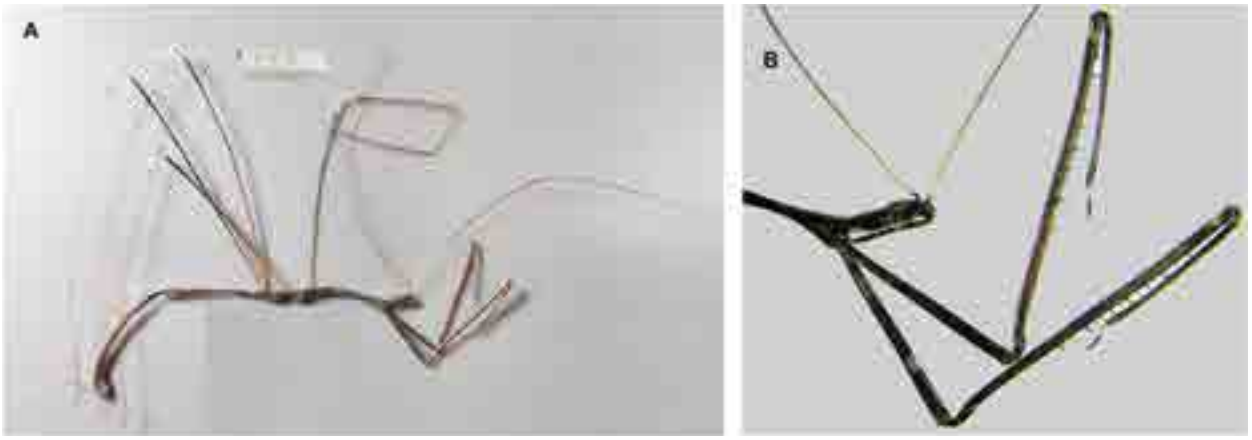

Image 7. *Gardena melinarthrum* from Assam, female: A—Lateral view | B—anterior part in lateral view, details of fore legs. © Santanta Saikia.

Apterous female: The apterous female from Assam (leg. S. Saikia, Morigaon District, 17 March 2020) is 25 mm in length. Other measurements are quite comparable to that of macropterous male given above, as seen from the Image 7A. The specimen was damaged in transit so genitalia preparation was not possible and so those photographs are not included. Close up of anterior half (Image 7B) again shows elongate head, bent labium and slender fore legs. Note the distance of first femoral spiniform process from the base which is a diagnostic character.

General morphology, except for thoracic region,

is similar to winged form; pronotum is longer than meso and meta notum put together; posterior lobe of pronotum very short, not covering mesonotum. The fore legs are very slender, the femoral posteroventral series of spiniform setae starts away from the base (at one third length) of the femur itself, fore tibia are slightly less than one-half length of fore femur. Fore femur has preapical pale spot (mentioned in var. *femoralis* by McAtee & Malloch 1926), which is absent in winged form.

Discussion

Gardena melinarthrum is evidently a widely distributed species. Wygodzinsky (1966) gives distribution as "Oriental and Australian regions, from Ceylon (Sri Lanka; type locality) to Formosa (Taiwan) and Australia". Its presence in India is therefore not surprising, even then, it has not been authentically documented before, with a series of illustrations of the diagnostic characters, as we have done here. It has already been pointed out that the report of this species by Mukherjee & Saha (2017) is likely to be a misidentification; it is clear from the measurements given by them, as well as the image that shows posteroventral series of spines beginning before one third length of the femur itself (i.e., the first process is closer to the base than is known for *G. melinarthrum*). These aspects were previously discussed while reporting *Gardena brevicollis* Stål, 1871 from India (Sarode et al. 2018). The apterous form which we have from Assam is about 25 mm and shows all the diagnostic characters of *G. melinarthrum.* It is interesting, at this juncture, to note that this species has not been reported from Sri Lanka in more than 150 years, i.e., since its original description by Dohrn (Ranasinghe & Ghate 2022).

Wygodzinsky (1966) illustrated diagnostic features of this species, however, a redescription was not provided. Ishikawa (2005) presented an excellent comparative account of five species of *Gardena* that occur in Japan, two of those being new species; he also included diagnostic characters and details of the male and female genitalia and revised the key to the Japanese species of *Gardena* (the key includes *G. melinarthrum, G. muscicapa* (Bergroth, 1906) and *G. brevicollis*, that occur in India).

Ambrose (2006) had listed only *Gardena muscicapa* to be present in India; with the present report, and the already reported *G. brevicollis* (Sarode et al. 2018), the number of *Gardena* species known from India becomes three.

Much remains to be done about the Indian Emesinae and more thorough surveys need be conducted to know about the distribution and biology of the existing species and to check for possibilities of new species or new records.

References

Ambrose, D.P. (2006). A checklist of Indian assassin bugs (Insects: Heteroptera: Reduviidae) with taxonomic status, distribution and diagnostic morphological characteristics. *Zoos' Print Journal* 21(9): 2388–2406. [With a separate supplement that gives checklist of species, etc.]. https://doi.org/10.11609/JoTT.ZPJ.871.2388-406

Capriles, J.M. (1990). *Systematic Catalogue of the Reduviidae of the World (Insecta: Heteroptera).* Caribbean Journal of Science. Special publication No 1. University of Puerto Rico, Mayagüez, 694 pp.

Dohrn, A. (1860). Beiträge zu einer monographischen Bearbeitung der Familie der Emesina. *Linnaea Entomologica* 14: 206–255.

Dohrn, A. (1863). Beiträge zu einer monographischen Bearbeitung der Familie der Emesina (Zweites Stuck). *Linnaea Entomologica* 15: 42–76.

Ishikawa, T. (2005). The thread-legged assassin bug genus *Gardena* (Heteroptera: Reduviidae) from Japan. *Tijdschrift voor Entomologie* 148: 209–224.

McAtee, W.L. & J.R. Malloch (1926). Philippine and Malayan Ploiariinae (Hemiptera, Reduviidae). *Philippine Journal of Science* 30(1): 117–152.

Mukherjee, P. & G.K. Saha (2017). First record of *Gardena melinarthrum* Dohrn (Heteroptera: Reduviidae: Emesinae) from India. *Munis Entomology & Zoology* 12(1): 254–257**.**

Ranasinghe, T. & H.V. Ghate (2022). On the rediscovery of *Gardena melinarthrum* Dohrn from Sri Lanka. *Journal of Threatened Taxa* 14(6): 21318–21320. https://doi.org/10.11609/jott.8052.14.6.21318-21320

Rédei, D. & J.F. Tsai (2010). A survey of the emesine assassin bugs of the tribes Collartidini, Leistarchini, Emesini, and Metapterini of Taiwan (Hemiptera, Heteroptera, Reduviidae). *Deutsche Entomologische Zeitschrift* 57(1): 11–36.

Sarode, B.V., S.S. Boyane & H.V. Ghate (2018). The first report of two thread legged assassin bugs (Heteroptera: Reduviidae: Emesinae) from India. *Journal of Threatened Taxa* 10(5): 11659–11664. https://doi.org/10.11609/jott.3971.10.5.11659-11664

Wygodzinsky, P.W. (1966). A monograph of the Emesinae (Reduviidae, Hemiptera). *Bulletin of the American Museum of Natural History* 133: 1–614

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SHORT COMMUNICATION

Reappearance of stomatopod *Gonodactylus platysoma* (Wood-Mason, 1895) after an era from the intertidal region of Chota Balu, South Andaman, India

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Abstract: Mantis shrimp *Gonodactylus platysoma* was observed during a survey for seaweed-related macrofauna from the intertidal region of Andamans after a century. The specimen was collected using a scoop net, identified based on Kemp (1913) and Ahyong (2001). The detailed description, images and illustrations are given in this article. The reappearance of *G. platysoma* after a century highlights the potential of revealing the rich biodiversity in Andaman and the need to monitor stomatopods for a better overview of their ecological interactions and diversity.

Keywords: Andaman, blue spot smasher, Crustacea, Mantis shrimp, shallow water, thumb splitter.

The Andaman & Nicobar group of islands are one of the richest repositories of biodiversity in southeastern Asia (Balakrishnan et al. 2008) with remarkable speciation and endemism because of their geographical isolation (Nair et al. 2008). Mantis shrimps are members of the marine crustacean order Stomatopoda inhabiting waters (Manning 1977; Cheroske et al. 2009). The members of the Bathysquilloids, living on greater depths (Caldwell 1991; Schram et al. 2013). The demographic composition of mantis shrimps varies spatially and seasonally with the habitat and environmental conditions (Abello & Martin 1993; Lui 2005). Stomatopods have unique feeding habits (Dingle & Caldwell 1978). The prey capture method utilised by stomatopods is often considered as one of the fastest animal movements, which involves smashing (smashers) or spearing (spearers), depending on whether the dactyl is held folded or extended (Dingle & Caldwell 1969; Caldwell & Dingle 1976). Smashers have well-built raptorial appendages which move with great pace and extreme force (Patek et al. 2004). Their ability to create strikes of extreme forces corresponds to their particular diet of crustaceans, molluscs and a variety of marine organisms, viz., fishes, squids and other benthic invertebrates (Caldwell & Dingle 1976; Dingle & Caldwell 1978; Hamano & Matsuura 1986; Caldwell et al. 1989; Hamano et al. 1996). Stomatopods are known to play a crucial role in the food web of the marine benthic community (Dingle & Caldwell 1978; Hamano & Matsuura 1986; Hamano et al. 1996).

There are 500 extant Stomatopoda species globally under seven superfamilies and 20 families (van Der Wal et al. 2019). Recently, Trivedi et al. (2020) listed 72 species, 35 genera, 10 families and five superfamilies from various parts of Indian coastal waters. The maximum species diversity was reported from the family Squillidae (43

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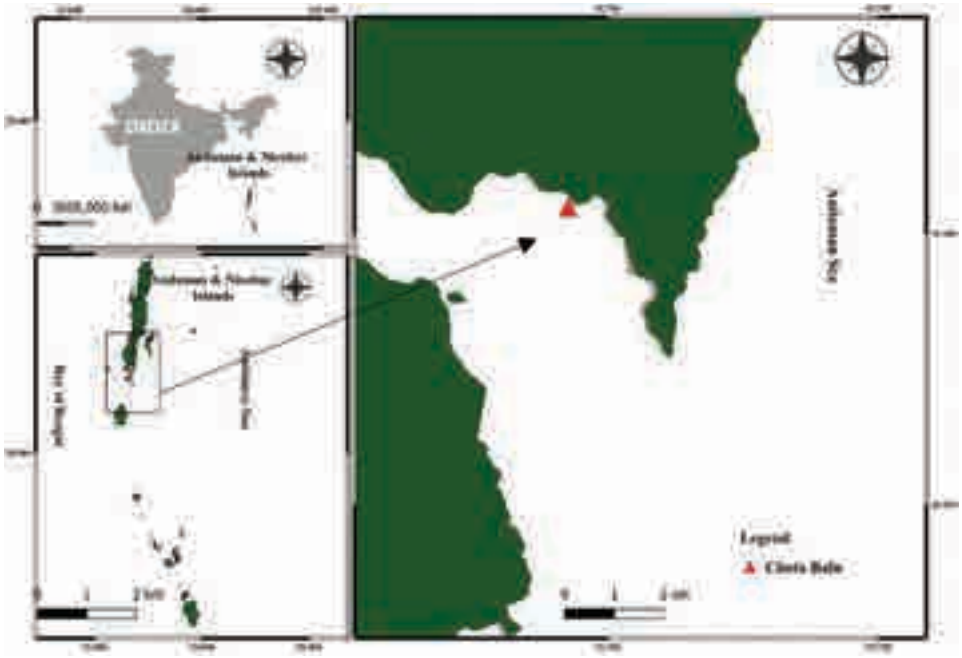

Figure 1. Map of the present sampling site.

species), followed by Gonodactylidae (seven species). The pioneering work on stomatopods from India was initiated by Wood-Mason (1875, 1876, 1895) with the description of several new species. After that, Kemp (1913) contributed to the first significant work on the stomatopods from the Indo-West Pacific region, which recognised 139 species globally and 98 species from the Indo-Pacific region. From Andaman & Nicobar Islands, 35 species of stomatopods were recorded (Trivedi et al. 2020). However, limited studies have been reported on the family Gonodactylidae from these islands (Jayabarathi et al. 2013; Kumaralingam & Raghunathan 2016; Kumaralingam et al. 2017; Niveditha et al. 2019; Trivedi et al. 2020). *Gonodactylus platysoma* was initially described from the Mauritius islands (Wood-Mason 1895). After that, Kemp (1913) recorded it from the Andaman Islands. In this study, *Gonodactylus platysoma* (Wood-Mason, 1895) has been recorded after 100 years from the Andaman Islands. During our ecological survey for seaweed (*Halimeda* sp.) macrofauna collection at Chota Balu (11.514°N, 92.495°E) in South Andaman, six mantis shrimps were observed to be in association within the seaweed habitat. A specimen was collected using a scoop net (net mouth: 30 x 30 cm; mesh size: 4 mm) and carried to the laboratory in a covered bucket. In the laboratory, the specimen was narcotised using five drops of eugenol (4-allyl-2-methoxy phenol) in 5 ml of ethanol dissolved in 1 L of seawater (Ahyong et al. 2017) and later photographed without delay (Canon PowerShot G1 X Mark II). Ocular scales were analysed under a Magnus zoom stereo trinocular microscope, and the specimen was identified from the literature by Kemp (1913) and Ahyong (2001). The specimen was preserved in 5% formaldehyde solution and deposited in the repository of the Zoological Survey of India (ZSI/ANRC/M/24202), Port Blair, A&N Islands.

Phylum: Arthropoda
Class: Malacostraca Latreille, 1802
Order: Stomatopoda Latreille, 1817
Suborder: Unipeltata Latreille, 1825
Family: Gonodactylidae Giesbrecht, 1910
Genus: *Gonodactylus* Berthold, 1827

Gonodactylus platysoma Wood-Mason, 1895 (Blue Spot Mantis Shrimp, Blue Spot Smasher)

Material examined: ZSI/ANRC/M/24202, 1 Female (TL 76 mm), Chota Balu, 11.637 N; 92.798 E, South Andaman Island, January 2020.

Diagnosis: The body is broader compared to other members of this family and live body is covered with green, white, and brown blotches. Presence of dorsal carinae in the sixth abdominal somite (AS6) and telson region. White meral spot is present in the raptorial claw. The ocular scales are separated, wide and flat (Image 1A) are about as large as the rostral plate. Telson (Image 1C) without lateral tooth, the margin of telson continuous between anterolateral angle and apex of intermediate tooth. Uropodal exopod at the distal segment of the

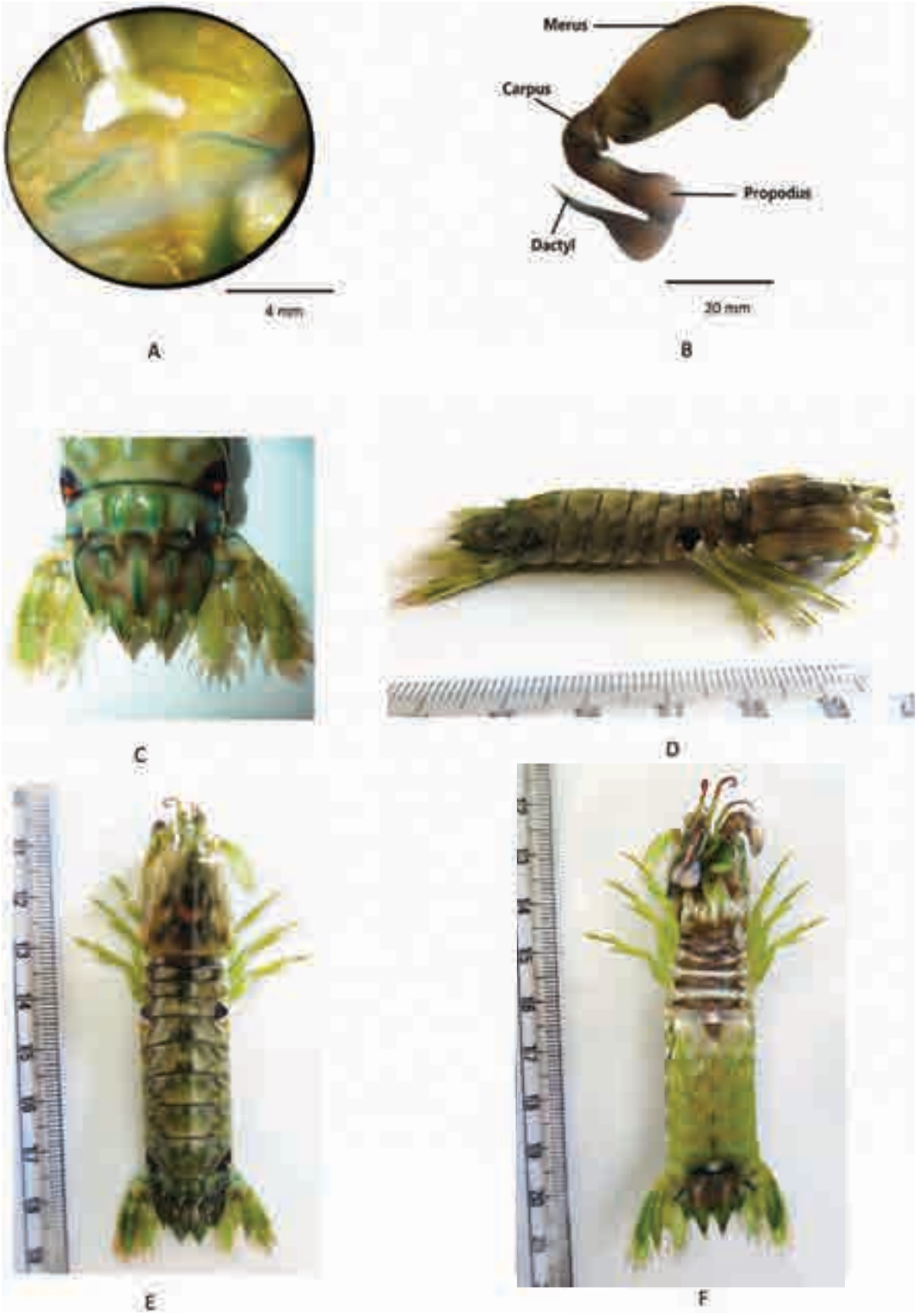

Image 1. ***Gonodactylus platysoma*** **Wood-Mason, 1895 (female 76 mm): A—Ocular scales | B—Raptorial claw | C—AS5–6, telson & uropod | D—*G. platysoma* lateral view | E—*G. platysoma* dorsal view (female 76 mm) | F—*G. platysoma* ventral view. © Naha 2020.**

outer margin with 9–13 movable spines. Previously, *G. platysoma* was reported before a century from the coarse collection of the Indian museum by Late Woods Mason in 1895 without any description or reference of the species but solely on the figures. However, Kemp (1913) distinguished it separately from the variant form of *G. chiragra* and described the species and added observation of two conspicuous black spots in the middle of AS1 based on the preserved specimen from the Indian museum. Live specimen description by Ahyong (2001) does not mention the presence of these conspicuous black spots in the AS1 of *G. platysoma* which are clearly observed in the specimen from the present study.

Distribution: French Polynesia to Okinawa, Australia, Indo-Malayan region to the western Indian Ocean (Ahyong 2001).

Gonodactylus have smashing raptorial appendages and are associated with the burrows and cavities of the sedimentary structures (living or dead coral/ inorganic rock) in the intertidal region, and their presence in the present sampling site directs its preference towards a particular type of habitat (Caldwell 1975; Silva et al. 2013). In view of the reappearance of *G. platysoma* after a century, it highlights the potential of revealing the rich biodiversity in Andaman and the need to monitor stomatopods for a better overview of their ecological interactions and diversity.

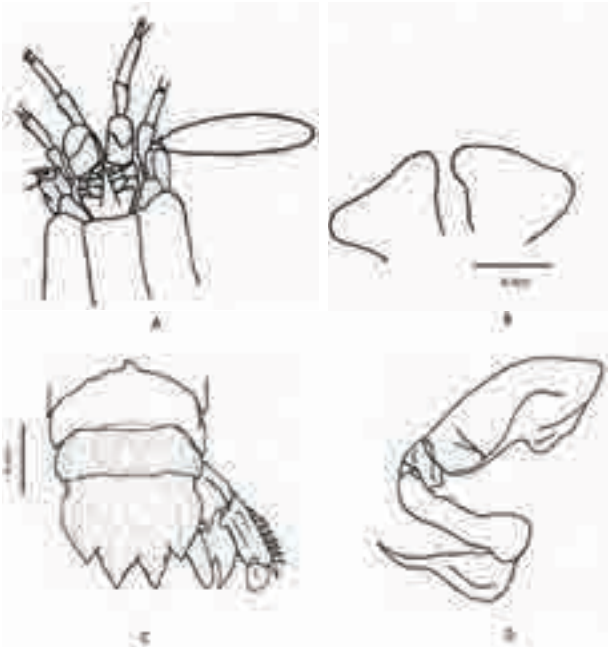

Figure 2. *Gonodactylus platysoma* Wood-Mason, 1895 (female 76 mm): A—Cephalic region | B—Ocular scale | C—Telson & uropod | D—Raptorial claw. © Naha 2020.

References

Abello, P. & P. Martin (1993). Fishery dynamics of the mantis shrimp Squilla mantis (Crustacea: Stomatopoda) population off the Ebro delta northwestern Mediterranean). *Fisheries Research* 16: 131–145. https://doi.org/10.1016/0165-7836(93)90048-C

Ahyong S.T., R.L. Caldwell & M.V. Erdmann (2017). Collection and processing stomatopods. *Journal of Crustacean Biology* 37(1): 109–114. https://doi.org/10.1093/jcbiol/ruw005

Ahyong, S.T. (2001). Revision of the Australian stomatopod Crustacea. *Records of the Australian Museum Supplement* 26: 1–326. https://doi.org/10.3853/j.0812-7387.26.2001.1333

Balakrishnan, M., R.C. Srivastava & P. Mayank (2008). Biodiversity of Andaman and Nicobar Islands. *Biobytes* 3: 9–12.

Berthold, A.A. (1827). Latreille's Natürliche Familien des Thierreichs, aus dem Französischen met Ammerkungen und Zusätzen. *Weimer*, 606 pp.

Caldwell, R.L. (1975). Ecology and Evolution of Agonistic Behavior in Stomatopods. *Naturwissenschaften* 62, 214-222.

Caldwell, R.L. (1988). Interspecific interactions among selected intertidal stomatopods, pp 371–385. In: Chelazzi G. & M. Vannini (eds.). *Behavioral Adaptation to Intertidal Life*. NATO ASI Series A: Life Sciences, Vol 151, Chapt-IV. Springer, Boston, MA, 524 pp. https://doi.org/10.1007/978-1-4899-3737-7_25

Caldwell, R.L. (1991). Stomatopods: the better to see you with my dear. *Australian Natural History* 23: 696–705. https://museum-publications.australian.museum/aus-nat-hist-1991-v23-iss9/

Caldwell, R.L. & H. Dingle (1976). Stomatopods. *Scientific American* 234: 80–89. https://doi.org/10.1038/scientificamerican0176-80

Caldwell, R.L., G. Roderick & S. Shuster (1989). Studies of predation by *Gonodactylus bredini*, pp. 117–131. In: Ferrero, E.A. (ed.) [R. B. Manning, M. L. Reaka, W. Wales, coeds.] "Biology of Stomatopods", Collana UZI: Selected Symposia and Monographs, *Mucchi Editore*, Modena, Italy.

Cheroske, A.G., T.W. Cronin., M.F. Durham & R. Caldwell (2009). Adaptive signaling behavior in stomatopods under varying light conditions. *Marine and Freshwater Behaviour and Physiology* 42(4): 219–232. https://doi.org/10.1080/10236240903169222

Cronin, T.W. & N.J. Marshall (1989). Multiple spectral classes of photoreceptors in the retinas of gonodactyloid stomatopod crustaceans. *Journal of Comparative Physiology* A 166: 267–275. https://doi.org/10.1007/BF00193471

Dingle, H. & R.L. Caldwell (1969). The aggressive and territorial behavior of the mantis shrimp *Gonodactylus bredini* Manning (Crustacea: Stomatopoda). *Behaviour* 33: 115–136. https://doi.org/10.1163/156853969X00341

Dingle, H. & R.L. Caldwell (1978). Ecology and morphology of feeding and agonistic Behaviour in mudflat stomatopods (Squillidae). *Biology Bulletin* 155: 134–49. https://doi.org/10.2307/1540871

Erdmann, M.V. & R.L. Caldwell (1997). Stomatopod crustaceans as bioindicatiors of marine Pollution stress on coral reefs. *Proceedings of the 8th International Coral Reef Symposium* 2: 1521–1526.

Giesbrecht, W. (1910). Stomatopoden : erster Teil . R. Friedlander and Sohn, Berlin. Hamano, T. & S. Matsuura (1986). Optimal prey size for the Japanese mantis shrimp from structure of the raptorial claw. *Nippon Suisan Gakkai Shi* 52: 1–10. https://doi.org/10.2331/suisan.52.1

Hamano, T., K. Hayashi., K. Kubota., H. Matsushita & K. Tabuchi (1996). Population structure and feeding behavior of the stomatopod crustacean Kempina mikado (Kemp and Chopra, 1921) in the East China Sea. *Fisheries Science* 62: 397–399. https://doi.org/10.2331/fishsci.62.397

Jayabarathi, R., I. Anandavelu & G. Padmavati (2013). First report of the Green Mantis Shrimp *Gonodactylellus viridis* (Serène, 1954) (Crustacea: Stomatopoda) from seagrass habitat of the South Andaman coast, India. *Journal of Threatened Taxa* 5(10): 4517–4520. https://doi.org/10.11609/JoTT.o3448.4517-20

Kemp, S. (1913). An account of the Crustacea Stomatopoda of

the Indo-Pacific region, based on the collection in the Indian Museum. *Memoirs of the Indian Museum* 4: 1–217. http://faunaofindia.nic.in/PDFVolumes/memoirs/004/01/0001-0217.pdf

Kumaralingam, S. & C. Raghunathan (2016). An account of some reef associated caridean shrimps and stomatopods of Andaman Islands. *Records of the Zoological Survey of India* 116(2): 117–128.

Kumaralingam, S., C. Raghunathan, T.T. Ajithkumar & K. Chandra (2017). Reef associated common crustaceans of Andaman and Nicobar Islands, Lakshadweep and Gulf of Mannar. *Records of Zoological Survey of India*, Occasional paper 380: 31–33.

Latreille, P.A. (1802). Histoire naturelle, générale et particulière, des Crustacés et des Insectes 3, 1–467. F. Dufart, Paris.

Latreille, P.A. (1817). Les crustacés, les arachnides et les insectes, In: Cuvier, G. (ed) Le Règne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée, 1ère édition: Paris, France, Déterville, 3l, 653 pp.

Latreille, P.A. (1825). Familles naturalles du règne animal, exposés succinctement et dans un ordre analytique, avec indication de leurs genres. Paris: 1–570.

Lui, K.K.Y. (2005). Ecology of commercially important stomatopods in Hong Kong. (Thesis). The University of Hong Kong, Hong Kong, 180 pp.

Manning, R.B. (1977). Stomatopod Crustacea in the Museum d'Histoire naturelle, Geneva. *Revue Suisse de Zoologie* 84(2): 279–295 https://doi.org/10.5962/bhl.part.91386

Manning, R.B. (1995). Stomatopod crustacea of vietnam: the legacy of raoul Serène. *Crustacean Research* 4: 1–339. https://doi.org/10.18353/crustacea.Special1995.4_1

Martin, W.J. (2016). Collecting and processing crustaceans: an introduction. *Journal of Crustacean Biology* 36(3): 393–395. https://doi.org/10.1163/1937240X-00002436

Nair, V.R., S.U. Panampunnayil, H.U.K. Pillai & R. Gireesh (2008). Two new species of Chaetognatha from the Andaman Sea, Indian Ocean. *Marine Biology Research* 4: 208–214.

Niveditha, S.K., L. Pongener & G. Padmavati (2019) First report of *Gonodactylus smithii* (Pocock, 1893) from South Andaman, India (Crustacea: Stomatopoda). *Zootaxa* 4688(3): 447–450. https://doi.org/10.11646/zootaxa.4688.3.11

Patek, S.N., W.L. Korff & R.L. Caldwell (2004). Deadly strike mechanism of a mantis shrimp. *Nature* 428: 819–820. https://doi.org/10.1038/428819a

Schram, F.R., S.T. Ahyong, S.N. Patek, P.A. Green, M.V. Rosario, M.J. Bok, T.W. Cronin, K.S.M. Vetter, R.L. Caldwell, G. Scholtz, K.D. Feller & P. Abello (2013). Subclass Hoplocarida Calman, 1904: order stomatopoda Latreille, 1817), pp. 179–355. In: Von Vaupel Klein, J.C., M. Charmantier-Daures & F.R. Schram (eds.). *Treatise on Zoology, Anatomy, Taxonomy, Biology. The Crustacea*. Brill, Leiden. https://doi.org/10.1163/9789047440451

Silva, K.C.A., I.H.A. Cintra, D.E.G. Martins & F.A. Abrunhosa (2013). Diversity and structure of the stomatopod (Crustacea) community on the Amazon continental shelf. *Zoologia* 30(2): 191–199.

Trivedi, J.N., S.T. Ahyong, K.D. Vachhrajani & A.B. Kumar (2020). An annotated checklist of the mantis shrimps of India (Crustacea: Stomatopoda. *Zootaxa* 4768(2): 221–238. https://doi.org/10.11646/zootaxa.4768.2.4

van Der Wal, C., S.T. Ahyong, S.Y.W. Ho, L.S.F. Lins & N. Lo (2019). Combining morphological and molecular data resolves the phylogeny of Squilloidea (Crustacea: Malacostraca). *Invertebrates Systematics* 33: 89–100. https://doi.org/10.1071/IS18035

Wood-Mason, J. (1875). (On some new species of stomatopod Crustacea). *Proceedings of the Asiatic Society of Bengal* 231–232.

Wood-Mason, J. (1876). On Some new species of Stomatopod Crustacea. *Annals and Magazine of Natural History*, Series 4(17): 263. https://doi.org/10.1080/00222937608681944

Wood-Mason, J. (1895). Figures and descriptions of nine species of Squillidae from the collection of the Indian Museum. *Indian Museum*, Calcutta, pp. 1–11.

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SHORT COMMUNICATION

Range extension of earthworm *Drawida impertusa* Stephenson, 1920 (Clitellata: Moniligastridae) in Karnataka, India

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Abstract: As a part of an ongoing study on the bio-ecology of earthworms, since 2017 surveys has been carried out in different ecosystems of Western Ghats, Karnataka. This has revealed the presence of one native peregrine species *Drawida impertusa* Stephenson, 1920 of the family Moniligastridae. The species is recorded for the second time from Karnataka state. The paper describes the morphological and anatomical details along with current distribution of the species.

Keywords: Anatomical details, biodiversity hotspot, distribution, ecosystems, native, peregrine species, Shivamogga, Western Ghats.

Earthworms are well-known terrestrial segmented worms belonging to phylum Annelida and they possess a unique position in soil macro fauna. They are the first group of multi-cellular, eucoelomate invertebrates (Kale & Karmegam 2010). Western Ghats and the western coast plains are the areas with highest diversity of earthworms in India (Narayanan et al. 2020). Karnataka state located in the southwestern part of peninsular India has high earthworm diversity. This richness is mainly due to the geographical position of the state, which has the western coastal plains, Western Ghats mountain ranges and Deccan Plateau. Taxonomic studies on the earthworms of the Western Ghats started towards the last quarter of the 19th century by Bourne (1886), but the Karnataka state was explored during the first quarter of the 20th century by Michaelsen (1910) with a report on the presence of a peregrine species, *Pontoscolex corethrurus* (Müller, 1857). Afterwards, eminent taxonomists described several new species and reported many species from different parts of the state, especially from the Western Ghats and western coastal plains (Stephenson 1917, 1920, 1921, 1924, 1925; Michaelsen 1921, 1922; Rao 1921, 1922; Gates 1937, 1940a,b, 1942, 1945). Subsequent to independence, studies on the earthworms of the state become sporadic and mostly faunistic in nature (Gates 1958, 1965; Julka 1988; Julka et al. 2004; SIddaraju et al. 2010; Hatti 2013; Padashetty & Jadesh 2014; Harish et al. 2018a,b; Mubeen & Hatti 2018; Hasyagar et al. 2021). Since 2017, we have been surveying various regions in the Western Ghats of Karnataka state as a part of an ongoing research on the bio-ecology of earthworms from various habitats. The existence of one native peregrine species, *Drawida impertusa* Stephenson, 1920, of the family Moniligastridae is being reported for the second time

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from the state of Karnataka.

Samplings were done by digging and hand sorting method as proposed by Julka (1990). Soil lumps were broken and the soil was sifted between fingers to sort out the worms. Collected specimens were preserved in 5% formalin. Important anatomical details of earthworm were examined under a stereomicroscope (Nikon SMZ800N). Illustrations were made with the help of a drawing tube attached to the microscope. Specimens were identified following Stephenson (1920, 1923), Gates (1965), and Blakemore (2012). Collected specimens were housed at the museum, Department of Applied Zoology, Mangalore University, Mangalore, and laboratory of Advanced Centre for Environmental Studies and Sustainable Development (ACESSD), Mahatma Gandhi University, Kottayam, Kerala, India.

***Drawida impertusa* Stephenson, 1920**

Drawida barwelli var. *impertusus* Stephenson, 1920: 200.

Drawida barwelli var. *impertusa* Stephenson, 1923: 134.

Drawida impertusa (Stephenson): Gates, 1965: 87.

Type locality: Victoria Gardens Bombay (Mumbai) (18.975° N, 72.825°E), Mumbai, Maharashtra State, India.

Type: ZSIC 301, BMNH 1925:5:12:77 (Reynolds & Wetzel 2020).

Material examined: ACESSD/EW/1177; 10 aclitellate, Nanjavalli (13.9928° N, 75.1876° E), Shivamogga District, Karnataka, India, 17 July 2017, elevation 610 m, edge of paddy field, coll. V. Hasyagar. (Image 1); 5 aclitellate, Eduvani (14.1948°N, 74.8348°E), Shivamogga District, Karnataka, India, 13 June 2017 elevation 549 m, semi-evergreen forest, coll. V. Hasyagar.

Description: Dimension: length 51–61 mm, diameter 3–4 mm, segments 144–168. Pigmentation dark pink at clitellar region, setae lumbricine, prostomium prolobous. Dorsal pores absent, indication present. Male pores are present on slightly raised papillae, bordered by thickened lips, at inter-segmental furrow 10/11, aligned to bc setal lines; genital markings present, paired, fairly large, long whitish papillae, anterior to male pores, in segment 10 (Figure 1). Genital glands absent. Female pores indistinct. Spermathecal pores paired, at inter-segmental furrow 7/8 below cd setal lines, close to *c*. Septa 5/6–7/8 muscular. Gizzards 4 in segments 12–15. Testis sacs paired, large irregular-shaped, anterior portion constricted by septum 9/10; vas deferens loosely coiled, entering prostate directly at median side. Prostates glandular, flat, sessile, circular (Figure 2); prostatic capsule circular. Spermathecae paired in segment 8, ampulla ovoid, each with short, lightly coiled duct, penetrating septum 7/8, ectal end lightly thickened (Figure 3); atrium absent. Ovisacs present in segments 12–13, slightly projecting to segment 14.

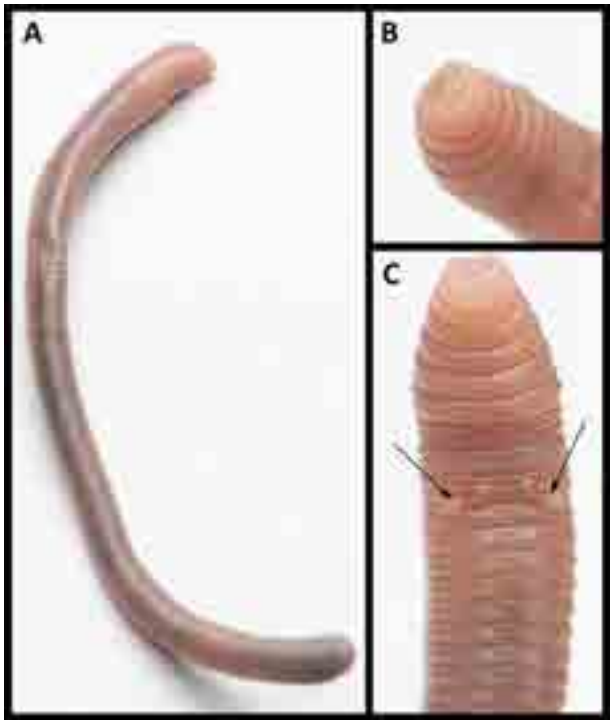

Image 1. *Drawida impertusa*: A—external morphology | B—prostomium region | C—male pores (pointed). © Vivek Hasyagar.

Ingesta: Mainly colloids of soil, tiny mineral particles, very few strands of rootlets and barks.

Distribution

India: Karnataka: Nanjavalli and Eduvani in Shivamogga district (present records), Bangalore (Bengaluru); Andhra Pradesh, Maharashtra, Kerala, and Tamil Nadu (Figure 4).

Elsewhere: Philippines.

Drawida impertusa was collected and reported for the second time from Karnataka state of southern Peninsular India. It is one among the 3% of native peregrine species reported from the Western Ghats and western coast plains of India (Narayanan et al. 2016, 2020). Nearly 16 species from the genus *Drawida* were reported from Karnataka (Stephenson 1917, 1920, 1923; Rao 1921; Gates 1958, 1965; Blanchart & Julka 1997, 2013; Mandal et al. 2013; Harish et al. 2018a,b; Mubeen & Hatti 2020). *D. impertusa* resembles *D. barwelli* but lacks dorsal pores and having a pair of genital markings. Earlier the species was reported from Bangalore in Karanataka state (Gates 1965). Apart from Karnataka it has been reported from Andhra Pradesh (Tirupati), Maharashtra (Victoria Gardens – Mumbai), Kerala (Kanjikode, Karumadi, Thiruvalla, and

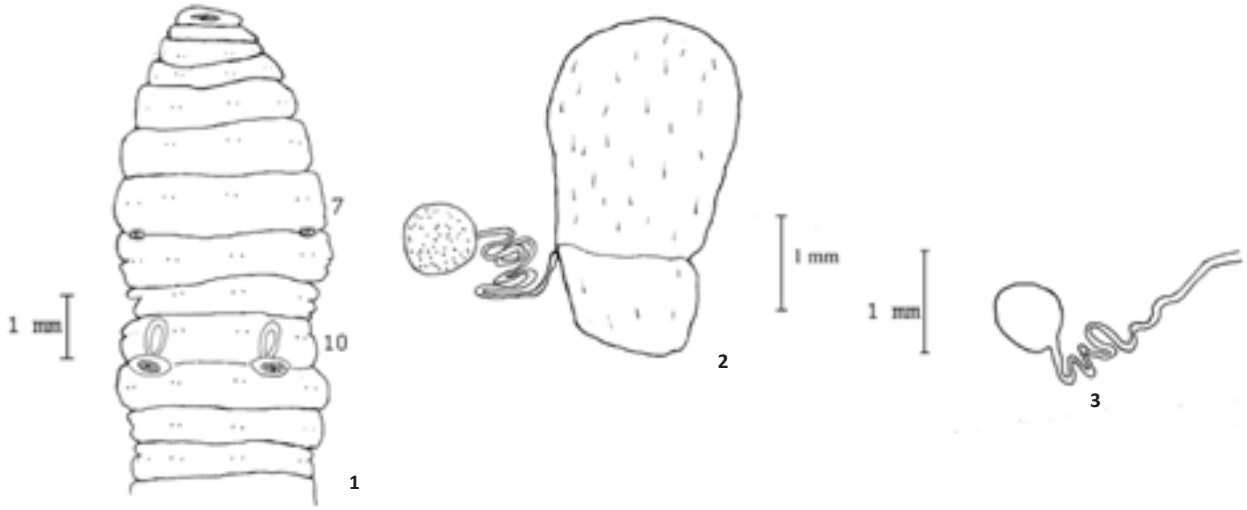

Figure 1–3. *Drawida impertusa*: 1—ventral view showing genital pores | 2—prostate gland | 3— spermatheca.

Figure 4. The distribution of *Drawida impertusa* in India.

Vandiperiyar) and Tamil Nadu (Coimbatore forest division) states of India (Michaelsen 1910; Stephenson 1920, 1924; Aiyer 1929; Gates 1965; Kathireswari et al. 2005, 2008; Blakemore et al. 2014; Narayanan et al. 2016). Outside India it was sampled from diverse habitats like garden, hills, rotting tree, sea-shore and considered as introduced species in Philippines (Blakemore 2012). But present specimen was collected from the semi-evergreen forest and paddy fields. *D. impertusa* is an endogeic species and analyses of the ingesta of the present specimens agrees with the findings of Gates (1965). Several areas of Karnataka state are still unexplored in terms of earthworm

fauna. Therefore, additional intensive survey may discover a few of the undescribed species of the genus *Drawida* from the state.

References

Aiyer, K.S.P. (1929). An account of the Oligochaeta of Travancore. *Records of the Indian Museum* 31(1): 13–76.

Blakemore, R.J. (2012). *Cosmopolitan earthworms – an eco-taxonomic guide to the peregrine species of the world, 5th edition*. VermEcology Solutions, Yokohama, Japan, 850 pp.

Blakemore, R.J., S. Lee & H. Y. Seo (2014). Reports of *Drawida* (Oligochaeta: Moniligastridae) from far East Asia. *Journal of Species Research* 3(2): 127–166. https://doi.org/10.12651/JSR.2014.3.2.127

Blanchart, E. & J.M. Julka (1997). Influence of forest disturbance on earthworm (Oligochaeta) communities in the Western Ghats (South India). *Soil biology and Biochemistry* 29(3-4): 303–306.

Bourne, A.G. (1886). On Indian earthworms - Part I. Preliminary notice of earthworms from the Nilgiris and Shevaroys. *Proceedings of the Scientific Meetings of the Zoological Society of London* pp.662–672.

Gates, G.E. (1937). Indian earthworms. I. The genus *Pheretima*. *Records of the Indian Museum* 39(2): 175–212.

Gates, G.E. (1940a). Indian earthworms. XII. The genus *Hoplochaetella. Records of the Indian Museum* 42(2): 199–252.

Gates, G.E. (1940b). Indian earthworms. VIII–XI. *Records of the Indian Museum* 42(1): 115–143.

Gates, G.E. (1942). Notes on various peregrine earthworms. *Bulletin of the Museum of the Comparative Zoology at Harvard College* 89(3): 61–144.

Gates, G.E. (1945). On some Indian earthworms II. *Journal of the Royal Asiatic Society Bengal* 11: 54–91.

Gates, G.E. (1958). On Indian and Burmese earthworms of the genus *Glyphidrilus*. *Records of the Indian Museum* 53(1&2): 53–66. (For the year 1955).

Gates, G.E. (1965). On peregrine species of the Moniligastrid earthworm genus *Drawida* Michaelsen, 1900. *Annals and Magazine of Natural History* series 13(8): 85–93.

Harish, K.T.S., K.S. Sreepada, S.P. Narayanan & J.W. Reynolds (2018a). Megadrile earthworms (Annelida: Oligochaeta) around Udupi Power Corporation Limited (UPCL), Udupi District, Karnataka, South-West Coast of India. *Megadrilogica* 23(5): 80–91.

Harish, K.T.S., M. Siddaraju, C.H.K. Bhat & K.S. Sreepada (2018b). Seasonal distribution and abundance of earthworms (Annelida: Oligochaeta) in relation to the edaphic factors around Udupi Power Corporation Limited (UPCL), Udupi District, South-Western Coast of India. *Journal of Threatened Taxa* 10(3):11432–11442. https://doi.org/10.11609/jott.3806.10.3.11432-11442

Hasyagar, V., S.P. Narayanan, K.S. Sreepada & J.W. Reynolds (2021). *Amynthas alexandri* Beddard, 1901(Clitellata: Megascolecidae) a new addition to the earthworm fauna of Karnataka state, Southern India. *Megadrilogica* 26(3): 43–48.

Hatti, S.S. (2013). Taxonomical studies on earthworm species of Gulbarga city, Karnataka, India. *Indian Journal of Applied Research* 3(7): 34–38.

Julka, J.M. (1988). *The Fauna of India and Adjacent Countries. Megadrile Oligochaeta* (*Earthworms*). *Haplotaxida: Lumbricina: Megascolecoidea: Octochaetidae*. Zoological Survey of India, Calcutta, 400 pp.

Julka, J.M. (1990). Annelida, pp 57–64. In: Jairajpuri, M.S. (ed.) *Collection and preservation of animals.* Zoological Survey of India, Calcutta, 246 pp.

Julka, J.M., E. Blanchart & L.C. Lardy (2004). New genera and new species of earthworms (Oligochaeta: Octochaetidae) from Western Ghats, South India. *Zootaxa* 486: 1–27.

Kale, R.D. & N. Karmegam (2010). The role of earthworms in tropics with emphasis on Indian ecosystems. *Applied and Environmental Soil Science*: 2010: 1–16. http://doi.org/10.1155/2010/414356

Kathireswari, P., R. Jeyaraaj & I.A. Jeyaraj (2005). Distribution and diversity of earthworm resources in Kanjikode, Palakkad district, Kerala state, India. *Pollution Research* 24: 117–120.

Kathireswari, P., J.M. Julka & J. Ramasamy (2008). Biodiversity of earthworm species of Coimbatore forest division, the Western Ghats, Tamil Nadu, India. *Megadrilogica* 12(8): 120–124.

Mandal, C.K., S. Mitra & S. Dhani (2013). Annelida: earthworm, In: *Fauna of Karnataka, State Fauna*. Zoological Survey of India, Kolkata. Series 21: 33–38.

Michaelsen, W. (1910). Die Oligochäten fauna der vorderindisch-ceylonischen region. *Abdruck Verhandelingen der Naturwissenschaftlichen Vereins zu Hamburg* 19(5): 1–108.

Michaelsen, W. (1921). Oligochätenvomwestlichen Vorderindien und ihre Beziehungen zur Oligochätenfauna von Madagaskar und den Seychellen. *Jahrbuch der hamburgischenwissenschaftlichen Anstalten* 38: 27–68.

Michaelsen, W. (1922). Oligochaten aus dem Rijks-Museum ban Natuurlijke Histoire zu Leiden. *Capita Zoological* 1(3): 1–67.

Mubeen, H. & S.S. Hatti (2018). Earthworm's diversity of Koppal district with the updated information on genus *Thatonia* of Hyderabad-Karnataka region, Karnataka, India. *Journal of Asia-Pacific Biodiversity* 11: 482–493.

Mubeen, H. & S.S. Hatti (2020). Diversity and distribution of earthworms of Yadgir district in relation to the soil chemical parameters of their habitats pp. 239–258. In: Joshi, P.C., N. Joshi, B.N. Pandey & D.K. Mansotra (eds.). *Ecology and Biodiversity*. Today & Tomorrow's Printers and Publishers, New Delhi, 390 pp.

Narayanan, S.P., S. Sathrumithra, G. Christopher, A.P. Thomas & J.M. Julka (2016). Checklist of the earthworms (Oligochaeta) of Kerala, a constituent of Western Ghats biodiversity hotspot, India. *Zootaxa* 4193(1): 117–137. http://doi.org/10.11646/zootaxa.4193.1.5

Narayanan, S.P., R. Paliwal, S. Kumari, S. Ahmed, A.P. Thomas & J.M. Julka (2020). Annelida: Oligochaeta, pp. 87–102. In: *Faunal Diversity of Biogeographic Zones of India: Western Ghats*. Zoological Survey of India, Kolkata, 744 pp.

Padashetty, S. & M. Jadesh (2014). A preliminary survey of earthworm species composition and distribution in the north Karnataka region, Gulbarga, Karnataka. *International Letters of Natural Sciences,* 27: 54–60.

Rao, C.R.N. (1921). On the anatomy of some new species of *Drawida. Annals and Magazine of Natural History* Series 9, 8(47): 496–536.

Rao, C.R.N. (1922). Some new species of earthworms belonging to the genus *Glyphidrilus. Annals and Magazine of Natural History* Series 9, 9: 51–68.

Reynolds, J.W. & M.J. Wetzel. (2020). Nomenclatura Oligochaetologica – a catalogue of names, descriptions and type specimens. Editio Secunda. https://www.inhs.illinois.edu/people/mjwetzel/nomenoligo Accessed: 13 June 2020.

Siddaraju, M., K.S. Sreepada, & J.W. Reynolds (2010). Checklist of earthworms (Annelida: Oligochaeta) from Dakshina Kannada, Karnataka South West India. *Megadrilogica* 14(5): 65–75.

Stephenson, J. (1917). On a collection of Oligochaeta from various parts of India and further India. *Records of the Indian Museum* 13: 353–416.

Stephenson, J. (1920). On a collection of Oligochaeta from the lesser known parts of India and from Eastern Persia. *Memoirs of the Indian Museum* 7(3): 191–261.

Stephenson, J. (1921). Oligochaeta from Manipur, the Laccadive Islands, Mysore, and other parts of India. *Records of the Indian Museum* 22(5): 745–768.

Stephenson, J. (1923). *The Fauna of British India, including Ceylon and Burma – Oligochaeta*. Taylor and Francis, London, 518 pp.

Stephenson, J. (1924). On some Indian Oligochaeta, with a description of two new genera of *Ocnerodrilinae. Records of the Indian Museum* 26: 317–365.

Stephenson, J. (1925). On some Oligochaeta mainly from Assam, South India and the Andaman Islands. *Records of the Indian Museum* 27: 43–73.

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SHORT COMMUNICATION

Pelatantheria insectifera (Rchb.f.) Ridl. (Orchidaceae): a new generic record for Eastern Ghats of Andhra Pradesh, India

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Abstract: The monopodial orchid *Pelatantheria insectifera* is reported here as a new generic record for the state of Andhra Pradesh (India). Further, detailed diagnostic description, colour photo plates for easy identification and note on ecology were provided.

Keywords: Orchid, Sileru Forest Range, Visakhapatnam.

Orchidaceae is the second largest family in the flowering plants, with about 28,000 species distributed in the world (Chase et al. 2003, 2015; Willis 2017; Fay 2018). They are distributed throughout the world except the hot desert and Antarctica (Kumar et al. 2007). India represents a total of 1,256 orchids belonging to 155 genera of which 388 orchids are endemic to Western Ghats (Singh et al. 2019) and a total of 54 species belonging to 30 genera of orchids are reported from Eastern Ghats of Andhra Pradesh (Venkaiah et al. 2020).

The genus *Pelatantheria* Ridl. is an epiphytic or lithophytic orchid distributed in Indo-Malesia region (Jalal et al. 2012; Govaerts et al. 2022). It is known to contain eight species, viz., *P. ctenoglossum* Ridl., *P. eakroensis* Haager, *P. rivesii* (Guillaumin) Tang & F.T.Wang, *P. woonchengii* P.O'Byrne, *P. scolopendrifolia* (Makino) Aver., *P. bicuspidata* Tang & F.T.Wang, *P. insectifera* (Rchb.f.) Ridl., and *P. cristata* (Ridl.) Ridl., which are distributed throughout Bangladesh, Bhutan, Cambodia, China, India, Japan, Korea, Laos, Myanmar, Nepal, Thailand, Vietnam, and western Malaysia (Jalal et al. 2012; Govaerts et al. 2021). In India only one species *P. insectifera* is reported from Arunachal Pradesh, Assam, Chattisgarh, Jharkhand, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tripura, and Uttarakhand (Jalal et al. 2012). But, so far it is not reported from Andhra Pradesh.

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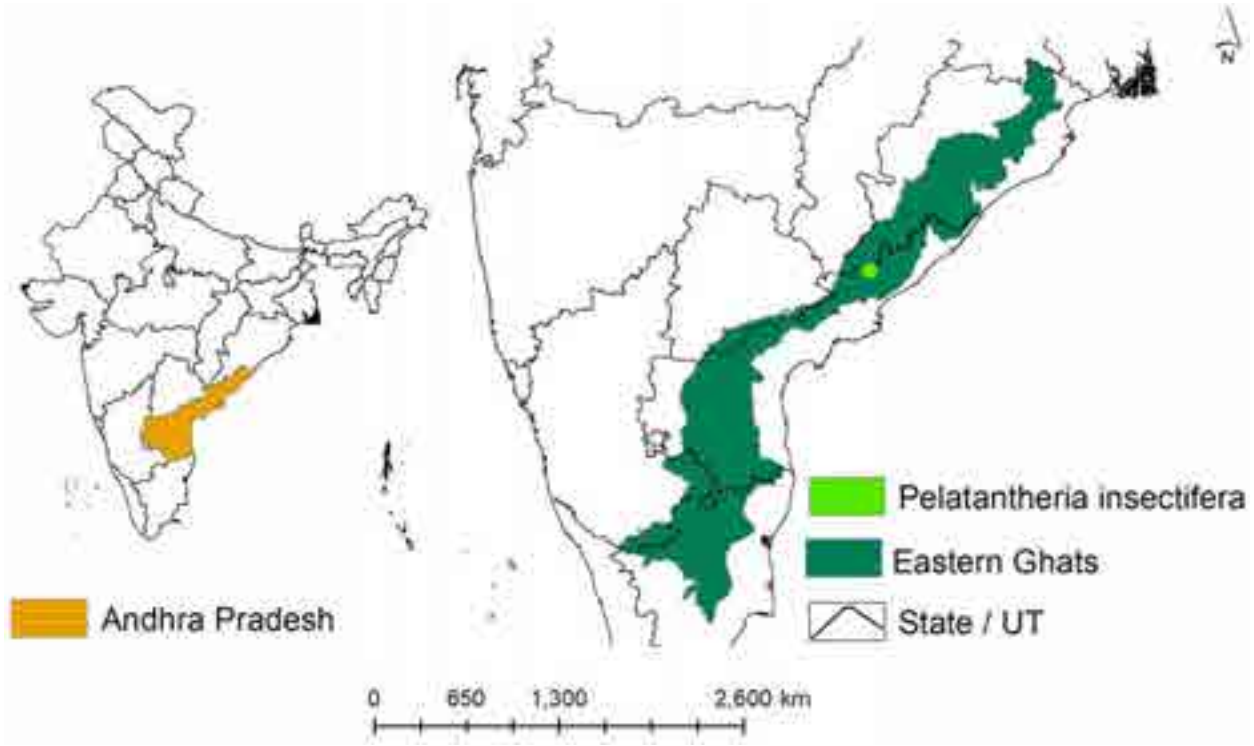

Figure 1. Location of *Pelatantheria insectifera* from Eastern Ghats of Andhra Pradesh.

Materials and Methods

Field explorations were carried out from August 2020 to December 2020 for the Department of Biotechnology (DBT) and Department of Space (DOS) biodiversity project in RV Nagar and Sileru Forest Range in the Eastern Ghats region of Andhra Pradesh. First and second authors found an interesting species of orchid in Sileru Forest Range. After critical examination at the laboratory with dissection microscope, literature study (Jalal et al. 2012; Singh et al. 2019), and consultation of type at K, it was identified as *Pelatantheria insectifera* (Figure 1). Voucher specimen was deposited in Herbarium AUV, Department of Botany, Andhra University (Image 2) and this species was also introduced into the University Botanical Garden on the stem barks of *Mangifera indica* L. and *Melaleuca citrina* (Curtis) Dum. Cours. for further observations and ex situ conservation practices. All the photographs were taken by Canon 500D, photo plate was prepared by using CS6 Photoshop software and location map was prepared by using Arc Map software.

Results

Pelatantheria insectifera (Rchb.f.) Ridl., J. Linn. Soc., Bot. 32: 373 (1896); *Sarcanthus insectifer* Rchb.f., Bot. Zeitung (Berlin) 15: 159 (1857). (Image 1).

Type: Myanmar, Moulmein, Parish 267 (K000942423, digital image)

Specimen examined: India, Andhra Pradesh, Visakhapatnam District, Sileru Range, 17.956 N; 82.046 E, 466 m, 11 November 2020, V. Ashok Kumar & P. Janaki Rao 23358 (AUV).

Monopodial tufted epiphytic herb. Stem scandent, stout, terete, up to 70 cm. Roots at nodes, vermiform, alternative, ca. 40×3 mm, straw yellow. Leaves sessile, coriaceous, deeply channelled, ca. 6×2 cm, distichous, oblong or oblong-lanceolate, unequally bilobed apex, base amplexicaul, sheathing the stem entire. Racemes axillary, ca. 2 cm long, 3–5 flowered. Floral bract green, broadly triangular, obtuse, 2×2.2 mm; Pedicel ca. 8×1 mm, pale green at base and purple tinged at tip. Flowers small, ca. 1.8 cm. Sepals 3, greenish-yellow and purple tinged, oblong-ovate or oblong-obovate, 3-veined, mid vain prominent, greenish yellow, acute or sub-acute, entire, dorsal sepal ca. 5×3 mm, lateral sepals ca. 6×3.4 mm. Petals 3, one is modified in to lip, lateral 2 are spreading, 3-nerved, mid vain prominent, oblong or oblanceolate, truncate or obtuse, sub-acute, ca. 6×2.3 mm. Lip sessile ca. 1×0.8 cm, fleshy, 3 lobed, discoid at middle, magenta colour; lateral lobes whitish yellow, magenta tinged, ca. 2×4 mm, incurved, lobulated or obscurely bilobulate. Middle lobe ca. 8×7 mm, magenta coloured, porrect, cordate, truncate or rounded, mid vain discoid. Spur ca. 5x3 mm, whitish yellow, compressed, conical, projected downwards, and hairy at mouth.

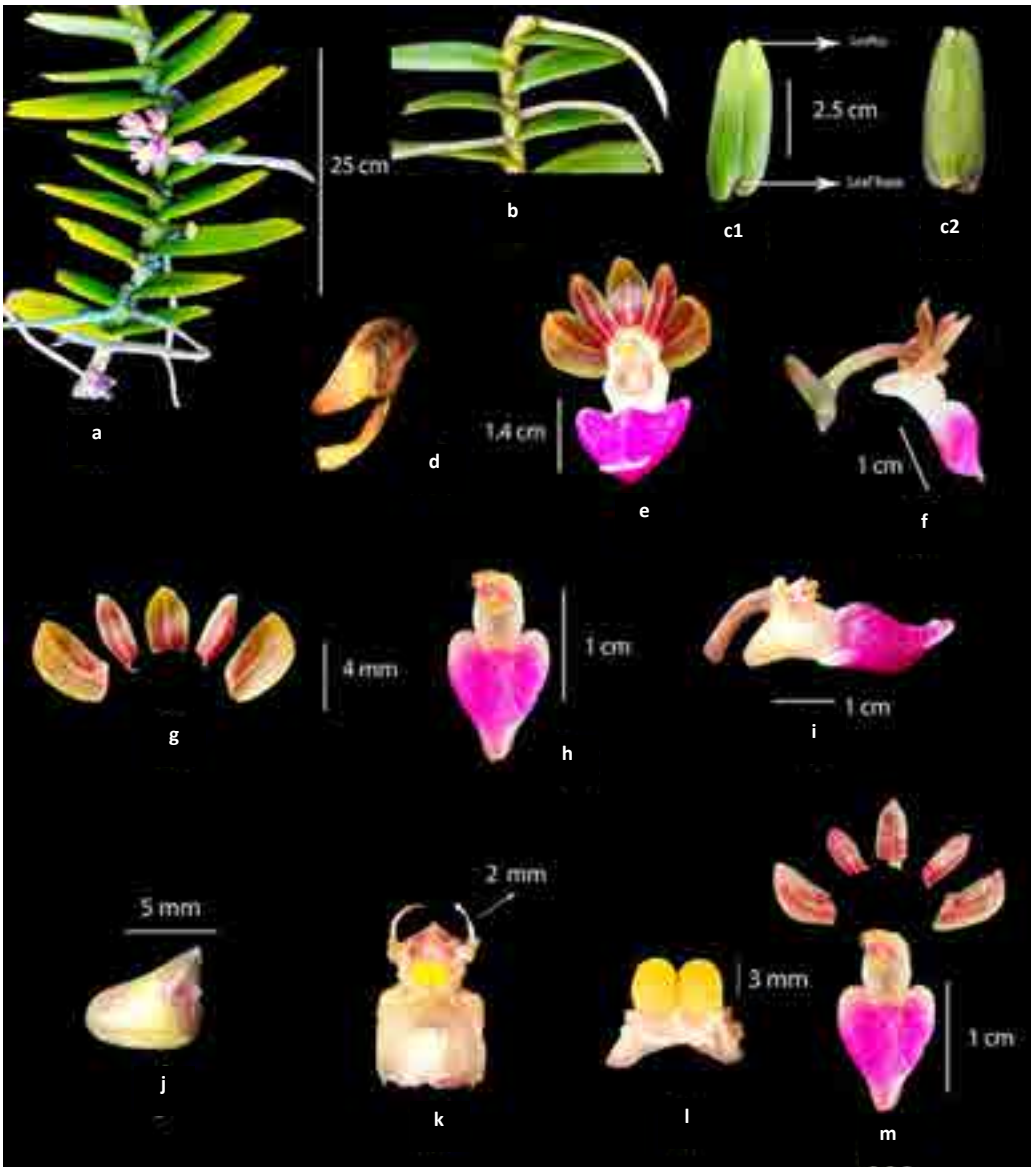

Image 1. ***Pelatantheria insectifera*****: a—Flowering twig | b—Close up of vegetative twig | c1—Leaf (dorsal view) | c2—Leaf (ventral view) | d—Floral bud | e—Flower (front view) | f—Flower (side view) | g—Sepals and petals | h—Lip (front view) | i—Lip (side view) | j—Spur | k—Column with pollinarium | l—Pollinarium | m–Dissected flower. © P. Janaki Rao.**

Column broad and stout, white, obovate, ca. 2x1.6 mm, with long stelidia, columnar processes long, slender, 2 horned, stigma triangular ovate and closed to column arms. Pollinia 2, placed on a broad viscidium, yellow, ca. 3×3 mm, subglobose. Capsules clavate, ca. 2.2 cm long.

Flowering and fruiting: October–December

Habitat & Ecology: Scarcely found in the moist deciduous forest of the study area as small nest-like clusters on tree trunks of *Mangifera indica* L., *Terminalia alata* Heyne ex Roth, *Schleichera oleosa* (Lour.) Merr. and *Syzygium cumini* (L.) Skeels. Habitat was dominated by trees such as *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr., *Diospyros sylvatica* Roxb., *Haldina cordifolia* (Roxb.) Ridsdale, *Nyctanthes arbor*-tristis L., *Polyalthia cerasoides* (Roxb.) Bedd., *Protium serratum* (Wall. ex Colebr.) Engl., *Terminalia bellirica* (Gaertn.) Roxb., *Xylia xylocarpa* (Roxb.) Taub. Apart from trees, a few middle story vegetation like *Barleria cristata* L., *Clerodendrum infortunatum* L., *Colebrookea oppositifolia* Sm., *Lantana camara* L., climbers: *Bauhinia vahlii* Wight & Arn., *Combretum ovalifolium* Roxb., *Dioscorea oppositifolia* L., and understory vegetation such as *Achyranthes bidentata* Blume, *Adiantum lunulatum* Burm. f., *Sida rhombifolia* L., *Senna hirsuta* (L.) H.S.Irwin & Barne, *Triumfetta rhomboidea* Jacq. were commonly

Image 2. Herbarium specimen of *Pelatantheria insectifera*.

seen in the habitat of this orchid.

Distribution

Native to Himalaya and Indo-China (Bangladesh, Bhutan, India, Nepal, Myanmar, Laos, Thailand, and Vietnam). In India: Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tripura, Uttarakhand, and West Bengal (Jalal et. al. 2012; Govaerts et al. 2022).

Discussion

Occurrence of *P. insectifera* in Sileru Range of Andhra Pradesh was not unexpected as it falls very near to the state border with Odisha, where this species is known to exist and has similar forest type. The present study observes that, several epiphytic orchids like *Acampe ochracea* (Lindl.) Hochr., *Acampe praemorsa* (Roxb.) Blatt. & Mc Cann, *Dendrobium aphyllum* (Roxb.) C.E.C.Fisch., *Luisia zeylanica* Lindl., *Oberonia ensiformis* (Sm.) Lindl., *Rhynchostylis retusa* (L.) Blume, *Vanda tessellata* (Roxb.) Hook. ex G.Don, & *Vanda testacea* (Lindl.) Rchb.f. and ground orchids like *Goodyera procera* (Ker Gawl.) Hook., *Habenaria furcifera* Lindl., & *Liparis nervosa* (Thunb.) Lindl. were luxuriantly growing in the Sileru and R.V.Nagar forest ranges due to the suitable bioclimatic conditions. There is a need for intensive explorations for orchid diversity in this area.

References

Chase, M.W., K.M. Cameron & J.V. Freudenstein (2003). DNA data and Orchidaceae systematics: a new phylogenetic classification, pp. 69–89. In: Dixon, K.W., S.P. Kell, R.L. Barrett & P.J. Cribb (eds.). *Orchid conservation*. Sabah Natural History Publications, Kota Kinabalu, 433 pp.

Chase, M.W., K.M. Cameron, J.V. Freudenstein, A.M. Pridgeon, G. Salazar, C.V. Berg & A. Schuiteman (2015). An updated classification of Orchidaceae. *Botanical Journal of the Linnean Society* 177(2):151–174.

Fay, M.F. (2018). Orchid conservation: how can we meet the challenges in the twenty-first centuries? *Botanical Studies* 16: 59. https://doi.org/10.1186/s40529-018-0232-z

Govaerts, R., P. Bernet, K. Kratochvil, G. Gerlach, G. Carr, P. Alrich, A.M. Pridgeon, J. Pfahl, M.A. Campacci, D.H. Baptista, H.Tigges, J. Shaw, P. Cribb, A. George, K. Kreuz & J.J. Wood (2022). World Checklist of Orchidaceae. Facilitated by the Royal Botanic Gardens, Kew. http://wcsp.science.kew.org/. Accessed on 22 March 2022.

Jalal J.S., P. Kumar, A. Kotia & G.S. Rawat (2012). On the occurrence of *Pelatantheria insectifera* (Orchidaceae) in Jim Corbett National Park, India. *Richardiana* 12(3): 108–115.

Kumar, P., J.S. Jalal & G.S. Rawat (2007). Orchidaceae, Chotanagpur, state of Jharkhand, India. *Check List* 3(4): 297–304.

POWO (2022). Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/ Accessed on 07 May 2022.

Singh, S.K., D.K. Agrawala, J.S. Jalal, S.S. Dash, A.A. Mao & P. Singh (2019). *Orchids of India-A Pictorial Guide*. Botanical Survey of India, Kolkata, 548 pp.

Truong, V.B., T.Q. Truong, K.V. Nguyen & J.C. Tes (2018). *Pelatantheria woonchengi:* A new Addition for the Orchid Flora of Vietnam. *Lankesteriana* 18(1): 69-73.

Venkaiah, M., J.P. Rao, M.T. Naidu, R. Prameela, P.J. Rao & S.B. Padal (2020). Orchid Diversity in the Eastern Ghats of Northern Andhra Pradesh, India, pp. 189–206. In: Khasim, S., S. Hegde, M. González-Arnao & K. Thammasiri (eds). *Orchid Biology: Recent Trends & Challenges*. Springer, Singapore 547 pp. https://doi.org/10.1007/978-981-32-9456-1_10

Willis, K.J. (ed.) (2017). State of the Worlds plants 2017. Report. Royal Botanic Gardens, Kew, 100 pp.

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NOTE

New breeding site record of Oriental White Ibis *Threskiornis melanocephalus* (Aves: Threskiornithidae) at Thirunavaya wetlands, Kerala, India

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The Oriental White Ibis *Threskiornis melanocephalus* (Latham, 1790) is a globally threatened species (Birdlife International 2021), coming under the family Threskiornithidae of the order Pelecaniformes. This wading bird is also called the Indian White Ibis, Black-headed Ibis or Black-necked Ibis. It is a widespread resident species across the Indian subcontinent, known to breed in India, Sri Lanka, Nepal, and Myanmar (Ali & Ripley 1968; Hancock et al. 2001; Grimmet et al. 2011). In the recent past, the population of the species has declined and continues so worldwide due to various anthropogenic reasons. The species is listed in the Near Threatened category of the IUCN Red List (Birdlife International 2021). In Kerala, the bird species was rare until the mid-1990s and now has become a regular in most of the wetlands (Sashikumar et al. 2011). Meanwhile, scientific information on the population and ecology of this near-threatened species is scanty except for a few reports. The present study is the first breeding record reported from the Malappuram district of Kerala state.

In Kerala, the first breeding record of the species was reported from Wayanad district (Balakrishnan & Thomas 2004); the area is well-known as Panamaram heronry. The second breeding report came from Kottayam district (Kumarakom) (Narayanan et al. 2006), which recorded a good breeding population. A recently small breeding population was noted at Palakkad district (Roshnath et al. 2017), Thiruvananthapuram Zoo (Bindya et al. 2019), and from Mavoor wetland, Kozhikode district (Shifa 2021).

Thirunavaya wetland (11.001N, 75.991E), is situated in the Malappuram district of Kerala state. The wetland is mainly an uncultivated paddy field and it is very close to the northern bank of the Bharathapuzha River, one of the largest rivers in Kerala. It spreads over nearly 150 ha bifurcated into two halves by the railway track. The wetland is also known for the cultivation of lotus flowers. One side of the wetland is modified into human habitation. The wetland is flooded during the south-west monsoon (June–September). During other seasons the wetland is extremely marshy. A small canal flows through the area. The margin of the canal is covered with a large number of screw pines (*Pandanus* sp.) which are also utilized by Openbill Stork for nesting. Being a breeding ground for Oriental White Ibis, Openbill Stork, and the 'Near Threatened' Oriental Darter, the wetland also acts as potential foraging habitat for a variety of water birds including Little Cormorant, Little Egret, Intermedi-

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Image 1. Colonial nesting of Oriental White Ibis seen associated with Open-billed Stork at Thirunavaya Wetland.

Image 2. Adult Ibis with a fledgling.

Table 1. Breeding of waterbird species in Thirunavaya heronry during October–December 2021.

Species	Total no. of nests	Total no. of fledglings	Nesting success
Oriental White Ibis	4	9	Success
Oriental Darter	1	2	Success
Openbill stork	3	5	Success

*Nesting success: nest with at least one fledgling (Mayfield 1975).

Image 3. Adult Ibis feeding the fledgling.

ate Egret, Common Kingfisher, Pied Kingfisher, Purple Heron, Pond Heron, Grey Heron, and other wetland associated avifauna.

Generally, the breeding period of Oriental White Ibis is in the monsoon season from June to September (Arif & Basheer 2012; Shifa 2021); the late breeders extend their breeding period from September to April (Narayanan et al. 2006). The nesting of Oriental White Ibis was noticed in October 2021 during a bird survey in Thirunavaya Wetland. The breeding plumage of the adult ibises and the begging behaviour of fledglings for food are very unique features to detect them as an active breeding colony. At the first observation itself all nestlings grew up into fledglings. Overall, eight nests were observed during the surveys. Out of which four were of Oriental White Ibis, three were of Openbill Stork, and one of Oriental Darter nest. The breeding site was observed weekly for three months from October to December. For observation Nikon binoculars (10 x 40) were used. Photographs were taken by the Nikon P1000 model. The tree species used for colonial nesting is *Barringtonia acutangula*. The height of the nest tree is 4m from the wetland. The water level is < 0.5m and covered by the invasive species *Salvinia molesta*. The GBH of the nest tree is 0.84 m and the width of canopy coverage is 1.69 m. The nests are made up of locally available twigs and grasses. The availability of food and low predation risk, as well as reduced anthropogenic stress, maybe the reasons for the selection of this breeding site.

The average height of the nesting tree species at Kumarakom wetlands, Kottayam district was 02.59 ±0.66 m from the water level (Narayanan et al. 2006), and in Panamaram, Wayanad district was 7±0.45 m (Balakrishnan & Thomas 2004); in Thiruvananthapuram Zoo the nest height is 6 m from the ground (Bindya et al. 2019), whereas in Palakkad district it is 5 m (Roshnath et al. 2017). The studies in Calicut district (Shifa 2021), did not measure the exact nest height. The present study shows certain deviations from the results of the above records. In Thirunavaya wetlands Oriental White Ibis used an average nest height of 3.18±0.49 m. The wetland heronry is a communal breed site that bears an association of

two species, Openbill Stork and Oriental Darter. Ibises bears a population count of eight adult parents and nine fledglings. Among Openbill Storks six adult parents and five young ones occur, whereas among Oriental Darter two adult parents and two young ones occur.

The Thirunavaya wetland is a feeding and breeding ground for a large number of avifauna including near-threatened species like Oriental White Ibis, Painted Stork, Oriental Darter, and Wooly Necked Stork; moreover, it is an abode for thousands of migratory birds. The spoting of large colonial nesting of Asain Openbill Stork is also witnessed the importance of this fragile ecosystem. Around 120 nests were counted by the survey conducted by Re Echo, an environmental organization in Thirunavaya. The proposed Silverline Railway Project is passing through this wetland, which will probably lead to an ecological disaster for the wetland in the future.

References

Ali, S. & S.D. Ripley (1968). Hand Book of the Birds of India and Pakistan, Vol. 1. Oxford University Press, London, viii+380 pp.

Balakrishnan, M. & S.K. Thomas (2004). Conserving the breeding habitat of the Near Threatened Oriental White Ibis (*Threskiornis melanocephalus*). *Current Science* 87(9): 1190–1192.

Bindya, A., R. Roshnath & J. Alexander (2019). Notes on breeding and management of Black-headed Ibis *Threskiornis melanocephalus* (Aves: Pelecaniformes: Threskiornithidae) at Thiruvananthapuram Zoo, Kerala, India. *Zoo's Print* 34(8): 27–31.

BirdLife International (2021). Species factsheet: *Threskiornis melanocephalus.* http://www.birdlife.org Accessed on 12 June 2021.

Grimmet, R., C. Inskipp & T. Inskipp (2011). *Birds of the Indian Subcontinent*. Oxford University Press & Christopher Helm., London, 528 pp.

Hancock, J.A., J.A. Kushlan & M.P. Kahl (2001). *Storks, Ibises and Spoonbills of the World*. Academic Press, Harcourt Brace Jovanovich, 385 pp.

Mayfield, H. (1975). Suggestions for calculating Nest success. *Wilson bulletin* 87: 456–466.

Narayanan, S.P., B. Sreekumar & L. Vijayan (2006). Breeding of the Oriental White Ibis (*Threskiornis melanocephalus*) at Kumarakom heronry (Kerala, India). *Indian Birds* 2(6): 150–151.

Roshnath, R., C. Sashikumar, C.K. Vishnudas, J. Palot, S. Raju, H. Mannar, B. Sreekumar, H. Mavelikara, A.K. Sivakumar & S. Meppayur (2017). Heronries of Kerala, 2015: a summary of the Heronry Census. *Malabar Trogon* 15(3): 35–40.

Sashikumar, C., J. Praveen, M.J. Palot & P.O. Nameer (2011). *Birds of Kerala- Status & Distribution*. DC Books, Kottayam, 835 pp.

Shifa, C.T. (2021). Breeding record of Black-headed Ibis *Threskiornis melanocephalus* (Aves: Threskiornithidae) at Mavoor Wetland, Kozhikode District, Kerala,India. *Journal of Threatened Taxa* 13(14): 20299–20301. https://doi.org/10.11609/jott.7717.13.14.20299-20301

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NOTE

Rediscovery of *Gardena melinarthrum* Dohrn from Sri Lanka

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The foregoing paper by Hiremath et al. (2022) points out that even though *Gardena melinarthrum* Dohrn, 1860 was first described on the basis of an apterous specimen collected from Sri Lanka (= Ceylon), there were no details of the location; more important fact is that there is no subsequent record of this species from Sri Lanka since 1860.

We are now confirming the presence of *G. melinarthrum* from Sri Lanka, after a gap of over 150 years, from three different localities shown in the map (Image 2). We are only providing photographic evidence, as the specimen collection was not permitted. All observed individuals were macropterous.

All the individuals were photographed using Canon EOS 7D or Canon EOS 7D Mark ii camera, with a Canon EF 100 mm f/2.8 L IS USM macro Lens. The map was prepared using Las Palmas version of QGIS.

All the specimens observed were about 25 mm long and showed specific proportion of the various regions of the fore leg which are diagnostic: especially important key character showed by the specimens was that the basal spineless area of the fore femur was about one-third of the total length of the femur. Wygodzinsky (1966) additionally mentioned in the key that the basal spineless area is at least 10 times in length of the first femoral spine (including its basal tubercle). These characters are evident in the close up images provided here (Image 1c).

The first observation of *G. melinarthrum* on 28 January 2016, was in Puleliya, Anuradhapura District of Sri Lanka. It was photographed on outside wall of a village house, at around 1910 h, most probably attracted to the electric lights on the wall. The area surrounding the house was a typical home garden with some crops and wild vegetation (Image 1a).

Another individual was photographed when it was attracted to the lights, in a guest house situated in front of a man-made lake, on 02 October 2021, in Mahaoya, Ampara District of Sri Lanka, at around 2030 h. It was actively flying towards the light (Image 1b).

Most recent sighting of this species was during a biodiversity assessment survey in Mannar District of Sri Lanka. Two individuals of *G. melinarthrum* were observed on 10 March 2022 in Andankulam at 1220 h. One individual was observed resting on a web of the spider *Parawixia dehaani* (Doleschall, 1859) and the other one was resting on a twig, few meters away, in nearby forest habitat.

Since most Emesinae tend to be nocturnal (Wygodzinsky 1966), the same can be assumed for

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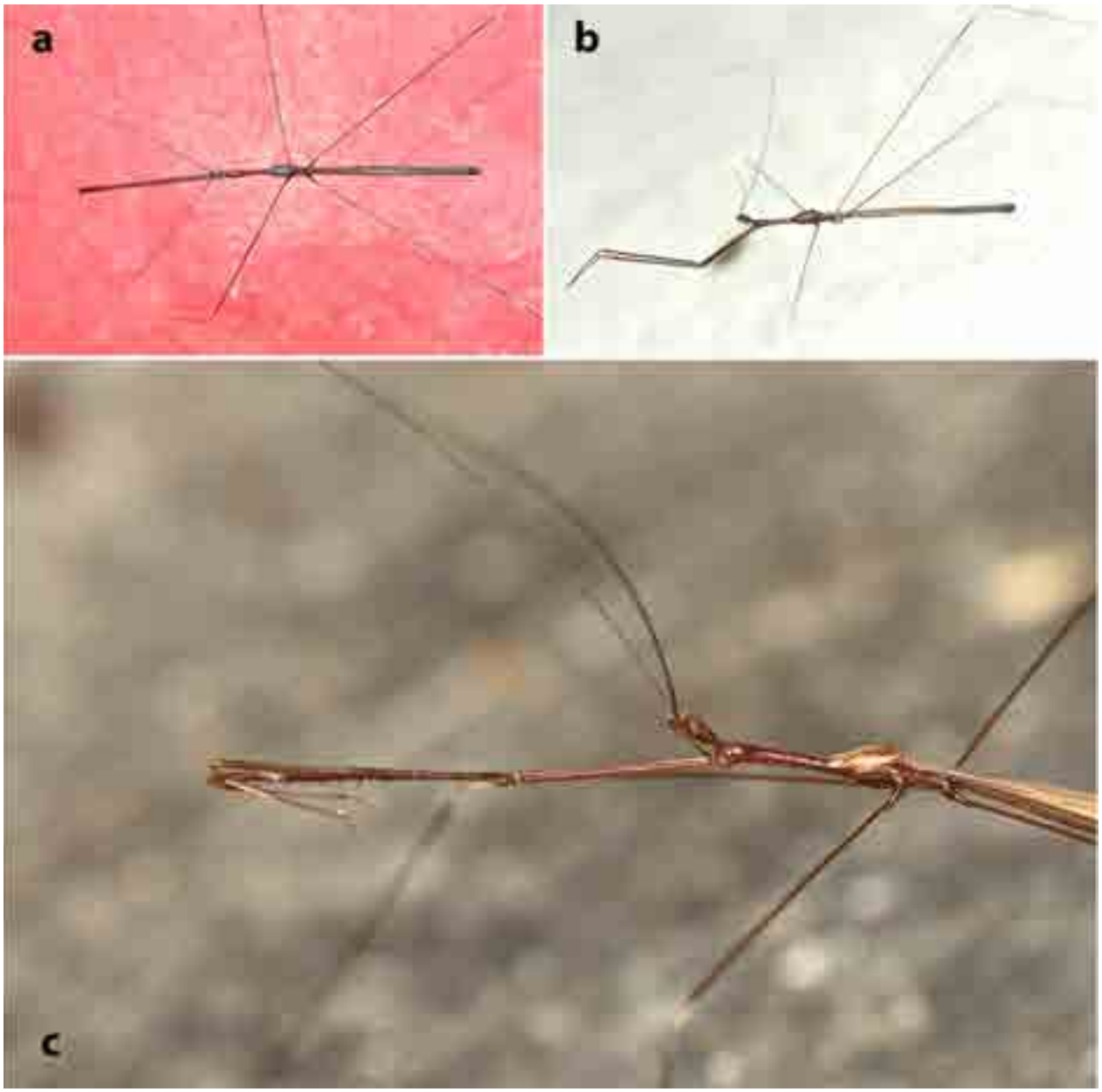

Image 1. *Gardena melinarthrum:* a—Dorsal view taken at Puleliya | b—Lateral view of individual at Mahaoya | c—Anterior half of specimen in 'b' in close up. © T. Ranasinghe.

G. melinarthrum as well, since both these observed individuals in Andankulam did not move and appeared to be resting during day time, in a shaded area. The insect was actually observed flying towards light at night on two separate occasions.

A map showing three recorded locations is presented here (Image 2). All the recorded locations are from the dry zone of Sri Lanka. Based on that, we can assume that this species mostly inhabits dry mix evergreen forests, but we can't say with conviction that this species is restricted to the dry zone. More targeted surveys are needed to confirm its range of distribution within Sri Lanka.

It is indeed heartening that such a delicate predatory bug is still present and is quite widely distributed in Sri Lanka. We did not observe any apterous form, may be because we did not look closely at the various undisturbed places that harbor spider webs. A search for such areas will be surely fruitful. This note is a kind of rediscovery of this interesting bug.

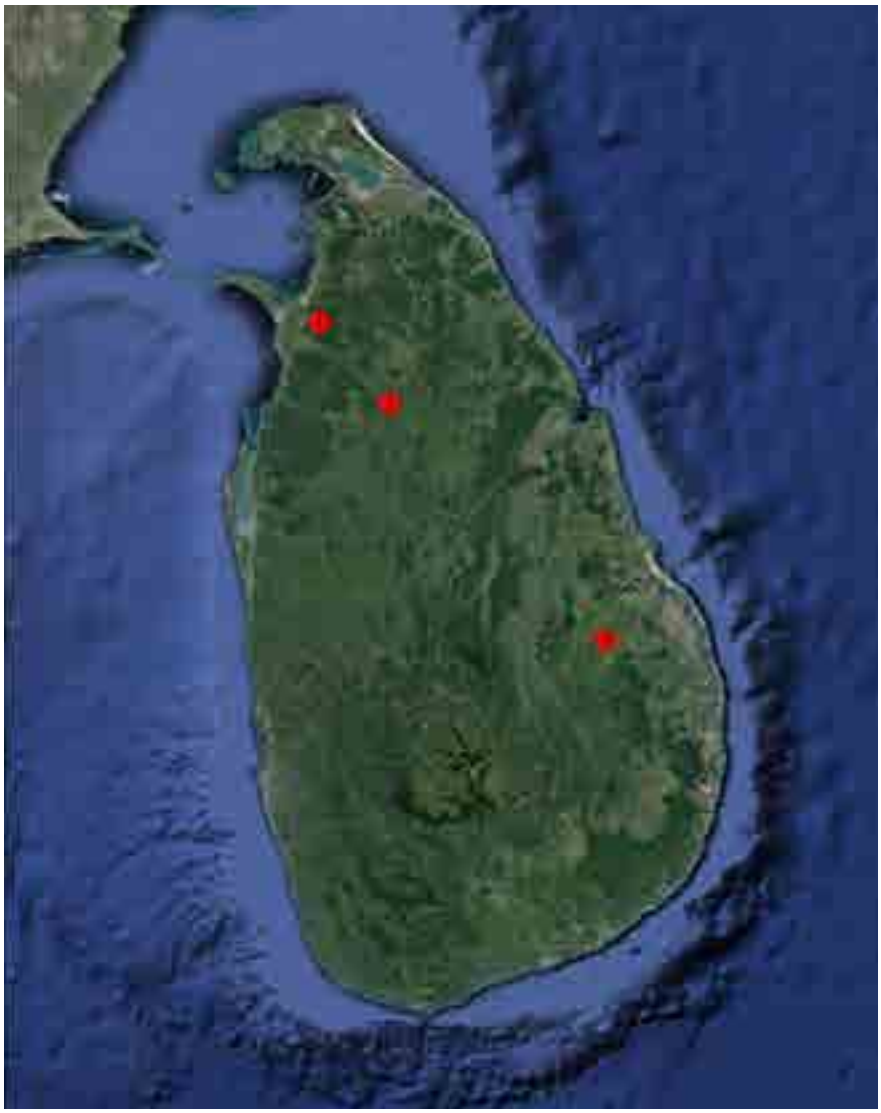

Image 2. Recorded locations of *G. melinarthrum* from Sri Lanka. 1—Andankulam (Mannar) | 2—Puleliya (Anuradhapura) | 3—Mahaoya (Ampara).

References

Hiremath, S.R., S. Saikia & H.V. Ghate (2022). Authentic report of the emesine bug *Gardena melinarthrum* Dohrn, 1860 (Hemiptera: Heteroptera: Reduviidae) from India. *Journal of Threatened Taxa* 14(6): 21296–21301. https://doi.org/10.11609/jott.7902.14.6.21296-21301

Wygodzinsky, P.W. (1966). A monograph of the Emesinae (Reduviidae, Hemiptera). *Bulletin of the American Museum of Natural History* 133: 1–614.

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NOTE

A report on the occurrence of the cicada *Callogaeana festiva* (Fabricius, 1803) (Insecta: Cicadidae) from Mizoram, India

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The family Cicadidae is the largest family of cicada made up of 3,200 species of which roughly 250 species are found in India (Kunte & Roy 2021). The genus *Callogaeana* Chou & Yao, 1985 consist of nine living species of Asian cicadas of which the species *Callogaeana festiva* Fabricius, 1803 is found in the majority of the southeastern Asian countries including China, Indonesia, Thailand, Sumatra, Laos, & Malaysia and in parts of southern Asia such as in Bhutan and northeastern India (Sanborn 2014). In India, it is reported from Sikkim and from Buxa Tiger Reserve, West Bengal (Image 1) (Kunte & Roy 2021). *Callogaeana* belongs to the tribe Gaeanini Distant, 1905 which bears close morphological resemblance to the tribe Tosenini Amyot & Audinet-Serville, 1843.

The diversity and distribution of cicadas within the state of Mizoram has been poorly studied and this report adds a new distribution record for the state in addition to *Tosena splendida* (Distant, 1878) and *Dundubia hastata* (Moulton, 1923) formerly reported by Marathe et al. (2021). Hruaitluangi et al. (2021) have also recently reported the occurrence of *Pomponia cinctimanus* (Walker, 1850) and *Dundubia annandalei* (Boulard, 2007) from the state.

The specimen was collected on the side of a forest track under a *Schima walichi* tree in a secondary forest utilized for potato and rice cultivations surrounded by primary forests at the outskirt of Hualtu, Serchhip District, Mizoram, India (23.53 N 92.91 E; 1,345 m) on 14 June 2021 (Image 1). It is currently preserved at the Departmental Museum of Zoology, Mizoram University (MZMU), under the accession number MZMU2409. The GPS coordinate of the collection site was recorded using a Garmin Montana 650-GPS navigator and the photographs were taken with Canon EOS m6 mark II digital camera.

The species identification of *Callogaeana festiva* (Image 2b) was based on the characters given by Distant (1892) where the species is characterised by "body above black; ocelli, eyes and a broad fascia behind them

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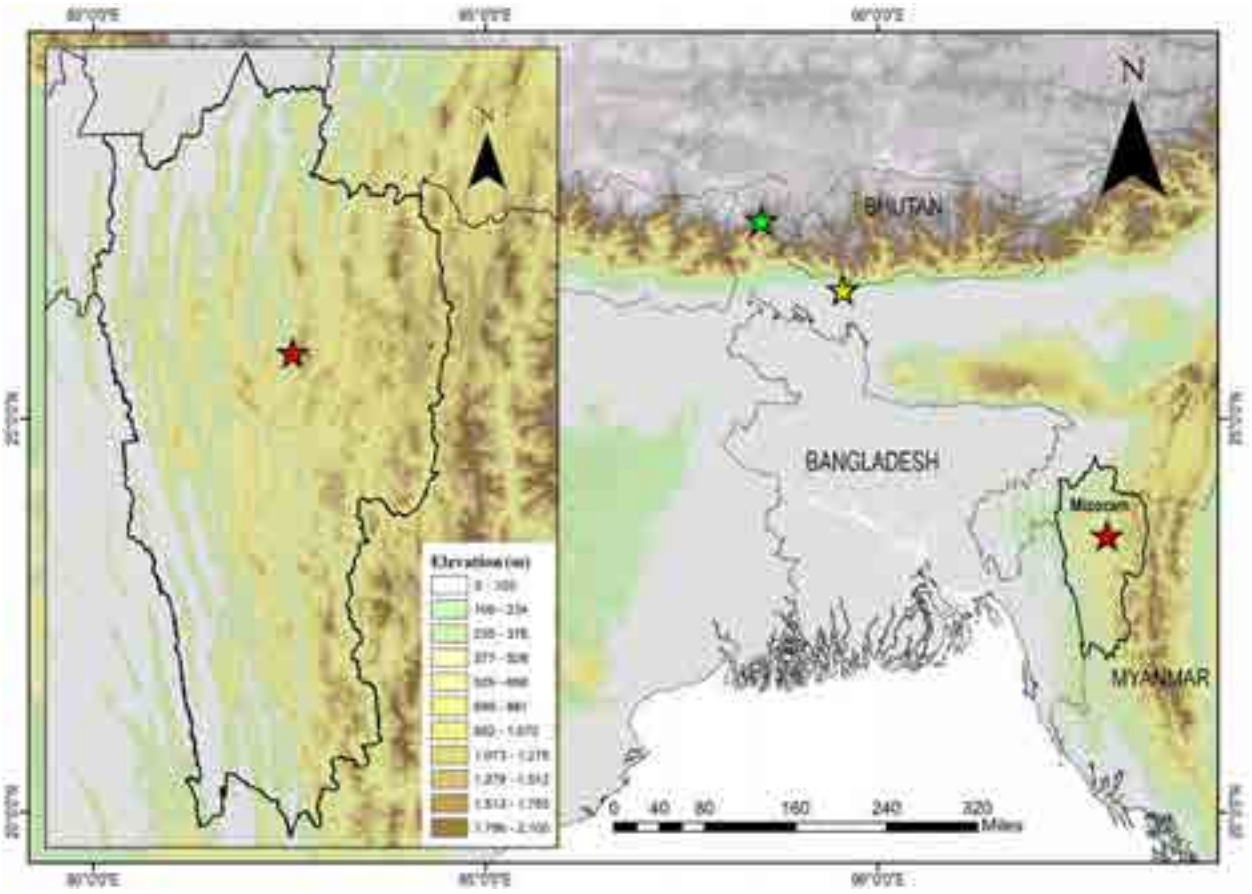

Image 1. Map showing the distribution of *Callogaeana festiva* within the Indian subcontinent; Sikkim (in green star), Buxa Tiger Reserve, West Bengal (in yellow star) and Hualtu, Mizoram (in red star).

Image 2. a–Habitat of *Callogaeana festiva* in the outskirt of Hualtu Village, Serchhip District, Mizoram, India | b–habitus of *Callogaeana festiva* collected. © Khawlhring Marova.

reddish ochre; margins of pronotum and four discal fasciae to mesonotum of which the two central ones are angulated and connected with the anterior angle at the basal cruciform elevation greenish ochraceous. Body beneath and legs black; apical half of face and a spot between face and eyes reddish ochre. Tegmina greenish ochre; the radial area, a transverse fascia crossing centre from apex of radial area, near which is a large triangular spot, apex and outer and inner margins, and two small spots near base, blackish. The black area at apex is more or less broken, sometimes including a small greenish–ochre spot. Wings pale bluish green; the apex broadly black containing a pale bluish spot and the margin, black, continued more narrowly to anal angle. The face is coarsely transversely striate, and broadly sulcated at base."

The collection site of *Callogaeana festiva* at the outskirt of Hualtu Village was ca. 83 km south-east from Aizawl city, the district capital of Mizoram (Image 1). It is surrounded by a forest with vegetation such as, *Aganope thysiflora*, *Amorphophallus bulbifer*, *Biedens pilosa*, *Diascorea alata*, *Paederia foetida*, and *Lithocarpus dealbatus*. The forest type of the surveyed area falls under the tropical wet evergreen forest and tropical semi-evergreen forest associated with moist deciduous forest corresponding to the Cachar tropical evergreen 1B/C3 and semi-evergreen 2B/C2 forest (Champion & Seth 1968). Earlier reports reveal that this species is distributed in two states- Sikkim and West Bengal in India. This report gives the third report of *C. festiva* from India. Nearest locality of this species is ca. 484 km (aerial distance) from previous locality at Buxa Tiger Reserve, West Bengal. Diversity of cicada in states of northeastern India is poorly studied and this report provides the easternmost as well as southernmost distribution of this species from India.

References

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

Distant, W.L. (1892). *A Monograph of Oriental Cicadidae*. West, Newman & Company, London, 157 pp.

Hruaitluangi, L., L. Muansanga, F. Malsawmdawngliana & H.T. Lalremsanga (2021). Report on the occurrence of the cicadas *Pomponia cinctimanus* Walker, 1850 and *Dundubia annandalei* Boulard, 2007 from Mizoram, India. *Bionotes* 23(1): 25–26.

Kunte, K. & P. Roy (2021). Species pages. Cicadas of India, v. 1. Indian Foundation for Butterflies. https://www.indiancicadas.org/species-pages. Accessed 2 June 2021.

Marathe, K., V. Sarkar, B.W. Price, P. Roy & K. Kunte (2021). Cicadas of India, v. 1. Indian Foundation for Butterflies. https://www.indiancicadas.org/home. Accessed 2 June 2021.

Sanborn, A.F. (2014). *Catalogue of the Cicadoidea (Hemiptera: Auchenorrhyncha)*. Elsevier, 1002 pp.

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NOTE

New distribution records of two species of metallic ground beetles of the genus *Chlaenius* (Coleoptera: Carabidae: Chlaeniini) from the Western Ghats, India

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Chlaenius Bonelli, 1810 is one of the largest and taxonomically most diverse genera of Carabidae. There are approximately 855 species and 62 subgenera of *Chlaenius* in the world (Lorenz 2005) and new species are continually being described (Anichtchenko 2018). The beetles belonging to this genus are popularly known as 'metallic ground beetles' because of their vivid metallic colour of most species (Hegde & Manthen 2017). They emit some chemical compounds (m-Cresol, 2,5-dimethylphenol, 3,5-dimethylphenol) as defensive secretions (Schildknecht et al. 1968a,b; Balestrazzi et al. 1985). The representatives of this genus are found in all zoogeographical regions of the world (Bousquet 2012).

While analysing the earlier collections of carabid beetles of the Western Regional Centre of Zoological Survey of India, we came across two unidentified specimens, which on examination turned out to be *Chlaenius* species—*Chlaenius* (*Chlaeniellus*) *cookei* Andrewes, 1933 and *Chlaenius* (*Pseudochlaeniellus*) *puncticollis* Dejean, 1826. Perusal of published works on the *Chlaenius* species of India (Andrewes 1930, 1933; Saha 1986, 1992, 1995; Saha et al. 1991; Anichtchenko & Kirschenhofer 2017; Chanu & Swaminathan 2017; Hegde & Manthen 2017) revealed that these two species have not been reported from the Western Ghats region earlier, and hence our findings represent new distribution records. The specimens were set-pinned, labelled, and assigned registration numbers. Identification was based on the literature (Andrewes 1933; Jedlička 1964). The photographs were taken with Leica EZ4HD stereo zoom microscope.

***Chlaenius* (*Chlaeniellus*) *cookei* Andrewes, 1933**

Chlaenius deserti Jedlička, 1964.

Material examined: Ent-1/3595, 01.x.2016, 1 male, collected at light, near Gagangiri mountain, Kolhapur District, Maharashtra (16.5380 N & 73.8238 E), coll. V.D. Hegde & party.

Diagnostic characters: Head metallic green, with small scattered punctures; antennomeres 1–3 light brown, remaining antennomeres dark brown. Pronotum wider than long, rounded at sides, punctate pubescent, metallic green, with narrow lateral margins brown; basal margin longer than apical margin; apical angles rounded; basal angles obtuse. Elytra dark green, with a small, oblique, narrow pale spot on each side, reaching

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Image 1. *Chlaenius* (*Chlaeniellus*) *cookei* Andrewes, 1933; Scale bar = 2 mm. © Vasanthakumar D.

Image 2. *Chlaenius* (*Pseudochlaeniellus*) *puncticollis* Dejean, 1826; Scale bar = 2 mm. © Vasanthakumar D.

apex as reported by Andrewes (1933) (Image 1).

Distribution: India (New Delhi, Rajasthan, and Western Ghats region of Maharashtra (new record)); Pakistan (Azadbaksh & Rafi 2017).

Remarks: This species was originally described by Andrewes (1933) from New Delhi. Jedlička (1964) described *Chlaenius deserti* from Barmer, Rajasthan which was then synonymised as *C.* (*Chlaeniellus*) *cookei* by Kirschenhofer (2003).

***Chlaenius* (*Pseudochlaeniellus*) *puncticollis* Dejean, 1826**

Material examined: Ent-1/3596, 13.vii.2017, 1 male, Near Tamhini, Pune District, Maharashtra) (18.450 N & 73.416 E), coll. Shripad Manthen.

Diagnostic characters: Head metallic green, moderately punctate. Pronotum also metallic green, very coarsely punctate, densely at the base and less densely in anterior half of pronotum; lateral grooves narrow; basal angles right. Elytra metallic green, with narrow yellow lateral band, strictly limited to two external intervals; apical part of band narrow; elytral striae fine, finely punctured; all intervals flat (Image 2).

Distribution: India (Himachal Pradesh, Uttarakhand, West Bengal, and Western Ghats region of Maharashtra (new record)); Afganistan, Pakistan, Iran, Nepal, Myanmar, and Sri Lanka (Anichtchenko & Kirschenhofer 2017).

References

Andrewes, H.E. (1930). *Catalogue of Indian Insects. Part 18. Carabidae*. Government of India, Central Publication Branch, Calcutta, 389 pp.

Andrewes, H.E. (1933). Papers on Oriental Carabidae—XXVII. *Annals and Magazine of Natural History* 11(61): 99–110. https://doi.org/10.1080/00222933308673630

Anichtchenko A. (2018). Carabidae of the World. (Accessed on 04th October 2018). http://carabidae.org

Anichtchenko, A. & E. Kirschenhofer (2017). To the knowledge of Oriental species of subgenus *Pseudochlaeniellus* Jeannel, 1949 (Coleoptera, Carabidae, *Chlaenius*). *Zootaxa* 4231(2): 187–202. https://doi.org/10.11646/zootaxa.4231.2.3

Azadbakhsh, S. & M.A. Rafi (2017). Checklist of ground beetles (Coleoptera: Carabidae) deposited in National Insect Museum of Pakistan, *Oriental Insects* 51 (4): 305–312. https://doi.org/10.1080/00305316.2017.1283256

Balestrazzi, E., M.L.V. Dazzini, M.D. Bernardi, G. Vidari, P. Vita-Finzi & G. Mellerio (1985). Morphological and chemical studies on the pygidial defence glands of some Carabidae (Coleoptera). *Naturwissenschaften* 72: 482–484.

Bousquet, Y. (2012). Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. *ZooKeys* 245: 1–1722. https://doi.org/10.3897/zookeys.245.3416

Chanu, N.Y. & R. Swaminathan (2017). Notes on species of the genus *Chlaenius* Bonelli, 1810 (Coleoptera: Carabidae, Chlaeniini) from four agro-climatic zones of Rajasthan, with description of two new species. *Zootaxa* 4237(3): 545–566. https://doi.org/10.11646/zootaxa.4237.3.5

Hegde, V.D. & S. Manthen (2017). To the knowledge of the genus *Chlaenius* Bonelli, 1810 (Coleoptera: Carabidae: Chlaeniini) from Maharashtra state (India). *Zoology and Ecology* 27(3–4): 257–260. https://doi.org/10.1080/21658005.2017.1383037

Jedlička, A. (1964). Neue Carabiden aus Indien (Col. Carabodae). *Entomologische Arbeiten aus dem Museum G. Frey Tutzing* 15(2): 305–318.

Kirschenhofer, E. (2003). Über neue und wenig bekannte Carabidae aus der äthiopischen und orientalischen Region (Coleoptera: Carabidae, Chlaeniinae, Pterostichinae). *Entomofauna* 24(3): 29–60.

Lorenz, W. (2005). *A Systematic List of Extant Ground Beetles of the World (Insecta, Coleoptera, Adephaga: Trachypachidae and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae). 2nd ed.* Published by the author, Tutzing, 530 pp.

Saha, S.K. (1986). Ground Beetles (Insecta: Coleoptera: Carabidae) of Silent Valley of Kerala, India. *Records of the Zoological Survey of India* 84: 1–4.

Saha, S.K. (1992). Carabidae of Calcutta. *Records of the Zoological Survey of India*, *Occasional Paper*. No. 144: 1–63.

Saha, S.K. (1995). Insecta: Coleoptera: Adephaga: Carabidae: Harpalini, pp.53–75. In: Fauna of West Bengal, State Fauna Series, 3, (Part-6A). Zoological Survey of India, Kolkata, 447 pp.

Saha, S.K., S. Biswas & S.K. Halder (1991). Insecta: Coleoptera: Cicindelidae, pp. 239–242. In: Fauna of Orissa, State Fauna Series, 1 (Part-3). Zoological Survey of India, Kolkata, 262 pp.

Schildknecht, H., U. Maschwitz & H. Winkler (1968a). Zur Evolution der Carabiden-Wehrdrüsensekrete. Über Arthropoden-Abwehrstoffe XXXII. *Naturwissenschaften* 55: 112–117.

Schildknecht, H., H. Winkler & U. Maschwitz (1968b). Vergleichend chemische Untersuchungen der Inhaltsstoffe der Pygidialwehrblasen von Carabiden. Über Arthropoden-Abwehrstoffe XXXI. *Zeitschrift für Naturforschung B (Chemical Sciences)* 23: 637pp.

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NOTE

Report of *Euphaea pseudodispar* Sadasivan & Bhakare, 2021 (Insecta: Odonata) from Kerala, India

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Euphaea pseudodispar Sadasivan & Bhakare, 2021 is a newly described damselfly in the family Euphaeidae. It was described along with *E. thosegharensis* Sadasivan & Bhakare, 2021 based on specimens collected from Thoseghar, Satara district, Maharashtra, northern Western Ghats, India (Bhakare et al. 2021). The genus *Euphaea* Selys, 1840 currently has 35 species distributed in the Indo-Malaya (Paulson et al. 2021). India has seven known species of *Euphaea*, five of them distributed in the Western Ghats and two in the northeastern region. The two newly described species, *E. pseudodispar* and *E. thosegharensis* were considered to be confined to the northern Western Ghats of Maharashtra (Bhakare et al. 2021). We report *E. pseudodispar* from Thirunelly, Wayanad district, Kerala, at a distance of more than 650 km from the type locality (Image 1).

Thirunelly (11.9117°N 75.9933°E, 850 m) is a small temple town adjoining the forests of North Wayanad Forest Division in Kerala, southern India. River Kalindi originates in the Brahmagiri hills, flows through the temple town briefly and re-enters the forest. Odonate species commonly encountered in this stretch of the river include *Neurobasis chinensis* (Linnaeus, 1758), *Vestalis apicalis* Selys, 1873, *Heliocypha bisignata* (Hagen in Selys, 1853), *Euphaea fraseri* (Laidlaw, 1920), *Copera vittata* (Selys, 1863), *Prodasineura verticalis* (Selys, 1860), *Pseudagrion rubriceps* Selys, 1876, *Anax immaculifrons* Rambur, 1842, *Gomphidia kodaguensis* Fraser, 1923, *Hylaeothemis apicalis* Fraser, 1924, and *Neurothemis fulvia* (Drury, 1773).

On 22 August 2021, during a walk along the river Kalindi, we encountered three species of *Euphaea,* viz., *fraseri*, *dispar*, and *pseudodispar* (Image 2). The river was in full spate and the authors recorded 40 individuals of *E. pseudodispar*, 35 individuals of *E. fraseri*, and four individuals of *E. dispar* in traversing 1 km along its bank (Image 3). Later, one male *E. pseudodispar* was collected for the detailed study of morphology and structure of secondary genitalia. The specimen was deposited at the insect collections of the Department of Geology and Environmental Science, Christ College, Thrissur district, Kerala. Photographs of live specimen were taken with a Nikon D850 camera and Nikkor 105 mm macro lens (Image 3). Secondary genitalia was studied under a Labomed Luxeo 6Z stereomicroscope (Images 5, Figure 1).

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Image 1. Map showing the site of current observation (Thirunelly) and type locality (Thoseghar) of *Euphaea pseudodispar*.

Image 2. The three *Euphaea* species seen in Thirunelly (males): A—*E. fraseri* | B—*E. dispar* | C—*E. pseudodispar*. © Muneer P.K.

Material examined: CC.G & ES.O12, 1 male, Thirunelly (11.911°N 75.993°E, 850 m), 31.x.2021, coll. Muneer P.K.

Description: Total length: 48 mm, abdomen: 38 mm, forewing: 34 mm, hindwing: 33 mm.

Head: Labium black; labrum pale bluish-white with a median black 'tongue' like mark; Mandible pale bluish-white with an upper transverse black streak; anteclypeus, postclypeus, antefrons, & postfrons black and genae pale yellowish-white. Eyes, antennae, and vertex black.

Thorax: Prothorax matte black with two yellowish spots. Ground colour of thorax orange-red; dorsal carina black; mesepisternum matte black; humeral stripe yellowish-orange; antehumeral stripe pale yellow and thin; mesepimeron yellow superiorly and orange inferiorly, and encloses a central broad black band. Legs: extensor surface of foreleg femora smoky black; hind and middle legs red; all joints black. Wings: hyaline, veins black; cubital space with three cross veins in all wings; distal fourth of hindwings coloured black.

Abdomen: Proximal segments reddish-orange and distal ones black, the transition happening on S6. S2 with black, rounded genital vesicle; penis with a single seta on each side. Hair tufts present on central part of sternite and lateral aspects of tergite on S8 and lateral tufts on proximal aspect of tergite of S9. On S9, the gonopore margin is oval; gonocoxae with blunt apices, no spine. In lateral view, the sternite of S9 extends mid-ventrally like a beak. Anal appendages: General structure as in the genus; cerci and paraprocts fully black.

The studied male specimen differed from the holotype in the following details: the extensor surface of the foreleg femora had only a smoky black colouration over the basal red and the distal fourth of the hindwings were coloured black instead of the distal fifth.

Three *Euphaea* species were known to occur in Kerala before the current observation. These include *E. cardinalis* (Fraser, 1924) seen in mountain streams south of the Palghat gap in the Anamalai, Palani, and Agasthyamalai hills; *E. dispar* Rambur, 1842 confined to the mountain

Image 3. Observation site: Kalindi River, Thirunelly, Wayanad district, Kerala. © Muneer P.K.

streams north of the Palghat gap from South Kanara and Coorg to the Nilgiris; and *E. fraseri* (Laidlaw, 1920) distributed throughout the foothills of the Western Ghats (Fraser 1934; Subramanian et al. 2018). This study adds a fourth *Euphaea* species, *E. pseudodispar* to the odonate fauna of Kerala state. In Thirunelly, where it co-occurred with two of its congenerics, *E. pseudodispar* stood out because of its thoracic colouration and intermediate size, *E. fraseri* being considerably smaller, and *E. dispar* slightly larger. This observation accentuates the need for undertaking more rigorous field surveys in the Western Ghats in order to have a better understanding of the distribution of its Odonata.

Image 4. Morphological details of *Euphaea pseudodispar*: A—face showing yellowish-white genae and bluish labrum with black 'tongue' | B—dorsal view of thorax | C—lateral view of thorax | D—ventral view of S9 showing the gonocoxae | E—lateral view of the abdominal tip showing the 'beaking' of S9 | F—abdominal tip showing the hair tufts on S8 & S9. © Muneer P.K.

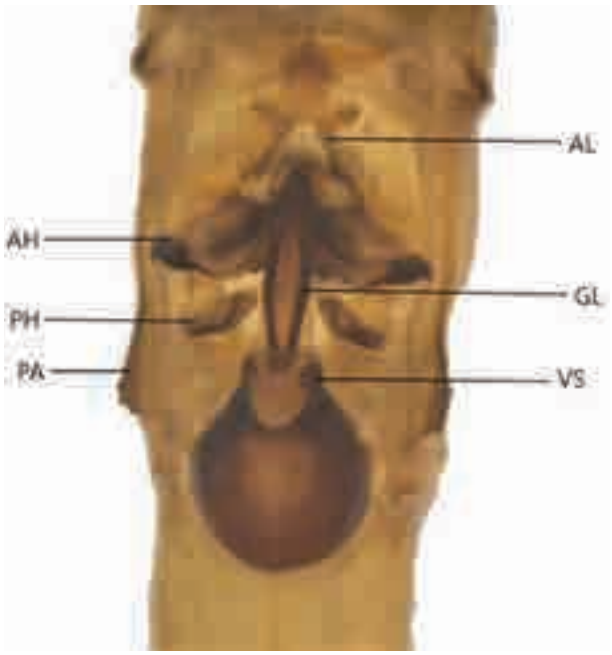

Image 5. Structure of secondary genitalia of *Euphaea pseudodispar* seen under the microscope: AL—anterior lamina | GL—genital ligula | VS—vesicaspermalis | AH—anterior hamule | PH—posterior hamule | PA—pseudoauricle. © A. Vivek Chandran.

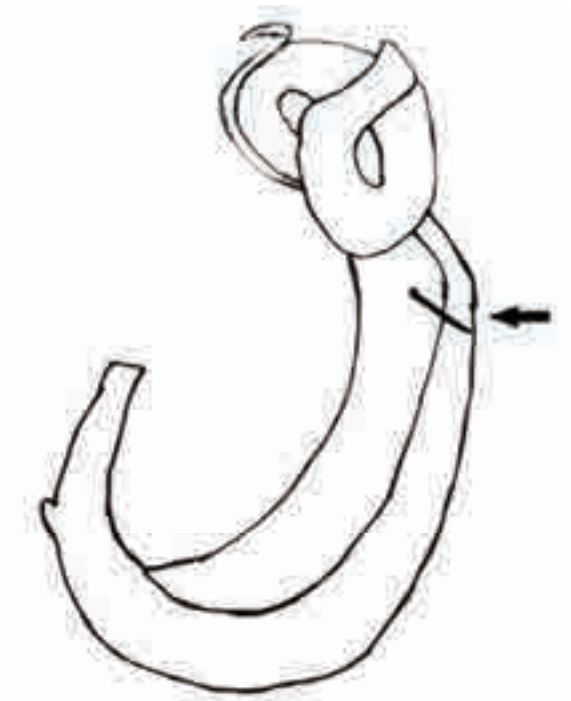

Figure 1. Genital ligula of *Euphaea pseudodispar* illustrated (arrow pointing to the seta on one side).

References

Bhakare, S.D., V.P. Nair, P.A. Pawar, S.H. Bhoite & K. Sadasivan (2021). Two new species of *Euphaea* Selys, 1840 (Odonata: Zygoptera: Euphaeidae) from Northern Western Ghats, India. *Journal of Threatened Taxa* 13(5): 18200–18214. https://doi.org/10.11609/jott.6579.13.5.18200-18214

Fraser, F.C. (1934). *The Fauna of British- India, including Ceylon and Burma, Odonata, Vol. II*. Taylor and Francis Ltd., London, XXIV+398 pp.

Paulson, D., M. Schorr & C. Deliry (2021). World Odonata List, University of Puget Sound. https://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonata-list2/ Accessed on 14 November 2021.

Subramanian, K.A., K.G. Emiliyamma, R. Babu, C. Radhakrishnan & S.S. Talmale (2018). *Atlas of Odonata (Insecta) of the Western Ghats.* Zoological Survey of India, Kolkata, 417 pp.

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