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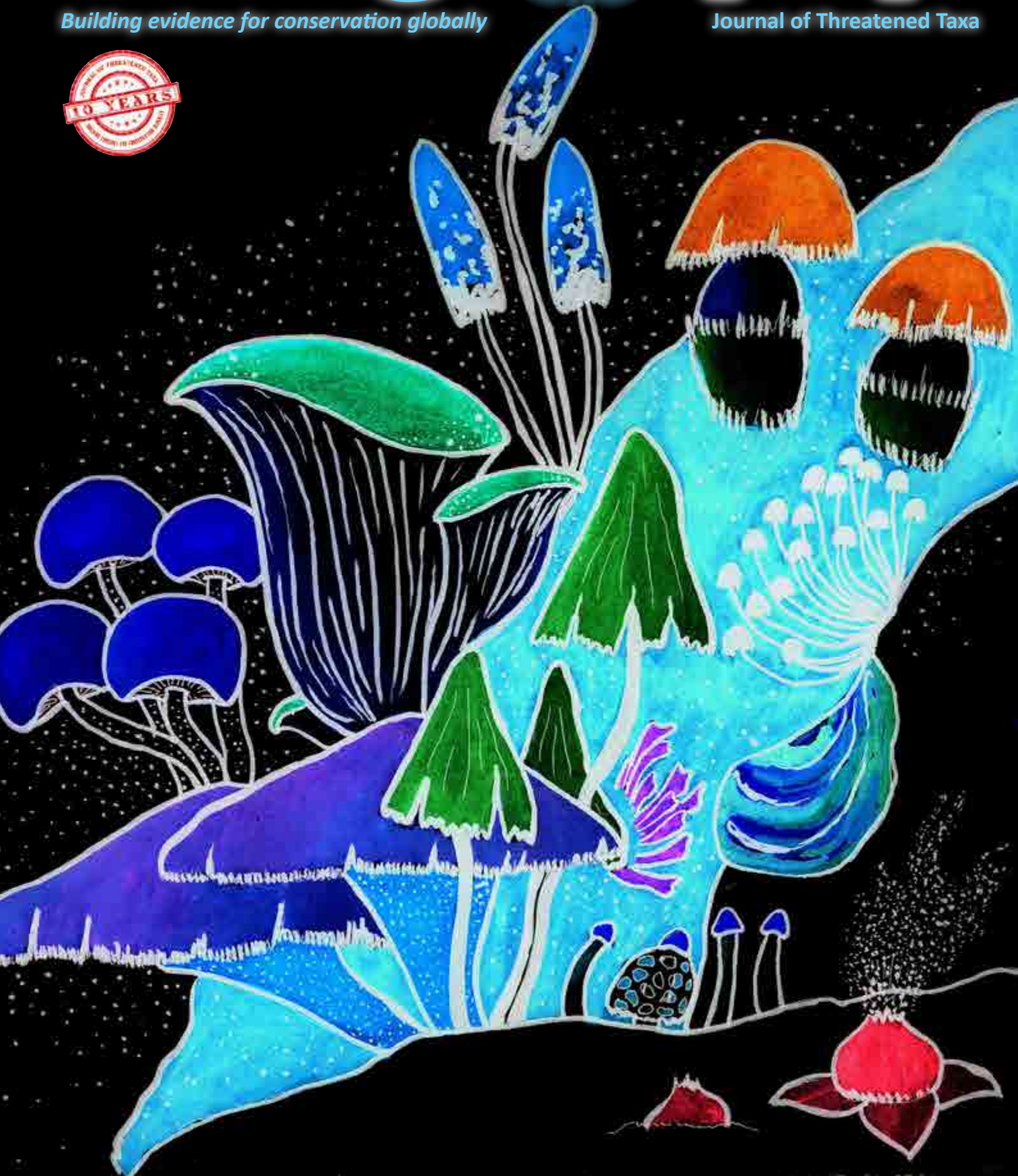

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continued on the back inside cover

Caption: Fungi are one of the few living things that break down dead wood playing a crucial role in nutrient recycling. Some fruiting bodies of fungi are bioluminescent.
Cover by Priyanka Iyer, Zoo Outreach Organization, Coimbatore.

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COMMUNICATION

Urban biodiversity: an insight into the terrestrial vertebrate diversity of Guwahati, India

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Abstract: This study focuses on the assessment of the terrestrial vertebrate diversity of Guwahati. Twenty-six species of amphibians, 57 species of reptiles, 214 species of birds, and 36 species of mammals were recorded during the study period. Thirty-three species were found to be threatened with extinction and another 62 species need evaluation. A single species of turtle was found to be categorized as Extinct in the Wild under the IUCN Red List of Threatened Species.

Keywords: Assam, Biodiversity, city, Deepor Beel, Guwahati, urban, vertebrate.

Abbreviations: EW: Extinct in the Wild; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened, LC: Least Concern; DD: Data Deficient; NE: Not Evaluated; NS: Non Scheduled, I: Schedule I of Indian Wildlife Protection Act, 1972; II: Schedule II of Indian Wildlife Protection Act, 1972; III: Schedule III of Indian Wildlife Protection Act, 1972; IV: Schedule IV of Indian Wildlife Protection Act, 1972; V: Schedule V of Indian Wildlife Protection Act, 1972; *: Introduced Species.

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INTRODUCTION

It has been estimated that the urban population of developing countries is growing at the rate of five million people per month. Roughly 70% of global population is expected to be urban by 2050, and the total urban area is expected to triple between 2000 and 2030 (U-Habitat 2013). Recent studies have focussed on the biodiversity of urban areas. A study in Hyderabad documented 1,305 vascular plant species, 30 odonates, 42 spiders, 141 butterflies, 60 fish, 16 amphibians, 41 reptiles, 314 birds and 58 mammal species (Srinivasulu & Srinivasulu 2012). A study at National Environmental Engineering Research Institute campus at Nagpur, Maharashtra recorded 135 vascular plants including 16 monocots and 119 dicots, belonging to 115 genera and 53 families (Gupta et al. 2008). A rapid assessment survey at the campus of Indian Institute of Technology, Madras recorded 298 plant species, 50 butterflies, eight amphibians, 13 reptiles, 51 birds and 12 mammal species (Care Earth 2006). Sudha & Ravindranath (2000) recorded 374 species of plants in Bangalore, where a study of street trees identified 108 species belonging to 33 families (Nagendra & Gopal 2010). A similar study in Delhi found 125 tree species (Bhalla & Bhattacharya 2015). A study in Chennai metropolitan city revealed the presence of 45 species of plants representing 21 families (Muthulingam & Thangavel 2012).

During the past 50 years the population of India has grown 2.5-fold and the urban population five-fold (Taubenböck et al. 2009). Analyses suggest that 8% of terrestrial vertebrate species on the IUCN Red List are imperiled largely because of urban development (McDonald et al. 2008), and 13% of endemics are in ecoregions that are under threat from urban expansion (McDonald et al. 2018). Thus, it is important to take research and conservation efforts regarding urban biodiversity more seriously. In urban landscapes the participation of inhabitants is a must for conservation, where effort must be invested in sensitising the community about the benefits of conserving urban biodiversity. Some of the services provided by urban biodiversity are improvement of air quality and regulation of microclimate by urban parks and vegetation. Tree cover and vegetation also helps in proper percolation of rain water to soil, adding to ground water and reducing floods while improving quality of life by adding aesthetic and recreational value. It has been estimated that a ten percent increase in canopy cover can reduce local temperature by 3–4 ^{0}C (Gill et al. 2007; Middel et al. 2015).

Guwahati (26.144^{0}N & 91.736^{0}E), the capital of Assam, is the biggest urbanized centre of northeastern India. The city falls within the Indo-Burma Biodiversity Hotspot, situated between the southern bank of the Brahmaputra River and the foothills of the Shillong plateau. It is spread over 216.79km^2 area, and has a population of around a million with a density of 2695.43 humans per sq.km. The city is situated on undulating plain with varying altitude of 49.5–55.5 m. The city is surrounded by 18 hills. Guwahati has eight reserve forests (South Kalapahar RF, Fatasil RF, Jalukbari RF, Gotanagar RF, Hengrabari RF, Sarnai Hill RF, Garbhanga RF, Rani RF) and two wildlife sanctuaries (Deepor beel WLS and Amchang WLS) along with an internationally acclaimed wetland and Ramsar Site, the Deepor Beel, within the city limits. Deepor Beel Wildlife Sanctuary (WS) is a part (4.01km^2) of the Ramsar site which is 40km^2 in area. The mighty Brahmaputra River flows through the city for about 25km dividing it into northern and southern areas (Devi & Bhattacharyya 2015).

Guwahati has a tropical monsoon climate and receives about 1,600mm annual rainfall with an average annual temperature of 23^{0}C. Certain patches of forest still exist within the city (Fig. 1). The overall habitat type in the study area mainly comprises of forest patches, scrublands, grasslands, plantations, wetlands, agricultural lands, human settlements and commercial areas. The forest patches are of moist deciduous type (Purkayastha 2012, 2015).

Due to urbanization and anthropogenic pressure, the biodiversity of the city is under stress. Cutting of hills, illegal felling of trees and degradation of wetlands is having an immense adverse effect on the biodiversity of the city. The hills of the city are used for illegal settlements most of which are reserve forest lands raising serious ecological concern. In the hills within Guwahati Municipal Area, there are 65,894 households of which 10,208 are within reserve forests (Devi & Bhattacharyya 2015). Importantly, a large part of Guwahati has been developed by filling of wetlands and the process of filling and degradation of wetlands still continues. Owing to this, Guwahati is seeing a rise of the artificial flood in the low lying city centers.

Due to factors cited above, an assessment of biodiversity of Guwahati becomes important for the formulation of long-term conservation policies. It is a fact that Guwahati has lost a big chunk of its biodiversity, but quantification of the same is not possible as we do not have data on its biodiversity from the past to compare with the present status of biodiversity. This paper provides an inventory of terrestrial vertebrate

biodiversity occurring in the city limits of Guwahati.

MATERIALS AND METHODS

This study was conducted between the year 2011 and 2016 spanning over a period of six years with survey emphasizing on terrestrial vertebrates. The study site was the Guwahati city (26.1859^{0}N, 91.7477^{0}E), the biggest metropolis of northeastern India and the economic hub of the region (Fig. 1). Since the main goal of the study was to create a checklist, visual encounter survey (Crump & Scott 1994) employing randomized walk (Lambert 1984) was conducted. Active search (Rolfe & McKenzie 2000) was employed specifically for herpetofaunal survey. For herpetofaunal survey, six man hours were invested per survey, with an approximate of six surveys per month from April to October each year between 2011 and 2016. Most of these surveys were undertaken in the evening and early night which also covered observations on nocturnal birds and mammals. Bird surveys were conducted round the year, with more survey efforts being invested during the winters (November–March). We used Olympus 10X50 DPS binocular for the survey. Twelve man hours were generally invested per survey with most conducted in early morning or evening. Mammal survey was conducted in association with bird survey. Records of rescued animal with locality details by Assam State Zoo were also taken into account while creating the checklist. In most cases animals were photographed and identified using literature (Smith 1931, 1935, 1943; Ahmed et al. 2009; Grimmett et al. 2011; Purkayastha 2012; Menon 2014).

RESULTS

During this study a total of 332 species of terrestrial vertebrates were recorded. Birds were found to be the most diverse group accounting for 214 species, followed by reptiles (57 species), mammals (36 species) and amphibians (25 species).

Amphibia: A total of 26 species of amphibians representing seven families were encountered. Among these, a single species is Vulnerable, four species are Data Deficient and 21 species are Least Concern (IUCN 2017). Of these, 11 species are included in Schedule IV of Indian Wildlife Protection Act, 1972 (IWPA) and rest were non-scheduled species (Table 1; Images 1–16).

Reptilia: A total of 53 species of reptiles representing eleven families were encountered from Guwahati City during the present study. Among these, a single species is Extinct in the Wild (Black Softshell Turtle), two species are Endangered, five are Vulnerable, 31 species are Not Evaluated and 14 species are Least Concern as per the

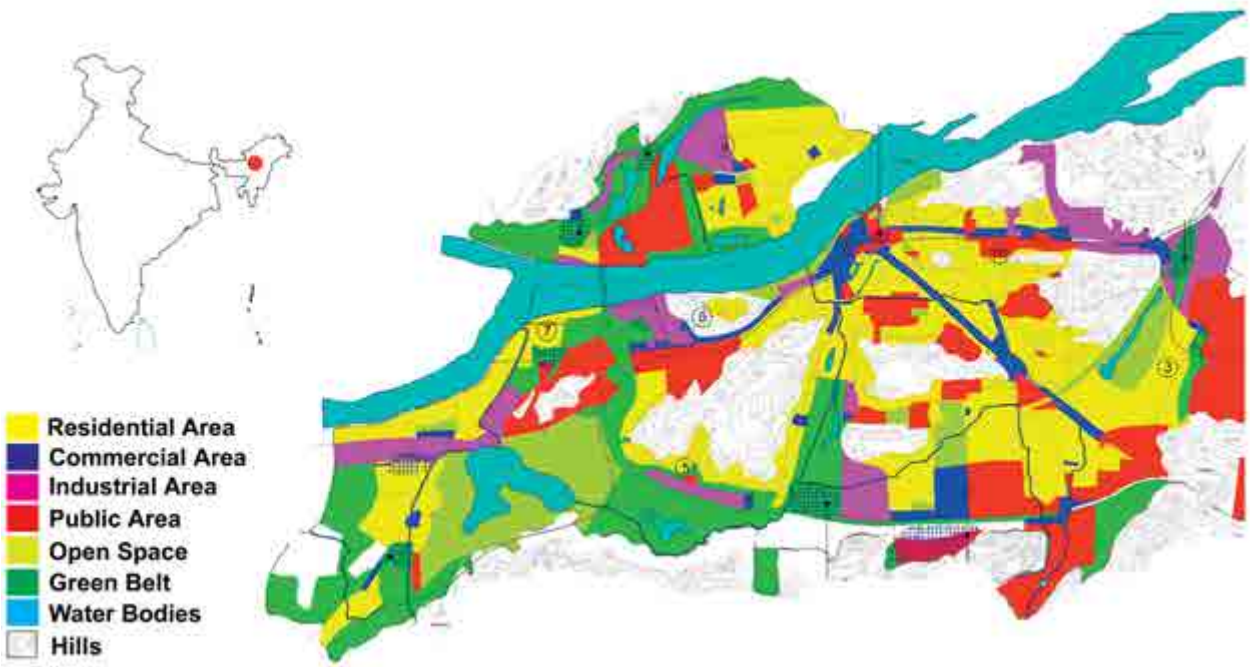

Figure 1. A map showing different zonation within Guwahati city, Assam

IUCN Red List of Threatened Species (IUCN 2017). Of these, seven species are under Schedule I, three are under Schedule II, 25 are under Schedule IV of Indian Wildlife Protection Act, 1972 (IWPA) and the rest are non-scheduled animals (Table 2; Images 17–43).

Aves: Birds are the most diverse group of animals found in the study area, with 214 species representing 59 families. One species is Critically Endangered (Baer's Pochard), two species each are Endangered (Greater Adjutant Stork, Steppe Eagle) and Vulnerable (Common Pochard, Lesser Adjutant), 14 species are Near Threatened and the rest are Least Concern species (IUCN 2017). Three species are listed in Schedule I, one species in Schedule V, and the rest were in the Schedule IV of Indian Wildlife Protection Act, 1972 (IWPA, Table 3; Images 44–58).

Mammalia: Mammals were represented by 36 species in 21 families. One species is Critically Endangered (Chinese Pangolin), six species are Endangered (Gee's Golden Langur, Bengal Slow Loris, Asiatic Elephant, Hog Deer, Dhole, and Ganges River Dolphin), six species are Vulnerable (Capped Langur, Smooth-coated Otter, Sambar, Leopard, Gaur, and Western Hoolock Gibbon), and the remaining twenty two species are Least Concern (IUCN 2017). A total of 36 species are scheduled under Indian Wildlife Protection Act, 1972 (Schedule I: ten species, Schedule II: 14 species, Schedule II: four species, Schedule IV: a single species, Schedule V: five species and two non-scheduled species (Images 59–63).

Conservation status

The conservation status of about 60% of the reptilian fauna recorded from Guwahati is yet to be evaluated (IUCN 2017), creating conservation concerns. Of all the turtles mentioned here, most of these are found in temple ponds of Urgratara and Kamakhya. Though protected by law, unorganized turtle trade for flesh and as pet still continues within the city. There also exists illegal trade for local bird species such parakeets which are sometimes sold under the veil of exotic bird trade.

Threats

The major threats to the terrestrial vertebrates of Guwahati perceived during the study are:

1. **Habitat destruction and alteration:** Many of the green patches are cleared away for constructional activities. Even the hills are used for settlement more than ever before with the city becoming the economic hub of the region. Again these hills are continuously exploited for resources. The city itself is fast losing its floral diversity and many of the trees planted through afforestation program lack suitability to provide nesting sites for birds. Moreover, concrete structures are replacing the age old Assam type houses which used to have nooks and corners providing living space to birds. Stone quarries and felling of trees in the hills is making the situation worse (All India Disaster Mitigation Institute 2014). The blasting of dynamite in stone quarries has made many species leave the area and surroundings. The blasting activities adjacent to Deepor Beel poses a challenge to its birdlife.

2. **Degradation and filling up of wetlands:** Most of Guwahati is reclaimed from wetlands and the process is a continuous one. As a result of the loss of wetland, we are losing out on a wide range of biodiversity which in turn is disturbing the local ecological balance. Due to filling up of the wetland, the city is under artificial floods more than ever before (All India Disaster Mitigation Institute 2014). Deepor beel, the biggest wetland of the city, suffers from degradation of water quality, encroachment, and development of industries around it. The wetland famous for its birdlife is fast losing its glamor with fewer birds visiting the place.

3. **Lack of interest:** Urban biodiversity conservation gets the least priority in the conservation arena in the region. In fact, the term urban biodiversity is alien to many policy makers. Thus very few efforts are taken in the region for research and conservation of urban biodiversity.

DISCUSSION

Cities form less than 3% of the terrestrial surface of the Earth, but they are responsible for 78% of carbon emissions, 60% of residential water use, and 76% of the wood used for various industrial purposes (Grimm et al. 2008). On the other hand, urban trees absorb pollutants to improve air quality and reduce the effects of greenhouse gases and, in some cases, they may do so three times more effectively than adjacent exurban forests (Akbari 2002). Since urban ecosystem is a human modified one, human induced habitat alteration makes the ecosystem susceptible to invasion of non-native species (Aggarwal & Butsch 2012). In this study, we also found an invasive reptile, *Hemidactylus flaviviridis* Rüppell, 1835, which was initially restricted to the commercial area but now has started spreading to residential areas and having a negative effect on native gecko populations (Das et al. 2011). The gecko made its way to the city through the interstate transportation system. Similarly, introduction of exotic trees is a threat not only to native trees but

also the biodiversity dependent on these native trees. A decline in bird diversity was seen with the increase in exotic plant species in Delhi (Khera et al. 2009). It is a myth that cities cannot be rich in biodiversity. Infact, with proper management plan and peoples participation cities can serve as a hub of biodiversity. A study of 61 gardens in the city of Sheffield, UK, found 4,000 species of invertebrates, 80 species of lichen, more than 1,000 species of plants (McDonald et al. 2008). One of the most developed cities in the world, Singapore still has a wealth of biodiversity. Among the native species recorded are 2,145 vascular plants, 52 mammals, 364 birds, 301 butterflies, 127 dragonflies, 103 reptiles, 400 spiders, 66 freshwater fishes, and 255 hard corals. Between 2000 and 2010, intensive surveys found more than 500 species of plants and animals new to Singapore, of which more than 100 were new to science (Cities & Biodiversity Outlook 2012). All of this points to the potentially huge scope of urban biodiversity research.

Since most of the studies in terms of biodiversity are conducted within protected areas (Brandon & Wells 1992; Scott et al. 2001; Rodrigues et al. 2004), human aspect in the framework of biodiversity is not well studied. India's population is currently about 30% urban and is expected to become 50% urban by about 2044 (Cities & Biodiversity Outlook 2012). All these point to the fact that our country will have more urbanized space than ever before with more proportion of biodiversity occupying these urbanized spaces. Thus we are in need of better understanding of the multidimensional aspect of urban biodiversity taking in consideration, the human aspect for formulating long term research and conservation policies.

Recommendations

1. Afforestation effort is to be hastened, but the selection of plant species is an important aspect. Often fast growing trees, usually exotic, are selected for the purpose rather than suitable trees, such as fruiting trees and trees which the birds generally prefer for building nests.

2. Artificial living space, more specifically for birds has to be created by installing nesting boxes and bird feeders. Not only shall it help birds but shall also help generate interest amongst masses regarding conservation of urban biodiversity.

3. Children's urban biodiversity tour is another important aspect that would help create awareness and conserve the biodiversity of Guwahati. These tours can be a part of schools ecological club program; can also be conducted through district administration. We can only save things we love and can only love things that we have seen, thus these tours shall serve the purpose of conservation in long run.

4. Deepor Beel is one of the most sensitive spots in terms of wetland birds, with 104 species of wetland birds recorded by us in the year 2016 including the endangered Greater Adjutant Stork which has a population of around 240 in the wetland. Unfortunately, this wetland is facing dual problems. The wetland is degrading mainly due to anthropogenic activity, and there is a tug of war between the community and an administration unable to find common ground. The current need to secure the future of the wetland is to adopt an approach that includes water quality improvement of the wetland via bioremediation (bacterial treatment) and a study of the socioeconomic structure of community living around the wetland to provide alternative sources of livelihood to the community who are primarily fishermen (this may include promotion of local handicraft, skill development programme for handicraft using water hyacinth, ecotourism, development of fisheries in government land, etc.). The selective incentive can be provided to the fishermen to encourage "no-fishing" in breeding seasons to help increase the productivity of the wetland.

5. Turtles are one of the most vulnerable groups of vertebrates with about half of the species threatened with extinction (Turtle Conservation Coalition 2011). Thus, through captive breeding programme with the stock in the temple ponds, and subsequently through release of the hatched turtles to the wild, we can boost the wild population of these threatened animals. The temple ponds can thus serve the role of a breeding, conservation and education centers in terms of turtles.

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Table 1. Checklist of amphibian diversity of Guwahati

Family	Common name	Scientific name	IUCN/RL	IWPAS
Bufonidae	Common Asian Toad	*Duttaphrynus melanostictus* (Schneider, 1799)	LC	NS
	Marbled Toad	*Duttaphrynus stomaticus* (Lütken, 1864)	LC	NS
Megophryidae	Red-eyed Frog	*Leptobrachium smithi* (Matsui et al. 1999)	LC	NS
	White-lipped Horned Toad	*Megophrys major* Boulenger, 1908	LC	NS
	Concave-crowned Horned Toad	*Megophrys parva* (Boulenger, 1893)	LC	NS
Microhylidae	Ornate Narrow-mouthed Frog	*Microhyla ornata* (Duméril & Bibron, 1841)	LC	NS
	Berdmore's Narrow-mouthed Frog	*Microhyla berdmorei* (Blyth, 1856)	LC	NS
Rhacophoridae	Garo Hills Bush Frog	*Philautus garo* (Boulenger, 1919)	VU	NS
	Six-lined Tree Frog	*Polypedates teraiensis* (Dubios, 1987)	LC	NS
	Double-spotted Tree Frog	*Rhacophorus bipunctatus* Ahl, 1927	LC	NS
	Annandale's Pigmy Tree Frog	*Chiromantis simus* (Annandale, 1915)	LC	NS
Dicroglossidae	Nepal Cricket Frog	*Fejervarya nepalensis* (Dubois, 1975)	LC	IV
	Pierre's Cricket Frog	*Fejervarya pierrei* (Dubois, 1975)	LC	IV
	Small Cricket Frog	*Fejervarya syhadrensis* (Annandale, 1919)	LC	IV
	Terai Cricket Frog	*Fejervarya teraiensis* (Dubois, 1975)	LC	IV
	Skittering Frog	*Euphlyctis cyanophlyctis* (Schneider, 1799)	LC	IV
	Indian Bull frog	*Hoplobatrachus tigerinus* (Daudin, 1802)	LC	IV
	Khasi Wart Frog	*Limnonectes khasianus* (Anderson, 1871)	DD	IV
Ranidae	Assam Hills Frog	*Clinotarsus alticola* (Boulenger, 1882)	LC	IV
	Theobald's Ranid Frog	*Hylarana tytleri* (Theobald, 1868)	LC	IV
	Bhamo Frog	*Humerana humeralis* (Boulenger, 1887)	LC	IV
	Cope's Assam Frog	*Hydrophylax leptoglossa* (Cope, 1868)	LC	IV
	Sengupta's Cascade Frog	*Amolops assamensis* (Sengupta, Hussain, Choudhury, Gogoi, Ahmed & Choudhury, 2008)	DD	IV
	Gerbil Stream Frog	*Amolops gerbillus* (Annandale, 1912)	LC	IV
Ichthyophidae	Garo Hills Caecilian	*Ichthyophis garoensis* (Pillai & Ravichandran, 1999)	DD	NS
	Manipur Moustached Ichthyophis	*Ichthyophis moustakius* Kamei et al. 2009	DD	NS

Image 1. *Duttaphrynus melanostictus*

Image 2. *Megophrys parva*

Image 3. *Leptobrachium smithi*

Image 4. *Microhyla ornata*

Image 5. *Limnonectes khasianus*

Image 6. *Fejervarya nepalensis*

Image 7. *Fejervarya teraiensis*

Image 8. *Hoplobatrachus tigerinus*

Image 9. *Clinotarsus alticola*

Image 10. *Humerana humeralis*

Image 11. *Hydrophylax leptoglossa*

Image 12. *Hylarana tytleri*

Image 13. *Amolops assamensis*

Image 14. *Philautus garo*

Image 15. *Rhacophorus bipunctatus*

Image 16. *Ichthyophis moustakius*

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Table 2. Checklist of reptilian diversity of Guwahati

Family	Common name	Scientific name	IUCN/RL	IWPAS
Agamidae	Common Garden Lizard	*Calotes versicolor* (Daidin, 1802)	NE	NS
	Blue-throated Lizard	*Ptyctolaemus gularis* (Peters, 1864)	NE	NS
Gekkonidae	Common House Gecko	*Hemidactylus frenatus* (Duméril & Bibron, 1836)	LC	NS
	Brook's House Gecko	*Hemidactylus brookii* (Gray, 1845)	NE	NS
	Garnot's House Gecko	*Hemidactylus garnotii* (Duméril & Bibron, 1836)	NE	NS
	Flat-tailed House Gecko	*Hemidactylus platyurus* (Scheider, 1792)	NE	NS
	*Yellow-bellied Gecko	*Hemidactylus flaviviridis* (Rüppell, 1835)	NE	NS
	Northern House Gecko	*Hemidactylus aquilonius* (McMahan & Zug, 2007)	NE	NS
	Tokay Gecko	*Gekko gecko* (Linnaeus, 1758)	NE	IV
	Assamese Day Gecko	*Cnemaspis assamensis* (Das & Sengupta, 2000)	NE	NS
		Cyrtodactylus sp 1		NS
		Cyrtodactylus sp 2		NS
Scindae	Many Lined Skink	*Eutropis multifasciata* (Kuhl, 1820)	NE	NS
	Bronze Skink	*Eutropis macularia* (Blyth, 1853)	NE	NS
	Spotted Forest Skink	*Sphenomorphus maculates* (Blyth, 1853)	NE	NS
	White-spotted Supple Skink	*Lygosoma albopunctata* (Gray, 1846)	NE	NS
Varanidae	Bengal Monitor Lizard	*Varanus bengalensis* (Daudin, 1802)	LC	I
	Yellow Monitor lizard	*Varanus flavescens* (Gray, 1827)	LC	I
Typhlopidae	Brahminy Blindsnake	*Indotyphlops braminus* (Daudin, 1803)	NE	IV
	Diard's Blindsnake	*Argyrophis diardii* (Schlegal, 1839)	LC	IV
Pythonidae	Burmese Python	*Python bivittatus* (Kuhl, 1820)	VU	I
Colubridae	Rainbow Water Snake	*Enhydris enhydris* (Schneider, 1799)	LC	IV
	Common Wolf Snake	*Lycodon aulicus* (Linnaeus, 1758)	NE	IV
	Zaw's Wolf Snake	*Lycodon zawi*Slowinski, Pawar, Win, Thin, Gyi, Oo & Tun, 2001	LC	IV
	Rat Snake	*Ptyas mucosa* (Linnaeus, 1758)	NE	II
	Indo-Chinese Rat Snake	*Ptyas korros* (Schlegal, 1837)	NE	IV
	Red-necked Keelback	*Rhabdophis subminiatus* (Schlegal, 1837)	LC	IV
	Painted Bronzeback	*Dendrelaphis proarchos* (Wall, 1909)	NE	IV
	White-barred Kukri Snake	*Oligodon albocinctus* (Cantor, 1839)	NE	IV
	Günther's Kukri Snake	*Oligodon cinereus* (Günther, 1864)	LC	IV
	Buff Striped Keelback	*Amphiessma stolatum* (Linnaeus, 1758)	NE	IV
	Eastern Cat Snake	*Boiga gokool* (Gray, 1835)	NE	IV
	Green Cat Snake	*Boiga cyanea* (Duméril, Bibron & Duméril,1854)	NE	IV
	Assamese Cat Snake	*Boiga quincunciata* (Wall, 1908)	NE	IV
	Checkered Keelback	*Xenochrohis piscator* (Schneider, 1799)	NE	II
	Bar-necked Keelback	*Xenochrohis schnurrenbergeri* (Kramer, 1977)	NE	IV
	Painted Keelback	*Xenochrohis cerasogaster* (Cantor, 1839)	NE	IV
	Common Mock Viper	*Psammodynastes pulverulentus* (Boie, 1827)	NE	IV
	Copper-headed Trinket Snake	*Coelognathus radiatus* (Schlegal, 1837)	LC	IV
	Trinket Snake	*Coelognathus helena* (Daudin, 1803)	NE	IV
	Long-nosed Whip Snake	*Ahaetulla nasuta* (Laćèpede, 1789)	NE	IV
	Ornate Flying Snake	*Chrysopelea ornata* (Shaw, 1802)	NE	IV
Elapidae	Monocled Cobra	*Naja kaouthia* (Lesson, 1831)	LC	II

Family	Common name	Scientific name	IUCN/RL	IWPAS
	Banded Krait	*Bungarus fasciatus* (Schneider, 1801)	LC	IV
	Greater Black Krait	*Bungarus niger* Wall, 1908	NE	IV
Viperidae		*Trimeresurus* sp.		IV
	Gumprecht's Green Pit Viper	*Trimeresurus gumprechti* David, Vogel, Pauwels & Vidal, 2002		IV
Trionychidae	Ganges Soft-shelled Turtle	*Nilssonia gangetica* (Cuvier, 1825)	VU	I
	Black Soft-shelled Turtle	*Nilssonia nigricans* (Anderson, 1875)	EW	IV
	Peacock Soft-shelled Turtle	*Nilssonia hurum* (Gray, 1831)	VU	I
	Indian Flap-shelled Turtle	*Lissemys punctata* (Bonnaterre, 1789)	LC	I
	Indian Narrow-headed Softshell Turtle	*Chitra indica* (Gray, 1831)	EN	IV
Geoemydidae	Assam Roofed Turtle	*Pangshura sylhetenis* (Jerdon, 1870)	EN	NS
	Indian Tent Turtle	*Pangshura tentoria* (Gray, 1834)	LC	NS
	Indian Roofed Turtle	*Pangshura tecta* (Gray, 1831)	LC	NS
	Indian Eyed Turtle	*Morenia petersi* (Anderson, 1879)	VU	NS
	Spotted Pond Turtle	*Geoclemys hamiltonii* (Gray, 1831)	VU	I

Image 17. *Ptyctolaemus gularis*

Image 18. *Calotes versicolor*

Image 19. *Sphenomorphus maculatus*

Image 20. *Lygosoma albopunctata*

Image 19. *Eutropis carinata*

Image 22. *Gekko gecko*

Image 23. *Hemidactylus brookii*

Image 24. *Pangshura sylhetensis*

Image 25. *Cuora amboinensis*

Image 26. *Geoclemys hamiltonii*

Image 27. *Nilssonia nigricans*

Image 28. *Lissemys punctata*

Image 29. *Argyrophis diardii*

Image 30. *Amphiesma stolatum*

Image 31. *Boiga cyanea*

Image 32. *Coelognathus radiatus*

Image 33. *Chrysopelea ornata*

Image 34. *Dendrelaphis proarchos*

Image 35. *Lycodon zawi*

Image 36. *Oligodon albocinctus*

Image 37. *Ptyas korros*

Image 38. *Psammodynastes pulverulentus*

Image 39. *Rhabdophis subminiatus*

Image 40. *Xenochrophis cerasogaster*

Image 41. *Enhydris enhydris*

Image 42. *Bungarus fasciatus*

Image 43. *Trimeresurus* sp.

Table 3. Checklist of avian diversity of Guwahati

Family	Common name	Scientific name	IUCN/RL	IWPAS
Anatidae	Fulvous Whistling Duck	*Dendrocygna bicolor* (Vieillot, 1816)	LC	I
	Lesser Whistling Duck	*Dendrocygna javanica* (Horsfield, 1821)	LC	IV
	Graylag Goose	*Anser anser* (Linnaeus, 1758)	LC	IV
	Bar-headed Goose	*Anser indicus* (Latham, 1790)	LC	IV
	Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	LC	IV
	Common Shelduck	*Tadorna tadorna* (Linnaeus, 1758)	LC	IV
	Cotton Pygmy Goose	*Nettapus coromandelianus* (Gmelin, 1789)	LC	IV
	Gadwall	*Mareca strepera* (Linnaeus, 1758)	LC	IV
	Eurasian Wigeon	*Mareca penelope* (Linnaeus, 1758)	LC	IV
	Mallard	*Anas platyrhynchos* Linnaeus, 1758	LC	IV
	Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)	LC	IV
	Northern Pintail	*Anas acuta* Linnaeus, 1758	LC	IV
	Garganey	*Spatula querquedula* (Linnaeus, 1758)	LC	IV
	Common Teal	*Anas crecca* Linnaeus, 1758	LC	IV
	Red-Crested Pochard	*Netta rufina* (Pallas, 1773)	LC	IV
	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	IV
	Baer's Pochard	*Aythya baeri* (Radde, 1863)	CR	IV
	Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT	IV
Podicipedidae	Little Grebe	*Tachybaptus ruficollis* (Pallas, 1764)	LC	IV
	Great Crested Grebe	*Podiceps cristatus* (Linnaeus, 1758)	LC	IV
	Black-necked Grebe	*Podiceps nigricollis* Brehm, 1831	LC	IV
Ciconiidae	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	LC	IV
	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT	IV
	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	VU	IV
	Greater Adjutant	*Leptoptilos dubius* (Gmelin, 1789)	EN	IV
Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis* Stephens, 1826	LC	IV
	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	LC	IV
	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	LC	IV
Anhingidae	Orinetal Darter	*Anhinga melanogaster* Pennant, 1769	NT	IV
	Great White Pelican	*Pelecanus onocrotalus* Linnaeus, 1758	LC	IV
	Spot-billed Pelican	*Pelecanus philippensis* Gmelin, 1789	NT	IV
Ardeidae	Gray Heron	*Ardea cinerea* Linnaeus, 1758	LC	IV
	Purple Heron	*Ardea purpurea* Linnaeus, 1766	LC	IV
	Great Egret	*Ardea alba* Linnaeus, 1758	LC	IV

Family	Common name	Scientific name	IUCN/RL	IWPAS
	Intermediate Egret	*Ardea intermedia* Wagler, 1829	LC	IV
	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	LC	IV
	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	LC	IV
	Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)	LC	IV
	Striated Heron	*Butorides striata* (Linnaeus, 1758)	LC	IV
	Black-crowned Night Heron	*Nycticorax nycticorax* (Linnaeus, 1758)	LC	IV
Ardeidae	Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)	NT	IV
	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	LC	IV
Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	LC	I
Accipitridae	Black-shouldered Kite	*Elanus axillaris* (Latham, 1801)	LC	IV
	Cinereous Vulture	*Aegypius monachus* (Linnaeus, 1766)	NT	IV
	Himalayan Griffon	*Gyps himalayensis* Hume, 1869	NT	IV
	Crested Serpent Eagle	*Spilornis cheela* (Latham, 1790)	LC	IV
	Changeable Hawk-eagle	*Nisaetus cirrhatus* (Gmelin, 1788)	LC	IV
	Lesser Spotted Eagle	*Clanga pomarina* (Brehm, 1831)	LC	IV
	Steppe Eagle	*Aquila nipalensis* Hodgson, 1833	EN	IV
	Grey-headed Fish Eagle	*Icthyophaga ichthyaetus* (Horsfield, 1821)	NT	IV
	Pied Harrier	*Circus melanoleucos* (Pennant, 1769)	LC	IV
	Shikra	*Accipiter badius* (Gmelin, 1788)	LC	IV
	Black Kite	*Milvus migrans* (Boddaert, 1783)	LC	IV
	Grey-headed Fish Eagle	*Icthyophaga ichthyaetus* (Horsfield, 1821)	NT	IV
	Long-legged Buzzard	*Buteo rufinus* (Cretzschmar, 1827)	LC	IV
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	LC	IV
	Purple Swamphen	*Porphyrio porphyrio* (Linnaeus, 1758)	LC	IV
	Eurasian Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	LC	IV
	Eurasian Coot	*Fulica atra* Linnaeus, 1758	LC	IV
Recurvirostridae	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	LC	IV
	Pied Avocet	*Recurvirostra avosetta* Linnaeus, 1758	LC	IV
Charadriidae	Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	NT	IV
	Gray-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)	LC	IV
	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	LC	IV
	Little Ringed Lapwing	*Charadrius dubius* Scopoli, 1786	LC	IV
Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	LC	IV
	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)	LC	IV
Scolopacidae	Common Sandpiper	*Actitis hypoleucos* Linnaeus, 1758	LC	IV
	Wood Sandpiper	*Tringa glareola* Linnaeus, 1758	LC	IV
	Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	LC	IV
	Spotted Redshank	*Tringa erythropus* (Pallas, 1764)	LC	IV
	Black-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	NT	IV
	Temminck's Stint	*Calidris temminckii* (Leisler, 1812)	LC	IV
	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	LC	IV
Glareolidae	Small Pratincole	*Glareola lactea* Temminck, 1820	LC	IV
Laridae	Brown-Headed Gull	*Larus brunnicephalus* Jerdon, 1840	LC	IV
	Black-headed Gull	*Larus ridibundus* Linnaeus, 1766	LC	IV
	Pallas's Gull	*Larus ichthyaetus* Pallas, 1773	LC	IV
	Whiskered Tern	*Chlidonias hybrid* (Pallas, 1811)	LC	IV

Family	Common name	Scientific name	IUCN/RL	IWPAS
	River Tern	*Sterna aurantia* Gray, 1831	NT	IV
Columbidae	Rock Pigeon	*Columba livia* Gmelin, 1789	LC	IV
	Oriental Turtle Dove	*Streptopelia orientalis* (Latham, 1790)	LC	IV
	Eurasian Collared Dove	*Streptopelia decaocto* Frivaldszky, 1838	LC	IV
	Red-collared Dove	*Streptopelia tranquebarica* (Hermann, 1804)	LC	IV
	Western Spotted Dove	*Spilopelia suratensis* (Gmelin, 1789)	LC	IV
	Grey-capped Emerald Dove	*Chalcophaps indica* (Linnaeus, 1758)	LC	IV
	Yellow-footed Pigeon	*Treron phoenicopterus* (Latham, 1790)	LC	IV
	Green Imperial Pigeon	*Ducula aenea* (Linnaeus, 1766)	LC	IV
Cuculidae	Pied Cuckoo	*Clamator jacobinus* (Boddaert, 1783)	LC	IV
	Large Hawk Cuckoo	*Hierococcyx sparverioides* (Vigors, 1831)	LC	IV
	Common Hawk Cuckoo	*Hierococcyx varius* (Vahl, 1797)	LC	IV
	Plaintive Cuckoo	*Cacomantis merulinus* (Scopoli, 1786)	LC	IV
	Asian Koel	*Eudynamys scolopaceus* (Linnaeus, 1758)	LC	IV
	Green-Billed Malkoha	*Phaenicophaeus tristis* (Lesson, 1830)	LC	IV
	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	LC	IV
Tytonidae	Barn Owl	*Tyto alba* (Scopoli, 1769)	LC	IV
Strigidae	Oriental Scops-owl	*Otus sunia* (Hodgson, 1836)	LC	IV
	Brown Hawk-owl	*Ninox scutulata* (Raffles, 1822)	LC	IV
	Brown Fish-owl	*Ketupa zeylonensis* (Gmelin, 1788)	LC	IV
	Tawny Fish-owl	*Ketupa flavipes* (Hodgson, 1836)	LC	IV
	Collared Owlet	*Glaucidium brodiei* (Burton, 1836)	LC	IV
	Asian Barred Owlet	*Glaucidium cuculoides* (Vigors, 1831)	LC	IV
	Jungle Owlet	*Glaucidium radiatum* (Tickell, 1833)	LC	IV
	Spotted Owlet	*Athene brama* (Temminck, 1821)	LC	IV
	Brown Hawk Owl	*Ninox scutulata* (Raffles, 1822)	LC	IV
Caprimulgidae	Long-tailed Nightjar	*Caprimulgus climacurus* Vieillot, 1825	LC	IV
Apodidae	House Swift	*Apus nipalensis* (Hodgson, 1836)	LC	IV
	Asian Palm Swift	*Cypsiurus balasiensis* (Gray, 1829)	LC	IV
Alcedinidae	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	LC	IV
	Stork-billed Kingfisher	*Pelargopsis capensis* (Linnaeus, 1766)	LC	IV
	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	LC	IV
	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	LC	IV
Meropidae	Blue-bearded Bee-eater	*Nyctyornis athertoni* (Jardine & Selby, 1830)	LC	IV
	Green Bee-eater	*Merops orientalis* Latham, 1802	LC	IV
	Chestnut-headed Bee-eater	*Merops leschenaulti* Vieillot, 1817	LC	IV
	Blue-tailed Bee-eater	*Merops philippinus* Linnaeus, 1766	LC	IV
Coraciidae	Indian Roller	*Coracias benghalensis* (Linnaeus, 1758)	LC	IV
	Dollarbird	*Eurystomus orientalis* (Linnaeus, 1766)	LC	IV
Bucerotidae	Oriental Pied Hornbill	*Anthracoceros albirostris* (Shaw & Nodder, 1807)	LC	IV
Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus* (Müller, 1776)	LC	IV
	Great Barbet	*Psilopogon virens* (Boddaert, 1783)	LC	IV
	Lineated barbet	*Psilopogon lineatus* (Vieillot, 1816)	LC	IV
	Blue-throated Barbet	*Psilopogon asiaticus* (Latham, 1790)	LC	IV
Picidae	Fulvous-breasted Woodpecker	*Dendrocopos macei* (Vieillot, 1818)	LC	IV
	Stripe-breasted Woodpecker	*Dendrocopos atratus* (Blyth, 1849)	LC	IV

Family	Common name	Scientific name	IUCN/RL	IWPAS
	Lesser Yellownape	*Picus chlorolophus* Vieillot, 1818	LC	IV
	Greater Yellownape	*Chrysophlegma flavinucha* (Gould, 1834)	LC	IV
	Gray-headed Woodpecker	*Picus canus* Gmelin, 1788	LC	IV
	Common Flameback	*Dinopium javanense* (Ljungh, 1797)	LC	IV
	Black-rumped Flameback	*Dinopium benghalense* (Linnaeus, 1758)	LC	IV
	Greater Flameback	*Chrysocolaptes guttacristatus* (Tickell, 1833)	LC	IV
Falconidae	Common Kestrel	*Falco tinnunculus* Linnaeus, 1758	LC	IV
	Red-necked Kestrel	*Falco chicquera* Daudin, 1800	NT	IV
	Oriental Hobby	*Falco severus* Horsfield, 1821	LC	IV
	Peregrine Falcon	*Falco peregrinus* Tunstall, 1771	LC	IV
Psittacidae	Rose-ringed Parakeet	*Psittacula krameri* (Scopoli, 1769)	LC	IV
	Blossom-headed Parakeet	*Psittacula roseata* Biswas, 1951	NT	IV
	Red-breasted Parakeet	*Psittacula alexandri* (Linnaeus, 1758)	NT	IV
Vangidae	Large Wood-shrike	*Tephrodornis virgatus* (Temminck, 1824)	LC	IV
	Common Woodshrike	*Tephrodornis pondicerianus (*Gmelin, 1789)	LC	IV
Artamidae	Ashy Woodswallow	*Artamus fuscus* Vieillot, 1817	LC	IV
Aegithinidae	Common Iora	*Aegithina tiphia* (Linnaeus, 1758)	LC	IV
Campephagidae	Short-billed Minivet	*Pericrocotus brevirostris* (Vigors, 1831)	LC	IV
	Scarlet Minivet	*Pericrocotus flammeus* (Forster, 1781)	LC	IV
	Large Cuckooshrike	*Coracina macei* (Lesson, 1831)	LC	IV
Laniidae	Brown Shrike	*Lanius cristatus* Linnaeus, 1758	LC	IV
	Long-tailed Shrike	*Lanius schach* Linnaeus, 1758	LC	IV
	Gray-backed Shrike	*Lanius tephronotus* (Vigors, 1831)	LC	IV
Oriolidae	Balck-hooded Oriole	*Oriolus xanthornus* (Linnaeus, 1758)	LC	IV
Dieruridae	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817	LC	IV
	Ashy Drongo	*Dicrurus leucophaeus* Vieillot, 1817	LC	IV
	Bronzed Drongo	*Dicrurus aeneus* Vieillot, 1817	LC	IV
	Hair-crested Drongo	*Dicrurus hottentottus* (Linnaeus, 1766)	LC	IV
	Greater Racket-tailed Drongo	*Dicrurus paradiseus* (Linnaeus, 1766)	LC	IV
Monarchidae	Black-naped Monarch	*Hypothymis azurea* (Boddaert, 1783)	LC	IV
Corvidae	Common Green Magpie	*Cissa chinensis* (Boddaert, 1783)	LC	IV
	Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)	LC	IV
	House Crow	*Corvus splendens* Vieillot, 1817	LC	V
	Large-billed Crow	*Corvus macrorhynchos* Wagler, 1827	LC	IV
Hirundinidae	Barn Swallow	*Hirundo rustica* Linnaeus, 1758	LC	IV
	Asian Plain Martin	*Riparia chinensis* (Gray, 1830)	LC	IV
	Collared Sand Martin	*Riparia riparia* (Linnaeus, 1758)	LC	IV
Stenostiridae	Gray-headed Canary Flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)	LC	IV
Paridae	Great Tit	*Parus major* Linnaeus, 1758	LC	IV
Pycnonotidae	Black-crested Bulbul	*Pycnonotus flaviventris* (Tickell, 1833)	LC	IV
	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	LC	IV
	Red-Whiskered Bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)	LC	IV
Phylloscopidae	Tickell's Leaf Warbler	*Phylloscopus affinis* (Tickell, 1833)	LC	IV
	Greenish Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	LC	IV
Locustellidae	Straited Grassbird	*Megalurus palustris* Horsfield, 1821	LC	IV
Cisticolidae	Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)	LC	IV

Family	Common name	Scientific name	IUCN/RL	IWPAS
	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)	LC	IV
	Dark-necked Tailorbird	*Orthotomus atrogularis*Temminck, 1836	LC	IV
	Jungle Prinia	*Prinia sylvatica* Jerdon, 1840	LC	IV
	Plain Prinia	*Prinia inornata* Sykes, 1832	LC	IV
Zosteropidae	White-bellied Yuhina	*Erpornis zantholeuca* (Blyth, 1844)	LC	IV
	Orinetal White-eye	*Zosterops palpebrosus* (Temminck, 1824)	LC	IV
Leiothrichidae	Striated Babbler	*Argya earlei* (Blyth, 1844)	LC	IV
	Jungle Babbler	*Turdoides striata* (Dumont, 1823)	LC	IV
Irenidae	Asian Fairy Bluebird	*Irena puella* (Latham, 1790)	LC	IV
Muscicapidae	Oriental Magpie Robin	*Copsychus saularis* (Linnaeus, 1758)	LC	IV
	White-rumped Shama	*Kittacincla malabarica* (Scopoli, 1788)	LC	IV
	Blue Whistling Thrush	*Myophonus caeruleus* (Scopoli, 1786)	LC	IV
	Black-backed Forktail	*Enicurus immaculatus* (Hodgson, 1836)	LC	IV
	Taiga Flycatcher	*Ficedula albicilla* (Pallas, 1811)	LC	IV
	Black Redstart	*Phoenicurus ochruros* (Gmelin, 1774)	LC	IV
	Blue rock Thrush	*Monticola solitarius* (Linnaeus, 1758)	LC	IV
	Common Stonechat	*Saxicola torquatus* (Linnaeus, 1766)	LC	IV
Turdidae	Black-throated thrush	*Turdus atrogularis* Jarocki, 1819	LC	IV
Sturnidae	Common Hill Myna	*Gracula religiosa* Linnaeus, 1758	LC	I
	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)	LC	IV
	Bank Myna	*Acridotheres ginginianus* (Latham, 1790)	LC	IV
	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	LC	IV
	Asian Pied Starling	*Gracupica contra* (Linnaeus, 1758)	LC	IV
	Chestnut-Tailed Starling	*Sturnia malabarica* (Gmelin, 1789)	LC	IV
Chloropseidae	Golden-Fronted Leafbird	*Chloropsis aurifrons* (Temminck, 1829)	LC	IV
Dicaeidae	Scarlet-backed Flowerpecker	*Dicaeum cruentatum* (Linnaeus, 1758)	LC	IV
Nectariniidae	Purple Sunbird	*Cinnyris asiaticus* (Latham, 1790)	LC	IV
	Crimson Sunbird	*Aethopyga siparaja* (Raffles, 1822)	LC	IV
	Little spiderhunter	*Arachnothera longirostra* (Latham, 1790)	LC	IV
Motacillidae	Citrine Wagtail	*Motacilla citreola* Pallas, 1776	LC	IV
	GrayWagtail	*Motacilla cinerea* Tunstall, 1771	LC	IV
	White Wagtail	*Motacilla alba* Linnaeus, 1758	LC	IV
	Paddyfield Pipit	*Anthus rufulus* Vieillot, 1818	LC	IV
	Rosy Pipit	*Anthus roseatus* Blyth, 1847	LC	IV
	Olive-Backed Pipit	*Anthus hodgsoni* Richmond, 1907	LC	IV
Passeridae	House Sparrow	*Passer domesticus* (Linnaeus, 1758)	LC	IV
	Eurasian Tree Sparrow	*Passer montanus* (Linnaeus, 1758)	LC	IV
Estrildidae	White-rumped Munia	*Lonchura striata* (Linnaus, 1766)	LC	IV
	Scaly-breasted Munia	*Lonchura punctulata*(Linnaeus, 1758)	LC	IV
	Tricolored Munia	*Lonchura malacca* (Linnaeus, 1766)	LC	IV
Ploceidae	Black-breasted weaver	*Ploceus benghalensis*(Linnaeus, 1758)	LC	IV
	Baya weaver	*Ploceus philippinus* (Linnaeus, 1766)	LC	IV

Image 44. Greylag Goose

Image 45. Little Cormorant

Image 46. Oriental Darter

Image 47. Small Pratincole

Image 48. Citrine Wagtail

Image 49. Greater Adjutant

Image 50. White-rumped Shama

Image 51. Black-hooded Oriole

Image 52. Green Bee-eater

Image 53. Indian Roller

Image 54. Grey-headed Canary-flycatcher

Image 55. Hoopoe

Image 56. House Sparrow

Image 57. Oriental Pied Hornbill

Image 58. Spotted Owlet

Table 4. Checklist of mammalian diversity of Guwahati

Family	Common name	Scienific name	IUCN/RL	IWPAS
Cercopithecidae	Capped Langur	*Trachypithecus pileatus* (Blyth, 1843)	VU	I
	*Gee's Golden Langur	*Trachypithecus geei* Khajuria, 1956	EN	I
	Assamese Macaque	*Macaca assamensis* M'Clelland, 1840	NT	II
	Rhesus Macaque	*Macaca mulatta* (Zimmermann, 1780)	LC	II
Hylobatidae	Western Hoolock Gibbon	*Hoolock hoolock* (Harlan, 1834)	VU	I
Lorisidae	Bengal Slow Loris	*Nycticebus bengalensis* (Lacépède, 1800)	EN	I
Elephantidae	Asiatic Elephant	*Elephas maximus* Linnaeus, 1758	EN	I
Bovidae	Gaur	*Bos gaurus* Smith, 1827	VU	I
Suidae	Wild Boar	*Sus scrofa* Linnaeus, 1758	LC	III
Cervidae	Barking Deer	*Muntiacus muntjak* (Zimmermann, 1780)	LC	III
	Sambar	*Rusa unicolor* (Kerr, 1792)	VU	III
	Hog Deer	*Axis porcinus* (Zimmermann, 1780)	EN	III
Felidae	Leopard	*Panthera pardus* (Linnaeus, 1758)	VU	I
	Jungle Cat	*Felis chaus* Schreber, 1777	LC	II
	Leopard Cat	*Prionailurus bengalensis* (Kerr, 1792)	LC	I
Canidae	Golden Jackal	*Canis aureus* Linnaeus, 1758	LC	II
	Bengal Fox	*Vulpes bengalensis* (Shaw, 1800)	LC	II
	Dhole	*Cuon alpinus* (Pallas, 1811)	EN	II
Herpestidae	Indian Mongoose	*Herpestes javanicus* (Hilaire, 1818)	LC	II
Viverridae	Large Indian Civet	*Viverra zibetha* Linnaeus, 1758	LC	II
	Small Indian Civet	*Viverricula indica* (Hilaire, 1803)	LC	II
	Common Palm Civet	*Paradoxurus hermaphroditus* (Pallas, 1777)	LC	II
Mustelidae	Smooth-coated Otter	*Lutrogale perspicillata* (Hilaire, 1826)	VU	II
Leporidae	Indian Hare	*Lepus nigricollis* Cuvier, 1823	LC	IV
Manidae	Chinese Pangolin	*Manis pentadactyla* Linnaeus, 1758	CR	I
Soricidae	Asian House Shrew	*Suncus murinus* Linnaeus, 1766	LC	NS
Hystricidae	Himalayan Crestless Porcupine	*Hystrix brachyura* Linnaeus, 1758	LC	II
Sciuridae	Himalayan Hoarybellied Squirrel	*Callosciurus pygerythrus* (Hilaire, 1832)	LC	II
	Particolored Flying Squirrel	*Hylopetes alboniger* (Hodgson, 1836)	LC	II
Muridae	Black Rat	*Rattus rattus* (Linnaeus, 1758)	LC	V
	House Mouse	*Mus musculus* Linnaeus, 1758	LC	V
	Lesser Bandicoot Rat	*Bandicota bengalensis* (Gray, 1835)	LC	V
Pteropodidae	Indian Flying Fox	*Pteropus giganteus* (Brünnich, 1782)	LC	V
	Greater Short-nosed Fruit Bat	*Cynopterus sphinx* (Vahl, 1797)	LC	V
Vespertilionidae	Indian Pipistrelle	*Pipistrellus coromandra* (Gray, 1838)	LC	NS
Platanistidae	Ganges River Dolphin	*Platanista gangetica* (Roxburgh, 1801)	EN	I

Image 59. Fruit Bat

Image 60. Rhesus Macaque

Image 61. Golden Jackal

Image 62. Mongoose

Image 63. Elephants at Deeporbeel

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COMMUNICATION

Status of raptors in the Moyar River Valley, Western Ghats, India

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Abstract: This study examined the species composition and nest-tree characteristics of diurnal raptors in the tropical forests of Moyar Valley, Western Ghats between December 2012 and March 2013. We recorded 28 species of raptors including three species of vultures. Accipitridae was the dominant family comprising of 25 species followed by two from Falconidae and the monotypic Pandionidae. Among them, eight species fall under various threatened category: three Critically Endangered, one Endangered, two Vulnerable and two Near Threatened. The Critically Endangered *Gyps bengalensis* was frequently recorded during the survey (175 sightings) followed by *Milvus migrans* (39 sightings) and *Haliastur indus* (27 sightings). We located 53 active nests of four species of raptors, viz., *Gyps bengalensis* (42 nests), *Nisaetus cirrhatus* (4 nests), *Haliastur indus* (4 nests), and *Milvus migrans* (3 nests). A notable difference in the nest-tree characteristics among the sympatric raptors was observed. These results would be important to identify priority areas for developing future conservation and management programs for the long-term conservation of raptorial birds in the Western Ghats.

Keywords: Birds of prey, distribution, nest-tree characteristics, Moyar Valley, Western Ghats.

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INTRODUCTION

Raptors generally occupy the apex of terrestrial and aquatic food webs, and thus play key roles in balancing ecosystems (Paine 1966; Thiollay 1989; Anderson 2001; Thiollay 2006) by maintaining community structures of prey species (Keith et al. 1998; Ferguson et al. 2005; Roth & Weber 2008). Raptors typically have low population density and require large home ranges, and they serve as good indicators of ecosystem quality (Newton 1979; Thiollay 1992; Redpath & Thirgood 1999) for conservation and management efforts (Sergio et al. 2006). Raptor populations are reportedly declining throughout the world owing to their high vulnerability to environmental contaminants, habitat destruction, direct persecution and diminishing prey availability (Crocker-Bedford 1990).

Raptor distributions are influenced by a variety of factors, including landscape heterogeneity, interspecific competition, predation and the availability of nest-sites and food resources (Thiollay 1989; Anderson 2001; Pearlstine 2006). Two-thirds of raptor species occur fully or partially in tropical regions (Bildstein et al. 1998; Ferguson et al. 2005), and India supports 69 raptor species together with several subspecies and races (Naoroji 2006). Information on raptors and their habitat associations are crucial for their conservation and management, but data on the distribution and populations of most Indian raptors are lacking due to difficulties in identification, low population densities and forest dwelling habits (Thiollay 1994; van Balen 1998; Naoroji 2006).

The Western Ghats biodiversity region (Myers et al. 2000) has lost nearly 50% of its forest cover since the early 1900s, and this trend is continuing with increased fragmentation and encroachment (Nair 1991; Jha et al. 2000) by agriculture, plantations, hydroelectric projects, logging, developmental activities, fire, grazing and over-exploitation of forest produce (Nair 1991; Jha et al. 2000; WGEEP 2011). In spite of this high anthropogenic pressure, remnant forest patches in the Ghats remain important habitats for diverse species of resident and migratory raptors (Naoroji 2006; Sashikumar et al. 2011). Except for a coarse-grained population survey, no information is available for raptors of the Western Ghats. The Nilgiris represent a unique landscape within the Western Ghats owing to their topographical, climatic and habitat features, and the region is an important wintering area for several migrant raptors (Primrose 1904; Gokula & Vijayan 1996; Thirumurthi 1999; Naoroji 2006; Zarri et al. 2008). Data on population status and ecological requirements of raptorial birds in the Nilgiris is poorly documented. In this context, we examined the distribution and nest-tree characteristics of raptors in Moyar Valley. The study results will provide baseline information for future conservation and management plans for raptorial birds in Moyar Valley.

MATERIALS AND METHODS

Study area

The study was carried out in Moyar River valley and adjacent Sigur Plateau (11.70128^{0}N–76.58706^{0}E and 11.47244^{0}N–77.147608^{0}E) in the Nilgiri Biosphere Reserve, which links the Western and Eastern Ghats (Venkitachalam & Senthilnathan 2016). It is a wide south-east facing valley located at the junction of four plateaus: the Sigur in the northwest, the Nilgiri in the west, the Mysore in the north and the Thalamalai Plateau in the northeast. The valley is within the borders of the Satyamangalam Tiger Reserve and the Nilgiris north forest division in Tamil Nadu, and Bandipur Tiger Reserve in Karnataka State. A deep gorge, the Moyar gorge or ditch, in the northern boundary of the Nilgiri District separates the Sigur and Mysore plateaus.

The terrain is hilly and the altitude of the study area ranges from 300–950 m; the main ridge of the Nilgiri Plateau is above 2,000m. The study area receives rain from both the northeast and southwest monsoons, with more rain coming during the former from September to December. The entire valley receives water from several perennial and seasonal rivers, and it forms an important drainage basin of the Moyar River, a tributary of the river Cauvery. The Moyar meets the Bhavani River in the east of the Nilgiri Plateau. The major vegetation types of the valley are tropical dry deciduous, southern tropical thorn forest, and tropical moist deciduous forest includes riparian forests along the streams interspersed with cultivated areas and reservoirs (Champion & Seth 1968; Prabhakar & Pascal 1994). Semi-evergreen and evergreen forests skirt along the eastern slope of the Nilgiri Plateau. At a comprehensive level, the thorn forest and dry deciduous are the general vegetation in the valley.

METHODS

Population survey

Study was carried out between December 2012 and March 2013. To survey the raptors we placed 16

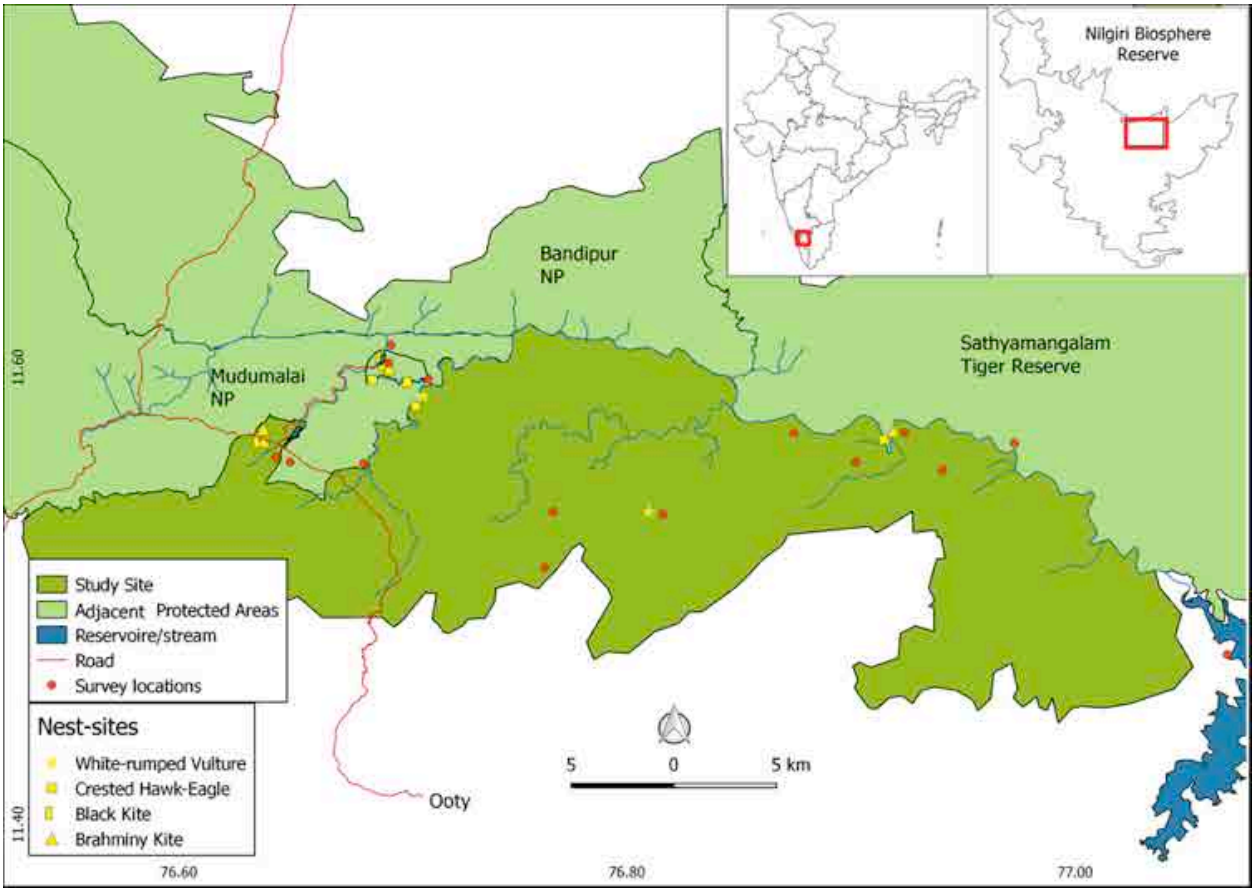

Figure 1. Map of the study area.

vantage points in the valley (Fig. 1). The points for the survey were selected in elevated places or locations with maximum visibility to detect the soaring raptors (Thiollay 1989; Nijman 2004; Eduardo et al. 2007) but no effort was made to sample canopy dwelling species. The survey locations were established in all major habitats of the study area. The surveys were carried out from 09:00hr to 17:00hr and all the raptors were identified and counted within the identifiable radius (ca. 700m) from the sampling locations (Eduardo et al. 2007; Kurup 2011). Altogether, we carried out 288 hours of observations across five different habitats, viz. 108 hours in open dry thorn forest (6 locations), 36 hours in mountain cliffs (2 locations), 54 hours in the reservoir (3 locations), 36 hours in the riparian forest (2 locations) and 54 hours in human habitations (3 locations). The raptors were observed by using Olympus (10×50) binocular and photographs were taken for the identification of the difficult species (Sony HX 200V Prosumer Camera, 30x optical zoom). Standard field guides were used for the identification based on the plumage, shape, and size of the raptors (Grimmett et al. 2011; Ferguson-Lees & Christie 2005; Naoroji 2006). Taxonomy follows BirdLife International (2017).

Nest survey and nest-tree characters

The nests of different raptors were located through intensive ground surveys by exploring all probable trees suitable for nesting. The secondary information from forest officials, field biologists, and settlers of the forest hamlets were also collected. Nest locations were geocoded with a global positioning system (Garmin eTrex 10) and the same was plotted on a forest boundary map using Q-GIS. The characteristic features of nesting trees were measured to understand the habitat signature of nesting trees opted by the raptors (Table 1).

RESULTS

We recorded 28 species of diurnal raptors, including seven migrants (Images 1–25). Family Accipitridae was dominant, contributing 25 species, followed by family Falconidae (2 species) and the monotypic family

Pandionidae (Table 2). Of the 28 species recorded, eight have high global conservation significance: three Critically Endangered (White-rumped Vulture *Gyps bengalensis*, Red-headed Vulture *Sarcogyps calvus*, and Indian Vulture *Gyps indicus*), one Endangered (Steppe Eagle *Aquila nipalensis),* two Vulnerable (Indian Spotted Eagle *Clanga hastata* and Greater Spotted Eagle *Clanga clanga*), and two Near-Threatened (Grey-headed Fish-Eagle *Icthyophaga ichthyaetus,* Lesser Fish Eagle *Icthyophaga humilis*). The White-rumped Vulture (42.2% of total sightings), Black kite *Milvus migrans* (9.4% of total sightings) and Brahminy Kite *Haliastur indus* (6.5% of total sightings) were detected commonly during sampling. Species such as Grey-headed Fish-Eagle, Western Marsh-Harrier *Circus aeruginosus,* Eurasian Sparrow Hawk *Accipiter nisus,* Crested Goshawk *Accipiter trivirgatus*, Steppe Eagle and Indian Spotted Eagle were encountered once during the study whereas Rufous-bellied Eagle *Lophotriorchis kienerii*, and Tawny Eagle *Aquila rapax* were recorded twice.

Among three species of vultures recorded, White-rumped Vulture had the maximum number of sightings (n=175) followed by Red-headed Vulture (n=8) and Indian Vulture (n=6). All the vulture sightings were recorded in the middle and lower ranges of the valley that has extensive open habitat. Maximum of 172 White-rumped Vulture, four Red-headed Vulture and three Indian Vulture were observed in a flock near Moyar Village. The vultures were observed feeding on different animal carcasses, viz., four Elephants *Elephas maximus*, four Chitals *Axis axis*, three Gaurs *Bos gaurus,* one Sambar Deer *Rusa unicolor*, and four livestock carcasses.

Nest-trees

We located 53 active nests of four sympatric raptors, namely: White-rumped Vulture (42), Crested Hawk-Eagle (4), Brahminy Kite (4), and Black Kite (3). Of these, nests of White-rumped Vulture and Crested Hawk-Eagle were exclusively recorded on live trees of *Terminalia arjuna* along the riparian forests of the valley. The nests of White-rumped Vulture were recorded from two different colonies such as Syriur (14 nests) and Jagalikadavu-Chemmanatham (28 nests) in Sigur Plateau. Both Black Kite and Brahminy Kite nested on smaller trees and all nests were recorded close to human habitation. Brahminy Kite nested on live trees of *Cocos nucifera* and *Albizia* spp. and nests of Black Kite were recorded on *Ficus religiosa* and *Albizia* spp. We also observed breeding activities such as courtship display, mounting and collection of nesting materials by Oriental Honey-buzzard.

Table 1. List of the variables measured for nest-trees and description of quantification method.

	Parameter	Quantification method
1	Altitude	GPS
2	Tree species	
3	Height of the nest tree	Ocular estimation
4	GBH	Handled measuring tape
5	Number of primary branches	Ocular estimation
6	Height of the first primary branch	Ocular estimation
7	Pacing distance	Measuring tape
8	Height of the nest above ground	Ocular estimation
9	Number of branches on which nest was built	Ocular estimation
10	Distance to the closest nesting tree	Measuring tape
11	Distance to the nearest water body	Ocular estimation/GIS
12	Distance to the nearest human habitation	GIS

Nest-tree characteristics

Among the observed nests, White-rumped Vulture selected the tallest trees (42.21 (±6.827m) with a higher gbh 1.92 (±0.39m) for nesting than other raptors (Table 3). The nests were placed at a mean height of 37.45 (±7.969m). Crested Hawk-Eagle preferred comparatively shorter trees for nesting 29 (±8.8m) with a smaller gbh 1.23 (±0.47m) and their nests were placed at a mean height of 22m from the ground. All their nests were supported by three branches. Brahminy Kite and Black Kite preferred small trees with thin branches for carrying their nests. They preferred shortest trees with a small gbh when compared with other species. Almost the same trend was seen in other characteristics features (Table 3).

DISCUSSION

The raptors of the Western Ghats biogeographic zone have not been extensively studied (Naoroji 2006). Within the short span of this study we recorded 28 species of diurnal raptors, including eight globally threatened species: three Critically Endangered, one Endangered, two Vulnerable and two Near Threatened. Of the raptors observed in this study, three species were common, and five were fairly common with White-rumped Vulture outnumbering all others. Comparison with other published literature from the Western Ghats region of Tamil Nadu reveals a high richness of raptors in

Table 2. List of diurnal raptors recorded during the study, their resident, IUCN, and abundance status (December 2012 to March 2013).

	Family/Common name	Binomial name	Migrant/resident (India)	IUCN	Abundance
	Accipitridae				
1	Black Eagle	*Ictinaetus malayensis*	BR	LC	R
2	Black Kite	*Milvus migrans*	BR	LC	C
3	Black-winged Kite	*Elanus caeruleus*	BR	LC	UC
4	Bonellis Eagle	*Aquila fasciata*	BR	LC	FC
5	Booted Eagle	*Hieraaetus pennatus*	W	LC	FC
6	Brahminy Kite	*Haliastur indus*	BR	LC	C
7	Changeable Hawk Eagle (Crested Hawk-Eagle)	*Nisaetus cirrhatus*	BR	LC	FC
8	Crested Goshawk	*Accipiter trivirgatus*	BR	LC	R
9	Crested Serpent-Eagle	*Spilornis cheela*	BR	LC	UC
10	Eurasian Sparrowhawk	*Accipiter nisus*	W	LC	R
11	Greater Spotted Eagle	*Clanga clanga*	W	VU	R
12	Grey-headed Fish-Eagle	*Icthyophaga ichthyaetus*	BR	NT	R
13	Indian Spotted Eagle	*Clanga hastata*	BR	VU	R
14	Indian Vulture	*Gyps indicus*	BR	CR	UC
15	Lesser Fish Eagle	*Icthyophaga humilis*	BR	NT	UC
16	Oriental Honey-buzzard	*Pernis ptilorhyncus*	BR	LC	FC
17	Red-headed Vulture	*Sarcogyps calvus*	BR	CR	UC
18	Rufous-bellied Eagle	*Lophotriorchis kienerii*	BR	LC	R
19	Shikra	*Accipiter badius*	BR	LC	UC
20	Short-toed Snake Eagle (Short-toad eagle)	*Circaetus gallicus*	BR	LC	FC
21	Steppe Eagle	*Aquila nipalensis*	W	EN	R
22	Western Marsh-Harrier (Eurasian Marsh-Harrier)	*Circus aeruginosus*	W	LC	R
23	White-eyed Buzzard	*Butastar teesa*	BR	LC	R
24	White-rumped Vulture	*Gyps bengalensis*	BR	CR	C
25	Tawny Eagle	*Aquila rapax*	W	LC	R
	Pandionidae				
26	Osprey	*Pandion haliaetus*	W	LC	R
	Falconidae				
27	Common Kestrel	*Falco tinnunculus*	BR	LC	UC
28	Shaheen Falcon	*Falco peregrinus peregrinator*	BR	LC	R

Status: BR - Breeding Resident, W - Winter Migrant, LC - Least Concern, NT - Near Threatened, VU - Vulnerable, EN - Endangered, CR - Critically Endangered, Abundance: C - Common (≥20 sightings), FC - Fairy Common (10–20 sightings), U - Uncommon (5–10 sightings), R - Rare (<5 sightings)

the Moyar Valley (Vijayan et al. 1992; Gokula & Vijayan 1996; Johnsingh 2001; Swami 2006; Bundell 2010; Ramesh et al. 2012; Ali et al. 2013; Babu & Bhupathy 2013). This could be attributed to habitat heterogeneity, resource availability and the geomorphological features of the valley.

Within the Nilgiris landscape, White-rumped Vultures breed in Wayanad Wildlife Sanctuary (Kurup 2011) and the Moyar Valley, which holds a large number of nests along the tributaries of the Moyar such as the Syriur and Jagalikadavu in the Sigur Plateau. Secondary data from longtime settlers in the valley revealed that White-rumped Vultures formerly bred in colonies at Arakadavupallam, Masikoil, Mangalapatty and Thotikadavu. Red-headed Vulture also used to breed near Anakkal Mariamman Koil of Nilgiri North Forest Division (Arulagam 2015). A recent study by Venkitachalam & Senthilnathan (2015) recorded four

Table 3. Variations (Range) in the nest-tree characteristics among four species of raptors recorded during the study.

Nest-site variables	Range (min-max)			
	Crested Hawk-Eagle (n=4)	White-rumped Vulture (n=42)	Black Kite (n=3)	Brahminy Kite (n=4)
Altitude	376–929	817–864	907–955	960–961
Height of the nest-tree (m)	20–37	25–53	16–19	17–30
GBH (m)	0.59–1.6	1.1–2.70	0.7–2	0.35–0.60
Number of primary branches	4–7	3–14	3–4	6
Height of the primary branch (m)	2.5–19	3–21	4–6	5
Pacing distance (m)	7–13	7.5–20	6–10.5	6–7
Height of the nest (m)	19–35	18–52	15–18	16–29
Number of branches on which nest was build	3	2–4	2–3	2–3
The distance between closest nest in the same tree (m)	-	3–15	-	-
Distance to the closest nesting tree (m)	-	12–1000	-	-
Distance to the nearest water body (m)	2–15	2–10	20–50	1000–1500
Distance to human habitation (m)	50–500	700–2000	0–50	0

nesting sites of Indian Vulture from the valley.

Of two species of near-threatened raptors recorded during the study, the Lesser Fish Eagle is uncommon along the Moyar River but seldom seen along its tributaries. Ten observations of this species were made during vantage point count, and we had more than 30 sightings while searching for raptor nests along the Moyar River. The Moyar River supports a good concentration of fish fauna (Bhaskar & Karthik 2015) and hence ensures ample food resources for fishing eagles. We recorded the juvenile of this species twice near Thengumarahada Village, and we presume they may be breeding in the Moyar Valley. We have also recorded this species from adjacent protected areas such as the Tholpetty Range and Bathery Range of Wayanad Wildlife Sanctuary, along Nagarahole River in Nagarahole Tiger Reserve, along Moyar River in Mudumalai Tiger Reserve and Nugu River in Bandipur Tiger Reserve. Little is known about the status of this species from southern India, but recently it was found breeding in Eastern Ghats of Karnataka and Western Ghats region in Kerala (Ramarao 2011; Sashikumar 2011). Grey-headed Fish-Eagle was sighted once in Thengumarahada Village on 9 December 2012. Earlier studies reported this species from Tamil Nadu region of Nilgiri Landscape such as from Mudumalai Tiger Reserve (Gokula & Vijayan 1996) and Upper Nilgiris (Thirumurthy & Balaji 1999). We spotted this species once along Nugu River in Bandipur Tiger Reserve. A Western Marsh-Harrier was observed in the grassy meadow of Bhavanisagar Reservoir on 7 December 2012. We also observed one female harrier near Ebanadu Village almost similar to Pallid Harrier, but we have labeled it as unidentified because of the confusion in identification with females of other harriers.

Of the two Vulnerable species recorded, Indian Spotted Eagle is an uncommon raptor that occurs at very low density across its distribution range and has been seldom recorded from the Western Ghats (Naoroji 2006; Birdlife International 2012). Previously, it was reported from Upper Nilgiris (Primrose 1904) and Mudumalai Tiger Reserve (Naoroji 2006), however, subsequent studies have not reported the species from Nilgiri landscape (Zarri et al. 2008; Thirumurthy & Balaji 2009). We recorded and photographed a single individual at Maravakandi dam near Masinagudi on 28 January 2013 at an altitude of 924m. It was mobbed by an Osprey during the observation. Greater Spotted Eagle has been recorded from 24 different sites of Tamil Nadu and Puducherry (Santhakumar et al. 2016) and frequently seen in the wetlands of Northern Kerala and also along Cauvery River basin of Karnataka (Naoroji 2006). This species was photographed four times around Bhavanisagar Reservoir. This reservoir supports a large concentration of wetland birds (Bharathidasan un-published data), which may ensure ample food source for this raptor. We observed and photographed the Steppe Eagle once near the Bhavanisagar Reservoir. This is a common Aquila Eagle in the northern Indian plains but rare in southern India (Sashikumar 2004; Naoroji 2006).

Tawny Eagle is a dry zone species found in the cultivated plains and plateau of Tamil Nadu (Naoroji 2006), and it was reported from Mudumalai Tiger Reserve and upper Nilgiris (Gokula & Vijayan 1996;

Thirumurthi & Balaji 1999). We recorded this species twice near Allimoyar Village on 25 December 2014 and at a waste dump in Masinagudi on 7 March 2013. The Brahminy Kite and Black Kite were sighted more often in and around towns and associated waste dumps. According to Naoroji (2006), these are common raptors in many parts of India and they are frequently found in human-dominated and disturbed habitats due to their high tolerance to human disturbance and scavenging trophic niche.

An earlier study has recorded the breeding of 13 species of raptors from upper Nilgiris (Thirumurthi & Balaji 1999), but the present study recorded only four species. Out of four species recorded, both Brahminy Kite and Black kite have strong fidelity to the human habitation for nesting and they select the young secondary woods for nesting. White-rumped Vulture and Crested Hawk-Eagle preferred live trees of *Terminalia arjuna* (primary forest trees) for nesting along the riparian forest in the valley. *Terminalia arjuna* is a hardwood tree, which provides support to the heavy nests, and their large spreading branches maximize nest height and reduce nest accessibility to predators. In addition, the riparian forest might reduce the thermal extremes by facilitating evapotranspiration during incubation and may be an important factor in nest-tree selection be these species. All nests of White-rumped Vulture were located in the riverine forest of Sigur Plateau; hence, the protection of riverine habitat is very crucial for in situ conservation of the southernmost breeding population of White-rumped Vulture in the subcontinent. Lesser Fish Eagle and Grey-headed Fish-Eagle are well suited to riverine habitats of the valley and we have sighted a juvenile of Grey-headed Fish-Eagle. Riparian forests are complex ecosystems which play a crucial role in maintaining the water and habitat quality. Even though the riparian forests along many river systems in the country are devastated, there are still some good stretches of riverine forest remaining in the Western Ghats that requires the attention of policy managers (Johnsingh & Joshua 1989). Moyar River supports unharmed and extensive areas of riparian forest with more than 100 species of woody angiosperms, 120 species of birds, 90 species of fish and several threatened mammalian fauna having been recorded along the riparian forests of the river (Bhaskar & Karthik 2015). Construction of hydroelectric projects, tourism and pollution are considered as the major threat to the riparian forest of the valley (Bhaskar & Karthik 2015).

Use of pesticide, forest fire, overfishing, spreading of invasive species and urbanization are prevalent in the landscape and expected to be a major threat to the survival of the raptorial birds in the valley. Hence, the present study suggests to carry out long-term research on raptorial birds that targets priority information gaps and paying special attention to the management of the endangered species.

In situ conservation of vultures in Moyar Valley

Even though Gyps vultures have undergone very rapid population decline across their distribution range, a few breeding populations have survived in small pockets (Prakash et al. 2003; MOEF 2006). Nilgiri Plateau and the surrounding protected area networks spread over the three south Indian states recorded the existence of five species of vultures: White-rumped Vulture, Red-headed Vulture, Indian Vulture, Egyptian Vulture and Himalayan Griffon (Gokula & Vijayan 1996; Ramesh 2011; Venkitachalam & Senthilnathan 2016; P.A. Vinayan pers. comm. 2015 December). Moyar River Valley supports one of the largest breeding populations of White-rumped Vulture in the Western Ghats, and it is the southernmost breeding range of the species. A major part of the Moyar valley is not a part of the existing protected area network (National park or Sanctuary), and hence this study recommends declaring the Moyar Valley as a "vulture conservation Reserve". Also, special attention should be given to the continuous monitoring of the selected breeding colonies in order to understand their breeding success in the forested landscape.

Food is a limiting factor for the vultures in Moyar and adjacent forests of Nilgiri landscape, because vultures mostly depend on the wild ungulate carcass. The Nilgiri-Eastern Ghats landscape complex supports a good concentration of large carnivores and their prey in the country (Jhala et al. 2014). The large carnivore kills contribute a substantial portion of the food consumed by the vultures in the Nilgiri landscape (Ramesh 2011). Hence, the population size of the vultures in the landscape is directly dependent on the density of prey and predator and their interactions. Generally, if a contagious disease is suspected in the death of a large herbivore, the carcass will be subjected to necropsy and eventually buried or burned. This leads to a reduction of food availability for vultures. Cattle depredation by larger carnivores is common in this area, and sometimes the cattle owners respond by poisoning a carcass (WWF 2010). Vultures are colonial birds, and poisoning one carcass can potentially lead to the death of several individuals. Measures must be taken to address this problem.

Vulture breeding colonies are located very close to human habitations having large cattle populations. Hence, monitoring the prevalence of diclofenac in areas close to vulture habitats is important to provide a clear understanding of the potential threat to vulture populations. This study also suggests exploring the movement ecology of vultures in the study site to understand their foraging ecology in forested areas and Diclofenac pressure. Awareness programs need to be conducted in the valley to increase the knowledge about the importance of raptors and ensure community participation in the conservation activities.

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Image 1. Osprey

Image 2. Oriental Honey-buzzard

Image 3. Black Kite

Image 4. Brahminy Kite

Image 5. Lesser Fish Eagle

Image 6. Grey-headed Fish- Eagle

Image 7. White-rumped Vulture

Image 8. Indian Vulture

Image 9. Red-headed Vulture

Image 10. Short-toed Snake Eagle

Image 11. Crested Serpent Eagle

Image 12. Eurasian Marsh Harrier

Image 13. Crested Goshawk

Image 14. Shikra

Image 15. White-eyed buzzard

Image 16. Black eagle

Image 17. Indian Spotted Eagle

Image 18. Greater Spotted Eagle

Image 19. Tawny Eagle

Image 20. Steppe Eagle

Image 21. Bonellis Eagle

Image 22. Booted Eagle

Image 23. Rufous-bellied Eagle

Image 24. Crested Hawk-Eagle

Image 25. Common Kestrel

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Tamil abstract:

மேற்குத் தொடர்ச்சி மலையைச் சேர்ந்த வெப்ப மண்டலக் காட்டுப் பகுதியுள் ஒன்றான மாயாறு படுகையில்வேட்டையாடி இனத்தைச் சேர்ந்த பறவைகள் எப்படித் தங்களுக்குள் ஒன்று கலந்து வாழ்ந்து வருகின்றன என்பதுகுறித்தும் கூடமைக்க அவை தேர்ந்தெடுக்கும் மரங்கள் குறித்தும் டிசம்பர் 2012 முதல் மார்ச் 2013 வரையானகாலகட்டத்தில் மேற்கொள்ளப்பட்ட பதிவு இது. இந்த கால கட்டத்தில் 28 வகையான வேட்டையாடிப் பறவைகள் பதிவு செய்யப்பட்டன. இதில் 3 வகையான பாறு கழுகினங்களும் அடக்கம். பதிவுசெய்யப்பட்டவற்றுள் வில்லேந்திரன் குடும்பத்தைச் சேர்ந்த 25 வகையான சிறப்பினங்கள் அதிகளவிலும் அதனைத்தொடர்ந்து வைரி வம்சத்தில் 2 சிறப்பினங்களும் வீரால் அடிப்பான் வம்சத்தில் 1 சிறப்பினமும் இருந்தன. இதில்எட்டு வகையான சிறப்பினங்கள் அழிந்துவரும் அபாயத்தில் உள்ளதாகத் தெரிய வந்த து. வெண்முதுகுப் பாறுகள்அதிகளவாக 175 முறை பார்க்கப்பட்டன. அதற்கடுத்தாற்போல, கள்ளப்பருந்து 39 முறையும் கருடன் 27 முறையும்பார்க்கப்பட்டன. மொத்தம் 53 கூடுகள் பதிவு செய்யப்பட்டதில் 42 கூடுகள் வெண்முதுகுப் பாறுகழுகினத்தைச் சேர்ந்தவையாகவும், 4கூடுகள் முறையே செம்பருந்தினதாகவும் குடுமிப் பருந்தினதாகவும், 3 கூடுகள் கள்ளப்பருந்தினதாகவும் இருந்தன. இக் களப் பயணத்தில் ஒரே பேரினத்தைச் சேர்ந்த வேட்டையாடிப்பறவைகள் கூடமைக்க மரத்தையும் இடத்தையும் எப்படி தேர்ந்தெடுக்கின்றன போன்ற வேறுபாடுகளும் பதிவுசெய்யப்பட்டன. இதன் மூலம் எதிர்காலத்தில் அவை எப்படிப்பட்ட இடங்களைக் கூடமைக்கத் தேர்ந்தெடுக்கும்என்பதை அனுமானித்து மேற்குத் தொடர்ச்சி மலையில் அவை வாழ்வாங்கு வாழத் தொலை நோக்குப்பாவையோடுதிட்டமிட இப்பதிவு உதவும்.

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Species composition and abundance estimates of reptiles in selected agroecosystems in southern Western Ghats, India

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Abstract: Species composition and abundance of reptiles in selected agroecosystems in Thrissur plains, near Palghat Gap, southern Western Ghats in India, was studied from January 2017 to May 2017. The agroecosystems surveyed were coconut, cashew & rubber plantations, home garden, paddy field, and botanical garden. Time-constrained visual encounter surveys of a total effort of 360 man-hours were done in the field. Coconut and cashew plantations reported the highest species richness with 11 species each, while the highest number of sightings (159) were recorded from botanical garden. Bronze Grass Skink *Eutropis macularia* was the most abundant species in agroecosystems. Correspondence analysis was done to compare the reptilian diversity in the agroecosystems. The reptile fauna of home garden and paddy field were found to be more distinct than the rest of the agroecosystems. A total of 17 species of reptiles were recorded during the study, thus highlighting the significance of agroecosystems in acting as important buffer landscapes for reptiles.

Keywords: Cashew plantation, coconut plantation, botanical garden, home garden, Important Bird Area, Kole wetlands, paddy field, Ramsar site, rubber plantation.

Malayalam Abstract

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Author Contribution: Both the authors contributed equally to the design of the study, field work, morphometric data collection, analysis and manuscript preparation.

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INTRODUCTION

Nearly two-thirds of the terrestrial environment of the world is made up of managed ecosystems with natural, undisturbed habitats accounting for only a meagre five percentage. These managed ecosystems include agricultural systems, forestry systems, and human settlements (Gamage et al. 2008). Herpetofauna makes up 48% of the terrestrial vertebrates that are threatened by agroforestry and forestry activities (Palacios et al. 2013).

Despite the fact that herpetofauna makes up half of vertebrate species, they are very much understudied in their response to change in habitats from natural forests to plantations. The review done by Palacios et al. (2013) on the herpetofauna of agroecosystems on a global scale found just 27 studies pertaining to amphibians and reptiles. Very few studies on the reptilian diversity of agroecosystems have been done in southern India too. Perhaps the only study on the reptiles of human-modified habitats is the one by Venugopal (2010), who studied the agamids of human-modified habitats in the Western Ghats.

In a time when more and more forest areas are being converted into plantations and agricultural lands for meeting the growing needs of human populations, it is important to evaluate the reptile diversity in these modified ecosystems. It is important to assess whether these agroecosystems are capable of supporting and sustaining reptile biodiversity, particularly that of habitat specialists and endemic species.

STUDY AREA

The study was conducted in selected agroecosystems in Thrissur District, southern Western Ghats, Kerala (10.53–10.55^{0}N & 76.27–76.28^{0}E, 20–70 m). The agroecosystems chosen included cashew, coconut & rubber plantations, home garden, paddy field, and botanical garden (Fig. 1). The study area chosen mostly comes within the main campus of Kerala Agricultural University in Kerala. The campus has a total area of 391.44ha and is located very close to Peechi-Vazhani Wildlife Sanctuary. The major habitats include gardens, botanical gardens, plantations of rubber, coconut, plantain & cocoa, and orchards of mango, jackfruit, sapota & guava. The whole area must have been under forests about one and a half centuries ago and was subsequently converted mostly into rubber plantations. Later, in 1971, the land was handed over to the Kerala Agricultural University (KAU), and the KAU developed these areas into different land uses as explained above. The 14-year mean minimum temperature is 23.3^{0}C and the 10-year mean maximum is 31.9^{0}C. The area receives southwest and northeast monsoons, the greater portion of the rainfall, however, is received from the southwest monsoon between June and September. The mean

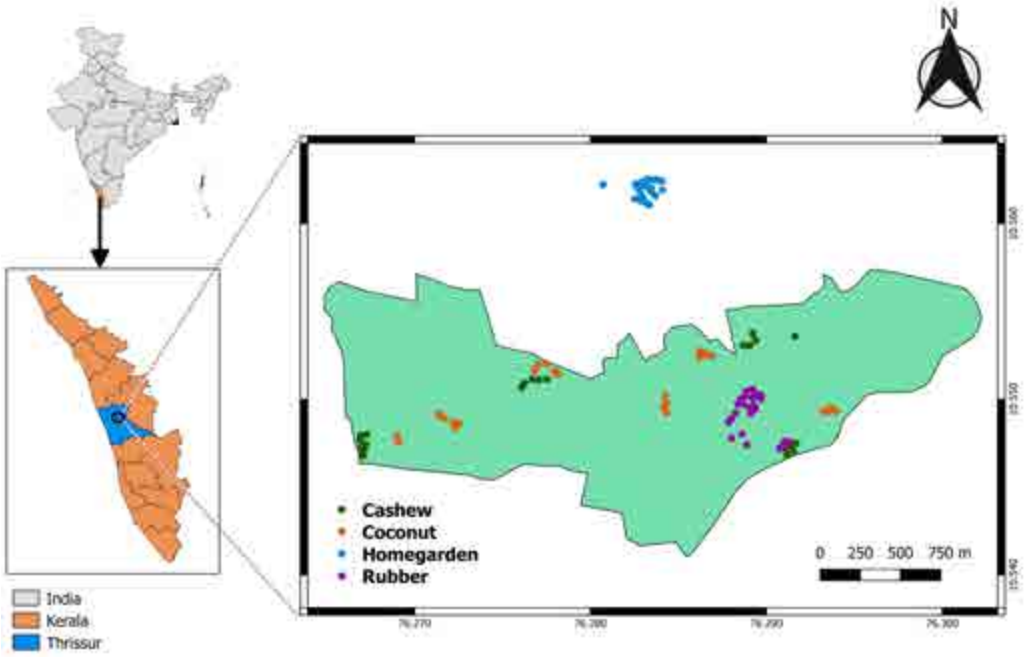

Figure 1. Location map of different study locations, Thrissur

annual rainfall is 2803.4mm. The mean number of rainy days per year is 112 (Manohar et al. 2017). The paddy field selected was located at the Kole Wetlands in central Kerala, which incidentally is a Ramsar site and an Important Bird Area (IBA) (Islam & Rahmani 2004, 2008).

METHODS

The method followed was time-constrained visual encounter survey of a two-hour duration in each of the agroecosystems in the morning (08:00–10:00 hr) and evening (19:00–21:00 hr). Each location was covered on foot and whenever a species was sighted, observations such as the name of the species, the number of sightings, time, and GPS location were recorded following Ishwar et al. (2001). At each agroecosystem, the survey was carried out for five days. Thus, the total effort spent during the entire course of the study was 360 man -hours. Additionally, micro-habitat parameters such as canopy height, canopy cover, leaf litter depth, leaf litter cover, shrub cover, herb cover, and number of fallen logs were recorded at each of the agroecosystems. Litter depth was measured using a steel scale (Elora) and canopy height was measured using Haga altimeter (Durga Enterprises). The rest of the measurements were visually estimated (see Vasudevan et al. 2001; Kanagavel et al. 2013). Weather data like maximum temperature, minimum temperature, and relative humidity for the study period was obtained from the Kerala Agricultural University Weather Station located in Thrissur District, Kerala. The study was carried out from January to May 2017 in the pre-monsoon season.

For confirming the identification of the species, the following literature were consulted: Das (2002), Whitaker & Captain (2004), Mahony (2011), Agarwal & Karanth (2015), Agarwal et al. (2016), Lajmi et al. (2016). The distribution range of the species was verified using Ganesh et al. (2013) and Palot (2016).

Statistical Analysis

Chi-square analysis of association was performed to understand whether the reptile fauna had a preference for any plantation types (coconut, cashew, rubber, home gardens, botanical gardens, or paddy fields). Patterns of relationship between species abundance across nine environmental parameters (canopy cover, canopy height, litter depth, litter cover, shrub cover, herb cover, maximum temperature, minimum temperature, and relative humidity) in different plantation types were investigated using canonical correspondence analysis (CCA), a multivariate constrained ordination technique (Legendre & Legendre 1998). A triplot of observations grouped for plantation types, species, and eigenvectors of environmental variables was plotted to understand the species distribution along the plantation types and environmental variables. A scree plot of eigenvalues and cumulative inertia explained by each canonical axes was plotted to understand the contribution of each axes. The significance of the canonical axes was tested using permutations test (Legendre et al. 2011). Statistical analysis was performed in PAST 3.19 (Hammer et al. 2001).

RESULTS AND DISCUSSION

A total of 594 sightings of 17 species (Table 1) was encountered from the agroecosystems during the study period, with an average pooled encounter rate of 1.27 reptiles/man-hour. The species richness was the highest in coconut and cashew plantations, with 11 species each (Table 2; Images 1–14). The abundance of the reptiles, however, was greatest in botanical gardens (159 sightings). Bronze Grass Skink *Eutropis macularia* was the most encountered species in the agroecosystems of Thrissur District with 220 sightings, followed by (Murray's) House Gecko *Hemidactylus* cf. *murrayi* totalling 87 sightings.

The variation in the number of sightings of the reptiles between day and night are given in Fig. 2. As expected, it can be seen that most of the reptiles were more active during night hours. Out of the six species of geckos seen during the study, all four species of *Hemidactylus* geckos, as well as *Cyrtodactylus* cf. *collegalensis*, were nocturnal in habit. The Day Geckos *Cnemaspis* spp., however, as its common name suggests, were observed mainly during morning hours. Among skinks, *Ristella* cf. *beddomii* was primarily a nocturnal species, while *Sphenomorphus dussumieri* was spotted only during day hours. *Eutropis macularia*, *E. carinata*, and the agamid lizard *Calotes versicolor* were observed during both morning and night hours. *Calotes versicolor* was observed to be sleeping when spotted during night hours. All the seven species of snakes observed were spotted during night hours (Fig. 2).

There was a significant association between plantation types and abundance of different reptile species (chi square = 1006.3, df = 80, $P < 0.0001$), indicating that the reptile fauna had a differential preference for the plantation type. The complex pattern of reptile species distribution across the plantation types

Table 1. Reptiles of selected agroecosystems in Thrissur District

	Common name	Scientific name	Family	IUCN status	Image
1	(Murray's) House Gecko	*Hemidactylus* cf. *murrayi*	Gekkonidae	NE	Image 1
2	Common House Gecko	*Hemidactylus frenatus*	Gekkonidae	LC	Images 2 & 3
3	Termite Hill Gecko	*Hemidactylus triedrus*	Gekkonidae	NE	Image 4
4	Day Gecko	*Cnemaspis* cf. *gracilis*	Gekkonidae		Images 5 & 6
5	Kollegal Ground Gecko	*Cyrtodactylus collegalensis*	Gekkonidae	NE	Image 7
6	Dussumier's Litter Skink*	*Sphenomorphus dussumieri*	Scincidae	LC	Image 8
7	Bronze Grass Skink	*Eutropis macularia*	Scincidae	NE	Image 9
8	Common Keeled Skink	*Eutropis carinata*	Scincidae	LC	Image 10
9	(Beddome's) Cat Skink*	*Ristella* cf. *beddomii*	Scincidae	LC	Image 11
10	Oriental Garden Lizard	*Calotes versicolor*	Agamidae	NE	Image 12
11	Common Indian Krait	*Bungarus caeruleus*	Elapidae	NE	
12	Beddome's Cat Snake	*Boiga beddomei*	Colubridae	LC	
13	Common Wolf Snake	*Lycodon aulicus*	Colubridae	NE	
14	Common Trinket Snake	*Coelognathus helena*	Colubridae	NE	
15	(Common) Vine Snake	*Ahaetulla* cf. *nasuta*	Colubridae	NE	Image 14
16	Russell's Kukri Snake	*Oligodon taeniolatus*	Colubridae	LC	Image 13
17	Checkered Keelback	*Xenochrophis piscator*	Natricidae	NE	

Table 2. Species diversity and abundance of reptiles in selected agroecosystems in Thrissur District

	Species	Coconut Plantation	Cashew Plantation	Rubber Plantation	Home garden	Botanical Garden	Paddy field	Total
		Number of sightings						
1	*Hemidactylus* cf. *murrayi*	47	20	3	2	10	0	82
2	*Hemidactylus frenatus*	40	6	16	4	3	0	69
4	*Hemidactylus triedrus*	0	2	0	0	0	0	2
5	*Cnemaspis* spp.	10	1	8	3	19	0	41
6	*Cryodactylus collegalensis*	7	6	18	2	11	0	44
7	*Sphenomorphus dussumieri*	0	0	0	13	0	0	13
8	*Eutropis macularia*	21	45	82	2	70	0	220
9	*Eutropis carinata*	1	9	0	0	14	0	24
10	*Ristella* cf. *beddomii*	0	11	5	0	28	0	44
11	*Calotes versicolor*	16	11	9	3	3	0	42
12	*Bungarus caeruleus*	0	0	0	1	0	0	1
13	*Boiga beddomei*	1	0	1	0	0	0	2
14	*Lycodon aulicus*	1	1	0	0	0	2	4
15	*Coelognathus helena*	1	0	0	0	0	0	1
16	*Ahaetulla* cf. *nasuta*	0	0	1	0	0	0	1
17	*Oligodon taeniolatus*	0	0	0	0	0	3	1
18	*Xenochrophis piscator*	0	0	0	0	1	0	3
	Total	145	112	143	30	159	5	594

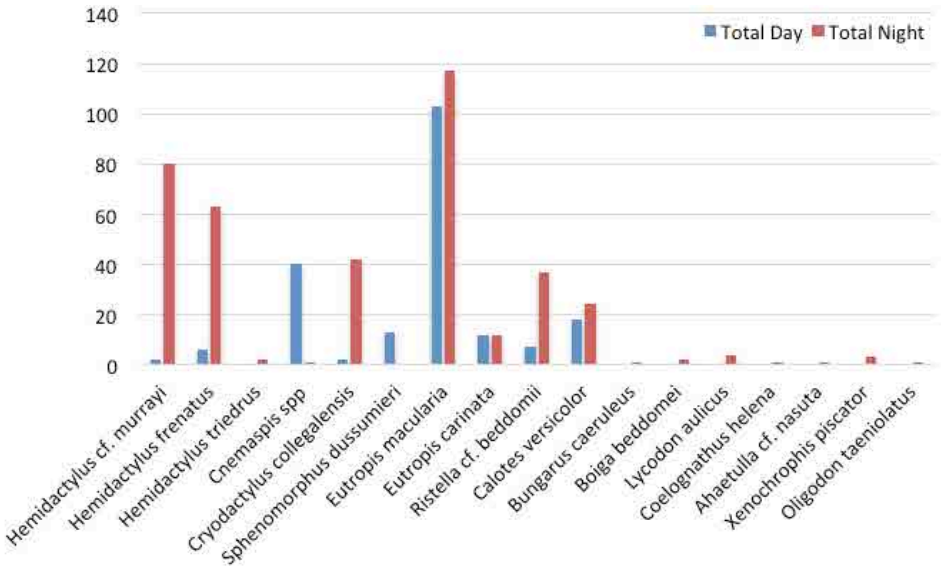

Figure 2. Number of sightings for each species of reptile recorded during morning and night hours

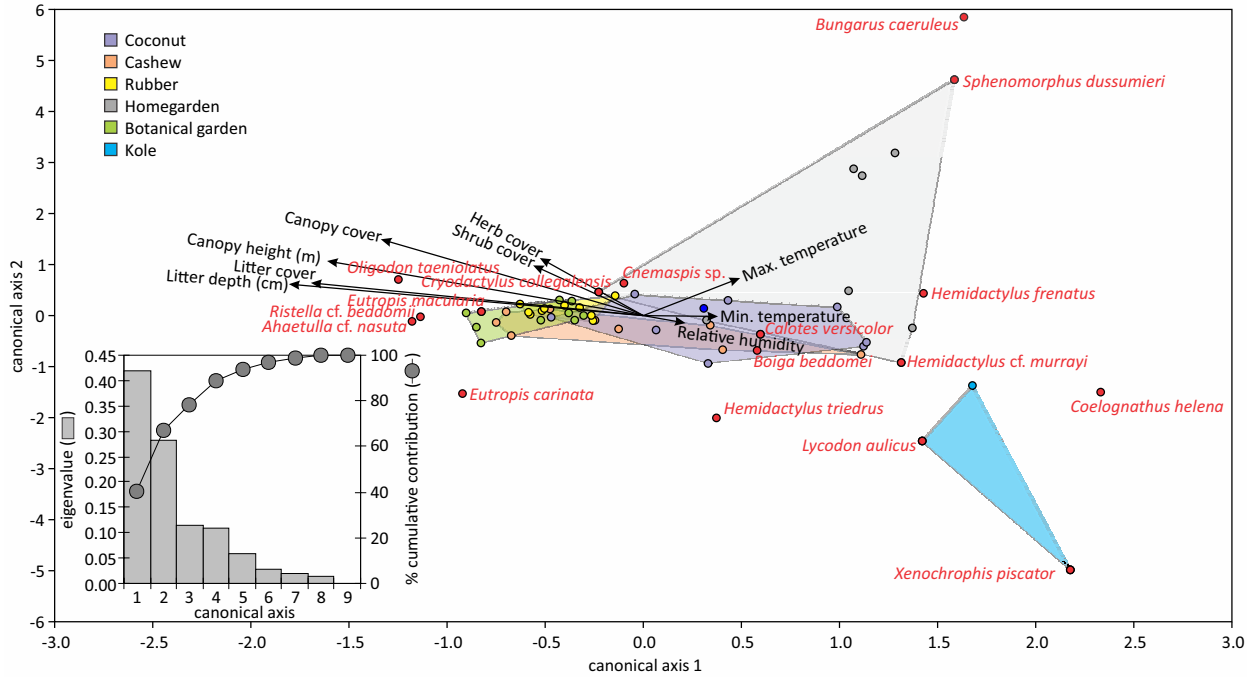

Figure 3. Canonical correspondence analysis triplot. Species are shown in red font and red circles. Observations are grouped for plantation type and a convex polygon was plotted to delineate observations for each plantation type. Eigen vectors of environmental variables are shown in black. Screen plot depicting the contribution explained by each canonical axis is shown in inset.

and environmental variables are depicted in the CCA triplot (Fig. 3). The first two CCA axes were significant (permutations 999, trace = 1.047, P = 0.001; canonical axis 1, eigen value = 0.4199, P = 0.001; canonical axis 2, eigenvalue = 0.2819, P = 0.001) and together they explained 67% total inertia in the data. Both species composition and environmental parameters of the different plantation types were different with no overlap for paddy fields, indicating that paddy fields are not only distinctly different in the environmental parameters but has a different reptile fauna. *Xenochrophis piscator* was unique to the paddy field habitat while *Lycodon aulicus* was more abundant in the paddy field as compared to other habitats and both these factors

could be correlated to the relatively higher humidity and temperature of paddy field habitats and lower canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover (Fig. 3). In general, species such as *Boiga beddomei*, *Bungarus caeruleus*, *Calotes versicolor*, *Coelognathus helena*, *Hemidactylus frenatus*, *H.* cf. *murrayi*, *H. triedrus*, *Sphenomorphus dussumieri*, *Lycodon aulicus*, and *Xenochrophis piscator* preferred relatively higher humidity and temperature and lower canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover. As a result, these species mainly favoured home gardens and paddy fields in Kole Wetlands, followed by cashew and coconut plantations and, rarely, rubber plantations or botanical gardens. On the other hand, *Ahaetulla* cf. *nasuta*, *Cnemaspis* sp., *Cryodactylus collegalensis*, *Eutropis macularia*, *Eutropis carinata*, *Oligodon taeniolatus*, and *Ristella* cf. *beddomii* preferred higher canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover and favoured rubber plantations and botanical gardens, followed by cashew and coconut plantations (Fig. 3).

While this is a preliminary, pooled analysis consisting of resource use frequencies of both active and dormant sightings, it gives at least a preliminary picture of probable impacts on resultant species records. We mention this with a caution that more studies with better sample size and discerning active and dormant sightings are needed to fully understand the impacts of these abiotic variables on species composition and assemblage structure. We believe that our work will pave the way for future studies to take a deeper look into this subject (also see Vijayakumar et al. 2006).

Palacios et al. (2013), who reviewed studies on the herpetofauna in human-modified habitats across the world, found that in 81% of the cases plantations supported more herpetofauna than natural forests. They also found that human-modified habitats support even some endemic species in agroecosystems. Two species of reptiles endemic to the Western Ghats, *Ristella* cf. *beddomii* and *Sphenomorphus dussumieri*, were recorded from the agroecosystems of central Kerala. The present sighting of the *Ristella* cf. *beddomii* from the agroecosystem at an elevation of 50m is lower than the known altitude range of 400–1300 m (Srinivasulu et al. 2014) of this species.

Apart from addressing reptile conservation in managed landscapes, our study also fills in a major gap in herpetological studies in southern India – their community assemblage structure. Very few studies have elaborated on this topic. Studies from Western Ghats rainforests (Inger et al. 1987), the Western Ghats dry forests (Vijayakumar et al. 2006), Eastern Ghats wet forests (Ganesh & Arumugam 2015; & Ramesh & Arumugam 2016), and the Coromandel coastal plains scrub forests (Ramesh et al. 2013) are available. The current paper provides a first-hand data on reptile assemblage structure from a central Kerala plains site, that too from the little-studied Palghat Gap region.

This documentation is important as it highlights the significance of agroecosystems in conserving and maintaining the reptilian fauna of the region, including some of the Western Ghats endemic species.

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Image 1. *Hemidactylus* cf. *murrayi*

Image 2. *Hemidactylus frenatus*

Image 3. *Hemidactylus frenatus* (in rubber plantation)

Image 4. *Hemidactylus triedrus*

Image 5. *Cnemaspis* cf. *garcilis* (female) from homegarden

Image 6. *Cnemaspis* cf. *gracilis* (male) from botanical garden

Image 7. *Cyrtodactylus collegalensis*

Image 9. *Eutropis macularia*

Image 11. *Ristella* cf. *beddomii*

Image 8. *Sphenomorphus dussumieri*

Image 10. *Eutropis carinata*

Image 12. *Calotes versicolor*

Image 13. *Oligodon taeniolatus*

Image 14. *Ahaetulla* cf. *nasuta*

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COMMUNICATION

Comparison of beach profiles conducive for turtle nesting in Andaman

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Abstract: The present study was undertaken to compare beach characteristics associated with turtle nesting in the Andaman group of islands. Karmatang, Kalipur, Ramnagar, Chidiyatapu, Carbyn's Cove, and Wandoor were chosen as study sites. Beach slope, sand grain characteristics, and general vegetation patterns were analysed. The angle of inclination of the beach slope ranged from 2.06 to 8.3 degrees. Beaches with a higher angle had a comparatively higher number of nesting sites. The study shows that a single factor does not make a beach more conducive for nesting. Chidiyatapu has the widest beach but lacks other features and so it is not a preferred nesting site. The grain size of sand in Wandoor is highly favourable, but the intertidal region is not long and there are streams that can drown the nests. Karmatang has a long beach and a higher slope angle. Ramnagar has a moderate beach length and a high slope angle. The dominant grains at both the beaches were found to be granules. The absence of streams and artificial light, fewer number of anthropogenic activities, lack of obstacles, the presence of bordering vegetation, and a conducive beach slope with granular sand grains make Ramnagar, Karmatang, and Kalipur ideal for turtle nesting.

Keywords: Sand grain, beach slope, intertidal, ecology, beach angle, turtle nesting, Andaman.

Tamil Abstract

அந்தமான் தீவுகளிலுள்ள கடற்கரைகளில் அதிகளவில் கடல் ஆமைகள் முட்டையிட வருவதற்கு எவையெல்லாம் ஏதுவான காரணிகள் என்பதைக் கண்டறிவதன் பொருட்டு இந்த ஆய்வு மேற்கொள்ளப்பட்டுள்ளது. அந்தக் காரணிகளைக் கண்டறிய கர்மாடாங், காளிப்பூர், ராம்நகர், சிடியாடாபு, கார்பின்ஸ் கோவ் மற்றும் வண்டூர் ஆகிய கடற்கரைகள் ஆய்வுக் களங்களாக எடுத்துக்கொள்ளப்பட்டன. இங்கிருக்கும் கடற்கரையின் சாய்வுக் கோணம், மணல் துகள்களின் அளவு, கடற்கரைகளிலிருந்த தாவரங்கள் ஆய்வுக்குட்படுத்தப்பட்டன. அவ்வாறு உட்படுத்தும்போது இந்தக் கடற்கரைகளின் சாய்வுக் கோண அளவு 2.06 முதல் 8.3 வரை இருந்தது. சாய்வுக் கோணம் அதிகமாய் இருந்த கடற்கரைகளில் அதிக அளவில் ஆமைகளின் வரத்து இருந்தது. ஆனால், இதை மட்டுமே ஆமைகள் கடற்கரைகளில் முட்டையிடுவதற்கான இன்றியமையாத காரணியாகச் சொல்ல முடியாது. ஏனெனில், சிடியாடாபுவில் கடற்கரையின் அகலம் (கோணம்) அதிகமாக இருந்தாலும் இது ஆமைகளால் பெரிதும் தேர்ந்தெடுக்கப்படவில்லை. வண்டூரில் மணல் துகள்களின் அளவு சரியான விகிதத்தில் இருந்தது. ஆனாலும் நீரும் குறைவானது. இங்கே இருக்கும் காலவாய்களும் முட்டைகளை மூழ்கடிக்கும் தன்மையில் அமைந்திருக்கும் என்பதால் இதுவும் ஆமைகள் முட்டையிட ஏற்றதாக இல்லை. ஆனால் ராம் நகர் மற்றும் கர்மாடாங், காளிப்பூர் ஆகிய கடற்கரைகளில் அதிக அளவில் ஆமைகள் முட்டையிடுகின்றன. இந்தக் கடற்கரைகள் அதிகக் கோணத்தில் சாய்வு அளவு கொண்டவை மட்டுமல்ல நீளமானவை. பெரிய அளவிட்டில் மணல் துகள்களைக் கொண்டவை. காலவாய்கள் இல்லாதவை. செயற்கை ஒளி, மனிதச் செயல்பாடுகள் போன்ற குறைவான தடைகளைக் கொண்டவை. மேலும் சுற்றித் தாவரங்களும் ஆமைகளின் வருகைக்கு ஏற்றவையாக இருக்கின்றன. எனவே இந்தப் பகுதிகள் ஆமைகள் அதிகமாக முட்டையிட ஏதுவாக இருக்கின்றன.

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Author Contributions: SN assisted in field surveys and prepared the manuscript. SV conceived and designed the work and finalised the drafts. AJD'S carried out the field surveys and assisted in the manuscript writing.

INTRODUCTION

Among the many species that appeared as part of the modern marine turtle families in the Cretaceous (Lutz & Musick 1996), only seven species remain today. Among these, one is endangered, three are vulnerable, two are critically endangered and one is listed as data deficient (Nicholas 2001; IUCN 2018). Five species are reported from India and four species are reported from Andaman & Nicobar Islands (Murugan 2010). Selection of a good nesting site is an important stage for oviparous animals, especially in those species that do not provide parental care (Morales-Mavil et al. 2016). Minimizing female mortality and maximizing offspring fitness are the driving forces for site selection by female turtles for nesting (Spencer 2002).

The Andaman & Nicobar archipelago is located in the Bay of Bengal between 6.750°–13.750° N & 92.000°–94.300° E, extends over 800km, and consists of islands, islets, and rocky outcrops with a coastline stretch of 1962km. Four species of marine turtles occur in the Andaman & Nicobar Islands: Leatherback *Dermochelys coriacea*, Hawksbill *Eretmochelys imbricata*, Green Turtle *Chelonia mydas*, and Olive Ridley *Lepidochelys olivacea*. These turtles are protected under Schedule I of the Indian Wildlife (Protection) Act, 1972. The ban on hunting and harvesting of turtles was enforced in 1977, but the indigenous groups of the Andaman & Nicobar Islands are exempt from the Act as marine turtles have been their source of food for centuries (Bhaskar 1984). The surveys and studies conducted in the Andaman & Nicobar Islands have recorded India's best nesting beaches for Leatherback, Hawksbill, and Green turtles (Andrews et al. 2006). The present study was undertaken to review the status of marine turtles in Andaman and to compare the beach characteristics associated with turtle nesting.

MATERIALS AND METHODS

The study was conducted during February–March 2014.

Study area

Six stations in the Andaman Islands were selected as study sites for this work. Karmatang Beach at 12.913^{0}N & 92.896^{0}E is a bay located in Mayabunder, North Andaman (Fig. 1). It is a sandy beach that is dark-coloured, giving the water a very turbid look. Good vegetation, with a mix of shrubs and trees, lines the beach. Ramnagar is

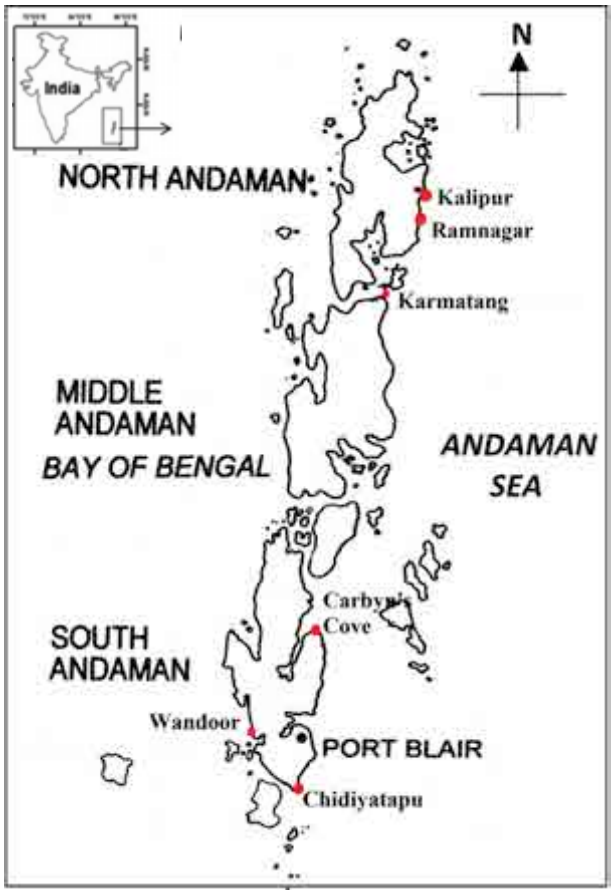

Figure 1. Study area

situated in Diglipur, North Andaman, and is located at 13.075^{0}N & 93.028^{0}E. This sandy beach is 15km away from Kalighat. It is surrounded by palm and coconut trees and coastal shrubs. Comparatively, it has stronger waves than the other study stations. Kalipur is located in Diglipur, North Andaman, and it is the only beach in the world where four species of turtles come to nest. Its coordinates are 13.235^{0}N & 93.896^{0}E and it is 18km from Diglipur. It has a combination of sand and rocks. Chidiyatapu houses the Munda Pahar Beach, which is 2.5km from Chidiyatapu Beach. Its geographical coordinates are 11.490^{0}N & 92.708^{0}E. The beach has a combination of sand and rocks and has small freshwater sources. Carbyn's Cove is a bay that is on the southeast of South Andaman. It is located at 11.490^{0}N & 92.700^{0}E. It is a sandy beach with rocks flanking its sides. There is an estuary adjoining it that supports a healthy mangrove vegetation. Wandoor is a marine national park located 29km from the city of Port Blair and is situated in the Bay of Bengal. It is located at 11.609^{0}N & 92.675^{0}E. It is a white sandy beach with two small freshwater inlets. It has a good surrounding vegetation of shrubs,

mangroves, and woody trees.

The slope of the beach

The slope of the beach was estimated by employing the method described by Varela-Acevedo et al. (2009) using Auto Level, DSZ2 (manufactured by Suzhou FOIF Co. Ltd.). The distance between the scale and the telescope was calculated. The values of distance against height were plotted on a graph to obtain the beach profile.

The angle of inclination

By finding the slope of the land, the height of the land was found at certain distances. Using the values of height and distance in the trigonometric formula tan ɵ, the value for the angle of inclination was obtained.

Grain size analysis

The grain size of the sand on the beach was analysed following Varela-Acevedo et al. (2009). Using a corer of length 12.7cm and a width of 5.08cm, sand samples were obtained from the part of the beach that is higher than the tide mark. None of these parts were in the dune area as there are no dunes in Andaman. The collected samples were placed in sample bags for analysis. The grains were mixed well and sprinkled onto a slide with a layer of oil to adhere to the grains. The grains were then viewed under a polarising microscope that was fixed with a graduated ocular lens. The diameter of each grain was measured individually in divisions and converted to millimetres. In each sand sample, diameters of 170 grains were measured. Size class intervals and their corresponding frequencies were made and the results were depicted graphically. The class interval with the highest frequency was taken as the representative of the sand at that corresponding sampling site. The sand grains were classified based on Wentworth (1922).

Extrinsic parameters

By comparing the vegetation at each of the six sites, the amount of vegetation at each site was classified as high, medium, or low. The presence of obstacles like trees was noted by visual examination. Anthropogenic activities/ influences like manmade structures, vehicles, shacks, and pollution were taken into account through comparison among the study stations. Techniques for identifying key parameters and estimating their values were followed from Varela-Acevedo et al. (2009). The transformed data of extrinsic parameters and the presence of turtle nests reported from literature (Andrews 2006; Murugan 2010) were used to perform principal component analysis and to generate a plot in PRIMER E-V6 package (Clark & Warwick 2001).

RESULTS

Extrinsic parameters

The extrinsic parameters are given in Table 1.

Beach slopes

Karmatang has a relatively flat reef slope (Fig. 2) with a minor dip at 2.4m and a major dip at 13.5m. The profile of Kalipur (Fig. 3) is very undulating with only one major visible rise at 31.4m. Ramnagar has a major rise at 7m and another at 12m (Fig. 4). The profile of Chidiyatapu (Fig. 5) shows that it has a number of indentations that can be difficult for turtles to navigate. From the profile of Carbyn's Cove (Fig. 6), it can be seen that there is only one major dip at 7m but otherwise, the land is relatively flat. In the case of Wandoor Beach (Fig. 7), there is a rise at 5.5m and a minor dip at 11.5m, but otherwise, the land is without many undulations. Chidiyatapu is the widest beach while Wandoor is the narrowest (Fig. 8).

Table 1. Extrinsic parameters in the study sites

Parameters	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn's Cove	Wandoor
Intertidal (m)	53.6	32.9	21.3	73.5	15.6	14.9
Vegetation	High	High	High	High	Low	Moderate
Streams through the beach	Nil	Nil	Nil	2	Nil	2
Creek	Nil	1	Nil	Nil	1	Nil
Obstacles on the beach	Nil	Nil	Nil	Yes	Nil	Yes
Presence of nearby islands	Nil	Nil	Nil	Nil	2	Nil
Presence of reefs	Yes	Yes	Yes	Yes	Yes	Yes
Anthropogenic activities	Low	Low	Low	Moderate	High	Moderate
Angle of inclination	7.86°	2.062°	8.3°	2.75°	2.29°	5.71°

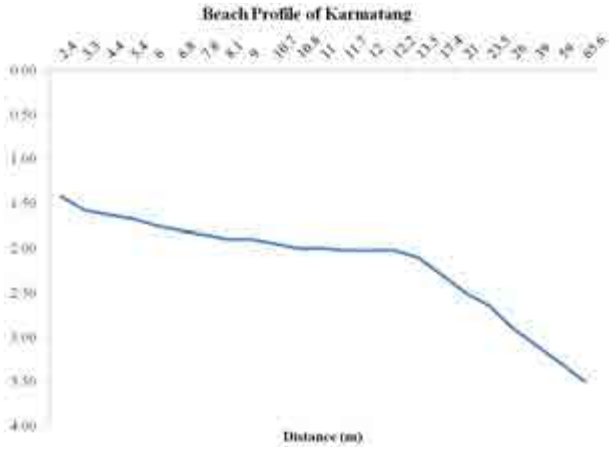

Figure 2. Beach profile of Karmatang

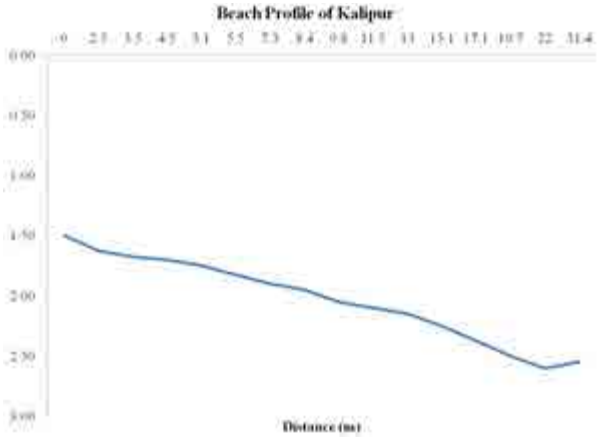

Figure 3. Beach profile of Kalipur

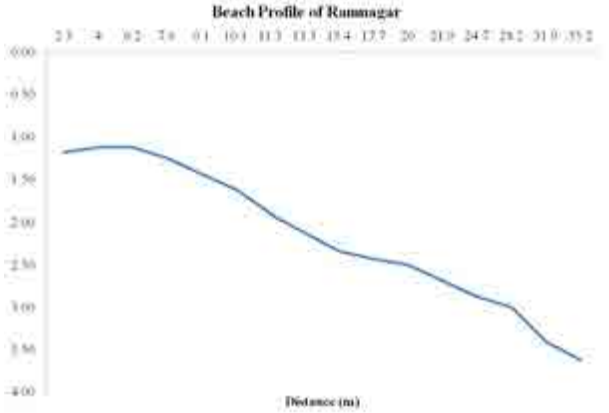

Figure 4. Beach profile of Ramnagar

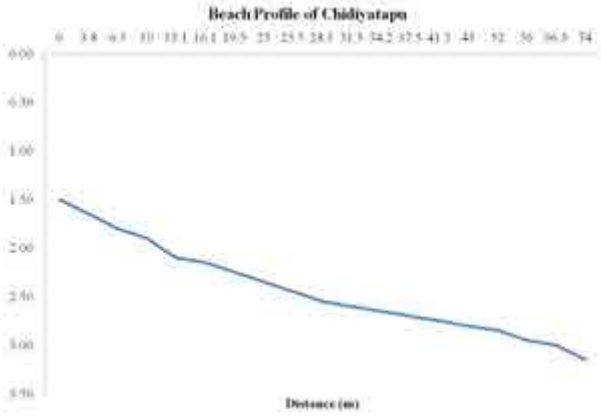

Figure 5. Beach profile of Chidiyatapu

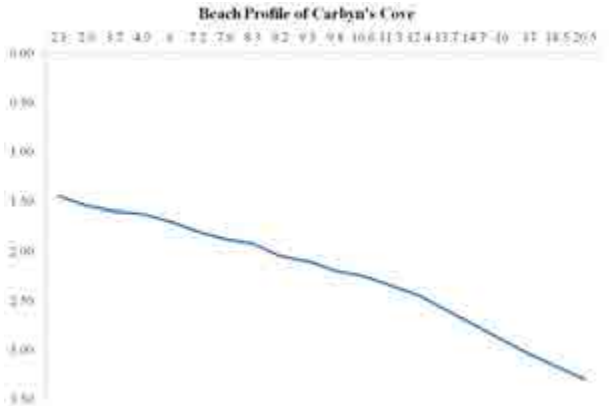

Figure 6. Beach profile of Carbyn's Cove

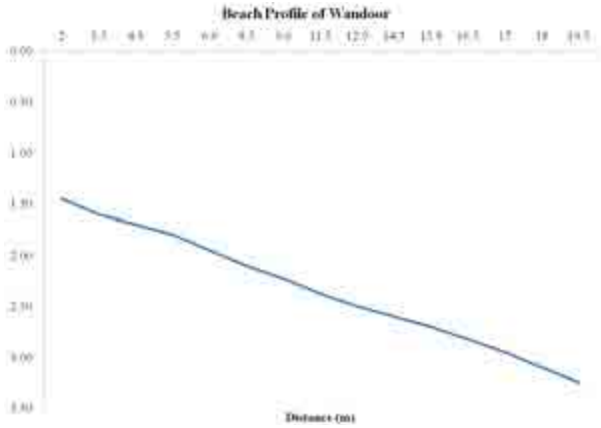

Figure 7. Beach profile of Wandoor

The angle of the slope

The slope angles of the study stations are presented in Table 1.

Sand grain analysis

In Karmatang, the majority of sand grains were small in size. This was the case in Kalipur and Ramnagar as well. In Chidiyatapu, the majority of sand grains were in

Table 2. Grouping of grains based on size classification by Wentworth (1922)

	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn	Wandoor	Classification
0–1	0	1	0	0	0	0	Coarse sand
1.0–2.0	76	112	17	12	2	36	Very coarse sand
2.1–4	75	55	106	142	28	78	Granules
4.1–16	19	2	47	16	124	56	Pebbles
>16.1	0	0	0	0	16	0	Gravel

Table 3. Effect of extrinsic parameters (++ very favourable, +favourable, - not favourable)

Site	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn's Cove	Wandoor
Sand grains	+	++	++	-	-	++
Beach width	+	+	+	++	-	-
Stream/ creek	+	+	+	-	+	-
Presence of obstacles	+	+	+	-	-	-
Artificial light	+	+	+	+	-	+
Vegetation	++	++	++	++	-	+
Anthropogenic activity	++	++	++	+	-	+

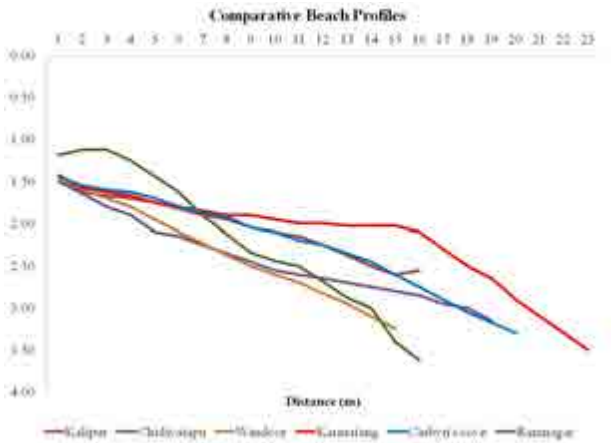

Figure 8. Comparison of beach profiles

the middle-size category. In Carbyn's Cove and Wandoor, the sand grains were small in general. According to the classification of sand grains by Wentworth (1922), Karmatang and Kalipur have very coarse grains, Chidiyatapu and Wandoor have granules, and Carbyn's Cove has pebbles (Table 2). Overall, the majority of grains were in the size range 2–4 mm. Wandoor and Karmatang had a more or less equitable distribution of sand grain sizes. There were proportionally more larger grains in Carbyn's cove and more smaller grains in Kalipur.

Effect of extrinsic parameters

With all the parameters mentioned above, Table 3 (++ very favourable, +favourable, - not favourable) provides a comparison of the study areas to show the effect of the analysed parameters on turtle nesting. The principal component analysis (Fig. 9) revealed that the absence of anthropogenic activities and nearby islands and the absence of creeks were closely associated with turtle nesting in the stations. The first two principal components accounted for 82% of the total variation. It is acknowledged here that if the specific number of nests in each area is included in the analysis, these results may vary. This is especially true of regions like Chidiyatapu and Wandoor for which results are only available from pre-Tsunami surveys.

Discussion

Sea turtle populations have decreased due to habitat destruction, anthropogenic activities on nesting beaches, predation of young hatchlings, and theft of unhatched eggs (Wyneken et al. 1988). The major potential terrestrial factors for choosing a beach for nesting are beach slope and width, the presence of interspecific competition, artificial lighting, and human activities. Studies have shown that there is a positive feedback between turtles and the beach dunes in which they nest (Bouchard & Bjorndal 2000). Beaches with good access to the sea, fine sands of small grain size, and adequate humidity and temperature were previously

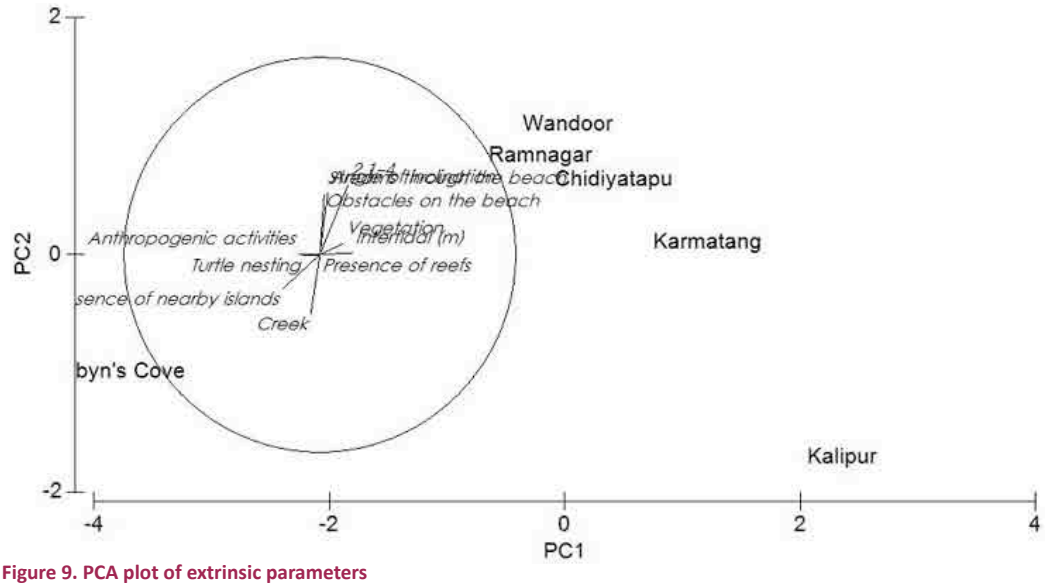

Figure 9. PCA plot of extrinsic parameters

noted as the desired features for site selection for turtle nesting (Wood & Bjorndal 2000; Morales-Mavil 2016).

The location of the nest in the tidal zone is crucial as the eggs must neither be flooded and eroded nor be exposed to land predators (Whitmore & Dutton 1985; Blamires & Guinea 1998). Hatchlings must be able to find the sea and the nest must not have visual obstructions that prevent the same (Godfrey & Barreto 1995). This shows that Wandoor, with the smallest beach width among all study stations, is not favourable for turtle nesting.

Debris on the beach prevents successful nesting and causes a phenomenon called as 'false crawl' where the females emerge from the water but do not deposit an egg clutch (Fujisaki & Lamont 2016). Artificial lighting too has been reported to disrupt patterns of nesting females (Weishampel et al. 2016).

Large angled beaches are preferred by turtles as water cannot move up the slope as easily and hence the nests are relatively safer from flooding (Godley et al. 1993). Ramnagar and Karmatang beaches have the steepest profile and larger angles, and so they are very favourable for turtle nesting. Ramnagar has the highest dominance of granules, which seem to be the ideal grain size as supported by the results from Hughes et al. (2009) that show that real nest contains medium sand or larger grains. Though Chidiyatapu has the widest beach, other factors are not very favourable and this leads to only sporadic nesting. Wandoor has the required grain size but the lack of intertidal width and the presence of streams in the beach are deterring factors. Considering all the features studied, the absence of streams, absence of artificial light, a significantly lesser number of anthropogenic activities, lack of obstacles, and the presence of bordering vegetation make Karmatang, Kalipur, and Ramnagar very conducive for turtle nesting. It has been reported that a total of 99 nesting sites belonging to four species of turtles were seen in Ramnagar, Karmatang, and Carbyn's Cove (Andrews 2006). While it could be deduced from the present study that Kalighat is a beach conducive for turtle nesting, the evidence for turtle nesting in this beach is mainly anecdotal. Unfortunately, data from the literature for these stations is sporadic. It is acknowledged here that a comprehensive list of sea turtle nests in these stations could be useful in comparing predicted conduciveness and actual preference. It is hereby recommended that the number of nests along each beach in these stations is to be quantified to empirically ascertain nesting preferences of turtles in this region.

The spatial and temporal consistency of turtle nesting behaviour are of basic importance to conservation efforts as they can be used to interpret scales of behavioural patterns in relation to environmental parameters. This can be used to regulate human activities in the beaches where turtles nest regularly (Weishampel et al. 2016).

There are numerous studies all around the world regarding turtle nesting site selection, environmental criteria for embryonic development, and other aspects of sea turtle biology. The focal point of all these studies is that a better understanding of the biology and life history of turtles can help in planning more effective conservation strategies. When compared to other regions, the studies regarding turtles from Andaman

& Nicobar are meagre. Further research can point out the salient features of turtle nesting behaviour in these regions and they can be used for the conservation of these marine reptiles.

CONCLUSION

Turtles have been part of Andaman's history since the 1800s. Their constant association with these waters and their homing in annually provides the best evidence that the beaches in Andaman do meet the turtles' requirements. This study shows that a single factor does not make a beach a better nesting site. It is shown from this study that there is a significant lack of literature pertaining to the reproductive biology of turtles in these islands. The results from further studies can be a backbone for planning developmental activities and developing infrastructure for these beaches in the future.

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A new record of the rare Hardwicke's Woolly Bat *Kerivoula hardwickii* (Horsefield, 1824) (Mammalia: Chiroptera: Vespertilionidae) after 23 years from a lowland rainforest of Sri Lanka

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Abstract: Distribution of *Kerivoula hardwickii*, Hardwicke's Woolly Bat, in Sri Lanka is restricted to the central highlands and to the northeastern region of the country, and so far, only recorded from four distinct locations. In Sri Lanka, this species was last documented in the year 1994 and no subsequent surveys recorded this species in Sri Lanka, thus considered rare in Sri Lanka. In contrast, within its South Asian biogeography, *K. hardwickii* is widely distributed, particularly in Southeast Asia. In this study, a single male of *K. hardwickii* was observed in lowland rainforest ecoregion of Sri Lanka near Labugama-Kalatuwana Forest Reserve where the bat was roosting on a curled live banana frond. The bat was roosting 1.8m above the ground. This was the first instance *K. hardwickii* recorded in the lowland rainforests of Sri Lanka, which extends this species' biogeography of Sri Lanka into the lowland wet zone. Thus, distribution range of *K. hardwickii* in Sri Lanka could be broader than historically documented. Intensive surveys, particularly in lowland rainforest regions, are required to validate the true distribution of this bat in Sri Lanka.

Keyword: Banana frond, canopy cover, distribution, *Kerivoula*, pitcher plants, threatened.

Sri Lanka, though a relatively small island (~65,610km^2) located in the Indian ocean, provides habitats for a rich assemblage of mammalian fauna. Of the 95 species of terrestrial mammals recorded in the island, bats are the second most diverse mammalian order with 32 species (13 yinpterochiropteran and 19 yangochiropteran species) closely behind rodents with 34 species (Phillips 1980; Leowinta & Luk 2016; Yapa 2017; Edirisinghe et al. 2018). Among Sri Lankan bats, two microbat species of the genus *Kerivoula represented are K. picta* (Painted Bat) and *K. hardwickii* (Hardwicke's Woolly Bat) (Phillips 1935; Yapa & Ratnasooriya 2012; Yapa & Ratnavira 2013). Although the latter species has a wide distribution range covering both southern and northern South Asia, southern China, and throughout continental and insular Southeast Asia, distribution of *K. hardwickii* in Sri Lanka is restricted to the central

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highlands and northeastern part of the country (Bates & Harrison 1997, 2000; Francis 2008; Slade 2017). This species is widespread in Southeast Asia, including Myanmar, Thailand, Laos, Vietnam, Cambodia, Peninsular and Bornean Malaysia, Indonesia, and the Philippines, but show a patchy and relatively isolated distribution in India, Pakistan, and China (Bates & Harrison 1997; Menon 2003; Francis 2008). Distribution of *K. hardwickii* is not well studied in Sri Lanka and recent surveys failed to document this species in or outside its historical range (Rubsamen et al. 2004; Yapa et al. 2005; DWC 2007a,b, 2008a,b; Yapa & Ratnasooriya 2012; Kusuminda et al. 2013; Yapa 2017; Edirisinghe et al. 2018). Given the marked deferential distribution status, there is a discrepancy in the conservation status of *K. hardwickii* in the IUCN Red List of Threatened Fauna and Flora of Sri Lanka (Critically Endangered: Ministry of Environment 2012) versus the Global Red List (Least Concern: Rosell-Ambal et al. 2008). Given the frequent records of *K. hardwickii* elsewhere, the low encounter rate of this species in Sri Lanka could be an artifact of imperfect detection or inadequacy of countrywide surveys on bats. Here, we report documentation of *K. hardwickii* in lowland rainforests of Sri Lanka.

Materials and Methods

We conducted field excursions for a period of six days (06-11 of August, 2017) in the vicinity of Labugama-Kalatuwana Forest Reserve (6.842–6.886^{0}N & 80.220–80.259^{0}E, altitude ranges 30–202 m) in southwestern Sri Lanka (lowland wet zone; average annual precipitation >2,000mm, elevation <300m). The general area is a habitat mosaic where lowland evergreen rainforests of secondary origin is the most dominant vegetation type. In addition, agricultural land-cover types such as rubber, coconut, and banana plantations, paddy fields, and home gardens are scattered around our study area. Through random walks, we first documented suitable bat roosting sites and subsequently surveyed each potential roosting site during both day (08:00–14:00 hr) and night (17:00–21:30 hr) and captured any bats present in the roosting site using a hand net (net depth: 45cm, net diameter: 30cm, mesh size: 1.5x1.5 mm). To confirm species identification, we used several standard guides and keys (Phillips 1980; Srinivasulu et al. 2010; Yapa & Ratnavira 2013). For all captured bats, we documented both morphological characteristics and morphometric variables using a digital Vernier calliper (RD-10, China), photographed (Canon 60D DSLR camera with EF 100mm f/2.8L Macro IS USM Lens) specimens, and immediately released them back to the site of capture. In addition, we recorded air temperature and relative humidity using a multi-digital hygrometer (TA-138, China), and wind speed using a digital anemometer (MS-6252-A, China).

Results

A single male of *K. hardwickii* (Image 1) was observed (17:19hr on 10 August 2017) roosting on a curled live banana frond of a mature banana tree *Musa paradisiaca* located in a secondary forest patch (~163ha in size). This site (6.866^{0}N–80.241^{0}E, altitude ~174m) is located 3.6km northeast of Labugama-Kalatuwana Forest Reserve in Thoranagoda (3.5km northwest of from Eheliyagoda City), situated in Ratnapura District within Sabaragamuwa Province of Sri Lanka (Fig. 1). The roosting site (1.8m height) had about 70% canopy cover. During the time of observations, the wind speed was 1.22–2.16 km/h (average 1.68 km/h), temperature 25.3–28.2 ^{0}C (average 26.7^{0}C), and humidity 57–83 % (average 69.5%). From our first time of observation, the bat remained in its roost for 51 minutes and left

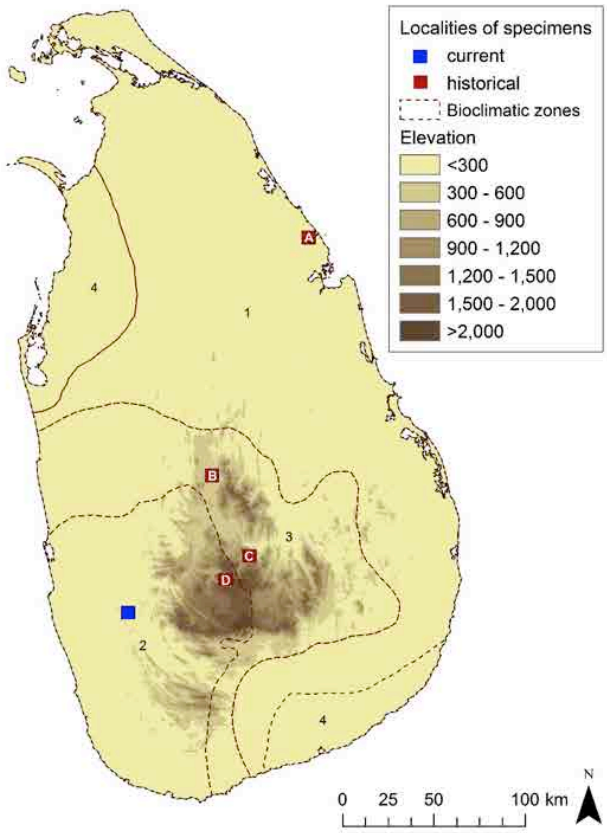

Figure 1. Historical and current distribution of *Kerivoula hardwickii* in Sri Lanka: Historical locations are according to Phillips (1980), Bates & Harrison (1997), and Slade (2017): (a) Nilaweli, (b) Pallama, (c) Kumbalgamuwa, (d) Pundaluoya, and new locality at Thoranagoda (blue square). Bioclimatic zones of Sri Lanka: (1) lowland dry zone, (2) lowland wet zone, (3) intermediate zone, and (4) arid zone.

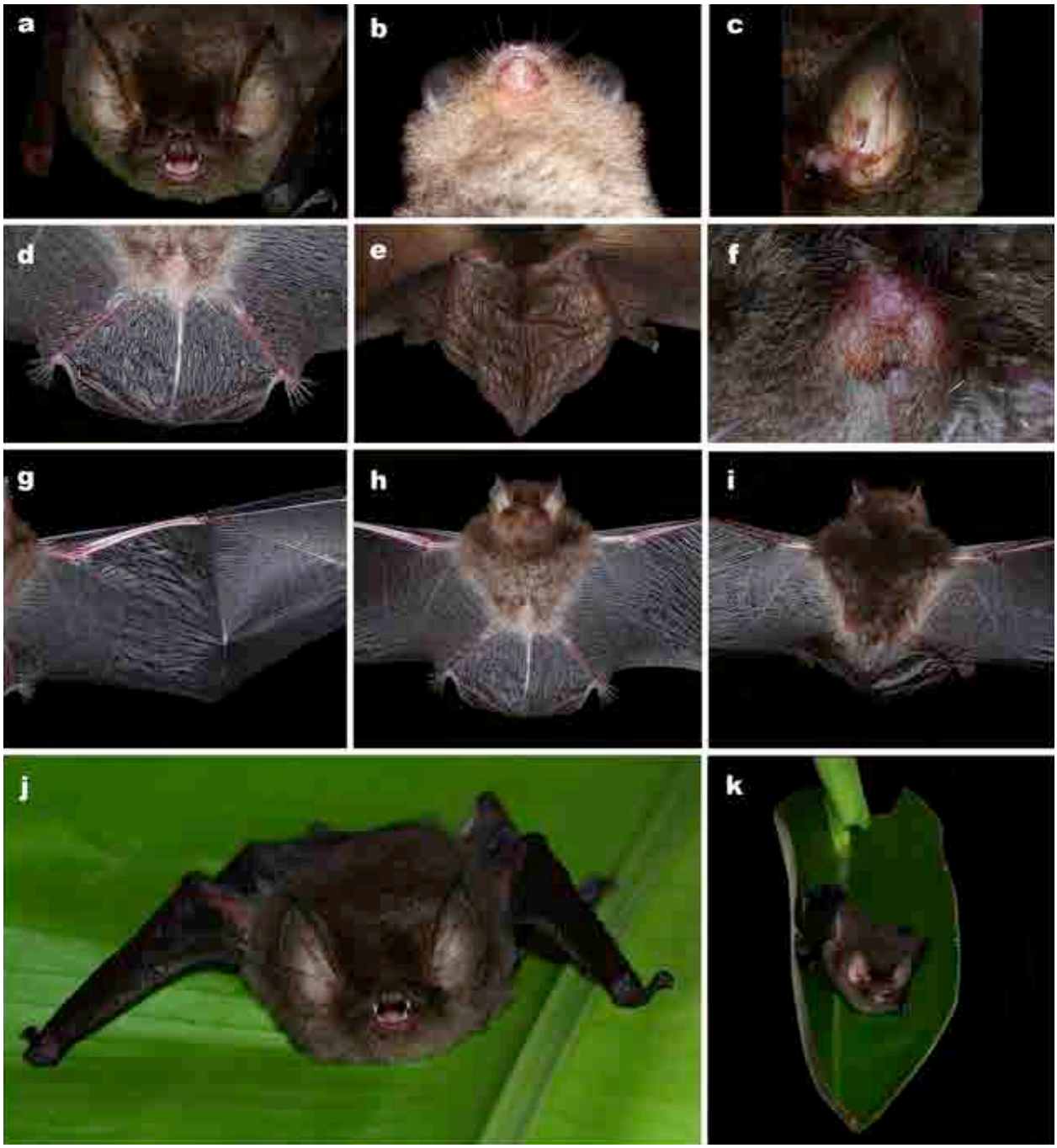

Image 1. Unique characters of *Kerivoula hardwickii* specimen recorded from Thoranagoda area: (a) facial structure, (b) throat area and fur color, (c) external ear lobe and tragus with a prominent notch, (d) and (e) ventral and dorsal aspects of the semitransparent interfemoral membrane (tail membrane), (f) presence of light brown, short hairs in the penis and the scrotum, (g) the ventral view of the wing membrane (patagium), (h) and (i) dorsal and ventral aspects of the bat, including the proximal parts of the patagium, (j) and (k) live specimen in the roosting site (banana frond). © Madhava Botejue.

the roost around 18:10hr, immediately after the sun set. The morphological and morphometrics featured of this individual resembled general description of *K. hardwickii* (Table 1 and 2). Other bat species we documented in this survey included *Pteropus giganteus, Rousettus leschenaulti, Cynopterus sphinx, Hipposideros ater, Hipposideros speoris, Pipistrellus tenuis,* and *Rhinolophus rouxii*.

Table 1. Morphometric variables recorded on *Kerivoula hardwickii* specimen recorded from Thoranagoda area, Sri Lanka, in this study, and also Phillips (1935), Bates & Harrison (1997) (measurements in mm.).

Measurement	2017	1935	1997
Head & Body length	40.37	43	39.0–55.0
Ear length	12.53	32	11.0–15.0
Ear width	6.20	-	-
Tragus length	5.98	-	-
Tragus width	1.16	-	-
Forearm length	32.47	32	31.7–36.0
1mt thumb +1st claw length	5.00	-	-
2nd metacarpal	33.42	-	-
3rd metacarpal	34.77	-	30.9–38.1
4th metacarpal	33.64	-	-
5th metacarpal	31.41	-	-
1ph 3mt length	14.22	-	-
2ph 3mt length	20.13	-	-
1ph 4mt length	9.53	-	-
2ph 4mt length	9.54	-	-
1ph 5mt length	8.24	-	-
2ph 5mt length	9.93	-	-
Wingspan length	230	-	-
Penis length	3.50	-	-
Penis width	1.19	-	-
Testicle height	1.54	-	-
Testicle width	1.33	-	-
Tibia length	17.21	-	-
Calcar length	13.44	-	-
Hind foot length	6.70	5	5.0–8.0
Tail length	38.50	-	35.0–43.0

Discussion

Previously-known occurrence of *K. hardwickii* in Sri Lanka was limited to four locations (Fig. 1)—Kumbalgamuwa (1931, 914m, near Walapane, Nuwara-Eliya District, Central Province, Natural History Museum of London, Cat No. BMNH.1931.11.7.1 (Phillips 1932)); Pundaluoya (1,062m, near Kikiliyamana, Nuwara-Eliya District, Central Province, Natural History Museum of London, Cat No. BMNH.3840346 (Bates & Harrison 1997)); and Pallama (1994, 500m, near Matale, Matale District, Central Province, Harrison Zoological Museum Cat No. HZM.3.31606 (Bates & Harrison 1997)); and Nilaweli (1945, 8m, near Kumpurupiddi, Trincomalee District, Eastern Province, Kansas University Biodiversity Institute, Cat No. KUM.135734, (Slade 2017)).

In Sri Lanka, this species is purported to occur in small numbers and inhabit warm, montane (500–1,100 m) well-sheltered forested valleys throughout the central highlands of Sri Lanka. According to our knowledge, this is the first photographic evidence of *K. hardwickii* from Sri Lanka with detailed morphological and morphometrics descriptions, and this is the first documentation after 1994 (Bates & Harrison 1997). Our sighting suggests a greater distribution range of *K. hardwickii,* which may extend beyond the central highlands and northeastern lowland dry zone, into the lowland wet zone of Sri Lanka. Since our encounter is limited to a single bat we draw a cautionary note regarding updating its conservation status. Further research with a combination of repeated visits and mist netting should be carried out in this region prior to updating the species extent of occurrence and area of occupancy. Moreover, we are also uncertain of the reason for low encounter rate of *K. hardwickii* and can be attributed to a combination of this species' illusive behavior, small-size, use of cryptic roosting sites, and lower population density stemming from lack of suitable habitats and low availability of critical resources.

Within its South Asian biogeography, this species is mostly found in forests and woodlands (Molur et al. 2002), but they are also found in forest edges, paddy fields, home gardens. Our documentation agrees with previous records of this species outside Sri Lanka as the landscape context of our study site is a habitat mosaic with home gardens, agricultural lands, isolated woodlands undergoing frequent anthropogenic disturbances, and many other forms of modified land-cover types. For instance, *K. hardwickii* is found in both subtropical and tropical China, and inhabits both forested and agricultural habitats, and forages around home gardens, paddy fields, and rural human settlements (Smith & Xie 2008). In Southeast Asia, *K. hardwickii* has been recorded from primary forests, secondary and disturbed forests, and montane forests (Rosell-Ambal et al. 2008). Throughout the overall distribution, *K. hardwickii* occurs along a broad elevation range (60–2,060 m) (Bates & Harrison 1997). Our observation is the first documentation of *K. hardwickii* from lowland rainforests of Sri Lanka, which in combination with its historic records from montane humid forests and dry mixed evergreen forests may suggest that this bat occupies a wider range of ecoregions within Sri Lanka similar to its biogeography in eastern and Southeast Asia.

Kerivoula hardwickii inhabits a wide variety of roosting habitats. Most often, they are found in buildings (both abandoned and those occupied by humans), large dead or dry leaves that are hanging downwards (which

Table 2. Detailed morphological features of *Kerivoula hardwickii* recorded from Thoranagoda area, Sri Lanka, in this study.

Morphological characters	Present specimen (Male)
Nose shape	Simple nostrils.
Head	Muzzle relatively small; Eyes small; The face covered in hair except for the nostrils, which are angled slightly downwards and outwards; the whiskers are conspicuous and protrude beyond the hairs on the snout.
Ears	Mostly naked but dark brown colour few short hairs present, Relatively large, funnel-shaped, tip-rounded.
Tip of the ear	Hair absent.
Tragus	Long and attenuated, narrowing gradually to a sharp point. A prominent notch present. Slightly concave, with a less angular tip.
Chin	Light brown, few short hairs present around the chin.
Throat	Light brown, few short hair present
Dorsal area	Dark brownish to grey or light brown, hair present throughout head and body.
Ventral area	Dark brown hair present in the nape and the chest. Light grey and light brown hair present on the abdomen.
Ante-brachial membrane	Present (Semi- transparent, thin in texture)
Radio metacarpal pouch	Absent.
Wing membrane	Well developed; the patagium and the skeletal elements supporting the patagium are naked. The wings and interfemoral membrane are brown; nearly transparent.
Forearm; 1st, 2nd, 3rd, 4th and 5th, metacarpals; 1st, 2nd, 3rd, 4th, and 5th phalanx to 1st, 2nd, 3rd, 4th, and 5th metacarpals	Naked.
Dorsal surface of tibia	Light brown, short hair present.
Inter-femoral membrane Dorsal area	Light brown, short hair present.
Inter-femoral membrane Ventral area	Light brown, short hair present.
Wing attached to	The base of the outer toe.
Penis (Foreskin)	Light brown, short hair present.
Testicles	Light brown, short hair present.
Anus	Light brown, short hair present.
Hind feet	Well-developed, light brown short hair present.
Calcar	Well-developed, light brown short hair present.
Tail	Enclosed with Inter-femoral membrane

conforms with our observation), clusters of dead leaves, hollow tree trunks, tall trees and dense bushes, and bamboo thickets (Bates & Harrison 2000; Francis 2008; Rosell-Ambal et al. 2008). A unique roosting habit of *K. hardwickii* has recently been documented from Southeast Asian island of Borneo where the bat roosts inside aerial pitchers of Raffles' Pitcher plant (*Nepenthes rafflesianaelongata*). This is considered a resource-service mutualistic association where bat excreta provide nitrogen for the plant and the aerial pitcher shelters and protects the bat from predators (Bauer et al. 2011; Grafe et al. 2011). In Sri Lanka, *K. hardwickii* has not been documented in pitcher plants so far. Although pitcher plants are abundant in and around our study site, we did not find *K. hardwickii* to associate pitcher plants for roosting purposes.

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Alarming population status of the Grizzled Giant Squirrel *Ratufa macroura* (Mammalia: Rodentia: Sciuridae) in Chinnar Wildlife Sanctuary, the Western Ghats, India

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Abstract: This study was carried out to assess the population of *Ratufa macroura* in Chinnar Wildlife Sanctuary located in the Kerala part of the southern Western Ghats. The population density of *Ratufa macroura* was estimated to be 15.26 squirrels/km^2. The total count method, however, gave the population range between 11 to 14 squirrels. The current population estimation is about 78–85 % lesser than the previous population estimation of the *Ratufa macroura* carried out in 1993 and 2007 respectively, which is quite alarming. The following conservation recommendations are suggested for the long-term conservation of *R. macroura*, which include habitat restoration to maintain the canopy contiguity and regulation of the pilgrimage and the tourism activities in and around the *R. macroura* habitat. Urgent steps should also be taken to undertake studies on the genetics of *R. macroura.* It is also suggested that systematic and scientific monitoring of the population of *R. macroura* be undertaken on a regular basis.

Keywords: Hybridization, Idukki District, Kerala, line-transect method, PHVA, *Ratufa indica,* riverine habitat, scrub jungle.

The family Sciuridae consists of 285 species of squirrels all over the world (Thorington et al. 2012), of which the Indian subcontinent harbours 28 species in 12 genera (Johnsingh & Nameer 2015; Nameer et al. 2015). Among the four giant arboreal squirrels belonging to the genus *Ratufa*, three are found within Indian borders. These are endemic to certain pockets of the Indian subcontinent, with the Indian Giant Squirrel (*Ratufa indica*) distributed in peninsular India, the Malayan Giant Squirrel *Ratufa bicolor* in northeastern India and the Grizzled Giant Squirrel *Ratufa macroura* in peninsular India and Sri Lanka (Menon 2014; Borges 2015; Joshua & Johnsingh 2015). There are three subspecies of *R. macroura*. These include *R. m. dandolena,* which occurs in southern India and Sri Lanka while *R. m. macroura* and *R. m. melanochra* are endemic to Sri Lanka (Phillips 1981). *Ratufa macroura* is endemic to southern India (Kerala, Karnataka and Tamil Nadu) and Sri Lanka. In India it is known to survive in nine severely fragmented locations, such as, the Grizzled Giant Squirrel Wildlife Sanctuary, Srivilliputhur, Theni Forest Division, Palani Hills, Anamalai Tiger Reserve, Sirumalai, Thiruvannamalai Forest Division, Hosur Forest Division and Cauvery Wildlife Sanctuary (all in Tamil Nadu), the Cauvery basin in Karnataka and Chinnar Wildlife Sanctuary in Kerala (Babu & Kalaimani 2014). The only known population of *R. macroura* in Kerala is in Chinnar Wildlife Sanctuary (CWS). The habitat of these

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giant squirrels in CWS is extremely unique and confined primarily to a narrow stretch of riparian vegetation along the Pambar and Chinnar rivers and their major tributaries (Ramachandran 1993). Perhaps the only long-term ecological study on the Grizzled Giant Squirrels at the Srivilliputtur Grizzled Giant Squirrel Wildlife Sanctuary, Tamil Nadu were by Joshua & Johnsingh (1994), Joshua et al. (2006), and Raja & Joshua (2006).

The *R. macroura* population in India has been estimated to be <500 mature individuals. It is also observed that the *R. macroura* population has been declining at a rate greater than 30% in the last 25 years due to habitat loss and hunting (Molur et al. 2005; Joshua et al. 2008).

The previous studies on the population estimation of *R. macroura* at CWS were by Ramachandran (1993) and Senthilkumar et al. (2007). The population data on a species with restricted range distribution is very crucial in conservation prioritisation and there has not been any recent population estimation carried out on the *R. macroura* in CWS, and hence the present study was undertaken.

Materials and Methods

Study area

The study was conducted in Chinnar Wildlife Sanctuary, which is spread over an area of 90.44km². It is located between 10.25–10.35^{0}N and 77.08–77.26^{0}E in the Kerala part of the southern Western Ghats, in Idukki District (Fig. 1). The terrain of Chinnar is undulating with altitudes varying between 440m and 2,372m . The major vegetation types found here are, the southern tropical thorn forest (scrub jungle), southern dry mixed deciduous forest (dry deciduous forest), southern moist mixed deciduous forest (moist deciduous forest), tropical riparian fringing forest (riparian forest), southern montane wet temperate forest (shola forests) and southern montane wet grassland (grasslands) (Champion & Seth 1968). The dominant vegetation among these is the dry deciduous forest followed by scrub jungle which is mainly found in the plains and at lower altitude. The dry deciduous and scrub jungle, together constitute about 70% of the total forest area in Chinnar. The riparian fringing forests are linearly distributed and are confined to the rivers Chinnar and Pambar, and their tributaries. Shola forests occupy a small fraction of the total area and are seen only in the higher reaches of Chinnar, above an altitude of 1800m.

Ratufa macroura in CWS is primarily seen only in the riverine forests along the Chinnar and Pambar rivers and their tributaries. The riverine or gallery forests are quite distinct and conspicuous among the surrounding scrub jungle and dry deciduous forests of CWS. The effective habitat for the *R. macroura* at CWS is estimated to be less than 2km^2.

Methods

a. Line transect method: The line transect method by Buckland et al. (2001, 2010) was used in this study to estimate the population density of *R. macroura*. The five transects were repeatedly walked once every month for 10 months (5x10=50) thus fifty, 2-km transects were walked from April 2013 to May 2014. Each transect was walked by a team of three persons. Each transect was walked in the morning, between 06:00–10:00 hr and afternoon between 15:00–18.00 hr. Thus, a total of 200km were walked during the study period. When a squirrel was sighted we recorded the cluster size, which means number of individuals at a time sighted, perpendicular distance, and azimuths along the transect. The data collected was analysed using DISTANCE programme (version 6.2) (Buckland et al. 2004). We evaluated different models of detection probability, viz. uniform, half-normal and hazard rate with three series adjustment terms and used the minimum Akaike information criteria (AIC) as the standard model selection procedure to select the best model for estimating density. Apart from the squirrel density, the encounter rate (squirrel clusters/km) was also calculated.

b. Total count: The total count of the *R. macroura* was carried out from seven different blocks within CWS. Whenever a *R. macroura* was sighted parameters like the number of individuals, time of sighting, habitat and tree species on which the squirrel was sighted were recorded. At each of these locations we walked for 3 to 4h and the number of *R. macroura* was counted. This was done simultaneously deploying a group of four people in each of the seven blocks for two days in the study area on 22–23 March 2014.

c. Regeneration survey: A regeneration survey was carried out at the study locations in the CWS, to find out the regeneration of the vegetation in the riverine habitats. One hundred quadrats of 100m^2 size were taken, with 20 each at each of the five study locations. In each of these quadrats all plants ≥10cm girth at breast height (1.37m) were enumerated, and the information such as species of tree, height of the tree in meters and girth at breast height in centimetres were recorded (Pascal 1988).

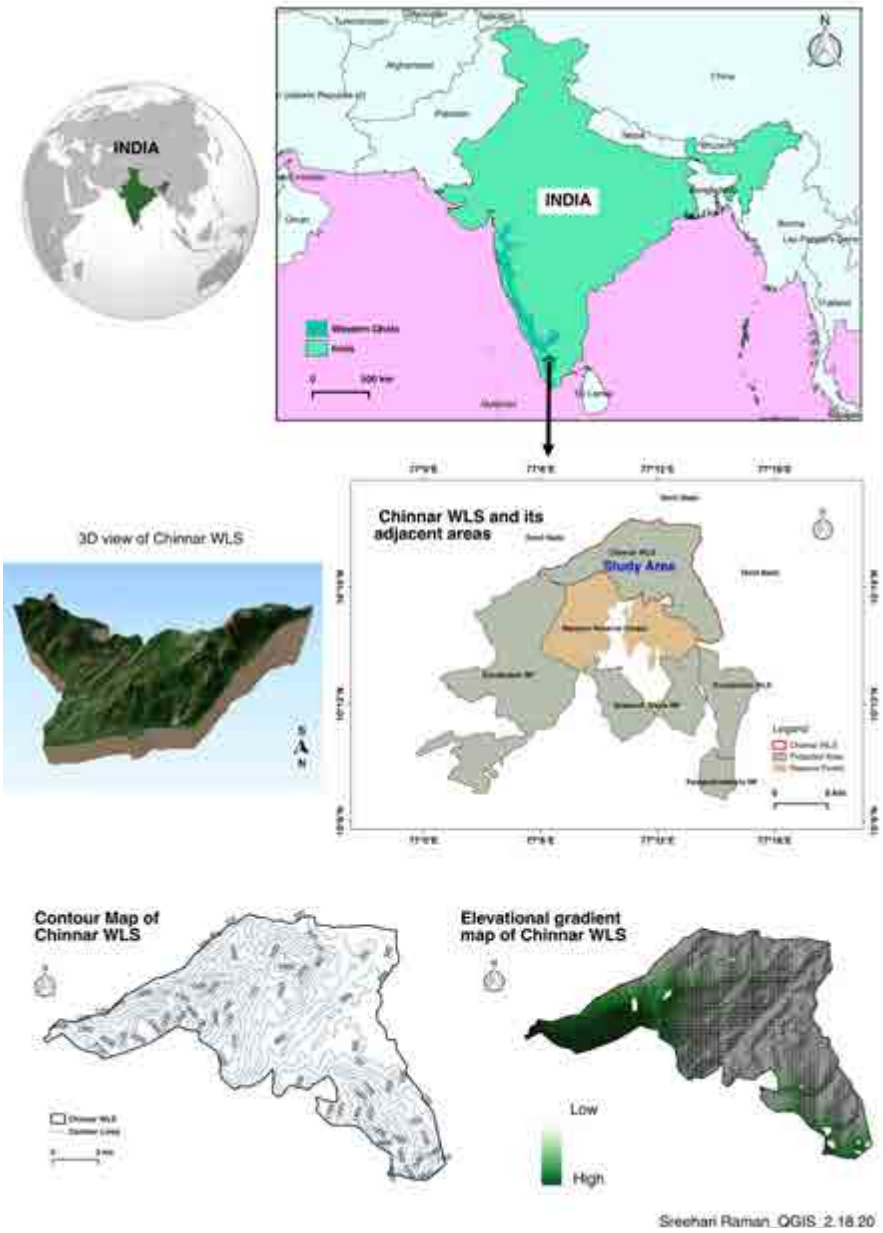

Figure 1. Location map of Chinnar Wildlife Sanctuary

Results

Population density estimation of *R. macroura* using line transect method in Chinnar Wildlife Sanctuary

The *R. macroura* is a solitary animal and is seen in pairs or as a family party of three individuals only during the breeding season.

A total of 85 detections of the *R. macroura* were made during the study period, with an encounter rate of 0.21 squirrels per km (Table 1). The density of the *R. macroura* was estimated to be 15.26 squirrels/km^2 (SE=2.96). The lower confidence limit was 10.45 squirrels/km^2 and the upper confidence limit was 22.30 squirrels/km^2 (Table 1).

Table 1. Density of Grizzled Giant Squirrel estimated using line transect method and DISTANCE software in Chinnar Wildlife Sanctuary, Western Ghats

Parameters	Values
Effort (distance in km)	200km
Number of cluster (group) detections (n)	85
Encounter rate (squirrel clusters/km)	0.21
Model selected	Hazard rate
Minimum Akaike Information Criteria	457.07
Squirrel density / km^2 ± Standard Error	15.26±2.96
Squirrel density 95% Confidence Interval, lower limit-upper limit	10.45±22.30

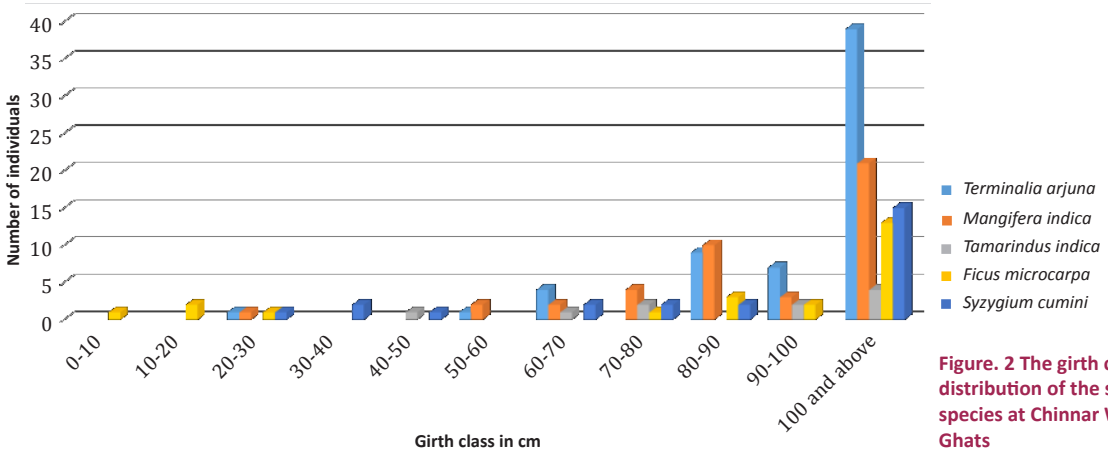

Figure. 2 The girth class distribution of the selected tree species at Chinnar WS, Western Ghats

Table 2. The total count of Grizzled Giant Squirrels at different study locations in Chinnar Wildlife Sanctuary, Western Ghats

Name of the block/ date of the count	Kootar	Churulipetti	Chambakkadu	Athioda	Alampetty	Thoovanam	Vannamthura	Total
22-03 2014	1	6	0	3	3	1	0	**14**
23-03-2014	1	2	4	0	0	1	3	**11**

The effective strip width of the riverine habitat used by the *R. macroura* was calculated to be 0.04km using the DISTANCE (6.2) programme. The total length of the riverine habitat was calculated using the software QGIS to be 40km. Thus, the effective habitat for the *R. macroura* at CWS is estimated to be only 1.6km^2.

The total population of *R. macroura* at CWS would be 24 squirrels (15×1.6km^2).

Total count of *R. macroura* in Chinnar Wildlife Sanctuary

The summary statistics of the total count of *R. macroura* is presented in Table 2. A total of only 11 to 14 *R. macroura* could be counted during the total count. The maximum number of *R. macroura* was sighted in the Churulipetti Block (8 numbers) followed by Alampetty Block (7).

Regeneration of riverine vegetation

The most preferred five plant species by the *R. macroura* at Chinnar were *Terminalia arjuna, Mangifera indica, Tamarindus indica, Ficus microcarpa* and *Syzygium cumini* (Thomas 2014). The girth class distribution of these five-plant species is given in Fig. 2. It is evident from Fig. 2 that the regeneration of these tree species is extremely low in CWS.

Discussion

Population of *R. macroura* in Chinnar Wildlife Sanctuary

The population density of the *R. macroura* in CWS was found to be 15.26 squirrels/km^2. The previous density estimations of *R. macroura* from Chinnar were 18-23 squirrels/km^2 (Ramachandran 1993) and 64 squirrels/km^2 (Senthilkumar et al. 2007). The population density estimated during the present study is lower than the previous estimations.

The two census methods that were used in the present study to estimate the population of the *R. macroura*, indicate that the population of the squirrels at Chinnar is between 14 and 24 individuals, using the total count method and line transect method, respectively. The previous population estimation of the *R. macroura* was 150 from CWS (Ramachandran 1993), while in another study it was estimated to be 107 squirrels (Senthilkumar et al. 2007). Thus, there has been a decline of about 78 to 85%, in the population of the *R. macroura,* which is quite alarming. Baskaran et al. (2011), however, mentioned that the population of *R.* macroura in the Anamalai landscape, including the CWS was 300 individuals. Joshua & Johnsigh (1994) estimated the population of *R macroura* to be between 82 to 115 individuals in the Alagarkoil Valley in the Srivilliputhur Grizzled Giant Squirrel Wildlife Sanctuary, in Tamil Nadu, southern India. The Srivilliputhur Grizzled

Giant Squirrel Wildlife Sanctuary may be the stronghold for the Grizzled Giant Squirrels in its entire range within the Western Ghats.

In one of the previous population estimates, Senthilkumar et al. (2007) gave a density figure of 64 squirrels/km^2, which seems to be an over estimation. Senthilkumar et al. (2007) states that "the squirrel density was calculated as the total number of squirrel sightings divided by the survey area" which is a crude method of density estimation and is not as per the standard density estimation protocol proposed by Buckland et al. (2004).

Conservation recommendations

The total population of the *R. macroura* (Image 1) in India is estimated to be fewer than 500 mature individuals (Molur et al. 2005) and 60% of this population is believed to be found in Chinnar and adjoining Tamil Nadu. Thus, the present findings, which indicate a drastic decline in the population of the *R. macroura* is a matter of grave concern.

This small population of the *R. macroura* at CWS, is faced with the several conservation challenges, such as increased predation risk (Thomas et al. 2017). This could be due to the opening up of the of the canopy in the riverine habitat of Chinnar. Moreover, the regeneration of the preferred food plant species of the *R. macroura* is extremely low. The poor regeneration is because of the heavy grazing by the domestic cattle. Thus urgent steps should be initiated to curtail the cattle grazing within the riverine habitat in Chinnar WS. Additionally, habitat restoration programmes need be initiated to ensure the regeneration of the most preferred five plant species of the *R. macroura* such as *Terminalia arjuna, Mangifera indica, Tamarindus indica, Ficus microcarpa* and *Syzygium cumini* urgently.

We saw several possible hybrid individuals (Images 2 & 3) between *R. macroura* and *R. indica.* The hybrid individuals were primarily seen in Kootar, Churulipetti and Chinnar-Marayur border. There could be at least three to four hybrids at Chinnar, which is about 17% of the total population of Grizzled Giant Squirrel. Detailed investigation on the status of hybrid individuals, reasons for hybridization, and the genetics of the *R. macroura* need to be urgently undertaken at Chinnar to find out the genetic purity of this species. Detailed taxonomic studies using molecular tools should be carried out to ascertain the taxonomic status of the Indian population of the *R. macroura*. The mix-up and hybridization between the *R. macroura* and *R. indica* also should be monitored to find out its effect on the long-term survival of the *R. macroura*. Importantly, a Population Habitat Viability Analysis (PHVA) is also recommended for the long-term conservation of *R. macroura.* Joshua & Johnsingh (1994), also recommend the need for systematic study on habitat quality, feeding and breeding ecology of *R. macroura* if the squirrel has to be conserved and saved from further population loss in its range.

In addition to the above-mentioned threats, anthropogenic disturbances in the form of pilgrimage at Churulipetti, tourism and road kills also pose conservation challenges to the *R. macroura*. The disturbances from the pilgrims and vandals in the riverine vegetation at Churulipetti region should be regulated. This causes considerable disturbance to the *R. macroura*, as the riverine vegetation is the key habitat of these squirrels, and thus the pilgrim's entry to the riverine vegetation should be stopped. To prevent the road kills, regular crossing points have to be identified and the animal should be provided with canopy connectivity using the artificial structures like bamboo bridges across the road. There are also some ill effects due to the ecotourism ventures, for example, the log houses constructed on the banks of the riverine habitat and the tree top huts, constructed on the top of the trees in the riverine habitat, could be detrimental to the long-term survival of the *R. macroura.*

It is also important to undertake regular, systematic and scientific population monitoring of *R. macroura* on a regular basis, at least once a year to understand the population fluctuation of this extremely small and dwindling population of *R. macroura* at Chinnar Wildlife Sanctuary. A population estimation of the *R. macroura* in its entire range in southern India, also should be carried out to ascertain their actual population in India.

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Image 1. *Ratufa macroura*

Image 2. A possible hybrid individual between *Ratufa macroura* and *R. indica*

Image 3. Two possible hybrid individuals between *Ratufa macroura* and *R. indica*, showing a mix of colours of both *R. macroura* and *R. indica*

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SHORT COMMUNICATION

Distribution and population status of Sambar *Rusa unicolor* (Mammalia: Cetartiodactyla: Cervidae) from Aravalli landscape with a note on its first record from Aravalli Hills of Haryana, India

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OPEN ACCESS

Abstract: Sambar is the most widespread deer in Southeastern Asia and is listed as Vulnerable in the IUCN Red List. In this communication, we report the results of an extensive literature review and camera trapping to present the historic and current distribution of Sambar in Aravalli Mountain region. The records state that the species is nearly exterminated in the protected areas of Gujarat Aravalli and bordering areas of Rajasthan, although a sizable population still survives in northern and central Aravalli (Pali-Rajasamand-Udaipur & Alwar-Sawai Madhopur region). We also report the first record of Sambar from the Aravalli Hill region of Haryana.

Keywords: Aravalli, Sambar, distribution, population.

Rusa unicolor was listed as Vulnerable in 2008 by IUCN due to rapid declines in several of its populations (Timmins et al. 2015). The Wildlife (Protection) Act, 1972 lists this species in Schedule III. The main reasons for its declining populations are attributed to habitat loss and poaching (Timmins et al. 2015).

Distribution in southeastern Asia and India

Rusa unicolor is native to southern and southeastern Asia and its distribution extends to India (Menon 2009), Sri Lanka (Eisenburg & Lockhart 1972), southern Nepal (Mishra 1982), Myanmar (Tun Yin 1967), southern China (Smith et al. 2010), Indonesia, Philippines (Prater 1971), and the islands of Borneo, Taiwan, and Hainan (Hsu & Agoramoorthy 1997). Its distribution, however, has decreased substantially and it is now rare in Malaysia (Timmins et al. 2015), Thailand (Ngampongsai 1987), Vietnam (Khun & Kan 1991), Bangladesh (Basbar et al. 2001), and Laos (Timmins & Evans 1996).

Sambar has been reported from several protected areas of India and has been intensively studied in Sariska (Chatterjee et al. 2014), Mundanthurai (Johnsingh & Sankar 1991), Rajaji National Park (Bhatnagar 1991), Ranthambore Tiger Reserve (Goswamy 2011), Corbett National Park (Pant et al. 1999), Gir National Park (Jhala et al. 2004), Periyar Tiger Reserve (Harikumar et al. 1999), Kanha National Park (Porwal et al. 1996), Bandipur

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National Park (Johnsingh 1983), Nagarhole National Park (Karanth & Sunquist 1992), and Pench Tiger Reserve (Biswas & Sankar 2002) in India.

Materials and Methods

Study area description

Aravallis extend from -Gujarat and Rajasthan in the southwest and to Haryana and Delhi in the northeast. The study area selected was the Aravalli region of the Haryana landscape, which lies between 28.58^{0}N–27.65^{0}N & 75.91^{0}E–77.16^{0}E (Fig. 1). Haryana is bound by Aravalli in the south-west region. The northern point of the range continues as isolated hills and rocky ridges into Haryana State, ending in Delhi. The famous Delhi Ridge is the last leg of the Aravalli range, which traverses through southern Delhi and terminates in central Delhi where Raisina Hill is its last extension. Sites in five divisions, namely, Mahendragarh, Rewari, Faridabad, Gurgaon, and Mewat, were extensively surveyed for mapping land use area/ land cover pattern and the status of key wildlife species.

Field data collection

Sign surveys and line transects were conducted in 51 sampling sites spread over five forest divisions for a period of four months (January–April 2016). Vegetation variables like floral diversity were also recorded to compare the habitat characteristics of each site. Opportunistic camera trapping was later conducted in October 2016 in two districts: Gurgaon and Faridabad. To get basic insights into the presence of mammalian species in the region, 360 camera trap nights (12 cameras for 30 days) were deployed. The sites selected to put cameras were Bhondsi (one), Gamroj (one), Manger (four), Bandhwari (two), Wazirabad (two), Gothda (one), and Anagpur (one).

There is currently no reliable and detailed information on the distribution of Sambar from the entire extent of Aravalli hill range. In the absence of such ecological information, proper research and management is difficult. Hence, to fill the information gap, records on the distribution of Sambar in three states, Rajasthan, Gujarat, and Haryana, were collected and compiled. No records of the natural population from Delhi NCR have been reported as of now. Though there are occasional records of Sambar sightings and rescue operations from Delhi NCR (Anonymous 2016), these do not confirm the areas where they actually occur. Present numbers

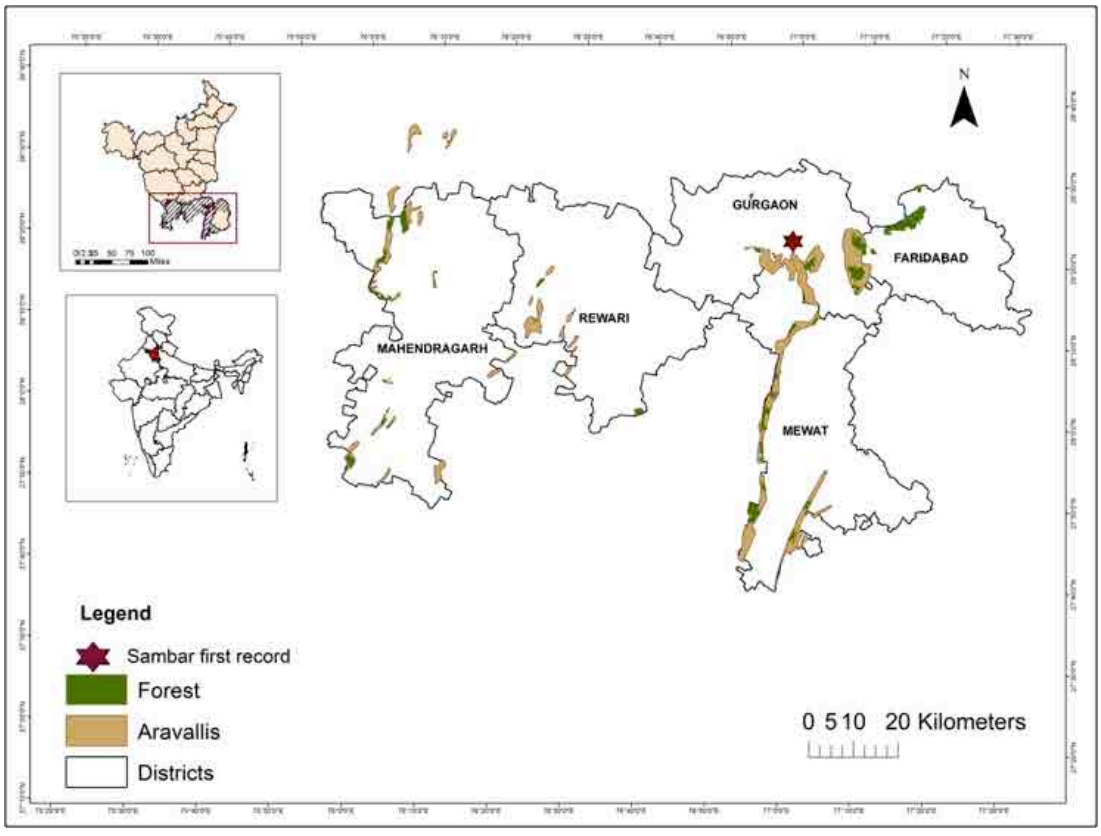

Figure 1. Map showing first record of Sambar from Aravallis in Gurgaon District, Haryana

and early records were collected from census records of respective forest departments, state gazetteers, and available publications.

Results

First record of Sambar from Aravallis Haryana in Gurgaon District

Images of *Rusa unicolor* on two consecutive days in October were recorded from Bhondsi Village in Sohna (Fig. 1 & Image 1). Bhondsi in Gurgaon District has an extremely rich forest habitat which still remains ignored by conservationists. Until now, *Rusa unicolor* in Haryana had been reported only from the Shivallik ranges (northern Haryana). They are known to occur in Morni Hills in Panchkula District (Anonymous 1892) and Kalesar National Park in Yamunanagar District (Habib et al. 2015). This postulates for more intensive monitoring of the species and its distributional status.

Distribution range from Aravalli Hill range

The Aravalli extends its northeastern portion to Gujarat covering the districts Banaskantha, Sabarkantha, Aravalli, Dahod, Panchmahal, and Vadodra. *Rusa unicolor*, although present in large numbers earlier, has disappeared from this region of Aravalli Hills. Jumbugodha Wildlife Sanctuary abounded in Sambar but now they have gone extinct. Jambugodha area was managed by an old state ruler. Tigers, panthers, sambars, deer, bears, wild boars, and antelopes were present here (Mehta et al. 2002). Earlier records have been reported from districts Banaskantha (Ryley 1914), Sabarkantha (Rajyagaor 1974), Panchmahal (Patel 1972), and Vadodra (Anonymous 1979). Description of Sambar from Jessore Wildlife Sanctuary in the faunal list has been described in a booklet released by Gujarat Forest Department (Anonymous 1984).

The Aravalli mountain range in Rajasthan is spread across districts Ajmer, Alwar, Bhilwara, Dungarpur, Jaipur, Jhunjhunu, Nagaur, Pali, Rajsamand, Sawai Madhopur, Sikar, Sirohi, Chittorgarh, Pratapgarh, Banswara, and Udaipur (Fig. 2). This is the most studied region in Aravalli in terms of the ecology of *Rusa unicolor*. Records of Sambar exist in several protected areas of the state and in some places they have been intensively studied by biologists. Currently, a healthy population exists in Ranthambore National Park, Sariska Wildlife Sanctuary, Keoladeo National Park, Darrah Wildlife Sanctuary, Mount Abu Wildlife Sanctuary, Kumbalgadh Wildlife Sanctuary, Sitamata Wildlife Sanctuary, Nahargarh Wildlife Sanctuary, Jamwa Ramgarh Wildlife Sanctuary, Todgarh-Raoli Wildlife Sanctuary, Mrigwan Chittorgarh Forest, Sawai Mansingh Wildlife Sanctuary, Sajjangarh Wildlife Sanctuary, National Chambal Wildlife Sanctuary, Ramgarh Vishdhari Wildlife Sanctuary, Kaila Devi Wildlife Sanctuary, and Jawahar Sagar Wildlife Sanctuary (Table 1).

In certain protected areas, however, the population of Sambar has been locally exterminated. Fauna of protected areas of Rajasthan and Gujarat by Zoological Survey of India (Kumar 2012) stated its presence in

Image 1. Camera trap photos of Sambar from Bhondsi, Gurgaon. © Paridhi Jain

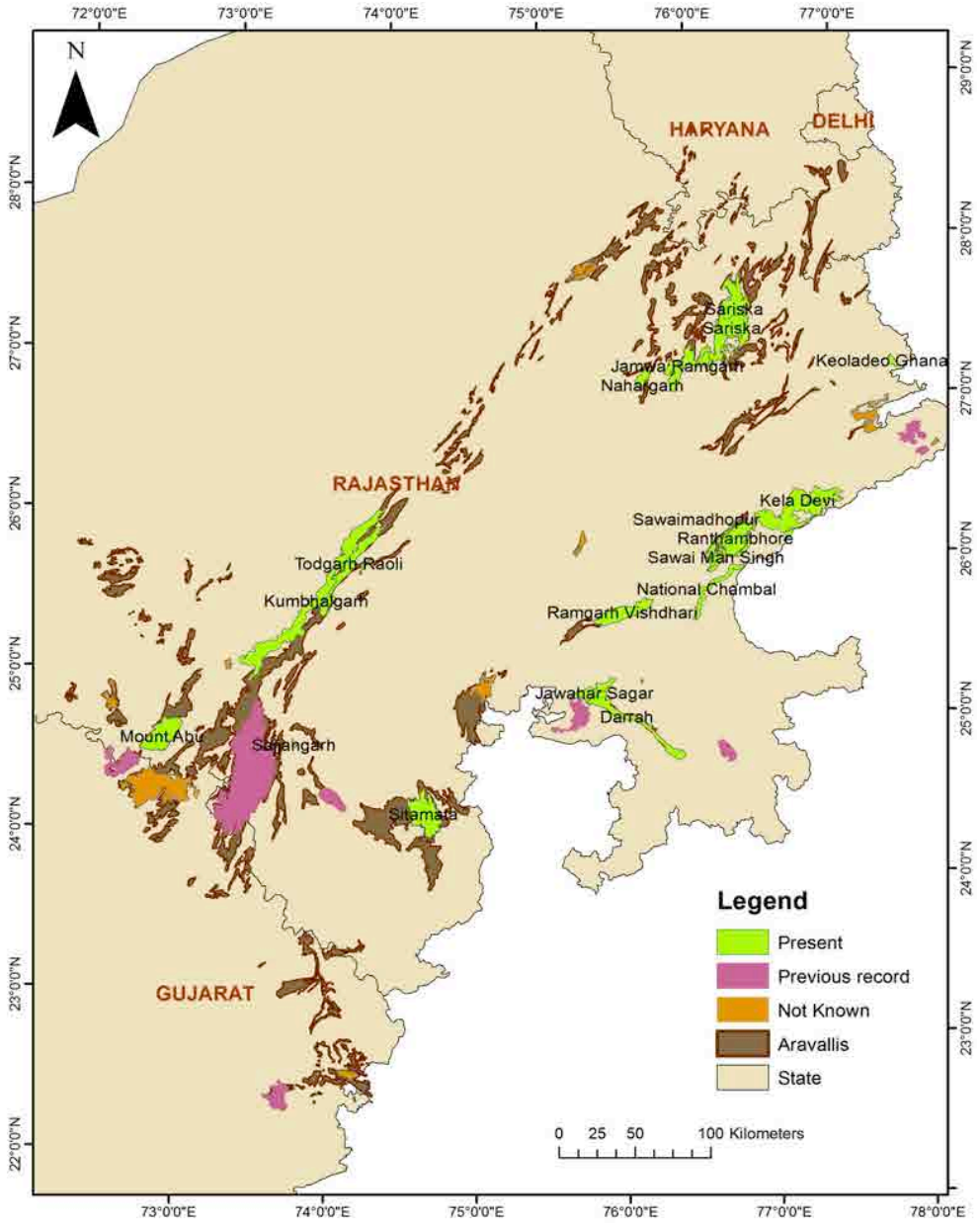

Figure 2. Current and historic range of Sambar from protected areas of Aravalli landscape

sanctuaries such as Bhainsrodgarh, Shergarh, Ramsagar, and Van Vihar (Table 1). Wildlife census of Rajasthan records (2011–2017) suggests this species is now absent from these areas. According to census records, Sambar was last recorded in Bhainsrodagarh in 2010 (n=2) and in Ramsagar (n=29), Shergarh (n=36), and Van Vihar (n=23) in 2007. Although the census record states that Sambar is extinct from Phulwari Ki Nal Wildlife Sanctuary, one record exists in biodiversity assessment survey by FES in 2010 (Anonymous 2010b). Sambar once also existed in Jaisamand Wildlife Sanctuary and got exterminated around 1997 (Dubey 2011). The last record of Sambar in Jaisamand as per wildlife census is of 1995 (n=5).

Aravalli region of Haryana exists in districts Gurgaon, Faridabad, Mewat, Mahendargarh, Rewari; some remnants of the range also exist in Bhiwani. The habitat in this region is declining rapidly due to rapid deforestation and development activities. The forests in the state are the least studied in the entire extent of the Aravalli hills. So far no records of any sighting of Sambar exist in this region. The record -stated above (Image 1) is the only present record from Aravalli region of Haryana.

Table 1. Records of Sambar from Aravallis extent

	Protected area	District	Present status	Current population estimate	Literature cited
Rajasthan (Aravallis)					
1	Bhainsrodgarh WS	Chittaurgarh	Extinct (PR)*	0	Kumar 2012; Forest dpt. Census (Anonymous 2010a)
2	Darrah WS	Kota	Exist	96	Forest dpt. Census 2013 (Anonymous 2011-2017)
3	Jaisamand WS	Udaipur	Extinct (PR)*	0	Forest dpt. Census (Anonymous 1995)
4	Jamwa Ramgarh WS	Jaipur	Exist	15	Forest dpt. Census 2016 (Anonymous 2011-2017)
5	Jawahar Sagar WS	Kota	Exist	2	Forest dpt. Census 2013 (Anonymous 2011-2017)
6	Kaila Devi WS	Sawai Madhopur	Exist	28	Forest dpt. Census 2013(Anonymous 2011-2017)
7	Keoladeo Ghana NP	Bharatpur	Exist	81	Forest dpt. Census 2016 (Anonymous 2011-2017)
8	Kumbalgadh WS	Rajsamand, Pali, & Udaipur	Exist	337	Forest dpt. Census 2016(Anonymous 2011-2017)
9	Mount Abu WS	Sirohi	Exist	90	Forest dpt. Census 2016 (Anonymous 2011-2017)
10	Mrigwan Chittorgarh Forest	Chittaurgarh	Exist	14	Forest dpt. Census 2016(Anonymous 2011-2017)
11	Nahargarh WS	Jaipur	Exist	15	Forest dpt. Census 2016(Anonymous 2011-2017)
12	National Chambal WS	Kota	Exist	11	Forest dpt. Census 2016 (Anonymous 2011-2017)
13	Phulwari Ki Nal WS	Udaipur	Extinct (PR)*	0	FES (Anonymous 2010b)
14	Ramgarh Vishdhari WS	Bundi	Exist	10	Forest dpt. Census 2016 (Anonymous 2011-2017)
15	Ramsagar WS	Dhaulpur	Extinct (PR)*	0	Kumar 2012; Forest Dept. Census (Anonymous 2007)
16	Ranthambore NP	Sawai Madhopur	Exist	25.67 (D)#	Jhala et al. 2015
17	Sajjangarh WS	Udaipur	Exist	10	Forest dpt. Census 2016 (Anonymous 2011-2017)
18	Sariska NP	Alwar	Exist	13.86 (D)#	Jhala et al. 2015
19	Sawai Mansingh WS	Sawai Madhopur	Exist	764	Forest dpt. Census 2012 (Anonymous 2011-2017)
20	Shergarh WS	Baran	Extinct (PR)*	0	Kumar 2012; Forest Dept. Census (Anonymous 2007)
21	Sitamata WS	Chittaurgarh, Udaipur	Exist	6	Forest. dpt. Census 2016 (Anonymous 2011-2017)
22	Todgad Raoli WS	Ajmer, Pali, Rajsamand	Exist	102	Forest dpt. Census 2016(Anonymous 2011 -2017)
23	Van Vihar WS	Dholpur	Extinct (PR)*	0	Kumar 2012; Forest dpt. Census (Anonymous 2007)
Gujarat (Aravallis)					
1	Jessore WS	Banaskantha	Extinct (PR)*	0	Gujarat Forest Dept. (Anonymous 1984)
2	Not known	Banaskantha	Extinct (PR)*	0	Ryley 1914
3	Not known	Vadodara	Extinct (PR)*	0	Gujarat State Gazetteer (Anonymous 1979)
4	Jambugodha WS	Panchmahal	Extinct (PR)*	0	Mehta et al. 2002; Patel 1972
5	Not known	Sabarkantha	Extinct (PR)*	0	Rajyagor 1974
Haryana (Aravallis)					
1	Bhondsi	Gurgaon	Present	Not known	Present study

(PR)* = previously recorded; (D)# = density per sq.km

Discussion

Aravalli in Haryana still remains one of the least studied landscapes. It has been recognized as a potential habitat for diverse species of biodiversity. It has been facing massive deforestation and denudation over the last decades. The forests of Aravalli range in Haryana are now the most degraded forests in India — most of the indigenous plant species here have disappeared; however, these areas are biologically rich and support unique elements of flora and fauna. The presence of Sambar in Aravalli landscape of Haryana signifies that the area still harbours important wildlife species that warrants immediate protection. It gives direction for future research studies to systematically monitor and identify the still undiscovered mammalian biodiversity. These ancient mountains hold several threatened species (Habib et al. 2017) that need urgent conservation programs.

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SHORT COMMUNICATION

DELAYED PERACUTE CAPTURE MYOPATHY IN A HIMALAYAN IBEX *CAPRA SIBIRICA* (MAMMALIA: CETARTIODACTYLA: BOVIDAE)

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OPEN ACCESS

Abstract: The present study documents a unique case of capture myopathy as a fatal consequence of the capture and rescue of a Himalayan Ibex kid. The ibex died 48 hours after capture without any visible clinical signs. Necropsy revealed alterations in kidneys with necrosis of the renal cortex, degeneration of tubular cells and congestion as the main histopathological alterations. Lesions in the heart consisted of multifocal degeneration of myofibres as well as hyalinization and nuclear degeneration with pyknosis. Skeletal muscles appeared macroscopically normal but on histopathology showed mild to moderate degeneration and fragmentation with intermittent loss of striation. The pathological findings were indicative of peracute capture myopathy. To our knowledge this is the first report of capture myopathy in a Himalayan Ibex from India underlining the importance of understanding the causes of mortality in such wild species as a prerequisite to their successful conservation.

Keywords: Capture, conservation, myopathy, Ibex, necropsy, pathological findings, rescue.

The Himalayan Ibex *Capra sibirica* is a member of the family Bovidae, sub-family Caprinae and is a true goat species. Being a 'sturdy, thick-set goat' (Prater 1980), the animals have a short broad face with a long beard in males but short one in females (Schaller 1977). The geographic distribution of Himalayan Ibex includes parts of China (Reading & Shank 2008; Xu et al. 2012), India (Gaston et al. 1983; Fox & Johnsingh 1997; Namgail 2006), Afghanistan (Heptner et al. 1961; Habibi 1997), north-eastern Uzbekistan, Tajikistan, Kyrgyzstan, Pakistan (Reading & Shank 2008; Li et al. 2015) and the Karakoram, the Himalaya and the Trans-Himalayan regions of Jammu & Kashmir (Fox & Johnsingh 1997). In India, the Himalayan Ibex is protected and included in the Schedule I of the Indian Wildlife Protection Act 1972 (Anon 1992). And its conservation is a priority.

Conservation plans are developed for wild animals around the world, in which capture and rescue operations are of paramount importance. Attempted in the interest of conservation of the concerned wild animals, capture can be detrimental causing extreme stress and fear in rescued wild animals leading to capture myopathy and eventual death (Spraker 1982; Ebedes & Raath 1999; McLaren et al. 2007).

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Capture myopathy or exertion rhabdomyolysis is a metabolic muscle disease of wild mammals and birds (free ranging and captive) associated with the stress of capture, restraint and transportation (Williams & Thorne 1996). The four clinical syndromes of capture myopathy documented in wild animals include capture shock syndrome, ataxic myoglobinuric syndrome, delayed peracute syndrome and ruptured muscle syndrome (Spraker 1993). The delayed peracute syndrome is usually seen in animals in captivity for at least 24 hours. These animals appear normal while undisturbed, but if recaptured or suddenly stressed they die within several minutes. The pathogenesis of the syndrome is a complex phenomenon confronting wildlife experts since ages, however, it is argued that the increase in stress-related catecholamines affects both cardiac and muscular systems, causing severe muscle damage, rhabdomyolysis and myoglobinuria (Spraker 1993). All the stages of the syndrome are potentially fatal due to cardiogenic shock, renal failure, metabolic disorders or chronic cardiac damage (Spraker 1993).

Materials and Methods

On 23 August 2017, an orphan Himalayan Ibex kid was rescued from Mahaguns Top Pahalgam (35.172^{0}N & 75.501^{0}E). The female Ibex kid was found abandoned by the field staff of the department who later captured the animal by physical handling apparently without use of any anaesthetic, tranquilizer or sedative. The kid was translocated to the mini zoo of Pahalgam (34.031^{0}N & 75.309^{0}E) in a transport box and was then placed in an observation and quarantine room. The observation room is situated away from the main enclosures with very little human interference, and is maintained in a way to simulate a natural environment for the rescued animals. Strict hygiene is maintained with foot baths containing bactericidal and virucidal agents, which are placed both at the entry and exit points. Separate utensils, equipments, clothing are provided for the personnel attending the animals in the quarantine area. Immediately after being rescued the animal was examined; it was approximately three months old, weighed 4.4kg and was found in good body condition showing no apparent signs of capture myopathy. The animal was further monitored closely for any signs of capture myopathy or abnormal behaviour. The animal died 48 hours after being captured without showing specific clinical signs. A complete necropsy was conducted within two hours of death. Samples were taken from the heart, kidneys, liver, lungs and skeletal muscles and were fixed in 10% neutral buffered formalin and embedded in paraffin wax, and sections (4mm) were stained with hematoxylin and eosin for routine histopathological examination.

Results

The external examination of the carcass revealed no lesion or violence inflicted injury. Also on dissection most organs appeared grossly normal only the heart showed focal to diffuse sub pericardial haemorrhages with clotted blood in all the four chambers (Images 3 & 4). But histopathological examination revealed changes in kidneys, heart, liver and skeletal muscles. The skeletal muscles showed mild to moderate degeneration and fragmentation with intermittent loss of striation (Image 1). Vascular congestion was found in the liver. The lung parenchyma showed focal alveolar emphysema with atelectasis as a main histopathological feature (Image 2). Myocardial lesions consisted of multifocal degenerative changes of myofibres, hyalinization and nuclear degeneration with pyknosis (Image 5). Both the kidneys were found to have developed hydronephrosis with severe congestion (Image 6). Renal cortical necrosis, degeneration of tubular cells and congestion were the marked the changes in the renal parenchyma (Image 7 & 8). Some other changes were increased bowman's space with or without serous exudate. The histopathological changes in different organs were suggestive of peracute capture myopathy.

Discussion

Capture myopathy is likely to occur when the capture procedure is tedious involving vigorous exercise, scaring and tense situations or the excessive use of tranquilizers. In this case the subject animal developed capture myopathy in absence of all these factors and the myopathy was in this case only caused by stress. Assessment of stress would have required measuring of cortisol levels in the animal after capture so that treatment measures could have been initiated. The gross changes observed during post-mortem examination in heart and kidneys indicated that the animal collapsed due to acute cardiac and renal failure both of which are the manifestations of rhabdomyolysis (Spraker 1993; Guis et al. 2005; Herráez et al. 2007). Renal changes leading to nephrosis and multiorgan failure as observed in this case have been previously reported to be the central pathway of capture myopathy (Montane et al. 2002; Herráez et al. 2007; Nuvoli et al. 2014). The myocardial lesions are attributed to elevated concentrations of endogenous catecholamines during stress and trauma (Jiang & Downing 1990; Harrez et al. 2007). Myocardial lesions are also frequently implicated

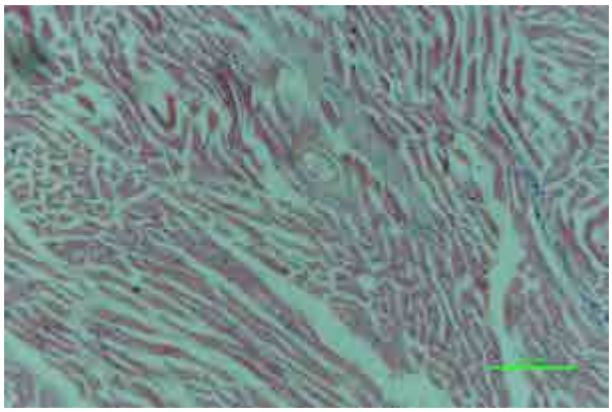

Image 1. Section of skeletal muscle depicting degeneration and fragmentation.

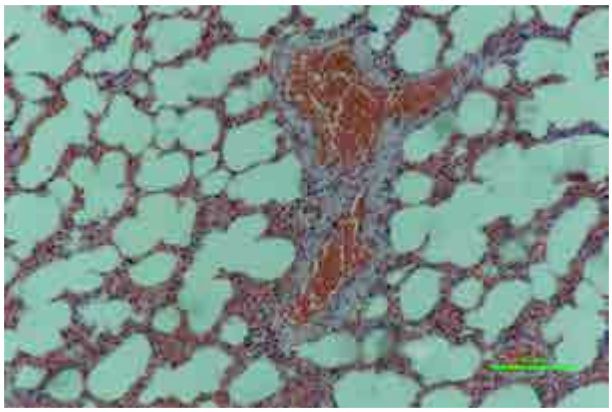

Image 2. Section of lung showing alveolar emphysema with atelectasis.

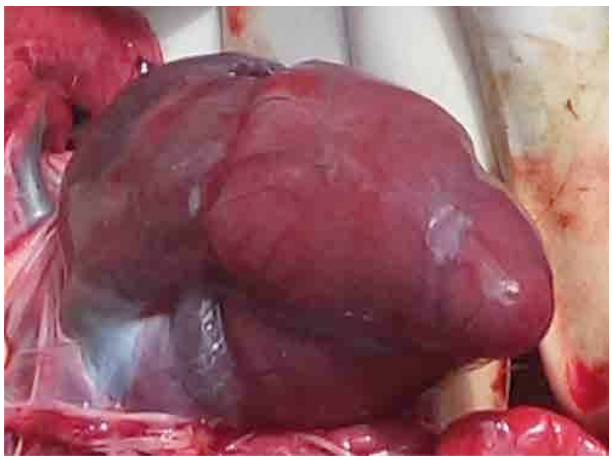

Image 3. Prominent diffuse sub pericardial hemorrhages

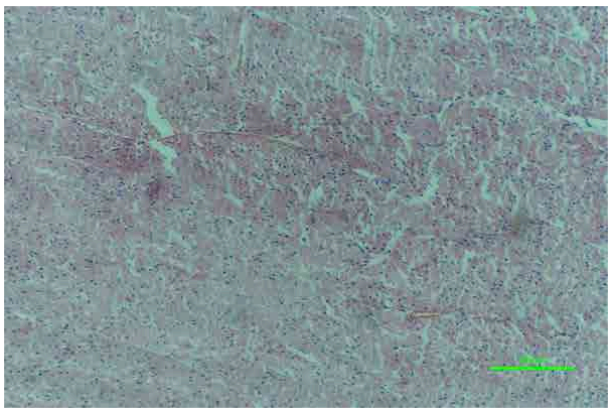

Image 5. Section of heart showing marked degeneration, hyalinization and pyknotic nuclei.

Image 4. Large blood clots in the heart

Image 6. Marked enlargement and severe congestion of the kidney

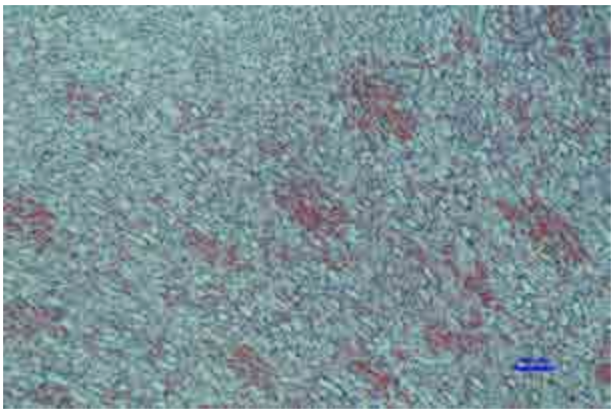

Image 7. Section of kidney showing severe congestion.

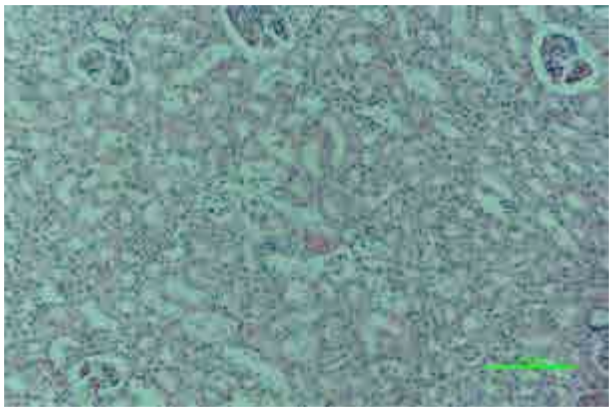

Image 8. Section of kidney showing cortical tubular necrosis and degeneration.

as an important reason for sudden death under extreme stress in wild animals and birds (Turnbull & Cowan 1998). These findings are supported by Wallace et al. (1987) who reported similar myocardial lesions in case of acute and delayed capture myopathy in African wild ungulates. The changes in skeletal muscles observed in the present case can be attributed to exertion, trauma and polysaccharide storage myopathy during rescue and capture procedure leading to ischemia of muscles and subsequent myocytolysis (Montane et al. 2002; Guis et al. 2005; Nuvoli et al. 2014). Similar findings in liver and lungs are reported by McAllum (1978) in a study of capture myopathy in Red Deer.

The case has been described as delayed peracute capture myopathy due to the fact that the ibex kid was apparently normal up to 48 hours after capture followed by sudden peracute death. Absence of prominent clinical signs and presence of characteristic histopathological findings in different organs further supported this diagnosis. The classification of this case as delayed capture myopathy follows Spraker (1993). And like previous studies, the present study also supports the fact that wild animals like the Himalayan Ibex capture myopathy is a fatal consequence of stress during capture and handling. Thus, wildlife personnel should exercise extreme care during trapping, handling and transportation of such endangered wild animals.

To the our knowledge this is the first report of capture myopathy in a Himalayan Ibex from India warranting further studies of the causes of mortality in such wild species as a prerequisite for a successful conservation programme. Moreover, special attention needs to be paid to issues including animal welfare and qualification and skills of the personnel who manage capture and rescue operations.

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Short Communication

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Checklist of the avifauna of Sagareshwar Wildlife Sanctuary, Maharashtra, India

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Abstract: Sagareshwar Wildlife Sanctuary in southern Maharashtra is one of the smallest sanctuaries in the state encompassing 10.87km^2. Our studies documenting avifauna of this wildlife sanctuary revealed the presence of 138 bird species including 71 residents, 21 local migrants, nine breeding migrants, 24 winter visitors and 13 species whose status could not be determined. The sanctuary harbours three Indian endemics, 23 South Asian endemics, and one Near Threatened bird species.

Keywords: Bird species, endemic, restored ecosystem, smallest sanctuary, Sangli District.

Sagareshwar Wildlife Sanctuary, which by any standard, is a small area of wilderness. It was created to restore the forest and to provide a home for flora and fauna. Since the area is protected and restoration work has been done several bird species have been noticed in the sanctuary. We have been visiting Sagareshwar since the early 1990s to document the biodiversity of the sanctuary. From 1990 to 2014 we have recorded the avifauna and analysed its status. This paper reports the results of the observations pertaining to the avifaunal diversity encountered in the area between 1990 and 2014.

Historical aspect

This was a densely wooded area during the British Raj. In the days before independence the hills near the temple were green and though there were no big carnivores in this jungle other variety of fauna were well represented. The animals that lived in this wilderness were hyena, jackal, wolf, hare, etc. There were no herbivores like Blackbuck, Sambar, Spotted Deer and Barking Deer which are now seen at Sagareshwar.

After independence the situation changed. Cutting down of trees, hunting and grazing became a norm and within a short span of 2–3 decades the hills turned barren and the sighting of animals became rare.

Mr. D.M. Mohite, a resident of a nearby village Mohityache Vadgaon, was disturbed to see this wanton destruction of the forest and its denizens. In the decade of 1970 he took up the task to restore this wilderness to some degree and make it a safe haven for animals to live and thrive. The word about his intentions spread and many volunteers joined in this noble task. His tenacity and sincerity attracted more people in this endeavour and eventually the Government of Maharashtra declared Sagareshwar as a wildlife sanctuary in 1985 (Mohite

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1996).

There is hardly any literature published on the birds of Sagareshwar except by Tuljapurkar (1992) where he mentions the occurrence of 40 bird species. The current study is the first systematic effort to document avifauna of this sanctuary. The study period encompasses 17 years of information on avifauna of the region.

Methods

Study Area

This area was declared a wildlife sanctuary on 16 September 1985. It is called as "The Yashwantrao Chavan Sagareshwar Wildlife Sanctuary" (Notification: WLP/1085/CR/588/VIIF-6/Dt – 16.9.1985. with coordinates - 74.321^{0}E & 17.088^{0}N).

The Wildlife Sanctuary is spread over an area of 10.87km^2 (Fig. 1). The average rainfall is 640mm and the temperature ranges between 14-42^{0}C. The terrain is uneven, with elevations, slopes of hills, valleys and small stretches of plateaus. The sanctuary faces acute shortage of water during summer months as there are no perennial streams or ponds. The forest department has built artificial water holes and they are replenished regularly during the summer season.

The flora of Sagareshwar is quite interesting. Southern tropical dry type of vegetation occupies large parts of the sanctuary and the area covered by dense forest is merely 8.86% which is approximately 99 hectares or 248 acres. The trees include *Butea monosperma*, *Acacia catechu, Semecarpus anacardium, Anogeissus latifolia, Morinda pubescens, Osyris quadripartita, Morinda tinctoria* variety *tomentosa, Ixora parviflora, Rhus sinuata, Buchanania lanzan, Bauhinia racemosa,* etc., and these are seen scattered over the area. *Delonix regia*, *Albizia lebbeck, Bauhinia purpurea, Tamarindus indica* and *Azadirachta indica* were planted by volunteers and the forest department. The tree *Dichrostachys cinerea,* also known as Chinese Lantern, has established in barren and degraded slopes of the sanctuary. *Carissa carandas* has formed thickets at places which help different species of birds. The climbers growing in the upper part of the hills belong to the Asclepidiaceae family.

Several species of herbs emerge from the wet earth during the rainy season. *Evolvulus alsinoides, Cyanotis fasciculata, Boerhavia diffusa* and *Leucas aspera* are commonly found here and add colour to the green landscape. A variety of leguminous forage plant, *Stylosanthes hamata,* has been introduced in Sagareshwar by the forest department.

The sanctuary is home to various native as well as introduced animals. The most significant are ungulates

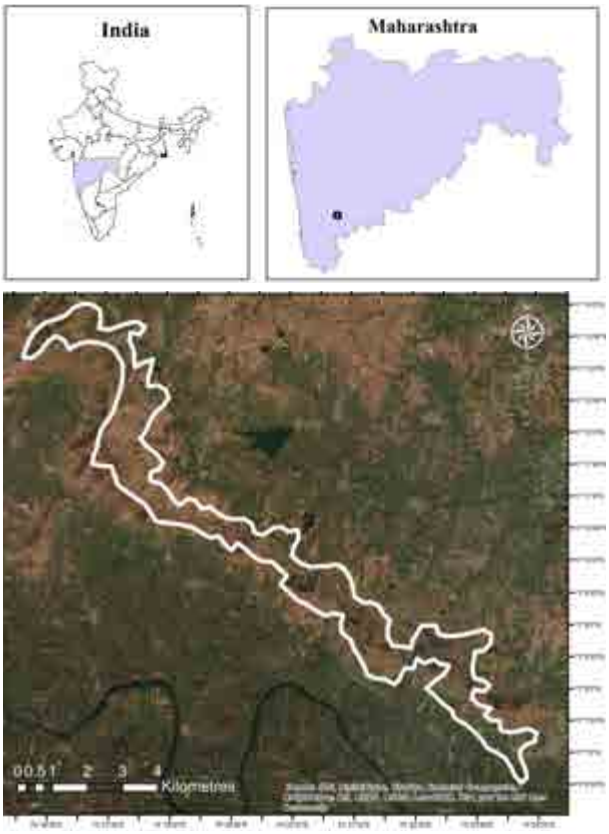

Figure 1. Sagareshwar Wildlife Sanctuary, Sangli District, Maharashtra, India

including Sambar *Rusa unicolor*, Spotted Deer *Axis axis* (Cervidae), and Blackbuck *Antelope cervicapra* (Bovidae). Other mammals include, the Wild Boar *Sus scrofa*, Striped Hyena *Hyena hyena*, Indian Wolf *Canis lupus*, Indian Fox *Vulpes bengalensis*, Black-naped Hare *Lepus nigricollis*, Jungle Cat *Felis chaus*, and Common Mongoose *Herpestes edwardsi.* There are at least three species of unidentified insectivorous bats found in some caves in the valley.

Amongst reptiles, six species of snakes, namely, Spectacled Cobra *Naja naja*, Saw-scaled Viper *Echis carinatus*, Striped Keelback *Amphiesma stolata*, Green Keelback *Macropisthodon plumbicolor*, Rat Snake *Ptyas mucosa*, and Common Wolf Snake *Lycodon aulicus*, are found here. Among lizards, three species, namely, Indian Monitor Lizard *Varanus benghalensis*, Garden Lizard *Calotes versicolor*, and Fan-throated Lizard *Sarada* sp. have been observed. About four species of amphibians, namely, Indian Bull Frog *Hoplobatrachus tigerinus*, Indian Burrowing Frog *Sphaerotheca breviceps*, Common Indian Tree Frog *Polypedates maculatus*, and Asian Common Toad *Duttaphrynus melanostictus*, have been recorded from the sanctuary. As many as 20 species of butterflies have been recorded from the sanctuary (Jathar

unpublished data).

Survey

We followed BirdLife International (2014) version 7 for taxonomy and nomenclature of bird species recorded in the sanctuary. Along with this, we also categorized the birds according to their status, occurrence, threatened, and endemicity. A wetland named Kumbhargao Talav which is adjacent to the sanctuary and now added in it was also included in the survey.

The data was mainly collected by the authors as part of a systematic avifaunal study, and occasional visits between 1990 and 2014. We have visited the sanctuary independently and have maintained the record of avifauna. A total of 83 visits were carried out during the study period.

The occurrence of species was defined using following criteria. Common—species observed repeatedly in suitable habitat; Uncommon—species occurs on a regular basis, but not frequently in suitable habitat; Occasional—species that were recorded occasionally in suitable habitat; Single record—species reported only once. Similarly, status of the species was defined by field observations and followinng (Ali & Ripley 1987). Endemic status was followed using (Jathar & Rahmani 2006). The IUCN Red List status was followed using (Rahmani 2012).

Results

A total of 138 bird species (Appendix I) were observed during the period from 1990 to 2014. Among these, 71 species are resident, 24 are winter migrants, 21 are local migrant, and nine species are breeding migrants. The status of 13 species could not be determined. Of the total diversity, 87 species were common, 42 were recorded occasional (irregular), one was uncommon and seven were recorded only once. There are no globally threatened species found in Sagareshwar Wildlife Sanctuary (WS). We, however, recorded Pallid Harrier *Circus macroursus* which is a Near Threatened species at the global scale. Sagareshwar WS also harbours three Indian endemic and 23 South Asian endemic bird species. All the details are given in Appendix I.

Most of the water birds are local migrants to the Sagareshwar WS. They visit the Sagareshwar WS when seasonal ponds and small check dams retain water in monsoon and post monsoon months. Kumbhargaon Lake which is now included in the Sagareshwar WS area, has added several new bird species to the checklist, especially the migrants.

Painted Francolin *Francolinus pictus*, Rain Quail *Coturnix coromandelica*, Baya Weaver *Ploceus philippinus* migrate to the Sagareshwar WS to breed during the monsoon. The Indian Blackbird *Turdus simillimus* and Black-headed Cuckoo-shrike *Coracina melanoptera* are breeding migrants to the Sagareshwar WS. They spend about eight months in the sanctuary from April to November. Interestingly, cuckoos such as Jacobin Cuckoo *Clamator jacobinus*, Common Hawk-cuckoo *Hierococcyx varius*, Grey-bellied Cuckoo *Cacomantis passerines* also come to the Sagareshwar WS during the same period (April to November). This may be due to the host-parasite relationship between these bird species.

The local migrants such as Thick-billed Flowerpecker *Dicaeum agil*e, Pale-billed Flowerpecker *Dicaeum erythrorhynchos*, Indian Blackbird *Turdus simillimus*, Black-headed Cuckoo-shrike *Coracina melanoptera* arrive in Sagareshwar WS (probably) from the Western Ghats during the monsoon. Some of them breed here and spend a significant time of the monsoon in Sagareshwar WS. This phenomenon of monsoon migration needs further investigations to understand patterns of migration, purpose of migration and the significance of the same for the breeding success of the species.

The winter migrants such as Long-tailed Shrike *Lanius schach*, Isabelline Shrike *Lanius isabellinus*, Common Kestrel *Falco tinnunculus,* Eurasian Crag-Martin *Ptyonoprogne rupestris,* Lesser Whitethroat *Sylvia curruca*, Blyth's Reed Warbler *Acrocephalus dumetorum*, Greenish Warbler *Phylloscopus trochiloides* and Rosy Starling *Sternus roseus* are seen in Sagareshwar WS for almost six months from early October to early April.

Savanna Nightjar *Caprimulgus affinis* visits the sanctuary during March to August. Though the territorial calls have been heard and recorded during this period, no active nest was observed. After August the birds leave Sagareshwar WS. During winter (November–January), Green Bee-eaters *Merops orientalis* gather in trees near the guest house for night roosting.

Some interesting migrants

Indian Black Bird *Turdus simillimus*

Indian Black Bird is a breeding migrant for Sagareshwar WS. It is generally seen and can be heard in the sanctuary from June onwards till November. Territorial calls were predominant in June and July. On one occasion, a nest with a clutch of three was observed in June. Juvenile birds have been observed in August. Interestingly the bird is not seen in the sanctuary after November. It would be very interesting to study its pre and post breeding habitats.

Grey-bellied Cuckoo *Cacomantis passerinus*

This is also a breeding migrant to the Sagareshwar WS.

It arrives in late May (last week of May) and stays there till the last week of September. It starts calling upon arrival and can be heard till the end of September. We could not observe any juvenile birds during our study period. It would be very interesting to know which species it exploits as foster parents to take care of the brood.

Square-tailed Bulbul *Hypsipetes ganeesa*

This species was observed only thrice in the Sagareshwar WS between 2005 and 2006. Its sighting was confined to the months of July to October. These birds might have strayed and settled in the sanctuary for some time. However, further investigation is required to know whether they are regular visitors or stray birds visiting Sagareshwar WS.

Vernal Hanging Parrot *Loriculus vernalis*

This is another interesting species observed in the Sagareshwar WS. It was only seen in 2006, from July to September. A small flock and individuals were observed across the months. They were seen foraging on pods of *Cassia siamia*, Indian Copperpod *Peltphorum pterocarpum* and *Ficus* spp.

Pallid Harrier *Circus macrourus*

Pallid Harriers were observed from 1997 to 2000. They were sighted from the second week of October to the first week of April. They were not seen in large flocks hence we assume that they could be roosting somewhere outside the Sagareshwar WS. Post 2000 this species, however, has not been observed in the sanctuary. This could be an outcome of their global decline during 1990–2000 (BirdLife International 2015).

Discussion

Our observations indicate that the species composition changes with the season. The region has two peak seasons when influx of species is observed. The first influx is during the monsoon where some species probably arrive here from the Western Ghats. They breed in the Sagareshwar WS and spend significant time here after the monsoon. The second influx of the species is observed post monsoon and early winter. Most of the winter migrants arrive here by early to mid-October and live in Sagareshwar WS till the end of March or early April.

The phenomenon of monsoon migration and breeding migration of some species needs further investigation to understand patterns of migration, purpose of migration and the significance of the same for breeding success of the species. This landscape also provides an opportunity to study the host-parasite relationship as four species of cuckoos that reside here and some host species that specifically come here to breed.

The species assemblage in different seasons certainly has linkages with restoration of the ecosystem and least anthropogenic interference. Therefore, this sanctuary is very important in terms of understanding the restoration of the ecosystem and its impact on avifauna. Though there is no data available on the avifauna of the region prior to restoration; the assemblage of species is indicative of the restoration. Similar observations have been made by several workers with the assumptions that richness and abundances of bird species are often enhanced by restoration practices (Passell 2000; Twedt et al. 2006; Hamel 2003; Gaines et al. 2007; Aerts et al. 2008; Farwig et al. 2008).

This sanctuary gives an opportunity to further investigate the turnover of species in restored landscapes. It can serve as a model for studying indicator species and track changes in the restored habitat. Continuation of the current study will certainly be a major contribution to understand the response of avifauna to restored landscapes.

Conservation significance

Prior to the official notification of Sagareshwar Wildlife Sanctuary in 1985, this area went through several transitions. In 1970s, people of nearby villages and volunteers from cities took up the task of revitalizing this ravaged land. Several trees were planted, and as they grew birds and animals began to settle in Sagareshwar. Their number gradually increased within a few years. Sagareshwar is an example which shows that an ecologically degraded area, can be restored to its full potential if protected and managed properly.

There are several small pockets of wilderness across the length and breadth of the country, which are degraded for one reason or another. Suitable protection and management will certainly improve such zones as can be seen from the development of Sagareshwar Wildlife Sanctuary.

A further study is required to understand species turnover and assemblage with changes in the habitats. This could be an ideal ecosystem to study the avifauna with respect to changes in the habitat over the period of time.

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Appendix 1. Checklist of the birds of Sagareshwar Wildlife Sanctuary, Sangli District, Maharashtra, India

	Species name	Scientific name	Status	Occurrence	Habitat	Red List Status	Endemic status
1	Little Grebe	*Tachybaptus ruficollis*	Local migrant	Common	Seasonal wetlands & Kumbhargao Talav	Least Concern	
2	Little Cormorant	*Phalacrocorax niger*	Local migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
3	Indian Pond-Heron	*Ardeola grayii*	Local migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
4	Little Egret	*Egretta garzetta*	Local migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
5	Woolly-necked Stork	*Ciconia episcopus*	Not defined	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
6	Indian Spot-billed Duck	*Anas poecilorhyncha*	Local migrant	Common	Seasonal wetlands & Kumbhargao Talav	Least Concern	
7	Black-shouldered Kite	*Elanus caeruleus*	Resident	Common	All habitats	Least Concern	
8	Shikra	*Accipiter badius*	Resident	Occasional	Campus	Least Concern	
9	White-eyed Buzzard	*Butastur teesa*	Not defined	Occasional	Not defined	Least Concern	
10	Pallid Harrier	*Circus macrourus*	Winter Migrant	Occasional	Grassland	Near Threatened	
11	Short-toed Eagle	*Circaetus gallicus*	Resident	Common	Grassland and hills	Least Concern	
12	Peregrine Falcon	*Falco peregrinus*	Not defined	Single Record	Not defined	Least Concern	
13	Eurasian Kestrel	*Falco tinnunculus*	Winter Migrant	Common	Rocky hills	Least Concern	
14	Painted Francolin	*Francolinus pictus*	Breeding Migrant	Common	Scrub	Least Concern	South Asia Endemic
15	Grey Francolin	*Francolinus pondicerianus*	Resident	Common	Grassland	Least Concern	
16	Rain Quail	*Coturnix coromandelica*	Breeding Migrant	Common	Grassland	Least Concern	
17	Jungle Bush-Quail	*Perdicula asiatica*	Resident	Common	Grassland	Least Concern	South Asia Endemic
18	Indian Peafowl	*Pavo cristatus*	Resident	Common	All habitats	Least Concern	South Asia Endemic
19	Barred Buttonquail	*Turnix suscitator*	Resident	Occasional	Not defined	Least Concern	
20	White-breasted Waterhen	*Amaurornis phoenicurus*	Local migrant	Common	Seasonal wetlands & Kumbhargao Talav	Least Concern	
21	Eurasian Moorhen	*Gallinula chloropus*	Local migrant	Common	Seasonal wetlands & Kumbhargao Talav	Least Concern	
22	Eurasian Coot	*Fulica atra*	Winter Migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
23	Red-wattled Lapwing	*Vanellus indicus*	Resident	Common	All habitats	Least Concern	
24	Yellow-wattled Lapwing	*Vanellus malabaricus*	Resident	Occasional	Grassland	Least Concern	South Asia Endemic
25	Green Sandpiper	*Tringa ochropus*	Winter Migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
26	Common Sandpiper	*Actitis hypoleucos*	Winter Migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
27	Black-winged Stilt	*Himantopus himantopus*	Winter Migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
28	Indian Thick-knee	*Burhinus indicus*	Not defined	Occasional	Grassland	Least Concern	
29	River Tern	*Sterna aurantia*	Local migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
30	Chestnut-bellied Sandgrouse	*Pterocles exustus*	Not defined	Single Record	Grassland	Least Concern	
31	Rock Pigeon	*Columba livia*	Local migrant	Occasional	Campus	Least Concern	
32	Eurasian Collared-Dove	*Streptopelia decaocto*	Resident	Common	All habitats	Least Concern	
33	Red Collared-Dove	*Streptopelia tranquebarica*	Resident	Uncommon	Grassland and Scrub	Least Concern	
34	Laughing Dove	*Streptopelia senegalensis*	Resident	Common	All habitats	Least Concern	
35	Rose-ringed Parakeet	*Psittacula krameri*	Local migrant	Occasional	Not defined	Least Concern	
36	Plum-headed Parakeet	*Psittacula cyanocephala*	Resident	Common	Scrub	Least Concern	South Asia Endemic

	Species name	Scientific name	Status	Occurrence	Habitat	Red List Status	Endemic status
37	Vernal Hanging-Parrot	*Loriculus vernalis*	Not defined	Occasional	Scrub	Least Concern	
38	Pied Cuckoo	*Clamator jacobinus*	Breeding Migrant	Common	Scrub	Least Concern	
39	Common Hawk-Cuckoo	*Hierococcyx varius*	Breeding Migrant	Common	Campus and Scrub	Least Concern	South Asia Endemic
40	Grey-bellied Cuckoo	*Cacomantis passerinus*	Breeding Migrant	Common	All habitats	Least Concern	South Asia Endemic
41	Asian Koel	*Eudynamys scolopaceus*	Local migrant	Occasional	Campus	Least Concern	
42	Sirkeer Malkoha	*Phaenicophaeus leschenaultii*	Resident	Occasional	Scrub	Least Concern	South Asia Endemic
43	Greater Coucal	*Centropus sinensis*	Resident	Common	All habitats	Least Concern	
44	Rock Eagle-Owl	*Bubo bengalensis*	Resident	Common	Valleys	Least Concern	South Asia Endemic
45	Spotted Owlet	*Athene brama*	Resident	Common	Campus, tempel and other old buildings	Least Concern	
46	Mottled Wood-Owl	*Strix ocellata*	Resident	Occasional	Not defined	Least Concern	Indian Endemic
47	Jungle Nightjar	*Caprimulgus indicus*	Resident	Common	Scrub	Least Concern	South Asia Endemic
48	Indian Nightjar	*Caprimulgus asiaticus*	Resident	Common	All habitats	Least Concern	
49	Savanna Nightjar	*Caprimulgus affinis*	Breeding Migrant	Common	Grassland and Scrub	Least Concern	
50	Little Swift	*Apus affinis*	Resident	Common	Campus, hills	Least Concern	
51	Common Kingfisher	*Alcedo atthis*	Local migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	
52	White-throated Kingfisher	*Halcyon smyrnensis*	Resident	Common	All habitats	Least Concern	
53	Green Bee-eater	*Merops orientalis*	Resident	Common	All habitats	Least Concern	
54	European Roller	*Coracias garrulus*	Not defined	Single Record	Not defined	Least Concern	
55	Indain Roller	*Coracias benghalensis*	Local migrant	Common	Grassland and Scrub	Least Concern	
56	Eurasian Hoopoe	*Upupa epops*	Resident	Common	All habitats	Least Concern	
57	Indian Grey Hornbill	*Ocyceros birostris*	Resident	Common	Campus	Least Concern	
58	Coppersmith Barbet	*Psilopogon haemacephalus*	Resident	Common	Campus	Least Concern	
59	Eurasian Wryneck	*Jynx torquilla*	Winter Migrant	Occasional	Scrub	Least Concern	
60	Yellow-crowned Woodpecker	*Dendrocopos mahrattensis*	Resident	Common	Scrub	Least Concern	
61	Singing Bushlark	*Mirafra cantillans*	Resident	Common	Grassland	Least Concern	
62	Indian Bushlark	*Mirafra erythroptera*	Resident	Common	Grassland	Least Concern	South Asia Endemic
63	Ashy-crowned Sparrow-Lark	*Eremopterix griseus*	Resident	Occasional	Grassland	Least Concern	South Asia Endemic
64	Rufous-tailed Lark	*Ammomanes phoenicura*	Resident	Common	Grassland	Least Concern	South Asia Endemic
65	Sykes's Lark	*Galerida deva*	Resident	Occasional	Grassland	Least Concern	Indian Endemic
66	Eurasian Crag-Martin	*Ptyonoprogne rupestris*	Winter Migrant	Common	Rocky cliffs	Least Concern	
67	Dusky Crag-Martin	*Ptyonoprogne concolor*	Resident	Common	All habitats	Least Concern	
68	Wire-tailed Swallow	*Hirundo smithii*	Not defined	Occasional	Not defined	Least Concern	
69	Red-rumped Swallow	*Cecropis daurica*	Resident	Common	All habitats	Least Concern	
70	Tree Pipit	*Anthus trivialis*	Winter Migrant	Common	Grassland	Least Concern	
71	Oriental Pipit	*Anthus rufulus*	Resident	Common	Grassland	Least Concern	
72	Tawny Pipit	*Anthus campestris*	Winter Migrant	Common	Grassland	Least Concern	
73	Grey Wagtail	*Motacilla cinerea*	Winter Migrant	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	

	Species name	Scientific name	Status	Occurrence	Habitat	Red List Status	Endemic status
74	White-browed Wagtail	*Motacilla madaraspatensis*	Resident	Occasional	Seasonal wetlands & Kumbhargao Talav	Least Concern	South Asia Endemic
75	Common Woodshrike	*Tephrodornis pondicerianus*	Resident	Common	Scrub	Least Concern	
76	Black-headed Cuckooshrike	*Lalage melanoptera*	Breeding Migrant	Common	Scrub	Least Concern	
77	Small Minivet	*Pericrocotus cinnamomeus*	Resident	Common	Scrub	Least Concern	
78	Red-vented Bulbul	*Pycnonotus cafer*	Resident	Common	All habitats	Least Concern	
79	White-browed Bulbul	*Pycnonotus luteolus*	Resident	Common	Scrub	Least Concern	
80	Square-tailed Bulbul	*Hypsipetes ganeesa*	Not defined	Occasional	Scrub	Least Concern	South Asia Endemic
81	Common Iora	*Aegithina tiphia*	Resident	Common	Campus and Scrub	Least Concern	
82	Southern Grey Shrike	*Lanius meridionalis*	Not defined	Single Record	Scrub	Least Concern	
83	Bay-backed Shrike	*Lanius vittatus*	Resident	Common	Scrub	Least Concern	
84	Isabelline Shrike	*Lanius isabellinus*	Winter Migrant	Occasional	Grassland	Least Concern	
85	Long-tailed Shrike	*Lanius schach*	Resident	Common	Scrub	Least Concern	
86	Oriental Magpie-Robin	*Copsychus saularis*	Resident	Common	Campus and Temple	Least Concern	
87	Black Redstart	*Phoenicurus ochruros*	Winter Migrant	Common	Campus	Least Concern	
88	Common Stonechat	*Saxicola maurus*	Winter Migrant	Common	Grassland	Least Concern	
89	Pied Bushchat	*Saxicola caprata*	Resident	Common	Grassland	Least Concern	
90	Indian Robin	*Copsychus fulicatus*	Resident	Common	All habitats	Least Concern	South Asia Endemic
91	Blue Rock-Thrush	*Monticola solitarius*	Winter Migrant	Occasional	Rocky hills	Least Concern	
92	Indian Blackbird	*Turdus simillimus*	Breeding Migrant	Common	Scrub	Least Concern	South Asia Endemic
93	Yellow-eyed Babbler	*Chrysomma sinense*	Resident	Common	Scrub	Least Concern	
94	Common Babbler	*Turdoides caudata*	Resident	Common	Grassland	Least Concern	
95	Large Grey Babbler	*Turdoides malcolmi*	Resident	Common	Campus and Scrub	Least Concern	South Asia Endemic
96	Jungle Babbler	*Turdoides striata*	Resident	Common	Scrub	Least Concern	
97	Taiga Flycatcher	*Ficedula albicilla*	Winter Migrant	Common	Campus and Scrub	Least Concern	
98	Tickell's Blue-Flycatcher	*Cyornis tickelliae*	Resident	Common	Thickly wooded areas	Least Concern	
99	Spot-breasted Fantail	*Rhipidura albogularis*	Resident	Common	Campus and Scrub	Least Concern	Indian Endemic
100	Asian Paradise-Flycatcher	*Terpsiphone paradise*	Not defined	Occasional	Not defined	Least Concern	
101	Zitting Cisticola	*Cisticola juncidis*	Resident	Common	Scrub and Grassland	Least Concern	
102	Grey-breasted Prinia	*Prinia hodgsonii*	Resident	Common	Campus and Scrub	Least Concern	
103	Plain Prinia	*Prinia inornata*	Resident	Common	Scrub	Least Concern	
104	Ashy Prinia	*Prinia socialis*	Resident	Common	Scrub	Least Concern	South Asia Endemic
105	Jungle Prinia	*Prinia sylvatica*	Resident	Common	Scrub	Least Concern	South Asia Endemic
106	Common Tailorbird	*Orthotomus sutorius*	Resident	Common	Campus and Scrub	Least Concern	
107	Clamorous Reed-Warbler	*Acrocephalus stentoreus*	Winter Migrant	Common	Seasonal wetlands & Kumbhargao Talav	Least Concern	
108	Blyth's Reed-Warbler	*Acrocephalus dumetorum*	Winter Migrant	Occasional	scrub	Least Concern	
109	Lesser Whitethroat	*Sylvia curruca*	Winter Migrant	Common	Scrub	Least Concern	
110	Common Chiffchaff	*Phylloscopus collybita*	Winter Migrant	Common	Scrub	Least Concern	
111	Greenish Warbler	*Phylloscopus trochiloides*	Winter Migrant	Common	Campus and Scrub	Least Concern	

	Species name	Scientific name	Status	Occurrence	Habitat	Red List Status	Endemic status
112	Cinereous Tit	*Parus cinereus*	Resident	Common	Campus and Scrub	Least Concern	
113	Thick-billed Flowerpecker	*Dicaeum agile*	Local migrant	Occasional	Scrub	Least Concern	
114	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	Local migrant	Common	Scrub	Least Concern	
115	Purple-rumped Sunbird	*Leptocoma zeylonica*	Resident	Common	Campus and Scrub	Least Concern	South Asia Endemic
116	Purple Sunbird	*Cinnyris asiaticus*	Resident	Common	Scrub	Least Concern	
117	Oriental White-eye	*Zosterops palpebrosus*	Resident	Common	Campus and Scrub	Least Concern	
118	Black-headed Bunting	*Emberiza melanocephala*	Winter Migrant	Occasional	Not defined	Least Concern	
119	Grey-hooded Bunting	*Emberiza buchanani*	Winter Migrant	Common	Scrub	Least Concern	
120	Striolated Bunting	*Emberiza striolata*	Not defined	Single Record	Not defined	Least Concern	
121	Crested Bunting	*Melophus lathami*	Resident	Common	Scrub	Least Concern	
122	Indian Silverbill	*Euodice malabarica*	Resident	Common	All habitats	Least Concern	
123	Scaly-breasted Munia	*Lonchura punctulata*	Resident	Common	All habitats	Least Concern	
124	House Sparrow	*Passer domesticus*	Resident	Common	Campus	Least Concern	
125	Chestnut-shouldered Petronia	*Petronia xanthocollis*	Not defined	Occasional	Not defined	Least Concern	
126	Baya Weaver	*Ploceus philippinus*	Breeding Migrant	Common	Scrub	Least Concern	
127	Chestnut-tailed Starling	*Sturnia malabarica*	Local migrant	Occasional	Scrub	Least Concern	
128	Malabar Starling	*Sturnia blythii*	Not defined	Single Record	Scrub	Least Concern	South Asia Endemic
129	Brahminy Starling	*Temenuchus pagodarum*	Resident	Common	Campus and Scrub	Least Concern	South Asia Endemic
130	Rosy Starling	*Pastor roseus*	Winter Migrant	Occasional	Scrub	Least Concern	
131	Common Myna	*Acridotheres tristis*	Resident	Common	Campus and Scrub	Least Concern	
132	Jungle Myna	*Acridotheres fuscus*	Resident	Common	Campus and Scrub	Least Concern	
133	Indian Golden Oriole	*Oriolus kundoo*	Local migrant	Occasional	Campus and Scrub	Least Concern	
134	Black Drongo	*Dicrurus macrocercus*	Local migrant	Common	Scrub	Least Concern	
135	Ashy Drongo	*Dicrurus leucophaeus*	Winter Migrant	Occasional	Scrub	Least Concern	
136	House Crow	*Corvus splendens*	Local migrant	Occasional	campus, temples	Least Concern	
137	Indian Jungle Crow	*Corvus macrorhynchos*	Resident	Occasional	Campus, temples	Least Concern	South Asia Endemic
138	Rufous Treepie	*Dendrocitta vagabunda*	Not defined	Single Record	Not defined	Least Concern	

Common: Species observed repeatedly in suitable habitat; Uncommon: Species occurs on a regular basis, but not frequently in suitable habitat; Occasional: Species that were recorded occasionally in suitable habitat; Single record: Species reported only once

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The rediscovery of Rurk's Cat Skink *Ristella rurkii* Gray, 1839 (Reptilia: Ristellidae) with remarks on distribution and natural history

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Abstract: The description of Rurk's Cat Skink *Ristella rurkii* is expanded herein based on recent field sightings and a voucher specimen. Three individuals comprising an adult male, an adult female, and a juvenile were encountered in Kodaikanal, Palni Hills of the southern Western Ghats. Morphological and ecological notes on the voucher specimen and these live sightings are elaborated to enrich the current knowledge on this little-known species. This species is also illustrated in life herein for the first time. The current report forms the rediscovery of this species after nearly 90 years and after a lapse of 175 years since its original description. A review of its past distribution records is compiled and further surveys are recommended to revise the geographic range and conservation status of this Data Deficient species.

Keywords: Distribution, morphology, Palni hills, scientific obscurity, Skink.

Skinks living in dense forests are hard to document due to their cryptic appearance and elusive habits. The newly recognized skink family Ristellidae, consisting of the genera *Ristella* Gray, 1839 from the Western Ghats and *Lankascincus* Greer, 1991 from Sri Lanka, is the only skink family endemic to the Indian subcontinent (see Hedges 2014). The genus *Ristella* is endemic to the Western Ghats of peninsular India and this group of small-sized, leaf-litter-dwelling skinks rank as one of the most poorly-studied lizards in India (Smith 1935). The first of the species to be described in this genus is *R. rurkii*, the type species of the genus. Gray (1839) described this species based on the syntypes BMNH 1946.8.15.64-68 in the Natural History Museum, London. The original description reads thus "*Ristella Rurkii* (*sic*). Crown and back pale brown, shining; scales 6-rowed, each of four central rows with a blackish central spot, forming four longitudinal series of spots; sides white-dotted; chin and belly white. North India, Dr. Rurk. Mus. Chatham."

Gray (1845) again included this species in his catalogue and stated it to be from northern India. Jerdon (1854) did not record or include this species in his catalogue. Günther (1864) did not include this genus or species in his book. Theobald (1868) included this species in his catalogue and mentioned that it is from northern India. Beddome (1870, 1871) and Stoliczka (1871) described further congeners and noted that these lizards occur in the Western Ghats rainforests, with a speculation about the provenance of the 'North Indian' *R. rurkii*. Günther (1875) remarked that R.H. Beddome's

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material from 'Toracada Valley' (now Thorakadavu near Aliyar in Anaimalai) fully agrees with *R. rurkii*. Theobald (1876) remarked that the genus *Ristella* was restricted to the Western Ghats. Boulenger (1887) categorically dissociated *R. rurkii* from northern India and mentioned its distribution as Anaimalai (also see Boulenger 1890).

In the 20th century, Roux (1928) collected *R. rurkii* from Palni Hills. Smith (1935) compiled the then present information on this species and stated that its purported type locality 'North India' is incorrect, as it is endemic to the Western Ghats. Further books on Indian lizards such as Daniel (2002) and Das (2002) could not shed light on this species (but see Sharma 2002). Pyron et al. (2013), however, discussed the phylogeny of Squamata in general including the relationship of *Ristella rurkii* and *Lankascincus fallax*. Even more basic information on this species, however, such as its morphology, distribution, and natural history still stands unknown. Of late, current compilations on Indian lizards customarily list this species (e.g., Venugopal 2010; Aengals et al. 2018). For a long time, the only published information adding extra information and reporting a subsequent collection of this species is that of Roux (1928). Then Ganesh & Asokan (2010) reported on a preserved specimen in the collection of the Madras Government Museum in India. My sighting of this little-known species during fieldwork and direct examination of a voucher specimen provide an opportunity to contribute this paper. This article herein communicates its rediscovery, illustrate this taxon in life for the first time, and furnish natural history notes based on my field observations.

Materials and Methods

Field observations on live lizards as well as data from the voucher specimen form the basis of this work. Morphological and morphometric details were scored from the preserved voucher specimen using standard vernier slide callipers (L.C. 0.5mm). Magnifying hand lens (5X zoom) was used for scale counting. I follow Smith (1935) for morphological terminology and definitions. Individuals sighted in the field were examined alive in situ. No animals were collected for preservation and deposition in a museum owing to survey rules and stipulations of the Tamil Nadu Forest Department. During field surveys, live individuals sighted were examined long enough to establish unambiguous species-identification but were not examined to the extent of the preserved specimen. To alleviate stress, fewer measurements were scored from live animals in situ, that too, only to the nearest mm. Photographs of the subject and habitat were taken using high-resolution digital cameras (Canon Powershot SX130 IS). Much of the scalation (except scale rows that were scored directly) and colouration notes of live animals were scored from such photographs, after bigger magnifications and zoom in a computer. Such voucher photographs were numbered as ZSI/SRC/R/PV-2018 and were deposited in the Zoological Survey of India, Chennai, a national repository of the Government of India. Some of these are also reproduced here in this article. Geo-coordinates (in decimal degrees to two decimal places) and elevation (in meters above mean sea level) were sourced from Google Earth software. Rodgers & Panwar (1988) was used for ecoregional classification and Champion & Seth (1968) was referred for habitat type classification. Higher taxonomic nomenclature follows Hedges (2014).

Taxonomy

***Ristella rurkii* Gray, 1839**

Ateuchosaurus travancoricus Beddome, 1870 (part)

Ristella travancorica — Beddome, 1871 (part)

Ristella malabarica Stoliczka, 1871

Ristella rurki — Roux, 1928; Smith, 1935

(Images 1 & 2; Table 1)

Material examined: MAD 1932 housed in Madras Government Museum, India, collected by Frederick Henry Gravely from Kodaikanal, Palni Hills (see Ganesh & Asokan 2010).

Description

Habitus: Body slender and elongate; head and neck of more or less same width; neck fairly long; forelimbs small, with four fingers; trunk slightly wider, supple, and elongate; hindlimbs larger than forelimbs, with five toes; tail thick and robust but incomplete, broken part missing.

Measurements (in mm): Snout-vent length 44.5, tail length 40+? (tail cut), head length 7.7, head width 5.8, head depth 5.2, body width 6.3, axilla-groin distance 33.4, distance from snout to fore-limb contained 14.5, humeral length 5.0, radius ulna length 4.2; femoral length 6.3; tibial length 4.3.

Scalation: Midbody scale rows 26; scales smooth or with feeble traces of keels, glossy; vertebral and paravertebral series of scales hexagonal, imbricate; dorsal and ventral scales slightly larger than lateral scales on trunk; parietals larger than interparietal, in contact with each other beyond interparietal; prefrontals two, distinctly separate, not in contact with each other; frontonasal one, in contact with frontal; supralabials

Image 1. *Ristella rurkii*. a - reproduction of type drawing from Boulenger (1887), b - live adult - dorsolateral view, c - live adult - ventral view, d - live juvenile. © S.R. Ganesh

Image 2. *Ristella rurkii* MAD, 1932. a - entire, b - close-up of trunk showing nearly smooth scales, c - preanofemoral region, d - top of head. © S.R. Ganesh

seven; infralabials seven to eight; supraoculars five; supranasals absent; nuchals absent; loreals two on each side of head; mid-dorsal scales between parietals and sacral scale 50; mid-ventral scales between mental and preanal scale 52; lower eyelid scaly; nasal scale pierced by nostril; fourth toe subdigitals 10; tympanum visibly larger than naris, but smaller than a lateral body scale; preanals two, not much larger than surrounding scales; subcaudals not much larger than other scales on tail.

Colouration in preservation: Overall light fawn brown throughout; scale borders slightly darker; scales lustrous and glossy; digital claw grooves darker; eye greyish-brown.

Colouration in life (based on live, uncollected conspecifics; n=3): Dorsum dark chocolaty-brown from snout tip to tail tip; dorsal trunk of same ground colour, with obscure blackish dots, atop each scale, resembling

Table 1. Main morphological characters of *Ristella rurkii* specimens

Characters	MAD, 1932	Individual 1	Individual 2	Individual 3
Snout-vent length	44.5mm	40mm	45mm	30mm
Tail length	40+?mm	12+?mm	90mm	55mm
Axilla-groin distance	33.4mm	32mm	37mm	22mm
Dorsal scale rows	26	26	26	26
Mid-ventral scales	52	50	50	53
Supralabials	7	8	7	7
Infralabials	7/8	8	8	8
Fourth toe subdigitals	10	9	10	10

Symbol +? denotes cut tail

stripes, 4–6 series in number on trunk; sides of head lighter brown, supralabial, infralabial, and loreal regions with whitish spots; sides of head (temporal), lateral trunk and tail with a distinct wide black wash finely dotted with white speckles; venter yellow in adults (dirty pinkish white in juvenile); mental and gular region white; subcaudals grey-brown in adults (ashy white in juvenile); iris brownish-grey with a black circular pupil.

Variation (n=3, one juvenile): Live individuals agreeing in morphology with the preserved specimen; snout-vent length 40mm, 45mm (juvenile 30mm); full, original tail length 90mm (juvenile 55mm); axilla-groin distance 32mm, 37mm (juvenile 22mm). Midbody scale rows 26; other scalation features (counted on high-resolution photographs) – supralabials seven to eight; infralabials eight; supraoculars five; loreals two on each side of head; mid-ventrals 50–53; fourth toe subdigitals nine to 10; preanals two (Table 1).

Field observations: In January 2015, during herpetological surveys in the Palni Hills of the southern Western Ghats, this species was sighted in some localities in and around the Kodaikanal Wildlife Sanctuary. From 60 man hours of survey, a total of three sightings of this species were obtained. A juvenile was sighted within dense grass clumps on open hill slopes at 16:35hr in Mannavanaur (10.22^{0}N & 77.36^{0}E; 1,900m). One adult female was sighted under a fallen log at 12:25hr in Mathikettan Shola (10.18^{0}N & 77.42^{0}E; 2,050m). An adult male was sighted at 14:20hrs under a rock in Berijam (10.18^{0}N & 77.39^{0}E; 2,100m). Two near-term eggs were visible when seen through the venter of the female. Sightings of gravid females and hatchlings indicate that January falls within the breeding season of *Ristella rurkii*, at least in the Palni hills region (Image 3).

Image 3. a - Steep escarpment rising abruptly from the surrounding plateau in Palni Hills, b - shola or montane cloud forests, the habitat of *Ristella rurkii*. © S.R. Ganesh

Discussions

In a broader sense knowledge on the genus *Ristella* itself is rather scanty (see Boulenger 1887, 1890; Smith 1935; Venugopal 2010). While *R. rurkii* Gray, 1839 is the first congener to be described (in fact, the type species of this genus), other congeners were described between 1870 and 1887, largely based on materials collected by R.H. Beddome from various parts of southern Western Ghats (Boulenger 1890; Smith 1935). Even in the original description of taxa such as *R. travancorica* (Beddome, 1870) the type series is reported to be composed of many specimens from localities as far afield as Travancore, Wayanad, and Anaimalais. Same holds true for *R. beddomii* Boulenger, 1887 and *R. guentheri* Boulenger, 1887 for which the locations were broadly given as southwestern India (see Boulenger 1887). Precise locations when mentioned, such as Sirumalai for *R. guentheri*, were later on postulated to be incorrect (see Ganesh & Arumugam 2016). Thus, a broad taxonomic revision of *Ristella* spp. is direly needed. Related congener *Lankascincus* Greer, 1991 of Sri Lanka was also found to contain greater diversity than initially realised (see Batuwita & Pethiyagoda 2007 and references therein).

Ristella rurkii has remained one of the most poorly known lizards in the entire Indian peninsula (Smith 1935; Venugopal 2010). Since *R. rurkii* is the senior most congener nomenclaturally, and has been first associated and later dissociated from another nomen, *R. travancorica* (Beddome, 1870), I believe the taxonomic stability of *R. rurkii* is not questionable. Its morphological uniqueness in being the only smooth-scaled *Ristella* (see Boulenger 1890; Roux 1928; Smith 1935) also sets it apart from other more cryptic congeners. Other more recently described lizards from the Western Ghats such as *Eutropis gansi* Das, 1991 and *Calotes aurantolabium* Krishnan, 2008 are also equally unknown (Venugopal 2010). Despite being long-known from as early as 1839, however, *R. rurkii* has remained obscure to science for as long as 175 years. The mishap with its type locality (Gray 1839; Smith 1935) perhaps evaded or disoriented subsequent attempts of finding this species. The sole published information reporting a subsequent collection was that of Roux (1928), who reported collecting four examples of this species, two each from Kukkal and Poomparai in Kodaikanal during March and June 1927. There is still a whopping 90 years, nearly a century-long gap between the last previous report of this species (Roux 1928) and the current rediscovery. The present examination (also see Ganesh & Asokan 2010) of this unique smooth-scaled congener stemming from a previously known, verified locality (Roux 1928), clearly backs up the veracity of this finding.

Till now, this species has been regarded as Data Deficient (Srinivasulu et al. 2014). As far as current knowledge goes, it is recommended that further targeted surveys should continue to discover more populations of this species. Historical reports (Smith 1935) from Travancore need a recent verification/validation. Surveys in Travancore Hills (see Annandale 1906; Inger et al. 1984; Ishwar et al. 2001; Chandramouli & Ganesh 2010) either recorded other congeners or did not identify their findings of *Ristella* spp. up to species

level. The nearby and contiguous High Wavys and Cardamom Hills harbour a very similar lizard assemblage as of Anaiamlai-Palni massif, including endemics such as *Salea anamallayana* (Beddome, 1878) (Srinivas et al. 2008). *Ristella* populations from these massifs only reveal the presence of *R. guentheri* Boulenger, 1887 (Chandramouli & Ganesh 2010). Therefore, pending further reliable reports, *R. rurkii* should currently be considered as endemic to the Anaiamlai-Palni hill complex. This has got a direct bearing on its conservation status and, therefore, further refinement of its threat status evaluation is recommended.

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Short Communication

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Dietary assessment of five species of anuran tadpoles from northern Odisha, India

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Abstract: Anuran tadpoles are gregarious predators capable of differentiating food items among diverse types of prey via varied feeding and oral structures. Tadpoles were collected from different study sites in three districts of northern Odisha during three consecutive rainy seasons (from July–October of 2015–2017). After morphometric measurements (total length and body length), the stomach contents of 75 tadpoles belonging to five different anuran species (*Duttaphrynus melanostictus*, *Euphlyctis cyanophlyctis*, *Fejervarya orissaensis*, *Polypedates maculatus* and *Microhyla ornata*) belonging to four families namely Bufonidae, Dicroglossidae, Rhacophoridae and Microhylidae were examined. The food spectrum of tadpoles included mostly detritus, followed by phytoplankton (represented by 5 classes and 54 genera). Such studies contribute to the understanding of the natural diets of these anuran species that can assist in developing management strategies for them. Aquatic habitats must be conserved and maintained so that conservation of anurans can be ensured.

Keywords: Anuran, conservation, food, Odisha, predators, tadpoles.

Amphibians are significant components of many fresh water and terrestrial ecosystems. The larvae of frogs and toads (Order Anura) are grossly different from adults and have many developmental (Alford & Johnston 1989) and morphological (Altig & McDiarmid 1999) features not seen in other amphibian larvae. They exhibit biphasic life cycles which refers to the ability of these animals to sustain the first part of their lives in water and the second part on land. Many Indian anuran species co-breed and utilize variety of lentic and lotic water bodies ranging from ephemeral ponds, damp grounds, temporary puddles, permanent ponds, streams and rivers following the south-west monsoon rain (Saidapur 1989). Unpredictable temporal, spatial distributions and cyclic pattern of nutrient availability are common features of these habitats. Tadpoles in temporary ponds must grow quickly to complete metamorphosis before the pond gets dried. The metamorphosis duration depends on a number of variables such as drying, predation, competition, food availability and water temperature. The amount of food a tadpole consumes directly affects its growth (Kiffney & Richardson 2001) and the quality of food consumed affects the rate of growth (Kupferberg et al. 1994; Brown & Rosati 1997). Hence, tadpoles of different species that live together are subjected to both intra- and inter-specific competition for food, space and to predation pressure

There is a dearth of information on the tadpoles of India, especially from northern Odisha. Most of the

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studies on amphibians have been concentrated in the Western Ghats (biodiversity hotspot), and other areas remain understudied (Aravind & Gururaja 2011). Twenty-six species of frogs are found in Odisha and 21 species of anurans from Similipal Biosphere Reserve including representatives from the families like Bufonidae (three species), Dicroglossidae (eight species), Microhylidae (five species), Ranidae (one species) and Rhacophoridae (four species) (Dutta et al. 2009).

Understanding food and feeding strategies is central to tadpole biology. Amphibians are generally considered to be feeding opportunists with their diets reflecting the availability of food of appropriate size. Typically, tadpoles are characterized by an oral disc with keratinised jaw sheaths and equally keratinised labial "teeth" (also called keratodonts), which they use to rasp algae or bacterial films from underwater surfaces for consumption. Most tadpoles are primarily herbivorous (Duellman & Trueb 1986) consuming a wide variety of algal taxa as well as detritus, viruses, bacteria, protists, plant fragments, pollen grains, fungi, various kinds of small animals, anuran eggs, and other tadpoles (Kupferberg et al. 1994; Mahapatra et al. 2017a). Besides these general considerations, studies on natural diets of tadpoles, including systematic and comparative evaluation of the food habits of tadpoles are still rare (Alford 1999; Hoff et al. 1999). Knowledge of food and feeding behaviour of the tadpole is essential as early part of life history of amphibian is dependent on the availability of the food items in their natural habitat (Díaz-Paniagua 1985; Inger 1986). It was only over the past three decades that dietary information on anuran larvae has been published (Khare & Sahu 1984; Ao & Khare 1986; Sekar 1990; Saidapur 2001; Sinha et al. 2001; Khongwir et al. 2003). The aim of the present study was to investigate the feeding biology of the co-occurring tadpoles in their natural habitats of northern Odisha.

Materials and Methods

Study area

The study was conducted in three northern districts (Balasore, Mayurbhanj and Keonjhar) of Odisha, India. It forms a part of the Eastern Ghats hill ranges. The climate of the area is sub-tropical with a hot summer (March to May, 40–42 ^{0}C), rainy (June-October, actual average precipitation, 1283.4mm) and a chilling winter (November-February, 5–7 ^{0}C). The breeding of most of the anurans occur during the rainy season. The sampling sites were selected based on primary survey of these temporary ponds having multiple species of tadpoles.

Sampling

The tadpole assemblages were sampled from temporary water bodies during the rainy seasons (July–October) of 2015, 2016 and 2017 using dip net (mesh size 1mm). The larvae (N = 15 for each species) were preserved in 10% formaldehyde immediately after collection in the field in order to prevent complete digestion of ingested food particles. In the laboratory, individuals of stages 35–38 (Gosner 1960) were separated and subsequently preserved in 4% formaldehyde.

The gut of each tadpole was removed carefully; gut length was recorded with the help of a digital vernier caliper (Mitutoyo™ to the nearest 0.1mm). The first four centimetre of gut was used for diet analyses. The gut contents were flushed with distilled water, taken on a Sedgewick rafter chamber and analyzed under a compound microscope (Laboscope, CMS-2). Photographs of the gut contents were taken with the help of a Sony cyber shot camera (5.1 megapixels, DCSW5) attached to the microscope. The food items were identified up to the genus level and quantified following standard procedures (Edmondson 1959; Smith 1994). Unidentified items, which formed a mass of organic material, were classified as detritus.

Results

Five species of anuran larvae namely *Duttaphrynus melanostictus, Polypedates maculatus, Fejervarya orissaensis, Euphlyctis cyanophlyctis* and *Microhyla ornata* were predominant co-occurring species in the study area and belonged to four families (Bufonidae, Dicroglossidae, Rhacophoridae and Microhylidae). They breed in most of the aquatic habitats (temporary ponds and ephemeral pools). All these tadpoles were exotrophic, lentic and representatives of Orton (1953) type IV except *M. ornata* type II.

Various types of food items were recorded from the gut contents of these co-occurring tadpoles. The trophic spectrum included mostly detritus, followed by phytoplankton represented by five classes and 54 genera and zooplanktons (Table 1). Most of the microalgae belonged to the class Bacillariophyceae followed by Chlorophyceae. Most of the zooplanktons belonged to *Amoeba, Hydra* and *Paramecium*.

Family: Bufonidae

***Duttaphrynus melanostictus* Schneider, 1799**

(Common Asian Toad)

General morphology of the tadpoles

(N = 15; Body Length: 8.22–8.66 mm; Total Length: 17.02–18.32 mm; Gut length: 55–67 mm)

The body is black in colour with many closely placed tiny melanophores on both inner and outer integuments (in life), roughly oval and elliptical in dorsal and lateral views, snout rounded. Eyes were large; located and oriented dorsolaterally. Spiracle sinistral. Vent tube was median and short. Oral disc was antero-ventral in location.

Gut contents

Phytoplanktons:

Cyanophyceae: *Merismopedia* sp*., Choococcus* sp*., Gloeotheca* sp*., Oscillatoria* sp.

Bacillariophyceae: *Naviculla* sp., *Pinularia* sp., *Fragillaria* sp., *Frustulia* sp., *Cymatopleura* sp. *Nitzschia* sp., *Synedra* sp., *Cymbella* sp., *Sellaphora* sp., *Actinella* sp., *Placoneis* sp., *Gomphonema* sp.

Chlorophyceae: *Oedogonium* sp., *Scehendesmus* sp., *Oocystis* sp., *Haematococcus* sp., *Cosmarium* sp., *Pediastrum* sp., *Tetrastrum* sp., *Closterium* sp., *Staurastrum* sp., *Euastrum* sp., *Ankistrodesmus* sp.

Euglenophyceae: *Phacus* sp., *Trachelomonas* sp.

Family: Dicroglossidae

1. *Euphlyctis cyanophlyctis* Schneider, 1799 (Indian skipper frog)

General morphology of the tadpoles

(N = 15; Body Length: 12.25-14.55 mm; Total Length: 45.95-47.2 mm; Gut length: 239.6-252.4 mm)

Body oval in both dorsal and lateral views. The snout was pointed in dorsal and rounded in lateral views. Eyes were large; located dorsolaterally. The nostrils were reniform. Spiracle sinistral. Oral disc was near ventral in location.

Gut contents

Phytoplanktons:

Cyanophyceae: *Merismopedia* sp., *Choococcus* sp., *Oscillatoria* sp., *Microcystis* sp.

Bacillariophyceae: *Amphipleura* sp., *Asterionella* sp., *Achnanthidium* sp., *Aulacoseira* sp., *Cocconeis* sp., *Craticula* sp., *Cyclotella* sp., *Cymbella* sp., *Diadesmis* sp., *Diatoma* sp., *Eunotia* sp., *Gomphonema* sp., *Gyrosigma* sp., *Naviculla* sp., *Nitzschia* sp., *Pinnularia* sp., *Tabellaria* sp.

Chlorophyceae: *Actinastrum* sp., *Ankistrodesmus* sp., *Ankyra* sp., *Closterium* sp., *Cosmarium* sp., *Oocystis* sp., *Scenedesmus* sp., *Staurastrum* sp., *Spirogyra* sp., *Ulothrix* sp., *Oedogonium* sp.

Euglenophyceae: *Phacus* sp., *Trachelomonas* sp.

Cryptophyceae: *Rhodomonas* sp.

Zooplankton: *Amoeba* sp., *Hydra* sp., *Paramecium* sp.

2. *Fejervarya orissaensis* Dutta, 1997 (Odisha Frog)

General morphology of the tadpoles

(N = 15; Body Length: 7.27–9.45 mm; Total Length: 21.67–26.7 mm; Gut length: 38.41–48.98 mm)

Body oval and elliptical in dorsal and lateral views. The snout was rounded in dorsal and lateral views. Eyes were large; located and oriented posterolaterally. The nostrils were spherical. Spiracle sinistral. Oral disc was near ventral in location.

Gut contents

Phytoplanktons:

Cyanophyceae: *Gloeotheca* sp., *Oscillatoria* sp., *Gomphospharia* sp.

Bacillariophyceae: *Naviculla* sp., *Pinnularia* sp., *Eunotia* sp., *Craticula* sp., *Nitzschia* sp., *Synedra* sp., *Fragillaria* sp., *Frustulia* sp., *Cymbella* sp., *Amphipleura* sp., *Diadesmis* sp., *Cocconeis* sp., *Cymatopleura* sp.

Chlorophyceae: *Closterium* sp., *Zygnema* sp., *Scenedesmus* sp., *Staurastrum* sp., *Chlamydomonas* sp., *Haematococcus* sp., *Cosmarium* sp., *Volvox* sp., *Ankistrodesmus* sp., *Oedogonium* sp., *Euastrum* sp., *Ankyra* sp.

Euglenophyceae: *Phacus* sp., *Trachelomonas* sp., *Euglena* sp.

Family: Rhacophoridae

***Polypedates maculatus* Gray, 1830 (Indian Tree Frog)**

General morphology of the tadpoles

(N = 15; Body Length: 13.68–17.87 mm; Total Length: 46.37–52.22 mm; Gut length: 184.34–211.54 mm)

Body oval and elliptical in dorsal and lateral views. Snout rounded. Eyes were large; located and oriented dorsolaterally. Nostrils spherical. Vent tube was dextral. Oral disc was anteroventaral in location.

Gut contents

Phytoplanktons:

Cyanophyceae: *Microcystis* sp., *Oscillatoria* sp., *Merismopedia* sp., *Choococcus* sp.

Bacillariophyceae: *Cyclotella* sp., *Fragillaria* sp., *Navicula* sp., *Nitzscia* sp., *Synedra* sp., *Cymbella* sp., *Pinnularia* sp., *Stauroneis* sp., *Amphipeura* sp., *Cocconeis* sp., *Craticula* sp., *Diadesmis* sp., *Frustulia* sp., *Gomphonema* sp.

Chlorophyceae: *Actinastrum* sp., *Ankistrodesmus* sp., *Cosmarium* sp., *Closterium* sp., *Oedogonium* sp., *Spirogyra* sp., *Chlamydomonas* sp., *Ulothrix* sp., *Scenedesmus* sp., *Oocystis* sp., *Pediastrum* sp., *Zygnema* sp., *Volvox* sp., *Pandorina* sp.

Euglenophyceae: *Phacus* sp., *Trachelomonas* sp., *Euglena* sp.

Family: Microhylidae

***Microhyla ornate* Dumeril and Bibron, 1841**

(Ornamented Pygmy Frog)

General morphology of the tadpoles

(N = 15; Body length: 8.41–10.96 mm; Total length: 26.90–31.47 mm; Gut length: 62.63–75.34 mm)

Dorsally the body shape was oval with a truncated anterior portion; laterally the body was ovoid and depressed on the dorsal side with an acutely rounded anterior and a broadly rounded posterior. Eyes were large, round and located and oriented laterally. Spiracle medial. Oral opening was at the anterior end of the body at the snout tip and visible dorsally and non-emarginated.

Gut contents

Phytoplanktons:

Cyanophyceae: *Merismopedia* sp., *Oscillatoria* sp., *Gloeotheca* sp., *Microcystis* sp.

Bacillariophyceae: *Naviculla* sp., *Pinnularia* sp., *Eunotia* sp., *Nitzschia* sp., *Frustulia* sp., *Cymbella* sp., *Cocconeis* sp.

Chlorophyceae: *Closterium* sp., *Scenedesmus* sp., *Staurastrum* sp., *Chlamydomonas* sp., *Haematococcus* sp., *Cosmarium* sp., *Ankistrodesmus* sp., *Oedogonium* sp., *Oocystis* sp., *Tetrastrum* sp.

Euglenophyceae: *Phacus* sp., *Trachelomonas* sp., *Euglena* sp.

Discussion

Anuran larvae are some of the least understood in terms of their trophic relations (Petranka & Kennedy 1999; Altig 2007). Most anurans breed in countless aquatic habitats, i.e., ephemeral ponds and puddles etc. of diverse nature that support the growth and abundance of different species of algae, diatoms and plankton. Though amphibians are leading a biphasic life, water is the basic need for their early larval development. Within the short period of time the tadpoles have to be metamorphosed by utilizing the ample source of nutrients in water and escaping from desiccation. Tadpoles may partition the available food resources. Duellman & Trueb (1986) commented that food partitioning among anuran tadpoles is caused by differences in the ability of the various species to ingest particles of varying sizes and also to the position they occupy in the water column, a consequence of morphological adaptations for the exploitation of specific microhabitats. Tadpoles of various species are often morphologically different and feed on different food items to reduce competition in single water bodies (Diaz-Paniagua 1985; Harrison 1987). Tadpoles feed at many sites throughout the water column (benthic, mid water, surface) and have characteristic morphologies and behaviour (McDiarmid & Altig 1999). Tadpoles of *F. orissaensis* and *E. cyanophlyctis* show characteristics of benthic water adaptation viz., dorsal eyes, weak tail fins and ventral mouth. On the other hand, *M. ornata* tadpoles are surface feeder and were always encountered on the surface with bulging lateral eyes, tail fins well developed, lower fin broader than upper one and antero-dorsal mouth. *D. melanostictus* tadpoles adopted to survive in shallow water and have thick black body, not so well-developed tail for swimming and weak tail musculature. *P. maculatus* show characteristics of nektonic habitat guild.

The result of the gut content analyses showed that apart from a large amount of detritus, the tadpole diet was largely based on microalgae as corroborated by several studies (Lajmanovich 2000; Rossa-Feres et al. 2004). We identified prey items from class Bacillariophyceae, Chlorophyceae, Euglenophyceae, Cyanophyceae and Cryptophyceae. Detritus, packed along the length of larval intestine, is mostly composed of degraded plant materials, which often bears little resemblance to the original plant tissue in terms of its structure and nutritional content. Much of the nutritional value of detritus may come from associated microbes than its particles per se (Cummins & Klug 1979). Diet composition of all anuran tadpoles revealed members of class Bacillariophyceae to be the most important prey category, an observation similar to Sinha et al. (2001). The importance of Bacillariophyceae as a food source has also been reported for other anuran genera such as *Lithobates, Dendrosophus, Eupemphix* and *Scinax* (Hendricks 1973; Kupferberg 1997; Rossa-Feres et al. 2004). Bacillariophyceae can be richer in calories, mainly as a form of lipids and they are more easily accessible for consumption than filamentous algae (Kupferberg et al. 1994). Being a source of carbohydrates, chlorophytic algae also form another important food source (Bold & Wynne 1985). The zooplanktons as seen from tadpole diets were represented by *Paramecium* sp., *Hydra* sp. and *Amoeba* sp. in *E. cyanophlyctis* tadpoles, an observation similar to Mahapatra et al. (2017b). The diet preference and choice of algae as food indicates that the conservation of habitat in terms of algal diversity is essential for the survival and successful completion of life cycle of amphibian tadpoles. Qualitative analyses of food spectrum of five species of anuran tadpoles (*B. melanostictus, Rhacophorus maximus, Amolops afghanus, Rana danieli* and *E. cyanophlyctis*) from Arunachal Pradesh, India by Sinha et al. (2001) recorded

Table 1. Phytoplankton species identified from the intestine of anuran tadpoles (DM: *Duttaphrynus melanostictus,* PM: *Polypedates maculatus,* FO: *Fejervarya orissaensis,* EC: *Euphlyctis cyanophlyctis* and MO: *Microhyla ornata*; + = Present, - = Absent).

Class	Genus	DM	EC	FO	PM	MO
Cyanophyceae	*Choococcus* sp.	+	+	-	+	-
	Gloeotheca sp.	+	-	+	-	+
	Microcystis sp.	-	+	-	+	+
	Merismopedia sp.	+	+	-	+	+
	Gomphospharia sp.	-	-	+	-	-
	Oscillatoria sp.	+	+	+	+	+
Bacillariophyceae	*Achnanthidium* sp.	-	+	-	-	-
	Actinella sp.	+	-	-	-	-
	Amphipleura sp.	-	+	+	+	-
	Asterionella sp.	-	+	-	-	-
	Aulacoseira sp.	-	+	-	-	-
	Cocconeis sp.	-	+	+	+	+
	Craticula sp.	-	+	+	+	-
	Cyclotella sp.	-	+	-	+	-
	Cymbella sp.	+	+	+	+	+
	Cymatopleura sp.	+	-	+	-	-
	Diadesmis sp.	-	+	+	+	-
	Diatoma sp.	-	+	-	-	-
	Eunotia sp.	-	+	+	-	+
	Fragillaria sp.	+	-	+	+	-
	Frustulia sp.	+	-	+	+	+
	Gomphonema sp.	+	+	-	+	-
	Gyrosigma sp.	-	+	-	-	-
	Naviculla sp.	+	+	+	+	+
	Nitzschia sp.	+	+	+	+	+
	Pinnularia sp.	+	+	+	+	+
	Placoneis sp.	+	-	-	-	-
	Sellaphora sp.	+	-	-	-	-
	Stauroneis sp.	-	-	-	+	-
	Synedra sp.	+	-	+	+	-
	Tabellaria sp.	-	+	-	-	-
Chlorophyceae	*Ankistrodesmus* sp.	+	+	+	+	+
	Actinastrum sp.	-	+	-	+	-
	Ankyra sp.	-	+	+	-	-
	Cosmarium sp.	+	+	+	+	+
	Closterium sp.	+	+	+	+	+
	Chlamydomonas sp.	-	-	+	+	+
	Euastrum sp.	+	-	+	-	-
	Haematococcus sp.	+	-	+	-	+
	Oedogonium sp.	+	-	+	+	+
	Oocystis sp	+	+	-	+	+
	Pandorina sp.	-	-	-	+	+
	Pediastrum sp.	+	-	-	+	+
	Scehendesmus sp.	+	+	+	+	+
	Spirogyra sp.	-	+	-	+	+
	Staurastrum sp.	+	-	+	-	+
	Tetrastrum sp.	+	-	-	-	+
	Ulothrix sp.	-	+	-	+	+
	Volvox sp.	-	-	+	+	+
	Zygnema sp.	-	-	+	+	-
Euglenophyceae	*Euglena* sp.	-	-	+	+	+
	Phacus sp.	+	+	+	+	+
	Trachelomonas sp.	+	+	+	+	+
Cryptophyceae	*Rhodomonas* sp.	-	+	-	-	-
Zooplankton	*Amoeba* sp.	-	+	-	-	-
	Hydra sp.	-	+	-	-	+
	Paramecium sp.	-	+	-	-	+

the presence of diatoms and Chlorophyta in all the five species which was also seen in the present study. Foraging behaviour is one of the most important components of reproductive fitness (Nishimura 1999). Therefore, the remarkable ability of most group-living organisms to distribute themselves precisely among feeding sites in proportion to habitat profitability is not surprising (Godin & Keenleyside 1984; Talbot & Kramer 1986). Tadpoles of anurans feed both on the phytoplankton community by means of filtration, and on a large variety of substrates (including algae, macrophytes & carrion) by rasping, scraping and chopping with their jaw sheaths and labial teeth (Seale & Wassersug 1979; Seale 1982).

Conclusion

In tropical aquatic ecosystems, the study of the natural diet of resident species is an important tool in understanding the biotic and abiotic interrelationships. Diet analysis of larvae provides valuable information on foraging pattern, nutritional requirements and trophic interaction in aquatic food webs which is critical for successful conservation and management. Further, such knowledge also indicates the susceptibility of the species in light of the current environmental alterations.

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SHORT COMMUNICATION

Inventory of prong-gilled mayflies (Ephemeroptera: Leptophlebiidae) of India with records of endemic taxa

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Abstract: The present study investigated leptophlebiid mayfly in 48 sampling sites from 11 states and one union territory of India including earlier report. It deals with diagnostic characters, diversity, distribution and status of 26 species belonging to 12 genera under two subfamilies of Leptophlebiidae from India. Twenty-three of them are endemic to India inclusive of 15 species and six genera are endemic to the Western Ghats and four species are endemic to the Himalaya. Due to this high percentage of endemism, conservation of habitats and microhabitats harbouring this ancient gondwanan lineage gains priority.

Keywords: Endemic taxa, Eastern Ghats, Himalaya, identification, Western Ghats.

The Leptophlebiidae Banks, 1900 or 'prong-gilled' mayflies are a cosmopolitan, specious and morphologically diverse family. The oldest identified leptophlebiid fossil is *Aureophlebia sinitshenkovae* Peters and Peters from the Upper Cretaceous, dated to about 90 million years ago (Peters & Peters 2000), and representatives of the modern subfamilies are documented from Baltic Amber, dated to about 50 million years ago (Hubbard & Savage 1981). The Leptophlebiidae consists of approximately 110 genera and more than 600 described species, roughly a quarter of all currently recognized species of mayflies. In understudied regions like Madagascar, taxonomic work on leptophlebiids is expected to yield upwards of 15 genera and 100 species new to science (Benstead et al. 2003). Leptophlebiid mayflies are considered to have undergone extensive adaptive radiation resulting in their present occupation of different aquatic microhabitats (Tsui & Peters 1975) and highly diverse gill morphologies. Previously, gill morphology has been linked to ecological factors (Peters et al. 1964; Riek 1973; Towns & Peters 1996). Leptophlebiid has maximum diversity in the Southern Hemisphere (Edmunds, 1972). It represents one of the major stem groups within the Ephemeroptera consisting of relatively ancestral and highly derived components (McCafferty & Edmunds 1979). Leptophlebiidae is a basal lineage and a sister group to a relatively derived clade that includes a pair of sister groups, Scapphodonta and Pannota (McCafferty & Wang 2000), in addition to a more basal lineage represented by the Behningiidae (McCafferty 2004).

Faunistic studies on Leptophlebiidae have progressed significantly in India. Sporadic taxonomic studies on

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Leptophlebiidae were conducted in Himalayan streams by Dubey in the early 1970s and two species viz., *Atalophlebia chialhnia* (Dubey, 1971) and *Thraulodes marhienus* (Dubey, 1970) were described from imagoes. The genus *Atalophlebia* Eaton, l881 is known only from Australia, and the genus *Thraulodes* Ulmer, 1920 is known only from the New World and hence the species are probably misplaced at the generic level (Hubbard & Peters 1978). Detailed studies using standardized generic delineations of Eastern Hemisphere Leptophlebiidae (Peters & Edmunds 1970) have resulted in the discovery of several new species belonging to ten genera, from India. Two genera viz., *Choroterpes* Eaton, l881 and *Thraulus* Eaton, 1881 are widely distributed, two genera viz., *Gilliesia* Peters and Edmunds, 1970 and *Isca* Gillies, 1951 have an Oriental distribution and six genera viz., *Edmundsula* Sivaramakrishnan, 1985, *Indialis* Peters & Edmunds, 1970, *Klugephlebia* Selvakumar, Subramanian & Sivaramakrishnan, 2016, *Nathanella* Demoulin, 1955, *Notophlebia* Peters & Edmunds, 1970 and *Petersula* Sivaramakrishnan, 1984 are endemic to the Western Ghats and probably many of them are of a Gondwanan in origin. Presently, 26 species belonging to 12 genera under this family are reported in India (Sivaramakrishnan 2016; Selvakumar et al. 2016, 2017a, b). The aim of the present study is to provide diagnostic characters, extension of distribution, endemic status and comprehensive knowledge of Leptophlebiidae species from India.

Material and Methods

Collections were made in streams and river basins of the all over India during 2009 to 2015. The present study investigated leptophlebiid mayfly in 48 sampling sites from 11 states and one union territory of India including earlier report (Table 1). Sampling area is mountainous with waterfalls and streams, and holds promise as harboring taxa. Collecting was conducted with an aquatic D-frame net. In streams, the substrate was kick-sampled, allowing the current to carry organic debris, including insects, into the net. Waterfalls were sampled by scouring the rock surfaces by hand, allowing the current to carry insects into the net. Along stream margins and in ponds, vegetation was swept with the aquatic D-frame net. All insects were preserved into 70% ethyl alcohol. Mayfly nymphs are particularly fragile because the gills and terminal filaments detach from the body very easily. Therefore, when possible, series of specimens were collected to maximize the likelihood of obtaining intact specimens and accurate determinations. To minimize damage to specimens, mayflies were collected in containers separate from other aquatic insects. Collected samples were brought to laboratory and were examined using a Leica M205A microscope and identified using published taxonomic literature and type specimens in the Zoological Survey of India (ZSI) and Southern Regional Centre (ZSI/SRC), Chennai. Identified specimens were deposited in ZSI, Kolkata, ZSI, SRC, Chennai and Department of Zoology (DZ), The Madura College (MC), Madurai.

Results

Systematic account

Twenty six species belonging to 12 genera under two subfamilies of Leptophlebiidae from India are documented. All genera and species are presented alphabetically for convenience. This order should in no way be regarded indicating phylogeny.

Order: Ephemeroptera

Suborder: Rectracheata

Superfamily: Leptophlebioidea

Family: LEPTOPHLEBIIDAE

Subfamily: Atalophlebiinae

1. *Atalophlebia chialhnia* Dubey, 1971
2. *Choroterpes* (*Choroterpes*) *kaegies* Selvakumar, Subramanian & Chandra, 2017
3. *Choroterpes* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003
4. *Choroterpes* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017
5. *Choroterpes* (*Dilatognathus*) *nigella* (Kang & Yang, 1994)
6. *Choroterpes* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009
7. *Choroterpes* (*Euthraulus*) *nambiyarensis* Selva-Kumar, Arunachalam & Sivaramakrishnan, 2013
8. *Choroterpes* (*Euthraulus*) *parvula* (Gillies, 1951)
9. *Choroterpes* (*Monochoroterpes*) *nandini* Selvakumar & Sivaramakrishnan, 2015
10. *Edmundsula lotica* Sivaramakrishnan, 1985
11. *Indialis badia* Peters & Edmunds, 1970
12. *Indialis rossi* Peters, 1975
13. *Isca* (*Isca*) *purpurea* Gillies, 1951
14. *Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016
15. *Nathanella indica* Demoulin, 1955
16. *Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996
17. *Notophlebia ganeshi* Kluge, 2014
18. *Notophlebia hyalina* Peters & Edmunds, 1970
19. *Notophlebia jobi* Sivaramakrishnan & Peters, 1984

20. Petersula courtallensis Sivaramakrishnan, 1984

21. Petersula nathani Sivaramakrishnan & Hubbard, 1984

22. Thraulodes marhieus Dubey, 1970

23. Thraulus gopalani Grant & Sivaramakrishnan, 1985

24. Thraulus mudumalaiensis Arumuga-Soman, 1991

25. Thraulus semicastaneus (Gillies, 1951)

Subfamily: Leptophlebiinae

26. Gilliesia hindustanica (Gillies, 1951)

Subfamily: Atalophlebiinae

Diagnosis: Atalophlebiinae can be differentiated from Leptophlebiinae by the possession of square facets in the dorsal portion of the eyes of adult males (Peters & Gillies, 1995), a trait unique among hexapods, as well as by leg and styliger plate characters (Peters 1980; Kluge 1994) and a suite of nymphal mouthpart characters [e.g., patterning and arrangement of hairs and setae and shape/emargination of the labrum (Peters 1980)].

Genus: *Atalophlebia* Eaton, 1881

Remarks: The genus *Atalophlebia* Eaton, l881 is known only from Australia and hence the species, *Atalophlebia chialhnia* Dubey, 1971 probably misplaced at the generic level (Hubbard & Peters 1978).

1. *Atalophlebia chialhnia* Dubey, 1971

Material reported: 1 female imago, 25.v.1970, Himachal Pradesh, Alhni River, 3200m, coll. O.P. Dubey.

Diagnosis: *Atalophlebia chialhnia* can be differentiated by the following characters: In the subimago (i) forewing 9mm in length, 3.5mm in width, translucent brown, venation pale white; and (ii) tarsal claws similar, slender, hooked (Dubey 1971).

Distribution: Known only from type locality Alhni River (Himachal Pradesh).

Status: Endemic to the Himalaya.

Remarks: Diagnostic characters are provided based on original description. Larva and imago are unknown. Further detailed study is required to assign this species to suitable genus.

Genus: *Choroterpes* Eaton, 1881

Type species: *Choroterpes lusitanica* Eaton, 1881

Diagnosis: The *Choroterpes* complex is recognised by the following characters: in the larvae (i) a pair of slender filaments of first abdominal gill different from gills 2–6; (ii) apex of glossae provided with broad spatulate setae and (iii) posterior row of setae on the labrum arises close to its middle (except in some *Neochoroterpes*). In the adults (i) in forewing, MP (Media Posterior) symmetrical fork while in MP_2 asymmetrical; (ii) cubital area broad with four (sometimes three) intercalaries; (iii) forceps in the male abruptly widened in its basal and (iv) penes as two simple lobes, very short to elongate and lacking spines or accessory lobes (Selvakumar et al. 2013).

Distribution: Oriental, Paleartic, Afrotropical, Nearctic and Neotropical.

Status: Wide distribution.

Remarks: The genus encompasses the six subgenera viz., *Choroterpes* s.s. Eaton, 1881, cosmopolitan in distribution, *Euthraulus* Barnard, 1932 restricted to the Old World, *Neochoroterpes* Allen, 1974 restricted to the New World and *Cryptopenella* Gillies, 1951, *Dilatognathus* Kluge, 2012 and *Monochoroterpes* Kluge, 2012 restricted to the Oriental region.

Subgenus: *Choroterpes* s. s. Eaton, 1881

Diagnosis: This subgenus *Choroterpes* can be differentiated from other subgenera by the following combination of characters: In the larvae (i) a broad, terminal lobe on the lamina of gills 2–6 and indistinguishable characters in the adults between subgenera.

2. *Choroterpes* (*Choroterpes*) *kaegies* Selvakumar, Subramanian & Chandra, 2017 (Image 1)

Material examined: 5144/H13, 1 larva, 02.iii.2016, Meghalaya, East Khasi Hills, Khrang Village, Wankwar River, 25.324^{0}N & 91.775^{0}E, 1,658m, coll. E. Eyarin Jehamalar; 5147/H13, 2 larvae, 05.iii.2016, Meghalaya, East Khasi Hills, Thangasalai Village, Umkhen River, 25.591^{0}N & 92.054^{0}E, 937m, coll. E. Eyarin Jehamalar; 5147/H13, 1 larva, 26.vi.2016, Meghalaya, East Garo Hills, Upper Rongbu Village, 25.916^{0}N & 90.831^{0}E, 101m, coll. E. Eyarin Jehamalar; MCDZ/E-1, 1 larva, 18.xi.2012, Himachal Pradesh, Bilaspur District, Mandodari, River stream, 31.783^{0}N, 76.332^{0}E, coll. K.A. Subramanian.

Diagnosis: This species can be distinguished from all known species of *Choroterpes* (*C.*) by the following characters: In the larva (i) anteromedian emargination of labrum broad; (ii) each femur with a dark brown spot at middle and near apex; (iii) gill 1 single and slender and (iv) upper and lower lamellae of gills 2–7 with three apical processes, median process relatively slender and longer than laterals (Selvakumar et al. 2017b).

Distribution: Himachal Pradesh and Meghalaya.

Status: Endemic to the Himalaya.

Remarks: Adult stage is unknown.

3. *Choroterpes* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003 (Image 2)

Material examined: MCDZ/E-2, 2 larvae, 23.ii.2012, Tamil Nadu, Tirunelveli, Nambiyar River, Nambikovil, 08.260^{0}N & 77.295^{0}E, 412m, colls. C. Selvakumar & K. G. Sivaramakrishnan; MCDZ/E-3, 1 larva, 10.v.2014, Kerala, Silent Valley-Kunthi River at Attappadi, 11.035^{0}N & 76.321^{0}E, 550m, coll. C. Selvakumar; MCDZ/E-4, 9 larvae, 19.v.2015, Karnataka, Someshwara Wildlife Sanctuary, Tunga River, Minu Hole, 13.344^{0}N & 75.061^{0}E, 665m, coll. S. Ramya Roopa.

Diagnosis: This species can be differentiated from other species by the following combination of characters: In the larvae (i) abdominal gill 1 slender with dorsal and ventral portions;(ii) median projection of gills 2–7 plate-like and markedly larger and longer than laterals and (iii) labrum with three transverse rows of setae on dorsal surface, middle row without setae medially; anteromedian margin of labrum with a deep U-shaped ventral incision. In the adults (i) male genital penes each with a finger-like process on the top, acute costal projection of the hindwings and (ii) apex located approximately 2/3 distance from base (Tong & Dudgeon 2003).

Distribution: India (Karnataka, Kerala and Tamil Nadu) and China: Hong Kong.

Himachal Pradesh

Status: Oriental distribution.

Remarks: This species was originally described from Hong Kong based on reared larvae and adults in the laboratory (Tong & Dudgeon 2003). Larvae of this species from southern Western Ghats is extension of its distributional range down south to 8–11^0 north of equator by Selvakumar et al. (2015).

Subgenus: *Dilatognathus* Kluge, 2012

Diagnosis: This subgenus can be differentiated from other subgenera by the following combination of characters: In the larvae (i) abdominal gills 2–7; (ii) labrum widened with median incision; (iii) maxilla with inner-apical projection stretched or not stretched to a tusk-like process with ventro-apical flange, palp elongated and bears long filtering setae; (iv) labial palp elongated and bears long filtering setae which form regular longitudinal rows.

4. *Choroterpes* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017 (Image 3)

Material examined: 5154-5155/H13, 3 larvae, 4.iv.2012, Andaman and Nicobar Islands, Nicobar District, Great Nicobar Biosphere Reserve (GNBR), East West Road, 16th km, Galathea tributary, 6.588^{0}N & 93.518^{0}E, 62m, coll. E. Eyarin Jehamalar; 5156/H13, 4 larvae, 10.xi.2010, GNBR, East West Road, Govind Nagar, a stream on nature trail ½ km away from forest check post, 7.002^{0}N & 93.528^{0}E, 106m, coll. E. Eyarin Jehamalar; 5157/H13, 1 larva, 06.xi.2010, GNBR, East West Road, Govind Nagar, 12th km, 7.001^{0}N & 93.528^{0}E,

Image 1. *C.* (*Choroterpes*) *kaegies* Selvakumar, Subramanian & Chandra, 2017; Image 2. *C.* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003; Image 3. *C.* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017; Image 4. *C.* (*Dilatognathus*) *nigella* (Kang & Yang 1994)

83 m, coll. E. Eyarin Jehamalar.

Diagnosis: This species can be distinguished from all other species by the structure of the maxillary apex which lacks a tusk, with well-developed ventro-apical flange and dentiseta directed distally (Selvakumar et al. 2017a).

Distribution: Andaman and Nicobar Islands.

Status: Endemic to Andaman and Nicobar Islands.

Remarks: Adult stage is unknown.

5. *Choroterpes* (*Dilatognathus*) *nigella* (Kang & Yang, 1994) (Image 4)

Material examined: 7367/H13, 3 larvae, 21.iv.2015, Arunachal Pradesh, Lower Subansiri District, Ranga River, 27.396^{0}N, 93.757^{0}E, 625 m, colls. K.A. Subramanian & B. Sinha; 7372/H13, 10 larvae, 23.iii.2013, West Bengal, Darjeeling (Sikkim border), Rishikhola, Rishi River, 27.169^{0}N, 88.635^{0}E, 554m, coll. Srimoyee Basu; 7368/H13, 5 larvae, 3.ii.2007, Meghalaya, Jaintia Hills district, Wah Malidar, Malidar Village, colls. J. Lyngdoh & Party.

Diagnosis: This species can be distinguished from all other species by (i) the labrum with deep median emargination and (ii) sharp semicircular impression on the dorsal surface (Kang & Yang 1994).

Distribution: India, Thailand, Hainan and Taiwan Islands.

Status: Oriental distribution.

Remarks: Larva and adult are known.

Subgenus: *Euthraulus* Barnard, 1932

Diagnosis: This subgenus *Choroterpes* can be differentiated from other subgenera by the following combination of characters: in the larvae (i) gills 2–6 bear three narrow filaments on the apex of each lamina and indistinguishable characters in the adults between subgenera.

6. *Choroterpes* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009 (Image 5)

Material examined: MCDZ/E-5, 6 larvae, 11.viii.2013, Tamilnadu, Tirunelveli, Alwarkurichi, Ramanathi river, 08.470^{0}N & 77.240^{0}E, 109 m, coll. C. Selvakumar; MCDZ/E-6, 18 larvae, 12.vii.2009, Gadana river at Alwarkurichi, 08.461^{0}N & 77.235^{0}E, 69m, coll. C. Selvakumar; MCDZ/E-7, 8 larvae, 04.vii.2009, Tamiraparani River, Papanasam, 08.423^{0}N, 77.220^{0}E, 108m, coll. C. Selvakumar; MCDZ/E-8, 4 larvae, 04.vii.2009, Tamiraparani River at Kallidaikurichi, 08.413^{0}N, 77.273^{0}E, 105m, coll. C. Selvakumar; MCDZ/E-9, 5 larvae, 28.iii.2015, Virudhunagar, Srivilliputhur, Shenpagathoppu stream, 08.362^{0}N & 77.145^{0}E, 1,435m, coll. C. Selvakumar; MCDZ/E-10, 3 larvae, 29.vii.2012, Dindigul, Kodaikanal, Manjalaru river, Moolaiyaru, 10.141^{0}N & 77.291^{0}E, 1,216m, coll. C. Selvakumar.

Diagnosis: This species can be distinguished from other species by the following combination of characters. In the larvae: (i) labrum anteromedian emargination well broad and 'U' shaped; (ii) mandibles with outer margin slightly angled a tuft of setae at angle; and (3) apical, median and basal part of femora with dark brown spots. In the imagoes: (i) hind wing dark brown marking on nodus; (ii) forceps and penes yellow and (iii) penis lobes short (Dinakaran et al. 2009).

Distribution: Eastern and Western Ghats.

Status: Endemic to the Eastern and Western Ghats.

Remarks: Larva and adult are known.

7. *Choroterpes* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013 (Image 6)

Material examined: MCDZ/E-11, 4 larvae, 22.ii.2010, Tamil Nadu, Tirunelveli, Nambiyar river at Checkpost, 08.262^{0}N & 77.313^{0}E, 227m, coll. C. Selvakumar; MCDZ/E-12, 6 larvae, 11.vii.2009, Tamil Nadu, Tirunelveli, Ramanathi, above dam, 08.848^{0}N & 77.314^{0}E, 237m, coll. C. Selvakumar; MCDZ/E-13, 8 larvae, 20.vii.2013, Tamil Nadu, Tirunelveli, Gadana River, above dam (Kallar), 08.480^{0}N & 77.180^{0}E, 144m, coll. C. Selvakumar; MCDZ/E-14, 5 larvae, 17.vii.2013, Tamil Nadu, Tirunelveli, Gundar, Kannupullimettu, 08.562^{0}N & 77.122^{0}E, 164m, coll. C. Selvakumar; MCDZ/E-15, 7 larvae, 28.ix.2013, Tamil Nadu, Dindigul, Kodaikanal, Moolaiyar, 10.050^{0}N & 77.145^{0}E, 1,216m, coll. C. Selvakumar; MCDZ/E-16, 5 larvae, 02.v.2013, Karnataka, Agumbe, Jogigudi falls, 13.295^{0}N & 75.061^{0}E, 514 m, coll. C. Selvakumar.

Diagnosis: This species can be identified by the following combination of characters: In the larvae (i) anteromedian emargination of labrum comparatively narrow and deeply cleft ('V' shaped), lateral margin broadly acute; (ii) mandibles with outer margin comparatively deeply angled with a tuft of setae at angle; apical and median dark brown dark brown maculae at femora and (iii) dorsal and ventral lamellae plate-like narrow and terminated in three slender subequal process, tracheae unbranched (Selvakumar et al. 2013).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: Adult stage is unknown.

8. *Choroterpes* (*Euthraulus*) *parvula* (Gillies, 1951)

Material examined: 5480/H13, 1 male imago, 2 male subimagoes and 2 female subimagoes, 29.iii.2014,

Chhattisgarh, Kabirdham District, Bhoramdeo Wildlife Sanctuary, Sakri River, Chapri, 22.054^{0}N & 81.074^{0}E, 444m, colls. E. E. Jehamalar & Party; 5470/H13, 10 male subimagoes, 6 female subimagoes, 25.iii.2014, Chhattisgarh, Korba District, Lemru, 22.384^{0}N & 82.483^{0}E, 383m, colls. E. E. Jehamalar & Party.

Diagnosis: *Choroterpes* (*Euthraulus*) *parvula* (Gillies, 1951) can be distinguished from other species by the following combination of characters: In imago (i) foreceps base not divided, but extended to cover base of penes in a gently rounded curve; forceps stout, four segmented, jointed, basal broad and rounded, second long and curved, arising from the outer half of the basal, third segment incompletely divided from preceding, fourth segment thick and elongate; (ii) penes simple, without appendages, skittle-shaped, continuous at the base, separated apically; and (iii) ninth sternum of female with subanal plate well developed and with a very slight apical notch (Gillies 1951).

Distribution: Chhattisgarh and Madhya Pradesh.

Status: Endemic to India.

Remarks: Larva is unknown.

Subgenus: *Monochoroterpes* Kluge & Jacobus, 2015

This subgenus *Choroterpes* can be differentiated from other subgenera by the following combination of characters: in the larvae (i) gills 1–7 unilamellate, terminated in three processes with slender, subequal processes.

9. *Choroterpes* (*Monochoroterpes*) *nandini* Selvakumar & Sivaramakrishnan, 2015 (Image 7)

Material examined: MCDZ/E-17, 1 male and 1 female larvae, 03.v.2013, Karnataka, Sringeri, Nanthini hole, 13.232^{0}N & 75.104^{0}E, 640m, colls. C. Selvakumar & K.G. Sivaramakrishnan; MCDZ/E-18, 2 female larvae, 03.v.2013; Sringeri, Srimane falls, 13.231^{0}N & 75.104^{0}E, 716m, colls. C. Selvakumar & K. G. Sivaramakrishnan.

Diagnosis: *Choroterpes* (*Monochoroterpes*) *nandini* can be distinguished from *C.* (*Monochoroterpes*) *monophyllus* by the following combination of characters: (i) median emargination of labrum moderately deep, without denticles; (ii) gills 2–7 without tracheation and (iii) abdominal segment 6 and 7 without colour pattern (Selvakumar et al. 2015).

Distribution: Karnataka part of the Western Ghats.

Status: Endemic to the Western Ghats.

Remarks: Adult is unknown.

Genus: *Edmundsula* Sivaramakrishnan, 1985

Type species: *Edmundsula lotica* Sivaramakrishnan, 1985

Diagnosis: This genus can be distinguished from other genera of Leptophlebiidae by the following combination characters: In adults: (i) fork of MP and fork of Icu_1 from CuA in the forewings occur about 1/3 of the

Image 5. C. (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009; Image 6. C. (*Euthraulus*) *nambiyarensis* Selva-Kumar, Arunachalam & Sivaramakrishnan, 2013; Image 7. *C.* (*Monochoroterpes*) *nandini* Selvakumar & Sivaramakrishnan, 2015 Image 8. *Edmundsula lotica* Sivaramakrishnan, 1985

distance from the base of wings to margin; both forks symmetrical; (ii) costal margin of hind wings possesses a blunt costal projection; apex of costal projection located less than ½ distance from base of wings; (iii) claws of a pair dissimilar, one apically hooked, the other obtuse, pad-like; (iv) penes divided, tubular, broader at base and tapering towards apex; apex of each penis lobe curved ventrally and (v) ninth sternum of female cleft apically. In larvae: (i) gills present on abdominal segments 1–7; (ii) dorsal and ventral portions of lamellae of gill 1 slender and lanceolate with few tracheae; (iii) dorsal and ventral portion of lamellae of gills 2–7 lanceolate, long, and smoothly tapered near apex; (iv) segment 3 of labial palpi with a row of short heavy spines on inner dorsal margin; (v) denticles on claws progressively larger apically, apical denticle much larger and (vi) posterolateral spines occur on abdominal segments 4–9, spines progressively larger posteriorly, apices of spines on segments 8–9 sharp (Sivaramakrishnan, 1985).

Distribution: Tamil Nadu and Karnataka.

Status: Endemic to the Western Ghats.

Remarks: The genus was established for the single species, *Edmundsula lotica* Sivaramakrishnan, 1985.

10. *Edmundsula lotica* Sivaramakrishnan, 1985
(Image 8)

Material examined: MCDZ/E-19, 3 larvae, 19.ix.2009, Tamil Nadu, Tirunelveli, Tamiraparani river, Vanathertham falls, 08.625^{0}N & 77.311^{0}E, 263m, coll. C. Selvakumar; MCDZ/E-20, 1 larva, 06.xi.2012, Tamil Nadu, Tirunelveli, Nambiyar river, Nambikovil, 08.260^{0}N & 77.295^{0}E, 412 m, coll. C. Selvakumar; MCDZ/E-21, 2 larvae, 03.v.2013, Karnataka, Sringeri, Nanthinihole, 13.232^{0}N & 75.104^{0}E, 640 m, coll. C. Selvakumar.

Diagnosis: *Edmundsula lotica* can be distinguished by the following combination of characters: In adults: (i) fork of MP and fork of Icu_1 from CuA in the forewings occur about 1/3 of the distance from the base of wings to margin; both forks symmetrical; (ii) costal margin of hind wings possesses a blunt costal projection; apex of costal projection located less than ½ distance from base of wings; (iii) claws of a pair dissimilar, one apically hooked, the other obtuse, padlike; (iv) penes divided, tubular, broader at base and tapering towards apex; apex of each penis lobe curved ventrally and (v) ninth sternum of female cleft apically. In larvae: (i) gills present on abdominal segments 1–7; (ii) dorsal and ventral portions of lamellae of gill 1 slender and lanceolate with few tracheae; (iii) dorsal and ventral portion of lamellae of gills 2–7 lanceolate, long, and smoothly tapered near apex; (iv) segment 3 of labial palpi with a row of short heavy spines on inner dorsal margin; (v) denticles on claws progressively larger apically, apical denticle much larger and (vi) posterolateral spines occur on abdominal segments 4–9, spines progressively larger posteriorly, apices of spines on segments 8–9 sharp (Sivaramakrishnan 1985).

Distribution: Tamil Nadu and Karnataka.

Status: Endemic to the Western Ghats.

Remarks: Occurs in the some part of the Western Ghats.

Genus: *Indialis* Peters & Edmunds, 1970

Type species: *Indialis badia* Peters and Edmunds, 1970

Diagnosis: This genus can be differentiated from all other Leptophlebiid genera by the following combination of larval characters: In the larvae (i) abdominal gills 1–7 alike and slender with tracheae branched; (ii) a large tooth-like projection present on inner anterior margin of the maxillae; (iii) tarsal claws hooked, with a row of denticles that progressively larger apically and (iv) five denticles present on anteromedian emargination of labrum. In the adults: (i) more than two intercalaries in cubital area of forewings; (ii) vein of MP forked less than 1/2 of distance from base to margin and (iii) apex of each penis lobe bulbous and reduced tip, outer margin of apical half each penis lobe without a row of spinules (Peters & Edmunds 1970).

Distribution: Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

Status: Endemic to southern India.

Remarks: Peters and Edmunds (1970) established *Indialis* for the species *I. badia* based on one male subimago and forty nine larvae collected by W.L. Peters and J.G. Peters in Kerala and Andhra Pradesh states of India. Sivaramakrishnan (1985a) described the female imago and egg structure of *I. badia* from the Tamiraparani River, southern Western Ghats. Peters (1975) described *I. rossi* from a male imago from Kerala state.

11. *Indialis badia* Peters & Edmunds, 1970 (Image 9)

Material examined: MCDZ/E-22, 4 larvae, 04.vii.2009, Tamiraparani river, Papanasam, 08.423^{0}N & 77.220^{0}E, 108m, coll. C. Selvakumar; MCDZ/E-23, 20 larvae, 04.vii.2009, Tamiraparani River at Kallidaikurichi, 08.413^{0}N & 77.273^{0}E, 105m, coll. C. Selvakumar; MCDZ/E-24, 2 larvae, 28.09.2013, Kodaikanal, Moolaiyar, 10.050^{0}N & 77.145^{0}E, 1,216m, coll. C. Selvakumar; MCDZ/E-25, 1 larva, 09.xi.2013, Andhra Pradesh, Chittoor district, Tada falls, 13.602^{0}N & 79.845^{0}E, 100m, coll. C. Selvakumar; MCDZ/E-26, 1 larva, 03.v.2013,

Karnataka, Sringeri, Nanthinihole, 13.232^{0}N & 75.104^{0}E, 640m, coll. C. Selvakumar.

Diagnosis: This species can be identified by following combination of characters: In the larvae (i) third segment of the labial palp without a row of spine on the inner dorsal margin; rather sparse or scattered setae on the outer margin the mandibles; (ii) posterolateral spines on abdominal segments 5–9; (iii) denticles on dorsal claws increase in size apically; (iv) tip of the dorsal claw strongly hooked and (v) trachea of gills branched. In the adults (i) MP forked more basally than the fork of vein Rs; (ii) Cu-A area of fore wings narrower and less developed than *I. rossi* and (iii) costal projection of hind wings narrower than *I. rossi* (Peters & Edmunds 1970).

Distribution: Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

Status: Endemic to southern India.

Remarks: Egg, larva and adults are known to this species.

12. *Indialis rossi* Peters, 1975

Material reported: California Academy of Science, 1 male imago, 22.iii.1962, Kerala, Kottayam District, Kittikanam, near Peermade, 1,000m, colls. E.S. Ross & D.Q. Cavagnaro.

Diagnosis: This species can be distinguished from *I. badia* by the following combination of characters: In the adults (i) all cross veins in forewings surrounded with narrow, yellowish-brown clouds; (ii) abdominal segments 1-7 translucent and washed with brown; (iii) caudal filaments pale, with wide, dark brown annulations at articulations and (iv) costal projection of hind wings well developed and broadly rounded at apex (Peters 1975).

Distribution: Kerala.

Status: Endemic to the Western Ghats.

Remarks: Diagnostic characters are provided based on original description by Peters 1975. Larval stage is unknown.

Genus: *Isca* Gillies, 1951

Type species: *Isca* (*Isca*) *purpurea* Gillies, 1951

Diagnosis: This genus can be differentiated from all other leptophlebiid genera by the following combination of characters. In the imago, (i) hind wings absent; (ii) cross veins absent in basal 1/2 of cell C in forewings; (iii) tarsal claws dissimilar; and (iv) segments 2 and 3 of male genital forceps short. In the larvae, (i) abdominal segments extend around to venter of abdomen; (ii) dorsal and ventral portion of abdominal gills 2-6 slender and tracheae unbranched; gill 7 consists of 1 slender lamella and tracheae unbranched; (iii) claws apically hooked, and with a row of denticles; apical denticle larger; and (iv) small posterolateral spinas present on abdominal segments 7–9, and spines progressively

Image 9. *Indialis badia* Peters & Edmunds, 1970; Image 10. *Isca* (*Isca*) *purpurea* Gillies, 1951; Image 11. *Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016; Image 12. *Nathanella indica* Demoulin, 1955; Image 13. *Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996

larger posteriorly (Peters & Edmunds 1970).

Distribution: Hong Kong, India, Sri Lanka and Thailand.

Status: Oriental distribution.

Remarks: Gillies (1951) established the genus *Isca* from male and female imagoes of *I. purpurea* that collected in Hong Kong and India. Larva of *Isca* was described by Peters & Edmunds (1970) and two new species of *Isca* also described. Larvae of these two species were congeneric with those of *I. purpurea*. However, the adults are so morphologically distinct from *I. purpurea* and each other that two new subgenera viz., *Minyphlebia* Peters & Edmunds, 1970 and *Tanycola* Peters & Edmunds, 1970 were established for these species by Peters & Edmunds (1970).

Subgenus *Isca* s.s. Gillies, 1951

Diagnosis: This subgenus can be differentiated from all other leptophlebiid genera by the following combination of characters: (i) vein MA forked a little more than 1/2 of distance from base to margin, fork asymmetrical; cilia present along posterior margin of wings; (ii) abdominal terga extend around onto venter of abdomen, this most marked on segment 7 but scarcely at all on segments 1 and 2; (iii) penes divided, tubular, broad, apex of each penis lobe curved inwardly and ventrally; (iv) ninth sternum of female apically cleft.

13. *Isca* (*Isca*) *purpurea* Gillies, 1951 (Image 10)

Material examined: MCDZ/E-27, 2 larvae, 19.ix.2009, Tamil Nadu, Tirunelveli, Tamiraparani river, Vanathertham falls, 08.625^{0}N & 77.311^{0}E, 263m, coll. C. Selvakumar; MCDZ/E-28, 4 larvae, 06.xi.2012, Nambiyar river, Nambikovil, 08.260^{0}N & 77.295^{0}E, 412m, coll. C. Selvakumar; MCDZ/E-29, 1 larva, 31.iii.2012, Kodaikanal, Gundar, 10.133^{0}N & 77.270^{0}E, 2,323m, coll. C. Selvakumar; MCDZ/E-30, 4 larvae, 09.xi.2013, Andhra Pradesh, Chittoor District, Tada falls, 13.602^{0}N & 79.845^{0}E, 100m, coll. C. Selvakumar; MCDZ/E-31, 1 larva, 03.v.2013, Karnataka, Srimanae falls, 13.231^{0}N & 75.104^{0}E, 716m, coll. C. Selvakumar; MCDZ/E-32, 1 larva, 03.v.2013, Karnataka, Nandini hole, 13.232^{0}N & 77.104^{0}E, 640m, coll. C. Selvakumar.

Diagnosis: This species can be differentiated from all other leptophlebiid genera by the following combination of characters. In the imago (i) hind wings absent; (ii) cross veins absent in basal 1/2 of cell C in forewings; (iii) tarsal claws dissimilar; and (iv) segments 2 and 3 of male genital forceps short. In the larvae (i) abdominal segments extend around to venter of abdomen; (ii) dorsal and ventral portion of abdominal gills 2-6 slender and tracheae unbranched; gill 7 consists of 1 slender lamella and tracheae unbranched; (iii) claws apically hooked, and with a row of denticles; apical denticle larger; and (iv) small posterolateral spinas present on abdominal segments 7–9, and spines progressively larger posteriorly (Gillies 1951).

Distribution: India (Andhra Pradesh, Karnataka, Tamil Nadu and West Bengal) and Hong Kong.

Status: Oriental distribution.

Remarks: Larva and adult stages are known.

Genus: *Klugephlebia* Selvakumar, Subramanian & Sivaramakrishnan, 2016

Type species: *Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016

Diagnosis: This genus can be differentiated from all other genera of Atalophlebiinae by the following combination of characters: In the imago: (i) vein MP forked slightly less than half of distance from base to margin, MP2 attached at base to vein MP1 by a crossvein; (ii) costal margin of hindwings with bluntly convex projection; apex of costal projection located less than half distance from base; (iii) claws of a pair dissimilar, one apically hooked, the other obtuse, pad-like and (iv) segments 2 and 3 of forceps short, apex of segment 3 rounded, base of forceps broad, inner margin forming a smooth bend near middle of forceps; penis divided, tubular, broader at base and tapering towards apex. In the larvae: (i) gills present on abdominal segments 1–7; dorsal and ventral portions of lamellae of gill 1 slender and lanceolate with branched tracheae, dorsal and ventral portions of lamellae of gills 2–7 wider and lanceolate, long and suddenly tapering at apex; (ii) fore and mid femora with a regular row of long, thin setae on outer margin; denticles on claws progressively larger apically; (iii) length of the labrum more than half of the width, lateral lobes rounded, anteriomedian emargination deeply cleft, apparently with two denticles; proximal transverse setal row laterally curved distally; (iv) maxillary palp short, with long setae on third segment and third segment of labial palp with 5–6 thick, spine-like setae on dorsal surface, inner and outer margins with short, thin setae (Selvakumar et al. 2016).

Distribution: Known only from type locality Kodaikanal, Palni Hills (Tamil Nadu).

Status: Endemic to the Western Ghats.

Remarks: The genus was established for the single species, *Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016.

14. *Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016 (Image 11)

Material examined: ZSI/SRC-I/E 16-18, 3 imagoes and 5 larvae, 01.ii.2015, Tamil Nadu, Dindigul, Kodaikanal, Pillar Rock stream, 10.123^{0}N & 77.275^{0}E, 2,185m, colls. C. Selvakumar & T. Sivaruban.

Diagnosis: This species can be differentiated from all other genera of Atalophlebiinae by the following combination of characters: In the imago: (i) vein MP forked slightly less than half of distance from base to margin, MP2 attached at base to vein MP1 by a crossvein; (ii) costal margin of hindwings with bluntly convex projection; apex of costal projection located less than half distance from base; (iii) claws of a pair dissimilar, one apically hooked, the other obtuse, pad-like and (iv) segments 2 and 3 of forceps short, apex of segment 3 rounded, base of forceps broad, inner margin forming a smooth bend near middle of forceps; penis divided, tubular, broader at base and tapering towards apex. In the larvae: (i) gills present on abdominal segments 1–7; dorsal and ventral portions of lamellae of gill 1 slender and lanceolate with branched tracheae, dorsal and ventral portions of lamellae of gills 2–7 wider and lanceolate, long and suddenly tapering at apex; (ii) fore and mid femora with a regular row of long, thin setae on outer margin; denticles on claws progressively larger apically; (iii) length of the labrum more than half of the width, lateral lobes rounded, anteriomedian emargination deeply cleft, apparently with 2 denticles; proximal transverse setal row laterally curved distally; (iv) maxillary palp short, with long setae on third segment and third segment of labial palp with 5–6 thick, spine-like setae on dorsal surface, inner and outer margins with short, thin setae (Selvakumar *et al.*, 2016).

Distribution: Known only from Palni Hills (Tamil Nadu).

Status: Endemic to the Western Ghats.

Remarks: The species was described both larva and adult.

Genus *Nathanella* Demoulin, 1955

Type species: *Nathanella indica* Demoulin, 1955

Diagnosis: This genus can be distinguished from all other genera by the following combination of characters: In the larvae (i) abdominal gills present on segments 1–7, and dorsal and ventral portions of lamellae leaf-like and apicaly terminated three projections, median longer than laterals; (ii) outer margin of mandibles smoothly curved basally and straight apically with a row of hair in the apical half; (iii) anteromedian margin of labrum straight with 5 broad-based denticles and (iv) lateral margins of the head capsule broadly expanded. In the adults (i) hind wings absent; (ii) vein MP_2 of fore wings attached at base to vein MP_1 and CuA by a cross vein, and attachment of vein MP_2 to MP_1 greater than1/4 to 1/3 distance from base to margin; (iii) penes divided, straight with apex expanded dorsally and (iv) claw similar (Peters & Edmunds 1970).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: Demoulin (1955) established *Nathanella* for a distinctive species, *N. indica* known only from male imagoes collected in southern India. Sivaramakrishnan et al. (1996) described female imago and larvae of *N. indica* and male and female imagoes and larvae of *N. saraswathiae* from Kerala border, near Bodi Mettu.

15. *Nathanella indica* Demoulin, 1955 (Image 12)

Material examined: MCDZ/E-33, 2 larvae, 28.ix.2013, Tamil Nadu, Kodaikanal, Perumalmalai, 10.161^{0}N & 77.331^{0}E, 1,484m, coll. C. Selvakumar.

Diagnosis: This species can be distinguished from *N. saraswathiae* by the following combination characters: In the larvae: (i) median projection of abdominal gills broad and approximately twice length of laterals; (ii) tracheation in gills uniformly distributed; and (iii) distal, irregular light brown maculae on femora of legs. In the adults: (i) membrane of fore wing golden brown, cross veins in cells C and Sc narrowly clouded with brown; (ii) abdominal terga 3–7 of male brown except irregularly pale apically; and (iii) dorsal margin of styliger plate of male broadly convex (Demoulin, 1955).

Distribution: Known only from Palni Hills (Tamil Nadu).

Status: Endemic to the Western Ghats.

Remarks: Male imago was described by Demoulin (1955). Female imago and larva were described by Sivaramakrishnan et al. (1996).

16. *Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996 (Image 13)

Material examined: MCDZ/E-34, 4 larvae, 06.xi.2012, Tamil Nadu, Nambiyar river, Nambikovil, 08.260^{0}N & 77.295^{0}E, 386 m, coll. C. Selvakumar; MCDZ/E-35, 4 larvae, 10.v.2014, Kerala, Silent Valley, tributary of Kunthipuzha river, 11.274^{0}N & 76.456^{0}E, 923m, coll. C. Selvakumar.

Diagnosis: This species be identified by the following combination of characters: In the larvae (i) median projection of abdominal gills narrow and approximately 1-1/2 length of laterals; (ii) main trunk of tracheae of gills forked near distal half of lamellae and (iii) medial

and distal, irregular black maculae on femora of legs. In the adults (i) membrane of fore wing hyaline with weak brown tint, veins in forewing broadly clouded with dark brown; (ii) maculae on male abdominal terga 3–7 and (iii) dorsal margin of styliger plate of male convex with a median shallow depression (Sivaramakrishnan et al. 1996).

Distribution: Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: This species is found above 1,400m in very small, well-shaded, intermittent streams.

Genus: *Notophlebia* Peters & Edmunds, 1970

Type species: *Notophlebia hyalina* Peters & Edmunds, 1970

Diagnosis: This genus can be distinguished from other genera of this family by following combination of characters: In the larvae: (i) both distal and proximal transverse setal rows regular; (ii) gills present on abdominal segments 1–6; and (iii) apical denticle on the tarsal claws greatly enlarged. In the adults: (i) hind wings absent; (ii) MP of forewing without symmetric fork and (iii) apically each penis lobe bears a slender pointed serrate projection (Peters & Edmunds 1970).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: This genus was established for the species *Notophlebia hyaline* Peters & Edmunds (1970) from Tamil Nadu. Only three species viz., *N. hyaline*, *N. ganeshi* and *N. jobi* are described in this genus from India.

17. *Notophlebia ganeshi* Kluge, 2014 (Image 14)

Material examined: MCDZ/E-36, 2 larvae, 10.v.2014, Kerala, Silent Valley, tributary of Kunthipuzha River, 11.274^{0}N & 76.456^{0}E, 923m, coll. C. Selvakumar; MCDZ/E-37, 1 larva, 03.v.2013, Karnataka, Sringeri, Srimane falls, 13.231^{0}N & 75.104^{0}E, 716m, coll. C. Selvakumar.

Diagnosis: This species can be identified by the following combination of characters: In the larvae (i) abdominal gills narrower; (ii) third segment of maxillary palp with moderately long, slender setae, situated densely and irregularly and (iii) third segment of labial palp with moderately long filtering setae on dorsal side and directed apically-inward. In the adults (i) apically each penis lobe bears a slender pointed serrate projection straight, lobe forms convexity laterally with a small sharp incision medially (Kluge 2014).

Distribution: Karnataka and Kerala.

Status: Endemic to the Western Ghats.

Remarks: The larva of this species has non-dilatognathan mouth apparatuses.

18. *Notophlebia hyalina* Peters & Edmunds, 1970

Material reported: Florida A & M University, 1 male imago, 02.i.1962, Tamil Nadu, Kanyakumari, Kunjankhuzi,

Image 14. *Notophlebia ganeshi* Kluge, 2014; Image 15. *Notophlebia jobi* Sivaramakrishnan & Peters, 1984; Image 16. *Petersula courtallensis* Sivaramakrishnan, 1984; Image 17. *Thraulus gopalani* Grant & Sivaramakrishnan, 1985

120m, coll. F. Schmid.

Diagnosis: This species can be distinguished by the following combination of characters: In the adult (i) cilia occur on posterior margin of fore wings; (ii) membrane of anal area of fore wings enlarged posteriorly; and (iii) penes of male genitalia tubular, straight, and pointed (Peters & Edmunds 1970).

Distribution: Known only from the type locality Kunjankhuzi, Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: Diagnostic characters are provided based on the original description. Larva is unknown.

19. *Notophlebia jobi* Sivaramakrishnan & Peters, 1984 (Image 15)

Material examined: MCDZ/E-38, 3 larvae, 20.vii.2013, Tamil Nadu, Tirunelveli, Gadana River, Kallar (above dam), 08.480^{0}N & 77.180^{0}E, 144m, coll. C. Selvakumar; MCDZ/E-39, 4 larvae, 11.vii.2009, Tirunelveli, Ramanathi, above dam, 08.848^{0}N & 77.314^{0}E, 237m, coll. C. Selvakumar; MCDZ/E-40, 1 larva, 17.vii.2013, Gundar, Kannupullimettu, 08.562^{0}N & 77.122^{0}E, 164m, coll. C. Selvakumar; MCDZ/E-41, 1 larva, 03.xi.2013, Shengottai, Adavinayinar, above dam, 09.045^{0}N & 77.135^{0}E, 273m, coll. C. Selvakumar; MCDZ/E-42, 4 larvae, 21.i.2010, Theni, Kurangani stream, 10.050^{0}N & 77.145^{0}E, 1,744m, coll. C. Selvakumar; MCDZ/E-43, 10 larvae, 18.iv.2013, Kerala, Silent Valley National Park, Poochipara, 11.064^{0}N & 76.255^{0}E, 935m, coll. Jobin C. Tharian; MCDZ/E-44, 4 larvae, 03.v.2013, Karnataka, Sringeri, Srimane falls, 13.231^{0}N & 75.104^{0}E, 716m, coll. C. Selvakumar.

Diagnosis: This species can be identified by following combination of characters: In the larvae (i) gills not narrower; (ii) third segment of maxillary palp with very long stout pointed setae directed apically and forming nearly regular rows; (iii) third segment of labial palp with long pointed setae on outer side, dorsal side also with long setae. In the adults (i) apically each penis lobe bears a slender pointed serrate projection curved (Sivaramakrishnan & Peters 1984).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: The larva of this species has a highly specialized mouth apparatus of the Dilatognathus-type. This type of mouth apparatus has evolved independently in several non-related leptophlebiid taxa.

Genus: *Petersula* Sivaramakrishnan, 1984

Type species: *Petersula courtallensis* Sivaramakrishnan, 1984

Diagnosis: This genus can be distinguished from other genera by the following combination of characters: In the larvae: (i) labrum expanded and angled laterally; (ii) anterior margin of lingua of hypopharynx deeply cleft; apex of submedian lobes of lingua possesses a rack like process; (iii) outer margin of basal ½ of mandibles smoothly curved, while apical ½ almost straight; a row of hairs extends from mid outer margin almost to base of incisors; (iv) abdominal gills occur on segments 1–7 and are plate-like with margins unevenly fringed with broad filamentous processes and (v) posterolateral spines occur on abdominal segments 3–9 and progressively larger posteriorly. In the adults: (i) vein MP_2 of fore wings attached at base to vein MP_1 more than 1/3 of the distance from base to margin; (ii) costal margin of hind wings convex or with a rounded costal projection; (iii) each penis lobe with ventromedially directed spine-like projection near apex; (iv) claws of a pair alike, apically hooked with an opposing hook and (v) 9th sternum of female shallowly cleft apically (Sivaramakrishnan 1984).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: The genus *Petersula* was established for *P. courtrallensis* from the southern Western Ghats by Sivaramakrishnan 1984. A second species, *P. nathani* described based on adult from the Anamalai hills of southern Western Ghats (Sivaramakrishnan & Hubbard 1984). The genus is widespread in the Western Ghats.

20. *Petersula courtallensis* Sivaramakrishnan, 1984 (Image 16)

Material examined: MCDZ/E-45, 2 larvae, 20.vii.2013, Tamil Nadu, Tirunelveli, Gadana river, Kallar, 08.48045°N & 77.18053°E, 144 m, coll. C. Selvakumar; MCDZ/E-46, 4 larvae, 19.ix.2009, Tamiraparani River, Vanaththertham falls, 08.625^{0}N & 77.311^{0}E, 263m, coll. C. Selvakumar; MCDZ/E-47, 3 larvae, 17.vii.2013, Tirunelveli, Kannupullimettu stream, 08.562^{0}N & 77.122^{0}E, 164m, coll. C. Selvakumar; MCDZ/E-48, 5 larvae, 28.ix.2013, Kodaikanal, Perumalmalai stream, 10.161^{0}N & 77.331^{0}E, 1,484m, coll. C. Selvakumar; MCDZ/E-49, 4 larvae, 18.iv.2013, Kerala, Silent Valley National Park, Poochipara, 11.064^{0}N & 76.255^{0}E, 935m, coll. Jobin C. Tharian; MCDZ/E-50, 1 larva, 03.v.2013, Karnataka, Sringeri, Nanthinihole, 13.232^{0}N & 75.104^{0}E, 640m, coll. C. Selvakumar.

Diagnosis: This species can be identified by following combination characters: In the larvae (i) labrum expanded and angled laterally; (ii) anterior margin of lingua of hypopharynx deeply cleft; apex of submedian lobes of lingua possesses a racklike process; (iii) outer margin of basal ½ of mandibles smoothly curved, apical

½ almost straight; a row of hairs extended from mid outer margin almost to base of incisors; (iv) abdominal gills occur on segments 1–7 and plate-like with margins unevenly fringed with broad filamentous processes and (v) posterolateral spines occur on abdominal segments 3–9 and progressively larger posteriorly. In adults (i) vein MP_2 of fore wings attached at base to vein MP_1 more than 1/3 of the distance from base to margin; (ii) costal margin of hind wings convex or with a rounded costal projection; (iii) each penis lobe ventromedially directed spine-like projection near apex; (iv) claws of a pair alike, apically hooked with an opposing hook and (v) 9th sternum of female shallowly cleft apically (Sivaramakrishnan 1984).

Distribution: Karnataka, Kerala and Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: This species is wide distribution and abundant in the Western Ghats.

21. *Petersula nathani* Sivaramakrishnan & Hubbard, 1984

Material reported: Bernice P. Bishop Museum, 1 male imago, 02.v.1963, Tamil Nadu, Coimbatore, Kadamparai, 1,070m, coll. P.S. Nathan.

Diagnosis: This species can be distinguished from the only other species in the genus, *P. courtallensis* by the following characters: In imago: (i) terga 1–7 translucent yellowish brown and washed with brown; terga 8–10 opaque brown; (ii) paired longitudinal, submedian lines present on terga 3–5; (iii) vein MP_2 of fore wings attached at base only to vein MP_1 with a crossvein and (iv) length of spinelike projection arising from near apex of each penis lobe nearly 1/3 length of penis (Sivaramakrishnan & Hubbard 1984).

Distribution: Known only from type locality, Anamalai Hills (Tamil Nadu).

Status: Endemic to the Western Ghats.

Remarks: Diagnostic characters are provided based on the original description. Larva is unknown.

Genus: *Thraulodes* Ulmer, 1920

Remarks: The genus *Thraulodes* Ulmer, 1920 is known only from the New World and hence the species, *Thraulodes marhieus* Dubey, 1970 probably misplaced at the generic level (Hubbard & Peters 1978).

22. *Thraulodes marhieus* Dubey, 1970

Material reported: 986/56, 1 female imago, 17.vi.1956, Himachal Pradesh, Pir Panjal Range, Marhi, 3,880m, coll. Santokh singh.

Diagnosis: This species can be identified by the following combination of characters: in the imago (i) claws dissimilar; (ii) forewing hyaline, veins dark brown; (iii) hindwing hyaline, costal process obtusely pointed; and (iv) ovipositor yellowish-brown, two-segmented, first segment wider basally than apically, length one and one-fourth times its width (Dubey, 1970).

Distribution: Known only from the type locality, Marhi (Himachal Pradesh).

Status: Endemic to the Himalaya.

Remarks: Diagnostic characters are provided based on the original description. Larva is unknown.

Genus: *Thraulus* Eaton, 1881

Type species: *Thraulus bellus* Eaton, 1881

Diagnosis: The genus can be differentiated from all other genera of the Leptophlebiidae by the following combination of characters. In the imago, (i) fork of vein MP of fore wings is closer to base of wings than fork of vein Rs; (ii) 2 intercalaries occur in cubital area of fore wings; (iii) penes tubular, divided and simple; and (iv) costal projection of hind wings acute and well developed, except for the costal projection of *T. bellus* which is more rounded. In the nymph, (i) dorsal and ventral portions of abdominal gills 2–7 ovate with fringed margins; (ii) dorsal and ventral portions of abdominal gills 1 slender, lanceolate, or ovate with fringed margins, or dorsal portion slender, lanceolate and ventral portion ovate with fringed margins; (iii) lateral tips of superlingua of hypopharynx emarginated; and (iv) tarsal claws hooked and narrow and with a row of denticles that are progressively larger apically (Peters & Edmunds 1970).

Distribution: Oriental, Afrotropical and Palearctic.

Status: Wide distribution.

Remarks: Presently, this genus encompasses 15 valid species, of which three are from Palearctic, three from Afrotropical and nine from Oriental realms (Barber-James et al. 2013). In India, the genus *Thraulus* Eaton, 1881 has 3 species viz., *T. gopalani* Grant & Sivaramakrishnan, 1985 described from both imago and larvae, *T. mudumalaiensis* Soman, 1991 described only from larvae and *T. semicastaneus* (Gillies, 1951) described only from imago.

23. *Thraulus gopalani* Grant & Sivaramakrishnan, 1985

(Image 17)

Material examined: MCDZ/E-51, 4 larvae, 26.xii.2013, Tamil Nadu, Tirunelveli, Tamiraparani river, Kottumthalam, 08.420^{0}N & 77.213^{0}E, 181m, coll. C. Selvakumar.

Diagnosis: This species can be distinguished from all other described species of *Thraulus* by the following

combination of characters: In the larva (i) labrum with a rectangular mesal emargination anteriorly; (ii) inner row of the dorsal setae located just anterior to middle of the labrum; (iii) outer margin of the mandibles lacks a tuft of setae at the base of the incisors; (iv) denticles on the claws decrease in size apically; and (v) abdominal gills 1 with a dorsal lanceolate portion and a ventral fimbriate lamellar portion and abdominal gills on segments 2–7 with dorsal and ventral fimbriate lamellar portions. In the adult (i) upper portion of male eyes separated; (ii) forewings with a narrow dark brown band between costal brace and vein A_2; (iii) bullae of veins Sc and R_2 have a small dark brown macula; (iv) basal ½ of hind wings brown and apex blundly rounded; and (v) each penis with single longitudinal row of spine-like setae on dorsal surface (Grant & Sivaramakrishnan 1985).

Distribution: Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: Larva and adult are known.

24. *Thraulus mudumalaiensis* Soman, 1991

Material reported: ZSI/SRC I-E 1a-p, female larva, 2.iv.1988, Tamil Nadu, Nilgri, Mudumalai, 950m, coll. A.K. Arumuga Soman.

Diagnosis: *Thraulus mudumalaiensis* can be distinguished from all other known species by the following combination of characters: In larvae: (i) claws with five minute denticles in apical set and 10 larger denticles in basal row in which the size increases medially, then decreases apically; (ii) labrum without denticles in the emargination, two rows of setae on dorsal side and an irregular intermittent setae ventrally in between two dorsal rows, a cluster of setae of either of the anterolateral side of its venter; (iii) coastal area of forewing pads hyaline, without longitudinal brown streak; (iv) mandibles with lateral sides smoothly rounded with some setae on mid region; (5) segment 2 of maxillary palp almost equal to the length of segment 1, segment 3, 0.74 the length of segment 2 and (6) segment 2 of labial palp 0.7 the length of segment 1, segment 3 a little longer than segment 2 (Soman, 1991).

Distribution: Known only from Nilgri, Tamil Nadu.

Status: Endemic to the Western Ghats.

Remarks: Diagnostic characters are provided based on the original description. Adult is unknown.

25. *Thraulus semicastaneus* Gillies, 1951

Material reported: British Museum (Natural History), 5 male imagoes, 13.ix.1945, Maharashtra, Pune, Mutha River, coll. M.T. Gillies.

Diagnosis: This species can be identified by the following combination of characters: in the imago (i) penes simple, narrow and divided but closely appressed; (ii) forewing translucent colourless, main veins amber, cross veins fine and numerous, two cubital intercalaries only, stigma containing 9–11 simple, sinuous vein-lets; and (iii) hindwing short, somewhat triangular, with tall costal spur and sharply upturned subcosta (Gillies 1951).

Distribution: Known only from the Mutha river, Pune (Maharashtra).

Status: Endemic to the Western Ghats.

Remarks: Diagnostic characters are provided based on the original description. Larva is unknown.

Subfamily: Leptophlebiinae

Diagnosis: Leptophlebiinae can be differentiated from Atalophlebiinae by a suite of mouthpart characters and an elongate and deeply cleft ninth sternum in adult females (Peters & Edmunds 1970; Peters 1980; Kluge 1994).

Genus *Gilliesia* Peters & Edmunds, 1970

Type species: *Gilliesia hindustanica* (Gillies)

Diagnosis: This genus can be differentiated from other genera of the Leptophlebiidae by the following combination of characters: In imago (i) hind wings present and well developed; (ii) vein MP_2 of the fore wings with independent of vein MP_1; (iii) female without ovipositor or egg guide; and (iv) 9th sternum of the female deeply cleft apically. In larva (i) posterolateral expansions of on abdominal segments 9 only well developed; (ii) gills long, slender and slightly forked at 2/5 basally; (iii) glossae narrow taped, with dense thickened-long hairs on ventral surface; and (iv) length of maxilla palpi segment three more than 1.6 times length of segment 2; apical-blunted, with numerous setae (Peters & Edmunds 1970).

Distribution: China, India and Thailand.

Status: Oriental distribution.

Remarks: The genus *Gilliesia* Peters & Edmunds, 1970 was established for the species *Thraulus hindustanicus* Gillies, 1951 described based on adult specimens only. *Gilliesia hindustanica* is known from India (Gillies 1951; Peters & Edmunds 1970). The second species, *G. pulchra* Zhou, 2004, was described from Southwestern China also based on adult stages only (Zhou 2004). Recently, third species *G. ratchaburiensis* Boonsoong & Sartori, 2015 described based on male and female imagoes, nymphs and eggs collected in western Thailand by Boonsoong & Sartori (2015).

Table 1. Details of sampling sites with list of species reported

State/Union territory	District	River	Site	Date of collection	Latitude (°N)	Longitude (°E)	Altitude (m)	Species collected/reported
Andaman and Nicobar Islands	Nicobar	16th km	Galathea tributary	4.iv.2012	6.588	93.518	62	*C.* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017
	Nicobar	Govind Nagar	Stream near checkpost	10.xi.2010	7.002	93.528	106	*C.* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017
	Nicobar	Govind Nagar	12th km	06.xi.2010	7.001	93.528	83	*C.* (*Dilatognathus*) *nicobarensis* Selvakumar & Chandra, 2017
Andhra Pradesh	Chittoor		Tada falls	09.xi.2013	13.602	79.845	100	*Indialis badia* Peters & Edmunds, 1970; *Isca* (*Isca*) *purpurea* Gillies, 1951
Arunachal Pradesh	Lower Subansiri	Ranga River		21.iv.2015	27.396	93.757	625	*C.* (*Dilatognathus*) *nigella* (Kang & Yang 1994)
Assam			Kameng Frontier Division	15.v.1961			930	*Gilliesia hindustanica* (Gillies, 1951)
Chhattisgarh	Kabirdham	Sakri River	Chapri	29.iii.2014	22.054	81.074	444	*C.* (*Euthraulus*) *parvula* (Gillies, 1951)
	Korba		Lemru	25.iii.2014	22.384	82.483	383	*C.* (*Euthraulus*) *parvula* (Gillies, 1951)
Himachal Pradesh		Alhni River		25.v.1970			3,200	*Atalophlebia chialhnia* Dubey, 1971
			Marhi	17.vi.1956			3,880	*Thraulodes marhieus* Dubey, 1970
	Bilaspur	Mandodari River		18.xi.2012	31.783	76.332		*C.* (*Choroterpes*) *kaegies* Selvakumar, Subramanian & Chandra, 2017
Karnataka	Shimoga	Tunga River	Minu Hole	19.v.2015	13.344	75.061	655	*C.* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003
	Shimoga		Jogigudi falls	02.v.2013	13.295	75.061	514	*C.* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013
	Sringeri		Nanthini hole	03.v.2013	13.232	75.104	640	*Choroterpes* (*Monochoroterpes*) *nandini* Selvakumar & Sivaramakrishnan, 2015; *Edmundsula lotica* Sivaramakrishnan, 1985; *Indialis badia* Peters & Edmunds, 1970; *Isca* (*Isca*) *purpurea* Gillies, 1951; *Petersula courtallensis* Sivaramakrishnan, 1984
	Sringeri		Srimane falls	03.v.2013	13.231	75.104	716	*Choroterpes* (*Monochoroterpes*) *nandini* Selvakumar & Sivaramakrishnan, 2015; *Edmundsula lotica* Sivaramakrishnan, 1985; *Indialis badia* Peters & Edmunds, 1970; *Isca* (*Isca*) *purpurea* Gillies, 1951; *Notophlebia ganeshi* Kluge, 2014; *Notophlebia jobi* Sivaramakrishnan & Peters, 1984
Kerala	Palakkad	Kunthi River	Attappadi	10.v.2014	11.0356	76.3214	550	*C.* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003
	Palakkad	Kunthi River	Silent Valley	10.v.2014	11.274	76.456	923	*Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996; *Notophlebia ganeshi* Kluge, 2014
	Palakkad		Silent Valley (Poochipara)	18.iv.2013	11.064	76.255	935	*Notophlebia jobi* Sivaramakrishnan & Peters, 1984; *Petersula courtallensis* Sivaramakrishnan, 1984
	Kottayam		Kittikanam	22.iii.1962			1,000	*Indialis rossi* Peters, 1975
Maharashtra	Pune	Mutha River		10.ix.1945				*Thraulus semicastaneus* Gillies, 1951
Meghalaya	East Khasi Hills	Wankwar River	Khrang Village	02.iii.2016	25.324	91.775	1,658	*C. (Choroterpes) kaegies* Selvakumar, Subramanian & Chandra, 2017
	East Khasi Hills	Umkhen River	Thangasalai Village	05.iii.2016	25.591	92.054	937	*C. (Choroterpes) kaegies* Selvakumar, Subramanian & Chandra, 2017
	East Garo Hills		Upper Rongbu Village	26.vi.2016	25.916	90.831	101	*C. (Choroterpes) kaegies* Selvakumar, Subramanian & Chandra, 2017
	Jaintia Hills	Wah Malidar	Malidar Village	03.ii.2007				*C.* (*Dilatognathus*) *nigella* (Kang & Yang 1994)
Tamil Nadu	Tirunelveli	Nambiyar	Nambikovil	23.ii.2012	08.260	77.295	412	*C.* (*Choroterpes*) *petersi* Tong & Dudgeon, 2003

State/Union territory	District	River	Site	Date of collection	Latitude (°N)	Longitude (°E)	Altitude (m)	Species collected/reported
	Tirunelveli	Nambiyar	Nambikovil	06.xi.2012	08.260	77.295	386	*Edmundsula lotica* Sivaramakrishnan, 1985; *Isca* (*Isca*) *purpurea* Gillies, 1951; *Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996
	Tirunelveli	Nambiyar	Checkpost	22.ii.2010	08.262	77.313	227	*C.* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013
	Tirunelveli	Ramanathi	Above dam	11.vii.2009	08.848	77.314	237	*C.* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013; *Notophlebia jobi* Sivaramakrishnan & Peters, 1984;
	Tirunelveli	Ramanathi	Alwarkurichi	11.viii.2013	08.470	77.240	109	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009
	Tirunelveli	Gadana River	Above dam	20.vii.2013	08.480	77.180	144	*C.* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013; *Notophlebia jobi* Sivaramakrishnan & Peters, 1984; *Petersula courtallensis* Sivaramakrishnan, 1984
	Tirunelveli	Gadana River	Alwarkurichi	12.vii.2009	08.461	77.235	69	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009
	Tirunelveli	Tamiraparani River	Vanathertham falls	19.ix.2009	08.625	77.311	263	*Edmundsula lotica* Sivaramakrishnan, 1985; *Isca* (*Isca*) *purpurea* Gillies, 1951; *Nathanella saraswathiae* Sivaramakrishnan, Venkataraman & Balasubramanian, 1996; *Petersula courtallensis* Sivaramakrishnan, 1984
	Tirunelveli	Tamiraparani River	Kottumthalam	26.xii.2013	08.420	77.213	181	*Thraulus gopalani* Grant & Sivaramakrishnan, 1985
	Tirunelveli	Tamiraparani River	Papanasam	04.vii.2009	08.423	77.220	108	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009; *Indialis badia* Peters & Edmunds, 1970
	Tirunelveli	Tamiraparani River	Kallidaikurichi	04.vii.2009	08.413	77.273	105	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009; *Indialis badia* Peters & Edmunds, 1970
	Tirunelveli	Gundar	Kannupulimettu	17.vii.2013	08.562	77.122	164	*C.* (*Euthraulus*) *nambiyarensis* Selvakumar, Arunachalam & Sivaramakrishnan, 2013; *Notophlebia jobi* Sivaramakrishnan & Peters, 1984; *Petersula courtallensis* Sivaramakrishnan, 1984
	Tirunelveli	Adavinayinar River	Above dam	03.xi.2013	09.045	77.135	273	*Notophlebia jobi* Sivaramakrishnan & Peters, 1984
	Virudhunagar		Shenpagathoppu stream	28.iii.2015	08.362	77.145	1,435	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009
	Dindigul	Manjalaru River	Moolaiyaru	29.vii.2012	10.141	77.291	1,216	*C.* (*Euthraulus*) *alagarensis* Dinakaran, Balachandran & Anbalagan, 2009; *Indialis badia* Peters & Edmunds, 1970
	Dindigul	Gundar	Kodaikanal	31.iii.2012	10.133	77.270	2,323	*Isca* (*Isca*) *purpurea* Gillies, 1951
	Dindigul		Kodaikanal (Pillar Rock)	01.ii.2015	10.123	77.275	2,185	*Klugephlebia kodai* Selvakumar, Subramanian & Sivaramakrishnan, 2016
	Dindigul		Kodaikanal (Perumalmalai)	28.ix.2013	10.161	77.331	1,484	*Nathanella indica* Demoulin, 1955; *Petersula courtallensis* Sivaramakrishnan, 1984
	Coimbatore		Kadamparai	02.v.1963			1,070	*Petersula nathani* Sivaramakrishnan & Hubbard, 1984
	Nilgri		Mudumalai	2.iv.1988			950	*Thraulus mudumalaiensis* Soman, 1991
	Theni	Kurangani River	Bodimettu	21.i.2010	10.050	77.145	1,744	*Notophlebia jobi* Sivaramakrishnan & Peters, 1984

State/Union territory	District	River	Site	Date of collection	Latitude (°N)	Longitude (°E)	Altitude (m)	Species collected/reported
	Kanyakumar		Kunjankhuzi	02.i.1962			120	*Notophlebia hyalina* Peters & Edmunds, 1970
West Bengal	Darjeeling	Rishi River	Rishikhola	23.iii.2013	27.169	88.635	554	*C.* (*Dilatognathus*) *nigella* (Kang & Yang 1994)
	Darjeeling			18.ix.1946			1,524	*Gilliesia hindustanica* (Gillies, 1951)

26. *Gilliesia hindustanica* (Gillies, 1951)

Material reported: British Museum (Natural History), 4 male and 6 female imagoes, 18–23.ix.1946, West Bengal, Darjeeling, 1,524m, coll. M.T. Gillies; University of Utah and Florida A & M University, 2 male and 2 female imagoes pinned, 15 male imagoes, 10 female imagoes, 5 male subimagoes and 4 female subimagoes in alcohol, 15.v.1961, Assam, North East Frontier Agency, Kameng Frontier Division, Lifakpo, 930m, coll. F. Schmid.

Diagnosis: This species can be distinguished from all other known species by the following combination of characters: In the larvae (i) tibiae of forelegs equal in length to tarsi, fore femur dark brown; (ii) abdominal terga dark brown with pitch brown on terga 1–8; (iii) apex of penis lobes broad, each lobe bent laterally and then ventrally; (iv) apex of female sternum 9 with V-shaped deep median cleft and (v) costal projection well developed and rounded, apex located about 1/2 distance from base (Gillies 1951).

Distribution: Assam and West Bengal (Darjeeling).

Status: Endemic to the Himalaya.

Remarks: Diagnostic characters are provided based on the original description. Larva is unknown.

Discussion

The present study deals with diagnostic characters, diversity, extension of distribution and status of 26 species belonging to 12 genera under two subfamilies of Leptophlebiidae from India. Twenty-three of them are endemic to India inclusive of 15 species and six genera viz., *Edmundsula* Sivaramakrishnan, 1985, *Indialis* Peters & Edmunds, 1970, *Klugephlebia* Selvakumar, Subramanian & Sivaramakrishnan, 2016, *Nathanella* Demoulin, 1955, *Notophlebia* Peters & Edmunds, 1970 and *Petersula* Sivaramakrishnan, 1984 are endemic to the Western Ghats and four species are endemic to the Himalaya. Due to this high percentage of endemism, conservation of habitats and microhabitats harbouring this ancient gondwanan lineage gains priority.

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Short Communication

First record of a coreid bug *Anhomoeus fusiformis* Hsiao (Hemiptera: Heteroptera: Coreidae: Coreinae: Anhomoeini) from India

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Abstract: A coreid bug *Anhomoeus fusiformis* Hsiao, 1963 is recorded for the first time from India; the species is described with several illustrations, including information about male and female genitalia.

Keywords: Additional description, *Anhomoeus*, *Dalbergia sissoo*, male-female genitalia.

A coreid bug, collected in Chandgad District of Kolhapur, was identified as *Anhomoeus fusiformis* Hsiao, 1963. The species was originally described from China. Two other species of the genus in India are *A. sulcatus* (Distant, 1908) and *A. nepalensis* (Distant, 1908); each species is known so far from Uttarakhand (Prabakar 2015). Distant (1908) had originally described these two species under the genus *Aschistus* Stål, 1873. Distant (1902 vol I page 369) also treated *Ornytus*? *brevicornis* Dallas, 1852 as *Aschistus brevicornis*: a species now treated as *Aschistocoris brevicornis* (Dallas) ([see Coreoidea SF Team; *Coreoidea Species File Online*. Version 5.0/5.0, for synonymy [retrieval date May 20, 2018], Prabakar 2015). The other species of the genus are *Anhomoeus haripurensis* Ahmad & Sheikh, 1983 and *Anhomoeus schaeferi* Ahmad & Sheikh, 1983; both these species are from Pakistan and the host plant recorded was *Dalbergia sissoo* Roxb. (Ahmad & Shaikh 1983). *A. fusiformis* has never been reported from India so far. Coreoidea Species File classifies *Anhomoeus* under Coreinae, tribe Anhomoeini Hsiao, 1964, and this classification is followed here.

The original description of *A. fusiformis* is in Chinese and is followed by an English translation. It is brief and without illustration (except general habitus drawing / photo). Here it is described with additional characters and adequately illustrated for the benefit of Indian students. Additional information on male genitalia is also included.

Materials and Methods

Material examined: One male and one female [(coll. More, Chandgad, March 2017 (female); April 2017 (male)]. Host Plant *Dalbergia sissoo* Roxb.

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***Anhomoeus fusiformis* Hsiao, 1963**

Additional description and Illustrations

Colouration and vestiture

Overall colour ochraceous with coarse and closely set black punctures on head, pronotum, scutellum, and corium. Punctures on head and pronotum closer together than on scutellum, clavus and corium. The punctures on scutellum, clavus and corium are also larger than those on head and pronotum.

Head and antenna with setigerous black granules while pronotum and the rest with setigerous punctures. Head with lateral ochraceous line in front of the eyes, median ochraceous line at base which is continued on pronotum and scutellum as a thin line. Pronotum also shows two pale lines lateral to median line in posterior half. Eyes pale brown, ocelli pink. Pronotal margin entirely ochraceous and thin ochraceous line continued on outer margin of corium, at least in basal half. Scutellum more ochraceous than rest of dorsal surface. All antennomeres and legs covered with fine black setigerous granules. Hemelytra with corium and clavus ochraceous, membrane pale brown, not reaching tip of abdomen; abdominal tip truncate in male with pygophoral tip visible from above.

Abdominal segments dorsally pale ochraceous (female) or reddish (male); ventrally with pale or ochraceous median, broad band flanked on either side by band of fine black setigerous granules, lateral margin also with band of black setigerous punctures with wavy outline on inner side. The area between two lateral bands marked by several black markings on ochraceous (female) or cream (male) background, markings symmetrical. Spiracles are closer to lateral than to anterior border.

Part of head beneath labium with fine black granules; similar fine black granules present laterally in front of eyes and below; rest of head ochraceous underneath. Prosternum with few black granules in front of coxae and also on lateral side; pleural area also has black setigerous punctures. Mesosternum medially shallowly sulcate, this sulcus with fine black punctures; lateral area more or less smooth with few black granules; extreme lateral side coarsely punctured, punctures black or ochraceous; few black granules also present. Metasternum identical except there is no median sulcus. Pygophore medially pale with lateral ochraceous band.

Female overall colouration slightly different from that of male dorsally and ventrally, ventral pattern of colouration similar in both sexes but bold in female. Eyes pale, antennae with slight reddish tinge in female. Terminalia in female slightly darker than rest of ventral area (for coloration see Image 1 A–I).

Morphology

Elongate fusiform insects (especially female) with almost parallel sided body behind pronotum; legs moderately robust; fore, mid, and hind femora of nearly the same diameter (none incrassate); tibiae slightly more slender than femora. Antennae long with first segment slightly incrassate but not thicker than femora, remaining segments slender except fourth which is slightly thicker; first three segments triquetral (or three cornered), fourth spindle shaped. Ventrally with body laterally slightly compressed.

Head

Head more or less rectangular, almost as long as broad; eyes of moderate size, semi-globose. Ocelli closer to eye than to each other; distinct transverse pre-ocellar groove present in front of each ocellus; longitudinal median sulcus present on vertex. Antenniferous tubercles prominent, visible from above, situated at distance from eyes, almost at the tip of head (Image 1B). Clypeus slightly sloping, projecting beyond mandibular plates (but these are seen only in frontal view, not in dorsal view). Antenna four segmented, first and second segments sub-equal, third shorter than second, fourth shortest. Bucculae very short, triangular. First segment of labium moderately thickened, remaining three slightly slender. First segment of labium not reaching base of head, second segment not reaching base of fore coxae; labium reaching slightly beyond middle of meso-sternum, its tip black (Image 1D,E).

Thorax

Pronotum rhomboidal, slightly narrow at anterior angles, moderately sloping. Anterior margin slightly concave behind head, lateral margin straight but granular and slightly raised. Entire dorsal surface covered with fine black setigerous punctures. A median levigate, pale line along entire midline and two indistinct similar lines starting from behind calli and ending indistinctly much before base; posterior margin truncate, slightly concave over scutellum. Humeral angles blunt but raised above like small tubercle (Image 1C). Prosternum coarsely granular, slightly sulcate in front of coxae, pleura vertical, coarsely punctured, with setae. Mesosternum slightly tumescent with a median wide and shallow sulcus; this sulcus with small fine punctures, lateral raised areas of sulcus with very few granules and setae. Pleura coarsely punctured, some punctures black others colourless and

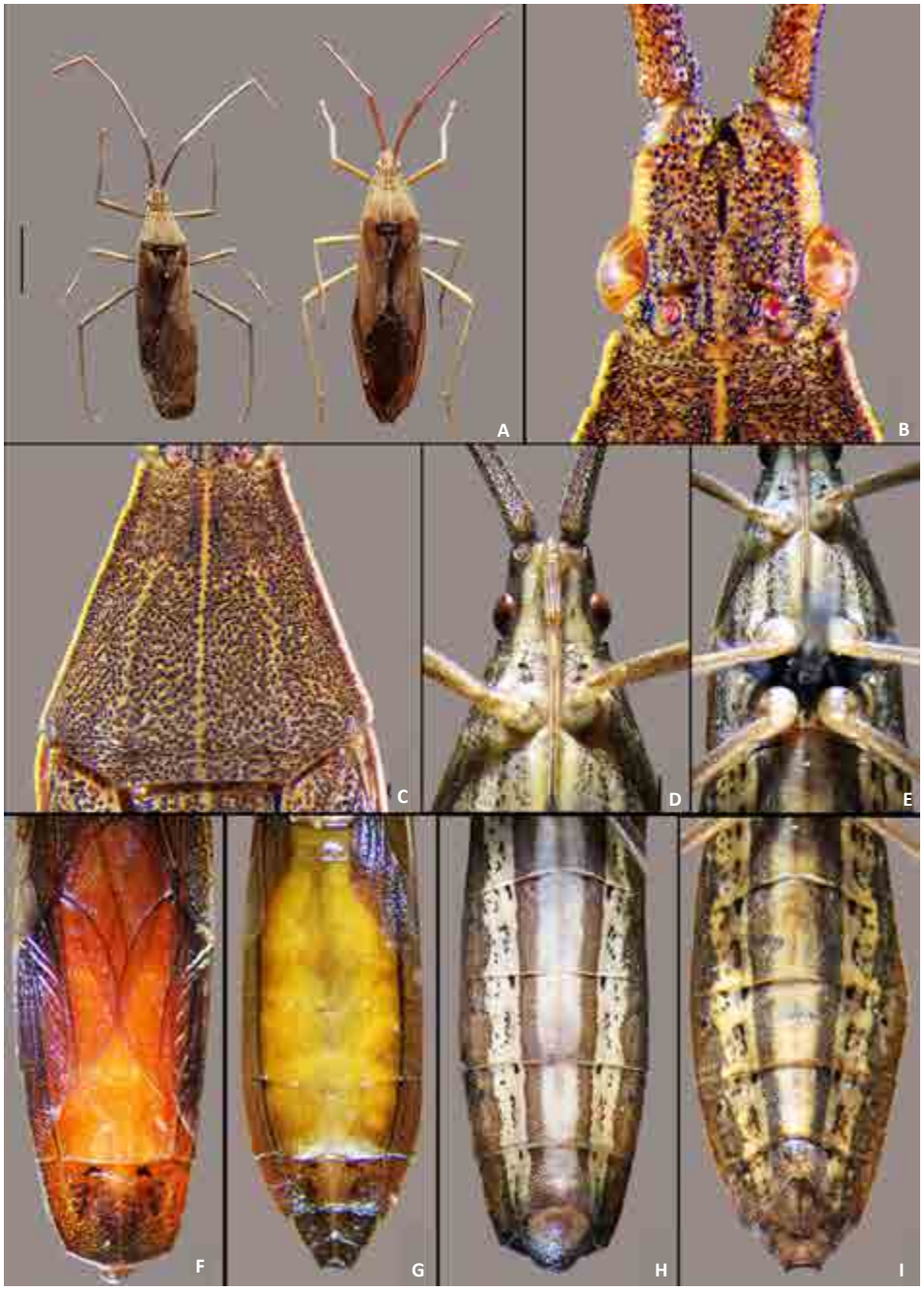

Image 1. *Anhomoeus fusiformis* coloration and morphology. A: dorsal habitus male (left) female (right); B: head dorsal view, details; C: pronotum dorsal view, details; D, E: head ventral view and prosternum details; F to I abdomen - F: tergites, male; G: tergites, female; H: sternites, male; I: sternites, female.

setose.

Mesocoxae with few black granules and setae (Image 1E). Metasternum moderately convex with median dark band of punctures; lateral area to these punctures smooth, followed by another area of black punctures at margin. Metathoracic pleural area coarsely punctured, meta-coxae as well as adjacent pleural area with fine black granules. Metathoracic scent gland prominent with small evaporatory area (Image 3B, C).

Scutellum triangular with narrow apex, slightly longer than broad, its entire surface coarsely punctured; extreme lateral margin and tip of scutellum without punctures.

All coxae globular; fore coxae very close to each other; meso-coxae and meta-coxae well separated (Image 1E). All femora and tibiae narrow at base, slightly dilated distally and covered with setigerous black granules. All tarsi long, first segment as long as remaining two; tarsal segments densely setose; claws widely separated with a prominent oval pulvillus at base.

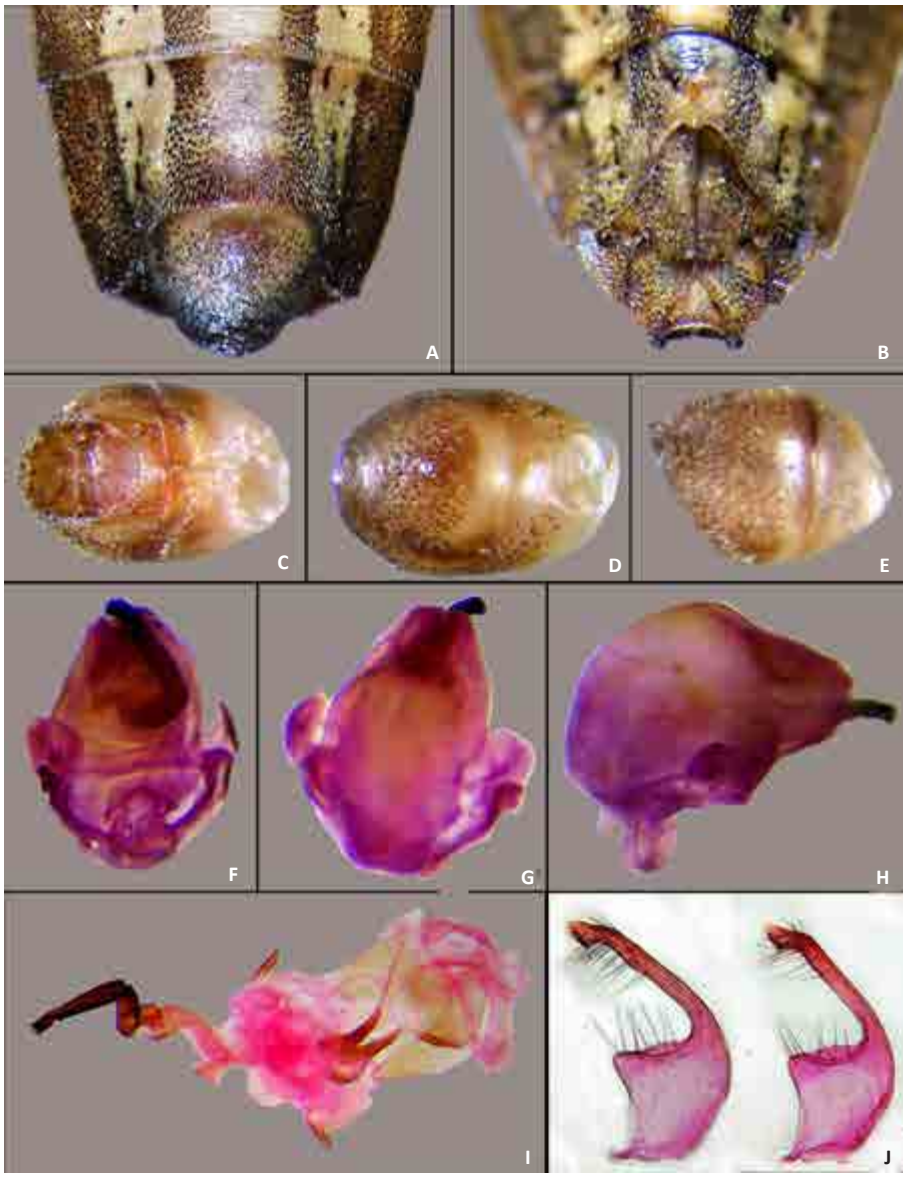

Image 2. *Anhomoeus fusiformis* pygophore and female terminalia. A: pygophore in situ. B: female terminalia in ventral view; C to E pygophore structure- C: dorsal, D: ventral & E: lateral view; F to H phallus – F: dorsal, G: ventral & H: lateral view; I: everted phallus, dorsal view; J: parameres in dorsal & ventral views

Hemelytron long, its external angle sharp, its inner angle rounded; clavus and corium uniformly punctured, extreme outer margin raised throughout, veins prominent; membrane with prominent parallel veins.

Abdomen

Abdominal segments laterally moderately compressed; segments three to seven almost equal in length and breadth. Abdominal tergites with a semi-circular elevation on posterior border of fourth and fifth tergite (= openings of dorso-abdominal glands) as shown in Image 3A. First visible abdominal sternite (actual second) compressed laterally and distinctly raised medially. Boundary between tergite and latero-tergite raised and almost brownish black. Pyrophore globular; spiracles prominent, situated laterally, closer to lateral margin than to anterior margin; trichobothria not very prominent (Image 1H, I).

Female slightly longer and broader with slightly broad connexivum; connexivum finely, blackly punctate, ventrally pale coloured but with identical bands of black punctures and spots. Metasternum appears entirely black. Abdomen more rounded, and less laterally compressed. Abdominal tergites in female ochraceous throughout except for last three segments which are spotted with black punctures.

Male and Female genitalia

Appearance of pygophore in situ, as seen from ventral side, is like shown in Image 2A. Pygophore oval

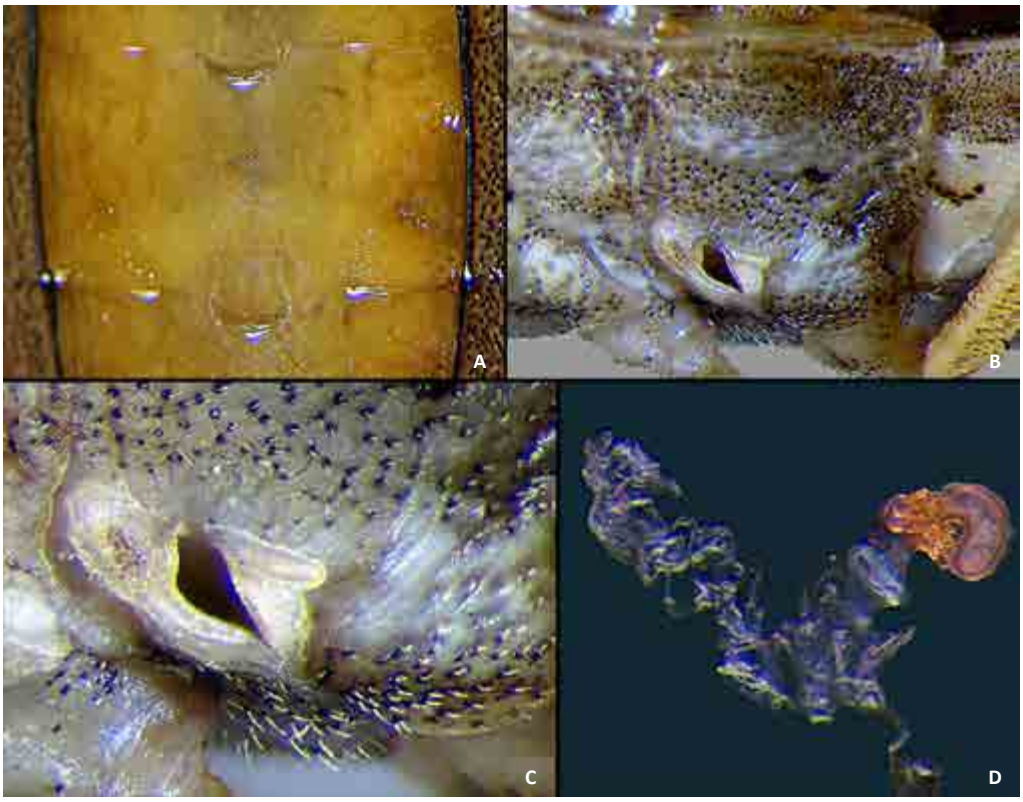

Image 3. *Anhomoeus fusiformis.* A. Adult dorsal abdominal glands; B, C. Metathoracic scent gland; D. Spermatheca

in dorsal (Image 2C) and ventral (Image 2D) view and is convex on ventral side, as seen in lateral view (Image 2E) but more or less flat on dorsal side. Ventral and ventrolateral surface has many black granules that are more or less evenly spaced. Its posterior opening is oval and anterior dorsal bridge relatively narrow. It is shown here with the eighth segment not removed. The un-everted phallus is also oval in dorsal (Image 2F) and ventral view (Image 2G) and occupies major portion of the pygophore. Lateral view of the phallus is shown in Image 2H. Phallus in everted state (Image 2I) is typical coreid type with short vesica (with one coil) and conjunctiva has one dorso-lateral pair of appendages, one frontal pair and one small dorsal pair; two of these pairs are with moderate sclerotisation. Parameres, shown here from outer and inner face, are moderately setose and with broad base and slender distal portion that expands at tip like a button (Image 2J).

Female terminalia are as shown in Image 2B. The eighth and ninth paratergites are clearly visible along with the first gonocoxae. Spermatheca is with extremely coiled distal and less coiled proximal duct and has round bulb (Image 3D).

Measurements

Measurements in millimetres (male / female): Total length 17 / 19; antenna: length of first segment 3.5 / 3.5, second segment 4.5 / 4.35, third segment 3 / 3, fourth segment 2.5 / 2.5; total length of labium 3.75 / 4, length of first segment of labium 1 / 1.25, second segment 0.75 / 1, third segment 1 / 0.75, fourth segment 1 / 1; fore leg lengths: fore coxa 0.625 / 0.5, fore femur 3.75 / 4.25, fore tibia 3.5 / 3.75, fore tarsus with claw 1.85 / 1.75; mid leg lengths: mid coxa 0.625 / 0.75, mid femur 3.75 / 4, mid tibia 3.5 / 3.75, mid tarsus with claw 1.75 / 1.6; hind leg lengths: hind coxa 0.625 / 0.9, hind femur 5.75 / 6, hind tibia 5.5 / 6.25, hind tarsus with claw 1.85 / 2; total length of head 1.5 / 1.75, head breadth at eye 1.65 / 1.65, interocular distance 1 / 1.4, inter-ocellar distance 0.5 / 0.6; pronotum: length 2.75 / 3.75, breadth at anterior angles 1.5 / 1.5, breadth at humeral angles 3.5 / 4; scutellum: length 1.85/ 1.75, breadth at base 1.5 / 1.1; hemelytra length 7.5 / 9.5.

Discussion

On the basis of the original description by Hsiao and the image of the type, the Chandgad specimens are treated here as *A. fusiformis.* Coloration of head

and pronotum in our specimens is identical with *A. fusiformis*, especially the original description mentions the two indistinct ochraceous lines lateral to median ochraceous line on pronotum, that are also clear in our specimens (Image 1C) as well as in the photo of female holotype of Hsiao's *A. fusiformis* available on Coreoidea SF online. These lines are neither mentioned by Distant (1908) nor by Ahmad & Shaikh (1983) in their two species; Distant did not provide any line drawings but the line drawings of Ahmad & Shaikh also do not show these lines in the species they described. Hsiao also mentions 'dorsum red' and in our male it is similar but in the female it is ochraceous. Ventral coloration is not fully described for *A. fusiformis, A. haripurensis* and *A. schaeferi* but Distant gave a more complete description of his two species; our specimens show ventral pattern similar to that described by Distant (1908). The length and ratio of antennal segments, head proportions and pronotal measurements in our specimen are almost the same as of *A. fusiformis* and not like those of the species from Pakistan or India. The phallus (aedeagus) and female terminalia as well as spermatheca are broadly similar to those described by Ahmad & Shaikh (1983).

As there is no previous record of such a distinctly different *Anhomoeus* from India, this becomes the first illustrated report of this species for India. The type locality of this species is Yunnan (Pu-er County), China, and there are no subsequent reports, at least in English. Attempts to trace records in other places of China were not successful. In an unpublished thesis (Gupta 2012) available on 'Shodhganga' website (http://shodhganga.inflibnet.ac.in/handle/10603/10215) gives description of morphology and genitalia of other *Anhomoeus* species (*A. nepalensis* and *A. sulcatus*) from northern India (Punjab and Himachal Pradesh). There is no other information about these two species from any other part of India either. The presence of *Anhomoeus* in Maharashtra itself is a considerable southward extension as all previous records are from northern parts of India.

Diagnosis of different species

There are now three species of *Anhomoeus* in India. These can be separated easily on the basis of size; *A. fusiformis* is the largest species. Brief diagnostic characters of the other two species, based on original descriptions by Distant, are given below.

Anhomoeus nepalensis (Distant): size 14mm; head with mandibular plates somewhat widely divergent apically; labium scarcely passing fore coxae; breadth at humeral angles 3mm; connexivum spotted. [According to thesis of Gupta 2012 (cited above) -- total length: 11.50mm in male; female 12.9–14.70 mm. Material studied from Punjab, Uttarakhand and Jammu & Kashmir].

Anhomoeus sulcatus (Distant): size 15.50mm; antennomeres I to III sulcate and relative proportional lengths of antennomeres different than that of *A. nepalensis;* apices of mandibular plates of the head upturned, sub-tuberculous; labium distinctly passing fore coxae; connexivum unspotted; breadth at humeral angles 3mm; [According to Gupta a single male found in Himachal Pradesh was 13.30mm]

Anhomoeus fusiformis Hsiao: size 17mm (male) and 19mm (female); breadth at humeral angles 3.5–4 mm; pronotum with three levigate pale lines; labium passing much beyond fore coxae, reaching to the middle of mesosternum.

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The gilled mushroom *Amanita spissacea* (Amanitaceae): a new report for India

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Abstract: Mizoram is regarded as one of the biodiversity hotspots of the World owing to the diverse group of flora and fauna documented here. Information regarding the macrofungi, however, is very limited. For this reason, a systematic study of mushrooms from Mizoram was undertaken and during the field survey, *Amanita spissacea* was collected and identified. This is the first report of this mushroom from India. This species was identified on the basis of its morphological and microscopic characteristics as well as molecular characterization of the ITS region of rDNA. Phylogenetic analysis also confirmed that *A. spissacea* was a distinct species from *A. fritillaria, A. sepiacea, A. citrina* and other closely related species *Amanita* section Valideae.

Keywords: Macrofungi, Mizoram, phylogeny, taxonomy.

Mizoram lies in northeastern India sharing its borders with Assam, Manipur and Tripura and has international borders with Bangladesh and Myanmar. It covers a geographical area of 21,081km^2 and lies between 21.966–24.583^{0}N and 91.250–92.483^{0}E. The Tropic of Cancer passes through the state at 23.500^{0}N (Mizoram Remote Sensing Application Centre 2009).

Amanita Pers., is a well known mushroom genus with global distribution comprising both edible and poisonous species which are usually mycorrhizal symbionts with plants. The genus *Amanita* Pers., contains about 500 species worldwide (Kirk et al. 2008), and for some time, only 66 species were reported from India (Bhatt et al. 2003; Semwal et al. 2005, 2007; Vrinda et al. 2005). Recently, a number of reports have been added to the list from several researchers (Singh & Kaur 2016; Bhatt et al. 2017) with the latest report of 80 species of Amanitaceae being listed including 73 species of *Amanita* reported from different parts of India (Verma & Pandro 2018).

During the course of macro-fungal foray to different parts of Mizoram, *Amanita spissacea* S. Imai was collected and identified. This species is described and illustrated for the first time from India.

Materials and Methods

Study Area

Collections of mushrooms growing on soil was done at Mizoram University Campus which is located in the Western side at a distance of about 15km away from the state capital, Aizawl, just below Tanhril Village. The Mizoram University Campus is about 980 acres in area

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and lies between 23.756–23.726^{0}N & 92.644–92.673^{0}E. The elevation ranges from 330–880 m.

Morphological study

Macro-morphological descriptions were based on field notes and color photographs of the macrofungi. Micro-morphological data was obtained from the dried specimens with the aid of a light microscope after sectioning and staining with cotton-blue. Spore prints were taken by placing the fresh specimen on a microslide. Descriptions of spore shapes are based on the study reported by Bas (1969).

Phylogenic study

DNA isolation, amplification and sequencing: Molecular methods were performed following Zothanzama et al. (2016), where DNA was extracted using a CTAB method, followed by amplification of the internal transcribed spacer region (ITS) of the rDNA and sequenced with both primers (ITS1F and ITS4B).

PCR amplification: PCR reactions were setup in 0.2ml centrifuge tubes that contained 12.5µl GoTaq Green Mastermix (Promega, Madison, WI), 9.5µl nuclease free water, 0.5µl bovine serum albumin (BSA), 1µl forward primer (5µM), 1µl reverse primer (5µM) and 1µl of fungal DNA template for a total reaction volume of 25.5µl. PCR was performed using primers ITS1-F (5'-CTT GGT CAT TTA GAG GAA GTA A-3') ITS4-B (5'-CAG GAG ACT TGT ACA CGG TCC AG-3') (White et al. 1990) with the following parameters; 94C for 5 minutes, followed by 35 cycles of 94C for 1 minute, 52C for 1 minute and 72C for 1 minute with a final extension step of 72C. PCR amplicons were verified by electrophoresis on a 1% agarose gel with SYBR green and visualized on a Gel Documentation System. Sequencing was performed using both primers by using Sanger sequencing using a ABI 3730xl DNA sequencer. Consensus sequences for contigs were trimmed and aligned using Bioedit sequence alignment editor. Sequences were then compared to those in GenBank database using the BLASTn (Altschul et al. 1990) search tool for similarities and submitted to Genbank.

Phylogenetic analysis: The ITS dataset was aligned with the MAFFT v7.222 (Katoh et al. 2002) and jModelTest 2.1.10 (Darriba et al. 2012) was used to determine the appropriate model for Bayesian analysis (HKY85). Phylogenetic analysis inferred from ITS sequences was performed using MrBayes 3.2.6 (Huelsenbeck & Ronquist 2001). 1.1 x 10^6 MCMC generations were used with a sampling frequency every 200 generations and the first 10% of sampled trees were discarded as burn-in.

Results

***Amanita spissacea* S. Imai**

(Fig. 1 & Image 1)

Specimens examined: EVS/SF/0012, 27.v.2014, India, Mizoram, Aizawl, Mizoram University Campus and EVS/SF/0165, 01.vi.2016 (Image 2).

Basidiomata: Small to medium. 4–9 cm in diam., convex to plano-convex, grayish-brown in color, volva remnants on pileus as scattered felted to crust like patches, margin non-striated, non-appendeculate, incurved. Lamellae-sometimes forked, lamellulae- of several length. Stipe: 8–14 cm long, 0.5–1 cm wide, tapering toward apex, stuffed, white to grayish-brown with brown scales. Annulus membranous, grayish brown, apical. Bulbous base upto 1.5cm long, 1–3 cm thick, glabrous with dark brown spots. The upper part of the bulbous base of the stipe is covered with dark grey volval remnants in 2–5 dotted rings. Context - white and thin. Sporeprint: White. Spores: 7-9.8 x 6.8 - 8.5µm[Q=1.02,1.15]and are globose to subglobose, sometimes rarely broadly ellipsoid, amyloid, colourless, hyaline, thin walled and smooth. Basidia: Clavate, 35–45

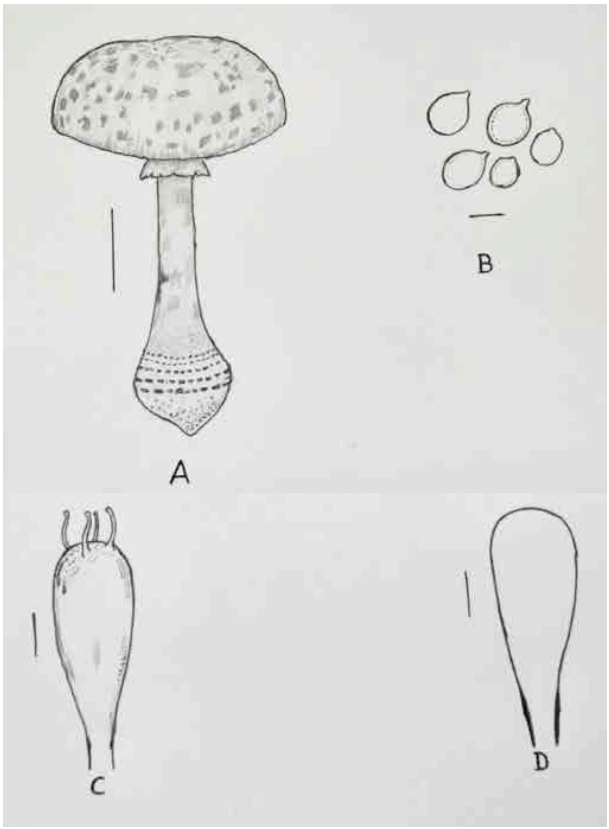

Figure 1. A–D *Amanita spissacea*.
A - Fruiting body, B - Spores, C - Basidium, D - Marginal cell or lamellae edge cell (scale: A - 3cm, B - 8µm, C & D - 6.5µm)

Image 1. A–C - Fruiting body of *Amanita spissacea* in their natural habitat; D - Fruiting body of Amanita spissacea in laboratory (scale A&B - 2cm; C&D - 4cm).

× 8–11 µm, four spored, sterigmata 3.2–4.6 x 0.8–1.8µm. Clamp connection absent. Lamellae edge cell: clavate, 35–45 × 7.5–9 µm.

Habitat: Solitary to scattered or gregarious on ground in a broad-leaved sub-tropical forest.

Molecular Phylogenetic analysis

The molecular phylogenetic analysis shown in figure (Fig. 2) involved 17 nucleotide sequences. The tree with the highest log likelihood (-2938.15) is shown. In the phylogenic analysis, the specimen of *Amanita spissacea* from Mizoram (MZ10-KY940266, MZJZR1-MG706138) is indicated in bold and clustered with *Amanita spissacea* from Belgium (KY747469), Republic of Korea (KM052550, KM052546) and Japan (AB015683).

Discussion

In this study, we identified this species based on morphological, microscopic and molecular characteristics. This is the first report of *Amanita spissacea* from India. Results from sectioning of the fruiting body and observations of basidiospores indicated this *Amanita* species was most closely related to *A. spissacea*. Species identification based on morphological characteristics is difficult to differentiate from other closely related species such as *A. fritillaria, A. sepiacea, A. citrina* and others.

The present species has been reported and described for the first time by Imai (1933) and Gilbert (1940) as *Amplariella spissacea*. The macro and microscopic features of the present species well matched with the description given by Imai (1933) who described *Amanita*

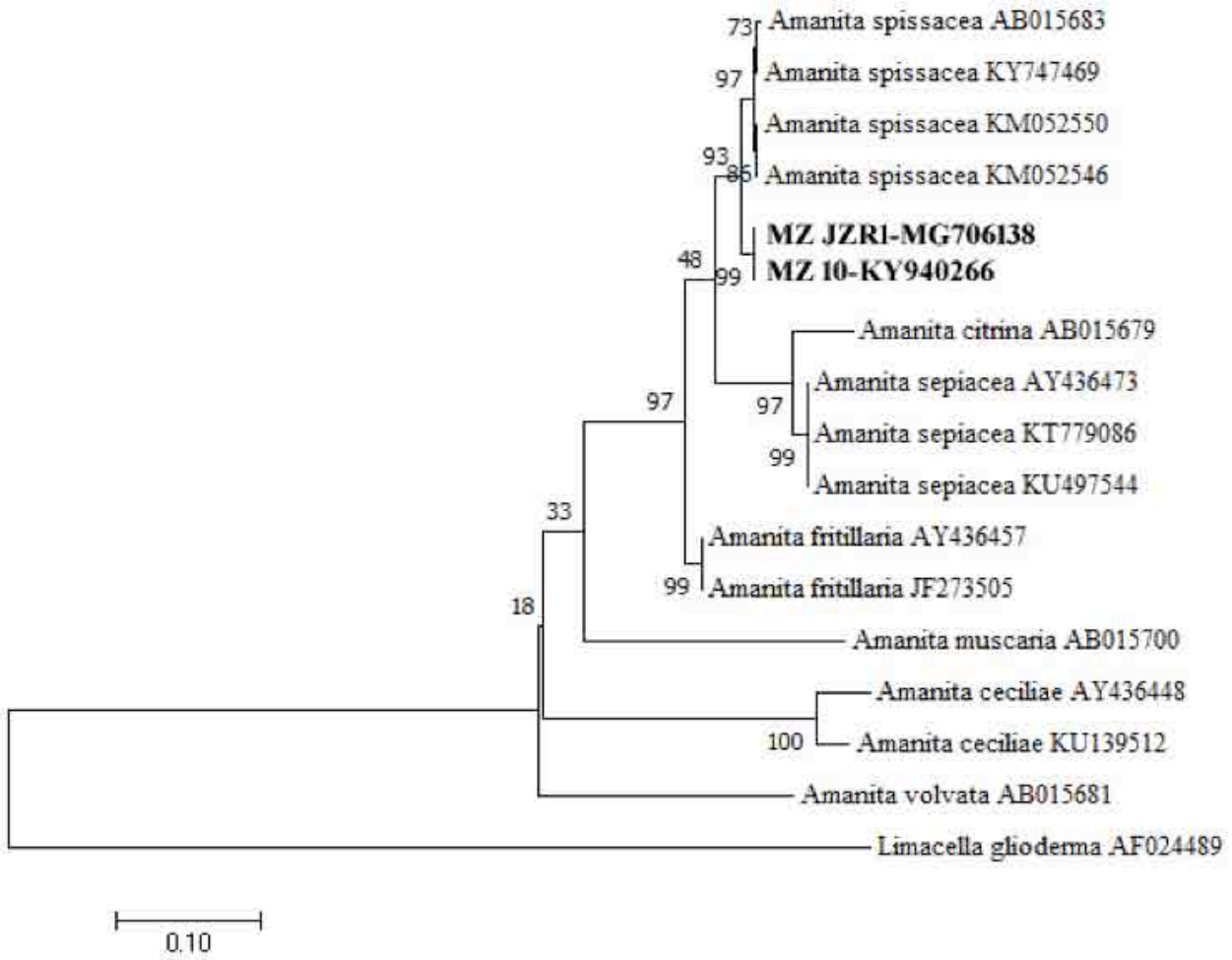

Figure 2. Phylogenetic tree of Amanita spissacea collected in Mizoram (MZ 10-KY940266 & MZ JZR1-MG706138) and other closely related Amanita species. The tree is drawn to scale, with branch lengths measured in the number of substitutons per site.

spissacea as pileus with 6–10 cm, convex, then extended, dark chestnut, warted, white flesh, stalk 10–15 cm long, firm, bulbous base, covered with dark margin, scaly, membranous ring. Spores globose, 7–8 µm, hyaline, apiculate.

Amanita spissacea is also closely related to *Amanita fritillaria* (Yang et al. 2001) and *Amanita sepiacea* (Imai, 1933). The macro and microscopic details are mostly identical but both *Amanita fritillaria and Amanita sepiacea* have spores broadly ellipsoid to ellipsoid, occasionally subglobose or ellipsoid, rarely globose and the upper part of the bulbous base of the stipe of *Amanita fritillaria* covered with dark grey volval remnants is only 2–4 rings while the former is 2–5 dotted rings. Moreover, the macroscopic feature of *Amanita sepiacea* is bigger in size as compared to *Amanita spissacea* with cap 6–15 cm diam., stipe 10–18 cm long, 1–2.5 cm thick and basal bulb 1.5–5.0 cm.

Image 2. Herbarium image of *Amanita spissacea*

Sequencing of the ITS region of rRNA and phylogenetic analysis further showed that the Mizoram sample matched GenBank accession *Amanita spissacea* from Belgium (KY747469), Republic of Korea (KM052550, KM052546) and Japan (AB015683) in a well-supported clade with *A. fritillaria* forming a sister clade. These results hence confirmed that the specimen of *Amanita* from Mizoram (MZ10-KY940266, MZJZR1-MG706138) is *Amanita spissacea,* a distinct species and separate from A*. frittilaria, A. sepiacea, A.citrina* and other previous reported *Amanita* species.

Mizoram is one of the northeastern states of India which is rich in mushroom flora. Like many other *Amanita* species, *A. spissacea* has been reported to be poisonous in China (Zhishu et al. 1993) and recent mushroom poisonings in Mizoram State (Zothanzama & Lalrinawmi 2015) are prompting efforts to identify mushrooms in this region that are poisonous. This report identifies this poisonous mushroom in India and confirms that it is a distinct species from other *Amanita* species. Limited information is available concerning the wild mushrooms found in Mizoram and further studies are needed to assess and document the wide variety of wild mushrooms that can be found in this region.

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Note

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Foraging habits of the Red Fox *Vulpes vulpes* (Mammalia: Carnivora: Canidae) in the Himalaya, India

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The Red Fox *Vulpes vulpes* is one of the most widely distributed and extremely adaptable carnivore in the world (Macdonald & Reynolds 2004), and found in a variety of habitats ranging from the arctic to temperate deserts (Macdonald & Reynolds 2004). It is an omnivorous opportunistic predator and feeds on essentially anything easily available or small enough to catch, from the wilderness to cities (Harris & Smith 1987; Jędrzejewski & Jędrzejewska 1992; Scott et al. 2014). Small mammals, birds and insects are the major food materials recorded in the Red Fox diet (Goszczynski 1974; Meisner et al. 2014). Red Foxes are mostly nocturnal (Ables 1969; Macdonald 1980; Travainiet et al. 1993; Weber et al. 1994) but their activity pattern and movement may overlap with the availability of forage and level of disturbance (Macdonald 1980; Lovari et al. 1994; König 2008). Keeping this in view, the present study is an attempt to understand if the nocturnal behavior of the Red Fox alters due to the easy availability of food resources in the daytime.

The study was conducted in 12 villages covering approximately 1,000km^2 of Kargil District with an area of about 14,000km^2 (Fig. 1). Kargil is a mountainous cold desert in Ladakh region with little or sparse vegetation and represents the biogeographic zone 1B (Trans-Himalaya-Tibetan Plateau) of India (Rodgers et al. 2000). The general elevation of Kargil ranges from 2,934–7,410 m with an average elevation of 3,400m (Maheshwari 2016).

Observations on the Red Fox were recorded during field studies on snow leopards *Panthera uncia* and associated species with special reference to large carnivore-human conflict, conducted from April 2009 to November 2012 (Maheshwari 2016). Due to the topography and remoteness of the area, all fieldwork was carried out in the form of discrete field expeditions that involved camping in the different areas. Each field survey usually lasted 10–15 days. Altogether, 1,100km were traversed on foot covering an altitudinal zone of 3,000–5,200 m. Every sighting of the Red Fox was recorded during the fieldwork, and interviews were conducted of all the 664 households across 12 villages in the study landscape. Information was gathered on livestock predation such as species and number of attacks with time and place of attack by Red Fox during the study period. While collecting data on Red Fox predation on livestock in order to reduce probability of response bias and avoid overestimation of livestock predation, protocols under participatory rural appraisal (PRA) (Maheshwari et al. 2014) were employed by using the semi-structured interview technique of PRA.

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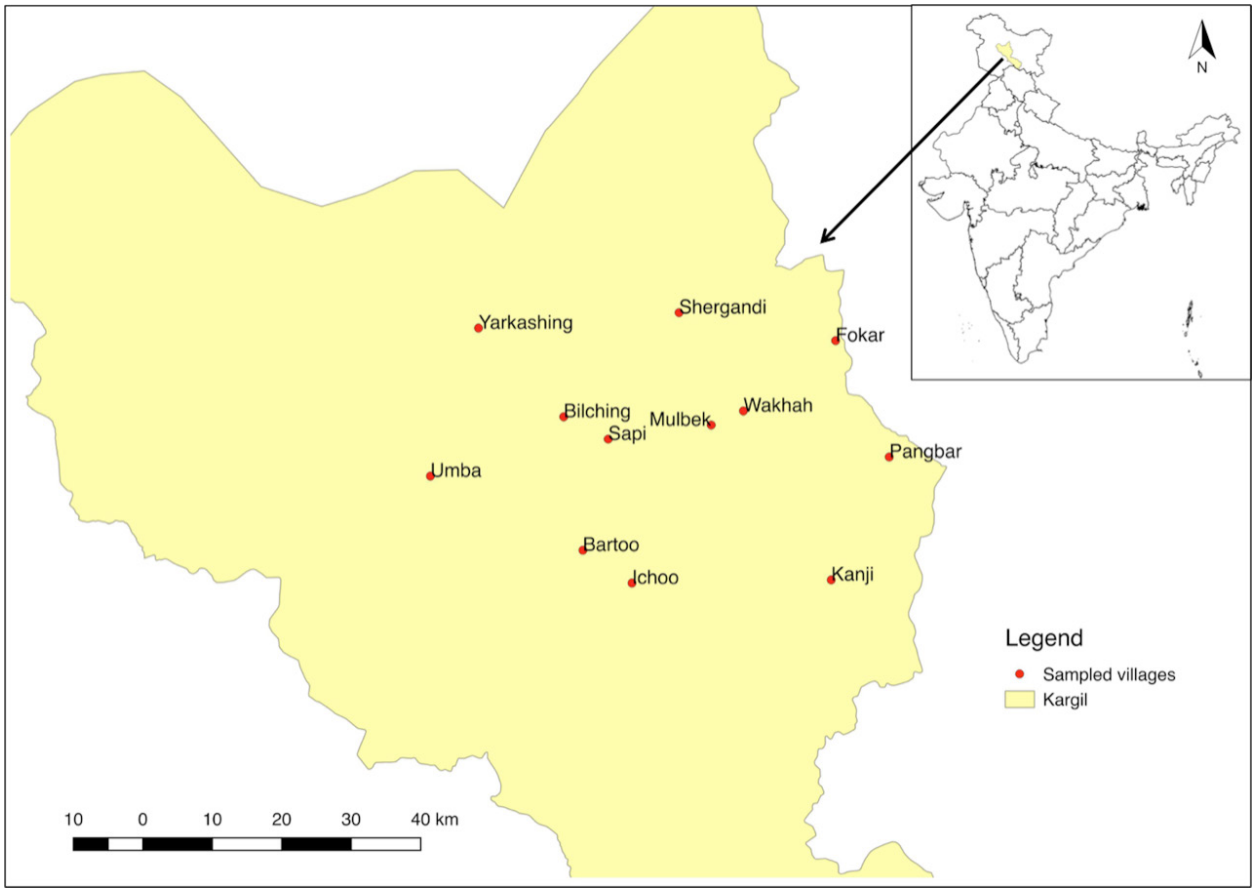

Figure 1. Study Area: location of the 12 sampled villages in Kargil, Ladakh, India

With the help of field assistants data on visual encounters (n=220) of the Red Fox from April 2009 to November 2012 were gathered. The maximum sightings were recorded during 15.01 to 18.00hr (45.4%) followed by 12.01 to 15.00hr (25.9%), 09.01 to 12.00hr (25.4%) and 06.00 to 09.00hr(13.2%). To understand Red Fox movement during day-light hours in a human dominated landscape, data were also collected on the availability of food resources, e.g., free ranging domestic fowls and inattentive young ones of the sheep/ goats in the villages (Image 1). A total of 230 domestic fowls and 74 young ones of the sheep/ goats were reportedly killed by the Red Fox in Kargil. Of 12 villages, the highest livestock attacks were recorded in Sapi (15.8%) followed by the remaining 11 villages (Table 1).

Data obtained from locals on the time of predation was overlapping with the time of sighting of the Red Fox in the villages. Most (40.9%) of the domestic fowls and 35.1% of sheep and goats' predation events were recorded during 09:01–12:00 hr followed by 34.3% (domestic fowls) and 27% (sheep and goats) during 12:01–15:00 hr (Table 2).

During the day time, when most of the family members were engaged in domestic work and other livestock grazing, they set free the fowls and young ones of the sheep and goats to move on their own and feed upon freely and naturally accessible food. At this point they were vulnerable for predation by the Red Fox.

Foxes may be found during the day pursuing prey and resting (Meisner et al. 2014). One breed of fox that is definitely diurnal is the Island Fox *Urocyon littoralis* (U.S. Fish & Wildlife Service 2015). Red Foxes are typically nocturnal animals, especially inhabiting in and around urban areas, to avoid being seen or disturbed by humans (Scott et al. 2014). Local people report that the Red Fox has got accustomed to raiding villages and houses for food. As it takes a lot of energy to scare these foxes, some locals are retaliating by killing the Red Foxes. Anthropogenic feeding has been reportedly supporting an increase in density of Red Fox range from 2–30 adults/ km^2 (Baker et al. 2000; Soulsbury et al. 2010; Scott et al. 2014) in the urban areas. But in Kargil, where local communities are primarily agro-pastoral and livestock rearing is one of the major sources of livelihood, loss of

Table 1. Red Fox predation on domestic fowls and sheep/ goats across 12 villages in Kargil

	Name of village	Total number of fowl predation	Total number of sheep and goat predation
1	Bartoo	14	4
2	Pangbar	7	3
3	Yarkashing	15	4
4	Bilching	4	2
5	Umba	30	9
6	Ichoo	12	3
7	Mulbek	22	7
8	Shergandi	12	1
9	Fokar	26	9
10	Kanji	28	12
11	Sapi	38	10
12	Wakhah	22	10
Total		**230**	**74**

Table 2. Red Fox predation during different time intervals of the day

Time interval (hr)	Domestic fowls	Sheep and goats	Total
06:00–09:00	30 (13.0%)	14 (18.9%)	44 (14.5%)
09:01–12:00	94 (40.9%)	26 (35.1%)	120 (39.5%)
12:01–15:00	79 (34.3%)	20 (27.0%)	99 (32.6%)
15:01–18:00	27 (11.7%)	14 (18.9%)	41 (13.5%)
Total numbers	230	74	304

Image 1. Red Fox predation on domestic fowl

Image 2. Red Fox road kill

livestock leads to retaliatory killing (Maheshwari 2016). Thus, similar to other carnivores in the global scenario, the Red Fox is also a victim of retaliation in Kargil. During the study five cases of retaliation against the Red Fox were recorded. Besides, there were two records of road kills during the same period (Image 2). In the absence of a proper mechanism to monitor and record Red Fox killing at landscape level this study presents only a fraction of the actual cases of retaliation and road kills. Nevertheless, retaliation and road kills constitute the major threats to the overall survival of the Red Fox population.

The lack of livestock guarding practices and poor or no search efforts by people to locate 'missing' animals are two of the major factors responsible for livestock loss in Kargil. The loss of domestic fowls and livestock constitute one of the major threats to the rural economy and the Red Fox is one of the major predators in Kargil. Diurnal alteration in foraging behavior of the Red Fox could be due to competition with the Snow Leopard and Wolf *Canis lupus chanco* (Maheshwari 2016). About 8.3% livestock loss (2009-2012) was due to predation by large carnivores, i.e., a total of 1113 heads of livestock were reportedly killed by wolf (43.6%) followed by unknown predators (31.4%) and Snow Leopard (21.5%) in the study site, which comes to 2.8% of total annual livestock losses (Maheshwari 2016). This study adds to the limited information available on the dynamics of human-Red Fox interaction in Kargil.

The Red Fox is a well-studied species across the world (Macdonald & Reynolds 2004), but information regarding its distribution, ecology, and subspecies remains rather limited in India (Maheshwari et al. 2013). The species in India, which is relatively better studied among the fox species, is the Indian Fox *Vulpes bengalensis* (Home 2005; Kumara & Singh 2012; Maurya et al. 2012). One of the important notes for future studies could be to gather crucial baseline information on the status, distribution, ecology and interaction with human of the other fox species and subspecies (Maheshwari et al. 2013) in India. This is crucial in quantifying changes in Red Fox densities due to interface with anthropogenic dimensions, and

develop strategies for conservation management.

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First record of Yellow-Rumped Flycatcher *Ficedula zanthopygia* (Hay, 1845) (Aves: Passeriformes: Muscicapidae) in eastern India

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The Yellow-rumped or Korean Flycatcher *Ficedula zanthopygia* (Hay, 1845) is a small to medium-sized flycatcher native to China, Indonesia, Korea, Laos, Malaysia, Mongolia, Taiwan, Thailand and Viet Nam (BirdLife International 2016; Anonymous 2018; Fig. 1). With its large distribution range this species has been categorized as 'Least Concern' in the IUCN Red List of Threatened Species (BirdLife International 2016). These birds breed along the low valleys of eastern North Korea, South Korea, and China in May–June (Liu & Wang 1981; Wang et al. 2007), and then the population moves south to Malaysia and Sumatra for wintering (Clement & de Juana 2018). Very few sightings of this species have been recorded in India and Sri Lanka (Grimmett et al. 2011; Grewal et al. 2016). In India, sightings are from five localities (Fig. 1). On 30 April 1989, Haribal (1991) first sighted a male individual of this species along a streambed in Melghat Wildlife Sanctuary in central India (Location 1 in Fig. 1). On 30 January 1996, Holt (2003) sighted a female along the Mangala Devi trail in Periyar National Park, Kerala (Location 2 in Fig. 1). On 15 July 2006, Baskaran (2006) sighted a male near Bandipur National Park, Karnataka (Location 3 in Fig. 1). Subsequently, on 25 December 2006, Jain (2006) sighted this bird in Gurukula Botanical Sanctuary, Kerala (Location 4 in Fig. 1). Very recently, on 15 February 2016, Athri (2016) sighted this bird in Thattekkad-Salim Ali Bird Sanctuary, Kerala (Location 5 in Fig. 1). Based on these few sightings, Grimmett et al. (2011) and Grewal et al. (2016) treated this species as 'vagrant' in India. Here we present the first sighting report of Yellow-rumped Flycatcher from eastern India.

On 20 April 2018, at about 15:40 hours, the first author sighted a single male individual of the species (Image 1) perching on a *Macaranga peltata* tree (locally known as Gondaguria) near Gadasimulia area of Kuldiha Wildlife Sanctuary, Odisha, eastern India (21.427^{0}N & 86.596^{0}E; elevation 139m) (Location 6 in Fig. 1). The bird stayed there without any activity for about two minutes and then flew away. The sighting location is situated along a riparian zone adjoining to Gadasimulia Hill stream. Vegetation in the area falls under the tropical mixed deciduous type (Champion & Seth 1968).

The species is distinguished from other congeners occurring in India by having black upperparts, yellow underparts, long white wing patch, pronounced white supercilium and yellow rump (Image 1). Based on the above characters, the species is confirmed as Yellow-rumped Flycatcher *Ficedula zanthopygia* following the identification characters described by Grimmett et al.

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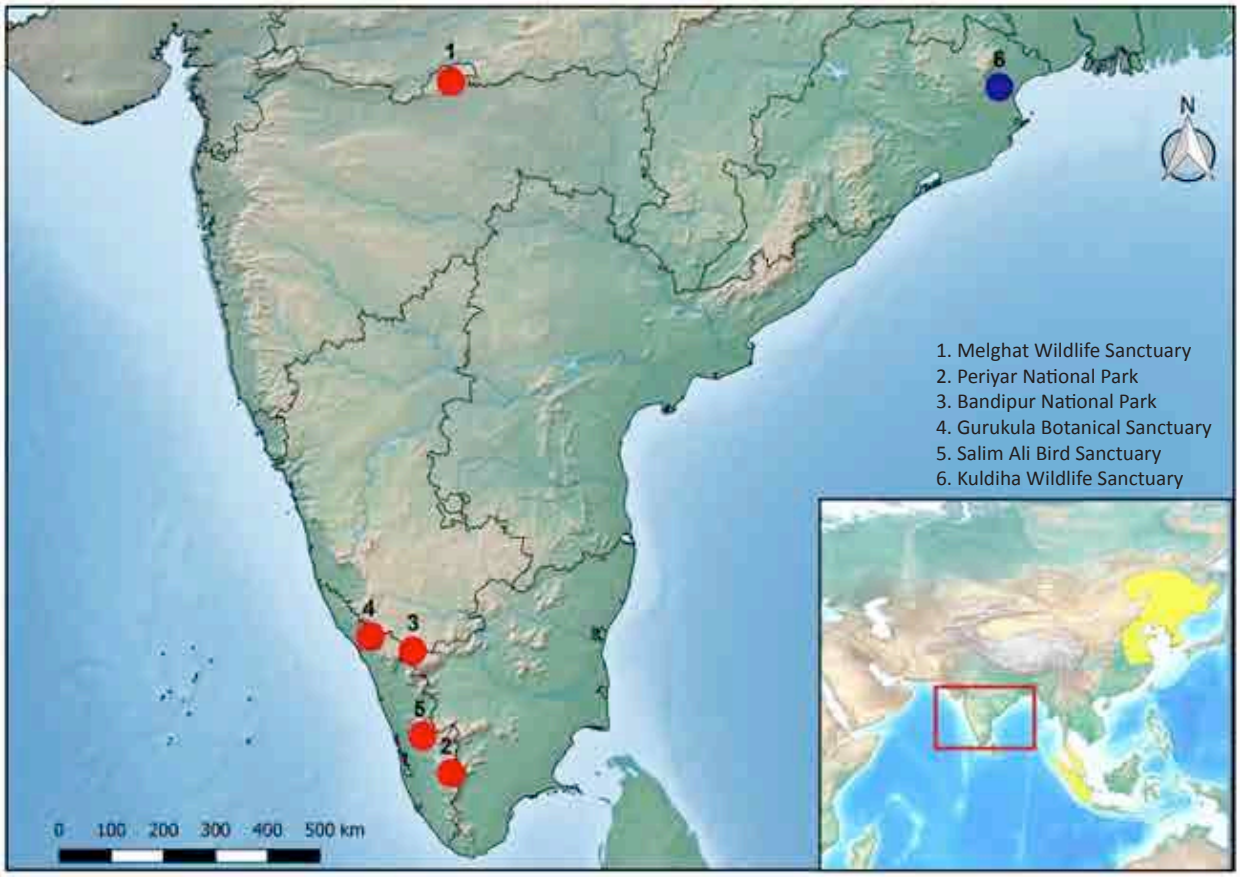

Figure 1. Map showing global distribution (inset) and detailed recorded localities of Yellow-rumped Flycatcher *Ficedula zanthopygia* in India. Red dots indicate earlier recorded localities and the blue dot indicates recent recorded locality.

(2011) and Grewal et al. (2016).

During the last two decades, there have been increasing efforts to document birds from different parts of India. Some of the new additions to Indian avifauna are Yunnan Nuthatch *Sitta yunnanensis* Ogilvie-Grant, 1900 (Bonpo & Kuriakose 2014), Black-browed Tit *Aegithalos bonvaloti* (Oustalet, 1891) (Sangha et al. 2013), Elliot's Laughingthrush *Trochalopteron elliotii* (Verreaux, 1870), Black-headed Greenfinch *Chloris ambigua* (Oustalet, 1896) (Dalvi 2013), Tristram's Bunting *Emberiza tristrami* Swinhoe, 1870 (Naniwadekar et al. 2013) and White-cheeked Starling *Spodiopsar cineraceus* (Temminck, 1835) (Hatibaruah et al. 2017). Sighting of Yellow-rumped Flycatcher from Kuldiha Wildlife Sanctuary in Odisha, eastern India along with five earlier reports from the central and southern India (Haribal 1991; Holt 2003; Baskran 2006; Jain 2006; Athri 2016) indicate that the species may regularly winter in the Indian subcontinent; further surveys are required to confirm this.

Image 1. A male Yellow-rumped Flycatcher *Ficedula zanthopygia* in Kuldiha Wildlife Sanctuary, Odisha, eastern India.

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Additional field records provide further resolution of the distribution of the Water Monitor *Varanus salvator* (Squamata: Varanidae) in northwestern Myanmar

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Despite being one of the most common and widely distributed varanids in South and Southeast Asia (Bennett et al. 2010; Das 2010; Chan-ard et al. 2015), the distribution of the Water Monitor *Varanus salvator* (Laurenti, 1768) within Myanmar remains poorly delineated, particularly for the central and northern regions of the country (Cota et al. 2009; Sai Sein Lin Oo & Bates 2016). Smith (1935) stated that *V. salvator* was "plentiful throughout Burma" [now Myanmar] without mentioning any specific localities. Anderson (1878) and Boulenger (1888) reported specimens of *V. salvator* from the Bhamo and the Kachin Hills, respectively. Cota et al. (2009) suggested these earlier records could be in error, perhaps representing specimens obtained in markets or transported as food, and further noted that extensive collecting by research teams from the California Academy of Sciences failed to record *V. salvator* anywhere in central and northern Myanmar. More recently, Oo & Bates (2016) confirmed the occurrence of *V. salvator* in north-central Myanmar after photographing a large adult in Bhamo and finding a locally-collected specimen being offered for sale at a market in Banmauk, about 140km west of Bhamo (Fig. 1). Sai Sein Lin Oo & Bates (2016) concluded these records either (1) represent an isolated and perhaps relict occurrence or (2) the distribution of *V. salvator* extends up the Ayeyarwady River and its tributaries.

We herein present two additional photo records, which further document the distribution of *V. salvator* within northwestern Myanmar (Fig. 1). The first record was obtained on 26 April 2016 when one of us (MMW) photographed a juvenile (total length [TL] ca. 90–100 cm) *V. salvator* while traveling by boat along Nam Pi Lin Stream (25.683^{0}N & 95.636^{0}E; elevation ca. 100m) in Sagaing Region (Image 1). The monitor was basking on a log extending from a steep bank and over-hanging the stream, and dropped into the water as the boat

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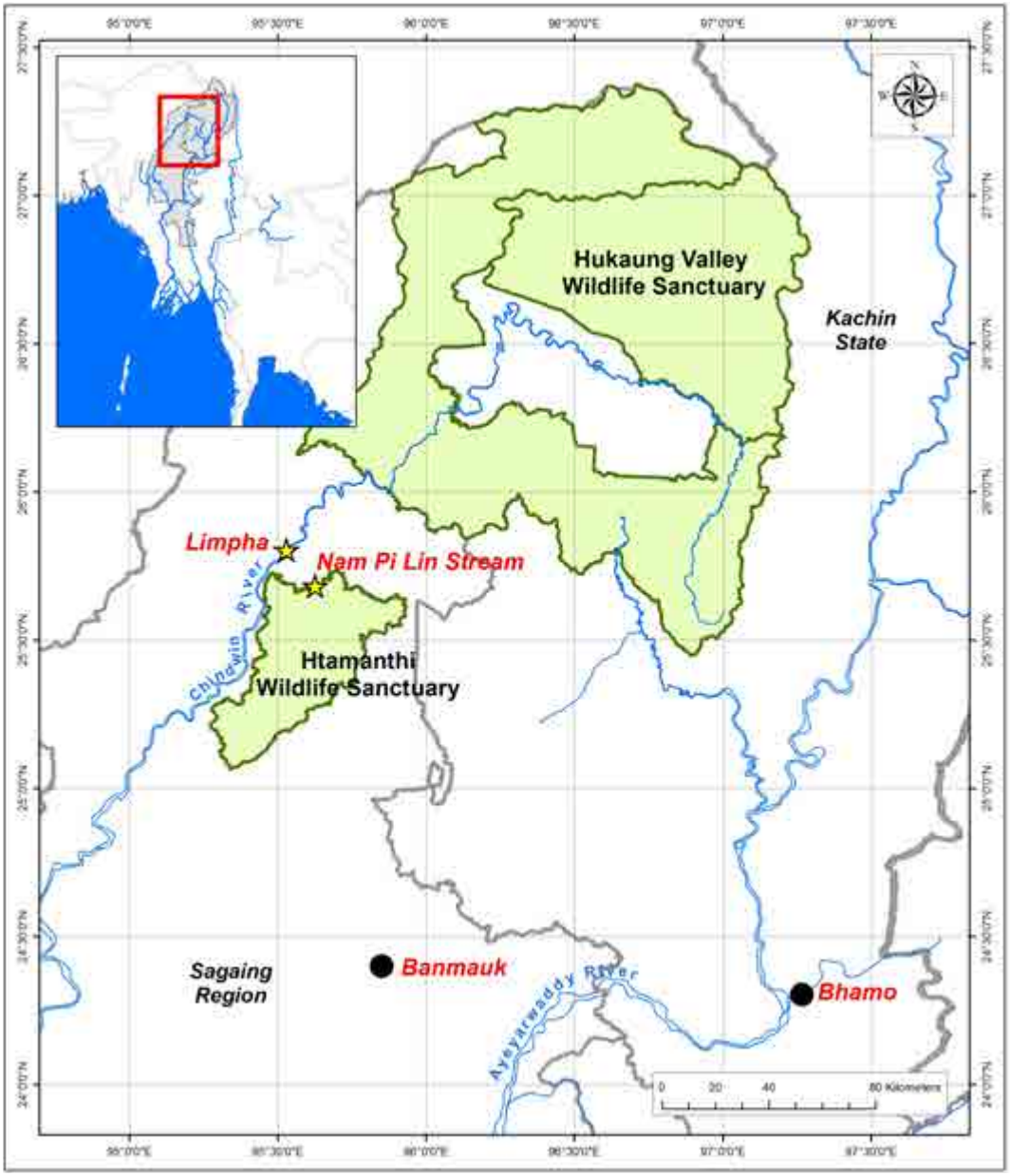

Figure 1. Map showing confirmed locality records for Water Monitors *Varanus salvator* in northern Myanmar: yellow stars (our study) and dark circles (Sai Sein Lin Oo & Bates 2016). Inset shows the area of interest within Myanmar.

approached. Nam Pi Lin Stream is encompassed within the boundaries of Htamanthi Wildlife Sanctuary. The habitat along this section of the stream is dense riparian forest and bamboo thickets transitioning into old-growth evergreen forest with increasing elevation away from the water. Additional information on the vegetation and physiography of Htamanthi Wildlife Sanctuary is provided by Beffasti & Galanti (2011).

The second photo record was obtained when a large adult *V. salvator* (TL ca. 150cm) was "captured" on a game camera deployed about 0.25km south-east of Limpha Village (25.808^{0}N & 95.536^{0}E; elevation ca. 132m) in Sagaing Region. The game camera (Moultrie Series A) was set in a densely vegetated seasonal swamp along the Chindwin River beside the carcass of a young domestic Water Buffalo *Bubalus bubalis* (Linnaeus, 1758) that had perished after becoming mired in deep mud. The motion-sensitive game camera (programed to take three photographs at 1-min intervals) was deployed from 17 February to 6 March 2018 (17 trap-nights) and captured a sequence of six images (1324-1326 hr) of a Water Monitor on 1 March (Images 2A–F). The first

Image 2. Juvenile Water Monitor basking on a limb over-hanging Nam Pi Lin Stream in Htamanthi Wildlife Sanctuary, Sagaing Region, Myanmar

image shows the monitor with head and neck extended back and upwards in a near-vertical position usually exhibited when swallowing (Image 2A). The monitor then investigates the remains of the carcass (Image 2B–C) and moves across and away from the camera (Image 2D–F). At the time these photographs were taken the buffalo carcass consisted of little more than bones in a pool of fetid muck (Stage 6 of Payne 1965).

Our photo records from Nam Pi Lin Stream and Limpha Village extend the known distribution of *V. salvator* in Myanmar approximately 170km north and westwards of the recent records from Bhamo and Banmauk (Oo & Bates 2016). Collectively, these records strongly suggest the distribution of *V. salvator* extends up the Ayeyarwady and Chindwin Rivers into northern and northwestern Myanmar. We see no reason to assume these records represent an isolated relict occurrence of *V. salvator* in northern Myanmar as suggested by Sai Sein Lin Oo & Bates (2016). Given the lack of apparent geographic barriers to dispersal, we further suggest the distribution of *V. salvator* extends at least as far north as the Hukaung Valley in Kachin State. Obviously additional investigation will be required to resolve these biogeographical questions.

Our photo records of *V. salvator* appear to be assignable to the subspecies *V. salvator macromaculatus* Deraniyagala 1944, which until recently was thought to be restricted to Thailand (Koch et al. 2007; Cota et al. 2009; Sai Sein Lin Oo & Bates 2016). Although considerable inter-population variation is evident in *V. salvator macromaculatus* (Cota et al. 2009), the two individuals in our photo records exhibit attributes consistent with this subspecies, namely, 1) brownish dorsal background color with at least five transverse rows of ocelli and light dotting between rows, 2) light chin with prominent crossbands on snout, 3) light ventral surface with six dark, sharply pointed bars on lateral surface, and 4) anterior tail with transverse rows of light spots and ocelli, and posterior tail with distinctive alternating light and dark crossbands (Koch et al. 2007). Similarly, Sai Sein Lin Oo & Bates (2016) concluded the two specimens they examined in northern Myanmar were assignable to *V. salvator macromaculatus.* Finally, our experience highlights the potential for using automated game cameras for documenting the occurrence and behaviors of varanids (see also Ariefiandy et al. 2013; Bennett & Clements 2014).

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Image 2. Series of six images from a game camera showing an adult Water Monitor at the badly decomposed remains of a young Water Buffalo in a swamp near Limpha Village, Sagaing Region, Myanmar. Monitor with head titled back and upwards (right arrow) with left arrow denoting location of buffalo remains in deep mud (A). Monitor investigates remains (B-C) and then moves across and away from camera (D-F).

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The first record of The Blue Admiral *Kaniska canace* Linnaeus, 1763 (Nymphalidae: Lepidoptera) from Bangladesh

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During the last five years, many rare species of butterflies have been reported from the northeastern and southeastern parts of Bangladesh which are new to the country. Considering the floral diversity and habitat variations, the northeastern region of Bangladesh hosts diversified faunal components like the northeastern state of Assam in India. Most of the protected areas of this part of Bangladesh contain mixed tropical evergreen forests, especially in Moulvibazar District under Sylhet Division (Sadat et al. 2016). This district contains a good number of forest areas with prevalent and diverse animal forms like butterflies, birds and mammals. The forest areas of Moulvibazar provide good shelter or habitat for diversified butterfly fauna. Recently, some remarkable new records have been enlisted in the butterfly fauna from Moulvibazar and its adjacent districts of Bangladesh (Shahadat et al. 2015; Neogi et al. 2016; Rahman et al. 2016; Sadat et al. 2016).

The butterfly *Kaniska canace* Linn. was recorded from Kauyargola forest beat in Rajkandi Reserve Forest (24.302^{0}N & 91.917^{0}E), Kamalganj Upazila, Moulvibazar District (Fig. 1) on 17 March 2017, as part of a study on butterflies initiated in March, 2011, intensively covering the northeastern forest ranges within the core area of Rajkandi Reserve Forest. The species was photographed during the survey, with both the under (Image 1) and upper wing (Image 2) views for species confirmation. The species was found to frequently settle on wet sands and damp patches, with a few instances of fast flying and resting on fern leaves. Like other nymphalids, occasional basking with open wings and vibration of its wings when susceptible to threat or disturbance were also observed. It was also pugnacious and highly territorial with other species of butterflies. Only a single species, however, was sighted during the entire survey period in the study area.

Short description: Upper wing color of the sighted individual was indigo blue with broad silvery blue discal band on both wings. On this band there were small black spots between the veins. FW apex was square cut and strongly concave along termen. Hind wing had small tail at vein 4. Underwing color was cryptically mottled dark brown and black.

Remarks: Palaearctic butterflies are normally restricted to the Himalayan mountain ranges, with

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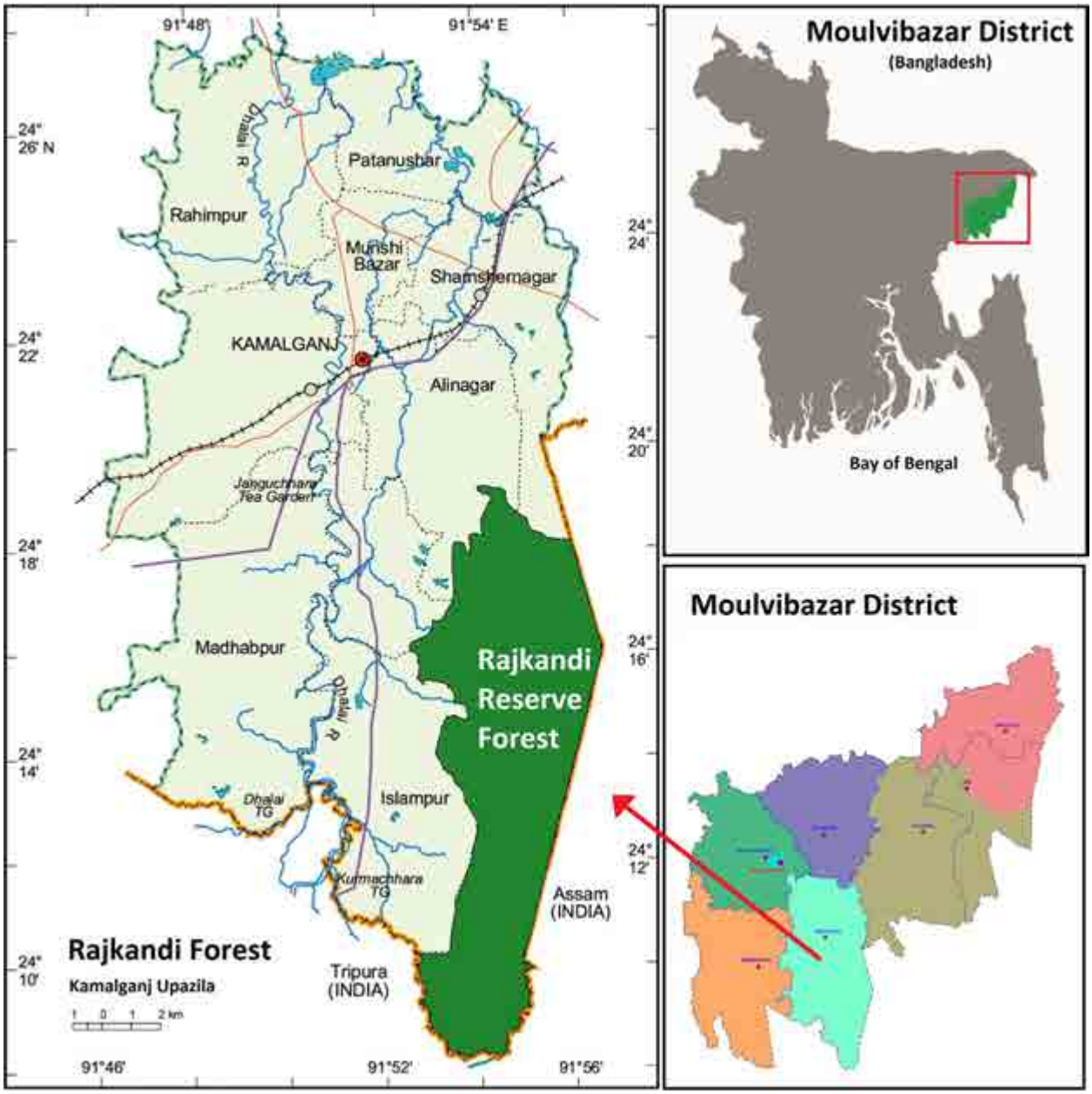

Figure 1. GIS map of the Kamalganj Upazila including Rajkandi Reserve Forest, Adompur (green area) under Moulvibazar District, selected as the present area of study.

the exception of very few species viz., *Pieris canidia* Linnaeus, 1768; *Colias erate* Esper, 1805; *Argyreus hyperbius* Linnaeus, 1763; *Vanessa indica* Herbst, 1794, and *Kaniska canace* Linnaeus, 1763 that occur in the southern Indian mountains as well (Larsen 1986). *K. canace* seems to have been rarely recorded from the plains and prefer hill forests. In the last two decades, *K. canace* has been sighted from a few locations of Assam, India (Bhuyan et al. 2005; Naik & Mustak 2016) which is more than 600km from the present study area. *K. canace*, however, has been reported to be present in the Himalayan region between 1,000m and 3,000m, and in the southern Indian hills between 1,000m and 1,200m (Kehimkar 2013).

The present study thus confirms the presence of *K. canace* in Rajkandi Forest at Adompur by successfully presenting the first photographic evidence in Bangladesh. This particular species of butterfly seems to always be in this area, but the season and time of its occurrence barred earlier surveys. This study also emphasizes on the need for a comprehensive butterfly study in the particular area, that will further enrich the

Image 1. *Kaniska canace* Linn. (underwing view) on wet sand at Rajkandi Reserve Forest

Image 2. *Kaniska canace* Linn. (upperwing view) resting on fern leaf with open wings at Rajkandi Reserve Forest

existing list of butterflies in Bangladesh.

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Note

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First record of *Hislopia malayensis* Annandale, 1916 (Bryozoa: Gymnolaemata) from freshwaters of India

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Freshwater bryozoans are the representatives of periphytic or aufwuch community. They grow on underwater substrata which may be living or nonliving. Bryozoan colonies have multiple subunits, known as zooids. In India Annandale (1911), Rao (1992) and Shrivastava (1981) made significant contribution to this fascinating phylum but further studies are obligatory to understand the real picture of diversity, distribution and the ecology of bryozoans in India.

Class Gymnolaemata includes five freshwater families from which the family Hislopiidae is represented by a single genus, *Hislopia*, with seven described species. Till date, only *Hislopia lacustris* Carter, 1858 and *Hislopia monoliformis* Annandale, 1907 have been documented from India. This is the first report on the occurrence of *Hislopia malayensis* Annandale, 1916 from the fresh waters of India. Formerly the species was only reported from Thailand by Annandale (1916) and Wood et al. (2006), as well as from Cambodia by Hirose & Mawatari (2007). It was initially described by Annandale (1916) from a small lake near Yala in Patani Province, Thailand where collections were made in 1901. Again in 2006 Wood et al. (2010) collected it from the same locality. Wood et al. (2006) reported it again from several sites across Thailand and described it as the "most frequently encountered freshwater bryozoan in Thailand".

Material and Methods: The colonies were collected from Visapur Dam ($19^0$32'N & $74^0$52'E) and Mula Dam ($19^0$0'N & $74^0$34'E) Ahmednagar District and Mombatta Lake ($19^0$57'N & $75^0$15'E) of Aurangabad District Maharashtra State, India. All kinds of hard submerged substrata were examined and colonies were observed under binocular dissection microscope in live condition. The colonies were also maintained in the laboratory as described by Wood (2005) for observing growth patterns.

Result and Discussion: The species is identified by the description provided by Annandale (1916) and Wood et al. (2006). The colonies are flat and zooids radiate in all directions. Zooids are broadly oval, with a wide zone of contact between the daughter zooids. The old zooids are brownish in color while the newly formed ones are transparent (Image 1B). Unlike *H. lacustris* spines are absent around the opening of zooid, the orifice and the presence of distal expansion (Image 1C–E), which later on develops as a daughter zooid. This expansion is a transparent tube, which later starts expanding from

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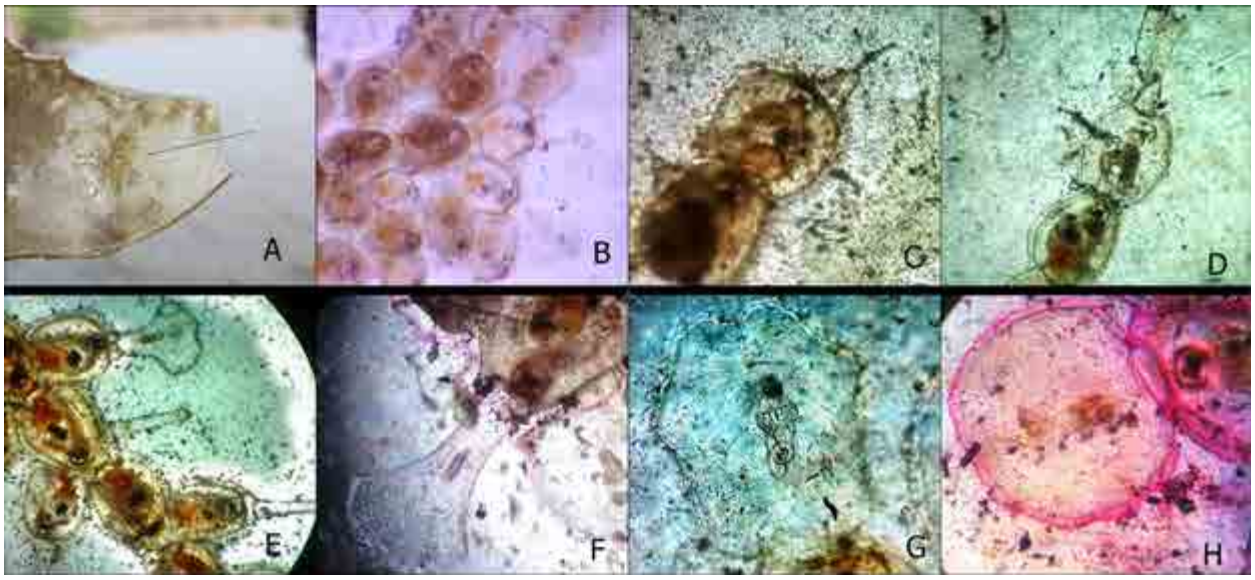

Image 1. A - colony of *Hislopia malayensis* on glass; B - zooids of *H. malayensis*; C–H - shows the development of new zooid through the distal tube and subsequently backward expansion

the tip and moves back towards the parental zooid (Image 1F–H). The distal expansion has a ball like cell mass, becomes spindle-shaped, which possibly forms all the internal organs of the daughter zooid during the development. This distal expansion with spines absent around the orifice of the zooids are the diagnostic characters of *H. malayensis* (Annandale 1916; Wood et al. 2006). In a fully grown colony, the digestive tract is of saffron color, with milky white peristome and a transparent ectocyst.

The colonies are abundant at all sites especially at Mula Dam where each and every submerged substratum, even the plastic boat used to catch fish is densely covered by the colonies. They are observed on rocks, twigs, plastic bottles glass (Image 1A), and clothes present in the water like *H. lacustris*, which is a common freshwater bryozoan across several sites of Maharashtra State.

Conclusion: According to Timothy S. Wood (pers. comm. 2015) there is no serious work on this genus and one has to understand the phenotypic plasticity and molecular taxonomy amongst the species to know the variation and exact number of species in the genus. This report points out the need to undertake further studies on the diversity and distribution of these fascinating animals in India.

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An extended distribution record of Western Ghats species *Litsea oleoides* (Meissn.) Hook.*f*. (Lauraceae) from Matheran, Maharashtra, India

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In the course of floristic explorations in the hill station, Matheran, in Raigad District of Maharashtra, we collected an interesting specimen of a *Litsea* species. After critical examination and comparing our specimens with all available collections in various herbaria including Kew, the specimen was identified to be *Litsea oleoides* (Meissn.) Hook.*f*., an endemic species of wet evergreen forests in southern India, hitherto not reported from Maharashtra.

Litsea oleoides

(Meissn.) Hook.*f*., Fl. Brit. India 5: 175. 1886; Gamble, Fl. Pres. Madras 2: 1236. 1925; V. Chandras. in A.N. Henry et al., Fl. Tamil Nadu 2: 211. 1987; Matthew, K.M. Illustrations on the Flora of the Palni Hills, southern India. 616. 1996; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 399. 2004; Udayan et al. Indian Forester 130 (5): 551–564. 2004; Bhuinya et al., Bangladesh J. Plant Taxon. 17(2): 183–191. 2010; Rajeev Kumar Singh et al. Bangladesh Journal of Plant Taxonomy 22(2): 77–81. 2015. *Tetranthera oleoides* Meissn. Prodr. 15(1): 195 1864.

Specimen examined: Phytocare Herbarium, Piramal Enterprises Limited, 20130725(1), 29.vi.2013, Maharashtra, Raigad, Matheran (in fruit), 750m, coll. Gurumurthi Hegde & Radha Veach.

Other specimens: The Herbarium at Center for Ecological Sciences (CES), Indian Institute of Science Bengaluru JCB 0291, 15.iii.2015, Karnataka, Kemmannugundi, Bababudengiri, Muthodi, Bhadra forest 13.530^{0}N & 75.785^{0}E, 1,375m, coll. Srinivas S.G & Y.L Krishnamurthy; Royal Botanic Gardens, Kew (KEW) K000357533, (date unknown) iv.1846, Kerala, Sispara (as Chispaurey) s.d., R. Wight.

Medium to large canopy trees 10–30 m tall, girth up to 3.82m; young bark smooth, lenticellate, green, turning greyish-brown or grey; older trunks buttressed with the bark exfoliating in longitudinal patches; branchlets green or yellowish-green, glabrous or glabrescent. Leaves sub-opposite to alternate; blade elliptic or elliptic-oblong or oblong (when young), up to 12–26 x 7–14 cm, apex short and bluntly acuminate, base cuneate, margin entire, sub-coriaceous, glabrous on both surfaces, dark green above, much paler and whitish beneath; new foliage pinkish-red turning to copper; petiole 1.5–3 cm long, glabrous; midrib shallowly sunken or flattened above, raised beneath, secondary veins 12–15 pairs, slightly prominent above, raised beneath, curving or curving

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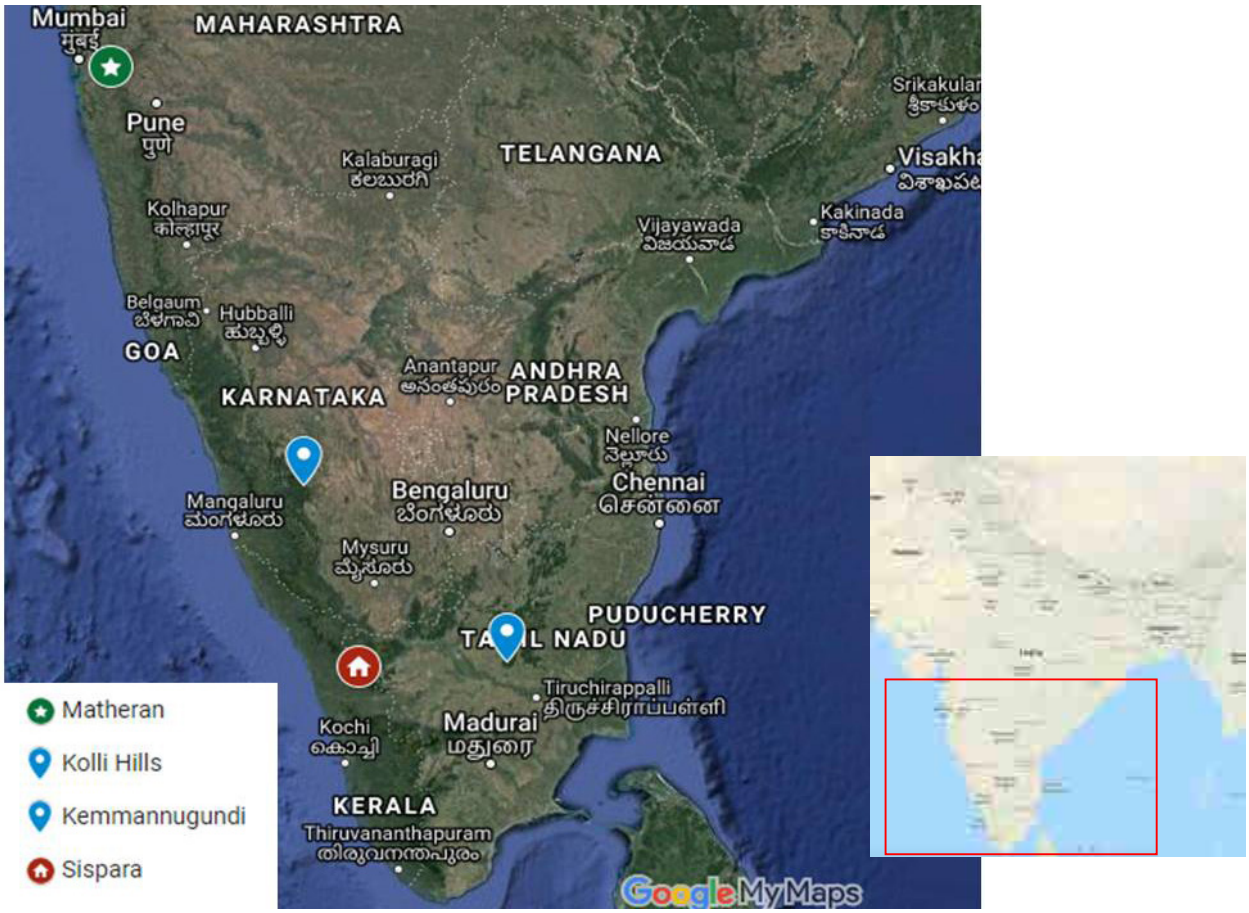

Figure 1. ***Litsea oleoides*** **(Meissn.) Hook.*f.* - Map of distribution in India. Imagery © 2017 Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Landsat / Copernicus, Map data ©2017 Google**

and looping near margin, tertiary veins reticulate, indistinct on both surfaces; prominent leaf galls on lower epidermis bursting stellately. Inflorescences on umbel-bearing reduced branchlets with the appearance of racemes of umbels, in axils of leaves or along branchlets, racemes of umbels 2–4 cm long; umbels 0.5–1 cm in diam.; peduncles 0.6–1.2 cm long, glabrous; bracts 4, decussate, sub-orbicular, broadly ovate, concave, 3.5–7 by 3–5 mm, membranous, with veins, two outer ones glabrescent, two inner ones glabrous. Male flowers 3–6 in each umbel; tepals 5, ovate-lanceolate, 3–3.5 by 2–3 mm, membranous, pubescent inside; pedicels 1–2 mm long, glabrous; stamens 8–11, unequal; anthers 1.5–2 mm long; filaments 1.5–2 mm long, villous, 2 glands at base or some without glands; pistillode 1–1.5 mm long, glabrous. Female flowers not seen. Fruits globose, 1.2-1.6 cm in diam., appressed at the top, pale green with faint white dots, turning dark cherry-pink and later dark red when ripe, glabrous, glossy; enlarged perianth tube obconical, glabrous; fruiting pedicels 0.3–0.7 cm long, glabrous; infructescence stalks 0.3–1 cm long, glabrous.

Flowering: September–October. Fruiting: April–June.

Phenology: Tight buds appear in early August and remain almost unchanged in appearance for a whole month. The buds are swollen by mid-September and single flowers bloom randomly all over the tree. By early October half of the total buds are open and within a week the tree is in full bloom. Flowering terminates by late October, and if heavy rains do not persist dried flowers remain on the tree until January. Green juvenile fruits are formed in the first week of March. They mature slowly and remain green faintly speckled with white through April. By early May the fruits ripen to pink and fall. Meanwhile many immature fruits are knocked down by impatient monkeys. Large numbers of Bonnet Macaque *Macaca radiata* collect ripe fruits, eat the fleshy portion and discard the seeds, thus assisting in their dispersal. Though frugivory by birds is common in the Lauraceous tree species, we did not observe birds feeding on the fruit. Lack of ornithochory may be the

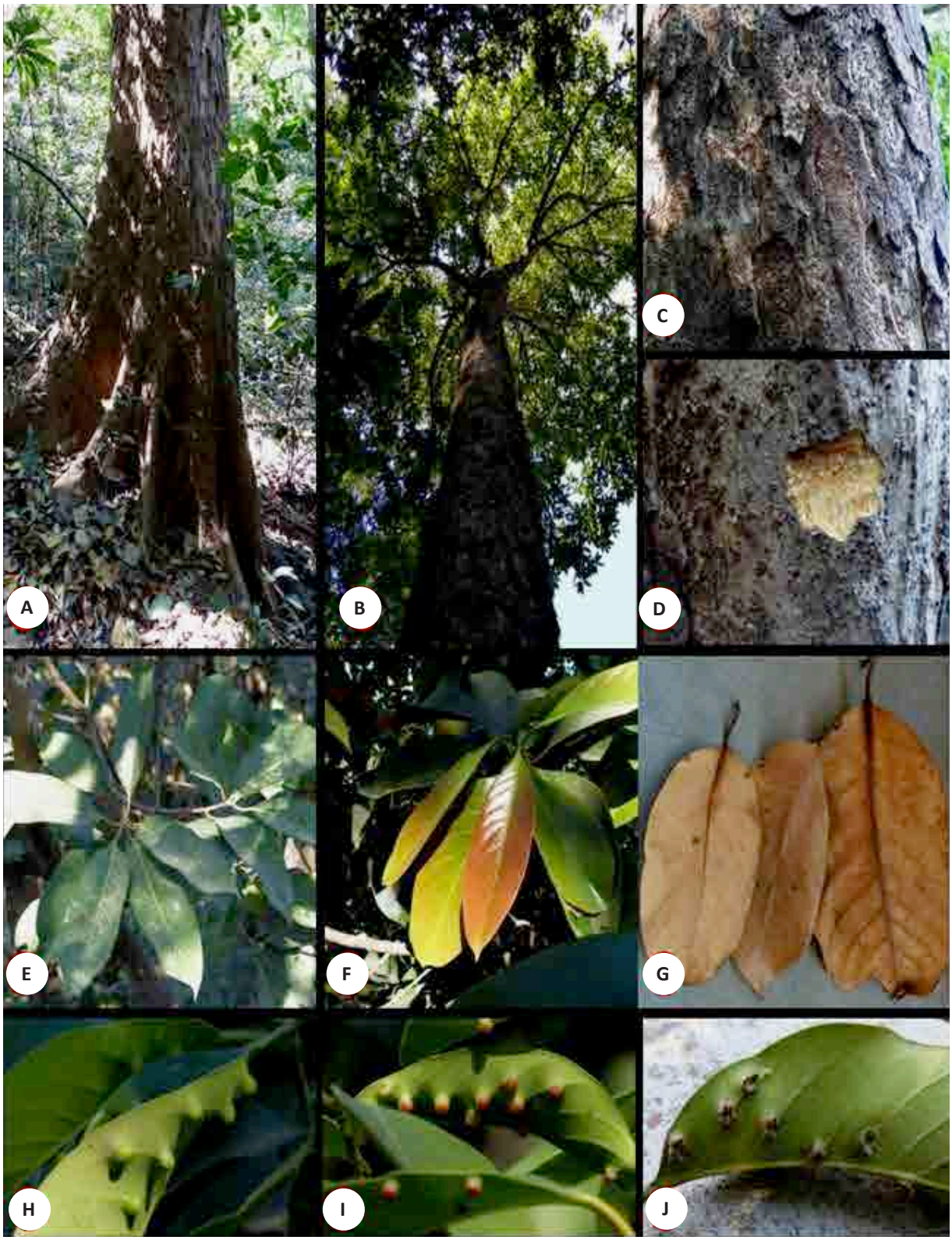

Image 1. *Litsea oleoides* (Meissn.) Hook.*f.* (A–J): A - Bole; B - Canopy; C - Bark; D - Blaze; E - Leaves; F - Young leaves with copper tinge; G - Fallen dried leaves; H–J - Galls on lower epidermis of leaves (H - younger stage, I - intermediate stage, J - older galls burst open)

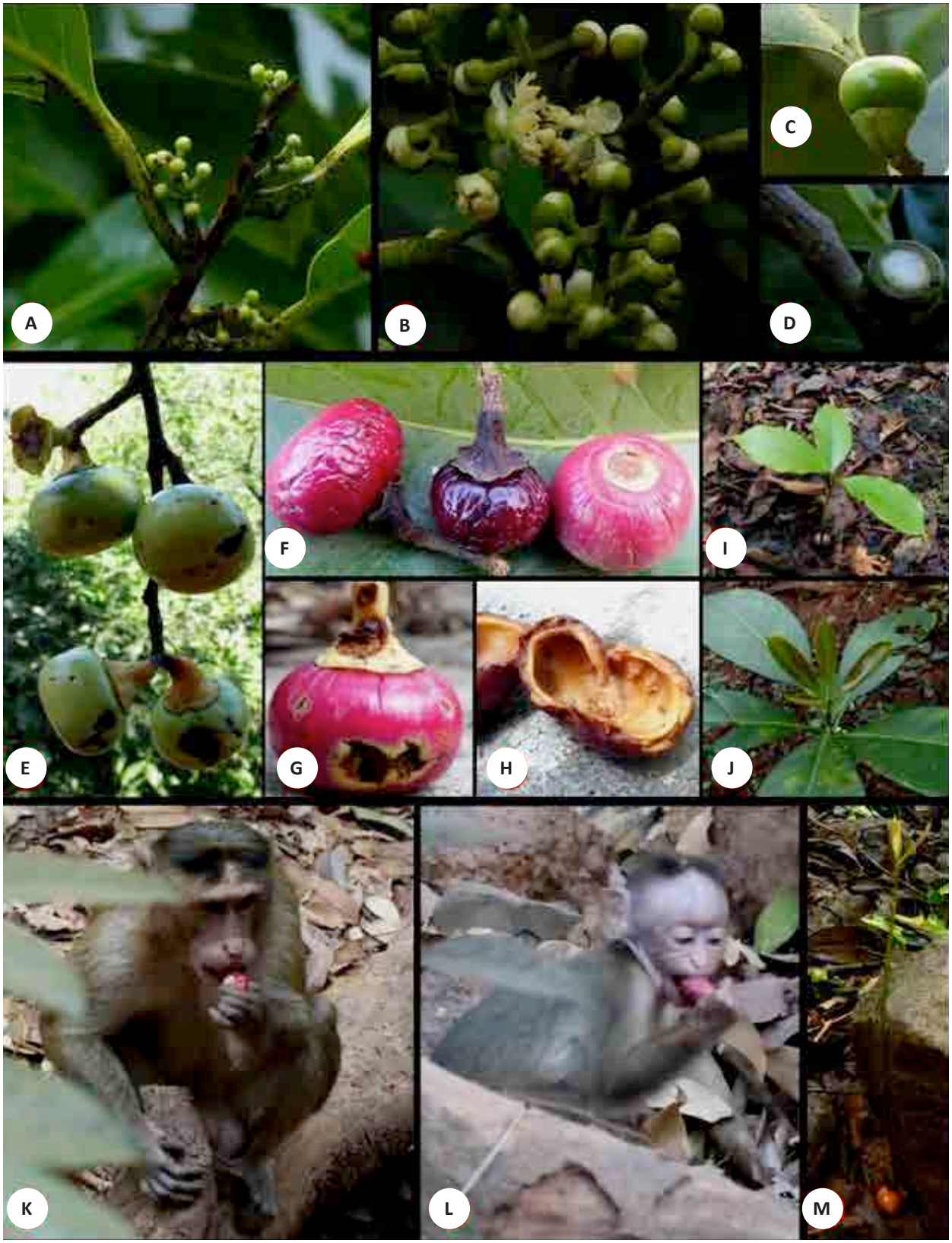

Image 2. ***Litsea oleoides*** **(Meissn.) Hook.*f*. A&B:. Flowers. A - buds, B - open flowers; C–H - Fruits (C - tender fruit, D - tender fruit cut transversely, E - just before maturity, F - different stages of maturity, G - Scars of frugivory, H - Epicarp); I & J - Saplings (I - 3-leaf stage, J - Two year old seedling); K & L - Frugovory by** ***Macaca radiata*****; M - Fresh seedling.**

cause for the present discontinuous distribution of this species. Seeds germinate beneath the parent trees. Seedlings at the 2-leaf and 4-leaf stages were observed in August. Of all 10 individual mature trees located in the slopes harbouring evergreen forest we saw an abundance of saplings ranging from 6–8 m tall with girths of 10–30 cm. The leaves of the saplings are much larger than those of the canopy trees. Though the tree is recorded as having opposite leaves in some locations, lower altitude plants have alternate leaves (Jose Robi pers. comm. 13 March 2014). The abundance of smaller seedlings in the vicinity of the parent trees indicates a good regeneration of the taxon locally.

Distributional notes: The tree is a known endemic to Kerala, Tamil Nadu (Nayar et al. 2006) and Karnataka (Udayan et al. 2004) states of southern India. Its northernmost distribution recorded to date is Kemmanagundi in Karnataka (Srinivas & Krishnamurthy 2016). The present collection site, Matheran, in the northern Western Ghats of Maharashtra is about 700km further north. Matheran's elevation is about 759m making it a new lower elevation record for *Litsea oleoides.* It is usually found in wet evergreen forests of 800–1300 m range.

Matheran is an isolated forested plateau west of the Ghats escarpment. It shelters a pocket of evergreen forest which has become isolated in the geological past leading to the present extremely discontinued distribution of the species. While the top of hill is a large lateritic plateau, deep ravines around it are covered by relatively small patches of evergreen forest of the type *Memecylon-Syzigium-Actinodaphne* (Puri et al. 1983). This forest type is quite unlike others in which *Litsea oleoides* commonly occurs. It is a common canopy tree or emergent in the type *Cullenia exarillata - Mesua ferrea - Palaquium ellipticum* (Pascal et al. 2004).

In Matheran, the population of *Litsea oleoides* is found in conjunction with other evergreen species including *Diospyros sylvatica* Roxb., *Beilschmiedia dalzellii* (Meisn.) Kosterm., *Cryptocarya wightiana* Thwaites, *Ficus nervosa* B.Heyne ex Roth, *Garcinia talbotii* Raizada ex Santapau*, Mangifera indica* L.*, Persea macrantha* (Nees) Kosterm., *Sageraea laurina* Dalzell and *Syzygium* spp. The ground layer of the forest includes *Ancistrocladus heyneanus* Wall. ex J.Graham, *Mallotus resinosus* (Blanco) Merr. and *Dimorphocalyx glabellus* var. *lawianus* (Hook. f.) Chakrab. & N.P. Balakr.

All the mature individuals of *Litsea oleiodes* existing at Matheran are of a great height, making detailed observation difficult. This may be a reason why the presence of the species has been unrecorded until now. With the present collection of *Litsea oleoides,* Matheran is the northernmost distribution limit for this species. Also, the presence of this southern evergreen endemic confirms the remnant legacy of an evergreen flora of Matheran.

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NOTES ON *JASMINUM ANDAMANICUM* N.P. BALAKR. & N.G. NAIR (OLEACEAE) FROM ANDAMAN & NICOBAR ISLANDS, INDIA

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Jasminum L., comprising of ca. 200 species, is distributed in tropical to temperate regions of the Old World (Mabberley 2017). This genus is found commonly in deciduous and evergreen forests as climbing shrubs with flowers generally in white, pink or yellow colours and sweet-scented.

Clarke (1882) in Hooker's "The Flora of British India" reported 43 species and 15 infra-specific taxa of *Jasminum* from India, Burma (now Myanmar), Sri Lanka, Bhutan, Malacca, Tibet, Nepal and Malaya Peninsula. Srivastava (1987) reported 10 genera, 87 species and 15 infra-specific taxa belonging to the family Oleaceae, in India including the Himalaya, the northeast, peninsular regions, and Andaman & Nicobar Islands. Among these, 27 are endemic taxa. A total of 17 taxa of *Jasminum* are listed under various threat categories (Srivastava & Kapoor 1987).

In India, *Jasminum* is represented by 37 species and 15 infra-specific taxa (Green 2003; Gastmans & Balachandran 2006), of which 12 species are considered endemic to India (Ahmedullah & Nayar 1986; Srivastava & Kapoor 1987; Singh et al. 2015). In Andaman & Nicobar Islands, so far 12 species are known to occur, namely, *J. acuminatissimum, J. andamanicum, J. angustifolium, J. arborescens, J. attenuatum, J. auriculatum, J. caudatum, J. elongatum, J. flexile, J. multiflorum, J. ritchiei,* and *J. syringifolium* (Green 2003; Pandey & Diwakar 2008), of which only one species, *J. andamanicum* is endemic to the Andaman group of Islands.

Balakrishanan & Nair (1981) described *J. andamanicum* based on the specimens collected from southern Andaman by Dr. King's collector. Later, Balakrishanan & Nair (1983) described a new species, *J. unifoliolatum* based on their collections from Saddle Peak in northern Andaman. This species was distinguished from *J. caudatum* by the leaves being mostly unifoliolate, broader, thick-coriaceous, penninerved; panicles densely white-hairy; cymes lax-flowered and corolla tube and lobes being short. Srivastava (1991) proposed a new name, *J. balakrishnanii* for *J. unifoliolatum* as the name was preoccupied and hence an illegitimate later homonym. Later, Green (2003) synonymized the name *J. balakrishnanii* and treated it as conspecific to *J. andamanicum* in his synopsis of the Oleaceae from the Indian subcontinent

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While studying some of the old collections of *Jasminum* housed at CAL, specimens collected by Dr. King's collector during 1891 and 1892 from southern Andaman were found as unidentified. On studying their morphological characters, and on consultation with the type specimens and relevant literature, they were identified as *Jasminum andamanicum*. It is interesting to note that these collections were made three years before the holotype collection. Also, one of the specimens was collected from a different locality, from where this species has never been reported earlier, until now. The present article provides a detailed description of the species, image of the one of the old specimens collected prior to the type collection, and a distribution map (Fig. 1) of this rare, endemic species. The species is evaluated as per the recent IUCN Red List Category and Criteria version 3.1 (IUCN 2018).

Jasminum andamanicum N.P. Balakr. & N.G. Nair
(Image 1)

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Type: India, Andaman & Nicobar Islands, southern Andaman: North Bay, hill jungle, 5.1.1894, King's collector s.n. (holotype CAL0000017761!; isotypes CAL0000017743!, CAL0000017744!, CAL0000017745!

Vine or scandent shrub; branchlets slender or terete, glabrous, young parts sparsely puberulous. Leaves opposite, 3-foliolate, sometimes lateral leaflets wanting or caducous; leaflets ovate or elliptic, 4–8 × 2.5–5 cm, obtuse or acute at base, entire at margins, acute to acuminate at apex, coriaceous, glabrous; lateral veins 5–8 pairs, ascending and interarching away from margin; petioles 2–2.8 cm long, geniculate, slender, leaf base bending or somewhat swelling; petiolules, 1cm long, terete. Inflorescences terminal or sometimes axillary at upper leaves, paniculate cymes, 4–16 cm long, densely white-hairy; peduncles 4–14 cm long, terete, sparsely white-hairy; bracts filiform or linear, 3–8 mm long, white-hairy. Flowers pentamerous, sessile or subsessile; central flower sessile, densely white-hairy and pedicels of lateral flowers, terete, 5–15 mm long, densely white-hairy. Calyx tube 1–2 mm long, densely white-hairy, 4 or 5-lobed; lobes ovate or triangular, 2–3 mm long, lower densely white-hairy and upper glabrous. Corolla milky white with pleasant smell; tube, 2–2.5 cm long; lobes 5, ovate, 4–6 mm long, acute at apex. Stamens 2 bright lemon yellow; filaments sessile or subsessile; anthers oblong, 3–4.1 mm long, acute at apex, dithecous, longitudinally dehiscing. Ovary 2-loculed; ovules 2, less than 1.5mm long; style linear or filiform, 15–20 mm long; stigma bilobed, ca. 1mm long, glabrous. Drupes ellipsoid or oblongoid, 1–1.5 mm long, glabrous.

Flowering: December–February; Fruiting: March–April.

Distribution: Endemic to Andaman group of Islands.

Additional specimens examined: CAL0000029896!, 5.xii.1891, India, Andaman & Nicobar Islands: Southern Andaman, North Bay, hill jungle, King's Collector s.n. ;

5.xii.1892, South Andaman, North Bay, hill jungle, King's Collector s.n. (CAL!); 20.xii.1892, Dhanikhari, King's Collector s.n. (CAL!); CAL0000017760!, 17.xii.1915, Middle Andaman: Long Island, C.E. Parkinson 787, North

Figure 1. Distribution of *Jasminum andamanicum* N.P. Balakr. & N.G. Nair in Andaman group of Islands.

Andaman Island: (holotype CAL0000017747!; isotypes PBL!), 4766, Saddle Peak, 1.xii.1976, 400–700 m, N.P. Balakrishnan & N.G. Nair.

Conservation status

This species was first collected by King's collector in 1891 from North Bay area in southern Andaman. Later, C.E. Parkinson collected this species from Middle Andamans. The recent collection of this species dates back to 1976 by Balakrishnan & Nair from Saddle Peak of North Andaman Island. Mathew & Abraham (1994) rediscovered and reported it from Shoal Bay of Mount Harriet in South Andaman Island. There was no report on the occurrence of this species thereafter.

Jasminum andamanicum is reported so far only from four locations in Andaman Islands, India. The extent of occurrence (EOO, Criterion B1) of the species is calculated as ca. 1,139km^2 and the area of occupancy (AOO, Criterion B2) of the species is calculated as ca. 16km^2 (severely fragmented and with a suspected decline of mature individuals, being sparsely distributed). The AOO is measured against the grid size of 4km^2 for each of the four locations.

Other than Saddle Peak National Park in North Andaman Island, the habitat quality of other places of collection of this species has degraded to a large extent as they are under extreme pressure from human interference, as they do not fall under any protected area. The quality of habitat in these places also face serious threat due to developmental activities like the construction of a dam in Dhanikhari, tourism activities, and grazing by herbivorous animals.

The species is assessed here as Endangered [B1ab(iii,iv)+2ab(iii,iv)] as per the IUCN Red List of Threatened Species guidelines version 3.1.

Image 1. Image of the oldest specimen of *Jasminum andamanicum* N.P. Balakr. & N.G. Nair collected in 1891 housed at CAL

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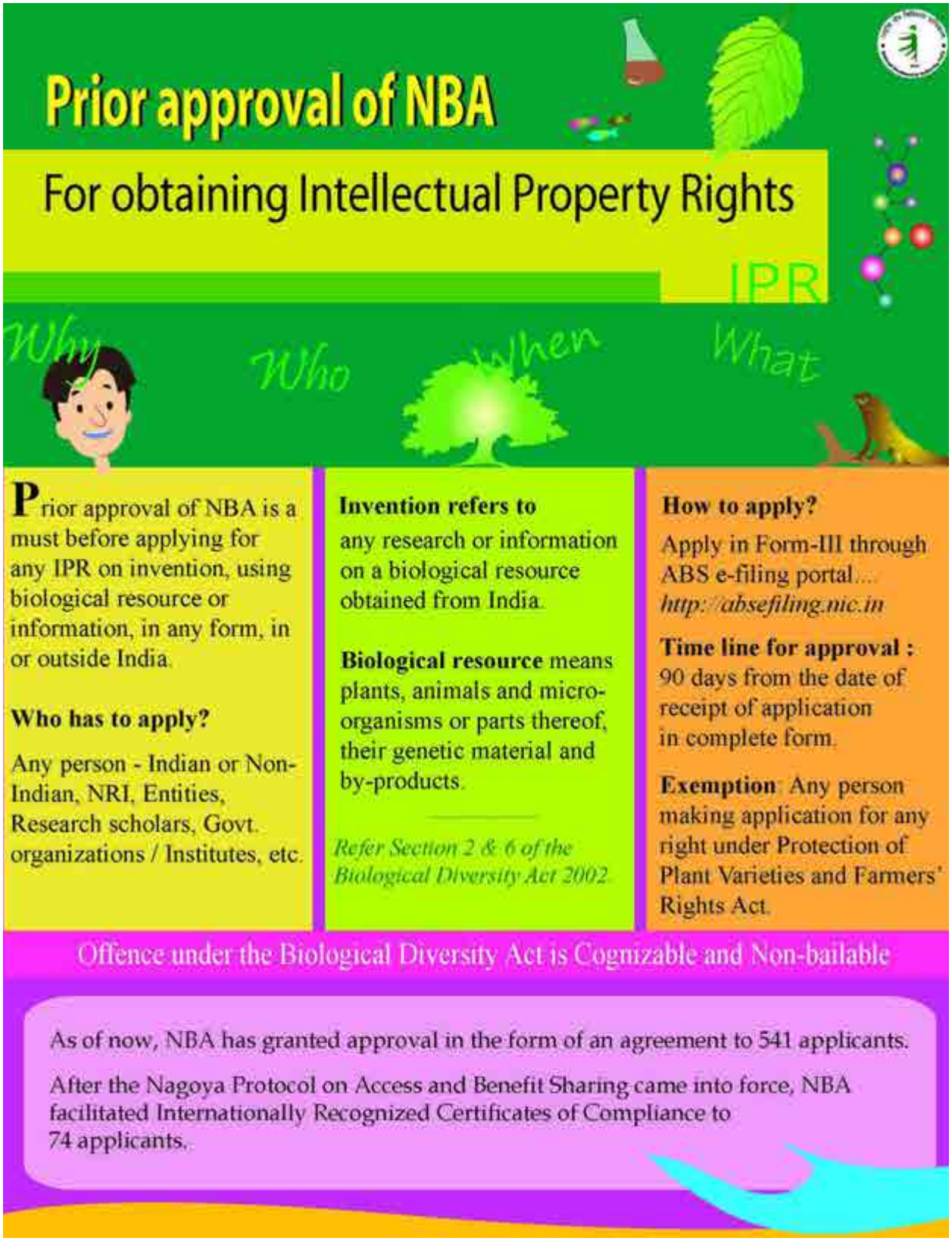

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