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The status of wild canids (Canidae, Carnivora) in Vietnam

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Abstract: Four species of wild canids are documented as occurring in Vietnam: Dhole *Cuon alpinus*, Eurasian Golden Jackal *Canis aureus,* Red Fox *Vulpes vulpes* and Raccoon Dog *Nyctereutes procyonoides*. Except for Dhole, all species are widely distributed globally and are listed as Least Concern on the IUCN Red List of Threatened Species. Concerned by the paucity of recent records of these species from Vietnam, especially in the context of rapidly declining mammal populations in the country in general, we undertook a review of the status of these species in Vietnam. All traceable and potentially verifiable canid records from 01 January 2002 until 31 December 2018 were collated and reviewed. The Dhole, formerly the most widely distributed of all canid species in Vietnam, and Raccoon Dog, apparently formerly widely distributed in the northern part of the country, appear to have both declined; Dhole is now either extirpated, or close to extirpation, while Raccoon Dog is of uncertain status. The Eurasian Golden Jackal does not seem to have been reliably observed in the wild since 2004, although it is possible the species may persist in some areas. Red Fox has only ever been known from a handful of records, and the current status of this species is unknown. In summary, Vietnam cannot be considered to sustain healthy populations of any of its four native wild canid species. These declines seem largely attributable to hunting of both the canids themselves and, for Dhole, their prey base, exacerbated by habitat loss.

Keywords: *Canis aureus*, *Cuon alpinus*, *Nyctereutes procyonoides*, *Vulpes vulpes.*

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INTRODUCTION

Vietnam has a diverse mammal fauna with the most recent checklist documenting 295 native species (Dang Ngoc Can et al. 2008), including four species of wild canids: Eurasian Golden Jackal *Canis aureus* (hereafter Golden Jackal), Dhole *Cuon alpinus*, Raccoon Dog *Nyctereutes procyonoides* and Red Fox *Vulpes vulpes*. The Golden Jackal, Raccoon Dog and Red Fox are all widely distributed globally and are listed as Least Concern on the IUCN Red List of Threatened Species (hereafter IUCN Red List). The Golden Jackal ranges from Western Europe (where it has been undergoing rapid range expansion) and the Middle East eastwards to mainland Southeast Asia; populations in Africa formerly assigned to *C. aureus* are now understood to represent a distinct species, the African Wolf *Canis lupaster* (Koepfli et al. 2015; Viranta et al. 2017). The Raccoon Dog is native to East Asia, occurring from northern Vietnam north to the Russian Far East, but was introduced to the European part of the former Soviet Union in the mid-20th Century and has now established itself in northern and eastern Europe (Kauhala & Kowalczyk 2011). The Red Fox has the widest distribution of all the world's wild canid species, with a native range in most of the northern hemisphere. In contrast to these three species, the Dhole historically occurred throughout southern and eastern Asia, to as far north as the Russian Far East, and as far west as eastern Kazakhstan to northern Pakistan. The species has undergone substantial declines across its range and is currently categorized as Endangered on the IUCN Red List.

A global status assessment of these four canid taxa was undertaken as part of a process of updating the IUCN Red List. During this assessment, evidence emerged to suggest that the population status of wild canids in Vietnam is of more significant concern than it is in much of the rest of these species' ranges. While Vietnam has more species of native canids than any other southeastern Asian country, pressures on ground-dwelling mammals in general in the country are very high, and have resulted in localised extirpations, or in some cases national-level extinctions of some mammals (such as Javan Rhinoceros *Rhinoceros sondaicus*; Brook et al. 2012). A general lack of available records of canids from Vietnam for the global assessment, and an understanding of the general trajectory of mammal populations in Vietnam, prompted us to undertake a more detailed review of the status of these species in the country.

METHODS

We surveyed recent literature, as well as current and recent conservation workers and researchers with significant experience working across the country, for published and unpublished records or observations of each of the four species. We adopted methods similar to Willcox et al. (2014) seeking any and all traceable records in the country from 01 January 2002 until 31 December 2018 (a period of ~16 years, equivalent to three generation lengths of the Dhole, which is the time-frame relevant for Red List assessment purposes). Records were compiled from potentially verifiable direct observations, camera trap images, and captives in villages near natural or semi-natural areas. Due to the general paucity of records, we remark also on observations not supported by photographic evidence, such as signs, and on reports from interviews, mentioned in the literature (although these records are not mapped). We briefly summarize these results below, put them in the context of what is known concerning each species' historical range, and discuss reasons for the current apparent scarcity of canid species in the country.

RESULTS

Eurasian Golden Jackal *Canis aureus*

There are very few historical records of Golden Jackal in Vietnam, although Millet (1930) and Delacour (1940) observed animals in zoos. The Muséum National d'Histoire Naturelle (MNHN), Paris, holds three historical Vietnamese specimens: one from Tay Ninh Province (with specimen number MNHN 1984-844); one that died in the Saigon Zoo in 1931 (MNHN 1932-3204); and a third specimen without locality data but with a date label of 9 March 1934 (MNHN 1941-82) (Duckworth et al. 1998). Pham Trong Anh (1990) was the first modern author to include the species among Vietnam's fauna; this was based on a specimen collected in 1987 in Ea Sup District of Dak Lak Province and held at the Institute of Ecology and Biological Resources in Hanoi. In their review of the status of the species in Indochina, Duckworth et al. (1998) observed this specimen, and a second taken in the same area, also in 1987, held at the Museum of the National University of Hanoi, and documented two sightings of single animals in Yok Don National Park, Dak Lak Province in June 1997. A specimen in the Tay Nguyen Institute of Scientific Research in Da Lat may have come from Lam Dong Province (Pham Trong Anh 1996). Dang Ngoc Can et al. (2008) listed the species

Image 1. Female Eurasian Golden Jackal at the Saigon Zoo.

as occurring in Dak Lak, Dak Nong (from Ta Dung Nature Reserve) and Kien Giang provinces. The latter record ostensibly comes from Phu Quoc National Park, although there are no further details provided and this record is best considered as equivocal; the species was not recorded in surveys by Abramov et al. (2007) or in camera-trapping studies conducted between December 2017 and September 2018 (4237 camera-trap nights, 69 camera-trap stations; Tran Van Bang et al. unpub. data).

The most recent confirmed records of the species in the wild appear to be those from Yok Don National Park. Two Golden Jackals were seen on 11 March 2003 (coordinates given as: 12.996^{0}N & 107.625^{0}E) and two animals were seen running across the T15 road on 16 June 2004 (12.853^{0}N & 107.544^{0}E) (Eames et al. 2004). Camera-trapping surveys undertaken in Yok Don National Park in 2017, however, only detected Eurasian Wild Pig *Sus scrofa*, Northern Red Muntjac *Muntiacus vaginalis* and Banteng *Bos javanicus,* although survey effort was low (499 camera-trap nights, 17 stations; WWF-Vietnam unpub. data). Recent surveys in Bu Gia Map National Park, Binh Phuoc Province, failed to detect the species in the wild, although local people reported that the species still occurs in some areas such as Dak Sa, Dak Manh and Dak Ka rivers (Nguyen Xuan Dang et al. 2011; Luu Hong Truong et al. 2012). In 2007, a hunted animal was apparently brought to the village of Bu Reng (Nguyen Xuan Dang et al. 2011). In Tay Ninh Province, camera-trapping surveys conducted in Lo Go - Xa Mat National Park between November 2017 and July 2018 (4844 camera-trap nights, 76 stations; Tran Van Bang et al. unpub. data) failed to record the species (among canids, only domestic dogs were photographed). The only other recent record traced is a captive individual that has been kept at Saigon Zoo since 2007 (Image 1), and which is believed to have come from Dak Lak Province. Given the general adaptability of jackals, including their more opportunistic diets and potential use of degraded landscapes, the Golden Jackal may yet be shown to persist in some areas (especially in the border regions with neighbouring Cambodia) and it would be premature to consider the species extirpated from Vietnam. The species is listed as Data Deficient in the Vietnam Red Data Book (MoST) & (VAST) 2007.

Dhole *Cuon alpinus*

Historically, the Dhole occurred throughout most of, perhaps all, Vietnam (Dang Ngoc Can et al. 2008); it is unclear how far south it ranged, although Osgood (1932) documents a specimen from "Saigon" (housed in the Field Museum, FMNH 33500, collected in 1929).

There are very few recent confirmed records of the species from the country. The last confirmed records we could trace come from: 1999 in Pu Mat National Park, Nghe An Province (prior to January 2002, but included here for completeness); 2003 and 2004 in Yok Don National Park; and, incredibly, 2014 in Ninh Thuan Province. In Pu Mat, the report authors note that "One individual was observed crossing the Khe Bong on 18 July 1999. A single individual and a group of at least three individuals were photographed in the upper Khe Bu valley at c. 1,200m during October 1999. A fresh track was found on 16 June 1999 in the Khe Bong valley" (SFNC 2000). In Yok Don, a group of five Dholes was seen in the Dak Tol area on 19 March 2003, and another group of five was seen in the Yok Da area on 27 March 2003. A single Dhole was observed on 20 March 2003, and later a group of five pups were camera-trapped on the border of Cu Jut and Yok Don on 2 April 2003 (12.785^{0}N & 107.719^{0}E). In 2004, a group of five individuals were sighted in the Dak Ken area on 4 April, and a group of 4-5 individuals were sighted again in the Dak Tol area on 16 June 2004 (Eames et al. 2004). The most recent record from Ninh Thuan Province was recorded while conducting acoustic surveys for gibbons when To Van Quang, a staff member of the Southern Institute for Ecology, observed two individuals on 25 May 2014 (coordinates given as 11.568860°N, 108.651378°E, right on the border with Lam Dong Province) (SIE unpub. data). Finally, there is also an unconfirmed report of Dhole from 2002: Mahood & Tran Van Hung (2008) noted that residents of Cup and Cuoi villages in Bac Huong Hoa Nature Reserve, Quang Tri Province, reported the presence in the reserve of an animal taken to relate to this species by the authors, and

that two hunters reported that an animal taken to relate to a Dhole was trapped in the Cuoi area.

Recent camera-trap surveys in Yok Don National Park have failed to record the species (WWF-Vietnam unpub. data), although as noted above survey effort was low. The largest forest blocks remaining in Vietnam are within the Annamites mountain range bordering southeastern Lao PDR, western Vietnam and northeastern Cambodia. Although camera-trapping surveys have been patchy, these have been relatively intensive in the northern and central Annamites (including Bach Ma National Park, Quang Nam Saola Reserve, Thua Thien Hue Saola Reserve, Song Thanh Nature Reserve, Bac Hai Van proposed Nature Reserve, Phong Dien Nature Reserve and Pu Mat NP, totalling more than 44,000 camera-trap nights) (Leibniz-IZW & WWF-Vietnam unpub. data; Leibniz-IZW & SVW unpub. data), although less so in the south. All have failed to detect the species. Also noteworthy is the apparent absence of Dhole in Cat Tien National Park (at least based on extensive camera-trap surveys as well as absence of reports from various bird-watching and other tourists), even while a number of other co-occurring species susceptible to high hunting pressure (including Sambar *Rusa unicolor* and Green Peafowl *Pavo muticus*) have managed to survive.

Kamler et al. (2015) remarked that individuals may occasionally enter the country from neighbouring eastern Cambodia or from Lao PDR, where the species persists. At this point, it seems unlikely that animals would enter Vietnam from Lao PDR (given that the species has seriously declined there in the last 20 years), and very likely that the Dhole, as a resident species, is extirpated or near-extirpated from the country. The species is listed as Endangered (A1c,d; C1+2a) in the Vietnam Red Data Book (MoST) & (VAST) 2007.

Raccoon Dog *Nyctereutes procyonoides*

The Raccoon Dog is recorded in Vietnam only from the north-east. Dang Huy Huynh et al. (1994) and Kuznetsov (2006) listed it as occurring north-east of the Ma River, in the provinces of Thai Nguyen, Lao Cai, Yen Bai, Ha Giang, Cao Bang, Bac Kan, Lang Son, Hoa Binh, Vinh Phuc, Quang Ninh, Thai Binh, Ninh Binh and northern Thanh Hoa. Dang Ngoc Can et al. (2008) and Nguyen Truong Son et al. (2011) listed it for Ha Giang, Cao Bang, Tuyen Quang, Bac Kan, Lang Son, Phu Tho, Thai Nguyen, Vinh Phuc, Quang Ninh and Hoa Binh provinces. The Institute of Ecology and Biological Resources, Hanoi and the Zoological Museum, Hanoi University, have, between them, specimens from Lang Son, Thai Nguyen, Hoa Binh, Bac Kan, Thanh Hoa and Vinh Phuc provinces.

Image 2. Two young Raccoon Dogs observed in a household in Na Vang Village on 13 July 2004 in Tuyen Quang Province.

We found few recent published or observed records. Le Trong Trai et al. (2004) recorded two young in captivity observed in a household in the village of Na Vang (coordinates given as 22.509^{0}N, 105.273^{0}E; Le Trong Trai, pers. obs. 2004), Tuyen Quang Province, on 13 July 2004 (Image 2). The owner apparently took the two from a litter of three in a small cave in the Lung Nhoi area. A rapid assessment undertaken in Tam Dao National Park, Vinh Phuc Province, in late 2004 and early 2005 documented ample evidence of signs (tracks, dens and other) identified as Raccoon Dogs, although no Raccoon Dog was observed directly (Nguyen Xuan Dang et al. 2005); given possible confusion with, among others, domestics dogs, these identifications need to be treated with much caution and are not included in Fig. 1. Kim et al. (2013) reported on samples collected for DNA analysis in Lang Son Province. The samples were taken from eight animals captured by local hunters in 2010, including several individuals in Huu Lien Nature Reserve (Nguyen Truong Son pers. obs. 2010); three of these specimens are now housed in the Department of Vertebrate Zoology, IEBR. Finally, the most recent record is of an adult individual trapped by a hunter in secondary forest in Vu Son Commune, Bac Son District, Lang Son Province on July 26, 2018 (Phan Van Thuc pers. comm. 2018). Further, two young cubs, from an unidentified province in northern Vietnam and housed in Ho Chi Minh City, were found advertised for sale on the internet in late 2018 (Hoang Minh Duc pers. obs.). The species is not listed in the Vietnam Red Data Book (MoST) & (VAST) 2007.

Red Fox *Vulpes vulpes*

The first Vietnamese record of the Red Fox was a female individual from Lang Son province taken during 1926–1927 (Thomas 1928; Delacour 1940). Dao Van Tien (1977) documented a male and female collected 14 and 17 May 1966 at Trung Khanh, Cao Bang Province. Dang Ngoc Can et al. (2008) mapped its distribution also in Thanh Hoa Province, although the material basis for this latter record is unclear. The Zoological Museum of Hanoi University has the specimens from Trung Khanh, Cao Bang Province. There is also a record from Thang Hen in Cao Bang Province in 1999 (Tordoff et al. 2000). The record in question was a hunter's satchel, made out of the pelt of a Red Fox (A.W. Tordoff pers. comm. 2018), and may have come from an animal killed nearby or been traded from somewhere else or hunted on a trip to another location.

We were unable to trace any recent confirmed records of the species. Several localities are mapped for the species in neighbouring Guangxi, Guangdong and Yunnan provinces in China (Wang 2002), and it is entirely possible that this species may have been overlooked recently in far northeastern Vietnam, especially if it were mainly using open degraded habitats or areas of secondary growth within highly modified anthropogenic landscapes, while biologists and surveyors tend to concentrate efforts on a small number of remaining patches of remnant natural and semi-natural habitats in this region of Vietnam. Interestingly, there are several bird species that are widely distributed outside Vietnam and often found in degraded habitats that until recently were very poorly known in Vietnam, such as Collared Crow *Corvus pectoralis*, Carrion Crow *C. corone*, Eurasian Magpie *Pica pica* and Common Pheasant *Phasianus colchicus*. All are known from a handful of historical records from the same areas of northeastern Vietnam (Cao Bang, Lang Son, Quang Ninh), but it is only in the last decade that reliable recent observations of these species have been recorded (A.W. Tordoff pers. comm. 2018). Red Fox is listed as Data Deficient in the Vietnam Red Data Book (MoST) & VAST) 2007.

DISCUSSION

The status of canids in Vietnam (Fig. 1; Table 1) is clearly cause for concern, certainly in contrast to their global situation. The reason for the apparent scarcity of canids in the country is probably attributable to a combination of factors, but most likely driven by hunting exacerbated by habitat loss (very few tracts of large, little-degraded forest remain in Vietnam). The impact of hunting on wildlife is well known in Vietnam and may have had significant non-target impacts on canids. All species of ground-dwelling mammals from the size of a rat and up are subject to non-selective snaring, an activity which is particularly widespread in the region (Gray et al. 2017, 2018) and will surely have contributed to keeping populations much lower than would otherwise be the case. Targeted hunting for canids is likely to have been much less marked, although Nguyen Dao Ngoc Van & Nguyen Tap (2008) mention both Golden Jackal and Red Fox as being used in traditional medicine in Vietnam. The basis for this, however, is unclear, given that there are only a handful of historical specimens of either species from Vietnam

Table 1. Records of wild canids in Vietnam between 01 January 2002 and 31 December 2018 indicating locality details (mapped in Fig. 1), type of observation, year of observation and reference. Only potentially verifiable claims are included; other claims are given in the main text.

Species	Locality	Province	Observation type	Year	Reference	Fig. 1 ref.
Eurasian Golden Jackal	Yok Don NP	Dak Lak	Direct observation	2003	Eames et al. 2004	1
	Yok Don NP	Dak Lak	Direct observation	2004	Eames et al. 2004	1
Dhole	Yok Don NP	Dak Lak	Direct observation	2003	Eames et al. 2004	1
	Yok Don NP	Dak Lak	Direct observation	2004	Eames et al. 2004	1
	11.568°N & 108.651°E	Ninh Thuan	Direct observation	2014	SIE unpub. data	2
Raccoon Dog	Na Vang Village	Tuyen Quang	Captive animals	2004	Le Trong Trai et al. 2004	3
	Huu Lien NR	Lang Son	Direct observation (caught by hunters)	2010	Kim et al. 2013; Nguyen Truong Son pers. obs. 2010	4
	Vu Son Commune	Lang Son	Direct observation (caught by hunters)	2018	Phan Van Thuc pers. comm. 2018	5
Red Fox	None					

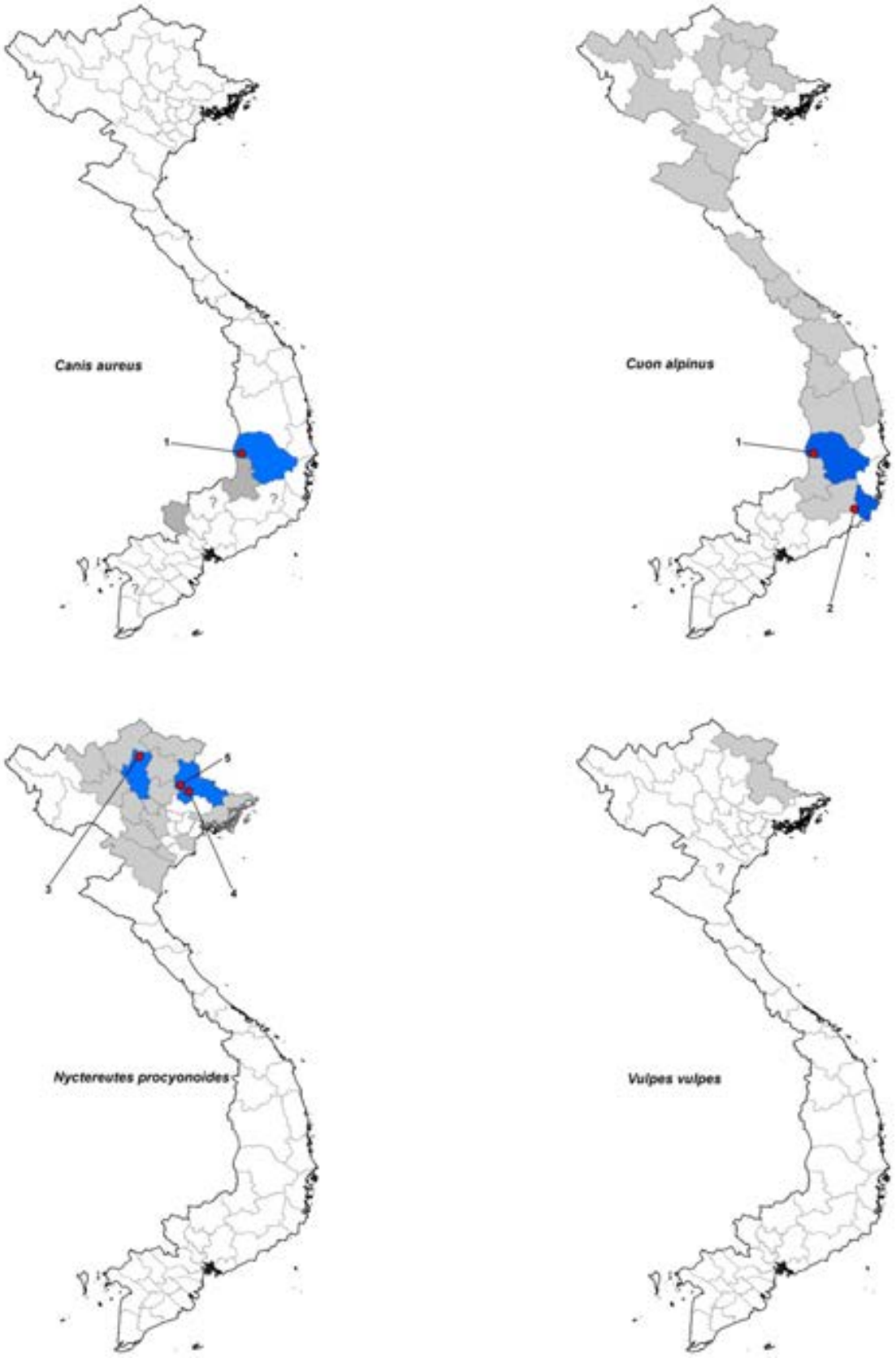

Figure 1. Current and former distribution, by province, of the four wild canid species in Vietnam. Grey areas show previously published range; question marks denote uncertain former presence (see text for references). Blue areas show provinces with confirmed site records (red dots) since 2002 (see Table 1 and main text for details).

compared with Dhole, which was until very recently far more widespread, far more abundant, and, hence, likely to have figured far more in folk resonance. High hunting pressure has also led to ungulate populations being at well below carrying capacity (Timmins et al. 2015, 2016), even in protected areas, and this depletion of the prey base is surely a key reason for the decline of the (formerly widely distributed) Dhole in Vietnam. Intensive snaring is surely also a leading cause of decline in Golden Jackal in Vietnam, although because jackals are generally more adaptable and opportunistic, very low numbers may persist in degraded landscapes where ungulates have already been extirpated and, consequently, snaring intensity is lower.

The paucity of records might conceivably be in part attributable to confusion with other species (jackals, for example, may readily be confused with domestic dogs). Domestic dogs, however, are also likely to be mistaken for Dholes or Golden Jackals, thus potentially inflating numbers of sightings (and this is even more so the case with signs). Thus, the fact that there are so few reports of Dhole and of Golden Jackal suggests that it is an accurate reflection of status. Paucity of records might also be considered a function of general detectability (given the nocturnal and evasive behaviour of some species). Given the extensive camera-trapping work that has been undertaken in protected areas (which cover the majority of remaining natural habitat) throughout the country over the last 10–15 years, it seems reasonable to expect that Dhole, at least, if present even at low densities, would have been picked up. This is less likely to be the case with other species, especially perhaps Red Fox, which may have been missed simply because of a focus of camera-trapping efforts on habitats not typically suited to Red Fox. Equally, Raccoon Dog may have gone undetected as camera-trapping effort in northern Vietnam has not been as high. Further, meat of Raccoon Dogs, sold at VND500,000 (~USD20), and live cubs, sold at VND2,500,000 (~USD110), are posted on wildlife trade groups on social media sites. Overall, it is possible that both Red Fox and Raccoon Dog are more numerous in modern Vietnam than records suggest, but given the poor national statuses of nearly all mammals of this size class or over, it is inconceivable that either has a widespread healthy population there.

In summary, available evidence suggests that wild canids in Vietnam are (except for Red Fox, which may never have been numerous) very likely to have undergone extensive declines. Dhole, formerly widely distributed, and Raccoon Dog, previously also widely distributed in the north-eastern part of the country, have clearly both declined and are now either extirpated or close to extirpation in the case of the former, or of uncertain status in the case of the latter. For Golden Jackal, records probably do not accurately portray what is likely to have been a formerly fairly large range in the southern part of Vietnam, at least based on historical habitats; the paucity of recent records, together with the ongoing trends in hunting and habitat fragmentation, suggests that the species is now very scarce. For Red Fox, there is no evidence of anything more than marginal historical occurrence; the absence of records is difficult to interpret as it may reflect poor survey coverage of appropriate habitats or the species may genuinely be very rare. Its status is probably best considered equivocal at this juncture.

The trends for wild canids mirror, to some extent, those for wild cats in Vietnam: Willcox et al. (2014) noted a current rarity of recent records of small cats, except Leopard Cat *Prionailurus bengalensis*, and considered all the others to be in serious decline and plausibly extirpated from an increasing number of protected areas. Combatting the ongoing snaring crisis in Vietnam's forests is a critical first-step to averting the current devastating toll on the country's life. Gray et al. (2018) suggest several immediate steps that could be taken, including legislative reform, and accompanying enforcement, that criminalises the possession of snares, and the materials used for their construction, inside and immediately adjacent to protected areas. Such actions need to be accompanied by radical cultural change in the country and in neighbouring regions with respect to use of illegal wildlife, and other forest, products (Nguyen Van Song 2008). What is certain is that a major concerted effort to focus on key issues and key sites is critical and that piecemeal conservation activities will do little to forestall the loss of Southeast Asian biodiversity.

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Vietnamese abstract: Bốn loài Chó hoang dã được ghi nhận phân bố ở Việt Nam bao gồm Sói đỏ Cuon alpinus, Chó rừng Canis aureus, Cáo lửa Vulpes vulpes và Lửng chó Nyctereutes procyonoides. Ngoại trừ loài Sói lửa, các loài còn lại có vùng phân bộ rộng trên thế giới và mức độ bảo tồn theo danh lục các loài bị đe dọa của IUCN được đánh giá là Ít quan tâm. Lo ngại về số ghi nhận ít ỏi của các loài này trong những năm gần đây ở Việt Nam, nhất là trong bối cảnh suy giảm nhanh chóng các quần thể thú nói chung, chúng tôi thực hiện việc rà soát tình trạng của các loài thuộc Chó hoang dã ở Việt Nam. Tất cả các ghi nhận có thể kiểm chứng và truy nguyên từ ngày 1 tháng Giêng năm 2012 đến 31 tháng 12 năm 2018 được tập hợp và đánh giá. Loài Sói đỏ từng có vùng phân bố rộng nhất trong họ Chó ở Việt Nam, và loài Lửng chó, từng phân bố rộng rải ở Miền Bắc Việt Nam, dường như cả hai đếu suy giảm; Loài Sói lửa đã tuyệt diệt hoặc gần tuyệt diệt, trong khi tình trạng loài Lửng chó là không chắc chắn. Đối với loài Chó rừng, không có ghi nhận khả tín nào ở ngoài tự nhiên từ năm 2004, mặc dù loài này vẫn còn khả năng phân bố ở một số vùng. Cáo lửa là loài duy nhất còn được ghi nhận nhưng tình trạng quần thể hiện không rõ ràng. Tóm lại, không có quần thể khỏe mạnh của bất cứ loài nào nêu trên tồn tại ở Việt Nam. Sự suy giảm này dường như do việc săn bắn các loài chó hoang dã cũng như thức ăn của chúng, như trường hợp Sói lửa, và trầm trọng thêm bởi tình trạng mất sinh cảnh.

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Author contributions: MH conceived the study and wrote the first draft of the paper. AA, HMD, LTT, BL, AN, NTS, BR, RT, TVB and DW provided data and contributed to the writing of the paper.

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Diel activity pattern of meso-carnivores in the suburban tropical dry evergreen forest of the Coromandel Coast, India

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Abstract: Sympatric and similar body-sized species exhibit interspecific competition for resources. The present study investigated diel activity of five meso-carnivore species (*Canis aureus, Felis chaus, Paradoxurus hermaphroditus, Viverricula indica*, and *Herpestes edwardsii*) in a human-dominated region of Auroville and around Pondicherry University using camera-trap survey data. Diel activity pattern and overlap were estimated using the kernel density method. The Jungle Cat *Felis chaus* and the Golden Jackal *Canis aureus* exhibited cathemeral diel activity with a high overlap between them ($\hat{\Delta}_1$ = 0.78). The Indian Grey Mongoose *Herpestes edwardsii* displayed a diurnal activity pattern and had low overlap with the Small Indian Civet *Viverricula indica* ($\hat{\Delta}_1$ = 0.34). Moderate overlap was found between the Small Indian Civet and the Palm Civet *Paradoxurus hermaphroditus* ($\hat{\Delta}_1$ = 0.32). Therefore, diel activity patterns of mesocarnivores indicate inter- and intra-specific trade-off competition avoidance resulting in successful foraging. The present camera-trap survey has provided insights into diel activity patterns and more attention is required to be paid to the study of feeding and breeding ecology of these species in human-dominated landscapes.

Keywords: Camera trap, competition avoidance, diurnal, nocturnal, overlap.

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Author contribution: Conceptualisation: K. Muthamizh Selvan. Analysis, manuscript writing, reviews and editing: B.M. Krishnakumar and K. Muthamizh Selvan. Data collection: All.

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INTRODUCTION

Interspecific competition among carnivores is one of the significant factors which regulate the natural population and therefore determine community diversity (Cruz et al. 2018). Interspecific competition is greatly recognized when competing species are similar in eco-morphology or phylogenetic-proximity and diet adaptations (Morin 1999). A successful species has to forage optimally, find a potential mate, reduce rivals with conspecifics and avoid encounter with predators (Ross et al. 2013). The dominant species may exclude subordinate species from their territory through competition (Polis et al. 1989). The subordinate species usually are displaced to suboptimal habitats, which are less fertile environments, or have the high impact of anthropogenic pressures (Steinmetz et al. 2013). In this kind of situation, coexistence may be facilitated by temporal shift (Case & Gilpin 1974; Carothers & Jaksic' 1984).

A mammalian carnivore is ecologically important as it directly influences the structure and function of an ecosystem (Roemer et al. 2009). Though carnivore guilds are wide, small- to medium-sized mammalian carnivores with less than 15kg body weight are collectively called meso-carnivores (Buskirk 1999; Roemer et al. 2009). The meso-carnivores occurring in forest fragments and disturbed habitats may also serve as indicator species for environmental change (Justina 2000). In India, larger carnivores have received more research and conservation attention than meso or smaller carnivores (Kalle et al. 2013). Here we report the diel activity patterns of a meso-carnivore community (*Canis aureus, Felis chaus, Paradoxurus hermaphroditus, Viverricula indica, Herpestes edwardsii*) in a human-dominated tropical dry evergreen forest landscape near the southern coastal areas of Tamil Nadu and Puducherry, India.

The Golden Jackal *Canis aureus* (body weight 8–11 kg), the Jungle Cat *Felis chaus* (2.3–8.6 kg) (Hunter 2015; Mukherjee et al. 2019), the Common Palm Civet *Paradoxurus hermaphroditus* (2.7–4.5 kg), the Small Indian Civet *Viverricula indica* (3–4 kg) and the Grey Mongoose *Herpestes edwardsii* (1.4kg) (Prater 1971; Majumder et al. 2011) are known to occur syntopically and prey on rodents (Mukherjee et al. 2004). In general, both civet species (Su & Sale 2007; Kalle et al. 2013) and Jungle Cats are found to be strictly nocturnal (Majumder et al. 2011; Athar et al. 2017), whereas, the Grey Mongoose displays purely diurnal activity (Ramesh et al. 2015). The Golden Jackals are diurnal at low anthropogenic pressure (Gupta et al. 2016), whilst they shift their activity pattern to nocturnal and crepuscular at high human activity (Majumder et al. 2011). The present study is the first one to document activities of meso-carnivores in a tropical dry evergreen forest. The findings of the study will help the managers to strategize the management and conservation plan for these meso-carnivores in highly fragmented human-dominated landscapes.

Study area

We conducted this study in an area of 18km^2 that covers Auroville and its adjacent agricultural lands (belonging to Vanur Taluk of Villupuram District, Tamil Nadu) and Arana Forest, Pondicherry University campus in Puducherry (Fig 1). The vegetation of this region has been classified as tropical dry evergreen forest (TDEF) (Champion & Seth 1968). TDEF is distributed along the coasts of Karnataka, Tamil Nadu, and Nellore District of Andhra Pradesh (Daniel et al. 2007). It also occurs inland, ranging between 30km and 60km (Gamble 1967) of the southeastern seaboard of peninsular India (Champion 1936). *Manilkara hexandra*, *Memecylon* spp., *Diospyros* sp., *Eugenia* spp., *Chloroxylon sweitenia*, and *Albizzia amara* (Daniel et al. 2007) are some of the dominant tree species in TDEF, in addition to other species such as *Anacardium occidental*, *Acacia auriculiformis*, and *A. mangium*. TDEF is populated with a range of birds, mammals, reptiles, fungi and other taxa, some of which play a pivotal role in seed dispersal, pollination and other supporting services (Everard 2018). The major mammalian species are Golden Jackal, Jungle Cat, Common Palm Civet, Small Indian Civet, and the Indian Grey Mongoose. Seemingly, 69% of the trees in the coastal forests are dispersed by jackals, civets, bats and rodents (Daniel et al. 2007). The region experiences a mean annual temperature between 21.6°C and 36.4°C and precipitation between 1311mm and 1172mm (Padmavathy et al. 2010; Ponnuchamy et al. 2013).

METHODS

Camera trapping

We established 20 camera-trap stations deployed for 70 days between December 2017 and February 2018. We set up an independent camera-trap at each camera-trap station (Cuddeback C1-white flash). Cameras were housed in metal camera cases (Cuddeback bear safes) to avoid pilferage. A station was at a regular interval ranging from 1.0–3.0 km close to the animal and man-made trails and ravines to maximize the capture probability. Data were collected without scent lure. We set one-min delay

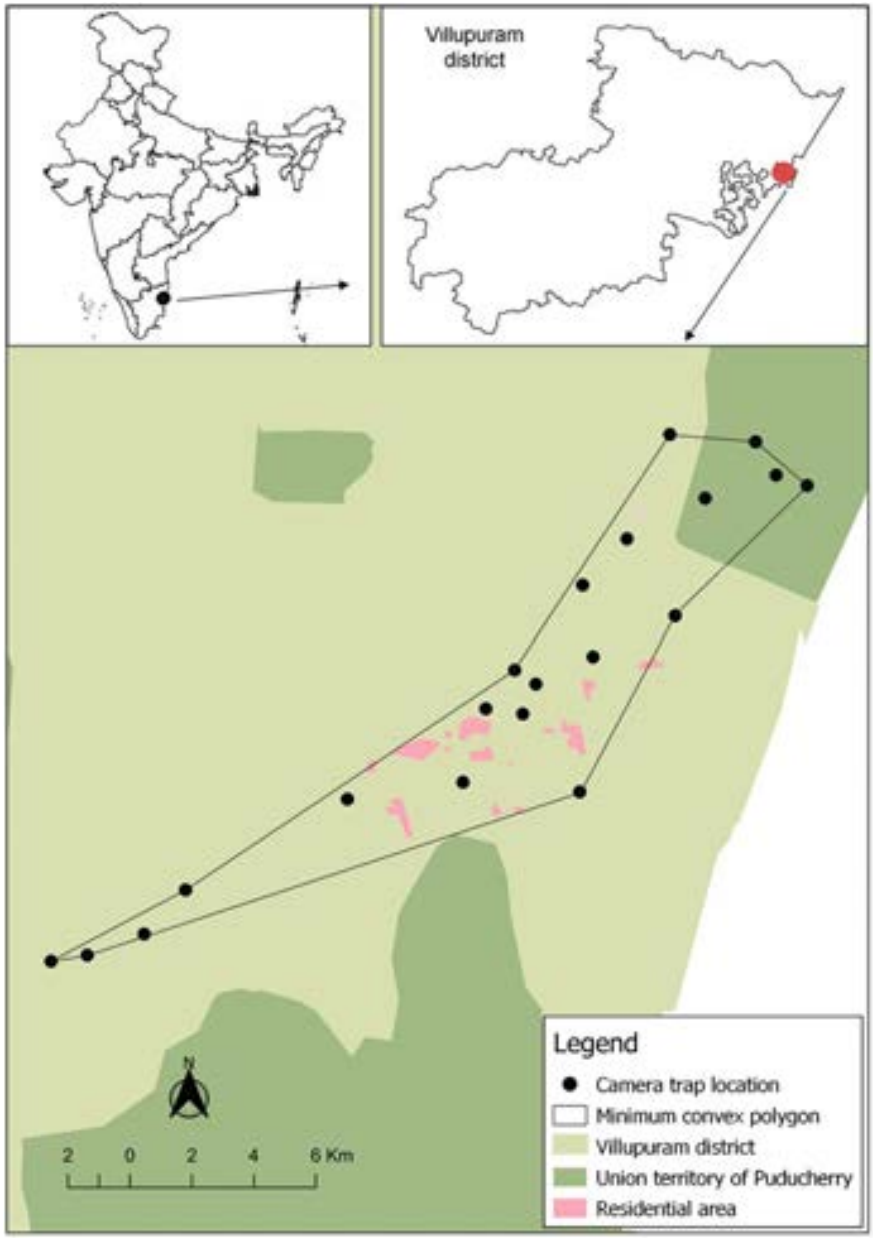

Figure 1. Location of camera traps in tropical dry evergreen in Villupuram District in Tamil Nadu, southern India.

for a subsequent capture.

Analysis of diel activity

We identified species, date, time and camera station for every camera-trap record. In addition, we defined multiple records of the same species at the same camera-trap station as independent capture when pictures were taken at least 30min apart unless we were able to unambiguously distinguish an individual (Linkie & Ridout 2011). Correspondingly, if several individuals of similar or different species were captured in a single image, each individual was considered as a distinct event (Mukherjee et al. 2019).

The timings of sunrise and sunset in the study area were recorded consistently throughout the study period. Sunrise and sunset are approximately at 06:30h and 18:00h, local time (GMT + 5), respectively. We categorized the day into three periods on the basis of sunrise and sunset; day (07:30–17:00 h), night (19:00 to 05:30 h) and crepuscular (dawn 05.30 to 07.30 h and dusk 17.00 to 19.00 h) (Gerber et al. 2012; Ross et al. 2013; Ikeda et al. 2016, 2015). Diel activity of species was classified as diurnal (<10% of records at night), nocturnal (≥90% of records at night), mostly diurnal (10–29 % of records at night), mostly nocturnal (70–89 % of records at night), or cathemeral (30–69% of records at night) (Gomez et al.

2005; Azevedo et al. 2018). We used a non-parametric circular kernel-density method to determine diel activity pattern and coefficient of activity overlapping (Ridout & Linkie 2009). The coefficient of overlapping ($\hat{\Delta}$) differs from 0 (no overlap) to 1 (complete overlap) (Ridout & Linkie 2009; Linkie & Ridout 2011). Analysis of species-specific activity pattern and coefficient of overlapping between two species were performed with 'overlap' R-package (Meredith & Ridout 2018) in R environment v.3.5 (R Development Core Team 2014). We have calculated the 95% confidence intervals of Δ with 1000 bootstrap to obtain bias-corrected percentile (Meredith & Ridout 2018).

RESULTS

A total of 431 independent detections were obtained from 1400 trap nights, wherein, 92 were of Common Palm Civet, 121 of Small Indian Civet, 79 of Golden Jackal, 56 of a Jungle Cat and 83 of Grey Mongoose.

Diel activity pattern

Diel activity pattern of each species is shown in Fig. 2. Indian Grey Mongoose showed a strong diurnal pattern of activity (Fig. 2). Small Indian Civet was mostly diurnal with high peak activity from afternoon to before dusk. In contrast, the Common Palm Civet was mostly nocturnal and showed two high peaks of activity, one from midnight to dawn and another right after dusk. The Golden Jackal and Jungle Cat were largely cathemeral, and they had distinct peak activity after dusk. They also were active right after midnight and right before sunrise.

Diel activity overlap

Diel activity overlap patterns of five meso-carnivores detected in the study area are presented in Fig. 3. The highest diel activity overlap was observed between the Golden Jackal and Jungle Cat with $\hat{\Delta}_1$ of 0.78 (0.66–0.87), followed by Palm Civet and Jungle Cat ($\hat{\Delta}_1$ 0.77; 0.53–0.74), and then Palm Civet and Golden Jackal ($\hat{\Delta}_1$ 0.65; 0.55–0.77). A moderate overlap was observed in small Indian Civet and Golden Jackal with $\hat{\Delta}_1$ of 0.45 (0.36–0.56), Small Indian Civet and Jungle Cat ($\hat{\Delta}_1$ 0.44; 0.35–0.55), whereas, the least overlap was observed between Common Palm Civet and Indian Grey Mongoose with $\hat{\Delta}_1$ of 0.11 (0.06–0.17), Grey Mongoose and Golden Jackal ($\hat{\Delta}_1$ 0.27; 0.18–0.37), Grey Mongoose and Jungle Cat ($\hat{\Delta}_1$ 0.28; 0.19–0.39), Palm Civet and Small Indian Civet ($\hat{\Delta}_1$ 0.32; 0.24–0.41), and between Small Indian Civet and Grey Mongoose ($\hat{\Delta}_1$ 0.34; 0.25–0.44).

DISCUSSION

The present study provides significant information in relation to temporal activity pattern of meso-carnivores in a human-modified environment. The most cost-efficient and non-invasive method of camera-trap survey provides very detailed information on diel activity patterns.

In the present study, the Jungle Cat was found to be cathemeral, which is contrary to the finding from Dachigam National Park (Athar et al. 2017) and Pench Tiger Reserve (Majumder et al. 2011), wherein it was found to be strictly nocturnal. Due to the hunting efficiency, the activity patterns of many felids highly depend on their prey's activity patterns (Harmsen et al. 2011; Bashir et al. 2013; Mugerwa et al. 2017). The main reason for the Jungle Cat being cathemeral in the study area could be because of the secondary importance of birds (e.g., Grey Francolin *Francolinus pondicerianus*, Jungle Bush Quail *Perdicula asiatica*) in their diet. The Jungle Cat may have preyed more often on these birds than on nocturnal rodents which is the case in other regions (Sunquist & Sunquist 2002; Mukherjee et al. 2004; Majumder et al. 2011). Even a pair of Grey francolin was captured in a camera-trap during the study period. The temporal activity pattern of the Jungle Cat had the greatest overlap with the Golden Jackal and the Palm Civet. A detailed study of its diet could provide comprehensive details about its overlap, coexistence and competition avoidance.

The Golden Jackal exhibited cathemeral activity which correlated highly with the Palm Civet. This observation concurs with the earlier report at Pench Tiger Reserve (Majumder et al. 2011) and Bulgaria (Georgiev et al. 2015). Conversely, it contradicts the observations in Gujarat and Bangladesh (Aiyadurai & Jhala 2006; Jaeger et al. 2007), where it was reported to be active at twilight and night. Unified diel activity generally occurs between closely related and unrelated species (Stensland et al. 2003). The strong overlap in diel activity between the Golden Jackal and Palm Civet might be a foraging strategy of the former. The jackals may be feeding on the fruits dropped by the activity of the Palm Civet as the diet of the jackal has been known to include vegetative matter (Khan et al. 2017). Such synchrony has been documented in other taxa (Newton 1989; Ramesh et al. 2012). Concurrently, interspecific competition is avoided through arboreal and terrestrial feeding habits of Palm Civet (Nakabayashi et al. 2016) and Golden Jackal, respectively.

The activity of two morphologically similar-size species *P. hermaphroditus* and *V. indica,* overlapped minimally because the former was primarily active

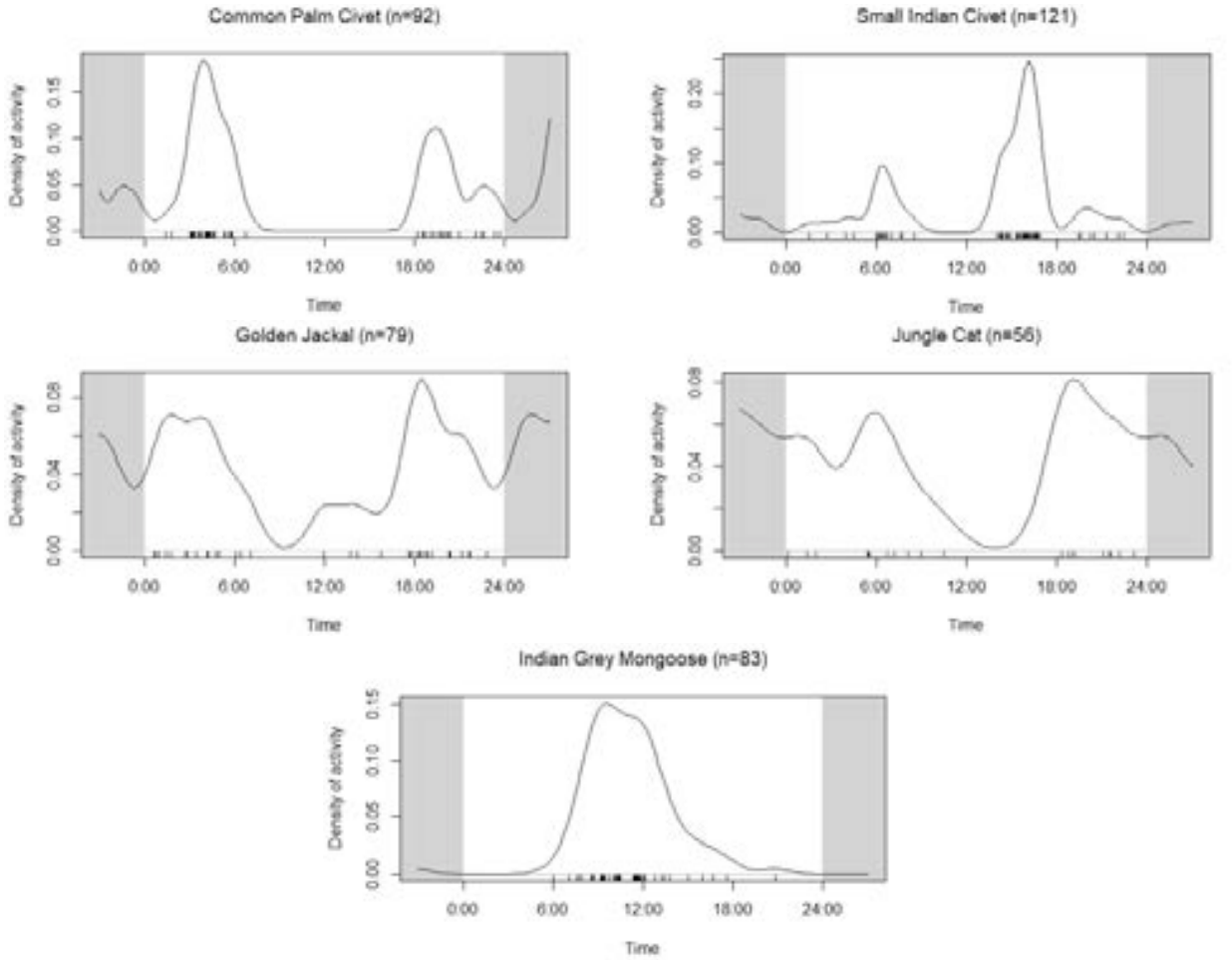

Image 2. Activity patterns of five meso-carnivores based on camera-trap surveys in the study area.

from midnight to dawn and right after dusk, while the latter was active from afternoon to before dusk. Documentation of available data on *P. hermaphroditus and V. indica* implies that they share a similar generalist diet, which often consist of fruits, seeds, arthropods, lizard, mice, rats and gerbils (Prater 1971; Rabinowitz 1991; Su & Sale 2007), which may account for why these two species have such dissimilar temporal activity, that in turn allows coexistence.

Though the Small Indian Civet is mostly diurnal, it exhibited a relatively high movement from afternoon to before dusk during the study period. In Hlawga Wildlife Park, Myanmar, the Small Indian Civet is active immediately after dusk (Su & Sale 2007). It could do so to avoid interspecific interference with the Jungle Cat which is active immediately after dusk. Temporal activity pattern of the Grey Mongoose had the least overlap with the Palm Civet, the Golden Jackal and the Jungle Cat, whereas, it overlapped moderately with the activity of the Small Indian Civet as it is mostly diurnal. Moreover, the Grey Mongoose is also observed as diurnal and well acclimatized with human activity.

Though camera-traps are effective in recording temporal activity patterns, there was a certain constraint in detection probability with species. Thus, placement of the camera might be biased towards ground-dwelling animals which would consequently affect the capture rate of semi-arboreal species such as civets. The present study examining diel activity in meso-carnivores suggests no difference in activity were observed between the Golden Jackal and Jungle Cat, whereas the Small Indian Civet, Palm Civet and mongoose exhibited a difference in their activity. Diet analysis of meso-carnivore could give comprehensive information on its temporal segregation.

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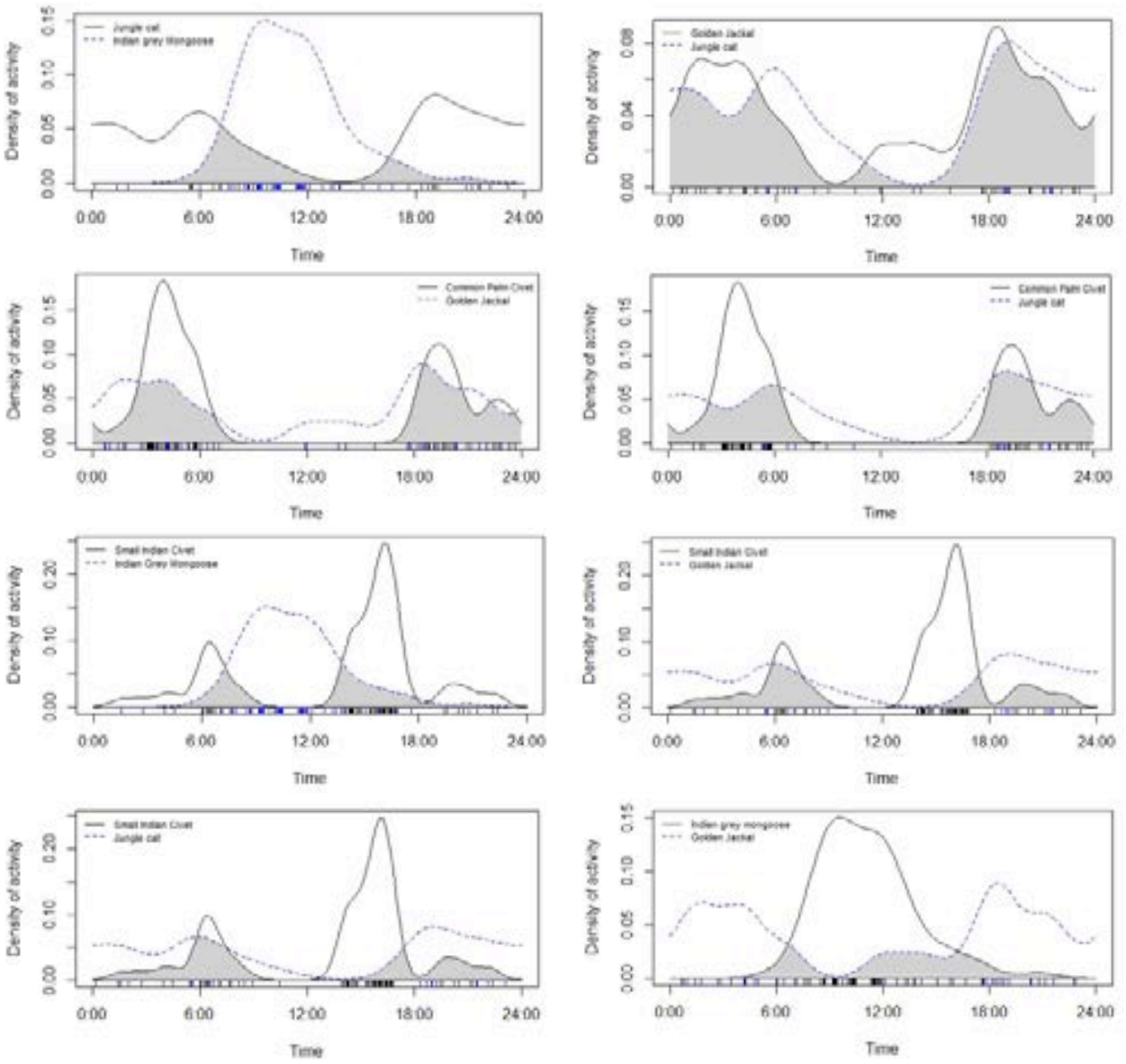

Image 3. Activity overlap of the meso-carnivores. The coefficient of overlapping is represented by the shaded area.

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On the importance of alpha behavior integrity in male Capybara *Hydrochoerus hydrochaeris* (Mammalia: Rodentia: Caviidae) following immuno-contraceptive treatment

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Abstract: As the human population continues to grow, habitat for wildlife shrinks, driving fauna either into extinction or into new habitats, which can create new problems. In Brazil, the Capybara *Hydrochoerus hydrochaeris* has become a pest by invading urban and agricultural areas. These mammals quickly multiply owing to abundant food supply and a lack of natural predators, and they can serve as amplifying hosts for *Rickettsia rickettsii,* the pathogen of potentially life-threatening Brazilian spotted fever. Species-specific population management strategies that respect public opinion and consider animal welfare are required for the effective mitigation of this tick-borne zoonotic disease. In order to control Capybara populations it is necessary to take into account their social dynamics, which are centered on polygynous dominant males with hormone-driven secondary sexual characteristics. To be a viable management tool, a contraceptive strategy targeting these males must preserve their social status to prevent other males from replacing them. As part of a larger research project on the efficiency of anti-Gonadotropin-releasing hormone (GnRH) vaccine treatment in free-ranging Capybaras, the aim of this study was to observe the impact of this treatment on alpha male and overall social group behavior. At the end of the 18-month-study, there were no recorded births involving the immunized animals, and alpha male sexual characteristics and group integrity were preserved. These results encourage the use of this anti-GnRH vaccine as an alternative population control tool in male Capybara.

Keywords: Agonistic behavior, Brazilian spotted fever, Gonacon, Rickettsia, secondary sexual characteristics, wildlife population control.

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Author contribution: DAR and CSP conceived the work, designed and conducted the field surveys, data collection, and analysis.

For **German** & **Portuguese** abstracts see end of this article.

INTRODUCTION

Hydrochoerus hydrochaeris, commonly known as Capybara, the world's largest rodent species, endemic to South America, and are habitat generalists surviving in open grasslands and scrub vegetation. Capybaras are semi-aquatic so stay close to water, which is used as their principal getaway and serves as a place for thermoregulation, defecation, mating, as well as an important food source (Mones & Ojasti 1986; Magnusson 1998; Moreira et al. 2012; Elias 2013). Intensive anthropogenic activities have dramatically changed the landscapes and habitats where Capybara live. With diminishing natural space and an increase in agricultural and urban areas, these animals are re-occupying and thriving in their human-modified habitats.

Their social structure is based on polygyny (harem), with one dominant (alpha) male, females that are divided into dominant (breeding females) and subordinate females, male and female juveniles, and, depending on the season, pups. In Brazil, a wild herd can reach up to 50 members (Macdonald 1981). Isolated Capybara, known as satellites, can often be seen maintaining a certain distance from the main group; these are sexually mature males forced out by the alpha male (Image 1).

Subordinate females, although sexually mature, do not mate with the alpha male; their restraint is due to interactions with dominant females and their social stimuli, which is believed to cause reproductive suppression, either physically, endocrinologically, or by olfactory cues (Maldonado-Chaparro & Blumstein 2008). However, some subordinate females have been observed leaving their group for short periods of time to seek out nearby satellite males to mate with, as observed during this present study.

Due to several contributing factors, such as the loss of natural predators, the Capybara's ability to quickly adjust to agricultural and urban settings, their tolerance to human presence, the abundance of available foods, combined with their high proliferation rates, have allowed the Capybara to become Brazil's second most important pest-species, the other being Wild Boar (Pedrosa et al. 2015). Under these conditions Capybaras attain large population sizes, with herd numbers that can reach over 100 individuals which creates traffic accidents, damage to private property, invasion of public and private spaces, and destruction to crops, particularly corn and sugarcane plantations (Ferraz et al. 2003; Labruna et al. 2007; Labruna 2013; Felix et al. 2014; de Oliveira Vieira et al. 2015; Abreu Bovo et al. 2016).

The main concern, however, is the threat to human health as Capybara are associated with the maintenance and spread of the tick-borne disease Brazilian spotted fever (Portuguese: febre maculosa). Capybara are considered an amplifying host for this emerging vector-borne zoonosis caused by the potentially deadly bacterium *Rickettsia rickettsii*, which is spread by ticks of the genera *Amblyomma* sp. (Fortes et al. 2011; Labruna, 2013; Brites-Neto et al. 2015).

They fulfill five requirements to be considered a good amplifying vertebrate host for *R. rickettsia*:

(1) be abundant in the endemic area, (2) be a good host for the ticks, (3) be susceptible to Rickettsia infection, (4) have high population growth rates, and (5) have enough bacteremia counts to infect ticks (Labruna et al. 2009).

Although there are other native wildlife species reported to host *R. rickettsii*, such as dog, horse, opossum, among others (Labruna et al. 2009; Milagres et al. 2010), there are a number of reasons that Capybara are the major contributing factor for *R. rickettsii* infection in endemic areas. They exclusively occupy areas close to bodies of water and move slowly, making them conducive for ticks to infest in large numbers and feed upon. Some tick species such as *Amblyomma dubitatum* are highly specific to Capybaras and rarely feed on other host species. Humans, however, may become accidental hosts (Guglielmone et al. 2006; Labruna et al. 2007; Beati et al. 2013; Brites-Neto et al. 2015).

Several field studies and stochastic models have been developed that have reported spotted fever transmission dynamics, postulating that birth-rate reduction not just can directly control Capybara population growth, but potentially slow disease transmission (Sonenshine & Mather 1994; Labruna et al. 2002; Federico & Canziani 2005; Polo et al. 2017; Polo et al. 2018; Rosenfield et al. 2019).

In an effort to control these fast-growing super-populations, several research projects are being conducted, seeking methods that are effective in managing populations while conforming to environmental protection laws and public opinion. Capybara, as it's categorized as Brazilian native fauna, is protected from hunting, slaughter, and abuse (Presidência da República 1981; Rodrigues 2013).

In Brazil, Capybara potentially reproduces all year round, however, they are constrained by environmental factors, food availability and human impacts. As the principal breeder, the alpha male protects the herd and mates with many females. Focusing on the sterilization of the dominant male could be a population control strategy of choice, provided that the procedure does

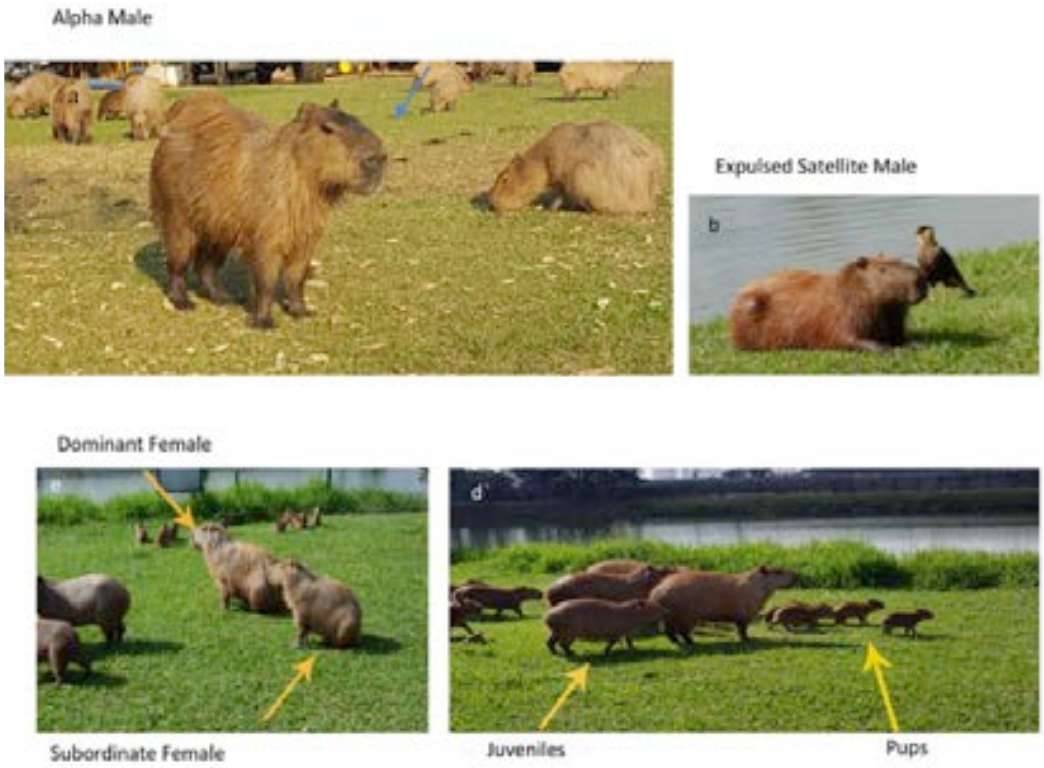

Image 1. Capybara hierarchal group organization: (a) alpha male, blue arrow, prominent nasal gland, position, vigilant | (b) satellite male, isolated/distant from group | (c) dominant female and subordinate female | (d) juveniles and pups. © D. Rosenfield, 2018

not alter its dominant status (Alho & Rondon 1987; Rodrigues 2008; Paula & Walker 2013). Capybara are fiercely territorial, protecting harem and habitat, driving out potential male intruders or subordinate males that attempt to challenge the alpha male (Herrera & Macdonald 1993); thus, the importance to maintain testosterone production which influences their secondary sexual characteristics and dominance (agonistic) behavior. For this reason, vasectomy was considered initially a suitable intervention as sperm conduction is interrupted, yet, leaving the gonad function intact so a continuation of steroidogenesis is ensured (Meira et al. 2013). If performed correctly, it is completely effective. On the downside, the logistics, cost, skill availability and access to the testes which is in an intra-abdominal position, are more challenging. The biggest dilemma, despite being considered a minimally invasive surgical procedure, is the time for recovery. Capybara, when injured, sick, or during labor, distance themselves from the group until healing is complete (D.A. Rosenfield xi.2016 – xii.2018). Observations indicate that vasectomized males distance themselves from the group for up to 10 days, potentially allowing competitors to move in and take over, jeopardizing the efforts to manage the population growth.

Additionally, subordinate males are known to breed opportunistically, even as much as 40% of the overall growth rate (Rodrigues 2008), which is initiated by subordinate females temporarily leaving the main group (Labruna Marcelo & Fernanda Nunes pers. comm. 20.ix.2018). In this case, an alternative method to consider is tubal ligation (tubectomy) in all sexually mature females. The concept is analogous to the deferentectomy procedure in males, with the intent to inhibit gamete transmission but preserve gonadal steroidogenesis, and, hence, social behavior/group stability.

In general, we can organize the breeding hierarchy into one alpha male and several dominant females as the principal breeders. Subordinate females (believed to be in reproductive suppression due to the presence of dominant females), and/or their opportunistic mating with external (satellite) males (Fig. 1), which postulates three distinct population control strategies:

Contraceptive strategies

1) The immuno-contraceptive treated alpha male effectively maintains agonistic conduct and secondary sexual characteristics. They successfully defend against potential intruders; however, the alpha male does not

mate with dominant females. Subordinate females opportunistically and temporarily leave the group to join nearby satellite males to mate (Fig. 2). After the mating event, the now pregnant female returns to the group and remains there during gestation. Following birth, the pups are brought up in an allo-parental manner, as commonly observed in Capybaras (Nogueira et al. 2000).

2) Due to the castration, the original alpha male loses agonistic conduct and secondary sexual characteristics. Growing males, sexually mature, or dominant growing satellite males challenge the alpha male, leading to his defeat and consequently driving the ex-alpha male out of the group or even killing him (Fig. 3). The new (untreated) dominant male will become the alpha male and restart the mating process.

3) The treated alpha male does not leave the group post-treatment and maintains alpha associated conduct and secondary sexual characteristics. Alpha male is now infertile (Fig. 4), but the group's social structure is stable. Also, treating all satellite males and all sexually mature females will prevent opportunistic mating encounters with satellite males.

Illustrated contraceptive strategies

In order to find alternative contraceptive methods that would address the weaknesses of currently employed population control strategies in Capybaras, an intensive literature review on contraceptive methods in wildlife was conducted. The objective was to match most of the desired characteristics of a contraceptive agent, which would include antifertility effectiveness of more than 90%; long-term effect of more than 12 months; with very little to no adverse effects (physiological/behavioral). Especially, considering a polygynous society, like Capybara, the importance of maintaining the dominant male's agonistic behavior is supreme. Furthermore, it is applicable in both the sexes; represents no risks to pregnant females; potentially reversible; easy and safe application; allows for remote drug delivery (long-distance darting); does not provoke environmental pollution; does not have contraceptive effects when entering the food-chain, and lastly, is economically viable and available (Figs. 2–4).

The anti-GnRH vaccine GonaCon™ was selected as it conformed to most of these conditions (Asa 2005; Gionfriddo et al. 2008; Ajadi & Oyeyemi 2015; Rosenfield 2016). The objective of this research was to demonstrate the effectiveness of an anti-GnRH immuno-contraceptive (Gonacon™) in reducing population growth in the capybara without interfering with the behavioral characteristics of the alpha male.

MATERIALS & METHODS

Location

A large man-made water pool (Olympic Lake, Portuguese: Raia Olimpica) surrounded by diverse

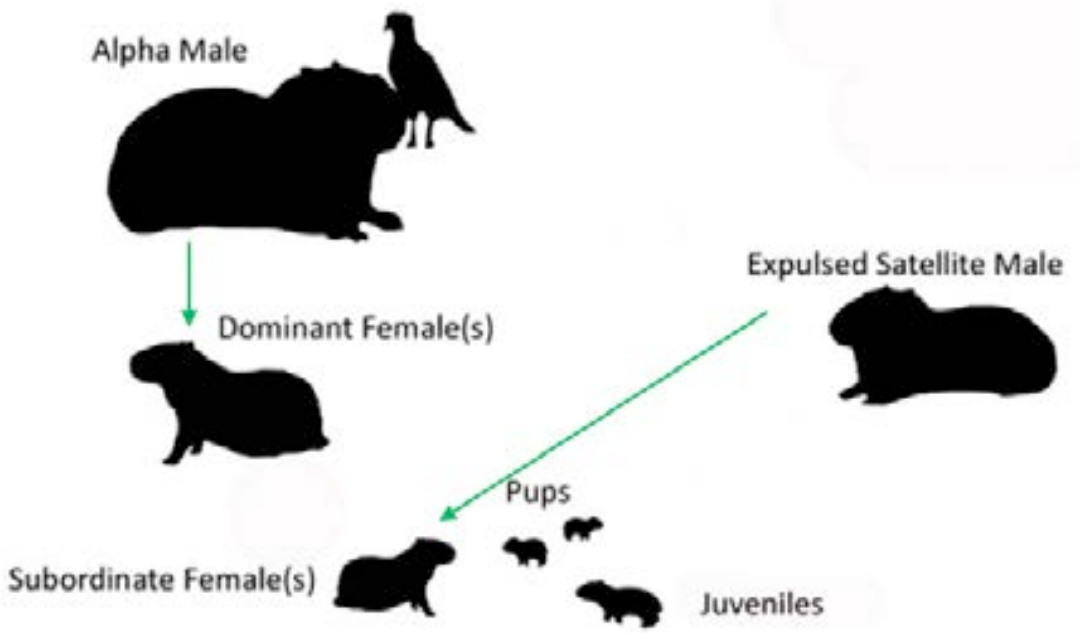

Figure 1. Capybara: Potential mating dynamics (green arrows): Alpha male, dominant females, subordinate female(s), male and female juveniles, pups. Expulsed satellite male (sexually mature). © D. Rosenfield, 2019

Image 2. Capybara: (a) nasal gland, red arrow | (b) scent marking using nasal gland, blue arrow | (c) visible testes, yellow arrows. © D. Rosenfield, 2018

vegetation and extended grassy areas, used for the university's aquatic sports activities, was selected in Sao Paulo (Image 3). The environmental conditions are very similar to the natural Capybara habitats, allowing for a unique opportunity to observe free-ranging Capybaras in an open confined setting.

Identifying males

At first sight, the urogenital apparatus is not easily distinguishable between male and female Capybara, as the male penis is situated within a large anogenital invagination. In sub-adult males, gender can be confirmed by palpation and exposure. Capybara alpha males have specialized androgen-driven secondary sexual characteristics (SSC), such as a prominently developed nasal and perianal glands for scent-marking (Image 2a,b). The testes, in immature males, are located subcutaneously in the inguinal region, whereas in dominant males, they migrate from the inguinal region towards the area of the inner/upper thigh, becoming slightly visible (Image 2c).

Veterinary intervention

Two groups were selected for the study and were based on their population size and pest status: Group 1 consisted of more than 40 individuals and Group II of seven individuals. The socio-sexual and reproductive behavior of male and female Capybaras were recorded for approximately 100 hours pre- and >120 hours post-treatment using the continuous focal observation method (Martin & Bateson 2007) between June 2016 and December 2018.

In Group I, three individuals (male n=1, female n=2), and in group II, six individuals (male n=2, female n=4) were treated with the anti-GnRH vaccine GonaCon™. The vaccine was administered intramuscularly in the larger muscle group of the hind leg. The rest of the population served as control.

This project-specific ethogram (Table 1) was used to assist in identifying any treatment-associated alterations, allowing an interpretation of cues of a successful antifertility method and the integrity of the alpha male's agonistic behavior. This is essential for maintaining the group's social stability and preventing an intruder from mating, and hence, providing an appropriate population growth management tool.

Contraceptive effect analysis

As part of the evaluation process of the anti-fertility effect, steroid-hormone, spermogram, biometry, and testicular morphology were employed. At the end of the study period, males were hemi-castrated for further histological investigation of the testicular parenchyma. These specific findings are submitted for publishing elsewhere.

RESULTS

Effects of treatment

The immunized alpha males showed oligospermia, compared to control, while their agonistic behavior and secondary sexual characteristics were preserved (Tables 1 & 2).

DISCUSSION

The leadership dynamics observed of all involved males was very compelling, as it proved that the immuno-contraception was effective in rendering the treated males infertile, while concurrently, preserved their alpha male behavior, and thereby the group's integrity. Confirmed by the behavioral observations made of an untreated sexual mature male, used as the control variable, demonstrated during involved transitional dynamics the take-over of a leader-less group as the new alpha male, consequently producing offspring.

Positive antifertility effects of the immuno-contraceptive was confirmed in similar studies and in various species; however, where the findings differ are the observations that state the loss of agonistic behaviors in males (Snape at al. 2011; Donovan et al. 2013; Doughty et al. 2014) while others report no significant changes (Massei et al. 2008; Young, 2018), including the present work.

Also important is the fact that the treated animals did not distance themselves from the group for recovery, hence, preventing any opportunity for a satellite male

Table 1. Experimental interventions and outcomes. (PDB: preserved dominant behavior; SSC: secondary sexual characteristics).

Group no.	Target	Intervention	Result	Remarks
1	Alpha male	Immunised	Oligospermia PDB (driving out any male invader) Preserved SSC No offspring	After vaccination, male maintained with the group (no recovery period). Animal died through acute cecal tympany (sever dilation of the cecum, provoked by the failure to release gas).
2	Alpha male	Immunised	Oligospermia PDB Preserved SSC No offspring	After vaccination, male maintained with the group (no recovery period)
3	satellite male control male	No intervention	Produced offspring	Males mated with females from group 1 and 2, that left the group temporarily. In the absence of a dominant male, satellite males will take over the group.

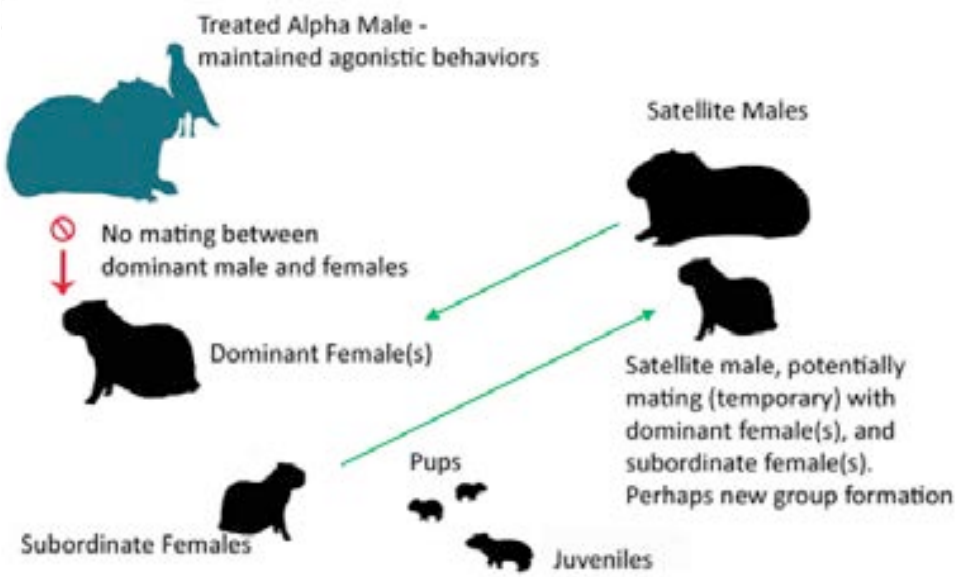

Figure 2. Contraceptive strategy I. Treated dominant male, infertile but with preserved alpha characteristics/behavior. No mating between treated dominant male and dominant females (red arrow). Opportunistic mating between satellite male and subordinate females (may leave the group temporarily). © D. Rosenfield, 2019

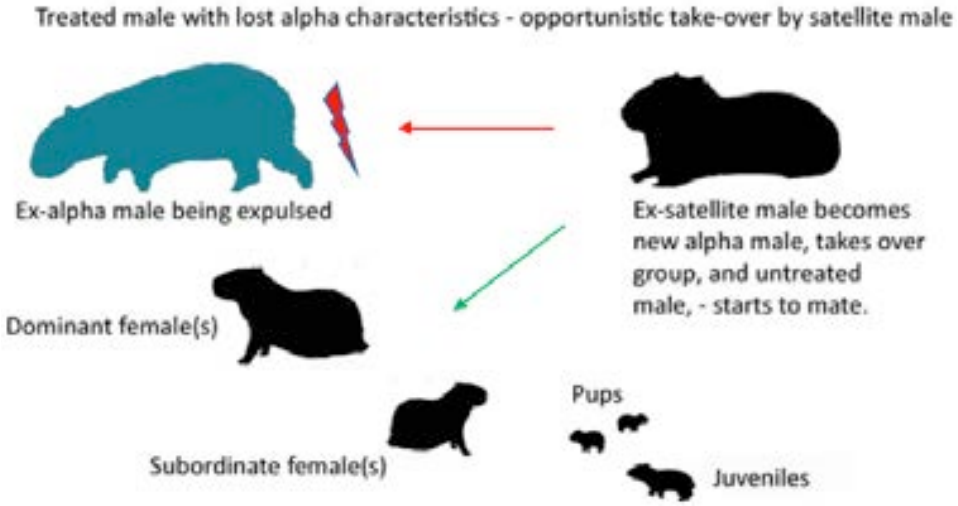

Figure 3. Contraceptive strategy II. Effects of castration: Loss of male's alpha characteristics (mainly agonistic behavior), subordinate/satellite males challenge the alpha male for dominance, eventually taking over the group. Effects of vasectomy: Alpha male will distant himself from the group for a short period of time (recovery phase from surgical injury), leaving the group temporarily without alpha male. Opportunistic window for a satellite male to invade/take over the group. © D. Rosenfield, 2019.

Table 2. Ethogram of recorded behavior.

Ethogram Alpha Male		Observations Control Alpha Male	Treated Alpha Male	Satellite Male
Behavior	**Description of behavior**			
Any visual treatment-related discomfort	Separating from the group immediately after treatment; Apathetic; no foraging; allowing an intruder to get close to the group/females	n/a	The treated alpha did not distance himself at any moment post-treatment. All alpha related conducts remained intact.	n/a
Vigilance	Alpha male remained at a certain distance in a sitting or ventral decubitus position watching over the group	Confirmed	Confirmed	Observing the group. Infrequent contact with subordinate females
Relocation	Leading group to a different location (for better foraging grounds, or for safety)	Confirmed	Confirmed	n/a
Scent marking	Marking territory by rubbing with nasal gland surface or perianal gland surface over stationary objects; urinating onto the ground	Confirmed	Confirmed	Confirmed
Courtship behavior	Seeking physical contact with females. Testing receptivity for mating by sniffing urogenital region, pushing snout into female's flank, or snout. Putting head onto female's dorsal pelvic region.	Confirmed	Frequent contact (sniffing) but no mating conduct	Observed when approached by a female
Mating	Male continuously follows the female. Frequent mounting attempts by placing upper torso onto female's lumbar/pelvic region, performing a thrusting motion with the pelvis.	Confirmed	Not observed. Possible attempts, but infertile male.	Observed when approached by a female
Agonistic (aggressive) behavior	Attacking, fighting, and chasing the intruder	Confirmed	Confirmed	n/a

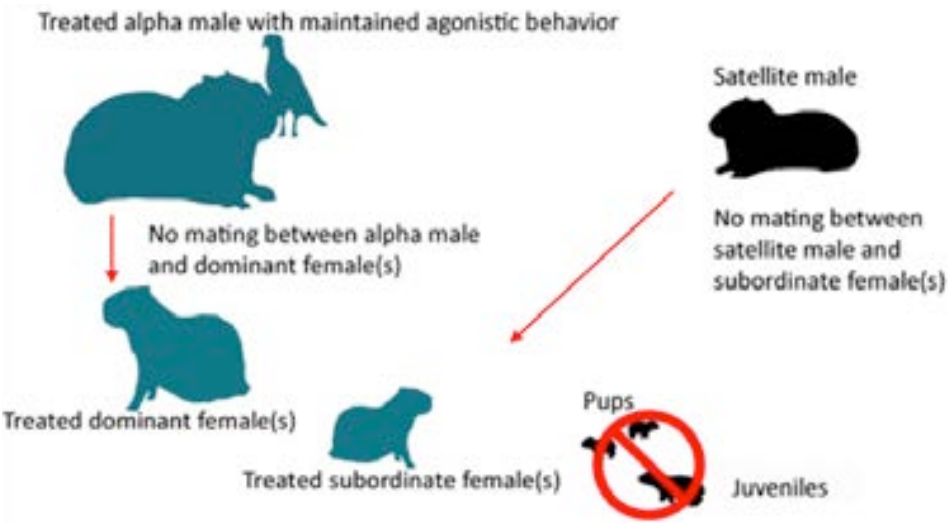

Figure 4. Contraceptive strategy III. Treated dominant male with maintained alpha characteristics; treated dominant females and satellite males. No mating between alpha/satellite males and treated dominant females (red arrows); contraceptive strategy most indicated for Capybaras. © D. Rosenfield, 2019.

to invade.

Noteworthy, alpha males, given the right circumstance, would leave their group in order to take over a group with a larger number of females, as observed twice.

There were no significant phenotypic or behavioral alterations, nor any pathological adverse effects in the treated animals. Although the treated alpha males were considered infertile, their secondary sexual characteristics and agonistic behaviors appeared to be preserved, as well as the groups' overall social integrity, which is an important key fact to successfully managing the population of this species, and exceeded all minimum expectations.

Other currently considered male fertility strategies, such as castration and vasectomy, which are 100%

Image 2. (a) South America/Brazil, Sao Paulo State, Sao Paulo City | (b) Raia Olimpica | (c) direct view of the lake with a group of Capybaras. © D. Rosenfield, 2019.

effective and do have their merits when employed in the right situation, seem less adequate when considering large-scale intervention in the field, considering logistics, as well as animal well-being.

Furthermore, as the findings suggest, injured or sick individuals tend to retreat from the group until recovered, which can take several weeks, representing a window of opportunity for a fertile rival male to take over the group, undoing any population control attempt.

In regard to the relevance to public health, specifically for Brazil and spotted fever, based on a stochastic model (Polo et al. 2017), that indicated a birth-rate reduction of ≥ 90%, the etiological agent of the tick-borne zoonotic disease, hypothetically, could be controlled after two years of intervention, utilizing the alternative population control method for Capybaras described in this work.

The observations conducted over the study period of 18 months suggest that the birth rate reduction needed to directly manage a Capybara population, and indirectly the dynamics involved in maintaining and spreading *R. rickettsii*, could be achieved.

CONCLUSION

When it comes to population control, no one solution fits all situations. Each is unique and requires a specific study to choose the most appropriate solution. In free-ranging Capybaras, being able to treat the alpha male, satellite males, as well as all dominant females, seems to be the most promising method for controlling their population growth with the highest success rate. Nevertheless, it is important to understand that all efforts are temporary, and in order to maintain functioning population management, this method must be practiced continuously.

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[German] Abstrakt: Mit ständiger weiterwachsender menschlicher Bevölkerung somit auch der notwendige Lebensraum, unvermeidlich, schrumpft auch der natürliche Raum für wildlebende Tiere, dass treibt die Fauna entweder zum Aussterben oder in neue Lebensräume, einschließlich die von Menschen besätzten. Dies führt unweigerlich zu Problemen auf mehreren Ebenen. In Brasilien, wird insbesondere eine einheimische Wildtier Spezies für den Menschen immer lästiger. Der synanthropisch heranwachsende Capybara, oder Wasserschwein (*Hydrochoerus hydrochaeris*), der in seiner Natur stark proliferativ ist, entwickelt sich zu einer Superpopulation und wird zu einer Bedrohung für die menschliche Gesundheit, aufgrund seiner Funktion als einer der wichtigsten Wirt-Tiere für *Rickttsia rickettsii*, der Pathogen für das Brasilianische Flecken Fieber. Daher ist die Entwicklung von artengerechter Bevölkerungs-Kontrolle, unter Beachtung der öffentlichen Meinung und die Berücksichtigung des Tierschutzes, zur wirksamen Eindämmung von durch Zecken übertragenen Zoonose Erkrankungen erforderlich. Ein Konsens darüber, wie die Krankheitsübertragung des möglicherweise kontrolliert werden kann, besteht darin, die Bevölkerung des Wirts direkt zu kontrollieren und gleichzeitig die Dynamik zu beseitigen, die die Aufrechterhaltung des Pathogens ermöglicht. Als polygynische Gesellschaft mit einer starken hierarchischen Organisation, die von einem dominanten Männchen aufrechterhalten wird, ist die Beibehaltung der Integrität der hormonabhängigen sekundären Geschlechtsmerkmale und des agonistichen Verhaltens von entscheidender Bedeutung. Damit ein Eingriff durch Verhütungsstrategien ein wirksames Managementinstrument in Capybara sein kann, ist es unbedingt erforderlich, die phänotypischen und Dominanzmerkmale des Alpha-Männchens zu erhalten. Der Verlust des dominanten Status würde den opportunistischen Einstieg eines „Satelliten"- Männchens ermöglichen und somit das angestrebte Ziel der Geburtenkontrolle verfehlen. Ziel dieser Arbeit war es, im Rahmen eines größeren Forschungsprojekts zur Effizienz des Immunokontrazeptivums Anti-GnRH (Gonacon ™) in Wild-Capybaras die Auswirkungen dieser Bevölkerungskontrollstrategie auf das alpha Männchen sowie dem sozialen Verhalten der Gruppe zu untersuchen. Beobachtungen, die über einen Zeitraum von 18 Monaten gemacht wurden, rapportieren eine Reduktion der Geburtenrate von 100% der immunisierten Tiere unter Beibehaltung der alpha-Merkmale des dominanten Männchens und somit die Aufrechterhaltung der sozialen Struktur der Gruppe. Zusammenfassend lässt sich festhalten, dass die Ergebnisse die Verwendung dieses Immunokontrazeptiva-Impfstoffs zur Populationskontrolle in frei-lebendem Capybara empfohlen werden kann.

[Portuguese] Resumo: À medida que a população humana continua a crescer e expandir seu habitat, o espaço natural para a vida selvagem diminui, levando a fauna à extinção ou a novos habitats, incluindo áreas ocupadas por seres humanos. Isso, inevitavelmente, gera problemas em vários níveis. No Brasil, uma espécie nativa, em particular, está se tornando mais incômoda. A capivara sinantrópica (Hydrochoerus hydrochaeris), altamente proliferativa por natureza, atinge superpopulações, sendo uma ameaça emergente à saúde humana já que é um dos principais hospedeiros da Rickettsia rickettsii, patógeno da febre maculosa brasileira. Assim, o desenvolvimento de estratégias de gestão de populações específicas de espécies, respeitando a opinião pública e considerando o bem-estar animal são necessárias para a mitigação eficaz dessas doenças zoonóticas transmitidas por carrapatos. Um consenso sobre como potencialmente conter a transmissão da doença é controlando diretamente a população do hospedeiro, enquanto indiretamente remove a dinâmica que permite que os patógenos sejam mantidos. Como uma sociedade polígina com forte organização hierárquica que é sustentada por um macho dominante, a integridade das características sexuais secundárias e do comportamento agonístico a hormônios é crucial. Para que uma intervenção das estratégias contraceptivas seja uma ferramenta de gestão viável, é imperativo preservar as características fenotípicas e agonísticas do macho alfa. Perder o status dominante permitiria a entrada oportunista de um macho competitivo, consequentemente, levando a uma falha do gerenciamento populacional pretendido. Como parte de um projeto de pesquisa maior sobre a eficiência de um imunocontraceptivo em capivaras de vida livre, o objetivo deste trabalho foi observar seu impacto sobre o comportamento do macho alfa e do grupo. No final do estudo de 18 meses, não houve registros de nascimentos envolvendo os animais imunizados. Concomitantemente, as características do macho alfa foram preservadas e subsequentemente a integridade do grupo. Em conclusão, os resultados encorajam o uso desta vacina anti-GnRH como uma ferramenta alternativa de controle populacional em capivaras machos.

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COMMUNICATION

Dietary analysis of the Indian Flying Fox *Pteropus giganteus* (Brunnich, 1782) (Chiroptera: Pteropodidae) in Myanmar through the analysis of faecal and chewed remnants

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Abstract: The diet of Indian Flying Fox *Pteropus giganteus* in southern Myanmar was analyzed from June 2017 to April 2018. Food resources were identified by collecting faeces, food remnants, and rejecta pellets beneath day roosts. *Pteropus giganteus* consumed fruits, flowers, and leaves of 14 species of plants. Six species of fruits were found in the faeces below the day roosts, 13 species of fruits and two species of leaves in the rejecta, and seven species of fruits and one species of leaf at the day roost. These observations indicate that *P. giganteus* is a phytophagous bat with rapid intestinal passage.

Keywords: Flying fox, food resources, pollination, seed dispersal.

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Author contribution: MMA - developed research design and hypothesis. She made the collection of some data, most of the manuscript writing and reviewing. TTH - collected most of the sample, took sample photos, made data arrangement and wrote a few part of manuscript.

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INTRODUCTION

The Old World bat family Pteropodidae is distributed throughout the tropics and subtropics of Australasia, Africa, and Oceania (Marshall 1983; Mickleburgh et al. 1992). It comprises 196 species (Simmons 2005) that feed primarily on fruits, flowers (nectar, pollen, petals, and bracts), and leaves of at least 188 plant genera from 64 families (Lobova et al. 2009; Fleming & Kress 2011; Aziz et al. 2015). Some species were also recorded eating insects (Clulow & Blundell 2011; Scanlon et al. 2013).

Seed dispersal plays a significant role in forest regeneration and maintenance. Flying foxes are often posited as effective long-distance seed dispersers due to their large home ranges and ability to disperse seeds while flying (Oleksy et al. 2017). Long-distance seed dispersal can be important for the regeneration of forested habitats, especially in regions where deforestation has been severe. Old World fruit bats (Pteropodidae) have considerable potential for long-distance seed dispersal (Oleksy et al. 2015). Pteropodid bats, however, also damage a wide range of fruit crops in some countries, leading to persecution. In some of these countries, bats are not legally protected. In others, legal protection is either not implemented or over-ridden by legislation specifically allowing the killing of bats (Aziz et al. 2015).

Pteropodids primarily eat ripe fruits; the seeds are often swallowed and defecated unharmed or dropped during food processing (Banack 1998; Dumont & Irvine 1998). Moreover, bat-dispersed fruits in the Palaeotropics are morphologically variable and have a variety of colours, and some are strongly scented (Thomas 1984; Tan et al. 1998). Many fruit-eating bats depend heavily on plant resources throughout the year (Banack 1998; Fleming 1998; Tan et al. 1998). Figs, in particular, are thought to be staples in fruit bat diets because of their nutritional value and year-round asynchronous fruiting cycle (Shanahan et al. 2001; Stier & Mildenstein 2005). These ecosystem services are dependent on large populations of flying foxes and are necessary to maintain the Old World tropical forests (Fujita & Tuttle 1991; Nyhagen et al. 2005; McConkey & Drake 2006). The aim of this study was to provide information on food resources of *P. giganteus* and to confirm whether this species is a seed disperser in Myanmar, where the fruit bats remain the limited number of publication. *Pteropus giganteus*, therefore, plays an essential role in seed dispersal and pollination (Whitaker & Jones 1994) and thereby in structuring forest communities.

MATERIALS AND METHODS

Study site and study colony

This study was conducted within the Municipal Office Compound in Pyay Township (18°49'19.662''N & 95°12'47.368''E) in the Bago region on the eastern bank of the Ayeyarwady River in Myanmar (Fig. 1; Images 1 & 2). Some bat roosting trees are on the eastern bank of the river. The northern and northeastern parts of the district are forest-covered and contain numerous valleys and ravines. The Bago and Yakhine range forests are found on the western bank of the Ayeyarwady River opposite Pyay. Pyay has a tropical savanna climate. Temperatures are high throughout the year, especially before the monsoon from March to May when the average maximum temperature exceeds 36^0C.

The colony size was estimated by counting the bats emerging after sunset with the help of two observers following Moe Moe Aung (2013).

Dietary analysis

Two main methods were used to investigate the diet of *P. giganteus* in the study area. These are:

(i) regular faecal and rejecta collections at day roosts and nocturnal perches and

(ii) chance discovery of food items carried into day roosts by the bats.

Regular faecal and rejecta collections at day roosts

The diet of *P. giganteus* was investigated throughout the year using plastic sheets which were placed directly below the day roosts to catch faeces and discarded fruit parts.

Chance collections of seeds and fruits

Dietary information was occasionally collected by chance, either when a bat carried fruit and/or other feed remnants directly into day roosts. These were also collected from the plastic sheets.

Identification of food plants

Seeds, fruits, flowers, and leaves from dropped, defecated, and rejecta plant parts were identified following Kress et al. (2003) to determine the different food items consumed seasonally.

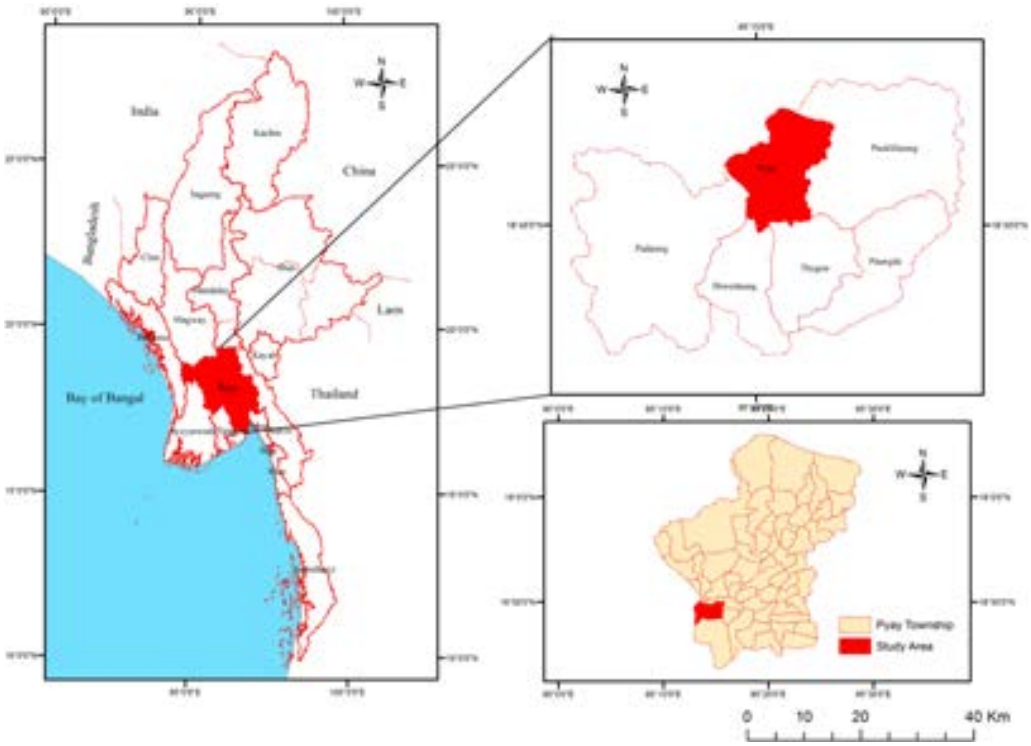

Figure 1. Location of Pyay Township in Myanmar.

Images 1 & 2. *Pteropus giganteus* from Pyay Township, Myanmar. © Than Than Htay.

RESULTS

Study colony

The study colony comprised 1799±128 individuals (n=4) in June 2017 on the first count. The number of bats did not markedly change until March 2018 although this month was the breeding season of the bats—juveniles were not able to fly and therefore could not be counted. The number of bats increased in April 2018 to 2171±271 individuals as young bats were volant and could be counted at that time.

Food resources

Pteropus giganteus was found to feed on 10 species of fruits, flowers and fruits of a single species, and both fruits and leaves of three species (Table 1). Of these, six

Table 1. Food resources exploited by *Pteropus giganteus* in the Municipal Office Compound in Pyay Township, Myanmar.

	Plant species	Food type	Food resources		
			F	R	C
1.	*Albizzia lebbek* Benth	Fruit/ leaf	-	+	+
2.	*Bombax ceiba* L.	Fruit/ flower	-	+	+
3.	*Ficus racemosa* L.	Fruit	+	+	-
4.	*F. virens* Aiton	Fruit/ leaf	+	+	-
5.	*Syzygium jambos* (L.) Alston	Fruit	+	+	-
6.	*Psidium guajava* L.	Fruit	+	+	-
7.	*Tamarindus indica* L.	Fruit/ leaf	-	+	+
8.	*Mangifera indica*	Fruit	+	+	-
9.	*Ziziphus jujuba* Lam	Fruit	-	+	+
10.	*Terminalia catappa* L.	Fruit	-	+	+
11.	*Musa sapientum* L.	Fruit	-	+	+
12.	*Mimusops elengi* Roxb	Fruit	+	+	-
13.	*Morinda angustifolia* Roxb	Fruit	-	+	+
14.	*Calophyllum inophyllum* L.	Fruit	-	+	+

F - Feces collected below day roosts | R - Rejecta and large seeds | C - Food items carried into day roosts by bats | + Available | - Not available.

species of fruits were observed in faeces below the day roosts and feeding perches and 13 species of fruits and three species of leaves as rejecta and large seeds under the day roosts. Five species of fruits, one species of fruit and flower, and two species of leaves were carried into the day roost by bats and eaten there.

Feeding habits

Fourteen species of plant resources were consumed by *Pteropus giganteus* (Table 1). Of these, the seeds of *Ficus racemosa, F. virens*, *and Psidium guajava* were observed from faecal pellets. The pulp of these fruits was consumed and the seeds appeared to be swallowed. The leaves of *Albizzia lebbek* and *Ficus virens* were chewed and the soluble contents were extracted. The fibrous contents were discarded as fibrous pellets. Petioles and veins were common in these pellets. The flowers of *Bombax ceiba* were also observed beneath the day roost.

Characteristics of food resources

Colour

Pteropus giganteus within the Municipal Office Compound consumed fruits of a variety of different colours, including yellow, green, red, and purple (Table 2). The majority of the fruits observed in this study, however, were yellow, green, and orange. All the leaves were green in colour.

Odour

Eleven species of fruits produced an odour that could be detected when the fruits were held close to the nose of a human observer in the field. Nevertheless, the odour emitted by different species of fruits was markedly different (Table 2).

Growth form

Of the 14 species of food plants exploited by *P. giganteus*, 10 were tall trees and four were small trees. Shrubs and herbs were not included among the bat food sources in this study (Table 2).

DISCUSSION AND CONCLUSION

Of the 14 species of plants eaten by *Pteropus giganteus*, four species, namely *Ficus racemosa*, *F. virens, Terminalia catappa*, and *Musa sapientum*, were available to bats throughout the year; other plant species that had a long fruiting season were *Psidium guajava, Mangifera indica,* and *Ziziphus jujuba.* Therefore, these plant species may be important for maintaining the population of *P. giganteus*. Some of the food plants are agricultural (or those used by humans): *Syzygium jambos, Psidium guajava, Tamarindus indica, Mangifera indica, Ziziphus jujuba*, and *Musa sapientum*. There is, however, no known negative interaction between fruit bats and fruit-growers in the study area. In this study, bats consumed fruits of a variety of different colours displayed openly by plants so that they are easily accessed by bats in flight. Fruits also tended to have distinct odours as well. Many samples of faeces contained seeds which are dispersed by bats (Image 3). In contrast, seeds in some rejecta pellets, such as *F. virens* (Image 4), were parasitized by fig wasps and were no longer viable. Some fruits were observed in both faeces and rejecta under the day roost. Kunz & Diaz (1996) suggested that one of the consequences of seed dispersal by bats is that the survival and growth of trees from such seeds may ultimately provide roost trees for other bats. In addition to dispersing seeds over a wide area, the concentration of seeds deposited beneath roosting sites may give rise to a clumped distribution of seedlings. *Pteropus giganteus* often defecate or drop seeds during flight, which potentially disperses seeds over a large area each night (Oleksy et al. 2017). Dietary studies can provide the concept of dietary importance to the conservation of *P. giganteus*. In the present study, most plants in the diet of *P. giganteus* were from the forests of Pyay environs and this together with the fact that forests are critically important for the diet of *P. giganteus* may

Table 2. Characteristics of food resources exploited by *Pteropus giganteus* in the Municipal Office Compound in Pyay Township, Myanmar.

	Family	Plant species	Growth form	Food colour	Odour
1.	Mimosaceae	*Albizzia lebbek* Benth	T	Green	Y
2.	Bombacaceae	*Bombax ceiba* L.	T	Orange	N
3.	Moraceae	*Ficus racemosa* L.	T	Mauve	Y
4.	Moraceae	*Ficus virens* Aiton	T	Brownish	Y
5.	Myrtaceae	*Syzygium jambos* (L.) Alston	T	Dark purple	N
6.	Myrtaceae	*Psidium guajava* L.	ST	Greenish-yellow	Y
7.	Caesalpiniaceae	*Tamarindus indica* L.	T	Reddish-brown	Y
8.	Anacardiaceae	*Mongifera indica*	T	Yellow	Y
9.	Rhamnaceae	*Ziziphus jujuba* Lam	ST	Reddish	Y
10.	Combretaceae	*Terminalia catappa* L.	T	Pinkish	Y
11.	Musaceae	*Musa sapientum* L.	ST	Yellow	Y
12.	Sapotaceae	*Mimusops elengi* Roxb	T	Orange	Y
13.	Rubiaceae	*Morinda angustifolia* Roxb	ST	Creamy	Y
14.	Clusiaceae	*Calophyllum inophyllum* L.	T	Green	N

T - Tree | ST - Small tree | Y - Yes | N - No. Plant growth form follows Kress et al. (2003).

Image 3. Seeds apparent in the *Pteropus giganteus* faeces collected below day roosts in Pyay Township in Myanmar: a - *Syzygium jambos* | b - *Psidium guajava* | c - *Mangifera indica* | d - *Mimusops elengi* | e - *Ficus racemosa* | f - *Ficus virens*. © Than Than Htay.

Image 4. Rejecta pellets and food remnants of *Pteropus giganteus* collected in Pyay Township in Myanmar: a - *Albizzia lebbek* (leaf) | b - *Albizzia lebbek* (fruit) | c - *Bombax ceiba* (flowers) | d - *Ficus racemosa* | e - *Ficus virens* (leaf) | f - *Ficus virens* | g - *Syzygium jambos* | h - *Psidium guajava* | i - *Tamarindus indica* | j - *Mangifera indica* | k - *Ziziphus jujuba* | l - *Terminalia catappa* | m - *Musa sapientum* | n - *Mimusops elengi* | o - *Morinda angustifolia* | p - *Calophyllum inophyllum*. © Than Than Htay.

indicate the role of forest in maintaining the population of this species. The information in this study suggests that there exists a considerable potential for future research on the management and conservation strategies of fruit bats.

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Report on three ectoparasites of the Greater Short-nosed Fruit Bat *Cynopterus sphinx* Vahl, 1797 (Mammalia: Chiroptera: Pteropodidae) in Cachar District of Assam, India

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Abstract: Ectoparasites of bats (Chiroptera: Pteropodidae), with a description of three species of of which two belong to order Mesostigmata (family: Ameroseiidae and Macronyssidae) and one belong to order Ixodida (family: Ixodidae), from northeastern India are discussed. The present study was carried out for six months (January–June 2014) to identify the various ectoparasites of the Short-nosed Fruit Bat *Cynopterus sphinx* in Cachar District of Assam, northeastern India. A total of 12 individuals of *C. sphinx* was captured using mist nets from eight different localities of the study area. During the study, a total of 125 parasites was collected from *C. sphinx*. The identified parasites were *Dermacentor* sp. Indet., *Ameroseius* sp. Indet., and *Steatonyssus* sp. Indet. and falls under the class Arachnida.

Keywords: Ameroseiidae, *Ameroseius*, *Dermacentor*, Ixodidae, Macronyssidae, Megachiroptera, Mesostigmata, *Steatonyssus*.

Bengali সংক্ষিপ্তসার : উত্তর পূর্ব ভারতের আসামে বাদুড়ের উপর থাকা তিন প্রজাতির পরজীবীকে নিয়ে এই গবেষণা পত্র। ছোট নাক বিশিষ্ট ফলাহারী বাদুড় (ইংরাজি নাম, *Cynopterus sphinx*) এর উপর দীর্ঘ ছয় মাস (২০১৪ সালের জানুয়ারী থেকে জুন) অধ্যয়ন করে এই প্রজাতির ১২টা বাদুড়ের শরীর থেকে ১২৫টি পরজীবী সংগ্রহ করা হয়েছিল। গবেষণা করে দেখা গেছে যে মেসো স্টিগ্মাটা পরিবারের এমেরোসিডি ও মেক্রনাইসিডি এবং ইক্সডিডা পরিবারের ইক্সডিডি এই বর্গের প্রাণীগুলো পরজীবী রূপে বাদুড়ের ত্বকের বাইরে বাস করে। শনাক্ত করা পরজীবী গুলোর বৈজ্ঞানিক নাম গুলো হল, ডারমাসেন্টর ও এমেরওসিয়াস প্রজাতি এবং স্টিটোনাইসাস প্রজাতি। বাদুড়ের দেহে এদের উপস্থিতি খুবই উদ্বেগের, এবং এদের দমন করা বাদুড়দের সংরক্ষণের জন্য আসু প্রয়োজন।

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Author contribution: AR contributed to the sample collection, identification, data analysis and wrote the manuscript. PC participated in designing and editing the manuscript.

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INTRODUCTION

Ectoparasites are organisms that infest the external body surface of host animals (Hopla et al. 1994; Hunter et al. 2001) during various stages of their life cycles (nymph, pupa, or adult) and consume blood as well as epithelial cell contents directly from the hosts (Desch et al. 1972; Mullen & Durden 2002). Ectoparasites may be obligate or facultative. An obligate parasite cannot complete its life cycle without exploiting a suitable host. It is considered to be host-specific and completes its entire life cycle on the host (Marshall 1982; Durden et al. 1992). A facultative parasite, on the other hand, can parasitize but does not rely on the host to continue its life cycle. It may change its host during the different life stages. Some facultative ectoparasites may live in the same nests or share the same environment with the host and visit the host periodically (Galloway & Danks 1990).

With more than 1,250 globally known species, the order Chiroptera holds the second largest position in the entire mammalian fauna (Helms 2010; Ghassemi et al. 2012). Chiroptera is subdivided into two suborders, i.e., Megachiroptera (Old World fruit bats) and Microchiroptera (echolocating bats), which represent herbivorous and insectivorous bats, respectively (Bates & Harrison 1997; Sophia 2010). As many as six different bat species were recorded from the Cachar District of southern Assam in India. Three of them are megachiropterans while the other three are microchiropterans. The megachiropteran species recorded from the study area are *Pteropus giganteus*, (Brünnich, 1782), *Cynopterus sphinx* (Vahl, 1797), and *Eonycteris spelaea* (Dobson, 1871) while the microchiropteran species from the area are *Megaderma lyra* (É. Geoffroy, 1810), *Pipistrellus coromandra* (Gray, 1838), and *Scotophilus kuhlii* (Leach, 1821).

Short-nosed Fruit Bat *Cynopterus sphinx* (Image 1) is frugivorous and is placed under the order Megachiroptera (Bates & Harrison 1997). It is a widespread and very common species. IUCN has categorized it as Least Concern. In southern Asia, it is considered to be more adaptable than *C. brachyotis* (Müller, 1838), and the population of *C. sphinx* seems to be stable (Molur *et al.* 2002).

Cynopterus sphinx is widely distributed along the southern Asian range, through southern China and most of mainland and insular southeastern Asia. In southern Asia, this species is presently known from Bangladesh (Dhaka, Khulna, and Rajshahi divisions), Bhutan (Phuntsholing), India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Nicobar Islands, Odisha, Rajasthan, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, and West Bengal), Nepal (central, eastern, far western, and western Nepal), Pakistan (Sind), and Sri Lanka (Central, Eastern, North Central, Sabaragamuwa, Southern, Uva, and Western provinces) (Molur et al. 2002). In southern China, it is found from Tibet to Fujian (Smith & Xie 2008). Although the species was reported from almost all major areas of southern Asia, comparatively limited information is available from these areas on the organisms that parasitize on them.

Bat parasites are highly diversified groups of organisms and were reported from all over the world (Jaunbauere et al. 2008; Dahal & Thapa 2010; Orlova 2011); however, ectoparasites of bats from some regions of the world remain understudied. As the present study site represents one such area, an attempt was made to document this much-ignored segment of bat ecology, i.e., the ectoparasites associated with the bat *Cynopterus sphinx*.

Study area

The area is located in the Cachar District of Assam in India and lies in the southern part of Assam having tropical evergreen vegetation which is characteristics feature of Barak Basin of northeastern India (Fig. 1). The district is located within 24.367-25.133 in the north and 92.417-93.250 in the east, covering an area of 3,786km^2. The area has an altitude of about 39–40 m. It is characterized by undulated topography, wide plain lands, and low lying waterlogged areas. The climatic condition of the area is subtropical, warm, and humid. Most of the precipitation occurs during May–August/September, which is mainly controlled by the southwestern monsoon. The average rainfall of this area is about 2600–2700 mm. The temperature ranges between 10°C and 38°C while the humidity ranges between 65% and 100% round the year.

MATERIALS AND METHODS

The study was carried out for six months (January–June 2014). For investigating ectoparasites, individuals of *Cynopterus sphinx* were captured using mist net (Kunz & Kurta 1988; Barlow 1999) from various locations of Cachar. Mist nets were placed slightly away from the roosting locations so that minimum disturbance was caused to the bat species. The captured bats were

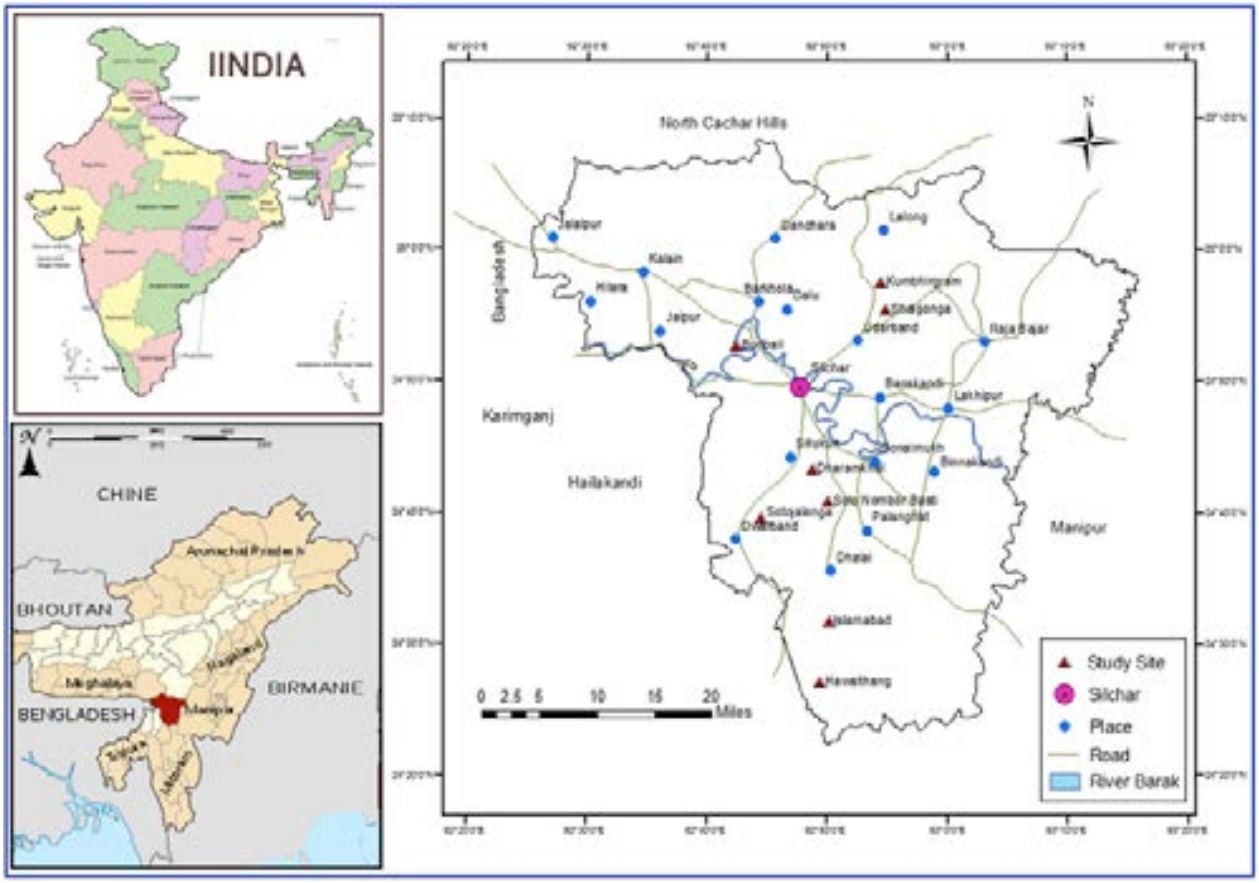

Figure 1. Cachar District in Assam, India, showing the study sites.

Image 1. Greater Short-nosed Fruit Bat *Cynopterus sphinx* in Cachar District of Assam, India.

segregated into two groups (i.e., adult and juvenile) based on the ossification of the phalangeal epiphyses (Burnett & Kunz 1982; Anthony 1988) and then according to sex (male/ female) based on external genitalia. To minimize the capture of pregnant bats, sampling was avoided during parturition period, which typically occurs in February–March and again in June–July each year. Their body mass was measured using analytical balance (Adair Dutt make; Model No:XB-220A). Body condition index (BCI) was calculated as the body weight/forearm length (Speakman & Racey 1996). Body mass, accurate to 0.1g, was measured. Data was converted to a body condition index by dividing the mass by the individual's forearm length in milimetres (as per Speakman & Racey 1996) and then multiplying by mean forearm length of all the bats (Ransome 1995). All the body parts, i.e., wing, ear and tail membrane pelage were visually inspected for ectoparasites (as per Gannon & Willing 1995). Special care was taken to minimise stress during the inspection and all the bats were released within 20min of capture. Ectoparasites were removed using forceps and preserved in vials containing 70% ethyl alcohol (Marshall

1982; Ritzi & Clark 2001). During the process, separate vials were used for the collection of ectoparasites from different individuals. The collected ectoparasites were sent to the Department of Entomology, IARI, New Delhi, for proper identification. Images of ectoparasites were taken using LEICA DFC 425C attached to a LEICA M205 FA stereo zoom microscope with auto montage. Locations of sites from where the bats were collected were noted using GPS (GARMIN E trex 20) and the map of the study site was prepared with Arc View 3.3 ESRI. Inc. 2001.

Image 2. A group of Greater Short-nosed Fruit Bats in Cachar District of Assam, India.

RESULTS

Cynopterus sphinx is a foliage-living species and is found in groups of 3–8 individuals (Image 2). The distribution and abundance of its ectoparasites are elaborately discussed here. During the field survey, a total of 11 roosting locations was documented which harbours 231 individuals of *C. sphinx* (Table 1). The maximum number of individuals was recorded from Urunabandh Tea Estate (39) while the minimum was recorded from Gumra Khelma IV (8). In the course of the study, ectoparasites of *C. sphinx* were collected from eight different study sites (Table 2) as hitherto no information was available on the ectoparasites of any available bat species of Cachar and the adjoining areas of Barak Valley in Assam, India.

During the course of the study, 125 ectoparasites (95 mites, 23 ticks, and 07 unidentified) from 12 individuals of *C. sphinx* (four males, eight females) were collected from different locations as mentioned in Table 2. Dermal ectoparasites were of three different types. The identified species are *Ameroseius* sp. Indet., *Dermacentor* sp. Indet., and *Steatonyssus* sp. Indet. Class/ family-wise distribution of the ectoparasites of *C. sphinx* are furnished in Table 3.

***Dermacentor* sp. Indet**: It is a thallus-bodied tick with legs radiating out from the central lobe. The body is 0.489mm long and 0.331mm wide. The legs are approximately 0.280–0.3 mm long. Gnathosoma, chelicera, and the legs bear numerous sensilla (Image 3A/I,A/II). The present study documented 23 individuals on seven bats from four (out of eight) locations (Table 4).

***Ameroseius* sp. Indet**: The main body is oval-shaped. The length is 0.248mm and the width is 0.161mm. The

Table 1. Population status and distribution of *Cynopterus sphinx* in Cachar District of Assam, India.

	Roosting site	Geographical coordinates	Type of roosting	No. of individuals
				Year: 2014
1	Muniarkhal Tea Estate	24.576°N & 92.950°E	Perennial	17
2	Shalgonga	24.917°N & 92.953°E	Perennial	18
3	Kumbhirgam	24.913°N & 92.974°E	Perennial	36
4	Arunabandh Tea Estate	24.900°N & 92.919°E	Perennial	39
5	Rukni Part II	24.643°N & 24.643°E	Perennial	13
6	Islamabad	24.555°N & 92.842°E	Perennial	35
7	Gumra Khelma VI	24.979°N & 92.520°E	Seasonal	8
8	Simultola	24.908°N & 92.673°E	Perennial	23
9	Kajalbasti	24.825°N & 93.116°E	Seasonal	14
10	Dharamkhal	24.577°N & 92.949°E	Seasonal	16
11	Solo Numbor Basti	24.650°N & 92.841°E	Seasonal	12
			Total	231
		Mean roosting size per tree (mean±SE)		21.00±0.98

Table 2. Summary of mist net locations and number of captured bats and ectoparasite species observed at each site including the total number of parasites and ectoparasite abundance in Cachar District of Assam, India.

Site(s)	Mist-netted locations	Geographical coordinates	No. of bat capture sites	*Ameroseius* sp. Indet	*Dermacentor* sp. Indet	*Steatonyssus* sp. Indet	Unidentified nymph	Total	Abundance
I	Hawaithang	24.519°N & 92.816°E	1	4	0	7	0	11	8.8%
II	Shalgonga	24.923°N & 24.923°E	2	3+5=8	1+2=3	4+3=7	0	18	14.4%
III	Kimbhirgram	24.928°N & 92.960°E	1	0	5	9	0	14	11.2%
IV	Islamabad	24.555°N & 92.844°E	2	4+3=7	0	5+6=11	2+1=3	21	16.8%
V	Solo Nomborbasti	24.649°N & 92.842°E	1	2	6	6	0	14	11.2%
VI	Buribail	24.883°N & 92.699°E	1	0	0	2	0	2	1.6%
VII	Dharamkhal	24.654°N & 92.725°E	3	4+4+3=11	3+4+2=9	6+6+5=17	0	37	29.6%
VIII	Sotojalengah	24.577°N & 92.949°E	1	0	0	4	4	8	6.4%
	Total		**12**	**32**	**23**	**63**	**7**	**125**	

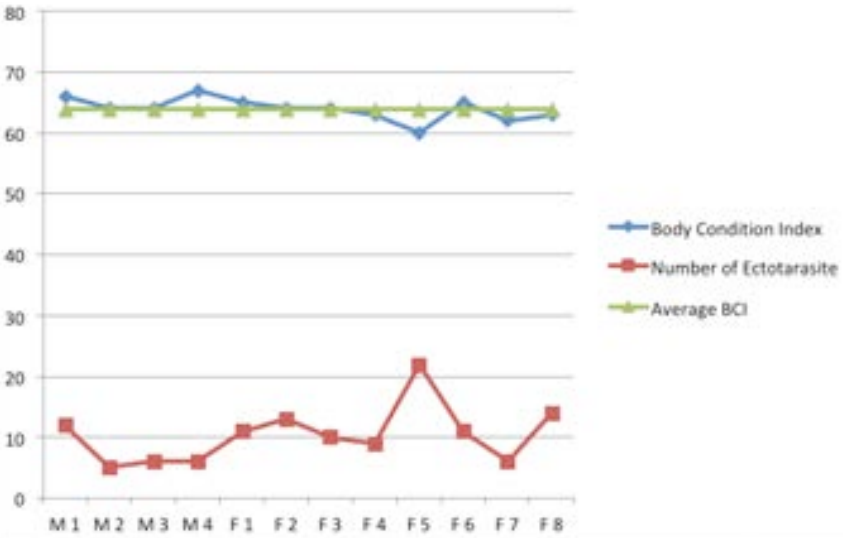

Figure 2. Body condition index and the number of ectoparasites of *Cynopterus sphinx*.

legs are slender and 0.12–0.18 mm long. Oral segment and the chelicera are thickly covered with sensilla (Image 3B/I,B/II). The present study documented 32 individuals on nine bats from five (out of eight) locations (Table 4).

***Steatonyssus* sp. Indet**: It is a slim-bodied parasite having a length of 1.085mm and width of 0.446mm. The long, radiating legs are 0.448–0.452 mm and thinly covered with sensilla (Image 3C/I,C/II). The present study documented 63 individuals on 12 bats from all eight locations (Table 4).

In the present study, individual body condition index (BCI) for males (M_1–M_4), females (F_1–F_8), average BCI of all the 12 bats, and the number of ectoparasites of each of them are given in Fig. 2. Some differences in ectoparasite abundance were observed between males (5–12) and females (7–22). In the case of one female bat (F_5), lower BCI was seen to be associated with a higher occurrence of ectoparasites (22). In other bats, this was not pronounced and may be due to the fact that in general *C. sphinx* have large body mass and thus greater accumulation of adipose tissue.

DISCUSSION

The extensive field survey carried out in the eight different locations of Cachar District revealed the presence of 125 ectoparasites on 12 individuals of *C. sphinx*. Bertola et al. (2005) studied 22 species of bat (sample size of 591) belonging to the families

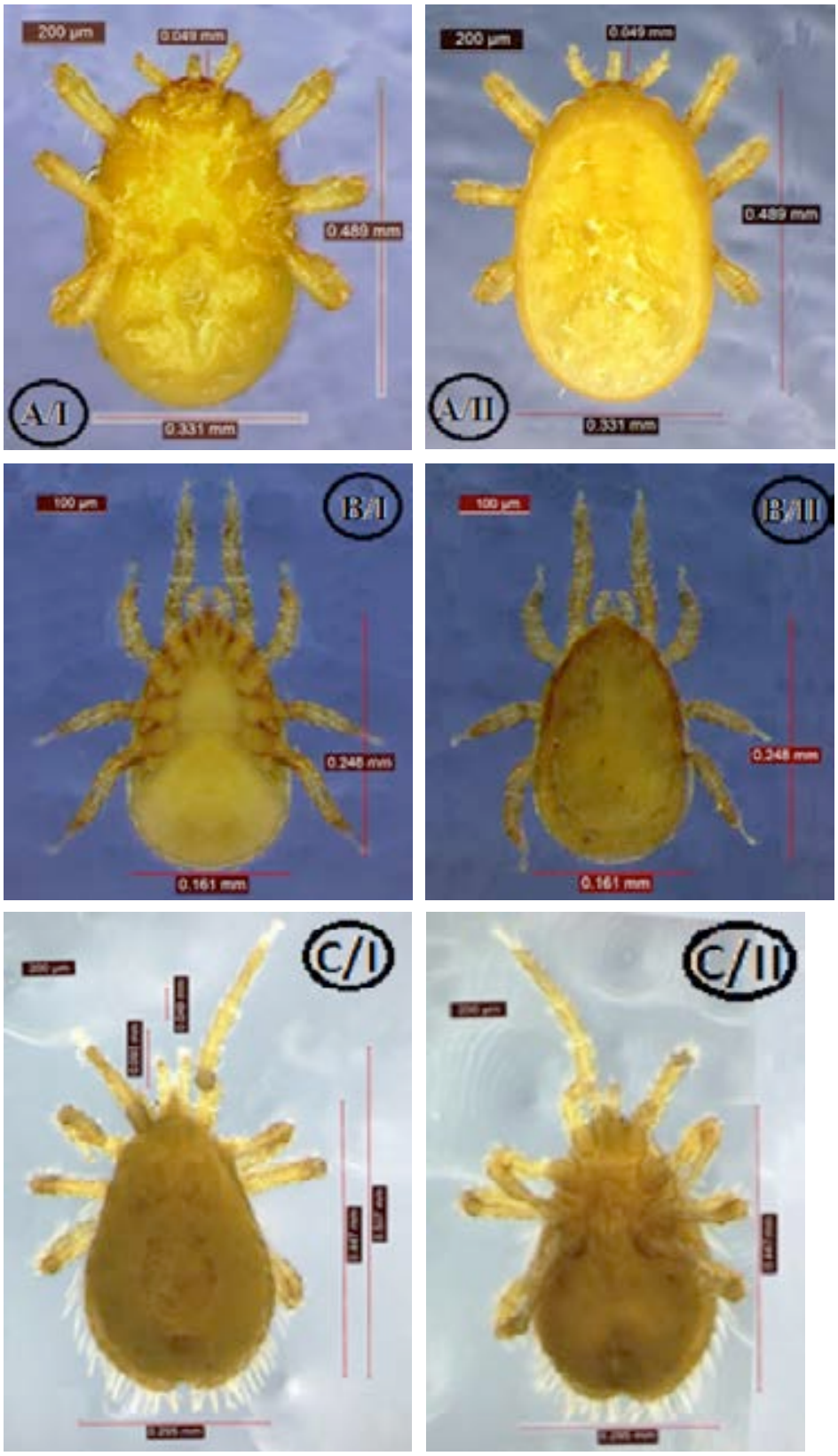

Image 3. Ectoparasites of Greater Short-nosed Fruit Bat *Cynopterus sphinx*: A/I & A/II - Dorsal and ventral view of *Dermacentor* sp. Indet | B/I & B/II - Dorsal and ventral view of *Ameroseius* sp. Indet | C/I & C/II - Dorsal and ventral view of *Steatonyssus* sp. Indet.

Table 3. Class/ family-wise distribution of ectoparasites of *Cynopterus sphinx* in Cachar District of Assam, India.

	Ectoparasite	Order	Family
1	*Ameroseius* sp. Indet	Mesostigmata	Ameroseiidae
2	*Dermacentor* sp. Indet	Ixodida	Ixodidae
3	*Steatonyssus* sp. Indet	Mesostigmata	Macronyssidae
4	Unidentified nymph		

Table 4. Site-wise distribution of ectoparasites of *Cynopterus sphinx* in Cachar District of Assam, India.

	Ectoparasite	Number	Number of bats	No. of recorded locations (out of eight locations)
1	*Ameroseius* sp. Indet	32	9	5
2	*Dermacentor* sp. Indet	23	7	4
3	*Steatonyssus* sp. Indet	63	12	8
4	Unidentified nymph	07	-	-

Molossidae, Vespertilionidae, and Phyllostomidae. Alvarez et al. (2015) studied ectoparasite diversity and host-parasite association of bats and found an ectoparasitic infestation in 46.42% of the bats (65 out of 140). In comparison to those studies, the present study reveals 100% infestation (125 parasite in 12 bats) in the bats. *Dermacentor* sp. Indet was found in 50% (four out of eight) of the locations, *Ameroseius* sp. Indet in 62.5% (five out of eight) of the locations, and *Steatonyssus* sp. Indet in 100% (eight out of eight) of the locations of the area studied.

Studies on ectoparasites of Kathmandu Valley by Dahal & Thapa (2010) recorded 33 ectoparasites belonging to five families (Cimicidae, Ischnopsyllidae, Nycteribidae, Spinturnicidae, and Streblidae) that were associated with five species of bats. On the other hand, the present study reports three ectoparasite species belonging to three families (Ameroseiidae, Macronyssidae, and Ixodidae) on a single bat species (*C. sphinx*).

Esbérard et al. (2005) and ter Hofstede & Fenton (2005) reported higher rate of ectoparasite infestation in enclosed-roosting species than in foliage-roosting bats. Since the present study deals with foliage-roosting bats only, such comparative studies could not be made. As already mentioned, however, variations were observed from 50% to 100% with respect to ectoparasite abundance in all the eight different areas studied.

Variations in ectoparasite abundance (1.6–29.6 %) among different sites were observed (Table 2). Out of the eight sites, the maximum abundance was found at Dharamkhal (Site VII), followed by Islamabad (Site IV) and Salganga (Site II). Due to the limitation of the bat species not being widespread in the area, extensive surveys considering more number of sites was beyond the scope of this study. Generally, it has been observed that bats cannot stay for long in areas with medium to high anthropogenic disturbances. Site VII (Dharamkhal) is a relatively undisturbed area. Since anthropogenic issues are absent in this area, bats stay here longer and so do their ectoparasites.

There are many taboos about bats such as i) seeing bats is inauspicious, ii) their nests in residential areas bring doomsday for families, and iii) the species is sent from hell. Hence, most people dislike them. Therefore, there is little resistance in cutting down their roosting trees and damaging their nesting sites. Semi-structured questionnaire surveys among indigenous communities residing in the area (n=1350) revealed that 4.12% of the people think that bats spread lice and house bugs. The present study found no basis for this and boldly advocates that bats are not responsible for spreading such infestations. These fallacies are responsible for unwanted killings of bats in roosting as well as foraging sites. Awareness among the masses will help in saving bat species from killing due to misconceptions.

CONCLUSION

During the present study, we encountered three individuals of *C. sphinx* that fell down from the roosting location, possibly due to excessive infestation caused by the ectoparasites. The new reporting of three ectoparasites (*Ameroseius* sp. Indet, *Dermacentor* sp. Indet, and *Steatonyssus* sp. Indet) on *C. sphinx* in the biodiversity-rich areas of Assam is remarkably important, especially since it is already mentioned that altogether six different bat species occur in the area. Studies on the ectoparasites of the other five species of bats (two megachiropterans and three microchiropterans) is the future component of our study. Once this is done, bat-ectoparasite relationships would be understood in a better way that would help in formulating conservation strategies for all the chiropterans in a holistic way.

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PLATINUM
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A checklist of mammals of Tamil Nadu, India

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Abstract: A checklist of mammals of Tamil Nadu State is presented in this paper. Accepted English names, scientific binomen, prevalent vernacular names in Tamil, IUCN conservation status, Indian Wildlife (Protection) Act schedules, the appendices in the CITES, endemism, the distribution of species in India, the Western Ghats & plains of Tamil Nadu, and the complete bibliography pertaining to the 132 species of mammals of Tamil Nadu are given.

Keywords: CITES, Indian Wildlife (Protection) Act, Tamil name, vernacular name, Western Ghats.

Abbreviations: IUCN - International Union for Conservation of Nature; IUCN Red List of Threatened Species: categories (CR - Critically Endangered; EN - Endangered; VU - Vulnerable; NT - Near Threatened; LC - Least Concern; NA - Not Assessed); END - Endemism; IWPA - Indian Wildlife (Protection) Act, 1972 (Schedule I, II, III, IV, and V); CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora (Appendix I, II and III); TN - Tamil Nadu; KL - Kerala: AP - Andhra Pradesh; WG - Western Ghats; PI - Peninsular India

Tamil Abstract: தமிழ்நாட்டில் காணப்படும் பாலூட்டி விலங்கினங்களின் பட்டியல் இப்பிரதியில் கொடுக்கப்பட்டுள்ளது. இவ்விலங்குகளின் சரியான ஆங்கில பெயர், அறிவியல் பெயர், வழக்கமான தமிழ் பெயர், சிறப்பின தன்மை, பன்னாட்டு இயற்கைப் பாதுகாப்புச் சங்கத்தின் செம்பட்டியல் (IUCN Red List), இந்திய வனவிலங்கு (பாதுகாப்பு) சட்ட அட்டவணை மற்றும் அருகிய இன காட்டு விலங்குகள் மற்றும் தாவரங்களின் பன்னாட்டு வர்த்தகம் பற்றிய மாநாடு பட்டியல் (CITES) ஆகியவை குறிப்பிடப்பட்டுள்ளது. மேலும், இவ்விலங்குகள் இந்தியாவின் மற்ற மாநிலங்களில் காணப்படுதல் மற்றும் தமிழக மேற்குத் தொடர்ச்சி மலைகள் மற்றும் அதன் சமவெளிகளில் காணப்படுதல் ஆகியவையும் குறிப்பிடப்பட்டுள்ளது. தமிழ்நாட்டில் காணப்படும் மொத்தம் 132 பாலூட்டி இனங்களின் முழு அறிவியல் குறிப்புகள் கொடுக்கப்பட்டுள்ளது.

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INTRODUCTION

Taxonomic accounts on the mammals of Tamil Nadu were carried out along with other Indian mammals by many authors, viz., Jerdon (1867), Blanford (1888-1891), Pocock (1939, 1941), Bates & Harrison (1997), Nameer (2000), and systematic review done by Ellerman & Morrison-Scott (1951), Prater (1971), Corbet & Hill (1992), Menon (2003, 2014), and Johnsingh & Manjrekar (2013, 2015). Notably, the Mammal Survey of India of Bombay Natural History Society conducted the systematic mammal survey in different regions of India including Tamil Nadu from 1912 to 1923 and the results were published by Thomas (1914–1924), Wroughton (1913–1921), Ryley (1913–1914), Hinton (1918–1923), and Lindsay (1926). Sathasivam (1996, 1998) published regional checklists of mammals together for Tamil Nadu and Kerala states where he listed 168 species; however, he did not mention any separate list for Tamil Nadu State alone. Moreover, after 1998, no updated checklist of mammals is available for Tamil Nadu State despite many taxonomic and biogeographic revisions (Bates & Harrison 1997; Agrawal 2000; Johnsingh 2001; Nameer et al. 2001; Molur et al. 2005; Sridhar et al. 2008; Molur & Singh 2009), new records on smaller mammals (Pradhan et al. 1997; Vanitharani et al. 2003, 2005; Vanitharani 2006), molecular phylogeny studies on primates (Karanth et al. 2008; Nag et al. 2011), and on the genus *Hemitragus* (Ropiquet & Hassanin 2005) in Tamil Nadu and its neighbouring states. Therefore, we provide the updated checklist along with the distribution and conservation status of mammalian species of Tamil Nadu State based on the recorded evidence.

METHODS

The taxonomic arrangement of the species was primarily based on Wilson & Reeder (2005) and further updated using Wilson & Mittermeier (2009) and nomenclature of the species as per the International Commission on Zoological Nomenclature (ICZN). The distribution of species in India (outside of Tamil Nadu State), and the current conservation status as per the IUCN Red List of Threatened Species, mammal species listed in the different schedules of the Indian Wildlife (Protection) Act, 1972 and the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) are also provided.

RESULTS AND DISCUSSION

As Sathasivam (1996, 1998) provided a combined regional checklist of mammals for Tamil Nadu and Kerala, determining the mammal species only for Tamil Nadu is not possible from these checklists. Of the 168 species of mammals (136 terrestrial and 32 marine) provided by Sathasivam (1996, 1998), there are 29 species neither found in Tamil Nadu nor in Kerala, and 12 species found only in Kerala, but not in Tamil Nadu (Table 1). The nomenclatures of 11 species (Table 2) have been changed as per Wilson & Reeder (2005) and ICZN. Two species, namely Sahyadri Forest Rat *Rattus satarae* and Lenis Woolly Bat *Kerivoula lenis* (Vanitharani et al. 2003; Molur et al. 2005) have been included in the present checklist (Table 4), which were not listed in the earlier checklist. The current checklist also has additional details such as the updated nomenclature of species and their systematic account, prevalent vernacular names in Tamil, conservation status as per IUCN, IWPA and CITES, endemism, the distribution of species in India and the Western Ghats and plains of Tamil Nadu, and the complete bibliography for all species.

A total of 132 (108 terrestrial and 24 marine) species of mammals belonging to 12 orders and 37 families are listed in the present checklist (Table 4). Of the 108 terrestrial mammal species, 32 species are found only in the Western Ghats region of Tamil Nadu and remaining species are found both in the Western Ghats and the plains of Tamil Nadu. The order Chiroptera represents a maximum number of species (35 species) followed by Rodentia (28 species) and these two taxa jointly account for 47 percent of the total mammalian fauna in Tamil Nadu (Fig. 1; Table 3). A total of 32 species of marine mammals including *Platanista gangetica* Ganges River Dolphin have been reported from Indian waters so far (Kumaran 2002, 2012; Nameer 2016), of which, 24 species are distributed in Tamil Nadu State along the Bay of Bengal and the Indian Ocean. Out of 51 known endemic species of mammals in India (Johnsingh & Nameer 2015), 22 species are found in the Tamil Nadu, and 14 of which are endemic to the Western Ghats. Elvira Rat *Cremnomys elvira*, a Critically Endangered species found in Tamil Nadu State until now is known only from its type locality of Kurumbapatti, Salem District, in the Eastern Ghats of Tamil Nadu. The genera namely *Anathana*, *Latidens,* and *Nilgiritragus* are monotypic and found only in the Tamil Nadu and its neighbouring states across the Western Ghats. The Nilgiri Tahr *Nilgiritragus hylocrius*, the only wild goat endemic to the southern Western Ghats in Kerala and

Table 1. List of mammal species as mentioned by Sathasivam (1996, 1998) and their present systematic and distribution status.

	Name of the species as mentioned by Sathasivam (1996, 1998)	Present systematic and distribution status	References
	ORDER PRIMATES **Family Cercopithecidae**		
1.	*Semnopithecus entellus* Common or Hanuman Langur	*Semnopithecus entellus* split into seven species in India, of which two species (*S. hypoleucos* and *S. priam*) are known from TN	Karanth et al. (2008); Nag et al. (2011)
	ORDER RODENTIA **Family Sciuridae**		
2.	*Funambulus layardi* Layard's Striped Squirrel	Restricted to Sri Lanka	Molur et al. (2005)
	Family Muridae		
3.	*Mus dunni* Dunn's Mouse	Synonyms of *Mus terricolor*; it is difficult to define, as it is often confused with *Mus booduga*	Musser & Carleton (2005)
4.	*Rattus norvegicus* Brown Rat or Norway Rat	Not native to India	Ruedas (2016)
5.	*Rattus ranjiniae*	Distribution records from KL, not from TN	Molur et al. (2005)
	ORDER EULIPOTYPHLA **Family Soricidae**		
6.	*Suncus montanus*	*Suncus montanus* is restricted to Sri Lanka; the species found in TN is *Suncus niger*	Molur & Singh (2009)
7.	*Suncus stoliczkanus* Anderson's Shrew	No distribution either in TN or KL	Molur et al. (2005)
8.	*Suncus etruscus* Indian Pygmy Shrew	Distribution records from KL, not from TN	Molur et al. (2005)
9.	*Crocidura horsfieldi* Horsfield's Shrew	No distribution either in TN or KL	Molur et al. (2005)
	ORDER CHIROPTERA **Family Rhinopomatidae**		
10.	*Rhinopoma hardwickii* Lesser Mouse-tailed Bat	No distribution records from TN	Bates & Harrison (1997); Molur et al. (2002)
11.	*Rhinopoma microphyllum* Greater Mouse-tailed Bat	Doubtful record	Bates & Harrison (1997); Molur et al. (2002)
12.	*Rhinopoma muscatellum* Small Mouse-tailed Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)
	Family Emballonuridae		
13.	*Taphozous saccolaimus* Pouch-bearing Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
14.	*Taphozous theobaldi* Theobald's Tomb Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
	Family Rhinolophidae		
15.	*Rhinolophus affinis* Intermediate Horseshoe Bat	No exact locality	Bates & Harrison (1997); Molur et al. (2002)
16.	*Rhinolophus luctus* Great Eastern or Woolly Horseshoe Bat or Large Leaf-Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
17.	*Rhinolophus pusillus* Least Horseshoe Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
18.	*Rhinolophus beddomei* Lesser Woolly Horeshoe Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
	Family Hipposideridae		
19.	*Hipposideros galeritus* Cantor's Leaf-nosed Bat or Fawn Leaf-nosed Bat	No distribution records from TN	Bates & Harrison (1997); Molur et al. (2002)
20.	*Hipposideros lankadiva* Kelaart's Leaf-nosed Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)
21.	*Hipposideros hypophyllus* Kolar Leaf-nosed Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)
	Family Molossidae		
22.	*Otomops wroughtoni* Wroughton's Free-tailed Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)

	Name of the species as mentioned by Sathasivam (1996, 1998)	Present systematic and distribution status	References
	Family Vespertilionidae		
23.	*Tylonycteris pachypus* Bamboo Bat or Flat-headed Bat	Distribution records from KL, not from TN	Bates & Harrison (1997); Molur et al. (2002)
24.	*Myotis hasseltii* Van Hasselt's Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)
25.	*Kerivoula hardwickii* Hardwicke's Forest Bat	No distribution either in TN or KL	Bates & Harrison (1997); Molur et al. (2002)
	ORDER CARNIVORA Family Canidae		
26.	*Canis lupus* Indian Gray Wolf	Known only from historic records	Prater (1971)
	Family Mustelidae		
27.	*Lutra lutra* Common or Eurasian Otter	Known only from historic records	Jerdon 1867; Blanford 1888–1891; Pocock 1941; Prater 1971
	Family Viverridae		
28.	*Viverra civettina* Malabar Civet	Known only from historic records from KL. However, recent studies have ruled out the distribution from KL and TN.	Nandini & Mudappa (2010)
	Family Herpestidae		
29.	*Herpestes javanicus* Small Asian Mongoose	No distribution either in TN or KL	Patou et al. (2009)
	Family Felidae		
30.	*Prionailurus viverrinus* Fishing Cat	Known only from historic records and recent studies ruled out its presence from southern India.	Mukherjee et al. (2012); Janardhanan et al. (2014)
	ORDER ARTIODACTYLA Family Bovidae		
31.	*Boselaphus tragocamelus* Nilgai	Known only from historic records	Prater (1971); Sankar and Johnsingh (2015)
	Order CETACEA Family Delphinidae		
32.	*Lagenodelphis hosei* Fraser's Dolphin	No records from India	Sathasivam (2000)
33.	*Orcaella brevirostris* Irrawady Dolphin	No distribution either in TN or KL; there was a record of one live animal stranded on the Chennai coast after cyclone	Sathasivam (2000)
34.	*Feresa attenuata* Pygmy Killer Whale	Distribution records from KL, not from TN	Nameer (2015)
35.	*Mesoplodon ginkgodens* Gingko-toothed Beaked or Japanese Beaked Whale	Distribution records from KL, not from TN	Nameer (2015)
	Family Ziphiidae		
36.	*Mesoplodon pacificus* Longman's Beaked Whale	No records from India	Sathasivam (2000)
37.	*Mesoplodon densirostris* Blainville's Beaked Whale	No records either from TN or KL	Sathasivam (2000)
38.	*Hyperoodon planifrons* Southern Bottlenose Whale	No records either from TN or KL	Sathasivam (2000)
39.	*Tursiops truncatus* Bottlenose Dolphin or Bottle-nosed Dolphin	The species reported from India is *Tursiops aduncus* not *T. truncatus*	Wang et al. (2014)
40.	*Delphinus delphis* Common Dolphin	The species reported from India is *Delphinus capensis* not *D. delphis*	Jayasankar et al. (2008)
	Family Balaenidae		
41.	*Balaena glacialis* Black or Northern Right Whale	No records either from TN or KL	Sathasivam (2000)

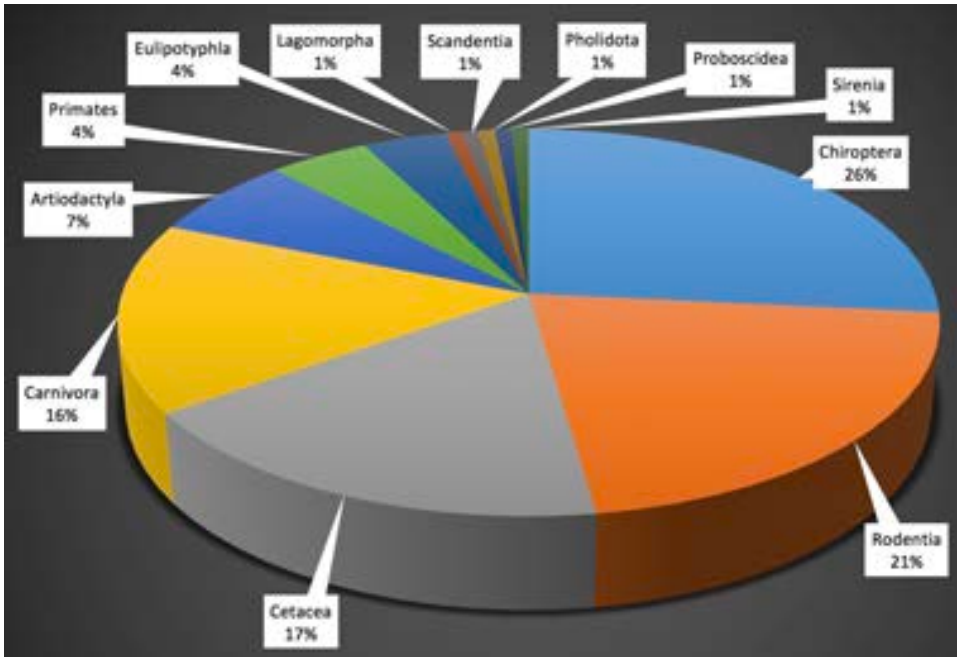

Figure 1. Percentage frequency of mammalian species of Tamil Nadu in different orders of class Mammalia.

Table 2. Mammal species as mentioned by Sathasivam (1996, 1998) and their current nomenclature as per Wilson & Reeder (2005) and ICZN.

	Name of the species as mentioned by Sathasivam (1996, 1998)	Current nomenclature as per Wilson & Reeder (2005) and ICZN
1.	*Cremnomys blanfordi* Blanfords' Rat or White-tailed Wood Rat	*Madromys blanfordi* Blanford's Rat
2.	*Paraechinus micropus* Pale or Indian Hedgehog	*Paraechinus nudiventris* Bare-bellied Hedgehog
3.	*Pipistrellus affinis* Chocolate Bat	*Falsistrellus affinis* Chocolate Pipistrelle
4.	*Pipistrellus dormeri* Dormer's Bat	*Scotozous dormeri* Dormer's Pipistrelle
5.	*Tadarida plicata* Wrinkle-lipped Free-tailed Bat	*Chaerephon plicatus* Wrinkle-lipped Free-tailed Bat
6.	*Ursus ursinus* Sloth Bear	*Melursus ursinus* Sloth Bear
7.	*Martes flavigula* Nilgiri Marten or Nilgiri Yellow-throated Marten	*Martes gwatkinsii* Nilgiri Marten
8.	*Moschiola meminna* Indian Mouse-Deer or Chevrotain	*Moschiola indica* Indian Chevrotain
9.	*Cervus unicolor* Sambar	*Rusa unicolor* Sambar
10.	*Hemitragus hylocrius* Nilgiri Tahr	*Nilgiritragus hylocrius* Nilgiri Tahr
11.	*Kogia simus* Dwarf Sperm Whale	*Kogia sima* Dwarf Sperm Whale

Tamil Nadu, was accorded the status of State Animal of Tamil Nadu (Gazette Notification of the Government of Tamil Nadu, 1988).

The checklist of mammals of any particular region needs to be periodically updated as the number of species changes due to new discoveries, taxonomic revisions and molecular phylogeny studies (Wilson & Reeder 2005). Recently, Nameer (2015, 2016) provided a comprehensive checklist of mammals of Kerala, and the information on mammals of both Tamil Nadu (present checklist) and Kerala together will help in understating the mammal diversity of southern Western Ghats. Moreover, the present checklist would help the researchers and state forest and wildlife managers to plan conservation strategies to manage the mammals in Tamil Nadu.

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Table 3. A total number of mammalian species of Tamil Nadu in different orders of class Mammalia and their conservation status as per the IUCN, IWPA and CITES.

Order of class Mammalia	No. of species
Chiroptera	35
Rodentia	28
Cetacea	23
Carnivora	21
Artiodactyla	9
Primates	6
Eulipotyphla	5
Lagomorpha	1
Scandentia	1
Pholidota	1
Proboscidea	1
Sirenia	1
IUCN Red List Threatened Species (2019)	
Critically Endangered	1
Endangered	14
Vulnerable	17
Near Threatened	8
Least Concern	82
Data Deficient	9
Not Assessed	1
Indian Wildlife (Protection) Act, 1972	
Schedule I	22
Schedule II	38
Schedule III	5
Schedule IV	2
Schedule V	25
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Appendix I	21
Appendix II	25
Appendix III	11

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Table 4. Checklist of mammals of Tamil Nadu.

	English name	Species name	Authority	Tamil name (தமிழ் பெயர்)	Vernacular name	WG / Plains of TN	END	IUCN	IWPA	CITES
	TERRESTRIAL MAMMALS (நில பாலூட்டிகள்)									
	I. ORDER PROBOSCIDEA									
	1. Family Elephantidae (elephants)									
1	Asiatic Elephant (Indian Elephant)[1]	*Elephas maximus*	Linnaeus, 1758	யானை	Yāṉai	Both		EN	I	I
	II. ORDER SCANDENTIA									
	2. Family Tupaiidae (tree shrews)									
2	Madras Treeshrew (Indian Tree Shrew)[2]	*Anathana ellioti*	(Waterhouse, 1850)	சென்னை மர மூஞ்சூறு	Ceṉṉai Mara Mūñcūṟu	Both	PI	LC		II
	III. ORDER PRIMATES									
	3. Family Lorisidae (lorises)									
3	Gray Slender Loris (Highland Slender Loris)[3]	*Loris lydekkerianus*	Cabrera, 1908	தேவாங்கு	Tēvāṅku	Both		LC	I	II
	4. Family Cercopithecidae (old world monkeys)									
4	Bonnet Macaque (Zati)[4]	*Macaca radiata*	(E. Geoffroy, 1812)	குரங்கு	Kuraṅku	Both	PI	LC	II	II
5	Lion-tailed Macaque (Wanderoo)[5]	*Macaca silenus*	(Linnaeus, 1758)	சிங்க-வால் குரங்கு	Ciṅka-vāl Kuraṅku	WG	WG	EN	I	I
6	Black-footed Gray Langur (Malabar Sacred Langur)[6]	*Semnopithecus hypoleucos*	Blyth, 1841	கருப்பு-கால் சாம்பல் நிற குரங்கு	Karuppu-kāl Cāmpal Niṟa Kuraṅku	WG	WG	VU		I
7	Tufted Gray Langur (Coromandel Sacred Langur)[7]	*Semnopithecus priam*	Blyth, 1844	நூற்குஞ்சமுள்ள சாம்பல் நிற குரங்கு	Nūṟkuñcamuḷḷa Cāmpal Niṟa Kuraṅku	Both		NT		I
8	Nilgiri Langur (Nilgiri Leaf Monkey)[8]	*Semnopithecus johnii*	(J. Fischer, 1829)	கருங்குரங்கு	Karuṅkuraṅku	WG	WG	VU	I	II
	IV. ORDER RODENTIA									
	5. Family Sciuridae (squirrels)									
9	Indian Giant Squirrel (Malabar Giant Squirrel)[9]	*Ratufa indica*	(Erxleben, 1777)	மலபார் அணில்	Malapār Aṇil	Both	PI	LC	II	II
10	Grizzled Giant Squirrel (Sri Lankan Giant Squirrel)[10]	*Ratufa macroura*	Pennant, 1769	நரைத்த அணில்	Naraitta Aṇil	Both		NT	I	II
11	Indian Giant Flying Squirrel (Large Brown Flying Squirrel)[11]	*Petaurista philippensis*	(Elliot, 1839)	இந்திய பறக்கும் அணில்	Intiya Paṟakkum Aṇil	Both		LC	II	
12	Travancore Flying Squirrel[12]	*Petinomys fuscocapillus*	(Jerdon, 1847)	திருவாங்கூர் பறக்கும் அணில்	Tiruvāṅkūr Paṟakkum Aṇil	WG		NT	I	
13	Indian Palm Squirrel (Three-striped Palm Squirrel)[13]	*Funambulus palmarum*	(Linnaeus, 1766)	மூன்று பட்டைக்கோடிட்ட அணில்	Mūṉṟu Paṭṭaikkōṭiṭṭa Aṇil	Both		LC		
14	Nilgiri Palm Squirrel (Dusky Palm Squirrel)[14]	*Funambulus sublineatus*	(Waterhouse, 1838)	மங்கிய பட்டைக்கோடிட்ட அணில்	Maṅkiya Paṭṭaikkōṭiṭṭa Aṇil	WG		VU		
15	Jungle Palm Squirrel (Western Ghats Striped Squirrel)[15]	*Funambulus tristriatus*	(Waterhouse, 1837)	ஜங்கிள் பட்டைக்கோடிட்ட அணில்	Jaṅkiḷ Paṭṭaikkōṭiṭṭa Aṇil	WG	WG	LC		

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	6. Family Platacanthomyidae (spiny dormouse)									
16	Spiny Tree Mouse (Spiny Dormouse)[16]	*Platacanthomys lasiurus*	Blyth, 1859	முள் மர எலி	Muḷ Mara Eli	WG	WG	VU	V	
	7. Family Muridae (rats and mice)									
17	Indian Gerbil (Antelope Rat)[17]	*Tatera indica*	(Hardwicke, 1807)	இந்திய கெர்பில் எலி	Intiya Kerpil Eli	Both		LC	V	
18	Lesser Bandicoot Rat (Indian Mole Rat)[18]	*Bandicota bengalensis*	(Gray, 1835)	சிறிய பெருச்சாளி	Ciṟiya Peruccāḷi	Both		LC	V	
19	Greater Bandicoot Rat (Large Bandicoot Rat)[18]	*Bandicota indica*	(Bechstein, 1800)	பெரிய பெருச்சாளி	Periya Peruccāḷi	Both		LC	V	
20	Cutch Rock Rat[19]	*Cremnomys cutchicus*	Wroughton, 1912	கட்ச் பாறை எலி	Kaṭc Pāṟai Eli	Plains	PI	LC	V	
21	Large Rock Rat (Elvira Rat)[20]	*Cremnomys elvira*	(Ellerman, 1946)	பெரிய பாறை எலி	Periya Pāṟai Eli	Plains	TN	CR	V	
22	Indian Bush Rat[18]	*Golunda ellioti*	Gray, 1837	இந்திய புதர் எலி	Intiya Putar Eli	Both		LC	V	
23	Blanford's Rat (White-tailed Wood Rat)[21]	*Madromys blanfordi*	(Thomas, 1881)	வெள்ளை வால் எலி	Veḷḷai Vāl Eli	Both		LC	V	
24	Common Metad (Soft-furred Field Rat)[21]	*Millardia meltada*	(Gray, 1837)	மெட்டடு எலி	Meṭṭaṭu Eli	Both		LC	V	
25	Little Indian Field Mouse (Common Indian Field Mouse)[18]	*Mus booduga*	(Gray, 1837)	இந்திய சிறிய கள சுண்டெலி	Intiya Ciṟiya Kaḷa Cuṇṭel	Both		LC	V	
26	Cook's Mouse (Ryley's Spiny Mouse)[23]	*Mus cookii*	Ryley, 1914	குக்கி-ன் சுண்டெலி	Kukki-ṉ Cuṇṭeli	WG		LC	V	
27	Bonhote's Mouse (Servant Mouse)[24]	*Mus famulus*	Bonhote, 1898	வேலைக்கார சுண்டெலி	Vēlaikkāra Cuṇṭeli	WG	WG	EN	V	
28	House Mouse[18]	*Mus musculus*	Linnaeus, 1758	வீட்டு சுண்டெலி	Vīṭṭu Cuṇṭeli	Both		LC	V	
29	Phillips's Mouse (Wroughton's Small Spiny Mouse)[25]	*Mus phillipsi*	Wroughton, 1912	பிலிப்ஸ்-ன் சுண்டெலி	Pilips-ṉ Cuṇṭeli	Plains	PI	LC	V	
30	Flat-haired Mouse (Brown Spiny Mouse)[26]	*Mus platythrix*	Bennett, 1832	பழுப்பு முள் சுண்டெலி	Paḻuppu Muḷ Cuṇṭeli	Both	PI	LC	V	
31	Elliot's Spiny Mouse (Rock-loving Mouse)[27]	*Mus saxicola*	Elliot, 1839	பாறை வாழ் சுண்டெலி	Pāṟai Vāḻ Cuṇṭeli	Both		LC	V	
32	Common House Rat (Black Rat)[28]	*Rattus rattus*	(Linnaeus, 1758)	வீட்டு எலி	Vīṭṭu Eli	Both		LC	V	
33	Sahyadris Forest Rat[29]	*Rattus satarae*	Hinton, 1918	ஷயாத்ரிக்கள் வன எலி	Ṣayātrikkaḷ Vaṇa Eli	WG	WG	VU	V	
34	Nilgiri Long-tailed Tree Mouse (Nilgiri vandeleuria)[30]	*Vandeleuria nilagirica*	Jerdon, 1867	நீலகிரி நீண்ட வாலுடைய மர எலி	Nīlakiri Nīṇṭa Vāluṭaiya Mara Eli	WG	WG	EN	V	
35	Asiatic Long-tailed Tree Mouse (Common Vandeleuria)[18]	*Vandeleuria oleracea*	(Bennett, 1832)	ஆசிய நீண்ட வாலுடைய மர எலி	Āciya Nīṇṭa Vāluṭaiya Mara Eli	Both		LC	V	
	8. Family Hystricidae (porcupines)									
36	Indian Crested Porcupine (Indian porcupine)[31]	*Hystrix indica*	Kerr, 1792	முள்ளம்பன்றி	Muḷḷampaṉṟi	Both		LC	IV	
	V. ORDER LAGOMORPHA									
	9. Family Leporidae (hares)									
37	Black-naped Hare (Indian Hare)[31]	*Lepus nigricollis*	F. Cuvier, 1823	காட்டு முயல்	Kāṭṭu muyal	Both		LC	IV	
	VI. ORDER EULIPOTYPHLA									
	10. Family Erinaceidae (hedgehogs)									

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38	Bare-bellied Hedgehog (Madras Hedgehog)[32]	*Paraechinus nudiventris*	(Horsfield, 1851)	முள்ளெலி	Muḷḷeli	Both	TN, KL & AP	LC		
	11. Family Soricidae (shrews)									
39	Kelaart's Long-clawed Shrew[33]	*Feroculus feroculus*	(Kelaart, 1850)	கீலார்ட்-ன் நீண்ட விரல் மூஞ்சூறு	Kīlārṭ-ṉ Nīṇṭa Viral Mūñcūṟu	WG		EN		
40	Day's Shrew[34]	*Suncus dayi*	(Dobson, 1888)	டே-ன் மூஞ்சூறு	Ṭē-ṉ Mūñcūṟu	WG	WG	EN		
41	Nilgiri Highland Shrew[35]	*Suncus niger*	Horsfield, 1851	நீலகிரி மேட்டு மூஞ்சூறு	Nīlakiri Mēṭṭu Mūñcūṟu	WG	WG	NA		
42	Asian Musk Shrew (House Shrew)[36]	*Suncus murinus*	(Linnaeus, 1766)	ஆசிய கஸ்தூரி மூஞ்சூறு	Āciya Kastūri Mūñcūṟu	Both		LC		
	VII. ORDER CHIROPTERA									
	12. Family Pteropodidae (flying foxes)									
43	Lesser Short-nosed Fruit Bat (Common Short-nosed Fruit Bat)[37]	*Cynopterus brachyotis*	(Müller, 1838)	சிறிய குறுகிய-மூக்கு பழ வௌவால்	Ciṟiya Kuṟukiya-mūkku Paḻa Veḷavāl	Both		LC	V	
44	Greater Short-nosed Fruit Bat (Short-nosed Indian Fruit Bat)[38]	*Cynopterus sphinx*	(Vahl, 1797)	பெரிய குறுகிய-மூக்கு பழ வௌவால்	Periya Kuṟukiya-mūkku Paḻa Veḷavāl	Both		LC	V	
45	Lesser Dawn Bat (Common Nectar Bat)[39]	*Eonycteris spelaea*	(Dobson, 1871)	மலர்த் தேன் வௌவால்	Malart Tēṉ Veḷavāl	WG		LC	V	
46	Salim Ali's Fruit Bat[40]	*Latidens salimalii*	Thonglongya, 1972	சலீம் அலி-ன் பழ வௌவால்	Calīm Ali-ṉ Paḻa Veḷavāl	WG	WG	EN	I	
47	Indian Flying Fox (Greater Indian Fruit Bat)[38]	*Pteropus giganteus*	(Brünnich, 1782)	இந்திய பெரிய பழ வௌவால்	Intiya Periya Paḻa Veḷavāl	Both		LC	V	II
48	Leschenault's Rousette (Shortridge's Rousette)[38]	*Rousettus leschenaultii*	(Desmarest, 1820)	லீஸ்செனால்டு-ன் ரூசெட்டே வௌவால்	Līsceṉāḷṭu-ṉ Rūceṭṭē Veḷavāl	Both		LC	V	
	13. Family Rhinolophidae (horseshoe bats)									
49	Blyth's Horseshoe Bat[41]	*Rhinolophus lepidus*	Blyth, 1844	பிளைத்-ன் குதிரை லாட வௌவால்	Piḷait-ṉ Kutirai Lāṭa Veḷavāl	Both		LC		
50	Rufous Horseshoe Bat[42]	*Rhinolophus rouxii*	Temminck, 1835	ரூ்பஸ் குதிரை லாட வௌவால்	Rūḥpas Kutirai Lāṭa Veḷavāl	Both		LC		
	14. Family Hipposideridae (old world leaf-nosed bats)									
51	Dusky Leaf-nosed Bat (Bi-coloured Leaf-nosed Bat)[43]	*Hipposideros ater*	Templeton, 1848	மங்கிய இலை மூக்கு வௌவால்	Maṅkiya Ilai Mūkku Veḷavāl	Both		LC		
52	Fulvus Leaf-nosed Bat (Fulvus Roundleaf Bat)[44]	*Hipposideros fulvus*	Gray, 1838	ஃபுல்வுஸ் இலை மூக்கு வௌவால்	Ḥpulvus Ilai Mūkku Veḷavāl	Both		LC		
53	Pomona Leaf-nosed Bat (Andersen's Leaf-nosed Bat)[45]	*Hipposideros pomona*	K. Andersen, 1918	பொமோனா இலை மூக்கு வௌவால்	Pomōṉā Ilai Mūkku Veḷavāl	Both		LC		
54	Schneider's Leaf-nosed Bat (Schneider's Roundleaf Bat)[46]	*Hipposideros speoris*	(Schneider, 1800)	ஸ்னைடர-ன் இலை மூக்கு வௌவால்	Sṉaiṭara-ṉ Ilai Mūkku Veḷavāl	Both		LC		
	15. Family Megadermatidae (false vampire bats)									
55	Greater False Vampire Bat (Indian False Vampire Bat)[47]	*Megaderma lyra*	É. Geoffroy, 1810	பெரிய காட்டேரி வௌவால்	Periya Kāṭṭēri Veḷavāl	Both		LC		

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56	Lesser False Vampire Bat (Common Asian Ghost Bat)[48]	*Megaderma spasma*	(Linnaeus, 1758)	சிறிய காட்டேரி வெளவால்	Ciṟiya Kāṭṭēri Veḷavāl	WG		LC		
	16. Family Emballonuridae (sac-winged bats)									
57	Long-winged Tomb Bat[49]	*Taphozous longimanus*	Hardwicke, 1825	நீண்ட சிறகு கல்லறை வெளவால்	Nīṇṭa Ciṟaku Kallaṟai Veḷavāl	Both		LC		
58	Black-bearded Tomb Bat[50]	*Taphozous melanopogon*	Temminck, 1841	கருப்பு-தாடி கல்லறை வெளவால்	Karuppu-tāṭi Kallaṟai Veḷavāl	Both		LC		
59	Naked-rumped Tomb Bat[51]	*Taphozous nudiventris*	Cretzschmar, 1830	திறந்த ரம்ப்டு கல்லறை வெளவால்	Iṟanta Rampṭu Kallaṟai Veḷavāl	Plains		LC		
	17. Family Molossidae (free-tailed bats)									
60	Wrinkle-lipped Free-tailed Bat (Wrinkle-lipped Bat)[52]	*Chaerephon plicatus*	(Buchannan, 1800)	மடிப்பு-உதடு வாலற்ற வெளவால்	Maṭippu-utaṭu Vālaṟṟa Veḷavāl	Plains		LC		
61	Egyptian Free-tailed Bat (Egyptian Nyctinome)[53]	*Tadarida aegyptiaca*	(E. Geoffroy, 1818)	எகிப்திய வாலற்ற வெளவால்	Ekiptiya Vālaṟṟa Veḷavāl	Both		LC		
	18. Family Vespertilionidae (evening bats)									
62	Tickell's Bat[54]	*Hesperoptenus tickelli*	(Blyth, 1851)	டிக்கிள்ஸ்-ன் வெளவால்	Ṭikkiḷs-ṉ Veḷavāl	WG		LC		
63	Greater Asiatic Yellow House Bat (Asiatic Greater Yellow House Bat)[55]	*Scotophilus heathii*	(Horsfield, 1831)	ஆசிய பெரிய மஞ்சள் வீட்டு வெளவால்	Āciya Periya Mañcaḷ Vīṭṭu Veḷavāl	Both		LC		
64	Lesser Asiatic Yellow Bat (Lesser Asian House Bat)[55]	*Scotophilus kuhlii*	Leach, 1821	ஆசிய சிறிய மஞ்சள் வீட்டு வெளவால்	Āciya Ciṟiya Mañcaḷ Vīṭṭu Veḷavāl	Both		LC		
65	Kelaart's Pipistrelle[56]	*Pipistrellus ceylonicus*	(Kelaart, 1852)	கீலார்டு-ன் பீபீஸ்டுர்லே வெளவால்	Kīlārṭu-ṉ Pīpīsṭurlē Veḷavāl	Both		LC		
66	Indian Pipistrelle (Little Indian Bat)[57]	*Pipistrellus coromandra*	(Gray, 1838)	இந்திய பீபீஸ்டுர்லே வெளவால்	Intiya Pīpīsṭurlē Veḷavāl	Both		LC		
67	Least Pipistrelle (Indian Pygmy Bat)[38]	*Pipistrellus tenuis*	(Temminck, 1840)	மீச்சிறு பீபீஸ்டுர்லே வெளவால்	Mīcciṟu Pīpīsṭurlē Veḷavāl	Both		LC		
68	Dormer's Pipistrelle (Dormer's Bat)[38]	*Scotozous dormeri*	Dobson, 1875	டோர்மெர்-ன் பீபீஸ்டுர்லே வெளவால்	Ṭōrmer-ṉ Pīpīsṭurlē Veḷavāl	Both		LC		
69	Chocolate Pipistrelle (Grizzled Pipistrelle)[58]	*Falsistrellus affinis*	(Dobson, 1871)	சாக்லேட் பீபீஸ்டுர்லே வெளவால்	Cāklēṭ Pīpīsṭurlē Veḷavāl	WG		LC		
70	Horsfield's Myotis (Lesser Large-tooth Bat)[59]	*Myotis horsfieldii*	(Temminck, 1840)	ஹார்ஸ்ஃபியெல்டு-ன் மீயோடிஸ் வெளவால்	Hārsḥpiyelṭu-ṉ Mīyōṭis Veḷavāl	Both		LC		
71	Burmese Whiskered Myotis (Large Brown Myotis)[60]	*Myotis montivagus*	(Dobson, 1874)	பர்மிஸ் மீசைடைய மீயோடிஸ் வெளவால்	Parmis Mīcaiṭaiya Mīyōṭis Veḷavāl	WG		LC		
72	Small Long-fingered Bat (Nicobar Long-fingered Bat)[61]	*Miniopterus pusillus*	Dobson, 1876	சிறிய நீண்ட விரலுள்ள வெளவால்	Ciṟiya Nīṇṭa Viraluḷḷa Veḷavāl	WG		LC		
73	Schreibers's Long-fingered Bat[62]	*Miniopterus schreibersii*	(Kuhl, 1817)	ஸ்ரைபர்ஸ்-ன் நீண்ட விரலுள்ள வெளவால்	Sraipars-ṉ Nīṇṭa Viraluḷḷa Veḷavāl	Plains		NT		
74	Lesser Hairy-winged Bat (Hairy-winged Bat)[63]	*Harpiocephalus harpia*	(Temminck, 1840)	சிறிய முடியுடைய சிறகு வெளவால்	Ciṟiya Muṭiyuṭaiya Ciṟaku Veḷavāl	WG		LC		
75	Round-eared Tube-nosed Bat[64]	*Murina cyclotis*	Dobson, 1872	வட்ட-காது குழாய் மூக்கு வெளவால்	Vaṭṭa-kātu Kuḻāy Mūkku Veḷavāl	Both		LC		

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76	Lenis Woolly Bat[65]	*Kerivoula lenis*	Thomas, 1916	லெனிஸ் ரோம வெளவால்	Leṉis Rōma Veḷavāl	WG		LC		
77	Painted Woolly Bat (Painted Bat)[66]	*Kerivoula picta*	(Pallas, 1767)	வர்ண ரோம வெளவால்	Varṇa Rōma Veḷavāl	WG		LC		
	VIII. ORDER PHOLIDOTA									
	19. Family Manidae (pangolins)									
78	Indian Pangolin (Scaly Anteater)[67]	*Manis crassicaudata*	E. Geoffroy, 1803	எறும்புண்ணி	Eṟumpuṇṇi	Both		EN	I	I
	IX. ORDER CARNIVORA									
	20. Family Felidae (cats)									
79	Jungle Cat (Swamp Cat)[68]	*Felis chaus*	Schreber, 1777	காட்டு பூனை	Kāṭṭu Pūṉai	Both		LC	II	II
80	Leopard Cat[69]	*Prionailurus bengalensis*	(Kerr, 1792)	சிறுத்தை பூனை	Ciṟuttai Pūṉai	Both		LC	I	I
81	Rusty-spotted Cat[70]	*Prionailurus rubiginosus*	(I. Geoffroy Saint-Hilaire, 1831)	துருஏறிய நிற-புள்ளிகளுடைய பூனை	Turu'ēṟiya Niṟa -puḷḷikaḷuṭaiya Pūṉai	Both		VU	I	I
82	Leopard (Panther)[71]	*Panthera pardus*	(Linnaeus, 1758)	சிறுத்தை	Ciṟuttai	Both		NT	I	I
83	Tiger (Royal Bengal Tiger)[72]	*Panthera tigris*	(Linnaeus, 1758)	புலி	Puli	WG		EN	I	I
	21. Family Viverridae (viverrids)									
84	Asian Palm Civet (Mentawai Palm Civet)[73]	*Paradoxurus hermaphroditus*	(Pallas, 1777)	ஆசிய பாம் புனுகு பூனை	Āciya Pām Puṉuku Pūṉai	Both		LC	II	III
85	Jerdon's Palm Civet (Brown Palm Civet)[74]	*Paradoxurus jerdoni*	Blanford, 1885	ஜெர்ந்தோன்-ன் பாம் புனுகு பூனை	Jerntōṉ-ṉ Pām Puṉuku Pūṉai	WG	WG	LC	II	III
86	Small Indian Civet (Oriental Civet)[75]	*Viverricula indica*	(E. Geoffroy Saint-Hilaire, 1803)	இந்திய சிறிய புனுகு பூனை	Intiya Ciṟiya Puṉuku Pūṉai	Both		LC	II	III
	22. Family Herpestidae (mongooses)									
87	Grey Mongoose (Common Mongoose)[76]	*Herpestes edwardsii*	(É. Geoffroy Saint-Hilaire, 1818)	சாம்பல் நிற கீரிப்பிள்ளை	Cāmpal Niṟa Kīrippiḷḷai	Both		LC	II	III
88	Indian Brown Mongoose (Brown Mongoose)[77]	*Herpestes fuscus*	Waterhouse, 1838	பழுப்பு நிற கீரிப்பிள்ளை	Paḻuppu Niṟa Kīrippiḷḷai	WG		VU	II	III
89	Ruddy Mongoose[78]	*Herpestes smithii*	Gray, 1837	சிவந்த கீரிப்பிள்ளை	Civanta Kīrippiḷḷai	Both		LC	II	III
90	Stripe-necked Mongoose (Striped-necked Mongoose)[77]	*Herpestes vitticollis*	Bennett, 1835	கழுத்து- கோடிட்ட கீரிப்பிள்ளை	Kaḻuttu- Kōṭiṭṭa Kīrippiḷḷai	WG		LC	II	III
	23. Family Hyaenidae (hyaenas)									
91	Striped Hyena (Hyena)[79]	*Hyaena hyaena*	(Linnaeus, 1758)	கழுதைப்புலி	Kaḻutaippuli	Both		NT	III	III
	24. Family Canidae (dogs)									
92	Golden Jackal (Jackal)[80]	*Canis aureus*	Linnaeus, 1758	நரி	Nari	Both		LC	II	III
93	Dhole (Wild Dog)[81]	*Cuon alpinus*	(Pallas, 1811)	செந்நாய்	Cennāy	WG		EN	II	II
94	Bengal Fox (Indian Fox)[82]	*Vulpes bengalensis*	(Shaw, 1800)	குள்ள நரி	Kuḷḷa Nari	Both		LC	II	III
	25. Family Ursidae (bears)									

	English name	Species name	Authority	Tamil name (தமிழ் பெயர்)	Vernacular name	WG / Plains of TN	END	IUCN	IWPA	CITES
95	Sloth Bear (Labiated Bear)[83]	*Melursus ursinus*	(Shaw, 1791)	கரடி	Karaṭi	Both		VU	I	I
	26. Family Mustelidae (badgers, martens, otters)									
96	Oriental Small-clawed Otter (Asian Small-clawed Otter)[84]	*Aonyx cinerea*	(Illiger, 1815)	சிறிய நகங்களுடைய நீர்நாய்	Ciṟiya Nakaṅkaḷuṭaiya Nīrnāy	Both		VU	I	II
97	Smooth-coated Otter (Indian Smooth-coated Otter)[85]	*Lutrogale perspicillata*	(I. Geoffroy Saint-Hilaire, 1826)	மென்மையான- சரும நீர்நாய்	Meṉmaiyāṉa- Caruma Nīrnāy	Both		VU	II	II
98	Nilgiri Marten[86]	*Martes gwatkinsii*	Horsfield, 1851	நீலகிரி கீரி	Nīlakiri Kīri	WG	WG	VU	II	III
99	Honey Badger (Ratel)[87]	*Mellivora capensis*	(Schreber, 1776)	தேன்வளைக்கரடி	Tēṉvaḷaikkaraṭi	Both		LC	I	
	X. ORDER ARTIODACTYLA									
	27. Family Suidae (pigs)									
100	Wild Boar (Wild Pig)[88]	*Sus scrofa*	Linnaeus, 1758	காட்டுப்பன்றி	Kāṭṭuppaṉṟi	Both		LC	III	
	28. Family Tragulidae (mouse deer)									
101	Indian Chevrotain (Mouse Deer)[89]	*Moschiola indica*	Gray, 1852	சருகு மான்	Caruku Māṉ	Both		LC	I	
	29. Family Cervidae (deer)									
102	Chital (Spotted Deer)[90]	*Axis axis*	(Erxleben, 1777)	புள்ளி மான்	Puḷḷi Māṉ	Both		LC	III	
103	Indian Muntjac (Barking Deer)[91]	*Muntiacus muntjak*	(Zimmermann, 1780)	குரைக்கும் மான்	Kuraikkum Māṉ			LC	III	
104	Sambar (Sambar Deer)[92]	*Rusa unicolor*	(Kerr, 1792)	கடா மான்	Kaṭā Māṉ	Both		VU	III	
	30. Family Bovidae (bovids)									
105	Blackbuck (Indian Antelope)[93]	*Antilope cervicapra*	(Linnaeus, 1758)	கலைமான்	Kalaimāṉ	Both		NT	I	
106	Gaur (Indian Bison)[94]	*Bos gaurus*	C.H.Smith, 1827	காட்டு எருமை	Kāṭṭu Erumai	WG		VU	I	I
107	Four-horned Antelope (Chousingha)[95]	*Tetracerus quadricornis*	(de Blainville, 1816)	நான்கு கொம்பு மான்	Nāṉku Kompu Māṉ	Both		VU	I	
108	Nilgiri Tahr (Nilgiri ibex)[96]	*Nilgiritragus hylocrius*	(Ogilby, 1838)	வரையாடு	Varaiyāṭu	WG	WG	EN	I	
MARINE MAMMALS (கடல் பாலூட்டிகள்)										
	XI. ORDER SIRENIA									
	31. Family Dugongidae (Dugongs)									
109	Dugong (Sea Cow)[97]	*Dugong dugon*	(Muller, 1776)	கடல் பசு	Kaṭal Pacu			VU	I	I
	XII. ORDER CETACEA									
	32. Family Delphinidae (marine dolphins)									
110	Long-beaked Common Dolphin[98]	*Delphinus capensis*	Gray, 1828	நீண்ட மூக்கு டால்பின்	Nīṇṭa Mūkku Ṭālpiṉ			DD	II	II
111	Short-finned Pilot Whale[99]	*Globicephala macrorhynchus*	Gray, 1846	குறுகிய துடுப்புடைய பைலட் திமிங்கிலம்	Kuṟukiya Tuṭuppuṭaiya Pailaṭ Timiṅkilam			DD	II	II
112	Risso's Dolphin[100]	*Grampus griseus*	(G Cuvier, 1812)	ரிஸ்ஸோ -ன் டால்பின்	Ris'sō -Ṉ Ṭālpiṉ			LC	II	II

	English name	Species name	Authority	Tamil name (தமிழ் பெயர்)	Vernacular name	WG / Plains of TN	END	IUCN	IWPA	CITES
113	Killer Whale[101]	*Orcinus orca*	(Linnaeus, 1758)	கொலைகார திமிங்கிலம்	Kolaikāra Timiṅkilam			DD	II	II
114	Melon-headed Whale[102]	*Peponocephala electra*	(Gray, 1846)	மெலன் தலை திமிங்கலம்	Melaṉ-Talai Timiṅkalam			LC	II	II
115	False Killer Whale[103]	*Pseudorca crassidens*	(Owen, 1846)	தவறான கொலைகார திமிங்கிலம்	Tavaṟāṉa Kolaikāra Timiṅkilam			DD	II	II
116	Indo-Pacific Hump-back Dolphin[104]	*Sousa chinensis*	(Osbeck, 1765)	இந்தோ-பசிபிக் கூன்முதுகு டால்பின்	Intō-Pacipik Kūṉmutuku Timiṅkalam Ṭālpiṉ			NT	II	I
117	Pantropical Spotted Dolphin[105]	*Stenella attenuata*	(Gray, 1846)	வெப்பமண்டல புள்ளிகளுடைய டால்பின்	Veppamaṇṭala Puḷḷikaḷuṭaiya Ṭālpiṉ			LC	II	II
118	Striped Dolphin[106]	*Stenella coeruleoalba*	(Meyen, 1833)	வரிகளுடைய டால்பின்	Varikaḷuṭaiya Ṭālpiṉ			LC	II	II
119	Spinner Dolphin[107]	*Stenella longirostris*	(Gray, 1828)	ஸ்பின்னர் டால்பின்	Spiṉṉar Ṭālpiṉ			DD	II	II
120	Rough-toothed Dolphin[108]	*Steno bredanensis*	(G. Cuvier in Lesson, 1828)	கரடுமுரடு பற்களுடைய டால்ஃபின்	Karaṭumuraṭu Paṟkaḷuṭaiya Ṭālḥpiṉ			LC	II	II
121	Indo-Pacific Bottlenose Dolphin[109]	*Tursiops aduncus*	(Ehrenberg, 1833)	இந்தோ-பசிபிக் பாட்டில் மூக்குடைய டால்பின்	Intō-Pacipik Pāṭṭil Mūkkuṭaiya Ṭālpiṉ			DD	II	II
	33. Family Phocoenidae (porpoises)									
122	Finless Porpoise[110]	*Neophocaena phocaenoides*	(G Cuvier, 1829)	துடுப்பற்ற கடல் பன்றி	Tuṭuppaṟṟa Kaṭal paṉṟi			VU	I	I
	34. Family Physeteridae (sperm whales)									
123	Sperm Whale[111]	*Physeter macrocephalus*	Linnaeus, 1758	விந்து வடிவான திமிங்கிலம்	Vintu Vaṭivāṉa timiṅkilam			VU	II	I
	35. Family Kogiidae (pygmy and dwarf sperm whales)									
124	Pygmy Sperm Whale[112]	*Kogia breviceps*	(Blainville, 1838)	விந்து வடிவான சிறிய திமிங்கிலம்	Vintu Vaṭivāṉa Ciṟiya timiṅkilam			DD	II	II
125	Dwarf Sperm Whale[113]	*Kogia sima*	(Owen, 1866)	விந்து வடிவான குள்ள திமிங்கிலம்	Vintu Vaṭivāṉa Kuḷḷa timiṅkilam			DD	II	II
	36. Family Ziphiidae (beaked whales)									
126	Cuvier's Beaked Whale[114]	*Ziphius cavirostris*	G. Cuvier, 1823	குவியரி-ன் அலகு திமிங்கிலம்	Kuviyariṉ pīc timiṅkilam			LC	II	II
	37. Family Balaenopteridae (rorquals)									
127	Minke Whale[115]	*Balaenoptera acutorostrata*	Lacépède, 1804	மின்கே திமிங்கிலம்	Miṉkē Timiṅkilam			LC	II	I
128	Sei Whale[116]	*Balaenoptera borealis*	Lesson, 1828	சீய் திமிங்கலம்	Cīy Timiṅkalam			EN	II	I
129	Bryde's Whale[117]	*Balaenoptera edeni*	Anderson, 1879	பிரைட்-ன் திமிங்கிலம்	Piraiṭ-Ṉ Timiṅkilam			DD	II	I
130	Blue Whale[118]	*Balaenoptera musculus*	(Linnaeus, 1758)	நீல திமிங்கிலம்	Nīla Timiṅkilam			EN	II	I
131	Fin Whale[119]	*Balaenoptera physalus*	(Linnaeus, 1758)	துடுப்பு திமிங்கலம்	Tuṭuppu Timiṅkalam			EN	II	I
132	Humpback Whale[120]	*Megaptera novaeangliae*	(Borowski, 1781)	கூன்முதுகு திமிங்கலம்	Kūṉmutuku			LC	II	I

[1] North-eastern and southern India, Bihar, Jharkhand, Odisha, Uttarakhand, Uttar Pradesh and West Bengal (Oliver 1978)
[2] South of Ganges river, eastern, central, south-western and southern parts of peninsular India (Chakraborty 2005)
[3] Eastern Ghats to Mangalore, Karnataka and Malabar Coast from Goa to Trivandrum, Kerala (Roonwal & Mohnot 1977)
[4] Southern India, Goa, Gujarat and Maharashtra (Roonwal & Mohnot 1977)
[5] Karnataka, Kerala and Tamil Nadu (Roonwal & Mohnot 1977)
[6] Southern India and Maharashtra (Roonwal & Mohnot 1977; Karanth et al. 2008; Nag et al. 2011)
[7] Southern India (Roonwal & Mohnot 1977; Karanth et al. 2008; Nag et al. 2011)
[8] Karnataka, Kerala and Tamil Nadu (restricted to Western Ghats) (Roonwal & Mohnot 1977; Karanth et al. 2008; Nag et al. 2011)
[9] Southern, eastern and central India and Gujarat and Maharashtra (Ellerman 1961; Shanker & Sukumar 1998; Molur et al. 2005)
[10] Kerala and Tamil Nadu (Ellerman 1961; Molur et al. 2005)
[11] Southern India, Assam, Bihar, Chhattisgarh, Gujarat, Goa, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and West Bengal (Ellerman 1961; Molur et al. 2005; Sridhar et al. 2008)
[12] Karnataka, Kerala and Tamil Nadu (Ashraf et al. 1993; Molur et al. 2005; Sridhar et al. 2008)
[13] Southern India, Bihar, Chhattisgarh, Gujarat, Jharkhand, Maharashtra, Madhya Pradesh, Odisha and Rajasthan (Ellerman 1961; Molur et al. 2005)
[14] Western Ghats (south of Kodagu) in Karnataka, Kerala and Tamil Nadu (Ellerman 1961; Molur et al. 2005; Sridhar et al. 2008)
[15] Western Ghats in Karnataka, Kerala, Goa, Maharashtra and Tamil Nadu (Molur et al. 2005; Sridhar et al. 2008)
[16] Karnataka, Kerala and Tamil Nadu (Prabhakar 1997; Shanker & Sukumar 1998; Molur et al. 2005)
[17] Throughout India except North-eastern India, high altitudes of Himalaya and Sikkim (Agarwal 2000; Molur et al. 2005)
[18] Almost throughout the country (Agarwal 2000; Molur et al. 2005)
[19] Andhra Pradesh, Bihar, Gujarat, Jharkhand, Karnataka, Rajasthan and Tamil Nadu (Molur et al. 2005; Molur & Nameer 2016)
[20] Tamil Nadu (Agarwal 2000; Molur et al. 2005)
[21] Southern India, Bihar, Chhattisgarh, Goa, Jharkhand, Madhya Pradesh, Maharashtra, Odisha and West Bengal (Shanker & Sukumar 1998; Molur et al. 2005)
[22] Throughout the country except North-eastern India (Shanker & Sukumar 1998; Agarwal 2000; Molur et al. 2005)
[23] Arunachal Pradesh, Assam, Karnataka, Maharashtra, Manipur, Meghalaya, Nagaland, Tamil Nadu and West Bengal (Agarwal 2000; Molur et al. 2005)
[24] Kerala and Tamil Nadu (fragmented locations of Western Ghats) (Shanker & Sukumar 1998; Agarwal 2000; Molur et al. 2005)
[25] Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan and Tamil Nadu (Agarwal 2000; Molur et al. 2005)
[26] Southern India, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal (Shanker & Sukumar 1998; Agarwal 2000; Molur et al. 2005)
[27] Andhra Pradesh, Gujarat, Himachal Pradesh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Punjab, Uttarakhand and West Bengal (Agarwal 2000; Molur et al. 2005)
[28] Almost throughout the country (Shanker & Sukumar 1998; Agarwal 2000; Molur et al. 2005)
[29] Western Ghats in Karnataka, Maharashtra and Tamil Nadu (Musser & Carleton 2005; Molur et al. 2005)
[30] Western Ghats in Kerala and Tamil Nadu (Shanker & Sukumar 1998; Agarwal 2000; Molur et al. 2005)
[31] Almost throughout the country (Ellerman 1961)
[32] Andhra Pradesh, Kerala and Tamil Nadu (Johnsingh 2001; Molur et al. 2005)
[33] Kerala and Tamil Nadu (Pradhan et al. 1997; Molur et al. 2005)
[34] Kerala and Tamil Nadu (Shanker & Sukumar 1998; Pradhan & Kurup 2001; Molur et al. 2005)
[35] Karnataka, Kerala and Tamil Nadu (Shanker & Sukumar 1998; Molur et al. 2005; Molur & Singh 2009)

[36] Almost throughout the country (Molur et al. 2005)
[37] Southern India, Andaman & Nicobar Is., Bihar, Goa, Gujarat, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Uttar Pradesh and West Bengal (Bates & Harrison 1997)
[38] Almost throughout the country (Bates & Harrison 1997)
[39] North-eastern India, Andaman & Nicobar Is., Andhra Pradesh, Karnataka, Sikkim, Tamil Nadu and Uttarakhand (Vanitharani et al. 2005)
[40] Tamil Nadu (Vanitharani et al. 2005)
[41] Throughout the country except Gujarat, Jammu & Kashmir and Himachal Pradesh (Das 1986)
[42] Southern and North-eastern India, Chhattisgarh, Goa, Himachal Pradesh, Maharashtra, Odisha, Sikkim, Uttarakhand and West Bengal (Bates & Harrison 1997)
[43] Southern India, Andaman & Nicobar Is., Madhya Pradesh, Maharashtra, Meghalaya and Odisha (Bates & Harrison 1997)
[44] Throughout country except high Himalaya and North-eastern India (Bates & Harrison 1997)
[45] Southern India, Andaman & Nicobar Is., Assam, Arunachal Pradesh, Meghalaya, Nagaland, Sikkim and West Bengal (Bates & Harrison 1997)
[46] Southern India, Gujarat, Maharashtra, Odisha and Uttar Pradesh (Bates & Harrison 1997)
[47] Throughout country except high Himalaya and deserts (Bates & Harrison 1997)
[48] Southern India, Andaman & Nicobar Is., Assam, Goa, Maharashtra, Meghalaya Mizoram and West Bengal (Bates & Harrison 1997)
[49] Southern India, Assam, Bihar, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Nagaland, Odisha, Rajasthan, Tripura, Uttar Pradesh and West Bengal (Bates & Harrison 1997)
[50] Southern India, Andaman & Nicobar Is., Bihar, Chhattisgarh, Goa, Gujarat, Madhya Pradesh, Maharashtra, Odisha and Rajasthan (Bates & Harrison 1997)
[51] Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh and West Bengal (Bates & Harrison 1997)
[52] Andhra Pradesh, Goa, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal (Bates & Harrison 1997)
[53] Southern India, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal (Bates & Harrison 1997)
[54] Southern India, Andaman & Nicobar Is., Assam, Goa, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and West Bengal (Bates & Harrison 1997)
[55] Throughout country except high Himalaya and Jammu & Kashmir (Bates & Harrison 1997)
[56] Southern India, Bihar, Goa, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal (Bates & Harrison 1997)
[57] Throughout country except Rajasthan (Bates & Harrison 1997)
[58] Almost throughout the country (scattered population) (Bates & Harrison 1997)
[59] Andaman & Nicobar Is., Goa, Karnataka, Kerala, Madhya Pradesh, Maharashtra and Tamil Nadu (Bates & Harrison 1997)
[60] Southern India and Maharashtra (Vanitharani 2006)
[61] Andaman & Nicobar Is., Karnataka and Tamil Nadu (Bates & Harrison 1997)
[62] Arunachal Pradesh, Maharashtra, Meghalaya, Sikkim, Uttar Pradesh, West Bengal and Tamil Nadu (Bates & Harrison 1997)
[63] Assam, Kerala, Meghalaya, Mizoram, Sikkim, Tamil Nadu and West Bengal (Bates & Harrison 1997)
[64] Andhra Pradesh, Meghalaya, Mizoram, Andaman & Nicobar Is., Sikkim, Tamil Nadu and West Bengal (Vanitharani et al. 2005)
[65] Known from Tamil Nadu and West Bengal (Vanitharani et al. 2003)
[66] Southern India, Assam, Goa, Maharashtra, Odisha, Rajasthan, Sikkim and West Bengal (Bates & Harrison 1997)
[67] Widely distributed from the plains and lower hills south of the Himalayas to Southern India (Ellerman & Morrison-Scott 1951)
[68] Throughout the country except the high Himalayas (Mudappa 1998)
[69] Throughout the country except desert parts of Gujarat and Rajasthan, and parts of Deccan Plateau (Mudappa 1998)
[70] Scattered pockets in the peninsular India upto Rajasthan, and also recorded from Uttar Pradesh and Jammu & Kashmir (Mudappa 1998; Johnsingh 2001)

[71] Throughout country except extreme high altitudes, hot and cold deserts (Pocock 1939, 1941)
[72] Throughout country in the suitable isolated pockets except Jammu & Kashmir and North-western India (Pocock 1939, 1941)
[73] Throughout the country except arid parts of Rajasthan and Gujarat and Jammu & Kashmir and high Himalayas (Mudappa 1998)
[74] Goa, Karnataka, Kerala and Tamil Nadu (Mudappa 1998)
[75] Throughout the country in suitable habitats except high Himalayas in Jammu & Kashmir (Mudappa 1998)
[76] Throughout the country in suitable habitats (Mudappa 1998)
[77] Karnataka, Kerala and Tamil Nadu (Mudappa 1998; Sridhar et al. 2008)
[78] Southern and central India, Bihar, Chhattisgarh, Gujarat, Jharkhand, Maharashtra, Odisha, Rajasthan, Uttar Pradesh and West Bengal (Mudappa 1998)
[79] South to the Nilgiri hills, west to Gujarat, north to lowland of Jammu & Kashmir and Kumaon, east to West Bengal (Johnsingh 2001)
[80] Throughout the country (Pocock 1939, 1941)
[81] South of river Ganges peninsula from Coorg and Nilgiri hills, and from northwards Jammu & Kashmir to North-eastern India (Pocock 1939, 1941)
[82] Throughout the country except high Himalayas and North-eastern India (Pocock 1939, 1941)
[83] Throughout country in suitable habitats except Jammu & Kashmir, high Himalayas and arid parts of Gujarat and Rajasthan (Pocock 1939, 1941)
[84] Southern India, Himalayan terai to north-eastern states and Sundarbans in West Bengal (Mudappa 1998)
[85] Throughout the country except high regions of Himalayas, and arid regions of Gujarat and Rajasthan (Mudappa 1998)
[86] Karnataka, Kerala and Tamil Nadu (Mudappa 1998)
[87] Throughout the country except high Himalayas and North-eastern India (Mudappa 1998)
[88] Throughout the country except the high Himalayas and desert areas of Gujarat and Rajasthan (Ellerman & Morrison-Scott 1951)
[89] From Tamil Nadu to Madhya Pradesh (Groves & Meijaard 2005)
[90] Peninsular India, northwards Kumaon and Sikkim including Andaman & Nicobar Is. and West Bengal (Ellerman & Morrison-Scott 1951)
[91] Throughout the country except high Himalayas of Jammu & Kashmir and desert region of Gujarat and Rajasthan (Ellerman & Morrison-Scott 1951)
[92] Throughout the country except high Himalayas of Jammu & Kashmir and arid regions of Gujarat and Rajasthan (Ellerman & Morrison-Scott 1951)
[93] Punjab south to Tamil Nadu and east to Bihar, and Gujarat and Rajasthan (Ellerman & Morrison-Scott 1951)
[94] Southern and North-eastern India, Bihar, Chhattisgarh, Goa, Madhya Pradesh, Maharashtra, Odisha, Uttar Pradesh and West Bengal (Ellerman & Morrison-Scott 1951)
[95] From the sub-Himalayan foothills to peninsular India, Gujarat, Maharashtra and North and western parts of Tamil Nadu (Ellerman & Morrison-Scott 1951)
[96] Kerala and Tamil Nadu (Ropique & Hassanin 2005)
[97] Reported from Andaman & Nicobar Is., Gulf of Mannar, Palk Bay and Gulf of Kachchh (Silas & Fernando 1985; Sathasivam 2000)
[98] Reported from east and west coasts of India in Goa, Karnataka, Kerala, Tamil Nadu and Odisha (Pillai & Kasinathan 1988; Sathasivam 2000)
[99] Reported from Bay of Bengal and Hooghly River mouth, Serampur, West Bengal also from Gulf of Mannar and off Maharashtra in the west coast (Alagarswami et al. 1973)
[100] Reported from Kerala, Tamil Nadu and around Andaman & Nicobar Is. and Lakshadweep Is. (Rajagopalan et al. 1984)
[101] Reported from east coast (off Tamil Nadu), west coast (off Gujarat) and around Andaman & Nicobar Is. and Lakshadweep Is. (Sathasivam 2004)
[102] Reported from Bay of Bengal in Andhra Pradesh, Andaman & Nicobar Is. and Tamil Nadu (Leatherwood et al. 1991; Sathasivam 2000)
[103] Reported from east and west coasts and Andaman & Nicobar Is., Andhra Pradesh, Lakshadweep Is. and Tamil Nadu (Thiagarajan et al. 1984)
[104] Reported from east and west coasts of Andaman & Nicobar Is., mouth of Ganges, Bay of Bengal, Arabian Sea and Indian Ocean (Arumugam et al. 1992; Muralidharan 2013)
[105] Reported from Bay of Bengal off West Bengal (Sundarbans) and Tamil Nadu (Sathasivam 2000)

[106] Reported from east coast of Southern India (Alling 1986; Kumaran 2003)

[107] Reported from east and west coasts of India in Andhra Pradesh, Tamil Nadu, Lakshadweep Is., Kerala, Maharashtra and Karnataka (Pillai et al. 1989; Sathasivam 2004)

[108] Reported from Bay of Bengal in Andaman & Nicobar Is. and Tamil Nadu (Sathasivam 2004)

[109] Reported from east and west coasts of India in Maharashtra to Kerala and Tamil Nadu (Afsal et al. 2008)

[110] Reported from east and west coasts of India, Andaman & Nicobar Is., Lakshadweep Is., Tamil Nadu and Hooghli estuary in West Bengal (Ganapathy 1992; Kumaran & Subramanian 1993)

[111] Reported from Arabian Sea and Bay of Bengal in Andaman & Nicobar Is., Lakshadweep Is., Gujarat, Kerala, Maharashtra and Tamil Nadu (Moses 1947; James & Soundararajan 1979)

[112] Reported from east coast and west coasts of India in Tamil Nadu, Andhra Pradesh, Andaman & Nicobar Is. and Kerala (Sathasivam 2004; Velayutham et al. 2010)

[113] Reported from east and west coasts of India in Tamil Nadu, Andhra Pradesh and Kerala (De Silva 1987; Sathasivam 2000)

[114] Reported from coast of Tamil Nadu and Lakshadweep Is. (Sathasivam 2000)

[115] Reported from east and west coasts of India in Gujarat, Odisha and Tamil Nadu (Kasinathan 2002; Sathasivam 2004)

[116] Reported from east and west coasts of India in Gujarat, Kerala and Tamil Nadu (Pillai et al. 1995; Balasubramanian 2000)

[117] Reported from east and west coasts of India in Karnataka, Kerala and Tamil Nadu (Leatherwood 1984; Sathasivam 2002)

[118] Reported from east and west coasts and washed ashore in Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu (Moses 1947; Marichamy et al. 1984)

[119] Reported from east and west coasts of India and washed ashore in Southern India, Gujarat, Goa, Maharashtra and Odisha (Nammalwar et al. 1983; Sathasivam 2000)

[120] Reported from Gulf of Mannar and off west coast of India (Sathasivam 2002)

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COMMUNICATION

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A comparative study on dragonfly diversity on a plateau and an agro-ecosystem in Goa, India

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Abstract: The present study was carried out to fill the lacuna in the understanding of the diversity of odonates of Goa in general and dragonflies in particular on plateau and paddy fields in coastal villages—agricultural area at Velsao and Taleigao Plateau. Diversity in plateau ecosystem was higher possibly due to a greater plant and insect diversity on the plateau, in comparison with the monoculture paddy agro-ecosystem. Highest number of species recorded belonged to the family Libellulidae. Monthly diversity showed correlation with monthly average rainfall and humidity.

Keywords: Odonates, Taleigao Plateau, Velsao.

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Author contribution: ARMD was involved in field work, sample collection, data analysis, and manuscript preparation. IKP was responsible for designing the study, analyzing the data, directing and supervising and preparation of the manuscript.

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INTRODUCTION

Initial work on odonates in the state of Goa was carried out by Prasad (1995), followed by Rangnekar et al. (2010, 2014), and Subramanian et al. (2013), indicating the diversity to be 87 species. Considerable amount of research has been carried out in the Western Ghats and the neighboring state of Maharashtra (Subramanian et al. 2011; Kulkarni & Subramanian 2013; Muthukumaravel et al. 2015; Tiple & Koparde 2015). Despite this, there are several lacunae in understanding the diversity of odonates in general and dragonflies in particular. Hence, this attempt is to study diversity, distribution patterns, specific species abundance and status of dragonflies in plateau and paddy field areas at Taleigao Plateau and paddy fields in a coastal village of Goa, in Velsao. In the present work we have analyzed the odonates from Goa in general and plateau and agro-ecosystem in particular, which has not been attempted previously.

MATERIALS AND METHODS

Study sites

The areas chosen for the study include Velsao (15.354^{0}N & 73.891^{0}E, 11m) (Image 1), which is a coastal village and the Taleigao Plateau (15.457^{0}N & 73.834^{0}E, 50m) (Image 2) which is a lateritic region.

Velsao comprises of several paddy field ponds and streams; four sites were chosen (Image 3a–d) in the village. On the other hand, Taleigao Plateau is a lateritic region comprising several temporary monsoon water pools. Four sites (Image 4a–d) were chosen on Taleigao Plateau, representing the lateritic water pools.

At the plateau study site, the soil is mostly lateritic with vegetation belonging to Asclepiadaceae, Acanthaceae, Leguminosae Mimosaceae, Rubiaceae, Rutaceae families. Paddy fields are composed of loamy-clay mostly with water logging with vegetation comprising of *Tridax* sp., *Gliricidia* spp., *Justicia* spp., and *Centella* spp. seen around the paddy field bunds.

Weather parameters

Table 1 provides meteorological data of the sites under study. The monthly average temperature ranged between 26.86°C to 27.64°C; wind speed from 2.13–6.84 km/h; sunshine was between 97.3–290.1 hr/ month; relative humidity was between 78.2–93.7 % and rainfall was from 1–449.5 mm/ month (Fig. 1).

METHODS

The study was conducted from August 2016 to February 2017. The sampling is done by monthly direct counts, by following all out opportunistic surveys, at the selected sites from 08.30 to 12.00 hr, which coincides

Image 1. Study sites at Velsao. (Courtesy: Google Maps)

Image 2. Study sites at Taleigao Plateau. (Courtesy: Google Maps)




Image 3. Study sites at Velsao (Agro-ecosystem). © Authors.

Image 4. Study sites at Taleigao plateau (plateau ecosystem). © Authors.

Table 1. Weather profile of Goa during the study period (August 2016 to February 2017).

Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C°)	27.64	27.3	27.21	27.4	27.11	26.86	27.6
Wind speed (km/hr)	6.84	4.4	3.29	3.2	3.13	3.35	3.96
Sunshine hours	97.3	136	204.2	268.9	273.4	290.1	271.7
Relative humidity	91.5	93.7	92.52	78.2	78.48	79.74	86.14
Rainfall (mm)	449.5	242.9	157.3	1	-	-	-

(Source: Anonymous, Goa Meteorological Department, Panaji, Goa)

with the insect's active period. Species observed were recorded and photographed, using Nikon Coolpix L840 and Nikon Coolpix S6300 cameras. A monthly record of species at the sites was maintained. Species which could not be identified in the field were collected using insect collecting net and maintained by dry preservation (Kapoor 2008) and identified using standard literature such as Fraser (1939), Subramanian (2009) and Nair (2011).

Statistical analysis

From the data obtained of dragonflies species at the sites diversity indices such as shannon diversity index, evenness index, species richness index and species abundance, were calculated using PAST software and MS-Excel. Correlation between the diversity indices and weather parameters was calculated using correlation coefficient (Fig. 2).

RESULTS

The list of dragonflies encountered at the study sites is given in Table 2. During the study period, a combined total of 28 species of dragonflies belonging to 18 genera and three families were encountered.

Table 2. Dragonfly species observed at the study sites.

Family	Genera	Common name	Scientific name	Plateau	Paddy field
Gomphidae	*Ictinogomphus*	Common Clubtail	*Ictinogomphus rapax* Rambur, 1842	+	+
Aeshnidae	*Anax*	Blue-tailed Green Darter	*Anax guttatus* Burmeister, 1839	+	-
	Gynacantha	Parakeet Darter	*Gynacantha bayadera* Selys, 1854	-	+
	Gynacantha	Brown Darter	*Gynacantha dravida* Lieftinck, 1960	+	-
Libellulidae	*Acisoma*	Trumpet Tail	*Acisoma panorpoides* Rambur, 1842	-	+
	Brachythemis	Ditch Jewel	*Brachythemis contaminata* Fabricius, 1793	+	-
	Bradinopyga	Granite Ghost	*Bradinopyga geminata* Rambur, 1842	+	+
	Cratilla	Emerald Banded Skimmer	*Cratilla lineata* Foerster,1903	+	-
	Crocothemis	Ruddy Marsh Skimmer	*Crocothemis servilia* Drury, 1770	+	+
	Diplacodes	Ground Skimmer	*Diplacodes trivialis* Rambur,1842	+	+
	Indothemis	Blue Ground Skimmer	*Indothemis carnatica* Fabricius, 1798	+	-
	Lathrecista	Asiatic Blood Tail	*Lathrecista asiatica* Fabricius, 1798	+	+
	Neurothemis	Fulvous Forest Skimmer	*Neurothemis fulvia* Drury, 1773	-	+
	Neurothemis	Pied Paddy skimmer	*Neurothemis tullia* Drury, 1773	+	+
	Orthetrum	Brown-backed Red Marsh Hawk	*Orthetrum chrysis* Selys, 1891	+	+
	Orthetrum	Tricoloured Marsh Hawk	*Orthetrum luzonicum* Brauer, 1868	+	-
	Orthetrum	Crimson-tailed Marsh Hawk	*Orthetrum pruinosum* Rambur, 1842	+	+
	Orthetrum	Green Marsh Hawk	*Orthetrum sabina* Drury, 1770	+	+
	Orthetrum	Small Skimmer	*Orthetrum taeniolatum* Schneider, 1845	+	-
	Pantala	Wandering glider	*Pantala flavescens* Fabricius, 1798	+	+
	Rhodothemis	Rufous Marsh Glider	*Rhodothemis rufa* Rambur, 1842	+	+
	Rhodothemis	Common Picturewing	*Rhyothemis variegate* Linnaeus, 1763	+	+
	Tholymis	Coral-tailed Cloud Wing	*Tholymis tillarga* Fabricius, 1798	-	+
	Tramea	Red Marsh Trotter	*Tramea basilaris* Kirby, 1889	+	-
	Tramea	Black Marsh Trotter	*Tramea limbate* Rambur, 1842	+	-
	Trithemis	Crimson Marsh Glider	*Trithemis aurora* Burmeister, 1839	+	-
	Trithemis	Black Stream Glider	*Trithemis festiva* Rambur, 1842	+	-
	Trithemis	Long-legged Marsh Glider	*Trithemis pallidinervis* Kirby, 1889	+	-

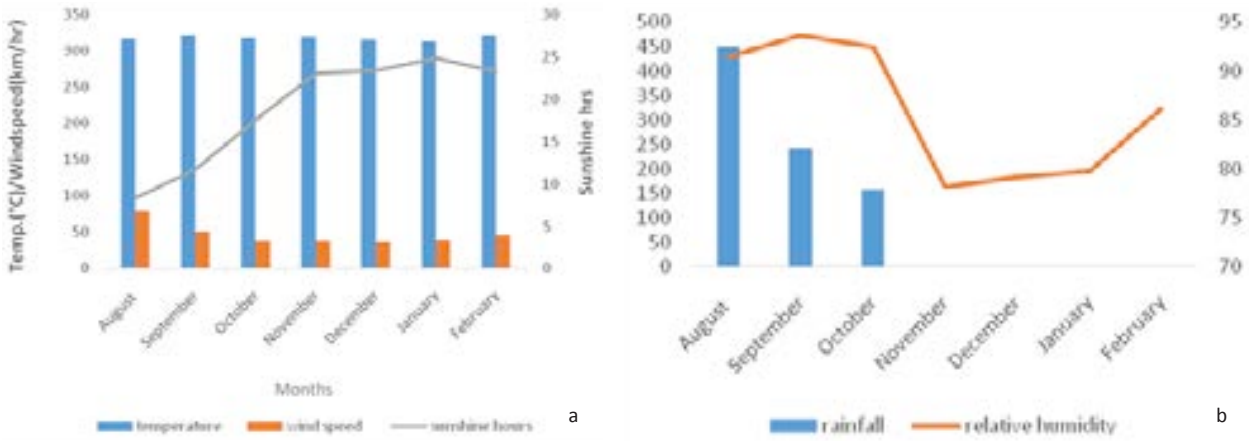

Figure 1. Monthly profile of weather conditions prevalent in Goa during the study period. a - Temperature, wind speed and sunshine hours | b - Rainfall and humidity.

Table 3. Family-wise percentage composition of dragonflies in ecosystems under study.

	Families	Number of species	
		Agro-ecosystem	Plateau ecosystem
1	Gomphidae	1	1
2	Aeshnidae	1	2
3	Libellulidae	14	21

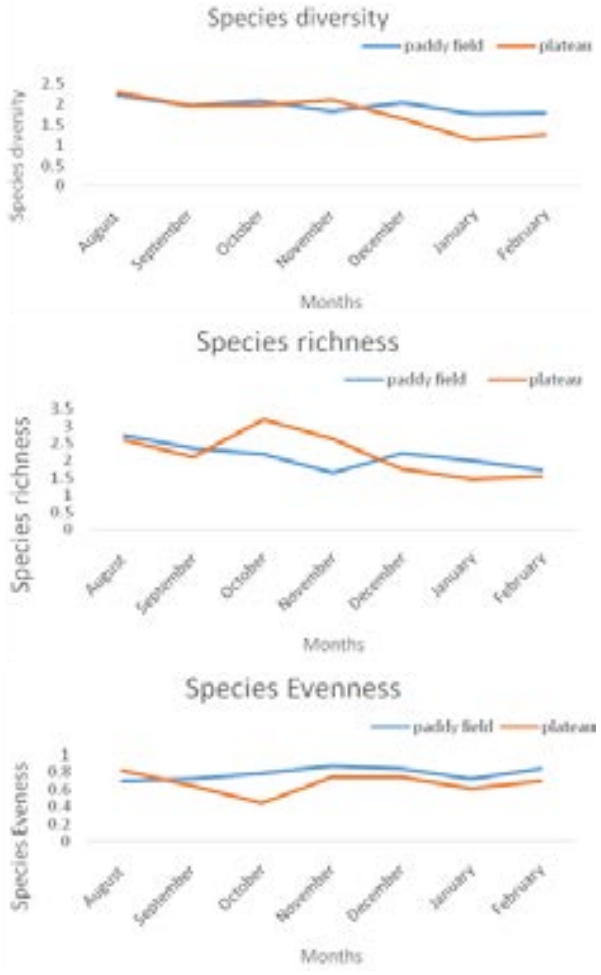

Figure 2. Monthly variation in the population indices such as diversity, evenness and richness.

Of the above, 24 species belonging to 16 genera and three families were sighted in the plateau ecosystem; while 16 species belonging to 12 genera and three families were sighted in the agro-ecosystem. There were 12 species of dragonflies belonging to 12 genera that were common to both the ecosystems (Fig. 3).

a. Agro-ecosystem

A total of 16 species belonging to 12 genera and three families were sighted in the agro-ecosystem. Most number of species noted during post monsoon (October–December) were 13, monsoon (August, September) were 12, and winter (January and February) were nine. Species diversity (H') was found to be 1.944 ± 0.158, species evenness (J') was 0.782 ± 0.066, and species richness (SR) recorded was 2.11 ± 0.347 (Table 3).

Table 4. General composition of dragonfly community and species indices in paddy field and plateau ecosystem.

	Agro-ecosystem	Plateau ecosystem
Affiliations		
Total no. of individuals recorded	308	402
Total no. of species	16	24
Total no. of genera	12	16
Total no. of families	3	3
Species indices		
Species diversity (H')	1.944 ± 0.158	1.762 ± 0.405
Species evenness (J')	0.782 ± 0.066	0.674 ± 0.111
Species richness (SR)	2.113 ± 0.347	2.172 ± 0.603

b. Plateau ecosystem

A total of 24 species belonging to 16 genera and three families were sighted in the plateau ecosystem. Most species were noted in post monsoon (17), followed by monsoon (14) and winter (7).

Species diversity (H') was 1.762 ± 0.405, species evenness (J') 0.674 ± 0.111, and species richness (SR) 2.172 ± 0.603 (Table 3).

Weather parameters vs. dragonflies

The monthly diversity of dragonfly species recorded was correlated with the different weather parameters like monthly average rainfall, relative humidity, wind speed, sunshine hours and temperature (Table 1). Monthly diversity of dragonflies showed a significant positive correlation with the monthly average rainfall in the agro-ecosystem (cr cf = 0.765, $p < 0.05$) and relative humidity in both the ecosystems (agro-ecosystem- cr cf = 0.759, $p < 0.05$ and plateau ecosystem- cr cf = 0.796, $p < 0.05$) and a low correlation with temperature and wind speed. Further, it was also found to be strongly negatively correlated with the monthly sunshine hours (agro-ecosystem- cr cf = -0.758, $p < 0.05$ and plateau ecosystem- cr cf = -0.731, $p = 0.06$).

Table 5. Seasonal variations in species indices of dragonflies in (a) agro-ecosystem and (b) plateau.

a) Agro-ecosystem

Species indices	Monsoon	Post-monsoon	Winter
Species diversity (H')	2.145	2.138	1.801
Species evenness (J')	0.711	0.652	0.673
Species richness (SR)	2.373	2.435	1.903

(a1) Abundance and species richness at the agro-ecosystem

Family	Common name	Scientific name	Monsoon	Post-monsoon	Winter
Gomphidae	Common Clubtail	*Ictinogomphus rapax* Rambur, 1842	4	1	1
Aeshnidae	Blue-tailed Green Darter	*Anax guttatus* Burmeister, 1839	-	-	-
	Parakeet Darter	*Gynacantha bayadera* Selys, 1854	-	-	-
	Brown Darter	*Gynacantha dravida* Lieftinck,1960	-	1	-
Libellulidae	Trumpet Tail	*Acisoma panorpoides* Rambur, 1842	4	7	-
	Ditch Jewel	*Brachythemis contaminata* Fabricius, 1793	-	-	-
	Granite Ghost	*Bradinopyga geminata* Rambur, 1842	2	4	-
	Emerald Banded Skimmer	*Cratilla lineata* Foerster,1903	-	-	-
	Ruddy Marsh Skimmer	*Crocothemis servilia* Drury, 1770	-	-	-
	Ground Skimmer	*Diplacodes trivialis* Rambur,1842	11	27	17
	Blue Ground Skimmer	*Indothemis carnatica* Fabricius, 1798	-	-	-
	Asiatic Blood Tail	*Lathrecista asiatica* Fabricius, 1798	1	1	1
	Fulvous Forest Skimmer	*Neurothemis fulvia* Drury, 1773	-	-	1
	Pied Paddy Skimmer	*Neurothemis tullia* Drury, 1773	30	28	20
	Brown-backed Red Marsh Hawk	*Orthetrum chrysis* Selys, 1891	-	4	-
	Blue Marsh Hawk	*Orthetrum glaucum* Brauer, 1865	-	-	-
	Tricoloured Marsh Hawk	*Orthetrum luzonicum* Brauer, 1868	-	-	-
	Crimson-tailed Marsh Hawk	*Orthetrum pruinosum* Rambur, 1842	5	9	4
	Green Marsh Hawk	*Orthetrum sabina* Drury, 1770	9	17	6
	Small Skimmer	*Orthetrum taeniolatum* Schneider, 1845	-	-	-
	Wandering Glider	*Pantala flavescens* Fabricius, 1798	11	22	10
	Rufous Marsh Glider	*Rhodothemis rufa* Rambur, 1842	14	15	7
	Common Picturewing	*Rhyothemis variegata* Linnaeus, 1763	2	2	-
	Coral-tailed Cloud Wing	*Tholymis tillarga* Fabricius, 1798	10	-	-
	Red Marsh Trotter	*Tramea basilaris* Kirby,1889	-	-	-
	Black Marsh Trotter	*Tramea limbata* Rambur,1842	-	-	-
	Black Stream Glider	*Trithemis festiva* Rambur, 1842	-	-	-
	Long-legged Marsh Glider	*Trithemis pallidinervis* Kirby, 1889	-	-	-

Table continued on next page

(b) Plateau ecosystem

Species indices	Monsoon	Post-monsoon	Winter
Species diversity (H')	2.203	2.077	1.289
Species evenness (J')	0.646	0.469	0.578
Species richness (SR)	2.49	3.056	1.764

(b1) Abundance and species richness at the Plateau ecosystem

Family	Common name	Scientific name	Monsoon	Post-monsoon	Winter
Gomphidae	Common Clubtail	*Ictinogomphus rapax* Rambur, 1842	-	3	-
Aeshnidae	Blue-tailed Green Darter	*Anax guttatus* Burmeister, 1839	-	1	-
	Parakeet Darter	*Gynacantha bayadera* Selys,1854	-	-	-
	Brown Darter	*Gynacantha dravida* Lieftinck,1960	-	-	-
Libellulidae	Trumpet Tail	*Acisoma panorpoides* Rambur, 1842	-	-	-
	Ditch Jewel	*Brachythemis contaminata* Fabricius, 1793	-	1	-
	Granite Ghost	*Bradinopyga geminata* Rambur, 1842	9	10	3
	Emerald Banded Skimmer	*Cratilla lineata* Foerster, 1903	-	-	1
	Ruddy Marsh Skimmer	*Crocothemis servilia* Drury, 1770	10	6	1
	Ground Skimmer	*Diplacodes trivialis* Rambur, 1842	19	39	18
	Blue Ground Skimmer	*Indothemis carnatica* Fabricius, 1798	17	10	-
	Asiatic Blood Tail	*Lathrecista asiatica* Fabricius, 1798	-	1	-
	Fulvous Forest Skimmer	*Neurothemis fulvia* Drury, 1773	-	-	-
	Pied Paddy skimmer	*Neurothemis tullia* Drury, 1773	3	1	-
	Brown-backed Red Marsh Hawk	*Orthetrum chrysis* Selys, 1891	-	-	-
	Blue Marsh Hawk	*Orthetrum glaucum* Brauer, 1865	-	1	-
	Tricoloured Marsh Hawk	*Orthetrum luzonicum* Brauer, 1868	-	-	-
	Crimson-tailed Marsh Hawk	*Orthetrum pruinosum* Rambur, 1842	2	-	-
	Green Marsh Hawk	*Orthetrum sabina* Drury, 1770	18	17	
	Small Skimmer	*Orthetrum taeniolatum* Schneider, 1845			1
	Wandering Glider	*Pantala flavescens* Fabricius, 1798	59	67	5
	Rufous Marsh Glider	*Rhodothemis rufa* Rambur, 1842	3	6	
	Common Picturewing	*Rhyothemis variegata* Linnaeus, 1763	14	2	1
	Coral-tailed Cloud Wing	*Tholymis tillarga* Fabricius, 1798	-	-	-
	Red Marsh Trotter	*Tramea basilaris* Kirby, 1889	7	4	-
	Black Marsh Trotter	*Tramea limbata* Rambur, 1842	18	12	-
	Black Stream Glider	*Trithemis festiva* Rambur, 1842	5	7	-
	Long-legged Marsh Glider	*Trithemis pallidinervis* Kirby, 1889	1	-	-

DISCUSSION

A combined total of 28 species of dragonflies recorded at both sites makes about 59.5% of the total dragonflies recorded in the state so far (Rangnekar 2014).

The highest diversity recorded belonged to family Libellulidae (23) followed by Aeshnidae (3) (in plateau ecosystem) and Gomphidae (1). All over the world, species belonging to family Libellulidae dominate unshaded habitats with stagnant water, include species with great migratory ability and distributions covering more than one continent including isolated islands (Kalkman et al 2008).

Diversity in plateau ecosystem was more with 24 species while paddy field ecosystem displayed 16 species. This could possibly be due to a greater plant and insect diversity on the plateau, as opposed to the

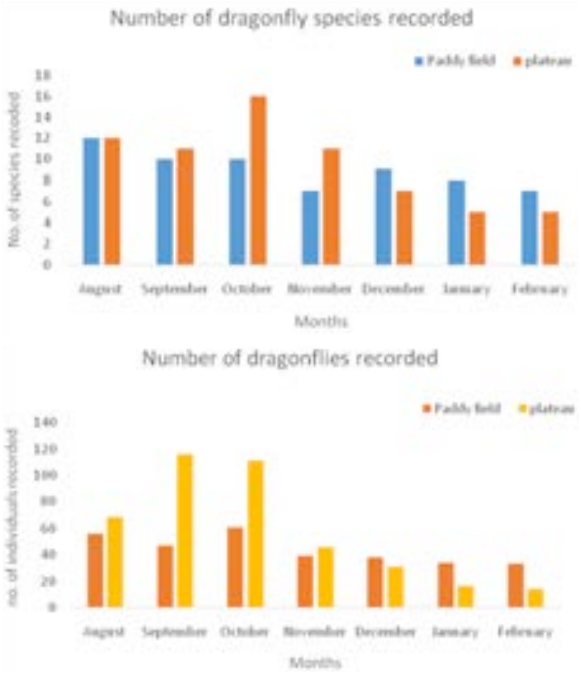

Figure 3. Monthly variation in the number of dragonfly species and number of dragonflies recorded.

monoculture paddy agro-ecosystem, which supports a lesser number of plant species and thus fewer insect species that are the prey base for dragonflies. Aquatic bodies in paddy fields were mostly covered by invasive weed like *Salvinia*, which hampers the growth of other native aquatic plant and animal diversity (Balzan 2012).

In the present study, seasonal variation in dragonfly species was also observed. Highest number of species and individuals were recorded during post monsoon, followed by monsoon and least in winter in both the ecosystems. Species diversity (H') was highest in monsoon followed by post monsoon and winter. Similar studies were carried out by Muthukumaravel et al. (2015). This may be attributed to drying up of the habitats which results in reduction in food resources post monsoon.

Monthly diversity of dragonflies showed a significant positive correlation with the monthly average rainfall in the agroecosystem and relative humidity in both the ecosystems. Similar observations were reported by Kalita et al. (2015) and Muthukumaravel et al. (2015). Weather plays an important role in the survival and activity patterns of adult odonates (Aguilar 2008). These environmental factors, along with vegetation directly affect diversity and distribution of food resources (Morais et al. 1999). The influence of rainfall is seen on density and distribution of vegetation, which leads to increase in abundance of herbivorous insects (prey for dragonflies).

It was observed that the species diversity (Fig. 2) in both ecosystems continue to be fairly similar in months August to October, however declined in January and February in the plateau ecosystem, along with a decline in the species richness, which can be attributed to the drying up of temporary water bodies following the monsoon season in the plateau ecosystem. Highest number of species was recorded in the month of October on the plateau ecosystem. Many of the species have their flight period during this period and a higher diversity of odonates could be attributed to this (Kulkarni & Subramanian 2013).

Neurothemis tullia shows the highest species abundance, followed by *Diplacodes trivialis* and *Rhodothemis rufa* in the paddy field ecosystem and *Pantala flavescens* in the plateau ecosystem followed by *Diplacodes trivialis.* Similar studies at agricultural areas were also reported by Kulkarni & Subramanian (2013).

Dragonflies are important bio-indicator species (Stewart 1998; Nair 2011). Presence of species like *Brachythemis contaminata,* which is known as a dragonfly of polluted waters (Subramanian 2009), was recorded at some of the sites in the plateau ecosystem, may indicate deterioration of the aquatic body. The presence of *Neurothemis fulvia, Neurothemis tullia, Bradinopyga geminata and Trithemis festiva* at the sites can indicate superior quality water and species *Brachythemis contaminata, Orthetrum chrysis, and Orthetrum sabina* which are common species at the sites could possible indicate lower water quality.

Most of the species recorded belong to the Least Concern category of the IUCN Red List, while one species *Indothemis carnatica* is Near Threatened.

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Table 6. Species abundance from most abundant to least abundant.

Scientific name	Agro-ecosystem	Scientific name	Plateau ecosystem
Neurothemis tullia Drury, 1773	25.324	*Pantala flavescens* Fabricius, 1798	32.506
Diplacodes trivialis Rambur, 1842	17.857	*Diplacodes trivialis* Rambur,1842	18.858
Pantala flavescens Fabricius, 1798	13.961	*Orthetrum sabina* Drury, 1770	8.684
Rhodothemis rufa Rambur, 1842	11.688	*Tramea limbata* Rambur,1842	7.444
Orthetrum sabina Drury, 1770	10.389	*Indothemis carnatica* Fabricius, 1798	6.699
Orthetrum pruinosum Rambur, 1842	5.8441	*Bradinopyga geminata* Rambur, 1842	5.459
Acisoma panorpoides Rambur, 1842	3.5714	*Crocothemis servilia* Drury, 1770	4.218
Tholymis tillarga Fabricius, 1798	3.246	*Rhyothemis variegata* Linnaeus, 1763	4.218
Ictinogomphus rapax Rambur, 1842	1.948	*Trithemis festiva* Rambur, 1842	2.977
Bradinopyga geminata Rambur, 1842	1.948	*Tramea basilaris* Kirby,1889	2.729
Orthetrum chrysis Selys, 1891	1.298	*Rhodothemis rufa* Rambur, 1842	2.233
Rhyothemis variegata Linnaeus, 1763	1.298	*Neurothemis tullia* Drury, 1773	0.992
Lathrecista asiatica Fabricius, 1798	0.974	*Ictinogomphus rapax* Rambur, 1842	0.744
Gynacantha bayadera Selys, 1854	0.324	*Orthetrum pruinosum* Rambur, 1842	0.496
Neurothemis fulvia Drury, 1773	0.324	*Anax guttatus* Burmeister, 1839	0.248
Anax guttatus Burmeister, 1839	0	*Brachythemis contaminata* Fabricius, 1793	0.248
Gynacantha dravida Lieftinck, 1960	0	*Cratilla lineata* Foerster,1903	0.248
Brachythemis contaminata Fabricius, 1793	0	*Lathrecista asiatica* Fabricius, 1798	0.248
Cratilla lineata Foerster, 1903	0	*Orthetrum glaucum* Brauer, 1865	0.248
Crocothemis servilia Drury, 1770	0	*Orthetrum taeniolatum* Schneider, 1845	0.248
Indothemis carnatica Fabricius, 1798	0	*Trithemis pallidinervis* Kirby, 1889	0.248
Orthetrum glaucum Brauer, 1865	0	*Gynacantha bayadera* Selys,1854	0
Orthetrum luzonicum Brauer, 1868	0	*Gynacantha dravida* Lieftinck,1960	0
Orthetrum taeniolatum Schneider, 1845	0	*Acisoma panorpoides* Rambur, 1842	0
Tramea basilaris Kirby, 1889	0	*Neurothemis fulvia* Drury, 1773	0
Tramea limbata Rambur, 1842	0	*Orthetrum chrysis* Selys, 1891	0
Trithemis festiva Rambur, 1842	0	*Orthetrum luzonicum* Brauer, 1868	0
Trithemis pallidinervis Kirby, 1889	0	*Tholymis tillarga* Fabricius, 1798	0

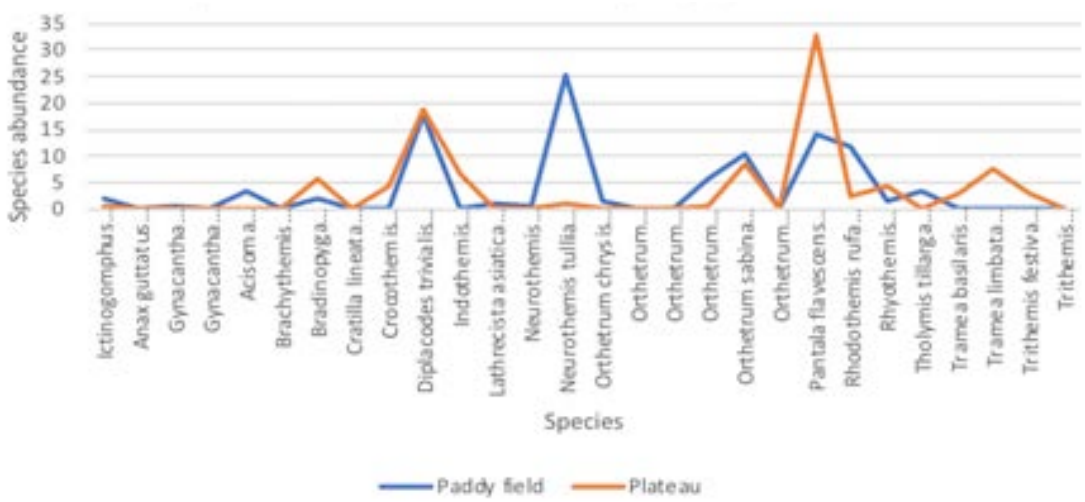

Figure 4. Species abundance of the dragonfly species recorded.

Image 5. Common Clubtail *Ictinogomphus rapax* Rambur, 1842.

Image 6. Ditch Jewel *Brachythemis contaminata* Fabricius, 1793.

Image 7. Granite Ghost *Bradinopyga geminata* Rambur, 1842.

Image 8. Ruddy Marsh Skimmer *Crocothemis servilia* Drury, 1770.

Image 9. Ground Skimmer *Diplacodes trivialis* Rambur, 1842 (male and female).

Image 11. Pied Paddy skimmer *Neurothemis tullia* Drury, 1773 (male and female).

Image 10. Blue Ground Skimmer *Indothemis carnatica* Fabricius, 1798.

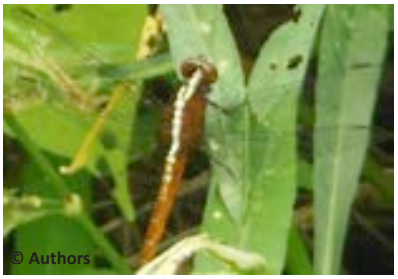

Image 12. Rufous Marsh Glider *Rhodothemis rufa* Rambur, 1842 (male and female).

Image 13. Common Picturewing *Rhyothemis variegata* Linnaeus, 1763.

Image 14. Coral-tailed Cloud Wing *Tholymis tillarga* Fabricius, 1798.

Image 15. Long-legged Marsh Glider *Trithemis pallidinervis* Kirby, 1889.

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PLATINUM
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Contributions to the knowledge of moths of Bombycoidea Latreille, 1802 (Lepidoptera: Heterocera) of Bhutan with new records

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Abstract: An annotated checklist of the superfamily Bombycoidea (Lepidoptera) of Bhutan is given, including three taxa of the family Bombycidae, two of Brahmaeidae, four of Endromidae, 12 of Eupterotidae, 37 of Saturniidae, and 93 of Sphingidae. Among these, 14 taxa are new records for the country: two Bombycidae (*Penicillifera apicalis* (Walker, 1862) and *Trilocha varians* (Moore, 1855)), two Endromidae (*Mustilizans hepatica* (Moore, 1879) and *Comparmustilia sphingiformis* (Moore, 1879)), three Saturniidae (*Saturnia cidosa* Moore, 1865, *Loepa sikkima* (Moore, [1866]), and *Salassa thespis* (Leech, 1890)), and seven Sphingidae (*Rhodoprasina floralis* (Butler, 1876), *Amplypterus mansoni mansoni* (Clark, 1924), *Acosmerycoides harterti* (Rothschild, 1895), *Hippotion celerio* (Linnaeus, 1758), *Theretra tibetiana* Vaglia & Haxaire, 2010, *T. silhetensis silhetensis* (Walker, 1856), and *Cechenena helops helops* (Walker, 1856)).

Keywords: Bombycidae, Brahmaeidae, Endromidae, Eupterotidae, new country record, Saturniidae, Sphingidae.

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Author contribution: JSI conceived and designed the study; JSI & MJI collected the materials, processed, identified the materials, compiled the checklist; and JSI prepared the manuscript.

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INTRODUCTION

The superfamily Bombycoidea comprises 10 families of the most charismatic and well-studied moths, grouped currently into 520 genera and 6,092 named species (Kitching et al. 2018). The Bombycoidea of the Indian subcontinent are relatively poorly studied and those of Bhutan, where the superfamily is represented by members of the families Eupterotidae, Brahmaeidae, Bombycidae, Endromidae, Saturniidae, and Sphingidae, have never been intensively researched. Thus, data on the bombycoid fauna of the country are very limited in terms of taxonomy, ecology, and distribution. A few works published include information on the Bombycoidea fauna of Bhutan: Dudgeon (1898a,b), Hampson (1892, 1910), Bell & Scott (1937), Dierl (1975), Brechlin (1997, 2009a,b,c,d, 2010a,b, 2014a,b,c, 2015), Schnitzler & Stünning (2009), Irungbam & Kitching (2014), Geilis & Wangdi (2017), Jamtsho & Irungbam (2019), and Irungbam & Norbu (2019), and these have mostly focused on Saturniidae and Sphingidae. In the present paper, we present the results of the survey conducted in central and southern Bhutan, together with a collation of all earlier known records of Bhutanese Bombycoidea.

MATERIALS AND METHODS

Study area

Bhutan is in the eastern part of the Himalaya and is bordered to the south, east, and west by India and to the north by Tibet (autonomous region of China). The country is 38,500km^2 in area, of which 72% is covered by forest. Approximately 60% of the land area falls under protected areas comprising 10 national parks and sanctuaries. The landscape ranges from subtropical plains in the south to the Himalayan heights in the north. The major forest types are fir forests, mixed conifer forests, blue pine forests, chir pine forests, broadleaf mixed with conifer, upland hardwood forests, lowland hardwood forests, and tropical lowland forests. The forest in the study area in central and southern Bhutan consists of eastern Himalayan subalpine conifer forests at higher elevations and eastern Himalayan broadleaf forest at lower elevations.

Sampling site

Moths were surveyed at nine localities in central and southern Bhutan (Tsirang, Dagana, Sarpang, Gelephu, Zhemgang, Trongsa, and Bumthang). The details of trapping localities, including GPS coordinates and elevations, are provided in previous publications (Irungbam et al. 2016, 2017).

Sampling period and time

Over a period of three years (2013–2015), each study site was visited once a month. Nocturnal moths were recorded with light traps (run between 18.00–05.00 h) and diurnal species were observed during the day whenever the weather permitted.

Sampling techniques

Nocturnal field collection was carried out using either fluorescent bulbs hung in front of a vertical white cloth sheet or mercury vapour (MV) light traps (Irungbam et al. 2016). Moths were also collected from the whitewashed walls of residential homes and schools where fluorescent bulbs were kept lit throughout the night. Digital images of all moths were taken using Canon 1100D (Canon Inc., Tokyo, Japan) and Nikon Coolpix P510 (Nikon Inc., Tokyo, Japan) cameras. Voucher specimens were also collected for further investigation and were deposited in the Invertebrate Referral Collection Centre (IRCC), National Biodiversity Centre (NBC), Thimphu, Bhutan.

Review and Identification of species

Historical records were reviewed and recently collected specimens were identified by comparison with available literature (Dudgeon 1898a,b; Hampson 1892; Mell 1922; Bell & Scott 1937; Michener 1949; Dierl 1975; d'Abrera 1986 [1987]; Holloway 1987; Pinratana & Lampe 1990; Haruta 1992a,b, 1994, 1995; Pittaway 1993; Kishida 1993, 1994a,b, 1998; Kitching & Spitzer 1995; Chu & Wang 1996; Inoue et al. 1997; Kitching & Cadiou 2000; Pittaway & Kitching 2000; Kendrick 2002; Witt & Pugaev 2007; Nässig & Oberprieler 2007, 2008; Zolotuhin & Witt 2009; Vaglia et al. 2010; Rafi et al. 2014; Wang et al. 2015; Kaleka et al. 2017; Gielis & Wangdi 2017; Kitching et al. 2018; Sanyal et al. 2018; Jamtsho & Irungbam 2019; Irungbam & Norbu 2019). Online repositories available for the moths of Asia (Nakao 2019), Sphingidae (Kitching 2018; Pittaway & Kitching 2019), and Saturniidae (Nässig 2002; Paukstadt & Paukstadt 2018) were also accessed to compare and confirm the identity of the collected materials. Specimens with uncertain species identifications are referred as 'cf.' (confer meaning = to compare; Sigovini et al. 2016).

The classification and nomenclature follow Kitching et al. (2018), except for *Rhodoprasina nenulfascia* (q.v.) (Řézáč, 2018). For all identified species, general information on their local (in Bhutan) and global distributions are given.

RESULTS, DISCUSSION, AND CONCLUSION

The present checklist of the superfamily Bombycoidea (Lepidoptera) in Bhutan comprises three Bombycidae, two Brahmaeidae, four Endromidae, 12 Eupterotidae, 37 Saturniidae, and 93 Sphingidae (Table 1). New country records for Bhutan are two Bombycidae (*Penicillifera apicalis* (Walker, 1862) and *Trilocha varians* (Moore, 1855)), two Endromidae (*Mustilizans hepatica* (Moore, 1879) and *Comparmustilia sphingiformis* (Moore, 1879)), three Saturniidae (*Saturnia cidosa* Moore, 1865, *Loepa sikkima* (Moore, [1866]), and *Salassa thespis* (Leech, 1890)), and seven Sphingidae (*Rhodoprasina floralis* (Butler, 1876), *Amplypterus mansoni mansoni* (Clark, 1924), *Acosmerycoides harterti* (Rothschild, 1895), *Hippotion celerio* (Linnaeus, 1758), *Theretra tibetiana* Vaglia & Haxaire, 2010, *T. silhetensis silhetensis* (Walker, 1856), and *Cechenena helops helops* (Walker, 1856)).

In the present survey, we covered only a small area in central and southern Bhutan. The earlier studies of Dudgeon (1898a,b) reported on just the lower elevations of the Bhutan Himalaya, and the Swiss expedition team of the Natural History Museum, Basel, visited only the eastern part of Bhutan in 1972 (Dierl 1975). Thus, a vast area of eastern Bhutan, which is known to be very rich in butterfly species (Wangdi et al. 2012) is unstudied. Irungbam & Kitching (2014) reported 27 species of Sphingidae from Tsirang District of southern Bhutan and reported *Clanis hyperion* for the first time from Bhutan. Later, Geilis & Wangdi (2017), who conducted surveys in many parts of Bhutan, produced an updated list of 107 species of Bombycoidea consisting of two taxa of Brahmaeidae, two taxa of Endromidae, seven taxa of Eupterotidae, 33 taxa of Saturniidae, and 63 taxa of Sphingidae. Surveys in other parts of Bhutan are therefore expected to add more species, and a systematic investigation in all parts of Bhutan is recommended to understand the complete fauna of the country's bombycoid moths.

Taxonomic list

Species reported from Bhutan for the first time are marked by an asterisk (*).

Superfamily Bombycoidea Latreille, 1802

Family Bombycidae Latreille, 1802

The recorded global distributions of species of Bombycidae were extracted from Hampson (1892 [1893]), Dudgeon (1898a), Dierl (1975), Kishida (1994b), Chu & Wang 1996, Kendrick (2002), Zolotuhin & Witt (2009), Wang et al. (2015), Geilis & Wangdi (2017), Kitching et al. (2018), Sanyal et al. (2018), and Nakao (2019).

Subfamily Bombycinae Latreille, 1802

Genus *Bombyx* Linnaeus, 1758

1. Bombyx huttoni Westwood, 1847 (Image 1A)

Material examined: BM-214, 1 male, 07.x.2013, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m, coll. J.S. Irungbam; BM-682, 1 male, 2.ix.2014, Damphu (Tsirang), 27.072^{0}N and 90.109^{0}E, 1,058m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trongsa, and Sarpang), Pakistan, India, Nepal, China, Taiwan, Thailand, Vietnam, and Malaysia.

Genus *Penicillifera* Dierl, 1978

2. Penicillifera apicalis (Walker, 1862) * (Image 1B)

Material examined: 1 male (image record), 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang), India, China, Hongkong, Hainan Island, Philippines, Indonesia, Malaysia, Vietnam, and Thailand.

Remarks: A new country record for Bhutan.

Genus *Trilocha* Moore, [1860]

3. Trilocha varians (Moore, 1855) * (Image 1C)

Material examined: 1 male (image record), 20.v.2012,

Table 1. Summary of the Bombycoidea fauna of Bhutan based on old literature records and specimens collected during the study period.

	Family	Species recorded in the present study	Old records	New country records	Total species
1	Bombycidae	3	1	2	3
2	Brahmaeidae	2	2	0	2
3	Endromidae	2	2	2	4
4	Eupterotidae	5	12	0	12
5	Saturniidae	27	34	3	37
6	Sphingidae	60	86	7	93
Grand Total		**109**	**137**	**14**	**151**

Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Trashigang), Nepal, India including the Andaman Islands, Sri Lanka, China, Taiwan and Hainan Islands, Hong Kong, southern Japan, Philippines, Malaysia, Indonesia, Vietnam, and Thailand.

Remarks: A new country record for Bhutan.

Family Brahmaeidae Swinhoe, 1892

The recorded global distributions of species of Brahmaeidae were extracted from Hampson (1892), Holloway (1987), Nässig (1994b), Kendrick (2002), Brechlin (2009a), Kaleka et al. (2017), Geilis & Wangdi (2017), Kitching et al. (2018), Sanyal et al. (2018), and Nakao (2019).

Genus *Brahmaea* Walker, 1855

4. Brahmaea wallichii wallichii (Gray, 1831) (Image 1D)

Material examined: BM-573, 1 male, 09.v.2014 Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m, coll. J.S. Irungbam; BM-702, 1 female, 24.vi.2015, Bhutan, Damphu (Tsirang), 27.072^{0}N and 90.109^{0}E, 1,058m, coll. M.J. Irungbam

Distribution: Bhutan (Tsirang, Thimphu, Pemagatshel, Chukha, Bumthang, Trashigang, and Samdrup Jongkhar), Nepal, northern India, Myanmar, China, Japan, northern Vietnam, Thailand, Laos, Taiwan, and Sundaland.

5. Brahmaea hearseyi White, 1862 (Image 1E)

Material examined: BM-571, 1 female, 22.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m, coll. J.S. Irungbam; BM-572, 1 male, 24.vi.2015, Bhutan, Damphu (Tsirang), 27.072^{0}N and 90.109^{0}E, 1,058m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trashigang, and Pemagatshel), Nepal, northeastern India, Myanmar, southwestern China, Thailand, Laos, Cambodia, Vietnam, and Sundaland.

Family Endromidae Boisduval, 1828

The recorded global distributions of species of Endromidae were extracted from Hampson (1892), Dudgeon (1898a), Dierl (1975), Wang et al. (2015), Geilis & Wangdi (2017), Kitching et al. (2018), Sanyal et al. (2018), and Nakao (2019).

Genus *Mustilizans* Yang, 1995

6. Mustilizans hepatica (Moore, 1879) * (Image 1F)

Material examined: BM-213, BM-674, 2 males, 03.x.2012, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Trashiyangtse), Pakistan, Nepal, northeastern India, China, Hainan, northern Vietnam, northern Malaysia, Laos, and northern Thailand.

Remarks: A new country record for Bhutan. Wang et al. (2015) transferred the species from the genus *Mustilia* to *Mustilizans.*

Genus *Comparmustilia* Wang & Zolotuhin, 2015

7. Comparmustilia sphingiformis (Moore, 1879) * (Image 1G)

Material examined: BM-215, BM-728, 2 males, 08.viii.2013, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang) Nepal, India, Myanmar, China, Taiwan, northern Thailand, northern Vietnam, and northern Malaysia.

Remarks: A new country record for Bhutan. Wang et al. (2015) transferred the species from the genus *Mustilia* to *Comparmustilia.*

Genus *Mustilia* Walker, 1865

8. Mustilia falcipennis Walker, 1865

Material examined: None.

Distribution: Bhutan (Thimphu), Nepal, India, China, Hainan, Sumatra, and Java.

Remarks: This species was not recorded in the study.

9. Mustilia castanea Moore, 1879

Material examined: None.

Distribution: Bhutan (Thimphu), Nepal, India, and China.

Remarks: This species was not recorded in the study.

Family Eupterotidae Swinhoe, 1892

The recorded global distributions of species of Eupterotidae were extracted from Hampson (1892), Dudgeon 1898a, Dierl (1975), Kishida (1994a), Kendrick (2002), Nässig & Oberprieler (2008), Geilis & Wangdi (2017), Savela (2018), Kitching et al. (2018), Sanyal et al. (2018), Zolotuhin (2018), and Nakao (2019).

Subfamily Eupterotinae Swinhoe, 1892

Genus *Eupterote* Hübner, [1820]

10. Eupterote cf. *fabia* (Cramer, [1779]) (Image 1H)

Material examined: BM-589, BM-745, 2 males, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m, coll. J.S. Irungbam; BM-746, 1 male, 08.viii.2013, Bhutan, Dagapela (Dagana), 26.941^{0}N

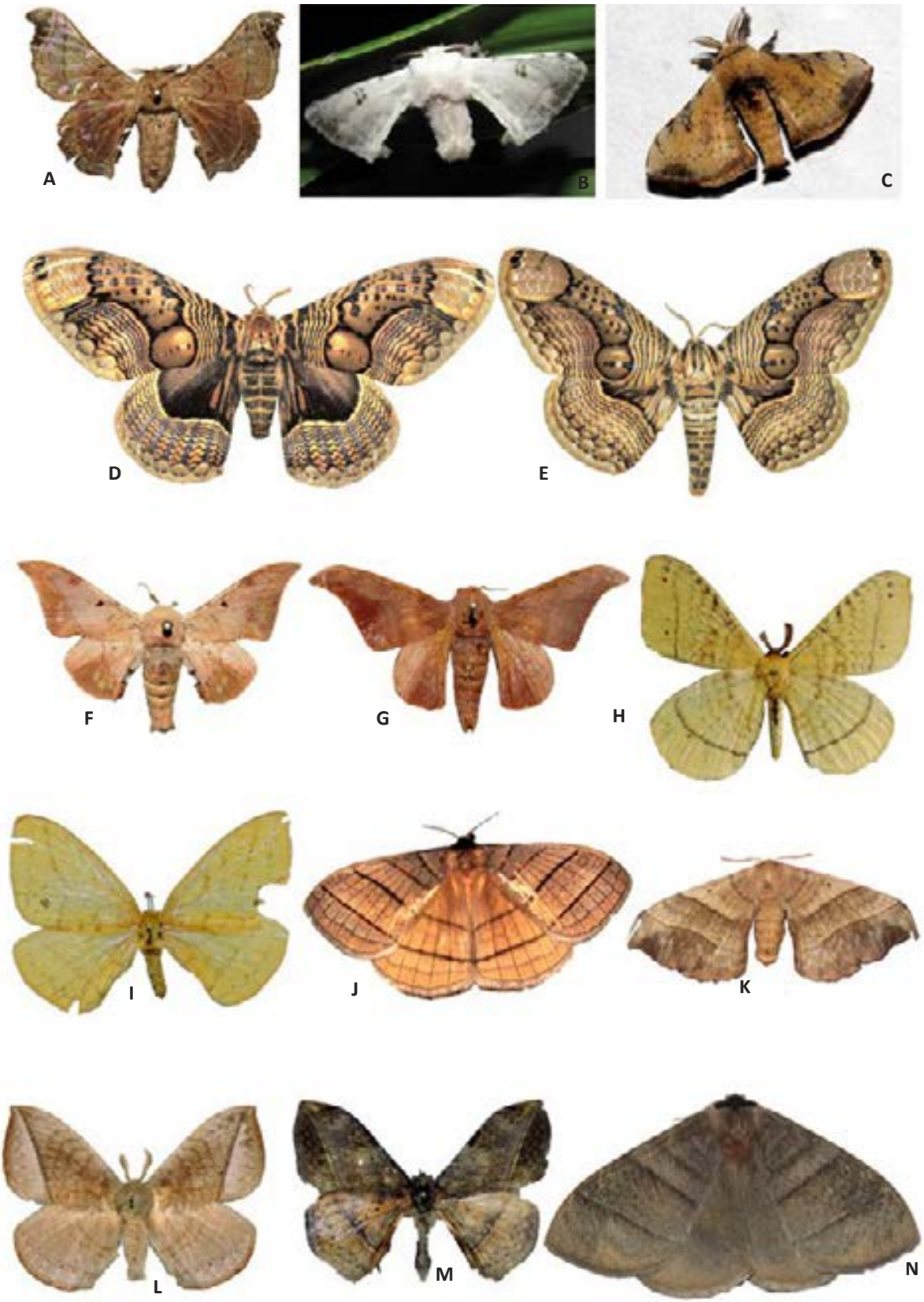

Image 1. A - *Bombyx huttoni* Westwood, 1847 | B - *Penicillifera apicalis* (Walker, 1862)* | C - *Trilocha varians* (Moore, 1855)* | D - *Brahmaea wallichii wallichii* (Gray, 1831) | E - *B. hearseyi* White, 1862 | F - *Mustilizans hepatica* (Moore, 1879)* | G - *Comparmustilia sphingiformis* (Moore, 1879)* | H - *Eupterote* cf. *fabia* (Cramer, [1779]) | I - *E.* cf. *lineosa* | J - *Palirisa lineosa* (Walker, 1855) | K - *Apona cashmirensis* (Kollar, [1844]) | L - *Ganisa similis* Moore, 1884 | M - *Pseudojana incandescens* (Walker, 1855). Species marked with "*" incates new record to Bhutan.

and 89.923^{0}E, 1,576m, coll. J.S. Irungbam; BM-658, 1 male, 12.x.2014, Bhutan, Jakar (Bumthang), 27.545^{0}N and 90.725^{0}E, 2,884m, coll. J.S. Irungbam

Distribution: Bhutan (Dagana and Bumthang), India, and Sri Lanka.

11. Eupterote cf. *lineosa* (Walker, 1855) (Image 1I)

Material examined: BM-589, 1 male, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950^{0}N and 90.114^{0}E, 1,233m, coll. M.J. Irungbam; BM-590, IJ-413, 2 males, 18.v.2015, Bhutan, Dagapela (Dagana), 26.941^{0}N and 89.923^{0}E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Dagana) and Nepal.

12. Eupterote glaucescens (Walker, 1855)

Material examined: None.

Distribution: Bhutan (Wangdue Phodrang), Nepal, and India.

Remarks: This species was not recorded in the study.

13. Eupterote orientalis (Fabricius, 1793)

Material examined: None.

Distribution: Bhutan, India, and Sri Lanka.

Remarks: This species was not recorded in the study. The species was previously known as *Eupterote geminata* but this was recently synonymized with *E. orientalis* by Zolotuhin (2018).

14. Eupterote undatus Blanchard, 1853

Material examined: None.

Distribution: Bhutan (Trashiyangtse) Pakistan, India, Nepal, Sri Lanka, Myanmar, Sumatra, Java, and the Philippines.

Remarks: This species was not recorded in the study.

Genus *Palirisa* Moore, 1884

15. Palirisa lineosa (Walker, 1855) (Image 1J)

Material examined: 1 male (image record), 7.vi.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by M.J. Irungbam); 1 female (image record), 19.vii.2014, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Dagana), Nepal, India, and Bangladesh.

"Ganisa-group"

Genus *Apona* Walker, 1856

16. Apona cashmirensis (Kollar, [1844]) (Image 1K)

Material examined: 1 male (image record), 04.iii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang), northern India, and Nepal.

Genus *Ganisa* Walker, 1855

17. Ganisa similis Moore, 1884 (Image 1L)

Material examined: BM-210, BM-211, BM-212, 3 males, 08.viii.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. M.J. Irungbam

Distribution: Bhutan (Tsirang and Zhemgang), Nepal, India, China, and Sundaland.

18. Ganisa postica Walker, 1855

Material examined: None.

Distribution: Bhutan (Thimphu and Wangdue Phodrang), northeastern India, Bangladesh, and Sri Lanka.

Remarks: This species was not recorded in the study.

19. Ganisa pandya (Moore, 1865)

Material examined: None.

Distribution: Bhutan, India, Bangladesh, China, and Hong Kong.

Remarks: This species was not recorded in the study.

Genus *Apha* Walker, 1855

20. Apha subdives Walker, 1855 (Image 1M)

Material examined: IJ-425, IJ-426, 2 males, 5.vii.2014, Bhutan, Daga (Dagana), 27.032°N and 89.489°E, 1,576m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Dagana and Wangdue Phodrang), northeastern India, Bangladesh, Myanmar, Thailand, Vietnam, and China.

Remarks: This species was not recorded in the study.

Genus *Pseudojana* Hampson, [1892]

21. Pseudojana incandescens (Walker, 1855) (Image 1N)

Material examined: 1 male (image record), 09.iv.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, (Image by J.S. Irungbam); BM-616, 1 male, 14.v.2015, Bhutan, Khuri (Lhuntse), 27.675°N and 91.178°E, 1,780m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang, Trongsa, and Lhuentse), Nepal, and northeastern India.

Family Saturniidae Boisduval, [1837]

The recorded global distributions of species of Saturniidae were extracted from Hampson (1892), Dudgeon (1898a), Arora & Gupta (1979), Nardelli (1986), Holloway (1987), Peigler (1989), Pinratana & Lampe (1990), Haruta (1992b), Nässig (1994a, 1994b.), Chu

& Wang (1996), Nässig & Treadaway (1998), Kendrick (2002), Nässig (2002), Gupta (2003), Peigler & Naumann (2003), Tikader et al. (2014), Witt & Pugaev (2007), Naumann et al. (2008), Racheli (2008), Brechlin (2009a), Nässig et al. (2010), Naumann & Nässig (2010a, 2010b), Naumann & Löffler (2012, 2013), Gogoi et. al. (2014), Geilis & Wangdi (2017), Kitching et al. (2018), Paukstadt & Paukstadt (2018), Sanyal et al. (2018), and Nakao (2019).

Subfamily Saturniinae Boisduval, [1837]

Genus *Attacus* Linnaeus, 1767

22. Attacus atlas atlas (Linnaeus, 1758) (Image 2A)

Material examined: BM-618, 1 female, 09.vi.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Zhemgang, and Pemagatshel), India, Myanmar, China, Cambodia, Laos, Taiwan, Hong Kong, Borneo, Sumatra, Java, Bali, the Philippines, New Guinea, and The Moluccas.

Genus *Archaeoattacus* Watson in Packard, 1914

23. Archaeoattacus edwardsii (White, 1859) (Image 2B)

Material examined: BM-627, 1 male, 17.ix.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Bumthang, Mongar, Thimphu, Chukha, and Punakha), northern India, Nepal, Myanmar, China (Tibet), Vietnam and western Malaysia.

Genus *Samia* Hübner, [1819]

Samia canningi (Hutton, 1859) (Image 2C)

Material examined: BM-581, BM-631, BM-632, BM-633, 2 females, 2 males, 27.v.2012, 21.ix.2012, 22.vii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-635, BM-636, 2 females, 22.viii.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang, Punakha, Sarpang, Gelephu, Chukha, Phuentsholing, Mongar, Trashigang and Zhemgang), Pakistan, northern and northeastern India, Nepal, Myanmar, Thailand, Cambodia, Laos, Vietnam, and southern China.

Genus *Rhodinia* Staudinger, 1892

24. Rhodinia newara (Moore, 1872) (Image 2D)

Material examined: 1 female (image record), 16.xi.2014, Bhutan, Tingtibi (Zhemgang), Sarpang-Gelephu-Trongsa Highway, 27.142°N and 90.690°E, 575m (Image by W. Kezang).

Distribution: Bhutan (Bumthang, Mongar, Zhemgang, and Lhuentse), Nepal, northern India, Bangladesh, northern Myanmar, northern Thailand, northern Vietnam, and southwestern China.

Genus *Actias* Leach, 1815

25. Actias selene selene (Hübner, 1806) (Image 2E,F)

Material examined: BM-579, BM-580, BM-642, BM-643, 2 females, 2 males, 31.x.2013, 23.viii.2014, 12.iv.2015, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-646, 1 female, 22.viii.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam; BM-645, 1 male, 5.vii.2014, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.455°N and 90.489°E, 1,924m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trongsa, Thimphu, Sarpang, Paro, Chukha, Samtse, Luentse, and Trashiyangtse), Afghanistan, Pakistan, Nepal, western and northeastern India, Bangladesh, northern Thailand, Vietnam, China, Korea and the Philippines.

26. Actias parasinensis Brechlin, 2009 (Image 3A,B)

Material examined: BM-576, BM-577, BM-578, 2 females, 1 male, 23.viii.2014, 12.iv.2015, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-639, 1 female, 22.viii.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam & Rinchen K.; BM-649, BM-652, 1 male, 1 female, 12.ix.2013, 5.vii.2014, Bhutan, Daga (Dagana), 27.032°N and 89.887°E, 1,576m, coll. J.S. Irungbam.

Distribution: Bhutan (Tsirang, Dagana, Sarpang, Chukha, Thimphu, Zhemgang, and Trongsa), northern India, Thailand, Laos, and Vietnam.

27. Actias maenas maenas Doubleday, 1847 (Image 3 C)

Material examined: BM-575, IJ-234, 1 male, 1 female, 23.viii.2014, 20.iv.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; IJ-240, 1 female, 20.ix.2013, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam; BM-654, 1 male, 5.vii.2014, Bhutan, Daga (Dagana), 27.032°N and 89.489°E, 1,576m, coll. J.S. Irungbam.

Distribution: Bhutan (Tsirang, Sarpang, Dagana, Paro,

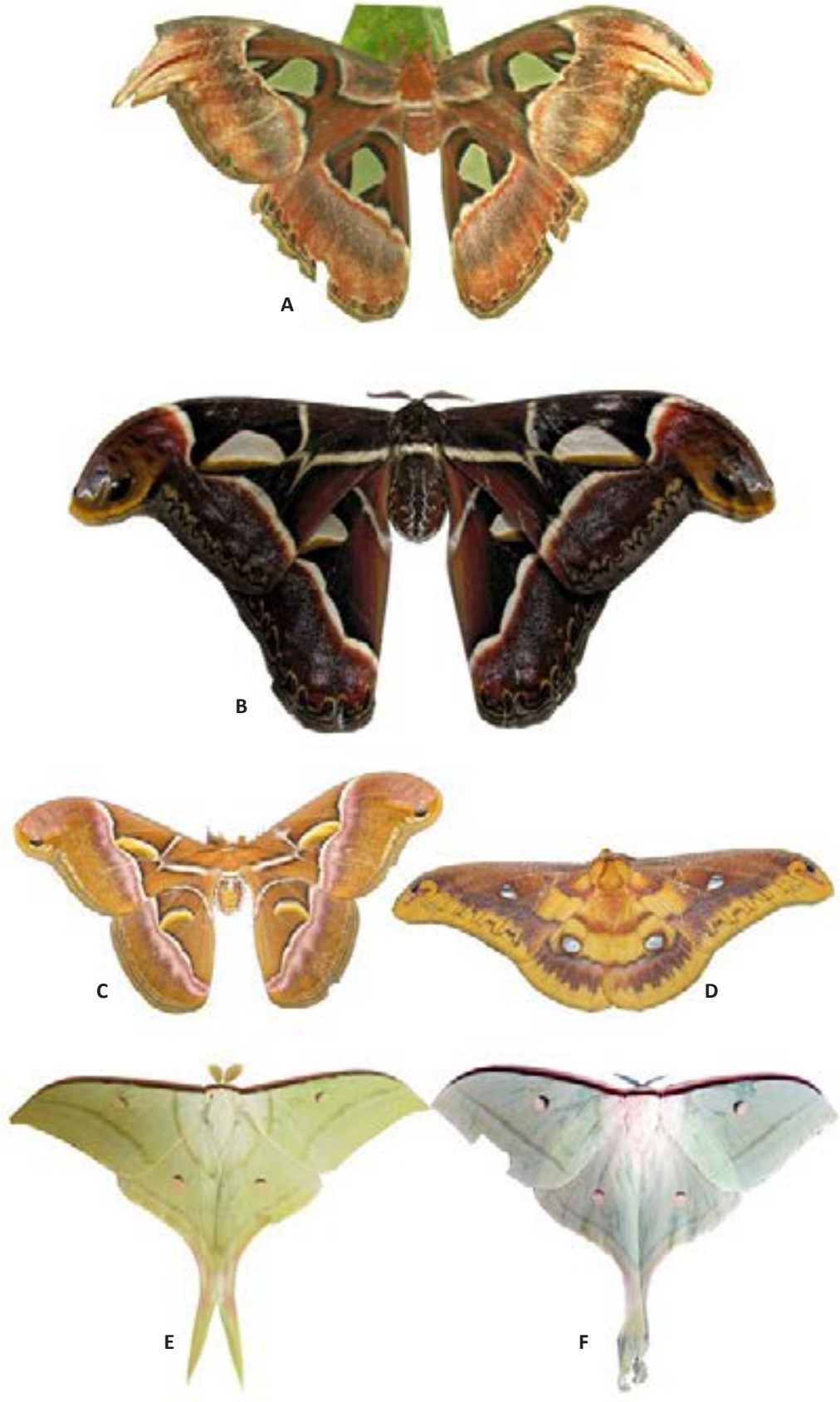

Image 2. A - *Attacus atlas atlas* (Linnaeus, 1758) | B - *Archaeoattacus edwardsii* (White, 1859) | C - *Samia canningii* (Hutton, 1859) | D - *Rhodinia newara* (Moore, 1872) | E - female of *A. selene selene*, Hübner, 1806 | F - male of *A. selene selene* Hübner, 1806.

Samtse, Samdrup Jongkhar, Mongar, Bumthang, and Trashiyangtse), Nepal, India, Bangladesh, southwestern China, northern Thailand, Laos, and Vietnam.

Genus *Saturnia* Schrank, 1802

28. Saturnia (Rinaca) zuleika Hope, 1843 (Image 3D)

Material examined: IJ-658, 1 female, 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.455°N and 90.489°E, 1,924m, coll. J.S. Irungbam & K. Rinchen.

Distribution: Bhutan (Trongsa, Thimphu, Trashigang, and Trashiyangtse), Nepal, northern India, Myanmar, southwestern China, northern Thailand, Laos, and northern Vietnam.

29. Saturnia (Rinaca) simla Westwood, 1847 (Image 3E)

Material examined: 1 female (image record), 16.xi.2014, Bhutan, Tingtibi (Zhemgang), Sarpang-Gelephu-Trongsa Highway, 27.142°N and 90.690°E, 575m (Image by Rinchen K).

Distribution: Bhutan (Zhemgang and Trashigang), Pakistan, India, Nepal, Myanmar, China, Thailand, Laos, and Vietnam.

30. Saturnia (Rinaca) thibeta (Westwood, 1853) (Image 3 F)

Material examined: BM-159, IJ-549, 2 females, 17.xii.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang, Zhemgang, Trashiyangtse, Chukha, and Phuentsholing), India, Nepal, Vietnam, China, Thailand, Malaysia, and Taiwan.

31. Saturnia (Rinaca) anna Moore, [1866] (Image 3G)

Material examined: 1 male (image record), 29.iv.2014, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.455°N and 90.489°E, 1,924m (Image by K. Rinchen).

Distribution: Bhutan (Thimphu, Trongsa, and Trashiyangtse), northern India, Nepal, China, and Vietnam.

32. Saturnia (Rinaca) bonita (Jordan, 1911)

Material examined: None.

Distribution: Bhutan (Thimphu and Paro), Nepal, northeastern India, and Tibet (China).

Remarks: This species was not recorded in the study.

33. Saturnia (Rinaca) witti Brechlin, 1997

Material examined: None.

Distribution: Bhutan (Trongsa) and Nepal.

Remarks: This species was not recorded in the study.

34. Saturnia (Rinaca) cidosa Moore, 1865* (Image 3H, I)

Material examined: BM-591, BM-592, BM-593, BM-594, 2 females, 2 males, 21.ii.2012, 02.iii.2014, 08.iii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-595, BM-596, 2 males, 23.iii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Zhemgang, Trongsa, and Samdrup Jongkhar), northeastern India, and Nepal.

Remarks: A new country record for Bhutan. Brechlin (2009a) expected the species to be present in Bhutan, but it was not recorded in his study.

35. Saturnia (Rinaca) pelelaensis Brechlin, 2009c

Material examined: None.

Distribution: Bhutan (Trongsa).

Remarks: This species was not recorded in the study.

Genus *Loepa* Moore, [1860]

36. Loepa miranda Atkinson in Moore, 1865 (Image 4A)

Material examined: 1 male (image record), 15.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang, Paro, Thimphu, and Trongsa), Nepal, northern India, northern Myanmar, southwestern China, Thailand, Laos, and Vietnam.

37. Loepa diffundata Naumann, Nässig & Löffler, 2008

Material examined: None.

Distribution: Bhutan (Mongar), Nepal, northern India, Myanmar, southwestern China, Thailand, Laos, Cambodia, and Vietnam.

Remarks: This species was not recorded in the study.

38. Loepa sikkima (Moore, [1866]) * (Image 4B)

Material examined: IJ-344, 2 males, 23.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang), northern India, Nepal, Myanmar, Hong Kong, Thailand, Malaysia, Sumatra, Java, and Sundaland.

Remarks: A new country record for Bhutan.

Image 3. A - Female of *A. parasinensis* Brechlin, 2009 | B - male of *A. parasinensis* Brechlin, 2009 | C - *Actias maenas maenas* Doubleday, 1847 | D - *Saturnia (Rinaca) zuleika* Hope, 1843 | E - *S. (R.) simla* Westwood, 1847 | F - *S. (R.) thibeta* Westwood, 1853 | G - *S. (R.) anna* Moore, [1866] | H - female of *S. (R.) cidosa* Moore, 1865* | I - male of *S. (R.) cidosa* Moore, 1865*. Species marked with "*" incates new record to Bhutan.

39. Loepa diffunoccidentalis Brechlin, 2010a (Image 4C)

Material examined: BM-587, 1 male, 05.iii.2013, 13.iii.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang, Trashigang, Trashiyangtse, and Punakha) and Myanmar.

40. Loepa katinka (Westwood, 1847) (Image 4D)

Material examined: BM-588, IJ-345, 2 males, 14.iv.2012, 23.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Zhemgang), Nepal, northeastern India, Myanmar, China, Hong Kong, and Vietnam.

41. Loepa bhutanensis Naumann & Löffler, 2012

Material examined: None.

Distribution: Bhutan (Thimphu and Punakha).

Remarks: This species was not recorded in the study.

Genus *Cricula* Walker, 1855

42. Cricula trifenestrata trifenestrata (Helfer, 1837) (Image 4E)

Material examined: BM-582, BM-583, IJ-201, females, 1 male, 06.vi.2012, 31.x.2013, 23.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-281, IJ-205, IJ-206, 2 females, 1 male, 12.ix.2013, 5.vii.2014, Bhutan, Daga (Dagana), 27.032°N and 89.887°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Chukha, and Zhemgang), India, Nepal, Sri Lanka, China, Tibet, Thailand, Cambodia, Laos, Vietnam, and The Philippines.

43. Cricula andrei Jordan, 1909 (Image 4F)

Material examined: BM-584, IJ-204, 2 males, 31.x.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, and Trashigang), northeastern India, China (Tibet), Myanmar, Vietnam, Thailand, and Indonesia.

Genus *Antheraea* Hübner, [1819]

44. Antheraea (Antheraeopsis) assamensis Helfer, 1837 (Image 4G)

Material examined: BM-585, 1 female, 31.x.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-666, 1 male, 5.vii.2014, Bhutan, Daga (Dagana), 27.032°N and 89.887°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Dagana), northern India, Nepal, Myanmar, Thailand, Laos, and Vietnam.

45. Antheraea (Antheraeopsis) castanea Jordan, 1910

Material examined: None.

Distribution: Bhutan (Trashigang), northeastern India, Myanmar, Laos, and Sundaland.

Remarks: This species was not recorded in the study.

46. Antheraea (Antheraea) frithi frithi Moore, 1858 (Image 4H)

Material examined: 1 male (image record), 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.456°N and 90.489°E, 1,165m (Image by D. Sonam).

Distribution: Bhutan (Trongsa, Paro, Haa, Thimphu, and Trashiyangtse), northern India, Nepal, Thailand, Laos, Cambodia, Vietnam, Myanmar, and southwestern China.

47. Antheraea (Antheraea) rubicunda Brechlin, 2009 (Image 4I)

Material examined: 1 male (image record), 20.ix.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Trongsa), Nepal, and northeastern India.

48. Antheraea (Antheraea) roylei Moore, 1858 (Image 4J)

Material examined: BM-586, 1 male, 20.ix.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Chukha, and Zhemgang), northern India, Nepal, Myanmar, southwestern China, Thailand, Cambodia, Laos, and Vietnam.

49. Antheraea (Antheraea) helferi Moore, 1858 (Image 5A)

Material examined: 1 male (image record), 01.iii.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang, Chukha, and Trashigang), northern India, Myanmar, Thailand, Laos, Vietnam, and southwestern China.

Subfamily Salassinae Michener, 1949

Genus *Salassa* Moore, 1859

50. Salassa mesosa mesosa Jordan, 1910

Material examined: None.

Image 4. A - *Loepa miranda* Moore, 1865 | B - *L. sikkima* (Moore, [1866])* | C - *L. diffunoccidentalis* Brechlin, 2010a | D - *L. katinka* (Westwood, 1847) | E - *Cricula trifenestrata trifenestrata* (Helfer, 1837) | F - *C. andrei* Jordan, 1909 | G - *Antheraea (Antheraeopsis) assamensis* Helfer, 1837 | H - *A. (Antheraea) frithi frithi* Moore, 1859 | I - *A. (Antheraea) rubicunda* Brechlin, 2009 | J - *A. (Antheraea) roylei* Moore, 1858. Species marked with "*" incates new record to Bhutan.

Distribution: Bhutan (Monger), northeastern India, and Myanmar.

Remarks: This species was not recorded in the study.

51. Salassa lola (Westwood, 1847) (Image 5B)

Material examined: 1 male (image record), 04.vi.2015, Bhutan, Chendebji (Trongsa), Thimphu-Trongsa-Bumthang Highway, 27.474°N and 90.349°E, 2,451m (Image by Kezang W.).

Distribution: Bhutan (Trongsa), Nepal, northern and northeastern India, and Bangladesh.

52. *Salassa bhutanensis* Brechlin, 2009c (Image 5C)

Material examined: 1 male (image record), 04.vi.2015, Bhutan, Thimphu (Hongtsho), Thimphu-Punakha Highway, 27.490°N and 89.748°E, 3,040m (Image by Sonam D.); 1 male (image record), 07.v.2015, Bhutan, Bumthang (Jakar), Lamaigoenpa, 27.545°N and 90.723°E, 2,650m (Image by Yeshi T.D.).

Distribution: Bhutan (Thimphu, Trongsa, and Bumthang).

53. Salassa belinda Witt & Pugaev, 2007 (Image 5D)

Material examined: 1 male (image record), 04.vi.2015, Bhutan, Chendebji (Trongsa), Thimphu-Trongsa-Bumthang Highway, 27.474°N and 90.349°E, 2,451m (Image by Kezang W.); 1 male (image record), 07.v.2015, Bhutan, Bumthang (Jakar), Lamaigoenpa, 27.545°N and 90.723°E, 2,650m (Image by Sonam D.).

Distribution: Bhutan (Thimphu, Bumthang, and Trongsa) and eastern Nepal.

54. Salassa royi (Elwes, 1887)

Material examined: None.

Distribution: Bhutan, northeastern India, and Nepal.

Remarks: This species was not recorded in the study.

55. Salassa thespis (Leech, 1890) * (Image 5E)

Material examined: 1 male (image record), 04.vi.2015, Bhutan, Chendebji (Trongsa), Thimphu-Trongsa-Bumthang Highway, 27.474°N and 90.349°E, 2,451m (Image by Kezang W.).

Distribution: Bhutan (Trongsa and Zhemgang), Myanmar, Thailand, and China.

Remarks: A new country record for Bhutan.

56. Salassa pararoyi Brechlin, 2009c.

Material examined: None.

Distribution: Bhutan (Thimphu) and western Bhutan.

Remarks: This species was not recorded in the study.

57. Salassa iris Jordan, 1910

Material examined: None.

Distribution: Bhutan (Trashigang) and northern India (Sikkim).

Family Sphingidae Latreille, 1802

The recorded global distributions of species of Sphingidae were extracted from Bell & Scott (1937), Ebert (1969), Eichler (1971), d'Abrera (1986 [1987]), Holloway (1987), Pittaway (1993), Haruta (1992), Smetacek (1994), Kitching & Spitzer (1995), Inoue et al. (1997), Brechlin (1997, 2009a,b,c,d, 2010a,b, 2014a,b,c, 2015), Danner et al. (1998), Hogenes & Treadaway (1998), Kitching & Cadiou (2000), Zwick & Treadaway (2001), Kendrick (2002), Schnitzler & Stünning (2009), Eitschberger & Melichar (2010), Vaglia et al. (2010), Eitschberger & Nguyen (2012), Pathania et al. (2014), Rafi et al. (2014), Singh & Kitching (2014), Haxaire et al. (2017), Yakovlev & Doroshkin (2017), Pittaway & Kitching (2000; 2019), Kitching (2018), Ivshin et al. (2018), Sanyal et al. (2018), Nakao (2019), Jamtsho & Irungbam (2019), and Irungbam & Norbu (2019).

Subfamily Sphinginae Latreille, 1802

Genus *Acherontia* Laspeyres, 1809

58. Acherontia lachesis (Fabricius, 1798) (Image 5F)

Materials examined: BM-088, BM-089, BM-753, 2 males, 1 female, 10.iv.2014, 07.viii.2014, 18.ix.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-750, BM-751, 2 males, 21.iii.2014, 20.iv.2014, Bhutan, Dagana (Dagana), 27.032°N and 89.887°E, 1,580m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Chukha, Haa, Zhemgang, and Samdrup Jongkhar), eastern Pakistan, India, Sri Lanka, Nepal, Myanmar, China, Hong Kong, southern Japan, Thailand, Laos, Vietnam, Malaysia, The Philippines, and Indonesia to Papua New Guinea.

59. Acherontia styx (Westwood, 1848) (Image 5G)

Materials examined: BM-090, BM-762, 2 males, 11.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang, Dagana, and Pemagatshel), Pakistan, Nepal, India, Bangladesh, Myanmar, China, northern Thailand, Iran to Saudi Arabia, and Iraq.

Image 5. A - *Antheraea (Antheraea) helferi* Moore, 1858 | B - *Salassa lola* (Westwood, 1847) | C - *S. bhutanensis* Brechlin, 2009 | D - *S. belinda* Witt & Pugaev, 2007 | E - *S. thespis* (Leech, 1890)* | F - *Acherontia lachesis* (Fabricius, 1798) | G - *A. styx* (Westwood, 1848) | H - *Agrius convolvuli* (Linnaeus, 1758) | I - *Apocalypsis velox velox* (Butler, 1876) | J - *Psilogramma increta* (Walker, 1865) | K - *P. discistriga discistriga* (Walker, 1856). Species marked with "*" incates new record to Bhutan.

Genus *Agrius* Hübner, [1819]

60. Agrius convolvuli (Linnaeus, 1758) (Image 5H)

Materials examined: BM-99, BM-100, BM-101, BM-102, BM-108, BM-110, 6 males, 26.ix.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Wangdue Phodrang, Trongsa, Phuentsholing, and Thimphu), Pakistan, India, Sri Lanka, Myanmar, China, Hong Kong, Malaysia, Indonesia, Africa, Australia, the Pacific, and southern Europe. Migratory in Mongolia, Siberia, and Japan.

Genus *Apocalypsis* Rothschild & Jordan, 1903

61. Apocalypsis velox velox (Butler, 1876) (Image 5I)

Materials examined: BM-086, BM-087, 2 males, 18.vi.2014, 20.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-689, 1 male, 23.vi.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Dagana), northeastern India, southwestern China, and northern Vietnam.

Genus *Psilogramma* Rothschild & Jordan, 1903

62. Psilogramma increta (Walker, 1865) (Image 5J)

Materials examined: BM-92, BM-93, 2 males, 13.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Wangdue Phodrang, and Trashigang), northern Pakistan, northwestern India, Nepal, Myanmar, Thailand, Laos, Vietnam, Taiwan, Hong Kong, eastern China to Korea, and Japan.

63. Psilogramma discistriga discistriga (Walker, 1856) (Image 5K)

Materials examined: BM-94, 1 male, 3.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-111, BM-112, 2 males, 21.iii.2014, 20.iv.2014, Dagana (Dagana), 27.032°N and 89.887°E, 1,580m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Samdrup Jongkhar, and Zhemgang), northern and northeastern India, Nepal, China, Hong Kong, Taiwan, Thailand, Laos, Vietnam, Indonesia, and The Philippines.

Genus *Sphinx* Linnaeus, 1758

64. Sphinx bhutana Brechlin, 2015

Materials examined: None.

Distribution: Bhutan (Paro).

Remarks: This species was not recorded in the study.

65. Sphinx oberthueri (Rothschild & Jordan, 1903)

Materials examined: None.

Distribution: Bhutan (Thimphu) and central and southwestern China to northern Thailand.

Remarks: This species was not recorded in the study. Recorded from Bhutan by Dierl (1975) as *Hyloicus oberthueri.*

Genus *Pseudodolbina* Rothschild, 1894

66. Pseudodolbina fo fo (Walker, 1856)

Materials examined: None.

Distribution: Bhutan, Nepal, northeastern India, Tibet, and China.

Remarks: This species was not recorded in the study.

Genus *Dolbina* Staudinger, 1877

67. Dolbina inexacta (Walker, 1856) (Image 6A)

Materials examined: BM-73, BM-74, 2 males, 29.iv.2013, 11.iv.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-322, 1 female, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Sarpang), Pakistan, northern and central India, Nepal, Myanmar, Thailand, southern China, and Taiwan.

Subfamily Smerinthinae Grote & Robinson, 1865

Genus *Marumba* Moore, [1882]

68. Marumba cristata cristata (Butler, 1875) (Image 6B)

Materials examined: BM-338, BM-339, 2 males, 29.iv.2013, 20.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-342, 1 male, 18.v.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, and Sarpang), northeastern India, Thailand, Indo-China, and China.

69. Marumba dyras dyras Walker, 1856 (Image 6C)

Materials examined: BM-34, BM-232, BM-270, 2 males, 1 female, 29.iv.2013, 24.v.2013, 20.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-32, BM-33, 2 males,16.ix.2014, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Sarpang, Trongsa, Trashiyangtse and Samdrup Jongkhar), northwestern India, Nepal, Sri Lanka, Andaman & Nicobar Islands,

Myanmar, China, Taiwan, Thailand, Vietnam, Cambodia, Laos, Peninsular Malaysia, Java, Sumatra, and The Philippines.

70. Marumba sperchius sperchius (Ménétriés, 1857) (Image 6D)

Materials examined: BM-39, 1 female, 09.v.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Zhemgang), northern Pakistan, northern India, Nepal, southwestern, central & eastern China, Taiwan, Russian Far East, North Korea, South Korea, Japan, Thailand, Laos, and northern Vietnam.

71. Marumba spectabilis spectabilis Butler, 1875 (Image 6E)

Materials examined: BM-27, BM-192, 2 males, 11.v.2013, 02.ix.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-147, 1 male, 21.iii.2015, Bhutan, Gelephu (Sarpang), 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Gelephu), northeastern India, Nepal, southern China, Thailand, Laos, Vietnam, Malaysia, and Indonesia.

Genus *Polyptychus* Hübner, [1819]

72. Polyptychus trilineatus trilineatus Moore, 1888 (Image 6F)

Materials examined: BM-178, BM-200, 2 males, 11.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-30, 1 male, 21.iii.2015, Bhutan, Damphu (Tsirang), 27.072°N and 90.109°E, 1,058m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trongsa and Trashiyangtse), northern Pakistan, Nepal, northern India, Myanmar, southern China, Thailand, and Vietnam.

73. Polyptychus dentatus (Cramer, 1777)

Materials examined: None.

Distribution: Bhutan (Trashigang and Trashiyangtse), Sri Lanka, India, and Pakistan.

Remarks: This species was not recorded in the study.

Genus *Langia* Moore, 1872

74. Langia zenzeroides zenzeroides Moore, 1872

Materials examined: None.

Distribution: Bhutan (Trashiyangtse), Pakistan, India, Nepal, eastern and southern China, South Korea, northern Thailand, and Vietnam.

Remarks: This species was not recorded in the study. Recently recorded from Yangtse Town, Trashiyangtse, eastern Bhutan, by Irungbam & Norbu (2019).

Genus *Rhodoprasina* Rothschild & Jordan, 1903

75. Rhodoprasina nenulfascia Zhu & Wang, 1997

Materials examined: None.

Distribution: Bhutan (Mongar), northeastern India (Arunachal Pradesh), and China (Tibet).

Remarks*:* This species was not recorded in the study. Specimens from Bhutan were described by Brechlin (2010b) as *Rhodoprasina koerferi*, but this taxon was synonymized with *R. nenulfascia* by Řézáč (2018).

76. Rhodoprasina floralis (Butler, 1876)*(Image 6G)

Materials examined: 1 male (image record), 11.v.2014, Bhutan, Gelephu (Sarpang), 26.884°N and 90.464°E, 329m (Image by J.S. Irungbam).

Distribution: Bhutan (Gelephu), northern India, and Nepal.

Remarks: A new country record for Bhutan.

Genus *Cypoides* Matsumura, 1921

77. Cypoides parachinensis Brechlin, 2009d (Image 6H)

Materials examined: BM-26, 1 male, 11.v.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-25, 1 male, 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.456°N and 90.489°E, 1,165m, coll. J.S. Irungbam

Distribution: Bhutan (Mendrelgang, Trongsa, and Zhemgang), northeastern India (Arunachal Pradesh), China (Tibet), and northern Myanmar.

Genus *Callambulyx* Rothschild & Jordan, 1903

78. Callambulyx poecilus Rothschild, 1898 (Image 6I)

Materials examined: BM-21, BM-22, 2 males, 27.iv.2013, 12.ix.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-158, 1 male, 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.456°N and 90.489°E, 1,165m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Trongsa), Pakistan, Nepal, and northeastern India.

79. Callambulyx rubricosa (Walker, 1856)(Image 6J)

Materials examined: BM-19, BM-20, males, 15.vi.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-160, 1 male, 21.iii.2014, Bhutan, Dagana (Dagana), 27.032°N

Image 6. A - *Dolbina inexacta* Walker, 1856 | B - *Marumba cristata cristata* (Butler, 1875) | C - *M. dyras dyras* Walker, 1856 | D - *M. sperchius sperchius* (Ménétriés, 1857) | E - *M. spectabilis spectabilis* Butler, 1875 | F - *Polyptychus trilineatus trilineatus* Moore, 1888 | G - *Rhodoprasina floralis* (Butler, 1876)* | H - *Cypoides parachinensis* Brechlin, 2009c | I - *Callambulyx poecilus* Rothschild, 1898 | J - *C. rubricosa* (Walker, 1856) | K - *C. junonia* (Butler, 1881) | L - *Clanis hyperion bhutana* Brechlin, 2014c | M - *C. titan* Rothschild & Jordan, 1903 | N - *C. undulosa gigantea* Rothschild, 1894 | O - *Ambulyx ochracea* Butler, 1885.

and 89.887°E, 1,580m, coll. J.S. Irungbam

Distribution: Bhutan (Mendrelgang, Dagana, and Paro), Nepal, northeastern India, Thailand, and Vietnam.

80. Callambulyx junonia (Butler, 1881) (Image 6K)

Materials examined: BM-161, 1 male, 15.v.2015, Bhutan, Damphu (Tsirang), 27.072°N and 90.109°E, 1,058m, coll. J.S. Irungbam; BM-128, 1 male, 26.vii.2014, Bhutan, Damthang (Haa), 27.430°N and 89.199°E, 3,414m, coll. Irungbam J.S & Bhakta G.

Distribution: Bhutan (Tsirang, Trongsa, Paro, Haa and Samtse), northeastern India, southern China, northern Thailand, and northern Vietnam.

Genus *Anambulyx* Rothschild & Jordan, 1903

81. Anambulyx elwesi (Druce, 1882)

Materials examined: None.

Distribution: Bhutan (Trashigang and Trashiyangtse), northern Pakistan, northern India, Nepal, southwestern China, Myanmar, northern Thailand, and northern Vietnam.

Remarks: This species was not recorded in the study.

Genus *Sataspes* Moore, [1858]

82. Sataspes infernalis (Westwood, 1848)

Materials examined: None.

Distribution: Bhutan (Zhemgang?), southern and eastern India, Bangladesh, Nepal, Myanmar, China, Hong Kong, Thailand, Vietnam, Borneo, and Java.

Remarks: This species was not recorded in the study.

Genus *Clanis* Hübner, [1819]

83. Clanis hyperion bhutana Brechlin, 2014c (Image 6L)

Materials examined: BM-60, 1 male, 13.v.2012. Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m.

Distribution: Bhutan (Tsirang and Zhemgang), northeastern India, southern China, and northern Thailand.

Remarks: Reported the species for the first time from Bhutan by Singh & Kitching (2014).

84. Clanis titan Rothschild & Jordan, 1903 (Image 6M)

Materials examined: BM-125, 1 male, 12.vi.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-321, 1 male, 18.v.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Samdrup Jongkhar, and Zhemgang), southern and northeastern India, Nepal, Myanmar, northern Thailand, Peninsular Malaysia, and Sumatra.

85. Clanis undulosa gigantea Rothschild, 1894 (Image 6N)

Materials examined: BM-61, 1 male, 29.ix.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-302, 1 male, 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.455°N and 90.489°E, 1,924m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trongsa, and Zhemgang), northeastern India, Nepal, Thailand, and Peninsular Malaysia.

Genus *Clanidopsis* Rothschild & Jordan, 1903

86. Clanidopsis exusta (Butler, 1875)

Materials examined: None.

Distribution: Bhutan (Trashigang), northern Pakistan, northwestern India, central Nepal, and China (Tibet).

Remarks: This species was not recorded in the study. Recently recorded from Lungten Zampa Village, Trashigang, eastern Bhutan, by Jamtsho & Irungbam (2019).

Genus *Ambulyx* Westwood, 1847

87. Ambulyx bhutana Brechlin, 2014b

Materials examined: None.

Distribution: Bhutan (Trongsa).

Remarks: This species was not recorded in the study.

88. Ambulyx ochracea Butler, 1885 (Image 6O)

Materials examined: BM-05, BM-06, BM-07, 2 males, 1 female, 18.vi.2014, 12.ix.2014, 20.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-10, 1 male, 07.iv.2015, Bhutan, Damphu (Tsirang), 27.072°N and 90.109°E, 1,058m, coll. J.S. Irungbam; BM-08, 1 male, 10.iv.2014, Bhutan, Dagana (Dagana), 27.032°N and 89.887°E, 1,580m, coll. J.S. Irungbam & M.J. Irungbam; BM-09, 1 male, 20.v.2015, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Sarpang, Chukha, and Samdrup Jongkhar), northeastern India, Nepal, China, Taiwan, Hong Kong, Thailand, Vietnam, Cambodia, Laos, Japan, and Korea.

89. Ambulyx substrigilis (Westwood, 1848) (Image 7A)

Materials examined: BM-01, BM-02, 2 males, 27.ix.2013, 15.vi.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-152, BM-153, 1 male, 1 female, 15.iii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m; BM-154, 1 female, 21.ix.2015, Bhutan, Gelephu (Sarpang), 26.897°N and 90.212°E, 329m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, and Sarpang), northern and southern India, Nepal, Bangladesh, Thailand, Vietnam, Peninsular Malaysia, Borneo, Sumatra, Sri Lanka, and The Philippines (Palawan).

90. Ambulyx liturata Butler, 1875 (Image 7B)

Materials examined: BM-03, BM-04, 1 male, 1 female, 10.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Zhemgang), northeastern India, Nepal, Myanmar, southern China, Hong Kong, Thailand, Vietnam, Cambodia, and Laos.

91. Ambulyx maculifera Walker, 1866 (Image 7C)

Materials examined: MB-186, MB-187, 2 males, 15.v.2015, Bhutan, Damphu (Tsirang), 27.072°N and 90.109°E, 1,058m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang), India, and Nepal.

92. Ambulyx sericeipennis sericeipennis Butler, 1875 (Image 7D)

Materials examined: BM-132, 1 male, 12.ix.2013, Bhutan, Damphu (Tsirang), 27.072°N and 90.109°E, 1,058m, coll. J.S. Irungbam & M.J. Irungbam; BM-75, 1 male, 15.iii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam; BM-68, 1 male, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, and Sarpang), northern Pakistan, Nepal, northern India, Myanmar, China, Thailand, Laos, Cambodia, Vietnam, Taiwan, Java, and The Philippines.

Genus *Amplypterus* Hübner, [1819]

93. Amplypterus panopus panopus (Cramer, 1779) (Image 7E)

Materials examined : BM-17, 1 male, 17.vi.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-16, 1 male, 15.iii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, and Samdrup Jongkhar), Nepal, India, Sri Lanka, Myanmar, Thailand, Cambodia, Laos, Vietnam, China, Sundaland, and The Philippines.

94. Amplypterus mansoni mansoni (Clark, 1924) * (Image 7F)

Materials examined: BM-15, 1 male, 06.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; 1 female (image record), 15.v.2015, Bhutan, Darachu (Tsirang), Gelephu-Thimphu Highway, 26.947°E and 90.203°N, 1,866m (Image by I. Kehimkar).

Distribution: Bhutan (Tsirang and Sarpang), northeastern India, Nepal, Thailand, Vietnam, Sumatra, and Malaysia.

Remarks: A new country record for Bhutan.

Subfamily Macroglossinae Harris, 1839

Genus *Cephonodes* Hübner, [1819]

95. Cephonodes hylas hylas (Linnaeus,1771)

Materials examined: None.

Distribution: Bhutan, northern Pakistan, India, Nepal, Sri Lanka, Myanmar, China, South Korea, southern Japan, Thailand, Laos, Vietnam, Indonesia, Taiwan, Hong Kong, Peninsular Malaysia, The Philippines, and Russian Far East.

Remarks: This species was not recorded in the study.

Genus *Neogurelca* Hogenes & Treadaway, 1993

96. Neogurelca hyas (Walker, 1856)

Materials examined: None.

Distribution: Bhutan, India, Nepal, Myanmar, central and southern China, Taiwan, southern Japan, Thailand, Vietnam, Malaysia, Indonesia, and The Philippines.

Remarks: This species was not recorded in the study.

97. Neogurelca masuriensis (Butler, 1875)

Materials examined: None.

Distribution: Bhutan (Thimphu), northwestern and northern India, and China (Yunnan).

Remarks: This species was not recorded in the study.

Genus *Nephele* Hübner, [1819]

98. Nephele hespera (Fabricius, 1775) (Image 7G)

Materials examined: BM-81, 1 male, 28.iv.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang), Afghanistan, Pakistan, Sri Lanka, India, Nepal, the Andaman Islands, Myanmar,

Image 7. A - *Ambulyx substrigilis* (Westwood, 1848) | B - *A. liturata* Butler, 1875 | C - *A. maculifera* Walker, 1866 | D - *A. sericeipennis sericeipennis* Butler, 1875 | E - *Amplypterus panopus panopus* (Cramer, 1779) | F - *A. mansoni mansoni* (Clark, 1924)* | G - *Nephele hespera* (Fabricius, 1775) | H - *Daphnis hypothous crameri* Eitschberger & Melichar, 2010 | I - *Elibia dolichoides* (C. & R. Felder, 1874) | J - *Ampelophaga rubiginosa rubiginosa* Bremer & Grey, 1853 | K - *A. khasiana* Rothschild, 1895 | L - *Eupanacra variolosa* (Walker, 1856) | M - *E. metallica* (Butler, 1875) | N - *Acosmeryx anceus subdentata* Rothschild & Jordan, 1903 | O - *A. naga naga* (Moore, [1858]).

southern China, Hong Kong, Thailand, Vietnam, Laos, Peninsular Malaysia, Sumatra, and Java.

Genus *Hayesiana* Fletcher, 1982

99. Hayesiana triopus (Westwood, 1847)

Materials examined: None.

Distribution: Bhutan (Zhemgang and Sarpang), Nepal, northeastern India, southern China, Hong Kong, Thailand, northern Vietnam, and Peninsular Malaysia.

Genus *Eurypteryx* C. & R. Felder, 1874

100. Eurypteryx bhaga (Moore, [1866])

Materials examined: None.

Distribution: Bhutan, Nepal, northeastern India, southwestern to central China, Thailand, Malaysia, Sumatra, Java, and Kalimantan.

Remarks: This species was not recorded in the study.

Genus *Daphnis* Hübner, [1819]

101. Daphnis hypothous crameri Eitschberger & Melichar, 2010 (Image 7H)

Materials examined: 1 male (image record), 08.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).; 1 male (image record), 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m (Image by Namgyel D.).

Distribution: Bhutan (Tsirang, Trongsa, Sarpang, and Zhemgang), India, Nepal, Sri Lanka, Myanmar, southern China, Taiwan, Hong Kong, The Philippines, Thailand, Malaysia, western Indonesia, and the Western Palearctic region.

Genus *Elibia* Walker, 1856

102. Elibia dolichoides (C. & R. Felder, 1874) (Image 7I)

Materials examined: 1 male (image record), 03.ix.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Zhemgang), northeastern India, Nepal, Thailand, and Peninsular Malaysia.

Genus *Ampelophaga* Bremer & Grey, 1853

103. Ampelophaga rubiginosa rubiginosa Bremer & Grey, 1853 (Image 7J)

Materials examined: BM-50, BM-135, 2 males, 19.ix.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Trashigang, and Zhemgang), northeastern Afghanistan, Pakistan, India, Nepal, Myanmar, China, Korean Peninsula, the Russian Far East, Japan, Thailand, Hong Kong, Laos, Vietnam, Peninsular Malaysia, and northern Sumatra.

104. Ampelophaga khasiana Rothschild, 1895 (Image 7K)

Materials examined: BM-287, 1 male, 12.ix.2013, Bhutan, Langthel (Trongsa), Sarpang-Gelephu-Trongsa Highway, 27.456°N and 90.489°E, 1,165m, coll. J.S. Irungbam

Distribution: Bhutan (Trongsa and Zhemgang), Nepal, northeastern India, Myanmar, and China.

Genus *Eupanacra* Cadiou & Holloway, 1989

105. Eupanacra perfecta perfecta (Butler, 1875)

Materials examined: None.

Distribution: Bhutan (Tsirang), northeastern India, Myanmar, southwestern China, Thailand, and Vietnam.

Remarks: This species was not recorded in the study.

106. Eupanacra variolosa (Walker, 1856) (Image 7L)

Material examined: BM-80, 1 male, 11.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan, India, Bangladesh, southwestern China, Thailand, Malaysia, and Indonesia.

107. Eupanacra metallica (Butler, 1875) (Image 7M)

Materials examined: 1 male (image record), 02.x.2014, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m (Image by Namgyel D.).

Distribution: Bhutan (Tsirang, Dagana and Trashiyangtse), India, Nepal, Bangladesh, Myanmar, and China.

108. Eupanacra mydon (Walker, 1856)

Materials examined: None.

Distribution: Bhutan, Nepal, northeastern India, Bangladesh, Myanmar, China, Thailand, Vietnam, and Peninsular Malaysia.

Remarks: This species was not recorded in the study.

109. Eupanacra busiris busiris (Walker, 1856)

Materials examined: None.

Distribution: Bhutan (Tsirang), Nepal, northeastern India, Bangladesh, Myanmar, Thailand, southern China, Laos, Vietnam, Malaysia, and Indonesia.

Genus *Acosmeryx* Boisduval, [1875]

110. Acosmeryx anceus subdentata Rothschild & Jordan, 1903 (Image 7N)

Materials examined: BM-42, BM-43, 1 male, 1 female, 12.v.2013, 10.xi.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-146, 1 female, 20.iv.2014, Bhutan, Dagana (Dagana), 27.032°N and 89.887°E, 1,580m, coll. J.S. Irungbam; BM-148, 1 male, 16.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam.

Distribution: Bhutan (Tsirang, Dagana, Sarpang, and Zhemgang), India, Nepal, China, Thailand, Vietnam, Malaysia, Indonesia, and The Philippines.

111. Acosmeryx naga naga (Moore, [1858]) (Image 7O)

Materials examined: BM-47, BM-49, 2 males, 21.v.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-48, 1 male, 16.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Sarpang, Zhemgang, and Trongsa), India, Nepal, Thailand, Malaysia, Vietnam, China, Taiwan, Korea, Japan, and Russian Far East.

112. Acosmeryx pseudonaga Butler, 1881 (Image 8A)

Materials examined: BM-52, BM-53, 1 male, 1 female, 21.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-51, 1 female, 20.iv.2014, Bhutan, Dagana (Dagana), 27.032 N and 89.887°E, 1,580m, coll. J.S. Irungbam; BM-112, 1 male, 16.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Dagana, Sarpang, and Zhemgang), western and northeastern India, China, Thailand, Laos, Malaysia, and Indonesia.

113. Acosmeryx shervillii Boisduval, 1875 (Image 8B)

Materials examined: BM-44, 1 male, 09.ix.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang Trashigang and Samdrup Jongkhar) Nepal, northern India, Sri Lanka, southern China, Hong Kong, Thailand, Vietnam, Peninsular Malaysia, Sumatra, Borneo, and Java.

114. Acosmeryx omissa Rothschild & Jordan, 1903 (Image 8C)

Materials examined: BM-40, BM-41, 2 males, 02.xii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trashigang, and Samdrup Jongkhar), Nepal, northeastern India, northern Thailand, and Vietnam.

115. Acosmeryx sericeus (Walker, 1856) (Image 8D)

Materials examined: BM-45, BM-46, 2 males, 29.iv.2013, 27.iv.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang), Nepal, northeastern India, Bangladesh, southern China, Thailand, Vietnam, and Peninsular Malaysia.

Genus *Acosmerycoides* Mell, 1922

116. Acosmerycoides harterti (Rothschild, 1895) * (Image 8E)

Materials examined: BM-97, 1 male, 21.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-186, 1 male, 18.vii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Dagana), northeastern India, Myanmar, China, Taiwan, Malaysia, Thailand, Laos, and Vietnam.

Remarks: A new country record for Bhutan.

Genus *Dahira* Moore, 1888

117. Dahira sinyaevorum Brechlin, 2014a

Materials examined: None.

Distribution: Bhutan (Trongsa, Zhemgang, and Samdrup Jongkhar).

Remarks: This species was not recorded in the study.

118. Dahira marisae Schnitzler & Stüning, 2009

Materials examined: None.

Distribution: Bhutan (Thimphu).

Remarks: This species was not recorded in the study.

119. Dahira yunnanfuana (Clark, 1925)

Materials examined: None

Distribution: Bhutan (Thimphu), Nepal, Myanmar, and China.

Remarks: This species was not recorded in the study. It was recorded from Bhutan as *Acosmeryx montivaga* Kernbach, 1966 by Dierl (1975), which is now synonymous with *Dahira yunnanfuana*. Occurs along the southeastern slopes of the Himalaya.

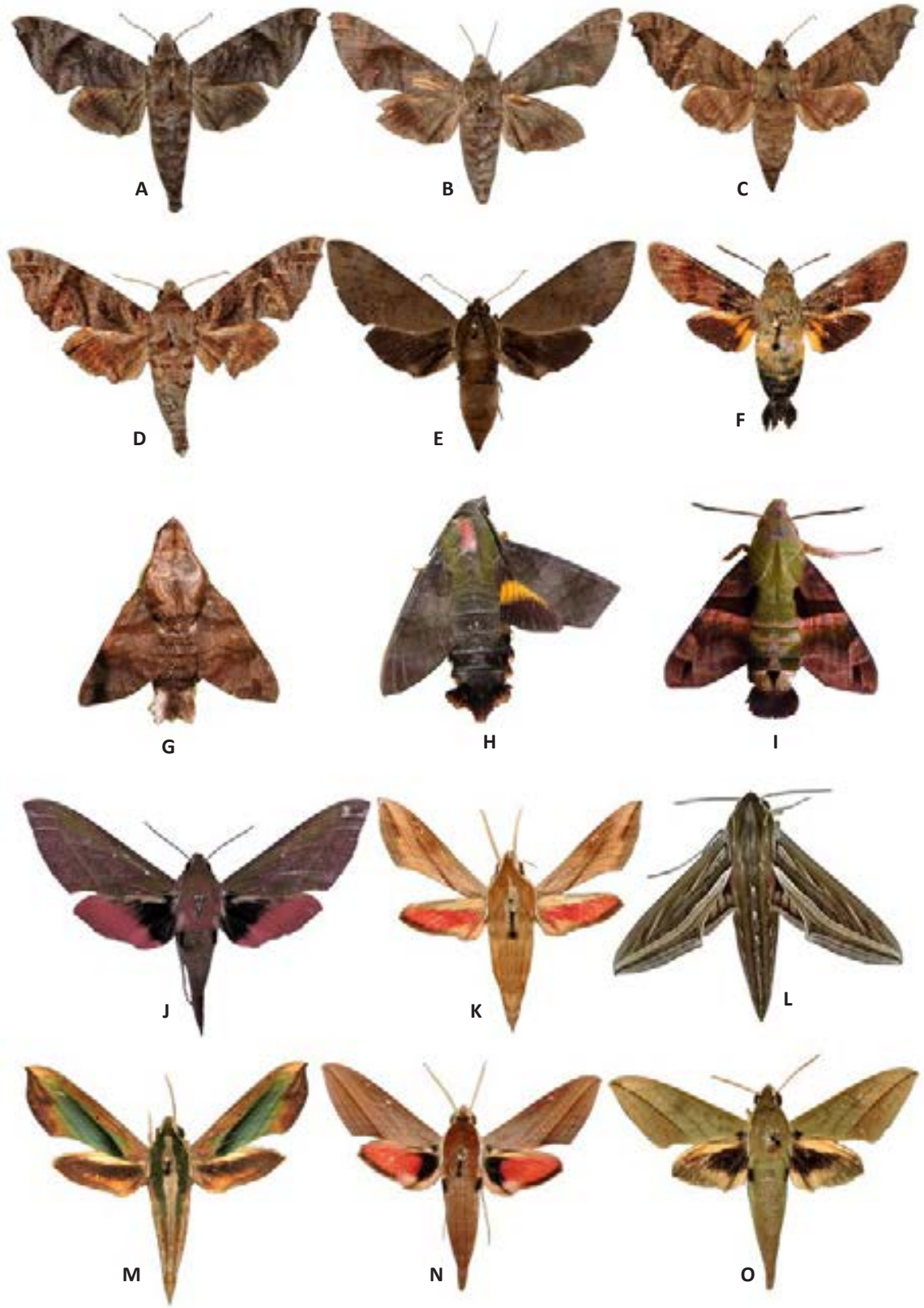

Image 8. A - *Acosmeryx pseudonaga* Butler, 1881 | B - *A. shervillii* Boisduval, 1875 | C - *A. omissa* Rothschild & Jordan, 1903 | D - *A. sericeus* (Walker, 1856) | E - *Acosmerycoides harterti* (Rothschild, 1895)* | F - *Macroglossum bombylans* Boisduval, 1875 | G - *M. neotroglodytus* Kitching & Cadiou, 2000 | H - *M. corythus corythus* Walker, 1856 | I - *M. sitiene* Walker, 1856 | J - *Deilephila elpenor* (Linnaeus, 1758) | K - *Hippotion rosetta* (Swinhoe, 1892) | L - *H. celerio* (Linnaeus, 1758)* | M - *Pergesa acteus* (Cramer, 1777) | N - *Theretra alecto* (Linnaeus, 1758) | O - *T. clotho clotho* (Drury, 1773). Species marked with "*" incates new record to Bhutan.

Genus *Macroglossum* Scopoli, 1777

120. Macroglossum bombylans Boisduval, 1875 (Image 8F)

Materials examined: BM-78, BM-79, 2 males, 30.iii.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang), Nepal, India, China, Taiwan, Hong Kong, Korea, Japan, northern Thailand, northern Vietnam, and The Philippines.

121. Macroglossum neotroglodytus Kitching & Cadiou, 2000 (Image 8G)

Materials examined: 1 male (image record), 16.iii.2013, 05.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Trongsa), Nepal, southern and northeastern India, Sri Lanka, S China,Taiwan, Thailand, Peninsular Malaysia, Indonesia (Sumatra, Java, and Sulawesi), and The Philippines.

122. Macroglossum nycteris Kollar, 1844

Materials examined: None.

Distribution: Bhutan (Tsirang and Haa), Afghanistan, Pakistan, Nepal, India, northern Myanmar, and China.

Remarks: This species was not recorded in the study.

123. Macroglossum corythus corythus Walker, 1856 (Image 8H)

Materials examined: 1 male (image record), 18.viii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Samdrup Jongkhar), Nepal, western and northeastern India, Bangladesh, Andaman Islands, eastern and southern China, Japan, Taiwan, Hong Kong, Thailand, Vietnam, Malaysia, Indonesia, The Philippines, Wallacea, and Sundaland.

124. Macroglossum sitiene Walker, 1856 (Image 8I)

Materials examined: 1 male (image record), 26.vii.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by Gyeltshen); 1 male (image record), 18.xi.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang, Lhamoyzingkha, and Sarpang), India, Bangladesh, Sri Lanka, Myanmar, southern China, Taiwan, Hong Kong, southern Japan, Thailand, Vietnam, Peninsular Malaysia, and Indonesia (Sumatra).

125. Macroglossum belis (Linnaeus, 1758)

Materials examined: None.

Distribution: Bhutan, northern Pakistan, Nepal, India, Sri Lanka, Bangladesh, Myanmar, China, Taiwan, Hong Kong, Thailand, Laos, Vietnam, and Japan.

Remarks: This species was not recorded in the study.

126. Macroglossum pyrrhosticta Butler, 1875

Materials examined: None.

Distribution: Bhutan, Nepal, eastern India, Sri Lanka, China, South Korea, North Korea, Japan, the southern Russian Far East, Taiwan, Hong Kong, Thailand, Vietnam, Malaysia (Sarawak), Indonesia, The Philippines, and Sundaland.

Remarks: This species was not recorded in the study.

Genus *Hyles* Hübner, [1819]

127. Hyles gallii (Rottemburg, 1775)

Materials examined: None.

Distribution: Bhutan (Wangdue Phodrang?), temperate Europe (resident), temperate Russia, southwestern Mongolia, northern China (Tibet), Korea, northern Japan, northern Turkey, The Caucasus, Tajikistan, Kyrgyzstan, Afghanistan, eastern Kazakhstan, northern Pakistan, and Nepal. This species is also present in the USA and Canada.

Genus *Deilephila* Laspeyres, 1809

128. Deilephila elpenor (Linnaeus, 1758) (Image 8J)

Materials examined: BM-226, IJ-331, 2 males, 21.vi.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Thimphu and Tsirang), Palearctic region from western Europe to the Russian Far East and Japan, south and west through China to Nepal, northeastern India, Bangladesh, northern Myanmar, northern Thailand, and northern Vietnam.

Genus *Hippotion* Hübner, [1819]

129. Hippotion boerhaviae (Fabricius, 1775)

Materials examined: None.

Distribution: Bhutan (Wangduephodrang), northeastern Pakistan, India, Sri Lanka, Nepal, Thailand, southeastern China, Vietnam, The Philippines, Indonesia, New Guinea, eastern Australia, The Solomon Islands, and New Caledonia.

Remarks: This species was not recorded in the study.

130. Hippotion rosetta (Swinhoe, 1892) (Image 8K)

Materials examined: BM-75, BM-224, 1 male, 1 female, 09.vii.2012, 11.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Trongsa, and Zhemgang), southern Pakistan, India, Sri Lanka, Thailand, China, Taiwan, Hong Kong, southern Japan, The Philippines, Maldives Islands, Andaman Islands, The Solomon Islands, and New Guinea.

131. Hippotion celerio (Linnaeus, 1758) * (Image 8L)

Materials examined: 1 female (image record), 11.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang), Africa, southern Europe, Arabian Peninsula, Pakistan, India, Nepal, Australia, southern China, Hong Kong, and southern Japan.

Remarks: A new country record for Bhutan.

132. Hippotion rafflesii rafflesii (Moore, [1858])

Materials examined: None.

Distribution: Bhutan, Nepal, southern and eastern India, Sri Lanka, Myanmar, Thailand, southern China, Peninsular Malaysia, Sumatra, Java, Sulawesi, and The Philippines.

Remarks: This species was not recorded in the study.

Genus *Pergesa* Walker, 1856

133. Pergesa acteus (Cramer, 1777) (Image 8M)

Materials examined: BM-70, BM-71, 2 males, 06.ix.2013, 11.viii.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Zhemgang), Nepal, India, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Japan, Thailand, Peninsular Malaysia, Indonesia, Sundaland, Moluccas, and The Philippines.

Genus *Theretra* Hübner, [1819]

134. Theretra alecto (Linnaeus, 1758) (Image 8N)

Materials examined: BM-59, 1 male, 07.vi.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-146, 1 female, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 692m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang, Sarpang, Zhemgang, and Trashigang), Pakistan, Nepal, India, Sri Lanka, China, Taiwan, Hong Kong, Japan, The Philippines, Indonesia, Greece, Bulgaria, Turkey, Iran, Turkmenistan, Uzbekistan, Kyrgyzstan, Afghanistan, Iraq, Lebanon, Israel, and Egypt.

135. Theretra clotho clotho (Drury, 1773)(Image 8O)

Materials examined: BM-58, BM-59, 2 males, 12.ix.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Chukha), northern Pakistan, Nepal, India, Sri Lanka, Myanmar, China, Hong Kong, Japan, Indonesia, the Philippines, and Sundaland.

136. Theretra tibetiana Vaglia & Haxaire, 2010* (Image 9A)

Materials examined: BM-221, BM-223, 2 males, 12.ix.2012, 12.ix.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam.

Distribution: Bhutan (Tsirang), northeastern India, China (Tibet), Thailand, and northern Vietnam.

Remarks: A new country record for Bhutan and range extension to Bhutan from its earlier known distribution range.

137. Theretra nessus nessus (Drury, 1773) (Image 9B)

Materials examined: BM-54, BM-56, BM-220, 2 males, 1 female, 20.vi.2013, 10.ix.2014, 07.x.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-98, BM-219, 2 males, 16.viii.2015, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam; 1 female (image record), 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 692m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang, Dagana, Sarpang, and Chukha), India, Nepal, Sri Lanka, Myanmar, southern China, Taiwan, Thailand, Vietnam, South Korea, Japan, Malaysia, Singapore, Indonesia, Sundaland, the Philippines, and Australia.

138. Theretra oldenlandiae oldenlandiae (Fabricius, 1775) (Image 9C)

Materials examined: BM-85, 1 male, 10.ix.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; 1 male (image record), 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 692m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang and Sarpang), northern Afghanistan, northern Pakistan, Nepal, India, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Vietnam, South Korea, Japan, The Solomon Islands, New Guinea, and The Philippines.

139. Theretra silhetensis silhetensis (Walker, 1856) * (Image 9D)

Materials examined: 1 male (image record), 08.ix.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N

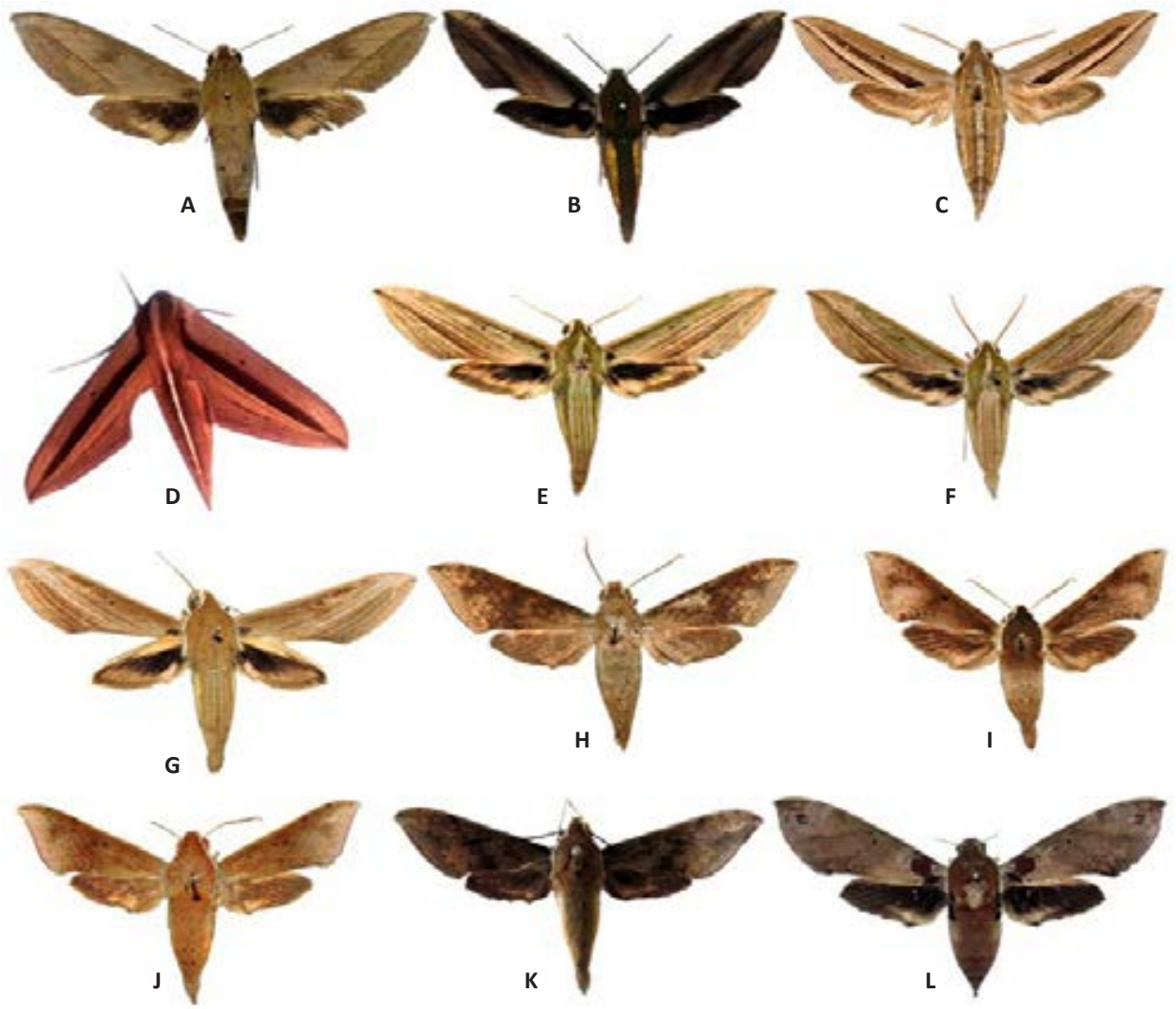

Image 9. A - *Theretra tibetiana* Vaglia & Haxaire, 2010* | B - *T. nessus nessus* (Drury, 1773) | C - *T. oldenlandiae oldenlandiae* (Fabricius, 1775) | D - *T. silhetensis silhetensis* (Walker, 1856)* | E & F - *C. lineosa* (Walker, 1856) | G - *C. minor minor* (Butler, 1875) | H - *Rhagastis velata* (Walker, 1866) | I - *Rhagastis velata* (Walker, 1866) (dark form) | J - *R. albomarginatus albomarginatus* (Rothschild, 1894) | K - *R. castor aurifera* (Walker, 1856) | L - *Cechenena helops helops* (Walker, 1856)*. Species marked with "*" incates new record to Bhutan.

and 90.114°E, 1,233m (Image by J.S. Irungbam); 1 male (image record), 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 692m (Image by J.S. Irungbam).

Distribution: Bhutan (Tsirang, Samtse, and Sarpang), India, Nepal, Bangladesh, Sri Lanka, Myanmar, the Andaman Islands, Thailand, China, Taiwan, Japan, Vietnam, Malaysia, and Indonesia.

Remarks: A new country record for Bhutan.

Genus *Cechetra* Zolotuhin & Ryabov, 2012

140. Cechetra scotti (Rothschild, 1920)

Materials examined: None.

Distribution: Bhutan (Tsirang and Trongsa), Pakistan, Nepal, India, southwestern China, and northern Vietnam.

Remarks: This species was not recorded in the study.

141. Cechetra lineosa (Walker, 1856) (Image 9E,F)

Materials examined: BM-81, BM-82, 1 male, 1 female, 28.iv.2014, 10.v.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam; BM-83, 1 male, 08.v.2013, Bhutan, Dagapela (Dagana), 26.941°N and 89.922°E, 1,576m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Dagana), northern India, Nepal, Bangladesh, Myanmar, Thailand, southern China, Taiwan, Vietnam, Malaysia, Indonesia (Sumatra, Java, and Kalimantan).

142. Cechetra minor (Butler, 1875) (Image 9G)

Materials examined: BM-72, BM-76, 1 male, 1 female, 20.iv.2014, 15.v.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and eastern Bhutan), India, Nepal, Thailand, China, Taiwan, Japan, and Vietnam.

143. Cechetra bryki Ivshin & Krutov, 2018

Materials examined: None.

Distribution: Bhutan, Nepal, northeastern India, Myanmar, southwestern China (Yunnan), Laos, and northern Vietnam.

Genus *Rhagastis* Rothschild & Jordan, 1903

144. Rhagastis velata (Walker, 1866) (Image 9H,I)

Materials examined: BM-64, BM-65, 2 males, 22.vii.2013, 14.i.2015, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; 1 male, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang and Sarpang), Nepal, northeastern India, Thailand, China, and Taiwan.

145. Rhagastis albomarginatus albomarginatus (Rothschild, 1894) (Image 9J)

Materials examined: BM-68, 1 male, 15.iv.2013, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam; BM-69, 1 female, 20.ix.2014, Bhutan, Sarpang Tar (Sarpang), Tsirang-Sarpang-Gelephu Highway, 26.897°N and 90.212°E, 829m, coll. J.S. Irungbam.

Distribution: Bhutan (Tsirang, Sarpang, and Samdrup Jongkhar), India, Nepal, China, Taiwan, Hong Kong, Myanmar, Sumatra, Java, and Borneo.

146. Rhagastis castor aurifera (Walker, 1856) (Image 9K)

Materials examined: BM-66, BM-67, 2 males, 22.iii.2012, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam

Distribution: Bhutan (Tsirang), Nepal, northeastern India, Thailand, southern China, and Vietnam.

147. Rhagastis olivacea (Moore, 1857)

Materials examined: None.

Distribution: Bhutan (Tsirang), northeastern Pakistan, northern India, Nepal, Myanmar, northern Thailand, Laos, northern Vietnam, and southern China.

Remarks: This species was not recorded in the study.

148. Rhagastis gloriosa (Butler, 1875)

Materials examined: None.

Distribution: Bhutan (Tsirang and eastern Bhutan), Nepal, northeastern India, Myanmar, China, Thailand, and Vietnam.

Remarks: This species was not recorded in the study.

Genus *Cechenena* Rothschild & Jordan, 1903

149. Cechenena aegrota (Butler, 1875)

Materials examined: None.

Distribution: Bhutan, Nepal, northeastern India, Bangladesh, southern China, Hong Kong, Thailand, Vietnam, Laos, and Vietnam.

Remarks: This species was not recorded in the study.

150. Cechenena helops helops (Walker, 1856) * (Image 9L)

Materials examined: BM-95, BM-96, 2 males, 03.ix.2014, 29.xi.2014, Bhutan, Mendrelgang (Tsirang), 26.950°N and 90.114°E, 1,233m, coll. J.S. Irungbam & M.J. Irungbam

Distribution: Bhutan (Tsirang), Nepal, northeastern India, Thailand, southwestern China, Vietnam, Malaysia, Indonesia, and The Philippines.

Remarks: A new country record for Bhutan.

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SHORT COMMUNICATION

First camera trap documentation of the Crab-eating Mongoose *Herpestes urva* (Hodgson, 1836) (Carnivora: Feliformia: Herpestidae) in Barandabhar Corridor Forest in Chitwan, Nepal

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Abstract: The systematic study in 2015 and 2016 documented the first camera trap image of the Crab-eating Mongoose *Herpestes urva* in Barandabhar Corridor Forest in Chitwan, Nepal. The corridor was divided into 88 grids, each of 1km by 1km. A pair of cameras was placed for 15 nights in each grid and the total camera trap night effort was 2,640. There were two separate events capturing three independent images and five separate events capturing seven independent images of the Crab-eating Mongoose in 2015 and 2016, respectively. Photo capture rate in camera traps were 0.01 and 0.03 respectively in 2015 and 2016. The presence of this species opens new scope for wildlife professionals and scientific communities to take further steps for its conservation.

Keywords: Camera trap ratio, camera trap survey, carnivore.

A mongoose is an agile and resilient carnivore with a long pointed face with small rounded ears, a tubular body with short legs, and a tapering bushy tail (Yonzon 2005). Four species of mongoose, namely the Small Indian Mongoose, the Indian Grey Mongoose, the Crab-eating Mongoose, and the Ruddy Mongoose, are found in Nepal (Sharma & Lamichhane 2017). The Crab-eating Mongoose *Herpestes urva* is characterized by a white stripe on its neck that runs from its cheeks to the chest (De & Chakraborty 1995). According to the IUCN Red List of Threatened Species, the population trend of this species is decreasing. It is categorized as Vulnerable in Nepal's National Red List (Jnawali et al. 2011).

The current status of the Crab-eating Mongoose within Nepal is poorly known as only a few records have been published on the species historically or recently (Thapa 2013). Jnawali et al. 2011 mentioned that the species occurs between 100m and 1300m in regions including the protected areas of the Terai and in the lowland forests of eastern Nepal; however, none of these is associated with specific detail records. Hodgson

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(1836) mentioned that the Crab-eating Mongoose was first reported as 'Gulourva' in the central and northern regions of Nepal. Fry (1925) was the first to publish the record of the mongoose with its specific locality. Additionally, Thapa (2013) confirmed the image-validated direct sighting of the Crab-eating Mongoose in eastern Sankhuwasabha District in Nepal. Further, the camera trap image of the Crab-eating Mongoose was recorded in Parsa National Park in 2017 (Sharma & Lamichhane 2017). The recent findings of Thapa (2013) and Sharma & Lamichhane (2017) validate the details mentioned by Jnawali et al. (2011).

Sharma & Lamichhane (2017) mentioned that the priority species for camera traps are large charismatic species like the Tiger *Panthera tigris* and the Leopard *P. pardus* in comparison to smaller carnivores. In Barandabhar Corridor Forest (BCF), a camera trap survey was carried out as 'Tiger and prey base monitoring in Barandabhar Corridor Forest', focusing particularly on the Bengal Tiger *Panthera tigris tigris*. The camera trap, however, also worked as a means to disclose the photographic proof for the existence of many species including smaller carnivores like the Crab-eating Mongoose. This study presents the first image documentation of the Crab-eating Mongoose using a systematic camera trap technique. Since corridors are the cornerstones of modern conservation and act as a linear strip of habitat to facilitate the movement of species through the landscape (Puth & Wilson 2001), the presence of the Crab-eating Mongoose in BCF represents its healthy functionality. The study also supports managers and researchers for future conservation actions in BCF.

Study area

BCF (87.9km^2) is the only remaining forest patch of Chitwan that joins Chitwan National Park in the south with the Mahabharat range in the north (Bhattarai & Basnet 2004). Though continuous, it is in two parts, the south and the north, from the existing Mahendra Highway. The southern part is a buffer zone and the northern part lies in the district forest area. The southern part is guarded by the Nepal Army and is enlisted as a Ramsar Site (site number 1313), as Beeshazar and associated lakes. The aim of the corridor is to mitigate the effects of local communities on conservation and vice versa (Axelsson & Andersson 2012). There are heavy populated municipalities around the corridor, namely Ratnagar Municipality in the east, Kalika in the northeast, and Bharatpur Metropolitan City in the west.

Methods

BCF was divided into 88 grids of 1km by 1km. Camera traps were systematically placed in each grid. The whole operation was completed in two shifts due to limited resources, i.e., the southern part of the corridor (59 grids) was covered in the first deployment and the northern part (29 grids) in the second deployment. In each grid, one pair of cameras was installed locating a suitable place on each side at a distance of about 4–5 m from the midline of the trail, and the installation details with GPS points were recorded. Four models of cameras, namely Reconyx 550, Moultrie 40D, Bushnell HD, and Cuddeback, were used. Each camera was checked on alternate days to ensure its functionality. The cameras were left for 15 nights in each grid (Karanth & Nicholas 2002; Pokheral 2002; Wang & MacDonald 2009; Thapa 2013; Lamichhane et al. 2014) with a sampling effort of 1,320 trap nights. The monitoring was conducted in two consecutive years, i.e., from March to April 2015 and from January to February 2016. The same method was used in both the years and the total sampling effort was doubled from 1,320 to 2,640 trap nights. All camera trap images were downloaded. The images were considered independent events if they were 30 minutes or more apart (Silver et al. 2004; Thapa 2013). The trapping rate was calculated as the number of independent images per total number of captured images per 100 trap nights (Karanth & Nicholas 2002).

Results

From a total of 44,783 camera trap images from 88 camera trap locations, we obtained seven separate events capturing 10 independent images of the Crab-eating Mongoose in BCF in two consecutive years, i.e., 2015 and 2016 (Images 1–4). In 2015, two separate events capturing three independent images of the species were recorded. One event was captured towards the south of the highway and the other was captured towards the north of the highway. Similarly, in 2016, five separate events capturing seven independent images of the species were recorded towards the north of the highway. The image was confirmed by experts in the National Trust for Nature Conservation and through the digital image archive of the Smithsonian Institute. This is the first camera trap photographic evidence of the Crab-eating Mongoose in this protected corridor. The species was captured in five different grids (Fig. 1). Seventy per cent of the total capture was from 08.00h to 12.00h, after which no camera trap images were captured (Fig. 2). The trapping ratio of 2015 was 0.01 and of 2016 was 0.03 per 100 trap nights.

Image 1. A pair of Crab-eating Mongoose captured in grid no. 67 towards north of BCF (2016).

Image 2. A pair captured in grid no. 73 towards north of BCF (2016).

Image 3. Crab-eating Mongoose captured in grid no. 18 towards south of BCF (2015).

Image 4. Crab-eating Mongoose captured in grid no. 81 towards the north of the highway (2015).

Discussion

The Crab-eating Mongoose is common in southeastern Asia except for Nepal (Than Zaw et al. 2008). The primary reason for this rarity in the country remains unclear (Thapa 2013), but it has affected the study and data of the species. Sharma & Lamichhane (2017) referred to camera traps focusing only on large charismatic mammals as the apparent reason for the mongoose species being rare and localized. Wildlife research in southeastern Asia is largely donor-dependent and the probability of the acceptance of a proposal on small carnivores like Crab-eating Mongoose is low and in the case of high budget research null and void. It is the charismatic species that receive attention from the government and the media and have higher chances of acceptance in high budget proposals. Therefore, it is obvious that the selected proposal will determine the focus of camera trap studies, as mentioned by Sharma & Lamichhane (2017).

Jnawali et al. (2011) mentioned that the mongoose species inhabits tropical, subtropical, evergreen, and moist deciduous forests and the record of the Crab-eating Mongoose from the subtropical BCF in this study supports the finding. The Crab-eating Mongooses were mostly camera-trapped during morning hours, which is typical in southeastern Asia (Than Zaw et al. 2008; Thapa 2013). The species was captured only on sunny days. Chuang & Lee (1997) mentioned fishes, reptiles, amphibians, and crustaceans as the prey species of the Crab-eating Mongoose. These are all cold-blooded species and hence are active on sunny days. We do not have a single camera trap image of the Crab-eating Mongoose at night. Therefore, we may hypothesize that the activities of the predator depends on that of the

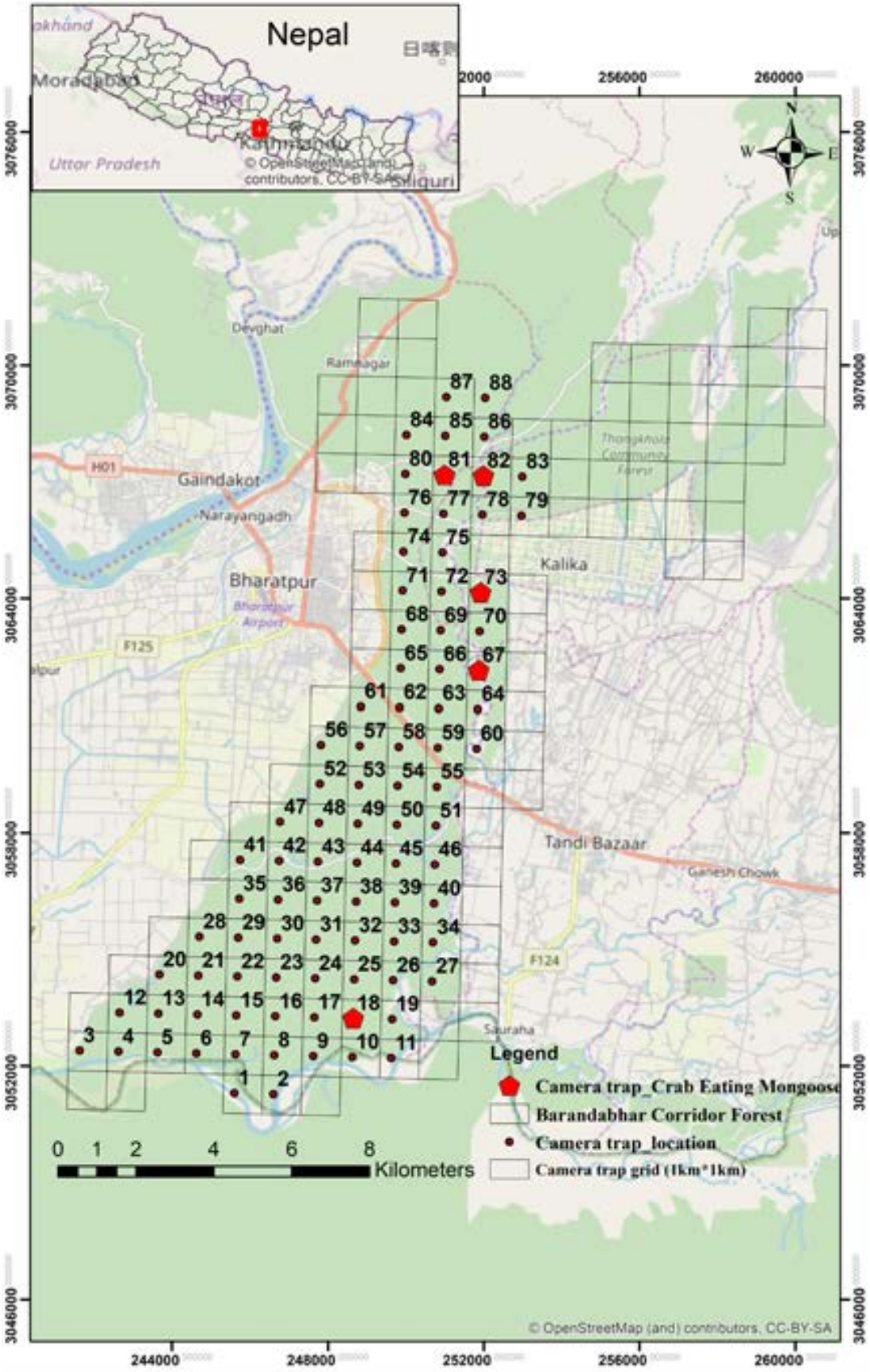

Figure 1. Barandabhar Corridor Forest in Chitwan, Nepal, with the camera trap grid.

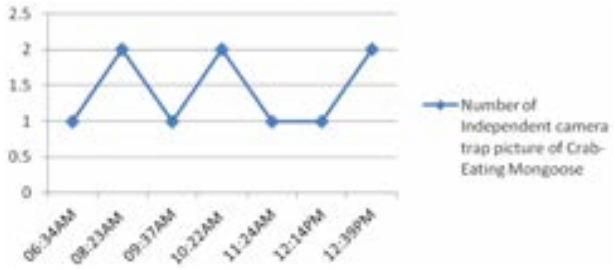

Figure 2. Camera trap time of Crab-eating Mongoose (2015 and 2016) in Barandabhar Corridor Forest in Chitwan, Nepal.

prey. This may be because the predator saves energy according to the foraging theory, i.e., to minimize energy for capturing and searching for food.

Habitat destruction and poaching of the mongoose for fur trade are considered the major threats of the species in Nepal (Yonzon 2005; Jnawali et al. 2011; Thapa 2013; Sharma & Lamichhane 2017). No evidence of poaching, however, was found in Chitwan District. Other possible threats to the species in this region are overfishing, habitat loss, and the poisoning of waterholes (a method of illegal fishing). In BCF, the result showed an increase in camera trap ratio in consecutive years. This has spread a positive message on the success of conservation and management in the BCF.

This study reveals the presence of the Crab-eating Mongoose in both the southern and the northern parts of the highway and presents the first camera trap distribution documentation of the species in BCF. It extended the present range of this species and highlights the value of the corridor in its conservation. Publication of similar records is essential for the updated status of the distribution of the species in Nepal. This data opens a new scope and base for wildlife professionals and scientific communities to take further steps for the conservation of the Crab-eating Mongoose to maintain a healthy ecosystem in BCF.

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Short Communication

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First camera trap record of Red Panda *Ailurus fulgens* (Cuvier, 1825) (Mammalia: Carnivora: Ailuridae) from Khangchendzonga, Sikkim, India

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Abstract: The Red Panda *Ailurus fulgens* (Cuvier, 1825) is recognized as one of the most elusive arboreal carnivores of the eastern Himalaya that is poorly documented. We report the first camera trap record of the Red Panda from the Prek catchment of Khangchendzonga Biosphere Reserve (KBR) in Sikkim, India. A total of three independent image captures were recorded during the sampling. All occurrence records were exclusively from the sub-alpine habitat and restricted to an elevation range of 3,000–3,850 m. This study not only accentuates the significance of sub-alpine habitats for the conservation of the Red Panda but also elucidates the importance of camera traps as an efficient sampling tool. Through this study, we propose the requirement of a long-term study on the species within and outside the protected areas of Sikkim.

Keywords: Conservation, opportunistic records, Prek catchment, sub-alpine habitat.

The Red Panda *Ailurus fulgens* (Cuvier, 1825), also known as the Lesser Panda, is an endangered monotypic member of the family Ailuridae and the only representative of the genus *Ailurus* (Roberts & Gittleman 1984; Glatston 2011). Primarily associated with the eastern Himalaya, its distribution range extends from western Nepal through Bhutan, India, and Myanmar to southern Tibet and the western Yunnan Province of China (Choudhury 2001; Glatston et al. 2015). In India, its distribution is restricted to small pockets of the eastern Himalaya in the states of Arunachal Pradesh, West Bengal (Darjeeling District), and Sikkim (Choudhury 2001; Ghose & Dutta 2011), with anecdotal records from Meghalaya and Assam (Choudhury 2013). Its habitat is typically characterized by the presence of mixed deciduous and coniferous forests with bamboo-thicket understory (Choudhury 2001; Pradhan et al. 2001; Zhang et al. 2006; Chakraborty et al. 2015; Bista et al. 2017). Being an unusual member of Carnivora, it occupies a highly specialized niche as a bamboo feeder like that of the Giant Panda *Alieuropoda melanoleuca* (Wei et al. 1999; Pradhan et al. 2001). In the eastern Himalaya, it occupies an elevation range of 1,500–4,800 m (Yonzon & Hunter 1991; Choudhury 2001).

The Red Panda mainly feeds on bamboo, with supplements of fruits, roots, succulent grasses, mushrooms, acorns, and lichens, and occasionally on bird eggs, insects, and grubs (Reid et al. 1991; Pradhan et al. 2001; Zhang et al. 2009; Panthi et al. 2012). Fallen logs, tree stumps, and shrubs are important habitat

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elements for Red Pandas that provide substrates suitable for defecation (Pradhan et al. 2001; Zhang et al. 2006). Being a habitat specialist, even a minor change in habitat conditions can cause a significant impact on its occurrence and survival (Dorji et al. 2011; Chakraborty et al. 2015). The species has been under tremendous threat across its distribution range due to habitat loss and fragmentation, habitat degradation, harvesting of timber, bamboo, and minor forest products, livestock grazing, inefficiently managed tourism, and other physical threats such as poaching for pelts (Sharma & Belant 2010; Dorji et al. 2012; Panthi et al. 2017) and killing by stray dogs (Chakraborty et al. 2015). Its global population is decreasing continuously and declined by nearly 50% over the last three decades as a result of which it was listed as Endangered by IUCN (Glatston et al. 2015). In spite of being a charismatic species of the eastern Himalaya, there is limited information on the ecology of the species from most parts of its distribution range, particularly from India, except for a few long-term studies (Pradhan et al. 2001; Chakraborty et al. 2015). Apart from these, information available on the species is merely based on incidental records, secondary information, and local knowledge (Sharma & Belant 2009; Srivastava & Dutta 2010; Dorjee et al. 2014; Khatiwara & Srivastava 2014). Moreover, the elusive, arboreal nature of the species and the difficult terrain it inhabits also pose limitations and challenges for conducting field surveys.

Sikkim holds the second largest extent of Red Panda habitat in India after the state of Arunachal Pradesh (Ghose & Dutta 2011). Despite being recognized as the state animal of Sikkim occurring in all seven protected areas (PAs) of the state (Ghose et al. 2011), very little information is available on the Red Panda from the area. Moreover, Khangchendzonga Biosphere Reserve (KBR) represents the largest PA in Sikkim (including the Khangchendzonga National Park and its buffer zone) having an array of habitat types that inhabit a rich diversity of flora and fauna including 1,580 species of vascular plants (Maity & Maiti 2007), 195 species of butterflies (Chettri 2000, 2010), 42 species of reptiles (Chettri et al. 2010), over 213 species of birds (Chettri et al. 2001, 2005) and more than 42 species of mammals (Sathyakumar et al. 2011). The Red Panda is also being considered critical for maintaining the quality of sub-alpine habitats (Pradhan et al. 2001) and, therefore, a detailed understanding of its ecology seems a prerequisite. Therefore, as a first step towards filling the knowledge gap, an attempt towards generating baseline information on the occurrence and distribution of this elusive species was made using camera traps.

Material and Methods

Study area

Khangchendzonga Biosphere Reserve covers an area of 2,620km² (National Park = 1,784km² and buffer zone = 836km²) and is categorized into seven watersheds, namely Lhonak, Jemu, Lachen, Rangyong, Rangit, Prek, and Churong. The area encompasses a sharp elevation gradient of 1,220–8,586 m accompanied by a wide range of habitat types (Tambe 2007; Fig. 1a). We selected Prek catchment (182km²) for our camera trapping surveys because it represents all the habitat types found in KBR (Sathyakumar et al. 2011). Covering an elevation range of 1,220–6,691 m, the major habitats types in Prek catchment include mixed sub-tropical, mixed temperate, sub-alpine, krummholz, alpine pastures, rock and snow cover, and water bodies (Tambe 2007). The relative humidity recorded for the Prek catchment is more than 60% all through the year in temperate, sub-alpine, and alpine habitats and reaches even above 90% in the months of June and July in the sub-alpine habitats (Chettri 2000; Tambe 2007). The annual temperature of the catchment varies from -16.11°C to 33.9°C and from -8.89°C to 15°C in the sub-alpine habitat.

Camera trapping

As part of a multi-disciplinary sampling exercise carried out in KBR to document the faunal assemblage of the area, Prek catchment was initially divided into 2km x 2km sampling grids. Camera traps were deployed (at least one in each grid) based on the occurrence of animal signs and the accessibility of the sampling grids. A total of 27 camera trap units (Stealth Cam, Model STC-I540IR) was deployed at 71 different locations during 2008–2011 across the elevation range of Prek catchment, covering different habitat types (Fig. 1b). Camera units were attached to trees or rocks 15–30 cm above the ground and 3–5 m away from the trail or location of expected animal movement. Camera traps were set for 24h-monitoring covering all seasons. Moreover, geographical coordinates, elevation, and forest type were recorded at each camera trap location. Since the sampling design was extensive in its approach, not focusing on any particular genus (e.g., Red Panda), the camera traps were not placed on treetops to capture arboreal species. This implies that our results on Red Panda are opportunistic records.

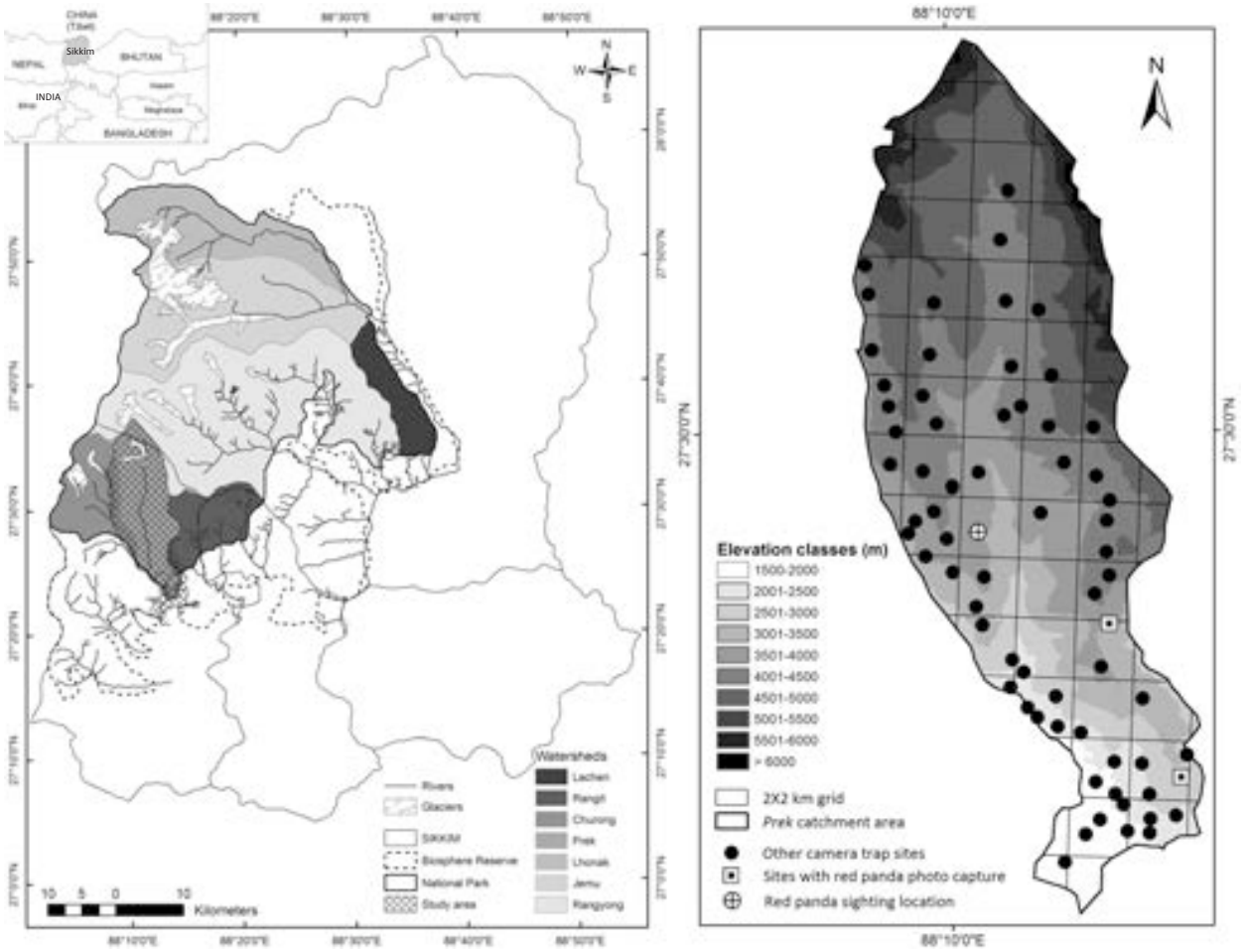

Figure 1. a - Khangchendzonga Biosphere Reserve in Sikkim showing the seven catchments including Prek catchment area; the shaded area in the inset indicates Sikkim in northeastern India | b - Deployment of camera traps in 2km × 2km grids in Prek catchment area indicating Red Panda occurrence records.

Results

A total sampling effort of 6,910 camera trap days included 629 trap days in sub-tropical, 1,426 in temperate, 2,671 in sub-alpine, 702 in krummholz, and 1,482 in alpine habitats. The Red Panda was image captured only at two camera trap locations (namely Kasturi ridge and Phedi; Table 1) with a total of three independent image captures (Image 1). Image captures were recorded during both night and daytime. These camera locations were in sub-alpine fir *Abies densa* and birch *Betula utilis* forests with *Rhododendron* spp. as the understory. A luxuriant growth of bamboo *Arundinaria maling* was also present in the lower elevation areas of Kasturi ridge. Moreover, besides a single sighting (in Kokchurong area), no indirect evidence (droppings/scats or feeding marks) of Red Panda was recorded during the study period. The habitat at Kokchurong was a typical eastern Himalayan fir forest with *Abies densa* as the most dominant species and *Rhododendron hodgsonii* as the undergrowth. All presence records (sighting and images) were exclusively from the sub-alpine habitat and restricted to an elevation range of 3,000–3,850 m, particularly around the Kasturi area which is free from organized tourism.

Discussion

The present study reports the first camera trap record of the elusive Red Panda from the intricate habitats of KBR. It also plausibly documents the highest elevation record (3,850m) of the species from the state of Sikkim. Irrespective of the nocturnal and cryptic behaviour of the species, its detections during the night as well as the daytime only in winter can be attributed to its increased activity during the mating season, occurring mostly between early January and mid-March (Nowak 1999).

The occurrence records revealed a narrow elevation belt of just 850m (3,000–3,850 m) for the Red Panda in the area, which coincides with its preferred altitude

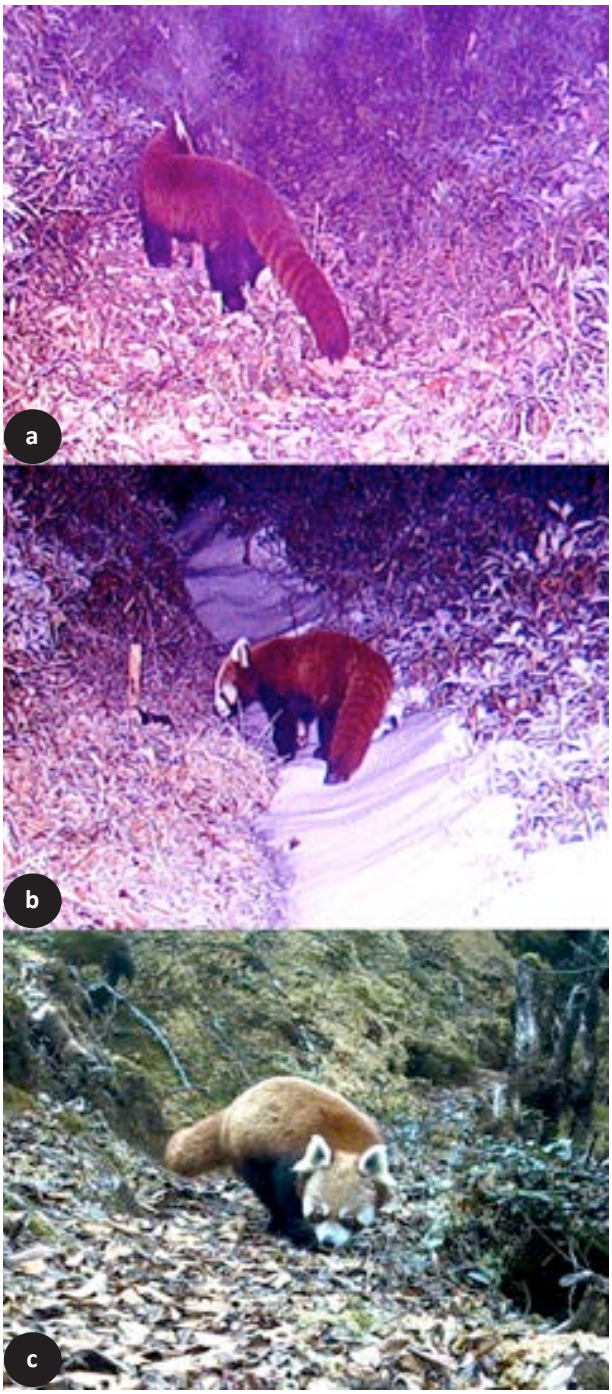

Image 1. Camera trap image of the Red Panda Khangchendzonga Biosphere Reserve in Sikkim: a & b - at Kasturi ridge | c - at Phedi.

range of 2,800–3,600 m reported in similar habitats (Yonzon et al. 1991; Pradhan et al. 2001). Besides the present record, Red Pandas were also camera trapped in Barsey Rhododendron Sanctuary and Kyongnosla Alpine Sanctuary, Sikkim, up to an elevation of 3,630m with direct sightings and feces recorded up to 3,780 and 3,789m, respectively, in different forest types including *Rhododendron* forest with scattered *Abies* and *Abies*-dominated coniferous forest contiguous with bamboo thickets (WWF-India 2011; Khatiwara & Srivastava 2014). Such habitat specificity is in coherence with the present occurrence records, thus validating the affinity of the species for the sub-alpine forests of the Sikkim Himalaya. Similarly, a preference for mixed coniferous and *Rhododendron* forests were also shown in studies conducted in Wolong Reserve in China (Reid et al. 1991), Dhorpartan Hunting Reserve in Nepal (Sharma & Belant 2009; Panthi et al. 2012), Jigme Dorji National Park in Bhutan (Dorji et al. 2011), and Chitwan-Annapurna Landscape in Nepal (Bista et al. 2017). Moreover, the Red Panda was also reported to be relatively abundant between 2,800m and 3,600m in other parts of Sikkim, Darjeeling, and Arunachal Pradesh (Pradhan et al. 2001; Srivastava & Dutta 2010; Bhutia 2011; Ghose et al. 2011; Chakraborty et al. 2015), although its occurrence was also reported at 2,350m in Neora Valley National Park in Darjeeling (Mallick 2010) and at 4,325m in Tawang District of Arunachal Pradesh (Dorjee et al. 2014). Given the arboreal habit of Red Panda, however, habitats above the tree-line may not be considered consistently occupied by them (Choudhury 2001).

Non-detection of Red Panda signs during the sampling period could be attributed to the arboreal, cryptic nature of the species and its habit of defecating at feeding sites generally on trees and fallen logs (Pradhan et al. 2001; Zhang et al. 2006). Previous studies reported the presence of the Red Panda in the northeastern states and parts of Nepal but very few calculated their abundance indices. While comparing the present records with that of 32 sightings in three years (Pradhan et al. 2001), 10 in one year (Mallick 2010, by the study team), 10 in five years (Chakraborty et al. 2015), and four in one year

Table 1. Records of the Red Panda in the Prek catchment of Khangchendzonga Biosphere Reserve, Sikkim, India, during 2008–2011.

Place	Evidence	Date	Time	Elevation (m)	Coordinates	
Kasturi ridge	Photo capture	26.xii.2009	02.12h	3,000	27.399N	88.244E
Kasturi ridge	Photo capture	06.i.2010	04.14h	3,000	27.399N	88.244E
Phedi	Photo capture	18.xii.2009	10.57h	3,850	27.439N	88.218E
Kokchurong	Sighting	10.iii.2010	16.28h	3,720	27.464N	88.173E

with 13 image captures for an effort of 2,398 trap days (Khatiwara & Srivastava 2014), Red Pandas seem to be either more elusive or in very low densities in KBR. A species-specific camera trap design, however, would increase Red Panda detection and thereby its capture rate, aiding in a more comprehensive comparison.

Conclusion

This scientific documentation symbolizes a crucial step towards the conservation of the Red Panda and its habitat in KBR. In spite of a strong pro-conservation attitude shown by the government of Sikkim by declaring Red Panda as its state animal, very less work has been done on the ground to ensure efficient conservation and management of the species and its habitat across the Sikkim landscape. This study highlights the importance of sub-alpine forests for the occurrence and survival of the Red Panda in the area. Considering its low abundance status, increasing threats on habitat, and the lack of detailed ecological information from the area, any management intervention towards its conservation seems impractical. We, therefore, propose an urgent need for a long-term ecological study across the Sikkim Himalayan landscape covering the entire sub-alpine belt (within and outside the PAs), as an essential step towards Red Panda conservation in Sikkim. In view of this, the Forest, Environment and Wildlife Management Department (FEWMD), Govt. of Sikkim, recently initiated a camera trap based monitoring program which resulted in first occurrence records of species like Tiger *Panthera tigris*, Snow Leopard *Panthera uncia*, and Marbled Cat *Pardofelis marmorata* from different PAs of the state. We recommend the continuation of such monitoring programs along with serious attention on the ecological study on the Red Panda to benefit its conservation and management in the area. We also recommend referring the management guidelines proposed by Pradhan et al. (2001) to append further towards achieving this goal.

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First record of black scavenger fly of the genus *Meroplius* Rondani, 1874 (Diptera: Sepsidae) from Pakistan

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Abstract: A new record is added to the black scavenger fly fauna of Pakistan by the reporting of *Meroplius minutus* (Wiedemann, 1830), a rare species from Rawalakot, Azad Jammu & Kashmir, Pakistan. The genus is also a new record for the country. Diagnostic characters of both the genus and the species are provided in detail with the help of images. In addition, detailed distribution notes and information about their habitats are provided.

Keywords: *Meroplius minutus*, new record, Rawalkot, saprophagous fly.

The family Sepsidae (Diptera) is a moderately large, cosmopolitan group of saprophagous flies with over 300 extant species recorded from all zoogeographic regions (Ozerov 2005). About 23 species have been described under the genus *Meroplius* Rondani, 1874 till date. At present, this genus is known from all zoogeographic regions except the Antarctic (Ozerov 2018). The majority of the *Meroplius* species is distributed in the Afrotropical region (13). At present, eight species are listed from the Oriental region by Ozerov (2005), namely *M. beckeri* (de Meijere, 1906), *M. elephantis* Iwasa, 1994, *M. maximus* Iwasa, 1994, *M. mirandus* Iwasa, 1994, *M. sauteri* (de Meijere, 1913), *M. wallacei* Iwasa, 1994, *M. fasciculatus* (Brunetti, 1910), and *M. minutus* (Wiedemann, 1830). *Meroplius fasciculatus* is widely distributed in the Australasian/Oceanian, Oriental, and Palaearctic regions and *M. minutus* (Wiedemann, 1830) in the Nearctic, Oriental, and Palaearctic regions and in Europe and northern Africa.

Taxonomic work on Sepsidae from Pakistan was done by Iwasa (1989) and Hassan et al. (2017a,b). So far, 27 species under the subfamily Sepsinae in eight genera have been recorded from Pakistan. The objective of this study was to determine the occurrence of the genus *Meroplius* Rondani, 1874 in the country.

Materials and Methods

During the collection of saprophagous flies from Pakistan, including Gilgit-Baltistan and Azad Jammu & Kashmir, in 2016–2018, four male specimens of *Meroplius minutus* (Wiedemann, 1830) were collected from Rawalakot (Azad Kashmir). Specimens were deposited at the National Insect Museum, Pakistan. Identification was done with the help of Iwasa (1995), Pont & Meier (2002), and Letana (2014). The specimens were photographed using a Nikon Digital camera attached to a Olympus SZX7, Model SZ2-ILST stereo-microscope. Adobe Photoshop CS 6.0 was used to achieve clarity in the images. Morphological terminology follows Pont & Meier (2002).

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Results

During the present study, we reported *Meroplius minutus* (Wiedemann, 1830) for the first time from Pakistan. The detailed diagnostic characters of both the genus and species, their images, distribution, and information on habitats are provided.

Taxonomy

Family Sepsidae

Genus *Meroplius* Rondani, 1874

Diagnostic characters: Head: roundish or slightly flattened dorsoventrally, arista bare. Chaetotaxy: fronto-orbital bristle developed and outer vertical setae present (Fig. 1a). Wing: devoid of black spots (Fig. 1); cells bm (basal medial cell) and br (basal radial cell) separate, alula well-developed or moderate and completely covered with microtrichose. Thorax: humeral bristle present and acrostichal setae absent, forelegs in male with distinct setae. Abdomen: without constriction after syntergite 1+2 (Fig. 1c).

Meroplius minutus (Wiedemann, 1830) (Image 1a–c)

Synonyms: *Sepsis minuta* Wiedemann, 1830: 468; *Sepsis lutaria* Fallén, 1820b: 22; *Nemopoda stercoraria* Robineau-Desvoidy, 1830: 745; *Nemopoda nigrilatera* Macquart, 1835: 481; *Sepsis rufipes* Meigen, 1838: 349; *Nemopoda varipes* Walker, 1871: 345; *Nemopoda polita* Duda, 1926a: 96, 98.

Material examined: National Insect Museum, Diptera Section, Reg. No. 200, 4 ex., male, 25.ix.2016, Pakistan, Azad Jammu & Kashmir, Rawalakot (Thandi Kasi), 33.850^{0}N & 73.800^{0}E, 1,524m, coll. M.A. Hassan.

Diagnostic characters: This species can be easily diagnosed by the presence of outer vertical and orbital seta with basal scutellar seta absent, apical distinct. The wings are devoid of black spots. Male fore femur on distally two ventral spines, straight (Fig. 1b); forelegs yellow, mid- and hind legs basally yellowish, remaining brownish (Fig. 1c). The detailed diagnostic characters of both the adult and the juvenile were provided by Pont & Meier (2002).

Distribution: Pakistan (new record), Nepal, China, Japan, Korea, Republic of Georgia, and Russia in Asia, Europe, and Egypt in northern Africa (Ozerov 2005).

Discussion

The adult species of *Meroplius* Rondani, 1874 are particularly attracted towards unclean habitats: human excrement, the faecal mass of cattle in pens, pig dung, rotting fungi, rabbit hutches, decaying cabbages, rotting vegetables, and fish and animal carrion (Pont & Meier 2002). The species also carry forensic importance as they are abundant in the mid- to late stages of decomposition of carcasses (Tabor 2004). During our present study, we recorded *M. minutus* from rotten meat and the bones of animals near a slaughterhouse. This was the only record of the species from Rawalakot (Azad Kashmir) during our extensive collection of saprophagous flies in 2016–2018 in the mountainous areas of Gilgit-Baltistan, forest areas in Poonch District of Azad Jammu & Kashmir, and Pothwar region of Punjab; this indicates that the species is not common in Pakistan, as Van der Goot (1987) suggested. He stated that the decline of this species might be due to improved methods of sewage management and the

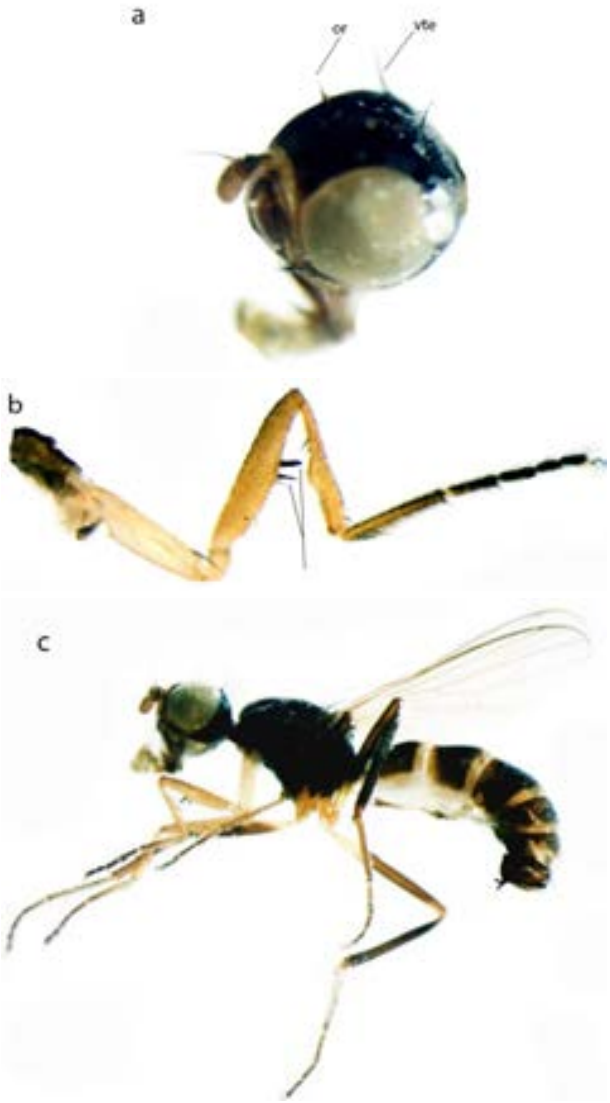

Image 1. Male specimen of *Meroplius minutus* (Wiedemann, 1830): a - oblique lateral view of head (or - orbital seta, vte - outer vertical seta) | b - anterior view of foreleg and tibia with two ventral spines | c - lateral view of habitus. © N. Fatima.

liberal use of poisonous toilet-cleaning chemicals. The species is considered rare in Japan (Iwasa 1984) and in central and eastern Europe (Pont & Meier 2002).

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Scully's Balsam *Impatiens scullyi* Hook.f. (Balsaminaceae): a new record for India from Himachal Pradesh

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Abstract: *Impatiens scullyi* Hook.f. is reported here as a new record for India as well as for the western Himalaya from Kullu and Mandi districts of Himachal Pradesh. To facilitate its identification, detailed description along with colour images are provided here.

Keywords: Angiosperm, balsam, flora, western Himalaya.

Impatiens L. (Balsaminaceae) is one of the largest genera of angiosperms in the world represented by over 1,000 recognized species (Bhaskar 2012; Yu 2012; Mabberley 2018) distributed in the tropical, subtropical, and northern temperate regions of the Old World, with several species reaching North America. In India, the genus is represented by more than 210 taxa, mostly distributed across the Himalaya and the Western Ghats (Vivekananthan et al. 1997; Bhaskar 2012). According to Gogoi et al. (2018), there are at present around 235 species of the genus in India.

During the recent botanical expeditions to some remote valleys of Kullu District in Himachal Pradesh, the first author came across an interesting *Impatiens* species which, after detailed studies, turned out to be *Impatiens scullyi* Hook.f. A screening of the literature revealed that this species was first collected by J. Scully from Nepal and was mentioned by Sir J.D. Hooker from central Nepal (Hooker 1904–1906). It was described in detail later by Akiyama et al. (1991) from central and eastern Nepal. The species was regarded as confined to the country in the list of endemic plants of Nepal (Rajbhandari et al. 2016). Yu (2012), however, reported it from southern Tibet (Xizang).

After further critical analysis, the authors came across an old specimen preserved at the herbarium of the Royal Botanic Garden Edinburgh, collected from Sungri in Shimla in September 1888. This was identified as *Impatiens micranthemum* Edgew. probably by the collector, Sir George Watt himself (Image 3A). The collection, however, was finally identified as *Impatiens* aff. *scullyi* in 2015 by Dr. Shinobu Akiyama, who was working on the revision of the Nepalese *Impatiens*.

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This specimen forms the only herbarium record for this species (or its allies) from India, but its identification was not confirmed. There is no information on *I. scullyi* in botanical literature from the western Himalaya (Chowdhery & Wadhwa 1984; Aswal & Mehrotra 1994; Dhaliwal & Sharma 1999; Singh & Rawat 2000; Basu & Uniyal 2002; Kaur & Sharma 2004; Klimeš & Dickoré 2005; Singh & Sharma 2006; Chawla et al. 2008, 2012; Dad & Khan 2010; Verma & Sharma 2012; Dar et al. 2014; Pal et al. 2014; Subramani et al. 2014; Singh et al. 2015; Kumar et al. 2016; Das et al. 2018; Pusalkar & Srivastava 2018). As there is no record of this species from India, the authors hereby report the newly collected specimen as the first authentic distribution record of *I. scullyi* Hook.f. from India.

Taxonomic treatment

Impatiens scullyi Hook.f. in Rec. Bot. Surv. India 4: 15. (1905); H. Hara in H. Hara & L.H.J. Williams, Enum. Flow. Pl. Nepal 2: 80 (1979); S. Akiyama et al. in Bull. Univ. Tokyo No. 34: 78 & Image 4C (1991).

Annual herbs, 30–90 cm tall, stem succulent, swollen at nodes, often rooting from lower nodes. Leaves alternate, aggregated at the apical part of stem; petiole 10–20 mm long; lamina broadly lanceolate to oblong-ovate, 8–14 cm x 4–6 cm, glabrous with crenate margins. Inflorescence racemose, 6–13 cm long, axillary, with 6–10 flowers, flowers congested on top of peduncle. Pedicel 1.5–2 cm long, slender, glabrous, with a bract at base. Bracts 3–4 mm long, narrowly ovate, acute at apex. Flowers 1.4–2.0 cm x 1.2–2.8 cm. Lateral sepals two, ovate, 3–4 mm long; lower sepal pale green to white, 5–7 mm x 12–20 mm, tubular; spur inconspicuous. Dorsal petal white, 4–6 mm x 6 mm, cucullate, with thickened greenish midrib, ending in a short horn or appendage; lateral united petals generally white to pale rose-coloured (only observed in a few individuals) with a yellow spot at the base of the lower lobe, 11–14 mm long; the upper lobe ovate, c. 3mm x 2mm; the lower lobe with two rounded lobes, 9–11 mm x 5–6 mm, with a very characteristic long appendage (10–13 mm long) elongating into the tubular lower sepal. Stamens five; anthers without appendage. Capsules unevenly linear, 2–3 cm long, green with pale yellowish stripes, enclosing 2–5 seeds. Seeds c. 4mm long (Images 1 & 2).

Phenology: Flowering was observed starting from the end of June, commencing along with fruiting until September. Seeds ripen in September–October.

Ecology and Distribution

Impatiens scullyi is primarily a terrestrial species growing along ravines in dense colonies and often beneath wet, dripping rocks in association with *I. leggei*, *I. devendrae*, *Urtica ardens*, *Lecanthus peduncularis*, *Pilea scripta*, and *Elatostema sessile.*

Impatiens scullyi is distributed between 1,600–2,400 m along ravines in Kullu and Mandi districts of Himachal Pradesh. It is most likely also distributed in some neighbouring districts, especially in Shimla, as can be concluded from an old, initially misidentified collection. A few images of this species, again misidentified as *I. micranthemum*, can be seen on efloraofindia portal (Efloraofindia 2007 onwards), wherein one record exists from the Great Himalayan National Park of Kullu District and two others from Shimla District. Both these localities correspond to the same districts as observed here, thus further confirming the present distribution evidence.

Impatiens scullyi was reported from Nepal growing between 1,800m and 2,630m (Akiyama et al. 1991) and from southern Tibet between 700m and 2,400m (Yu 2012).

Conservation status

Impatiens scullyi Hook.f. was earlier known only from Nepal and southern Tibet in the central and eastern Himalaya. We hereby present its first distribution record from the western Himalaya. We assess this species as Vulnerable in India as per the IUCN Red List regional criteria due to its restricted and fragmented distribution range, as it is distributed only in a few localities and that too with a low population of some 100 mature individuals. In both the surveyed locations, the species is generally distributed along ravines. Flash floods in monsoon may pose some minor threat to the plant population distributed along the ravines. Based on field surveys conducted in the last two years, we are of the view that this taxon is restricted in its distribution for reasons yet unknown. Along with flash floods, the competition faced from other fiercely growing plants of the same habitat can also be one of the reasons for its low population.

Remarks

Edgeworth (1846) described many new species from northwestern India on the basis of his own herbarium collection. For most species, he had not only herbarium specimens but also the notes taken from living plants at the moment of collection. One of these species is *Impatiens micranthemum* Edgew.

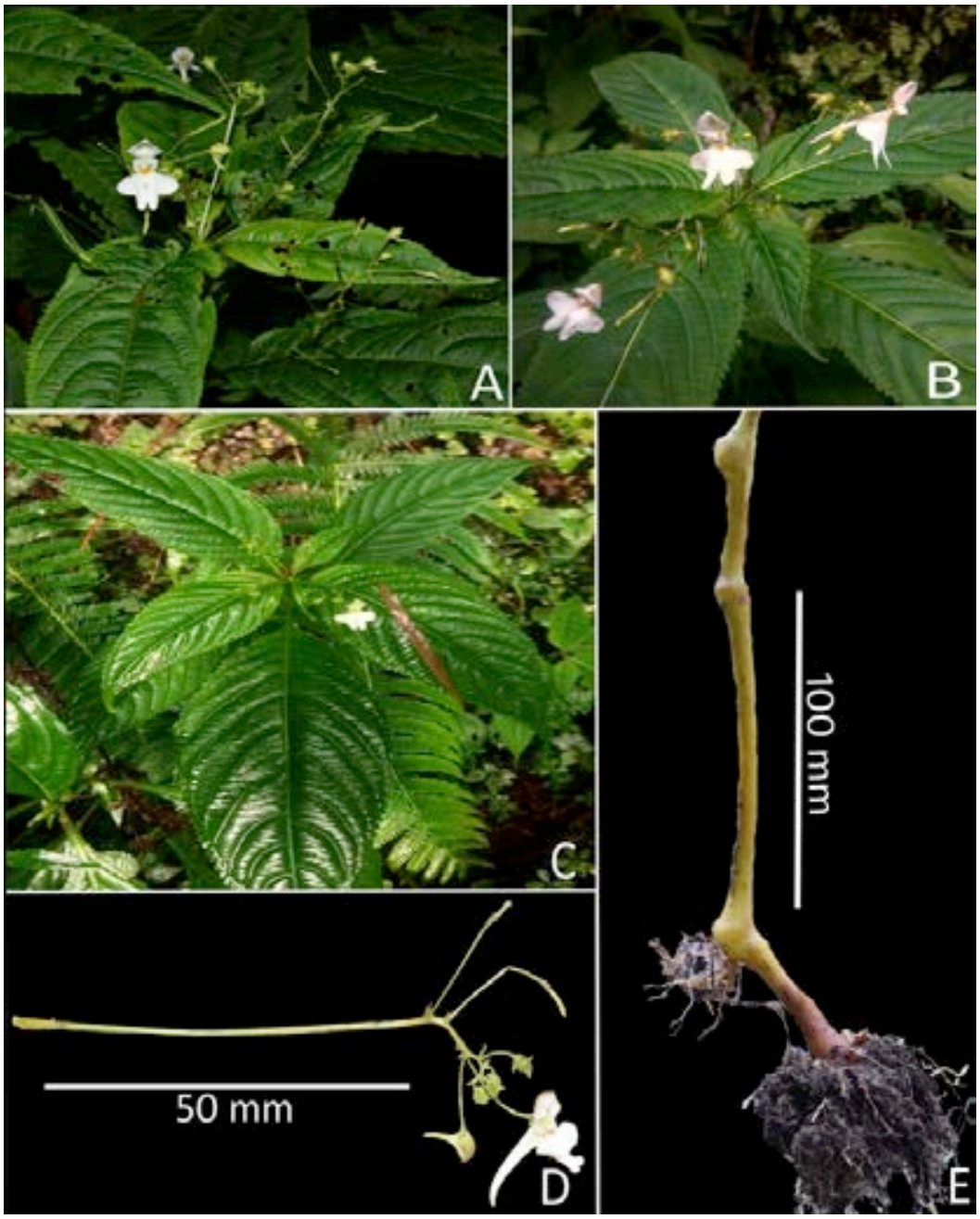

Image 1. *Impatiens scullyi* Hook.f.: A–B - Plant flowering in its natural habitat | C - Habit | D - Inflorescence | E - Swollen nodes with adventitious roots appearing on the lower node. © Ashutosh Sharma.

(Edgeworth 1846: 40). In most sources, it is treated as a synonym of *I. laxiflora* Edgew. (Edgeworth 1846: 40; Grey-Wilson 1991; The Plant List 2013). It was described as having predominantly white or whitish flowers, but inflorescences with 3–4 flowers, stems with sparse black glands and round lower lobe of lateral united petals. These features clearly differentiate it from *I. scullyi*, as described by Hooker (1904–1906) and Akiyama et al. (1991). There is, however, nothing in Edgeworth's description of *I. micranthemum* about a long appendage on lateral united petals, characteristic of *I. scullyi* (see Akiyama et al. 1991 and Image 2) and very rare in other species of the *Impatiens* genus.

The material of *I. scullyi* from Nepal (Akiyama et al. 1991) and southern Tibet (Yu 2012) look very similar to the material from Himachal Pradesh. There are slight differences in the colour of the different flower parts and the shape of lateral united petals, without taxonomic

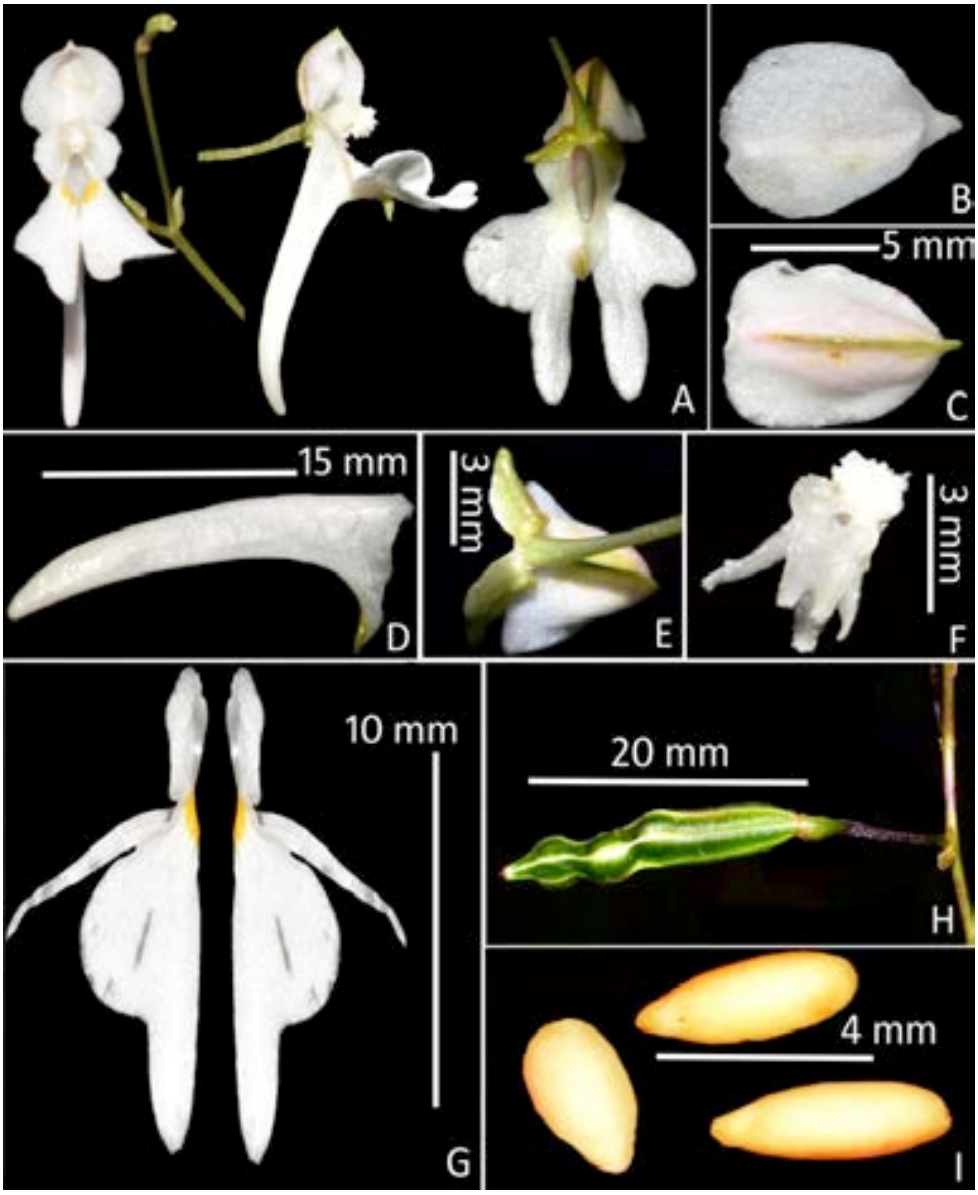

Image 2. A - Flower in front view, lateral view, and back view | B - Dorsal petal in dorsal view | C - Dorsal petal in ventral view | D - Lower sepal | E - Lateral sepals | F - Column | G - Lateral united petals | H - Seed capsule | I - Seeds (unripe). © Ashutosh Sharma.

significance. Akiyama et al. (1991) comment that flower size and shape of lateral united petals are variable in this species.

Impatiens scullyi seem to be more widely distributed in Nepal, as confirmed by specimens from E (Royal Botanic Garden Edinburgh Herbarium) and KATH herbaria (National Herbarium and Plant Laboratories, Lalitpur, Nepal), as well as images from Langtang National Park, north of Kathmandu, posted on the iNaturalist portal (iNaturalist) under the name *I. edgeworthii*. *Impatiens edgeworthii* could have white flowers but has lower sepal with distinct spur and the characteristic shape of the upper lateral petal (for images, see (for images, see Korina 2019).

There are two surprising records of *I. scullyi* from the easternmost Himalaya, west of Namcha Barwa Mountain (southeastern Tibet) on the Global Biodiversity Information Facility portal (GBIF Secretariat). We tracked these records in MSG herbarium (Ludwig-Maximilians-Universität, Munich) in Munich and found that these are misidentifications of another balsam species with small, coarsely crenate leaves and one-flowered inflorescences (see Image 4).

Specimens examined: DD172573, 04.viii.2018, India, Himachal Pradesh, Mandi District, Dhaved (near

Image 3. A - Specimen of *Impatiens* aff. *scullyi* from the Herbarium of the Royal Botanic Garden Edinburgh (E00848289) | B - Specimen of *Impatiens scullyi* from the Herbarium of FRI, Dehradun (DD 172574; own collection).

Khanni), 31.653^{0}N & 77.283^{0}E, 1,600–1,900 m, coll. Ashutosh Sharma; DD172574, 15.viii.2018, India, Himachal Pradesh, Kullu District, Jhuni, 31.870^{0}N & 77.324^{0}E, 1,800–2,100 m, coll. Ashutosh Sharma (Image 3B); No. 9420261, 12.viii.1994, Nepal, Rasuwa District, Lingju Tibling, 28^{0}12'N & 85^{0}07'E, 2,040–2,130 m, coll. F. Miyamoto, K.R. Rajbhandari, S. Akiyama, M. Amano, H. Ikeda & Y. Tsukaya (KATH005907; seen as a picture); No. 8427, 16.ix.1954, Nepal, Mardi Khola, 2,280m, coll. Stainton, Sykes & Williams (KATH030467; seen as a picture); No. 4367, 12.ix.1954, Nepal, Gurjakhani, 2,590m, coll. Stainton, Sykes & Williams (E00848293; seen as a picture); No. 9043, 15.x.1954, Nepal, Bhujihola, 2,440m, coll. Stainton, Sykes & Williams (E00848290; seen as a picture). One individual was collected from each location listed.

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Image 4. Specimen of *Impatiens* from Tsangpo Gorge in southeastern Tibet stored in the Ludwig-Maximilians-Universitat, Munich (MSG) Herbarium, misidentified as *I. scullyi*. Notice the small leaves, coarsely crenate leaf margins, and one-flowered inflorescences

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Odisha's first record of a free-tailed bat (Mammalia: Chiroptera: Molossidae): what could it be?

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Bats are one of the most abundant and widely distributed mammalian groups after rodents, represented by more than 1,300 species worldwide (Bat Conservation International 2013). Free-tailed bats (Molossidae) are the fourth largest family of bats, containing approximately 110 species worldwide (Ammerman et al. 2012). In general, free-tailed bats are characterised by a robust body, relatively long and narrow wings, and a free tail projecting beyond the end of the uropatagium (Srinivasulu et al. 2010). In India, a total of 125 species of bats were reported (Ruedi et al. 2012; Srinivasulu & Srinivasulu 2012; Senacha & Dookia 2013; Saikia et al. 2017; Thong et al. 2018), which represents about a quarter of the country's mammalian diversity. Still, information on the diversity and distribution of different bat species from different parts of India is sporadic. In India, the bat family Molossidae is represented by four species, namely the Wrinkle-lipped Free-tailed Bat *Chaerephon plicatus* (Buchanan, 1800), Wroughton's Free-tailed Bat *Otomops wroughtoni* (Thomas, 1913), the European Free-tailed Bat *Tadarida teniotis* (Rafinesque, 1814), and the Egyptian Free-tailed bat *T. aegyptiaca* (É. Geoffroy, 1818) (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012). These bats are quite widely distributed throughout the country, except for *Otomops wroughtoni* which is known only from five localities in Karnataka and Meghalaya (Bates & Harrison 1997; Thabah & Bates 2002; Srinivasulu & Srinivasulu 2012; Ruedi et al. 2014) and *Tadarida teniotis* from a single locality in West Bengal (Hill 1963) (Table 1). Among these bats, *Chaerephon plicatus* and *Otomops wroughtoni* can be clearly distinguished from the other two species in having a membrane between the ears over the forehead (Bates & Harrison 1997; Srinivasulu et al. 2010). Among all the four species of free-tailed bats occurring in India, *Otomops wroughtoni* is a very rare species and is legally protected under Schedule I of the Indian Wildlife (Protection) Act, 1972.

Odisha is one of the eastern coastal states of India and its bat fauna is represented by 25 species in seven families (Debata et al. 2016). To our present knowledge, there is no report on the occurrence of any free-tailed bats from Odisha. In this communication based on examination of a pup, we report the occurrence of a free-tailed bat in the state.

During a regular survey of bat roosting sites in Similipal Biosphere Reserve (SBR) in northern Odisha from September 2014 to August 2017, a pup of an unidentified bat (Image 1a,b) was spotted laying over a rock adjoining Sitakund Waterfall in the northeastern side of SBR (Fig. 1; 21.924°N & 86.570°E; 303m). Bat guano was present at the location where the pup was found and the screaming sound of bats from an

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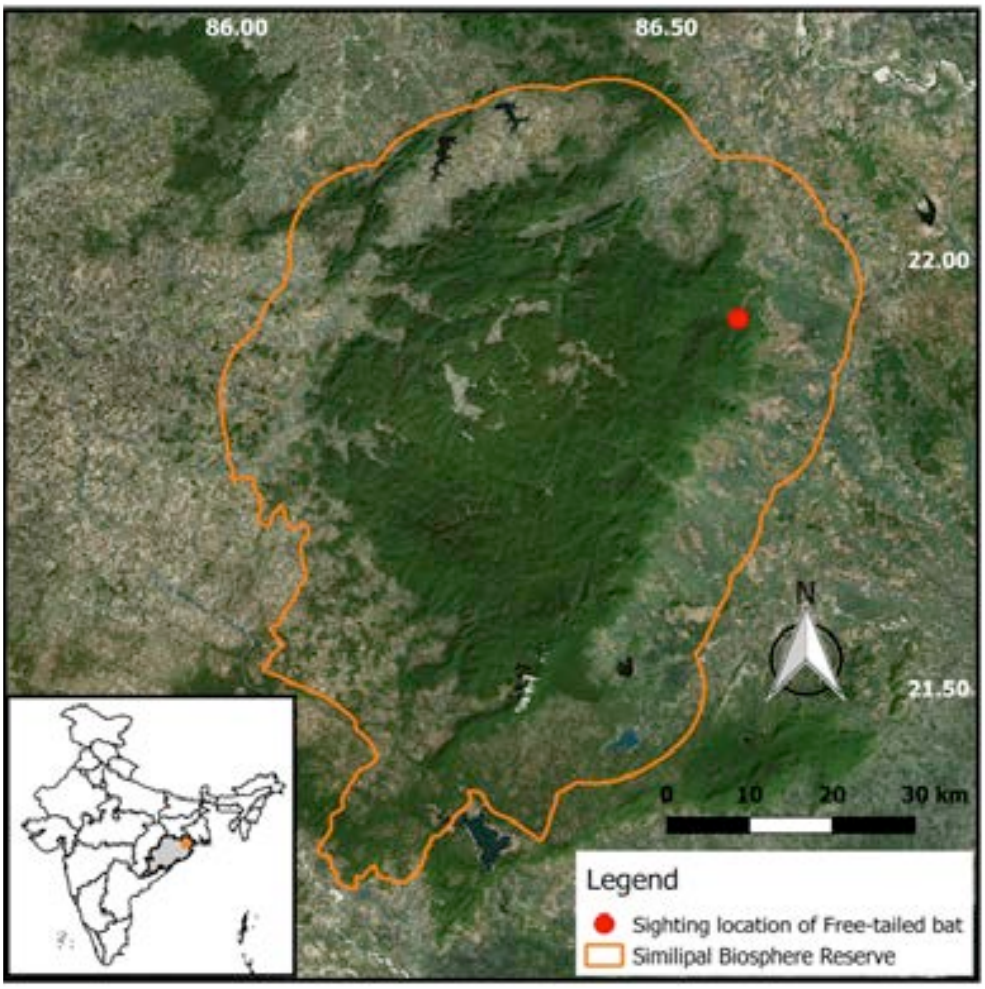

Figure 1. Sighting location of the pup of a free-tailed bat in Similipal Biosphere Reserve in Odisha, eastern India.

inaccessible cliff above was audible (Image 1c). The recorded location is situated along a riparian zone of moist deciduous forest adjoining a perennial hill stream of Sitakund Waterfall. The sighting location also falls within the boundary of Similipal Wildlife Sanctuary and Tiger Reserve. As we did not have permission to collect any specimens from protected areas, we took close-up images using a Fujifilm Finepix HS 10 digital camera and noted the morphological characters of the pup for identification.

The pup was characterised by a free tail, wrinkled lips, and strong and stout hind feet (Image 1a,b) and thus belongs to the Molossidae family as per the descriptions provided by Bates & Harrison (1997) and Srinivasulu et al. (2010). The species-level identity of the pup could not be confirmed as we could not collect the pup or capture any adult from the inaccessible roost for further examination (Image 1c). As the base of the ears of the pup was connected by a membrane over the forehead (Image 1a,b), however, we narrowed down the unidentified pup to either *Chaerephon plicatus* or *Otomops wroughtoni*.

Chaerephon plicatus is widely distributed in India and was recorded from different localities in Andhra Pradesh to Goa, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012); therefore, there is a possibility of its occurrence in the forests of SBR. On the other hand, *Otomops wroughtoni* is a rare species and is restricted to a few localities in Karnataka and Meghalaya (Bates & Harrison 1997; Thabah & Bates 2002; Srinivasulu & Srinivasulu 2012; Ruedi et al. 2014). As the known distribution range for this species is quite disjunct so far, a continuous population covering the forested regions of eastern India may be possible.

Although the present study could not confirm the species-level identification of the examined pup, we

Image 1. a & b - The recorded pup of the unidentified free-tailed bat | c - Roost (red arrow) and site where the pup was found (white arrow) in Similipal Biosphere Reserve, Odisha, India.

Table 1. Diversity and distribution of free-tailed bats (Family: Molossidae) in India.

	Species	Common name	Distribution in India
1	*Chaerephon plicatus*	Wrinkle-lipped Free-tailed Bat	Andhra Pradesh, Goa, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.
2	*Otomops wroughtoni*	Wroughton's Free-tailed Bat	Karnataka and Meghalaya.
3	*Tadarida teniotis*	European Free-tailed Bat	West Bengal.
4	*T. aegyptiaca*	Egyptian Free-tailed Bat	Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, and West Bengal.

can at least confirm the occurrence of molossid bats in Odisha. As the locality is within the Similipal Wildlife Sanctuary and Tiger Reserve area, we did not get permission to deploy mist nets at night. We, therefore, propose acoustic monitoring in future inventories, which can help reveal the identity of the species. This can also aid in revising the distribution record of the proposed species in India.

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PLATINUM
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Additions to the flora of Arunachal Pradesh State, India

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current manuscript as additions to the angiosperm flora of the state. Accordingly, detailed descriptions, herbarium images, and relevant notes based on the collector's information are provided to facilitate their easy identification in the field.

Arunachal Pradesh, by virtue of its geographical position, climatic conditions, and altitudinal variations, is a biodiversity-rich region in northeastern India and the eastern Himalaya, with a large zone of tropical wet evergreen, subtropical, temperate, and alpine forests. The state is recognized as one of the 200 globally important regions (Olson & Dinerstein 1998). The flora of Arunachal Himalaya comprises well over 4,055 species of flowering plants (Hajra et al. 1996).

During the course of a floristic exploration under the project 'Flora of East Kameng District' of the Botanical Survey of India, the author collected some interesting specimens from the district. These specimens were identified with the help of existing flora and confirmed by comparing with authentic specimens housed at various herbaria such as SIKKIM (Gangtok), ASSAM (Shillong), ARUN (Itanagar), and CAL (Howrah). A critical examination of literature (Hooker 1881, 1885, 1890, 1897; Chowdhery 1995; Chowdhery et al. 2009; Giri et al. 2009; Das & Mao 2011; Pal 2013; Bhaumik & Satyanarayana 2014a,b; Tiwari 2015–2016, 2016; Tiwari & Mao 2016; Tiwari & Rawat 2018; Tiwari et al. 2018; Gogoi et al. 2019) revealed that these species had not been reported from the state of Arunachal Pradesh until now. Hence, these species are reported in the

Synedrella nodiflora (L.)

Gaertn., Fruct. Sem. Pl. 2: 456, t. 171, f. 7. 1791; Hook.f., Fl. Brit. India 3: 308. 1881; H.J. Chowdhery in Hajra et al., Fl. India 12: 413. 1995; Karthik. et al., Flow. Pl. India Dicot. 1: 278. 2009. *Verbesina nodiflora* L., Cent. Pl. 1: 28. 1755 (ASTERACEAE) (Image 1).

Annual herbs, erect up to 1.0–1.5 m tall, appressed-pilose with ascending white hairs; stems terete. Leaves cauline, opposite, petiolate; blade ovate to elliptic, 3–10 cm × 3–4 cm, base rounded or cuneate, margin shallowly serrate to subentire, apex acute, both surfaces ± scabrid, usually 3-veined. Capitula radiate, sessile or subsessile in axillary glomerules or capitula solitary, aggregated in groups of 1–4 at the forks of the stem or leaf axils enclosed in foliaceous bracts; involucral bracts in 2–3 series, outermost foliaceous, phyllaries persistent, lanceolate, herbaceous to papery. Receptacle convex. Ray florets 4–9, 1- or 2-seriate, female, fertile; corolla yellowish, ca. 3–4 mm long; bilobed, tube 2–3 mm long. Disk florets 10–15, bisexual, fertile; corolla yellowish, lobes short, dorsally pubescent. Anthers dark. Ovary slightly compressed, oblong, with two flattened, stout, apical awns; style branched flattened, marginally pilose. Achenes dimorphic, ca. 4mm long, slender, tuberculate, puberulous.

Flowering and fruiting: March–October.

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Image 1. *Synedrella nodiflora* (L.) Gaertn. herbarium specimen M. Bhaumik 29911 (ARUN!).

Specimen examined: 29911 (ARUN!), 08.vii.2014, Arunachal Pradesh, Pashighat, New Yingkiang, 28.624°N & 95.031°E, 200m, coll. M. Bhaumik.

Notes: The species grows as a weed in marshy places in the rainy season.

Distribution: India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Sikkim, Assam, Meghalaya, Tamil Nadu, Kerala, Andaman & Nicobar Islands, and Arunachal Pradesh), Bhutan, Nepal, China, Sri Lanka, Malaya, and tropical America.

Lindenbergia grandiflora

(Buch.-Ham. ex D.Don) Benth., Scroph. Ind.: 22. 1835; Hook.f., Fl. Brit. India 4: 261. 1885. *Stemodia grandiflora* Buch.-Ham. ex D. Don, Prodr. Fl. Nepal.: 89. 1825 (SCROPHULARIACEAE) (Image 2a,b).

A rambling perennial, with flexuous stem and branches sometimes densely pilose. Branches slender, flexuous, 15–80 cm long. Leaves opposite; petiole up to 7cm long; leaf blade ovate, up to 20cm long, decreasing in size upwards, margins undulate and serrate; lateral veins 6–10 on each side of the midrib. Inflorescences spike, lax, up to 25cm long, ovate, sessile or shortly peduncled. Flowers sub-sessile, solitary from bract axils, 2.5–3.0 cm long. Calyx 7–8 mm long, glandular hairy; lobes equal, spreading flat, orbicular, apex obtuse. Corolla golden yellow, up to 3cm long; tube three times as long as the calyx, sparsely hairy; throat with two oblong red-punctate plaits; lower lip broader than wide, up to 2.5cm long, lateral lobes oblong, middle lobe smaller than other lobes, orbicular, and emarginate; upper lip short and orbicular, emarginate. Filaments hairy below middle. Ovary sericeous. Capsules ovoid, tip exserted

Image 2. *Lindenbergia grandiflora* (Buch.-Ham. ex D. Don) Benth.: A - in the wild | B - herbarium specimen U. Tiwari 47060 (ARUN!).

from persistent calyx. Seeds ca. 0.5mm long.

Flowering and fruiting: July–December.

Specimen examined: 47060 (ARUN!), 14.xi.2015, Arunachal Pradesh, East Kameng District, Doka Pipu, Seppa, 27.462°N & 93.027°E, 467m, coll. U. Tiwari.

Notes: The species grows as a weed in marshy places in the rainy season.

Distribution: India (Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, and Arunachal Pradesh), Bhutan, Nepal, and China.

Balanophora polyandra

Griff., Proc.Trans. Linn. Soc. London 1: 220. 1844; Hook. f., Fl. Brit. India 5:238. 1885 (BALANOPHORACEAE) (Image 3a,b).

Plants dioecious, yellowish-orange to dark red. Rhizomes clustered into a mass; branches covered with granular warts and scattered greyish-white stellate lenticels. Scapes reddish-orange, 12–15 cm x 2–3 cm. Leaves decussate but spirally arranged apically on scape, ovate-oblong, ca. 2cm × 1.5cm. Scales of peduncle imbricate. Flowers pedicellate. Male inflorescences narrowly ellipsoid, ca. 3.7cm long; flowers zygomorphic, each subtended by a single stout and truncate bract, perianth lobes 4–6, reflexed; ca. 1cm in diameter, anther cells transversely divided into small locelli, lateral lobes deltoid to ovate, apex acute; apical and lower lobes oblong, ca. 3.4cm × 2.2.5 mm, apex truncate. Synandria sub-discoid, ca. 4.5mm in diameter; anthers broken up into 20–40 dehiscent by short slits.

Flowering and fruiting: September–December.

Specimen examined: 47244 (ARUN!), 22.xi.2015, Arunachal Pradesh, East Kameng District, Bamang on the way to Seppa, 27.543N & 92.949°E, 1047m, coll. U. Tiwari.

Notes: The species grows on the roots of various trees.

Distribution: India (West Bengal, Sikkim, Meghalaya, and Arunachal Pradesh), Bhutan, Nepal, Myanmar, and China.

Image 3. *Balanophora polyandra* Griff.: A - in the wild | B - herbarium specimen U. Tiwari 47244 (ARUN!).

Maoutia puya

(Hook.) Wedd., Ann. Sci. Nat., Bot., Sér. 4, 1: 194. 1854; Hook.. f. Fl. Brit. India 5:592. 1885. *Boehmeria puya* Hook. in Hooker's J. Bot. Kew Gard. Misc. 1: 26. 1849 (URTICACEAE) (Image 4a,b).

Shrubs up to 2m tall; branches pubescent, monoecious; branchlets zigzag, brown to greyish-brown hirsute. Stipules connate, linear-lanceolate, 6–16 mm, 2-fissured. Leaves 6–18 cm × 4–8 cm, membranous, scabrid above, beneath white except the pubescent nerves, appressed strigose, elliptic caudate-acuminate, coarsely toothed; secondary veins 2–4 on each side, adaxially rugose, thickly snow white tomentose, base broadly cuneate or rounded, apex acuminate. Flowers minute monoecious; cymose globose head in pairs, 3–5 cm long; glomerules lax, 2–3 mm in diameter; bracts triangular or lanceolate, membranous. Male flowers shortly pedicellate, obovoid in the bud, 1mm in diameter; perianth lobes 5, valvate, ovate, connate at the middle, apex acuminate. Stamens 0, inflexed in

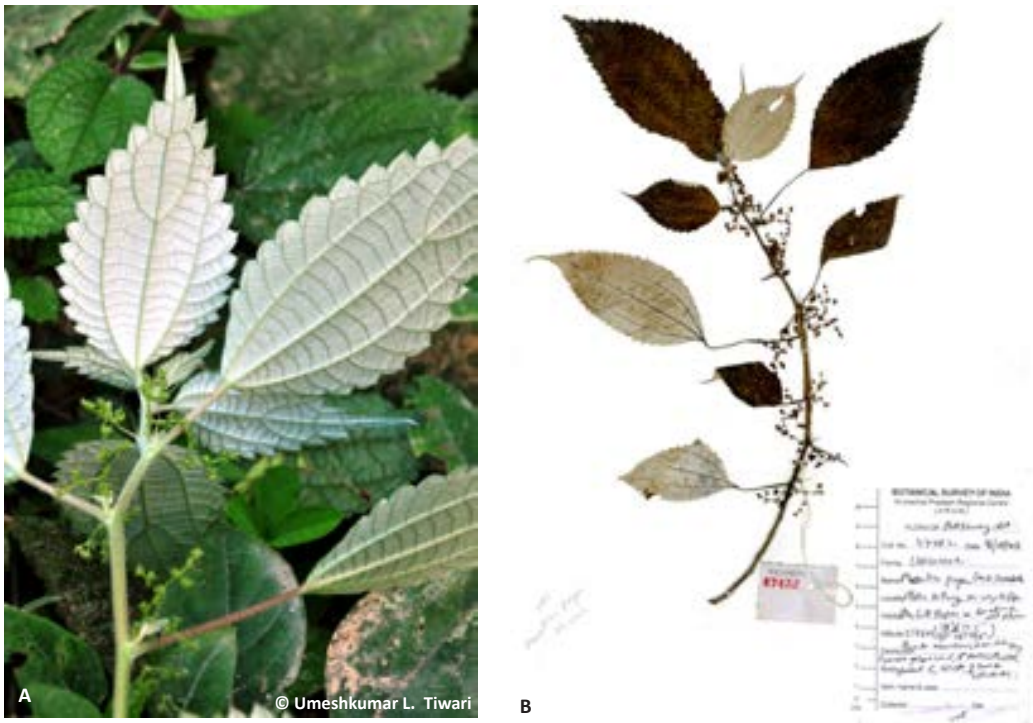

Image 4. *Maoutia puya* (Hook.) Wedd.: A - collected from the wild | B - herbarium specimen U. Tiwari 47482 (ARUN!).

bud, rudimentary ovary trigonous-ovoid, ca. 0.4mm long. Female flowers sessile; perianth lobes 2, minute, unequal, enclosing base of ovary; stigma penicillate, ovule erect. Achenes gibbously ovoid-trigonous, hispid, ca. 1.2mm long, appressed strigillose, albumen scanty, cotyledons oblong.

Flowering and fruiting: June–October.

Specimen examined: 47482 (ARUN!), 18.vii.2016, Arunachal Pradesh, East Kameng District, Moku Sollung on the way to Pipu Village, 27.514°N & 93.073°E, 1476m, coll. U. Tiwari.

Notes: This species occurs in dry hill slopes and sometimes in wet places.

Distribution: India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Sikkim, Assam, Meghalaya, and Arunachal Pradesh), Bhutan, Nepal, China, and Vietnam.

Isachne pulchella

Roth in Roemer & Schultes, Syst. Veg. 2: 476. 1817. *Sphaerocaryum elegans* (Nees ex Steud.) Nees ex Hook.f., Fl. Brit. India 7: 246. 1896 (POACEAE) (Image 5a,b).

Annual. Culms very slender, 10–25 cm tall, prostate and rooting at below then erect, rarely branched, nodes bearded. Leaves 2.5–4 cm long, acute or acuminate, ciliate-serrulate, subcoriaceous, ecostate, nerves very close, leaf sheaths much shorter than internodes, ligule of closed white hairs, outer margin ciliate; leaf blades ovate or ovate-lanceolate, 2–3 cm × 0.8–1.0 cm, scabrid to thinly hispid, base cordate-amplexicaul with pectinate margin, apex shortly acuminate. Panicle 1–2 in solitary and terminal, with very rarely 1–2 lower on the stem; peduncle very short; concealed in the leaf-sheath; rachis rather stout; branches very many, opposite and alternate, capillary, spreading, primary branches inserted singly, stiffly and regularly spreading with branchlets to their base; pedicels mostly shorter than spikelets. Spikelets elliptic; florets clearly dissimilar; lower floret male, upper floret bisexual or female; glumes slightly shorter than lower floret; lower glume elliptic-oblong, 5-veined, upper glume broadly elliptic, 5–7-veined both glabrous, apex obtuse; lower lemma herbaceous, elliptic-oblong, dorsally flattened, smooth, glabrous; upper lemma slightly shorter, crustaceous, pubescent.

Flowering and fruiting: May–October.

Specimen examined: 47502 (ARUN!), 18.vii.2016, Arunachal Pradesh, East Kameng District, near Langyak Sullung, Pipu Block, 27.525°N & 93.119°E, 1176m, coll. U. Tiwari.

Notes: The species grows in open and dry slopes of forests.

Distribution: India (Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, and Arunachal Pradesh), Bhutan, Nepal, and China.

Image 5. *Isachne pulchella* Roth: A - in the wild | B - herbarium specimen U. Tiwari 47502 (ARUN!).

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A report on additions to the flora of Andaman & Nicobar Islands, India

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The Andaman & Nicobar Islands, with a total geographical area of 8,250km^2, is the largest archipelago representing an arcade of Islands situated about 1,200km off the southeastern coast of India in the Bay of Bengal, stretching from Myanmar in the north to Sumatra (Indonesia) in the south (6.750–13.683 N & 92.200–93.950 E). These Islands harbour luxuriant lowland rainforests besides wetlands, mangroves, and coral reefs. There are 106 protected areas in the Andaman & Nicobar Islands, including nine national parks, 96 wildlife sanctuaries, and one biosphere reserve (Rao 1986). The floral elements of these Islands often show a close affinity with that of Indonesia, Malaysia, Myanmar, Thailand, and Sri Lanka. The phytodiversity of these islands is unique and one of the richest in India in terms of diversity with a remarkable degree of genetic variations.

While working on the 'Quantitative assessment and mapping of plant resources of the Andaman and Nicobar Islands', some specimens were collected from Dhanikari Botanical Gardens, South Andaman and Palmtikiri, Little Andaman Islands. A critical study revealed that they were hitherto unreported from this archipelago. After a detailed consultation of literature (Srivastava 1998; Sinha 1999; Sabu 2006; Pandey & Diwakar 2008) and a critical examination of the specimens, they were identified as *Monochoria hastata* and *Alpinia malaccensis*. Thus, the present findings constitute new distribution records for Andaman & Nicobar Islands. Detailed descriptions along with field images are provided for these two species to facilitate easy identification for future studies.

Alpinia malaccensis

(Burm. f.) Rosc., Trans. Linn. Soc. London 8: 345. 1807; Hook. f., Fl. Brit. India 6: 255. 1820. *Maranta malaccensis* Burm.f., Fl. Ind. 2. 1768.

Rhizomatous herbs. Leafy stems robust, to 3m high. Leaves narrowly lanceolate, acuminate, up to 60cm × 7cm, usually pubescent; ligule c. 1cm long, hairy, coriaceous, entire; sheaths shortly pubescent; petiole 3–5 cm, rounded, pubescent. Inflorescence erect or slightly curved, main axis pubescent; bracts absent. Cincinni of two very shortly pedicellate flowers or reduced to a single flower, stalk 0.5–1.5 cm, pubescent; bracteoles white, open to base, 1.5–2.0 cm, folded around the bud becoming quickly deciduous as the flower opens, lightly pubescent at apex. Calyx white, 2cm, pubescent at least at the apex, shortly 3-lobed and deeply split unilaterally. Corolla white, tube up to 1cm, glabrous; lateral lobes 3cm × 1cm, ciliate-margined, dorsal lobe broader, also ciliate. Labellum yellow-orange, heavily lined with scarlet strips, 3–5 cm, 3cm across at widest part, sides incurved, narrowing to an emarginate

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भारतीय वनस्पति सर्वेक्षण
BOTANICAL SURVEY OF INDIA

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Image 1. ***Alpinia malaccensis*** **(Burm. f.) Rosc.: A - Habit | B - Flower | C - Fruit. © M.V. Ramana.**

apex, with twp papillose swellings at the base. Lateral staminodes subulate, less than 5mm; filaments c. 1cm; anther of equal length or longer, thecae parallel, connective not prolonged into a crest. Epigynous glands 5mm, free from each other. Ovary 5mm, pubescent, trilocular. Capsules turning red at length, globose, up to 3cm in diameter, shortly pubescent.

Flowering and fruiting: May–November.

Distribution and habitat: Extends from northeastern India (and now from Andaman & Nicobar Islands) to Indochina, southwards to Peninsular Malaysia and Java. Found along banks of streams in evergreen forests.

Specimens examined: 0965 (PBL, CAL), 22.v.2012, India, Andaman & Nicobar Islands, South Andaman Islands, Dhanikari Botanical Garden, 11.575N & 92.664E, 35m, coll. M.V. Ramana & J.K. Tagore.

Note: The species was collected from the Nicobar Islands and introduced in Dhanikari Botanical Gardens, South Andaman.

Monochoria hastata

(L.) Solms in A. de Candolle & C. de Candolle, Monogr. Phan. 4: 523. 1883; Hook.f., Fl. Brit. India 6: 362. 1892. *Pontederia hastata* L., Sp. Pl. 1: 288. 1753.

Perennial aquatic herbs. Vegetative stems often long and robust; 60–120 cm. Radical leaves with sheath broadened at base; leaf blade triangular or triangular-ovate, 5–15(–25) cm × 3–15 cm, base sagittate to hastate, apex acute to acuminate; petiole 25–75 cm. Flowering stems erect or obliquely so, 45–80 cm. Inflorescences erect or suberect, remaining so after anthesis, sub-umbellate to shortly racemose, 15–50-flowered; peduncle distinctly shorter than associated leaf petiole. Pedicels 1–3 cm. Perianth segments bluish with green median vein and reddish blotch, ovate, 9–15 mm. Larger stamen: anther 5–6 mm, bluish. Smaller stamens: five, filiform; anthers 3.0–3.5 mm, pale yellow. Style densely and shortly spreading, hairy at apex. Capsule oblong, 6–7 mm. Seeds brown, oblong; wings c. 10mm.

Image 2. ***Monochoria hastata*** **(L.) Solms: A - Habit | B - Flower | C - Fruit. © M.V. Ramana.**

Flowering: August–December.

Fruiting: December–March.

Distribution and habitat: It is found in marshy regions near waterfalls. It also occurs in wet swamps, freshwater pools, drainage channels, mudflats in rivers, and along canal banks. It is a purely submerged aquatic herb. It is recorded as a component of floating mat vegetation. This species occurs in Bhutan, India (throughout Assam and other northeastern states; also as weeds in northern and central states of India and now from Andaman & Nicobar Islands), Nepal, Sri Lanka, and southeastern Asia, extending to New Guinea and Australia.

Specimens examined: 1089 (PBL, CAL), 13.xi.2012, India, Andaman & Nicobar Islands, Little Andaman, Palmtikiri, 10.617N & 92.508E, 120m, coll. M.V. Ramana.

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Range extension of *Trigonella uncata* Boiss. & Noë (Leguminosae) in peninsular India and a new record for Maharashtra State, India

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Leguminosae is one of the most diverse and widely distributed families in India. While exploring the flowering plants around Pune District in Maharashtra State, India, in 2018, we found a herb belonging to the genus *Trigonella* L. of Leguminosae. In subsequent surveys, specimens were collected from Lonavala, Talegaon Dabhade, and Bhugaon in the district. Detailed photo-documentation was carried out with the fresh specimens.

A total of 12 *Trigonella* species are listed in India (Sanjappa 1992), but a key has not been provided. Out of these, six are reported only from the Himalayan and sub-Himalayan regions. The *Trigonella* species reported from northwestern and central Indian regions are *T. corniculata*, *T. incisa*, *T. occulta*, *T. obcordata, T. foenum-graecum*, and *T. uncata*. For the identification of our specimens, a key was prepared using their characters reported by Duthie (1960), Shah (1968), Shetty & Singh (1987), and Verma et al. (1993).

Three of the six species reported from the northwestern and central Indian regions (*T. corniculata, T. incisa*, and *T. occulta*) are easily distinguished based on the characters reported in the literature. *Trigonella foenum-graecum* is either cultivated or naturalized in some places. *Trigonella uncata* and *T. obcordata*, however, have a large number of overlapping characters. None of the characters reported in Indian floras or monographs were useful in differentiating these species. The unavailability of a national key for the *Trigonella* species made the task more difficult. Hence, in order to clearly distinguish the two species, we consulted other relevant literature and herbarium specimens.

The identification of the collected specimens was confirmed after viewing the images of the type of *T. uncata* housed in herbaria Muséum National d'Histoire Naturelle (P) and Naturhistorisches Museum Wien (W). There is no mention of peduncle length of the species in Shetty & Singh (1987). The description of *T. uncata* in Shah et al. (1968) indicates the peduncle length to be less than that of the leaves. The type specimen housed in W (W–Rchb. 1889-0361491) and P (MNHN–P–P02952755), however, clearly showed the peduncles to be longer than the leaves. This feature was further evident after viewing the images of more herbarium specimens from Royal Botanic Gardens Kew (K) (K000998695 Image!) and Royal Botanic Garden Edinburgh (E) (E00336751 Image!).

We also checked the description of *T. obcordata* in Duthie (1960), which mentions racemes equaling or shorter than the leaves as one of the characters for *T. obcordata* Wall. On consulting The Wallich Catalogue 5986, a specimen of *T. obcordata* (K001122698 Image!)

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collected in Tikari (mentioned by Sirjaev 1928) and housed in K, we found the peduncles of the specimen to be much shorter than the leaves. Sanjappa (1992) mentions the catalogue number as 5989, which seems to be erroneous as it refers to a species of *Vitis* mentioned on page 205 of The Wallich Catalogue.

The two species also differ in having different pod shapes. Sirjaev (1928) in description of *T. obcordata* mentions pods to be straight or a little curved (also evident in K001122698), while the description of *T. uncata* says pods are a little arcuate to semicircular (also clearly visible in W–Rchb. 1889-0361491). The illustrations in Sirjaev (1928) also clearly depict these features. The pods in our collected specimens are arcuate to semicircular.

Considering the specimens, peduncle length and pod shape can be used as key characters that distinguish *T. obcordata* and *T. uncata*. We concluded that the collected specimens belong to *Trigonella uncata* Boiss. & Noë.

This species was not reported from Maharashtra in the earlier regional floras by Cooke (1903), Santapau (1967), Almeida (1998), and Singh et al. (2000). Sanjappa (1992), in his list of *Trigonella* species from India, only mentions Gujarat and Rajasthan in the distribution of *T. uncata*. Hence, our collection from Pune District extends the known distribution of the species in peninsular India to include Maharashtra and is a new record for the state.

There have been different opinions regarding the identity and nomenclature of this species. Townsend (1968) considered *T. uncata* to be a subspecies of *T. hamosa* (*Trigonella hamosa* ssp. *uncata*). According to him, "The differences between *T. hamosa* and *T. uncata* are slight and purely of degree, are correlated with geographical distribution, and it seems best to regard them as subspecies". Later, Lassen (1987) treated it as *T. glabra* ssp. *uncata* (Boiss. & Noë) Lassen; the same was used by The Plant List (2013) for which *T. uncata* is given as a synonym. Sanjappa (1992), however, treated it as a separate species. The determinavit slip on type sheet from W (W– Rchb. 1889-0361491) also mentions the species as *T. uncata*. Taxonomic resolution of the species is beyond the scope of the current paper. Hence we place the current specimens under *T. uncata* following Sanjappa (1992).

We suggest here a key to aid identification of *Trigonella uncata* Boiss. & Noë.

Description: Description is prepared based on specimens collected.

***Trigonella uncata* Boiss. & Noë (Images 1 & 2)**

in Boiss., Diagn. Ser. 2: 12. 1856; Boiss, Fl.Orient.2: 84. 1872; Sirj. in Publ. Fac. Sci. Univ. Masaryk no. 102; 45.t.2 f. 38. 1928; Shah et al., in J. Bombay Nat. Hist. Soc.65: 262. 1968. *T. hamosa* subsp. *uncata* (Boiss. & Noë) Townsend, Kew Bull. 21: 437. 1968,Townsend & Guest, in Fl. Iraq 3: 91. pl. 14 f. 16. 1974; B.V. Shetty & V. Singh, Fl. Rajasthan 1: 268. 1987.

Diffuse annual herb; caespitose, branches prostrate, many from base, 10–50 cm long; stem angled, glabrous. Leaves 3-foliolate; petiole 10–15 mm, angular, softly hairy, extending 5–8 mm beyond basal pair of leaflets; petiolules 1–2 mm; leaflets 10–15 mm, obovate, cuneate, dentate, retuse to truncate, glabrous above, softly pubescent beneath; stipules 4–6 mm, auricled at base, ovate-lanceolate, laciniate, softly hairy. Flowers head-like, capitate in a raceme on axillary peduncle 10–30 mm long, peduncle terminating in a spine, peduncle slightly shorter than, equal to, or longer than leaves; racemes 6–18-flowered; pedicels recurved, 1–2 mm long; calyx 1.5–2.0 mm long, softly hairy, teeth shorter than tube. Corolla 4–5 mm long, yellow. Pods 8–11 mm long, 1.5–2.0 mm wide, turgid, semi-circular, 4–6-seeded, veins transverse; seeds 0.8–1.5 mm, ovoid, brownish-yellow.

Flowering and fruiting: February–March.

Habitat: Locally common in moist places, along banks of rivers and streams and on margins of drying ponds in association with *Hygrophila serpyllum* T. Anderson, *Cyathocline purpurea* (Buch.-Ham. ex D. Don) Kuntze, *Gnaphalium luteo-album* L., and *Grangea maderaspatana* (L.) Poir.

Distribution: Iraq, Iran, Afghanistan, Pakistan, and India (Rajasthan, Gujarat, and Pune District in Maharashtra).

Specimens examined: *Trigonella uncata* Boiss. & Noë. India, Maharashtra, Pune District: 002 (BSI!), 25.ii.2018, Lonavala, 18.761^{0}N & 73.444^{0}E, 676m, coll. Shrikant Ingalhalikar; AVD–20183 (BSI!), 17.ii.2018, Kamshet, 18.755^{0}N & 73.522^{0}E, 610m, coll. Adittya Dharap; AVD–20181 (AHMA!), 09.ii.2018, Talegaon Dabhade, 18.737^{0}N & 73.653^{0}E, 614m, coll. Adittya Dharap; 003 (BLAT!), 26.ii.2018, Bhugaon near Pune, 18.494^{0}N & 73.738^{0}E, 739m, coll. Shrikant Ingalhalikar; K000998695 (K Image!) 1018, Iraq, coll. F.W. Noë; E00336751 (E Image!), 27.iii.1974, Iran, coll. P.H. Davis & M.H. Bokhari.

Type: W-Rchb. 1889-0361491(W image!) 1018, 1851, Iraq, coll. F.W. Noë; MNHN-P-P02952755 (P image!), 1018, 1851, Iraq, Kattam Tigris, coll. F.W. Noë.

Note: The *T. uncata* specimens collected under 1018 by Noë are in P (MNHN-P-P02952755), K (K000998695),

Image 1. ***Trigonella uncata*** **Boiss. & Noë: a - habit | b - twig | c - inflorescence | d - stipule | e - pods | f - seeds. © Shrikant Ingalhalikar.**

Key to northwestern and central Indian species of *Trigonella*

1	Flowers solitary or clustered in leaf axils	2
1	Flowers clustered at the end of axillary peduncles	3
2	Pods more than 2cm long, with a long beak	*Trigonella foenum-graecum*
2	Pods less than 2cm long, without a beak	*Trigonella occulta*
3	Pods not turgid, flat	*T. corniculata*
3	Pods turgid	4
4	Pods with 10–20 seeds	*T. incisa*
4	Pods with 4–6 seeds	5
5	Racemes slightly shorter, equal to or longer than leaves, pods arcuate to semicircular	*T. uncata*
5	Racemes equal or much shorter than leaves, pods straight or slightly curved	*T. obcordata*

Image 2. Herbarium sheet of *Trigonella uncata* Boiss. & Noë (Reg.no. AVD-20181 collection date 09.02.2018).

and W (W-Rchb. 1889-0361491). While the specimens in W and P are clearly designated as 'type', the specimen in K is not. The resemblance of collection numbers, however, indicates that all the specimens probably belonged to the same set collected by Noë.

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