

UNVEILING THE DIVERSE MAMMALIAN SPECIES OF A TROPICAL RAINFOREST IN NORTHEAST BANGLADESH

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ABSTRACT: Tropical rainforest supports an incredible diversity of mammalian species. The forest patches of northeast Bangladesh are considered hotspots for a range of threatened mammals. However, the transboundary Lathitila reserve forest in Moulvibazar district of northeast Bangladesh remained largely unexplored. We assessed the diversity of medium- and small-sized mammals using camera-trapping, and distance sampling, which was supplemented by sign survey and interviews. We recorded a total of 38 species of mammals belonging to 9 orders and 22 families. The Carnivora (34%) contained the highest number of mammals followed by Rodentia (21%), Primates (18%), Chiroptera (10%), and Artiodactyla (5%). Thirty seven percent of the recorded species were rare, followed by very common (26%), occasional (24%) and common (13%). Of these, 45% were categorized as threatened in the updated national Red List of IUCN Bangladesh. The remarkable species that we recorded are the Critically Endangered Asian elephant (*Elephas maximus*), Western hoolock gibbon (*Hoolock hoolock*), Chinese pangolin (*Manis pentadactyla*), Phayre's leaf monkey (*Trachypithecus phayrei*), Northern pig-tailed macaque (*Macaca leonina*), and Bengal slow loris (*Nycticebus bengalensis*). The Endangered Fishing cat (*Prionailurus viverrinus*), and Asian small-clawed otter (*Aonyx cinerea*) were also recorded. The principal threats to the Lathitila forest are the habitat degradation, habitat fragmentation, human disturbance, illegal wood extraction, and wildlife poaching. This study highlights the conservation importance of this least-known forest, thereby protection measures are urgently needed to conserve its diverse mammalian fauna.

Key words: Bangladesh, camera-trapping, forest habitat, Lathitila, mammals, threats.

INTRODUCTION

Terrestrial mammals are a key component of tropical forest communities as indicators of ecosystem health and providers of important ecosystem services

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(Ahumada *et al.* 2011). Bangladesh, a tropical country, is rich in mammalian fauna due to its geographic location between the Indo-Burma subregions of the Indo-Malayan realm (Ahsan and Chowdhury 2008, Aziz 2011, Haque *et al.* 2020). As a result, a quarter of Indian mammalian species, 26% of south-Asian mammalian species, and 2.4% of all global mammalian species are supported by the country (Ahsan and Chowdhury 2008, IUCN Bangladesh 2015). However, tropical forest habitats have undergone to significant degradation in southeast Asia, with the highest rate of deforestation and fragmentation due to agriculture expansion, human settlement, and logging (Barlow and Peres 2006). Consequently, these adversely influenced faunal species composition, relative abundance, species richness and diversity (Zakaria *et al.* 2016). Bangladesh is a low-forest cover country, with less than 10% of the under-forest cover (FAO 2008), and this is a significant decline from 16-18% forested earlier in the 20th century (Hossain *et al.* 2013, Reddy *et al.* 2016, UN-REDD Bangladesh National Program 2016).

Bangladesh has 127 species of mammals spread over 35 families and 9 orders (IUCN Bangladesh 2015). The presence of such a diverse assemblage of species in a tiny, densely populated nation is commendable (Ahsan and Chowdhury 2008, Khan 2008). Yet, the diversity of mammal fauna in the forest habitats of the country is not fully documented, and thereby the importance of these forest patches remains unrecognized for conservation actions.

Several patches of mixed-evergreen forests are found in the northeast (NE) and southeast (SE) Bangladesh, of which Lathitila is an inseparable part of the greater Patharia Hill Reserve (PHR) forest in Moulvibazar along the border shared with Indian state of Assam (Hossain 2016). It is anticipated that the hilly habitats serve as a climatic sanctuary for animals, as rising temperatures drive certain species to restrict their distribution to higher altitudes (Khan *et al.* 2022). The terrestrial community comprising frugivorous, folivorous, and granivorous mammals are expected to occur in these mixed evergreen forest patches due to having plenty of leaves, fruits and seeds (Rahman *et al.* 2021). There have been a few studies so far done on the mammalian assemblage in the PHR, with no comprehensive investigation in the forest of Lathitila. Several studies focused on a single species such as Asian elephant (Dutta *et al.* 2018), particolored flying squirrel (Al-Razi and Maria 2019), Bengal slow loris (Al-Razi *et al.* 2020) or on a particular group of species such as carnivore (Zakir *et al.* 2021), bats (Khan 2001), primates (Das *et al.* 2003, Ahmed and Naher 2021) and medium- and small-sized mammals in and around the PHR forest (Rahman *et al.* 2023). We commissioned this study to provide a detailed species level

information of mammals that will help making an informed decision for protecting the remaining biodiversity of this forest in the NE Bangladesh.

MATERIAL AND METHODS

Study sites: The Lathitila reserve forest is the southern part of PHR located in the northeastern district of Moulvibazar of Bangladesh (Fig. 1). The PHR comprising of about 80 km² includes historic bamboo-dominated forest that contains Lathitila forest on the southeastern region. The Lathitila forest, located between 24°32'56"N and 24°34'19" N and 92°12'01"E and 92° 13' 53" E and covering 22 km², is one of the last natural forests in NE Bangladesh (Islam *et al.* 2006). This forest is 61 km away from Juri, the closest city in Sylhet Division. The forest is managed as reserve forest by the Sylhet Forest Division. The eastern boundary of this forest is shared with the Indian state of Tripura (Talukdar and Choudhury 2017).

The study area enjoys monsoon climate (Islam *et al.* 2006). The forest is comprised of rocky hills, streams, and waterbodies, which have led to significant watersheds within of the jungles with plentiful yearly precipitation (Khan *et al.* 2022). The total annual rainfall is 3334 mm, with a maximum average temperature of 33.2 °C in May to October and a lowest average temperature of 13.6 °C in November to April (Sarker *et al.* 2014). The average monthly rainfall fluctuates greatly from season to season. Most of the year, relative humidity remains high (75 to 90%), with the months of May to October having the greatest levels (Bangladesh Meteorological Department 2012). The reserve forest is built upon stones from the Upper Tertiary period, primarily sandstone but also siltstones, mudstones, and sometimes slates and shales (Sarker *et al.* 2014).

The hilly terrains intermingled with numerous streams and bamboo grooves at Lathitila created a mosaic of habitats that could support high diversity of wild animals. Lathitila forest contains old teak (*Tectona grandis*) plantations and bamboo-dominated stands. The major vegetation types include *Dipterocarpus sp.*, *Artocarpus chaplasha*, *Swintonia floribunda*, *Ficus sp.*, *Bombax sp.*, *Dillenia pentagyna*, *Syzygium sp.*, *Mangifera longipe*, *Phyllanthus emblica*, *Terminalia chebula*, *Phyllanthus acidus*, *Dioscorea sp.*, etc. Some of the hilly areas were also planted with *Acacia sp.* Besides, bamboo-dominated areas were covered with *Melocanna sp.*, *Bambusa sp.*, *Dendrocalamus sp.*, etc. (Feeroz *et al.* 2012). Forest margins and human settlement areas were mostly cultivated with *Oryza sativa*, *Triticum aestivum*, *Zea mays*, *Musa sp.* Additionally, *Citrus sp.*, *Citrus maxima*, *Cheirolophus crassifolius*. Moreover, the *Tamarindus indica*, and *Olea sp.* were spotted in almost every house in the forest village inside the Lathitila. Surrounding tea gardens are covered with green grasses. There were also

numerous small-sized ponds around the forest villages as well as the edges of the forest.

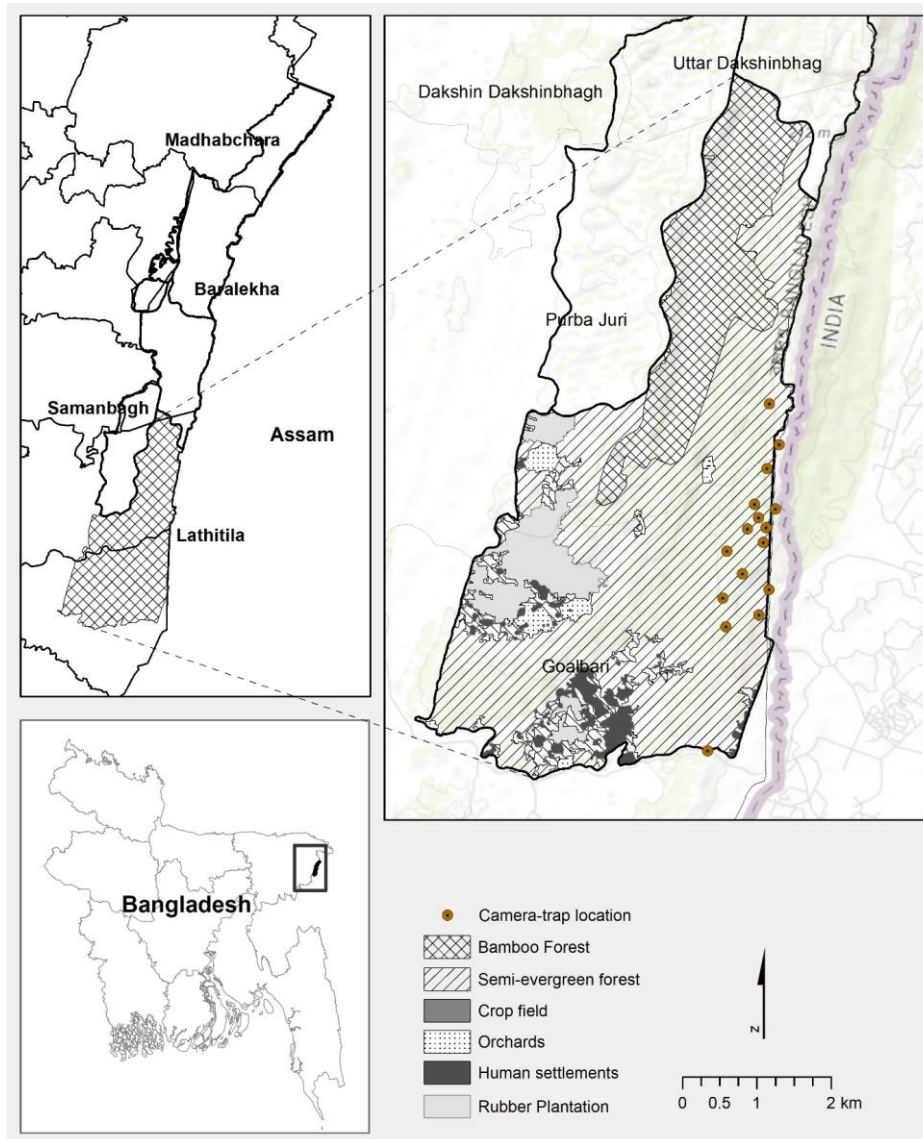


Fig. 1. Lathitila forest in the greater Patharia Hill Reserve of Bangladesh.

Camera trapping: Photographic camera-traps have become a popular technique for assessing animal diversity over decades (Silveira *et al.* 2003, Rahman *et al.* 2023). A total of 16 trail cameras (Browning Dark OPS HD Pro X) were deployed between 7th October 2021 and 15th January 2022 across Lathitila

forests. Human trails, streams and forest floors were chosen for setting camera-traps; the locations were selected based on footprints and other animal signs (Chakma 2017). Date and time of records were automatically stamped on the photographs which were used to estimate naive frequency of a particular species being detected (Rowcliffe *et al.* 2014). All the camera-traps were set to run continuously, using infrared photography at night, and were set to take three photographs at a time with a 1-minute interval before another three photographs could be triggered (Weiskopf *et al.* 2018). Camera trap's locations were chosen in a fashion that they were placed at the junctions of waterways and animal trails with distance from one camera to another was about at least 500 m to 1 km to capture ground-dwelling mammals (Hossain *et al.* 2016). Camera-traps were deployed approximately 25-30 cm above the ground and cemented to a tree using a metal chain (Anaconda Lock). Camera-traps were faced in such a way to avoid direct sun glare and towards forest clearings to minimize vegetation obstructing the field of view. Vegetation close to camera-traps was minimally trimmed to reduce false-trigger events (Seidlitz *et al.* 2021). Camera-traps were checked on regular interval to replace batteries and memory cards if needed (Weiskopf *et al.* 2018). Each photograph of an animal was identified to species level (Francis 2019), otherwise eliminated from the analysis due to low quality for identification. Photographs of the same species captured within half an hour of the first photograph were considered one photographic event (Silveira *et al.* 2003, Rahman *et al.* 2023).

Line transects: Along with camera-trapping, existing forest paths, hill tops, and streams were used as transect to record animals (Varman and Sukumar 1995, Silveria *et al.* 2003, Ferrari *et al.* 2010). Two local assistants guided the survey team for data collection to ensure robust and effective surveys in the hilly terrains of Lathitila. A total of 34 transects with an average length of 1.2 km (ranging from 0.7 km to 2.1 km) was conducted covering approximately the entire study areas, including the forest patches within the forest villagers. Several transects were walked at night to detect nocturnal mammals using spotlight (Smith and Nydegger 1985). The location of each sighting was recorded in handheld Garmin GPS. Photographs of the sighted animals were taken wherever possible using Sony a6400 camera for identification.

Sign survey: Animal sign provides strong basis of animal presence in any forest habitats. The presence of tracks, trails, scats, quills, feeding signs, hair or fur, on forest floors have been used to identify mammalian species (Aziz 2011). During our transect walk, we have observed and examined signs left by animals following standard procedures and protocols (Aziz 2011, Peralta *et al.* 2023). We

noted shape, size and patterns of footprints, and scats, types of vegetation eaten by animals. These data provided clues to species identity (Seidlitz *et al.* 2021).

Live trapping: Box traps, which are usually made of steel-wire, are used to survey small mammals including rats, mice, and tree shrews. We deployed a total of 12 traps with peanut and banana in the forests and within forest villagers. In forests, we selected trapping location based on animal signs to increase the probability of capture. The traps were checked every alternative day to avoid any health issues of trapped animals. Coat patterns and morphological measurements were taken of captured animals for identification (Wijesinghe 2010, Aziz 2011). After taking morphometric measurements, animals were released from where they were trapped.

Interview: Over 300 households of forest villagers have been living within the Lathitila forest landscape who frequently encounter forest animals. We have taken this opportunity to obtain information regarding the presence of mammalian species by interviewing local people who live close to this forest. Therefore, we interviewed a total of 82 forest villagers who were with an average of 44 years old (ranging from 21 to 67 years). We used semi-structured questionnaire aided with prospective animal photographs if they have seen them inside the forests during their forest-related works (Aziz 2011). Interviews were more conversational than formal question-and-answer sessions (Talukdar and Choudhury 2017).

Data analysis: Mammalian species observed at transects was evaluated following 4 categories: very common (vc), common (c), occasional (oc), and rare (r). A species encountered on 75-100% of 34 transects was considered very common, 50-74% of transects as common, 25-49% of transects as occasional and <25% of transects as rare (Bibby *et al.* 2000). The national status and global status of the recorded species were reported from the updated Red List of IUCN Bangladesh (2015) and IUCN global Red List (2023), respectively. The abundance of a species captured in the camera-traps was expressed as encounter rate following Rahman *et al.* (2023), where an independent record of a species was considered if it is captured more than 30 minutes apart at a given camera-trap station. Then the encounter rate was calculated as the number independent records of a given species per 100 camera-trap nights.

RESULTS AND DISCUSSION

A total of 38 mammalian species belonging to 9 orders and 22 families were recorded from the Lathitila forest. Our study revealed that the Lathitila forest holds at least 30% of the total species of the country, which is remarkable considering the mammalian diversity so far reported from any other forest

habitats in the NE region (Aziz 2011, Akash *et al.* 2021, Rahman *et al.* 2021, Rahman *et al.* 2023).

Carnivores: The order Carnivora was represented by 34% of the total recorded species, of which the Felidae comprised the highest number of species (31%) followed by the Viverridae (23%), Herpestidae (15%), Mustelidae (15%), Canidae (8%), and Prionodontidae (8%).

We have recorded 13 species of carnivores, of which 10 were detected by camera-traps (Table 1). The notable of them were the Golden cat (*Catopuma temminckii*), Fishing cat (*Prionailurus viverrinus*), Leopard cat (*Prionailurus bengalensis*), Asian small-clawed otter (*Aonyx cinerea*), and ferret badger (*Melogale* sp.). The presence of Leopard (*Panthera pardus*) remained undetected in camera-traps and sign surveys. However, interview data suggested its presence in the Lathitila reserve forest.

The Golden cat, and Fishing cat could be at low population density in Lathitila forest. The inherent rarity of Golden cat has been reflected in previous studies with limited or no detection in PHR forest (Rahman *et al.* 2021, Rahman *et al.* 2023). It was also reported from other forest habitats in the NE Bangladesh (Rahman *et al.* 2021). Similar holds true for Fishing cat which remained undetected in a study carried out by Rahman *et al.* (2021), and detected only in a single occasion in the nearby forest of PHR (Rahman *et al.* 2023). Although specific records of the distribution of Golden cat are very scanty in Bangladesh, it appeared to be restricted to the NE and SE hilly forests of Bangladesh (McCarthy *et al.* 2015, Rahman *et al.* 2023). The status of Leopard cat seems reasonable which is widely distributed in the country (IUCN Bangladesh 2015).

The Crab-eating mongoose (*Herpestes urva*), Common palm civet (*Paradoxurus hermaphroditus*), and Asian small-clawed otter (*Aonyx cinerea*) were the frequently encountered species among carnivores. Although there are record of this least-known carnivore outside the Sundarbans (Aziz 2018, Rahman *et al.* 2023), this study found it with reasonable detection in the study area. Our field observations suggest that the abundant network of hilly streams enriched with crustaceans and fish could provide an excellent foraging habitat for Asian small-clawed otter as well as Crab-eating mongoose. Elsewhere, crab eating mongoose are known to inhabit tropical and subtropical evergreen and most deciduous forests having abundant crabs, birds, rodents, lizards, and snakes (Choudhury *et al.* 2015, Karim and Ahsan 2016).

We recorded three species of civets, of which Common palm civet scored the higher relative abundance of all species detected in camera-traps, suggesting this species being very common species in this forest habitat. However, Small Indian civet and Masked palm civet appeared to be relatively rare in the study

area. Although we could not detect the Large Indian civet in our study, a recent study detected this species from the nearby forest (Rahman *et al.* 2023), suggesting that it could also be present in Lathitila.

Table 1. Mammalian species recorded during this study in the Lathitila forests of Bangladesh

Order	Family	Scientific Name	Local Name	Study methods	Encounter rate (ct)	Status (this study)	National status	Global status	
Carnivora	Canidae	<i>Canis aureus</i>	Golden jackal	ts		c	LC	LC	
	Felidae	<i>Catopuma temminckii</i>	Golden cat	ct	0.23		VU	NT	
		<i>Prionailurus bengalensis</i>	Leopard cat	ct	0.23		NT	LC	
		<i>Panthera pardus</i>	Leopard	iv, ps		r	CR	VU	
		<i>Prionailurus viverrinus</i>	Fishing cat	ts, ss		r	EN	VU	
	Herpestidae	<i>Herpestes urva</i>	Crab-eating mongoose	ct	13.49		NT	LC	
		<i>Herpestes edwardsii</i>	Indian grey mongoose	ts		c	LC	LC	
		<i>Paradoxurus hermaphroditus</i>	Common palm civet	ct	9.45		LC	LC	
	Viverridae	<i>Viverricula indica</i>	Small Indian civet	ct	0.34		NT	LC	
		<i>Paguma larvata</i>	Masked palm civet	ct	0.46		VU	LC	
		Mustelidae	<i>Aonyx cinerea</i>	Asian small-clawed otter	ct	9.34		EN	VU
			<i>Melogale sp.</i>	Ferret badger	ct	1.03		DD	LC
		Prionodontidae	<i>Prionodon linsang</i>	Banded linsang	ps, iv		r	LC	LC
	Rodentia	Muridae	<i>Vandeleuria oleracea</i>	Asiatic long-tailed climbing mouse	ct	6.57		LC	LC
Spalacidae		<i>Cannomys badius</i>	Lesser bamboo rat	ps, ss		c	DD	LC	
Hystriidae		<i>Hystrix brachyura</i>	Malayan crestless porcupine	ct	8.41		LC	LC	
Sciuridae		<i>Callosciurus pygerythrus</i>	Hoary-bellied squirrel	ts, lt		vc	LC	LC	
		<i>Callosciurus erythraeus</i>	Pallas's squirrel	ts		c	LC	LC	
		<i>Ratufa bicolor</i>	Black giant squirrel	ts		oc	VU	NT	
		<i>Dremomys lokriah</i>	Orange-bellied squirrel	ts		r	LC	LC	

Order	Family	Scientific Name	Local Name	Study methods	Encounter rate (ct)	Status (this study)	National status	Global status
Scandentia Chiroptera	Tupaiaidae	<i>Hylopetes alboniger</i>	Particolored flying squirrel	ts, lt		oc	EN	LC
		<i>Tupaia belangeri</i>	Northern tree shrew	lt	1.96		NT	LC
		<i>Pteropus giganteus</i>	Indian flying fox	ts		vc	LC	LC
		<i>Saccolaimus saccolaimus</i>	Pouched tomb bat	ts		r	LC	LC
		<i>Megaderma lyra</i>	Greater false vampire bat	ts		oc	LC	LC
Primates	Rhinolophidae	<i>Rhinolophus lactus</i>	Woolly horseshoe bat	ts		r	LC	LC
	Cercopithecidae	<i>Macaca assamensis</i>	Assamese macaque	ct	2.88		DD	NT
		<i>Macaca leonina</i>	Northern pig-tailed macaque	ct	0.23		CR	VU
		<i>Macaca mulatta</i>	Rhesus macaque	ct, ts	0.8	vc	VU	LC
	<i>Trachypithecus pileatus</i>	Caped langur	ts		oc	EN	VU	
	<i>Trachypithecus phayrei</i>	Phayre's leaf monkey	ts		c	CR	EN	
	Hylobatidae	<i>Hoolock hoolock</i>	Western hoolock gibbon	ps, iv		oc	CR	EN
Loridae	<i>Nycticebus bengalensis</i>	Bengal slow loris	ps, iv		r	CR	EN	
Artiodactyla	Cervidae	<i>Muntiacus vaginalis</i>	Northern red muntjac	ct	24.22		EN	LC
	Suidae	<i>Sus scrofa</i>	Wild boar	ct	6.11		LC	LC
Lagomorpha	Leporidae	<i>Lepus nigricollis</i>	Indian hare	ts		oc	EN	LC
Pholidota	Manidae	<i>Manis pentadactyla</i>	Chinese pangolin	ps		r	CR	CR
Proboscidea	Elephantidae	<i>Elephas maximus</i>	Asian elephant	ts, ss		r	CR	EN

Study method code: ts - transect survey, lt - live trapping, ps - people's sighting, ss - sign survey, iv - interview

Status Code (this study): vc - very common, c - common, oc - occasional, r - rare

IUCN Status Code: DD - Data Deficient, NT - Near Threatened, LC - Least Concern, VU - Vulnerable, EN - Endangered, CR - Critically Endangered.

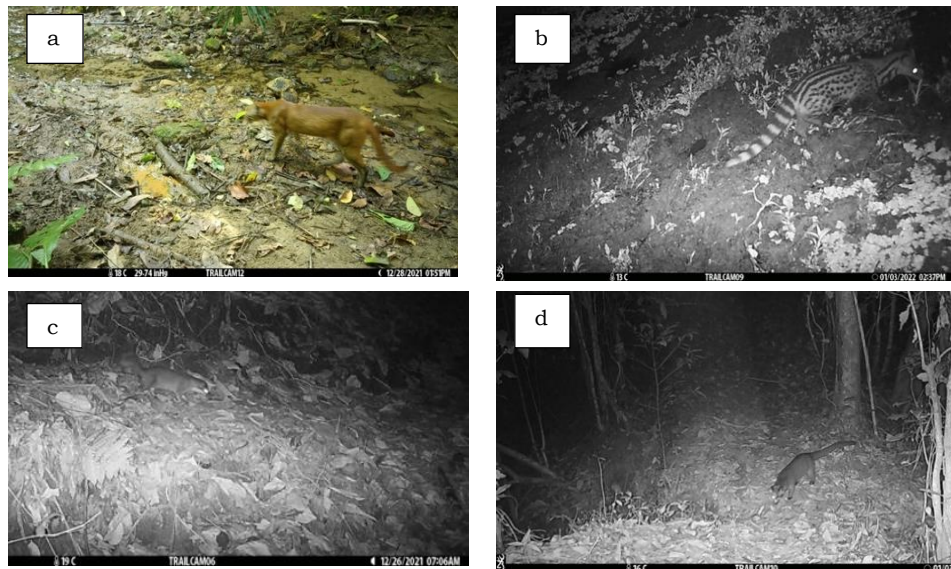
Our interviewees repeatedly mentioned about the occurrence of another viverrid, the Spotted linsang (*Prionodon pardicolor*) in the study area which, however, never been reported from any forest patches of Bangladesh. Its global range and distribution records in the NE Indian forests support the speculation of local inhabitants that this could also occur in this transboundary forest (Choudhury 2013, Duckworth *et al.* 2016).

Primates: Seven species of primates were recorded from the study area. Of them, the globally Endangered Western hoolock gibbon (*Hoolock hoolock*), Bengal slow loris (*Nycticebus bengalensis*) and Phayre's leaf monkey (*Trachypithecus phayrei*) were remarkable including the vulnerable Capped langur (*Trachypithecus pileatus*) and Northern pig-tailed macaque (*Macaca leonina*). We also recorded Assamese macaque (*Macaca assamensis*) which is nationally Data Deficient according to the latest assessment (IUCN Bangladesh 2015), and none of the NE forest patches so far reported any viable population of this primate. All these primates were found during the transect surveys whilst the Assamese macaque were frequently detected in camera-traps. The Western hoolock gibbon and Assamese macaque entirely inhabit the trans-boundary forest areas with less human disturbance whilst the remaining primate fauna were found mostly in the plantation forests across the boundary. Naher *et al.* (2021) reported three groups of Western hoolock gibbon from the PHR whilst the Bengal slow loris was detected by a recent study (Choudhury *et al.* 2022). The Rhesus macaque was common across the plantation forests, with frequent sightings on south and western regions. Among the langurs, the Phayre's leaf monkey was common, encountered frequently across the degraded forest habitats whilst the Capped langur, relatively uncommon, inhabit forest areas away from the forest edges. The later species is common and well-adapted to many of the forest habitats, disturbed and degraded, in the NE Bangladesh (Aziz and Feeroz 2009, Naher *et al.* 2022). The species diversity of primates in this forest appeared to be the highest among all forest habitats in the NE Bangladesh.

Asian elephant: We recorded a herd of 4 female individuals of Asian elephants across the border of Bangladesh and India. The herd is considered trans-boundary and is known to forage between Bangladesh and Indian forest patches of PHR (Islam *et al.* 2011, Talukdar and Choudhury 2017, Rahman *et al.* 2023). Until 2009, this lone herd reportedly had a single male elephant which died later due to unknown reason, leaving the herd with female elephants only (Talukdar *et al.* 2020). This is only herd of Asian elephant across the entire PHR of Bangladesh and India, and has no connectivity with any other populations in the regions, leaving the elephants with no opportunity for reproduction (Talukdar *et al.* 2020). A transboundary effort of introducing a male elephant in the herd may help the population reproduce for their survival.

Artiodactyls: The Northern red muntjac (*Muntiacus vaginalis*) and Wild boar (*Sus scrofa*) were two common ungulates being detected in camera-trap with higher number of records of the former one. These ungulates were exclusive forest dwellers and remain active during the day and night across the less-disturbed forest patches along the borders. Camera-trap records and field observations suggest that both ungulates perhaps use stream-beds for movement and feeding rather than crossing the hills and slopes. Both of these species are also common across the forest patches of NE Bangladesh (Aziz 2011, Feeroz *et al.* 2011, Rahman *et al.* 2021, Rahman *et al.* 2023).

Chiropterans: We detected two species of rare chiropterans that include the Pouched tomb bat (*Saccolaimus saccolaimus*), and Woolly horseshoe bat (*Rhinolophus lactus*). Besides, roosts of Greater false vampire bat (*Megaderma lyra*), and Indian flying fox (*Pteropus giganteus*) were found in the study areas. A small colony of pouched tomb bat comprising approximately 12 individuals were found in crevices of banyan tree (*Ficus sp.*) whilst only two individuals of woolly horseshoe bat were in a small cave inside the forest. There are very few records of these bat species in Bangladesh, suggesting that the forest is also rich in supporting rare bat fauna (IUCN Bangladesh 2015). The greater false vampire bat was detected in an abandoned house of forest department on the fringe of forests. The remaining two chiropterans were observed during roosting and foraging in a variety of fruit trees (*Ficus sp.*, *Artocarpus chaplasha*) inside and on the fringe of the forest. A population of approximately 400-500 individuals of Indian flying fox was recorded in two roosting sites.



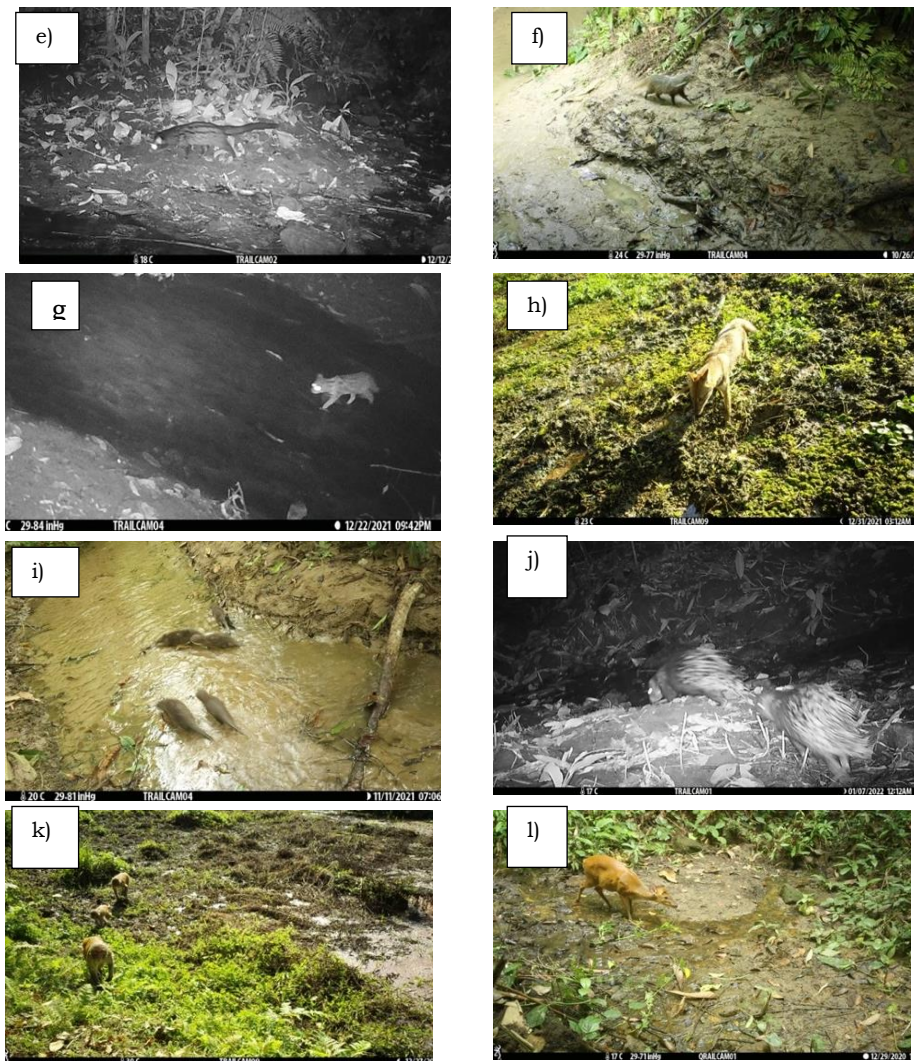


Fig. 2. Mammalian species captured in the camera-traps in Lathitila forest of Bangladesh. (a) Golden cat *Catopuma temminckii* (b) Small Indian civet *Viverricula indica* (c) Ferret badger *Melogale* sp. (d) Masked palm civet *Paguma larvata* (e) Common palm civet *Paradoxurus hermaphroditus* (f) Crab-eating mongoose *Herpestes urva* (g) Leopard cat *Prionailurus bengalensis* (h) Golden jackal *Canis aureus* (i) Asian small-clawed otter *Viverricula indica* (j) Malayan crestless porcupine *Hystrix brachyura* (k) Rhesus macaque *Macaca mulatta* (l) Northern red muntjac *Muntiacus vaginalis*



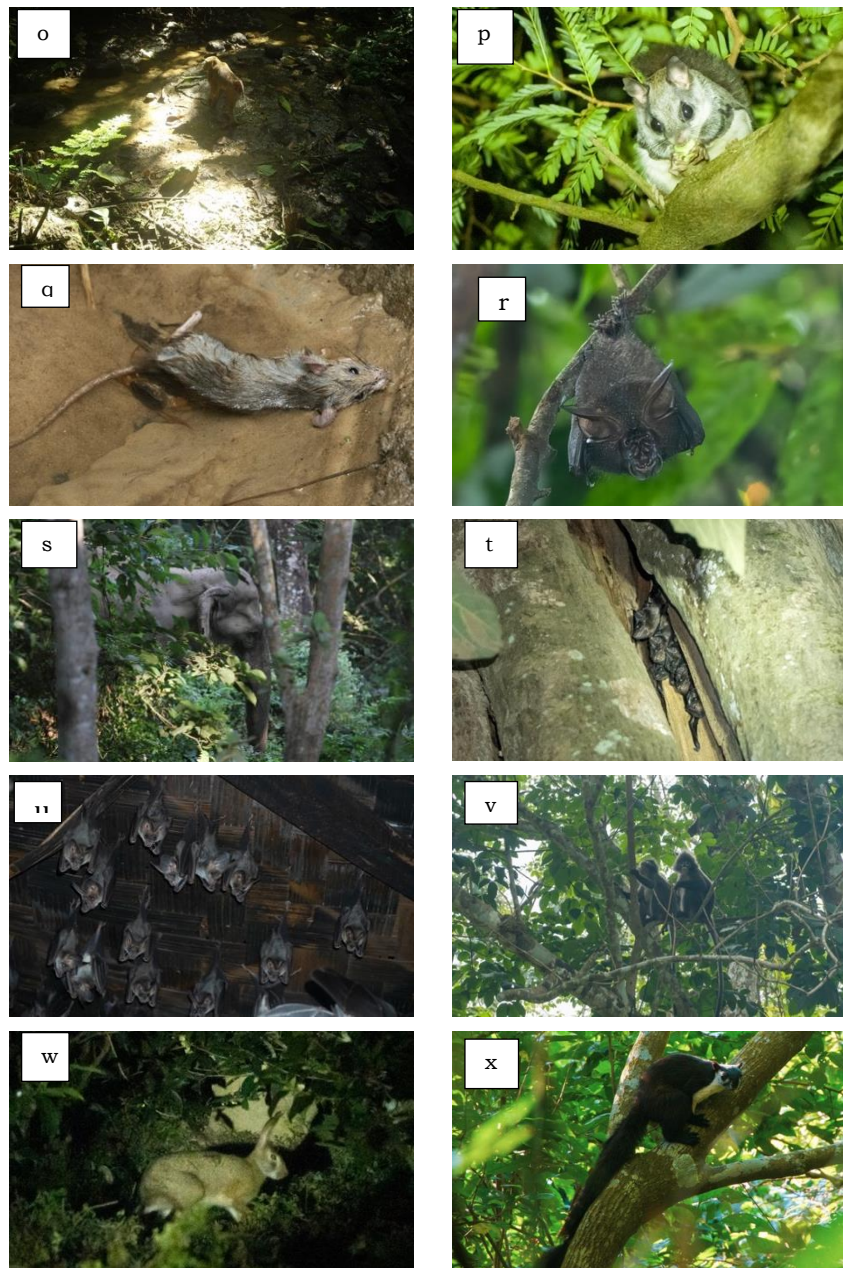


Fig. 3. Mammalian species captured in the camera-traps (m-o) and photographed during transect surveys (p-x) in the Lathitila forest of Bangladesh: (m) Wild boar *Sus scrofa* (n) Assamese macaque *Macaca assamensis* (o) Northern pig-tailed macaque *Macaca leonina* (p) Particolored flying squirrel *Hylopetes alboniger* (q) Asiatic long-tailed climbing mouse *Vandeleuria oleracea* (r) Woolly horseshoe bat *Rhinolophus lactus* (s) Asian elephant *Elephas maximus* (t) Pouched tomb bat *Saccolaimus saccolaimus* (u) Greater false vampire bat *Megaderma lyra* (v) Phayre's leaf monkey *Trachypithecus phayrei* (w) Indian hare *Lepus nigricollis* (x) Black giant squirrel *Ratufa bicolor*.

Rodents: Eight species were recorded from the order Rodentia, six of them were sighted directly during transect survey. Notable species includes the Black giant squirrel (*Ratufa bicolor*) and Particolored flying squirrel (*Hylopetes alboniger*), of which the later one is exclusively nocturnal. The black giant squirrel was found mostly in plantation forests where human disturbance is relatively low. On the other hand, Particolored flying squirrel was detected in orchards around forest villages at night. A previous study has also reported the majority of sightings in orchards (Al-Razi and Maria 2019). The Lesser bamboo rat (*Cannomys badius*) was also recorded by direct sighting and from the feeding sign around bamboo grooves. The Northern tree shrew and Asiatic long-tailed climbing mouse (*Vandeleuria oleracea*) were captured by live-trapping whilst the Malayan crestless porcupine (*Hystrix brachyura*) was detected by camera-traps (Hasan and Neha 2019). The northern tree shrew, Asiatic long-tail climbing mouse, and Malayan crestless porcupine were found common across the trans-boundary areas of the forest.

Other mammals: Our camera-traps could not detect the Chinese pangolin (*Manis pentadactyla*) during the study (Trageser et al. 2017); however, signs of potential holes were observed in several locations, deep inside the transboundary forest region. Majority of interviewees (81%) suggest its occurrence in the Lathitila forest. This finding also corroborates the observations of Talukdar and Choudhury (2017) who mentioned its presence in the Indian side of the PHR. It is reported by interviewees that local poachers were engaged by disguised illegal traders to supply the pangolins over the past few years. We have found the Indian hare (*Lepus nigricollis*) across the forest fringes surrounded by tea gardens on the south and west of Lathitila. However, its presence deep inside the forest was not detected by camera-traps, suggesting that this mammalian forages close to the areas between tea garden and forests. It appeared that tea garden might have provided excellent foraging ground and refuge for this animal. Similarly, Golden jackal (*Canis aureus*) was captured in camera-traps from the south border of the forest near the forest villages. It seems that they avoid forest interior perhaps due to steep hills and network of streams. However, it is commonly found around human habitations and tea gardens surrounding the Lathitila forests.

CONCLUSION

The mammalian population shows a clearly downward trend over the previous few decades in Bangladesh (Islam et al. 2006). The continued human pressures are accelerating the sharp decline of populations of large-bodied animals across their habitats (Rawshan et al. 2012, Talukdar et al. 2020). Bangladesh already has lost 11 species of mammals whilst 29.7% have been

classified as threatened (IUCN Bangladesh 2015). However, occurrence of mammalian species and their habitats have consistently been shown to be valuable due to continuous degradation of forest (Mazumdar *et al.* 2011). The mammalian species recorded in this study contains 55% of nationally threatened mammalian fauna, of which 26% are globally threatened. This clearly highlights the richness and potential of these least-known forest habitats to support mammalian diversity in the NE Bangladesh.

A thorough species inventory is a valuable resource for systematic monitoring of biodiversity of any habitat (Sharma *et al.* 2015). Our study provided substantial information about medium- and small-sized mammalian species of this forest habitat. However, additional species is expected in the list from the rodents and chiropterans in future studies that would require systematic investigations by using mist-netting and live-trapping techniques. We believe that our study would be useful in future updating the national Red List for the species which were categorized Data Deficient or threatened.

Worryingly, the Lathitila forest is losing its vigour and ecosystem integrity very rapidly. Specifically, the forest is threatened by rapid encroachment and illegal extraction of forest resources, leaving the diverse mammalian fauna in jeopardy. The condition of forest habitat is further aggregated by cross-border wildlife and forest related crimes, local wildlife hunting, and widespread settlements by 'forest' villagers (Mazumder 2014). The south and west fringes of the Lathitila forest have been heavily settled by over three hundred forest villagers, who have been reportedly engaged with a range of illegal forest and wildlife related crimes, including their regular livelihood activities by encroaching reserve forests. We recommend to elevate the status of the reserve forest and to take the entire Patharia Hill Reserve under PA networks of the country. This will supplement an increase of a very low coverage of protected areas comprising only 1.4% of Bangladesh (Sunderland *et al.* 2011).

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LITERATURE CITED

- AL-RAZI, H., and MARIA, M. 2019. Population status of particolored flying squirrel (*Hylopetes alboniger*) in four forest patches of northeast Bangladesh. *NeBIO*, **10**(2), 77-79.
- AL-RAZI, H., MARIA, M., MUZAFFAR, S.B., and NEKARIS, K.A.I. 2020. Population Status, Threats and Conservation of the Bengal slow loris *Nycticebus bengalensis* in Northeast Bangladesh. *Folia Primatologica*, **91**(3), 327-328.

- AHMED, T., and NAHER, H. 2021. Population status of Northern pig-tailed macaque (*Macaca leonina*) in Satchari National Park, Bangladesh. *Asian Primates Journal*, **9**, 32-40.
- AHSAN, M.F., and CHOWDHURY, M.W. 2008. Mammals of the Chittagong University Campus, Chittagong. *Bangladesh Journal of Zoology*, **36**(2), 131-147.
- AHUMADA, J.A., SILVA, C.E., GAJAPERSAD, K., HALLAM, C., HURTADO, J., MARTIN, E., MCWILLIAM, A., MUGERWA, B., O'BRIEN, T., ROVERO, F., and SHEIL, D. 2011. Community structure and diversity of tropical forest mammals: data from a global camera trap network. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **366**(1578), 2703-2711.
- AZIZ, M.A., and FEEROZ, M.M. 2009. Utilization of forest flora by Phayre's Leaf-Monkey *Trachypithecus phayrei* (Primates: Cercopithecidae) in semi-evergreen forests of Bangladesh. *Journal of Threatened Taxa*, **1**(5), 257-262.
- AZIZ, M.A. 2011. Notes on the status of mammalian fauna of the Lawachara National Park, Bangladesh. *Ecoprint: An International Journal of Ecology*, **18**, 45-53.
- AZIZ, M.A. 2018. Notes on population status and feeding behaviour of Asian small-clawed Otter (*Aonyx cinereus*) in the Sundarbans Mangrove Forest of Bangladesh. *IUCN Otter Spec. Group Bull*, **35**(1), 3-10.
- BANGLADESH METEOROLOGICAL DEPARTMENT. 2012. Climate in Bangladesh. Accessed on January, 2012. Available at <http://www.bmd.gov.bd/>
- BARLOW, J., and PERES, C.A. 2006. Effects of single and recurrent wildfires on fruit production and large vertebrate abundance in a central Amazonian Forest. *Biodiversity & Conservation*, **15**, 985-1012.
- BIBBY, C.J., BURGESS, N.D., HILL, D.A., and MUSTOE, S.H. 2000. Bird census techniques. Academic Press, London.
- CHAKMA, S. 2017. Assessment of large mammals of the Chittagong Hill Tracts of Bangladesh with emphasis on Tiger (*Panthera tigris*), Unpublished PhD Thesis, University of Dhaka, Bangladesh, pp. 99-105.
- CHOUDHURY, A.S., CHOUDHURY, P., and GASSAH, R. 2022. Habitat suitability modelling for the endangered Bengal slow loris (*Nycticebus bengalensis*) in the Indo-Chinese subregion of India: a case study from southern Assam (India). *Primates*, **63**, 173-184. <https://doi.org/10.1007/s10329-021-00967-x>
- CHOUDHURY, A., TIMMINS, R., CHUTIPONG, W., DUCKWORTH, J.W., MUDAPPA, D., and WILLCOX, D.H.A. 2015. *Herpestes urva* (errata version published in 2016). *The IUCN Red List of Threatened Species* 2015: e.T41618A86159618. <https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T41618A45208308.en>. Accessed on 18 August 2023.
- CHOUDHURY, A. 2013. *The mammals of North east India*. Guwahati: Gibbon Books, Assam, India, ix+431 pp.
- DAS, J., FEEROZ, M.M., ISLAM, M.A., BISWAS, J., BUIARBORUA, P., CHETRY, D., MEDHI, R., and BOSE, J. 2003. Distribution of hoolock gibbon (*Bunopithecus hoolock hoolock*) in India and Bangladesh. *Zoos' Print Journal*, **18**(1), 969-976.

- DUCKWORTH, J.W., LAU, M., CHOUDHURY, A., CHUTIPONG, W., TIMMINS, R.J., WILLCOX, D.H.A., CHAN, B., LONG, B., and ROBERTON, S. 2016. *Prionodon pardicolor*. *The IUCN Red List of Threatened Species* 2016: e.T41706A45219917.
<https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41706A45219917.en>.
- DUTTA, H., SINGHA, H., DUTTA, B.K., and DEB, P. 2018. Human-Elephant Conflict in Patheria Hills Reserve Forest along the Indo-Bangladesh Border in Northeast India. *Gajah*, Asian Elephant Specialist Group, **48**, 24–26.
- FAO. 2008. National Forest and tree resources assessment 2005–2007, Bangladesh. Rome, Italy. Online at: <http://www.fao.org/forestry/17847/en/bgd>
- FEEROZ, M.M., HASAN, M.K., and KHAN, M.M.H. 2011. Biodiversity of protected areas of Bangladesh. Vol. I: Rema-Kalenga Wildlife Sanctuary. Bangladesh: BioTrack, *Arannayk Foundation*. Dhaka. pp. 8-20.
- FEEROZ, M.M., HASAN, M.K., and HOSSAIN, M.K. 2012. Biodiversity of Protected Areas of Bangladesh, Vol. II: Dudpukuria-Dhopachari Wildlife Sanctuary. BioTrack, *Arannayk Foundation*, Dhaka, pp. 10-39.
- FERRARI, S.F., CHAGAS, R.R., and SOUZA-ALVES, J.P. 2010. Line transect surveying of arboreal monkeys: problems of group size and spread in a highly fragmented landscape. *American Journal of Primatology*, **72**(12), 1100-1107.
- FRANCIS, C. 2019. *Field guide to the mammals of South-east Asia*. Bloomsbury Publishing.
- HAQUE, M.A., KHAN, M.M.H., and KABIR, M.M. 2020. Assessment of status and threats of wild mammals in some selected locations of Dinajpur district, Bangladesh. *Jahangirnagar University Journal of Biological Sciences*, **9**(1-2), 21-34.
- HASAN, M.A.U., and NEHA, S.A. 2019. The Himalayan Crestless Porcupine *Hystrix brachyura* Linnaeus, 1758 (Mammalia: Rodentia: Hystricidae): first authentic record from Bangladesh. *Journal of Threatened Taxa*, **11**(12), 14624-14626.
- HOSSAIN, M.N., ROKANUZZAMAN, M., RAHMAN, M.A., BODIUZZAMAN, M., and MIAH, M.A. 2013. Causes of deforestation and conservation of Madhupur Sal Forest in Tangail Region. *J. Environ. Sci. & Natural Resources*, **6**(2), 109-114.
- HOSSAIN, M.K. 2016. Bangladesh national conservation strategy biodiversity: Flora. *Ministry of Environment and Forests*, GoB, Dhaka, pp. 23-24.
- HOSSAIN, A.N.M., BARLOW, A., BARLOW, C.G., LYNAM, A.J., CHAKMA, S., and SAVINI, T. 2016. Assessing the efficacy of camera trapping as a tool for increasing detection rates of wildlife crime in tropical protected areas. *Biological Conservation*, **201**, 314-319.
- ISLAM, M.A., FEEROZ, M.M., MUZAFFAR, S.B., KABIR, M.M., and BEGUM, S. 2006. Conservation of the hoolock gibbons (*Hoolock hoolock*) of Bangladesh: Population estimates, habitat suitability and management options. *Technical Report. US Fish and Wildlife Service*, pp. 48.
- ISLAM, M.A., MOHSANIN, S., CHOWDHURY, G.W., CHOWDHURY, S.U., AZIZ, M.A., UDDIN, M., SAIF, S., CHAKMA, S., AKTER, R., JAHAN, I., and AZAM, I. 2011. Current status of Asian elephants in Bangladesh. *Gajah*, **35**, 21-24.

- IUCN Bangladesh. 2015. Red List of Bangladesh Volume 2: Mammals. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, xvi+232 pp.
- KARIM, R., and AHSAN, F. 2016. Mammalian fauna and conservational issues of the Baraiyadhala National Park in Chittagong, Bangladesh. *Open Journal of Forestry*, **6**(02), 123.
- KHAN, M.A.R. 2001. Status and distribution of bats in Bangladesh with notes on their ecology. *Zoos' Print Journal*, **16**(5), 479-483.
- KHAN, M.M.H. 2008. Protected areas of Bangladesh: A guide to wildlife. Nishorgo Program, Wildlife Management and Nature Conservation Circle, Bangladesh Forest Department, pp. 304.
- KHAN, M.A.R., HAWUE, E.U., KHAN, M.M.H., AHMED, I., CHAKMA, S., NAHER, H., CHOWDHURY, M.A.W., MUKUL, S.A., CHOWDHURY, S.U., RAHMAN, S.C., and KABIR, M.T. 2022. A Proposed Safari Park in a Subtropical Forest in Northeastern Bangladesh Will Be Detrimental to Native Biodiversity. *Conservation*, **2**(2), 286-296.
- MAZUMDAR, K., SOUD, R., and GUPTA, A. 2011. Mammalian diversity of degraded forest habitats around Assam University Campus, Cachar, Assam, India, with notes on conservation status. *Our Nature*, **9**(1), 119-127.
- MAZUMDER, M.K. 2014. Diversity, habitat preferences, and conservation of the primates of Southern Assam, India: The story of a primate paradise. *Journal of Asia-Pacific Biodiversity*, **7**(4), 347-354.
- MCCARTHY, J., DAHAL, S., DHENDUP, T., GRAY, T.N.E., MUKHERJEE, S., RAHMAN, H., RIORDAN, P., BOONTUA, N., and WILCOX, D. 2015. *Catopuma temminckii*, *The IUCN Red List of Threatened Species* 2015: e.T4038A97165437. <https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T4038A50651004.en>.
- NAHER, H., AL-RAZI, H., AHMED, T., HASAN, S., JARADAT, A., and MUZAFFAR, S.B. 2021. Estimated Density, Population Size and Distribution of the Endangered Western Hoolock Gibbon (*Hoolock hoolock*) in Forest Remnants in Bangladesh. *Diversity*, **13**(10), 490.
- NAHER, H., MONDAL, T., HASAN, M.S., KHAN, S.I., and MUZAFFAR, S.B. 2022. Activity Budget and Diet of Phayre's Langur (*Trachypithecus phayrei*) in Satchari National Park, Bangladesh. *Primate Conservation*, **36**, 173-189.
- PERALTA, D., VAZ-FREIRE, T., FERREIRA, C., MENDES, T., MIRA, A., SANTOS, S., ALVES, P.C., LAMBIN, X., BEJA, P., PAUPERIO, J., and PITA, R. 2023. From species detection to population size indexing: the use of sign surveys for monitoring a rare and otherwise elusive small mammal. *European Journal of Wildlife Research*, **69**(1), 9.
- RAHMAN, M.A., SUZUKI, A., UDDIN, M.S., MOTALIB, M., CHOWDHURY, M.R.K., HAMZA, A., and AZIZ, M.A. 2023. Presence of medium and large sized terrestrial mammals highlights the conservation potential of Patharia Hill Reserve in Bangladesh. *Journal of Threatened Taxa*, **15**(6), 23283-23296.
- RAHMAN, H.A., MCCARTHY, K.P., MCCARTHY, J.L., and FAISAL, M.M. 2021. Application of Multi-Species Occupancy Modelling to assess mammal diversity in northeast Bangladesh. *Global Ecology and Conservation*, **25**, e01385. doi:10.1016/j.gecco.2020.e01385

- RAWSHAN, K., FEEROZ, M.M., and HASAN, M.K. 2012. Human-carnivore conflicts in Bangladesh. *Tigerpaper*, **39**(3), 17-21.
- REDDY, C.S., PASHA, S.V., JHA, C.S., DIWAKAR, P.G., and DADHWAL, V.K. 2016. Development of national database on long-term deforestation (1930–2014) in Bangladesh. *Global and Planetary Change*, **139**, 173-182.
- ROWCLIFFE, J.M., KAYS, R., KRANSTAUBER, B., CARBONE, C., and JANSEN, P.A. 2014. Quantifying levels of animal activity using camera trap data. *Methods in ecology and evolution*, **5**(11), 1170-1179.
- SARKER, S.K., RASHID, S., SHARMIN, M., HAQUE, M.M., SONET, S.S., and NUR-UN-NABI, M. 2014. Environmental correlates of vegetation distribution in tropical Juri forest, Bangladesh. *Tropical Ecology*, **55**(2), 177-193. www.tropecol.com
- SEIDLITZ, A., BRYANT, K.A., ARMSTRONG, N.J., CALVER, M.C., and WAYNE, A.F. 2021. Sign surveys can be more efficient and cost effective than driven transects and camera trapping: a comparison of detection methods for a small elusive mammal, the numbat (*Myrmecobius fasciatus*). *Wildlife Research*, **48**(6), 491-500.
- SHARMA, G., KAMALAKANNAN, M., and VENKATARAMAN, K. 2015. A checklist of mammals of India with their distribution and conservation status. *Zool Surv India*, pp. 111.
- SILVERIA, L., JÁCOMO, A.T., and DINIZ-FILHO, J.A.F. 2003. Camera trap, line transect census and track surveys: a comparative evaluation. *Biological conservation*, **114**(3), 351-355.
- SMITH, G.W., and NYDEGGER, N.C. 1985. A spotlight, line-transect method for surveying jack rabbits. *The Journal of wildlife management*, **49**(3), 699-702.
- SUNDERLAND, T.C.H., KIBRIA, M.G., RAHMAN, S.A., and IMTIAJ, A. 2011. Depleting tropical forest at a landscape scale: finding solutions for Bangladesh. *Journal of Biodiversity and Ecological Sciences*, **1**(1), 53-64.
- TALUKDAR, N.R., and CHOUDHURY, P. 2017. Conserving wildlife wealth of Patharia Hills reserve forest, Assam, India: A critical analysis. *Global Ecology and Conservation*, **10**, 126-138.
- TALUKDAR, N. R., CHOUDHURY, P., AHMAD, F., AHMED, R., and AL-RAZI, H. 2020. Habitat suitability of the Asiatic elephant in the trans-boundary Patharia Hills Reserve Forest, northeast India. *Modeling Earth Systems and Environment*, **6**(3), 1951-1961.
- TRAGESER, S.J., GHOSE, A., FAISAL, M., MRO, P., MRO, P., and RAHMAN, S.C. 2017. Pangolin distribution and conservation status in Bangladesh. *PloS one*, **12**(4), e0175450. doi:10.1371/journal.pone.0175450
- UN-REDD BANGLADESH NATIONAL PROGRAM. 2016. Drivers of Deforestation and Forest Degradation in Bangladesh: Final report. UN-REDD Bangladesh National Program, 10 January 2017.
- VARMAN, K.S., and SUKUMAR, R. 1995. The line transect method for estimating densities of large mammals in a tropical deciduous forest: An evaluation of models and field experiments. *Journal of Biosciences*, **20**(2), 273-287.

- WEISKOPF, S.R., MCCARTHY, K.P., TESSLER, M., RAHMAN, H.A., MCCARTHY, J.L., HERSCH, R., FAISAL, M.M., and SIDDALL, M.E. 2018. Using terrestrial haematophagous leeches to enhance tropical biodiversity monitoring programmes in Bangladesh. *Journal of Applied Ecology*, **55**(4), 2071-2081.
- WIJESINGHE, M.R. 2010. Efficiency of live trapping protocols to assess small mammal diversity in tropical rainforests of Sri Lanka. *Belgian Journal of Zoology*, **140**(2), 212-215.
- ZAKARIA, M., RAJPAR, M.N., OZDEMIR, I., and ROSLI, Z. 2016. Fauna diversity in tropical rainforest: Threats from land-use change. *Tropical forests-the challenges of maintaining ecosystem services while managing the landscape*, pp. 11-49.
<http://dx.doi.org/10.5772/64963>
- ZAKIR, T., DEBBARMA, H., MAHJABIN, R., DEBBARMA, R., KHAN, Z., MINU, M.M.R., ZAHURA, F.T., and AKASH, M. 2021. Are northeastern forests of Bangladesh empty? Insights from camera-trapping into spatiotemporal activity pattern of mammals in a semi-evergreen national park. *Mammal Study*, **46**(4), 323-339.

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