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ESTIMATING MAMMALIAN ABUNDANCE AND OCCUPANCY IN TROPICAL FOREST INDIAN HIMALAYA, DAMPA TIGER RESERVE, MIZORAM, INDIA

Janmejay SETHY[1*], Netrapal Singh CHAUHAN[1], Meesala Krishna MURTHY[2]

[1] Amity Institute of forestry and Wildlife (AIFW), Amity University, Sector-125, Noida, 201303, Gautam Buddha Nagar, Uttar Pradesh, India
[2] Department of Zoology, Mizoram University, Tanhril, Aizawl-796004, Mizoram, India

Abstract

It is common to use noninvasive camera traps for detecting mammals in the Neotropics. However, little research has been conducted to evaluate how effective this method is for monitoring species diversity. In Dampa Tiger Reserve (DTR), 43 line-transect surveys and automated acoustic monitoring were carried out between August 2014 and March 2016. This information provides baseline knowledge of global mammal distribution and abundance. Twenty-five mammalian species were identified during the survey, and 15 were confirmed through photographs and direct sightings. Among these species, 6 are endangered, 1 is deficient in data, 1 is lower risk, 11 are vulnerable, 5 are near-threatened, and 16 are of least concern according to the 2010 IUCN Red List. The majority of trapped was Ursus thibetanus, Helarctos malayanus, Neofelis nebulosa, Bos gaurus, Sus scrofta, Rusa unicolor, Hystrix indica and Atherurus marourus. Mammals were found in New Chika (40.57%), Old Chika (19.04%), Malpui (22.85), Tuilut (21.5%), Tuichar (12.63%), IR camp (33.33%) and Pathloi (6.25%). Among the mammals in the area, Sus scrofta (16.26%) was the most abundant. The activity pattern indicates a large carnivorous preferring evening or late at night. Most photos were taken between 4.00 and 10:00 pm and 4.00 to 8:00 am for the Asian black bear and Malayan sun bear, respectively. During the hours of 6-12 pm, small carnivorous animals were active. Study results demonstrate that using camera traps, monitoring programs, and local knowledge could provide precise information about the abundance and distribution of mammals in a reserve that indeed could serve to conserve the species for the long term.

Keywords: *Activity pattern; Dampa Tiger Reserve; Distribution; Mammals; Photo capture*

Introduction

Most of the Earth's habitats are occupied by mammals, which include some of the fastest runners, deepest divers, and most agile fliers. A total of 25 percent of mammals of conservation status are at risk of extinction. In spite of the usefulness of protected areas for measuring national conservation efforts [1, 2], reduction of tropical forests and the combined impacts of habitat loss (affecting 40% of mammals), fragmentation, hunting and harvesting (affecting 17% of mammals) by native wildlife populations have forced many species to the point of extinction [2, 3].

The Northeast of India (Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram, Nagaland, and Sikkim), which is unique in its variety of habitats and diversity of biota [4-6]. It comprises around 8% of the country's geographical area and accounts for around

* Corresponding author: jsethy@amity.edu

25% of its total forest cover [7, 8]. India harbors 417 species of mammals, of which 54% are threatened in the northeastern regions [9]. There is a great variety of floral and faunal species in the region due to the diverse climatic conditions, rainfall and other environmental factors. For management interventions and the conservation status of the flora and faunas of the region, knowledge of species diversity, distribution, and abundance is paramount [10]. Studies of species richness and abundance and efficient and reliable methods are also essential for determining conservation priorities.

Herpesids, mustelids, and viverrids (small carnivores) are mainly found in two major ecological regions of the Indian subcontinent, the Eastern Himalaya and the North-East Hills, as well as the Western Ghats. North-East India has the highest diversity of small carnivores due to its geographic location at the confluence of three important bio-geographic realms, with a variety of species that are unique to the region.

A region's ecosystem and its biodiversity are often maintained by species of large mammals [11]. Considering the scarcity of zoological data for the entire range, we made an effort to provide a status report on the mammalian diversity of Dampa Tiger Reserve (DTR) along with evidence on the abundance and occurrence of mammals. Many of the flora and fauna species in DTR are yet to be documented. It is one of the last low- to mid-elevation forests in western Mizoram.

Materials and methods

Study area

The present study was carried out in the Dampa Tiger Reserve (DTR), located in the Mamit district of Mizoram along the Bangladesh border. In 1994, it was reclassified as a Tiger Reserve from a Wildlife Sanctuary (Fig. 1). The reserve occupies an area of 550 square kilometers, and it is located between 23° 23' 15" N and 23° 42' 20" N latitudes, and 92° 16' 25" E and 92° 25' 55" E longitudes [12]. Reserve habitats consist of a variety of habitats characterized by diverse biota, with a rich floral and faunal diversity. There is tropical evergreen vegetation to semi-evergreen vegetation in the reserve.

Fig. 1. Map of Study area

Forests in moist valleys consist primarily of evergreens, but higher slopes on the western aspect are dominated by deciduous trees, with sympodial bamboo in their understory [13]. We recorded mammalian diversity using indirect sighting, scats, trophies, questionnaire surveys, and camera traps between February 2014 and March 2016 (Fig. 2). Many modern records come from sightings; however, since most species rarely seen and many of them are nocturnal, camera traps are preferred to observational studies when it comes to documenting species richness and assessing population status [14].

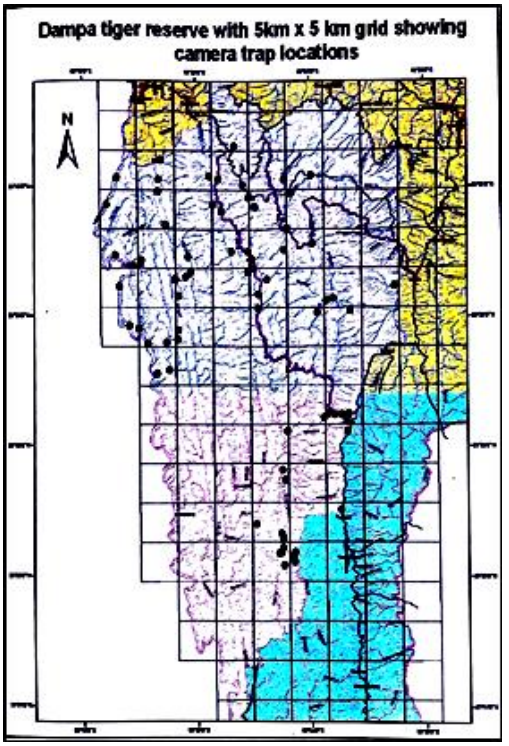

Fig. 2. Camera trapping location with gride

Preliminary surveys

To collect first-hand information about the distribution of different mammalian species occurring in Dampa Tiger Reserve, a pilot survey was conducted in the initial months of the study period on trails, footpaths, and transects lines. In addition to local interviews, the assessment of mammalian fauna (distribution and relative abundance) was also made depending on the terrain.

Camera trapping

In the tiger reserve, 43 camera-trap units were placed in 8 different areas based on preliminary information. By sensing the animal's body heat and movement, the cameras take photographs automatically. Within a Geographic Information System (GIS), the study area was divided into 3 km^2 blocks. In areas with fruiting trees, water bodies, and animal wallowing hovels, the cameras were positioned 30-50 cm off the ground. Each season of the year, the cameras were active 24 hours a day, and trapping sessions lasted an average of 15 days.

Occupancy

In order to organize and manage binary detection histories for each species detected, we combined all photos from both field seasons (1 = detected species, 0 = not detected species) after the surveys were completed. The first metric used to evaluate the effectiveness of cameras

was the latency to initial detection (LTD). We simply calculate the number of trap nights needed to detect the species of interest as the mean number of trap nights. To compare to previous camera studies in the Neotropics, I calculated the number of independent detections for each species per 1000 trap nights. After estimating species richness and single-species detection probabilities at the landscape level, I used an occupancy modeling approach similar to that described by Mackenzie *et al.* [15, 16]. To determine the proportion of species, present in each site, the modeling process treats each species as a site and incorporates species-specific detection probabilities (Ψ) [16].

Local interviews

We conducted interviews, camera trapping results, and informal discussions in 10 villages (Damparengpui, Khawhnai, Serhmun, Tuipuibari, Rajivnagar, Terei, Tuirum, Saithah, Phuldungsui, and West Pheling) residing in and around the Tiger Reserve to assess the awareness of local people regarding mammal diversity in the area. Approximately 1000 households were interviewed, including Gaon Buras (village leaders), farmers, livestock herders, former hunters, wildlife guards, and trackers. Field guides [17-19] contained pictures and drawings of selected mammal species; respondents were asked to note their knowledge of species occurrence and distribution based on their observations.

Data analysis

For each species, the photo-capture rates were calculated as the number of days required to obtain a photo of the species [20]. Images of a species were only considered valid if they were taken independently. According to O'Brien *et al.* [21], independent detections include (1) consecutive images of individuals of the same species or of different species, (2) consecutive photographs of the same species taken more than 30 minutes apart, and (3) non-consecutive photographs of the same species [22, 23].

In each habitat and location covered during the study, the trap index was computed as follows:

$$\text{Trap Index} = \frac{\text{Total no. of species}}{\text{No. of trapping days X No of traps}} \text{X } 100 \quad (1)$$

According to the model, the relative abundance index (RAI) of the mammals was determined using camera traps and track plots; I/N x 100, where I is the number of occurrences of species; N is the total number of occurrences in the physiognomy [24, 25].

The day was divided into two-hour periods and the number of photos taken during each interval was noted in order to understand the activities of the mammalian species based on their time of capture. The following formula was used to calculate a daily activity index (DAI) [26].

For estimating the density, it should be noted that different animals have a minimum habitat limit, and it solely depends on the species. Additionally, the number of captures was far too low to make more accurate calculations regarding the populations. A crude block density of different forest locations can be calculated if individuals captured by independent camera traps one time are considered to be separate individuals.

$$\text{Blockwise density (crude)} = \frac{\text{Photos captured at least once by the camera in a block}}{\text{Area of the block in which camera has been set up}} \quad (2)$$

The range of a species can vary depending on the species. Therefore, two images captured on adjacent cameras may be of the same animal. Considering this, caution should be exercised when interpreting the current assessments given their crude nature. Until more robust data have been collected through repeated surveys soon, an inference regarding the population cannot be made with scientific accuracy.

Our results were compared with those from studies in geographically and climatically similar forests found in nine South-east Asian sites under substantially low or similar hunting pressure [23, 27-35].

Results and discussion

Status and distribution of mammals in Dampa Tiger Reserve (DTR)

As a result of the study, Dampa Tiger Reserve (DTR) is home to 40 species of mammals spanning 19 families. The confirmation was based on visual encounters, photo-captures (Camera-trap), sign and trophies **(**Table 1). 25 species were recorded from the camera trap (Fig. 3) and while the other fifteen were confirmed through scats, trophies and direct sighting.

Fig. 3. List of camera trap mammal pictures from the study area (Dampa Tiger Reserve)

Of the 40 species, 6 (15%) are listed as endangered (*Elephas maximus, Cuon alpines, Trachypithecus pileatus, Hoolock hoolock, Trachypithecus phayrei* and *Manis pentadactyla*), 1 (3%) as data deficient ((*Helarctos malayanus*), 1 (3%) as lower risk (*Mellivora capensis*), 11 (27%) as vulnerable, 5 (12%) as near threatened and 16 (40%) as least concern species by the IUCN Red List (2010) (Table 1 and Fig. 4).

Table 1. Status and distribution of mammals in Dampa Tiger Reserve (DTR)

Sl. No	Common name	Zoological name	IUCN status	Evidence	Occurrence in different Habitat								Photo capture rate (RAI_1) days	RAI_2
					CR	P	OC	M	IR	T	Tu	NC		
1	Asiatic black bear	*Ursus thibetanus*	V	P C, S	+	-	+	+	-	+	+	-	15.02	6.65
2	Malayan Sun bear	*Helarctos malayanus*	DD	P C, S	+	-	+	+	-	+	+	-	21.64	4.62
3	Clouded leopard	*Neofelis nebulosa*	V	P C	+	-	+	+	+	+	+	-	38.64	2.58
4	Leopard cat	*Prionailurus bengalensis*	L C	P C	+	-	-	-	+	-	-	-	77.28	1.29
5	Asiatic golden cat	*Catopuma temmincki*	V	P C	+	-	-	-	+	-	-	-	0.36	0.36
6	Marble Cat	*Pardofelis marmorata*	V	P C	+	-	-	-	+	-	-	-	0.36	0.36
7	Elephant	*Elephas maximus*	EN	S, T	-	+	-	-	-	+	+	+	-	
8	Gaur	*Bos gaurus*	V	P C	+	-	-	+	+	+	+	-	49.18	2.03
9	Himalayan serow	*Carpicornis thar*	NT	S, T	-	+	-	-	-	-	+	-	-	
10	Wild Buffalo	*Bubalus arnee*	V	T	-	-	-	-	-	-	-	-	-	
11	Common palm civet	*Paradoxurus hemaphroditus*	L C	PC	+	-	+	+	-	+	+	-	77.28	1.29
12	Large Indian civet	*Viverra zibetha*	V	P C	-	-	+	-	-	+	-	-	541	0.18
13	Small Indian civet	*Viverricula indica*	L C	P C	+	-	+	+	+	+	+	-	90.16	1.10
14	Indian or Red muntjac	*Muntiacus muntjak*	L C	P C, T	+	+	+	+	+	+	+	+	11.04	9.07
15	Himalayan crestless porcupine	*Hystrix brachyuran*	L C	P C,T	+	-	+	-	-	-	+	-	31.82	3.14
16	Asiatic brush tail porcupine	*Atherurus marourus*	L C	P C	+	-	+	+	+	-	-	-	31.82	3.14
17	Indian crested porcupine	*Hystrix indica*	LC	P C, T	+	-	+	-	-	-	-	-	20.03	4.99
18	Honey badger	*Mellivora capensis*	L R	P C	+	-	+	-	+	-	+	-	135.25	0.73
19	Hod badger	*Arctonyx collaris*	NT	P C	+	-	+	-	+	-	-	-	33.81	2.95
20	Yellow throated marten	*Martes flavigula*	L C	P C	+	-	+	-	-	-	-	-	270.5	0.36
21	Wild dog	*Cuon alpines*	EN	P C, DS	-	-	+	+	+	+	+	+	135.25	0.73
22	Sambar	*Rusa unicolor*	V	P C, T, DS	+	+	+	+	+	+	+	+	10.60	9.42
23	Assamese macaque	*Macaca assamensis*	N T	P C, DS	-	+	+	-	-	-	-	-	-	
24	Northern pig-tail macaque	*Macaca leonine*	V	P C, DS	-	-	+	-	-	+	+	-	13.52	7.39
25	Capped langur	*Trachypithecus pileatus*	EN	DS	-	+	-	-	+	+	-	-	-	

Sl. No	Common name	Zoological name	IUCN status	Evidence	Occurrence in different Habitat								Photo capture rate (RAI_1) days	RAI_2
					CR	P	OC	M	IR	T	Tu	NC		
26	Western Hoolock gibbon	*Hoolock hoolock*	EN	DS	+	-	+		+		+	+	-	
27	Phayre's leaf monkey	*Trachypithecus phayrei*	EN	DS	-	+	+	-	-	-	+	-	-	
28	Bengal slow loris	*Nycticebus bengalensis*	V	DS	-	+	-	+	+	-	-	-	-	
29	Orange belled Himalayan Squirrel	*Dremomys lokriah*	L C	P C, DS	-	+	-	+	+	-	-	-	-	
30	Black giant squirrel	*Ratufa bicolor*	NT	DS	-	+	-	+	+	-	+	-	-	
31	Northern or Malay tree squirrel	*Tupaia belangeri*	L C	P C, DS	-	+	-	+	+	--	+	+	180.33	0.55
32	Pallas's squirrel	*Callosciurus erythraeus*	L C	DS	-	+	-	+	+	-	-	-	-	
33	Crab eating mongoose	*Herpestes urva*	L C	S	-	-	-	-	-	-	+	-	-	
34	Wild boar	*Sus scrofta*	L C	P C, T, DS	+	+	+	+	+	+	+	+	6.21	16.26
35	Assam mole shrew	*Anourosorex squamipes*	LC	DS	-	-	-	-	-	-	+	+	541	0.18
36	Orange long tail tree mouse	*Vandeleuria*	L C	P C	+	-	+	-	-	-	-	-	30.05	3.32
37	Common Indian mongoose	*Herpestes edwardsii*	L C	P C	+	-	+	-	-		-	+	-	
38	Chinese pangolin	*Manis pentadactyla*	EN	P C	-	-	-	-	+	-	+	-	270.5	0.36
39	Clawless otter	*Aonyx cinerea*	V	P C	-	-	-	-	-	-	+	-	270.5	0.36
40	Himalayan brown Gorals	*Nemorhaedus goral*	NT	T	-	-	-	-	-	-	-	-	-	

Note: PC- Photo capture, S- Scat, T- trophy, DS- Direct sighting, LC-Least Concern, NT- Near threatened, DD- Data deficient, EN-Endangered, V- Vulnerable, LR- Lower risk, CR- Chikha Road, P- Pathloi, OC- Old chikha, M- Malpui, IR- IR camp, T- Tuilut, TU- Tuichar, NC- New chikha (Deserted village), RAI_1 - Number of days required to get a single photo-capture, RAI_2 - Number of independent photos per 100 trap-nights.

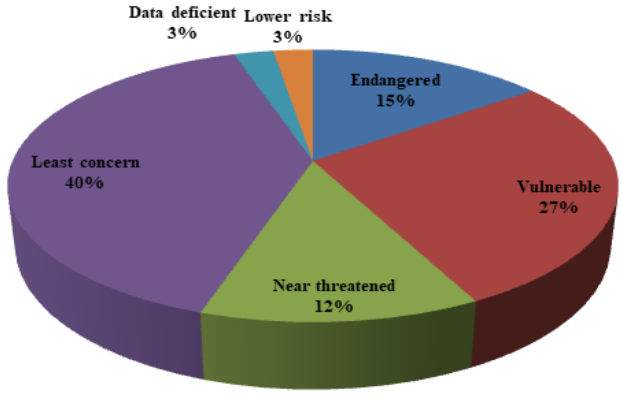

Fig. 4. Status of IUCN mammalian species in DTR

Trap index

The trap index was found to decrease in the area with an increase in human activity. Among all the study area, the deserted villages within the reserve were found to be highly diversified with a trap index of 40.57% (New chikha deserted village), 33.33% (IR camp) and 19.04% (Old Chikha Deserted Village) followed by Malpui (22.85%) and Tuilut (21.5%) as shown in Table 2. The high density in the area can be attributed to the presence of a large number of fruiting trees such as *Actocarpus heterophyllus*, *Trema orientalis*, *Syzygium cumini*, etc. that most mammals feed on.

Table 2. Trap Index of mammalian diversity in DTR

Sl. No	Habitat	Trap Index
1	Chikha road	8.82%
2	Pathloi	6.25%
3	Old Chikha (Deserted Village)	19.04%
4	Malpui	22.85%
5	IR camp	33.33%
6	Tuilut	21.5%
7	Tuichar	12.63%
8	New Chikha (Deserted Village)	40.57%

Daily activity index

The daily activity pattern of all the mammalian species was recorded through camera trapping. The results are shown in Table 3. The bear duo of Asiatic black bear and Malayan sun bear was mostly the photo captured during early evening i.e. 4.00-10.00 or early morning (4.00-8.00 am). Small carnivorous group of *Hystrix brachyuran*, *Atherurus marourus*, *Hystrix indica*, *Viverricula indica*, and *Paradoxurus hemaphroditus* were found to be active during the time of 6-12.00 pm.

Table 3. Daily activity Index (DAI) of mammalian diversity in Dampa Tiger Reserve (DTR)

Common name	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
Asiatic black bear	6.06	12.12	12.12	12.12	6.06	6.06	0	18.18	9.09	6.06	6.06	6.06
Malayan Sun bear	0	4.25	4.25	2.12	2.12	2.12	0	0	10.63	14.89	8.51	4.25
Clouded leopard	5.88	23.52	0	11.76	5.88	0	0	0	5.88	17.64	29.41	0
Leopard cat	12.5	12.5	12.5	0	12.5	0	0	0	12.5	0	25	12.5
Asiatic golden cat	0	0	0	0	0	0	0	0	50	0	50	0
Marble Cat	0	0	0	0	0		100	0	0	0	0	0
Gaur	0	10	10	30	0	0	0	0	40	0	10	0
Common palm civet	25	12.5	0	0	0	0	0	0	0	12.5	25	25
Large Indian civet	0	0	50	0	0	0	0	0	0	0	50	0
Small Indian civet	26.66	6.66	0	0	0	0	0	0	0	20	26.66	20
Indian or Red muntjac	8.51	6.38	19.14	8.51	2.12	0	0	6.38	21.27	6.38	10.63	10.63
Himalayan crestless porcupine	18.18	13.63	0	0	0	0	0	0	0	18.18	45.45	4.45
Asiatic brush tail porcupine	28	20	4	0	0	0	0	0	0	12	24	12

Common name	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
Indian crested porcupine	10	5	0	0	0	0	0	0	0	35	30	20
Honey badger	0	0	0	16.6	0	16.6	50	0	33.33	0	0	0
Hod badger	37.5	6.25	25	6.25	0%	0%	6.25	13.5	6.25	0	0	0
Yellow throated marten	0	0	0	0	0	50		50	0	0	0	0
Wild dog	0	12.5	12.5	0	0	0	12.5		62.5	0	0	0
Sambar	4.95	5.94	7.92	6.93	2.97	2.97	0.99	6.93	11.88	34.65	09.90	03.96
Assamese macaque	0	0	0	21.05	10.52	31.57	26.31	5.26	5.26	0	0	0
Northern pig-tail macaque	0	0	03.44	13.79	24.13	30.03	27.58	0	0	0	0	0
Wild boar	8.45	12.67	12.67	8.45	8.45	0	05.63	8.45	16.9	9.85	04.22	02.81
Orange long tail tree mouse	36.84	5.26	0	0	0	0	0	0	0	15.78	31.57	10.52
Northern or Malay tree squirrel	0	0	0	0	0	33.33	0	66.66	0	0	0	0

Mammalian density

The density of the mammalian species was estimated through block-wise distribution. A crude data was generated using the photo capture rate in a 3 km^2 grid within a time species of 30 min interval (Table 4). As discussed above *Sus scrofta*, *Rusa unicolor* and *Muntiacus muntjak* were uniformly distributed in most of the study locations. Primates were found to be inhabited only in Old chikha deserted village (9.66) and Tuichar (1.66). Bears species in Dampa were distributed in Old chikha (Deserted village), Chikha road and Malpui (4.66: 3.00: 0.66) per 9.00km respectively. Felids were found to be present in regions of higher altitude i.e. Chikha road and IR camp (0.33-4.33 photos per 9km). Members of the Viverridae family were mostly the photo captured in Old chikha (1.33), Malpui (0.33) and Tuichar (4.33). Erethizontidae were also present through-out the reserve with the highest numbers recorded in old chikha (4.33).

Table 4. Blockwise distribution on mammals in different location of DTR

Common name	Old chikha (Deserted village)	Chikha road	Malpui	New chikha (Deserted village)	Tuichar	IR	Tuilut
Asiatic black bear	9	0.66	1.33	0	0	0	0
Malayan Sun bear	4.66	3	0.66	0	0	0	0
Clouded leopard	0.33	4.33	0.33	0	0	0.66	0
Leopard cat	0.33	1.33	0	0	0	0	0
Asiatic golden cat	0	0.33	0	0	0	0.33	0
Marble Cat	0	0.66	0	0	0	0	0
Elephant	0	0	0	0	0	0	0
Gaur	0.33	0.66	0	0	0	0	2.66
Common palm civet	1.33	0.66	0.33	0	0.33	0	
Large Indian civet	0.33	0		0	0	0	0.33
Small Indian civet	0.33	0	4.33	0	0.33	0	
Indian or Red muntjac	5.66	5.33	0.33	0	1.44	1	2
Himalayan crestless porcupine	4.33	3	0	0	0	0	0
Asiatic brush tail	1.33	3.66	0.66	0.33	1	1	0.33

Common name	Old chikha (Deserted village)	Chikha road	Malpui	New chikha (Deserted village)	Tuichar	IR	Tuilut
porcupine							
Indian crested porcupine	4.33	1	0	0	0	0	0
Honey badger	0	2.66	0	0	0	0	0
Hod badger	0	5	0.33	0	0	0	0
Yellow throated marten	0	0.66		0	0	0	0
Wild dog	0	0.66	0.33	0.33	1	0	0.33
Sambar	2.66	4.66	1	2.66	8.66	2.66	11.66
Assamese macaque	4.66	0	0	0	1.66	0	0
Northern pig-tail macaque	9.66	0	0	0	0	0	0
Northern or Malay tree squirrel	0	0	1	0	0	0	0
Wild boar	12	6.66	0.33	0	3.33	1.33	0
Orange long tail tree mouse	0.66	4.66	0	0	1	0	0

Species richness and abundance: comparison with other sites

Generally, capturing rates of twenty-four species in Dampa Tiger Reserve were higher than those in South-east Asian tropical forest sites. According to other studies [24, 28-34, 36] we have found that it takes a lot of trapping effort to catch many small carnivore species in an area.

In this study, we demonstrated that the use of a camera trap, standardized field methods, such as line transects and sign surveys, and statistical analyses to analyze the camera trap data to develop a camera trap baseline assessment of mammalian communities in tropical forests. Our relative abundance estimations were based on observations from camera traps and sign surveys conducted at sample locations.

Terrestrial mammals are known for their high biodiversity and abundance in tropical forests [36]. Terrestrial mammals are unable to survive in degraded, destroyed, and modified habitats of Tropical Forest [37]. So, in this study, we investigated abundance, density, and daily activity patterns of mammals in human-dominated landscapes. In our knowledge, this is the first comprehensive study on mammals' density in Dampa Tiger Reserve (DTR).

The forty-mammal community was reported in the Dampa Tiger Reserve as expected. Members of the felidae community (*Neofelis nebulosa*, *Prionailurus bengalensis*, *Catopuma temmincki*, *Pardofelis marmorata*) and canine (*Cuon alpines*) (135.25 days) were found to be present in high altitude regions of Malpui and IR camp with *Muntiacus muntjak* (11.04 days) and *Rusa unicolor* (10.60 days) as their main prey species [38]. Similar results were also recorded by Datta *et al.* [23] and Peh *et al.* [39] where most carnivorous were found often in degraded open habitats. Habitat variables should consider in mammal abundance, management, and conservation. Some other previous studies also found 86% of mammals' species in the Dampa Tiger Reserve resembles our findings [40].

In our study, some mammal species were showed a higher abundance (Wild boar, Northern pig-tail, and Asiatic black bear) and some were not (Asiatic golden cat, Elephant) whereas some were detected in few times (Honeybadger) in human-dominated areas of the forest reserve. Forest reserve is not active than national parks in wildlife protection [41-43] because of anthropogenic activities such as hunting [44, 45], shifting cultivation, and forest fires introduced by the local community people [46, 47].

The relative abundance index (RAI) of the mammalian species is presented in Table 1. *Ursus thibetanus* (6.65), *Helarctos malayanus* (4.62), *Rusa unicolor* (9.42), *Muntiacus muntjak* (9.07), and *Sus scrofta* (16.26) were found to be relatively abundant in the area. Among the primate, Northern pig-tailed macaque (*Macaca leonine*) was present in the highest

concentration of 7.39%. *Hoolock Hoolock* and *Trachypithecus phayrei* mostly occupy the tree canopy and were confirmed through direct sighting as also reported by Pachuau *et al.* [48]. Species behavior and areas of study are intrinsically influenced by factors such as generalist or specialist species, age, sex, reproductive status, habitat suitability, availability of food, shelter and dens, predators, environmental variables, and anthropogenic impacts [49-51].

The field track of mammal species can be useful for the identification of species and their habitat [52, 53]. Species like Clouded leopard and Marble Cat [54], Malayan sun bear [55, 56] abundance was reported previously were also recorded during our survey in Dampa Tiger Reserve. These species were found lesser abundance in our study due to hunting or human-induced disturbances. Wild boar, Sambar, and Indian or Red muntjac species were present a relatively high local abundance in Dampa Tiger Reserve. Forests or agricultural lands with open or degraded areas are preferred by these species [57].

One of the most uncommon felid species is the marbled cat, *Pardofelis marmorata*. According to IUCN Red List and CITES Appendix I, it is Near Threatened. In India, the species is restricted to eastern Himalayan foothills, especially Arunachal Pradesh. Twice a marbled cat was photo-captured in tropical mixed forest of Dampa Tiger Reserve at an elevation of 586 m in December 2015 [58].

Throughout South Asia, *Catopuma temminckii* is an elusive wild cat known as the Asiatic golden cat. By IUCN, it is classified as Near Threatened, and by the Indian Wildlife Preservation Act, it is Scheduled I. Very modest information is available on this cat and it is rarely seen in the wild. Dampa Tiger Reserve along the international border with Bangladesh remained one of the least explored areas of north-east India [59].

Small carnivorous such as *Hystrix indica* (4.99), *Arctonyx collaris* (2.95), and *Atherurus marourus* (3.14) were found to have significantly higher densities in patches of deserted villages of chikha region as found by Sridhar *et al.* [39] and Peh *et al.* [60] in private fragments of plantations sites and grasslands. Open degraded areas provide better opportunities to small carnivorous as they have a wide range of prey species within such areas. The density of the mammalian species was estimated through block-wise distribution. A crude data was generated using the photo capture rate in a $3km^2$ grid within a time species of 30 min interval (Table 4). As discussed above *Sus scrofta*, *Rusa unicolor* and *Muntiacus muntjak* were uniformly distributed in most of the study locations. Primates were found to be inhabited only in the Old chikha deserted village (9.66) and Tuichar (1.66). Bears species in Dampa were distributed in Old chikha (Deserted village), Chikha road and Malpui (4.66: 3.00: 0.66) per 9.00km respectively. Felids were found to be present in regions of higher altitude i.e. Chikha road and IR camp (0.33-4.33 photos per 9km). Members of the Viverridae family were mostly the photo captured in Old chikha (1.33), Malpui (0.33) and Tuichar (4.33). Erethizontidae were also present through-out the reserve with the highest numbers recorded in old chikha (4.33).

The daily activity pattern of all the mammalian species was recorded through camera trapping. The results are shown in Table 3. The activity pattern was found to vary from species to species. Most of the carnivorous preferred to come out in the evening or late night between 8.00 pm-2.00 am with none appearing between 10.00 am to 2.00 pm excluding primate and Hod badger (*Arctonyx collaris*) [19]. The bear duo of Asiatic black bear and Malayan sun bear were mostly the photo captured during early evening i.e. 4.00-10.00 or early morning (4.00-8.00 am). Small carnivorous group of *Hystrix brachyuran*, *Atherurus marourus Hystrix indica*, *Viverricula indica*, and *Paradoxurus hemaphroditus* were found to be active during the period of 6-12.00pm. The common feature of the tropical forest is to shelter a small to a large group of mammals in different protected areas [61, 62]. Larger mammal species and top predators are reduced due to hunting [63, 64] and the cascade effect of the ecological community [65-67].

In the comparative study, twenty-four species were captured in Dampa Tiger Reserve (DTR) with an effortof only 450 trap-nights whereas five species were caught in Namdapha with 350 trap-nights [35]. In Pakke, only four species were captured after 231 trap-nights,

whereas in Namdapha, six species were captured after 1537 trap-nights, with a further species captured after 215 trap-nights [23] whereas with 1,224 trap-nights, only five species were caught in Thailand [27]. 11 small carnivore species were camera-trapped in Laos with 3,588 trap nights [31], and eight were detected in Hkakaborazi National Park, Myanmar with 1238 trap nights [30]; however, species – specific capture rates were not provided for the last two studies. During 8836 nights of trapping, only ten species were caught in the Hukaung Valley, Myanmar [32]. Nine different carnivore species have been recorded with 8836 trap-nights in Hukawng Valley Tiger Reserve, Myanmar (which has a somewhat different assemblage than north-east India) [28]. Seventeen species were captured with a trap-night effort of 14054 in Taman Negara National Park, Peninsular, Malaysia [29]. There were eight species captured in Java, Indonesia [34] while nine species were captured in Thung Yai Sanctuary, Thailand [33].

All these studies cover only about half or less than half (22-62%) of the total number of small carnivores that may be located in the camera trapping area. There are differences in frequency between sites, but it is difficult to draw conclusions because most of these studies have focused on tigers and other large carnivores. However, the number of species captured seems to require a lot of effort to reach the asymptote. It is useful to compare the proportion of the total number of small carnivores caught in a particular area with systematic efforts aimed at small carnivores. Carnivores and assess other factors, such as hunting pressure and habitat quality, which can better understand the amount of effort required to maximize species trapping in a given area.

Conclusions

Dampa Tiger Reserve (DTR) has a rich faunal diversity and has been harboring several endangered and threatened species. However, due to the continuous degradation of forest land, expansion of agriculture land, illegal hunting and increasing in population in nearby areas has resulted in a decline of several animal species in the reserve. Taking into consideration the advantages and limitations, nonviable methods such as camera trapping can provide reliable and standardized methods for identifying large and medium-sized mammals in conservation reserves. Well-designed monitoring programs along with regular patrolling from forest officials and local information can help to estimate precise information on the abundance of mammals and their distribution in the reserve.

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