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Estimating Mammalian Abundance and Occupancy in Tropical Forest Indian Himalaya, Dampa Tiger Reserve, Mizoram, India

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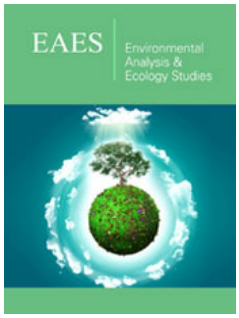

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Abstract

Noninvasive camera traps are commonly used to detect mammals in the Neotropics, but few studies have evaluated the effectiveness of this technique for species inventories. Forty-three line-transect surveys along with photo-identification and automated acoustic monitoring methods were carried out between August 2014 and March 2016 to gather baseline information on the occurrence and distribution of mammals in Dampa Tiger Reserve (DTR). During the survey, forty mammalian species were identified in the reserve, of which 25 were photo captured and 15 were confirmed through trophies and direct sighting. It includes 6 endangered species, 1 Data deficient, 1 Lower risk, 11 Vulnerable species, 5 Near-threatened and 16 least concern species as per IUCN Red list, 2010. The majority of trapped was *Ursus thibetanus, Helarctos malayanus, Neofelis nebulosa, Bos gaurus, Sus scrofta, Rusa unicolor, Hystrix indica* and *Atherurus marourus*. The trap index of different locations shows the distribution of mammals 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%). *Sus scrofta* (16.26 %) were found to be the most abundant mammalian species in the area. The activity pattern indicates a large carnivorous preferring evening or late at night. The duo of Asiatic black bear and Malayan sun bear were mostly photos captured from 4.00-10.00 pm and 4.00-8.00 am respectively. Small carnivorous were found to be active during 6-12.00 pm. The study depicts that the use of camera traps, monitoring programs, and local information can help to estimate precise information on the abundance and distribution of mammals in the reserve which indeed may serve for long term conservation of the animal species.

Keywords: Activity pattern; Dampa tiger reserve; Distribution; Mammals; Photo capture

Abbreviations: DTR: Dampa Tiger Reserve; GIS: Geographic Information System; LID: Latency to Initial Detection; RAI: Relative Abundance Index; DAI: Daily Activity Index

Introduction

Mammals are a highly versatile group that includes some of the world's fastest runners, deepest divers, and most agile fliers, having colonized most of the earth's habitats. Twenty-five percent of all mammals for which the conservation status is known are threatened with extinction. Although protected areas are useful tools to measure national and international contributions to species conservation [1,2], reduction of tropical forest, and the combined impacts of habitat loss (affecting 40% of mammals), fragmentation, hunting and harvesting (affecting 17% of mammals) by native wildlife populations have pushed many species to the brink of extinction [2,3]. The Northeast region of India comprising of the states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram, Nagaland, and Sikkim is unique in providing a profusion of habitat, which features diverse biota with a high level of endemism [4-6]. The region forms about 8% of the geographical area of the country having around 25% of the total forest cover of the country [7,8]. Of the 417 species that India harbors the northeastern regions account for 54% of threatened mammals [9]. The regions are gifted with diverse climatic conditions, rainfall and other environmental parameters that support a great

variety of floral and faunal species. However, prior knowledge of species diversity, distribution and abundance is essential, to detect significant changes for appropriate management interventions and conservation status of the floral and faunal species present within the regions [10]. Detailed studies, efficient and reliable methods for rapid assessment of species richness and abundance are also crucial to determine conservation priorities.

Small carnivore (herpestids, mustelids, *viverrids*) diversity is centred in two major regions in the Indian sub-continent, in the Eastern Himalaya and North-East Hills and the Western Ghats. The high diversity of small carnivores in North-East India is due to the region being located at the confluence of three important bio-geographical realms, with several species being unique to the region within India. Large mammals are often keystone species that maintain ecosystem stability and biodiversity of any region [11]. Hence, due to the extreme paucity of zoological information on the entire range, an effort was made to provide the status and support the lesser-known information's on the mammalian diversity of Dampa Tiger Reserve (DTR) with confirming data and evidence on the occurrence of mammals in the reserve. The area has one of the last remaining low- to mid-elevation forests in western Mizoram with many species yet to be documented.

Materials and Methods

Study area

The investigation was undertaken in the Dampa Tiger Reserve (DTR) located in the Mamit district of Mizoram along the Bangladesh border. It was initially a Wildlife Sanctuary but was later given the status of a Tiger Reserve in 1994 (Figure 1). The reserve is situated at the western limit of the state and falls within 23° 23' 15'' N - 23° 42' 20'' N latitudes and 92° 16' 25'' E - 92° 25' 55'' E longitudes and stretches over an area of 550sqkm [12]. The reserve harbors a rich floral and faunal diversity and contains a profusion of habitats characterized by diverse biota. The natural vegetation in the reserve is tropical evergreen to semi-evergreen. The forest in the moist valleys is lofty and evergreen, while the steeper slopes on the west aspect have more deciduous elements, often with sympodial bamboos in the understory [13]. The study was carried out from February 2014 to March 2016 and the mammalian diversity was recorded through indirect sighting, scats, trophies, questionnaires survey and camera trapping (Figure 2). Much of the modern information comes from sighting records; however, as most species are rarely sighted and several are nocturnal, camera-trapping is preferred to observational studies to document species richness and assess status [14].

Figure 1: Map of study area.

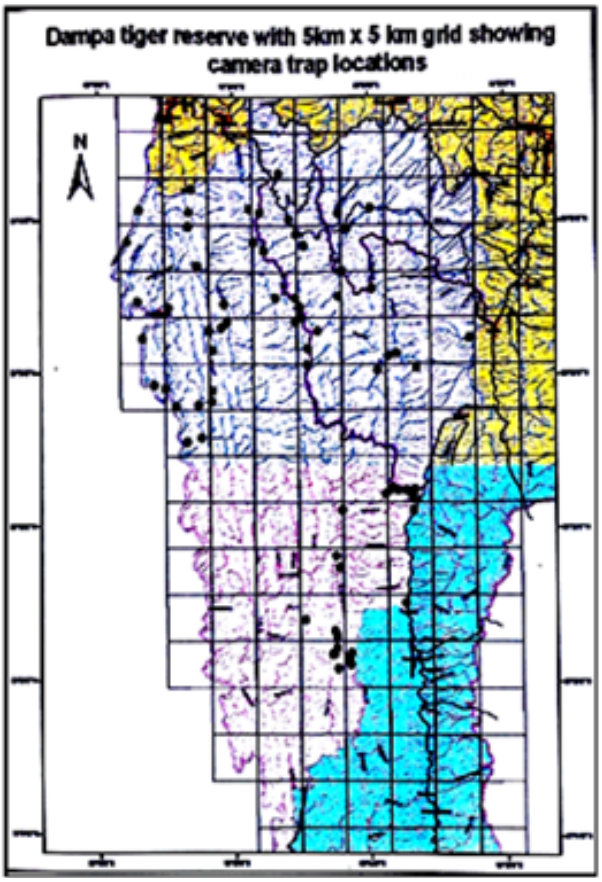

Figure 2: Camera trapping location with gride.

Preliminary surveys

A pilot survey was carried out in the early months of the study period on trails, footpath and transects line for signs of animals and to gather first-hand information on the distribution of different mammalian species in Dampa Tiger Reserve. Local interviews were also used for the assessment of mammalian fauna (distribution and relative abundance) depending on the feasibility of the terrain.

Camera trapping

Based on the preliminary information, camera-trap units (cudde back) were placed at 43 sites in 8 different areas within the tiger reserve. The cameras take photographs automatically by the animal body heat and movement. The study area was divided into 3km^2 blocks within a Geographic Information System (GIS). The cameras were positioned at heights of 30-50cm from the ground on animal trails and paths, near fruiting trees, water bodies and animal wallows. Cameras were active for 24 hours per day and trapping sessions lasted an average of 15 days in one location in all seasons throughout the year.

Occupancy

After the surveys were complete, we combined all photos from both field seasons to organize and manage binary detection histories for each species detected (1=species detected, 0=species not detected). The first metric used to evaluate the effectiveness of cameras was the Latency to Initial Detection (LTD). This metric is simply calculated as the mean number of trap nights required to first detect the species of interest. I also calculated detection frequencies for each species as the number of independent detections/1000 trap nights for comparison to previous camera studies in the neotropics. I then used an occupancy modeling approach, as described by Mackenzie et al. [15,16] to estimate species richness and individual species detection probabilities for the landscape-level corridor [15,16]. The modeling process requires an a priori list of species and treats each species as a site to determine the proportion of species present (Ψ) as corrected by incorporating species-specific detection probability [16].

Local interviews

To assess the awareness of local people regarding the mammal diversity of the area and to verify it with camera trapping results, interviews, and informal discussions were conducted in 10 villages viz; Damparengpui, Khawhnai, Serhmun, Tuipuibari, Rajivnagar, Terei, Tuirum, Saithah, Phuldungsui, and West Pheling all residing in and around the tiger reserve. The interviews were conducted in about 1000 households which included Gaon Buras (village heads), farmers, livestock herders, former hunters, wildlife guards and tracking guides. The respondents were shown photographs and drawings of the mammal species provided in field guides [17-19] and their knowledge on species occurrence and distribution was recorded.

Data analysis

The photo-capture rates defined as the number of days required to obtain a photo of a species was calculated for individual species [20]. Only independent pictures of a particular species were counted as valid. Independence of detections was defined, following O'Brien et al. [21], as (1) consecutive images of different individuals of the same or different species, (2) consecutive photographs of individuals of the same species taken more than 30min apart and (3) non-consecutive photos of individuals of the same species [22,23]. The Trap index for each habitat and locality covered during the study period was computed by using the following method.

$$\text{Trap Index} = \frac{\text{Total no.of species}}{\text{No.of trapping days} \times \text{No of traps}} \times 100$$

The Relative Abundance Index (RAI) of the mammals was recorded by camera traps and track plots according to the model; I/Nx100, where I=number of occurrences of species; N=total occurrences in the physiognomy [24,25]. To understand the activity pattern of the mammalian species, based on their time of capture, the day was divided into 12 two-hour periods and the number of photos in each interval was noted. A Daily Activity Index (DAI) was calculated following [26]. While estimating the density it may be noted that different animal shares their minimum limit for their habitat and it solely varies with the animal species. Further, the number of captures was far too less to perform other calculations to assess the populations with more conviction. However, if it is considered that animals that were captured by independent camera

traps at least once are separate individuals, then a crude block density of different individual forest location may be calculated as

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

It may be noted that different species may have a minimum home range. Considering this, it may be said that two captures made on adjacent cameras could be of the same animal. Keeping this in mind, one needs to understand that the present assessments are very crude, and caution should be taken in interpreting the information. A scientifically reliable inference regarding the population can be proposed only after more robust data have been generated through repeated surveys soon. Photo-capture rates from the present study were compared with those obtained from studies in geographically and climatically similar forests in nine sites in South-east Asia which face lower or comparable hunting pressures [23,27-35].

Result

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

From the study, a total of 40 mammalian species belonging to 19 different families were confirmed to be present in Dampa Tiger Reserve (DTR). The confirmation was based on visual encounters, photo-captures (Camera-trap), sign and trophies (Table 1). 25 species were recorded from the camera trap (Figure 3). while the other fifteen were confirmed through scats, trophies and direct sighting. 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 & Figure 4).

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

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

S. No	Common Name	Zoological Name	IUCN Status	Evidence	Occurrence in different Habitat								Photo Capture Rate (RAI1) Days	RAI2
					CR	P	OC	M	IR	T	Tu	NC		
1	Asiatic black bear	*Ursus thibetanus*	V	PC, S	+	-	+	+	-	+	+	-	15.02	6.65
2	Malayan Sun bear	*Helarctos malayanus*	DD	PC, S	+	-	+	+	-	+	+	-	21.64	4.62
3	Clouded leopard	*Neofelis nebulosa*	V	PC	+	-	+	+	+	+	+	-	38.64	2.58
4	Leopard cat	*Prionailurus bengalensis*	LC	PC	+	-	-	-	+	-	-	-	77.28	1.29
5	Asiatic golden cat	*Catopuma temmincki*	V	PC	+	-	-	-	+	-	-	-	0.36	0.36
6	Marble Cat	*Pardofelis marmorata*	V	PC	+	-	-	-	+	-	-	-	0.36	0.36
7	Elephant	*Elephas maximus*	EN	S, T	-	+	-	-	-	+	+	+	-	
8	Gaur	*Bos gaurus*	V	PC	+	-	-	+	+	+	+	-	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*	LC	PC	+	-	+	+	-	+	+	-	77.28	1.29
12	Large Indian civet	*Viverra zibetha*	V	PC	-	-	+	-	-	+	-	-	541	0.18
13	Small Indian civet	*Viverricula indica*	LC	PC	+	-	+	+	+	+	+	-	90.16	1.1
14	Indian or Red muntjac	*Muntiacus muntjak*	LC	PC, T	+	+	+	+	+	+	+	+	11.04	9.07
15	Himalayan crestless porcupine	*Hystrix brachyuran*	C	PC, T	+	-	+	-	-	-	+	-	31.82	3.14
16	Asiatic brush tail porcupine	*Atherurus marourus*	LC	PC	+	-	+	+	+	-	-	-	31.82	3.14
17	Indian crested porcupine	*Hystrix indica*	LC	PC, T	+	-	+	-	-	-	-	-	20.03	4.99
18	Honey badger	*Mellivora capensis*	LR	PC	+	-	+	-	+	-	+	-	135.25	0.73
19	Hod badger	*Arctonyx collaris*	NT	PC	+	-	+	-	+	-	-	-	33.81	2.95
20	Yellow throated marten	*Martes flavigula*	LC	PC	+	-	+	-	-	-	-	-	270.5	0.36
21	Wild dog	*Cuon alpines*	EN	PC, DS	-	-	+	+	+	+	+	+	135.25	0.73
22	Sambar	*Rusa unicolor*	V	PC, T, DS	+	+	+	+	+	+	+	+	10.6	9.42
23	Assamese macaque	*Macaca assamensis*	NT	PC, DS	-	+	+	-	-	-	-	-	-	
24	Northern pig-tail macaque	*Macaca leonine*	V	PC, DS	-	-	+	-	-	+	+	-	13.52	7.39
25	Capped langur	*Trachypithecus pileatus*	EN	DS	-	+	-	-	+	+	-	-	-	
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*	LC	PC, DS	-	+	-	+	+	-	-	-	-	
30	Black giant squirrel	*Ratufa bicolor*	NT	DS	-	+	-	+	+	-	+	-	-	
31	Northern or Malay tree squirrel	*Tupaia belangeri*	LC	PC, DS	-	+	-	+	+	--	+	+	180.33	0.55

32	Pallas's squirrel	*Callosciurus erythraeus*	LC	DS	-	+	-	+	+	-	-	-	-	
33	Crab eating mongoose	*Herpestes urva*	LC	S	-	-	-	-	-	-	+	-	-	
34	Wild boar	*Sus scrofta*	LC	PC, T, DS	+	+	+	+	+	+	+	+	6.21	16.26
35	Assam mole shrew	*Anourosorex squamipes*	LC	DS	-	-	-	-	-	-	+	+	541	0.18
36	Orange long tail tree mouse	*Vandeleuria*	LC	PC	+	-	+	-	-	-	-	-	30.05	3.32
37	Common Indian mongoose	*Herpestes edwardsii*	LC	PC	+	-	+	-	-		-	+	-	
38	Chinese pangolin	*Manis pentadactyla*	EN	PC	-	-	-	-	+	-	+	-	270.5	0.36
39	Clawless otter	*Aonyx cinerea*	V	PC	-	-	-	-	-	-	+	-	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), RAI1 - Number of days required to get a single photo-capture, RAI2 - Number of independent photos per 100 trap-nights.

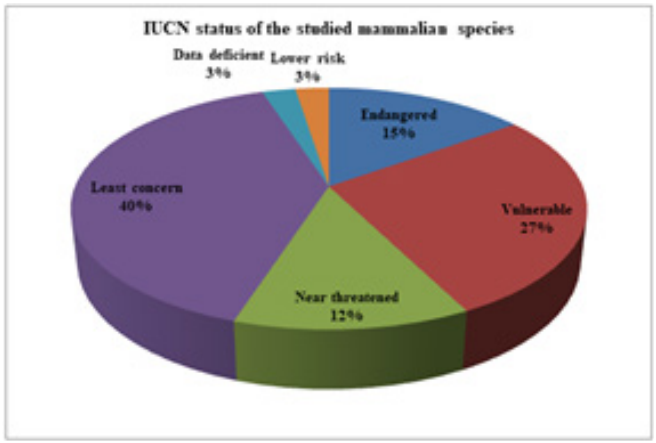

Figure 4: Status of mammalian species in DTR.

Camera trapping

The photo capture rates of different mammals in the Dampa Tiger Reserve indicate the habitat (forest type-specific) pattern of mammal distribution. Comparison between photo capture rates in different habitats showed *Ursus thibetanus* (15.02 days), *Helarctos malayanus* (21.64 days), *Hystrix indica* (20.03 days) and *Sus scrofta* (6.21 days) as the main inhibitor of mixed deciduous forest in the deserted villages of Dampa (Table 1).

Relative abundance index (RAI_1)

The high relative abundance of the prey species depicts the lower number of predator species in the region. *Sus scrofta* was found to be the most abundant species in the reserve forest with a photo capture rate of 6.21 days followed by *Rusa unicolor* (10.6), *Muntiacus muntjak* (11.04) and *Macaca leonine* (13.52) as shown in (Table 1).

Relative abundance index (RAI_2)

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. Mammals such as *Macaca assamensis*, *Trachypithecus pileatus*, *Trachypithecus phayrei*, *Hoolock Hoolock*, *Nycticebus bengalensis,* and other aerial species could not be a trap as they mostly occupy the canopy and were confirm only through direst sighting during trails walks.

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.

S. 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	21.50%
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	4-Feb	6-Apr	8-Jun	10-Aug	12-Oct	14-Dec	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
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	9.9	3.96
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	3.44	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	5.63	8.45	16.9	9.85	4.22	2.81
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 3km^2 grid within a time species of 30min 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 porcupine	1.33	3.66	0.66	0.33	1	1	0.33
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

Capture rates of twenty four species in Dampa Tiger Reserve were generally higher than in tropical forest sites in South-East Asia (Table 5). From comparisons with other studies, it appears that very high trapping effort is required to capture many small carnivore species in a given area.

Table 5: Photo-capture rate (number of trap-nights required to get a single photo-capture of a species) derived from camera-trap surveys in Dampa Tiger Reserve (DTR) Park and nine other protected areas in South-east Asia.

Location	Dampa Tiger Reserve, Northeast India	Namdapha National Park, north-east India	Namdapha National Park, north-east India	Hukawng Valley TigerHukawng Valley Tiger Reserve, Myanmar Reserve, Myanmar	Hkakaborazi National Park, Myanmar	Hukaung Valley, Myanmar	Taman Negara National Park, Peninsular, Malaysia	Nam Et-Phou Louey National Protected Area, Laos	Bukit Barisan Selatan National Park, Indonesia	Various sites on Java, Indonesia	PhuKheio Wildlife sanctuary, Thailand	Thung Yai Sanctuary, Thailand
Reference	Present Study (2014 - 2016)	Sethy et al. [35]	Datta et al. [23]	Lynam [28]	Rao et al. [30]	Duckworth [32]	Kawanishi & Sunquist [29]	Johnson et al. [31]	O'Brien et al. [21]	Rodemargono et al. [34]	Grassman [27]	Chutipong et al. [33]
Type of Camera Trap	Passive motion and heat sensor infrared	Passive	Passive	Passive	Passive	Passive	Active and Passive	Passive	Passive	Passive	Active and Passive	Passive
Effort (Number of Trap-Days)	450	350	1537	8836	1238	8836	14054	3588	24 045	705	1224	4550
Tiger	-	-	-	2945	-	-	230	417	481	-	408	14
Leopard	77	-	-	-	-	-	94	144	-	121	-	1
Wild dog	135	-	-	4418	29	-	878	359	6024	-	111	-
Clouded leopard	38	-	768	4418	16	-	878	-	587	-	612	1
Indian muntjac	11	-	22	184	6	-	25	36	26	-	15	-
Sambar	10	-	512	192	-	-	44	400	89	-	34	-
Wild pig	-	-	512	1767	9	-	28	250	39	-	31	-

Gaur	49	-	-	2945	-	-	1562	1250	-	-	35	-
Serow	-	-	-	-	20	-	270	326	4007	-	-	-
Porcupines (3 Species)	31	-	40	1104	6	-	95	55	43	-	122	-
Primates	13	-	37	1767	8	-	351	23	20	-	15321	-
Hog badger	33	-	-	-	179	4418	NA	163	-	-	408	-
Yellow-throated Marten	270	13	384	-	-	492	2008	-	-	1	-	4
Ferret badgers	-	-	384	-	-	-	NA	-	-	37	-	2
Linsang	-	3	-	-	-	2945	14054	-	-	2	-	-
Large Indian Civet	541	-	140	-	-	442	2008	-	-	-	-	-
Large-spotted Civet	-	-	NA	-	-	8836	-	-	-	-	-	48
Small Indian Civet	90	-	-	-	-	1767	-	-	-	8	-	-
Common Palm Civet	77	4	384	-	-	353	3513	-	-	145	-	6
Masked Palm Civet	-	3	307	-	-	8836	2342	-	-	-	-	12
Binturong	-	-	-	-	-	1473	4685	-	-	3	-	
Crab-eating Mongoose	-	2	768	-	-	233	NA	-	-	4	-	13
Asiatic Black Bear	15	-	-	-	-	-	-	-	-	-	-	-
Malayan Sun Bear	21	-	-	-	-	-	-	-	-	-	-	-
Honey badger	135	-	-	-	-	-	-	-	-	-	-	-
Malay tree squirrel	180	-	-	-	-	-	-	-	-	-	-	-
Wild boar	6	-	-	-	-	-	-	-	-	-	-	-
Wild Buffalo	-	-	-	-	-	-	-	-	-	-	-	-
Assam mole shrew	541	-	-	-	-	-	-	-	-	-	-	-
Orange long tail tree mouse	30	-	-	-	-	-	-	-	-	-	-	-
Chinese pangolin	270	-	-	-	-	-	-	-	-	-	-	-
Clawless otter	270	-	-	-	-	-	-	-	-	-	-	-
Himalayan brown Gorals	-	-	-	-	-	-	-	-	-	-	-	-
Common Indian mongoose	-	-	-	-	-	-	-	-	-	-	-	-
Bengal slow loris	-	-	-	-	-	-	-	-	-	-	-	-
Asiatic golden cat	0.3	-	-	-	-	-	-	-	-	-	-	-
Marble Cat	0.3	-	-	-	-	-	-	-	-	-	-	-
Elephant	-	-	-	-	-	-	-	-	-	-	-	-
Total Species recorded	24	5	12	9	8	10	17	11	9	8	10	9

Discussion

Our study shows how camera trap data collected using a camera trap, standardized field methodology i.e., line transect and sign survey, and analysed with statistical approaches that account for imperfect detection and incorporate ecological factors, can provide a camera trap baseline assessment of mammalian communities in tropical forests. In particular, we estimated relative abundance using a camera trap and sign survey observations 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 [23,39]. 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 (Honey badger) 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]. This is due to the intrinsic characteristics of the species or of the study area such as generalist or specialist species, sex, age, reproductive status, habitat suitability, availability of food, presence of shelter and dens, presence of predators or competitors, environmental variables and anthropogenic pressures [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 were 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. These species prefer open or degraded forests and agricultural areas [57]. The marbled cat *Pardofelis marmorata* is one of the rarest and the least known felid species. It is listed as near threatened in the IUCN Red List and in Appendix I of cites. 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 586m in December 2015 [58].

The Asiatic golden cat *Catopuma temminckii* elusive wild cat distributed throughout South Asia. It is classified as near threatened by IUCN and as scheduled I species by Indian Wildlife Protection Act. 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. [60] and Peh et al. [39] in private fragments of plantations sites and grasslands [39,60]. 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 30min 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 6-12.00 pm. 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 [65,66].

In the comparative study, twenty four species were captured in Dampa Tiger Reserve (DTR) with an effort of only 450 trap-nights while in Namdapha, we captured five species with 350 trap-nights [35]. In Pakke, with an effort of 231 trap-nights, only four species were captured whereas in Namdapha, with an effort of 1537 trap-nights, six species were captured while an additional species was captured after 215 more trap-nights [23]. In Thailand, with 1,224 trap-nights, only five species were captured [27]. In Laos, with 3,588 trap-nights, 11 small carnivore species were camera-trapped [31], and eight were recorded in Hkakaborazi National Park, Myanmar in 1238 trap-nights [30], although species-specific capture rates are not provided in the last two studies. In the Hukaung Valley, Myanmar, even after 8,836 trap-nights, only ten species were captured [32]. In Hukawng Valley Tiger Reserve, Myanmar (where the small carnivore assemblage differs somewhat from that in north-east India), only nine small carnivore species were recorded in 8836 trap-nights [28]. In Taman Negara National Park, Peninsular, Malaysia seventeen species were captured with an effort of 14054 trap-nights [29]. Various sites on Java, Indonesia eight species were captured [34] where as in Thung Yai Sanctuary, Thailand nine species were captured [33]. In all these studies, only about half or much less than half (22-62%) of the total small carnivore species assemblage, predicted to be within the camera-trapped area, were captured.

Variation in species recorded and capture rates may reflect real differences in abundance among sites, but it is difficult to make conclusions, given that most of these studies were designed primarily for tigers and other large carnivores. In addition, a few of these represent data from multiple trapping sessions carried out over several years. However, the number of species captured appears to reach an asymptote with very high effort. It would be useful to compare the proportion of the total small carnivore species assemblage that is captured in a given area with a trapping effort systematically for small carnivores and assess other factors such as hunting pressure and habitat quality. This would enable a better understanding of how much trapping effort is required to maximise species captures in a given area. 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. Considering the benefits and limitations, non-viable techniques such as camera-trapping can provide a reliable and standardized means to document the presence of large and medium-sized mammalian species in the reserve. 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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References

1. Wilson DE, Reeder DM (2005) Mammal Species of the World: A Taxonomic and geographic Reference-3rd (edn), Johns Hopkins University Press, Baltimore, Maryland 2: 1-2141.
2. Rodrigues ASL, Pilgrim JD, Lamoreux JF, Hoffmann M, Brooks TM (2006) The value of the IUCN Red List for conservation. Trends Ecol Evol 21(2): 71-76.
3. Sharma G, Kamalakannan M, Venkataraman K (2014) A Checklist of mammals of India with their distribution and conservation status. ZSI e-publication. Published by the Director, Zool Surv, Kolkata, India, p. 123.
4. Gaurav S, Kamalakannan M, Dam D, Akhlaq H (2014) Status and conservation of mammalian diversity in Indian Himalaya. Biol Forum 6(2): 273-299.
5. Chatterjee S, Saika A, Dutta P, Ghose A, Worah S (2006) Review of biodiversity in Northeast India. WWF, Delhi India, pp. 1-45.
6. Mazumdar K, Soud R, Gupta A (2011) Mammalian diversity of degraded forest habitats around Assam University Campus, Cachar, Assam, India, with Notes on Conservation Status. Our Nature 9: 119-127.
7. Choudhury B, Khan ML (2010) Conservation and management of endangered plant species: A case study from Northeast India. Biorem Biodiv Bioavail 4(1): 47-53.
8. Takhtajan AL (1969) Flowering plants: Origins and dispersal. Smithsonian Institution Press, Washington DC, USA, p. 310.
9. Choudhury A (2006) The status of endangered species of North-east India. J Bombay Nat Hist Soc 103(2-3): 157-167.
10. Sathyakumar S, Bashir T, Bhattacharya T, Poudya K (2011) Assessing mammal distribution and abundance in intricate eastern Himalayan habitats of Khangchendzonga, Sikkim, India. Mammalia 75: 257-268.
11. Terborgh JW (1988) The big things that run the world- a sequel to EO Wilson. Conserv Biol 2(4): 402-403.
12. Lalrinchhana C, Solanki GS (2015) Lizard (*Reptilia: Sauria*) diversity of Dampa Tiger Reserve, Mizoram, India Sci Vis 15(1): 19-28.
13. Pawar S, Birand A (2001) A Survey of amphibians, Reptiles and Birds in Northeast India. CERC Technical Report 6, Centre for Ecological Research and Conservation, Mysore, Karnataka, India.
14. Nettelbeck AR (1997) Sightings of Binturong in the Khao Yai National Park. Small Carniv Conserv 16: 22-24.
15. MacKenzie DI, Nichols JD, Royle JA, Pollock KH, Bailey LL, et al. (2005) Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence. Elsevier, San Diego, CA.
16. MacKenzie DI, Nichols JD, Royle JA, Pollock KH, Bailey LL, et al. (2006) Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence.
17. Menon V (2003) A Field guide to Indian Mammals. Dorling Kindersely (India) Pvt Limited, p. 200.
18. Menon V (2014) A Field guide to Indian Mammals. Hachette Book Publishing (India) Pvt Limited, p. 528.
19. Gubbi S, Linkie M (2012) Wildlife hunting patterns, techniques, and profile of hunters in and around Periyar Tiger Reserve. J Bombay Nat Hist Soc 109(3): 165-172.
20. Karanth KK, Nichols JD, Hines JE, Karanth KU, Christensen NL (2009) Patterns and determinants of mammal species occurrence in India. J Appl Ecol 46: 1189-1200.

21. O' Brein TG, Kinnaird MF, Wibisono HT (2003) Crouching tigers hidden prey: Sumatran tiger and prey population in a tropical forest landscape. Anim Conserv 6: 131-139.

22. Prakash I, Singh H (2001) Composition and species diversity of small mammals in the hilly tracts of southeastern Rajasthan. Trop Ecol 42(1): 25-33.

23. Datta A, Naniwadekar R, Anand MO (2008) Occurrence and conservation status of small carnivores in two protected areas in Arunachal Pradesh, North-East India. Small Carniv Conserv 39: 1-10.

24. Jorge MCL, Ciocheti G, Pivello VR (2008) Carnivore mammals in a fragmented landscape in northeast of Sao Paulo State, Brazil. Biodivers Conserv 17: 1573-1580.

25. Jenks KE, Chanteap P, Damrongchainarong K, Cutter P, Redford T, et al. (2011) Using relative abundance indices from camera-trapping to test wildlife conservation hypotheses - An example from Khao Yai National Park, Thailand. Trop Conserv Sci 4(2): 113-131.

26. Li S, Mcshea WJ, Wang D, Shao L, Shi X (2010) The use of infrared-triggered cameras for surveying phasianids in Sichuan Province. China Ibis 152(2): 299-309.

27. Grassman Jr LI (2003) Thailand cat project. Unpublished final report submitted to Cat Action Treasury, Thailand.

28. Lynam A (2003) A national tiger action plan for the union of Myanmar. Myanmar forest department, unpublished report. Ministry of forestry, Myanmar & Wildlife Conservation Society-International Program.

29. Kawanishi K, Sunquist ME (2004) Conservation status of tigers in a primary rainforest of peninsular Malaysia. Biol Conserv 120: 329-344.

30. Rao M, Myint T, Zaw T, Htun S (2005) Hunting patterns in tropical forests adjoining the Hkakaborazi National Park, North Myanmar. Oryx 39(3): 292-300.

31. Johnson A, Vongkhamheng C, Hedemark M, Saithongdam T (2006) Effects of human-carnivore conflict on Tiger (*Panthera tigris*) and prey populations in Lao PDR. Anim Conserv 9(4): 421-430.

32. Duckworth J (2008) Status and distribution of small carnivores in Myanmar. Small Carniv Conserv 38: 2-28.

33. Chutipong W, Lynam AJ, Steinmetz R, Savini T, Gale GA (2014) Sampling mammalian carnivores in western Thailand: Issues of rarity and detectability. Raffles B Zool 62: 521-535.

34. Rode Margono EJ, Voskamp A, Spaan D, Lehtinen JK, Roberts PD, et al. (2014) Records of small carnivores and of medium-sized nocturnal mammals on Java, Indonesia. Small Carniv Conserv 50: 1-11.

35. Sethy J, Samal D, Chauhan NPS (2014) Occurrence of small carnivores in Gandhigram range of Namdapaha National Park, Arunachal Pradesh, India. J Wildl Res 2(3): 11-17.

36. Ceballos G, Ehrlich PR (2002) Mammal population losses and the extinction crisis. Science 296(5569): 904-907.

37. Wanyama F, Muhabwe R, Plumptre AJ, Chapman CA, Rothman JM (2009) Censusing large mammals in Kibale National Park: Evaluation of the intensity of sampling required to determine change. Afr J Ecol 48(4): 953-961.

38. Ghimirey Y, Ghimire B, Pal P, Koirala V, Acharya R, et al. (2012) Status of felids in Makalu-Barun National Park, Nepal. Cat News 56: 23-27.

39. Peh KSH, Sodhi NS, Dejong J, Sekercioglu CH, Yap CAM, et al. (2006) Conservation value of degraded habitats for forest birds in southern Peninsular Malaysia. Divers Distrib 12(5): 572-581.

40. Solanki GS, Lalchhandama D, Lalnunpuii (2016) Use pattern of faunal resources by tribal and its impact on biodiversity in Dampa Tiger Reserve in Mizoram, India. J Bioresour 3(1): 24-29.

41. Plumptre AJ, Reynolds V (1994) The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. J Appl Ecol 31(4): 631-641.

42. Fashing JP, Cords M (2000) Diurnal primate densities and biomass in the Kakamega Forest: An evaluation of census methods and a comparison with other forests. Am J Primatol 50(2): 139-152.

43. Plumptre AJ, Mugume S, Cox D, Montgomery C (2001) Chimpanzee and large mammal surveys of Budongo forest reserve and Kibale National Park. Report to Wildlife Conservation Society on surveys in Western Uganda, Wildlife Conservation Society, Kampala, Uganda.

44. Bruner AG, Gullison RE, Rice RE, Dafonseca GAB (2001) Effectiveness of parks in protecting tropical biodiversity. Science 291(5501): 125-128.

45. Naughton TL, Alix Garcia J, Chapman CA (2011) A decade of forest loss and economic growth around Kibale National Park, Uganda: Lessons of poverty reduction and biodiversity conservation. Proc Natl Acad Sci 108: 13919-13924.

46. West P, Igoe J, Brockington D (2006) Parks and peoples: the social impact of protected areas. Annu Rev Anthropol 35: 251-277.

47. Hartter J, Goldman A, Southworth J (2011) Responses by households to resource scarcity and human-wildlife conflict: Issues of fortress conservation and the surrounding agricultural landscape. J Nat Conserv 19: 79-86.

48. Pachuau SV, Qureshi Q, Habib B, Nijman V (2013) Habitat use and documentation of a historic decline of Western Hoolock Gibbon (*Hoolock hoolock*) in Dampa Tiger Reserve, Mizoram, India. Primate Conserv 27: 85-90.

49. Monroy Vilchis O, Zarco González MM, Rodríguez Soto C, Soria Díaz L, Urios V (2011) Mammal phototrapping in the Sierra Nanchititla, Mexico: Relative abundance and activity pattern. Tropical Biology Journal 59: 373-383.

50. Lira Torres I, Briones Salas M (2012) Relative abundance and activity patterns of the mammals of the chi-malapas, Oaxaca, Mexico. Mexican Zoological Act 28(3): 566-585.

51. Navarro J, Gomez A (2015) Terrestrial mammal diversity in forests near pineapple crops, Curtis de San Carlos, Costa Rica. Research Notebooks UNED 7(1): 1659-4266.

52. Salvador S, Clavero M, Pitman RL (2011) Large mammal species richness and habitat use in an upper *Amazonian Forest* used for ecotourism. Mamm Biol 76: 115-123.

53. Forsey ES, Baggs EM (2001) Winter activity of mammals in riparian zones and adjacent forests prior to and following clear-cutting at Copper Lake, Newfoundland, Canada. For Ecol Manag 145(3): 163-171.

54. Singh P, Macdonald DW (2017) Populations and activity patterns of clouded leopards and marbled cats in Dampa Tiger Reserve, India. J Mammal 98(5): 1453-1462.

55. Sethy J, Chauhan NPS, Gouda S (2016) Population status and ecology of highly endangered Malayan Sun bear (*Helarctos malayanus*) and sensitization of local communities for its conservation in Dampa Tiger Reserve, Mizoram, India. A Report submitted to Ocean Park Conservation Foundation, Hong Kong, p. 109.

56. Gouda S, Chauhan NS, Sethy J (2019) Status and distribution of Malayan Sun Bear (*Helarctos malayanus*) in Dampa Tiger Reserve, Mizoram, India. Journal of Wildlife and Biodiversity 3(4): 45-56.

57. Vanak AT, Gompper ME (2010) Interference competition at the landscape level: The effect of free-ranging dogs on a native mesocarnivore. J Appl Ecol 47(6): 1225-1232.

58. Sethy J, Gouda S, Chauhan NPS (2017) Confirm occurrence and photographic evidence of marbled cat from Dampa Tiger Reserve, Mizoram, India, CATnews Autumn 65: 26-27.

59. Chauhan NPS, Gouda S, Sethy J (2016) First photo capture of Asiatic golden cat in Dampa Tiger Reserve, Mizoram, India, CATnews Autumn 64: 26-27.

60. Sridhar H, Raman TRS, Mudappa D (2008) Mammal persistence and abundance in tropical rainforest remnants in the southern Western Ghats, India. Curr Sci 94(6): 748-757.

61. Ramesh T, Kalle R, Sankar K, Qureshi Q (2012) Spatiotemporal partitioning among large carnivores in relation to major prey species in Western Ghats. J Zool 287(4): 269-275.

62. Majumder A, Sankar K, Qureshi Q (2013) Co-existence patterns of large sympatric carnivores as influenced by their habitat use in a tropical deciduous forest of Central India. J Biol Res Thessalon 19: 89-98.

63. Peres CA, Dolman PM (2000) Density compensation in neotropical primate communities: Evidence from 56 hunted and non-hunted Amazonian forests of varying productivity. Oecologia 122: 175-189.

64. Peres CA (2010) Effects of subsistence hunting on vertebrate community structure in Amazonian forests. Conserv Biol 14(1): 240-253.

65. Wright SJ, Duber HC (2001) Poachers and forest fragmentation alter seed dispersal, seed survival, and seedling recruitment in the palm Attalea butyraceae, with implications for tropical tree diversity. Biotropica 33(4): 583-595.

66. Berger KM, Gese EM, Berger J (2008) Indirect effects and traditional trophic cascades: A test involving wolves, coyotes and pronghorn. Ecology 89(3): 818-828.