Research Article

Daily activity pattern of Malayan Sun bear in Dampa Tiger Reserve, Mizoram, India

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Abstract

Sun bear (*Helarctos malayanus*) is the smallest bear species and remains the least known bear among the ursids. Reliable information on population and activity pattern of Sun bear has been lacking, thereby creating difficulties for field managers and conservationists to develop a management plan for their conservation. The study was an attempt to determine the habitat preference and daily activity of Sun bear through camera trapping and other signs survey methods. In the study, we had a combined trapping effort of 647 trap-nights with a total of 18 independent images of Sun bear recorded between May 2014 and March 2016. Distribution of bear signs per hectare was found to be highest in the Bamboo forest (0.398), owing to large numbers of termite's mounds. The photo capture rate of Sun bear in Dampa Tiger Reserve was found to vary by different habitats with high numbers in degraded forest landscape within the Reserve. The variation was also influenced by the disturbance of humans in the area and other feeding opportunities. The relative abundance index shows that Old Chikha has the highest index of 1.89 with a mean value of 5.26 ±0.670 among all blocks in Dampa Tiger Reserve. The daily activity index suggests that Malayan Sun bears are more active during the crepuscular period than diurnal. The highest activity was recorded between 1800- 2200 with 14.89% detection probability. No activity was recorded during the mid-noon phase. Primary forests and degraded forests with their large fruiting trees were represented as important habitat owing to the availability of fruits, termites and invertebrates. The study will hopefully be an important step towards acquiring more knowledge on the ecology of the species and provide valuable information for the conservation of the species and their habitat.

Introduction

The Malayan Sun bear (*Helarctos malayanus*) is a cryptic and solitary mammalian species, occurring throughout South-east Asia, including the islands of Sumatra and Borneo, Bangladesh, and northeast India. Sun bear is known to be the most arboreal of all bear species and is found predominantly in the lowland dipterocarp rainforest (Smith and Xie 2008). Ecology of these tropical bears is little known, mainly because of their secretive, solitary nature and inhabiting dense forest habitats, making them challenging to follow. However, with increases in anthropogenic pressure in forms of habitat destruction and poaching for their body parts as traditional medicine, Sun bears are reported to extinct from some of its home range such as Singapore (Fredriksson *et al.* 2008) or confined to few forest patches like in India and Bangladesh (Islam *et al.* 2013, Sethy and Chauhan 2012). Knowledge of the abundance and factors influencing the abundance of any species is essential in many areas of ecological research (demography, habitat), management, and policy-making (species listings) (Stanley and Royle 2005, Stephens *et al.* 2006). Considering the fact Sun bear is a "Threatened Species," and there has been a great amount of paucity of information even on basic biology such as food habits, home range size, and reproductive characteristics of Sun bear, its make them a priority species for research

amongst the Ursids members (Servheen 1999, Wong *et al.* 2004, Scotson *et al.* 2017).

The introduction of camera-trap surveys has revolutionized wildlife studies and has dramatically increased the amount of information on secretive and cryptic species in tropical rainforest habitats and also in steep terrain where other field methods are likely to fail (Karanth and Nichols 1998, O'Brien *et al.* 2003, Rowcliffe and Carbone 2008). The camera trapping technique is well developed within a robust capture-recapture statistical framework and is applicable where individuals within a species can be identified with their uniquely identifiable coat patterns (strips/spots). However, for the majority of tropical mammals, including Sun bears, it is not possible to identify individual bears with confidence unless the chest marks are photo-captured, as developed by Ngoprasert *et al.* (2012). Although radio-telemetry studies of Sun bears were carried out to determine their activity budgets, habitat use and ranging behavior by several researchers in many parts of the world (Nomura *et al.* 2004, Wong *et al.* 2004, Linkie *et al.* 2007), few studies have addressed the use of camera trapping rate as an index of abundance (Kelly 2008). Linkie *et al.* (2007) were the first to estimates Sun bear occupancy through a detection/ non-detection sampling technique using camera-trap data. Henceforth, we aimed to use the camera trap data along with relative ubiquity and long-term persistence signs of Sun bear to determine the habitat use and the activity patterns of Malayan Sun bear in the tropical forest of Mizoram, India.

Material and Methods
Study area
The study was carried out in the Dampa Tiger Reserve (DTR) located in the Mamit district of Mizoram along the Indo-Bangladesh border. The Reserve lies 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 550 km^2. The Reserve harbors a rich floral and faunal diversity and contains a profusion of habitats characterized by diverse biota. The Reserve consists of moist deciduous forests at the lower reaches and evergreen and semi-evergreen with natural grassland at higher altitudes (Pawar and Birand 2001, Lalrinchhana and Solanki 2015). Bamboo forest and abandoned shifting forest can also be found along the periphery of the tiger reserve which make the Reserve a conducive habitat for several mammalian species like clouded leopard, elephant, gaur (Indian Bison), wild dog, sambar, barking deer, porcupine, etc. (Devi *et al.* 2011). Altitude in the Reserve is from 800 to1500m above mean sea level and experiences a temperature between 12°C to 25°C during winter and 22°C to 35°C in summer.

Line transect
34 transects were carried out in a stratified manner covering different habitat in the tiger reserve. Each transect were marked along trails and were covered at least 2-3 times in a season by a group of 3-4 persons with 15-20 days interval. During the transect walks, bears signs (Sun bear and Asiatic black bear) (claw marks, footprints, feeding signs, feces, digging, crop-raiding, etc. were extensively searched. Each tree with claw marks was recorded and in a condition where claw marks of different age categories were observed on one tree the most recent sign was recorded following Steinmetz and Garshelis (2008). GPS coordinates of the tree with claw marks were also recorded. Based on the distribution of bear signs in the region, the density of signs per ha was determined (Stephens *et al.* 2006) .

Camera trapping
Based on a preliminary sign survey, that indicated the presence of both Sun bear and Asiatic black bear in the Reserve, the study was focused on an area of 160 km^2 roughly encompassing the moist evergreen habitat within the Dampa Tiger Reserve below 1200m. A uniform grid (4x4 km) was imposed on a map of the area. A grid size of 16 km^2 was selected to match the scale of other camera-trapping surveys in South-east Asia (O'Brien *et al.* 2003, Kawanishi and Sunquist 2004, Jackson *et al.* 2006). The study area was further categorized into 8 blocks based on anthropogenic pressure in forms of human activities, presence of fruiting trees and indirect shreds of evidence found during the sign survey. Camera traps were laid on eight blocks of the reserve forest *namely* Old

Chikha, New Chikha, Malpui, Tuichar, Chikha road, Pathloi, IR camp, and Tuilut. Sun bear were photo-captured using 10 passive camera trap units (Cuddeback) between May 2014 and March 2016. All camera traps was operational for 24 hours per day and had a 10 Seconds delay between photographs. Cameras traps were placed on trees at ~75 cm from the ground and 1-10m from the monitoring area. Consecutive photographs of the same species at the same site were deemed independent when there was at least 1-h interval between them (Bowkett *et al.* 2007, O'Brien *et al.* 2003). The photo-capture rate was determined using method suggested by Linkie *et al.* (2007), Tobler *et al.* (2008) and Rovero and Marshall (2009) that describe it as the number of days requires to get a single image of a species in any given areas.

The relative abundance index (RAI) was calculated as photo-captured of the species by all camera traps over all days, multiplied by 100, and divided by the total number of camera trap nights (Jorge *et al.* 2008, Jenks *et al.* 2011). The activity pattern of Sun bears in the study area was determined by dividing the day into 12 two-hour periods and summing the number of photo-captured in each time interval. A daily activity index (DAI) was calculated following the methods of Li *et al.* (2010) to understand the movement and time utility pattern of Sun bear in the Reserve.

Results

Secondary pieces of evidence in forms of claws marks, scats, and other bear signs indicate the presence of bears (Sun bear and Asiatic black bear) in the reserve forest. The bamboo forest was found to have the highest signs (0.4 signs/ha) followed by Tropical semi-evergreen forest, Tropical wet-evergreen forest, and Semi evergreen forest. Mix forests and temperate forests had the lowest density of bear signs (Table 1).

Table 1. Distribution and density of bear signs in different habitat in DTR

Sl No.	Habitat category	Sampling plots (n=310)	No. of bear signs in sample plots (n=258)	No. of plots with bear signs (n=236)	Density of signs (signs/ha)
1	Mix forest	30	22	20	0.085
2	Tropical wet-evergreen forest	50	31	39	0.165
3	Tropical semi-evergreen forest	50	44	41	0.174
4	Semi-evergreen forest	40	31	27	0.114
5	Temperate forest	30	20	15	0.064
6	Bamboo forest	110	98	94	0.389

During the study period, a total of 18 independent images of the Sun bear was photo-capture using ten camera traps from 8 different blocks within the study (Table 2). The photo-capture rate in 8 forest blocks shows that Chikha block requires the minimum numbers of days (n=12) to acquire a single photograph of Malayan Sun bear in DTR, whereas; Tuichar block was found to require the maximum numbers of days (n=37) for a single image of Sun bear (Table 2). Tuichar block is known to experience higher cases of poaching as there is no proper demarcation or fences along its border with Bangladesh, and poachers can quickly move across, thereby leading to the low frequency of sighting or photo-capture. The Mann Whitney U-test perform for non-parametric values for the photo-capture rate in disturbed and undisturbed forest habitat suggest a statistically significant difference in ranked distribution between the two forest types with *U-value* of 7.00, *p*= 0.886, and *Z-value* =-2.90. Similar statistics were also used by Stephens *et al.* (2006) to determine the density for red deer (*Cervus elaphus xanthopygus*), Siberian roe deer (*Capreolus pygargus*) and Sika deer (*Cervus nippon*) where the population size was relatively very low (n=<10).

The relative abundance index (RAI^2) shows that Old Chikha has the highest RAI$_2$ value (1.89) followed by Chikha road, New Chikha, and Tuilut with values of 1.23, 0.78, 0.45

respectively (Table 2, Fig. 1). The mean value was estimated to be 5.26 ± 0.670 for all the blocks within DTR. Mann Whitney U-test for the relative abundance index was 3.00, with *Z-value*=-1.443, p<0.05, thus showing a difference between the ranks for the disturbed and undisturbed forest habitat. Tuilut, however, was found to have a comparatively higher value due to the abandoned agriculture fields that are in the vicinity of the reserve forest. Primary forests with their large fruiting trees have undoubtedly been represented as excellent habitat for Sun bear as reported in previous literature published on the Sun bear (Wong 2002, Bailey *et al.* 2004, Wong *et al.* 2004, Datta *et al.* 2008, Wong *et al.* 2013, Steinmetz

et al. 2013). The Daily activity index (DAI) of Malayan Sun bear in the Reserve was determined from the camera-trap images. The activity of Sun bear was recorded from 0200-2400 h, and high detection probability was between 1600- 1800 h, 1800- 2000 h and 2000-2200 with 10%, 15%, 18%, respectively. No activity was recorded during mid-noon that may occur probably due to the high temperature that may range up to 35^0C during day times. Between 1000 h to 1200 h the activity of the Sun bears reached its lowest level with about 2% detection probability (Table 3, Fig. 2). These data suggest that Malayan Sun bears were more active during the crepuscular period than diurnally.

Table 2. Photo-capture and relative abundance Index of Sun bear in DTR

Area/blocks	Malayan Sun bear				Asiatic Black bear			
	No. of total photos	Independent photos	RAI1	RAI2	No. of total photos	Independent photos	RAI1	RAI2
Old Chikha	17	7	15	1.89	21	10	9	2.07
Malpui	5	2	21	0.23	4	4	11	0.05
Tuichar	2	2	37	0.05	5	2	16	0.23
Chikha road	11	3	12	1.23	7	3	17	0.45
Pathloi	0	0	0	0	0	0	0	0
IR camp	1	1	31	0.12	0	0	0	0
Tuilut	4	1	21	0.45	2	1	23	3.97
New chikha	7	2	14	0.78	0	0	0	0
Total/ Mean	47	18	21.57	5.26	39	20	15.02	6.65

RAI^1: Number of days required to get a single photo-capture, RAI^2: Number of independent photos per 100 trap-nights.

Table 3. Daily Activity Index (DAI) of Sun bear in the tiger reserve

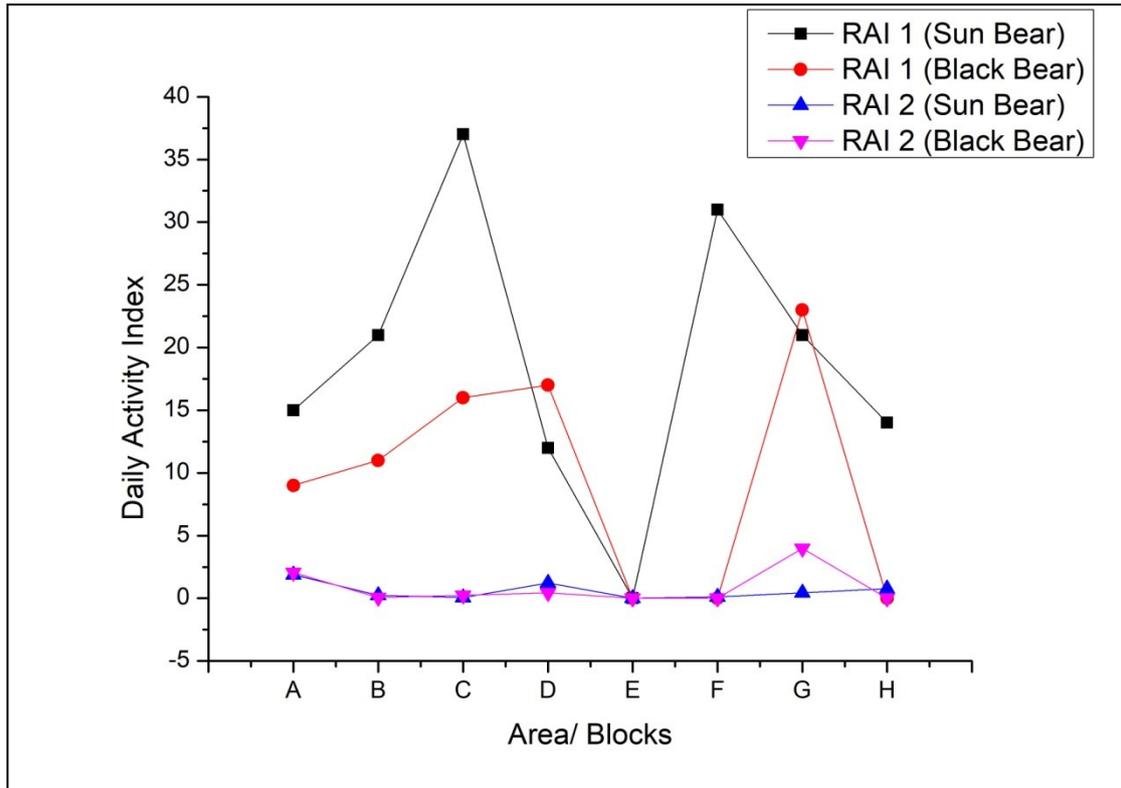| Common name	0.00-02.00	02.00-04.00	04.00-06.00	06.00-08.00	08.00-10.00	10.00-12.00	12.00-14.00	14.00-16.00	16.00-18.00	18.00-20.00	20.00-22.00	22.00-24.00
Malayan Sun bear	0	4.25	6.32	12.12	12.12	2.64	0	0	10.63	14.89	18.18	18.25
Asiatic black bear	6.06	12.12	12.12	12.12	6.06	6.06	0	18.18	9.09	6.06	6.06	6.06

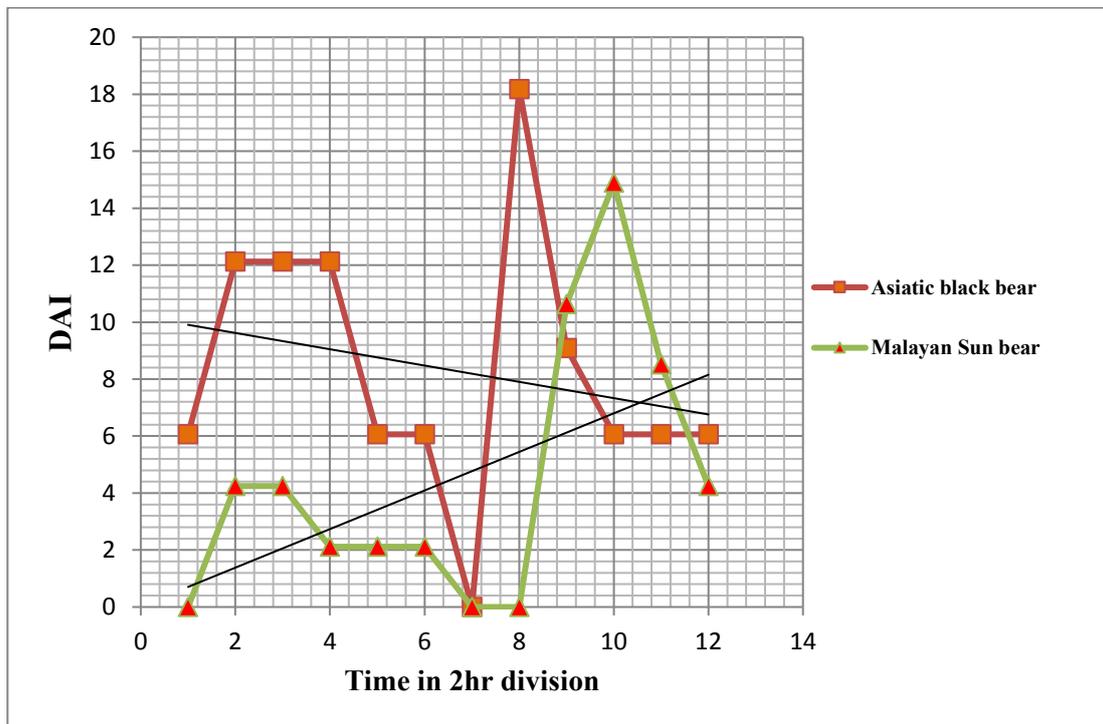**Figure 1.** Photo-capture and relative abundance Index of Sun bear in DTR

Figure 2. Daily activity index of Malayan Sun bear in DTR

Discussion

Sign surveys are an important means for the identification of cryptic species or species with a low population in a relatively large area. The higher number of bear signs in the bamboo forest in the study may be due to the presence of termite mounds and large wooden logs. Fredriksson *et al.* (2006) and Wong *et al.* (2004)

have also considered logged, and degraded forests as important habitat as they provide with varied forms of food sources necessary for Sun bear dietary requirement.

Statistical analysis for the non-parametric values shown as uneven variation in the distribution of Sun bear, that may be attributed to the anthropogenic pressure experienced in the region. The blocks, namely Malpui, Pathloi, IR camp, and Tuilut have high human disturbance and vehicular movement as it is the main route connecting villages that lies in the periphery of DTR, thus contributing to their lower RAI[2] values.

The high sighting frequency of Sun bear in block-like Old Chikha, were mainly due to the presence of a high number of feeding plants for bears. The blocks being an abandoned village have wide ranges of fruiting trees such as figs, Jackfruit (*Artocarpus heterophyllus*), Charcol tree (*Trema orientalis*), Chaplash (*Artocarpus chama*), Hairy fig (*Ficus hispida*), Beal (*Aegle marmelos*), *Ficus benghalensis,* etc. providing excellent fruiting phenology for the bear species. The degraded forest can also represent important habitat owing to the availability of termites and invertebrates (Linkie *et al.* 2007, Fredriksson *et al.* 2006, Wong *et al.* 2004).

The Daily activity index (DAI) determined through camera-trapping shows that the bear duo of Asiatic black bear and Malayan Sun bear are highly sympatric in their ecology as they not only share their habitat but also their frugivory time. They were active mostly during the late-night hours and at early dawn hours. The area is located in the tropical belt experiencing a moderately high temperature, i.e., 35ºC, which also explains the zero photo-capture of bears between 1200- 2000 hrs. The sympatric bear's species in the Reserve, i.e*.,* the Asiatic black bear and Sun bear, both have similar activity index and also share the same niches. Activity patterns of animals are considered to be an adaptation to seasonal, physiochemical and diurnal variation in the surrounding environment. However, it may also be influenced by human disturbance and other anthropogenic activities that were supported by findings from Meijaard (1999), Griffiths and Van Schaik (1993) and Augeri (2005) where a shift in Sun bear daily activity patterns was observed in relation to human disturbance. Blocks such as Tuichar, IR camp, Pathloi and Tuilut experience higher human activities in forms of vehicular movement, collection of fuel woods and other daily livelihood activities, hence restricting and affecting the movement of bears.

Conclusion

Sun bear as noted by many has been curbed from most of their natural habitat and is now restricted to few forest patches across their home ranges. Nevertheless, with increasing anthropogenic pressure such as deforestation and over-hunting, it is essential to determine their population trends in the wild accurately for driving conservation efforts. As suggested by Steinmetz and Garshelis (2008) and Rovero and Marshall (2009) Sun bears leave different forms of relative ubiquity and long-term enduring signs, such as scats, logs ripped apart, and claw marks on trees, which reveal presence and activities and is also a widely relevant technique for individuals that cannot be distinguished from photographs (Rowcliffe *et al.*, 2008). The use of camera trapping in recent times have allows detection of the rarest and /or nocturnal and crepuscular species, such as Sun bear (Bowkett *et al.* 2007). During the study it was observed that forest habitat, fruiting phenology and human disturbance plays significant roles in habitat selection and distribution of Sun bear in DTR. Increase in agriculture practices (Shifting cultivation) though requires logging and felling of large areas, they also provide opportunities for food in forms of termites mounds and growth of several fruiting plants for bears such as *Artocarpus heterophyllus, Cucurbita pepo, Zea mays, Trema orientalis, Syzygium cumini, Carica papaya, Ficus Spp* etc. Degraded forest lands and abandoned agriculture fields in and around the Reserve can serve as important foraging ecology and therefore cannot be ruled out for trespassing of bear to regions with human settlement. The study explores traditional as well as modern techniques to determine density and daily activity patterns of Sun bear and will hopefully be an important step towards acquiring more knowledge on the ecology of the species and its conservation in eastern Himalayan regions of Southeast Asia.

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