STATUS AND DISTRIBUTION OF MALAYAN SUN BEAR IN NAMDAPHA TIGER RESERVE, ARUNACHAL PRADESH, INDIA

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Abstract

The Malayan sun bear Helarctos malayanus, is categorized globally as a Critically Endangered species on the IUCN Red List. However, recent studies have indicated that sun bear have disappeared from large areas, probably as a result of habitat loss, a low prey base and poaching, indicating this species may not be as common in India as previously believed. Our findings indicate that the species has declined dramatically, with confirmation of presence at only some sites in provinces, despite extensive surveys. Current populations are small and fragmented, and occur mainly in tiger reserve. In Namdapha Tiger Reserve, 379 different bear signs were identified along 43 transects. The number of claw marks was found to be highest as compared to number of scats, nests, diggings, dens and footprints. All these bear signs were observed in summer, monsoon and winter months in different forest types in Namdapha Tiger Reserve. The mean signs were highest during the winter months (41.5±5.80), followed by monsoon months (31.0±6.25) and summer months (22.25±3.83) during the study periods. There was a distinct relationship between season, elevation and density of bear signs per unit area (R^2 Linear = 0.81488). The density of bear signs showed an increasing trend with the increasing elevation in the tiger reserve. But from 1500m and above, the density of bear signs decreased drastically. In India, there is no information on the population status, distribution and ecology of sun bear. Our findings are the first reliable estimates of the current distribution and status of the Malayan sun bear in India, and provide valuable information that will help guide the conservation efforts.

Keywords: Status; Distribution; Sun bear; Namdapha TR; Arunachal Pradesh

Introduction

Sun bear (*Helarctos malayanus*) remains the least known bear species in the world. The historic distribution of the sun bears in India was in the tropical rainforest habitats of Manipur and Assam states south of the Brahmaputra River [1], although there were reports of its occurrence in the north-eastern hilly region during the 1960s and 1970s. During the 1980s and 1990s, sun bear population apparently declined, and its occurrence became doubtful in the north-eastern hilly region. The reason for the dwindling sun bear population is probably the increased human population with its attendant activities. Rapid deforestation resulting in habitat destruction and fragmentation coupled with indiscriminate hunting has also threatened with extinction the sun bears population of India.

Due to increase in human populations, loss, degradation and fragmentation of forests, sun bear population has sharply declined to low levels in most areas. They are found in the

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forest of Laos, Thailand, Myanmar, Bangladesh, Kampuchea, Southern China, Vietnam, Peninsular Malaysia and the Islands of Sumatra and Borneo [2]. There were also reports of occurrence of sun bears on the Island of Java [3-5]. In India, the historic distribution of sun bear was in the tropical rain forest habitats in the north-eastern region [6-13]. According to the report [1], there were no sun bears in India in the 1990s.

Recently sun bears were reported to occur in mainland South-East Asia as far west as Bangladesh and north-eastern India. Occurrence of sun bear was reported in Manipur, Mizoram, Nagaland, Arunachal Pradesh and Assam [14-29]. During 1996-97, a sun bear was photographed in a camera trap in Namdapha [30].

Study Area

The Eastern Himalayas and the hills of north-east India are recognized as a global biodiversity hotspot. While north-east region occupies 8% of the country's area, it harbours 56% of its faunal diversity. Within this region, arguably the most biodiversity rich state (the largest among the seven in north-east India, covering 83743km^2) is the state of Arunachal Pradesh (26°28' - 29°30' N and 91°30' - 97°30' E). Namdapha Tiger Reserve (Fig. 1) is situated in the Changlang district of Arunachal Pradesh and has common boundary with Kamlang wildlife sanctuary in the north, Miao reserve forest (RF), Nampong RF, Diyun RF etc. in the west, forest areas of Kachin Province of Myanmar in the south and unclassed state forest areas of Gandhigram in the east.
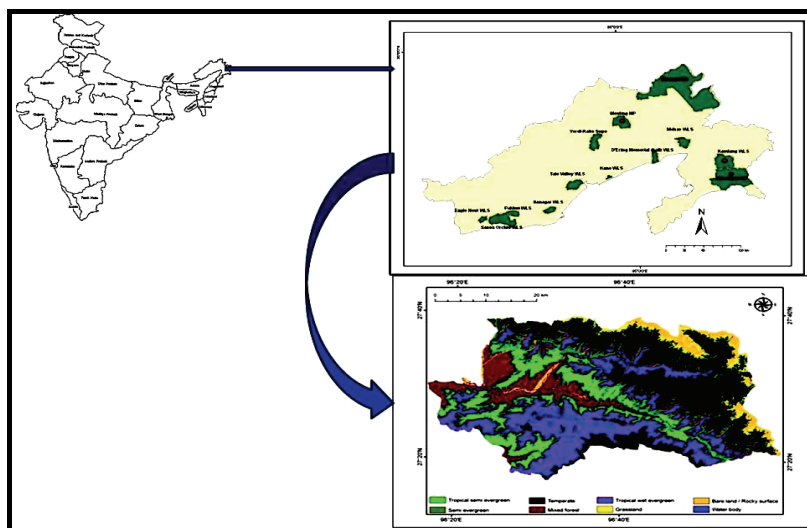

Fig. 1. Study area of Namdapha Tiger Reserve, Arunachal Pradesh

Methodology

The status and distribution of sun bear was studied based on questionnaire surveys by conducting interview of local people in different villages located in the vicinity of Namdapha Tiger Reserve, and also by using line transects and recording indirect evidences of sun bears. To find the distribution of sun bear, different forest types available in the Tiger Reserve were categorised. There were broadly Mix forest, Tropical wet-ever green forest, Tropical semi-ever green forest, Semi-ever green forest, Temperate forest and Bamboo forest.

Questionnaire survey

A basic premise was that the survey should cover the entire population of sun bears in Namdapha Tiger Reserve. A questionnaire format to carry out field investigations was used,

and this was based on the assumption that people who were engaged in outdoor activities had some idea of the sun bear, black bear and sloth bear distribution and abundance in their areas. Questionnaire formats was therefore distributed in different villages. Following this, questionnaire surveys with photographs of sun bear, Asiatic black bear and sloth bear were carried out in different villages located in and around the protected area and information on the distribution of sun bear was collected during 2008 to 2010. Village houses were also surveyed to look for bear trophies or body parts. Interviewees were selected by considering their knowledge of the local region into account, in particular their knowledge of the forest and wildlife (Fig. 2.).
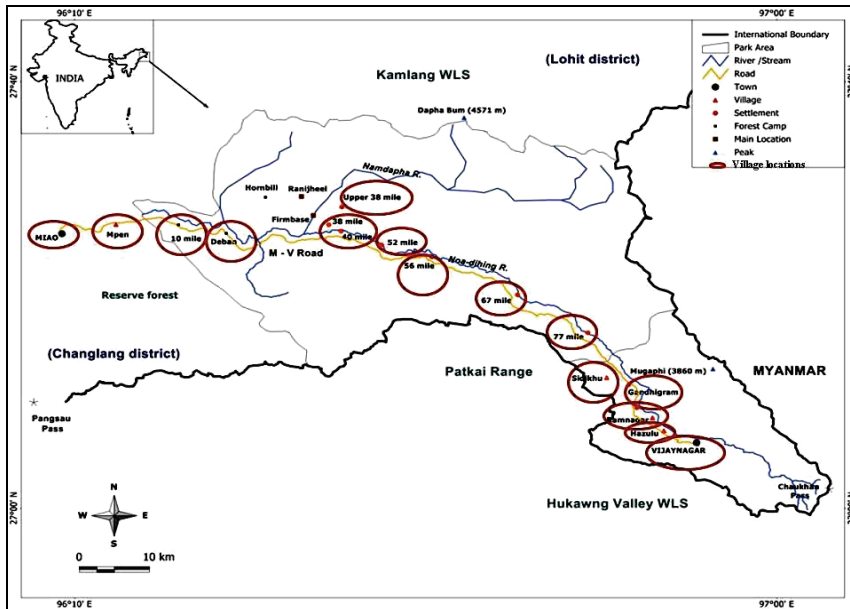

Fig. 2. Location of villages in and around the Namdapha Tiger Reserve.

Use of line transects

Extensive field surveys were carried out in the Tiger Reserve and then 43 line transects were laid in different parts to collect information on distribution of sun bear based on direct sightings of bears and their indirect evidences (tracks, scats, claw marks, nests and etc.). Locations of these line transects are shown in (Fig. 3). The starting points of transects were chosen randomly in different forest types within a range. Forest types often changed along transects so the extent of each forest type surveyed was recorded. Each line transect was walked by a team of 4-5 people. A direction (north, south, east or west) was chosen randomly in advance and one person (temporary local staff) acted as navigator, leading the way by using a compass. One person walked along the midline, measured the length of transect with a measuring rope, and recorded the information.

Two to three people searched for bear signs along five meter strips on either side of the mid-line, and recorded the data. To avoid any basis the team members held the same role for all transects although, they alternated on sides of the midline. Field equipment comprised of a compass, map and GPS unit (Garmin) were used for navigation and 10 meter and 5 meter lengths of rope for measuring the widths and length of transects. A flexible measuring tape was used to measure the circumference of tree trunks at breast height. Templates of very fresh, fresh, old and very old claw marks were recorded in a ring-bound note pad. All transects were covered at least 2-3 times in a season with 15-20 days of interval. On every 100m along transect, sun bear scats were collected and other indirect signs were recorded. All instances of bear signs

within transect boundaries were recorded in the data sheet. Elevations were also recorded at the start, middle and end points of each transect. Fruit trees, ant nests and termite nests were counted along transects to obtain a measure of food abundance. The distribution of sun bear was mapped in different forest types in the Tiger Reserve.
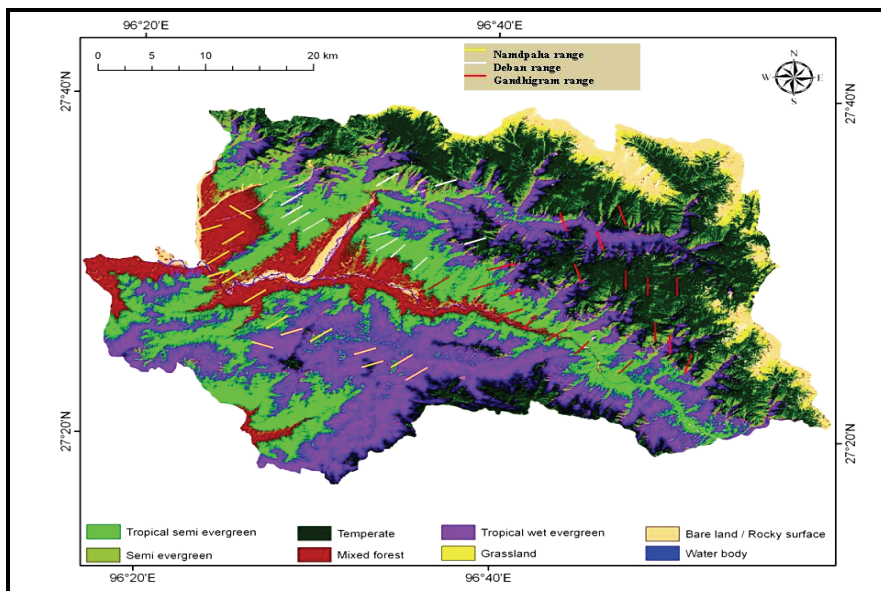

Fig. 3. Location of transects in Namdapha Tiger Reserve

Description of signs

All claw marks, bear nests, broken bee's nests, digging sites, scats, tracks and trails were recorded as signs. Claw marks on climbed trees were also recorded as one sign. In case where claw marks of different age categories were observed on one tree, the most recent sign was recorded. Signs were allocated into broad age categories; very fresh (1-3 days), fresh (3-15 days), old (3-16 weeks) and very old (>16 weeks).The age of sign was decided through a combination of expertise and protocol. R. Steinmetz [31] found that claw marks from climbing events could be placed in broad age categories and that wood hardness and seasonal effect had little consequence on aging rates. But in this study, signs were assigned the age categories using aging characteristics adopted.

Age categories

*Very fresh -*Sign estimated to be aged 1-3 days. Claw marks were void of woody grit, becoming smooth and hard with new bark growth spreading across the inside of the gouge. Edges were faded and less distinct than very fresh marks.

*Fresh -*Sign estimated to be aged less than 3-15 days. Claw marks had fine woody grit within gouge and distinct sharp edges. According to some studies [30] 1 to 3 months old signs considered as fresh signs.

Old - Sign estimated to be aged between 1 – 2 years. Claw marks are filled by wood re-growth or bark which builds around the edges. Edges are often raised out from the tree trunk [31].

Very old - Sign estimated to be aged more than 2 years. Claw marks are stretched and distorted considerably due to tree growth. Bark re-growth often results in claw marks being pushed out from tree [31].

Distinguishing claw marks

The field reference to classify Asiatic black bears and sun bears from the measurements of hind foot claw marks on climbed trees is given in Table 1.

Table 1. Claw mark reference table adopted by Steinmetz and Garshelis (2008)

Species	Step 1 4-claw width (cm)	Step 2 5 claw-width (cm)	Step 3 3 claw-width (cm)
Black bear	> 6.6	> 9.0	> 4.1
Sun bear	< 6.0	< 6.2	< 4.0
Indeterminate	6.0-6.6	6.2-9.0	4.0-4.1

Step 1. Recognizing claw marks of the hind foot: Claw marks of only the hind foot were used for measurements. Usually, the claw set axis from hind foot marks is horizontal with respect to the tree trunk while the front foot marks are oriented diagonally.

Step 2. Making a template of the claw mark set: A template of the claw marks was prepared by placing a piece of paper over the claw mark set following the curvature of the tree trunk. Holes were then punched at the bottom centre of each claw mark and the outline of each claw mark drawn above the holes.

Step 3. Measuring the claw marks: After preparing the template, straight-line measurements were taken. a) the middle 3 claws, b) the outer 5 claws and c) the shortest distance between 4 claws as shown in (Fig. 4).

Step 4. Comparing with reference table: Then measurements obtained from the template were compared with the reference Table 1.
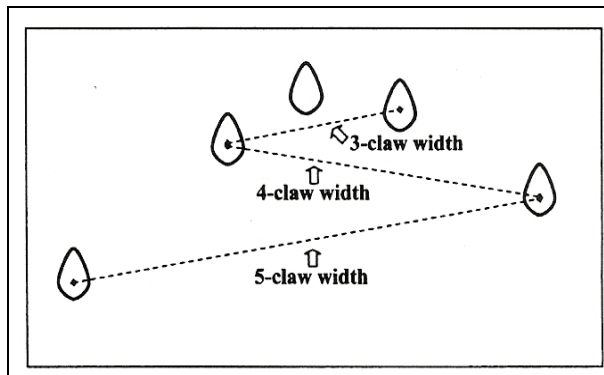

Fig. 4. Measurement of claw marks for identification of bear species

Camera-trapping surveys

In Namdapha Tiger Reserve, a grid size of 2km^2 was selected as followed in other camera-trapping surveys in south-east Asia [35-37]. Of the 40 grids covering the study area, a random selection of 20 grids was made in the Tiger Reserve. All field work was carried out on foot. Given logistic difficulties in the hilly terrain, limitations of time, manpower and equipment, sampling was carried out from August 2008 to November 2010. For this study 10 passive infrared camera trap units (DEERCAM) and 20 Digital (Wild view) camera traps were deployed for 320 days and 390 nights. Traps were deployed along animal trails, streambeds, and ridgelines, in locations with evidences of animal movement. The GPS locations, altitude and other habitat parameters at each trap site were recorded. A group of highly skilled *Lisu* trackers assisted in identifying suitable locations for deploying camera traps. At every location, one passive infra-red camera trap was placed perpendicular to the expected direction of animal movement at a height of 25-35cm from the ground. A minimum distance of 1km between trap

locations was maintained. However, the traps were operational for 24 hours a day, and were removed after a period of 7 days. The number of camera trap days was calculated from the date of deployment till the date of retrieval (if film was not used up) or till the date of the final photo. A potential bias of our survey was that all camera traps were located on the ground; therefore certain species that were more reported to be more arboreal might not be captured as frequently.

Results

The occurrence and distribution of sun bear population based on the village interviews, transects by observing indirect evidences: claw marks, nests, scats and digging of termite mounds along, and camera trapping in the Namdapha Tiger Reserve is presented as under:

Distribution based on questionnaire survey

During the study period from 2008 to 2010, questionnaire surveys were conducted in 18 fringe villages, namely, Gandhigram, Vijoy Nagar, Sidhikhu, 52 Mile, 56 Mile, 77 Mile, Ram Nagar, Hazulu, 40 Mile, 38 Mile, Upper 38 Mile, Deban, Lama Camp, Chhemile, Tera Mile, Tuhat, Phaparbari and Miltary camp to know the occurrence and distribution of sun bears. The locations of these villages are shown in (Fig. 1**)**.

Sighting of sun bear

In total 785 respondents were interviewed in different villages located in and around Namdapha Tiger Reserve. Out of these respondents, 265 respondents (33.6%) confirmed the presence of sun bear based on direct sightings (Table 2), and they had also observed the indirect evidences in the forest area adjacent to their villages during the study period. Highest number of respondents confirming presence of sun bear was from Gandhigram (n = 108), followed by Vijoynagar (n = 27), 52 Mile (n = 22), 77 Mile and Sidikha (n = 21 each), 38 Mile (n = 19), Hazulu (n = 11) and so on. According to 21 respondents there was probability of occurrence of sun bear in these villages as (2.7%). Rest of the respondents (63.7%) did not respond about the occurrence of sun bear. Among these, the status of sun bear occurrence was low in three villages (Tuhat, 40 Mile and Miltary camp) and medium in five villages (Vijoy Nagar, Sidhikhu, Ram Nagar, Hazulu and Phaparbari). In Chhemile village and Tera Mile, there were no reports of sun bear occurrence although most of the respondents reported that they used to ramble around these areas long time back.

Sun bear were reported to use different forest types in Namdapha Tiger Reserve (Fig. 5). The respondents observed sun bears them maximum times in the Tropical wet-ever green forest (30.5%), followed by Semi-ever green forest (26.7%), Mix forest (19.6%), Tropical semi-ever green forest (17.2%) and Bamboo forest (6.0%). Number of sightings of sun bear was more in the Tropical wet-ever green forest and Semi-ever green forest because there was plenty of food available in these areas and low disturbance**.**

During the questionnaire surveys, the respondents also sighted indirect evidences of sun bear such as claw marks, nests, scats, foot prints and dens. They sighted highest number of claw marks (n = 289), followed by nests (n = 73), scats (n = 95), footprint (n = 73) and dens (n = 12) in the Namdapha Tiger Reserve**.**

Respondents also sighted of sun bear performing different activities; they were found resting on the tree branches (n = 90), moving (n = 75), feeding (n = 43) in forest and a few times in cultivated area**.** Generally sun bear were reported to be active during morning, evening, noon and night time. According to respondents, sun bear were found to be the active during the day time. Sun bear were observed 47 times in the morning, 48 times in the evening and 86 times in the noon times. They were reported to be the least active during night time; the respondents observed sun bears only 7 times in the night**.**
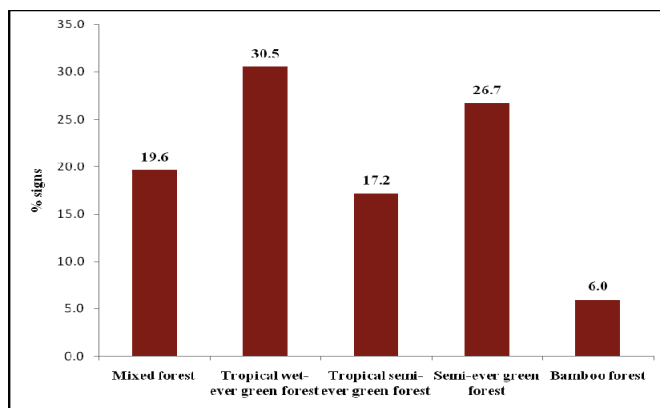
Fig. 5. Occurrence of signs in different forest habitat based on respondent.

Table 2. Number of respondents in different villages who sighted sun bear in various forest types in and around Namdapha Tiger Reserve.

Name of villages	No. of respondents	Occurrence in forest types
Gandhigram	108	Tropical wet-evergreen, Tropical semi-ever green forest and Bamboo forest.
77 mile	21	Tropical wet-evergreen tropical semi-ever green forest and bamboo forest
52 mile	22	Tropical semi-ever green and Mixed forest
56 mile	2	Tropical wet-evergreen and semi-ever green forest
40 mile	2	Mixed forest and semi-ever green forest
38 mile	19	Mixed forest and semi-ever green forest
Upper 38 mile	3	Mixed forest and semi-ever green forest
Sidikha	21	Tropical wet-evergreen tropical semi-ever green forest and bamboo forest
Ramnagar	5	Tropical wet-evergreen and tropical semi-ever green forest
Vijoynagar	27	Tropical wet-evergreen and tropical semi-ever green forest
Hazulu	11	Tropical wet-evergreen and tropical semi-ever green forest
Phaparbari	3	Tropical wet-evergreen and tropical semi-ever green forest
Chhemile	0	-
Theramile	0	-
Deban	3	Mixed forest and semi-ever green forest
Lama camp	7	Mixed forest and semi-ever green forest
Tuhat	5	Tropical wet-evergreen and tropical semi-ever green forest
Military camp	4	Mixed forest

Distribution based on surveys and transects

During the survey period, 43 transects laid in Namdapha, Deban and Gandhinagar ranges**.** These transects were located in Tropical wet-ever green forest, Temperate forest, Semi ever green forest, Tropical semi ever-green forest, Bare land and Bamboo forest **(**Fig. 2). Through intensive surveys and transect study, all these forest types were covered during plot sampling and their availability and locations of active and inactive nesting and den sites of sun bear were found out in Namdapha Tiger Reserve.

Availability of forest types

The availability of forest types varied in the Namdapha Tiger Reserve (Fig. 6). The area of Tropical wet-ever green forest was highest (618.61km^2), followed by Temperate forest

(510.60km^2), Semi ever-green forest (316.05km^2), Tropical semi-ever green forest (280.40km^2), Mix forest (166.05km^2), Bare land (135.70km^2), Bamboo forest (44.17km^2) and Water body (6.07km^2). Similarly the percentage availability of Tropical wet-ever green was highest (29.8%), followed by Temperate forest (24.6%), semi ever-green forest (15.2%), Tropical semi-ever green forest (13.5%), Mix forest (8.0%), Bare land (6.5%), Bamboo forest (2.1%) and water body (0.3%). These habitat types were more or less evenly distributed in the whole area. All these land cover and land use categories fell into 500 to 4000m elevations range and occurred in flat to undulation terrain facing different directions.
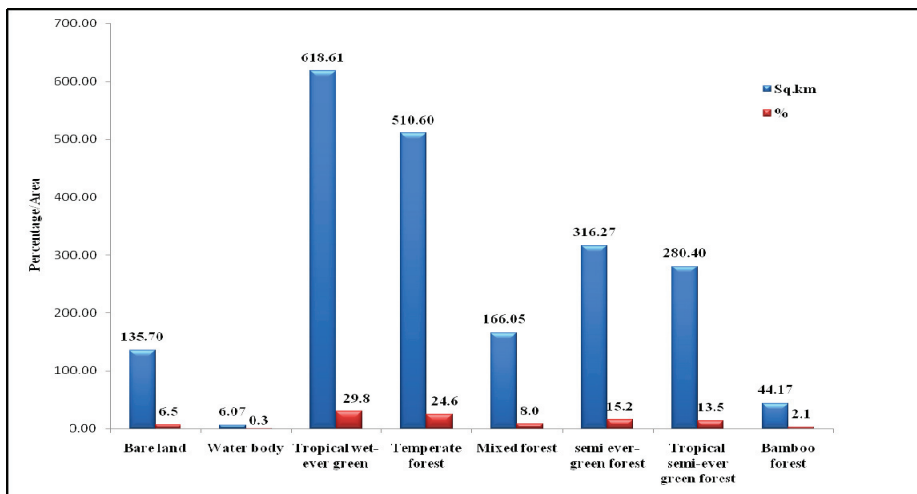

Fig. 6. Availability of forest types in Namdapha Tiger Reserve.

Extent of forest types

While doing plot sampling along the transects, 3.768ha of Tropical semi-ever green forest, 3.454ha of Tropical wet-ever green forest, 2.198ha of Semi-ever green forest, 1.571ha of Mix forest, 1.256ha of Temperate forest and 1.256ha of Bamboo forest were covered in the study areas (Fig. 7).
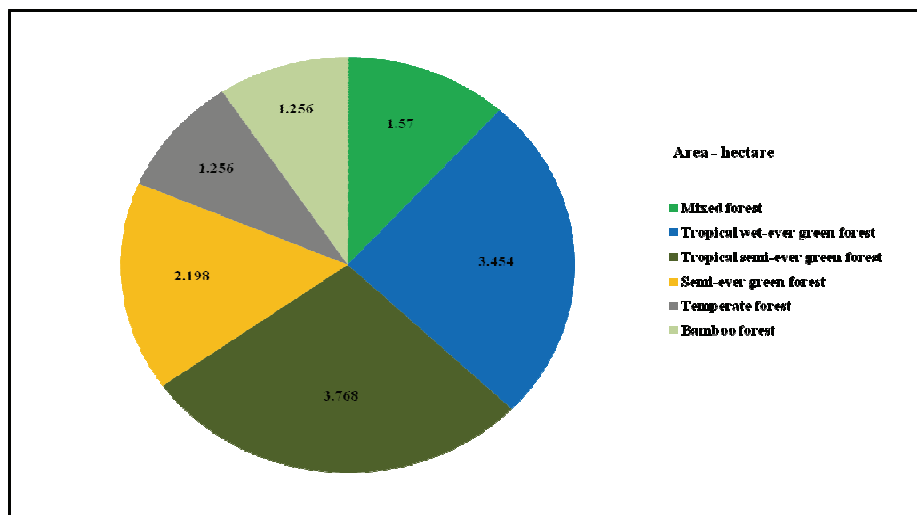

Fig. 7. Area of forest types covered during plot sampling along transects in Namdapha Tiger Reserve.

Occurrence of bear signs

In Namdapha Tiger Reserve, different types of sun bear signs were recorded along the 43 transects. The signs distribution was recorded in different habitat types.

Age of bear signs

During the transect study, bear signs observed were of different age groups (Fig. 8). Many of them were very fresh (36.7%) as compared to fresh signs (25.6%) and old signs (23.5%). Very old bear signs were only (14.2%).
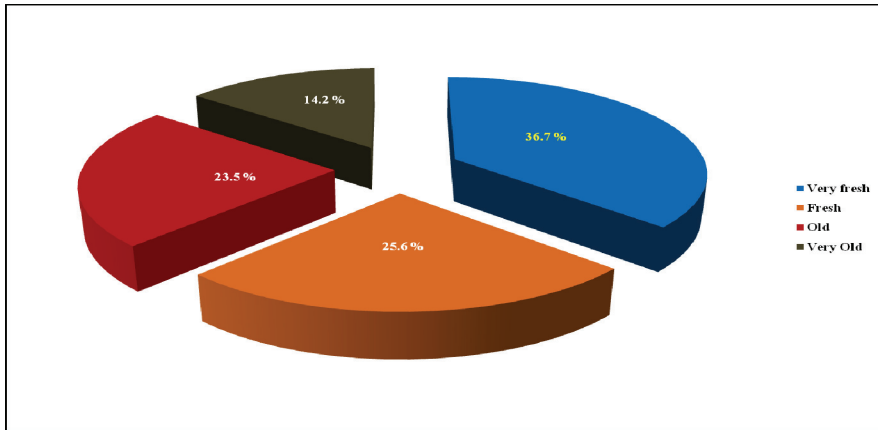

Fig. 8. Age categories of bear signs observed along transects in Namdapha Tiger Reserve.

Bear signs and reasons

Sun bear signs recorded along the transects included claw marks on trees for fruit consumption, claw marks for unknown uses, tree-tear for beehives, tree-tear for termites, log-tear for insects in addition to nests, scats, diggings, dens and footprints (Fig. 9).The percentage of claw marks was highest (59.1%). Sun bear left different types of claw marks on trees for different proposes. They climbed trees to eat fruits and left claw marks on them, they were 35.6%. Similarly, they left claw marks and tree tear for feeding on beehives (9.2%), tree tear for feeding on termites (7.7%), log tear for feeding insects (1.3%) and claw marks on trees for unknown reason (5.3%).
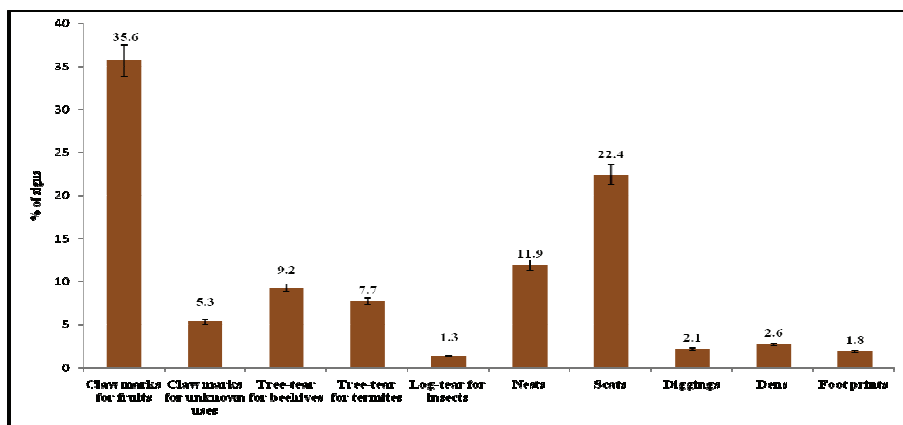

Fig. 9. Type of bear signs and their percentage recorded along transects in Namdapha Tiger Reserve.

Other signs recorded in the study areas were scats (22.4%), nests (11.9%), dens (2.6%), diggings (2.1%) and footprints (1.8%) during the study period (Figs. 10 and 11). Claw marks were found on trees were 12.4-86cm in diameter at breast height (DBH). The mean DBH was calculated 39cm (SD = 16.5), and the mean height of trees was 26m (SD = 11.3).
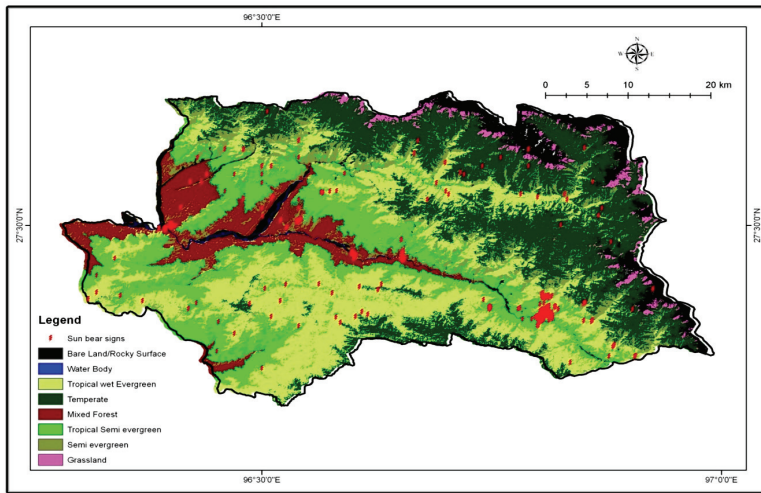

Fig. 10. Signs distribution of sun bear recorded in Namdapha Tiger Reserve.
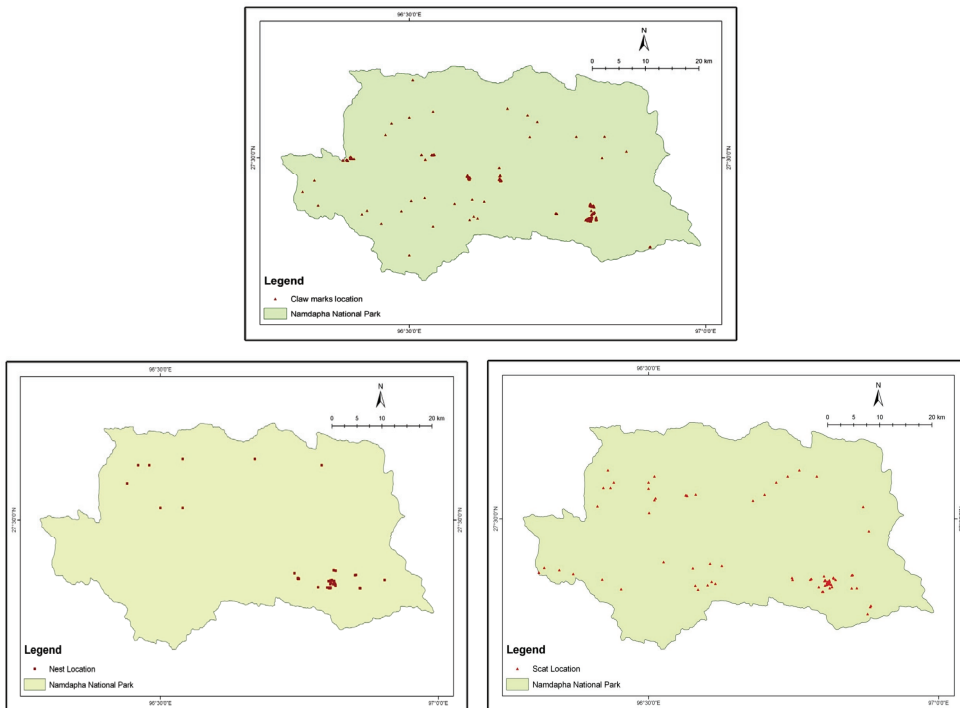

Fig. 11. Claw marks distribution (a), nests distribution (b) and scats distribution (c) of sun bear observed in Namdapha Tiger Reserve during 2008 to 2010.

Season wise occurrence of bear signs

All these bear signs were recorded in summer, monsoon and winter months. The percentage occurrence of bear signs was highest in winter (43.8%), followed by monsoon (32.7%) and summer (23.5%) season (Fig. 12). Similarly the mean signs were highest during the winter months (41.5±5.80), followed by monsoon months (31.0±6.25) and summer (22.25±3.83) months during the study period.
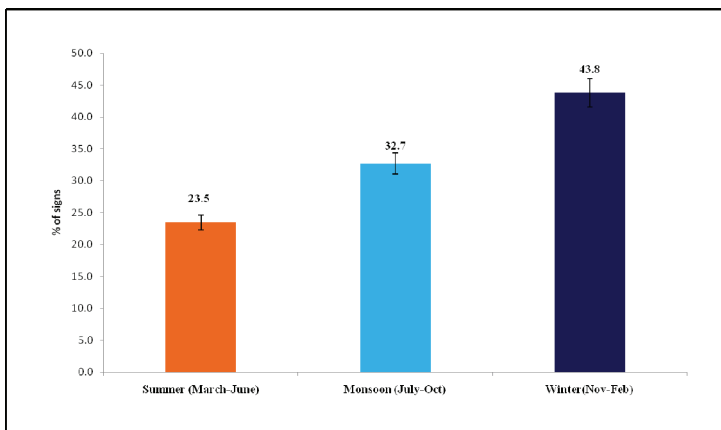

Fig. 12. Percentage of signs in different seasons in Namdapha Tiger Reserve.

Seasonal occurrence of signs in forest types

As mentioned above, distribution of sun bear signs showed seasonal variation in different forest types in Namdapha Tiger Reserve (Fig. 13). During winter season, sun bear signs were highest in Tropical wet-ever green forest (17.2%), followed by Tropical semi-ever green forest (15.6%), Semi-ever green forest (11.3%), Mix forest (7.1%), Temperate forest (3.7%) and Bamboo forest (1.3%). In summer season, bear signs were highest in Temperate forest (6.3%), followed by Tropical semi-ever green forest (6.1%), Tropical wet-ever green forest (5.5%), Semi-ever green forest (5.0%), Mix forest (4.5%) and Bamboo forest (0.8%).Whereas in monsoon season, sun bear signs were highest in Tropical semi-ever green forest (4.2%), followed by Tropical wet-ever green forest (3.4%), Mix forest (2.9%), Semi-ever green forest (2.6%), Temperate forest (1.6%) and Bamboo forest (0.8%).

Occurrence of signs along elevations

The occurrence of bears signs also varied along transects laid along different altitudinal gradients (Fig. 14). The percentage of bear signs was highest at an elevation of 1001 - 1500msl (50.9%), followed by 501 - 1000msl (26.4%) and 0 - 500msl (20.1%). The percentage of bear signs was lowest at an elevation of 1500 and above (2.6%). There was distinct relationship between the season, elevation and density of bear signs per unit area (R^2 Linear = 0.81488). The density of bear signs showed an increasing trend with the increasing elevation in the Tiger Reserve (Fig. 15). But from 1500msl or above, the density of bear signs decreased drastically.

Distribution based on camera trapping

By using 30 camera traps (20 Digital and 10 infrared Deer cam), distribution of sun bear was found out in Namdapha Tiger Reserve. Initial two surveys were conducted in diverse habitats in Deban and Namdapha ranges from August 2008 to January 2009. Later three sites were selected in the Gandhigram range based on surveys conducted from August 2009 to November 2010.

Based on camera trapping efforts, the animal capture in 560 days/nights was highest (n = 32) in Gandhigram range as compared to capture in 100 days/nights in Deban range (n = 7), and capture in 76 trap days/nights in Namdapha range (n = 4) (Table 3). Out of total 32 animal

captures, only three sun bear captures were from within Gandhigram range. There were no sun bear capture in other two ranges because of high human interference and disturbance due to road network.
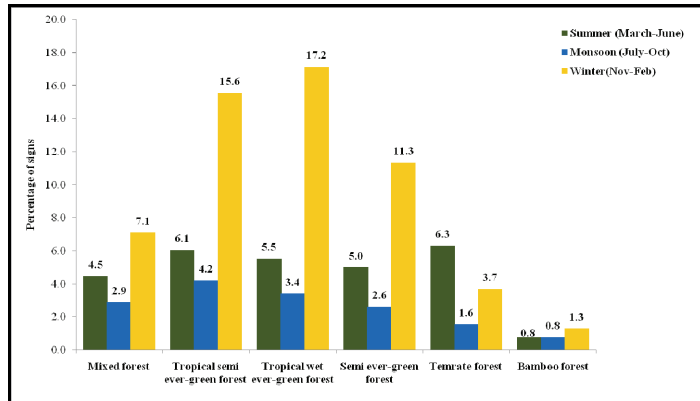

Fig. 13. Seasonal variation in sign distribution in different forest types in Namdapha Tiger Reserve.
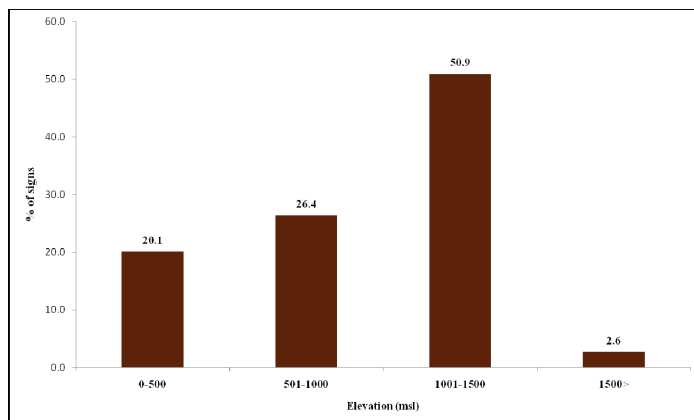

Fig. 14. Percentage of signs along transect in different elevations in Namdapha Tiger Reserve.
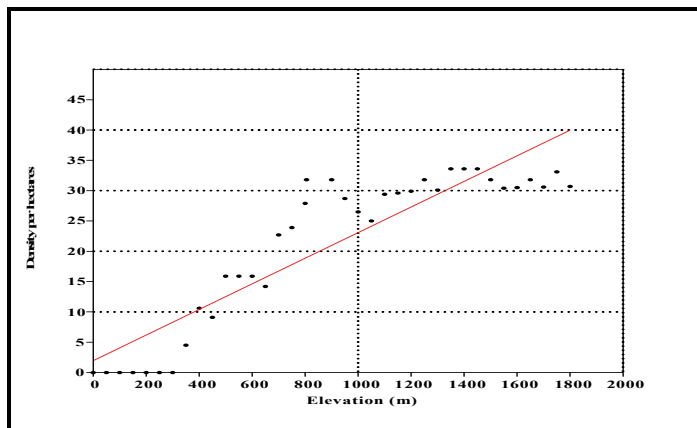

Fig. 15. Relationship between mean elevation and the density of signs per hectare (R^2 Linear = 0.81488).

Table 6. Camera-trapping efforts in different ranges at Namdapha Tiger Reserve.

Range	Elevation (msl)	Survey period	No. of camera stations	Trap days and nights	Total photos	Animal Photos	Bear Photos
Gandhigram	500-1500	12[th]Aug. 2009 to 20th Nov. 20 10	125	560	380	32	3
Deban	300-790	23rd Aug. 2008 to 9th Jan.2009	25	100	120	7	0
Namdapha	300-700	23rd Aug.2008 to 9th Jan. 2009	25	50	76	4	0
Total			175	710	576	43	3

Discussions

Very little information is available on the status and distribution of Malayan sun bear (*Helarctos malayanus*), the least known bear species in north-eastern states of India. The historic distribution of sun bear in India was in the tropical rainforest habitats of Manipur and Assam states south of the Brahmaputra river [1] although there were reports of its occurrence in the North-Eastern hilly region during the 1960s and 1970s. C. Servheen [2] reported that sun bear no longer exists in Arunachal Pradesh, Manipur, Mizoram, Nagaland and Assam.

In 2006, the WCS/IUCN-BSG Range Wide Assessment of Asian Bears Workshop used expert opinion to map the extant range of sun bear throughout Southeast Asia. In changing environment, population distribution of animal species is essentially required not only to know the trend but also to effectively manage decline or increasing problematic species populations. Since human-black bear and sun bear conflicts are on the little bit rise in Namdapha Tiger Reserve, hence it requires to know the population abundance of bears and their distribution so that future course of action to deal with the conflicts can be developed.

The questionnaire surveys conducted in 18 fringe villages, namely, Gandhigram, Vijoy Nagar, Sidhikhu, 52 Mile, 56 Mile, 77 Mile, Ram Nagar, Hazulu, 40 Mile, 38 Mile, Upper 38 Mile, Deban, Lama Camp, Chhemile, Tera Mile, Tuhat, Phaparbari and Miltary camp during 2008 to 2010 showed distribution of sun bear in forest areas in the vicinity of these villages except Chhemile and Tera Mile. In total, 785 respondents were interviewed in different villages located in and around Namdapha Tiger Reserve. Out of these respondents, 265 respondents confirmed the presence of sun bear based on direct sightings and indirect evidences in the forest areas adjacent to their villages.

Highest number of respondents confirming the presence of sun bear was from Gandhigram, followed by Vijoynagar, 52 Mile, 77 Mile, Sidikha, 38 Mile, Hazulu and so on. Amongst these villages, the status of sun bear occurrence was low in three villages and medium in five villages. In Chhemile village and Tera Mile, there were no reports of sun bear occurrence although most of the respondents reported that they used to ramble around in these areas long time back.

According to the respondents, sun bear were reported to use different forest types in Namdapha Tiger Reserve. The respondents observed them maximum times in the Tropical wet-ever green forest, followed by Semi-ever green forest, Mix forest, Tropical semi-ever green forest and Bamboo forest. Number of sightings of sun bear was high in the Tropical wet-ever green forest and Semi-ever green forest because there was plenty of food available in these areas and low disturbance**.**

In Namdapha Tiger Reserve, sun bear were reported to be active during morning, evening, noon and night time. According to respondents, sun bear were most active during the

day time. Sun bear were observed 47 times in the morning hours, 48 times in the evening and 86 times in the noon. They were reported to be the least active during night time, the respondents observed sun bear only 7 times in the night.

In general, activity patterns of animals are considered an adaptation to seasonal and diurnal variation in environmental factors [38, 39]. Nielsen [40], stated that the daily activity pattern of animal result from a complex compromise between optimal foraging time, social activities, and environmental constraints. In a study, movements and activity patterns of female sun bears in East Kalimantan, Indonesian Borneo was reported to have implications for conservation. Male sun bear exhibited a definite diurnal pattern of activity [41].

Sun bear were primarily diurnal animals. Sun bear were distinctly more active during daylight hours than at night (a-z-animals.com/animals/sun-bear/). They spent the daytime foraging for food and resting high in their tree-top nests at night. They tended to become active about 0.5h before sunrise and ceased activity about 2.5h after sunset. Peaks of activity generally occurred during 0700-0900h and 1600-1800h, with diminished activity during 1000-1400h. In those areas that were increasingly affected by growing levels of human activity, sun bear were known to adopt a more nocturnal way of life to avoid confrontation (a-z-animals.com/animals/sun-bear/). The human-habituated individuals were found to be frequently slept for brief periods during the hottest time of day on fallen log or on the forest floor. When these bears were cubs (< 1 year), they spent large parts of the day resting alone in trees [42].

Daily activity rhythms and time budgets in bears have been related to seasonal changes in sunrise and sunset, weather conditions, food type and abundance, human disturbance, presence of other bear species and the sex, age and family associations of bears [43-55]. During the survey period, transects were laid in Tropical wet-ever green forest, Temperate forest, Semi ever green forest, Tropical semi ever-green forest, Bare land and Bamboo forest in Namdapha, Deban and Gandhinagar ranges. Through intensive surveys, transect study and by talking to villagers, the availability of forest types, location of sun bear nesting and occurrence of active and inactive den sites were found out.

The availability of forest types varied in different parts of Namdapha Tiger Reserve. The area of Tropical wet-ever green forest was highest, followed by Temperate forest, Semi ever-green forest, Tropical semi-ever green forest, Mix forest, Bare land, Bamboo forest and Water body. Similarly, the percentage availability of Tropical wet-ever green was highest, followed by Temperate forest, Semi ever-green forest, Tropical semi-ever green forest, Mix forest, Bare land, Bamboo forest and Water body. They were more or less evenly distributed in the whole area. In the Tiger Reserve, 1.256 to 3.768ha of area was covered under the Tropical semi-ever green forest, Tropical wet-ever green forest, Semi-ever green forest, Mix forest, Temperate and Bamboo forest. All these land cover and land use categories fell into 500 to 4000m range and flat to undulation terrain facing different directions.

In reality, most organisms, mammals in particular, found to have natural irregular distributions due to differences in forage distribution and habitats or effects from population pressures (e.g. density dependence), competition, predation, or climate [56, 57]. Results were consistent with this supposition and demonstrated that the distribution of sun bear habitat use between undisturbed forest areas is patchy.

In Namdapha Tiger Reserve, 379 different bear signs were identified along 43 transects. Number of claw marks was found to be highest as compared to number of scats, nests, diggings, dens and footprints. Distribution of sun bear was found to quite widespread in Gandhigram range as compared to Namdapha and Deban ranges. In Gandhigram range, number of claw marks was highest as compared to number of scats, nests, diggings and footprints and dens each.

Occurrence of scratch marks on trees confirmed the presence of sun bear in different parts of the Tiger Reserve. But as such low numbers of sun bear in the reserve could be due to natural population gradient which decreased into the northern parts of their range. Sun bear are more vulnerable to poachers as they venture closer to villages than black bear, and exhibit bolder behaviour towards humans. Poachers may also favour sun bear as their bile has a higher market value. Bear population in the Tiger Reserve is threatened by habitat disturbance (shifting cultivation, livestock grazing, logging, collection of NTFP and other illegal forest activities). However, hunting for the international wildlife trade poses an even bigger threat.

All these bear signs were observed in summer, monsoon and winter months in different forest types in Namdapha Tiger Reserve. The percentage occurrence of bear signs was highest in winter (43.8%), followed by monsoon (32.7%) and summer (23.5%) season. But the mean signs were highest during the winter months (41.5±5.80), followed by monsoon months (31.0±6.25) and summer months (22.25±3.83) during the study period. This seasonal variation could be related to fruiting of trees and availability of fruit biomass during winter season than other season.

During winter season, sun bear signs were highest in Tropical wet-ever green forest (17.2%), followed by Tropical semi-ever green forest (15.6%), Semi-ever green forest (11.3%), Mix forest (7.1%), Temperate forest (3.7%) and Bamboo forest (1.3%), In summer season, bear signs were highest in Temperate forest (6.3%), followed by Tropical semi-ever green forest (6.1%), Tropical wet-ever green forest (5.5%), Semi-ever green forest (5.0%), Mix forest (4.5%) and Bamboo forest (0.8%).Whereas in monsoon season, sun bear signs were highest in Tropical semi-ever green forest (4.2%), followed by Tropical wet-ever green forest (3.4%), Mix forest (2.9%), Semi-ever green forest (2.6%), Temperate forest (1.6%) and Bamboo forest (0.8%). This variation in bear signs was mainly due to availability food resources in different forest types during winter, monsoon and summer month.

The percentage of bears signs also varied along the transects laid along different altitudinal gradients. The percentage of bear signs was highest at an elevation of 1001-1500msl (50.9%), followed by 501-1000msl (26.4%) and 0-500msl (20.1%). The percentage of bear signs was lowest at an elevation of 1500 and above (2.6%). There was distinct relationship between season, elevation and density of bear signs per unit area (R^2 Linear = 0.81488). The density of bear signs showed an increasing trend with the increasing elevation in the tiger reserve. But from, 1500msl or above, the density of bear signs decreased drastically. Altitudinal variation in occurrence of sun bear might be and to habitat presence shelter, availability of food resources, and disturbance factor.

By using camera traps, distribution of sun bear was conducted at Namdapha Tiger Reserve from August 2008 to November 2010. Based on camera trapping efforts, the animal capture in 560 days/nights was highest in Gandhigram range as compared to capture in 100 days/nights in Deban range, and capture in 76 trap days/nights in Namdapha range. Out of total 32 animal captures, only three sun bear captured from Gandhigram range. There were no sun bear capture in other two ranges because of high human interference and disturbance due to road network. Though sun bear were captured in camera traps in Gandhigram range, not in Deban and Namdapha ranges, there were more chances of their movement pattern which could not enable photo capture in camera traps in later two ranges.

Bears have patchy distributions, often with concentrated seasonal or annual activities in specific locations, that can change in their life-time [58-60]. For sun bear in undisturbed areas, patchy distribution is associated with microhabitat traits, such as tree stand structure, diversity, and maturity level, dead biomass or elevation gradient. Such habitat features will concentrate termite colonies, ant colonies, and beehives, optimize fruit productivity, or will provide suitable ground cover, canopy cover, security, and topography.

In a fragmented landscape, the capacity of bears to access resources and suitable habitats might be limited or blocked beyond the borders of a truly isolated 'Island' patch surrounded by disturbance, inhospitable terrain, or intensive human activity [61] .

Conclusion

The Malayan sun bear Helarctos malayanus, categorized globally as a Critically Endangered on the IUCN Red List. However, recent studies have indicated that sun bear have disappeared from large areas, probably as a result of habitat loss, a low prey base and poaching, indicating this species may not be as common in India as previously believed. Our findings indicate that the species has declined dramatically, with confirmation of presence at only some sites in provinces, despite extensive surveys. Current populations are small and fragmented, and occur mainly in tiger reserve.

It could be concluded from these analyses that the sun bear use of disturbed and non forested areas, young secondary forests, edges, agricultural areas, clear-cuts, and so forth by sun bears was insignificant relative to the overall population and landscape use. At a landscape scale, habitat loss will obviously produce clumped distribution of bears between suitable and unsuitable areas. Essentially, sun bear distributions in this area were too patchy and fragmented across the landscape matrix.

This study marked the first of its kind in this country and provided valuable and encouraging information on the distribution of sun bears in Namdapha Tiger Reserve.

Our findings are the first reliable estimates of the current distribution and status of the Malayan sun bear in India, and provide valuable information that will help guide conservation efforts.

Namdapha Tiger Reserve (NTR) has a rich faunal diversity and has been harboring a number of endangered and threatened species. However, due to continuous degradation of forest land, expansion of agriculture land, illegal hunting and increasing in population in nearby areas has resulted in decline of a number of species in the reserve. Considering the benefits and limitations, nonviable techniques such as camera-trapping can provide a reliable and standardized means to document the presence of sun bear specie in the reserve. Well-designed monitoring programs along with regular patrolling from forest officials and local information can help to estimate precise information on abundance of sun bear and their distribution in the reserve.

Acknowledgements

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