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Dietary preference of Malayan sun bear *Helarctos malayanus* in Namdapha Tiger Reserve, Arunachal Pradesh, India

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We characterized the dietary pattern of Malayan sun bear *Helarctos malayanus* from three seasons in Namdapha tiger reserve, Arunachal Pradesh, India. Eighty five scat samples were collected between August 2008 and November 2010. Scats were analysed both qualitatively and quantitatively to determine the food composition of sun bear in the region. The contents were manually separated and examined. Cumulative frequency was used to determine the contribution of food items in the diet of sun bear. Malayan sun bear was observed to feed on a wide variety of food items. Coleoptera were the most frequently occurring food item in their diet. Sun bear consumed 10 plant species. The items/species area curve was developed to find the minimum number of scats required to study the dietary composition. Food of animal origin comprised of the class Arachnida, Insecta, Mammalia and Osteichtyes. Sun bear were also found to feed on 15 families of insects that were mainly from the order Coleoptera, Hymenoptera and Isoptera. Among 15 families, 14 insects were identified as regular food items of sun bear in the study area. Presence of rodents and scorpions in food of sun bear was also recorded. Among these, 8 families of beetles (Coleoptera), one family of stingless bee (Apidae), one family of ants (Formicidae) and one wasp (Vespidae) could be identified.

The Malayan sun bear *Helarctos malayanus* is one of the least known bear species in the world. Even basic biology such as food habits, activity and ranging pattern and reproductive biology are unknown. It is listed as an Appendix I species by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (<https://cites.org/eng/gallery/species/mammal/sun_bear.html>) as the species is in danger of extinction which is or may be affected by international trade. Sun bear is also among the Schedule 1 species in the Indian Wildlife Protection Act, 1972 and "Vulnerable" in IUCN, Red list of Threatened Species, 2015.

Food utilization is an important aspect in the study of carnivore ecology, since trophic resources dominate several aspects of their biology (MacDonald 1983, Bekoff et al. 1984). Food environments vary both temporally and spatially with variations in local vegetation. The survival of bears and their physiological activities are governed by the availability of food items and dietary components in their habitat. Most bears are opportunistic omnivores and their diet varies from fruits, other vegetative material, insects, fishes, small birds, reptiles and mammals (Kanchanasakha et al. 1998, Lim 1998, Yasuma and Andau 2000). Information on composition and seasonal variation in bear diets can be studied either by making direct observations on feeding activities and signs in the areas or indirectly through scat analysis. Dietary composition through analysis of scats had been widely studied both qualitatively and quantitatively in different bear species. In a few studies on black bear, both scats and stomach contents were used and in many other studies, only scats were used to study the feeding ecology of bears (McLellan and Hovey 1995, MacHutchon and Wellwood 2003, Kobayashi et al. 2012, Minamiyama et al. 2006, Xu et al. 2006). Food habits of Malayan sun bear are poorly documented, but relatively few studies had briefly described the general dietary pattern (Nowak 1991, Servheen 1993, MacKinnon et al.1996, Kanchanasakha et al.1998, Lim 1998, Yasuma and Andau 2000, Fredriksson 2007, Wong et al. 2002).

In most bear species including Asiatic black bear, sloth bear, American black bear, grizzly bear and brown bear, it has been found that in addition to the animal matter, plant matter constituted major parts of diet (Cicnjak et al. 1987, Schaller 1969, Landers et al. 1979, Nozaki et al. 1983, Maehr and Brady 1982, Mace and Jonkel 1986, Ohdachi and Aoi 1987, Manjrekar 1989). All species of bears, except polar bear *Ursus maritimus*, were found to feed on insects, especially ants.

Owing to the paucity of information on sun bear and its food habits in the region the study was undertaken with an aim to determine the dietary pattern and composition of food of sun bear found in the Eastern Himalayan belt of Arunachal Pradesh, India.

Material and methods

Study site

The Eastern Himalayas and the hills of north-east India are recognized as a global biodiversity hotspot. While this northeast 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 northeast India, covering 83 743 km^2) is the state of Arunachal Pradesh (26°28′–29°30′N and 91°30′–97°30′E). Arunachal is considered among the least developed and most remote state. Lying in the Eastern Himalayan region, Arunachal Pradesh has remained isolated from the rest of India by virtue of its geographical position and inaccessible terrain. It is situated in the north eastern most part of India and is surrounded by international boundaries of Bhutan to the west, Tibet to the north and Myanmar to the east. About 82% of the geographical area is actually forested compared to the national average of 21%, albeit the recorded forest area is 62% of the total area reported (Anonymous 2009).

The study was undertaken in Namdapha Tiger Reserve (27°29′00″N and 96°23′00″E) situated in the Changlang district of Arunachal Pradesh in the eastern belt of Himalayas also recognized as a global biodiversity hotspot. The total area of the reserve is 1985.25 km^2 (1807.82 km^2 core and 177.43 km^2 reserve forest area as buffer), delineated on the north south and south east by the international boundary between Myanmar and China (Fig. 1). The habitat changes with increasing altitude from tropical moist forests to montane forests, temperate forests and at the higher elevations, to Alpine meadows and perennial snow.

Sampling and data collection

Firstly, we differentiate the sun bear and black bear scat through present of different signs near the scats, such as claw marks, foot prints, bite marks and tree nest and also where we found sun bear tracks. At such feeding sites, we also collected uneaten food items for identification. Malayan sun bears are well known for their arboreal behavior. They climb trees in order to harvest ripe fruit and bee nests, to seek shelter, and to escape danger (Payne et al. 1985, Lim 1998, Yasuma and Andau 2000). Malayan sun bear is basically omnivores. The scat is semi solid to solid and cylindrical in consistency. Scat size is usually bigger in winter due to more incorporation of fruits in their diet. Through observation of sun bear and analyses of scat samples, it was understood that the invertebrates made up an imperative extent of the bears' diet during summers, and sun bears were observed tearing open decayed wood in search of termites as remains of beetles were most commonly found in scat. The scat size normally varies between 1.4 to 1.8 inches in diameter and 5 to 6 inches in length and are cylindrical in shape (Supplementary material Appendix 1 Plate 1–4). The consistency and odour (usually insect and termite kill kind) made us easy to distinguish sun bear scats as they are distinctly different from other carnivore or primate scats. In case of Asiatic black bear, droppings are generally largest with heap/pile, the size is 2.6 to 3 inches in diameter (Supplementary material Appendix 1 Plate 5–6). In case of sun bears, occasionally, clusters of seedlings are encountered that have sprouted from a bear scat deposited during a fruiting season. Seedlings from these scats can be identified and they provide information on the species of fruits that the bears feed on in the survey area.

The food habits of Malayan sun bear were determined by analysing scat samples collected between August 2008 and November 2010. Dietary composition and seasonal

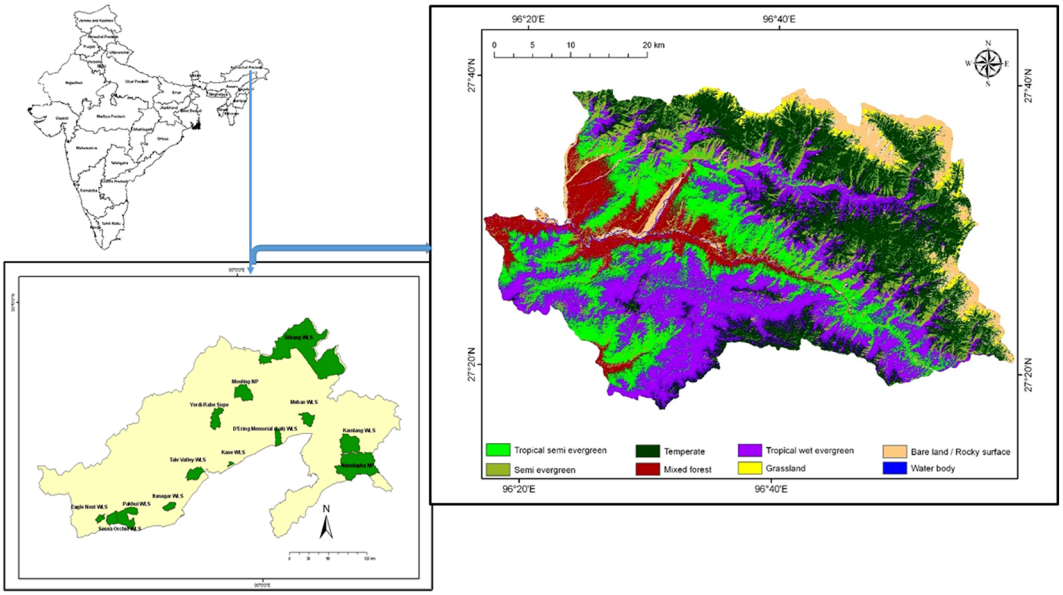

Figure 1. Map showing the Namdapha Tiger Reserve.

variation were studied in terms of frequency occurrence of food items in the scats, and percent dry weight of each of the items. Variation in dietary composition in different seasons viz. summer (March–June), monsoon (July–October) and winter (November–February) was also estimated.

During the sampling period, scats were collected from different parts of Namdapha Tiger Reserve (Fig. 2). Though a completely systematic collection technique was not feasible in the mountainous and rugged terrain, bear scat samples were collected during sign surveys of sun bear along the transects (n = 43) as well as opportunistically. Scat collection was easy during November (n = 45) because of a lack of rain fall and a lack of leaf litter, but somewhat less efficient during September and December. Scat collection was least successful during other months due to heavy rainfall that dissolves scats in the frequent heavy rain, and other complications like dung beetle activity. Scat samples were collected in plastic bags and weighed wet. They were later air-dried either in trays or on newspaper in the sun and stored.

Dietary content and food composition

Firstly, we calculated the minimum number of scats required for the analysis which could provide significant results. On the basis of number of food items and scats, items/species area curve was plotted to find the minimum number of scats required. An observation area curve for the percent frequency of occurrence of major food items represented in the diet was calculated at an interval of every five scats (Mukherjee et al. 1994, Edgaonkar and Chellam 2002). Scats were analysed both qualitatively and quantitatively. In the laboratory, scats were oven dried for 24 h at 70°C and reweighed. Dried scats were then soaked in water for 1–3 h, washed thoroughly in 0.7 and 0.3 mm mesh sieves, and dried again. The contents were manually separated and examined. Dried materials from scat samples were sorted by using either hand lens or a binocular dissecting scope (2×~8×). Whenever insect parts (particularly termites and beetles) were observed, their body parts were sorted by using a hand lens. Other items such as hairs in the scats were collected with sterilised tweezers and stored for analysis in clean envelopes. Envelopes with hairs were then stored inside plastic bags with silica beads.

Taxonomic classes of organisms (e.g. termites, ants, beetles) were sorted and grouped for further identification. Many scats were contaminated with items such as live ants, live dung beetles, dead leaves and twigs (sometimes attached to scats when collected from the forest floor). These materials were removed from the scat samples during analysis. Other items such as bear hairs were not included in the analysis.

Frequency of occurrence was defined as the total number of times a specific food item appeared in a scat sample. Percent frequency of occurrence was calculated as the total number of times a specific food item appeared in hundred scats of the samples divided by total number of scats collected. Analyses were focussed on patterns of sun bear resource use relative to biogeography, general habitat, disturbance, and interactive variables. χ^2-tests were used to determine any seasonal variation in the dietary composition.

Results

Based on feeding signs, scat analysis and indirect signs, the dietary composition of sun bears and seasonal difference in their food habits was studied in Namdapha Tiger Reserve. Eighty five scats were collected from August 2008 to November 2010 during the field survey. The average scat weight was 329 g, the scat weight ranged from 73 to 1119 g (1.81 ± 2.28).

The items/species area curve was developed to find the minimum number of scats required to study the dietary composition (Fig. 3). The analysis of total 85 scats revealed that the curve flattened out for most of the food items as well as other food items to greater extent, and all the food items were represented within 40 scats. The scats collected during summer (n = 28), monsoon (n = 15) and rainfall (n = 42)

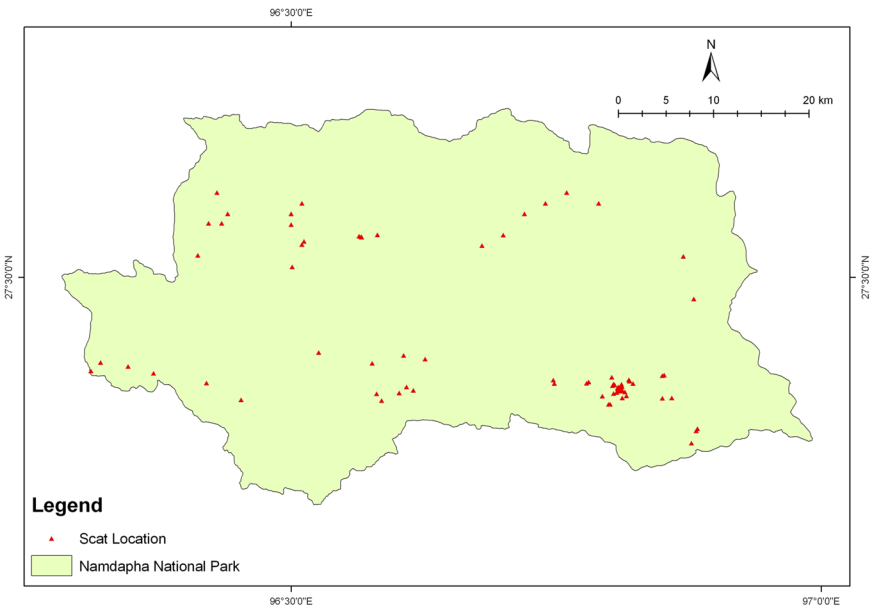

Figure 2. Scats collection of sun bears in Namdapha Tiger Reserve.

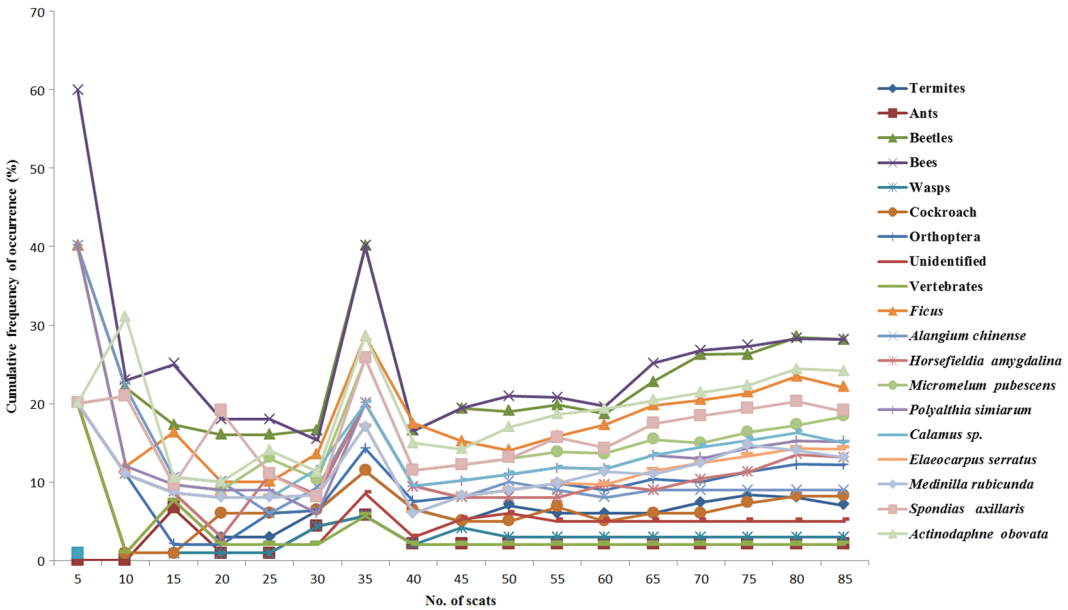

Figure 3. Observation of area curve to determine the adequacy of sample size of scats for quantifying frequency of food items (n = 85).

were analysed, and the proportion of food items and inseparable mixture was calculated.

Dietary pattern and food composition

Food items in scats

Analysis of 85 scats of sun bear showed presence of animal food items belonging to different classes, orders and families (Table 1). Food of animal origin comprised of Arachnida, Insecta, Mammalia and Osteichtyes classes. Insects consumed by sun bear were mainly from order Coleoptera, Hymenoptera and Isoptera. Presence of rodents and scorpions in food of sun bear was also recorded. There were some unidentified items in the scats. Invertebrates and vertebrates were 43.7% and 1.5% respectively in the scats of sun bear. Beetles and termites were the most common food items in the scats. Beetles constituted 13.7% and termites 10.2%. Among other animal matter, ants were 6.1%, cockroach 4.1%, wasps 3.6%, orthoptera 3.0% and bees were 2.5%. The unidentified food items were 0.5% in the scats of sun bear.

There were 15 families of insects: Carabidae, Chelonariidae, Chrysomelidae, Dytiscidae, Histeridae, Passalidae,

Table 1. List of animal food items of sun bears in Namdapha Tiger Reserve.

Class	Order	Family	Species
Arachnida	Scorpionida		
Insecta	Coleoptera	Carabidae	
Insecta	Coleoptera	Chelonariidae	
Insecta	Coleoptera	Chrysomelidae	
Insecta	Coleoptera	Dytiscidae	
Insecta	Coleoptera	Histeridae	
Insecta	Coleoptera	Passalidae	*Aceraius* spp.
Insecta	Coleoptera	Scarabaeidae	*Chalcosoma* spp.
Insecta	Coleoptera	Tenebrionidae	
Insecta	Dictyoptera	Blattidae	*Panesthia* spp.
Insecta	Hymenoptera	Apidae	*Trigona collina*
Insecta	Hymenoptera	Apidae	*Trigona* sp.
Insecta	Hymenoptera	Apoidea	
Insecta	Hymenoptera	Formicidae	*Camponotus gigas*
Insecta	Hymenoptera	Formicidae	*Camponotus* sp.
Insecta	Hymenoptera	Formicidae	*Gnamptogenys menadensis*
Insecta	Hymenoptera	Vespidae	*Polistine* spp.
Insecta	Isoptera	Termitidae	*Globitermes globosus*
Insecta	Isoptera	Termitidae	*Hypotermes xenotermitis*
Insecta	Isoptera	Termitidae	*Macrotermes*
Insecta	Isoptera	Termitidae	*Odontotermes* sp.
Insecta	Isoptera	Termitidae	*Bulbitermes* sp.
Insecta	Orthoptera	Gryllotalpidae	
Insecta	Orthoptera		
Mammalia	Rodentia		
Osteichtyes	Cyprinidae		

Table 2. List of plant food items found in the of sun bears in Namdapha Tiger Reserve.

Family	Species
Anacardiaceae	*Spondias axillaris*
Myristicaceae	*Horsefieldia amygdalina*
Moraceae	*Ficus*
Cornaceae	*Alangium chinese*
Annonaceae	*Polyalthia simiarum*
Acoraceae	*Acorus calamus*
Elaeocarpaceae	*Elaeocarpus serratus*
Melastomataceae	*Medinilla rubicunda*
Lauraceae	*Actinodaphne obovata*
Rutaceae	*Micromelum pubescens*

Scarabaeidae, Tenebrionidae, Blattidae, Apidae, Apoidae, Formicidae, Vespidae, Termitidae and Gryllotalpidae used by sun bear in their diet. Among these, eight families of beetles (Coleoptera), one family of stingless bee (Apidae), one family of ants (Formicidae) and one wasp (Vespidae) could be identified. Other three animal food items, belonging to order Scorpionidae, Rodentia and Cyprinidae, found in the sun bear scats could not be identified at the family level. Among 15 families, 14 insects were identified as regular food items of sun bear. They were *Aceraius* sp., *Chalcosoma* sp., *Panesthia* sp., *Trigonacollina*, *Trigona* sp., *Camponotus gigas*, *Camponotus* sp., *Gnamptogeny smenadensis*, *Polistine* sp., *Globitermes globosus*, *Hypotermes xenotermitis*, *Macrotermes* sp., *Odontotermes* sp. and *Bulbitermes* sp. found in sun bear scats (Table 1).

Although plants from 15 different families were evident (indirect evidence such as claw marks) to be used by sun bear (Table 2), analysis of sun bear's scat samples collected during the study period revealed the presence of plants items in form of seeds, twigs, and leaves remains of plant species belonging to 10 different species namely *Spondias axillaris*, *Horsefieldia amygdalina*, *Ficus* sp., *Alangium chinense*, *Polyalthia simiarum*, *Acorus calamus*, *Elaeocarpus serrata*, *Medinillaru bicunda*, *Actinodaphne obovata* and *Micromelum pubescens*.

Dietary composition

Over all seasons combined, sun bears were found to be omnivorous, consuming both animal and plant items. An analysis of the total of 85 scats collected over all seasons showed both plant and animal matter in the diet of sun bears. When only plant and animal matter were considered to separate their contribution to the annual diet, it was found that the frequency of occurrence of plant matter was higher (54.8%) than the animal matter (45.2%) in the scats of sun bear (Fig. 4).

Turning now to the diet in different seasons, the frequency occurrence of animal matter was highest in summer (53.2%), followed by 49.5% in fall and 32.2% in monsoon (Fig. 5). The frequency occurrence of plant matter was found highest in the scats in monsoon (67.8%), followed by fall (50.5%) and summer (46.8%). Similarly, the percent composition of animal matter in scats of sun bear was highest in summer (42.9%), followed by 40.5% in fall and 40.0% in monsoon (Fig. 6). The annual percent composition of animal matter was 38.8%. The percent composition of plant matter was highest in monsoon season (60.0%), followed by 59.5% in fall and 57.1% in summer. The annual percent composition of plant matter was 49.4%.

Amongst the overall annual frequency occurrence, there were 9 animal food items and 10 plant species in different seasons. The annual frequency occurrence of animal items was 45.2% and plant matter was 54.8% (Table 3). The annual frequency occurrence of beetles was highest (13.7%), followed by termites (10.2%), ants (6.1%), cockroaches (4.1%) and wasps (3.6%).

The animal matter was comprised of beetles, termites, ants, cockroaches, wasps, orthoptera and bees, and unknown items including hairs and bones in the bear diet (Table 3). The plant matter identified in scat of sun bear comprised of 10 plant species: seven species during the summer season, eight during the monsoon and nine plant species during the fall season.

During summer, the frequency occurrence of beetles was highest (19.1%), followed by termites (10.6%), ants (6.4%), and cockroaches, orthoptera and wasps constituted 4.3% each. Similarly, the frequency occurrence of beetles was highest (13.7%) during monsoon. Whereas the frequency occurrence of termites and ants was 5.1% each, cockroaches were 3.4% and bees, orthoptera and vertebrates was 1.7% each in this season. In contrast, the frequency occurrence of termites was highest (13.2%) during fall, followed by beetles (12.1%), ants (6.6%), wasps (5.5%) and cockroaches (4.4%).

During summer, the frequency occurrence of *Ficus* sp. was highest (14.9%), followed by *Horsefieldia amygdalina*

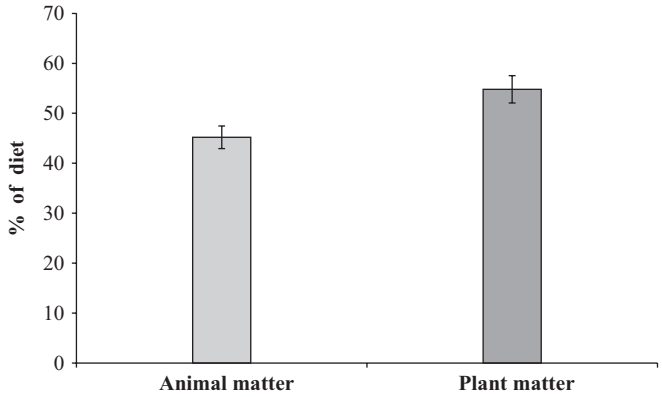

Figure 4. Percentage of animal and plant matters diet in the scats of sun bear in Namdapha Tiger Reserve.

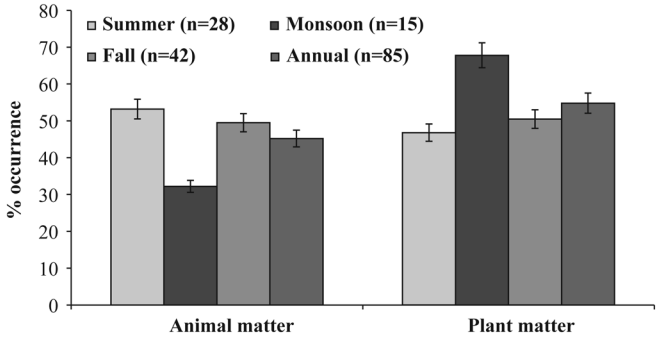

Figure 5. Frequency occurrence of animal and plant matter in the scat of sun bears in the tiger reserve.

(10.6%), *Alangium chinense* and *Medinillaru bicunda* (6.4% each) and *Calamus* sp. (4.3%) (Table 3). Whereas the frequency of occurrence of *Spondias axillaris* and *Actinodaphneo bovata* were 2.1% each. During summer, *Elaeocarpus serrata, Micrommelum pubescens* and *Polyalthia simiarum* were not found in the scats of sun bear. During monsoon the frequency occurrence of *Ficus* sp. was highest (15.3%), followed by *Elaeocarpus serrata* (13.6%), *Medinillaru bicunda* (10.2%), *Alangium chinense* (8.5%), *Horsefieldia amygdalina* (6.8%), *Calamus* sp. (5.1%) and *Spondias axillaris* (3.4%). The frequency of occurrence of *Micrommelum pubescens, Polyalthia simiarum* and *Actinodaphneo bovata* were 1.7% each. During fall season, the frequency of occurrence of *Ficus* sp. was highest (12.1%), followed by *Calamus* sp. (9.9%), *Polyalthia simiarum* (6.6%), *Alangium chinense* and *Micrommelum pubescens* (5.5% each), *Spondias axillaris* (5.1%), *Horsefieldia amygdalina* and *Elaeocarpus serrata* (2.2% each) and *Actinodaphneo bovata* (1.1%). *Medinillaru bicunda* was not present in the scats in the fall season

The estimated volume of animal and plant matter varied from small to medium or large in different seasons (Table 3). The annual estimated volume bees were large, followed by medium volume of beetles, orthoptera and unidentified food items. The annual estimated volume of termites, ants, wasps and cockroaches were small. Similarly, the estimated volume of bees was large in summer season, followed by medium volume of beetles and orthoptera. The annual estimated volume of termites, ants, wasps and cockroaches was small. During monsoon, the estimated volume of beetles, bees, orthoptera and unidentified food items was medium, whereas the estimated volume of termites, ants, wasps and cockroaches were small. During fall, the estimated volume of beetles and bees was medium, and it was small for rest of the food items.

Percent dry weight

The percent dry weight of plant matter was higher than animal matter in the scats of sun bear, there was distinct variation in animal and plant food items (Table 4). Among animal matter, the percent dry weight of vertebrates was highest (6%), followed by unidentified items (3.4%), bees (2.5%), ants (1.9%), termites and beetles were (1.8% each), orthoptera (1.6%), cockroaches (1%) and wasps (0.6%). The percent dry weight of plant matter was highest in *Micrommelum pubescens* (10.6%), followed by *Alangium chinense* (9.8%), *Spondis axillaris* (9.5%), *Calamus* sp. (9.1%), *Polyalthia simiarum* (8.2%), *Horsefieldia amygdalina* (7.3%), *Medinillaru bicunda* (6.6%), *Actinodaphneo bovata* (6.5%), *Elaeocarpus serrata* (6.3%) and *Ficus* sp. (5.3%). The overall annual percent dry weight of plant matter was higher (78.4%) than the animal matter (21.6%).

During the summer season, the percent dry weight of plant matter was much greater (77.3%) than the animal matter (22.7%) (Table 4). Among the animal matter, the dry weight of vertebrates was highest (6.5%), followed by unidentified items (4.1%), ants (3.7%), bees (2.4%), termites (2%), orthoptera (1.6%), beetles (1.2%), cockroaches (0.8%), and wasps (0.4%). Whereas among plant matters, the dry weight *Micrommelum pubescens* was highest (12.6%), followed by *Spondis axillaris* (12.2%), *Alangium chinense* (10.2%), *Calamus* sp. (9.3%), *Horsefieldia amygdalina* (8.1%) and *Ficus* sp. (6.1%). The dry weight of *Polyalthia simiarum*, *Elaeocarpus serrata* and *Actinodaphneo bovata* was 4.9% each and *Medinillaru bicunda* was 4.1%.

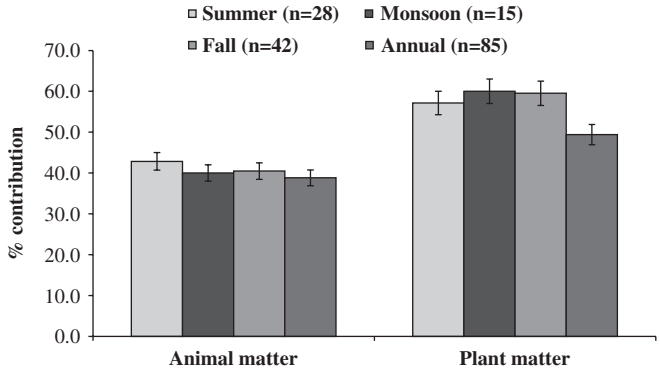

Figure 6. Percent composition of animal and plant matter in the scats of sun bears in different seasons in Namdapha Tiger Reserve.

Table 3. Frequency occurrence and estimated volume of food items in the scats of sun bear in different seasons in Namdapha Tiger Reserve. S=small, L=large, M=medium.

	Summer, n=28			Monsoon, n=15			Fall, n=42			Annual, n=85		
Food item	Occurrence	Frequency of occurrence (%)	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Estimated volume (v)
Termites	5	10.6	S	3	5.1	S	12	13.2	S	20	10.2	S
Ants	3	6.4	S	3	5.1	S	6	6.6	S	12	6.1	S
Beetles	9	19.1	M	7	11.9	M	11	12.1	M	27	13.7	M
Bees	1	2.1	L	1	1.7	M	3	3.3	M	5	2.5	L
Wasps	2	4.3	S	0	0.0	S	5	5.5	S	7	3.6	S
Cockroach	2	4.3	S	2	3.4	S	4	4.4	S	8	4.1	S
Orthoptera	2	4.3	M	1	1.7	M	3	3.3	S	6	3.0	M
Unidentified	0	0.0	–	1	1.7	M	0	0.0	S	1	0.5	M
Vertebrates	1	2.1	M	1	1.7	M	1	1.1	S	3	1.5	M
Ficus	7	14.9	L	9	15.3	L	11	12.1	L	27	13.7	L
Alangium chinense	3	6.4	L	5	8.5	L	5	5.5	L	13	6.6	L
Horsefieldia amygdalina	5	10.6	L	4	6.8	L	2	2.2	L	11	5.6	L
Micromelum pubescens	0	0.0	L	1	1.7	L	5	5.5	L	6	3.0	L
Polyalthia simiarum	0	0.0	L	1	1.7	L	6	6.6	L	7	3.6	L
Calamus sp.	2	4.3	L	3	5.1	L	9	9.9	L	14	7.1	L
Elaeocarpus serratus	0	0.0	L	8	13.6	L	2	2.2	L	10	5.1	L
Medinilla rubicunda	3	6.4	L	6	10.2	L	0	0.0	L	9	4.6	L
Spondias axillaris	1	2.1	L	2	3.4	L	5	5.1	L	8	4.1	L
Actinodaphne obovata	1	2.1	L	1	1.7	L	1	1.1	L	3	1.5	L

Summer: bootstrap sampling using 28 sampling with 28 observations (seed=28).
Monsoon: bootstrap sampling using 15 sampling with 15 observation (seed=15).
Winter: bootstrap sampling using 42 sampling with 42 observation (seed=42).
Annual: bootstrap sampling using 85 sampling with 85 observation (seed=85).

During monsoon, the percent weight of plant mater was more (88.7%) than the animal matter (11.3%). Among the animal matter, the percent dry weight of bees and vertebrates was 2.1% each, followed by beetles, cockroach and orthoptera (1.4% each). The dry weight of termites, ants and wasps was 0.7% each. Whereas among the plant matters, the dry weight of *Micrommelum pubescens* was highest (14.3%), followed by *Actinodaphneo bovata* (11.3%) and *Calamus* sp.

Table 4. Percent dry weight of food items in the scats of sun bear in different seasons in Namdapha Tiger Reserve.

	Summer (n=28)		Monsoon (n=15)		Winter (n=42)		Annual (n =85)	
Food items	% dry weight	± SE	% dry weight	± SE	% dry weight	± SE	% dry weight	± SE
Termites	2.0	0.2	0.7	1.5	2.0	0.2	1.8	0.1
Ants	3.7	0.2	0.7	0.5	1.0	0.2	1.9	0.1
Beetles	1.2	0.3	1.4	0.4	2.4	0.2	1.8	0.1
Bees	2.4	0.2	2.1	0.4	2.7	0.2	2.5	0.1
Wasps	0.4	0.5	0.7	0.4	0.7	0.2	0.6	0.1
Cockroach	0.8	0.3	1.4	0.4	1.0	0.3	1.0	0.1
Orthoptera	1.6	0.3	1.4	0.7	1.7	0.2	1.6	0.1
Unidentified	4.1	1.5	0.7	0.9	4.1	0.5	3.4	0.1
Vertebrates	6.5	0.6	2.1	0.5	7.5	0.3	6.0	0.1
Ficus	6.1	0.5	7.8	0.6	3.4	0.2	5.3	0.1
Alangium chinense	10.2	0.5	6.4	0.6	11.5	0.2	9.8	0.1
Horsefieldia amygdalina	8.1	0.3	5.0	0.5	7.8	0.1	7.3	0.0
Micromelum pubescens	12.6	0.3	14.3	0.4	7.5	0.2	10.6	0.1
Polyalthia simiarum	4.9	0.2	9.2	0.6	10.5	0.2	8.2	0.0
Calamus sp.	9.3	0.3	10.6	0.4	8.1	0.1	9.1	0.1
Elaeocarpus serratus	4.9	0.3	7.1	0.2	7.1	0.2	6.3	0.1
Medinilla rubicund	4.1	0.2	9.2	0.6	7.5	0.2	6.6	0.1
Spondias axillaris	12.2	0.2	7.8	0.4	8.1	0.2	9.5	0.0
Actinodaphne obovata	4.9	0.3	11.3	0.3	5.4	0.1	6.5	0.1

(10.6%). Dry weight of *Polyalthia simiarum* and *Medinillaru bicunda* was 9.2% each, and the dry weight of *Spondis axillaris* and *Ficus* sp. was 7.8% each. The dry weight of *Elaeocarpus serrata*, *Alangium chinense* and *Horsefieldia amygdalina* was 7.1%, 6.4% and 5.0% respectively. Likewise, during winter, the percent dry weight of the plant matter was higher (76.9%) than the animal matter (23.1%).

Among the animal matter, the percent dry weight of vertebrates was 7.5%, followed by unidentified food items (4.1%), bees (2.7%), beetles (2.4%), termites (2.0%), orthoptera (1.7%), cockroaches and ants (1% each) and wasps (0.7%). Whereas among the plant matter, dry weight of *Alangium chinense* was 11.5%, followed by *Polyalthia simiarum* (10.5%), *Calamus* sp. and *Spondis axillaris* (8.1% each), *Horsefieldia amygdalina* (7.8%), *Micrommelum pubescens* and *Medinillaru bicunda* (7.5% each), *Elaeocarpus serrata* (7.1%) and *Actinodaphneo bovata* (5.4%). Thus all these dietary compositions showed that the frequency of occurrence of plant matter was more than the animal matter during all seasons. By percent dry weight, plant matter was also always more than the animal matter in all seasons (Table 4). Using two-way ANOVA without replication, it was found that there was no difference in the diet of sun bear between monsoon and fall seasons ($F_{crit} = 1.798$, df = 18, $p = 0.019$).

Important food plant and animal items were grouped together for calculation of their frequency of occurrence in the scats of sun bear diet in different seasons (Fig. 7). The major categories were insects, other animals, *Ficus* sp. and other plants. The annual frequency of occurrence of insects was highest (42.7%), followed by other plants (37.5%), *Ficus* sp. (13.6%) and other animal matter (6.0%). During summer, the frequency occurrence was highest again for insects (47.0%), followed by other plants (31.4%), *Ficus* sp. (13.7 %) and other animal matter (7.9%).

During monsoon, the frequency of occurrence of other plant matter was highest (48.2%), followed by insects (29.3%), *Ficus* sp. (15.5%) and other animal matter (6.8%). During fall, the frequency of occurrence of insects was highest (48.8%), followed by other plants (34.5%), *Ficus* sp. (12.2 %) and other animal matter (4.4%). Thus, the frequency occurrence of insects was high in summer and fall except monsoon season (Fig. 6). The *Ficus* sp. was an important food component of the sun bear diet dominating in all seasons. Using two-way ANOVA without replication, it was found that there was no difference in the diet of sun bear between summer, monsoon and fall ($F_{crit} = 1.798$, df = 18, $p = 0.00001$).

Month-wise presence of food items

Presence of food items in the scat of sun bear showed marked monthly variation (Fig. 8). The animal matter, namely, bees, termites and beetles occurred in the scats during most of the months. Wasps were found in the scats for four months in a year. Ants and orthropods were found present in the scats almost for three months. Plant matter was found to be present in the scats collected during different months. *Ficus* sp. and *Actinodaphre obovata* occurred in the scats almost for 6–7 months. *Ficus* sp. was present during January, February, May, June, July, November and December. Whereas *Actinodaphre obovata* was present in the scats collected during January, February and September to December. *Elaeocarpus serrata* was found in the scats from August to December. *Alangium chinense* and *Horsefieldia amygdalina* occurred from September to December. *Polyalthia simiarum* was present in the scats during January to March and November and December. *Calamus* sp. and *Spondis axillaris* were present during January, February and November and December. Remaining plant matter occurred for 2–3 months.

Discussion

We studied food habits of Malayan sun bears in Namdapha Tiger Reserve. Sun bears have been found opportunistic omnivores, and they have developed adaptation for herbivory that included having longer claws for digging soil. Important foods for sun bears, were especially acorns and figs produced by *Ficus* spp. and *Alangium chinense* respectively. Ten plant species were identified in scats of sun bear: seven species during the summer season, eight species during the monsoon and nine plant species during the fall season.

Fredriksson (2007) reported that Malayan sun bears feed on more than 50 plant species and more than 100 species of

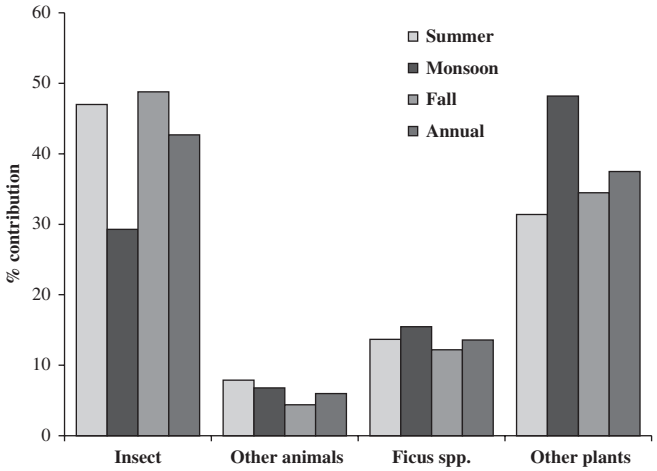

Figure 7. Percentage of food items in different seasons.

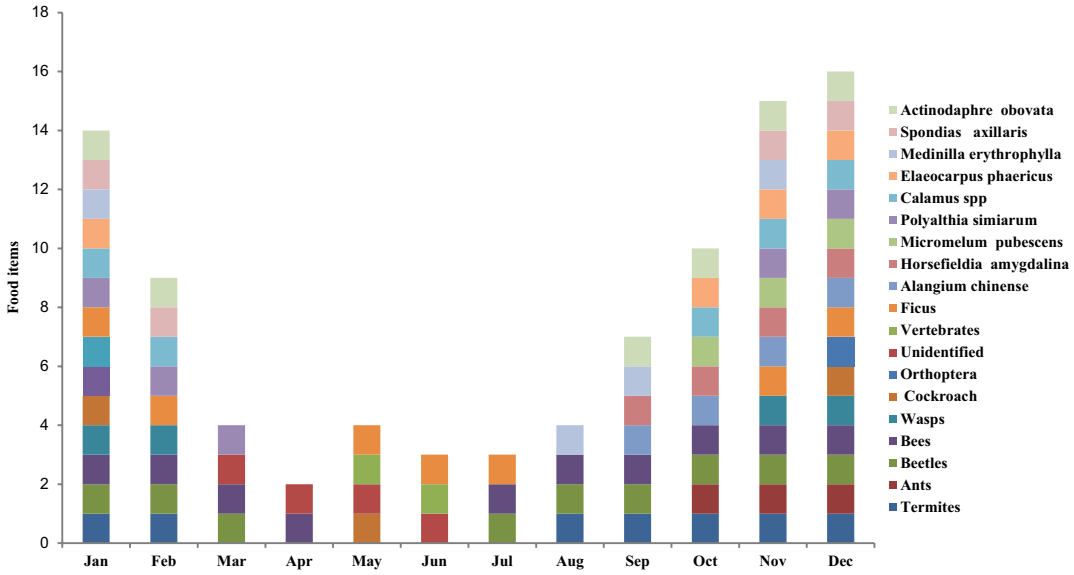

Figure 8. Presence of food items in the scats of sun bear in different months in Namdapha Tiger Reserve.

insects in the Sugai Wain Protection Forest, East Kalimantan, Indonesian, and Borneo. Wong (2002), from Sabah, Malaysia and Borneo reported that sun bear mostly feed on plant species such as figs. Seven types of sun bear feeding sites were identified in Namdapha Tiger Reserve. Decayed wood or logs were the most common feeding site. Decayed standing tree stumps, decayed wood or decayed log on forest floor, fruiting trees, underground termite nests, different types of termite mounds, tree cavities with bee hive and tree root cavity were all common feeding sites.

The method of faecal matter analysis is time consuming but it also has the major advantage of yielding substantial data without locating or disturbing free-ranging animals (McLellan and Hovey 1995, Bargali et al. 2004). Also, other than our study, studies have been conducted on the basis of frequency occurrence and percent weight of different food items found in the scats of bear (MacHutchon and Wellwood 2003, Huygens et al. 2003, Xu et al. 2006). Frequency of feeding was found to be dependent on availability of varied types of food material in a particular area (Desai et al. 1997).

Our analysis revealed that *Ficus* sp. and termites constituted the maximum proportion of the diet of sun bear in the study area (wet weight = 350 g) and similar finding were reported by Fredriksson (2007), Kalko et al. 1996 and Kinnaird et al. 1999. Feeding of sun bear on hard seeds of the Fagaceae family were reported by Davies and Payne (1982), Nozaki et al. 1983, Schaller et al. 1989, Clevenger et al. 1992. Feeding of sun bear on hard seeds of the of the Fagaceae's was similarly reported by Davies and Payne (1982), Nozaki et al. 1983, Schaller et al. 1989, Clevenger et al. 1992. The low encounter rate of Fagaceae's shells in our study was likely due to extremely low fruit production in the region. Among the overall annual frequency occurrence, there were nine animal food items and 10 plant species in different seasons in the diet of sun bear.

The Malayan sun bear is also known as "honey bear" which refers to its voracious appetite for honey combs and honey (Meijaard 1999). Thus, bees, beehives, and honey, are another important food item (Lekagul and McNeely 1977, Medaway 1978, Payne et al. 1985). We found sun bears occasionally feed on wild bees, especially the stingless bee *Trigona* sp. Sun bears are known to tear open trees with their long, sharp claws and teeth in search of wild bees (*Trigonacollina* and *Trigona* sp.) and leave behind shattered tree trunks (MacKinnon et al. 1996, Lim 1998, Meijaard 1999). Lim (1998) reported only a desperately hungry bear would prey on vertebrates, such as pheasants, civets, cats, and rodents. However, fragments of bones, claws, scales, feathers and egg shells found in scat analysis suggest sun bears opportunistically prey upon small vertebrates in the study area or at least scavenge them at times.

Our study examined the dietary pattern and food composition of one of the least-studied bear species. Further steps towards determining the habitat and prey composition of sun bear in other northeastern states along the states of Arunachal Pradesh such as Mizoram and Manipur and Assam are needed to give a more certain picture of variation among different animals, insects and plant species that may be included in the regular diet of sun bear in this region.

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References

Anonymous 2009. Forest Survey of India. Report submitted to Ministry of Environment and Forests, Govt. of India. pp. 318. <www.fsi.nic.in/india_sfr_2009/india_sfr_2009.pdf>.

Bargali, H. S. et al. 2004. Feeding ecology of sloth bears in a disturbed area in central India. – Ursus 152: 212–217.

Bekoff, M. et al. 1984. Life history patterns and comparative social ecology of carnivores. – Annu. Rev. Ecol. Syst. 15: 191–232.
Cicnjak, L. et al. 1987. Food habits of brown bears in Plitvice Lakes National Park, Yugoslavia. – Int. Conf. Bear Res. Manage. 7: 221–226.
Clevenger A. P. et al. 1992. Food habits of brown bears (*Ursus arctos*) in the Cantabrian Mountains, Spain. – J. Mammal. 73: 415–421.
Davies, G. and Payne, J. 1982. A faunal survey of Sabah. IUCN/WWF (World conservation Union/World Wide Fund for Nature) Project no.1962. – WWF-Malasiya, Kuala Lumpur, Malaysia.
Desai, A. A. et al. 1997. Behavioural ecology of the sloth bear in Mudumalai Wildlife Sanctuary and National Park. Report. Tamil Nadu and Bombay Natural History Society collaborative project. – Bombay Nat. Hist. Soc. Mumbai, India.
Edgaonkar, A. and Chellam, R. 2002. Food habits of the leopard, Panthera pardus, in the Sanjay Gandhi National Park, Maharashtra, India. – Mammalia 2002: 353–360.
Fredriksson, G. 2007. Effects of forest fires on sun bear conservation in East Kalimantan (Indonesian Borneo). – Biodivers. Conserv. 16: 1823–1838.
Huygens, O. C. et al. 2003. Diet and feeding habits of Asiatic black bears in the northern Japanese Alps. – Ursus 14: 236–245.
Kalko, E. J. et al. 1996. Relation of fig fruit characteristics to fruit-eating bats in the New and Old World tropics. – J. Biogeogr. 23: 565–576.
Kanchanasakha, B. et al. 1998. Conservation of mainland South East Asia. – Worldwide Fund for Nature-Thailand Project Office, Bangkok, Thailand.
Kinnaird, M. F. et al. 1999. The importance of figs to Sulawesi's imperiled wildlife. – Trop. Biol. 6: 5–18.
Kobayashi, K. et al. 2012. Increased brown bear predation on sika deer fawns following a deer population irruption in eastern Hokkaido, Japan. – Ecol. Res. 27: 849–855.
Landers, J. L. et al. 1979. Food habits of black bears in southern North Carolina. – J. Wildl. Manage. 43: 143–153.
Lekagul, B. and McNeely, J. A. 1977. The mammals of Thailand, 2nd edn. – Association for the Conservation of Wildlife, Bangkok.
Lim, B. L. 1998. The sun bears. – In: Yong H. S. (ed.), The encyclopedia of Malaysia-animals. Archipelago Press, Kuala Lumpur, pp. 24–25.
Mace, R. D. and Jonkel, C. 1986. Local food habits of grizzly bear in Montana. – Int. Conf. Bear Res. Manage. 6: 105–110.
MacDonald, D. W. 1983. The ecology of carnivore social behaviour. – Nature 301: 379–384.
MacHutchon, A. G. and Wellwood, D. W. 2003. Grizzly bear food habits in the northern Yukon, Canada. – Ursus 142: 225–235.
MacKinnon, K. et al. 1996. The ecology of Kalimantan. – Periplus Eds, Singapore.
Maehr, D. S. and Brady, J. R. 1982. Florida black bear-beekeeper conflict: 1981 Beekeeper survey. – Am. Bee J. 122: 372–375.
Manjrekar, N. 1989. Feeding ecology of the (*Ursus thibetanus*) in Dachigam National Park. – MSc thesis, Saurashtra Univ., Rajkot, India.
McLellan, B. N. and Hovey, F. W. 1995. The diet of grizzly bears in Flathead River drainage of southeastern British Columbia. – Can. J. Zool. 73: 704–712.
Medaway, L. 1978. The wild mammals of Malaya (Peninsular Malayasia) and Singapore. – Oxford Univ. Press, Kuala Lumpur.
Meijaard, E. 1999. Ursus (*Helarctos malayanus*) the neglected Malayan sun bears. – Netherland Commission for Int. Nature Protection. Mededelingen 34.
Minamiyama, M. et al. 2006. Food habits of brown bear in relation to acorns production. – Proc. 17th Int. Conf. Bear Res. Manage., Nagano, Japan.
Mukherjee, S. et al. 1994. Standardization of scats analysis techniques for leopards (*Panthera pardus*) in Gir National Park, western India. – Mammalia 58: 139–143.
Nowak, R. M. 1991. Walker's mammals of the world, 5th edn. Vol. II. – The Johns Hoopkins Univ. Press.
Nozaki, E. et al. 1983. Food habits of Japanese black bear. – Int. Conf. Bear Res. Manage. 5: 106–109.
Ohdachi S. and Aoi T. 1987. Food habits of brown bears in Hokkaido, Japan. – Int. Conf. Bear Res. Manage. 7: 215–220.
Payne, J. et al. 1985. A Field guide to the mammals of Borneo. – The Sabah Society with WWF Malaysia. Kota Kinabalu, Sabah, Malaysia, Kuala Lumpur.
Schaller, G. B. 1969. Food habits of Himalayan black bear (*Selenarctos thibetanus*) in Dachigam Sanctuary, Kashmir. – J. Bombay Nat. Hist. Soc. 65: 156–159.
Schaller, G. B. et al. 1989. The feeding ecology of giant pandas and Asiatic black bears in the Tangjiahe Reserve, China. – In: Gittleman, J. (ed.), Carnivore behavior, ecology and evolution. Comstock Publ. Assoc., Ithaca, NY, pp. 212–241.
Servheen, C. 1993. The future of bears in the wild. – In: Stiriling, I. (ed.), Bears, majestic creature of the World. Rodale Press, Emmaus, pp. 212–221.
Sheng, H. L. et al. 1998. The wild mammals of China. – China Forestry Press, Beijing, China.
Wong, S. T. 2002. The ecology of Malayan sun bear (*Helarctos malayanus*) in the Lowland Tropical Forest of Borneo. – MSc thesis, Univ. of Montana.
Wong, S. T. et al. 2002. Food habits of Malayan sun bears in Lowland tropical forest of Borneo. – Ursus 13: 127–136.
Xu, A. et al. 2006. Summer food habits of brown bears in Kekexili Nature Reserve, Qinghai-Tibetan plateau, China. – Ursus 17: 132–137.
Yasuma, S. and Andau, M. 2000. Mammals of Sabah, Part 2, Habitat and ecology. – Jpn Int. Cooperation Agency and Sabah Wildl. Dept, Kota Kinabalu, Malaysia.

Supplementary material (available online as Appendix wlb-00351 at <www.wildlifebiology.org/appendix/wlb-00351>). Appendix 1.