ECOLOGY OF BROWN BEAR (*Ursus arctos*) WITH SPECIAL REFERENCE TO ASSESSMENT OF HUMAN-BROWN BEAR CONFLICTS IN KUGTI WILDLIFE SANCTUARY, HIMACHAL PRADESH AND MITIGATION STRATEGIES.

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In
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By

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Ecology of brown bear (*Ursus arctos*) with special reference to assessment of human- brown bear conflicts in Kugti Wildlife Sanctuary, Himachal Pradesh and mitigation strategies.

Photograph by Bipan Chand Rathore

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Certificate

I have great pleasure in forwarding the Ph.D. thesis of Shri Bipan Chand Rathore entitled "Ecology of brown bear (*Ursus arctos*) with special reference to assessment of human-brown bear conflicts in Kugti wildlife sanctuary, Himachal Pradesh and mitigation strategies" for the acceptance for the degree of Doctor of Philosophy in Zoology (Wildlife Science). The thesis embodies original findings and interpretation of facts. The research was carried out by Shri Bipan Chand Rathore under my supervision and has not been submitted in part or full to any other University/Institution for the award of any degree.

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Summary

The brown bear is widely distributed in Europe, Asia and north America. In India, the potential Himalayan brown bear distribution range is about 36,800 km^2. The Himalayan brown bear occurs in very low densities in the sub-alpine and alpine regions between 3000-5000m in the Greater Himalayas and in some parts of the Trans-Himalayan regions. They occur in sub-alpine and alpine areas in the Himalaya. Brown bear is listed as vulnerable; it is potentially facing a precarious future. The brown bear is severely affected by poaching by graziers in retaliation as their livestock are predated upon by this bear, and for want of body parts. Poaching and deforestation have been slowly eroding the available population of brown bear and its habitat.

In Kugti wildlife sanctuary, Chamba district, Himachal Pradesh, the Himalayan brown bear occurs in low densities in rolling up lands, alpine meadows, scrub and sub-alpine forests. Due to increasing human population, habitat degradation, expansion of agricultural land, infrastructure development, road building, livestock grazing pressure (sheep and goat), collection of medicinal plants and other human activities, brown bear population is highly disturbed and threatened. Bear distribution and habitat use patterns were greatly impacted by increasing biotic pressure and habitat fragmentation. Habitat degradation is mainly due to unsustainable use of alpine regions.

The brown bear population is also causing lot of nuisance, they cause extensive damage to agricultural crops and livestock depredation in these areas, and now in the past few years, it has become beyond tolerable levels. The brown bear impacts the trans-human pastoralists in the sub-alpine and alpine areas by lifting their sheep and goats. The collection of non-timber forest produce from the forests coincides with the

breeding period of the bears, so there are frequent encounters of the mothers with human beings. The resources available in the vicinity of the villages are non-timber forest produce and agricultural crops, which perhaps attract bears to live in these areas and thus have resulted in human-brown bear conflicts. Further due to encroachment on the forest land and continuous habitat degradation in the course of time, the status of the bears not only be endangered in this area, but it may also lead to more conflicting situation. In the alpine pastures in India, brown bear causes extensive livestock depredation, and the migratory shepherds often eliminate them in retaliation to reduce livestock depredation.

As the brown bear is one of the least widely distributed large mammal in the Indian sub-continent, yet very little is known about its ecology and behaviour in India. There is no information available on its ecology and behavioural aspects, which can help conservation and scientific management of its population. To mitigate the conflicts to tolerable level, understanding of its ecology and behaviour of brown bear, pattern and circumstances of livestock killing, and nature and extent of crop damage and local protection methods is necessary. Hence the proposed study undertaken for the Ph.D. degree aims at the ecology of brown bear with special reference to human-brown bear conflict in Kugti wildlife sanctuary in Chamba district of Himachal Pradesh.

The chapter 1 deals with the Introduction, problem statement and objectives of the study on brown bears. The **Chapter 2 and 3** deal the Review of literature and Study area respectively.

In the **Chapter 4**, food habits of brown bear have been studied in Kugti wildlife sanctuary during 2002-2004. The food habits of Himalayan brown bear were determined by analyzing scat samples and direct observations on feeding activities and signs. Brown bears were seen actively feeding during the day time. Based on scat analysis, direct feeding observations and indirect signs, the dietary composition of

brown bears and seasonal difference in their food habits was studied. The dietary composition is based on analysis of total 222 scats, and both plant and animal matter constituted the diet of brown bear in all seasons. During summer, monsoon and fall, the frequency occurrence of animal matter was 27.8%, 23% and 9% respectively, and the frequency occurrence of plant matter was 72.2, 77% and 91% respectively. All these dietary composition revealed that the frequency of occurrence of plant matter was higher than the animal matter in all the seasons. The animal matter was found to be comprised of insects, ants and unknown items including hairs, bones, jaws, teeth, claws and nails in the bear diet. The annual frequency occurrence of plant matter in the scats of brown bear was 79%, and its major part (58.3%) was comprised of unknown plant matter. The plant matter eaten by brown bear comprised of 10 confirmed plant species. The annual frequency occurrence of agricultural crops was found to be 7.2% in the scats. Based on ocular estimation, the estimated volume for unknown plant matter was high in the bear scats, and insects and ants was medium. Based on 57 direct feeding observations, brown bears were found feeding on 29 species of plants including agricultural crops.

Both plant and animal matter constituted parts of its diet throughout the year. The animal matter of the brown bear diet was comprised of 8 different animals/parts during both summer and monsoon seasons, whereas no animal matter was found in the scats during fall season. Major part of the scats was comprised of unknown plant matter. The frequency occurrence of animal matter was highest in summer, followed by monsoon and fall. Among the plant matter, the frequency occurrence of unknown plant matter was found highest in the scats during fall, followed by summer and monsoon. The estimated volume for unknown plant matter was also high in all the seasons. There was also marked monthly variation in the occurrence of different food items in scats of brown bear. Availability of most of the food items of brown bear was between March and October months. Ants and insects were consumed by bears from

the time of emergence after hibernation. Livestock, sheep and goat, were present in large numbers from May till October.

In **Chapter 5**, habitat use pattern of brown bear and habitat availability have been described. Using random stratified transect sampling method, nine different habitat categories viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests, Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species have been classified in Kugti wildlife sanctuary. From the vegetation data of different sample plots, assessment of food plants and their abundance in each habitat type was calculated.

The habitat use by brown bear was found to be largely dependent on the availability of food resources, variety of food plants and shelter in different habitat types. There were 6 to 25 species of food plants found in different habitat categories. Maximum food plants species were in Agricultural land. These fruiting trees and other food items including insects and ant *(Solenopsis* sp.*)* were found to be available in different habitats and vicinity of village.

Based on the density of digging signs and scats per hectare, there was highest use of Moist sub-alpine scrub characterized by *Rhododendron* species and Himalayan moist temperate forest with conifers habitats by brown bears used, and then rest of the habita categories. The frequency occurrence of food plants in plots used by bears varied considerably. Among various habitat categories, the proportional availability was found to be highest of Agricultural land, followed by Grassland and forest blanks, followed by other habitats. In comparison to the availability of various habitats, the expected use of these habitat categories was found in proportion. The habitat use by brown bears was also found to be in proportion to the availability and the expected

use of these habitat categories. Similarly, the habitat use pattern by brown bears showed marked seasonal variation. Various terrain types: flat, undulating, gentle slope and steep slope were found to be differentially used by brown bears in the study area. But the use of flat terrain by brown bear was maximum, followed by gentle slope, undulating terrain and steep slope. Brown bears were found to use flat terrain maximum in Agricultural land, undulating terrain maximum in Near water bodies, river and streams and gentle slope terrain maximum in Riverine forest. The expected use of these terrain types was found to be directly proportional to the availability of these terrains. The utilization of each terrain category was also in proportion to its occurrence.

The **Chapter 6** deals with the human-brown bear conflicts. Information on human casualties, livestock killings and nature and extent of damage to agricultural and horticultural crops by brown bears was collected from the records of the forest department and by talking to field staff. Through village interviews, information on cropping pattern, nature and extent of damage to agricultural crops, time of depredation and protection methods, and collection of non-timber forest produce and time of their collection by villagers was also collected.

There were few cases of brown bears showing aggression to shepherds in different dhars. The migratory graziers used 22 grazing pastures or dhars in the sanctuary from April to October every year, and there were a total of 1539 livestock casualties by brown bears in different pastures during 2002-2004. Among all these dhars, maximum livestock depredation occurred in Nanaun dhar, followed by Ghiula dhar, Bharali Kinnaur dhar, Bhiad dhar, Andharli Kinnaur dhar, Ghei dhar, Duggi dhar, Sarni dhar, Bhunkar dhar, Bhug dhar, Andharali Dhamel dhar and Mundi dhar. Livestock depredation varied in different months, and maximum depredation on sheep and goat occurred during August, followed by September, July, June, May and October. Brown bears were to cause maximum depredation during night (62.8%),

followed by day time (16.8%), evening (15.2%) and morning time (5.2%). Maximum number of livestock depredation occurred mid-night.

Crop depredation by brown bear was found to be quite visible in crop fields. They preferred wheat tender leaves and grains, maize corn, and young shoots and grains of barley, phulen and bharesh crops. Damage to wheat, maize, barley, bharesh and phulan crops was high during the seeding stage and seed formation stage when corn in spikes developed. Maize and wheat plants were trampled more that eaten. Damage to wheat crop by bears was found during July-August and October-November. Maize and barley crops were damaged during August-September and June-July respectively. Wheat, maize, barley, phulan, bharesh, rajmash and vegetable crops were grown in these villages on rotational basis in different years. Amongst all the crops, maize suffered highest level of damage by brown bear. Maize crop suffered 10-35% damage by brown bears. Maximum damage to maize crop was in Seri agricultural land. Damage to wheat crop was 15-25%, and it was highest in Tendei agricultural area. Damage to barley crop was 10-20%, and maximum damage was found in Dalatu agricultural land. All these agricultural areas were located far away from the village and crop raiding by brown bears occurred in the evening and night time. Brown bears were found to damage peach and jamu everywhere in the sanctuary.

In **Chapter 7,** the suggestions and recommendations have been made for mitigation of human-brown bear conflicts and conservation and management of brown bear population. To avoid human-brown bear conflicts, people need to be vigilant and livestock grazing in different dhars inside the sanctuary should be regulated. There is also a need of public education and awareness with respect to species conservation, natural history of brown bear and other crop depredating wild animals and damage control etc.

Chapter 1

Introduction and objectives

1.1 Bear species and distribution

Bears have a wide global distribution and are found in every continent except Africa, Australia and Antarctica (Nowak and Paradiso, 1983). There are significantly more bears in the northern hemisphere than in the southern hemisphere. In the world, there are eight species of bears (Waits *et al*., 1999). They are Asiatic black bear (*Ursus thibetanus*), polar bear (*Ursus maritimus*), American black bear (*Ursus americanus*), brown bear (*Ursus arctos*), sloth bear (*Melursus ursinus*), spectacled bear (*Tremarctos oratus*), giant panda (*Ailuropoda melanoleuca*) and sun bear (*Ursus malayanus*). Family Ursidae can be divided into two sub families viz. Ailurinae (Giant and Red Panda) and Ursinae (Seven species of true bears). The members of family ursidae do not occur in Africa, Madagascar, Australia, various oceanic islands and the Antarctica, with the exception of polar bear, inhabiting the arctic region. Spectacled bear is found south of the equator. Malayan sun bear and Alaskan brown bears are the smallest and largest respectively in the bear family. Bears are found in around 62 countries. Two species occur in Europe, three in North America, one in South America, and six in Asia. Of the eight species of bears in the world, four bear species viz. sloth bear, Asiatic black bear, Himalayan brown bear and Malayan sun bear have been reported in India (Prater, 1990). Bears live in a variety of habitats and are found from the high arctic region (polar bear) to the low land tropical forests (sun bear).

The brown bear (*Ursus arctos*), is widely distributed throughout the Pelearctic (Europe and Asia) and Nearctic (North America) faunal regions. In the Palearctic region, *U. arctos* is commonly referred to as the brown bear, whereas in North America, it is called the grizzly bear. The brown bear is one of the eight species of bears distributed worldwide, and one of six members of the genus *Ursus*. The brown bear occupies a diverse array of habitats, from arctic tundra to boreal of Russia in the north and coastal forests, to the mountain forest and grassland ecotone of the Himalayas in the south (Servheen, 1990). The Asian range of brown bear extends from Turkey, Iran and Afganistan to Pakistan and along the Himalayas of India, Nepal and Bhutan, and then north and east through the mountains of central Asia, Tibet, Northern China and Mangolia to Russia (Jackson, 1990). Along the Himalayan-Tibetan region, two subspecies of brown bears have been reported (Prater, 1990 and Schaller, 1998). The brown bear subspecies, *Ursus arctos pruinosus*, which is known as Tibetan brown bear, has been recorded from Damodar Kunda valley, Mustang district, Nepal (Gurung, 2004), and the subspecies, *Ursus arctos isabellinus* often known as red bear is believed to occur in the northwestern parts of Nepal (Schaller, 1998). In China, the Himalayan brown bear has a more northerly distribution and inhabits high mountainous areas above the tree line and it has been recorded from the Tianshan and Pamir mountains in the western Xinjiang Uygur region (Ma, 1983). Three subspecies of brown bear has been recorded from these regions. In Pakistan, brown bear population is very small and is now distributed over three mountain ranges and four intermountain highlands, the western Himalaya, northern Karakoram, Hinhu Kush range, and to the Pamir range in Afghanistan. The sizes of these populaions do not exceed 20 individuals. The Deosai plateau in western Himalaya hosts the most stable population of about 40 individuals (Nawaz, 2005 and 2007). In

Hokkaido, the Hokkaido brown bear (*Ursus arctos yesoenis*) habitat has been severely limited by human activities, especially the forestry practices and road construction (Mano and Moll, 2001). It inhabits the island of Hokkaido and the neighboring Russian controlled islands Kunashiri and Etorofu.

In India, the potential Himalayan brown bear distribution range is about 36,800 km^2 based on the 2005 estimate, of which more than 10 % is protected under the existing network of protected areas in India (Sathyakumar, 2006a). The Himalayan brown bear occurs in very low densities in the sub-alpine and alpine regions between 3000-5000m in the Greater Himalayas and in some parts of the Trans-Himalayan regions (Sathyakumar, 2001 and 2006a). The Brown bears are largely confined to the northwestern and western Himalayan ranges in Jammu and Kashmir, Himachal Pradesh and Uttarakhand, and the Asiatic black bear occur in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, est Bengal, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Tripura, Manipur and Nagaland (Sathyakumar, 2006). They occur in the rolling uplands and alpine meadows above timberline in the Himalaya, ecologically separated from the forest dwelling Asiatic black bear (Schaller, 1977). In the north-western Himalaya, the brown bear is reported to occur in the sub-alpine and alpine areas (Sathyakumar, 2001 and 2006a). Practically nothing is known about these populations today, and little information is available about the population in Burma, Tibet, western China, Korea, and Manchuria. The early reference of occurrence of brown bear in India dates back to nineteenth century. After the sheep had left their summer camps at altitudes varying from 10,000 to 13,000 feet, it was not by any means uncommon to see 'Bhrubbu' as the hillman call him, feeding on the grassy plains in the morning and afternoons and signs of digging and hibernation in first

week of December (Donald, 1898). Local reports from Pensi La Pass and the upper parts of the Suru and Zanskar valleys, covering an area of about 1200 km^2 revealed low population of brown bear and no bears were seen during the survey (Mallon, 1991). Now in Jammu and Kashmir, the Himalayan brown bear is reported to occur in eight protected areas. It is reported to occur in suitable undisturbed alpine areas in the forest divisions of Lidder, Sindh, Marwa, Kistwar, Poonch and Badhruwa and in the Zanskar and Suru valleys in Ladakh (Sathyakumar, 2002). The brown bear is present in ten protected areas in Himachal Pradesh (Sathyakumar, 2002, Singh *et al*., 1990 and Green, 1993) and in some watershed areas outside protected areas. It is reported to occur in Malana valley, Hamta Pass, Solang valley Bara Bangal, Parbati valley, Ropa valley, Kaksthal, Manali, Pooh and Lingti and Ensa valleys (Lahul and Spiti). Survey conducted by Sathyakumar (2001) indicated occurrence of a fairly common population of brown bear in Great Himalayan national park and Kais, Tundah and Kugti wildlife sanctuaries. It is rare in Kanawar, Sangla and Rupi Bhaba wildlife sanctuaries. In Uttarakhand, the brown bear populations are present in and around the Nanda Devi national park and biosphere reserve (Lamba, 1987), Kedarnath wildlife sanctuary (Sathyakumar, 1994), Valley of Flowers national park, Govind and Askot wildlife sanctuaries, and in alpine regions of Yamnotri, Gangotri, Badrinath, Mana, Almora and Pithoragarh. They are rare in Kedarnath wildlife sanctuary, Nandadevi national park and Govind national park and wildlife sanctuary (Sathyakumar, 1994, 2001). In Sikkim, the brown bear was reported as 'present' in the upper reaches of Kanchendzonga national park and in some suitable undisturbed alpine areas (Gee, 1967 and Sathyakumar, 2001).

1.2 Status of bear species

All bear species are listed as endangered, threatened, or potentially facing a precarious future (Schoen, 1990). The North American black bear (*Ursus americanus*) and giant panda (*Ailuropoda melanoleuca*) are significantly impacted by change in the habitat composition (Schaller *et al*., 1985). Servheen (1990) mentioned that the Asiatic black bear (*Ursus thibetanus*), sun bear (*Ursus malayanus*) and sloth bear (*Melursus ursinus*) are in jeopardy because of degradation and loss of habitat. Mortality of threatened black bear of northern America, brown bear in Europe and spectacled bear in South America is very common because of forest fragmentation and insularisation. Knight (1984) mentioned that low density, secretive behaviour and high mobility make census of grizzly bear (*Ursus arctos horribilis*) difficult. Poaching and deforestation have been slowly eroding the available population of sun bear and its habitat. Long ago sloth bear inhabited the deciduous monsoon forests and thorn bush forests of India up to the Thar desert in the west and southern foot of the Himalayas (Kurt, 1995). They were also found in the rain forests and grass jungles in the North-eastern region. Over exploitation of sloth bears by poachers and kalanders (jugglers) and due to severe habitat loss and fragmentation, population of this species has declined steadily (Johnsingh, 1986).

The Himalayan brown bear is listed as "Vulnerable" in the Red Data Book (International Union for Conservation of Nature and Natural Resources IUCN 2006) but not listed as "threatened" in the 1996 Red List of Threatened Animals (IUCN 1996). It is also listed in the Appendix I of CITES (GOI, 1992) and on Schedule I of the Indian Wildlife (Protection) Act (1972) as amended in 2003. Wildlife species that are listed in Schedule I of the Indian Wildlife (Protection) Act are considered to be

"endangered species" and are accorded highest protection. The brown bear is severely affected by poaching by graziers in retaliation as their livestock are predated upon by this bear, and for want of body parts that are generally used for preparation of various medicines (WWF-India handbook published in 1998). The National laws in India forbid trade of any part of the sloth bears.

1.3 The problem: Study on brown bear

In Kugti wildlife sanctuary, Chamba district, Himachal Pradesh, the Himalayan brown bear occurs in low densities in rolling up lands, alpine meadows, scrub and sub-alpine forests. Due to increasing human population, habitat degradation, expansion of agricultural land, infrastructure development, road building, livestock grazing pressure (sheep and goat), collection of medicinal plants and other human activities, brown bear population is highly disturbed and threatened. Bear distribution and habitat use patterns were greatly impacted by increasing biotic pressure and habitat fragmentation. Habitat degradation is mainly due to unsustainable use of alpine regions. In addition, there is a growing demand for bear products in Asia which have led to serious impacts on bear population in India.

The brown bear population is also causing lot of nuisance, they cause extensive damage to agricultural crops and livestock depredation in these areas, and now in the past few years, it has become beyond tolerable levels. The brown bear impacts the trans-human pastoralists in the sub-alpine and alpine areas by lifting their sheep and goats. The collection of non-timber forest produce from the forests coincides with the breeding period of the bears, so there are frequent encounters of the mothers with

human beings. The resources available in the vicinity of the villages are non-timber forest produce and agricultural crops: maize (*Zea mays*), phulen (*Fagopyrum* sp.) and wheat (*Triticum aestivum*) etc., which perhaps attract bears to live in these areas and thus have resulted in human-brown bear conflicts. Further due to encroachment on the forest land and continuous habitat degradation in the course of time, the status of the bears not only be endangered in this area, but it may also lead to more conflicting situation. In the alpine pastures in India, brown bear causes extensive livestock depredation, and the migratory shepherds ('Gaddies' and 'Bakharwals') often eliminate them in retaliation to reduce livestock depredation (Sathyakumar, 1999a and Chauhan, 2003). Increased incidences of livestock depredation and attack on humans by black bears have also been reported (Sathyakumar, 1999b). In Zanskar, there were reports of a Himalayan brown bear attack on two villagers and a case of retaliatory killing of brown bear by villagers when livestock depredations were high (Sathyakumar 2002). In Great Himalayan National park, brown bear and black bear were found responsible for few human casualties and high livestock killings; there were 3 human casualties by black bear and 355 livestock killing by these two bears during 1989-1998 (Chauhan, 2003). In Garhwal and Kumaon districts of Uttaranchal, black bear caused 154 human casualties during period of 1991-2001 (Chauhan, 2004). Bears have been reported to cause extensive damage to agricultural damage (Ambrose and Sanders, 1978., Azuma and Torii, 1980., Calvert, 1992., Chauhan, 2003., Elowe, 1984., Fredriksson, 2005., Garshelis *et al*. 1999., Horstman and Gunson, 1982., Hygnstrom and Craven, 1985., Jonker *et al*., 1998., Knight and Judd, 1983., Maher, 1983., Mattson and Merrill, 2002., Peyton, 1980., Swenson *et al*. 1994., Vaughan *et al*., 1989., Servheen, 1990., Conover and Decker, 1991., Reid *et al*., 1991., Stowell and Willing, 1992, and Will, 1980).

As the brown bear is one of the least widely distributed large mammal in the Indian sub-continent, yet very little is known about its ecology and behaviour in India. The report on the status and conservation of the bears of the world indicated scant information on Asiatic black bear and Himalayan brown bear in India (Servheen, 1990). Only recently, a survey report has shown the presence and absence of the two species along the Himalayan range in India (Sathyakumar, 2006a). Even basic information such as presence and absence does not exist for many areas in the distributional range of these species in India. Whereas in western countries, several studies have been conducted on brown bear/grizzly bear related to its ecology, activity and movement pattern, food habits and conservation aspect etc. Only very little information on status and human-brown bear conflict aspect of brown bear is available in India (Mallon, 1991, Chauhan, 2003 and 2004, Sathyakumar, 2001 and 2006a). Though the brown bear is listed in the IUCN Red Data Book, Appendix I of CITES and protected as Schedule I species under Indian Wildlife (Protection) Act 1972, conservation and management efforts have been minimal. Further there is no information available on its ecology and behavioural aspects, which can help conservation and scientific management of its population. To mitigate the conflicts to tolerable level, understanding of its ecology and behaviour of brown bear, pattern and circumstances of livestock killing, and nature and extent of crop damage and local protection methods is necessary.

Hence the proposed study undertaken for the Ph.D. degree aims at the ecology of brown bear with special reference to human-brown bear conflict in Kugti wildlife sanctuary in Chamba district of Himachal Pradesh. The food habits, habitat use pattern and nature and extent of human-brown bear conflict, circumstances and local

protection methods have been studied in the Kugti wildlife sanctuary. The study will provide a basis for developing an action plan for conservation and management of brown bear population and to mitigate the problems effectively on a long-term basis.

1.4 Significance of study

i. Brown bear is an endangered species. Brown bear is sparsely distribution in India, and its habitats are encroached or degraded upon by the human beings. In Chamba district, forests are highly fragmented and interspersed with villages and agricultural crop fields. There is a growing demand for bear products in Asia, and which have led to serious impacts on bear population in India. The human-brown bear conflict has been increasing and now attained to serious levels. Consequently, the conservation efforts for the brown bear, an endangered species, are adversely affected.

ii. As the Brown bear *Ursus arctos* is one of the least widely distributed large mammal in the Indian sub continent, yet very little is known of its ecology and behaviour in India. Further there is no information available on its ecology and behaviour, human-brown bear conflict, and human dimension, which can help conservation and scientific management of its population. To mitigate the conflicts to tolerable level, study on ecology and behaviour of brown bear: habitat use pattern, food habits, pattern of livestock killing and circumstances, nature and extent of crop damage, socio-economic impacts of bear menace, and local protection methods is necessary.

iii. Though brown bear is listed in the IUCN Red Data Book, Appendix I of CITES and protected as Schedule I species under Indian Wildlife (Protection) Act 1972, conservation and management efforts have been minimal.

iv. Only some preliminary survey on human-bear conflict has been done in the Great Himalayan National Park and Zanskar valley. The research on ecology, behaviour and conflict aspect of brown bear is the first study conducted in Kugti wildlife sanctuary in India.

v. The study on human-brown bear conflict is of high research priority. The study has enabled to know the causes of human-brown bear conflict. By minimizing or reducing of livestock casualties and agricultural crop damage based on our research findings, the local villagers and tribal people will be greatly benefited. This will help the local people in improvement of their economy, and secondly conservation of brown bears, an endangered species.

vi. While the study is specific to a selected site, the project outcome would have the potential of application to similar habitat situation elsewhere in India.

vii. It is for the first time that an in-depth systematic scientific probe on ecology and management of brown bear of this nature is proposed in Himachal Pradesh. The study will provide a basis for developing an action plan for conservation and management of brown bear in the state and mitigation of the human-brown bear conflict effectively and on a long-term basis.

viii. The study will also help suggest ways to use the forest and other land resources in a sustainable way towards resolving the problem. Thus the knowledge gained on the ecology of brown bear and conflict aspect etc. will be highly beneficial for use by the wildlife managers and scientists.

1.5 Objectives

The objectives of the study are as follows

1. To study the food habits and seasonal dietary intake pattern of brown bear in Kugti wildlife sanctuary.

2. To evaluate the habitat use pattern of brown bear.

3. To assess the nature and extent of human-brown bear conflicts.

4. To formulate the mitigation strategies for reducing human brown bear conflicts in Kugti wildlife sanctuary.

Chapter 2

Review of literature

2.1 Introduction

Bears belong to the order Carnivora. Around 57 million years ago, Carnivora evolved from small arboreal predators, miacids (Herrero, 1999). On the evolutionary tree of the order Carnivora, bears are close relative of dogs, racoons and weasels, from which, the bear split about 34 million years ago (Catton, 1990). Today the bear family comprises of three genera containing eight living species. The six ursinae bears, namely, sun bear (*Ursus malayanus*), American black bear (*Ursus americanus*), sloth bear (*Melursus ursinus*), Asiatic black bear (*Ursus thibetanus*), brown bear (*Ursus arctos*) and polar bear (*Ursus maritimus*) were found to have a nearly identical karyotype with 74 diploid chromosomes (Ewer, 1973 and Waits *et al*., 1999). These chromosomes consisted of 72 autosomes (60 acrocentric and 12 metacentric or submetacentric) and 2 sex chromosomes, a large metacentric X and small acrocentric Y (Pasitschniak-Arts, 1993). The brown bear is one of eight species of bears distributed worldwide, and one of six members of the genus *Ursus*.

2.2 Physical characteristics

The brown bears were found to vary greatly in size and shape. However, certain characteristics were found consistent. The skeletal structure of the brown bear was larger and heavier than that of most other ursids, but the axial and appendicular skeleton was found similar to that of the American black bear (*Ursus americanus*).

Brown bears were found tetrapedal, with legs of approximately equal length, tapering to large pentigrade feet (Craighead and Mitchell, 1982). Each foot had 5 toes ending with a relatively long claw. Fore-claws were found much larger than black or polar bears. Claws of *Ursus arctos* evolved as tools for digging (Herrero, 1972) rather than tree climbing or capturing and holding prey as in *Ursus maritimus.* They were found to move with a heavy shuffling gait (Pasitschniak-Art, 1993). Features that distinguished the species included a large hump of muscle overlying the scapulae, characteristic skull and dental structure, and in some individuals, color and appearance of the pelage (Craighead and Mitchell, 1982). Size varied greatly among sex and age classes of bears, and seasonally. Brown bears were found sexually dimorphic, with males about 1.2 to 2.2 times larger than females (LeFranc *et al*., 1987; Stringham, 1990 and Hilderbrand *et al*., 1999a). Dimorphism developed early in life and was apparent between ages 2 and 4 years (Troyer and Hensel, 1969; Pearson, 1975 and Blanchard, 1987).

2.3 Hibernation

Body temperature in the brown bear was found to range from 36.5º to 38.5º C when active, but declined to 4º to 5º C during hibernation (Irving and Krog, 1954; Folk *et al*., 1968, 1972, 1976; Nelson, 1973; Folkman *et al*., 1979 and LeFranc *et al*., 1987). Bears were found to exhibit continuous dormancy for up to 7 months without eating, drinking, defecating or urinating (Craighead and Craighead, 1972 and Folk *et al.,* 1972). However, other did not consider winter denning in the bear to deep hibernation because body temperature did not go below 15º C (Watts *et al*., 1981; Lyman *et al*., 1982 and Pasitschniak-Arts, 1993). Body mass was found dynamic in brown bears.

During late summer and fall, brown bears were found to gain weight rapidly, primarily as fat (Troyer and Hensel, 1969; Pearson, 1975; Craighead and Mitchell, 1982; Kingsley *et al*., 1983; Nagy *et al*., 1983a; 1983b; Blanchard, 1987 and Hilderbrand *et al.*, 2000) when they fed intensively before denning (Nelson, 1980 and Nelson *et al.*, 1983a). Because bears were dependent solely on their stored energy reserves during hibernation, this pre-denning weight gain was essential for reproduction and survival. Weight loss during the denning season was dependent upon condition of the bear when entering the den (Atkinson and Ramsay, 1995; Atkinson *et al.*, 1996 and Hilderbrand *et al*., 1999a), length of the denning season and reproductive status (Hilderbrand *et al*., 1999a).

2.4 Denning

Denning ecology is important to bear survival and reproduction. American black bears (*Ursus americanus*) were often found to select specific den types, presumably to reduce energy expenditure and increase cub survival (Johnson and Pelton, 1979, 1981; Lentz *et al*., 1983 and Alt, 1984). Specific den types also might be important for predator avoidance, especially for females with cubs (Lindzey and Meslow, 1976, Rogers and Mech, 1981, Ross *et al.*, 1988 and Pikunov *et al*., 1991). Asiatic black bears used a greater variety of den types than did brown bears, and use of ground dens by Asiatic black bears has been documented in many areas (Abramov, 1972 and Reid *et al*., 1991). Brown bear dens were similar to those described for many other regions in Eurasia and North America (Stroganov, 1962; Bromlei, 1965; Servheen and Klaver, 1983; Judd *et al*., 1986 and Pazhetnov, 1990). The lower variability in den types used by brown bears might be related to the ability of brown bears to dig and

hence created their own dens. Brown bears were more selective for den site characteristics than Asiatic black bears and denned at higher elevations, on sleep slopes, and on the upper third of slopes (Seryodkin *et al.,* 2003b). Similar den characteristics have been reported for brown bears elsewhere (Vroom *et al*., 1980; Servheen and Klaver, 1983 and Judd *et al*., 1986). Grizzly bears (*Ursus arctos*) inhabiting northern latitudes might spend 5 to 6.5 months each year in a den (Vroom *et al.,* 1980; Judd *et al.,* 1986; Van Daele *et al*., 1990; Friebe *et al*., 2001 and Seryodkin *et al*., 2003). During denning, bears did not eat, urinate, or defecate and relied on fat reserves attained during the non-denning period (Hellgren, 1998). Dens were constructed or selected to provide thermal insulation (Vroom *et al*., 1980) and security cover (Seryodkin *et al*., 2003b) for denning bears and birth sites for pregnant females (Swenson *et al*., 1997). There was general agreement that denning behaviour might be triggered by a reduction in availability of forage items (Servheen and Klaver, 1983; Schoen *et al.,* 1987 and Haroldson *et al.,* 2002) and reproductive status of individuals (Van Daele *et al*., 1990 and Mace and Waller, 1997). Bears primarily excavated dens into the sides of slopes, and dens excavated by grizzly bears have been reported often (Vroom *et al*., 1980; Servheen and Klaver, 1983; Van Daele *et al.,* 1990; Seryodkin *et al*., 2003 and Ciarniello *et al*., 2005). Numerous authors have investigated the denning ecology of black bears using a variety of den types, such as excavated ground cavities (Johnson and Pelton, 1981), elevated tree cavities (Johnson and Pelton, 1981; Weaver and Pelton, 1994 and White *et al*., 2001), ground level tree cavities (Jonkel and Cowan, 1971; Johnson and Pelton, 1981 and Beecham *et al.,* 1983), rock crevices (Johnson and Pelton, 1981 and LeCount, 1983), brush piles i.e. logging slash, felled tree tops (Hellgren and Vaughan, 1989; Weaver and Pelton, 1994 and White *et al*., 2001) and other den types where bears were enclosed in a cavity (Jonkel and Cowan, 1971). Weaver and Pelton (1994) and White *et al.* (2001)

observed that bears preferred tree and excavated ground dens over nest or brush dens. However, study indicated that when cavity den types were rare or absent, bears predominantly used nest dens (Martorello and Pelton, 2003). Generally tree dens were preferred by bears over other den types (Hamilton and Marchinton, 1980 and Weaver and Pelton, 1994), and bears made extensive use of tree dens in bottom land hardwoods subject to flooding (Smith, 1986; Weaver and Pelton, 1994; Anderson, 1997; Oli *et al*., 1997 and Dobey *et al*., 2002). By using tree dens, bears were found to increase energy savings, minimize likelihood of disturbance, and might enhance neonatel survival (Johnson *et al*., 1978 and Johnson and Pelton, 1981). In Rocky Mountain Front, Montana, comparative ecology of dens study revealed that grizzly bear dens were found at significantly higher elevation and steeper slopes as compared to black bear dens (Aune, 1994).

Bears deaths were found to be primarily human related. Natural mortality could result from old age, intra and inter-specific killing, starvation, rock or snow avalanche, den collapse or unknown reason. Natural mortality constituted a greater proportion of total mortality for dependent young ones (Nagy *et al*., 1983b). Most bears were found to die during the non-denning season. Although an occasional mortality was documented during winter (McLellan *et al*., 1999), most deaths occurred when bears were active. Aune and Kasworm (1989) and Mace and Waller (1998) found that most grizzly bears in Montana died during autumn, and natural mortality was prominent during spring and summer. Grizzly bears, like most other animals, were afflicted with an array of parasites and diseases (LeFranc *et al*., 1987). Occasionally a bear succumbed to such ailments, but documenting cause of death was difficult, particularly under natural conditions.

2.5 Habitat use pattern

Johnson (1980) considered habitat selection a hierarchical process, with four spatial scales, defined as orders. First-order selection included the physical or geographic range of a species; second-order selection operated at a home range scale within a geographic range. Third-order selection occurred at feeding sites within the home range, and forth-order referred to specific foraging decisions. Most studies of brown bear habitat use focused on second and third-order selection.

Brown bears were found to occupy a variety of primary habitats (first-order selection) throughout North America, covering relatively broad environmental limits (Craighead, 1998). Their ability to effectively use vastly different landscapes could be attributed to their omnivorous generalist lifestyle, which was an indication of adaptability. On the north slope of Alaska and the barren ground of northern Canada, brown bears were found to occupy a treeless landscape, and in the Central Arctic, esker complexes and riparian tall shrub habitats were preferred by bears throughout the year (McLoughlin, 2000). In Alaska and British Columbia, bears were found to use a variety of habitats including old-growth forests, coastal sedge meadows and south facing avalanche slopes. During summer, most bears used alpine and subalpine meadows. From mid summer through early fall, they moved to coastal habitats and concentrated along streams to feed on spawning salmons (Lefranc *et al*., 1987 and Schoen *et al*., 1994). This typical pattern of habitat use was not seen in all bears, some did not visit salmon streams (Schoen *et al*., 1986), but remained in high-elevation habitats throughout the year. Mace and Waller (1997) observed that habitat selection often varied among individuals, even in an environment that appeared consistently

similar to humans. During late fall, bears were found to rely on fish or use berry-producing habitats (LeFranc *et al*., 1987 and Schoen *et al*., 1994).

In the northern Rocky Mountains, grizzly bears were dependent on a fairly predictable sequence of habitats that provided seasonally available forage. Seasonal habitats were separated into spring/early-summer pre-berry period, when bears were foraging on a variety of locally available graminoids, forbs and roots; and summer early-fall berry-producing period, when bears were feeding on locally available berry crops (LeFranc *et al*., 1987; Mace and Waller, 1997 and Herrero *et al*., 2000). During spring, bears were found in lower elevation habitats eating emergent vegetation and winter-killed ungulates. During late spring, they moved to higher elevations following the phonological advantage of vegetal foods. During summer, bears descended to lower sites to exploit habitats with early-ripening berry crops. They showed repeated altitudinal movements, following the ripening fruits to higher elevations during early fall (Darling, 1987; Hamer and Herrero, 1987 and Mace and Waller 1997). In the Greater Yellowstone Ecosystem, the pattern of seasonal elevation use was similar to that found for other populations occupying interior western mountains (Mealey, 1980). In Northeastern Alaska, tussock and tall shrub land were used by grizzly bears slightly more frequently during spring, whereas low shrub land was used much more frequently than expected (Phillips, 1987). In much of Alaska and northern Canada, habitats occupied by the grizzly bear were not significantly altered by humans. Most of the productive lands have been occupied by humans, and grizzly bear populations have been located in most remote and rugged mountainous areas; which were not the best habitats (Craighead and Mitchell, 1982 and Gibeau, 1998). In Rocky Mountain Front, Montana, comparisons of the habitat use between grizzly bear and black bear

revealed that although both preferred the closed timber habitat component, but black bears were using the closed timber community more than grizzly bears, and black bears also used the rock, talus, prairie grasslands, riparian shrub and riparian complex habitat component significantly less than did grizzly bears (Aune, 1994). The study also revealed that grizzly bears ranged broader spectrum of elevations and used the low and upper elevation range more frequently than black bears. In Trentino, Italy, the active period for brown bears was found from mid-April through early November, and elevation between 1000m to 1500m was used during the summer and bears denned above 1500m (Osti, 1975). In Denali National Park, Alaska, activity pattern and habitat use of brown bear was studied in alpine areas by Stelmock and Dean (1986), and found that brown bears were generally diurnal in the early spring with a crepuscular pattern of activity and during the fall phase bears were active throughout the daytime and twilight hours and possibly during darkness. Their study also revealed that habitat use and activity of bears were influenced by the phonological development of cowberry (*Empetrum nigrum*), peavine (*Hedysarum alpinum*), horsetail (*Equisetum arvense*), polar grass (*Arctagrostis latifolia*), soapberry (*Shepherdia canadensis*), and availability of animal food items. Several studies documented habitat use and movement patterns of coastal brown bears (Berns *et al*., 1980; Glenn and Miller, 1980; Schoen *et al*., 1986; Hamilton and Bunnell, 1987; Barnes, 1990 and Ballard *et al*., 1993) and interior areas (Ballard *et al*., 1982). Brown bears in British Columbia ranged widely during berry season and then restricted movements while feeding on salmon (Hamilton and Bunnell, 1987). On the Alaska Peninsula, bears moved greater distances in spring than in summer and fall (Glenn and Miller, 1980). Schoen *et al*. (1986) observed that bears of the Admiralty Island population did not feed on salmon, instead foraging in interior alpine and sub-alpine

habitats. In southwestern Alaska, brown bears occupied lower elevations during July and August, when salmon (*Oncorhynchus spp*.) were available and higher elevations in September, presumably to feed on berries, ground squirrels (*Spermophilus parryii*), and caribou (*Rangifer tarandus*). During the denning period, bears moved to higher elevations, remained through June and radio-marked females entered the den in mid October and emerged in mid May (Collins *et al*., 2005). In southwestern Oshima peninsula, Hokkaido, movement pattern, home range and habitat use of brown bears (*Ursus arctos yesoensis*) were investigated during 1987-1990. The male home range size was larger than that of females, and lower deciduous natural forest areas such as beech oak (*Fagus crenata*) and (*Quercus monoglica* var. *grosseserrata*) forest and maple linden (*Acer mono*) and (*Tilia japonica*) forest were intensively used by bears, but subalpine areas such as sasa birch (*Sasa kurilensis* or *S. senanensis and Betula ermani*) forest and sasa community were rarely used, and food availability could influence the habitat use by the bears (Mano, 1994). In Central India, habitat use by sloth bear was determined by availability and seasonal variation in food, shelter and vegetation cover and the availability of fruiting trees, shrubs densities, water, termites and ants (Akhtar *et al*., 2004). A study on sloth bears showed that home-range size was mainly dependent on food supply (Joshi *et al*., 1995 and Desai *et al*., 1997). Bowman (1999) developed a habitat suitability index (HIS) model for black bears in Mississipi based on measures of hard and soft mast production and found that soft mast basal area, hard mast canopy cover and hard mast area of mature trees were the best indicators of black bear habitat suitability. In addition to mast production data, factors like canopy closure, horizontal cover and den availability were found important habitat components for black bears (Landers *et al*., 1979; Hamilton and

Marchinton, 1980; Smith, 1986; Hellgren and Vaughan, 1989; Oli *et al*., 1997; Dobey *et al*., 2002 and Hersey *et al.,* 2005).

2.6 Feeding ecology

Most bears were opportunistic omnivores, their diets comprised of fruits, other vegetative materials, and in lesser amounts, mammals, fishes and insects. Evolutionary, brown bears have developed several adaptations for herbivory, including expansion of molar chewing surfaces and longer claws for digging. Nevertheless, they have maintained an unspecialized digestive system capable of digesting protein with efficiency equal to that of obligate carnivores (Bunnell and Hamilton, 1983). Most commonly, brown bear feeding habits have been quantified by analysis of scat contents. However, because of the differential digestibility of foods, contents of fecal residue were rarely equivalent to amounts of foods ingested by bears. The resulting underestimation of highly digestible foods was found most pronounced for meat and fish diets (Hewitt and Robbins, 1996).

The major food items of brown bear were grouped into variety of ways based on taxonomic group and method of acquisition (LeFranc *et al*., 1987). They included (1) vegetative matter readily available for grazing such as graminoids, horsetails and forbs; (2) roots, corns and bulbs acquired by digging; (3) fruits produced from shrubs; (4) insects harvested from nests or aggregation sites, including ants (Formicidae), wasps (Vespidae) and moths and beetles; (5) mammals and birds, acquired through predation or scavenging, including ungulates and rodents and (6) fish acquired through predation or scavenging, including salmon and trout.

The omnivorous nature of the grizzly bear was recognized decades ago (Wright, 1909 and Storer and Trevis, 1955). Because bears have been noncecal monogastrics, they could not digest fiber efficiently (Bunnell and Hamilton, 1983). Highly digestible and high calorie foods were found essential to their diet (Pritchard and Robbins, 1990; Welch *et al*., 1997 and Hilderbrand *et al*., 1999a). Brown bears were unlikely to attain large body size consuming vegetable diets (Welch *et al*., 1997; Hilderbrand *et al*., 1999a; Jacoby *et al*., 1999 and Rode, 1999). Grizzly bears were commonly found to consume herbaceous vegetation during spring and early summer in many ecosystems (Herrero, 1972). Pine nuts were found to be an important food in the more xeric portions of grizzly bear range (Herrero, 1972). Mealey (1977) and Kendall (1981) discussed the use of white bark pine nuts by bears in the Yellowstone National Park. Even in areas with abundant meat or fish resources, grasses, forbs, and sedges could make up the majority of diet in spring and early summer (Lefranc *et al*., 1987 and Mace and Jonkel, 1986). In the northern Rocky Mountains (McLellen and Hovey, 1995) and in captive feeding studies (Rode *et al*., 2001), brown bears selected forbs over grasses. This was due to the fact that forbs retained their nutritional value longer than grasses with advanced phenology (McLellan and Hovey, 1995). In the wild, male bears were found to be more carnivorous than females (Jacoby *et al*., 1999). Meat eating by adult males provided the necessary calories to maintain a large body size, which led to sexual dimorphism (Hilderbrand *et al*., 1999a).

Bears can also be effective predators. In early summer, neonates were actively hunted. Moose, caribou and elk calves were found to be seasonally important foods (Ballard *et al*., 1981; Larsen *et al*., 1989; Gunther and Renkin, 1990; Hamer and Herrero, 1991; Green *et al*., 1997; Mattson, 1997 and Gau, 1998). Marine mammals, rodents

and ground nesting birds and their eggs were eaten when available (Nagy *et al*., 1983b and LeFranc *et al*., 1987). Insects were found high in lipid content and formed one of the most calorie rich foods consumed by bears (Kevan and Kendall, 1997). Fruits of blueberries, huckleberries, buffaloberries, devil's club, bearberry and other species were seasonally important foods for bears throughout much of their range in North America. High carbohydrate content made berries important summer and fall foods. When available, bears were found to spend up to 50% of the day foraging on berries; foraging efficiency was related to fruit abundance, size and distribution (Welch *et al*., 1997). Roots, corns and bulbs were commonly used by bears in the Rocky Mountains and interior Alaska. Roots of hedysarum (*Hedysarum spp*.) were dug in all mountainous and arctic habits of Canada and Alaska, but were not a major diet item (LeFranc *et al*., 1987). White bark pine nuts were also an important food wherever the species was abundant in the contiguous United States (Mattson *et al*., 1991a; Mattson *et al*., 1991a and Mattson and Reinhart, 1997). Almost all seeds consumed by bears were excavated from the middens of red squirrels (Mattson and Reinhart, 1997). Pine nuts were found high in fat content and one of the most energy rich foods consumed by bears. Consumption of soils has also been documented in the GYE (Mattson *et al*., 1999a). Soils consumed by bears were high in potassium, magnesium, and sulfur. This behavior was high prominent primarily during March-May and then during August-October, and also coincided with the time of peak consumption of ungulate meat and mushrooms. Mattson *et al*. (1999a) speculated that bears were consuming soils to compensate potassium deficiencies incurred during hibernation. Anthropogenic foods (i.e., garbage, livestock feed, pet food, bird seed, human foods, garden crop, honey) were used by brown bear wherever humans and bears coexisted (Herrero, 1985). Open garbage dumps remained a source of highly nutritious foods

when available. On the north slope of Alaska and the barren grounds of northern Canada, brown bears occupied a treeless landscape, and they were found dependent on herbaceous plants, roots and berries when seasonally available (Gebhard, 1982; Hechtel, 1985 and Phillips, 1987). Meat from scavenging or predation on caribou (*Rangifer terandus*), ground squirrels and microtines was also seasonally important for bears (Nagy *et al*., 1983b; Hechtel, 1985; Phillips, 1987 and Gau, 1998).

Likewise the Hokkaido brown bear was also found to be an omnivorous mammal. Herbaceous plants were the dominant food in springs and summer, whereas fruits were the dominant food in autumn (Aoi, 1985; Abe *et al*., 1987; Ohdachi and Aoi, 1987 and Yamanaka and Aoi, 1988). Insects such as ants of formicidae and wasps of Vespidae were also consumed by brown bear during summer. Studies reported that brown bear diet consisted of 50 species in the Daisetsu Mountains, central Hokkaido (Itoh *et al*., 2001), and 75 species in Shiretoko Peninsula (Yamanaka *et al*., 1985). Whereas some studies showed extensive consumption of agricultural crops in late summer (August and September) and also the consumption of sika deer in eastern Hokkaido (Sato *et al*., 2004 and Sato *et al*., 2005a). Brown bears were found to consume various items in late summer when the nutritional values of herbaceous plants decreased (Sato, 2005).

In the Russian Far East which is located in the northeastern region of Eurasia, brown bears were found to consume berries prior to the emergence of vegetation during spring (March-May) in the northern regions, and they consumed Korean pine nuts and Mongolian oak in the south (Revenko, 1993). Ungulates were also found to be an important food source. In coastal regions, brown bears were found to scavenge on

kelp, mollusks, fish and remains of marine mammals and birds. In summer (May-August), diets were made up of mostly of herbaceous plants (Bromley, 1965; Perovskiy, 1991; Revenko, 1993; Berzan, 1997 and Seryodkin *et al*., 2003a). Important food plant families included: Apiaceae, Fabaceae, and Asteraceae in southern regions, and Rosaceae in northern regions. In autumn (August-November), bears were found to eat food with high calories. In most regions of the Russian Far East, brown bears consumed Pacific salmon, Siberian dwarf pine nuts and berries (Ostroumov, 1968; Chernyavskiy *et al*., 1993; Revenko, 1993; Yudin, 1993b and Seryodkin and Paczkowski, 2004). In most of the Amur region, high calorie foods were limited to two species of berries and Siberian dwarf pine nuts (Yudin, 1993b).

The feeding behaviour and seasonal changes in the dietary intake of bears was studied through scat analysis (Hamer and Herrero, 1987; Lander *et al*., 1979; Laurie and Seidensticker, 1977; Mace and Jankel, 1986; Maehr and Brady, 1984; Schller, 1967, 1969; Baskaran, 1990; Manjrekar, 1989; Saberwal, 1989; Schaller, 1969, 1989; Tisch, 1961; Mealey, 1980; Craighead *et al*., 1982; Grenfell and Brody, 1983; LeCount *et al*., 1984; Hewitt and Robbins, 1996; Dahle, *et al*., 1998; Sathyakumar, 2003; MacHutchon and Wellwood, 2003; Robbins *et al*., 2004; Kobayashi *et al*., 2006; Minamiyama *et al*., 2006; Xu *et al*., 2006; Yoshida *et al*., 2006; Nishio *et al*, 2006 and Seomun *et al*., 2006). Many field naturalists and wildlife biologists relied heavily on fecal analysis to quantify diets for various bear species (Mattson *et al*., 1991; McLellan and Hovey, 1995 and Murie, 1981). In Sweden, bears obtained their main energy from berries and ungulates and also from insects, forbs and graminoids (Dahle *et al*., 1998). Bears were also found to consume domestic sheep. The seasonal food habits of brown bears were estimated based on scats analysis in central Norway and

Sweden revealed that there was large consumption of domestic sheep (*Ovis aries)* which provided proteins and lipids to the animal (Dahle *et al.,* 1998). Bear depredation on sheep occurred frequently on Norwegian summer pastures (Mysterud, 1980; Kvam *et al*., 1993; Wabakken and Maartmann, 1994; Dahle, 1996 and Knarrum *et al*., 2006). Food habits of brown bears were studied in agricultural regions and adjoining national parks of Slovakia by analyzing scats and the result indicated that plant material constituted 90.8% of %V and 83.5% of %D (Rigg and Gorman, 2005). Green vegetation, mainly grasses, sedges and herbs, dominated in diet during spring and early summer, with a shift to fruits. Also seasonal congregations of bears in maize (*Zea mays*) fields, and less frequent events of predation on livestock and defensive attacks on humans were observed. Grizzly-brown bear predation on livestock has been documented and described by Murie (1948) and Mysterud (1974). Black bear predation on livestock has been widely documented, but verification of alleged predation was often lacking (Jorgensen *et al*., 1978). A study in Targhee National Forest in Idaho and Wyoming during 1976 and 1977 revealed that black bears killed sheep during both day and night time, but grizzly bears killed sheep only at night (Jorgensen, 1983). Sheep losses were also due to stampede, straying, and decreased contentment often resulted when bears encounter sheep, whether predation occurred or not. Cowan (1972) indicated that sheep killing by bears required experience, and specialized predation techniques might spread through a population via learning behavior.

In Baniff National Park, Alberta, the study showed that graminoids (grasses, sedges and rushes) were the major component of the grizzly bear's diet from May to September, and horsetails (*Equisetum arvense*) were the main food of grizzly bears

during early summer (Hamer and Herrero, 1987). Their study also revealed that ants (Formicidae) were common in bear's diet. Of the 329 scats analyzed from early May to early September, 161 (49%) contained ants. In Greece, brown bear diet was dominated by food items of plant origin (87%), followed by animal material (13%), mostly composed of insects. Grasses and fleshy and dry fruits composed the major proportion of the vegetable part in the bear diet (Mertzanis, 1994). Brown bears in Scandinavia were found to forage in the early spring on ants (Formicidae) they excavated from large ant mounds (Elgmork and Unander, 1998). Of the 143 ant mounds recorded along the tracking routes, 63 (44%) were excavated by bears. Of these, 54 (86%) were used for food and the study also revealed that brown bears used large ant mounds for 3 purposes: for nutrition, as day beds, and for winter dens. In Sweden, Bjorklund (1996) reported that bears resting on ant hill might be benefited from the formic acid sprayed by the ants on the fur, which acted as a repellent against ectoparasites. Ohdachi and Aoi (1987) collected seasonal food habits information from 1975 to 1984 in 4 diverse areas on Hokkaido island and found that bears food varied seasonally in each area and differed among areas largely because of differences in food availability. Their study revealed that brown bears on Hokkaido Island were principally vegetarians, and animal material was only 5% by weight of the annual diet. Ants were the most abundant animal material. Food habits of European brown bears have also been investigated by Couturier (1959), Berducou *et al*. (1982, 1983) and Dendaletche (1982) in France, and by Zunino (1976) in Italy.

Food habits of brown bears have been studied in Plitvice Lakes National Park, Yugoslavia by Cicnjak *et al*. (1987) by analyzing 95 scats and plant material was found in 76% of the samples, whereas 24% contained both plant and animal material

mostly insects. The seasonal food habits of grizzly bears were documented in the firth river valley, Ivvavik National Park, Northern Yukon, Canada during 1993-95 based on scats analysis, direct observations and feeding sites investigations. The study revealed that in spring, the grizzly bear primary food plants were alpine hedysarum (*Hedysarum alpinum*) roots and over-wintered berries such as crowberry (*Empetrum nigrum*). The main food plants in summer were common horsetail (*Equisetum arvense*) and bearflower (*Boykinia richardsonii*). Bears fed primarily on bog blueberries (*Vaccinium uliginosum*), crowberries, horsetail and bearflower in fall. When blueberries were not available, grizzly bears dug for alpine hedysarum roots. In addition to eating plants, grizzly bears killed or scavenged caribou (*Rangifer tarandus*) and hunted Arctic ground squirrels (*Spermophilus parryii*) and microtines when available. (MacHutchon and Wellwood, 2003). Grizzly bears in Ivvavik National Park were also found to feed on insects during summer (Hamilton and Bunnel, 1987; Hamer *et al*., 1991; Mattson *et al*., 1991 and McLellan and Hovey, 1995). Hechtel (1985) found a few instances of insect feeding by grizzly bears, and alpine hedysarum roots, bear berries and arctic ground squirrels were the most common fall foods in western Brooks Range. Roots of pink hedysarum (*Hedysarum alpinum*) were also are an important food for grizzly bears in Baniff National Park (Hamer and Herrero, 1987b) and elsewhere in Canada (Pearson, 1975 and Russell *et al*., 1979) and Alaska (Murie, 1981 and Phillips, 1987). Hedysarum roots were major food for grizzly bears over much of their Canadian and Alaskan range (Pengelly and Hamer, 2006). Arctic ground squirrels and microtines were more commonly eaten by bears as fall progressed (Phillips, 1987). Grasses, crowberry and some soopolallie (*Shepherdia canadensis*) were the most common fall foods in the Barn Range, but alpine hedysarum roots and arctic ground squirrels were also used (Nagy *et al*.,

1983a). Although insects constituted >40% of the diet of bears in some areas, but it constituted <10% in brown bears (Clevenger *et al*., 1992; Elgmork and Kassa, 1992; Mattson *et al*., 1991a; Mertzanis, 1994 and Ohdachi and Aoi, 1987). The comparison of black and grizzly bear food habits were investigated by Aune (1994). The scat analysis showed that the food items represented 11 major taxonomic groups including mammals, insects, birds, trees (pine nuts), sporophytes, forbs, roots, graminoids, shrub fruits, garbage and others. Graminoids, forbs and insects were the most common bear foods and had the highest percent volume of all bear food taxon. Domestic cattle (*Bos taurus*) and deer (*Odocoileus sps*) were the most common mammals eaten by black and grizzly bears. Other large hervivores in the scats of bears were domestic sheep (*Ovis aries*) and elk (*Cervus elaphus*). Insects and birds were also found in bear diets. The study also revealed that only grizzly bear dug roots during the summer and fall while black bear did not as very little root matter was detected in black bear scats.

Consumption of pondweed rhizomes by grizzly bears (*Ursus arctos hirribilis*) was documented in the Yellowstone region (Mattson *et al*., 1991, 2004, 2005 and Craighead *et al*., 1995). Grizzly bear were found to consume mice and voles in this region. Grizzly bears in Yellowstone National Park were also relied heavily on garbage dumps (Craighead *et al*., 1995). Brown bears in Dillingham, Alaska were frequent visitors to the city dump sites, and for some bears, it was a primary food source (Van Daele, 1995 and Peirce *et al*., 2006). Grizzly bears found to feed on meat wherever it was available, and the meat provided the majority of energy to bears (Mattson, 1997 and Jacoby *et al*., 1999). Meat was found highly digestible to bears and contained high concentrations of energy (Pritchard and Robbins, 1990). Grizzly

bears relied on predation to obtain meat from smaller-bodied ungulates (Mattson, 1990, 1997). Abundant meat resources were found to positively affect body size, reproductive success and population density of grizzly bears, and adult female body mass and mean litter size and density of brown bear populations were related to salmon consumption (Hilderbrand *et al*., 1999). Populations of brown bears without access to salmon were found to have lower body weights, produce smaller litters and occur at lower population densities than populations with access to salmon (Miller *et al*., 1997 and Hilderbrand *et al.*, 1999). Northern grizzly bears feeding on caribou on a regular basis were found to have higher densities and productivity than population that did not feed on caribou (Reynolds and Garner, 1987). Hechtel (1985) and Nagy *et al*. (1983a) found only small amount of caribou in scats, but suggested that caribou were under represented in scats and actually were a more common food. Caribou were the primary food of grizzly bears in the central Canadian Arctic during most of their active season (Gau *et al*., 2002). Arctic ground squirrels were commonly eaten by grizzly bears on the northern coastal plain of the Prudhoe Bay oil fields, Alaska (Shideler and Hechtel, 2000) and the Tuktoyaktuk Peninsula and Richards Island, Northwest Territories (Nagy *et al*., 1983). Variation in grizzly bear food habits was common (Hechtel, 1985; Stemlock and Dean, 1986; Hamer and Herrero, 1987; Mattson *et al*., 1991 and McLellan and Hovey, 1995). Bunnell and Hamilton (1983) indicated that grizzly bears changed food plants with seasons in response to changes in digestibility to optimize their energy and protein intake.

Mclellan and Hovey (1995) studied the food habits of grizzly bears and revealed important food types by seasons were: spring graminoids, forbs and ferns; summer oats, insects, fruits and forbs; autumn-tree fruits, nuts and insects; and winter nuts,

fruits and mammals. Their study also suggested that brown bears of the Plitvice Lakes National Park were largely herbivorous and exhibited distinct seasonal cycles in food consumption and mature beech forests were a major food source for bears in the spring. The food habits of grizzly bears were found to vary with season in the Mission Mountains, Montana (Servheen, 1983). Perennial graminoids and forbs, such as *Taraxacum spp.* and *Trifolium spp.* comprised the bulk of spring foods. Mammal carrion and birds were also important as spring foods. Grizzly bears obtained spring insects by excavating rotting wood from tree stumps and logs. Forbs with starchy and tuberous roots such as *Erythronium grandiflorum*, *Lomatium spp*., and *Hedysarum spp.* were excavated by bears during June and July. Domestic tree fruits (apples, plums and pears) were the major autumn food resource used on the west slope of the Mission. In Trentino, Italy, agricultural lands and orchards provided an important autumn food source for brown bears (Osti, 1975). Feeding habits of Asiatic black bears have been investigated in Japan by analyzing the isotopic changes along the entire length of hair samples (Mizukami *et al*., 2005). Diets were estimated from fecal residues and stable isotope analyses of hair (Fortin *et al*., 2007). Their study reveals that both sexes of brown bears visited salmon streams and consumed significant amounts of salmon, but only male American blacks visited streams and then consumed minimal amount of salmon. Thus, brown bears were largely carnivorous and black bear were largely herbivorous and frugivorous. Like brown bears, sloth bear (*Melursus ursinus*) has been the only species of ursidae adapted to feed on insects, especially termites and ants. Dietary composition of sloth bear was studied based on frequency occurrence and percent weight of different food items in scats (Gokula *et al.*, 1995; Baskaran *et al*., 1997 and Desai *et al*., 1997) as well as through direct observation of feeding behavoiur (Joshi *et al*., 1997). In Central India, *Ficus* species

was found to be important to bears (Bargali *et al*., 2004). Study on diets of sloth bears in Royal Chitwan National Park, Nepal revealed that diets of sloth bears were dominated by insects (>90%), especially termites (>50%) from September through April, but they relied heavily on fruits from May through August (Joshi *et al*. 1997).

2.7 Reproduction

Reproductive biology of the brown bear was found to be similar to that of the black bear (Craighead *et al*., 1995). Breeding occurred in late spring, and the fertilized ova developed to the blastocyst stage. Implantation occurred in late November, followed by a 6 to 8-week gestation period and birth (Pasitschniak-Arts, 1993). On average, females attained sexual maturity sometimes between 4 and 7 years of age, and found to give birth to one to three cubs about every 3 years (Craighead and Mitchell, 1982). Offspring remained with the female for 2-4 years before weaning. Brown bears have been found promiscuous. Females were found to mate with multiple males and might have a litter with offspring sired by different males; males could sire litters with multiple females in a breeding season (Craighead *et al*., 1995, 1998). Mating was found to occur at concentrated food sources (Glenn *et al*., 1974 and Craighead *et al*., 1995) or in poor-quality foraging sites (Herrero and Hamer, 1977; Hamer and Herrero, 1990 and Brady and Hamer, 1992). Pair bonds could last several weeks (Murie, 1944; Herrero and Hamer, 1977and Hamer and Herrero, 1990) or might last only a few hours (Craighead *et al.,* 1969). Female brown bears did not reach sexual maturity until 3.5 years old (Hensel *et al.,* 1969; Ballard *et al.,* 1982; Craighead and Mitchell, 1982 and Aune *et al*., 1994), and some females were found to produce first litters at the age 4 years. Age of first litter production in brown bears varied widely

geographically (LeFranc *et al*., 1987; Blanchard, 1987; Stringham, 1990 and McLellan, 1994), and was related to age at maturation and body size (Blanchard, 1987 and Stringham, 1990), which in turn was positively related to diet quality (Hilderbrand *et al*., 1999a). The number of cubs varied among individuals and populations but was found typically 1-3 per litter. Litters of four were rare (Onoyama and Haga, 1982; Bunnell and Tait, 1985; Sellers and Aumiller, 1994 and Case and Buckland, 1998), but litters as large as six were also documented. Mean litter size has been correlated with adult female body mass, intake of dietary meat, primarily salmon and ungulates (Bunnell and Tait, 1981; Stringham, 1990; McLellan, 1994 and Hilderbrand *et al*., 1999a); and garbage (Stringham, 1986). Litter size has also been related to latitude (Bunnell and Tait, 1981 and Stringham, 1984), climate (Picton, 1978 and Picton and Knight, 1986); there were some exceptions (Wielgus and Bunnell, 2000). Mean litter size upon emergence from dens was 2, which decreased to 1.5 at weaning. (Kovach *et al.*, 2006). Though lactation in many species was found to occur when food resources were abundant, brown bear cubs were born in winter when female was fasting. Farley and Robbins (1995) examined milk composition, lactation characteristics, cub growth, and maternal mass changed for brown bears during denning season. Brown bear milk was more concentrated than that of most terrestrial carnivores and found to contain about half the fat and total energy of polar bear milk. The mass of milk consumed throughout lactation averages 224 kg/cub (Farley and Robbins, 1995).

2.8 Human-bear conflicts

Bears have been reported to cause extensive damage to agricultural crops, apiaries, orchard fruits, and livestock (Bargali *et al*., 2005; Peyton, 1980; Jorgensen, 1978,

1983; Vaughan *et al*., 1989; Servheen, 1990; Conover and Decker, 1991; Reid *et al*., 1991, Stowell and Willing, 1992; Ambrose and Sanders, 1978; Azuma and Torii, 1980; Will, 1980; Watanabe, 1980; Singer and Bratton, 1980; Horstman and Gunson, 1982; Knight and Judd, 1983; Maehr, 1983; Elowe, 1984; Hygnstrom and Craven, 1985; Calvert, 1992; Swenson *et al*., 1994; Huzumi, 1994, 1999; Garcia-Gaona, 1997; Jonker *et al*., 1998; Garshelis *et al*., 1999; Huygens and Hayashi, 1999; Angeli, 2000; Iswariah, 1984; Chauhan, 2003; Huygens *et al*., 2004 and Fredriksson, 2005). In the alpine pastures in India, brown bears were found to cause extensive livestock depredation, and there were reports of killing of brown bears by the migratory graziers to reduce livestock depredation and there were reports of killing of brown bear by the migratory graziers (Sathyakumar, 2006a). Increased incidences of livestock depredation and attack on humans by black bears have also been reported by Sathyakumar (2006b). In Great Himalayan National park, brown bear and black bear were found responsible for high livestock casualty (Chauhan, 2003). There were 3 human casualties by black bear and 355 livestock killing by both black and brown bears during 1989-1998. In Garhwal and Kumaon districts of Uttarakhand, black bear caused 154 human casualties during 1991-2001 (Chauhan, 2004). Bears caused 42 fatal human injuries in the Province of Alberta during 1960-1998, 29 (69%) casualties were by grizzly bears (*Ursus arctos*) and 13 (31%) injuries by American black bears (Herrero and Higgins, 2003).

In Mexico, United States and Canada, black bears were found to damage agricultural crops, apiaries, fish farms and caused livestock and human casualties (Michael *et al*., 1999). Black bear depredation on agriculture crops has become an increasing concern in Massachusetts (Jonker *et al.,* 1998). Bears were found to damage agricultural

commodities in their search for alternative food sources (Will, 1980; Horstman and Gunson, 1982; Maehr, 1983; Elowe, 1984 and Hygnstrom and Craven, 1985). Depredation by black bears was found to be linked with mature growth stages of corn, peak pollination activities of bees and calving season of livestock (Jonkel *et al*., 1998 and Calvert, 1992). In Japan, black bears caused significant damage to coniferous plantations, agricultural crops, apiaries, fish farms and livestock and human casualties (Toshihiro, 1999 and Tsutomu and Joseph, 1999). The inappropriate disposal of trash, agricultural and marine refuse acted as major attractants for brown bears and resulted human bear conflict (Yamanaka, 1986 and Mano, 1990a, b). In Austria, attacks on cattle, pigs and beehives were found quite common (Gulleb, 1993). In Scandinavia, the brown bear population was reported increasing and dispersing, that resulted in more interactions with humans (Swenson *et al*., 1999).

The human-brown bear conflict was studied in the northeastern region in Turkey, where human settlements were small and scattered, and there was relatively high level of conflict, especially involving damage to beehives, field crops, orchards and livestock mainly sheep (Ambarli and Bilgin, 2005). In a study conducted on the human-bear conflict in Greece, there was significant difference in regard to the temporal and spatial distribution of both livestock depredation and crop damage (Karamanlidis *et al.*, 2005). Ohdachi and Aoi (1987) studied the feeding behaviour of brown bears in Hokkaido, Japan and found that besides fruits, agricultural crops, including corn, potatoes and rice, were also consumed by brown bears during spring season that resulted in conflict situation. In Romania, large carnivores were found to live near livestock than in any other European country and economic aspects of large carnivore-livestock conflicts have been studied (Mertens and Promberger, 2001).

Species killing livestock during summer were primarily wolves (*Canis lupus*, 63%) and bears (*Ursus arctos*, 36%). Ninety one percent of livestock was sheep. Interaction between brown bears and humans was studied in Scandinavia (Swenson *et al*., 1999) and no cases of direct attack or physical contact were recorded, but bluff charges were made, and they concluded that the Scandinavian brown bear was not particularly dangerous. One of the most important factors negatively influencing public attitudes towards brown bears and other large carnivores was depredation on livestock (Kaczensky, 1999). This was especially true in Norway, where a small population of 20-55 bears killed about 2,000 sheep annually and unattended sheep grazing on forested range was responsible for this depredation. Bears were found to attack livestock primarily at night or during fog, heavy rain or storms (Genov and Wanev, 1992). Bear population size and livestock damage was not necessarily correlated, though sheep were the most important domestic prey for bears (Kaczensky, 1999). Similarly in the Abruzzo region, Fico *et al*. (1993) did not observe a significant correlation between number of livestock present and number of livestock taken by bears in different years. A study on human-sloth bear conflict was conducted in Madhya Pradesh, India by Chauhan and Rajpurohit (1996) and Rajpurohit and Krausman (2000). Their study revealed that number of human casualties by bears was substantial. In 13 protected areas and 17 forest divisions, 48 human deaths and 687 mauling occurred during the years 1989 to 1994. In North America, only approximately 100 people were killed by grizzly bears in the past 100 years (Herrero, 1985). In Glacier National Park, there were 24 injuries and 6 deaths caused by grizzly bears between 1939 and 1980. Conversely, there was only one death from a black bear in Yellowstone Park and none in Glacier park from 1939 to 1978 (McCullough, 1982). Grizzly bears equipped with radio transmitters were monitored in and around

Yellowstone National Park between 1974 and 1979 for studying livestock depredation. Ten of the bears were known or suspected to kill livestock; 3 preyed on cattle, 6 on sheep, and 1 on both. Their study also revealed that most bears that came into contact with cattle did not make kills, and cattle were less likely to cause conflict with grizzly bears than were sheep (Knight and Judd, 1983). There was considerable level of human-bear conflicts in Jewal basin hiking Area, Swan Mountains, Montana (Mace and Waller, 1996). Human-sun bear conflict in form of agricultural crop damage was also recorded in East Kalimantan Indonesian Borneo (Fredriksson, 2005). Predation on sheep by brown bears in Slovakia was studied and it was found that in 87% of reported attacks, 0-3 sheep were lost and most attacks occurred between dusk and dawn (Rigg and Gorman, 2005). A comparison among European countries revealed that Norway had highest livestock depredation rates by far; at least 25 times as many sheep were annually lost to bear predation per brown bear than in other countries (Kaczensky, 1996). In Norway, large carnivore-livestock conflicts have prompted several studies on the prevention or reduction of sheep depredation, including the economics and social aspects of depredation (Wabaakken and Maartmann, 1994; Linnell *et al*., 1996; Mysterud *et al*., 1996; Flaten and Kleppa, 1999; Krogstad *et al*., 2000 and Zimmermann *et al*., 2003). Bear depredation on sheep occurred frequently on Norwegian summer pastures (Mysterud, 1980; Kvam *et al*., 1993; Wabakken and Maartmann, 1994; Warren and Mysterud, 1995 and Dahle, 1996). In Norway, bears selected ewes over lambs (Mysterud, 1980; Kvam *et al*., 1994; Warren and Mysterud, 1995 and Knarrum *et al*., 2006). Brown bears were reported to kill more cattle in other countries (Murie, 1948; Knight and Judd, 1983; Kaczensky, 1996 and Swenson *et al*., 1999). Studies revealed that in many areas with both sheep and cattle, brown bears preferred sheep (Bobek *et al*., 1995; Garcia-gaona,

1995; Nedelec *et al*., 1995; Kaczensky, 1996 and Swenson *et al*., 1999). Body size of the predator was found to influence prey selection. Consequently, large brown bears were more likely to kill cattle than smaller bears. Haglund (1968) found that adult moose were killed mainly by large brown bears, and Eide (1965) found the same for cattle on Kodiak Island. Adult male bears were found to be predominantly active during night, and this time was crucial for livestock depredation (Wabakken and Maartmann, 1994). In North America, domestic livestock and beehives were found to attract to grizzly bears (Mattson, 1990). Under certain conditions, grizzly bears were found to kill substantial number of cattle and sheep (Murie, 1948; Johnson and Griffel, 1982; Jorgenson, 1983; Knight and Judd, 1983 and Brown, 1985). Both grizzly and black bears were found to cause substantial damage to beehives (Jorgensen *et al*., 1978). Along Rocky Mountain East Front in Montana, 44% of conflicts were due to cattle depredation by bears and 40% were due to property damage during 1980s (Aune and Kasworm, 1989). The conflict locations were found to be most strongly associated with rivers and creeks, followed by sheep lambing areas and fall sheep pastures and majority of conflicts occurred in a small portion of the study area, where concentrations of attractants existed that overlapped with bear habitat. During 1991-1994, 82% of all human-grizzly bear conflicts were attractant related and approximately 55% of conflicts were associated with livestock presence (Madel, 1996). Grizzlies were found to prefer ambush predation while preying on large animals such as adult moose (*Alces alces*), elk (*Cervus elaphus*) and domestic cattle (Murie, 1948 and Mattson, 1997). In Venezuela, Colombia, Ecuador, Peru, and Bolivia, Andean bears were perceived as livestock predators where herding was common and direct observations of cattle depredation by bears were reported at 3 sites in Colombia and Ecuador (Goldstein, 2006). In Venezuela, numerous cases of

bear-livestock interactions were reported (Goldstein, 1991a, 2002). There have been recent reports of bear-livestock conflicts from Austria, Bulgaria, Canada, China, Finland, France, Greece, India, Italy, Japan, Mexico, Norway, Poland, Romania, Russia, Slovakai, Sweden, Spain, United States and the former Yugoslavia (Servheen *et al*., 1999). Overall, injuries to humans caused by bears of any species were rare, though such events were often well publicized (Herrero, 1985; Middaugh, 1987 and Herrero and Fleck, 1990). Conflicts between people and American black and grizzly bears have been well documented.

Chapter 3

Study area

3.1 Background

Endowed with natural beauty, Himachal Pradesh (H.P.) has geographical area of 55, 673 km^2. The state is almost wholly mountainous with altitudes ranging from 350m to 6,975m above the main sea level. Its location is between latitude 30°22′40″ N to 33° 12′ 40″ N and longitude 75° 45′ 55″ E to 79° 04′ 20″ E. The area falls in the Himalayan chain of mountain systems which is the line of demarcation between faunal realms; the oriental region to the South and Palaearctic towards the North. The majority of the area falls in the Western Himalayan Temperate Zone. The temperate climate is more because of altitude than latitude and is thus different from the temperate climate met within Europe.

The Chamba and Kangra districts comprise of interesting landscape features due to intermingling and proximity of various mountain ranges viz., Shivaliks, Dhauladhar, Pir Panjal, Greater Himalayan and Zanskar. The region is generally located at higher latitude compared to rest of the Himachal and western Himalaya. Proximity to the western arid region, sharp ecological gradients, long and severe winters, shorter monsoon season compared to rest of the Himalaya, and relatively long history of human use have greatly influenced the floral and faunal communities in the area. Biogeographically these districts'-fall in the North-western Himalaya (2 A) flanked by hot and cold arid regions on the south and north respectively. The existing protected areas in the region, viz. Kugti wildlife sanctuary, Tundah, Kalatop Khajjiar and

Gamgul Siabehi are relatively less disturbed and support several rare and endangered species of flora and fauna.

3.2 Biophysical features

The study was carried out in Kugti wildlife sanctuary which was first notified in the year 1962. In 1974, it was re-notified by the Government of Himachal Pradesh in order to give legal protection to its wildlife. The sanctuary is located in the north-eastern part of Bharmour forest division of Chamba district, Himachal Pradesh, covering an area of 379 km^2. The geo-coordinates of the study area lie between the latitude 32º 20' N and 32º 35' N, and longitude 76º 35' E and 76º 55' E **(Map 1)**. On one side, the study area falls in the Pir Panjal Himalayan range. It forms the upper catchment of Budhil nala, one of the tributaries of river Ravi.

The topography of the area is mountainous comprising of rugged deep gorges and steep slopes with an altitudinal range of 2400m to 5000m, and includes different zones like temperate (2000-2800m), upper temperate (2800-3300m), subalpine (3300-3600m) and alpine zone >3600m. The upper reaches of the sanctuary has a large number of glaciers and snow banks which give rise to numerous streams and lakes. The sanctuary forms gateway to Lahul and Spiti through a number of high passes which have been used by the local Gaddi shepherds since historical times. On the south, several passes lead into Dhaula Dhar ranges. On the southern flank of the sanctuary lies a sacred peak locally known as Mount Kailash (5656 m) and a glacial lake, Mani Mahesh (4572 m). The lake is visited by over 70,000 pilgrims every summer. **Photograph 1** shows alpine and sub-alpine areas in Kugti wildlife sanctuary.

The climate of the area is typically temperate and alpine type. From December to March, temperature remains less than 10º C and comes down to –10º C because of heavy snowfall. The change over from winter to summer is gradual. The summer temperature goes up to 25 C. During March and April, weather is cool and bright, and the temperature begins to rise rapidly after the middle of April and continue till end of the rainy season in July. Month of October and November are comparatively dry and cold weather usually starts by the middle of November. The annual rainfall in the Kugti wildlife sanctuary is recorded 1400mm. As a whole, the climate is temperate with well-marked seasons. The south facing physical environment in the Kugti wildlife sanctuary can be described as rocky terrain with frequent outcrops of huge boulders, slate and rock faces while north facing part of sanctuary are having dense mixed forests.

3.3 Vegetation

The major vegetation types in the Kugti wildlife sanctuary include Temperate broad leaf (12/C 1e), Temperate conifer forest (12/C 1f), Moist deodar forest (l2/C 1c), Blue pine (12/2 S 1), Blue pine and spruce (12/C lc), Temperate broad leaf conifer (I 2/C 1d), Sub-alpine forest (I4/C 1b), Temperate secondary scrub (12/C 1/DS2), Alpine scrub (IS/C 1), Birch *Rhododendron* or stunted forest (IS/C 2/E1), Temperate grasslands (l2/D S3), Alpine meadows (1S/C 3) and a several intermediate and secondary seral stages (Champion and Seth, 1968). **Map 2** shows the vegetation and landcover with broad habitat categories in Kugti wildlife sanctuary. **Photograph 2** shows gots or pastures and agricultural land in the sanctuary area.

A list of angiosperms and gymnosperms occurring in Kugti wildlife sanctuary was prepared based on the earlier miscellaneous reports (cited in Chowdhery and Wadhwa, 1984) and a brief reconnaissance survey report (Rawat, 1998). During the present study, a checklist of flora with important plant species found in the sanctuary has been prepared and shown **Appendix I**.

The flora found to be comprised of about 88 families, 260 genera and 496 species. Of these, 75 families, 218 genera and 428 species belong to dicots and remaining are monocots. Some of the rare and endangered species found within the sanctuary are *Delphinium uncinatum, Erysimum thomsonii, Megacarpaea polyandra, Picrasma quasioides, Valeriana pyrolaefolia, Gentiana kuroo, Arnebia benthamii, Eremurus himalaicus* and *Dactylorhiza hatagirea.* Large families of flowering plants include Asteraceae, Fabaceae, Rosaceae, Ranunculaceae, Polygonaceae and Lamiaceae. Several species of local economic importance are patish (*Aconitum heterophyllum*), mitha parish (*Aconitum violaceum*), Bankakri (*Podophyllum hexandrum*), Himalayan blue poppy (*Meconopsis aculeata*), *Megacarpaea polyandra*, dhoop (*Jurinea macrocephala*), ratanjot (*Macrotomia benthaml*), karu (*Picrorhiza kurrooa*) and salam panja (*Dactylorhiza hatagirea*). A few tree species planted within the sanctuary are angu (*Fraxinus macrantha*), walnut (*Juglans regia*), and horse chestnut (*Aesculus indica*).

Much of the temperate belt (3000m), especially on the south facing slope is characterized by the secondary scrub and grassy slopes. The characteristic grass species include *Phaceleurus speciosus, Chrysopogon gryllus, Danthonia cachemyriana, Koeleria cristata, Andropogon munroi and Themeda anathera.* The steeper north facing and rocky slopes have largely spruce and fir. At higher slopes

these are replaced by birch and *Rhododendron*. Unlike in the eastern parts of Himachal Pradesh, there are very few patches of oak. Oaks are rather very sparse in the sanctuary. *Quercus ilex* forms scattered patched around villages towards lower fringes of the park. Bamboo brakes are rather sparse in the sanctuary.

The alpine vegetation in Kugti wildlife sanctuary is divisible into tall herbaceous formations in the valley bottoms, extensive patches of golden fern (*Osmunda claytoniana*), moist mixed meadows on the higher slopes, alpine scrub and alpine scree slopes towards the higher slopes. The valley bottoms are heavily degraded and dominated be excessive growth of opportunistic herbs such as *Circsium involucratus, Cirsium falconeri, Morina longifolia,* and *Rumex nepalensis, Impatiens sulcata.* Part of the valley bottom is also dominated by knot weed (*Polygonum polystachyum*). Towards higher slopes the alpine vegetation is laden with a variety of attractive herbs such as species of *Potentilla, Polygonum, Geum, Geranium, Pedicularis, Aster, Eregeron, Phlomis, Delphinium, Ranunculus, Draba, Saxifraga, Sedum, Senecio, Saussurea, Cyananthus, Campanula* and *Meconopsis aculeata*. **Photograph 3** shows *Juniperus spp., Rhododentron campanulatum* and *Betula spp.* in study area.

3.4 Faunal diversity

The Kugti wildlife sanctuary harbours as many as 23 species of mammals, over 150 species of birds and a variety of invertebrates. The mammals found in the sanctuary are given in Appendix II. Despite a heavy pressure by domestic livestock, this sanctuary still supports a variety of mountain ungulates. The sanctuary is also well known for a sizeable population of Himalayan brown bear. Besides brown bear

(*Ursus arctos*), the other wild animals in the study area are leopard (*Panthera pardus*), Himalayan tahr (*Hemitragus jemlahicus*), musk deer (*Moschus chrysogaster*), Himalayan ibex (*Capra ibex*), goral (*Nemorhaedus goral*), serow (*Capricornis sumatraensis*), blue sheep (*Pseudois nayaur*), langur (*Presbytus entellus*) and porcupine (*Hystrix indica*). This sanctuary forms the western most limit of tahr distribution. **Photograph 5** shows brown bear digging activity, and **Photograph 6** shows brown bear feeding on *Rumex nepalensis* in the study area.

Besides the sanctuary is known for a rich diversity of avifauna, major ones being cheer pheasant (*Catreus wallichil*), monal (*Lophophorus impeyanus*), kalij (*Lophura leucomelanos*), koklas (*Pucrasia macrolopha*) and others. The temperate belt of the sanctuary forms ideal habitat for black partridge, cheer pheasant, chukar, several species of laughing thrushes and kalij. The alpine zone have typically monal, koklass and a variety of other birds including golden eagle, upland buzzard, accentors and finches.

3.5 Habitat types

In the study area, vegetation showed high degree of heterogeneity and variable degree of biotic pressure. We classified the habitat types of the study area broadly into 9 different habitat categories viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan Moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests, Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species. The vegetation and landcover map showing different broad habitat categories is shown **(Map 2)**.

3.6 Human habitation

The sanctuary is surrounded by nine villages. There is one village, lower and upper Kugti village with a total population of about 1200 inside the protected area. The inhabitants hold rights to fodder, fuelwood, cultivation, burial grounds and religious activities. The land holding of the farmers are small and scattered. The farmers grow more than two crops in a year and follow crop rotation. Wheat (*Triticum aestivum*) and maize (*Zea mays*) are the main crops, followed by barley (*Hordeum vulgare*), rejma (*Phaseolus sativus*), potato (*Solanum tuberosum*) mash (*Phaseolus radiatus*) and Braresh.

The sanctuary is used by a large number of gaddi shepherds during summer for grazing. The number of sheep and goats brought for grazing in the sanctuary during May to October every year is estimated to be 12,000 to 15,000. The camping sites are locally known as got. **Photograph 4** shows livestock grazing in sub-alpine areas.

There are 22 grazing pastures or dhars located in the sanctuary. However, recent developments of sequential hydel projects in adjacent areas and erection of transmission lines have significantly altered the landscape and resulted in soil erosion and landslides. Increasing tourism, pilgrims and annual fairs and migratory livestock are considered as major conservation threats to this protected area.

Chapter 4

Feeding ecology of brown bear

4.1 Introduction

The Kugti wildlife sanctuary of Chamba district, Himachal Pradesh seems to harbour sizeable population of Himalayan brown bears. Inside Kugti wildlife sanctuary, there is only one village, upper and lower Kugti, and agricultural lands are located away from the village and close to mixed coniferous forests. People invade forests and share natural resources, which results in increasing competition and confrontation with wild animals. Brown bears were seen active during the day hours in alpine and sub-alpine areas, where there was less disturbance. Brown bears raid agricultural crops, fruiting trees in the vicinity of villages and use forest, alpine and sub-alpine areas in search of food and shelter while people collect non-timber forest produce and fuel wood from forests and take their livestock especially sheep and goats in forests for grazing. This common dependency and resource sharing of people and bears results into conflicts in form of livestock depredation and crop raiding by bears and developing antagonism by people for conservation of bears inside the sanctuary.

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, mammals and fishes to insects. Information on composition and seasonal variation in bear diet can be collected either by making direct observations on feeding activities and signs in these areas or indirectly through scat analysis. Scats are required to be analyzed both qualitatively and quantitatively. Dietary composition through scat

analysis has been widely studied on different bear species. In some studies on black bear, both scats and stomach contents were used and in few other cases, only scats were used to study the feeding ecology of bears (Tisch, 1961; Schaller, 1967; Laurie and Sedensticker, 1977; Landers *et al.*, 1979; Mealey, 1980; Kendall, 1983; Bunnell and Hamilton, 1983; Nagy *et al.*, 1983a; Graber and White, 1983; Hechtel, 1985; Maehr and Brady, 1984; Mace and Jonkel, 1986; Phillips, 1987; Hamer and Herrero, 1987b; Ohdachi and Aoi, 1987; Cicnjak *et al.*, 1987; Clevenger *et al.*, 1992; Mattson *et al.*, 1991a; Aune, 1994; McLellan and Hovey, 1995; Dahle *et al.*, 1998; MacHutchon and Wellwood, 2003; Kobayashi *et al.*, 2006; Minamiyama *et al*., 2006 and Xu *et al.*, 2006).

The brown bears have a holarctic distribution that stretches from Eurasia to North America. With such a wide geographic distribution, food habits of brown bears differ substantially in different geographic areas, and there is marked seasonal variation in food selection (Welch *et al.*, 1997; Hilderbrand *et al.*, 1999a; Rode and Robbins, 2000 and MacHutchon and Wellwood, 2003). In a study in Bieszczady Mountains, Poland, the diet of brown bears was found dominated by vegetable matter, accounting for almost 73% of the volume of scat sample analyzed (Frackowiak, 1997). Such a high percentage of vegetable food was observed in most of brown bear populations in Scandinavia, North America, former Yugoslavia, Japan and Italy (Mealy, 1980; Zuninio, 1976; Mace and Jonkel, 1986; Cicnjak *et al.*, 1987; Odhachi and Aoi, 1987 and Elgmork and Kassa, 1992). 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 a major part of diet (Cicnjak *et al.*, 1987; Schaller, 1969; Landers *et al*., 1979; Nozaki *et al.*, 1983; Maehr and Brady,

1984; Mace and Jonkel, 1986; Odhachi and Aoi, 1987, and Manjrekar, 1989). An examination of 177 scats of brown bear in the Mission mountains, Montana revealed that food habits varied with season. Perennial graminoids and forbs such as *Taraxacum spp.* and *Trifolium spp.* constituted the spring foods. During late spring and early summer, succulent forbes such as *Heracleum lanatum* and other apiaceae became the food sources. Domestic tree fruits (apples, plums and pears) were the major autumn food resources (Servheen, 1983). Manjrekar (1989) reported occurrence of 22 food items based on scat analysis in the diet of black bears in Dachigam national park, India. Over 22% of the overall diet by weight was foliage, 72% was fruit and about 2% was animal matter. *Prunus avium* and *Morus alba* (mulberry) were the major fruits in the diet during June-July, while *Quercus robber* (English oak) and *Juglans regia* (walnut) accounted for a major proportion of diet during September-early October (Manjrekar, 1989). Schaller (1969) investigated the diet of black bears in Dachigam national park during October based on scat analysis. Oak (12%), walnut (33%), and *Celtis australis* (40%) formed the major part of the black bear diet. He also observed bears feeding on fallen oak acrons and walnuts. Sathyakumar and Viswanath (2003) observed black bears on 6 occasions and reported bears feeding on *Rhododendron arboretum*, *Berberis asiatica* and remains of a cattle kill made by a common leopard. Schaller *et al.*, (1989) reported that in China, Asiatic black bears showed a shift from leafy material in early summer diet to fleshy fruits and then to fat-rich fruits before hibernation. In Yellowstone area of Wyoming, Montana and Idaho, food habits of grizzly bears were studied for eleven years and the study revealed that ungulate remains constituted a major portion of early season scats, graminoids of May and June scats and white bark pine seed scats of late season scats (Mattson *et al.,* 1991a). Berries constituted a minor portion of scats during all months

and their study also revealed that diet varied from year to year during May, September and October, and was most diverse during August. In Front Range of Banff national park, food habits were studied by Hamer and Herrero (1987b) during 1976-1980 and their study revealed that horsetails (*E. arvense*) were the main food of grizzly bears during summer. Graminoids (grasses, sedges and rushes) were another major food component of the grizzly bears from May through September. Their study also indicated that ants (Formicidae) occurred frequently in the bears' diet. All species of bears, except polar bears (*Ursus maritimus*), feed on insects, especially ants. In this chapter, we envisaged to study food habits of brown bear in Kugti wildlife sanctuary.

4.2 Methods

The food habits of Himalayan brown bear were determined by analyzing scat samples and direct observations on feeding activities and signs. Brown bears were seen actively feeding during the day time. Diet composition and seasonal variation were studied during the years 2002-2004.

4.2.1 Collection of scats

From April 2002 to December 2004, scats were collected from different parts of Kugti wildlife sanctuary, though systematic collection technique was not feasible in the mountainous and often rugged terrain. Scats were mainly collected while walking on the 22 transects. Scats were also collected from areas other than transects. **Photograph 7, 8 and 11** show collections of bear scat in Kugti wildlife sanctuary. All

these scats were separately placed in plastic bags and properly labeled date-wise and area-wise. Samples were air-dried in the field and stored.

4.2.2 Analysis

Firstly, we calculated the minimum number of scats required for the analysis as shown in **figure 1** 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. Out of the total collection, 222 scats were analyzed; 72, 69 and 81 scats were taken from the summer, monsoon and fall season respectively. Scats were analyzed both qualitatively and quantitatively.

At the time of analysis, scats were weighed separately and only 10% of each scat was taken for the purpose of analysis. Portion of scat sample was immersed in water in a beaker for 10-15 hours. Following this, scats samples were rinsed thoroughly using sieves to remove fruit, vegetative and undigested material, and then suspended in water. Scat samples were also washed in running water to remove the mud and other mix matter using 0.4mm and 0.7mm sieves. Remaining portions of scats were kept in Petridish for oven drying for 15-24 hours at 60º C. Then the scat samples were analyzed manually by separating different components viz. hairs, bones, claws, teeth, fruits, seeds, ants, insect parts and plant matter. Most plants were identified to species level using reference slides and food plants were recorded in the field area. Scat contents were easily identifiable when collected fresh in the field, and the plant remains were easily comparable with reference plant specimens (slides). After the course analysis in the field, scat materials were brought to the laboratory for further

study. Analysis of bear scats in the laboratory was based on the techniques of Tisch (1961), Mealey (1980), Ohdachi and Aoi (1987) and MacHutchon and Wellwood (2003). Basic steps involved were (1) rehydration of fecal material to render it pliable and to restore its original form, (2) separation of material into homogeneous groups by use of screens, (3) identification of contents, and (4) recording of identified materials. All inseparable and unidentifiable crushed matter were considered as waste and discarded.

Dietary composition was estimated in terms of frequency occurrence of food items in the scats and ocular estimate of their volume. Estimates of volume were ocularly assigned to one of the 3 categories: high (66.7%-100% of the scat), medium (33.4%-66.6%), or low (0-33.3%).

4.3 Results

Based on scat analysis, direct feeding observations and indirect signs, the dietary composition of brown bears and seasonal difference in their food habits are as follows:

The items/species area curve was developed to find minimum number of scats required to study the dietary composition. On the basis of this, minimum of 63 scats out of total 72 scats in summer, 45 out of 69 scats in monsoon and 64 out of 81 scats in fall were required to know the dietary composition of brown bear **(Figure 1)**. The analysis of total 222 scats revealed that all the food items were represented in as minimum as 183 scats. The scats collected during summer, monsoon and fall seasons

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

4.3.1 Dietary composition

An analysis of total 222 scats, comprising of 72 scats of summer season, 69 scats of monsoon and 81 scats of fall, showed both plant and animal matter in the diet of brown bear in all seasons. When only plant and animal matters were considered to know their contribution to the diet annually, it was found that the frequency of occurrence of plant matter was higher in the scats of brown bear (79%) than the animal matter (21%) **(Figure 2)**. During summer, monsoon and fall, the frequency occurrence of animal matter was 27.8%, 23% and 9% respectively, and the frequency occurrence of plant matter was 72.2, 77% and 91% respectively. All these dietary composition revealed that the frequency of occurrence of plant matter was higher than the animal matter in all the seasons. The animal matter was found to be comprised of insects, ants and unknown items including hairs, bones, jaws, teeth, claws and nails in the bear diet **(Table 1)**. The plant matter eaten by brown bear comprised of 10 plant species, as confirmed through scat analysis, included seeds of *Prunus persica* and *Prunus cornuta*, and fruits of *Rhamnus virgatus*, *Viburnum cotinifolium* and *Berberis aristata*, and guchhi mushroom *Morchella esculenta* and unknown herbaceous plant matter. Scats of brown bears were found to contain wheat (*Triticum aestivum*) leaves and seeds, jau (*Hordeum vulgare*) seeds, 'bharesh' (*Fagopyrum esculatum*) seeds, seeds of 'phulen' crop, maize (*Zea mays*) seeds, aru (*Prunus persica*) fruits, jammu (*Prunus cornuta*) fruits, kamulu (*Berberis aristata*) fruits, fruits of *Rhamnus virgatus* and *Viburnum cotinifolium* and plenty of herbaceous matter found in the study area.

Photograph 9 and 10 show fresh scats of brown bear containing wheat leaves and barley seeds respectively. **Photograph 12** shows fresh scat of brown bear containing maize seeds, and **Photograph 13** shows presence of barley seeds in the scat.

The annual frequency of occurrence of animal matter in the scats of brown bear was 21% **(Table 1, Figure 3)**. The annual frequency occurrence of ants and insects parts was 9.3% and 5.2% respectively. Whereas the annual frequency occurrence of hairs was 2.9%, bones 2.3%, jaws and teeth 0.6% and claws and nails 0.6% each in the scats of brown bears.

The annual frequency occurrence of plant matter in the scats of brown bear was 79%, and its major part (58.3%) was comprised of unknown plant matter **(Table 1, Figure 3)**. The annual frequency occurrence of agricultural crops was found to be 7.2% in the scats. Based on ocular estimation, the estimated volume for unknown plant matter was high (66.7%-100%) in the bear scats, and insects and ants was medium (33.4%-66.6%). And for rest of the animal and plant matter, it was low (0-33.3%).

Based on 57 direct feeding observations made during 2002 to 2004, brown bears were found feeding on 29 species of plants including agricultural crops. There was considerable difference in the number of items brown bear were observed feeding on food plants in different seasons **(Table 2, Figure 4)**. **Photograph 2, 3 and 4** show extensive digging by brown bear and feeding on plants/ants in different areas. Out of 57 direct sightings, brown bears were found feeding on food plants 184 times during summer, 141 times in monsoon and 139 times during fall season. They were found feeding on *Rumex nepalensis* 48 times, *Chaerophyllum reflexum* 39 times and

Fragaria nubicola 34 times. **Photograph 1** shows brown bear foraging on *Rumex nepalensis* in Kugti wildlife sanctuary. Other food plants/items such as *Impatiens scabrida, Taraxacum officinale, Triticum aestivum* and ants were also preferred by bears and eaten 26, 21, 21 and 26 times respectively while making observations. Whereas the number of times brown bears were found feeding on *Geranium pratens, Gegea elegans, Potentilla argyrophylla, Stellaria media, Stachys melissaefolia* and *Geum elatum* was found to be 19, 17, 15, 15, 14 and 11 respectively. Number of feeding observations made on *Malwa verticellata, Selinum vaginatum, Chenopodium album* and *Fagopyrum esculatum* was 10 times each. The number of feeding observations on *Capsella bursa pastoris* was 9 times, and *Origanum vulgare, Chenopodium foliolosum* and *Artemisia vestita* was 8 times each. *Nepeta laevigata* and *Typhonum spp.* were fed upon 6 and 5 times respectively**. Photographs 5 and 6** show important food plants in Kugti wildlife sanctuary.

4.3.2 Seasonal diet

Both plant and animal matter constituted parts of its diet throughout the year. Amongst the overall annual frequency occurrence of 15 plant and animal food items, plant matter was highest (58.3%) and occurrence of ants heads was highest (13.9%) in animal matter **(Table 1, Figure 3)**. The animal matter of the brown bear diet was comprised of 8 different animals/parts during both summer and monsoon seasons, whereas no animal matter was found in the scats during fall season **(Table 1)**. In case of plant matter, brown bear diet was found to be comprised of 5 plant species during the summer season, 9 plant species during the monsoon season and only 3 species during the fall. Major part of the scats was comprised of unknown plant matter.

The frequency occurrence of animal matter was highest in summer 27.9%, followed by 22.9% in monsoon and 9% in fall **(Table 1)**. During summer, hairs and bones constituted 7% and insect parts and ants constituted 20.9%. Hairs, bones, jaws, teeth, claws and nails constituted 10% of the animal matter during monsoon, and insect parts and ants were 12.9%. Except insects and ants, there was no animal matter found in the scat of brown bear during fall; insect parts and ants constituted 9%.

Among the plant matter, the frequency occurrence of unknown plant matter was found highest in the scats during fall (80.9%), followed by summer (57.4%) and monsoon (44.6%) **(Table 1)**. The estimated volume for unknown plant matter was also high in all the seasons. Fruits of *Prunus persica*, *Prunus cornuta*, *Rhamnus virgatus*, *Viburnum cotinifolium* and *Berberis aristata* showed 7.8%, 15.8% and 9% frequency of occurrence during summer, monsoon and fall respectively. The frequency of occurrence of agricultural crops was found highest (15.7%) during monsoon, followed by summer (1.7%) and fall (1.1%). The annual frequency occurrence of agricultural crops was found to be 7.2% in the diet of brown bears. *Morchella esculenta* was consumed more by brown bear during summer (5.2%) than monsoon season (0.7%). However, the estimated volume for these plants was low in all the seasons. **Photograph 16** shows scat containing mushroom, *Morchella esculenta*.

Using one way ANOVA it was found that bear diet was considerably different between monsoon and fall seasons (F_{crit}= 4.17, df = 1, p = 0.0011), and there was less difference between the bear diets of summer and monsoon seasons (F_{crit} = 4.17, df = 1, p = 0.226).

Figure 5 showed marked monthly variation in the occurrence of different food items in scats of brown bear. Plant matter occurred in the scats from April to December. Wheat was found in most of the scats during summer and fall, and seeds of *Fagopyrum esculatum* were found in the bear scats during August, September and October. *Morchella esculenta* was also recorded from scats during April, May, June and September. *Zea mays* seeds were found in the scats of brown bear during August and September. *Prunus persica* seeds were found in the scats of brown bear during September and October. **Photograph 14 and Photograph 15** show presence of *Prunus persica* seeds in the scats of brown bear.

Availability of most of the food items of brown bear was between March and October months **(Table 3 and 4)**. Food plants: *Capsella bursa pastoris, Chenopodium album, Fragaria nubicola, Rumex nepalensis* and *Taraxacum officinale* were available throughout March/April to September/October. Variety of food plants such as *Chaerophyllum reflexum*, *Napeta laevigata*, *Origanum vulgare*, *Potentilla argyrophylla, Impatiens scabrida*, *Stachys melissaefolia*, *Stellaria media* and *Typhonum seginatum* were available as food plants during May to September. Ants and insects were consumed by bears from the time of emergence after hibernation. Livestock, sheep and goat, were present in large numbers from May till October when nomadic graziers visited the sanctuary area. **Photograph 17 and 18** show scats with bones and hairs of sheep/goat and ants, preferred food of brown bear respectively in Kugti wildlife sanctuary.

4.4 Discussion

We attempted to investigate food habits and seasonal variation in the diet of Himalayan brown bear in Kugti wildlife sanctuary. Both local and migratory livestock and bears were found to share food resources and there was intense competition between them. Brown bears have been found opportunistic omnivores, and they have developed adaptation for herbivory that included having longer claws for digging soil. Food habits of brown bear have been studied in many places through direct feeding observations and scat analysis. The method has been used on a wide range of bear species to infer dietry composition (Schaller, 1967; Hamer and Herrero, 1987b; Mattson *et al.,* 1991a; McLellan and Hovey, 1995 and Bargali *et al.,* 2004).

Although the method of fecal analysis has some shortcomings, but it has the advantage of yielding substantial data without locating or disturbing free-ranging animals (McLellen and Hovey, 1995). It has been realized by making feeding observations on bears that it was not possible to precisely measure dietary intake and composition. Some studies were conducted on the basis of frequency occurrence and percent weight of different food items in the scats (Mealey, 1980; Nozaki *et al.,* 1983; Servheen, 1983; Graber and White, 1983; Maehr and Brady, 1984; Mace and Jonkel, 1986; Ohdachi and Aoi, 1987; Cicnjak *et al.,* 1987; Hamer and Herrero, 1987b; Mattson *et al.,* 1991a; Aune, 1994; Mclellen and Hovey, 1995; Noyce *et al.,* 1997; Frackowiak, 1997; Dahle *et al.,* 1998; Swenson *et al.,* 1999; MacHutchon and Wellwood, 2003; Huygens *et al.,* 2003 and Xu *et al.,* 2006). One could find the frequency of feeding on certain food items or presence of food items in the scats, but not the quantity of food item(s) consumed. Frequency of feeding was found dependent on availability of varied types of food material in a particular area. When

the method of percent occurrence of a food items used, it would not indicate the quantity consumed, and frequent consumption of small quantities would show frequent occurrence of the species in the scats and therefore it would indicate high percent occurrence of food items in the diet (Desai *et al.*, 1997).

We used the scat analysis method to study the feeding ecology of brown bears in our study area. This method has perhaps provided the reliable estimates of food items consumed by the brown bears. In Kugti wildlife sanctuary, the diet of brown bears was found to contain both plant and animal matter, and the annual frequency of occurrence of plant matter was much higher (79%) than the animal matter (21%) in the scats. During summer, monsoon and fall, the frequency occurrence of animal matter and plant matter varied considerably. All these dietary composition also revealed that the frequency of occurrence of plant matter was higher than the animal matter in all the seasons. Scat analysis showed presence of 10 plant species in the brown bear diet that included wheat leaves and seeds, seeds of jaun, bharesh, maize and fruits of aru, jammu, kamulu, *Rhamnus virgatus* and *Viburnum cotinifolium*, and guchhi (*Morchella esculenta*) and plenty of herbaceous matter found in the study area. But based on direct feeding observations, brown bears were found feeding on 29 species of plants including agricultural crops. There was considerable difference in the number of items brown bear were observed feeding on food plants in different seasons. They were found feeding on various food plants 184 times during summer, 141 times in monsoon and 139 times during fall season. These food plants might be present in the unknown plant matter of the scats, and could not be identified during the analysis. For this, reference slides of all food plants available in the study area were required to be carefully prepared and matched with the plant remains found in

the scats. The animal matter was found to be comprised of insects, ants and unknown items including hairs of sheep and goats, bones, jaws, teeth, claws and nails in the bear diet. The estimated volume for unknown plant matter was high in the bear scats, and insects and ants was medium, and for rest of the animal and plant matter, it was low. Like typical omnivorous food habits of brown bears, both animal and plant materials were found to be consumed by bears. Differential feeding on food plants by brown bear could be related with the food preference and availability of these plants in different seasons.

Various studies conducted on food habits elsewhere have been found comparable with our findings. Food habits of brown bears in Plitvice Lake national Park, Yugoslavia were studied and plant matter was found in 76% of the samples, whereas 24% contained both plant and animal matter (Cicnjak *et al*., 1987). Feeding on vegetable and animal material by bears showed their omnivorous feeding behavior, and high consumption of vegetation indicated availability of the items in that area and its importance to their diet. They also documented the evidences of bears preying on cattle and sheep. Grizzly bear (*Ursus arctos horribilis*) were found to consume apple (*Malus spp.*) and plums (*Prunus spp.*) in Montana (Mace and Jonkel, 1986). Grasses and sedges were a staple food for bears, and horsetails, clover (*Trifolium spp.*) and dandelions (*Taraxcum spp.*) were also important food items. Food habits of brown bear were studied in the Bieszczady Mountains in Polish eastern Carpathians and the results indicated that grasses and unidentified plants species constituted a very significant part of bear diet in summer (Frackowiak, 1997). A study on food habits of grizzly bear in the Firth River valley, Ivvavik national park, northern Yukon, Canada revealed that in spring, the primary grizzly bear food plants were alpine hedyserum

(*Hedysarum alpinum*) roots and main food plants in summer were common horsetail (*Equisetum arvense*) and bearflower (*Boykinia richardsonii*) (MacHutchon and Wellwood, 2003).

Most commonly, brown bears feeding habits have been quantified by analysis of scat contents. But because of the differential digestibility of foods, contents of fecal residue were rarely equivalent to amounts of foods ingested by bears. The resulting underestimation of highly digestible foods was found to be most pronounced for meat and fish diets (Hewitt and Robbins, 1996). Grizzly bears were found to consume herbaceous vegetation commonly during spring and early summer in many ecosystems. Even in areas with abundant meat and fish resources, grasses, forbs and sedges were found constituting the major part of the bear diet in spring and early summer (LeFranc *et al.,* 1987). In North America, fruits of blueberries, huckleberries, buffaloberry, bearberry and other species were found to be the seasonally important foods for bears throughout much of their range. Roots, corns and bulbs were found commonly used by bears in the Rocky Mountains and interior Alaska. Roots of hedysarum were extensively dug by bears in all mountainous and arctic habits of Canada and Alaska (LeFranc *et al.,* 1987). Brown bears were also found to be effective predators. In early summer, neonates were found to be actively hunted. Moose, caribou and elk calves were found to be seasonally important foods of bears (Ballard *et al.,* 1981; Larsen *et al.,* 1989; Gunther and Renkin, 1990; Hamer and Herrero, 1991; Green *et al.,* 1997; Mattson, 1997 and Gau, 1998). Anthropogenic foods such as garbage, livestock feed, pet food, human foods, garden crops, honey were also used by brown bears wherever humans and bears coexisted (Herrero, 1985; Van Daele, 1995; Craighead *et al.,* 1995 and Peirce and Daele, 2006). In Kugti

wildlife sanctuary, brown bears were found to extensively dig soil for feeding on grasses, forbs, roots of several plant species. Besides feeding on plant matter, the diet of brown bear was found consisting of insects, ants and livestock, particularly sheep and goats.

We observed that the annual frequency occurrence of plant matter in the scats of brown bear was very high, and its major part was comprised of unidentified food plants. Whereas the annual frequency of occurrence of animal matter in the scats of brown bears was comparatively less. Ants and insects constituted 9.3% and 5.2% respectively of the bear diet. The annual frequency occurrence of hairs, bones, jaws and teeth and claws and nails varied from 0.6% to 2.9%. Food habit studies of Mealey (1980), Servheen (1983), Mace and Jonkel (1986), Cicnjak *et al.* (1987), Ohdachi and Aoi (1987) and Hamer and Herrero (1987b) also revealed the similar findings that ants and insects were the most frequently eaten animal food, which provided consistent source of high quality animal proteins available to bears. According to Southwood (1973), ants were found to contain more than 50% protein. Even a food item comprising of fraction of the diet, such as ants, could provide essential amino acids to bears (Eagle and Pelton, 1983). Diggings and stone uplifting in alpine and sub-alpine zones of the study area suggested that ants and insects constituted the important food items of brown bear.

When we considered the annual frequency occurrence of plant and animal matter in the brown bear diet, there was more plant matter than the animal matter in all seasons in the brown bear diet in the study area. This was found to be similar with vegetarian food habits of brown bear diet studied elsewhere (Cicnjak *et al.,* 1987 and Ohdachi

and Aoi, 1987). The higher occurrence of plant matter in the diet during all seasons could be due to the availability of more preferred herbs in the study area. Presence of wheat leaves in the scats indicated that when the herbs got dried up in October, brown bears started foraging on wheat in the study area. After emergence from hibernation, brown bear dug extensively for foraging on available herbs. So there were large numbers of digging signs in alpine and sub-alpine areas. In the study area, seasonal variation in the dominance of different species in the bear diet also showed their contribution to the survival of brown bear in this area. During summer season, *Rumex nepalensis, Fragaria nubicola, Gagea elegans, Geranium wallichianum, Chenopodium album* and ants and insects contributed a major part in the bear diet. Whereas during monsoon season, livestock especially sheep and goats, crops like *Zea mays, Hordeum vulgare, Triticum aestivum* and *Fagopyrum esculatum* contributed significantly in the diet and during fall, fruits of *Prunus persica* and *Prunus cornuta* also contributed in bear diet. Occurrence of these food items in the scats or bear diet has been found directly correlated with the availability of these food items in different months. Similarly the occurrence of *Triticum aestivum* leaves and *Zea mays* seeds during fall and monsoon was due to their availability in these months. Presence of wheat, maize, jau and bharesh seeds in the brown bear scats in Kugti wildlife sanctuary indicated that when availability of other plants was scarce, dependency of bears on alternative food resources increased and bears opted for crop raiding in agricultural fields located far away from Kugti village and nearer to forests. Our study also showed the presence of *Morchella esculenta* during summer and monsoon, and which indicated that mushroom constituted the important food item of brown bear. A study on food habits of brown bears in 4 diverse areas in Hokkaido, Japan revealed that foods of bears varied seasonally in each area and differed among largely because

of differences in food available (Ohdachi and Aoi, 1987). They also reported consumption of mushrooms by brown bear and a seasonal variation in the frequency occurrence of mushrooms in scats in Hokkaido though its estimated volume was low.

Availability of most of the other food items of brown bear was between March and October months. Food plants: *Capsella bursa pastoris, Chenopodium album, Fragaria nubicola* and *Taraxacum officinale* were available throughout March/April to September/October, except *Rumex nepalensis* which was available till November. Brown bears were observed digging and feeding on this plant extensively before hibernation. Variety of food plants such as *Chaerophyllum reflexum*, *Napeta laevigata*, *Origanum vulgare*, *Potentilla argyrophylla*, *Impatiens scabrida*, *Stachys melissaefolia*, *Stellaria media* and *Typhonum seginatum* were available as food plants during May to September. Ants and insects were consumed by bears from the time of emergence after hibernation. Livestock, sheep and goat, were present in large numbers from May till October when nomadic graziers visited the sanctuary area. The presence of remnants of different food items in the scats of bears were directly correlated with the availability of food items in different months in Kugti wildlife sanctuary.

On the contrary, the summer food habits of brown bears investigated in Kekexili Nature Reserve, Quinghai-Tibetan plateau, China indicated that brown bears were primarily carnivorous plateau; their diet was mainly constituted of pika (*Ochotona curzoniae*), wild yak (*Bos grunniens*), and Tibetan antelope in that region (Xu *et al*., 2006). Vegetable matter also occurred in bear feces. Food habits of grizzly bears in the Yellowstone area of Wyoming, Montana, and Idaho revealed that ungulates

constituted a major portion of early season diet, graminoids of May and June diet, and Whitebark pine seeds of late season scats (Mattson *et al*., 1991a). Their study also revealed that mushrooms and puffballs also constituted a minor portion of scat volume, with peak representation in September.

Figure 1. Food items/species area curve to find minimum number of scats (marked by arrow) required to study dietary composition for different seasons.

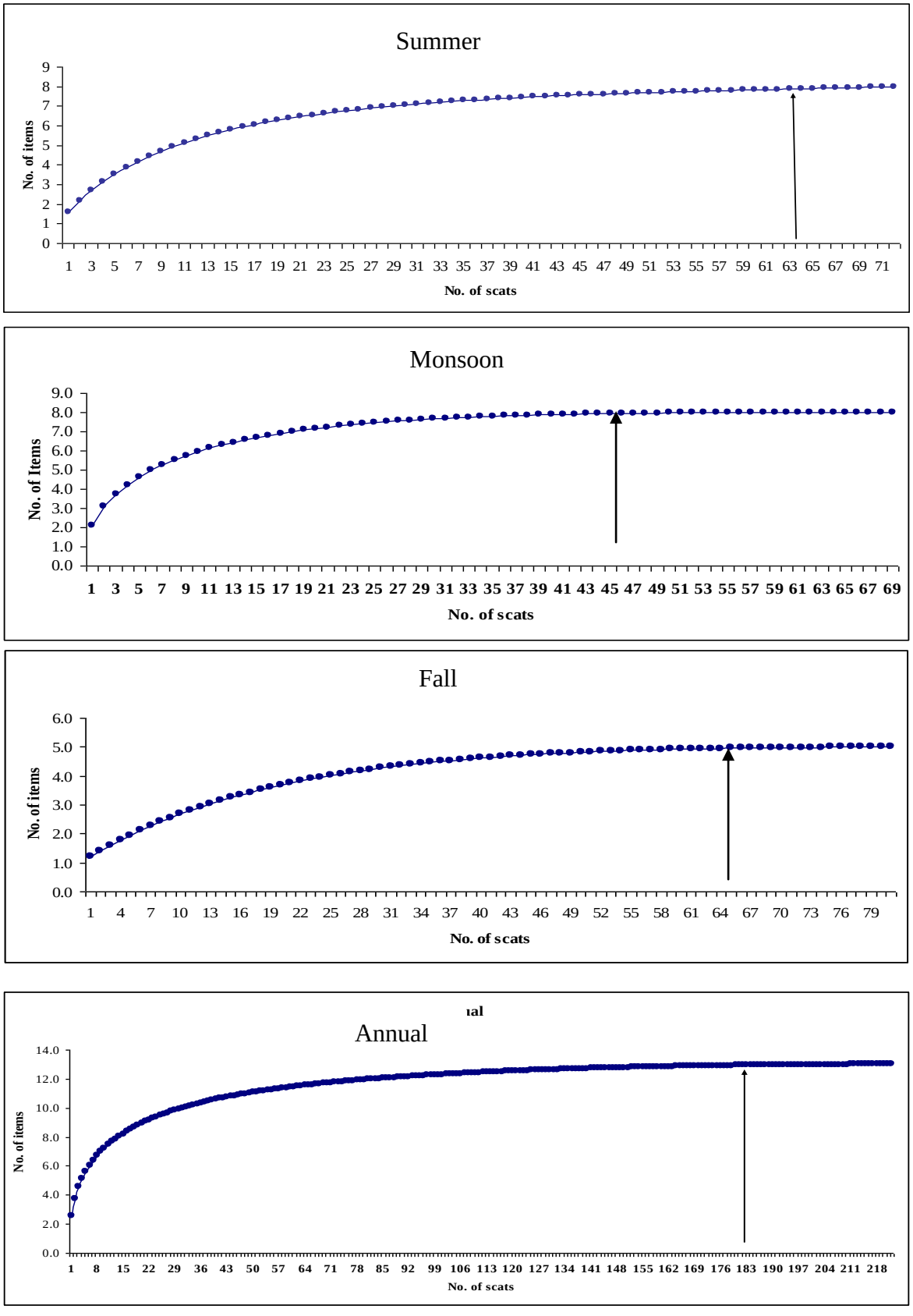


Figure 2. Frequency occurrence of animal and plant matter in scats of brown bear in different seasons in Kugti wildlife sanctuary during 2002-2004.

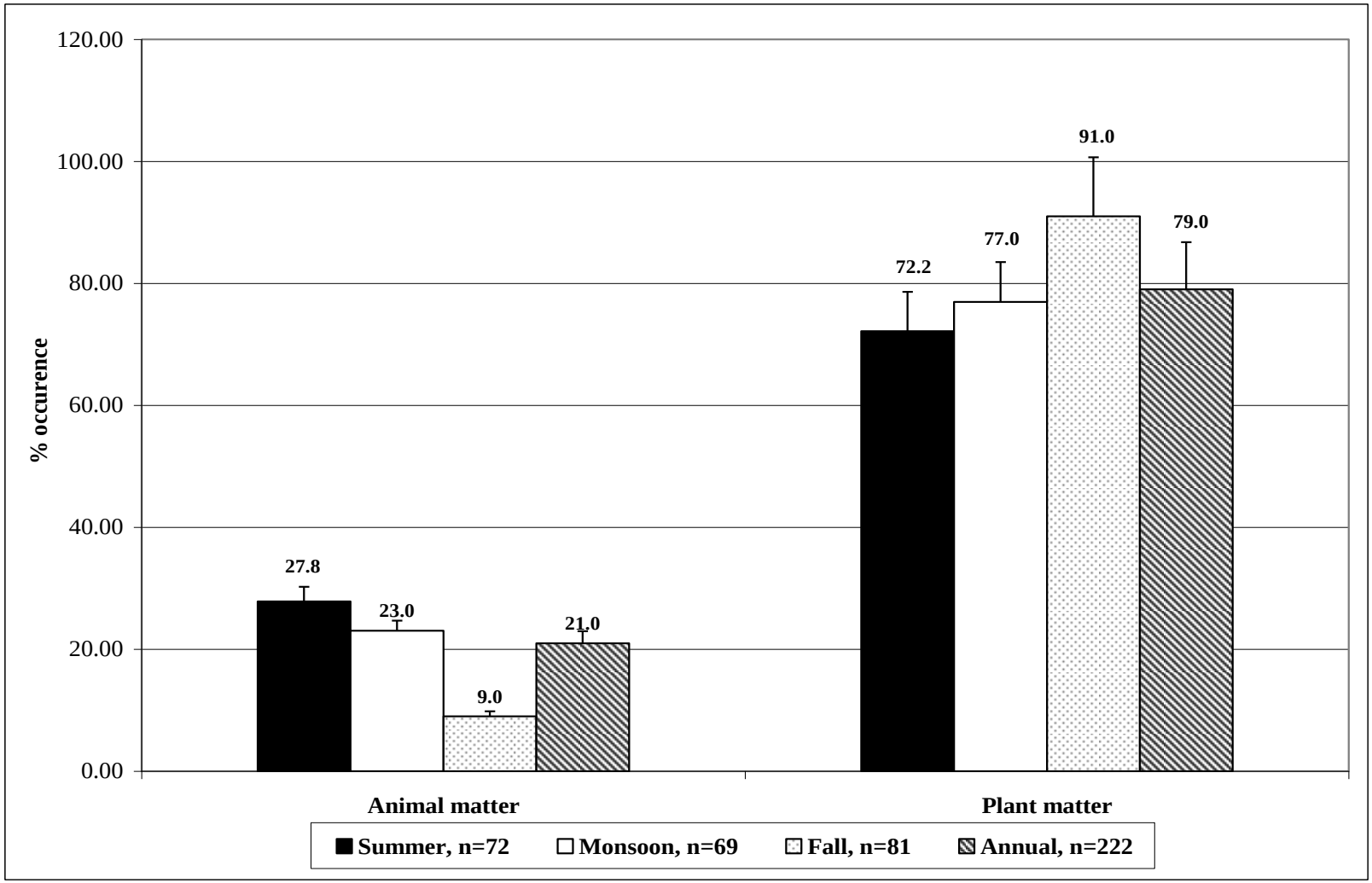


Table 1. Frequency of occurrence and estimated volume of food items in scats of brown bear in different seasons in Kugti wildlife sanctuary during 2002-2004.

Food items	Summer, n=72				Monsoon, n=69				Fall, n=81				Annual, n=222			
	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)
Hairs	4	3.5	0.27	L	6	4.3	0.32	L	0	0.0	0.00	L	10	2.9	0.25	L
Bones	4	3.5	0.27	L	4	2.9	0.20	L	0	0.0	0.00	L	8	2.3	0.19	L
Jaws, Teeth	0	0.0	0.00	L	2	1.4	0.07	L	0	0.0	0.00	L	2	0.6	0.05	L
Claws, Nail	0	0.0	0.00	L	2	1.4	0.07	L	0	0.0	0.00	L	2	0.6	0.05	L
Insects Parts	8	7.0	0.60	M	6	4.3	0.32	M	4	4.5	0.42	L	18	5.2	0.50	M
Ants Heads	16	13.9	1.26	M	12	8.6	0.69	M	4	4.5	0.42	L	32	9.3	0.94	M
Bharesh seeds	0	0.0	0.00	L	7	5.0	0.38	M	1	1.1	0.04	L	8	2.3	0.19	L
Wheat seeds	0	0.0	0.00	L	6	4.3	0.32	M	0	0.0	0.00	L	6	1.7	0.12	L
Zea mays seeds	0	0.0	0.00	L	7	5.0	0.38	M	0	0.0	0.00	L	7	2.0	0.16	L
Hordeum vulgare seeds	2	1.7	0.11	L	2	1.4	0.07	L	0	0.0	0.00	L	4	1.2	0.05	L
Berberis aristata	2	1.7	0.11	L	5	3.6	0.26	L	0	0.0	0.00	L	7	2.0	0.16	L

Continued

Food items	Summer, n=72				Monsoon, n=69				Fall, n=81				Annual, n=222			
	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)	Occurrence	Frequency of occurrence (%)	Standard Error ±	Estimated volume (v)
Rhamnus virgatus	3	2.6	0.19	L	0	0.0	0.00	L	0	0.0	0.00	L	3	0.9	0.04	L
Viburnum cotinifolium	4	3.5	0.27	L	2	1.4	0.07	L	0	0.0	0.00	L	6	1.7	0.12	L
Prunus persica seeds	0	0.0	0.00	M	13	9.4	0.75	M	5	5.6	0.54	L	18	5.2	0.50	M
Prunus cornuta	0	0.0	0.00	L	2	1.4	0.07	L	3	3.4	0.30	L	5	1.5	0.09	L
Morchella esculenta	6	5.2	0.44	L	1	0.7	0.04	L	0	0.0	0.00	L	7	2.0	0.16	L
Plant matter	66	57.4	5.33	H	62	44.6	3.75	H	72	80.9	8.57	H	200	58.3	6.16	H

Figure 3. Frequency occurrence of food items in scats of brown bear in Kugti wildlife sanctuary during 2002-2004.

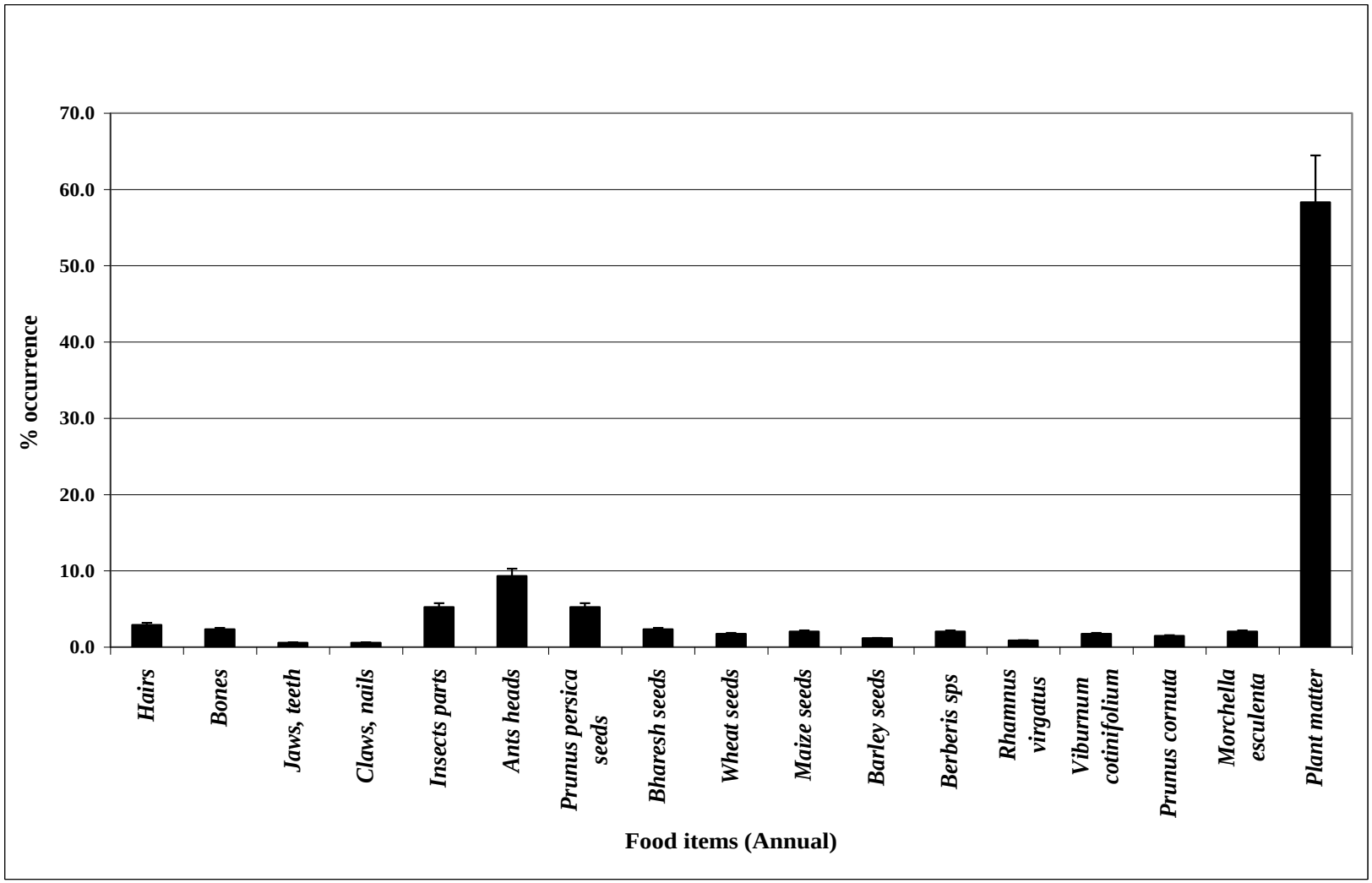


Figure 4. Number of direct feeding observations on food plants by brown bear in Kugti wildlife sanctuary during 2002-2004.

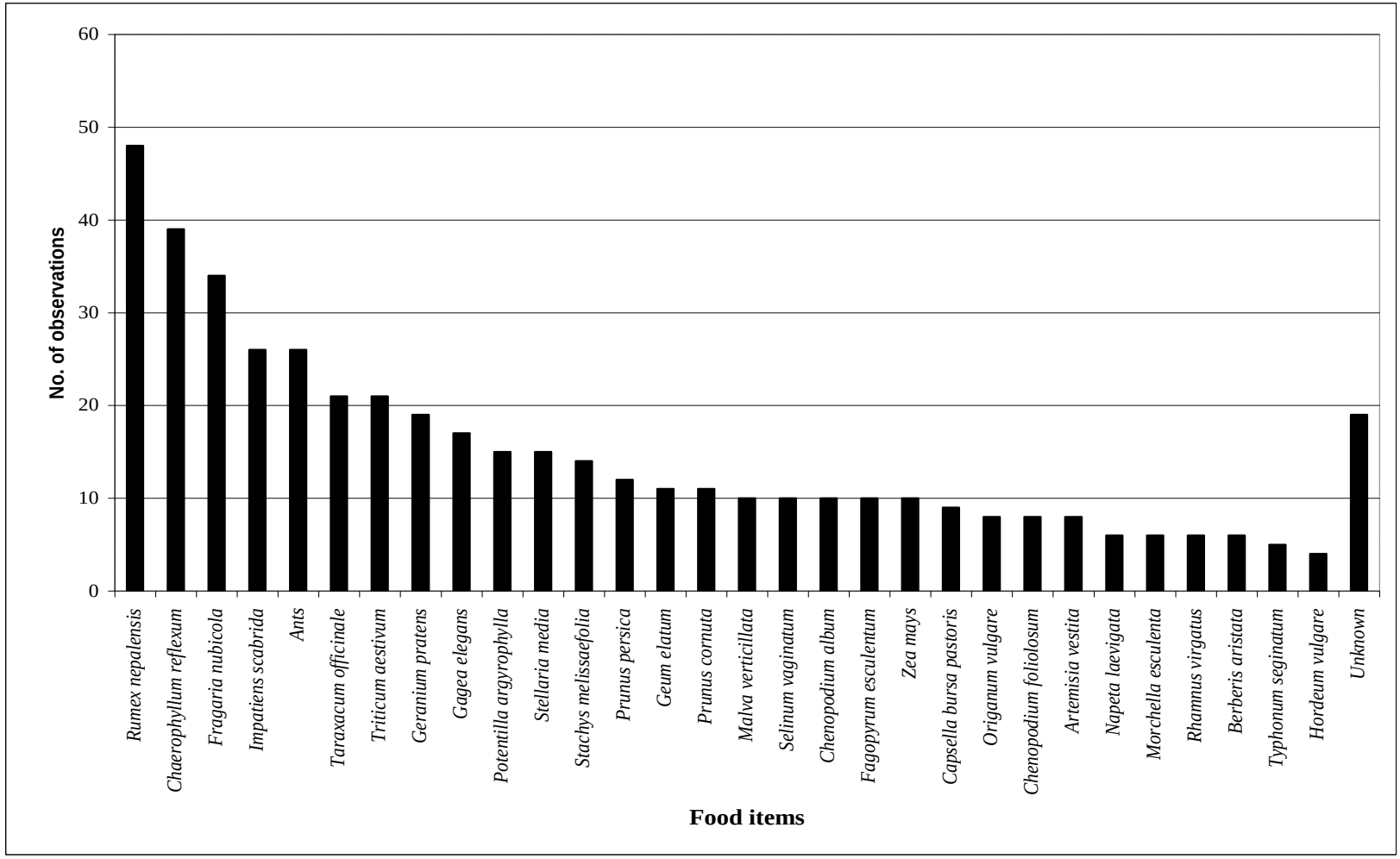


Figure 5. Presence of food items in brown bear scats in different months in Kugti wildlife sanctuary.

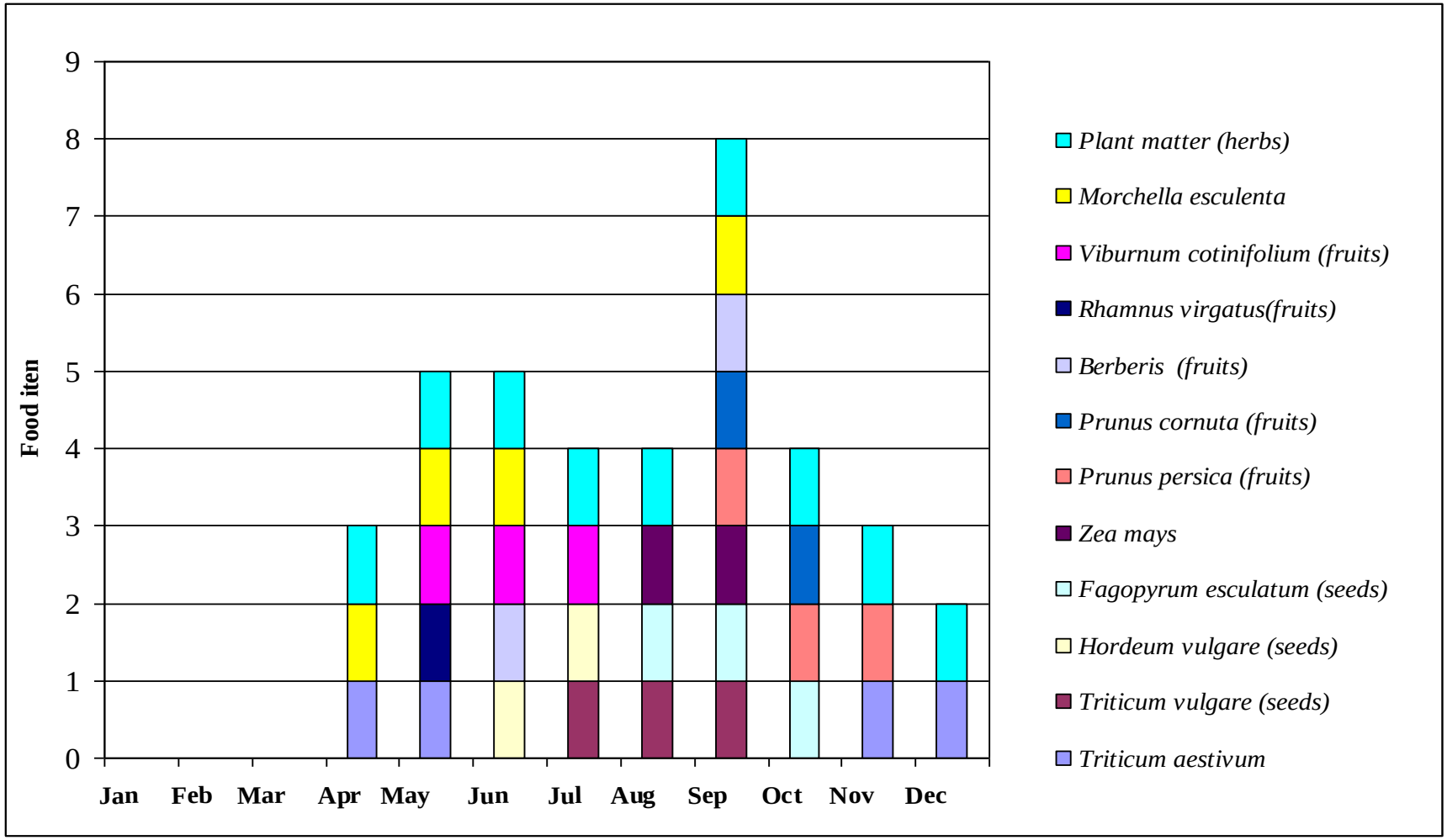


Table 3. Availability of food items of brown bear in different months in Kugti wildlife sanctuary.

Food Item	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Artemisia vestita	-	-	-	+	+	+	+	+	+	-	-	-
Berberis aristata (fruits)	-	-	-	-	+	+	+	+	-	-	-	-
Capsella bursa pastoris (leaves)	-	-	+	+	+	+	+	+	+	-	-	-
Chaerophyllum reflexum (leaves)	-	-	-	-	+	+	+	+	+	+	-	-
Chenopodium album (leaves)	-	-	+	+	+	+	+	+	+	+	-	-
Chenopodium foliolosum (leaves)	-	-	-	+	+	+	+	+	+	+	-	-
Fagopyrum esculatum ('bharesh' seeds)	-	-	-	-	-	-	+	+	+	+	-	-
Fragaria nubicola (leaves)	-	-	-	+	+	+	+	+	+	+	-	-
Gagea elegans (leaves & roots)	-	-	+	+	+	+	-	-	-	-	-	-
Geranium pratense (leaves)	-	-	-	-	+	+	+	+	+	+	-	-
Geum elatum (leaves, roots)	-	-	-	-	-	-	+	+	+	+	-	-
Hordeum vulgare (seeds)	-	-	-	-	-	+	+	+	-	-	-	-
Impatiens scabrida (seeds)	-	-	-	-	-	+	+	+	+	+	-	-
Malwa verticellata (leaves)	-	-	-	+	+	+	+	+	+	+	-	-
Morchella esculenta (fungi)	-	-	-	+	+	+	-	-	-	-	-	-
Nepeta laevigata	-	-	-	-	+	+	+	+	+	-	-	-
Origanum vulgare	-	-	-	-	+	+	+	+	+	-	-	-
Potentilla argyrophylla (leaves)	-	-	-	-	+	+	+	+	+	-	-	-
Prunus cornuta	-	-	-	-	-	-	+	+	+	+	-	-

Table 4. Availability of food items of brown bear in different months in Kugti wildlife sanctuary.

Prunus persica (fruits)	-	-	-	-	-	-	+	+	+	+	-	-
Rhamnus virgatus (fruits)	-	-	-	+	+	+	-	-	-	-	-	-
Rumex nepalensis (leaves, roots)	-	-	+	+	+	+	+	+	+	+	+	-
Selinum vaginatum (roots)	-	-	-	-	-	-	+	+	+	+	+	-
Stachys melissaefolia	-	-	-	-	+	+	+	+	-	-	-	-
Stellaria media	-	-	-	-	+	+	+	+	+	-	-	-
Taraxacum officinale	-	-	+	+	+	+	+	+	+	+	+	-
Triticum aestivum (leaves, seeds)	-	-	+	+	+	+	+	+	-	-	+	+
Typhonum seginatum (tubers)	-	-	-	-	+	+	+	+	-	-	-	-
Zea mays (seeds)	-	-	-	-	-	-	+	+	+	+	-	-
Ants, insects	-	-	-	+	+	+	+	+	+	+	+	-
Livestock (Sheep and goats)	-	-	-	-	+	+	+	+	+	+	-	-

Table 2. Number of direct feeding observations on food plants by brown bear in different seasons during 2002 to 2004.

Food items	Summer (n=184)	Monsoon (n=141)	Fall (n=139)	Total (n=464)
Rumex nepalensis	19	11	18	48
Chaerophyllum reflexum	12	12	15	39
Impatiens scabrida	9	13	4	26
Potentilla argyrophylla	3	6	6	15
Fragaria nubicola	15	10	9	34
Geranium pratens	8	5	6	19
Gagea elegans	15	2	0	17
Capsella bursa pastoris	7	2	0	9
Stellaria media	9	6	0	15
Malva verticillata	4	4	2	10
Selinum vaginatum	0	2	8	10
Origanum vulgare	2	4	2	8
Napeta laevigata	2	4	0	6
Stachys melissaefolia	4	6	4	14
Chenopodium album	6	2	2	10
Chenopodium foliolosum	2	6	0	8
Fagopyrum esculentum	2	5	3	10
Typhonum seginatum	2	3	0	5
Geum elatum	0	2	9	11
Morchella esculenta	6	0	0	6
Taraxacum officinale	10	6	5	21
Artemisia vestita	8	0	0	8
Prunus persica	0	0	12	12
Prunus cornuta	0	2	9	11
Rhamnus virgatus	6	0	0	6
Berberis sps	2	4	0	6
Triticum aestivum	6	4	11	21
Hordeum vulgare	4	0	0	4
Zea mays	2	8	0	10
Ants	12	9	5	26
Unknown	7	3	9	19

Chapter 5

Habitat use by brown bear

5.1 Introduction

In India, the increase in human and livestock populations has created pressure on all natural resources. Most of the protected areas are fragmented, degraded, and disturbed from anthropogenic activities. Forests, pastures and wastelands were brought under cultivation to sustain increased demand of cereals and other food products (Chauhan and Sawarkar, 1989). The unsustainable land-use patterns in rural areas have further altered landscapes. This habitat modification has caused wildlife species to become ecological dislocated.

The Himalayan brown bear (*Ursus arctos*) occurs in low densities in rolling up lands, alpine meadows, scrub and sub-alpine forests. Due to increasing human population, expansion of agricultural land, livestock grazing pressure and collection of medicinal plants, brown bear population is disturbed and threatened. Survival of brown bear depends on availability of suitable habitat, food and water in the sanctuary. The quality of habitat is generally reflected in the status of food, shelter, vegetation cover and its seasonal variation. The necessity of assessing preference or avoidance of a given habitat or plant species in terms of its availability has long been recognized (Neu *et al.*, 1974).

The habitat utilization by bears showed varied patterns in different places. The ability of brown bears to effectively use vastly different landscapes can be attributed to their

omnivorous generalist lifestyle. Brown bears were found to occupy a variety of habitats in North America (Craighead, 1998). In Alaska and British Columbia, bears were found to use a variety of habitats including old-growth forests, coastal sedge meadows and south facing avalanche slopes. During summer, most bears used alpine and subalpine meadows (Lefranc *et al*., 1987 and Schoen *et al*., 1994). In Alaska, brown bears were found to occupy a treeless landscape, and in the Central Arctic, esker complexes and riparian tall shrub habitats were preferred by bears (McLoughlin, 2000). In the northern Rocky Mountains, grizzly bears were dependent on a fairly predictable sequence of habitats that provided seasonally available forage (LeFranc *et al*., 1987; Mace and Waller, 1997 and Herrero *et al*., 2000). In Northeastern Alaska, tussock and tall shrubland were used by grizzly bears slightly more frequently during spring, whereas low shrubland was used much more frequently than expected (Phillips, 1987). Seasonal habitats were separated into spring and early summer pre-berry period, when bears were foraging on a variety of graminoids, forbs and roots; and summer early fall berry producing period, when bears were feeding on locally available berry crops (LeFranc *et al*., 1987; Mace and Waller, 1997 and Herrero *et al*., 2000). During spring, bears were found in lower elevation habitats eating growing vegetation and winter-killed ungulates. During late spring, they moved to higher elevations following the phonological advantage of vegetal foods. During summer, bears descended to lower sites to exploit habitats with early ripening berry crops. They showed repeated altitudinal movements, following the ripening fruits to higher elevations during early fall (Darling, 1987; Hamer and Herrero, 1987 and Mace and Waller 1997). In the Greater Yellowstone Ecosystem, the pattern of seasonal elevation use was similar to that found for other populations occupying interior western mountains (Mealey, 1980). In much of Alaska and northern Canada, habitats

occupied by the grizzly bear were not significantly altered by humans. Most of the productive lands have been occupied by humans, and grizzly bear populations have been located in most remote and rugged mountainous areas; which were not the best habitats (Craighead and Mitchell, 1982 and Gibeau, 1998).

In southwestern Oshima peninsula, Hokkaido, habitat use by brown bears was investigated (Mano, 1994). The lower deciduous natural forest areas such as beech oak forest and maple linden and forest were intensively used by bears, but subalpine areas such as sasa birch forest and sasa community were rarely used, and food availability could influence the habitat use by the bears. In Rocky Mountain Front, Montana, comparisons of the habitat use between grizzly bear and black bear revealed that although both preferred the closed timber habitat component, but black bears were using the closed timber community more than grizzly bears, and black bears also used the rock, talus, prairie grasslands, riparian shrub and riparian complex habitat component significantly less than did grizzly bears (Aune, 1994). In Central India, habitat use by sloth bear was determined by availability and seasonal variation in food, shelter vegetation cover and availability of fruting trees, shrubs densities, water, termites and ants (Akhtar *et al*., 2004). A study on sloth bears showed that ranging pattern was mainly dependent on food supply (Joshi *et al*., 1995 and Desai *et al*., 1997). Depletion of natural habitat and expansion of human habitation and agriculture establishment have greatly impacted the movement and habitat utilization of sloth bear (Chauhan *et al*., 1999).

For conservation and management of brown bear population, information on its ecology, habitat use, food habits etc. suited to a particular species is necessary. No

systematic information is available on the habitat use, seasonal variation and denning of brown bear. How the increasing biotic pressure is affecting brown bear habitat and its population in this area is also not known? The study therefore envisages assessing the habitat use pattern of brown bear in Kugti wildlife sanctuary.

5.2 Methods

To study the habitat use pattern of brown bear, the following methods have been used in Kugti wildlife sanctuary.

5.2.1 Transect Sampling

In the study area, vegetation showed high degree of heterogeneity and variable degree of biotic pressure. After the reconnaissance survey, 22 linear transects were laid at random **(Appendix 3)** encompassing in nine different habitat categories viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests, Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species in Kugti wildlife sanctuary. Along each transect of 1 km length, five sampling plots of 10 m radius with 250 m interval were laid. **Figure 1** shows the sampling layout for vegetation quantification and collection of bear evidences. Indirect evidences such as digging signs, presence of scats and claw marks, were recorded from within 110 plots along the transects. In addition, information on habitat variables like terrain, vegetation type, tree and shrub species, number of cut

and lopped trees, stand height, canopy cover, nearest water source, cattle dung and distance from the habitation and water etc. was recorded from within these sample plots as per the formats **(Appendix 4)**. The data of each sampling plot was pooled as per habitat type for analysis. Bear sighting on both sides of transects and habitat types of bear locations were recorded.

5.2.2 Availability of food plants

From the vegetation data of different sample plots, assessment of food plants and their abundance in each habitat type was calculated. The food plants were counted within circular plot of 10 m radius and shrub species were counted within plot of 5 m radius for their density estimation. Certain species with ≥ 30 cm GBH were considered as tree and other species with ≤ 30 cm GBH were considered as shrub. Identification of food plants of bear diet was ascertained on the basis of analysis of scats, collected from the study area.

To assess the habitat use by brown bear in Kugti wildlife sanctuary, availability and utilization approach of Neu *et al.* (1974) was adopted here and analysis was done in the '*PREFER*' software package developed at the Wildlife Institute of India. During this exercise, following hypothesis was tested using Chi square test: bear utilized each habitat category in exact proportion to its occurrence within the study area. To know the difference between the habitat variables in the plots where bear signs were present or absent, Kruskal-Wallis non-parametric test was used (Zar, 1984). Multi-dimensional scaling, regression analysis, and non-parametric analysis were performed in SPSS software (Norussis, 1994).

5.3.0. Results

In Kugti wildlife sanctuary, encompassing an area of 379 km^2, nine distinct habitat types viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan Moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests, Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species have been classified. **Photograph 1, 2, 3 and 4** show the Himalayan moist temperate forest with conifers habitat in Kangru reserve forest, Agricultural land and Mixed forest with conifer and broad leaf species habitats, Dry alpine scrub characterized by *Juniperus spp*. habitat and Moist sub-alpine scrub with *Rhododendron campanulatum* habitat respectively in Kugti wildlife sanctuary. There is only one village, namely, upper and lower Kugti inside the sanctuary. In all these diverse landscapes, assessment of habitat use by brown bear was done based on direct sighting of bears and indirect evidences.

5.3.1. Food plants vs. habitats use

The habitat use by brown bear was found to be largely dependent on the availability of food resources, variety of food plants and shelter in different habitat types. There were 25 species of food plants found in Agricultural land, 13 species in Grassland and forest blanks, 9 species in Mixed forest with conifers and broad leaf species, 9 species in Himalayan moist temperate forest with conifers, 11 species in Near water bodies, river & stream, 10 species in Dry alpine scrub characterized by *Juniperus* species, 6 species in Riverine forest, 8 species in Exposed rock with slope grasses and 9 species Moist subalpine scrub with *Rhododendron* species **(Table 1)**. The herbaceous food

plants consumed by brown bear in different habitats were *Artemisia vestita, Berberis aristata, Morchella esculanta, Rhamnus virgatus, Capsella bursa-pastoris, Chaerophyllum reflexum, Chenopodium album, Chenopodium foliolosum, Fagopyrum esculatum, Fragaria nubicola, Gagea elegans, Geranium pratens, Geum elatum, Impatiens scabrida, Malva verticillata, Nepeta laevigata, Origanum vulgare, Potentilla argyrophylla, Rumex nepalensis, Selinum vaginatum, Stachys melissaefolia, Stellaria media, Taraxacum officinale* and *Typhonum seginatum.* Agricultural crops used by brown bear were *Hordeum vulgare, Triticum aestivum, Zea mays, Fagopyrum esculatum,* '*Bharesh*' crop and '*Phulen*' crop. The fruiting tree species present in these habitat classes were mainly *Prunus cornuta, Prunus persica. Pyrus pashia, Berberis chitria, Berberis aristata, Rubus fruticosus, Viburnum cotinifolium* and *Rhamnus virgatus.* These fruiting trees and other food items including insects and ant *(Solenopsis* sp.*)* were found to be available in different habitats and vicinity of village.

5.3.2 Habitat use pattern

The data on habitat use by brown bear collected from the 110 sample plots along the 22 transects showed that maximum number of sample plots with bear signs fell in the Agricultural land category (n=23), followed by Grassland and forest blanks (n=21), Near water bodies river and streams (n=10), Dry alpine scrub characterized by *Juniperus* species (n=9), Himalayan moist temperate forest with conifers (n=8), Mixed forest with conifers and broad leaf species (n=6), Moist sub-alpine scrub characterized by *Rhododendron* species (n=5), Exposed rock with slope grasses (n=4), and Riverine forest (n=4) **(Table 2)**. Although brown bears showed some preference

for Agricultural land category and Grassland and forest blanks habitat categories, but as such there was no preference or avoidance by bears for rest of the habitats. **Photograph 5, 6, 7 and 8** show the Grassland with forest blanks habitat; Near water bodies, river and streams and Mixed coniferous forest habitats, Exposed rock with slope grasses habitat and Riverine Forest and Mixed coniferous forest habitats respectively.

Out of 110 plots along the transects, bear evidences were found in 90 plots. Density of digging signs per hectare was found highest in Moist sub-alpine scrub dominated by *Rhododendron* species (101.91 diggings/ha), followed by Mixed forest with conifers and broad leaf species (92.35 diggings/ha), Himalayan Moist temperate forests with conifers (82.8 diggings/ha), Grassland and forest blanks (75.15 diggings/ha), Dry alpine scrub characterized by *Juniperus* species (47.77 diggings/ha), Agricultural land (45.64 diggings/ha), Riverine forests (38.21 diggings/ha), Exposed rock with slope grasses (31.84 diggings/ha) and Near water bodies, river and streams (3.18 diggings/ha) **(Table 2)**. Whereas, number of scats per hectare was highest in Agricultural land (53.07 scats/ha), followed by Exposed rocks with slope grasses (50.95 scats/ha), Himalayan moist temperate forest with conifers (38.21 scats/ha), Grassland and forest blanks (26.75 scats/ha), Mixed forest with conifers and broad leaf species (22.39 scats/ha), Near water bodies, river and streams (22.39 scats/ha), Riverine forest (19.1 scats/ha), Moist sub-alpine scrub characterized by *Rhododendron* species (19.1 scats/ha) and Dry alpine scrub characterized by *Juniperus* species (15.92 scats/ha).

When the density of digging signs and scats per hectare was considered separately for the extent of habitat use, the results were not consistent and as such no trend could be established. There was a specific pattern of habitat use observed in the study area, and this could be established when brown bear's signs: number of diggings and scats were combined together. According to this, density of brown bear signs per hectare was highest in Moist sub-alpine scrub characterized by *Rhododendron* species (121 signs/ha) and Himalayan moist temperate forest with conifers (121 signs/ha), followed by Mixed forest with conifers and broad leaf species (114.6 signs/ha each), Grassland and forest blanks (101.91 signs/ha), Agricultural land (98.72 signs/ha), Exposed rocks with slope grasses (82.8 signs/ha), Dry alpine scrub characterized by *Juniperus* species (63.69 signs/ha), Riverine forest (57.32 signs/ha) and Near water bodies, river and streams (25.47 signs/ha).

The frequency occurrence of food plants in plots used by bears varied considerably **(Table 3)**. Plots with presence of 1, 2 and 3 food plant species were 11.81%, 21.8% and 31.8% respectively. Further as the number of food plant species increased, the percentage of these plots decreased. Plots with presence of 6, 7 and 8 food plant species were 3.6%, 2.7% and 1.8% respectively. Irrespective of this variation, the proportional utilization these plots with variable number of food plant species was very high, except the plots without any food plants. The high proportional utilization of these plots ranged from 72.7% to 100%.

5.3.3 Habitat availability vs. utilization

The data on habitat use by brown bears collected from the 110 sample plots along the transects showed maximum number of plots in Agricultural land category (30), followed by Grassland and forest blanks (25), and there were 10 plots in each of Mixed forest with conifers and broad leaf species, Himalayan moist temperate forest with conifers, Near water bodies, river and streams and Dry alpine scrub characterized by *Juniperus* species **(Table 4)**. Habitat categories: Riverine forest, Exposed rocks with slope grasses and Moist sub-alpine scrub characterized by *Rhododendron* species were found to have 5 plots in each. So among various habitat categories, the proportional availability was found to be highest of Agricultural land (0.273), followed by Grassland and forest blanks (0.227), and it was 0.09 in each of Mixed forest with conifers and broad leaf species, Himalayan moist temperate forest with conifers, Near water bodies, river and streams and Dry alpine scrub characterized by *Juniperus* species. Likewise the proportional availability was 0.045 in each of these habitat categories: Riverine forest, Exposed rocks with slope grasses and Moist sub-alpine scrub characterized by *Rhododendron* species. In comparison to the availability of various habitats, the expected use of these habitat categories was found in proportion.

The habitat use based on density of bear signs per hectare was highest Agricultural land (25.6%), followed by Grassland and forest blanks (23.3%), Near water bodies, river and streams (11.1%), Dry alpine scrub characterized by *Juniperus* species (10%), Himalayan moist temperate forest with conifers (8.9%), Mixed forest with conifers and broad leaf species (6.7%), Moist sub-alpine scrub characterized by *Rhododendron* species (5.6%), Riverine forest (4.4%) and Exposed rocks with slope

grasses (4.4%) **(Table 4)**. The use of Agricultural land and Grassland and forest blanks habitats was high, and the expected use was highest. Rest of the habitat categories Near water bodies, river and streams, Exposed rocks with slope grasses, Dry alpine scrub characterized by *Juniperus* species, Riverine forest and Himalayan moist temperate forest with conifers were utilized more or less in proportion to the expected use. So the habitat use by brown bears was also found to be in proportion to the availability and the expected use of these habitat categories.

The Goodness of fit comparison showed that there was no significant difference between the expected utilization of each habitat category and the use of these habitat categories within the study area **(χ^2=1.389, df=8, p=0.9)**. The null hypothesis was therefore accepted, implying that observed bear evidences were distributed proportionally to the occurrence of habitat categories.

5.3.4 Seasons and habitat utilization

The habitat use pattern by brown bears showed marked seasonal variation **(Table 5)**. Except Near water bodies, river and streams, although the overall extent of habitat use was considerably high for most of the habitat categories as indicated in table 2, but there was considerable seasonal variation in the use of each of the habitat category.

Based on number of digging signs and presence of scats, use of different habitats was highest during summer (37.7%), followed by monsoon (33.2%) and fall (29.1%). During summer season, use of Dry alpine scrub characterized by *Juniperus* species (65%) by bears was highest, followed by Moist sub-alpine scrub characterized by *Rhododendron* species habitat (57.8%), Grassland and forest blanks (52.5%), Exposed

rocks with slope grasses (38.4%), Mixed forest with conifers and broad leaf species (33.3%), Himalayan moist temperate forest with conifers (31.5%), Agricultural land (22.5%), Riverine forest (22.2%) and Near water bodies, river and streams (12.5%). During monsoon season, use of Himalayan moist temperate forest with conifers (57.9%) by bears was highest, followed by Mixed forest with conifers and broad leaf species (50%), Riverine forest (44.5%), Agricultural land (43.1%), Exposed rocks with slope grasses (30.8%), Near water bodies, river and streams (25%), Grassland and forest blanks (15%), Moist sub-alpine scrub characterized by *Rhododendron* species habitat (10.6%) and Dry alpine scrub characterized by *Juniperus* species (5%). Whereas during fall season, use of Near water bodies, river and streams (62.5%) by bears was highest, followed by Agricultural land (34.4%), Riverine forest (33.3%), Grassland and forest blanks (32.5%), Moist sub-alpine scrub characterized by *Rhododendron* species habitat (31.6%), Exposed rocks with slope grasses (30.8%), Dry alpine scrub characterized by *Juniperus* species (30%), Mixed forest with conifers and broad leaf species (16.7%) and Himalayan moist temperate forest with conifers (10.6%).

5.3.5 Use of Terrain

Based on digging signs and presence of scats, various terrain types: flat, undulating, gentle slope and steep slope were found to be differentially used by brown bear in the study area **(Table 6)**. But the use of flat terrain by brown bear was maximum (44%), followed by gentle slope (31%), undulating terrain (14.9%) and steep slope (10.1%). Brown bears were found to use flat terrain maximum in Agricultural land (64.5%), followed by Grassland and forest blanks (61.2%), Mixed forests with conifers and

broad leaf species (55.5%), Exposed rocks with slope grasses (46.1%) and Moist sub-alpine scrub characterized by *Rhododendron* species (21%). Use of flat terrain in rest of the habitat categories was nil. Brown bears were found to use undulating terrain maximum in Near water bodies, river and streams (37.5%), followed by Dry alpine scrub characterized by *Juniperus* species (35%), Exposed rocks with slope grasses (23.1%), Agricultural land (17.2%), Grassland and forest blanks (15%), Himalayan moist temperate forest with conifers (13.2%) and Riverine forest (11.1%). Use of undulating terrain in rest of the habitat categories was nil. Whereas, brown bears were found to use gentle slope terrain in all the habitat categories. They were found to use gentle slope terrain maximum in Riverine forest (88.9%), followed by Moist sub-alpine scrub characterized by *Rhododendron* species (79%), Himalayan moist temperate forest with conifers (73.6%), Dry alpine scrub characterized by *Juniperus* species (65%), Near water bodies, river and streams (62.5%), Exposed rocks with slope grasses (30.8%), Agricultural land (18.3%) and Grassland and forest blanks (7.5%). The steep slope terrain was used by bear only in 3 habitat categories, namely, Mixed forests with conifers and broad leaf species (38.9%), Grassland and forest blanks (16.3%) and Himalayan moist temperate forest with conifers (13.2%). Other habitat categories in the steep slope terrain were not used.

The data on proportional availability of various terrain types: flat, undulating, gentle slope and steep slope has been compared with the expected use of these terrains by brown bear **(Table 7)**. The proportional availability of gentle slope terrain was found to be highest (0.39), followed by flat terrain (0.273), undulating terrain (0.227) and steep slope terrain (0.109). Similarly the expected use of these terrain types was found to be directly proportional to the availability of these terrains. The expected use of

gentle slope terrain was found to be highest (20.327), followed by flat terrain (14.182), undulating terrain (11.818) and steep slope terrain (5.673). Following hypothesis was tested using the Chi square test: brown bear used each type of terrain category in exact proportion to its occurrence within the study area (null hypothesis). The observed utilization of each terrain category was compared with expected utilization of terrain. Goodness fit of comparison showed that the expected utilization of each terrain category was not significantly different (χ^2=3.787, df=3, p=0.9) from the observed utilization. The null hypothesis was therefore accepted, implying that the observed utilization of each terrain category was in proportion to its occurrence. There was neither any preference nor avoidance by bears for any type of terrain. Bear used certain category of terrains for specific purpose.

5.3.6. Analysis for variance among the variables (Kruskal-Wallis test)

We assessed two hypotheses; first was that all the habitat variables viz. number of trees, lopped trees, fell trees, number of shrubs, number of herbs, cattle dung, sheep and goat dung, distance from habitation, distance from water and distance from road, were evenly distributed in the used and unused areas of brown bears i.e. null hypothesis (H_0), and second was that habitat variables were not evenly distributed in the areas where bear signs were present and absent i.e. Alternative hypothesis (H_A).

The Chi-square values clearly showed that when habitat variables within the sampled plots were correlated with the bear presence as a fixed variable, then the number of shrubs (0.000), distance from human habitation (0.000), distance from water sources (0.002), Sheep and goat dung (0.004) and cattle dung (0.005) had significant

correlation with bear presence. This has proved that these variables were not the same in areas where bear signs were present or absent. This rejects the Null hypothesis (H_0) and accepts the Alternative hypothesis (H_A). Whereas, for the number of trees, lopped trees, fell trees, number of herbs and distance from road, Chi-square values were not significant. This showed that these habitat variables were almost the same in the areas where bear signs were present or absent (Table 8). Therefore null hypothesis was not rejected.

5.4 Discussion

In Kugti wildlife sanctuary, the Himalayan brown bear occurs in low densities in rolling up lands, alpine meadows, scrub and sub-alpine forests. There is one village, upper and lower Kugti inside the sanctuary and several villages are located on the fringes. Due to increasing human population, expansion of agricultural land, continuous encroachment on forest land, livestock grazing pressure and biotic pressure due to collection of fuelwood and non-timber forest produce, brown bear population seems to be adversely impacted in this area, and so it is threatened. All these factors together might have also adversely impacted the habitats and their use in the study area. Survival of brown bear depends on availability of suitable habitats, and food, water and shelter within these habitats.

Brown bears have been found to use different habitat categories viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan Moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests,

Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species in Kugti wildlife sanctuary. However there was a specific pattern of habitat use in the study area. The data on habitat use by brown bear showed maximum number of sample plots with bear signs in the Agricultural land category, followed by Grassland and forest blanks, Near water bodies river and streams, Dry alpine scrub characterized by *Juniperus* species, Himalayan moist temperate forest with conifers, Mixed forest with conifers and broad leaves species, Moist sub-alpine scrub characterized by *Rhododendron* species, Exposed rock with slope grasses and Riverine forest. Although brown bears showed some preference for Agricultural land category and Grassland and forest blanks habitat categories, but as such there was no preference or avoidance by bears for rest of the habitats. Since maximum bear signs were from agricultural land located far away from the Kugti village, perhaps bears did spent much time in this habitat to feed on crops and other food items. More bear signs in the Agricultural areas, Grassland and forest blanks, Near water bodies river and streams, Dry alpine scrub characterized by *Juniperus* species, Himalayan moist temperate forest with conifers and Mixed forest with conifers and broad leaf species might be due to intensive use of these habitats by bears and more availability of preferred food items and shelter to bears. In Kugti, the land holdings were 3-5 km away from the village but close to forests. In such situation brown bears might easily be raiding agricultural areas to feed on crops. Brown bears were also found to use *Indigofera heterantha*, *Rhododentron campanulatum* and *Sorbaria tomentosa* for taking shelter and ambush cover as these shrubs were profusely growing in habitats used by bears.

Presence of bear signs in different habitats varied with availability of food items in different seasons. Black bear feeding signs in decaying stumps and ground cavities on sand ridges to feed on insects were seen frequently during spring and summer. Black bears need large areas with a variety of habitat types in coastal plains of North Carolina to meet their food and cover requirement (Landers *et al.*, 1979*).* In Denali National Park, Alaska, habitat use and activities of bears were found to be influenced by the phenological development of cowberry (*Empetrum nigrum*), peavine (*Hedysarum alpinum*), horsetail (*Equisetum arvense*), polar grass (*Arctagrostis latifolia*), soapberry (*Shepherdia canadensis*) and availability of animal food items (Stelmock and Dean, 1986). The indirect evidences in different available habitats revealed that brown bears were generalistic as far the habitat use was concerned. In Denali National Park, another study on the habitat use by grizzly bear indicated that differences in family age, seasons, and years contributes to differences in overall habitat use patterns (Darling, 1987). In spring, bears were generally on low slopes and in valley bottoms, whereas in summer they were found on upper and middle hillsides. They moved back down to lower hillsides and valleys in fall but were less concentrated in valley bottoms than in spring.

The habitat use pattern by brown bears in Kugti wildlife sanctuary revealed that they differentially used available habitat types. similarly, sloth bear population also showed no avoidance or preference for any habitat type in North Bilaspur forest division, Madhya Pradesh (Akhtar *et al*., 2002). Sloth bears were found to use different habitat types covering smaller areas and showed distinct seasonal shifts between Sal forest, Land near to water bodies, Sal mix Forest, Mix forest, Scrub land, Plantation, Open land and Crop field. Presence of bear signs in different habitats was

found mainly dependent on availability of food items in different seasons. In Mudumalai wildlife sanctuary, maximum scats were found in Dry deciduous tall grass forest, followed by Dry deciduous short grass, Thorn forest and Moist deciduous forest (Desai *et al*., 1997). In North Carolina, black bears need large areas with a variety of habitat types in coastal areas to meet food and cover requirement (Landers *et al*., 1979*).*

Density of brown bear signs per hectare was highest in Moist sub-alpine scrub characterized by *Rhododendron* species and Himalayan moist temperate forest with conifers, followed by Mixed forest with conifers and broad leaf species, Grassland and forest blanks, Agricultural land, Exposed rocks with slope grasses, Dry alpine scrub characterized by *Juniperus* species, Riverine forest and Near water bodies, river and streams. As already stated, the habitat use by brown bear was found to be largely dependent on the availability of food resources, food plants species and shelter in different habitat types. There were 25 species of food plants found in Agricultural land, 13 species in Grassland and forest blanks, 9 species in Mixed forest with conifers and broad leaf species, 9 species in Himalayan moist temperate forest with conifers, 11 species in Near water bodies, river and stream, 10 species in Dry alpine scrub characterized by *Juniperus* species, 6 species in Riverine forest, 8 species in Exposed rock with slope grasses and 9 species Moist subalpine scrub with *Rhododendron* species. All these herbaceous food plants were consumed by brown bear in different habitats. The fruiting tree species present in these habitats were mainly *Prunus cornuta, Prunus persica. Pyrus pashia, Berberis chitria, Berberis aristata, Rubus fruticosus, Viburnum cotinifolium* and *Rhamnus virgatus*. These fruiting trees and other food items including insects and ant *(Solenopsis* sp.*)* available

in these habitats and vicinity of village were preferred by brown bears. The frequency occurrence of food plants in plots used by bears varied considerably Irrespective of this variation, the proportional utilization of these plots with variable number of food plant species was very high, except the plots without any food plants.

The proportional availability of Agricultural land was highest, followed by Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan moist temperate forest with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forest, Exposed rocks with slope grasses and Moist sub-alpine scrub characterized by *Rhododendron* species. In comparison to the availability of various habitats, the expected use of these habitat categories was found in proportion. The habitat use based on density of bear signs per hectare was highest for Agricultural land, followed by Grassland and forest blanks, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Himalayan moist temperate forest with conifers, Mixed forest with conifers and broad leaf species, Moist sub-alpine scrub characterized by *Rhododendron* species, Riverine forest and Exposed rocks with slope grasses. The use of Agricultural land and Grassland and forest blanks habitats was high, and the expected use was also proportionally high. Rest of the habitat categories Near water bodies, river and streams, Exposed rocks with slope grasses, Dry alpine scrub characterized by *Juniperus* species, Riverine forest and Himalayan moist temperate forest with conifers were utilized more or less in proportion to the expected use. So the habitat use by brown bears was in proportion to the availability and the expected use of these habitat categories. Thus, habitat use in proportion to its availability could be correlated with availability of food items and also shelter. The relation between utilization and

availability of brown bear habitat features using ten variables was compared by testing the hypothesis i.e. bears used habitats in proportion to their availability. The null hypothesis was not rejected.

Brown bears preferred forested habitats and used beach (*Fagus sylvatica*) and durmast (*Querus petaea*) oak forest in greater proportion than their availability (Clevenger *et al*., 1992). The habitat used by grizzly bear more than expected were riparian zones and wet seeps in spring, wet seeps and alpine slab rock in summer and reparian zones and, wet seeps, in spring, wet seeps and alpine slab rock in summer and riparian zones, wet seeps, wet meadows, and alpine slab rock (Servheen, 1983). In Arctic National Wildlife Refuge, northeast Alaska, tussock tundra and tall shrubland were used slightly more frequently by grizzly bears during spring than expected based on availability, whereas low shrubland was used much more frequently than expected and bears were observed in tall and low shrubland usually digging hedysarum roots (Phillips, 1987). In North Bilaspur forest division, sloth bear population used different habitat types, and the expected utilization in each habitat category differed significantly from the occurrence of habitat categories within the study area (Akhtar *et al*., 2002). Reynold and Beecham (1980) also recorded the movements of black bears in response to the phenological stages of food plants in different areas. Amstrup and Beecham (1976) indicated that bears associated mostly with particular plant species during its peak fruit availability. Manjrekar (1989) in Dachigam National Park found that black bears were mainly dependent on fruits of *Prunus avium, Morus alba, Quercus robur and Juglans regia* by extensively utilizing forest habitats.

The habitat use pattern of brown bear showed marked seasonal variation. The overall extent of habitat use was high for most of the habitat categories except Near water

bodies, river and streams, but there was considerable seasonal variation in the use of each the habitat category. During summer, brown bears used Dry alpine scrub characterized by *Juniperus* species, Moist sub-alpine scrub characterized by *Rhododendron* species habitat and Grassland and forest blanks very extensively. This could be due to the reason that when brown bears emerged after hibernation, they required plenty of food and shelter, and so they used these habitats extensively. Because in summer months, graziers with their livestock were present mainly in sub-alpine riverine areas, so there was no human and livestock disturbance. During monsoon, bears used Himalayan moist temperate forest with conifers, Mixed forest with conifers and broad leaf species, Riverine forest and Agricultural land to very high extent. Because maize crop was available in agricultural areas and livestock was also present in 'dhars' or pasture areas, so bears were confined to these habitats for seeking food and shelter. During fall, since herbaceous plants got dried up in pastures and livestock descended to riverine forest, so bears also concentrated to Near water bodies, river and streams and mixed of habitats for seeking food.

In Rocky mountain Front, Montana, grizzly bears were found to dig roots during the summer and fall, while black bears did not (Aune, 1994). In the western French Pyreness, the preferred spring habitat of brown bears was open meadows and clearings; fir (*Abies alba*) and beech forests were used in summer; during late summer and fall, the berry producing areas in sub alpine meadows were favoured; and typical habitat of breeding females was characterized by dense vegetation, where there were streams and low human activity (Camarra, 1983). Several studies documented habitat use and movement patterns of coastal brown bears (Berns *et al*., 1980; Glenn and Miller, 1980; Schoen *et al*., 1986; Hamilton and Bunnell, 1987; Barnes, 1990 and

Ballard *et al*., 1993) and interior (Ballard *et al*., 1982). Brown bears in British Columbia ranged widely during berry season and then restricted their movements while feeding on salmon (Hamilton and Bunnell, 1987). On the Alaska Peninsula, bears moved greater distances in spring than in summer and fall (Glenn and Miller, 1980). In southwestern Alaska, brown bears occupied lower elevations during July and August, when salmon (*Oncorhynchus spp*.) were available, and higher elevations in September, presumably to feed on berries, ground squirrels (*Spermophilus parryii*) and caribou (*Rangifer tarandus*). During the denning period, bears moved to higher elevations, remained through June and radiomarked females entered the dens in mid October and emerged in mid May (Collins *et al*., 2005).

Brown bears differentially used flat, undulating, gentle slope and steep slope terrains; flat terrain was used maximum, followed by gentle slope, undulating terrain and steep slope. They used flat terrain maximum in Agricultural land, followed by Grassland and forest blanks, Mixed forests with conifers and broad leaf species, Exposed rocks with slope grasses and Moist sub-alpine scrub characterized by *Rhododendron* species. The grizzly bears were also found to use flatter slopes more often than black bear (Aune, 1994). Brown bears used undulating terrain maximum in Near water bodies, river and streams, followed by Dry alpine scrub characterized by *Juniperus* species, Exposed rocks with slope grasses, Agricultural land, Grassland and forest blanks, Himalayan moist temperate forest with conifers and Riverine forest. Whereas, brown bears used gentle slope terrain in all the habitat categories. They used gentle slope terrain maximum in Riverine forest, followed by Moist sub-alpine scrub characterized by *Rhododendron* species, Himalayan moist temperate forest with conifers, Dry alpine scrub characterized by *Juniperus* species, Near water bodies,

river and streams, Exposed rocks with slope grasses, Agricultural land and Grassland and forest blanks. The steep slope terrain was used by bear only in Mixed forests with conifers and broad leaf species, Grassland and forest blanks and Himalayan moist temperate forest with conifers.

In Kugti wildlife sanctuary, the differential use of terrains in various habitat types could be related to factors like availability food, resting, seeking shelter, escape cover and biotic disturbance. As observed in field areas, bears might be using flat terrain in Agricultural land and Grassland and forest blanks, Mixed forests with conifers and broad leaf species and Exposed rocks with slope grasses maximum for feeding on herbaceous plants, insects and ants, and also for killing livestock and feeding on them. They might also be using this terrain for resting. All the habitat categories in gentle slope terrain were found to be used differentially presumably for seeking food and shelter and resting activity. The use of Moist sub-alpine scrub characterized by *Rhododendron* species and Dry alpine scrub characterized by *Juniperus* species habitats in different terrains could be mainly for shelter and escape cover. Whereas the use of Near water bodies, river and streams and Riverine forest habitats in undulating and gentle slope terrains by bears might be for food, water requirement and movement from one area to another. Brown bears might be using Mixed forests with conifers and broad leaf species, Grassland and forest blanks and Himalayan moist temperate forest with conifers habitats in steep slope terrain mainly for seeking food and their requirement.

When the proportional availability of various terrain types was compared with the expected use of these terrains by brown bear, the proportional availability of gentle

slope terrain was found to be highest, followed by flat terrain, undulating terrain and steep slope terrain. Similarly the expected use of these terrain types was found to be directly proportional to the availability. The expected use of gentle slope terrain was found to be highest, followed by flat terrain, undulating terrain and steep slope terrain. There was no difference between the proportional availability of terrain types and expected utilization of each terrain within the study area. So the proportional availability of various terrain types was found to be directly proportional to the expected use of the terrain.

Table 1. Availability of food plants of brown bear in different habitats in Kugti wildlife sanctuary during 2002-2004.

S. No.	Agricultural land	Grassland & forest blanks	Mixed forest with conifers & broad leaf species	Himalayan moist temperate forest with conifers	Near water bodies, river & stream
1	*Berberis aristata*	*Capsella bursa pastoris*	*Chaerophyllum reflexum*		*Berberis aristata*
2	*Capsella bursa pastoris*	*Chaerophyllum reflexum*	*Geranium pratens*	*Chaerophyllum reflexum*	*Chaerophyllum reflexum*
3	*Chaerophyllum reflexum*	*Chenopodium album*	*Impatiens scabrida*	*Geranium pratens*	*Chenopodium album*
4	*Chenopodium album*	*Chenopodium botrys*	*Malva verticillata*	*Impatiens scabrida*	*Berberis aristata*
5	*Chenopodium foliolosum*	*Chenopodium foliolosum*	*Origanum vulgare*	*Malva verticillata*	*Geranium pratens*
6	*Fagopyrum esculatum*	*Geranium pretanse*	*Potentilla argyrophylla*	*Origanum vulgare*	*Impatiens scabrida*
7	*Gagea elegans*	*Impatiens scabrida*	*Rumex nepalensis*	*Rumex nepalensis*	*Malva verticillata*
8	*Geranium pratens*	*Malva verticillata*	*Silene inflata*	*Selinum vaginatum*	*Origanum vulgare*
9	*Impatiens scabrida*	*Nepta laevigata*	*Taraxacum officinale*	*Taraxacum officinale*	*Rumex nepalensis*
10	*Malva verticillata*	*Origanum vulgare*			*Silene inflata*
11	*Morchella esculanta*	*Rumex nepalensis*			*Taraxacum officinale*
12	*Origanum vulgare*	*Stellaria media*			
13	*Potentilla argyrophylla*	*Taraxacum officinale*			
14	*Prunus cornuta*				
15	*Prunus persica*				
16	*Rhamnus virgatus*				
17	*Rumex nepalensis*				
18	*Selinum vaginatum*				
19	*Taraxacum officinale*				
20	*Typhonum seginatum*				
21	*Hordeum vulgare*				
22	*Triticum aestivum*				
23	*Zea mays*				
24	'*Bharesh*' crop				
25	'*Phulen*' crop				

Table 1. Continued

S. No.	Dry alpine scrub characterized by *Juniperus* species	Riverine forest	Exposed rock with slope grasses	Moist subalpine scrub with *Rhododendron* species
1	*Capsella bursa-pastoris*	*Chenopodium foliolosum*	*Artemisia vestita*	*Artemisia vestita*
2	*Chaerophyllum reflexum*	*Fragaria nubicola*	*Chaerophyllum reflexum*	*Chaerophyllum reflexum*
3	*Fragaria nubicola*	*Geranium pratanse*	*Fragaria nubicola*	*Fragaria nubicola*
4	*Gagea elegans*	*Malva verticillata*	*Geranium pratens*	*Geranium pratens*
5	*Geranium pratens*	*Rumex nepalensis*	*Impatiens scabrida*	*Geum elatum*
6	*Impatiens scabrida*	*Stellaria media*	*Rumex nepalensis*	*Impatiens scabrida*
7	*Malva verticillata*		*Stachys melissaefolia*	*Rumex nepalensis*
8	*Origanum vulgare*		*Taraxacum officinale*	*Silene inflata*
9	*Rumex nepalensis*			*Taraxacum officinale*
10	*Taraxacum officinale*			

Table 2. Habitat use by brown bear based on indirect signs in Kugti wildlife sanctuary during 2002-2004.

S.No.	Habitat category	No. of plots (n=110)	No. of bear signs in sample plots	No. of plots with bear signs	Density of digging signs/ha	Density of scats/ha
1	Agricultural land	30	93	23	45.64	53.07
2	Grassland & forest blanks	25	80	21	75.15	26.75
3	Mixed forest with conifers & broad leaf species	10	36	6	92.35	22.39
4	Himalayan moist temperate forest with conifers	10	38	8	82.8	38.21
5	Near water bodies, river & stream	10	8	10	3.18	22.39
6	Dry alpine scrub characterized by *Juniperus sp.*	10	20	9	47.77	15.92
7	Riverine forest	5	9	4	38.21	19.1
8	Exposed rock with slope grasses	5	13	4	31.84	50.95
9	Moist subalpine scrub with *Rhododendron sp.* s	5	19	5	101.91	19.1

Table 3. Frequency of occurrence of food plants species in plots used by brown bear in Kugti wildlife sanctuary during 2002-2004.

No. of food plants species	No. of plots sampled (n=110)	Plots with or without food plants (%)	No. of plots used by bears (n=90)	Proportional utilization of plots (%)
0	9	8.2	3	33.3
1	13	11.81	11	84.6
2	24	21.8	21	87.5
3	35	31.8	32	91.4
4	11	10.1	8	72.7
5	9	8.2	7	77.7
6	4	3.6	3	75
7	3	2.7	3	100
8	2	1.8	2	100

Table 4. Habitat availability verses habitat use by brown bear in Kugti wildlife sanctuary during 2002-2004.

Habitat type	No. of sample plots (n=110)	No. of plots with bear signs	Proportional availability	% Utilization or use	Expected use of habitat	Lower confidence limit	Upper confidence limit
Agricultural land	30	23	0.273	25.6	24.54	0.128	0.383
Grassland & forest blanks	25	21	0.227	23.3	20.45	0.11	0.357
Mixed forest with conifers & broad leaf species	10	6	0.09	6.7	8.18	0.0	0.14
Himalayan moist temperate forest with conifers	10	8	0.09	8.9	8.18	0.006	0.172
Near water bodies, river & stream	10	10	0.09	11.1	8.18	0.019	0.203
Dry alpine scrub characterized by *Juniperus* species	10	9	0.09	10	8.18	0.012	0.188
Riverine forest	5	4	0.045	4.4	4.09	0.0	0.105
Exposed rock with slope grasses	5	4	0.045	4.4	4.09	0.0	0.105
Moist subalpine scrub with *Rhododendron* species	5	5	0.045	5.6	4.09	0.0	0.122

Table 5. Seasonal variation in habitat use based on indirect signs by brown bear in Kugti wildlife sanctuary during 2002-2004.

Habitat type	**No. of sample plots (n=110)**	**No. of bear signs**	**Summer No. of signs (%)**	**Monsoon No. of signs (%)**	**Fall No. of signs (%)**
Agricultural land	30	93	21 (22.5)	40 (43.1)	32 (34.4)
Grassland & forest blanks	25	80	42 (52.5)	12 (15)	26 (32.5)
Mixed forest with conifers & broad leaf species	10	36	12 (33.3)	18 (50)	6 (16.7)
Himalayan moist temperate forest with conifers	10	38	12 (31.5)	22 (57.9)	4 (10.6)
Near water bodies, river & stream	10	8	1 (12.5)	2 (25)	5 (62.5)
Dry alpine scrub characterized by *Juniperus* species	10	20	13 (65)	1 (5)	6 (30)
Riverine forest	5	9	2 (22.2)	4 (44.5)	3 (33.3)
Exposed rock with slope grasses	5	13	5 (38.4)	4 (30.8)	4 (30.8)
Moist subalpine scrub with *Rhododendron* species	5	19	11 (57.8)	2 (10.6)	6 (31.6)

Summer: April, May, June; Monsoon; July, August, September; Fall: October, November, December.

Table 6. Use of terrain in different habitats based on indirect signs by brown bear in Kugti wildlife sanctuary during 2002-2004.

Habitat type	No. of sample plots	Flat terrain	Undulating terrain	Gentle slope terrain	Steep slope terrain	Total no. of bear signs
Agricultural land	30	60 (64.5)	16 (17.2)	17 (18.3)	0	93
Grassland & forest blanks	25	49 (61.2)	12 (15)	6 (7.5)	13 (16.3)	80
Mixed forest with conifers & broad leaf species	10	20 (55.5)	0	2 (5.6)	14 (38.9)	36
Himalayan moist temperate forest with conifers	10	0	5 (13.2)	28 (73.6)	5 (13.2)	38
Near water bodies, river & stream	10	0	3 (37.5)	5 (62.5)	0	8
Dry alpine scrub characterized by *Juniperus* species	10	0	7 (35)	13 (65)	0	20
Riverine forest	5	0	1 (11.1)	8 (88.9)	0	9
Exposed rock with slope grasses	5	6 (46.1)	3 (23.1)	4 (30.8)	0	13
Moist subalpine scrub with *Rhododendron* species	5	4 (21)	0	15 (79)	0	19
Total	110	139	47	98	32	316

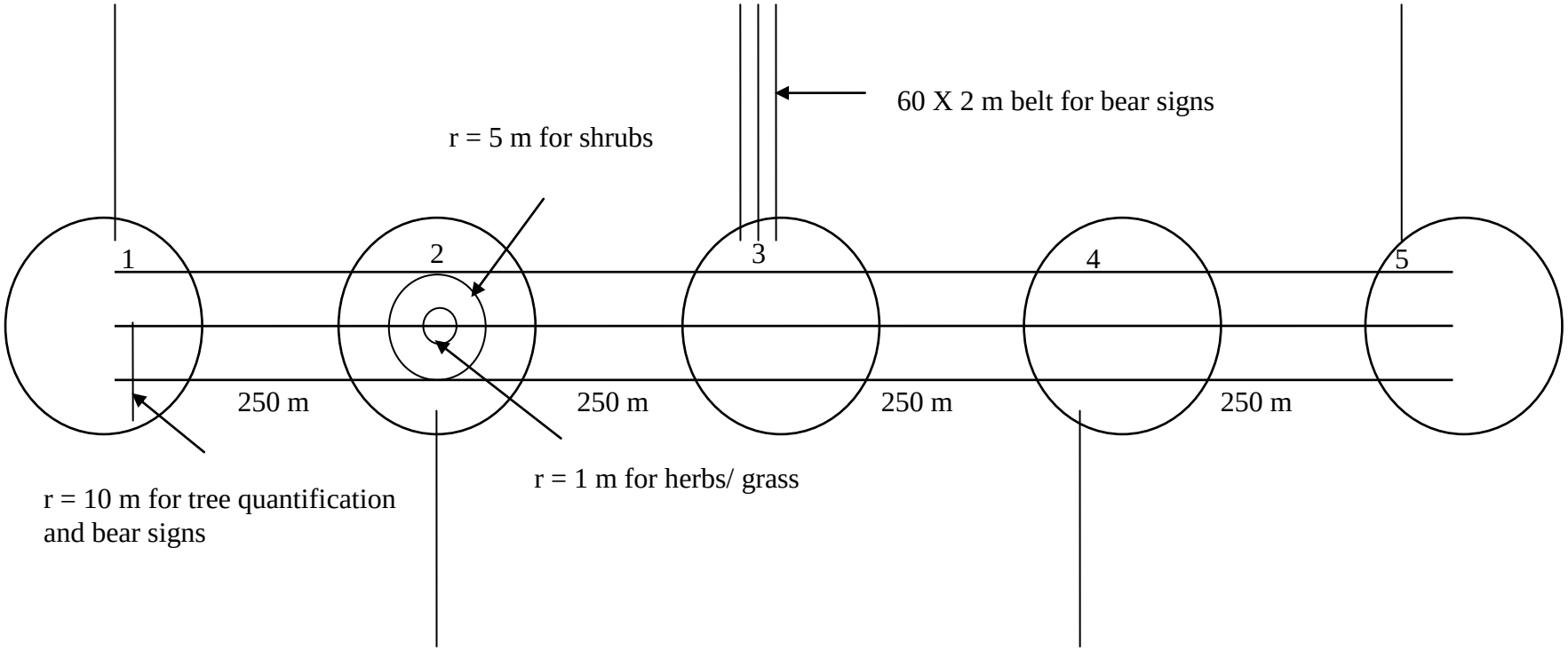
Table 7. Proportional availability and expected use of terrain by brown bear in Kugti wildlife sanctuary during 2002-2004.

Terrain type	No. of plots with terrain type	Proportional availability of terrain	No. of plots showing terrain use	Expected use of terrain	Lower confidence limit	Upper confidence limit
Flat	30	0.273	20	16.091	0.185	0.493
Undulating	25	0.227	12	13.409	0.072	0.334
Gentle slope	43	0.39	21	23.064	0.2	0.512
Steep slope	12	0.109	6	6.436	0.003	0.2
Total	110		59			

Table 8. Analysis of variance using Kruskal-Wallis non-parametric test for habitat use by brown bears.

Habitat variable	No. of trees	No. of shrubs	No. of herbs	No. of tree felled	No. of tree lopped	Cattle dung	Sheep and goat dung	Distance from habitation	Distance from road	Nearest water source
Chi-Sq.	1.015	16.108	.071	.637	1.050	7.993	8.177	21.775	2.768	9.624
df	1	1	1	1	1	1	1	1	1	1
Asymp. sig.	.314	0.000	.790	.425	.305	.005	.004	0.000	.096	.002

Figure 1: Sampling layout for vegetation quantification and collection of bear evidences.



Chapter 6

Human-brown bear conflicts

6.1 Introduction

In India, the increase in human and livestock populations has created pressure on all natural resources. Most of the protected areas are fragmented, degraded and disturbed from anthropogenic activities. Forests, pastures and wastelands were brought under cultivation to sustain increased demand of cereals and other food products (Chauhan and Sawarkar, 1989). The unsustainable land-use patterns in rural areas have further altered landscapes. This habitat modification has caused wildlife species to become ecological dislocates (Chauhan and Ramveer Singh, 1990). Some species i.e. nilgai and blackbuck, adapted to humans and have become locally overabundant, while a few others i.e. bears, lion, leopard and wolf, stray out of protected areas. Consequently most of these species cause damage to varying extent to human life and property.

The Greater Himalayan ranges that cover 2,33,800 km^2 (7.38%) of India's geographical region (Rodgers and Panwar, 1988), supports perhaps the largest population of Himalayan brown bear (*Ursus arctos*) and black bear (*Selenarctos thibetanus*). They are largely confined to the rolling uplands and alpine meadows above timberline, ecologically separated from the forest dwelling Asiatic black bear (Schaller, 1977).

In Kugti wildlife sanctuary in Himachal Pradesh, brown bear, black bear and other animals increasingly venture into human settlement and cultivation areas in search of food and cause extensive damage to the agricultural and horticultural crops, kill

livestock and attack on people. In Jammu and Kashmir, Himachal Pradesh, Uttarakhand and a few North-eastern states, human casualties and livestock killing by leopard (*Panthera pardus*) and bears are common. In the Great Himalayan National Park, India, human casualties, livestock killing and crop damage by Asiatic black (*Ursus thibetanus*) and brown bears (*Ursus arctos*) was found to be of varying extent (Chauhan, 2003). Increased incidences of livestock depredation and attack on humans by black bears have been reported (Sathyakumar, 1999b; Chauhan, 2003, 2004). In the alpine pastures in India, brown bear caused extensive livestock depredation, and migratory graziers often found to kill them to reduce the predation on their cattle (Sathyakumar, 1999a). In Himachal Pradesh, migratory graziers (gaddies) often killed bears to reduce livestock depredation (Sathyakumar, 2001 and Rathore and Chauhan, 2007). In Zanskar and Suru valleys of Ladakh, brown bear-human conflicts were fairly common during summer, and local villagers were found to resort to retaliatory killings when losses were severe (Sathyakumar, 2002). In Japan, Canada, Mexico and United States, black bears caused damage to agricultural crops, apiaries, fish farms, and livestock and human casualties (Michael *et al*., 1999; Toshihiro, 1999; Tsutomu and Joseph, 1999). In Scandinavia, the brown bear population was found increasing and dispersing, and resulted in more interactions with humans (Swenson *et al*., 1999). The Andeans bears (*Tremarctos ornatus*) in South America have been reported to predate on livestock (Goldstein 2002). Grizzly-brown bear predation on livestock has been documented and described by Murie (1948) and Mysterud (1974). The bear-livestock conflicts have been reported from Austria, Bulgaria, Canada, China, Finland, France, Greece, India, Italy, Japan, Mexico, Norway, Poland, Romania, Russia, Slovvakia, Sweden, Spain, United States, and former Yugoslavia (Servheen *et al*., 1999). Livestock depredation was reported to be a significant problem wherever

livestock and predator distributions overlapped (Kharel, 1997; Sekhar, 1998 and Stein, 2000). When livestock depredation occurred, local residents might have to invest significant resources to protect their property, and they frequently found to oppose wildlife conservation (Hill, 1997). In extreme cases, they might even seek to extirpate potentially damaging wildlife (Conover, 1994).

As a result of human-induced mortality and destruction of bear habitat throughout the world, bear populations have diminished or become locally extinct in many areas (Servheen, 1999; Mattson and Marrill, 2002). Black and brown bears could be characterized as opportunistic predators (Herrero, 1978). Even though global bear populations today have been found only a fraction of what they were in the past, livestock based conflicts continued to be a problem wherever bears and livestock coexisted. Even small population of bears could cause significant damage to livestock. In western Cantabrian brown bear (*Ursus arctos*) population in Spain, estimated at 50-60 individuals, was attributed with depredation resulting in 1,076 claims for damage compensation between 1973 and 1990 (Garcia-Gaona *et al*., 1993). Similarly in Norway, a small population of 20-25 bears was estimated to kill about 2,000 sheep annually (Kaczensky, 1999). Bear depredation on sheep has been found to occur frequently on Norwegian summer pastures (Mysterud, 1980; Kvam *et al*., 1993; Wabakken and Maartmann, 1994 and Dahle, 1996). In Venezuela, Colombia, Ecuador, Peru and Bolivia, Andean bears were perceived as livestock predators where herding was common and bears were frequently blamed for any livestock disappearance or death (Goldstein *et al*., 2006). The North American bears (grizzly bears *Ursus arctos* and American black bears *Ursus americanus*) were known to use apiaries, crops, orchard fruits, garbage, and livestock for food (Ambrose and sanders,

1978; Knight and Judd, 1983; Garshelis *et al*., 1999). Brown bears were the primary cause of mortality among adult female moose in several studies in Alaska and Canada (Larsen *et al*., 1989, Ballard *et al*., 1991; Keech *et al*., 2000 and Bertram and Vivion, 2002). Black and brown bears have been implicated as effective predators on ungulates (Schlegal, 1976; Franzmann and Schwartz, 1986; Larsen *et al*., 1989, Ballard, 1992 and Zager and Beecham, 2006). In Japan, Asiatic black bears (*U. Thibetanus*) were reported to raid crops, orchards and fish farms and caused extensive damage (Huygens and Hayashi, 1999).

In India, sloth bears (*Melursus ursinus*) have been reported to damage sugarcane and groundnut crops, and attack human beings (Iswariah, 1984; Rajpurohit and Krausman, 2000 and Bargali *et al*., 2005). Human casualties and crop depredation by sloth bear were common in many states. In Pendra and Marwahi ranges of North Bilaspur forest division, sloth bear population has developed an aberrant behaviour, and incidences of human casualties were frequent. More than 375 cases of human mauling and killings occurred from 1978 to 1998 (Chauhan *et al*., 1999; Bargali *et al*., 1999 and Akhtar *et al*., 2000). Sloth bears were found to raid maize, sweet potato, sugarcane and peanut crops (Laurie and Seidensticker, 1977 and Prater, 1990). They scavenged on meat also. The resources available in the vicinity of the villages were minor forest produces such as mahua flowers (*Madhuca indica*) and gular (*Ficus glamorata*), which were found to attract bears to live in these areas (Chauhan *et al*., 1999; Sankar and Murthy, 1995), and thus has resulted in increasing man-bear conflicts. In Melghat tiger reserve, 22 bear attacks on humans were reported during 1986-1992 (Pillarisett, 1993). Another study in the same area by Khaire *et al.* (1994) revealed 16 incidences of human casualties by sloth bear during 1988-1993 over five years. Information on

sloth bear-human conflicts from 23 forest divisions and protected areas of Madhya Pradesh showed that 607 human casualties occurred in the state during 1989-1994 (Chauhan and Rajpurohit, 1996 and Rajpurohit and Krausman, 2000). In Andhra Pradesh, 20-30 mauling cases by sloth bears were reported in different years (Krishna Raju *et al*., 1987). In other countries also, bears have been reported to cause extensive damage to agricultural crops (Peyton, 1980; Vaughan *et al*., 1989; Servheen, 1990; Conover and Decker, 1991; Reid *et al*., 1991 and Stowell and Willing, 1992).

In recent years, human-bears conflicts have been found on the increase at the interface of wildlife habitats and human use dominated landscapes. These problems have adversely affected the local rural economy and thus acceptance of conservation ideals by the local people has been also greatly affected. Though improvement in agricultural technology and practices and rural community development, and integrated forest management practices have been in progress in these areas, these measures alone would not help reduce the above conflicts. Under the circumstances, situation for both wildlife and rural people is rather tragic especially in the protected areas.

In Kugti wildlife sanctuary, migratory shepherds, villagers and brown bear conflicts have been a serious problem. Reports of livestock killing by brown bears and occasional attacks on humans have been fairly common in the north western and trans-Himalayan regions. Thus brown bears in India have been threatened largely due to killing by migratory graziers and local communities to reduce livestock depredation. Mitigation of human-brown bear conflicts in hilly areas is very complicated and therefore, scientists and wildlife managers are facing challenging situation. However, there is an urgent need to study the nature and extent of the conflicts to

develop mitigation strategies that can reduce the human-brown bear conflicts. In this chapter, the results of the study on human casualties, livestock killings, nature and extent of agricultural and horticultural crop damage by brown bears and circumstances have been presented.

6.2 Methods

The study on assessment of human-brown bear conflicts was conducted in Kugti wildlife sanctuary during 2002 to 2004. Information on human casualties, livestock (sheep and goat and others if any) killings and nature and extent of damage to agricultural and horticultural crops by brown bears was collected from the records of the forest department and from forest officials and field staff.

The migratory graziers used 22 grazing pastures or dhars in Kugti wildlife sanctuary from April to October every year. Out of 22 permanent grazing pastures, only 12 dhars, namely, Andarli Dhamel, Andarli Kinnaur, Bharali Kinnaur, Bhiad, Bhug, Bhumkar, Duggi, Ghiula, Mundi, Nanaun and Sarni dhar were selected for the conflict study. **Photograph 1 and 2** show nomadic shepherds with livestock in Kugti wildlife sanctuary. **Photograph 3** shows livestock grazing in Sarni dhar close to Dalatu agricultural land. The affected village(s) and the selected dhars or grazing pastures were surveyed and information on conflict aspects was collected by talking to the local people and migratory shepherds in the pre-designed questionnaire formats **(Appendix 5)**. In **Photograph 4**, a shepherd was interviewed in 'Bhug' dhar to collect information on livestock killings by bears. Information on the number, place of occurrence, time of livestock killings, and problem species was also recorded in the

questionnaire formats, and later, cross checked with the data of the forest department records. Sheep and goat losses were confirmed by spot visit of their bed grounds locally called as 'gots' and grazing ground or pastures for carcasses. The compensations (ex-gratia payment) relief measure paid for human and livestock casualties were also recorded from the forest department records.

Through village interviews, information on cropping pattern, nature and extent of damage to agricultural crops, time of depredation and protection methods, and collection of non-timber forest produce and time of their collection by villagers was also collected. Then in each of the above villages, randomly 2-4 affected crop fields were visited and part(s) of crop eaten or trampled and using random plot method and ocular estimation, percent damage to different crops was recorded. Information on damage to horticultural crops, time of damage and parts eaten by brown bears was also recorded.

6.3 Results

Information on human-brown bear conflicts: human casualties, livestock killings, cropping pattern, nature and extent of agricultural and horticultural crop damage etc. have been collected from the Kugti wildlife sanctuary. The human casualties were caused by leopard and black bear (*Selenarctos thibetanus)*, and livestock killings were mainly by leopard, black bear and brown bear (*Ursus arctos)* in these areas.

There were few cases of brown bears showing aggression to shepherds in different dhars within the sanctuary. Brown bears literally attacked on nomadic graziers who camped in different dhars and protecting their livestock from bears. In Chamba forest

division, Chamba wildlife division, Churah forest division and Bharmour forest division, there were 14, 25, 16 and 13 human casualties by black bear during 1995-2004. But no case of brown bear attacking and causing human casualty has been reported in these years. **Photograph 5** shows news clippings with information on incidences of bear attack on human beings and livestock in Chamba district.

6.3.1 Livestock depredation

In the Kugti wildlife sanctuary, there might be large number of livestock killings, which perhaps could not be reported timely, and the data on livestock depredation was collected by surveying different dhars and interviewing the shepherds. Amongst livestock, only sheep and goats were predated upon by brown bear, whereas cow, bull, horse, mule and dog were predated upon by leopard and black bear. **Photograph 6** shows sheep and goat killed and fed upon by brown bear in Kugti wildlife sanctuary.

The migratory graziers used 22 grazing pastures or dhars in Kugti wildlife sanctuary from April to October every year **(Table 1)**. **Map 1** shows the location of different dhars in the sanctuary area. Out of 22 permanent grazing pastures, information on human-brown bear conflicts was collected from 12 dhars. The dhars selected for conflicts study were Andarli Dhamel, Andarli Kinnaur, Ghei dhar, Bharali Kinnaur, Bhiad, Bhug, Bhumkar, Duggi, Ghiula, Mundi, Nanaun and Sarni dhar. Graziers parties, each comprising of 4 to 13 shephards alongwith their guarding dogs 2 to 4 in numbers, visited these grazing pastures during 2002 to 2004 **(Table 2, Map 2)**. They

brought 11,940, 12,970 and 13, 480 sheep and goats during the year 2002, 2003 and 2004 respectively.

During 2002-2004, there were a total of 1539 livestock casualties by brown bears in different pastures **(Table 3)**. In 2002, total 596 sheep and goats were predated upon by brown bears in 12 dhars from April to October months. Whereas in 2003 and 2004, total 512 and 431 sheep and goats respectively were predated upon by brown bears. Among all these dhars, maximum livestock depredation occurred in Nanaun dhar (199 livestock casualties i.e. 12.9%), followed by Ghiula dhar (194 livestock casualties i.e. 12.6%), Bharali Kinnaur dhar (189 livestock casualties i.e. 12.3%), Bhiad dhar (176 livestock casualties i.e. 11.4%), Andharli Kinnaur dhar (154 livestock casualties i.e. 10%), Ghei dhar (125 livestock casualties i.e. 8.1%), Duggi dhar (115 livestock casualties i.e. 7.5%), Sarni dhar (103 livestock casualties i.e. 6.7%), Bhunkar dhar (99 livestock casualties i.e. 6.4%), Bhug dhar (87 livestock casualties i.e. 5.7), Andharali Dhamel dhar (64 livestock casualties i.e. 4.2%) and Mundi dhar dhar (34 livestock casualties i.e. 2.2%) during 2002-2004. **Map 3** shows the extent of livestock depredation in different dhars that occurred during the period of three years.

Monthwise depredation by brown bear on livestock was also recorded **(Table 4)**. The results showed that livestock depredation varied in different months, and maximum depredation on sheep and goat occurred during August 485 (31.5%), followed by September 411 (26.7%), July 281 (18.25%), June 152 (9.87%), May 124 (8.05%) and October 86 (5.58%). During rest of the months i.e. December, January, February, March and April, there were no livestock depredations in Kugti wildlife sanctuary. This was the period when brown bears showed hibernation, and there were no graziers

in the sanctuary area. **Figure 1** also showed the monthly variation in livestock depredation in Kugti wildlife sanctuary.

Figure 2 shows the time of attacks by brown bears on sheep and goat in different dhars. The day timings have been divided into morning time as 0601-1000h, day time as 1001-1600h, evening as 1601-2000h. Whereas, the night timings have been divided into 2001-2400h, 0001-0400h and 0401-0600h. Time of livestock depredation was also recorded and the results showed that during 2002-2004, maximum depredation occurred during night 967 (62.8%), followed by day time 259 (16.8%), evening 233 (15.2%) and morning time 80 (5.2%).

Brown bears attacks occurring during night hours were further analysed, it was recorded that maximum number of livestock depredation occurred mid-night i.e. between 0001-0400 h (531 livestock killings i.e. 54.9%), followed by 0401-0600 h (239 livestock killings i.e. 24.7%) and 2000-2400 h (197 livestock killings i.e. 20.4%) **(Figure 3)**. This trend of livestock depredation remained the same during the years 2002, 2003 and 2004. Results also showed that depredations occurred during night time were mostly inside the 'gots' i.e. resting place of the herders, while during day and evening time, depredations occurred when livestock were grazing in different dhars.

6.3.2 Crop damage by bears

There is only one village, upper and lower Kugti village inside the wildlife sanctuary, and most of the agricultural areas are far away from village and nearer to the forest.

There was varying extent of damage to agricultural and horticultural crops depending on locations from the village. The crop depredating species found in this area were bears, Himalayan brown bear (*Ursus arctos*), langur (*Presbytis entellus*), monkey (*Macaca mulata*), goral (*Nemorhaedus goral*), porcupine (*Hystrix indica*) and rodents (squirrel, rats, mice, voles, shrew) and birds etc.

6.3.2.1 Agricultural crops

Different agricultural crops grown in Kugti wildlife sanctuary are shown in **Table 5**. In this area, the rabi crops were found to be wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*). The kharif crops cultivated were maize (*Zea mays*), phulan (*Fagopyrum esculentum*), bharesh, rajmash (*Phaseolus sativus*), mash (*Phaseolus radiatus*), potato (*Solanum tuberosum*) and peas (*Pisum sativum*). The wheat was the most dominant crop grown during winter and rainy seasons, and maize crop was grown abundantly during rainy season. The sowing and harvesting periods of these agricultural crops including vegetable crops are shown in **Table 5**.

The damage caused to these agricultural crops was found to be of varying extent. The results are as follows:

6.3.2.2 Nature and time of damage

Crop depredation by brown bear was found to be quite visible in crop fields. **Table 6** shows different agricultural crops, depredating species, damage time, part eaten or damaged and activities of brown bears and other animals resulting into the damage.

Different plant species, phenological stages and their parts preferred by these depredating species are also shown.

Brown bears preferred wheat tender leaves and grains, maize corn, and young shoots and grains of barley, phulen and bharesh crops (**Table 6)**. Damage to wheat, maize, barley, bharesh and phulan crops was maximum during the seeding stage and seed formation stage when corn in spikes developed. Maize and wheat plants were trampled more that eaten. **Photograph 7 and 8** show damage to wheat and maize crops by brown bear in Tendei and Seri agricultural areas respectively in Kugti wildlife sanctuary. Seeds of pea and rajmash were also consumed by bears. Brown bears were found to damage wheat, maize and barley grains mainly by its trampling and feeding activities. Seed formation stage of these crops was found highly susceptible to damage.

6.3.2.3 Monthly variations

In Kugti wildlife sanctuary, damage to agricultural crops by brown bears showed marked monthly variations depending on various phenological stages of crops preferred as food **(Table 7)**.

Brown bears were found to extensively damage wheat, maize, barley, bharesh and phulan crops by trampling and feeding activities. Damage to wheat crop by bears was found during July-August and October-November. Maize and barley crops were damaged during August-September and June-July respectively. Damage to phulen, bharesh and rajmash crops was found to occur in August, September and early

October. This period coincided with the fruiting phase or seed formation stage of these crops. Pea seedlings were found damaged during the sowing period April-May, and peas were damaged to maximum during June-July. Likewise potato seeds were damaged at the time of tuber formation during September-October.

6.3.2.4 Extent of crop damage

In lower and upper Kugti village, affected crop fields were surveyed and farmers were interviewed, and using random plot method, assessment of crop damage was carried out in different crop fields. The results of this crop damage assessment were comparable to the ones of ocular estimation. The crop damage assessment was carried out in Tendei, Dalautu, Seri, Bharmani and agricultural lands near lower Kugti and upper Kugti village during 2002-2004 **(Table 7)**. Wheat, maize, barley, phulan, bharesh, rajmash and vegetable crops were grown in these villages on rotational basis in different years as shown in the table.

Although damage was recorded almost to all agricultural crops grown in this area, but the quantum of damage varied considerably in different agricultural lands depending on their locations. Agricultural crop field adjacent to forest and far away from the village suffered greater losses than the crop fields located near the village. Amongst all the crops, maize suffered highest level of damage by brown bear. Maize crop suffered 10-35% damage by brown bears. Maximum damage to maize crop was 30% that occurred in Seri agricultural land located about 2 km far from Kugti village, and it was difficult to protect the crop especially during night time. **Photograph 9** shows guarding hut for protection of agricultural crops from depredation.

Damage to wheat crop was 15-25%. Maximum damage (25%) to wheat crop was assessed in Tendei agricultural area, which was located at higher altitude, far away from the village. Damage to barley crop was 10-20%, and maximum damage was found in Dalatu agricultural land, which was 3 km from the village. Assessment of damage to phulan crop was 15-25% in Tendei, Dalatu and Bharmani agricultural lands. All these agricultural areas were located far away from the village and crop raiding by brown bears occurred in the evening and night time. Likewise bharesh crop also suffered loss of 10-20%, and maximum damage was found in Tendei and lower Kugti village. Damage to rajmash and potato crops was found 5-10% each in Tendei and Seri areas. Pea crop suffered damage from 5-15% in Tendei, Dalatu and lower and upper Kugti village.

6.3.2.5 Horticultural crops

Among horticultural crops, apple (*Pyrus malus*), plum (*Prunus armeniaca*), pear (*Pyrus communis*), apricot (*Prunus padus*), peach (*Prunus persica*) and jamu (*Prunus cornuta*) were found in the study area. Brown bears were found to damage peach (*Prunus persica*) and jamu (*Prunus cornuta*) everywhere in the sanctuary. Apple crop was not damaged by brown bears.

6.4 Discussion

Investigations were carried out to assess human-brown bear conflicts in Kugti wildlife sanctuary, Himachal Pradesh. Data on human casualties, livestock killings, cropping pattern, nature and extent of agricultural and horticultural crop damage etc. have been analysed. In the Himalayan region, leopard and black bear were found to be mainly responsible for human casualties. In and around Kugti wildlife sanctuary, no incidence of human casualty by brown bear has been reported during 2002-2004. Few cases of brown bears showing aggression to shepherds in different dhars used for livestock grazing were recorded. A number of times, nomadic graziers who camped in different dhars alongwith their livestock were attacked by brown bears. This aggressive behaviour of brown bears was observed when they were stocking livestock and shepherds were guarding their livestock.

Black bear, brown bear and leopard were found responsible for livestock killings. In the Kugti wildlife sanctuary, there might be large number of livestock killings, which perhaps could not be reported timely. Amongst livestock, only sheep and goats were predated upon by brown bear, whereas cow, bull, horse, mule and dog were predated upon by leopard and black bear.

Sheep and goat killings by brown bears were recorded in all the 12 dhars. There were a total of 1539 livestock depredation by brown bears in Andarli Dhamel, Andarli Kinnaur, Bharali Kinnaur, Ghei, Bhiad, Bhug, Bhumkar, Duggi, Ghiula, Mundi, Nanaun and Sarni dhars during 2002-2004. A total of 596, 512 and 431 sheep and goats were predated upon by brown bears during the years 2002, 2003 and 2004 respectively. Maximum livestock depredation occurred in Nanaun dhar, followed by

Ghiula dhar, Bharali Kinnaur dhar, Bhiad dhar, Andharli Kinnaur dhar, Ghei dhar, Duggi dhar, Sarni dhar, Bhunkar dhar, Bhug dhar, Andharali Dhamel dhar and Mundi dhar dhar during this period. All the livestock killings took place from April to October months when graziers were present in these pastures and brown bears were active in these areas. Bears were actively feeding on herbaceous plants and also on livestock during this period. Yearly variation in livestock killings by bears in different dhars might be attributed to number of livestock present in these dhars, chance of interaction between bears and livestock, level of protection to livestock by shepherds and guarding dogs, availability of other food resources and also to number of bears present in this entire area.

Several studies on bears also revealed predation on sheep, goats and other livestock. In general, grizzly bears and sheep were found not compatible. Although sheep losses to grizzly bears were found not as high as from other causes, they were large enough to represent an economic loss to the herders (Knight and Judd, 1983). In the Targhee National Forest, predation by grizzly bears accounted for 14.6% of sheep losses in 1976 and 1977 (Johnson and Griffel, 1982). This was not very significant when losses due to herding practices were over twice as great. Warren and Mysterud (1995) monitored sheep mortality in Hedmark County in southeastern Norway and found summer mortality rates from bear depredation to be 7.2% for ewes and 9.1% for lambs. Similarly, another study in central Norway, revealed that among 337 radiocollared lambs, 37 were died, and 14 (42.4%) lambs were predated upon by bears (Knarrum *et al*., 2006). A study on bear-sheep interactions in Targhee National Forest, Idaho, and Wyoming during 1976-1977 indicated that limited occurrence of available food in spring and early summer increased the chance of interaction, and

interactions between bears and sheep usually resulted in conflicts (Jorgenson, 1983). Contact between bears and sheep often resulted in bear predation on sheep or the killing of the bears as a real or alleged threat to the sheep. Cattle were less likely to cause conflict with grizzly bears than were sheep (Knight and Judd, 1983).

Likewise increased incidences of livestock depredation by black bears have been reported (Sathyakumar, 1999b; Chauhan, 2003, 2004). In the Great Himalayan National Park, India, human casualties, livestock killing and crop damage by both Asiatic black and brown bears were found to be of varying extent (Chauhan, 2003). In the alpine pastures in India, brown bear caused extensive livestock depredation, and migratory graziers often found to kill bears to reduce the predation on their cattle (Sathyakumar, 1999a). In Japan, Canada, Mexico and United States, black bears caused damage to agricultural crops, apiaries, fish farms, and livestock and human casualties (Michael *et al*., 1999; Toshihiro, 1999; Tsutomu and Joseph, 1999). The bear-livestock conflicts have been reported from Austria, Bulgaria, Canada, China, Finland, France, Greece, India, Italy, Japan, Mexico, Norway, Poland, Romania, Russia, Slovvakia, Sweden, Spain, United States, and former Yugoslavia (Servheen *et al*., 1999). Bear depredation on sheep has been found to occur frequently on Norwegian summer pastures (Mysterud, 1980; Kvam *et al*., 1993; Wabakken and maartmann, 1994 and Dahle, 1996). Livestock depredation was reported to be a significant problem wherever livestock and predator distributions overlapped (Kharel, 1997; Sekhar, 1998 and Stein, 2000). In Kugti wildlife sanctuary, there were similar findings; the brown bear habitat use range was found overlapped with the livestock grazing areas.

Livestock depredation by brown bears varied in different months in Kugti wildlife sanctuary; maximum depredation on sheep and goat occurred during August, followed by September, July, June, May and October. During rest of the months i.e. December, January, February, March and April, there was no livestock depredation in the sanctuary. This was the period when brown bears were in hibernation, and there were no graziers and livestock in the sanctuary area.

The timings of brown bears attacks on sheep and goats showed specific pattern. Time of livestock depredation was maximum during night, followed by day time, evening and then morning time. Even during night, maximum livestock depredation occurred during mid-night i.e. between 0001-0400 h, followed by 0401-0600 h and then 2000-2400 h. Livestock depredation occurring during night time was mostly inside the 'gots' i.e. resting place of the herders, while during day and evening time, depredation occurred when livestock were grazing in different dhars. This pattern of livestock depredation could be attributed to activity pattern of brown bears, low disturbance, and chance of interaction between bears and livestock increased as graziers fell asleep and level of vigil reduced during night time. Substantial level of livestock depredation occurred early in the morning when the guarding dogs and herders got tired.

Other studies conducted on bears worldwide also revealed specific time pattern of bears and livestock interactions. All the grizzly bear-sheep predation incidents were reported to occur on sheep bedgrounds, either during night or early morning (Jorgenson, 1983). A study on bear-sheep interactions in Targhee National Forest, Idaho, and Wyoming also indicated that black bears killed sheep during both day and night time, but grizzly bears killed only at night (Jorgenson, 1983). The study also

indicated that herders who maintained close contact with their sheep, keeping their herds in tight bands, experienced lower predation losses than those who allowed their herds to wonder freely.

In the study area, a few times migratory herders eliminated nuisance brown bears in order to protect their livestock, which was found to be one of the serious limiting factors for brown bear conservation. **Photograph 10** shows carcass of brown bear killed by shepherds in Kugti wildlife sanctuary in retaliation to livestock depredation. In Zanskar and Suru valley, Ladakh, brown bear-human conflicts were fairly common, and villagers often resorted to retaliatory killing of bears when livestock losses were severe (Sathyakumar, 2002). Krott (1961) reported that bear population in Italy had been reduced to very low levels because of poaching by shepherds.

In Kugti wildlife sanctuary, most of the agricultural areas were found to be located far away from village and nearer to the forest. There was varying extent of damage to agricultural and horticultural crops depending on locations from the village. The rabi crops susceptible to damage were wheat and barley, and the kharif crops were maize, phulan, bharesh, rajmash, mash, potato and peas. Among these crops, brown bears extensively damaged wheat tender leaves and grains, maize corn, and young shoots and grains of barley, phulen and bharesh crops. Damage to wheat, maize, barley, bharesh and phulan crops was highest during the seeding stage and seed formation stage when corn in spikes developed. Seeds of pea and rajmash were also consumed by bears. Brown bears might have preference for wheat, maize and barley grains and damage these crops mainly by trampling and feeding activities. Wheat and maize plants were trampled more that eaten. Thus the seed formation stage of these crops was found highly susceptible to damage.

The studies conducted in India and several other countries also showed crop preference by bears; the nature of crop damage and preference for different phenological stages of crops were similar. In the Great Himalayan National Park, India, crop damage by Asiatic black and brown bears was found to be of varying extent and different parts of the crops and phenological stages were preferred by bears (Chauhan, 2003). Sloth bears were found to damage sugarcane and groundnut crops (Iswariah, 1984; Rajpurohit and Krausman, 2000 and Bargali *et al*., 2005). Crop depredation by sloth bear was common in many states. Sloth bears were found to raid maize, sweet potato, sugarcane and peanut crops (Laurie and Seidensticker, 1977 and Prater, 1980). In other countries also, bears have been reported to cause extensive damage to agricultural crops (Peyton, 1980; Vaughan *et al*., 1989; Servheen, 1990; Conover and Decker, 1991; Reid *et al*., 1991 and Stowell and Willing, 1992). The North American bears were known to use apiaries, crops, orchard fruits, garbage, and livestock for food (Ambrose and sanders, 1978; Knight and Judd, 1983; Garshelis *et al*., 1999). In Japan, Asiatic black bears were reported to raid crops, orchards and fish farms and caused extensive damage (Huygens and Hayashi, 1999).

Damage to agricultural crops by brown bears showed marked monthly variations. This might be due to availability of different phenological stages of the crops and preference for the plant parts as food. Brown bears were found to damage wheat, maize and barley grains mainly by its trampling and feeding activities. Wheat and maize plants were trampled more that eaten. This period coincided with the fruiting phase or seed formation stage of these crops, which were preferred by the bears.

Agricultural crops: wheat, maize, barley, phulan, bharesh, rajmash and vegetable crops were grown in Tendei, Dalautu, Seri, Bharmani and agricultural lands near lower Kugti and upper Kugti village on rotational basis in different years. As already stated that all agricultural crops were found to be damaged in this area, but the quantum of damage varied considerably in different agricultural lands depending on their locations. Agricultural crop field adjacent to forest and far away from the village suffered greater losses than the crop fields located near the village. Maize crop suffered highest level of damage by brown bears mainly because of food preference. Highest level of damage was recorded in Seri agricultural land, which was located about 2 km far from Kugti village, and it was difficult to protect the crop especially during night time. Damage to wheat crop was maximum in Tendei agricultural area, which was located at higher altitude, far away from the village. Likewise damage to barley crop was maximum in Dalatu agricultural land, which was about 3 km from the village. There was considerable damage to phulan crop in Tendei, Dalatu and Bharmani agricultural lands. All these agricultural areas were located far away from the village and crop raiding by brown bears occurred in the evening and night time. Bharesh crop also suffered maximum damage in Tendei and lower Kugti village.

Agricultural crop rotation has been a common practice in Kugti village. By following this pattern, crop damage by bears could be substantially reduced as 75% of land holdings were situated more than 2 km away from the village and nearer to the forest where bears could easily raid agricultural crops especially during night. Among horticultural crops, brown bears were found to damage peach (*Prunus persica*) and jamu (*Prunus cornuta*) everywhere in the sanctuary area.

Table 1. List of grazing pastures or dhars in Kugti wildlife sanctuary.

S. No.	Name of the dhars
1	Andarli Dhamel dhar*
2	Andarli Kinnaur dhar*
3	Bharali Dhamel dhar
4	Bharali Kinnaur dhar*
5	Bhiad dhar*
6	Bhug dhar*
7	Bhumkar dhar*
8	Buhar dhar
9	Duggi dhar*
10	Dhugdhar
11	Gan dhar
12	Ghadoi dhar
13	Ghei dhar*
14	Ghiula dhar
15	Gufai dhar
16	Hali dhar
17	Jousaha dhar
18	Karog dhar
19	Mundi dhar*
20	Nanaun dhar*
21	Sarni dhar *
22	Siya dhar

*** Dhars selected for the conflict study**

Table 2. Grazier parties and number of livestock visited different dhars in Kugti wildlife sanctuary during 2002-2004.

Name of dhar	Grazier party number	No. of shepherds	No. of livestock			No. of guarding dogs
			2002	2003	2004	
Ghiula	1	13	1545	1420	1600	4
Andhrali Kinnaur	2	10	1355	1200	1500	2
Bharali Kinnaur	3	9	1020	1130	1200	3
Bhunkar	4	6	1330	1500	1400	2
Mundi	5	5	770	850	900	2
Ghei	6	6	1120	1300	1200	3
Nanaun	7	6	860	1100	900	4
Bhug	8	6	740	900	940	2
Andhrali Dhamel	9	4	705	800	860	2
Duggi	10	6	950	1100	1100	2
Bhiad	11	5	765	820	920	3
Sarni	12	4	780	850	960	2
			11940	**12970**	**13480**	

Table 3. Livestock depredation in different dhars in Kugti wildlife sanctuary during 2002-2004.

Name of dhar	2002	2003	2004	Total (%)
Ghiula	88	61	45	194 (12.6)
Andhrali Kinnaur	69	59	26	154 (10)
Bharali Kinnaur	79	63	47	189 (12.3)
Bhunkar	43	31	25	99 (6.4)
Mundi	17	11	6	34 (2.2)
Ghei	44	45	36	125 (8.1)
Nanaun	74	76	49	199 (12.9)
Bhug	29	26	32	87 (5.7)
Andhrali Dhamel	27	18	19	64 (4.2)
Duggi	42	44	29	115 (7.5)
Bhiad	49	61	66	176 (11.4)
Sarni	35	17	51	103 (6.7)
	596	**512**	**431**	**1539**

Table 4. Livestock depradation in different months in grazing pastures or dhars in Kugti wildlife sanctuary during 2002-2004.

Name of dhar	May	June	July	August	September	October
Ghiula	16	15	35	58	61	9
Andhrali Kinnaur	12	12	21	53	46	10
Bharali Kinnaur	11	16	44	55	49	14
Bhunkar	8	5	10	26	45	5
Mundi	1	4	4	11	13	1
Ghei	11	7	34	32	36	5
Nanaun	20	15	27	60	62	15
Bhug	6	5	13	31	26	6
Andhrali Dhamel	3	9	17	18	15	2
Duggi	1	17	33	44	15	5
Bhiad	32	28	20	61	27	8
Sarni	3	19	23	36	16	6
	124 (8.05%)	**152 (9.87%)**	**281 (18.25%)**	**485 (31.5%)**	**411 (26.7%)**	**86 (5.58%)**

Figure 1. Livestock depredation in different months in grazing pastures or dhars in Kugti wildlife sanctuary during 2002-2004.

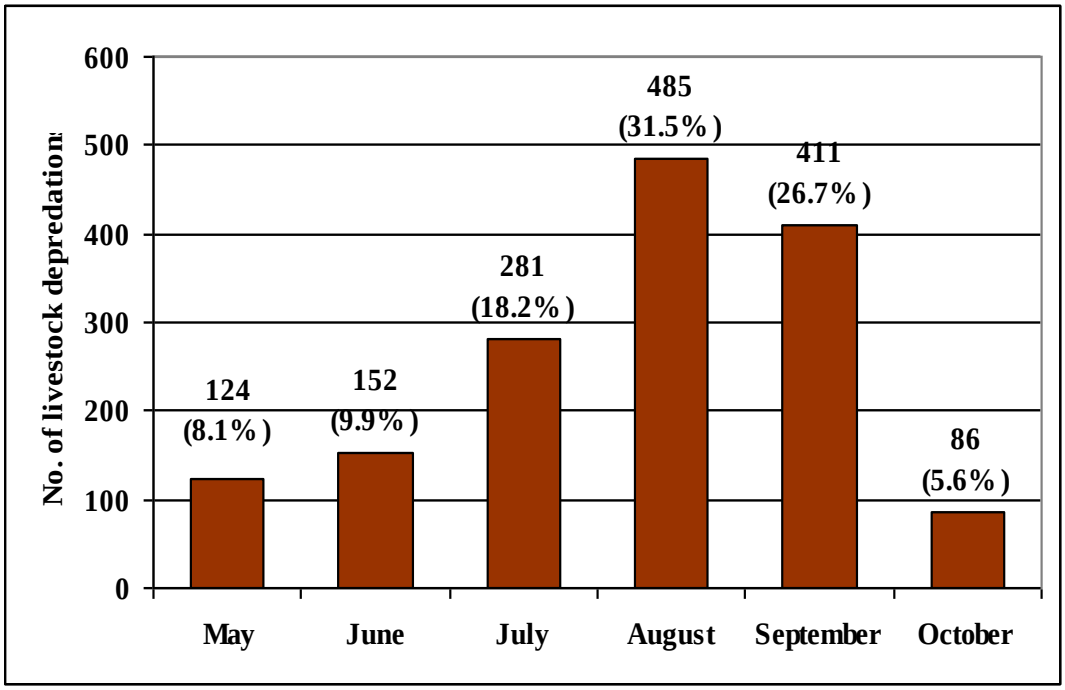


Figure 2. Time of livestock depredation by brown bear in Kugti wildlife sanctuary during 2002-2004.

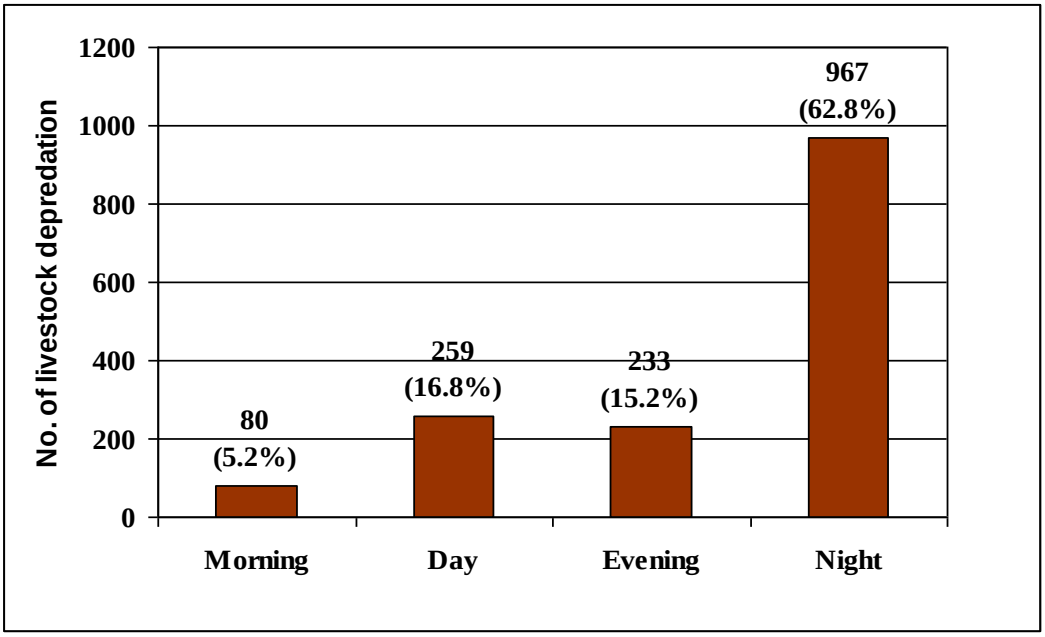


Figure 3. Time of livestock depredation by brown bear during night hours in Kugti wildlife sanctuary.

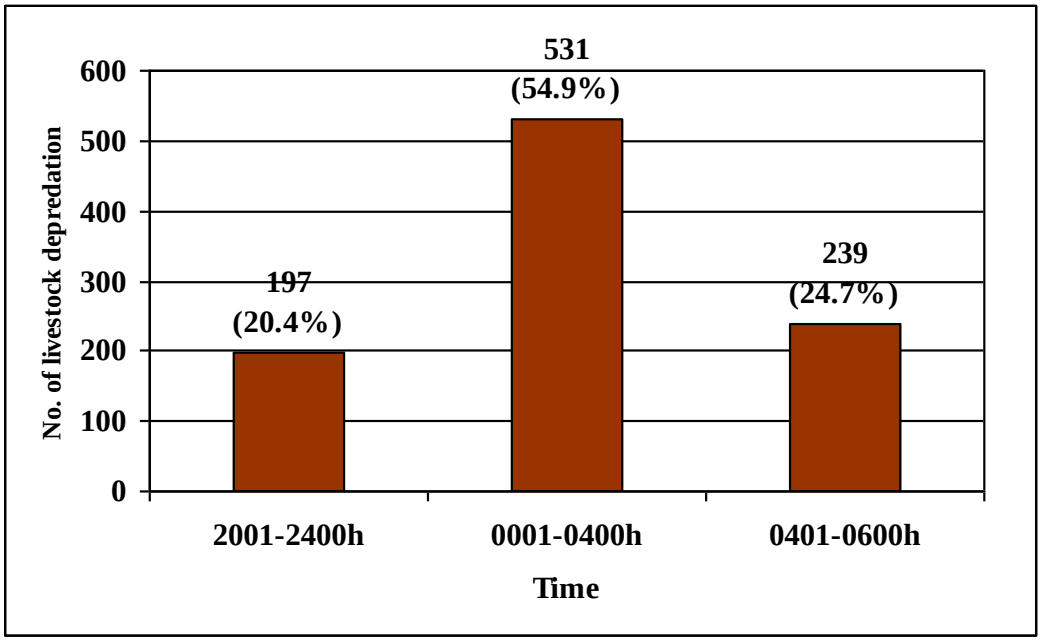


Table 5. Agricultural crops and their sowing and harvesting time in Kugti wildlife sanctuary.

Crop	Botanical name	Sowing time	Harvesting time
Wheat	*Triticum aestivum*	October-November	July-August
Maize	*Zea mays*	March	September-October
Barley	*Hordeum vulgare*	October	June-July
Phulan	*Fagopyrum esculantum*	March	September
Bharesh	*Fagopyrum spp.*	March	September
Rajmash	*Phaseolus sativus*	March	September-October
Mash	*Phaseolus radiatus*	March	September-October
Potato	*Solanum tuberosum*	April	October
Peas	*Pisum sativum*	April	October

Table 6. Agricultural crops depredating species, their activity and nature and time of damage in Kugti wildlife sanctuary.

Common name	Botanical name	Problem species	Damage time	Part eaten	Activity
Wheat	*Triticum aestivum*	Brown bear	October-November July-August	Leaves and grains	Trampling, feeding
		Goral	October-November	Young shoots	Feeding
		Monkey	January - February June - July	Young shoots, grains	Feeding
		Porcupine	January - February June - July	Roots, grains	Feeding
		Parrot	June - July	Grains	Feeding
Maize	*Zea mays*	Brown Bear	August - September	Corn	Trampling, feeding
		Monkey	May - June August - September	Young shoots, corn	Feeding
		Porcupine	May - June August - September	Roots, flowers, corn	Feeding
Barley	*Hordeum vulgare*	Brown bear	June -July	Young shoots, grains	Feeding
Phulan	*Fagopyrum esculentum*	Brown bear	August - September	Young shoots, grains	Feeding
Bharesh	*Fagopyrum spp.*	Brown bear	August-September	Grains	Trampling, feeding
Rajmash	*Phaseolus sativus*	Brown bear	September - October	Pods, seeds	Feeding
Peas	*Pisum sativum*	Brown bear	June-July	Peas	Feeding

Table 7. Damage to agricultural crops by brown bear in Kugti wildlife sanctuary during 2002-2004.

Name of agricultural land	Year	Wheat	Maize	Barley	Phulan	Bharesh	Rajmash	Potato	Pea
Tendei	2002	25%	-	-	25%	20%	-	-	-
	2003	-	-	-	-	-	10%	10%	15%
	2004	15%	-	-	-	-	-	-	-
Dalatu	2002		-	20%	-	-	-	-	-
	2003	-	-	-	15%	10%	-	-	-
	2004	5%	-	-	-	-	-	-	10%
Seri	2002	-	25%	-	-	-	-	-	-
	2003	-	-	-	-	-	5%	5%	-
	2004	-	35%	-	-	-	-	-	-
Bharmani	2002	-	-	15%	20%	-	-	-	-
	2003	15%	-	-	-	10%	-	-	-
	2004	-	-	-	-	-	-	-	-
Lower Kugti village	2002	-	10%	-	-	20%	-	-	10%
	2003	-	-	10%	-	-	-	-	5%
	2004	-	20%	-	-	-	-	-	-
Upper Kugti village	2002	-	20%	-	-	-	-	-	5%
	2003	-	20%	-	-	-	-	-	-
	2004	-	10%	-	-	-	-	-	-

Table 8. Horticultural crops, problem species and part eaten by brown bear, langur and monkey in Kugti wildlife sanctuary.

Common name	Botanical name	Problem species	Part eaten
Apple	*Pyrus malus*	Langur, monkey	Fruit, bark
Pear (Nashpati)	*Pyrus communis*	Langur, monkey	Fruit
Plum	*Prunus armeniaca*	Langur, monkey	Fruit
Apricot (Khumani)	*Prunus padus*	Langur, monkey	Fruit
Peach (Adu)	*Prunus persica*	Bear, langur, monkey	Fruit, bark
Jamu	*Prunus cornuta*	Bear, monkey	Fruit

7. Suggestions and recommendations

To resolve human-brown bear conflicts, we know that both the rights of wildlife and the livelihood rights of communities dependent on natural habitats need to be protected. The current processes of development and commercialization threaten both wildlife and local community livelihoods. Therefore, there is an urgent need to build a system that integrates biodiversity conservation and people's livelihood rights. The integration of wildlife conservation and people's livelihood requires actions to enable local communities to manage and sustainably harvest natural resources for their livelihoods, through establishing appropriate tenurial rights, and combining traditional and modern knowledge to monitor the ecological impacts of such harvesting. There is also a need to devise ecologically and culturally appropriate and equitable alternatives for livelihoods that are currently unsustainable.

So there is need to develop innovative mechanisms or strategies including the use of traditional methods used by the local communities, which can reduce brown bear damage problems. Ecology of problematic species, nature and extent of damage and circumstances of damage has been evaluated for developing mitigation strategies. Based on the ecological study, human-brown bear conflicts and survey of affected areas, the following general recommendations are made to reduce human-brown bear conflicts.

1. The landuse patterns in the hilly areas are changing constantly. Under such circumstances, some ameliorative action is required. Problem mitigation efforts should be made by way of protection and improvement of natural habitat of wild

animals including brown bear. In the disturbed, fragmented and degraded forest areas, habitat improvement through protection, plantation and reduction of biotic pressures need to be carried out to sustain wild animal populations. Local people should help and cooperate in protection of forests and wild animals therein, which will help increase in prey base in the wild. They should also protect forests from any outbreak of forest fire.

2. In Kugti wildlife sanctuary, nine distinct habitat types viz. Agricultural land, Grassland and forest blanks, Mixed forest with conifers and broad leaf species, Himalayan Moist temperate forests with conifers, Near water bodies, river and streams, Dry alpine scrub characterized by *Juniperus* species, Riverine forests, Exposed rock with slope grasses and Moist sub-alpine scrub dominated by *Rhododendron* species are used by brown bears for ranging, feeding, breeding activities, hibernation and seeking shelter. The habitat use by brown bear was found to be largely dependent on the availability of food resources, variety of food plants and shelter in different habitat types. There were 25 species of food plants available in these habitats. So it is very important to protect these habitats from increasing biotic interference, and exploitation of these resources by the people. Some regulation on collection of mushroom and medicinal plants used by brown bears in these habitats should be imposed.

3. Brown bear make highest use of Moist sub-alpine scrub characterized by *Rhododendron* species, Himalayan moist temperate forest with conifers, Mixed forest with conifers and broad leaf species and Grassland and forest blanks habitats. These habitats need to be protected from biotic interferences.

4. In Kugti wildlife sanctuary, there is increasing biotic pressure due livestock grazing, collection of medicinal plants and other non-timber forest produce, and to some extent fuelwood extraction. All these factors together might be affecting the habitat use and movement pattern of brown bear in these areas. Number of livestock population brought by the migratory shepherds in the sanctuary area is on the increase in alpine pastures, as a result, the prime habitats of brown bears and other wild animals are severely impacted. There is need for planning strategies for regulation of livestock grazing, imposing restriction on collection of medicinal plants in the highly preferred habitat use areas.

5. For mitigation of human-brown bear conflicts under given socio-economic and political framework, one of the ways is to minimize the ill effects of socio economic constraints and socio-ecological constraints in these areas. Livestock killings and agricultural and horticultural crop damage are the socio-ecological constraint identified. To minimize their ill effects on people, education and awareness programmes related to wildlife conservation, ecology of brown bear and genesis of human-brown bear menace is necessary.

6. In and around Kugti wildlife sanctuary, there were only a few cases of human casualties by black bear, which were accidental, and there was no incidence of human casualty by brown bear. The problem here is not significant; however people should be alert and vigilant moving in wildlife areas.

7. Graziers parties use 22 pastures permanently for grazing their livestock in the sanctuary, and they took 11,940, 12,970 and 13, 480 sheep and goats during the

year 2002, 2003 and 2004 respectively. There should be strict regulation on number of livestock which are taken by the shepherds inside the sanctuary, and also on the use of pastures. The grazing should be permitted only in prescribed number of dhars.

8. During 2002-2004, there were a total of 1539 livestock casualties by brown bears in 12 dhars from April to October months. Livestock depredation was high in all these pastures. There might be large number of livestock depredation in 22 dhars of the sanctuary which perhaps could not be timely reported. Most incidences of bear attacks on livestock killings occurred in gots, followed by forests. It is suggested that livestock grazing should be restricted to these pastures only and not near the scrub bushes and on the fringes of forests. They should have strict vigil and keep more number of guardian dogs.

9. Livestock depredation varied in different months; maximum depredation occurred during August, followed by September, July, June, May and October. Also maximum livestock depredation occurred during night time, especially mid night, followed by day time, evening and then morning time during 2002-2004. The shepherds should have strict vigil and cooperative guarding during the months and time when brown bears are most active and depredation is high.

10. Though livestock depredation occurred in both situations when attended by graziers and not attended by graziers, but depredation might be more when unattended by graziers. So the livestock when taken to gots, the livestock must be attended by more number of shepherds depending on herd size and location.

During evening and night time, the attendants should lit fire at 3-4 sites in gots, again depending on number of livestock they take to these pastures to scare away predators. This will help a lot in reducing their killings by bears.

11. These graziers should also keep more number of guarding dogs with their herds and also licensed sound producing fire-arms to scare away bears.

12. When the livestock are taken in pastures or near scrub bushes, graziers should attend them properly. Any type of bell or sound producing device should be put around the neck of some of the livestock. When the livestock are approached by predators, they will try to escape or run and produce alarm sound for remaining livestock, and will also give signal to the graziers. This way, incidences of livestock killing by bears can be contained.

13. Payment of compensation scheme by the state forest department for human casualties and livestock killings and property damage by wild animals is a good gesture. This would help develop understanding between affected people and forest department and help wildlife conservation. But the compensation procedure for livestock should be simplified so that ex-gratia amount is paid very quickly. The necessity to obtain a post-mortem report of the killed animal from veterinary doctor needs to be reviewed.

14. Allowing eco-regeneration of the forest both by reduction or regulation on livestock grazing over a long period of time will help replenishment of brown bear habitats and increase in prey-base. Besides, livestock population in the state could

be reduced by the way of introducing selectively breeding of high yielding local breeds, which could be stall-fed. This will help check the population of dry cattle, leading to the reduction of unwanted pressure on wildlife habitat. It can only reduce livestock killing incidences by black bears and leopard.

15. A detailed study on habitat use, ranging and activity patterns and feeding ecology, intra-specific interactions i.e. between brown bear and black bear, denning aspect and hibernation of brown bear as well as black bear, and socio-economic aspects of local people and mitigation of human-bear conflicts in Chamba district including Bharmour, Chamba wildlife division, Churah, Dalhousiae and Pangi forest divisions is proposed for developing a sound conservation and management plan for bear species. For conducting systematic research study on bear menace, we should take into account people's feelings, perceptions and attitudes towards the menace, and involve local community including migratory graziers in the planning, and implementation of wildlife conservation programme. It is also very crucial that all stakeholders viz. forest department, administrators, local community and migratory graziers are involved in developing tools and strategies to address human-brown bear conflicts. This partnership would give much needed credibility to management.

16. The systematic collection of conflict reports by the forest department will provide baseline information. Efforts must be made to inspect conflict sites immediately by the forest staff. A depredation inspection record will be further useful for the department and affected people in understanding the damage problem and in developing appropriate mitigation measures.

17. Brown bears cause extensive damage to wheat, maize, barley, bharesh and phulan crops in lower and upper Kugti village. Maize and wheat plants were trampled more that eaten. Brown bears were found to damage wheat, maize and barley grains mainly by its trampling and feeding activities. Damage to wheat crop by bears was found during July-August and October-November. Maize and barley crops were damaged during August-September and June-July respectively. Although in hilly terrain it is very difficult to protect crops, but protection measures such as use of live fences and wire fence with flying white coloured ribbons which flashes with wind in sun or moon light or plastic strips which produces scaring sounds should be encouraged in the crop fields throughout the crop season.

18. When the crops are vulnerable to damage, farmers need to keep strict and constant vigil in the crop fields for protection of crops. At the time of spike formation and crop maturation stage, frightening devices: scare-crows and dummies should be used in crop fields. Use of noise producing device, fire crackers and mashal during night will greatly help in keeping depredating animals including brown bear away.

19. There are some repellents and sonic and ultrasonic deterrent tried on animals in other countries. We need to conduct experiments on the use and efficacy of these repellents against problematic species in crop fields in reducing damage in our situations prior making any suggestion.

20. In agricultural areas showing significant crop damage, short term measure of co-operative crop guarding especially during the sowing period and spike/seed

formation stage when crop maturation takes place with the help of torches or mashals and crackers will be useful.

21. At present, there is no provision for compensation of crop losses and no crop insurance scheme in the state. Possibility of crop insurance scheme needs to be expedited.

22. Public education and awareness with respect to species conservation, natural history of brown bear and other crop depredating wild animals and damage control etc will be helpful in understanding the problems in the field.

23. To protect horticultural crops, use of sound and frightening devices is encouraged in these hilly areas.

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Appendix 1. Checklist of flora of Kugti wildlife sanctuary.

S. No.	Common name	Genus	Species	Family	Type of plant
1	Mandir ka buta	*Acer*	*caesium*	Aceraceae	T
2		*Cyathula*	*tomentosa*	Amaranthaceae	H
3		*Allium*	*humile*	Amaryllidaceae	H
4	Kakar Singhi	*Pistacia*	*integerrima*	Anacardiaceae	T
5	Chora	*Angelica*	*glauca*	Apiaceae	H
6		*Chaerophyllum*	*reflexum*	Apiaceae	H
7		*Chaerophyllum*	*villosum*	Apiaceae	H
8	Jangali Hing	*Ferula*	*jaeschkeana*	Apiaceae	H
9	Patishan	*Heracleum*	*candicans*	Apiaceae	H
10		*Pleurospermum*	*candollei*	Apiaceae	H
11		*Selinum*	*tenuifolium*	Apiaceae	H
12	Bhutkesh	*Selinum*	*vaginatum*	Apiaceae	H
13		*Arisaema*	*jacquemontii*	Araceae	H
14		*Arisaema*	*flavum*	Araceae	H
15		*Typhonum*	*seginatum*	Araceae	H
16		*Achillea*	*millefolium*	Asteraceae	H
17		*Achillea*	*latifolia*	Asteraceae	H
18		*Anaphalis*	*royleana*	Asteraceae	H
19		*Anaphalis*	*triplinervis*	Asteraceae	H
20		*Arctium*	*lappa*	Asteraceae	H
21		*Echinops*	*cornigerus*	Asteraceae	H
22		*Inula*	*grandiflora*	Asteraceae	H
23	Dhoop	*Jurinea*	*macrocephala*	Asteraceae	H
24		*Senecio*	*chrysanthemoides*	Asteraceae	H
25		*Serratula*	*pallida*	Asteraceae	H
26		*Tanacetum*	*longifolium*	Asteraceae	H
27		*Taraxacum*	*officinale*	Asteraceae	H
28		*Tenacetum*	*longifolium*	Asteraceae	H
29		*Waldhemia*	*tomentosa*	Asteraceae	H
30	Haloo	*Impatiens*	*scabrida*	Balsaminaceae	H

Continued

S. No.	Common name	Genus	Species	Family	Type of plant
31	Haloo	*Impatiens*	*sulcata*	Balsaminaceae	H
32	Kamalu	*Berberis*	*aristata*	Berberidaceae	S
33	Kamalu	*Berberis*	*chitria*	Berberidaceae	S
34	Kamalu	*Berberis*	*lycium*	Berberidaceae	S
35	Bhojpatra	*Betula*	*utilis*	Betulaceae	T
36		*Arnebia*	*benthami*	Boraginaceae	H
37		*Cynoglossum*	*glochidiatum*	Boraginaceae	H
38		*Eritrichium*	*canum*	Boraginaceae	H
39		*Myosotis*	*caespitosa*	Boraginaceae	H
40		*Barbarea*	*intermedia*	Brassicaceae	H
41		*Capsella*	*bursa-pastoris*	Brassicaceae	H
42		*Thlaspi*	*arvense*	Brassicaceae	W
43		*Sarcococca*	*saligma*	Buxaceae	S
44		*Codonopsis*	*rotundifolia*	Campanulaceae	H
45		*Cyananthus*	*lobatus*	Campanulaceae	H
46	Bhang	*Cannabis*	*sativa*	Cannabaceae	H
47		*Viburnum*	*cotinifolium*	Caprifoliaceae	S
48		*Viburnum*	*nervosum*	Caprifoliaceae	S
49		*Gypsophylla*	*cerastioides*	Caryophyllaceae	H
50		*Silene*	*inflata*	Caryophyllaceae	H
51		*Stellaria*	*media*	Caryophyllaceae	H
52		*Chenopodium*	*album*	Chenopodiaceae	H
53		*Chenopodium*	*botrys*	Chenopodiaceae	H
54		*Chenopodium*	*foliolosum*	Chenopodiaceae	H
55		*Sedum*	*ewersii*	Crassulaceae	H
56	Bithal	*Juniperus*	*communis*	Cupressaceae	S
57	Bithal	*Juniperus*	*pseudosabina*	Cupressaceae	S
58		*Carex*	*setigera*	Cyperaceae	Sg
59	Shingli-Mingli	*Doiscorea*	*deltoidea*	Dioscoreaceae	H
60		*Morina*	*longifolia*	Dipsacaceae	H

Continued

S. No.	Common name	Genus	Species	Family	Type of plant
61		*Hippophae*	*salicifolia*	Elaegnaceae	T
62		*Ephedra*	*gerardiana*	Ephedraceae	H
63		*Cassiope*	*fastigiata*	Ericacear	H
64		*Gaultheria*	*nummulariodes*	Ericacear	H
65		*Rhododendron*	*anthopogon*	Ericacear	S
66	Sergerh	*Rhododendron*	*campanulatum*	Ericacear	S
67		*Astragalus*	*candolleanus*	Fabaceae	H
68		*Desmodium*	*elegans*	Fabaceae	S
69	Kathu	*Indigofera*	*heterantha*	Fabaceae	S
70		*Trifolium*	*repens*	Fabaceae	H
71		*Trigonella*	*emodi*	Fabaceae	H
72	Ban	*Quercus*	*lechotrichophora*	Fagaceae	T
73	Ban	*Quercus*	*semicarpifolia*	Fagaceae	T
74		*Corydalis*	*cashmeriana*	Fumariaceae	H
75	Bhutkeshi	*Corydalis*	*govaniana*	Fumariaceae	H
76	Kuroo	*Gentiana*	*kurroo*	Gentianaceae	H
77		*Geranium*	*pratens*	Geraniaceae	H
78		*Geranium*	*wallichianum*	Geraniaceae	H
79	Killer	*Parrotiopsis*	*jacquemontiana*	Hamamelidaceae	T
80		*Aesculus*	*indica*	Hippocastanaceae	T
81		*Hypericum*	*elodeoides*	Hypericaceae	S
82		*Iris*	*kumaonensis*	Iridaceae	H
83	Akhrot	*Juglans*	*regia*	Juglandaceae	T
84		*Buddleija*	*asiatica*	Lamiaceae	S
85		*Clinopodium*	*umbrosum*	Lamiaceae	H
86		*Mentha*	*longifolia*	Lamiaceae	H
87		*Nepeta*	*elliptica*	Lamiaceae	H
88		*Origanum*	*vulgare*	Lamiaceae	H
89		*Phlomis*	*bracteosa*	Lamiaceae	H
90		*Stachys*	*melissaefolia*	Lamiaceae	H

Continued

S. No.	Common name	Genus	Species	Family	Type of plant
91	Ban Tulsi	*Thymus*	*linearis*	Lamiaceae	H
92		*Asparagus*	*racemosus*	Liliaceae	H
93		*Gagea*	*elegans*	Liliaceae	H
94		*Malva*	*verticillata*	Malvaceae	H
95		*Morus*	*serrata*	Moraceae	T
96		*Jasmine*	*humile*	Oleaceae	S
97	Hath Panja	*Dactylorhiza*	*hatagirea*	Orchidaceae	H
98		*Oxalis*	*corniculata*	Oxalidaceae	H
99		*Meconopsis*	*aculeata*	Papaveraceae	H
100		*Deutzia*	*staminea*	Philadelphaceae	S
101	Jharka	*Phytolacca*	*acinosa*	Phytolaccaceae	H
102	Tos	*Abies*	*pindrow*	Pinaceae	T
103	Diyar	*Cedrus*	*deodara*	Pinaceae	T
104	Tosh	*Picea*	*smithiana*	Pinaceae	T
105	Chil	*Pinus*	*roxburghii*	Pinaceae	T
106	Kail	*Pinus*	*wallichiana*	Pinaceae	T
107		*Agrotis*	*pilosula*	Poaceae	G
108		*Chrysopogon*	*echinulatus*	Poaceae	G
109		*Chrysopogon*	*gryllus*	Poaceae	G
110		*Dactylis*	*glomerata*	Poaceae	G
111		*Danthonia*	*cachemyriana*	Poaceae	G
112		*Festuca*	*gigentea*	Poaceae	G
113		*Festuca*	*valesiaca*	Poaceae	G
114		*Helictotrichon*	*virescens*	Poaceae	G
115		*Phacelurus*	*speciosus*	Poaceae	G
116		*Phleum*	*alpinum*	Poaceae	G
117		*Poa*	*alpina*	Poaceae	G
118	Ban Kakri	*Podophyllum*	*hexandrum*	Podophyllaceae	H
119	Fafru	*Fagopyrum*	*esculentum*	Polygonaceae	H
120		*Oxyria*	*digyna*	Polygonaceae	H

Continued

S. No.	Common name	Genus	Species	Family	Type of plant
121		*Polygonum*	*amplexicaulis*	Polygonaceae	H
122		*Polygonum*	*polystachyum*	Polygonaceae	H
123		*Rheum*	*australe*	Polygonaceae	H
124		*Rumex*	*hastatus*	Polygonaceae	H
125		*Rumex*	*nepalensis*	Polygonaceae	H
126		*Androsace*	*rotundifolia*	Primulaceae	H
127		*Primula*	*denticulata*	Primulaceae	H
128	Patish	*Aconitum*	*heterophyllum*	Ranunculaceae	H
129		*Anemone*	*rivularis*	Ranunculaceae	H
130		*Anemone*	*rupicola*	Ranunculaceae	H
131		*Aquilegia*	*fragrans*	Ranunculaceae	H
132		*Caltha*	*palustris*	Ranunculaceae	H
133		*Delphinium*	*denudatum*	Ranunculaceae	H
134		*Ranunculus*	*hirtellus*	Ranunculaceae	H
135		*Thalictrum*	*alpinum*	Ranunculaceae	H
136		*Thalictrum*	*cultratum*	Ranunculaceae	H
137		*Rhamnus*	*virgatus*	Rhamnaceae	S
138		*Cotoneaster*	*microphyllus*	Rosaceae	S
139		*Fragaria*	*nubicola*	Rosaceae	H
140		*Geum*	*elatum*	Rosaceae	H
141		*Potentilla*	*argyrophylla*	Rosaceae	H
142		*Potentilla*	*atrosanguinea*	Rosaceae	H
143	Jammu	*Prunus*	*cornuta*	Rosaceae	T
144	Chiuli	*Prunus*	*armeniaca*	Rosaceae	T
145	Jangli Aru	*Prunus*	*persica*	Rosaceae	T
146	Kainth	*Pyrus*	*pashia*	Rosaceae	T
147	Jangali Gulab	*Rosa*	*macrophylla*	Rosaceae	S
148		*Rosa*	*serica*	Rosaceae	S
149		*Rosa*	*webbiana*	Rosaceae	S
150	Aakhre	*Rubus*	*fruticosus*	Rosaceae	S

Continued

S. No.	Common name	Genus	Species	Family	Type of plant
151		*Sorbaria*	*tomentosa*	Rosaceae	S
152		*Spiraea*	*canescens*	Rosaceae	S
153		*Galium*	*aparine*	Rubiaceae	H
154		*Salix*	*lindleyana*	Salicaceae	S
155		*Bergenia*	*ciliata*	Saxifragaceae	H
156		*Bergenia*	*stracheyi*	Saxifragaceae	H
157		*Euphrasia*	*himalaica*	Scrophulariaceae	H
158		*Mazus*	*surculosus*	Scrophulariaceae	H
159		*Pedicularis*	*bicornuta*	Scrophulariaceae	H
160		*Picrorhiza*	*kurrooa*	Scrophulariaceae	H
161	Ban Tambaku	*Verbascum*	*thapsus*	Scrophulariaceae	H
162		*Lagotis*	*cashmeriana*	Selaginaceae	H
163	Aalu	*Solanum*	*tuberosum*	Solanaceae	H
164		*Daphne*	*papyracea*	Thymelaceae	S
165		*Celtis*	*tetrandra*	Ulmaceae	T
166		*Ulmus*	*wallichiana*	Ulmaceae	T
167	Bichoo-buti	*Girardinia*	*diversifolia*	Utricaceae	H
168	Beechghas	*Utrica*	*dioca*	Utricaceae	H
169		*Valeriana*	*hardwickii*	Valerianaceae	H
170	Mushkbala	*Valeriana*	*jatamansi*	Valerianaceae	H
171		*Viola*	*biflora*	Violaceae	H
172	Banafsha	*Viola*	*serpens*	Violaceae	H
173		*Osmunda*	*claytoniana*	Osmundaceae	F
174		*Pteridium*	*revolutum*	Pteridiaceae	F
175		*Adiantum*	*venustum*	Adiantaceae	F
176		*Dryopteris*	*barbigera*	Dryopteridaceae	F
177		*Polystichium*	*bakerianum*	Dryopteridaceae	F
178		*Pteris*	*cretica*	Pteridaceae	F

T = Tree, S = Shrub, H = Herb, G = Grass, W = Weed, F = Fern, Sg = Sedge.

Appendix 2. Mammals found in Kugti wildlife sanctuary.

Common name	**Scientific name**	**Local name**
Rhesus macaque	*Macacca mulatta*	Bandar
Common langur	*Pesbytis entellus*	Gaul
Common leopard	*Panthera pardus*	Mirgh
Snow leopard	*Panthera uncia*	Safed bagh
Jungle cat	*Felis chaus*	Jungli billi
Jackal	*Canis aureus*	Gidder
Red fox	*Vulpus vulpus*	Lomari
Himalayan weasel	*Mustela sibirica*	-
Himalayan yellowthroated marten	*Martes flavigula*	Dichlu
Himalayan palm civit	*Paguma larvata*	-
Asiatic black bear	*Ursus thibetanus*	Kala bhalu
Himalayan brown bear	*Ursus arctos*	Ghai
Himalayan musk deer	*Moschus chrysogaster*	Kastura
Barking deer	*Muntiacus munjak*	Kakkar
Goral	*Naemorhedus goral*	Gorar
Serow	*Naemorhedus sumatraensis*	Emmu
Himalayan tahr	*Hemitragus jemlahicus*	Karth
Himalayan ibex	*Capra ibex sibirica*	Tangrol
Blue sheep	*Pseudois nayaur*	Bharal
House mouse	*Mus musculus*	Mush
Kashmir flying squirrel (?)	*Hylopetes fimbriatus*	Ain
Indian porcupine	*Hystrix indica*	Shail
Himalayan mouse hare or pika	*Ochotoma roylei*	Lal chuha

Appendix 3. GPS location of line transects laid within Kugti wildlife sanctuary.

Transect No.	Name	Starting Point			Ending Point			Length
		Deg	Min	Sec	Deg	Min	Sec	
T1	Bhianu RF	N 32	27	5.9	N 32	27	43.4	1 km
		E 76	42	32	E 76	42	26.4	
T2	Bhianu RF	N 32	27	56.1	N 32	27	25.7	1 km
		E 76	42	22.8	E 76	42	39.5	
T3	Dalatu	N 32	26	42	N 32	27	14.7	1 km
		E 76	43	9.5	E 76	42	47.7	
T4	Lower Kugti AL	N 32	28	10.6	N 32	28	30.7	1 km
		E 76	42	6.6	E 76	41	39.9	
T5	Upper Kugti	N 32	28	25.2	N 32	28	54.6	1 km
		E 76	42	29.2	E 76	42	25.3	
T6	Bhianu RF	N 32	28	7.6	N 32	28	1.9	1 km
		E 76	42	30	E 76	43	2.7	
T7	Seri AL	N 32	28	1.1	N 32	27	56.5	1 km
		E 76	43	3	E 76	42	45.2	
T8	Bhianu RF	N 32	27	52.6	N 32	27	23.8	1 km
		E 76	42	45.7	E 76	42	43.4	
T9	Lower Kugti	N 32	28	13.5	N 32	28	31.2	1 km
		E 76	41	59.2	E 76	41	40.5	
T10	Lower Kugti AL	N 32	28	10.5	N 32	28	8.4	1 km
		E 76	42	24.7	E 76	43	3.5	
T11	Bharmani	N 32	28	3.1	N 32	27	34.4	1 km
		E 76	43	5.7	E 76	43	10.4	

T12	Dalatu	N 32	27	24	N 32	26	52.8	1 km
		E 76	42	42.5	E 76	42	46.5	
T13	Bharmani	N 32	27	33.1	N 32	27	10.4	1 km
		E 76	43	10.7	E 76	43	44.2	
T14	Bughdhar	N 32	27	10.8	N 32	27	2.7	1 km
		E 76	43	45.7	E 76	44	24.9	
T15	Above Upper Kugti	N 32	28	22.7	N 32	28	20.4	1 km
		E 76	42	31.5	E 76	43	9.9	
T16	Kangru RF	N 32	26	30.6	N 32	25	29.4	1 km
		E 76	42	45.8	E 76	42	51.1	
T17	Pernatu	N 32	28	13.2	N 32	28	23.2	1 km
		E 76	42	55	E 76	43	43	
T18	Temple side	N 32	28	25.4	N 32	28	50.7	1 km
		E 76	43	45.7	E 76	44	9.3	
T19	Duggi	N 32	28	49	N 32	29	22	1 km
		E 76	44	4.2	E 76	44	37.4	
T20	Tendei AL	N 32	27	54.5	N 32	27	31.9	1 km
		E 76	42	19.9	E 76	42	40.4	
T21	Tendei AL	N 32	27	6.3	N 32	27	33.8	1 km
		E 76	42	58.5	E 76	42	43.5	
T22	Kangru RF	N 32	28	5.3	N 32	28	18.2	1 km
		E 76	41	46.1	E 76	41	10.7	

Appendix 4

Format - 1(a) **Vegetation Composition: Trees**

Date: ..... **Compartment No.....** **Altitude:.....…….**
Range/Locality : ..... **Bearing .....** **Fire Incid.:.....……....**
Transect No.:..... **GPS Location ……...** **Start …… h End: …… h**
Circular Plot : r = 10 m

Sample Point	Tree species	Phenology	GBH	No. of trees felled	No. of trees lopped	Stand height (m)	Canopy cover (%)	Habitat
1								
2								
3								
4								
5								

Topography : Hill/Hillock - H; Undulating – UT; Plateau - P; Valley - V; Riverine- Ra.

Soil : Rocky – R ( ); Sandy-Sn ( ); Gravel – G ( ); Loamy – L ( ); Clay – C ( ).

Format - 1(b) **Vegetation Composition: Shrub**

Date:.....

Transect No.:..... **Circular Plot: r = 5 m**

Sample Point	Shrub species	Shrub height (m)	Dominant shrubs	Shrub cover (%)	Weed (%)
1					
2					
3					
4					
5					

Format - 1(c)

Vegetation Composition: Herb

Date: .....

Transect No: ..... **Circular Plot: r = 1 m**

Sample Point	Herb/grass species	Herb/grass height (cm)	Herb/grass cover (%)
1			
2			
3			
4			
5			

Format - 1(e) **Disturbance, Wildlife Evidence & Regeneration**

Date: .....
Transect No.: ....

Circular Plot : r = 10 m

Sample Point No		**1**	**2**	**3**	**4**	**5**
Disturbance	**Distance from nearest habitation (m)**					
	Disturbance from nearest road					
Cattle grazing	**Dung**					
	Hoof marks					
Wildlife evidences	**Faecal matter**					
	Pugmarks/Hoof marks					
	Digging					
	Others					
Nearest water source (m)						
Regeneration						

Disturbance from nearest road: **Nil = A;** **Medium = B;** **High = C**
Hoof marks: **High = H;** **Medium = M;** **Low = L**
Dung: **Present = +** **Absent = —**
Regeneration (Dominant tree): **Nil = 0** **Good = +** **Very Good = ++**

Format - 1(f)

Biotic Pressures

Transect No: ..... **Belt of 10 m each side along the transect**

Biotic Pressures	Yes/No	Near sample Point No.	Remarks
Lopping			
Cutting			
NTFP collection			
Grass cutting			
Fuel wood collection			
Direct sighting: Livestock			
Human			
Other wild fauna			
Dead animal			

Format - 2(a)

Distribution and Density by Direct Sighting

Date: …….. **Location on Map**

Transect No. : ..... **Time: Start ..... End.....**

Compt./ Locality	Time (h)	Activity	Group size	Habitat	Tree/Shrub/Grass				Distance		Sighting angle ( )	Angular singhting distance (m)	Perpend. Sighting distance (m)
					Species	Cover (%)	Terrain	Soil	HH	W			

Activity: Feeding - F; Sleeping - S; Moving - M; Suckling - SK; Resting – R; Rooting – RO; Wallowing – W; Any Other - Specify.

Habitat: Agricultural land (AL), Grassland and forest blank (GLFB), Mixed forest with conifers and broad leaf species (MFBL), Himalayan moist temperate forest s with conifers (HMTF), Near water bodies , river and streams (NWB), Dry alpine scrub characterized with Juniperus species (DASJ), Riverine forests (RF), Exposed rock with slope grasses (ERSG), Moist subalpine scrub characterized by Rhododendron species (MSAR)

.

Terrain: Flat - F; Gentle Slope - GS; Steep Slope - SS; Undulating – UD

Soil Type: Loam-L; Sandy-Sn; Gravel-G; Rockey-R

Biotic Pressure: Fire-F; Lopping-L; Grazing-G.

Remarks: GPS Location; Species and part eaten.

Format - 2(b) **Distribution and Abundance by Indirect Evidences**

Date: ..... **Location on Map**

Other Places & Transect No. : ..... **Time : Start**..... **End**..... …

Compart./ Locality	Evidences: Foot Print, Scats, Digging …	GPS Location	Habitat	Terrain	Soil Type	Scat (O / F)	Remarks

Evidences: Foot print - FP; Feeding sign - FS; Stone uplifting - SU; Digging sign - DS; Scat - S; Any Other - Specify.

Terrain: Flat - F; Gentle Slope - GS; Steep Slope - SS; Undulating – UD **Soil Type:** Loam - L; Sandy - Sn; Gravel - G; Rockey - R

Appendix 5

Questionnaire survey

(Village interview)

S. No. …….. Date: …….

Name of Village: …… …….. Post: …….. Time: ……

No. of families in the village: …….. …… …… …….. .. …….. …….

A. Demography of village:

1. Family details:

i. Name of Respondent: …….. ……

ii. Address: …… …….. …… ……..

iii. Caste. …….

v. Family size: Male (s) ……. Female (s) …….. ……..

vi. Age class: Adult …… Yrs …… Yrs …… Yrs …… Yrs …… Yrs

Children: …… Yrs …… Yrs …… Yrs …… Yrs …… Yrs

2. Details of property:

i. Landless / Marginal / Small / Large

ii. Type of House: Area ……., Concrete ……., Kutcha …….., Wooden ……., Door ……

iii. Area of crop fields (Bigha) Cultivated ……, Uncultivated ……, Barren ……..... ...

Cost of land (Bigha/Kanal = …… .) Rs. ……

iv. Household items: Car / Scooter / Bicycle / TV / Refrigerator / Tape Recorder / … …….

3. Educational Status:

Father ……. ……. Mother ……. ……. ….

Son 1. 2. 3. 4. 5.

Daughter 1. 2. 3. 4. 5.

Others …….. …… ……. … ……. ……. …..

Illiterate - IL, Primary - P, Jun. High School - JH, High School - HS, Intermediate - INT, Graduate - G, Above - A

4. Occupational Pattern:

i. Noumber of earning members: …… …….. .

ii. Members involved in agriculture …… Male (s) …….. Female(s) ….……. …… .

iii. Private …… Rs …… Yearly; Government …… Rs.. .. …… Month

iv. No. of dependents: ……

B. Livestock

i. No. of livestock: …….

ii.

Category	Adult	Young ones
Cow	[ ]	[ ]
Bull	[ ]	[ ]
Goat	[ ]	[ ]
Sheep	[ ]	[ ]
Horse/Mule	[ ]	[ ]
Poultry	[ ]	[ ]

iii. Are your livestock stall-fed: Yes/No

iv. Are Livestock taken in forests for grazing? Yes/No No. of livestock ……

v. Members accompanying livestock in forests: Adult Sub-adult

Male(s) …… ……

Female(s) …… ……

vi. Which period: Time period: a.m.

p.m.

Month(s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec

vii. No. of milching animals ……. No. of non-milching animals ……

……...

viii. Used in Agriculture: Bull [ ]

Horse/Mule [ ]

ix. How livestock are kept in village houses?

Livestock sheds: Concrete Kutcha Wooden Door Outside

C. Agricultural practices:

i. Crops grown: Wheat, Mustard, Jowar, Maize, Rajma, potato, ….. … …. …. ….. ….. ….. ….. .

ii. Extent of area under different crops:

Wheat Mustard Jowar, Maize Rajmash

Potato Any other …….

iii. Farming facilities (Tick mark): Tractor, tubewell, plough, . ……. ……..

……

iv. Crop damage: Wild animals …….. Pests ……. Disease Water scarcity ……...

v. Crop pattern:

Crops	Sowing time (Mo)	Seeds sown per bigha	Cost of seeds (Rs)	Harvesting time (Mo)	Crop yield (Kg)
Wheat					
Maize					
Barley					
Bharesh					
Phulan					
Potato					

vi. Crop damage by different wild animals. Tick mark (+ or --).

Crops	Brown bear	Black bear	Common langur				Total damage **(%)**
Wheat							
Maize							
Barley							
Bharesh							
Phulan							
Potato							
Rajmash							

vii. Crop damage month-wise: Tick mark yes (√) or no (x).

Crop	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Wheat												
Maize												
Barley												
Bharesh												
Phulan												
Potato												
Rajmash												

viii. Damage pattern & protection time.

Crops	Growth stage	Parts eaten	Month(s)
Wheat			
Maize			
Barley			
Bharesh			
Phulan			
Potato			
Rajmash			

ix. Damage to orchard (s)

Orchard	Problem species	Total damage (%)
Apple		
Akhrot		
Jammu		
Aru		
Nashpati		

D. Crop protection

a. Protection & vigil - No. of members involved in crop protection . ……. …….

b. Traditional methods used:

Method	**(y/x)**	**Specify animals**
Crop protection hut	[ ]	[ ]
Drum beating	[ ]	[ ]
Crackers	[ ]	[ ]
Gun shots	[ ]	[ ]
Driving away	[ ]	[ ]
Brush-wood fence	[ ]	[ ]
Animal Proof-trench	[ ]	[ ]
Barbed wire fencing	[ ]	[ ]
Any other	[ ]	[ ]

c. Protection provided by Forest Department.

Method	**(√ or x)**	**Cost/km**	**Animal(s)**	
Trench	[ ]	[ ]	[ ]	
Barbed wire fence	[ ]	[ ]	[ ]	
Rubble wall	[ ]	[ ]	[ ]	
Any other	[ ]	[ ]	[ ]	

E. NTFP collection:

Name	Species	Quantity (kg)	Month(s)	Time (h)
Medicinal plants				
Fodder				
Fuel wood				
Timber				
Grass				
Mushroom				
Fruits				
Honey				
Gum				
Others.				

Use & distance of water resource(s) from village: For bathing, washing clothes, livestock

River …….m, Pond ……..m, Nallah ……m, …… … m …… …m

Water collection: Frequency ……. Time ……..……

F. Income generating activities:

i. Family income Rs. …….. … /Month Rs. …… .. /Annum
Various sources Agriculture/Horticulture/Livestock/Fibre craft/Apiculture/Handicraft/ Mushroom/ …….. ……

ii. What fuels are used? Biogas / Kerosene / Solar energy / Dung cake / Agricul. residue

iii. Are these fuels available on subsidized rates? Yes No

iv. Do you sell milk or products? If yes Kg …… Kg ……Kg ……. ….. Month
Rs. …… Rs. …… Rs. …… Month

v. Purchase of cattle feed: …… …. …… …. …… …. …… ……
Rs. …… Rs. …… Rs. …… Rs. …… daily.

vi. Do you sell livestock? Adult/Sub-adult/Male/Female Rs. ……. ……..

vii.Do you sell dung cakes, fuel wood etc? Kg. …….. Rs. …….. .

viii. Do you sell agriculture/horticultural crops?

Crop	Quantity (Kg)	Rupees
Wheat		
Maize		
Barley		
Bharesh		
Phulan		
Potato		
Apple		
Akhrot		
Rajmash		

ix. Do you sell NTFP? Items . …….. …….. …….. …… ……
Rs. …… .. . …….. …….. .. ……..

x. Labour work? Yes ( ) No ( ) Rs. …… daily Rs. …… Yearly

G. People's attitude:

i. Do you wish to have/protect forests? Yes / No

ii. Attitude towards bear and other animals: ……..

iii. Any time bear shot or captured in your area: ……

iv. Peoples problems: Employment / Land / Education / Roads / Buses / Electricity / Dairy /
Fuelwood / Timber / Fodder / Drinking water for people / Drinking water for livestock / Medical facilities / Irrigation / Veterinary services / Crop protection / Others

H. Remarks