Observations on food habits of Asiatic black bear in Kedarnath Wildlife Sanctuary, India: preliminary evidence on their role in seed germination and dispersal

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In India, the Asiatic black bear (*Ursus thibetanus*) occurs in forested habitats of the Greater Himalaya at 1,200–3,000 m elevation (Sathyakumar 2001). Information on the feeding and movement patterns of Asiatic black bear in India is limited to 2 short studies (Manjrekar 1989, Saberwal 1989) and some observations by Schaller (1969), all in Dachigam National Park (NP) in Jammu and Kashmir, India. The Asiatic black bear in India is an omnivore, but feeds mainly on fruits and leaves of a few plant species. Consequently, its movement depends largely on the density and distribution of these key food plants in the area. In addition, food production is known to play a major role in reproduction of American black bears (*Ursus americanus*; Jonkel and Cowan 1971). In Dachigam National Park (NP), India, when fruits were available, a major proportion of Asiatic black bear diets were composed initially of sugar-rich fruits, followed by fat-rich fruits before hibernation (Manjrekar 1989).

There are few studies available on feeding habits of other bear species and their effects on seed germination. Traveset and Willson (1997) discussed effects of some birds, American black bear, and brown bear (*Ursus arctos*) on seed germination of fleshy-fruited plants in temperate rainforests of southeast Alaska. Their results indicated no difference in germination rates for seeds that passed through the guts of captive birds and black and brown bears; they reported that the advantages of seed dispersal lie more in seed movement away from the parent plant than in seed treatment within the dispenser's gut. McConkey and Galetti (1999), while reporting food and feeding habits of the Malayan sun bear (*Helarctos malayanus*) in Central Borneo, Indonesia, indicated that this species could be an important seed dispenser depending upon the species consumed, number of seeds ingested, and the deposition site.

Asiatic black bears are well known seed predators. Manjrekar (1989) reported that acorns (*Quercus robur*) and walnuts (*Juglans regia*) were totally crushed by black bears while feeding on them, thereby hindering dispersal. Black bears were also reported to feed on seeds fallen on the ground, and signs of regeneration of species, walnut in particular, were reported to be low. We present observations on the food and feeding habits of Asiatic black bear and observations on germination of bear food plants in Kedarnath Wildlife Sanctuary (WS), Western Himalaya during 1989–92.

Study area

Kedarnath WS (975 km^2) is located in Uttaranchal, Northern India, at elevation that varies from 1,200 to 7,068 m. It lies in the upper catchments of Alaknanda and Mandakini rivers (30°25′–30°45′N, 78°55′–79°22′E), major tributaries of Ganges. Kedarnath is influenced by the southwest monsoon in summer and by the passage of belts of low pressure in winter (Mani 1974). The major vegetation types include sub-tropical pine (*Pinus roxburghii*), temperate broad-leaved oak (*Quercus leucotrichophora*, *Q. glauca*, *Q. floribunda*) and associated species, sub-alpine oak (*Q. semecarpifolia*), fir (*Abies pindrow*), birch (*Betula utilis*)–rhododendron (*Rhododendron campanulatum*), and alpine scrub, meadows, and pastures. The status of Asiatic black bear in Kedarnath WS has been reported as 'rare' (Sathyakumar 2001). Most of the observations on Asiatic black bear and its food habits were made in an intensive study area (20 km^2; 1,700–3,680 m) near Mandal, located at the southern boundary of Kedarnath (Sathyakumar 1994).

Methods

We made casual observations on Asiatic black bear food and feeding habits during 1989–92. During direct sightings, information on habitat use and activity were recorded. If feeding was observed, data on food plants were recorded. Indirect observations such as scats,

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feeding sign, and tracks were also used to collect information on black bear habitat use, food, and feeding habits. An inventory of bear food plants was prepared based on fresh feeding signs and remnants of undigested plant material identified in their scats. We also recorded information on black bear food habits provided to us by wildlife staff and villagers.

In October 1990, 2 bear scats with intact seeds were encountered in the Mandal area at 1,900 m and were transported to the Forest Research Institute, Dehradun, for testing. The scats were washed thoroughly in running water and the entire intact seeds of *Symplocos theifolia* were separated (they could be easily recognized in the scat, especially the blue remnants of the outer coat of fruit/berry). At this same time, we collected freshly matured fruits (berries) from standing trees of *S. theifolia* from the study area. The mature fruits were depulped by hand and seeds extracted. Some fruits were left whole and kept as a control. All fruits and seeds retrieved from the scat were stored for 3 weeks at 5°C. The seeds were then tested for germination by allowing them to sit in moist filter paper in petri dishes. Three replicates of 25 seeds each were used for each of the 3 test conditions: seeds from bear scat, from depulped mature fresh fruit, and from whole fruit (control). All samples were exposed to 2 different temperature and light regimes using incubators: (1) alternating (12 hr at 25°C with 12 hr at 10°C) and (2) constant 25°C. The alternating temperature regime approximated the mean daily maximum and minimum temperatures at the Mandal study area during spring (Mar–Apr). The petri dishes were moistened regularly and observations on germination were noted at weekly intervals for 6 weeks. Seeds with emerged radicles were considered germinated and removed from petri dishes.

Separately, we also conducted germination tests in field nurseries in Mandal on *S. theifolia* seeds collected from standing trees (Table 1). In field nurseries within the study area, mature whole fruits of *S. theifolia* collected in October were sown in November in uncovered, raised germination beds (1.5 m × 10 m × 0.3 m) filled with soil, sand, and compost. For *S. theifolia*, 100 fruits (4 replications of 25 each) were sown.

Results

Black bear feeding habits

We observed black bears on 6 occasions and collected 20 scats (Table 2). Bears were observed feeding on *Rhododendron arboreum*, *Berberis asiatica*, and on the remains of a cattle kill made by a common leopard (*Panthera pardus*). We had indirect observations of bears such as feeding signs and remains in scats of acorns of oak (*Quercus leucotrichophora*, *Q. semecarpifolia.*), montane bamboo (*Arundinaria falcata*, *Thamnocalamus spathiflorus*), fruits and berries of *Symplocos theifolia*, and insects. Secondary information from several forest staff and local villagers indicated that black bears also feed on *Juglans regia*, *Prunus cornuta*, *Myrica nagi*, *Aesculus indica*, *Rubus elipticus*, *Fragaria indica*, and cultivated crops like maize and amaranth.

Germination studies of S. theifolia

Freshly matured *S. theifolia* seeds were dormant and did not germinate until the 3rd week in the laboratory tests. In contrast, the mature seeds with pulpy outer layer (control) showed very little signs of germination and deteriorated very fast at both temperature regimes. Observations in the laboratory showed increased germination of seeds that were ingested by bears when compared to control and freshly depulped seeds subjected to the same germination treatments (Fig. 1). The proportion of seeds that germinated from the bear scat kept at 25° was significantly higher than the proportion that germinated from the depulped seeds kept at 25° (2-sample $t = 3.29$, 34 df, $P < 0.002$). Under field nursery conditions, the seeds took nearly 5 months to germinate ($\bar{x} = 153$ days, SD = 5) with poor germination percent (22%; Table 1).

Discussion

Black bear feeding habits

Manjrekar (1989) reported that 22 food items were found in the diet of black bears in Dachigam NP, May–October, based on scat analysis. 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 in June–July, while *Quercus robur* (English oak) and *Juglans regia* (walnut) accounted for a major proportion of the diet in September–early October (Manjrekar 1989). Schaller (1969) investigated the diet of black bears in Dachigam NP during October based on scat analysis. Oak (12%), walnut (33%), and *Celtis australis* (40%) formed the major diet of black bears. Schaller also observed bears feeding on fallen oak acorns and walnuts.

Oak acorns constitute an important dietary item in bear food habit. Four species of oaks have been recorded in the study area: *Quercus leucotrichophora* and *Q. glauca* at lower elevations (1,600–2,000 m) and *Q. floribunda* and *Q. semecarpifolia* at the mid- (2,000–

Table 1. Germination data of some tree species tested in forest nurseries in Mandal.

S.No	Species	Life form[a]	Seed characteristics					
			Seed type	GG[b]	SOD[c]	MOS[d]	*n*	GC[e]
1.	*Abies pindrow*	ct	cone	ID	DS	12	100	3
2.	*Acer caesium*	ct	samara	ID	DS	11	100	4
3.	*Acer caudatum*	ct	samara	ID	DS	11	100	4
4.	*Acer oblongum*	ct	samara	ID	PR	4	80	3
5.	*Acer sterculiaceum*	ct	samara	ID	DS	11	100	3
6.	*Aesculus indica*	ct	capsule	ID	DS	11	100	2
7.	*Alnus nepalensis*	ct	winged nutlet	ID	PR	7	100	4
8.	*Berberis lycium*	us	berry	DR	RS	8	100	2
9.	*Betula alnoides*	ct	winged nutlet	ID	PR	7	100	2
10.	*Buxus wallichiana*	us	capsule	ID	DS	10	100	4
11.	*Caesalpina decapetala*	us	pod	ID	PR	5	40	3
12.	*Carpinus viminea*	ct	winged nut	ID	DS	9	100	3
13.	*Daphne papyracea*	us	berry	RR	RS	6	100	2
14.	*Daphniphyllum himalaense*	ct	berry	ID	DS	10	100	3
15.	*Euonymus tingens*	us	berry	RR	RS	8	100	2
16.	*Eurya acuminata*	us	berry	ID	DS	12	100	4
17.	*Fraxinus micrantha*	ct	winged nut	ID	DS	12	100	3
18.	*Hovenia dulcis*	ct	winged nut	ID	DS	11	100	3
19.	*Ilex dipyrena*	ct	drupe	DR	RS	8	60	4
20.	*Lindera pulcherrima*	us	berry	RR	RS	6	100	2
21.	*Lyonia ovalifolia*	ct	capsule	ID	DS	11	100	4
22.	*Meliosm dilleniifolia*	us	berry	RR	RS	8	60	2
23.	*Neolitsea pallens*	us	berry	ID	DS	11	20	2
24.	*Persea duthiei*	ct	berry	DR	RS	8	50	3
25.	*Persea odoratissima*	ct	berry	DR	RS	9	50	3
26.	*Phoebe lanceolata*	us	berry	RR	RS	8	100	2
27.	*Prinsepia utilis*	us	berry	ID	PR	4	60	3
28.	*Prunus cornuta*	us	berry	DR	RS	7	60	3
29.	*Pteracanthus alatus*	us	capsule	ID	DS	10	60	3
30.	*Quercus floribunda*	ct	acorn	RR	RS	8	100	1
31.	*Quercus glauca*	ct	acorn	ID	DS	10	100	2
32.	*Quercus leucotrichophora*	ct	acorn	ID	DS	10	100	2
33.	*Quercus semecarpifolia*	ct	acorn	RR	RS	7	100	1
34.	*Rhododendron arboreum*	us	capsule	ID	RS	10	60	2
35.	*Rhus javanica*	us	capsule	ID	PR	4	100	3
36.	*Sarcococca hookeriana*	us	berry	RR	RS	7	100	1
37.	*Symplocos paniculata*	us	berry	ID	DS	11	100	4
38.	*Symplocos theifolia*	us	berry	ID	DS	11	100	4

[a]Life form: ct = canopy tree species; us = understory species.
[b]Germination Groups: RR = Rapid Rainy; ID = Intermediate Dry; DR = Delayed Rainy.
[c]Season of Dispersal: DS = Dry season; PR = Pre-rainy season; RS = Rainy season.
[d]Month of Sowing of seeds in nursery beds: 1–12; *n* = number of seeds sown.
[e]Germination capacity = 1 (high >75%); 2 (intermediate 51–75%); 3 (low 26–50%); 4 (very low <25%).

2,600 m) and higher elevations (>2,600 m), respectively. For the latter 2 species, seed germination precedes seed fall in July–August and germination is rapid as seeds that are less viable germinate immediately on dispersal. For *Q. leucotrichophora* and *Q. glauca*, acorns are dispersed late in the autumn (Sep–Oct), and seeds require chilling before germination occurs on the forest floor. We believe it is not coincidental that the movement of black bears from higher to lower elevations during September–October follows the acorn dispersal pattern. Indirect feeding evidence also substantiated this movement pattern. Crop raiding in villages at lower elevations increased in frequency when the agricultural crops were nearing harvest.

Schaller et al. (1989) reported that in China, Asiatic black bears showed a shift from leafy material in the early summer diet, to fleshy fruits, and then to fat-rich fruits before hibernation. Manjrekar (1989) also reported similar trends in shift of black bear diet in Dachigam NP. The black bears in Kedarnath WS may also be adopting similar shifts in diets from sugar-rich fruits in summer to fat-rich fruits in late summer and autumn,

Table 2. Asiatic black bear sightings, indirect observations, and food habits in Kedarnath Wildlife Sanctuary (1989–92), India.

Months	Bear sightings	Scats encountered	Feeding observations [O] or food plants seen in scats [S]
Jan–Mar (winter)	1	0	none
Apr–Jun (spring)	2	3	*Rhododendron arboreum* [O] leaves
			Berberis asiatica [O] berry
			Rubus elipticus [O] berry
			Quercus leucotrichophora [S] acorn
Jul–Sep (summer)	2	14	*Quercus semecarpifolia* [S] acorn
			Symplocos theifolia [S] berry
			Arundinaria falcata [S] leaves
			Thamnocalamus spathiflorus [S] leaves
			Scavenging cattle kill [O]
Oct–Dec (fall)	1	3	*Thamnocalamus spathiflorus* [S] leaves
			Arundinaria falcata [S] leaves

before hibernation. For instance, the fruit dispersal of some of the species (*Aesculus indica*, *Q. leucotrichophora*, *Q. glauca*, *Juglans regia*) falls in the category of late autumn dispersal in the study area (Table 1).

Germination studies of S. theifolia

Observations of intact seeds in feces or regurgitated material of animals have caused many biologists to ask: Does being eaten affect seed germination? Baskin and Baskin (1998) mentioned several possibilities: (1) seeds are digested (destroyed); (2) seeds germinate while they are in the animal's digestive tract, but the resultant seedlings die; (3) dormancy is broken, and defecated or regurgitated seeds germinate in higher percentages than uningested seeds; or (4) longer retention time in the gut reduces seed viability.

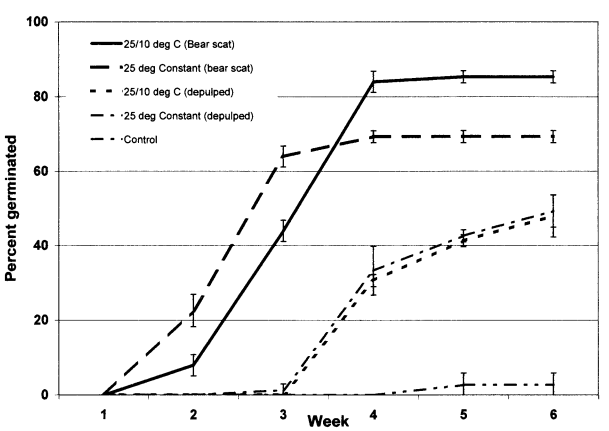

Fig. 1. Germination time and standard errors of bear ingested and mature depulped seeds of *Symplocos theifolia* subjected to 2 temperature (°C) regimes. Test control seeds incubated under the constant temperature regime did not germinate during the test and are not shown.

The way in which physical dormancy is broken is speculative, but it is assumed to be via acid (Lamprey et al. 1974) or mechanical (Cavanagh 1980). Freshly matured seeds eaten by an animal have an increased chance of germinating before the bruchid beetle larvae kills them than seeds not eaten for several weeks or months after maturation (Hoffman et al. 1989). This is true for most species like *Acacia* in dry savannah or dry deciduous forests in Asia and African regions. In most of the species occurring in Himalayan moist temperate forests (typical of the study area), dormancy due to physiological reasons is common and is broken by a period of brief chilling, stratification, or a combination of both.

S. theifolia is a small, evergreen understory tree in which the fruit is an obovate berry 0.75 cm long, 0.25 cm thick, with a 1–2 mm dark pulpy exocarp when ripe. The pulpy exocarp encloses the embryo and cotyledons and provides nutrition to the bear in this context. *S. theifolia* sheds ripe berries in October. After they fall to the ground, they do not germinate until spring or beginning of rainy season (Jul–Aug). For species like *S. theifolia* where the fruit is a berry, the pulpy seed coat may actually play a role in dispersal by animals or birds. Unpredated fruits may fall to the forest floor on maturity where the conditions for bacterial infestation and insect attack are ideal. Witmer (1991) suggested that the removal of fruit material from around seeds may prevent them from being destroyed by bacteria before germination occurred. In the present case, it may be argued that predation by black bear may have aided seed dispersal and enhanced its germination when intact seeds were defecated minus the pulpy seed coat.

The seed of *S. theifolia* has been classified as within the 'Intermediate Dry' (Oct–Dec) germination group based on the season of dispersal and has poor germination capacity (<25%) in forest nurseries (Viswanath 1999). During this period on the forest floor, due to the pulpy seed coat, the chance of bacterial attack is enhanced which, in turn, may kill the embryo before the seed germinates. When fruit predation by black bear occurs, the pulpy material is digested in the alimentary canal and only the scarified seed (endocarp intact) passes out in the feces. It is speculated that the removal of fruit material from around the seeds may prevent them from being destroyed by bacteria before germination occurs (Traveset and Willson 1997).

Although based on a very small sample, feeding by Asiatic black bear on *S. theifolia* appeared to have shortened the mean length of dormancy of the seeds and improved its over all germination percentage. Removal of fruit material around seeds by bears through feeding may have increased germination rate over those with intact fruit material (i.e., naturally dispersed in the forest floor) because in the latter case, the pulpy seed coat created favorable conditions for bacterial infestation and insect (Bruchid beetle) attack. However, further theoretical and empirical investigations and larger sample sizes are required to confirm the role of black bears in enhancing germination and dispersal of similar food plants.

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Literature cited

BASKIN, C.C., AND BASKIN, J.M. 1998. Seeds: Ecology, biogeography, and evolution of dormancy and germination. Academic Press, San Diego, California, USA.

CAVANAGH, T. 1980. A review of some aspects of the germination of Acacias, Proceedings of the Royal Society of Victoria 91:161–180.

HOFFMAN, M.T., R.M. COWLING, C. DOUIE, AND S.M. PIERCE. 1989. Seed predation and germination of *Acacia erioloba* in the Kuiseb River Valley, Namib Desert. South African Journal of Botany 55:103–106.

JONKEL, C.J., AND I.M. COWAN. 1971. The black bear in the spruce–fir forest. Wildlife Monographs 27.

LAMPREY, H.F., G. HALEVY, AND S. MAKACHA. 1974. Interactions between Acacia, bruchid beetles and large herbivores. East African Wildlife Journal 12:81–85.

MANI, M.S. 1974. Ecology and biogeography in India. Junk, The Hague, Netherlands.

MANJREKAR, N. 1989. Feeding ecology of the Himalayan black bear (*Selenarctos thibetanus* Cuvier) in Dachigam National Park. Master of Science Dissertation, Saurashtra University, Rajkot, India.

MCCONKEY, K., AND M. GALETTI. 1999. Seed dispersal by the sun bear *Helarctos malayanus* in Central Borneo. Journal of Tropical Ecology 15:237–241.

SABERWAL, V. 1989. Ranging patterns of Himalayan black bear (*Selenarctos thibetanus* Cuvier) in Dachigam National Park. Master of Science Dissertation, Saurashtra University, Rajkot, India.

SATHYAKUMAR, S. 1994. Habitat ecology of ungulates in Kedarnath musk deer sanctuary, Western Himalaya. Doctoral Thesis, Saurashtra University, Rajkot, India.

———. 2001. Status and management of Asiatic black bear and Himalayan brown bear in India. Ursus 12: 21–30.

SCHALLER, G.B. 1969. Food habits of the Himalayan black bear (*Selenarctos thibetanus*) in Dachigam Sanctuary, Kashmir. Journal of Bombay Natural History Society 66:156–159.

———. 1977. Mountain monarchs: Wild sheep and goats of the Himalaya. University of Chicago Press, Chicago, Illinois, USA.

———, Q.T. TENG, K.G. JOHNSON, X.M. WANG, H.M. SHEN, AND J.C. HU. 1989. The feeding ecology of giant pandas and Asiatic black bears in the Tangjiahe Reserve, China. Pages 212–241 *in* J.L. Gittleman, editor. Carnivore behaviour, ecology and evolution. Chapman & Hall, London, UK.

TRAVESET, A., AND WILLSON, M.F. 1997. Effect of birds and bears on seed germination of fleshy-fruited plants in temperate rainforests of southeast Alaska. Oikos 80:89–95

VISWANATH, S. 1999. Soil seed bank dynamics and germination eco-physiology of some selected species in a Himalayan moist temperate forest. Doctoral Thesis, Kumaon University, Nainital, India.

WITMER, M.C. 1991. The dodo and the tambalacoque tree: an obligate mutualism reconsidered. Oikos 61:133–137.

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