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Short communication

Interspecific feeding association between Central Himalayan langurs (*Semnopithecus schistaceus*) and Himalayan black bears (*Ursus thibetanus*), in a temperate forest of the Western Indian Himalayas

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Abstract. One aspect of interspecific feeding associations is gleaning, or the acquisition of food resources by one species eating items that incidentally drop to the ground by another species while feeding. Gleaning is a widespread phenomenon between primates and ungulates, but such primate–carnivore gleaning associations are extremely rare in the literature. While studying the behavior and ecology of the Central Himalayan langur (*Semnopithecus schistaceus*) in the alpine zone (3300 m–3500 m a.s.l.) of Rudranath, Kedarnath Wildlife Sanctuary, Uttarakhand State, India, we observed three direct instances and gathered indirect putative evidence of gleaning by Himalayan black bear (*Ursus thibetanus*) beneath large *Quercus semecarpifolia* trees with langurs feeding on acorns during the peak fruiting season. This is the first report of such a feeding association between langurs and bears, and the second for primates and carnivores.

Key words: acorn consumption, commensalism, gleaning, high altitude, increased foraging efficiency.

Interspecific feeding associations (IFAs) range from closely related species to species from different orders, and occur across a wide range of taxa (Stensland et al. 2003). Most of the documented relationships are mutualistic by nature, e.g., facilitating predator avoidance (Rasa 1983; Landeau and Terborgh 1986; FitzGibbon 1990; Dickman 1992; Makenbach et al. 2013) or promoting higher foraging efficiency (Cody 1971; Székely et al. 1989; Oommen and Shanker 2010).

One type of IFA is gleaning, the acquisition of food resources by one species picking up and eating items that incidentally drop to the ground by another species while feeding (Newton 1989). Gleaning associations involving primates are abundant in the literature. To date, at least 174 different examples involving 64 primate species (20 genera, seven families) and 95 non-primate species (73 genera, 35 families) have been documented (see Heymann and Hsia 2014). Primate–ungulate gleaning associations, including bovids and cervids, are most common across both Africa and Asia (e.g., Morgan-Davies 1960; Elder and Elder 1970; Hill 1974; Whitten et al. 1988; Newton 1989; Tsuji et al. 2007, 2015; Ramesh et al. 2012), with only one report from the Neotropics (Agoramoorthy 1997). Apart from this, there are reports of birds, reptiles, and fish (e.g., Glander 1979; González Kirchner 1996; Sabino and Sazima 1999) gleaning foods dropped by primates.

Gleaning shows a strong asymmetry in the type and distribution of benefits with the main benefactors usually being the animals that gain access to food incidentally dropped by foraging primates. There is only one case of gleaning reported between a carnivore, the golden jackal (*Canis aureus*) and a primate, the Hanuman langur (*S. entellus*), in the lower altitudes of central India (Newton 1985). The fruits of *Ficus infectoria*, *Syzygium cumini* and *Buchanania lanzan* were incidentally dropped by langurs and gleaned by golden jackals from the ground. Although jackals may prey on young langurs, they are not a threat to langurs in the trees.

Here, we describe three instances of gleaning between high altitude living Central Himalayan langur (*Semnopithecus schistaceus*) and Himalayan black bear (*U. thibetanus*, Carnivora). Himalayan black bears are known to eat langurs and even livestock when their preferred vegetable matter foods are scarce (Bishop 1975; Sangay and Vernes 2008), making this a particularly unique association. To the best of our knowledge, this is the first report of gleaning between primates and bears.

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Materials and methods

This research was conducted in Rudranath (30.5°N, 79.3°E; 3400 m–3800 m a.s.l.) located in the Kedarnath Wildlife Sanctuary (KWS), one of the largest designated Protected Areas in the Chamoli-Rudraprayag district of Uttarakhand, India. KWS covers an area of 975 km^2 (Fig. 1). The study area was a high altitude alpine area, consisting of two forest types: sub-alpine scattered tree and scrub (2800 m–3400 m a.s.l.) and alpine meadows and rocks (> 3400 m a.s.l.; Champion and Seth 1968). The dominant tree species is oak, *Q. semecarpifolia* found in the sub-alpine area.

The year in the study area is divided into three main seasons; a cool and relatively dry winter (November to March); a warm and dry summer (April to June); and a warm and rainy monsoon period (July to September) with transitional periods of February to March (Spring) connecting winter and summer, and October to November (Autumn) connecting the rainy and winter seasons (Gairola et al. 2010). The mean maximum temperature between April and November in Rudranath is 15.1°C, with a minimum temperature of 1.0°C. Mean relative humidity ranges from 43% to 98% (Bisht et al. 2014). The snow melts during April–May, producing an abundance of soil moisture. The climate is harsh with low temperatures, fluctuating atmospheric pressure, blizzards and hailstorms prevailing most months of the year. Even in May, well before the beginning of the monsoon, cloud and fog formation is common. In winter, snowfall is heavy covering most of the study area (Billings 1973).

Our observations were made between June and September 2016. The campsite was 7 km from the survey area, and we walked to the area daily along a fixed trail. The observations were carried out by four people on any given day, searching for, following, and habituating one troop of langurs, from morning (6 a.m.) to evening (6 p.m.), independent of weather conditions. As part of this daily routine, we systematically collected any indirect evidences of bears and their activity, i.e., scat, feeding traces, scratch marks on trees, sleeping dens, and footprints. Behavioural observations were carried out by naked eye or through binoculars (Olympus 8 × 40) for general activity (feed, travel, rest, play, social interactions, and others) by 15-minute scan sampling at five-minute intervals (Altmann 1974). Activity for each visible individual was recorded at the moment it was first observed. For individuals that were feeding during the scan, we recorded food species and plant part eaten.

The langur study group contained five adult males, seven adult females, eight sub-adults, and six juveniles. We spent a total of 468 hours (h) looking for and following langurs and looking for signs of bear activity, and an approximately equal number of hours were spent each

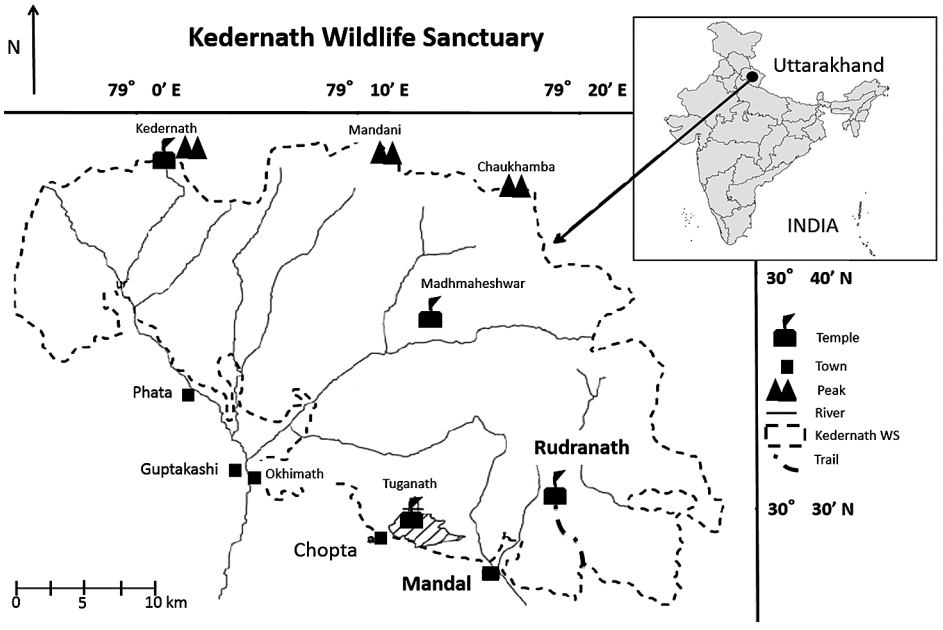

Fig. 1. The Kedarnath Wildlife Sanctuary in Chamoli-Rudraprayag district, Uttarakhand, India. The study area is indicated with a building icon in the map which represents a Hindu temple.

month; June (109 h), July (118 h), August (127 h) and September (113 h). All direct sightings of both species were recorded.

Results

Langur feeding behavior

Langurs were observed to spend the majority of their time feeding on *Q. semecarpifolia*, until the acorns were almost totally finished at the end of September. Langurs spent the rest of the time feeding on young leaves of *Betula utilis* and *Sorbus microphylla*. Time spent feeding on acorns was highest in July (61%) and lowest in September (6%, Table 1). In September, the langurs split up into two groups. Only one of these sub-groups could be found in the area, and they continued feeding on the remaining acorns.

Table 1. Feeding activity of Central Himalayan langur and Himalayan black bear activity between 3300 m–3500 m a.s.l. at Rudranath

Month	June	July	August	September
% individuals feeding on acorns by langurs (total number of feeding records in scan samples / month)	10.3 (58)	61 (359)	39.3 (351)	6 (200)
Direct bear sightings	0	2	3	0
Direct sightings of bear gleaning oak fruits under the langur feeding tree	0	2	1	0
Fresh bear scats encountered	1	25	32	6
Fresh tree scratch marks encountered	0	8	6	2
Fresh pugmark encountered	1	10	12	3

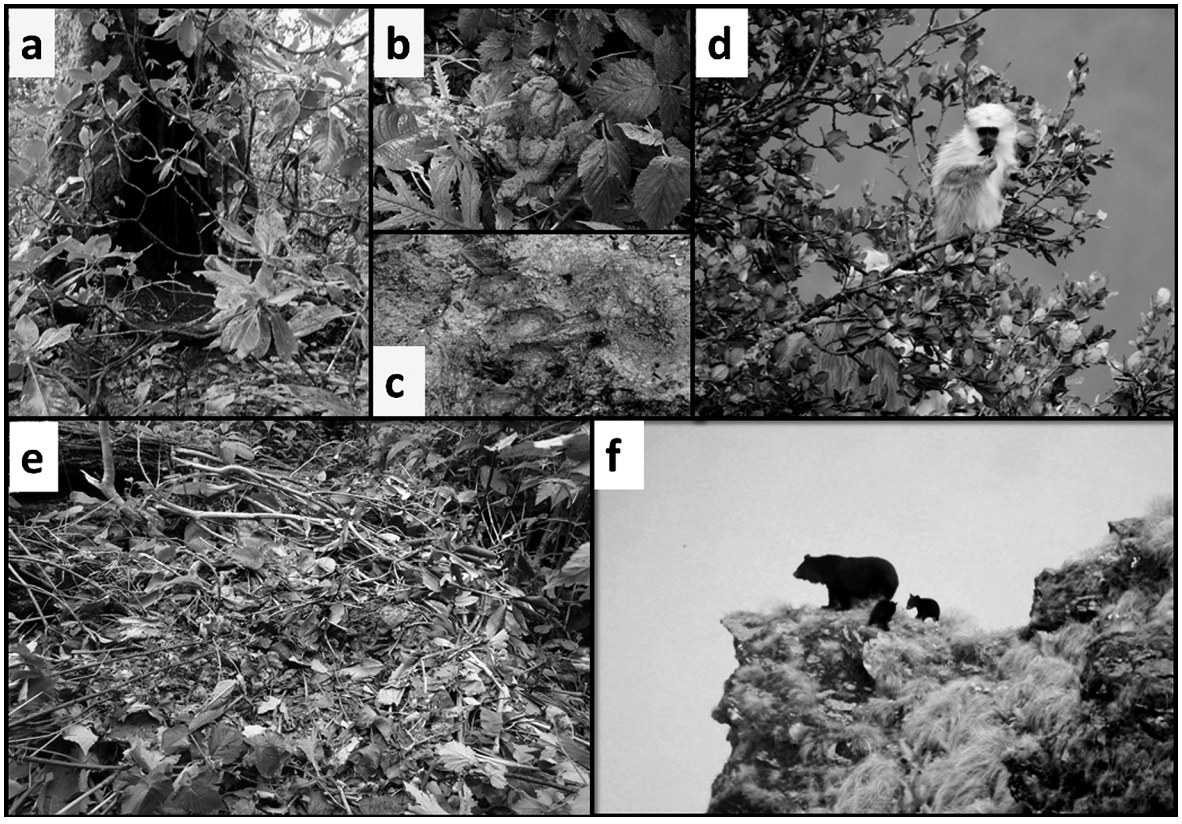

Fig. 2. Photographs suggesting the possible langur-bear association. a: bear den, dug out of a hollow standing tree; b: bear scat; c: bear footprints; d: a juvenile of the Central Himalayan langur feeding on *Quercus semecarpifolia* acorns; e: ground nest made by bear, f: an adult female with her cubs of the Himalayan black bear.

Direct evidences of bear gleaning

We encountered one adult female bear twice and sub-adults three times (Fig. 2) in the month of July and August. Gleaning by bears was observed only in July and August (Table 1), the peak period for langur acorn consumption. Three times we directly encountered bears gleaning acorns of *Q. semecarpifolia* on the ground that were incidentally dropped by langurs feeding above in the tree. Coinciding with peaks in langur feeding on acorns, our indirect evidence of Himalayan black bears in the study area also increased in July and August (Table 1).

Indirect evidence of langur-bear association

We frequently found bear scat (Fig. 2) under acorn trees where langurs had recently been observed feeding. The scat consisted mostly of digested acorn matter, as indicated by the pale, soft fecal matrix (Fig. 2).

Bear scat deposition and ground vegetation destruction, apparently, the result of searching for food, were frequently found in the langurs' home range area (Fig. 2). Additionally, indirect evidence of bear activity in the langur home range were four daily sleeping dens, dug out of hollow standing trees and one ground nest with fresh feces deposited nearby (Fig. 2). Partly attached broken branches up in a tree, a sign of bear feeding, were never observed, unlike what we commonly found at lower elevations, 1500 m to 2500 m a.s.l. (Nautiyal, personal observation).

Discussion

The nature of langur-bear gleaning interactions

The langur-bear feeding association described here appears to be beneficial for the bear to gain access to fallen *Q. semecarpifolia* acorns. What makes this association perhaps unique from other reports involving primates however is the fact that Himalayan black bears are potential predators of langurs, and have been reported to kill langurs in neighboring Nepal (Bishop 1975). While more observations are needed to make firm conclusions about the benefits and detriments of this association for langurs, we think that the nutritional benefits of gleaning highly nutritious acorns by bears outweighs the risk and energy expenditure of hunting, especially for females with their cubs (see below), at this critical time of year in Rudranath.

The black bear is normally omnivorous, but when food is scarce they are known to sometimes hunt. In the situation we report here however, the relationship was about getting seasonally available acorns fallen to the ground, a favored high energy content food item (McDonald and Fuller 2005). *Quercus semecarpifolia* is the dominant tree of the sub-alpine and alpine forest between 2100 m and 3800 m a.s.l. (Singh and Singh 1992) and flowering time is typically in June and July, with August being the peak fruiting period (Shrestha 2003). Bears select or shift habitats based not only on the distribution of food-producing plants, but also on the phenological development of these food plants (Davis et al. 2006; Koike 2009). During our study, langurs and bears were found together during the short *Q. semecarpifolia* fruiting season (July and August). As mentioned, the IFA described here involving females and their cubs occurred in the month of July and August, which is right before winter. For such bears acorns may be an important nutritional source for accumulating fat in preparation for the harsh winter ahead (Garshelis and Steinmetz 2008).

In this situation, it seems necessary for bears to minimize their expenditure of energy for foraging or hunting to maximize energy and fat stores. If so, then we would expect them to prefer the most easily available rich resources for themselves and their cubs. Hunting agile prey like langurs up in the canopy is not itself an easy task which involves climbing up in these tree, balancing on the thin branches to capture a langur. Thus, considering energy management, bears should prefer to glean the acorns rather than attempting to go after langurs high up in the oak canopy at Rudranath.

Why glean instead of forage in the trees?

Why did not we see bears climb up into the trees to forage on acorns themselves instead of gleaning them from the ground under langur feeding trees? Based on the observations reported here, we present three possible non-exclusive hypotheses to help explain this.

1. Increased foraging efficiency: In the alpine meadows of Rudranath, food resources are scarce throughout the year and negligible in the winter. *Quercus semecarpifolia* is the dominant tree in the study area. During our study, langurs and bears were found together during the short *Q. semecarpifolia* fruiting season (July and August). We noticed that the common feeding patches used by langurs and bears had higher concentration of fruiting *Q. semecarpifolia* trees as compared to other patches in the study area. In principle, bears can climb up trees to get acorns but the energetic cost involved in finding fruiting trees, climbing up into them and taking acorns from the terminal branches where they are found seems much

greater, compared to simply gleaning them from forest floor. Following a langur troop and gleaning acorns on the ground, may help bears, especially females with young cubs (see below), to easily locate fruiting trees in the forest, increase foraging success, and reduce energy expenditure. This strategy adopted by bears could help them to more effectively store energy needed to prepare themselves, and their cubs, for the upcoming harsh winter.

2. Offspring protection: Infanticide is a widespread behaviour by adult male bears and coincides with the breeding season of Asiatic black bears from mid-June to mid-August (our study period) (e.g., LeCount 1987; Bellemain et al. 2006; Libal et al. 2011; Steyaert et al. 2013) It is reported that during each breeding season, several males compete for breeding privileges with females. The langur-bear IFA described here coincided with this period of high risk of infanticide. For females with cubs, it is probably a safer option to follow langurs and glean the acorns from the forest floor, instead of leaving their cubs vulnerable to possible infanticide by males on the ground. At this stage, the cubs are too big to cling to mother but too small to climb up large girthed, tall trees.

3. Risk of falling: At our site, timberline *Q. semecarpifolia* are conspicuously wider girthed and taller (average 225 cm diameter, 15 m height, $n = 60$) than at the lower elevation *Q. leucotrichophora* (1500 m–2500 m a.s.l.) in our study areas (average 87 cm diameter, 10 m height, $n = 40$). Bears are generally good climbers, but adults become too heavy to climb out onto to the terminal branches where acorns are found. The risk of falling for a bear seems to be considerably higher in these taller trees, especially on terminal branches while reaching out for acorns. At the lower elevation site, bears frequently foraged and even built daily tree sleeping nests up in the shorter and smaller girthed *Q. leucotrichophora* trees, but this was simply never seen at Rudranath during our study (Nautiyal, personal observation).

We propose that this IFA is not a chance encounter, but rather an adaptive bear survival strategy, perhaps for females in particular, to combat lean times when access to highly nutritious food resources are scarce in high alpine meadows of the Himalayas.

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