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Habitat preference and forage selection by Himalayan Pika *Ochotona roylei* at high altitudinal zones of Chopta Tungnath, Western Himalaya

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Abstract
Himalayan Pika is an herbivore and selective forager. Selection of food by Himalayan Pika is influenced by different factors like food plant availability and how much abundant the food is, which in turn depends on soil fertility variables. Soil samples (0-15 cm) to (15- 30 cm) were collected from different altitudinal zones of study site. Various physical and chemical properties of soil were experimentally observed. Higher values of nutrients were found in soil samples of sub-alpine zone. Food plant abundance was recorded by Quadrat method. Mean plant density calculated for sub-alpine zone, timberline zone and alpine zone were 376.15, 290.00 and 310.8 (plants/m^2) respectively. Food preference was observed by focal sampling and selection indices. Selection index for alpine habitat, timberline habitat and sub-alpine habitat were 0.78, 1.05 and 1.14 respectively. Higher values of forage ratio index for different species at sub-alpine habitat were found. Values of habitat selection index and forage ratio index indicate that most preferred habitat by Himalayan Pika was sub-alpine habitat.

Keywords: forage ratio index, Himalayan Pika, quadrat method, selection index, soil fertility variables

Introduction

Western Himalaya is recognized as one of the major rich biodiversity centers in India as its different climatic conditions provide it with a high variety of ecosystems rich with myriad types of floral as well as faunal species (Nautiyal *et al*., 2001) [1]. Composition of plant communities and micro-habitats are strongly influenced by the presence of small mammals (Smith and Foggin, 1999) [2]. Accordingly, in the Indian Trans-Himalaya, plant species richness and diversity have been reported to be higher in the presence of small mammal colonies (Bagchi *et al*., 2006) [3]. Himalayan Mouse-Hare is one of the mammals, which is distributed within the high altitude habitats. Himalayan Mouse-hare belongs to the order lagomorpha within the family Ochotonidae (Bahuguna and Upadhyay, 2008) [4] with characteristic feature of having four incisors in the upper jaw differing them from rodentia having two incisors. There are approximately 30 species throughout the world, most are restricted to Asia with only three *Ochotona* species that presently live outside of Asia. In Western Himalayan area, this study animal is called “Runda” (Bahuguna and Upadhyay, 2008) [4]. The name “Runda” is derived from local Garhwali language, which means tail-less (Khanal, 2007) [5]. They are restricted to snow fed areas where aromatic and medicinal herbs are abundant. These animals are diurnal and easily visible, making them ideal for field observation (Beever *et al*., 2010). They are territorial and do not hibernate during the winter when the inhabited surrounded area covered with snow, they feed on vegetation that was collected and stored in a hay pile at the end of the summer (Bahuguna and Upadhyay, 2009) [6]. Pikas are one of the most important members of their native ecosystem, by collecting and feeding on different plant species, they play an important role in their distribution and also can be used as bait for many carnivores (Nowak, 1999) [7]. They strongly influence the composition of local plant community through ecological engineering that leads to increased plant diversity (Bagchi *et al*., 2006) [3]. Climate change might increase winter temperature, which could result in early snow melt as well as increase alpine soil dryness, reduced soil nitrogen availability, and altering growth and availability of alpine plants (Walker *et al*., 1994, 1995; Brooks and Williams, 1999) [7, 8]. In alpine and tundra ecosystems, soil nitrogen supply is limiting; thus, changes in nitrogen supply can significantly influence phenology and biomass of alpine plants (Shaver and Kummerow, 1992; Schimel *et al*., 1996). In present study, we determine (1) The habitat preference by Himalayan Pika (2) Food selection by Himalayan Pika (3) Analyzed different soil fertility variables of alpine, timberline and sub-alpine zone. (4) Recorded food plant density at different altitudinal zones.

Material and methods

Study area

The present study was carried out in Chopta-Tungnath area (30°29'22”N, 79°12'47”E) within Kedarnath Wildlife Sanctuary Western Himalaya Uttarakhand, India at an altitude of 2600m asl to 3650m asl (fig. 1). Study Site was observed during four prominent seasons viz., short summer (May-June), monsoon (July- mid September), autumn (mid September-October) and long winter (November-April). Typical features of the soils of West Himalayan oak-dominated forests are: soil is generally brown in colour, sandy loam in texture, and slightly acidic. The percentage of sand in the soil tends to decrease with increasing elevation, but is greater at disturbed sites. Soil is generally nitrogen-rich. However within the same forest the nitrogen content is invariably higher on mesic hill slopes than on drier slopes and generally acidic with pH value 5 to 6 (Saxena, 1979., Tewari, 1982 and Upreti, 1982., Bisht, 2005) [10, 12, 11].

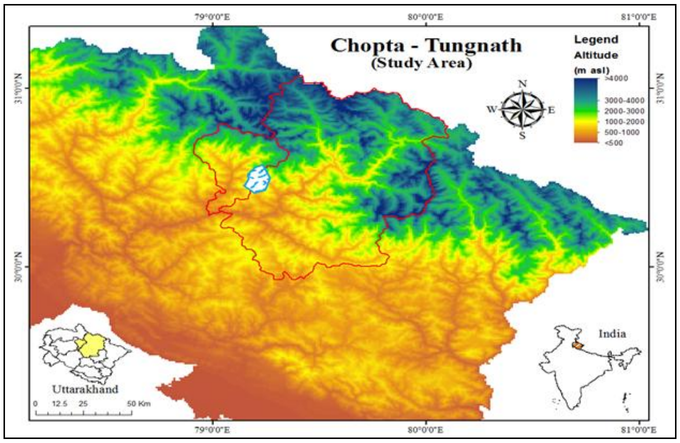

Fig 1: Map of study area.

Data collection

In present study data was collected for the period of one year (April 2016- March 2017). Study area was divided into 3 elevation zones: sub- alpine zone (2600m-3100m), timberline zone (3100m-3400m) and alpine zone (3400m- 3650m). We permanently marked one 50m × 50m plot in each zone to observe the Himalayan Pika foraging behavior and soil sampling of that area.

Pikas was observed by focal sampling in the morning (06:00-10:00 h) and in the evening (15:00–18:00 h) using binoculars from a high vantage point below which the entire study plot was visible, (Altmann, 1974) [9]. As Royle pikas are synanthropic, the presence of an observer does not appear to influence their natural activity (Kawamichi, 1968) [13].

Soil sample of 0-15 cm and 15-30 cm size were collected from permanently marked plots of three zones (Alpine, Sub-alpine and timberline) and were experimentally observed and analyzed.

Identification of food plant species were done by visual observation and standard quadrate method has been used to quantify them. Herbarium of identified foraged plants was prepared. Extensive survey was carried out to identify habitat at different altitude rich in Himalayan Mouse-Hare populations (Gaur, 1999) [36].

Data analysis

Data analysis for different soil parameters, plant density:

For soil- Various physical (water holding capacity, moisture content, color of soil) and chemical properties (pH, organic carbon, Nitrogen, phosphorous, potassium, some micronutrients) of soil were experimentally observed. Plant density was observed by deploying ten random (1m × 1m) traditional Quadrat within the permanently marked areas in every selected habitat of study area (Misra, 1968) [15].

Data analysis for habitat preference

Selection index were used to analyze habitat preference on the basis of a) proportion of habitat available b) number of study animal encountered during sampling within the particular habitat, and c) proportion of study animal within the particular habitat. Chi-square value was calculated to test Null Hypothesis (Krebs, 2014) [37].

Selection index: $w_i = \frac{o_i}{p_i}$

w_i = Selection index for species

o_i = Proportion or percentage of species i in the habitat.

p_i = Proportion or percentage of selected habitat available in the selected area.

Chi square test: $\chi^2 = \sum_{i=1}^{n}\left[u_i \ln\left({u_i}/{Up_i}\right)\right]$

Data analysis for food selection and preference

Forage ratio (*wi*) or selection index (Manly *et al*., 1993) and Standardized selection index (*Bi*) were calculated to analyse food preference by *Ochotona Roylei* with in different selected habitats (Krebs, 2014) [37].

Food ratio: $w_i = \frac{o_i}{p_i}$

w_i = forage ratio for species *i*

o_i = Proportion or percentage of species *i* in the diet.

p_i = proportion or percentage of species *i* available in the selected habitat

Standardized selection index: $B_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$

B_i = standardized selection index for species *i*

w_i = forage ratio for species *i*

Results

Soil samples from three different habitats were collected and analyzed, our results showed that the value of macronutrients, micronutrients, water holding capacity, and soil moisture was highest for sub- alpine habitat than timberline habitat followed by alpine habitat. This ensures that soil fertility value was highest for sub-alpine habitat (Table 1)

Mean foraged plant density was found to be highest for sub-alpine zone (376.15 plants/m²) than alpine (310.8 plants/ m²) followed by timber line zone (290.00 plants/ m²). Value of Selection index ($\hat{w}$) observed were 1.14 for sub-alpine habitat, 1.05 for timberline habitat and 0.78 for alpine habitat. Value of chi-square test (χ^2) found was 10.52 with 2 df. This value of chi- square is considerably larger than the critical value of 5.99 at α=5% so we reject the null hypothesis that Mouse-hare use all these habitats equally. Our results indicates that more preferred habitat for *Ochotona roylei* was sub-alpine than rest of two. (Table 2)

Forage ratio (*wi*) or selection index and Standardized selection index (*Bi*) for various dominant species of particular habitat were calculated. Standardized selection index (1/ number of resources) indicates preference. Therefore the value of Standardized selection index (*Bi*) should be higher than 0.2 for a plant to be preferred in sub-alpine and timberline habitat and 0.25 for alpine zone. (Table 3)

Table 1: Soil fertility variables, plant density food preference.

S. No.		Sub alpine zone	timberline Zone	Alpine Zone
(A)	Macronutrients			
	Nitrogen	1.276	1.16	0.947
	Phosphorus	27.88	27.4	23.38
	Potassium	255.92	245.94	192.4
(B)	Micronutrients			
	Zinc	0.89	0.75	0.73
	Copper	0.36	0.30	0.32
	Iron	5.10	5.62	4.92
	Sulphur	10.68	10.66	12.76
(C)	Water Holding capacity	74.25%	60.56%	63.77%
(D)	Soil moisture	57.08%	46.02%	42.06%
(E)	pH	7.11	6.8	6.25
(F)	Density(plants/m²)	376.15	290.00	310.8
(G)	% foraged plant	62.5	60.1	56.16
(H)	Dominant plant family	Apiaceae	Rosaceae	Salicaceae
			Apiaceae	Ericaceae
				Apiaceae
(I)	Food preference	*Trachydium roylei* (15%)	*Fragaria sp*. (35%)	*Rhododendron campanulatum* (20%)
		Fragaria nubicola (25%)	*Trachydium roylei* (36%)	*Sibbaldia micropetala* (18%)
		Potentilla atrosanguinea (5%)	*Oxygraphis polypetala* (11%)	*Trachydium roylei* (30%)
		Ranunculus hirtellus (11%)	*Ranunculus hirtellus* (16%)	*Fragaria sp*.(32%)
			Sibbaldia micropetala (2%)	

Table 2. Selection indices for Himalayan Pika in three habitat types

S. No.	Habitat	Proportion available(*pi*)	No. of Ochotona roylei encounterd (*ui*)	Proportion of Mouse-hare in habitat (*oi*)	Selection index(ŵ)	Chi- square value(χ²)
1.	Sub-Alpine habitat	0.35	32	0.40	1.14	
2.	Timberline habitat	0.20	17	0.21	1.05	10.56 with 2 df
3.	Alpine habitat	0.45	28	0.35	0.78	
	Total	1	80	1	3.17	

Table 3. Forage ratio or selection index

S. No.	Habitat	Percentage of species available(*pi*)	Percentage of species in diet (*oi*)	Forage ratio for species (*wi*)	Standardized selection index(*Bi*)
1.	Sub-Alpine habitat	*Trachydium roylei* (35%)	*Trachydium roylei* (15%)	0.43	0.12
		Fragaria nubicola (13%)	*Fragaria nubicola* (25%)	1.92	0.55
		Potentilla atrosanguinea (30%)	*Potentilla atrosanguinea* (5%)	0.17	0.05
		Ranunculus hirtellus (22%)	*Ranunculus hirtellus* (11%)	0.50	0.14
		Viola biflora (11%)	*Viola biflora (5%)*	0.45	0.13
				3.47	
	Timberline habitat	*Fragaria sp*. (9%)	*Fragaria sp*. (20%)	2.22	0.59
		Trachydium roylei (30%)	*Trachydium roylei* (8%)	0.27	0.07
		Oxygraphis polypetala (15%)	*Oxygraphis polypetala* (5%)	0.33	0.09
		Ranunculus hirtellus (20%)	*Ranunculus hirtellus* (16%)	0.80	0.21
		Sibbaldia micropetala (15%)	*Sibbaldia micropetala* (2%)	0.13	0.03
				3.75	
	Alpine habitat	*Rhododendron campanulatum* (15%)	*Rhododendron campanulatum* (10%)	0.67	0.36
		Sibbaldia micropetala (3%)	*Sibbaldia micropetala* (0.2%)	0.06	0.03
		Trachydium roylei (16%)	*Trachydium roylei* (8%)	0.50	0.27
		Danthonia cachemyriana (25%)	*Danthonia cachemyriana (*16%)	0.64	0.34
				1.87	
				9.09	

Discussion

Himalayan Pika plays an important functional role in Alpine ecosystem (Smith and Foggin, 1999) [2]. The composition of local plant community is strongly influenced by their presence (Bagchi *et al*., 2006) [3]. They have positive impact on soil nutrient and moisture gradients (Smith *et al*., 1990) [19]. Our results show that there was less or no relation between soil fertility variables and plant species abundance at different altitudinal zones and are in accordance with the results found by Nadeau and Sullivan, (2015). They found that species richness of herbs and shrubs was not related to any of the soil variables. The results in these studies were highly variable. (Moore and Keddy, (1988) [26] suggested that different patterns of species richness may be encountered with different understory species types. Grubb (1987) [25] and Goodland (1971) [28] discovered a negative relationship between herb species richness and soil fertility. Wright (1992) [27] and Nirmal Kumar *et al*. (2010) [18] found a positive relationship between soil fertility and species richness of herbs and shrub. A more specific study was done to demonstrate that there was a positive relationship between plant biodiversity (richness and diversity) and the concentration of extractable P and K in soil of sites located in temperate grassland ecosystems (Janssens *et al*., 1998) [16]. The relationship between tree species biodiversity (Shannon-Wiener and Simpson's diversities and species richness) and soil nutrient concentration in three different sites in a dry deciduous forest of western India was studied and strong positive correlation between tree species richness and the concentrations of N, P, and C was observed (Nirmal Kumar *et al*, 2010) [18]. Pikas are known as mammalian herbivores that attempt to collect heaps of plants (Dearing, 1996., Richardson, 2010) [20, 21] and they may choose different plant species at different stages in their development based on the quantity of nitrogen (Morrison *et al*. 2004; Morrison *et al*. 2007; Morrison & Hik 2008) [22., 23, 24].

Asian rock-dwelling pika are considered to be opportunistic herbivores with very weak selectivity among classes of forage (Krivosheyev, 1971., Khlebnikova, 1976 Yudin *et al*., 1976; Revin and Boeskorov, 1990) [30, 29, 31, 32]. As observed by Cherniavski, (1984) [33]; Voronov and Basarukin, (1992) [34] they tend to feed on or cache plants that are common and highly abundant in their environment. Site and the local composition of vegetation are the main factors for forage selection in the northern pika (*O. hyperborea*) (Gliwicz *et al*., 2006) [35]. We calculate the selection index (Manly *et al*., 1993) for dominant species at different altitudinal zones. Plant density at different altitudinal zones was calculated. Herb density decreases with increase in altitude in tungnath site (Gairola *et al*., 2008) [14]. In accordance with that we found that maximum forage plant density was found in sub-alpine (376.15 plants/m²) habitat than alpine habitat (290.00 plants/m²) than timberline (310.8 plants/m²). Himalayan Mouse-hare showed the presence at different zones of Garhwal Himalaya at an elevation range of 2800m – 5000m asl (Bahuguna and Upadhyay, 2008) [4]. In our study we apply Forage ratio (*wi*) or selection index and Standardized selection index (*Bi*) on various dominant species of particular habitat for habitat preference (Krebs, 2014) [37]. The observed value of habitat selection index (*Bi*) is higher for sub-alpine and timberline habitat in comparison to alpine habitat.

Findings of our study will contribute biodiversity conservation and sustainable management of the preferred habitat region by *Ochotona roylei*, a key stone species of Garhwal Himalaya. When pikas distance themselves from their refuge which is interconnected cliffs and rifts, there must be another refuge to enable them to displace longer and to feed on more varied and abundant plants (Sahneh *et al*., 2014).

In conclusion, we demonstrated that Himalayan Pika was selective in feeding habit and selection of foraged plants depends upon their abundance in particular habitat. Abundance of foraged plants in turn depends on soil fertility variables. According to our results, soil of sub-alpine habitat was more fertile with higher density and abundance of foraged plants in comparison to timberline habitat and alpine habitat. Thus more preferred habitat for Himalayan mouse-hare was sub-alpine.

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