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Population Density of Himalayan Mouse Hare (*Ochotona roylei*) Along High Elevational Region of Madhmahashwar Uttarakhand, Western Himalaya, India

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Abstract Small mammals play crucial role in building up the ecological balance at high elevational regions including Western Himalaya. The population density of Himalayan Mouse Hare (*Ochotona roylei*) was studied at high elevational areas of Madhmaheshwar region of Uttarakhand, Western Himalaya. Standard Quadrat method and focal sampling was done for identification and quantitative analysis of foraged plants. A total of about 20 plant species were observed to be consumed by Himalayan Mouse Hare. Cafeteria method was used for relative preference of foraged plants. Highest food preference was shown for *Rumex* sps. by Himalayan Mouse Hare with the Rodger's index value of about 8.20. Plugging tunnel method was implimented for den activity estimation and population density of Himalayan Mouse Hare. Highest population density of 17.43 *Ochotona roylei* per hectare was observed at an altitudinal gradient of 3200 m asl – 3500 m asl.

Keywords Cafeteria method, Focal sampling, Plugging tunnel method, Population density, Quadrat method.

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Introduction

Family Ochotonidae within the Order Lagomormpha, includes pika with a characteristic feature of having four incisors differentiating them from rodents having two incisors (Haleem et al. 2012). They are most ideal mammals for field observation and experimentation. Their habitat is restricted to, talus or piles of broken rocks adjacent to abundant foraged vegetation. They have characteristic vocalizations, diurnal and their presence is indicated by two prominent evidences. First is pile of small round droppings whether soft or hard and second is the presence of dried plants around their dens which they stored and used during unfavorable environmental conditions (Millar 1971, Smith 1974).

Social and semi-fossorial herbivore mammals play an important role in grasslands throughout the world and the ecosystem engineering and tropic effects done by these mammals are useful for maintaining grassland biodiversity as a result they frequently plays the role of keystone species in these ecosystems (Davison et al. 2012). They also influence the microhabitat and plant communities composition (Smith and Foggin 1999). It have been reported that, in Indian Trans-Himalayas, plant species richness and diversity was higher in the presence of small mammal colonies (Bagchi et al. 2006). Pikas spread from altitudinal gradient of 2500 m asl to 5000 m asl in Western Himalaya, inhabiting talus, open

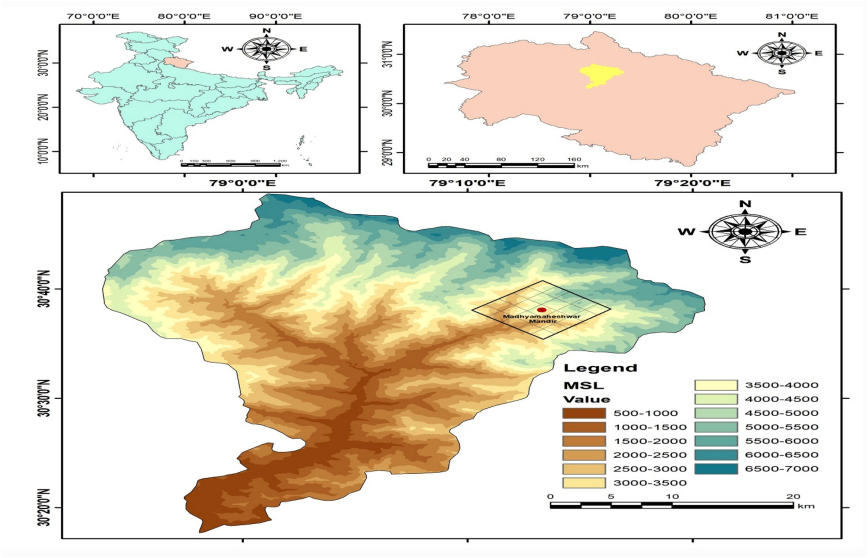

Fig. 1. Location on map of study area.

rocky terrain and *Rhododendron* forests (Bahuguna and Upadhyay 2008). Abundance and distribution of Himalayan Mouse Have directly depends on the availability of forage plant species (Bahuguna et al. 2017). In accordance with that herbivore and vegetation, are in direct proportion to each other: Effect of abundance on one affects the abundance of other (Morrison 2007).

Study area

Present study was carried out at one of the high elevational region of Kedarnath wildlife sanctuary with in the district Rudraparayag of Uttarakhand, Western Himalaya. The intensive study was carried out around Madhmaheshwar shrine along an altitudinal gradient of 2800 m asl–3800 m asl. The area is dominated by number of herbs mainly by *Rumex* sps. (Fig. 1).

Materials and Methods

Foraged plants

Extensive survey for the presence of Himalayan Mouse Hare was done firstly then, an area inhabited by Himalayan Mouse Hare was selected randomly for further study. In accordance with that behavioral study was done by Focal sampling (Altmann 1974).

Standard Quadrat method was used for plant quantification (Misra 1968) and focal sampling was done for identification of plants (Gaur 1999). Density, abundance and species diversity were calculated as following Misra (1968), Shannon and Weaver (1949), Odum (1971) respectively.

Species diversity index (H) = pi ln pi

Where, pi = ni/N, ni = Abundance of each species, N=Total abundance of all species.

$$\text{Density} = \frac{\text{Total number of individuals of a species in all the quadrates}}{\text{Total number of quadrat studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individuals of the species in all the quadrates}}{\text{Total number of quadrated in which the species occured}} \times 100$$

Population density

Den density, active, abandoned and inactive den count was done by using plugging tunnel method (Sun et al. 2008). Total observed dens were counted on first day and then are plugged with hay, dry cow-dung or

Table 1. Showing density, abundance and Shannon index value of foraged plant species.

Sl. No.	Botanical name	Family	Total no. of Quadrats studied	Total no. of Quadrat in which species occur	No. of individuals	Density	Abundance (ni)	pi=ni/N	pi*pi	Shannon index
1	*Rumex nepalensis*	Polygonaceae	30	24	177	5.9	7.375	0.2431	0.0591	– 0.4959
2	*Potentilla lineate*	Rosaceae	30	10	48	1.6	4.8	0.0659	0.0043	– 0.2585
3	*Potentilla atrosanguinea*	Rosaceae	30	6	23	0.7667	3.8333	0.0316	0.001	– 1574
4	*Cotoneaster microphyllus*	Rosaceae	30	8	21	0.7	2.625	0.0288	0.0008	– 0.1475
5	*Frageria nubicola*	Rosaceae	30	20	86	2.8666	4.3	0.1181	0.0139	– 0.3639
6	*Caltha palustris*	Asteraceae	30	5	13	0.4333	2.6	0.0179	0.0003	– 0.1036
7	*Rheum webbianum*	Polygonaceae	30	19	44	1.4666	2.3157	0.0604	0.0037	– 0.2446
8	*Rubus nepalensis*	Rosaceae	30	18	37	1.2333	2.0555	0.0508	0.0026	– 0.2184
9	*Cirsium verutum*	Asteraceae	30	10	18	0.6	1.8	0.0247	0.0006	– 0.1319
10	*Bistorta affinis*	Polygonaceae	30	13	32	1.0667	2.4615	0.0439	0.0019	– 1980
11	*Fragaria daltoniana*	Rosaceae	30	18	42	1.4	2.3333	0.0577	0.0033	– 0.2373
12	*Acronema tenerum*	Apiaceae	30	7	18	0.6	2.5714	0.0247	0.0006	– 0.1319
13	*Arnebia benthamii*	Boraginaceae	30	11	25	0.8333	2.2727	0.0343	0.0012	– 1669
14	*Clinopodium umbrosum*	Lamiaceae	30	11	19	0.6333	1.7272	0.0261	0.0007	– 0.1372
15	*Ajuga brachystemon*	Lamiaceae	30	10	16	0.5333	1.6	0.022	0.0005	– 0.121
16	*Danthonia cachemyriana*	Poaceae	30	20	46	1.5333	2.3	0.0632	0.0039	– 0.2516
17	*Gaultheria nummularioides*	Ericaceae	30	13	24	0.8	1.8461	0.033	0.001	– 0.1622
18	*Picrorhiza kurroa*	Plantaginaceae	30	11	27	0.9	2.4545	0.0371	0.0013	– 0.1762
						23.8667	Ni=51.2712			– 5226.18

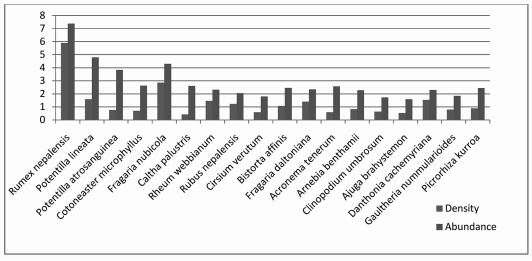

Fig. 2. Showing density and abundance (/m^2) of some dominant foraged plant species.

anything which can be easily removed by Himalayan Mouse Hare. For the next two days opened dens were counted and plugged repeatedly till third day. Count of the first day was total observed dens and the average count of the next two days was average active dens (Sun et al. 2015). Presence of spider webs and absence of scat at the den entry were two prominent evidence of abandoned dens.

In present study we counted number of den by following the method of focal sampling at each permanently marked spot in the study area. We observed that for one particular den there are minimum 4 and maximum 10 entry or exit points as they are interconnected with each other. In relation to that we recorded an average of 7 opening for each den (E_B).

$$PD = \frac{E_A}{E_B}$$

PD = Population density, E_A = Estimated number of active den per hectare, E_B = Average number of opening for one den. Population density is the measurement of population size per unit area and abundance refers to the relative representation of a species in a particular ecosystem.

Food preference

Cafeteria method was implemented for the observation of food preference. Selection index of foraged plant sps. was calculated using Rodgers index (Krebs 1999). Dominant plant species from Himalayan Mouse Hare inhabited area was collected and spread over a polyvinyl sheet in front of active den. The

Table 2. Showing the abundance of Himalayan Mouse Hare at different altitudinal zones of Western Himalaya.

Sl. No.	Altitudinal gradient		Spots	No. of active den	No. of inactive den	Total no. of observed den	Population density (PD)
1	2800 to 3200 m asl	Spot 1	A_1	20	4	24	13.28
			A_2	23	4	27	
			A_3	24	5	29	
			A_4	26	4	30	
			Total	93	17	110	
2	3200 to 3500 m asl	Spot 2	B_1	25	5	30	17.43
			B_2	35	6	41	
			B_3	30	6	36	
			B_4	32	5	37	
			Total	122	22	136	
3	3500 to 3800 m asl	Spot 3	C_1	30	4	34	15.14
			C_2	28	6	34	
			C_3	25	8	33	
			C_4	23	5	28	
			Total	106	23	129	
			Total	321	62	375	
			Average activity	107			
			Average inactivity		20.66		
			Total (PD)				45.85
Average relative abundance of Himalayan Mouse Hare for Madhmaheshwar area/hectare							15.28

Table 3. Showing value of food preference and Rodger's index for different foraged plant species. Sp 1 = *Rumex nepalensis*, Sp 2 = *Potentilla lineate*, Sp 3 = *Potentilla atrosanguinea*, Sp 4 = *Cotoneaster microphyllus*, Sp 5 = *Frageria nubicola,* Sp 6 = *Caltha palustris*, Sp 7 = *Rheum webbianum*, Sp 8 = *Rubus nepalensis*, Sp 9 = *Cirsium verutum*, Sp 10 = *Bistorta affinis*.

	Trial time	Percentage of species foraged									
	Time (h)	Sp1	Sp 2	Sp 3	Sp 4	Sp 5	Sp 6	Sp 7	Sp 8	Sp 9	Sp 10
	0–2 h	0.75	0.60	0.40	0.30	0.50	0.55	0.65	0.60	0.35	0.30
	2–4 h	1.00	0.70	0.50	0.35	0.60	0.65	0.70	0.65	0.30	0.25
	4–6 h	0.90	0.65	0.35	0.30	0.55	0.65	0.65	0.55	0.40	0.25
	6–10 h	1.0	0.70	0.40	0.30	0.50	0.70	0.60	0.50	0.55	0.35
Ai		8.20	5.95	3.65	2.80	4.85	5.85	5.85	5.15	3.60	2.55
Max (Ai)		8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20
Ri (Rodger's index)		1	0.72	0.44	0.34	0.59	0.71	0.71	0.62	0.44	0.31

experiment was done for 5 marked spots, all are equidistant from each other. Old plants were replaced by fresh ones after every 1 h. The trial lasts for 10 h and a day, during peak foraging hours (morning 6:00 h – 12:00 h and evening 17:00 h – 21:00 h) (Morrison et al. 2004).

Results

In the present study different plants species (18 species) viz. *Rumex nepalensis*, *Potentilla lineate*, *Potentilla atrosanguinea*, *Cotoneaster microphyllus*, *Frageria nubicola*, *Caltha palustri*, *Rheum webbianum*, *Rubus nepalensis*, *Cirsium verutum*, *Bistorta affinis*, *Fragaria daltoniana*, *Acronema tenerum*, *Arnebia benthamii*, *Clinopodium umbrosum*, *Ajuga brachystemon*, *Danthonia cachemyriana*, *Gaultheria nummularioides* and *Picrorhiza kurroa* were observed to be fed by Himalayan Mouse Hare (Table 1). Out of total foraged plant species *Rumex nepalensis* was found to be with highest abundance and density and *Ajuga brachystemon* was found with least abundance and density among the major fed species (Fig. 2).

Den activity and inactivity was ensured by spider web and scat which are the two main markers for den activity and inactivity. Population density of Himalayan Mouse Hare was recorded as 17.43 at spot 2 (3200 m asl – 3400 m asl). In average, relative abundance for Madhmaheshwar area was 15.22 Himalayan Mouse Hare per hectare (Table 2).

For food preference, highest value of Rodgers index was observed for *Rumex nepalensis* with the value of 1 and least value of 0.31 for *Bistorta affinis*, which indicated that the most preferred foraged plant by Himalayan Mouse Hare was *Rumex nepalensis* and least prefferd foraged plant was *Bistorta affinis* (Table 3).

$$\text{Rodger's index } Ri = \frac{Ai}{\max(Ai)}$$

Where, Ri=Rodgers' index of preference for cafeteria experiments for species i, Ai = Area under the cumulative proportion eaten curve for species i, max (Ai) = The largest value of the A.

Discussion

Small mammals play an important role in grasslands. The ecosystem engineering and trophic effects done by these mammals are useful for maintaining grassland biodiversity as a result they frequently plays the role of keystone species in these ecosystems (Davison et al. 2012). The local flora of inhabited area is strongly ifuenced by their presence (Bagchi et al. 2006). In accordance with that, in present study we found that population density of Himalayan Mouse Hare was highest with in an altitudinal range of 3200 m asl – 3400 m asl. Using the technique of cafeteria method (Morrison et al. 2004) followed by Rodger's index (Rodgers and Lewis 1985) we found that the most preferred food by Himalayan Mouse Hare in present study was *Rumex nepalensis* and least preferred food was *Bistorta affinis* with Rodgers index value of 1 and 0.31 respectively.

As plateau pika plays a crucial role in different ways to increased functioning of the plateau ecosystem. In different ecosystems, fussorial animals (including the prairie dog of North America) may act to increase primary plant productivity which results in the formation, aeriation and soil mixing and enhancement in the infilteration of water into soil (Hoogland 1995, Kotliar et al. 1999). In present study the density of Himalayan Mouse Hare was higher than that in Nepal Himalaya (12.5 / ha, Smith et al. 1990) and was in accordance with that in tungnath area of Uttarakhand, Western Himalaya (15.3 / ha, Bhattacharya et al. 2009).

Present study indicates that the plugging tunnel method for calculating Himalayan Mouse Hare population density was also applicable by counting total den, active and inactive den. Highest of active den count (122) was observed at altitudinal range of about 3200–3400 m asl possessing with highest no. of Himalayan Mouse Hare density (17.43/ha). However the relationship between pika and the total den count (Pech et al. 2007) was not appreciable. The cause may be that large variations in relation to microhabiat, food abundance and habitat utilization were shown by pika (David 1973).

Findings of our study will contribute to the further bigeographic study of Himalayan pika because it plays a key role in population dynamics study of Himalayan Mouse Hare and its conservation status in Western Himalaya.

In conclusion, We demonstarated that the abundance of Himalayan Mouse Hare is directly purpotional to foraged plant abundance, higher the abundance of foraged plant higher is the population density of Himalayan Mouse Hare.

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