Abundance of Royle's pika (Ochotona roylei) along an altitudinal gradient in Uttarakhand, Western Himalaya

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ABUNDANCE OF ROYLE'S PIKA (*OCHOTONA ROYLEI*) ALONG AN ALTITUDINAL GRADIENT IN UTTARAKHAND, WESTERN HIMALAYA

SABUJ BHATTACHARYYA, BHUPENDRA S. ADHIKARI*, GOPAL S. RAWAT

Department of Habitat Ecology, Wildlife Institute of India, P.O. Box # 18, Chandrabani, Dehradun-248001, India; *corresponding author, E-mail: adhikaribs@wii.gov.in

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ABSTRACT - The relative abundance of Royle's pika (*Ochotona roylei*) was studied in a part of the Kedarnath Wildlife Sanctuary, Uttarakhand, West Himalaya along an altitudinal gradient from 2900 to 3650 m a.s.l. Pikas' detection probability and relative abundance per month and habitat were recorded by monthly surveys consisting of three sampling sessions of four hours each. Food plant species were identified by visual observation and quantified by a standard quadrat method. The highest relative abundance was observed at man-made walls and surroundings in the alpine zone and on broken slopes in the sub-alpine one, whereas alpine meadows showed the lowest abundance. A total of 26 plant species were found to be consumed by pikas. The proportion of forage plants was the highest (77.4%) on the rocky slopes of the timberline zone The results of multiple regressions suggest that rock cover is the main factor affecting the relative abundance of Royle's pika. Rocky areas probably offer both nest-sites and temporary refuges to escape from predators.

Key words: Royle's pika, relative abundance, Kedarnath, Western Himalaya, India

RIASSUNTO - ***Abbondanza relativa del pica di Royle* (Ochotona roylei) *lungo un gradiente altitudinale in Uttarakhand, Himalaya occidentale*.** In un'area del Kedarnath Wildlife Sanctuary (Uttarakhand, Himalaya occidentale), é stata stimata l'abbondanza relativa del pika di Royle (*Ochotona roylei*) lungo un gradiente altitudinale compreso tra 2900 e 3650 m. Sono stati identificate tre fasce altitudinali e 10 habitat complessivi. La probabilità di osservazione e l'abbondanza relativa dei pika per ciascun mese e habitat sono state stimate tramite censimenti mensili consistenti in tre periodi di 4 ore ciascuno. Le specie vegetali consumate sono state identificate tramite osservazione diretta; la disponibilità è stata quantificata tramite rilievo fitosociologico standard. L'abbondanza relativa maggiore è stata riscontrata nella zona alpina, in aree caratterizzate dalla presenza di muri in pietra, e sui pendii della zona sub-alpina, mentre l'abbondanza minore è stata rilevata nelle praterie alpine. I pika sono stati osservati consumare 26 specie di vegetali. La maggiore percentuale di piante utilizzate è stata rilevata lungo i pendii rocciosi al limite della vegetazione arborea. Tramite regressione multipla si è evidenziato che la copertura rocciosa è il fattore che più influenza l'abbondanza della specie. Le aree rocciose offrono probabilmente sia aree idonee per la tana, sia riparo dai predatori.

Parole chiave: pika di Royle, abbondanza relativa, Kedarnath, Himalaya occidentale, India

INTRODUCTION

Small mammals strongly influence the composition of plant communities and micro-habitats (Smith and Foggin, 1999). 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). Pikas seem to be relatively primitive animals, having passed their evolutionary zenith (Thenius, 1972). The only living genus, *Ochotona*, includes a few species adapted to sub-alpine and alpine habitats of Asia and North America. Ochotonids reached their greatest diversity and widest distribution in the Miocene when they spread throughout Europe, Asia, Africa and North America (Dawson, 1967). It is believed that, in the past, nearly 16 species of *Ochotona* inhabited Europe and Africa (Thenius, 1972). Currently there are altogether 30 living species in the world, of which 27 are found in Asia, including 7 in the Indian Himalaya (Hoffmann and Smith, 2005). Royle's pika (*Ochotona roylei*) is quite common throughout the Himalayan region (Hoffmann and Smith, 2005). Its fur is reddish brown with a pale band over the nape. Body length ranges from 15 to 20 cm and the diameter of the head is *ca.* 7 cm; it weights 100-150 g (Alfred *et al.*, 2006). In the western Himalaya, pikas occur from 2500 m a.s.l. up to 5000 m a.s.l., inhabiting open rocky ground and *Rhododendron* forests (Tak and Lamba, 1985). Their distribution depends directly on the availability of forage plant species (Kawamichi, 1968). The bulk of the pikas' diet includes fresh grass, fallen leaves, mosses and the leaves of dwarf bamboo. Most species show a marked food hoarding behaviour, whilst, surprisingly, Royle's pikas hoard only a few plant species in their burrows (Kawamichi, 1968).

Few studies have been conducted on Royle's pikas, as they prefer rugged high altitude environments. Kawamichi (1968) suggested that Royle's pika is less vocal than other pikas and does not hibernate in winter. A preliminary study on the distribution pattern, behavior and social organization of *O. macrotis* and *O. roylei* was conducted by Kawamichi (1970) at Mt. Everest. In 1990, Smith *et al.* revised the data of Kawamichi (1968) and found a density of 12.5 pikas ha^{-1} in Nepal Himalaya. However the study of Kawamichi covered only a brief period and there is no long term study on the seasonal variation in the abundance of Royle's pika.

The present study is an attempt to assess the status and distribution of Royle's pika in relation to habitat use in the Indian Himalaya. The main aims were i) to assess the relative abundance of Royle's pika along an altitudinal gradient and ii) to identify the environmental factors which govern the relative abundance of pikas in different habitat types.

STUDY AREA

The study was carried out in a part of the Kedarnath Wildlife Sanctuary, which is situated in the district of Chamoli, Uttarakhand state (Fig. 1). The total area of Kedarnath WS, which coincides with the upper catchment of the River Alaknanda, is *ca.* 975 km^2 and altitude ranges from 1160 m a.s.l. to 7068 m a.s.l. The intensive study area (*ca.* 10 km^2) is located in the southern fringe of Kedarnath WS around Chopta and Tungnath (30°29' N, 79°12' E). This area

Figure 1 - Location of the study area in Kedarnath Wildlife Sanctuary.

was selected due to its suitable altitudinal range (2900-3680 m a.s.l.), variety of micro-habitat types and accessibility throughout the year.

The forests around Chopta are dominated by broadleaved sclerophyllous communities of *Quercus semecarpifolia, Rhododendron arboreum*, *R. campanulatum*, *Abies pindrow*, *A. spectabilis* and *Sorbus vestita.* The alpine meadows at and around Tungnath are dominated by herbaceous plant communities and *Danthonia* grassland (Sundriyal *et al*., 1987). The main potential predators of pikas in the study area are red fox *Vulpes vulpes*, yellow-throated marten *Martes flavigula,* Himalayan weasel *Mustela sibirica* and common leopard *Panthera pardus* (Green, 1985).

The climate of the area is influenced by a south-west monsoon in summer and westerly disturbances in winters (Mani, 1981). In particular, the intensive study area is characterized by a rainy season lasting from mid-June to September and a long severe winter from October to April.

METHODS

The study area was divided into three zones along an altitudinal gradient, *viz.* sub-alpine, timberline and alpine zone. In each zone, a permanent plot (50×50m) was marked within each available habitat type (N = 10). The location of the plots was recorded through a Global Positioning System (GPS, Garmin72); at each plot aspect and slope were determined through a compass and the percentage of rock cover was visually estimated. In each plot, pikas were searched for once a month from November 2007 to November 2008, except during heavy rains (September 2008) and winter (December 2007 - March 2008), yielding a total of 70 sampling sessions. Each survey lasted 12 hours, subdivided into 3 sampling sessions of 4 hours each. According to morphological features, we could distinguish three groups of individuals, corresponding to juvenile, sub-adult and adult pikas. The juveniles showed a regular light brown fur coat; medium sized sub-adults had very small black patches or moulting marks in the dorsal portion of their bodies and scar marks on one or both ears; adults showed prominent ear scar marks with blackish molting marks on their dorsal body surface. To facilitate the identification of the individuals, during each survey the location of each animal was recorded and photographs were taken from different angles for comparison. In this way we could identify individual pikas and then assess population size with reasonable care.

We estimated site and survey probabilities of detection of the pika by the ratio: $p_{kij} = n_{kij}/N_j$, where k is the sampling occasion ($k = 1, 2, 3$) during survey i in site j, n_{kij} is the number of observed individuals and N_j is the total number of pikas in site j over the study time. The average number of individuals seen in each survey ($\sum p_k/3 \pm SD$) was considered as an index of relative abundance. Mean relative abundances were compared by Kruskal-Wallis' test.

We tested our data for normality by the Kolmogorov-Smirnov test and, whenever necessary, applied the square root transformation to achieve normality (Zar, 1999). Data were also tested for autocorrelation by the Durbin-Watson test (Zar, 1999). We used general linear models (GLM) to test for the effects of site and survey covariates on detection probability and relative abundance of pikas. Detection probability was regressed against rock cover, altitude, food availability and herbaceous species richness. According to our results (see below) pika relative abundance was modeled against three covariates - rock cover, altitude and food availability - using a stepwise forward computation method in a multiple regression framework (SPSS version 15.0). The significance of the models was assessed by ANOVA. The plants eaten by pikas were identified by direct focal sampling (Altmann, 1974). For assessing the density of plant species by the standard quadrat method (Rawat and Adhikari, 2005), ten 1x1 m random quadrates were laid monthly within each plot; the availability of food plants (individuals m^{-2}) was assessed from total herbaceous vegetation cover. The chi-square (χ^2) test was performed to compare plant densities across different habitat types and altitudinal zones. The diversity of herbaceous species (Shannon-Wiener index) was calculated by the software EstimateS 7.51.

RESULTS

Five different habitats were identified in the alpine zone (i.e., rocky alpine meadows, alpine meadows, man-made walls and surroundings, broken slopes in alpine and *Danthonia* grassland), three in the timberline zone (mixed herbaceous meadows, rocky slopes and rocky forest edges) and two in the sub-alpine zone (broken slopes and forest gaps with boulders).

In both alpine and sub-alpine zones plant density was the highest (710 and 521 individuals m^{-2}, respectively) in broken slopes (respectively: $\chi^2 = 668.7$, d.f. = 4, P = 0.05 and $\chi^2 = 110.9$, d.f. = 1, P = 0.05), while no difference emerged among the habitats of the timberline zone ($\chi^2 = 0.10$, d.f.=2, N.S.). The proportion of forage plants was the highest (77.4%) on rocky slopes - timberline zone ($\chi^2 = 16.92$, d.f. = 9, P = 0.05; Table 1). A total of 26 plant species were consumed by pikas, of which 18 were herbs, 5 grasses, 2 shrubs and one fern (Table 2). Royle's pikas mainly ate leaves (18 species), or both leaves and flowers (7 species; Table 2). The Shannon-Wiener diversity index was the highest (2.95) at forest gaps with boulders during the monsoon (August) and the lowest (1.99) in rocky alpine meadows.

Mean density of royle's pika was 15.3 individuals ha^{-1}. Throughout the study period pikas were relatively more abundant at man-made walls in the alpine zone and on broken slopes in the sub-alpine zone ($\chi^2 = 52.1$, d.f. = 9, P < 0.0001; Table 3). The highest relative abundance (7.67 ± 0.33) was recorded around the man-made walls in June and on broken slopes in May. The lowest relative abundance (1.44 ± 0.56) was found in alpine meadows in October and November 2008. In *Danthonia* grassland and forest gaps with boulders

Table 1 - Density of plant species in different habitat types. Values in parentheses indicate the percent contribution of each species in the habitat.

Zone	Habitat	Density (plants m^{-2})	% of forage plants	Dominant species
Alpine	Rocky alpine meadow	197.0	53.1	*Salix elegans* (36%) *Danthonia cachemyriana*(15%) *Viola biflora* (15%)
	Alpine meadow	116.8	45.8	*Salix elegans* (34%) *R. anthopogon* (26%) *Danthonia cachemyriana* (20%)
	Man-made walls	279.5	61.9	*Trachydium roylei* (29%) *Ranunculus hirtellus* (24%) *Parnassia nubicola* (23%)
	Broken slope	710.4	59.3	*Trachydium roylei* (39%) *Oxygraphis polypetala* (19%) *Ranunculus hirtellus* (7%)
	Danthonia grassland	281.0	60.7	*Oxygraphis polypetala* (17%) *Ranunculus hirtellus* (17%) *Danthonia cachemyriana* (13%)
Timberline	Mixed herbaceous meadow	482.0	58.8	*Trachydium roylei* (31%) *Ranunculus hirtellus* (23%) *Oxygraphis polypetala* (16%)
	Rocky slope	479.1	77.4	*Trachydium roylei* (22%) *Ranunculus hirtellus* (19%) *Viola biflora* (12%)
	Rocky forest edge	472.3	71.1	*Trachydium roylei (38%)* *Sibbaldia micropetala* (32%) *Oxygraphis polypetala* (20%)
Sub-alpine	Broken slope	520.6	66.9	*Trachydium roylei* (53%) *Ranunculus hirtellus* (33%) *Viola biflora* (11%)
	Forest gap with boulders	231.7	36.5	*Potentilla atrosanguinea* (35%) *Ranunculus hirtellus* (14%) *Fragaria nubicola* (13%)

the relative abundance of pikas was rather low throughout the study period. Juveniles were observed from May to August. The highest relative abundance of juveniles (3.33 ± 0.33) was found at sub-alpine broken slopes, while the lowest (0.33 ± 0.33) at forest gaps with boulders in June and rocky alpine meadows in May (Fig. 2). In November 2007 and October-November 2008 no juveniles were reported. Detection probability (Table 4) was found to be

Table 2 - Main food plants and parts consumed by Royle's pika.

Family	Species	Parts consumed
Aspleniaceae	*Asplenium* sp.	leaf
Asteraceae	*Anaphalis royleana*	leaf
	Anaphalis triplinervis	leaf
	Jurinea dolomiaea	leaf
	Saussurea nepalensis	leaf
	Tanacetum longifolium	leaf and flower
	Taraxacum officinale	leaf and flower
Apiaceae	*Trachydium roylei*	leaf
Cyperaceae	*Carex setigera*	leaf
Ericaceae	*Rhododendron anthopogon*	leaf
	Rhododendron campanulatum	leaf
Lamiaceae	*Prunella vulgaris*	leaf
Plantaginaceae	*Plantago brachyphylla*	leaf
Poaceae	*Danthonia cachemyriana*	leaf
	Poa sp.	leaf
Polygonaceae	*Polygonum macrophylla*	leaf and petiole
Primulaceae	*Primula denticulata*	leaf and flower
Ranunculaceae	*Oxygraphis polypetala*	leaf and flower
	Ranunculus hirtellus	leaf
Rosaceae	*Geum elatum*	leaf and flower
	Potentilla atrosanguinea	leaf
	Potentilla fulgens	leaf
	Sibbaldia micropetala	leaf and flower
	Sibbaldia cuneata	leaf
Scrophulariaceae	*Pedicularis pectinata*	leaf
Violaceae	*Viola biflora*	leaf and flower

influenced only by herbaceous species richness (R^2 = 0.180, F = 10.516, d.f.= 1, P<0.002). Therefore, in each site the number of sightings during a survey (relative abundance) can be a reasonable surrogate of population abundance in a general linear (multiple regression) model that incorporates as site covariantes: (a) rock cover, (b) altitude and c) food availability.

We found a strong linear relationship between pika relative abundance and rock cover (R^2 = 0.327, F = 23.29, d.f.= 1, P<0.001), estimated by the following equation: Y= 1.73±0.54 + 0.05±0.01 * rock cover. No serial auto-correlation was found among data/variables by the Durbin-Watson test (1.07).

Table 3 - Mean relative abundance of Royle's pika in different habitat types and altitudinal zones.

Zone	Habitat	m a.s.l.	Mean relative abundance ± SD
Alpine	Rocky alpine meadow	3650	3.52 ± 1.34
	Alpine meadow	3633	2.89 ± 1.26
	Man-made walls	3520	5.57 ± 1.58
	Broken slope	3444	3.52 ± 0.97
	Danthonia grassland	3400	2.00 ± 0.43
Timberline	Mixed herbaceous meadow	3300	3.62 ± 0.70
	Rocky slope	3280	4.24 ± 0.76
	Rocky forest edge	3200	4.67 ± 1.46
Sub-alpine	Broken slope	3150	6.05 ± 1.29
	Forest gap with boulders	2900	2.29 ± 0.48

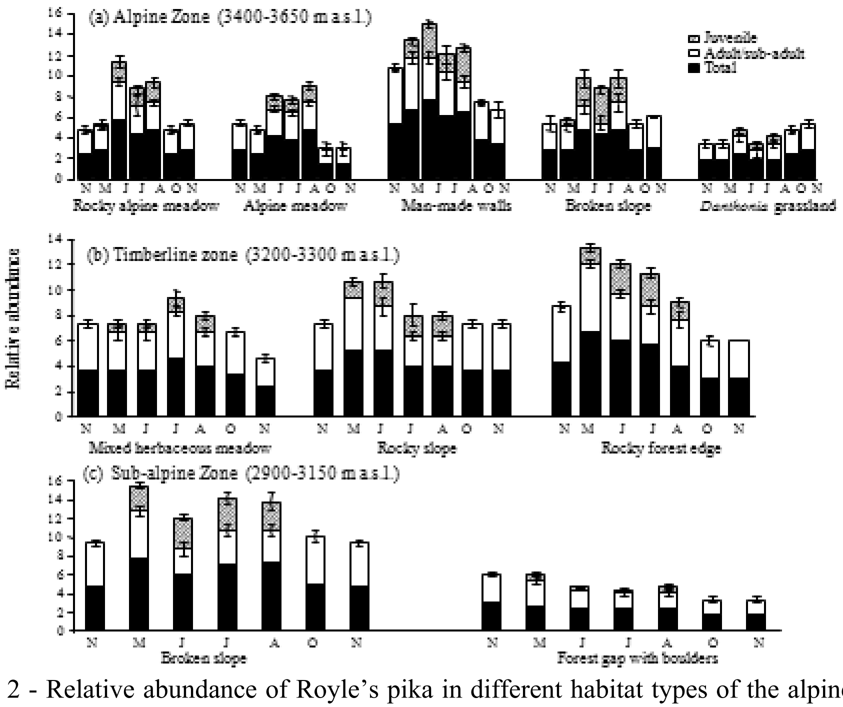

Figure 2 - Relative abundance of Royle's pika in different habitat types of the alpine, timberline and sub-alpine zones from XI 2007 to XI 2008 (except for XII 2007 - III 2008 and IX 2008).

Table 4 - Average detection probability (P) of Royle's pika across different habitat types.

Habitat types	P
Rocky alpine meadow	0.571
Alpine meadow	0.640
Man-made walls	0.750
Broken slope	0.644
Danthonia grassland	0.667
Mixed herbaceous meadow	0.644
Rocky slope	0.744
Rocky forest edge	0.714
Broken slope	0.741
Forest gap with boulders	0.480

DISCUSSION

Royle's pika density in the study area was markedly higher than that in Nepal Himalaya (12.5 ha^{-1}; Smith *et al.*, 1990). There may be several factors which possibly affect on the distribution and abundance of pika populations. Bunnell *et al.* (1974) reported that the physical characteristics of rock slides – mainly the size of the rocks - and accessibility of their periphery affect both the density and dispersal of the American pika (*O. princes*). Our results suggest that both the amount of rock cover and food availability are main factors shaping the relative abundance of Royle's pika populations. Pikas use rocky areas as both nest-sites and temporary refuges to escape from predators (Bunnell *et al.*, 1974). Accordingly, pika relative abundance was higher in man-made walls and broken slopes in sub-alpine habitats, the latter offering cover and higher accessibility to food resources than alpine meadows.

In the alpine area the growth season is limited and as soon as the monsoon ends most of the herbaceous plants become senescent. Therefore, pikas have to get an adequate amount of food in a relatively short time, as they do not hibernate to compensate for the prolonged winter food scarcity.

Royle's pika is a generalist herbivore, relying on a wide variety of herbs and grasses. Accordingly, its probability of detection was found to be influenced by the relative richness of herbaceous species.

Our study suggests that Royle's pika reproduces only once in a year, as other talus dwelling pikas.

This preliminary study represents a basis for further research aiming to estimate the seasonal and habitat variation of pika abundance, which will allow us to better understand the population dynamics of these high-altitude small mammals.

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