Kashmir Journal of Science
https://kjs.org.pk ISSN: 2958-7832

Kashmir Journal of Science (2023), 2(2): 38-53

Research Paper

Seasonal and Spatial Patterns of Habitat Use by Royle's Pika (*Ochotona roylei*) in Jagran Forest Range of District Neelum, Azad Jammu and Kashmir, Pakistan

Ghulam Ali*[1], Nasra Ashraf[1], Saba Khalid[1], Rukhsana Khatoon[1], Nuzhat Shafi[1], Nousheen Irshad[2], Sidra Qayoom[1]

[1]*Department of Zoology, The University of Azad Jammu & Kashmir, Muzaffarabad (13100)*
[2] *Department of Zoology, The University of Poonch, Rawalakot (12350)*
**Corresponding Author: ghulamalionline@hotmail.com*

ARTICLE INFO

Article history:

Received: 07 February 2023

Accepted: 21 March 2023

Available online: 30 March 2023

Keywords:

Royle's pika,

Jagran Forest Range,

Habitat use,

Rocky talus, Himalayas

Abstract

Royle's pika (*Ochotona roylei*) is an important species in the Himalayas. Understanding the relationships between this species and its environment is essential for its sustainable management. The current study was conducted in the Jagran Forest Range, a potential area of Royle's pika distribution in the Neelum district of Azad Jammu & Kashmir (AJ&K). To examine how Royle's pika uses and prefers its habitat, indirect signs, such as counting pellet groups, and direct observations using a focused scan-sampling method were employed. To understand the seasonal patterns of habitat use, surveys were conducted in three different seasons: summer, monsoon, and autumn, from April to November 2022. The habitat preference and other topographic factors, such as elevation, slope, aspect, and plant cover, were analyzed in three major localities and nine different types of habitats within the study area. Royle's pika was observed to be distributed in 86 out of 159 sampling sites in the Jagran Forest Range, within an altitudinal range of 2663-4282 meters above sea level (asl). The use of different habitat types by Royle's pika was significantly different among the three seasons ($F = 28.11$; $df = 2, 16$; $p<0.001$). Pikas predominantly use higher altitudes (3000 – 3500 m) with significant differences among seasons ($F = 45.133$; $df = 2, 12$; $p<0.001$) and localities ($F = 71.912$; $df = 2, 12$; $p<0.001$). Moreover, they showed a high preference for herbs in the study area (IEI = 0.238). Royle's pika appears to select habitats which provide both food and cover simultaneously regardless of the season.

Introduction

Pikas are small lagomorphs belonging to the monophyletic genus *Ochotona* in the family Ochotonidae. Himalayan pikas *(Ochotona roylei)* are small mammals related to rabbits and hares. They inhabit rocky talus fields in alpine regions (Kawamichi, 1968). The characteristics of pikas that distinguish them from most other lagomorphs include their propensity to vocalize (Conner, 1983). Pikas are crepuscular; meaning they are frequently active during hours of dawn and dusk (Koju & Chalise, 2013). They are generalist herbivores and have high energetic demands than other mountain mammals because they do not hibernate, so they make multiple trips per hour to collect vegetation during summer seasons to feed instantly as well as stored for winter (Beever et al., 2003). Their daily caloric intake is equivalent to filling their stomach nine times a day. Food intake is found to increase during pregnancy and lactation period (Smith et al., 1990). Pikas make two types of calls; the long call Chirrr…rrr and the short call 'chi chi; which they often make while musing on large rocks or during chasing each other. However, significance of calling is still mysterious (Koju et al., 2012).

Royle's pika is typically associated with scattered rocky slopes or talus in the Himalayan regions of Pakistan. They occur rather sparingly in Himalayan temperate forests, where the trees grow amongst talus or tumbled rocky slopes. The pika seems to be quite erratic in occurrence, being entirely absent from some apparently suitable regions. It is generally associated with drier Himalayan areas with deodar (*Cedrus deodara*) or spruce (*Picea smithiana)* forests amongst tumbled rock falls. They occur as low as 2400 m in Hazara district and Gilgit up to 3600 m, and probably much higher in the Karakorum. Royle's pika always prefers treeless areas but close to the gullies with some scattered bushes (Robert, 1997).

Pika's burrows are often difficult to detect because they make more use of natural rock cavities and live more exclusively in regions of rock talus. The Royle's pika is a widespread species with a steady population that does not appear to be experiencing a significant loss in its general distribution or abundance (IUCN, 2019). Unlike many alpine species, pikas do not hibernate. To ensure a supply of food for the long winter they spend the summer building hay piles. Because of their sensitivity to warm temperatures and variation in snowpack and vegetation patterns, the pika is believed to be an important indicator species for the impacts of global climate change on fragile alpines. Understanding how pika populations are responding to climate variability, therefore, can provide knowledge about the probable impacts on other species, ecosystem processes, and natural resources in alpine ecosystems. In Pakistan and AJ&K, a few studies have been conducted that just describe the presence of Royle's pika in this region (Khan et al., 2012); Faiz & Abass, 2016). Jagran Forest Range is a potential and significant area in the distribution range of Royle's pika in AJ&K. The present study was the first step to generate information about the seasonal patterns of distribution and habitat use by Royle's pika in the Jagran

Forest Range of district Neelum, AJ&K. This information will provide a base to assist wildlife managers in the conservation of this beautiful lagomorph in this part of the world.

Materials and Methods

Study Area

Jagran Forest Range (JFR) is the largest forest range of district Neelum, Azad Jammu & Kashmir, with an area of about 52026 ha (520.26 km^2) which comprised of 58 forest compartments. It is located about 84 kilometers northeast to Muzaffarabad City, the capital of AJ&K. The area of the forest range is linked with Kaghan Valley of Khyber Pakhtunkhwa (KP) on the western and northern sides, Machiara National Park of district Muzaffarabad, and Bandi Forest Range of district Neelum along the southern border, Keran Forest Range of district Neelum on the northeast, whereas Indian Occupied Kashmir is present along the eastern border (GOAJ&K, 2020; Figure 1). Jagran Forest Range is a notable area for its severe winters and heavy snowfall. The mean annual rainfall is 1540 mm, and the maximum rainfall occurs during the month of July with a mean rainfall of 339.6 mm (WWF, 2008). Summers are particularly pleasant and cool. The area is blessed with many freshwater springs and many perennial streams with cold and clear water (GOAJ&K, 2020).

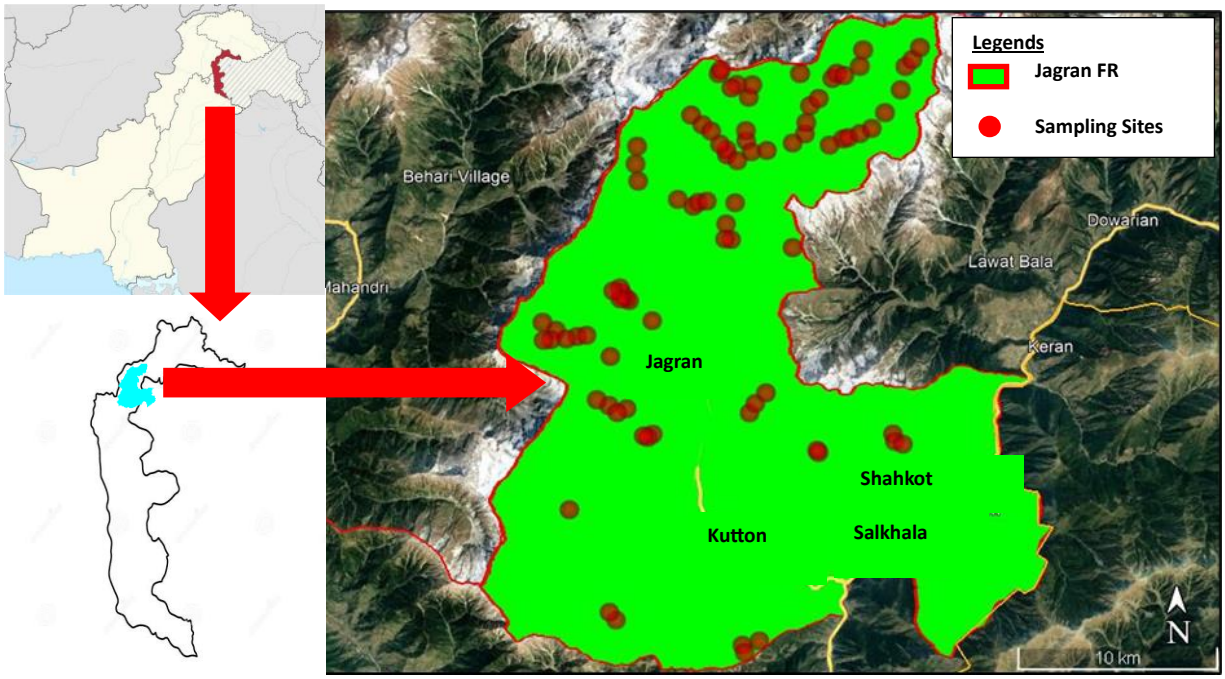

Figure 1. Location map of Jagran Forest Range with sampling sites of pikas during 2022.

Important wildlife species of study area include, Brown bear (*Ursus arctos*), Black bear (*Ursus thibetanus*), Himalayan ibex (*Capra ibex sibirica*), Himalayan musk deer (*Moschus chrysogaster*), Royle's pika (*Ochotona roylei*), Common Leopard (*Panthera pardus*), Leopard cat (*Prionailurus bengalensis*), Grey goral (*Naemorhedus goral*), Kashmir grey langur (*Semnopithecus ajax*), Snow leopard (*Panthera uncia*), Koklas pheasant (*Pucrasia macrolopha*), Kalij pheasant (*Lophura leucomelanos*), Western tragopan (*Tragopan melanocephalus*), Himalayan monal (*Lophophorus*

impejanus), Golden eagle (*Aquila chrysaetus*), and Himalayan vulture (*Gyps himalayensis*) (Qureshi, 1990; WWF, 2008). The area is characterized by forest trees including Deodar (*Cedrus deodara*), Blue pine (*Pinus wallichiana*), Silver fir (*Abies pindrow*), Spruce (*Picea smithiana*), Himalayan yew (*Taxus wallichiana*), and Indian horse chestnut (*Aesculus indica*) with a dense understory of deciduous shrubs dominated by *Viburnum* spp., *Rhododendron* spp., and *Juniperus* spp. (Roberts, 1991).

Data Collection

Based on reconnaissance survey and collected information from local villagers and herders, 86 sites were marked across the range to characterize the potential pika habitat available in this area (Figure 1). At each site, a 50m × 50m study plot was marked out to survey for evidence of pika following Bhattacharyya et al. (2015). The center of the plot was marked by a 3 – 5 rock cairn sitting atop a rock in the talus, to remember the marked sites for the next visits. Pikas were recorded in these marked study plots by conducting extensive surveys, through direct observations of animals, indirect signs such as fecal pellets, hay piles, and secondary information from herders and local villagers. The data was collected from April to November 2022, in three seasons: summer (April – June), monsoon (July – August), and autumn (September – November). However, no observations were made in winter due to the unapproachability of the study area with heavy snowfall. The study area was divided into three elevation zones: forest (≤3000 m), subalpine (3000 – 3600 m), and alpine (>3600 m). Each plot site was visited once in each study month, and pikas were observed in each site using the focal scan sampling method with 10 × 40 mm Canon binoculars from a location in which the entire study plot was visible (Altmann, 1974). During the current study, four different habitat types were identified in the alpine zone (rocky alpine meadows, alpine scrublands, man-made rocky structures and broken alpine slopes), three in the subalpine zone (mixed subalpine pastures, rocky talus in subalpine pastures, and rocky talus with subalpine shrubs) and two in the forest zone (forest gaps with boulders and rocky forest edges).

Following Vinod & Sathyakumar (1999), the habitat use of Royle's pika was assessed by the quadrate method through systematically sampling habitat characteristics in all marked sites. Quadrats of 10 m × 10 m for trees, 4 m × 4 m for shrubs, and 1 m × 1 m for grasses and herbs were plotted in all habitat types of pika. At each sampling point, the elevation, aspect, slope, percentage cover, and frequency of plant species within all quadrats were recorded (Schemnitz, 1980). In addition, vegetation characteristics, elevation, aspect, and slope were also recorded at locations with pikas' presence. The Importance Value Index (IVI) of plant species at each location was calculated by summing the relative density, relative frequency, and relative cover of each plant species recorded during surveys (Kent & Coker, 1992). To determine habitat preference, Ivlev's electivity Index was calculated using following formula (Fjellstad & Steinheim, 1996):

$$\mathrm{IEIi} = \frac{\mathrm{ri} - \mathrm{pi}}{\mathrm{ri} + \mathrm{pi}}$$

Where, "r_i" is the percentage of vegetation category *i* at the locations where pika was observed and "p_i" is the percentage of vegetation category *i* along all the systematically sampled quadrats (its availability in the environment). Thus, an IEI of 1.0 denotes maximum preference of a vegetation type, zero denotes use in proportion to availability and a value of -1.0 denotes complete avoidance (Fjellstad & Steinheim, 1996).

Data Analysis

The data was analyzed using t – test, chi square test and ANOVA to determine the significance of any difference in the use of altitude, aspect, vegetation, and habitat types by pika.

Results

Distribution of pika

Royle's pika was recorded in eighty-six sites under three major localities (including Kutton, Jagran and Shahkot) of Jagran Forest Range (Figure 1). A total population of 617 individuals of Royle's pika were estimated in Jagran Forest Range during the current study (Table 1).

Vegetation Composition of Pika's Habitat

A total of 150 plant species were recorded in habitats of Royle's pika at Jagran Forest Range. At Kutton, we recorded 118 plant species, 146 species at Jagran, whereas 111 species at Shahkot. In all localities, herbs dominated the flora, followed by shrubs and trees being the least dominant (Figure 2).

During summer, the pika habitat at Kutton consisted of 97 herbs, 12 shrubs, and 9 trees. The dominant tree species was *Pinus wallichiana* (IVI = 52.28), the dominant shrub was *Viburnum nervosum* (IVI = 29.94), while the dominant herb was *Poa nemoralis* (IVI = 99.42). The habitat at Jagran consisted of 121 herbs, 13 shrubs, and 12 trees. The dominant tree was *Abies pindrow* (IVI = 72.82), the dominant shrub was *Sambucus wightiana* (IVI = 62.56) and dominant herb was *Poa alpina* (IVI = 93.13). The habitat of pika at Shahkot consisted of 88 herbs, 12 shrubs, and 11 trees with *Pinus wallichiana* (IVI = 69.32), *Viburnum nervosum* (IVI = 21.91), *Poa nemoralis* (IVI = 55.22) as the dominant tree, shrub, and herb respectively.

During monsoon, the pikas' habitat at Kutton consisted of 97 herbs, 10 shrubs, and 9 trees. The dominant species as *Pinus wallichiana* (IVI = 97.18), *Viburnum nervosum* (IVI = 62.14), and *Poa nemoralis* (IVI = 112.72). The habitat at Jagran consisted of 115 herbs, 13 shrubs, and 12 trees with *Abies pindrow* (IVI = 99.76), *Viburnum nervosum* (IVI = 82.12), and *Rumex nepalensis* (IVI = 122.99) as the dominant species. At Shahkot, the habitat consisted of 81 herbs, 12 shrubs, and 10 trees, with *Pinus wallichiana* (IVI = 65.11), *Viburnum nervosum* (IVI = 33.15), and *Poa nemoralis* (IVI = 51.99) as the dominant tree, shrub, and herb respectively.

During autumn, the pika habitat at Kutton consisted of 52 herbs, 11 shrubs, and 7 trees including *Pinus wallichiana* (IVI = 9.12), *Viburnum nervosum* (IVI = 12.33), and *Poa nemoralis* (IVI = 21.66) as the dominant tree, shrub, and herb respectively. The pika habitat at Jagran consisted of 62 herbs, 12 shrubs, and 9 trees. The dominant tree was *Pinus wallichiana* (IVI = 43.12), the dominant shrub was

Table 1. Distribution and habitat use by Royle's pika (*Ochotona roylei*) in different localities of Jagran Forest Range, district Neelum, AJ&K, (April-November 2022).

Plot ID	Location	Elevation (m)	Aspect	Slope	Habitat Type	No. of pikas Recorded
KTF-1	Panjpathra	2927	SE	60°	Edge forest	2
KTSA-1	Nimali	3321	NE	52°	Talus/ Subalpine pasture	4
KTSA-2	Nimali	3209	S	49°	Talus/ Subalpine shrub	5
KTSA-3	Gualdori	3241	N	58°	Talus/ Subalpine pasture	11
KTSA-4	Gualdori	3266	NW	41°	Talus/ Subalpine pasture	17
JRF-1	Kamu	2663	N	69°	Boulder	4
JRF-2	Kamu	2772	NE	73°	Boulder	2
JRF-3	Kundi	2702	SW	37°	Boulder	6
JRF-4	Dumnag	2888	S	40°	Boulder	12
JRF-5	Dumnag	2911	SW	47°	edge forest	9
JRF-6	Dumnag	2872	N	45°	edge forest	3
JRF-7	Burzan	2917	S	40°	Boulder	8
JRF-8	Patlian	2921	SW	32°	Edge forest	7
JRSA-1	Bangus	3011	NW	45°	mixed Subalpine pasture	2
JRSA-2	Jirkhal	3380	NE	70°	Talus/ Subalpine pasture	9
JRSA-3	Jirkhal	3549	NW	23°	Talus/ Subalpine pasture	6
JRSA-4	Kundan	3101	NE	45°	Talus/ Subalpine shrubs	5
JRSA-5	Kundan	3183	NE	21°	Talus/ Subalpine shrubs	2
JRSA-6	Kundan	3321	N	40°	Talus/ Subalpine shrubs	5
JRSA-7	Gorial Behk	3136	NW	59°	Mixed Subalpine pasture	1
JRSA-8	Tandorian	3238	NE	64°	Talus/ Subalpine shrubs	3
JRSA-9	Tandorian	3369	NE	77°	Talus/ Subalpine shrubs	6
JRSA-10	Gatri	3188	W	82°	Mixed Subalpine pasture	4
JRSA-11	Gatri	3460	SE	53°	Talus/ Subalpine pasture	7
JRSA-12	Gatri	3421	E	59°	Talus/ Subalpine pasture	7
JRSA-13	Gatri	3488	SE	85°	Talus/ Subalpine pasture	9
JRSA-14	Seengal	3102	NW	41°	Talus/ Subalpine shrubs	6
JRSA-15	Seengal	3211	SW	79°	Talus/ Subalpine shrubs	14
JRSA-16	Seengal	3138	N	70°	Talus/ Subalpine shrubs	19
JRSA-17	Seengal	3155	N	75°	Talus/ Subalpine pasture	9
JRSA-18	Seengal	3191	N	65°	Talus/ Subalpine pasture	8
JRSA-19	Seengal	3149	N	37°	Talus/ Subalpine pasture	11
JRSA-20	Seengal	3201	SE	26°	Talus/ Subalpine pasture	17
JRSA-21	Patlian	3136	SE	39°	Mixed Subalpine pasture	5
JRSA-22	Patlian	3300	N	40°	Mixed Subalpine pasture	9
JRSA-23	Kundian	3480	S	45°	Talus/ Subalpine shrubs	8
JRSA-24	Kundian	3566	S	48°	Talus/ Subalpine shrubs	5
JRSA-25	Kundian	3582	SE	40°	Talus/ Subalpine pasture	3
JRSA-26	Shikar Behk	3085	W	75°	Talus/ Subalpine pasture	8
JRSA-27	Shikar Behk	3155	NW	70°	Talus/ Subalpine pasture	9
JRSA-28	Shikar Behk	3179	NW	75°	Talus/ Subalpine pasture	2
JRSA-29	Shikar Behk	3315	W	60°	Talus/ Subalpine pasture	5
JRSA-30	Doga	3249	N	30°	Talus/ Subalpine shrubs	15
JRSA-31	Doga	3519	N	41°	Talus/ Subalpine pasture	6
JRSA-32	Doga	3508	NE	35°	Talus/ Subalpine pasture	6
JRSA-33	Doga	3541	NE	37°	Talus/ Subalpine pasture	3
JRSA-34	Doga	3588	NW	40°	Talus/ Subalpine pasture	7
JRSA-35	Thud Behk	3081	NW	50°	Mixed Subalpine pasture	4
JRSA-36	Thud Behk	3319	NE	65°	Talus/ Subalpine shrubs	5
JRSA-37	Thud Behk	3515	NE	75°	Talus/ Subalpine pasture	5
JRSA-38	Batakanali Behk	3434	N	40°	Talus/ Subalpine pasture	9
JRA-1	Jirkhal	3661	N	80°	Broken alpine slope	6
JRA-2	Jirkhal	3879	NE	74°	Broken alpine slope	3
JRA-3	Gatri Gali	3809	SE	85°	Rocky alpine meadows	2
JRA-4	Gatri Gali	3601	NW	69°	Rocky alpine meadows	8
JRA-5	Gatri Gali	4042	N	81°	Rocky alpine meadows	4

JRA-6	Gatri Gali	3677	NE	65°	Alpine scrubland	6
JRA-7	Kundian	3621	NE	69°	Alpine scrubland	4
JRA-8	Kalapani Behk	3667	NW	72°	Manmade rocky walls	7
JRA-9	Kalapani Behk	3781	S	79°	Rocky alpine meadows	9
JRA-10	Kalapani Sar	3937	SW	61°	Rocky alpine meadows	17
JRA-11	Kalapani Sar	4019	S	55°	Rocky alpine meadows	20
JRA-12	Kalapani Sar	4154	S	52°	Rocky alpine meadows	6
JRA-13	Kalapani Sar	4189	SE	85°	Rocky alpine meadows	19
JRA-14	Shikar Gali	3696	SE	80°	Manmade rocky walls	4
JRA-15	Shikar Gali	3781	SE	84°	Alpine scrubland	5
JRA-16	Shikar Gali	3914	SW	83°	Alpine scrubland	2
JRA-17	Doga Gali	3661	SW	84°	Rocky alpine meadows	11
JRA-18	Doga Gali	3803	NE	85°	Broken alpine slope	4
JRA-19	Thud Gali	3855	NE	72°	Rocky alpine meadows	16
JRA-20	Thud Gali	3966	S	70°	Rocky alpine meadows	5
JRA-21	Thud Gali	3891	S	62°	Rocky alpine meadows	2
JRA-22	Thud Gali	3980	N	80°	Rocky alpine meadows	6
JRA-23	Thud Gali	4251	N	72°	Broken alpine slope	5
JRA-24	Thud Gali	4282	NE	79°	Broken alpine slope	11
JRA-25	Batakanali Behk	3641	NE	40°	Manmade rocky walls	8
JRA-26	Batakanali Sar	3901	NW	30°	Rocky alpine meadows	17
JRA-27	Batakanali Sar	3969	E	41°	Rocky alpine meadows	8
JRA-28	Batakanali Sar	4039	E	43°	Alpine scrubland	4
JRA-29	Batakanali Sar	4078	NW	49°	Rocky alpine meadows	9
JRA-30	Batakanali Gali	4074	N	78°	Broken alpine slope	5
JRA-31	Batakanali Gali	4171	S	89°	Broken alpine slope	7
JRA-32	Batakanali Gali	4246	NW	80°	Broken alpine slope	5
SKF-1	Doga Behk	2916	N	43°	Boulder	5
SKF-2	Doga Behk	2986	NW	69°	Edge forest	4
SKSA-1	Doga Behk	3111	SW	72°	Talus/ Subalpine pasture	9

Viburnum nervosum (IVI = 23.11), and dominant herb *Poa nemoralis* (IVI = 31.43). Similarly, at Shahkot 56 herbs, 9 shrubs, and 6 trees were recorded with *Pinus wallichiana* (IVI = 5.22), *Viburnum nervosum* (IVI = 7.12), and *Poa nemoralis* (IVI = 12.41) as the dominant tree, shrub, and herb respectively.

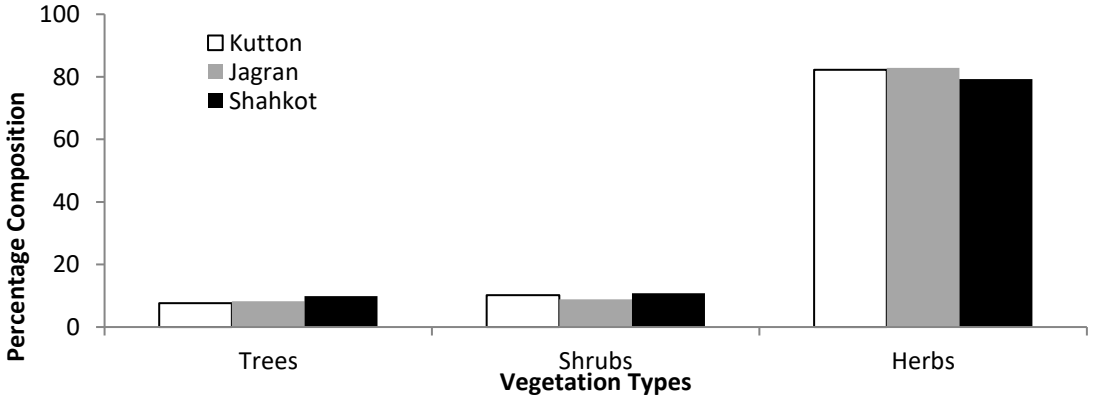

Figure 2: Floral composition in habitat of Royle's pika at three different localities of Jagran Forest Range, district Neelum, AJ&K during 2022.

Use of different Habitat Types

Throughout the study period pikas were relatively more abundant (23.86 ± 1.78) at rocky talus of subalpine shrubs, while the lowest mean relative abundance (2.94 ± 0.18) was recorded in the man-made rocky structures in alpine zone (Table 2).

Table 2: Mean relative abundance of Royle's pika in different habitats and altitudinal zones in Jagran Forest Range, district Neelum, AJ&K during 2022.

Zone	Elevation (m)	Habitat Type	Mean Relative Abundance ± SD
Alpine	3600 – 4500	Rocky alpine meadows	10.78 ± 1.55
		Alpine scrublands	12.74 ± 1.62
		Man-made rocky structures	2.94 ± 0.18
		Broken alpine slopes	10.02 ± 0.69
Sub-alpine	3000 – 3600	Mixed subalpine pastures	13.40 ± 1.02
		Rocky talus in subalpine pastures	11.87 ± 0.57
		Rocky talus in subalpine shrubs	23.86 ± 1.78
Forest	2600 – 3000	Forest gaps with boulders	8.28 ± 0.51
		Rocky forest edges	6.10 ± 0.83

The habitat use of Royle's pika varied significantly among three seasons of the study period ($F = 28.11$; $df = 2, 16$; $p<0.001$). In summer, Royle's pika most preferably used the rocky alpine meadows and subalpine rocky talus with shrubs (18.68%), while the least used habitat type was manmade rocky structures (2.19%). During monsoon season, Royle's pika used predominantly rocky talus in subalpine pastures (21.39%), while the least used habitat type was forest gaps with boulders (3.98%). In autumn, Royle's pika used mostly rocky talus in subalpine pastures (36%), and least used habitat type was subalpine rocky talus with shrubs (4%) (Figure 3).

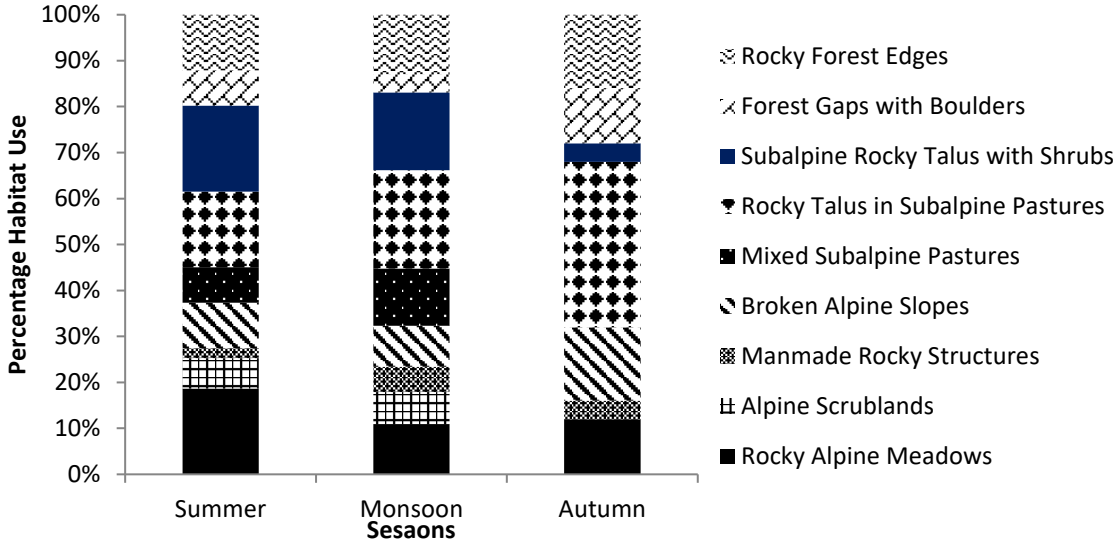

Figure 3: Percentage of nine types of habitats in Jagran Forest Range, district Neelum, AJ&K, including proportions of the Royle's pika habitat use patterns during three seasons (2022).

Altitudinal Variation in Habitat Use

Royle's pika was distributed along an altitudinal range of 2663-4282 m asl. At Kutton, during summer, Royle's pika used areas with elevations ranging from 2927-3266 m; during monsoon, they used areas from 2700-3456 m asl., whereas, during autumn, they used areas from 2791-3421 m asl. (Figure 4a). Areas below 2700 m were consistently avoided regardless of season. At Jagran, during summer, Royle's pika used areas between 2663-4090 m asl.; during monsoon, they used areas from 3140-4282 m asl., whereas, during autumn, they used 2663-3788 m asl. (Figure 4b). Areas below

2663 m were avoided by pika. At Shahkot, during summer, Royle's pika used areas with elevations ranging between 2916 – 3111 m; while during monsoon, they used areas from 2958-3009 m, whereas during autumn, they used areas from 2920-3105 m (Figure 4c). Areas below 2916 m were avoided by pika. The habitat use along altitudinal gradient was significantly different among different localities (F=21.12; df=2, 12; $p<0.001$) and seasons (F=9.112; df=2, 12; $p<0.001$).

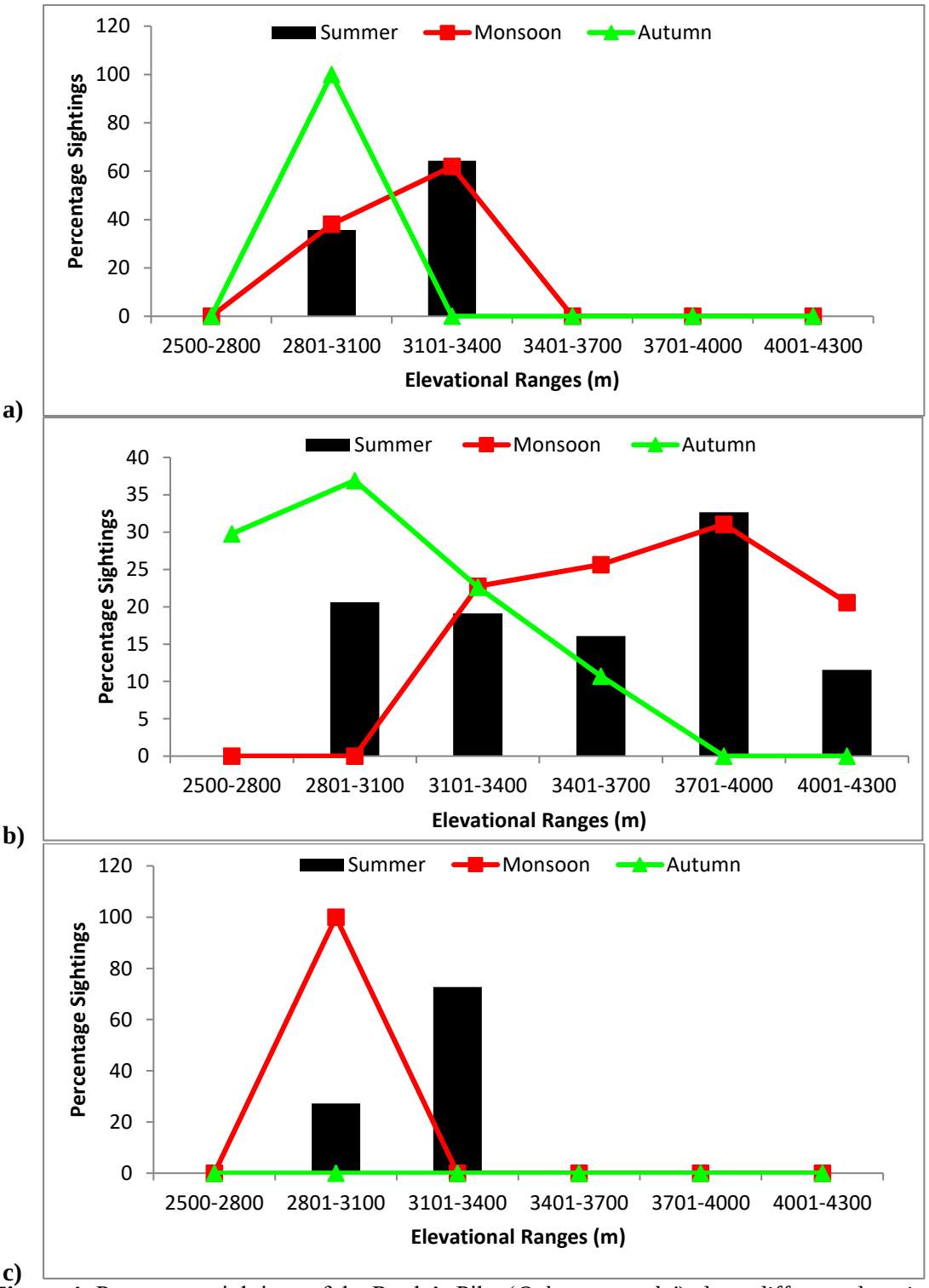

Figure 4: Percentage sightings of the Royle's Pika (*Ochotona roylei*) along different elevational ranges at (a) Kutton, (b) Jagran and (c) Shahkot localities (2022).

Use of Aspects and Slopes

The use of aspect by Royle's pika also varied significantly among seasons (F = 11.92; df=2, 12; *p<0.001*), and north- and northeast-facing aspects were used relatively more frequently than other aspects during all seasons in all localities (Figure 5 a,b,c). At two localities (Jagran and Shahkot), Royle's pika was most commonly found on steeper (60-70° and 70-80°) and steepest (80-90°) slopes during all seasons, whereas at Kutton, they were only recorded on moderate to steep slopes (40-50° and 50-60°) during all seasons (Figure 6 a,b,c).

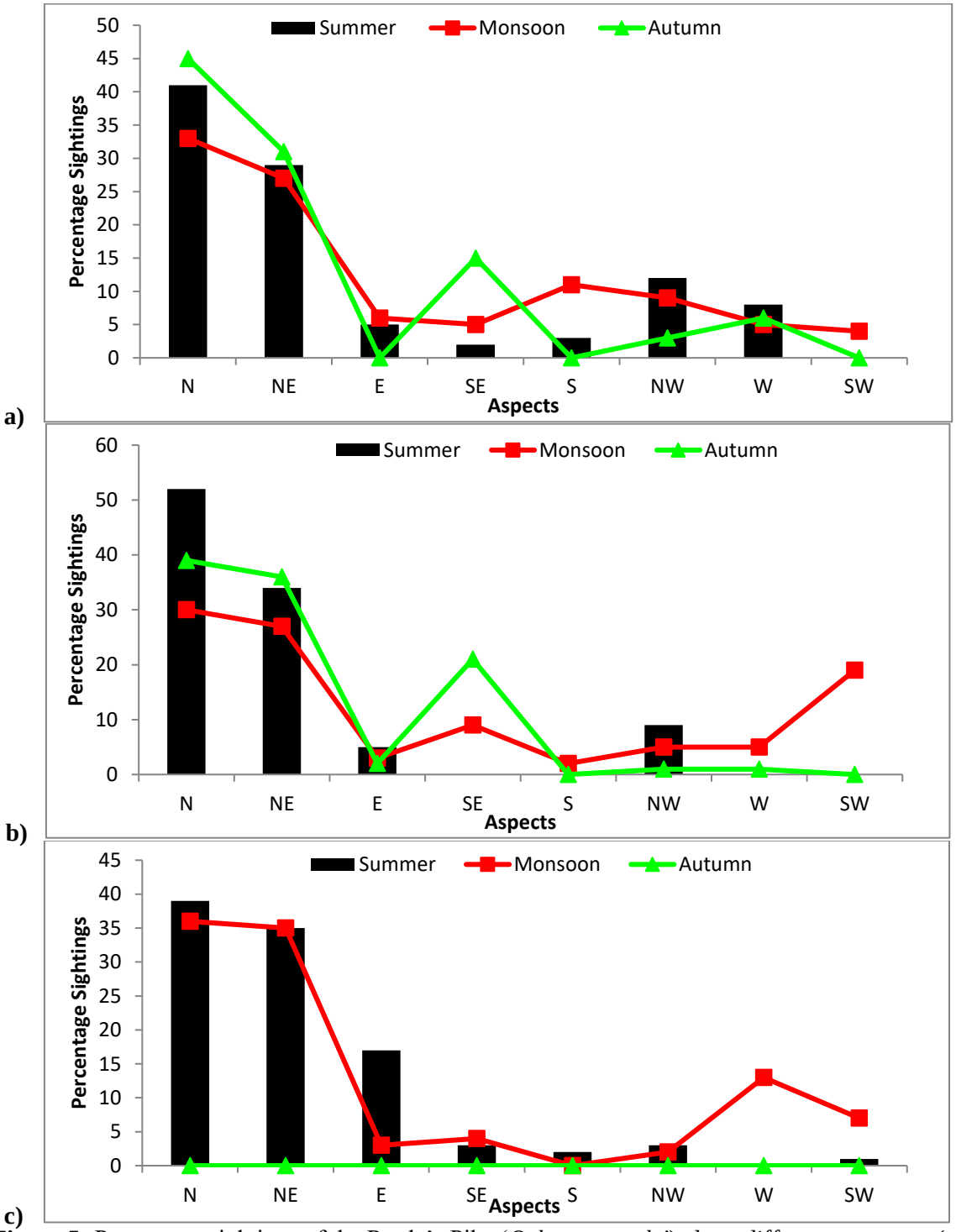

Figure 5: Percentage sightings of the Royle's Pika (*Ochotona roylei*) along different aspects at (a) Kutton, (b) Jagran and (c) Shahkot localities (2022).

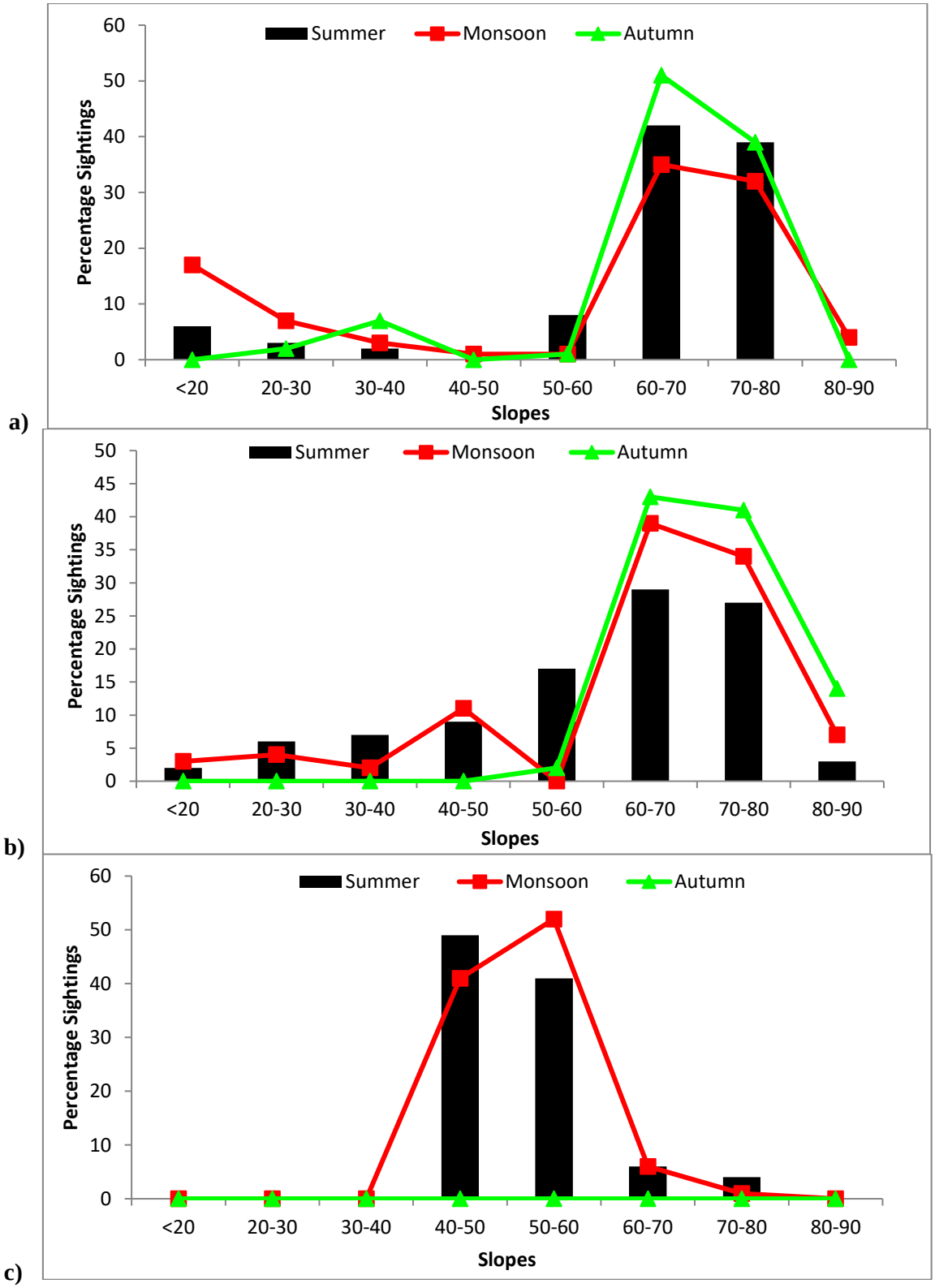

Figure 6: Percentage sightings of the Royle's Pika (*Ochotona roylei*) along different slope categories at (a) Kutton, (b) Jagran and (c) Shahkot localities (2022).

Use of Vegetation Cover

During all seasons, at Kutton, Royle's pika preferably used areas with very high rock and herb cover (80%) and low shrub cover (20%) (Figure 7a). At Jagran, it preferred areas with very high rock and herb cover (90 – 100%) with no tree and shrub cover (0%) (Figure 7b). However, at Shahkot, pika

used areas with very high rock and herb cover (70%), moderate shrub cover (20%), and low tree cover (10%) (Figure 7c). The use of vegetation cover by Royle's pika also varied significantly among different seasons (F = 45.133; df = 2, 12; *p<0.001*), and localities (F = 71.912; df = 2, 12; *p<0.001*).

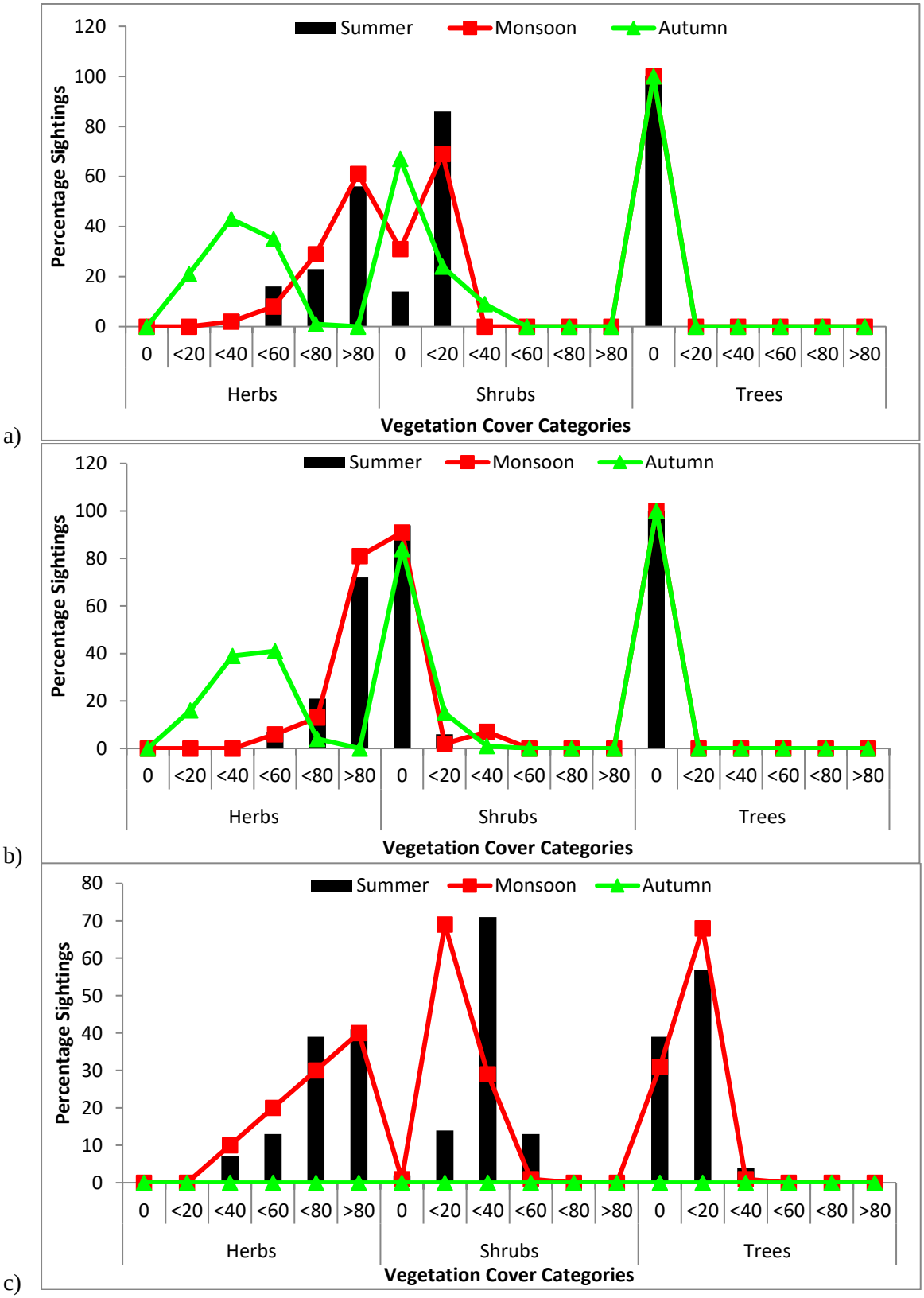

Figure 7: Percentage sightings of the Royle's Pika (*Ochotona roylei*) along different vegetation cover categories at, (a) Kutton, (b) Jagran and (c) Shahkot localities (2022).

Habitat Preferences

Royle's pika was not evenly distributed across all vegetation types in the study area (χ^2 = 121.22, $p<0.001$). The vegetation type most preferred by Royle's pika in Jagran Forest Range was herbs (IEI = 0.238), whereas shrubs (IEI = -0.476), and trees (IEI = -0.455) were avoided. At Kutton, Royle's pikas showed a positive preference for herbs (IEI =0.239), whereas shrubs (IEI = -0.439) and trees (IEI= -0.474) were avoided. Similar preference pattern was observed at Jagran and Shahkot, where these pikas also showed the positive preference for herbs [IEI(Jagran) = 0.243; IEI (Shahkot) = 0.222], whereas shrubs [IEI(Jagran) = -0.519; IEI (Shahkot) = -0.445], and trees [IEI(Jagran) = -0.444; IEI (Shahkot) = -0.366] were potentially avoided.

Discussion

The spatio-temporal patterns of habitat used by Royle's pika were assessed at three major locations (i.e., Kutton, Jagran and Shahkot) within Jagran Forest Range (JFR). In this study, Royle's pika was found distributed in areas with high rock and herb covers. However, no pika could be recorded from Salkhala region of JFR due to unavailability of the preferred habitats with rocky talus. Royle's pika was found between 2663-4282 m in JFR, and no pika was recorded below 2663 m asl. It is possibly due to the reason, that pikas are very sensitive to high temperature, and they only found in areas with short summers of less than 20 days per year above 25°C, long winters with greater than 180 days per year below 0°C, a freeze-free period of less than 90 days, and annual precipitation of >300 mm (Hafner, 1993). Similar results were recorded by Awan et al. (2004), Koju (2014), Shrestha & Gurung (2019), and Bhattacharyya et al. (2019), who also reported Royle's pika above 2600 m asl. Most pikas were observed between 3000-3500 m elevation range, which suggested that it was preferred elevation of pikas in JFR. However, in other areas of the Himalaya, they used even higher elevation between 3600 to 4000 m asl (Koju, 2014). Conversely, the findings of current study of elevation used by pika were higher than the results of Shrestha & Gurung (2019) in Nepal, where pikas distributed between 2974-3000 m asl. This variations in elevation used by pikas are possibly due to climatic variability in these areas.

Royle's pikas in JFR preferably used north- and northeast-facing slopes. This observation is similar to that of previous studies where pikas prefer slopes with a north- or northeast-facing aspect (Haleem et al., 2012). Yet other studies reported subtle differences. Shrestha & Gurung (2019) observed pikas preferably along northeast- or southwest-facing aspects, while Koju (2014) recorded that pika preferred slopes with southeast- or southwest-facing aspects. Cochard & Dar (2014) reported that the domestic livestock have been shown to prefer south-facing slopes, and hence, many wild herbivores including pikas avoid interactions with livestock to prevent forage competitions. Because pikas have to collect hay and store it for winters, therefore it is advantageous for pikas to use areas, which are inaccessible or less affected by livestock. In the present study, pikas were mainly observed on steeper slopes (60 – 70° and 70 – 80°). These results somehow coincide with the findings of Koju (2014), who

also reported pikas inhabiting at 50–60° slopes. There would be two non – mutually exclusive reasons for their use of steeper slopes. First, pikas, just like other herbivores, have to compete with local livestock for forage, so using the steeper slopes probably decrease their encounter with livestock animals, and hence they can save their hay-piles from other animals. Second possible reason to use steeper slopes are often inaccessible, and hence pikas keep themselves save from human interference.

The vegetation type most preferred by pikas was herbs (IEI = 0.238), while shrubs (IEI = -0.476) and trees (IEI = -0.455) were potentially avoided in all localities of the study area. It is due to the reason, that pikas are purely grass and forb eater (Koju, 2014). However, occasionally, they were also observed feeding on shrub twigs and tree bark, when grasses and forbs were not available (Roberts, 1997). Pikas may use shrub cover mainly during summer to hide themselves from elevating temperature of the day (Koju, 2014).

The study concluded that the use of different habitat types by Royle's pika was significantly different among the three seasons and they predominantly use higher altitudes with significant differences among seasons and localities. Royle's pika appears to select habitats which provide both food and cover simultaneously regardless of the season. Moreover, they showed a high preference for herbs in the study area.

Acknowledgements

The authors are highly grateful to the local community of Jagran Forest Range, and AJ&K Forest Department (Neelum Circle Athmuqam), especially Mr. Fida Hussain, for his utmost help and guidelines during the field work. We are also thankful to Ms. Shahida Rasheed**,** from AJ&K Wildlife & Fisheries Department, Muzaffarabad, for her help in providing literature and location maps pertaining to Jagran Forest Range.

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