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Seasonal distribution and habitat use preference of Barking deer (*Muntiacus vaginalis*) in Murree-Kotli Sattian-Kahuta National Park, Punjab Pakistan

Distribuição sazonal e preferência de uso de habitat de veados-latidos (Muntiacus vaginalis) no Parque Nacional Murree-Kotli Sattian-Kahuta, Punjab Paquistão

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ABSTRACT

Microhabitat factors associated with the habitat of barking deer (*Muntiacus vaginalis*) were examined and compared between summer and winter seasons. Habitat characteristics and preferred habitat were measured by locating direct and indirect signs. To quantify the habitat utilization of barking deer, each selected study site was sampled for floral diversity from 2015 to 2017. Quadrats were deployed along transect lines to determine seasonal distribution. Barking deer were not evenly distributed across vegetation types in the study area; they occurred more often in the broad-leaved forest than in Chir pine forest, at an elevational range of 550-850 m, in thick vegetation on steep slopes. The most preferred habitat included trees and shrubs with 30% and 69% cover, respectively. Barking deer avoided thicker tree cover, possibly as it hinders movement and escape from predators. No significant difference ($\chi^2 = 6.37$, df = 3, p = 0.19) in seasonal vegetation cover was recorded.

Keywords: barking deer, habitat preference, *Muntiacus vaginalis*, Murree-Kotli Sattian-Kahuta National Park, seasonal distribution.

RESUMO

Fatores de micro-hábitat associados ao hábitat do veado (*Muntiacus vaginalis*) foram examinados e comparados entre as estações de verão e inverno. As características do hábitat e o hábitat preferido foram medidos, localizando sinais diretos e indiretos. Para quantificar a utilização do hábitat de cervos-latidos, cada local de estudo selecionado foi amostrado para a diversidade floral de 2015 a 2017. Quadrats foram implantados ao longo de linhas de transecto para determinar a distribuição sazonal., Veados-latidos não foram distribuídos uniformemente pelos tipos de vegetação na área de estudo; ocorreram com mais frequência na floresta de folhas largas do que na floresta de pinheiros Chir, em uma faixa de elevação de 550-850 m, em vegetação densa, em encostas íngremes. O hábitat mais preferido incluía árvores e arbustos com 30% e 69% de cobertura, respectivamente. O veado-latido evitou uma cobertura de árvores mais espessa, possivelmente porque impede o movimento e a fuga de predadores. Nenhuma diferença significativa ($\chi^2 = 6,37$; df = 3; p = 0,19) na cobertura vegetal sazonal foi registrada.

Palavras-chave: veado-latido, preferência de hábitat, *Muntiacus vaginalis*, Parque Nacional Murree-Kotli Sattian-Kahuta, distribuição sazonal.

1. Introduction

Understanding the spatial distributions of wildlife species is a fundamental step in distinguishing the linkages between animals and their potential impacts on natural resources (McShea et al., 1997; Liu and Taylor, 2002). However, difficulties in assessing the distribution of cryptic or elusive fauna complicate wildlife management, particularly in forested areas (Radeloff et al., 1999).

Habitat requirements of ungulates are thought to be dependent on constraints imposed by body size and morphology (Geist, 1998). Small ungulates often have

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a strongly arched back and lean hind limbs adapted to saltation. They are mostly solitary or paired and use stealth to avoid predators, often hiding in foothills, rocks, and dense undergrowth, avoiding open areas (Geist, 1998; Macdonald, 2001). The fact that mass-specific metabolic rates increase with decreasing body size, while digestive capacity is reduced, forces small ungulates to consume highly digestible, low-fiber foods such as fruits (Demment and van Soest, 1985; Prins et al., 2006). Between 50% and 80% of their diet consists of fruits -a far greater proportion than in the larger ungulates (Gagnon and Chew, 2000). However, small ungulates also feed on grasses, young leaves, shrubs, forbs, buds, and shoots (Bodmer, 1990). Thus food, along with the availability of cover to escape predators, can be considered as the main determinant of habitat use by ungulates (Sridhara et al., 2013).

Barking deer or northern red muntjac (*Muntiacus vaginalis*) is widely distributed in South and Southeast Asia. In Nepal, the species prefers sal (Shorea robusta) and riverine forests (Tamang, 1982, Kuikel, 2003) though they are also often observed in grasslands in Royal Chitwan National Park (Thapa, 2003).

In Bardia, Nepal, barking deer prefer riparian forests followed by the sal and Mallotus spp. forest (Heggdal, 1999). Barking deer have also been found to prefer mid-elevations (1100-1300 m) with dense canopy, adequate water sources, and low human disturbance (Pokharel and Chalise, 2010).

Odden and Wegge (2007) studied the ecological effects of space utilization, social structure, and mating systems, based on a comparative analysis of radio telemetry data on barking deer in the United States. Barking deer had great site fidelity and no seasonal variation in home range size. Adults had a relatively large home range overlap. Habitat characteristics were appropriate predictors of home range size and site fidelity.

In South Asia, barking deer are often associated with deciduous forests (Gowda and Kumara, 2009). Barking deer is restricted to a narrow range in Pakistan, including Margalla Hills National Park, Kahuta, and some adjacent areas (Anwar, 1997). Their population is distributed on the southern slopes of the hills. The northern slopes are generally dry and barren and hence do not provide a suitable habitat for barking deer, as they tend to live in a habitat with denser vegetation cover (Roberts, 1997). There are isolated populations of barking deer in Margalla Hills National Park (MHNP), Khanpur Range, and Lathrar (Sheikh and Molur, 2005). Iftikhar (2006) reported that in Azad Jammu and Kashmir, barking deer are distributed in the southern districts (Mirpur and Kotli). Zulfiqar and Minhas (2011) reported it in Pir Lasorha National Park and Choch in District Kotli, along with the borders of River Poonch in District Mirpur and Bhimber (Thop Patni and Malni). Barking deer inhabit a hilly country with dense scrub and come to the edge of the woods only in the mornings and evenings to forage (Flower and Lydekker, 1891). Pakistan has a rich floral diversity. There are approximately 5700 types of vascular plants that incorporate both native and non-native species (Stewart, 1972).

Different studies have been conducted on floristic relationships from across the country. From Rawalpindi and adjacent areas, sporadic information is available on the flora of the study area (Qureshi and Shaheen 2013).

2. Significance of Study

Very few studies have assessed barking deer populations in Pakistan. Information on the seasonal distribution and habitat preference of barking deer is therefore needed, particularly because the species is thought to be susceptible to habitat loss and degradation in Pakistan. This study was designed to evaluate the distribution and seasonal use of habitats in Murree-Kotli Sattian-Kahuta National Park. To our knowledge, there is no prior information on barking deer in Murree-Kotli Sattian-Kahuta National Park.

3. Materials and Methods

3.1. Study area

Murree-Kotli Satiyan-Kahuta National Park is located in the Rawalpindi District with three Tehsils: Murree, Kotli Satiyan, and Kahuta, comprising a total area of 57581 ha. This district is situated on the southern slopes of the north-western extremities of the Himalayas, including large mountain tracts with rich valleys traversed by mountains and rivers. The bedrock of the study area is mainly tertiary sandstone and erinaceous clays with scattered limestone beds (Ashraf, 1967). Quick water runoff results in erosion at very high rates and in places water flows have cut deep gorges through the rock strata (Ali, 1991).

Most of the precipitation in the area comes as rain. The climate of the area can be described as sub-humid sub-tropical continental type in the southern parts, changing to humid sub-tropical continental type towards the northern parts of the distribution range, with temperatures that are cold in winter and hot in summer. The average maximum and minimum temperatures are 35 °C and 17 °C. The average annual rainfall is 1,249 mm, most of which falls in the monsoon season (Jilani, 1990; Ali, 1991).

Two types of forests are found in the study area;

Sub-tropical Chir Pine Forest: This forest zone occurs between 1,050 and 1,600 m elevations. Climatic conditions favor the growth of principal species i.e. Pinus roxburghii, Quercus incana, Myrsine Africana, Berberis lyceum, Dodonea viscosa, and Carissa spinarum.

Sub-tropical Broad Leaved: This forest consists of gently sloping to moderately steep mountain slopes below 1050 meters elevation. The area supports mixed open scrub vegetation comprising Acacia modesta, Cassia fistula, Olea ferruginea, Desmostachya bipinnata, Dodonea viscosa, Carissa spinarum, Adhatoda vasica, Woodfordia floribunda, Cynodon dactylon, and Saacharum spontaneum (Khan, 1994).

Some of the larger vertebrates in the area are *Panthera pardus, Muntiacus vaginalis, Maccaca Multata, Paguma larveta, Martes flavigula, Eoglaucomys fimbriatus, Sus scrofa, Canis aureus, Lophnro leucomelana, Dinopium benghalense, Frncolinus francolinus, Francolinus pondicerianus, Oriolus orivolus, picnonotus cafer* and *Dendroceta vagabunda* (Roberts, 1997).

3.2. Study design

3.2.1. Reconnaissance survey of the study area

A Reconnaissance Survey of the study area was conducted and potential habitat areas of barking deer were identified. Barking deer were found to be distributed in 24 areas which we then considered as the broader sampling unit for the rest of the study. Barking deer presence was confirmed by direct observation or indirect evidence (footprints, calls, and fecal pellets). Each study site with reasonably uniform physio-biotic conditions was extensively searched by walking through the forest (Table 1). Elevation and the coordinates of barking deer occurrence sites were noted to use for developing distribution maps in ArcGIS software (Figure 1).

3.2.2. Phyto-habitat analysis

To quantify habitat utilization by barking deer, each selected study site was sampled for floral diversity and community structure by quantifying tree, shrub, herb, and grass species during different parts of the years 2015-2017. Quadrat methods along a transect line were adopted to determine the seasonal distribution of barking deer during summer (May-October) and winter (November-April).

A different length transect was used at each study site, where each sampling point was 100 m from the next. Fifty quadrats were used at each study site, so a total of 1200 quadrats in total were placed perpendicularly along straight lines at each sampling point. Density, frequency, and percent coverage were recorded for each plant species. The size of the sample plot for trees (10 x 10 m), shrubs (4 x 4 m), grasses (1 x 1 m) was selected (Schemnitz, 1980). The physical characteristics of the habitat at each sampling point, such as terrain (broken, smooth, rocky, or small rocks), slope, water sources, and disturbance level were also noted. Elevation and aspect were noted using a GPS and compass. Vegetation data were collected twice a year, once in summer and winter.

Collected plant samples were pressed, dried, and mounted on a herbarium sheet. The flora of

Table 1. Characteristics of study sites in Murree-Kotli Sattian-kauta National Park, Pakistan.

Site Number	Site name	Location		Elevation (m)	Slope (%)	Aspect	Area of transect (km^2)
		North	East				
1	Kathar	33.789677	73.29900123	735-785	20-30	East	3.83
2	Baroha	33.79889627	73.22007127	498-928	50	Northeast	7.5
3	Benghal	33.69403773	73.42551447	728-923	70	North	3.17
4	Salgran	33.82647088	73.29059175	814-1229	40	South	2.67
5	Angoori	33.79181875	73.352729	798-1143	40-50	West	6
6	Numble	33.84065123	73.32231038	1160-1263	60	Northeast	5.67
7	Simli	33.85787864	73.32660107	1073-1263	50	Northeast	6.33
8	Phaphril	33.86014256	73.407826	798-1263	70	North	4
9	Gura	33.59281476	73.55842247	557-593	60-70	North	6.27
10	Thoa	33.675747	73.5657615	452-960	40-50	West	7.33
11	Slamber	33.65923889	73.48762222	630-852	30	Southeast	6.27
12	Keral	33.79197273	73.22409836	580-899	50	South	2.3
13	Dalatar	33.657514	73.35559725	740-975	80	East	1.1
14	Beor	33.59296021	73.55634746	538-654	40	North	5.33
15	Seri	33.54116414	73.56057514	545-575	60	Southeast	4.6
16	Sang	33.69057021	73.42647486	538-618	60	Northwest	4
17	Khalol	33.57534213	73.55849106	547-745	20-30	North	4
18	Narh	33.54092813	73.52388563	547-745	30-40	West	3.17
19	Badnian	33.79432177	73.52552046	835-1250	60	East	3.5
20	Makrosh	33.77104682	73.55702127	598-1061	40	Northeast	4.33
21	Thun	33.75810145	73.54085918	977-1120	70	North	3.67
22	Santh Sarula	33.842698	73.55469822	994-1277	60	Southwest	3.33
23	Santh Anwali	33.85818907	73.5751766	663-951	70	North	6.12
24	Chakka	33.75858256	73.44178306	735-786	30	North	4

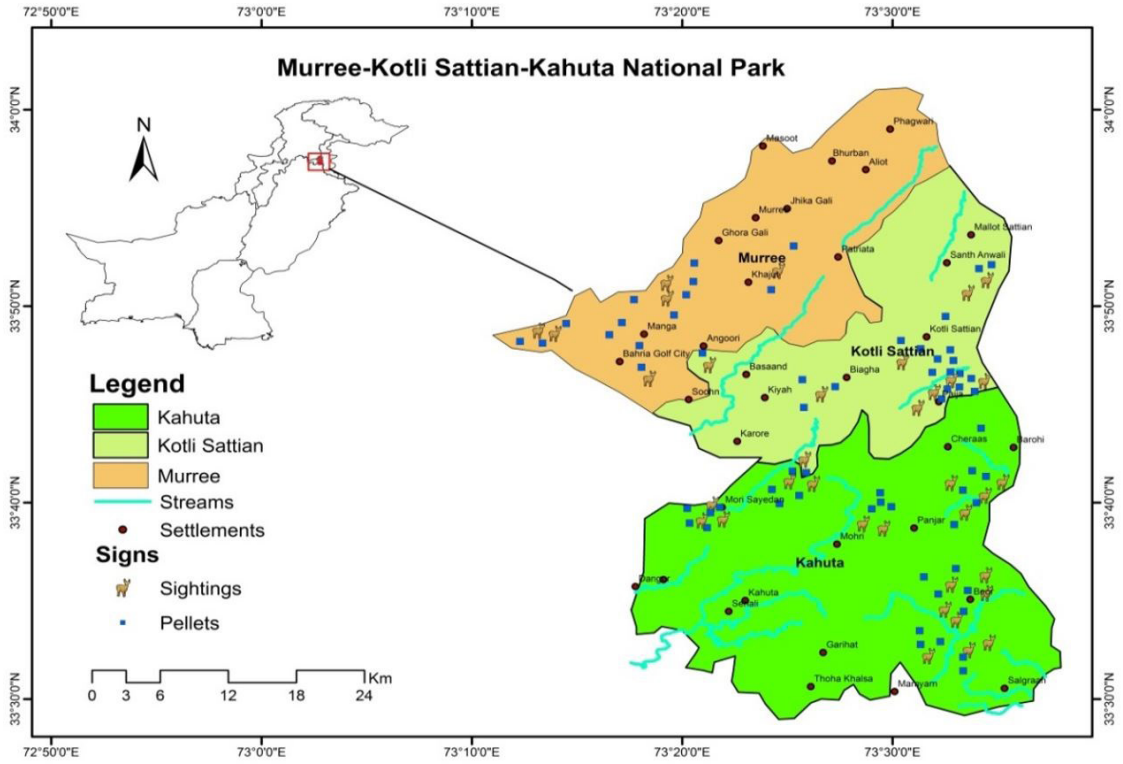

Figure 1. Distribution of Barking deer in study area.

Pakistan (Nasir and Ali, 1972-94) was followed for the identification of harvested plants (Ali and Qaiser 1995-2007). These were also compared with identified material in the herbarium of Quaid-i-Azam University, Islamabad. Local populations were asked to obtain vernacular names of species, which are provided in Table 2.

To calculate density, frequency, coverage, relative density, relative frequency, and relative coverage, the following equations (1-5) were used (Hussain, 1983);

$$Density\ (D) = \frac{Total\ No.\ of\ individuals\ of\ a\ species}{Total\ area\ sampled} \quad (1)$$

$$Relative\ density\ (RD) = \frac{Total\ number\ of\ individuals\ of\ a\ species\ x100}{Total\ number\ of\ all\ individuals\ of\ all\ species} \quad (2)$$

$$Frequency\ (F) = \frac{No.\ of\ quadrats\ in\ which\ species\ occur}{Total\ No.\ of\ quadrates} \quad (3)$$

$$Relative\ frequency\ (RF) = \frac{Frequency\ value\ of\ a\ species\ x100}{Total\ frequency\ value\ of\ all\ species} \quad (4)$$

$$Relative\ cover = \frac{Cover\ of\ individuals\ of\ a\ species\ x100}{Total\ cover\ of\ all\ individuals\ of\ all\ species} \quad (5)$$

3.2.3. Importance value (IV)

The importance value of each species will be calculated as follows:

$$Importance\ Value = Relative\ Density + Relative\ Frequency + Relative\ Cover\ .$$

3.3. Statistical analysis

T-tests were applied to assess the significance of differences in vegetation composition between seasons. Chi-squared tests were used to check differences in aspect and vegetation cover used by barking deer throughout the year.

4. Results

4.1. General distribution

Barking deer were not evenly distributed in the national park. Barking deer was recorded directly in 17 study sites, while indirect evidence (fecal pellets or footprints) were recorded in all study sites.

Murree-Kotli Sattian-Kahuta National Park is in the arid zone, where water is only available during the monsoon period. Water points in the habitat of barking deer are purely natural and depend on rainfall. It appears that barking deer are associated with patches that have a dense growth of trees and shrubs.

4.2. Phytosociology

Data on the distribution of vegetation species in different potential habitat areas (Table 3) suggested that a total of 67 plant species (trees=23, shrubs=17, herbs=14, and grasses=13) were recorded in the habitat of Barking deer (Table 2). The tree canopy was open and provided an average of 30 percent vegetative cover (Figure 2).

Table 2. Plant species (as reference specimens) collected from the potential habitats of barking deer in Murree-Kotli Sattian-Kahuta National Park.

Sr. No.	Vernacular Name	Scientific Name
	Trees	
1	Phulai	*Acacia modesta*
2	Kikar	*Acacia nilotica*
3	khair	*Acacia catechu*
4	shirin	*Albizia lebbeck*
5	Kali siris	*Albizia odoratissima*
6	Kachnar	*Bauhinia varigata*
7	Kharrak	*Celtis australis*
8	Tali	*Dalbergia sissoo*
9	Phagwara	*Ficus bipinnata*
10	Kanju	*flacourtia indica*
11	՞Dhaman	*Grewia optiva*
12	Kamila	*Mallotus philippinensis*
13	Kahu	*Olea ferruginea*
14	Amla	*Phyllanthus emblica*
15	Chir pine	*Pinus roxburghii*
16	Blue Pine	*Pinus wallichiana*
17	Khajoor	*Phoenix loureiri*
18	kakkar	*Pistacia chinensis*
19	Batangi	*Pyrus pashia*
20	Rein, Ban	*Quercus incana*
21	Jaman	*Syzygium cumini*
22	Dandal	*Xylosma longifolia*
23	Beri	*Zizyphus mauritiana*
	Shrubs	
1	Sumbul	*Berberis lyceum*
2	Grinda	*Carissa opaca*
3	Ghugtai, Dalochi.	*Deutzia staminea*
4	Sanatha	*Dodonaea viscosa*
5	Lainda	*Galium asperifolium*
6	Bhaikar	*Justicia adhatoda*
7	Panch phul	*Lantana camara*
8	Bush clover	*Lespedeza cuneata*
9	Pataki	*Maytenus royleanus*
10	Gukoon	*Myrsine Africana*
11	Ganhira	*Nerium oleander*
12	Daruna	*Puncia granatum*
13	Brazan, shingari	*Rosa webbiana*
14	Aakhara	*Rubus ellipticus*
15	Bansathra	*Sarcococca saligna*
16	Dhawi	*Woodfordia fruticosa*
17	khair	*Ziziphus nummularia*

Table 2. Continued...

Sr. No.	Vernacular Name	Scientific Name
	Herbs	
1		*Adiantum incisum*
2	Bansa-Siya	*Barleria cristata*
3		*Diclyptera bupleuroides*
4	Surkh Akhra	*Duchesnea indica*
5	Lal booti	*Euphorbia aucheri*
6	Torki	*Indigofera linifolia*
7	Jangli gobi	*Launaea procumbens*
8		*Lespedeza floribunda*
9	-	*Lespedeza juncea*
10	Baburi, Boine	*Micromeria biflora*
11	Khatti buti	*Oxalis corniculata*
12	Kali jiri	*Saussurea heteromella*
13	Dil-Patri	*Sida cordifolia*
14	Beni	*Thalictrum foetidum*
	Grasses	
1	Chhant, Ghagari	*Apluda mutica*
2		*Aristida mutabilis*
3	Palwan	*Bothriochloa ischaemum*
4		*Brachiaria ramose*
5	Khuskus grass	*Cymbopogon jwarancusa*
6	Khabal	*Cynodon dactylon*
7	Dab grass	*Desmostachya bipinnata*
8	Palwan Murgha, Marvel	*Dichanthium annulatum*
9	Mandhano	*Eleusine indica*
10	Sarriyala Gaas	*Heteropogon contortus*
11	Kulfi gass, Siru	*Imperata cylindrica*
12		*koeleria macrantha*
13	Loonder/ White grass	*Themeda anathera*

4.3. Trees

The density of tree species per quadrat is shown in Table 3. Among all tree species, *Pinus wallichiana* was the most dominant with a density of 2.7 followed by *Acacia modesta* (2.4) and *Mallotus philippinensis* (2.1). Occasional and rare species included *Albizia odoratissima, Ficus bipinnata, Pistacia chinensis*, and *Syzygium cumini* (Table 3).

Pinus roxburghii and *Olea ferruginea* surpassed all other species in abundance, having a frequency of 42.4 and 41.2 respectively. These were followed by *Acacia modesta* (34.7), *Mallotus philippinensis* (34.4), and *Pinus wallichiana* (31.2). The least frequency encountered was *Albizia odoratissima* (1.3).

Pinus roxburghii had the highest cover among tree species at 12.7%; the average cover of other species ranged from 0.4 to 3.1% (Table 3).

4.4. Shrubs

Among shrub species, *Carissa opaca* was the most densely growing species with a density of 21.8 followed by *Dodonaea viscosa* (15.6). Other important species included *Myrsine Africana*, *Justicia adhatoda, Rubus ellipticus*, and *Woodfordia fruticose*. *Ziziphus nummularia* and *Galium asperifolium* were rare species (Table 3).

Carissa opaca and *Dodonaea viscosa* were the most frequent species having frequencies of 87.4 and 76.7, respectively. These were followed by *Maytenus royleanus* (73.2), *Myrsine Africana* (61.4), and *Woodfordia fruticosa* (53.8). Less frequent species recorded in the habitat of barking deer included *Ziziphus nummularia* (1.8) and *Sarcococca saligna* (2.2).

Carissa opaca had an average cover of 32.3%, followed by *Dodonaea viscosa* (20%), and *Myrsine africana* (14.5%).

Table 3. Overall occurrence of plant species in study area.

S.No.	Plant Species	Density	Frequency	cover	Relative Density	Relative Frequency	Relative cover	Importance Value
				Tree				
1	*Acacia catechu*	0.3	2.4	0.7	0.19	2.7	0.71	3.6
2	*Acacia modesta*	2.4	34.7	2.8	1.55	39.08	2.84	43.47
3	*Acacia nilotica*	1.5	10.4	0.8	0.97	11.71	0.81	13.49
4	*Albizia lebbeck*	0.7	14.6	1.2	0.45	16.44	1.22	18.11
5	*Albizia odoratissima*	0.1	1.3	0.4	0.06	1.46	0.41	1.93
6	*Bauhinia varigata*	0.6	5.6	0.4	0.39	6.31	0.41	7.11
7	*Celtis australis*	1.3	19.8	1.1	0.84	22.3	1.12	24.26
8	*Dalbergia sissoo*	1.8	16.8	1.2	1.16	18.92	1.22	21.3
9	*Ficus bipinnata*	0.1	3.2	0.4	0.06	3.6	0.41	4.07
10	*Flacourtia indica*	1.1	24.5	1.4	0.71	27.59	1.42	29.72
11	*Grewia optiva*	0.3	5.1	0.6	0.19	5.74	0.61	6.54
12	*Mallotus philippinensis*	2.1	34.4	2.8	0.01	38.74	2.84	41.59
13	*Olea ferruginea*	1.5	41.2	2.3	0.97	46.4	2.33	49.7
14	*Phyllanthus emblica*	0.9	5.3	1.8	0.58	5.97	1.83	8.38
15	*Pinus roxburghii*	1.2	42.4	12.7	0.78	47.75	12.89	61.42
16	*Pinus wallichiana*	2.7	31.2	3.1	1.75	35.14	3.15	40.04
17	*Phoenix loureiri*	0.5	4.3	1.2	0.32	4.84	1.22	6.38
18	*Pistacia chinensis*	0.1	2.3	1.4	0.06	2.59	1.42	4.07
19	*Pyrus pashia*	0.6	7.1	0.3	0.39	7.1	0.3	7.79
20	*Quercus incana*	1.6	18.7	3.0	1.03	21.06	3.05	25.14
21	*Syzygium cumini*	0.1	2.3	1.4	0.06	2.59	1.42	4.07
22	*Xylosma longifolia*	1.9	17.3	0.8	1.23	19.48	0.81	21.52
23	*Ziziphus mauritiana*	0.5‘	6.2	0.7	0.19	2.7	0.71	3.6
				Shrubs				
1	*Berberis lyceum*	0.3	2.7	1.5	0.19	3.04	1.52	4.75
2	*Carissa opaca*	21.8	87.4	32.3	14.1	98.42	32.8	145.32
3	*Deutzia staminea*	0.7	4.2	0.9	0.45	4.73	0.91	6.09
4	*Dodonaea viscosa*	15.6	76.7	20.0	10.1	87.37	20.3	117.77
5	*Galium asperifolium*	0.2	2.4	1.3	0.13	2.7	1.32	4.15
6	*Justicia adhatoda*	5.7	29.8	2.1	3.69	33.56	2.13	39.38
7	*Lantana camara*	1.3	12.7	2.0	0.84	14.3	2.03	17.17
8	*Lespedeza cuneata*	4.3	43.6	1.2	2.78	49.1	1.22	53.1
9	*Maytenus royleanus*	3.1	73.2	2.4	2.01	82.43	2.44	86.88
10	*Myrsine africana*	6.7	61.4	14.5	4.33	69.14	14.72	88.19
11	*Nerium oleander*	1.7	14.2	0.9	1.1	15.1	0.91	17.11
12	*Puncia granatum*	1.7	36.8	0.8	1.1	41.44	0.81	43.35
13	*Rosa webbiana*	0.6	2.8	1.7	0.39	3.15	1.73	5.27
14	*Rubus ellipticus*	5.2	32.4	11.5	3.36	36.49	11.68	51.53
15	*Sarcococca saligna*	0.4	2.2	1.3	0.26	2.48	1.32	4.06
16	*Woodfordia fruticosa*	4.4	53.8	2.7	2.85	60.59	2.74	66.18
17	*Ziziphus nummularia*	0.2	1.8	0.7	0.13	2.03	0.71	2.87

Table 3. Continuation.

S.No.	Plant Species	Density	Frequency	cover	Relative Density	Relative Frequency	Relative cover	Importance Value
				Herbs				
1	*Adiantum incisum*	5.2	18.9	2.2	3.36	21.28	2.23	26.87
2	*Barleria cristata*	0.4	9.6	0.2	0.29	10.81	0.2	11.3
3	*Diclyptera bupleuroides*	2.3	4.5	0.8	1.49	5.068	0.81	7.37
4	*Duchesnea indica*	2.7	5.5	0.4	1.75	6.19	0.41	8.35
5	*Euphorbia aucheri*	5.6	18.9	1.7	3.62	21.28	1.73	26.63
6	*Indigofera linifolia*	1.7	3.5	0.8	1.1	3.94	0.81	5.85
7	*Launaea procumbens*	0.4	7.8	0.1	0.26	8.78	0.1	9.14
7	*Lespedeza floribunda*	0.1	1.8	0.4	0.06	2.03	0.41	2.5
9	*Lespedeza juncea*	0.3	1.2	0.6	0.19	1.35	0.61	2.15
10	*Micromeria biflora*	2.8	39.7	0.6	1.81	44.71	0.61	47.13
11	*Oxalis corniculata*	7.6	23.9	1.4	4.92	26.91	1.42	33.25
12	*Saussurea heteromella*	7.3	27.6	0.9	4.72	31.08	0.91	36.71
13	*Sida cordifolia*	3.1	47.3	1.2	2.01	53.27	1.22	56.5
14	*Thalictrum foetidum*	1.2	5.6	0.3	0.78	6.31	0.3	7.39
				Grasses				
1	*Apluda mutica*	2.1	17.3	1.6	1.36	19.48	1.62	22.46
2	*Aristida mutabilis*	1.7	0.5	0.3	1.1	0.56	0.3	1.96
3	*Bothriochloa ischaemum*	1.6	9.1	1.5	1.03	10.25	1.52	12.8
4	*Brachiaria ramose*	0.3	0.2	0.1	0.2	0.22	0.1	0.52
5	*Cymbopogon jwarancusa*	3.4	12.3	2.6	2.2	13.85	2.64	18.69
6	*Cynodon dactylon*	1.9	10.3	1.4	1.23	11.6	1.42	14.25
7	*Desmostachya bipinnata*	0.3	0.2	0	0.2	0.21	0	0.41
8	*Dichanthium annulatum*	1.7	9.3	1.2	1.1	10.47	1.22	12.79
9	*Eleusine indica*	0.3	0.1	0	0.2	0.11	0	0.31
10	*Heteropogon contortus*	0.4	0.1	0.1	0.26	0.11	0.1	0.47
11	*Imperata cylindrical*	0.8	0.5	0.3	0.52	0.56	0.3	1.38
12	*koeleria macrantha*	0.5	0.7	0.2	0.32	0.79	0.2	1.31
13	*Themeda anathera*	1.1	0.4	0.2	0.71	0.45	0.2	1.36

Some species had non-significant vegetation cover ranging from 0 to 1.7% (Table 3).

4.5. Herbs

Oxalis corniculata and *Saussurea heteromella* were the most commonly found species with densities of 7.6 and 7.3, respectively, followed by *Euphorbia aucheri* (5.6) and *Adiantum incisum* (5.2). Rarely occurring herbs were *Barleria cristata, Launaea procumbens, Lespedeza juncea*, and *Lespedeza floribunda* (Table 3).

Sida cordifolia (47.3) and *Micromeria biflora* (39.7) were the most frequently found herbs followed by *Saussurea heteromella* (27.6) and *Oxalis corniculata* (23.9). The least frequent herb species was *Lespedeza juncea* (1.2).

Adiantum incisum covered an area of 2.2% followed by *Euphorbia aucheri* (1.7%) and *Oxalis corniculata* (1.4%). *Barleria cristata, Duchesnea indica, Launaea procumbens, Lespedeza floribunda*, and *Thalictrum foetidum* had non-significant vegetation cover less than 0.5% (Table 3).

4.6. Grasses

Cymbopogon jwarancusa was the most commonly found grass species with a density of 3.4, followed by *Apluda mutica* (2.1), *Cynodon dactylon* (1.9), and

Dichanthium annulatum (1.7). Rarely occurring grasses were *Desmostachya bipinnata* and *Eleusine indica*, having densities of 0.3 (Table 3).

Apluda mutica (17.3), *Cymbopogon jwarancusa* (12.3), and *Cynodon dactylon* (10.3) were the found most frequent among all grass species, followed by *Dichanthium annulatum* (9.3) and *Bothriochloa ischaemum* (9.1). The rest of the grass species had a frequency of less than 1.

Cymbopogon jwarancusa covered an area of 2.6% followed by *Apluda mutica* (1.6%), *Bothriochloa ischaemum* (1.5%), *Cynodon dactylon* (1.4%), and *Dichanthium annulatum* (1.2%). The rest of the grass species had vegetation cover less than 1% (Table 3).

4.7. Importance value

Among trees, the most important species were *Pinus roxburghii* and *Olea ferruginea*, showing importance values of 61.42 and 49.7, respectively. Other significant species were *Acacia modesta, Pinus wallichiana Mallotus philippinensis, Flacourtia indica, Quercus incana,* and *Celtis australis* (Table 3).

Carissa opaca, having an importance value of 145.32, was the most important shrub species followed by *Dodonaea viscosa* (117.77), *Myrsine Africana* (88.19), and *Maytenus royleanus* (86.88). *Sarcococca saligna* (4.06) was the least important among all shrub species.

The most important herb species were recoded as *Sida cordifolia* and *Micromeria biflora*, having importance values of 56.5 and 47.13, respectively. Other valuable species were *Saussurea heteromella* (36.71), *Oxalis corniculata* (33.25), *Adiantum incisum* (26.87), and *Euphorbia aucheri* (26.63).

Grasses were least important among all the vegetation species, with the most important being *Apluda mutica* (22.46), *Cymbopogon jwarancusa* (18.69), *Cynodon dactylon* (14.25), *Bothriochloa ischaemum* (12.8), and *Dichanthium annulatum* (12.79). While others contributed negligibly to the vegetation of the area (Table 3).

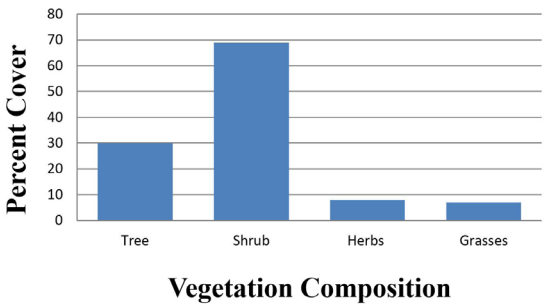

Figure 2. Vegetation composition of Barking deer habitat in Murree-Kotli Sattian-Kahuta National Park.

4.8. Seasonal distribution

4.8.1. Relationship with vegetation composition

During summer, the habitat of barking deer contained 47 plant species: 16 tree species, 11 shrub species, 10 herb species, and 10 grass species (Figure 3). Dominant tree species were *Olea ferruginea* (IV=49.70) and *Pinus wallichiana* (IV=40.04). Dominant shrub species were *Carissa opaca* (IV= 145.32) and *Rubus ellipticus* (IV= 51.53), dominant herb species were *Adiantum incisum* (IV= 26.87) and *Oxalis corniculata* (IV= 23.1), and dominant grass species were *Apluda mutica* (IV= 22.46) and *Bothriochloa ischaemum* (IV= 12.8).

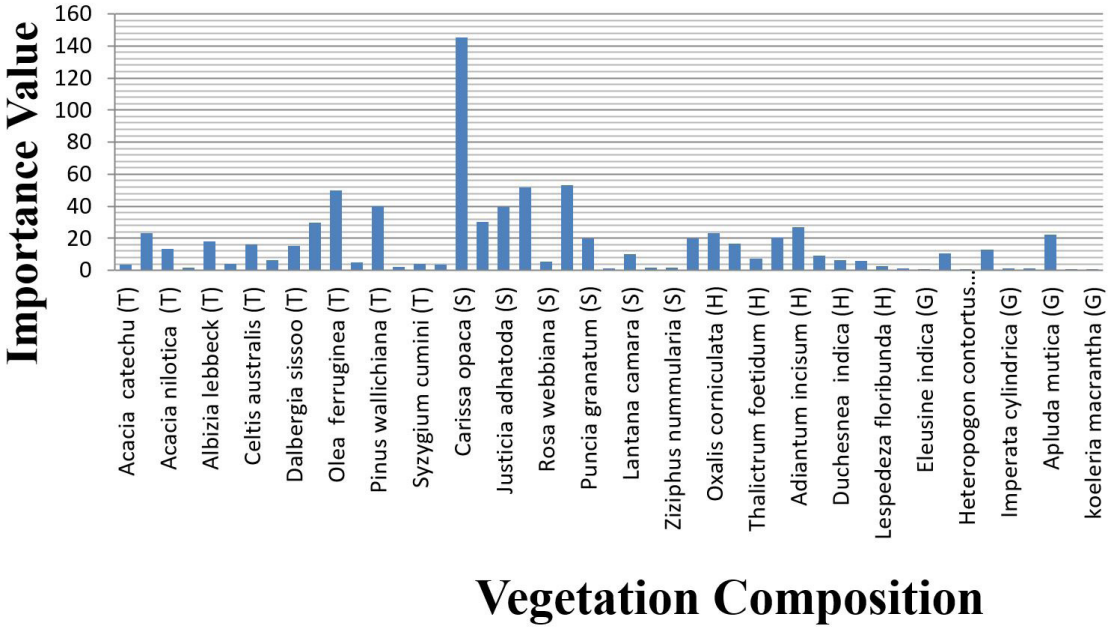

Figure 3. Plant species recorded in summer from habitat of Barking deer.

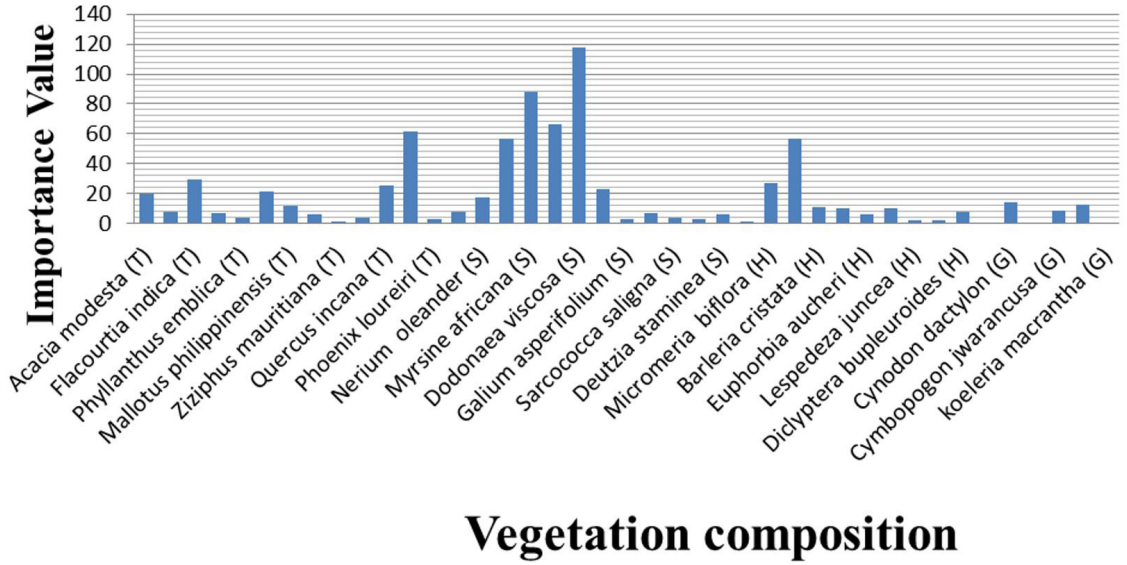

Figure 4. Plant species recorded in winter from habitat of Barking deer.

A total of 41 plant species were observed in the Barking deer habitat during winter, including 14 tree species, 12 shrub species, nine herb species, and six grass species (Figure 4). Dominant tree species during winter were *Pinus roxburghii* (IV= 61.42) and *Flacourtia indica* (IV= 29.72), dominant shrub species were *Dodonaea viscosa* (IV= 117.77) and *Myrsine africana* (IV= 88.19), dominant herb species were *Sida cordifolia* (IV= 56.5) and *Micromeria biflora* (IV= 27.05), and dominant grass species were *Cynodon dactylon* (IV= 14.25) and *Dichanthium annulatum* (IV= 12.79).

In both seasons, trees dominated the flora (34%), followed by shrubs (21%). Comparison of vegetation in both seasons revealed that there was no significant difference between tree density ($t = 8.31$, $p = 0.13$), shrubs ($t = 5.857$, $p = 0.10$) and grasses ($t = 7.28$ $p = 0.09$), while there was a significant difference between grass densities ($t = 8.18$, $p = 0.04$).

4.8.2. Relationship with elevation, slope, and aspect

No seasonal shift in elevation was found by barking deer in Murree-Kotli Sattian-Kahuta National Park. Barking deer preferred altitude between 550-850 m a.s.l in both winter and summer (Figure 5). Areas less than 500 m and above 1250 m have been avoided by barking deer, regardless of the season. Barking deer were found more frequently in dense forests and steep slopes, with a small percentage found in agriculture areas (Figure 6).

Chi-squared tests ($\chi 2 = 72.00$, d f=7, $p = 0.230$) revealed that there was no significant difference in the topographic aspect used by Barking deer throughout the year (Figure 7).

4.8.3. Habitat preference

Barking deer were not evenly distributed within vegetation types of the study area. They preferred Sub-

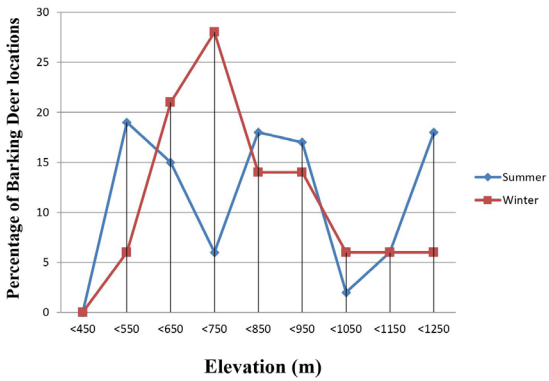

Figure 5. Slopes of occupied locations of Barking deer habitat.

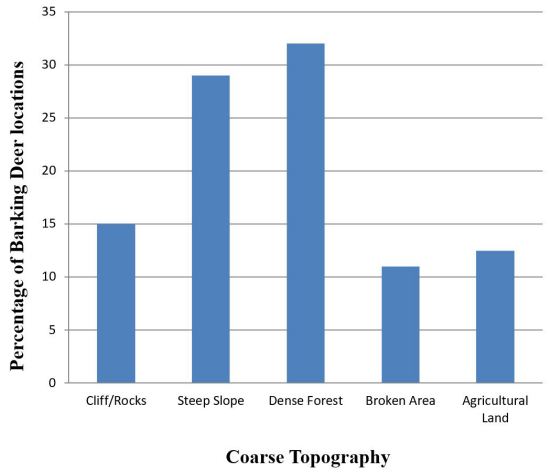

Figure 6. Coarse topography / habitat characteristics at occupied locations of Barking deer.

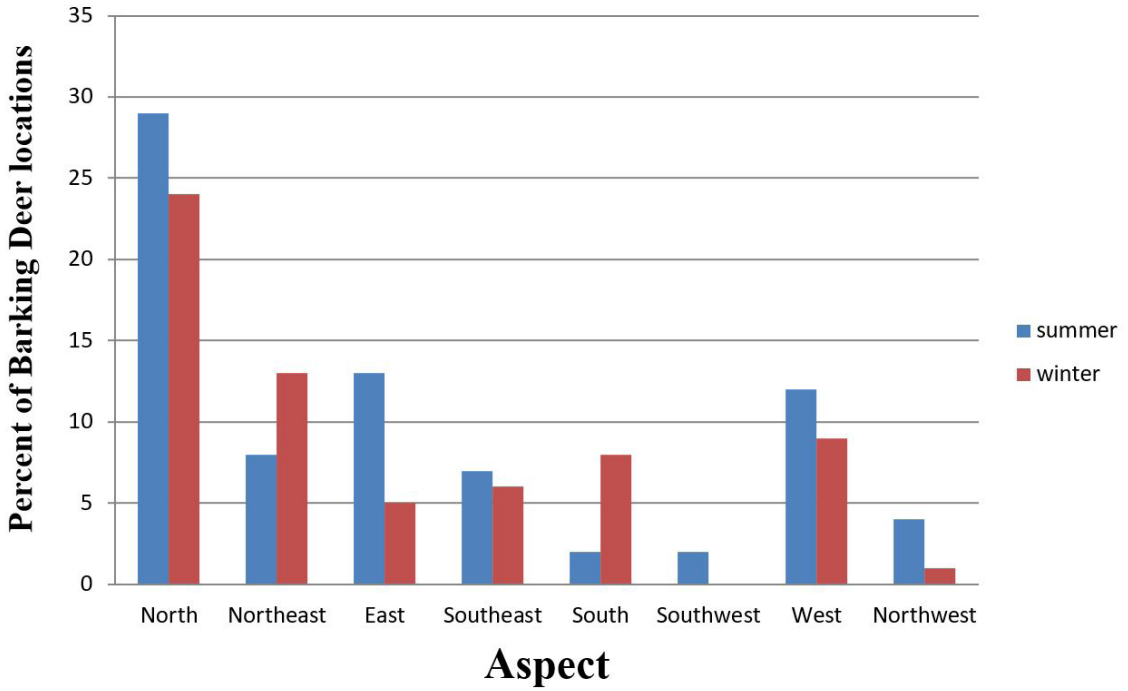

Figure 7. Aspects of occupied locations of Barking Deer in study area.

tropical Broad-Leaved forest with elevation ranges from 550-850 m which had thick vegetation steep slope. The most preferred vegetation types were trees and shrubs with 30 and 69 percent cover, respectively. Barking deer avoided thick tree cover. No significant differences ($\chi^2 = 6.37$, df =3, p = 0.19) in seasonal vegetation cover were recorded in the habitat of barking deer.

5. Discussion

Data on the distribution of vegetation in potential habitat areas suggested that most of the vegetation cover was occupied by shrubs (69%). Barking deer avoided thick tree cover, potentially because it hinders escape from predators or has a lower density of preferred forage species. The preferred tree canopy was open and provided an average of 30 percent of total vegetative cover.

The results of the present study are broadly in agreement with those of a previous study (Hameed and Mian, 2009) who suggested that a major part of the preferred vegetation cover in the barking deer habitat was contributed by shrubs (30.3- 68.7%). Lekagul and McNeely (1977) also reported that barking deer are browsers, so greater shrub cover ensures the availability of food.

The results of this study revealed that barking deer did not use a wide range of elevation in their habitat. Most of the direct sightings and indirect signs were recorded at a range of 550-850 m. No evidence of barking deer was found above 1250 m. Avoidance of areas below 450 m might be due to human and livestock disturbance. Pokharel and Chalise (2010) observed similar results during a study in Nepal, where barking deer used a middle range of mountains that had thick vegetation cover and was little disturbed by humans. No sightings or fecal pellets were recorded above 1500 m. Hameed and Mian (2009) also suggested that barking deer was distributed in Margalla Hills National Park up to 1200 m.

No seasonal shifts in elevation were observed in our study area. In contrast, Pokharel et al., (2015) found that in Nepal, barking deer preferred lower elevations during winter.

Barking deer have seasonal differences in their habitat preferences. The plant species collected from the habitat showed that barking deer used different plant communities in both seasons, but tree density dominated the flora (34%), followed by shrubs (21%). A comparison of vegetation in both seasons revealed that there was no significant difference among densities of trees, shrubs, and herbs, while there was a significant difference among the density of grasses. In contrast, Nagarkoti and Thapa (2007), in Nepal, showed that barking deer used mixed deciduous forests in spring and mixed pine and broad-leaved forests in the rainy season.

Barking deer in Murree-Kotli Sattian-Kahuta National Park used Sub-tropical Broad Leaved forest more than a pine forest. Gray and Phan (2011) recorded higher encounter rates of barking deer in semi-evergreen mixed deciduous forests in China. Teng et al., (2004) reported shrub habitat and deciduous monsoon forest as the preferred habitat of barking deer. Pokharel et al. (2015) suggested that barking deer were associated with deciduous hill forest, which is relatively drier and more open.

Direct and indirect sightings in Muree-Kotli Sattian-Kahuta National Park showed that barking deer were found more frequently in dense forests and on steep slopes. This result is similar to previous studies that reported

mountains with sloping terrain and steeper hills as the preferred habitat of barking deer (Pokharel and Chalise 2010; Shrestha 2003).

Acknowledgments

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