Pakistan J. Zool., vol. 50(1), pp 197-206, 2018. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2018.50.1.197.206

Habitat and Feeding Ecology of Ladakh Urial (*Ovis vignei vignei*) in Gilgit-Baltistan, Pakistan

Muhammad Siraj-ud-Din[1,2], Riaz Aziz Minhas[1], Usman Ali[3,*], Mayoor Khan[2], Muhammad Siddique Awan[1], Nuzhat Shafi[1] and Basharat Ahmad[1]

[1]*Department of Zoology, University of Azad Jammu and Kashmir, Muzaffarabad 13100, Azad Jammu and Kashmir, Pakistan*
[2]*Wildlife Conservation Society (WCS), Gilgit-Baltistan 15100, Pakistan*
[3]*Department of Zoology, Mirpur University of Science and Technology, Mirpur 10250, Azad Jammu and Kashmir, Pakistan*

M. Siraj-ud-Din and Riaz Aziz Minhas contributed equally to this work.

ABSTRACT

Ladakh urial or *shapu* (*Ovis vignei vignei*) is an endangered wild sheep still occurring in small pockets in certain areas of Gilgit Baltistan (GB) besides Ladakh in India. The present study was conducted to determine habitat use and feeding preference of urial in Gilgit Baltistan. Current study is the first and only detailed study about the habitat and feeding ecology of these wild sheep in Pakistan. The study provides baseline data about the study topic which will help conservation management of the species in the area. The habitat use of urial was determined on the basis of direct or indirect evidence (e.g. animal sightings, fecal pallets and hairs) in different habitats. Information on food consumption was collected by using scan sampling technique and also collected from local people, hunters and shepherds (n=78). During scan sampling, focused feeding animals were observed with the help of a telescope and spotting scope. Ladakh urial preferred montane dry sub-tropical scrub zone habitat with 41.87% evidences of its presence followed by alpine meadows/alpine scrub zone (21.14%), sub-alpine scrub zone (13.41%), and dry temperate coniferous forests (8.54%). On the other hand, agricultural lands (3.24%) and dry alpine zone/permanent snowfield (3.66%) were the least preferred habitats of urial in Gilgit Baltistan. Thirty-six (36) plant species were recorded to be consumed by the Ladakh urial in Gilgit Baltistan. Ladakh urial used *Artemisia maritima* (n=53) with 18.34% of observations followed by *Olea ferruginea* (n=28, 9.69%), *Ephedra intermedia* (n=25, 8.65%), *Pistacia khinjuk* and *Ephedra gerardiana* (n=23, 7.69%). Out of 36 plant species, 15 were consumed during summer (June to August), 10 in spring (April-May), six (6) in autumn (September-October) and five (5) in winter (February-March). Conservation of threatened Ladakh urial could be achieved by protecting its potential habitat and preferred food plant species.

Article Information
Received 29 September 2016
Revised 16 May 2017
Accepted 02 October 2017
Available online 09 January 2018

Authors' Contribution
RAM designed the study. MSD and MK collected field data. MSD and UA wrote the article. UA, MSA, NS and BA statistically analyzed the data.

Key words
Ladakh urial, *Ovis vignei vignei*, Food habits, Habitat, Gilgit Baltistan.

INTRODUCTION

The Ladakh urial or *shapu* (*Ovis vignei vignei*) is the smallest wild sheep with a very restricted distribution range confined in Pakistan to Chitral (Khyber Pakhtunkhwa), Gilgit Baltistan and Ladakh (Indian held Kashmir) (Roberts, 1997; Valdez, 2008). The Ladakh urial prefers rolling gentle slopes, hilly terrain and rugged canyons at low elevation, along river valleys in open areas, that are often close to human settlements; hence heavily used by livestock and readily accessible to hunters (Mallon, 1983; Shackleton, 1997; Raghavan and Bhatnagar, 2003). Ladakh urial inhabits moderate to very arid habitats, especially grasslands, but they are also found in agricultural fields and woodland areas (Raghavan and Bhatnagar, 2003; Valdez, 2008).

The Ladakh urial usually occupies higher altitude semi-desert habitat consisting of open stony hills, in steep grassy mountain slopes between 3000 to 4250 m elevations above sea level (Mallon, 1983). At higher elevations, only a few consumable plant species are available, that too in prostrate form and difficult to forage upon. The urial undertakes altitudinal migrations to areas with snow free and more exposed vegetation (Geist, 1971; Schaller, 1976; Festa-Bianchet, 1989; Fox *et al*., 1991). These elevations and habitats correspond to the region most heavily utilized by humans, and a combination of overhunting, disturbance, and competition with livestock. Hence, Ladakh urial, like many other wild animal species is affected by competition with livestock, leading it to the brink of extinction (Roberts, 1977; Schaller, 1979; Mallon, 1991; Shackleton, 1997; Chundawat and Qureshi, 1999).

* Corresponding author: usman.zoology@must.edu.pk
0030-9923/2018/0001-0197 $ 9.00/0

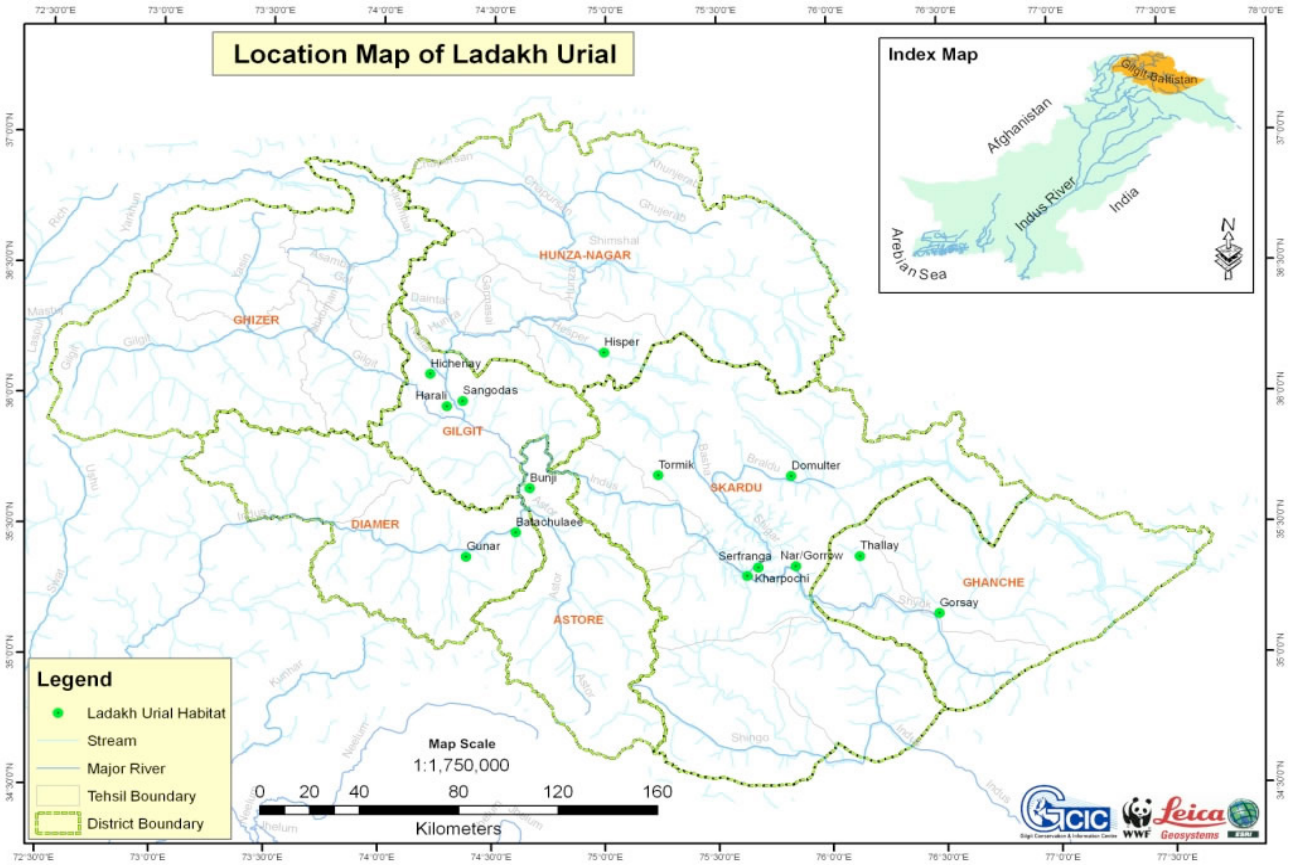

Fig. 1. Location map of Ladakh urial in Gilgit Baltistan (study area).

Urial is a grazer feeding on grasses and shrubs. In Ladakh, it has been recorded consuming at least 26 different plant species, including *Cousinia thomsonii*, *Thermopsis* spp., *Silene moorcroftiana,* and graminoids. According to Mallon (1983), the urial usually depend on shrubs, like *Ephedra gerardiana, Artemisia* spp. and *Capparis spinosa.* Roberts (1997) reported urial consuming the leaves of *Hippophae rhamnoides* in Baltistan. However, the detailed information about the habitat and food utilization by these urial has not been collected so far. The current study was carried out to fill this gap of information about this threatened species in Gilgit Baltistan. Information on the habitat use, food preference and availability of food plant species would be helpful for conservationists to design a suitable plan for the conservation of these urial in Pakistan.

MATERIALS AND METHODS

Study area

Gilgit Baltistan (GB), 72,971 km² area, is situated between 43-4' to 37-04' north latitude and 72-30 to 77-50 east longitude in the north of Pakistan (Fig. 1). The area is sandwiched among the highest peaks of Karakoram and Hindu-Kush ranges and western Himalayas. It is bordered by Pakistan's Khyber Pakhtunkhwa (KP) province in the west, Afghanistan's Wakhan Corridor in the north, China in the east and northeast, Azad Jammu and Kashmir (AJ&K) in the southwest and Indian-administered Jammu and Kashmir in the southeast (Khan, 2012) (Fig. 1).

The landscape is dominated by some of the world's highest mountain peaks, which overshadow the biological fertility of this region (Virk *et al*., 2003). Monsoon rains are blocked by the high Himalayan mountains, as a result, most of the valleys in the area receive less than 200-millimeter average annual rainfall hence classified as a cold desert. Heavy snowfall generally occurs in areas above 4000 m ASL, which further increases with increasing elevations (Virk *et al*., 2003; Zain, 2010). The physiography provides an ecological background for the floral and faunal species adapted to rugged high mountains. Based on Roberts (1997) classifications, as also described by Virk *et al.* (2003), GB has distinct ecological zones comprising, i) Montane Dry Sub Tropical Scrub in Gilgit and Hunza River valleys up to Raikot and Bunji in between 750–1219

meters elevation range, ii) Dry Alpine Zone and Permanent Snowfields predominating high altitudes around major peaks of the Karakoram mountains and upper Hunza, iii) Alpine Meadows and Alpine Scrub Zone between 3500 and 3800m in almost all the higher regions of Gilgit, Baltistan, Ghizer, Diamer and Astore, above the tree line *e.g.,* Deosai plateau, iv) Sub-alpine scrub zone, widespread throughout higher mountains of Himalayas-Hindu Kush-Karakoram, including Gilgit (Naltar), Skardu, Ghizer and Astore regions, v) Dry Temperate Coniferous Forests dominated by Abies pindrow, *Picea smithiana, Cedrus deodara* and *Pinus wallichiana*, in the inner or northerly slopes of the Himalayas in parts of Gilgit, Diamer, and Skardu districts, vi) Dry Temperate Evergreen Oak Scrub dominated by dry oak forest (*Quercus baloot*) in the lower valleys of Diamer District mainly in areas adjacent to Kohsitan District of KP between 1500 to 2500 m ASL.

Globally significant species of mammals are found in the area including some of the globally threatened species like the snow leopard (*Panthera uncia*), Himalayan brown bear (*Ursus arctos isabellinus*), black bear (*Ursus thibetanus*), Himalayan lynx (*Felis lynx*), Marco Polo's sheep (*Ovis ammon polii*), Ladakh urial (*Ovis vignei vignei*), flare-horned markhor (*Capra falconeri falconeri*), Himalayan ibex (*Capra ibex sibirica*), blue sheep (*Pseudois nayaur*), musk deer (*Moschus chrysogaster*) and woolly flying squirrel (*Eupetaurus cinereus*). Important bird species include monal pheasant (*Lophophorus impejanus*), snow cock (*Tetraogallus himalayensis*), snow partridge (*Lerwa lerwa*), chukar partridge (*Alectoris chukar*), Himalayan griffon vulture (*Gyps himalayensis*), lammergier (*Gypaetus barbatus*), golden eagle (*Aquila chrysaetos*), common kestrel (*Falco tinnunculus*), along with a large number of other migratory/non migratory passerines and non-passerine birds (Virk *et al*., 2003).

Methodology

In order to study the habitat and food utilization of Ladakh urial, areas from where reports of the occurrence of urial or their signs (fecal pellets and hairs), received, were completely scanned within ca. 100 m radius. Most (ca. >60%) of the urial habitat is arid sub desert, comprising of barren lands and rigid steep rocks. Vegetation type with dominant and most frequently found plant species, within 100 m radius of the highest animal aggregates, were estimated visually as this method is considered suitable for studying habitat attributes of rigid mountain dwelling ungulates (like urial) where most of the areas are inaccessible, and physical estimation of ground cover is very risky (Kittur *et al*., 2010).

Table I.- Number of Ladakh urial signs found at different habitat types in Gilgit Baltistan during 2013.

Habitat type	Localities	Urial evidence (No.)*	Dominant vegetation
Montane dry sub-tropical scrub zone	Bunji, Nanga Parbat	103	*Artemisia* spp., *Berberis* sp., *Capparis spinosa*, *Daphne oleoides, Dodonaea* sp., *Ephedra intermedia, Monotheca* sp., *Pistacia* sp., *Poa* spp. *Reptonia* sp., *Rosa moschata, Saccharum* sp.,
Alpine meadows and alpine scrub zone	Nanga Parbat, Nagar, Skardu	52	*Anemone* sp., *Artemisia* sp., *Euphorbia kanaorica, Iris* sp., Poa spp., *Polygonum affine*, *Primula* sp., *Saxifraga sibirica*,
Sub-alpine scrub zone	Nanga Parbat, Skardu,	33	*Anemone* sp., *Berberis* spp, *Betula utilis*, *Cotoneaster* sp., *Juniperus communis, Juniperus squamata, Lonicera korolkowii, Poa* grass, *Rhododendron hyperythrum, Salix denticulata*
Dry temperate coniferous forest	Nanga Parbat, Nagar, Skardu	21	*Artemisia maritima, Cedrus deodara, Ephedra intermedia, Indigofera gerardiana*, *Juglans regia, Picea smithiana, Pinus wallichiana, Plectranthus rugosus Quercus ilex, Sambucus ebulus, Sorbaria tomentosa*
Dry temperate evergreen oak scrub	Nanga Parbat, Nagar, Skardu	20	*Artemisia maritima, Berberis lyceum, Cedrus deodara, Cotoneaster nummularia, Daphne oleoides, Juniperus* spp. *Pinus gerardiana, Pinus wallichiana, Quercus ilex, Sophora griffithii*
Dry Alpine zones and permanent Snowfields	Skardu	09	*Capparis spinosa, Hippophae rhamnoides, Juniperus communis, Mertensia tibetica, Myricaria elegans, Peganum bannala, Potentilla desertorum Salix denticulata, Tribulus terrestris*
Agricultural lands	Bunji, Nanga Parbat, Nagar, Skardu	08	*Amaranthus retroflexus, Artemisia brevifolia, Artemisia gmlinii, Cannabis sativa, Capparis spinosa, Carthamus tinctorius, Chenopodium album, Datura stramonium, Ficus carica, Fraxinus hookeri, Hippophae rhamnoides, Medicago sativa, Mentha royleana, Olea ferruginea, Peganum harmala*
Total		246	

*Based on direct sighting, fecal droppings, foot prints, reports of community wildlife rangers, hunters, wildlife watchers, shepherds and local people.

Table II.- Seasonal variation in habitat preference by Ladakh urial in Gilgit Baltistan during 2013.

Habitat type	No. of urial signs	No. of urial signs (%)			
		Winter	Spring	Summer	Autumn
Montane dry sub-tropical scrub zone	103	23(22.33)	25(24.27)	21(20.38)	34(33.00)
Alpine meadows and alpine scrub zone	52	07(13.46)	13(25)	24(46.15)	08(15.38)
Sub-alpine scrub zone	33	07 (21.21)	08(24.24)	13(39.39)	05(15.15)
Dry temperate coniferous forest	21	08(38.1)	04(19)	04(19)	05(24)
Dry temperate evergreen oak scrub	20	07(35)	06(30)	03(15)	04(20)
Dry Alpine zones and permanent snowfields	09	0	01(11.11)	07(77.77)	01(11.11)
Agricultural lands	08	06(75)	02(25)	0	0
Total	246	58	59	72	57

General habitat features *i.e.,* coordinates, elevation above sea level (using GPS device), land use, aspects, slope/terrain, food/water availability, associations with other animals and humans was estimated visually. All data were recorded on data sheets. Preference of different habitat features (vegetation type, elevation above sea level, aspect, slope, terrain etc.) as well as seasonal variation in habitat use were determined on the basis of relative frequency of evidence (*e.g.,* animal sightings and fecal pallets, hairs) in different habitats. Seasonal variation in habitat use by Ladakh urial was also assessed through direct sighting or indirect signs to confirm its presence in the relevant habitat type. A total of 246 such observations were recorded and proportion based analysis was carried out.

Information on food consumption was collected using scan sampling technique. Feeding animals were observed with the help of telescope (Canon, 8×40 mm) and spotting scope (Bushnell, 20-60×65mm) in 211 observations. Plant species as well as the parts consumed were identified directly or recorded by accessing the area (on the same day or on the next) for collecting specimens for identification afterwards. Furthermore, the information about food and feeding of urial was also collected from local knowledgeable persons, hunters and shepherds (n=78). Food preference was estimated on the basis of proportional usage of different plant species in terms of frequency (%).

RESULTS

Habitat use

Seven different habitat types were recognized in Gilgit Baltistan (Table I). These habitats include montane dry sub-tropical scrub zone, alpine meadows and alpine scrub zone, sub-alpine scrub zone, dry temperate evergreen oak scrub, agricultural lands, dry temperate coniferous forests, dry alpine zone and permanent snowfields. Based on different direct and indirect evidence, assessment of habitat preference by Ladakh urial was carried out in all these habitat types. The evidence of the presence of Ladakh urial was found in all these habitats (Table II).

Ladakh urial, in the study area, preferred montane dry sub-tropical scrub zone habitat with 41.87% evidence of its presence (direct sightings, fecal pallets etc.) followed by alpine meadows/alpine scrub zone (21.14%), sub-alpine scrub zone (13.41%), and dry temperate coniferous forests (8.54%). Agricultural lands (3.24%) and dry alpine zone/ permanent snowfield (3.66%) were the least preferred habitats of urial in GB (Fig. 2).

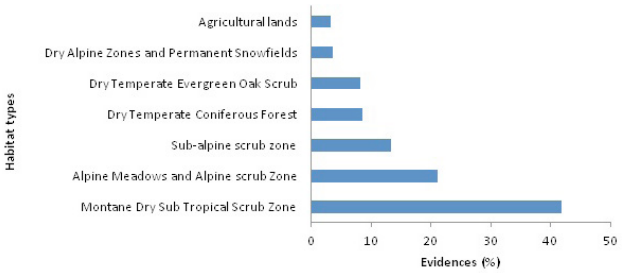

Fig. 2. Evidences (%) of Ladakh urial in different habitat types in GB.

Statistical analysis between numbers of evidence of urial habitat utilization of different habitat types, showed a highly significant difference *(X^2=191.87, df=6, p=<0.001)* suggesting that there was a significant variation among the evidence of different habitat utilization frequencies by the Ladakh urial in GB.

Most (ca. >60%) of the urial habitat area is the arid sub desert, comprising of barren lands with soils, sands, stones and rocks. The remaining portion of habitat contains scattered stunted vegetation comprising small trees, shrubs, herbs and grasses of various kinds including *Salix daphnoides, Quercus baloot, Pistacia integerrima, Juniperus excelsa, Juniperus communis, Elaeagnus angustifolia, Prunus amygdalus, Betula utilis, Thymus*

serpyllum, Fraxinus xanthoxyloides, Rosa webbiana, Hippophae rhamnoides, Morus alba, Ribes alpestris, Artemisia maritima (Table I). However, in some localities *viz.,* Nanga Parbat, Nagar and Skardu these urial were also observed/reported in dry temperate coniferous and dry temperate evergreen oak forests where *Cedrus deodara, Picea smithiana, Abies pindrow, Pinus wallichiana, Pinus gerardiana, Quercus baloot, Salix daphnoides* were the main plant/tree species between 2500 to 3800 m elevation (Table I).

Ladakh urial preferred different types of habitat during different seasons (e.g., winter, spring, summer and autumn; Table II). Montane dry sub-tropical scrub zone was frequently used by urial during autumn (33%), followed by spring (24.27%) and winter (22.33%). Alpine meadows and alpine scrub zone, and sub alpine scrub were frequently used during summer with 46.15% and 39.39% evidence. Dry temperate coniferous forest (38.1%) and Dry temperate evergreen oak scrub (35%) were preferably used during winter season while dry Alpine zone, permanent snowfields and agricultural lands were frequently used during summer (77.77%) and winter (75%) seasons, respectively (Table II).

Physiographic factors

Topographically, the study area was characterized by steep slopes; rocky and thick vegetation covered mountain and valleys. Based on direct and indirect evidence, it was inferred that the urial differentially used various types of terrain including smooth, broken and rocky in the study area (Table III). However, the rocky terrain was preferably used with 48% evidence of its presence, followed by broken terrain (30%), and smooth terrain (22%) in all habitats except agricultural lands where it preferred smooth terrain (Table III).

There was a highly significant difference *(X^2=26.65, df=2, p=<0.001)* in the numbers of evidence of urial among these types of terrains. Ladakh urial usually preferred an intermediate slope (51°-70°) with 56% evidence followed by gentle slope (<50°-29%). Steep slopes (>70°) were the least commonly used (Fig. 3).

Majority of urial herds (40%) were recorded on the southern aspects followed by northern (26%), western (18%) and eastern (16%) (Fig. 4). There was highly significant difference between the usage of different slope categories (*X^2=62.80, df=2, p=<0.001*) and aspects (*X^2=34.94, df=3, p=<0.001*) by urial in the study area.

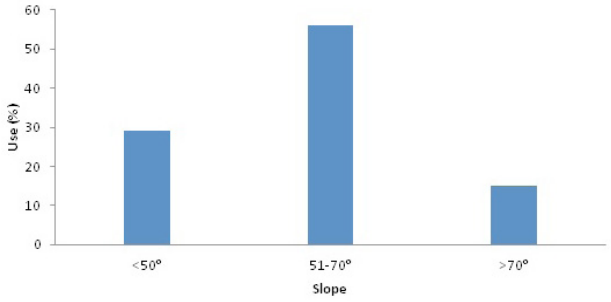

Fig. 3. Slope angles preferred by Ladakh urial in GB during 2013.

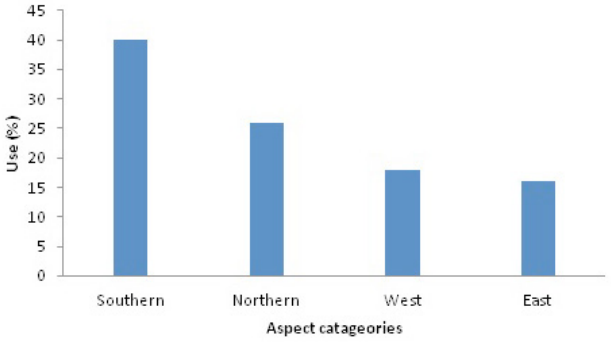

Fig. 4. Aspect preferred by Ladakh urial in GB during 2013.

Table III.- Terrain used by Ladakh urial in Gilgit Baltistan during 2013.

Habitat type	Smooth	Broken	Rocky	Total (#)
Montane dry sub-tropical scrub zone	15(15%)	26(25%)	62(60%)	103
Alpine meadows and alpine scrub zone	11(21.2%)	19(36.5%)	22(42.3%)	52
Sub-alpine scrub zone	09(27.3%)	11(33.3%)	13(39.4%)	33
Dry temperate coniferous forest	05(24%)	07(33.3%)	09(43%)	21
Dry temperate evergreen oak scrub	05(25%)	07(35%)	08(40%)	20
Dry Alpine zones and permanent Snowfields	02(22.2%)	03(33.3%)	04(44.4%)	09
Agricultural lands	06(75%)	02(25%)	-	08
Total	53	75	118	246
Percentage	22	30	48	100

Table IV.- List of plants consumed by Ladakh urial in Gilgit Baltistan during 2013.

Botanical Name	Local Name	Family	Part consumed	Observations /reports	
				No.	%
Abies pindrow	Fir	Pinacea	Seed/leaf	2	0.69
Artemisia brevifolia	Zhoon	Compositae	Shoot/root	5	1.73
Artemisia maritima	Zhoon	Compositae	Shoot/root	53	18.34
Artemisia strictaedgew	Zhoon	Compositae	Shoot/root	7	2.42
Berberis lyceum	Ishkeen	Berberidaceae	Roots and stem bark	9	3.11
Bergenia spp.	-	Saxifragaceae	All parts	5	1.73
Betula cordifolia	Birch	Betulaceae	Leaf/seed	3	1.04
Betula utilis	Jonjii	Betulaceae	Leaf	3	1.04
Bunium persicum	Hayo	Umbelliferae	All parts	3	1.04
Carum bulbocastanum	Hayo	Umbelliferae	All parts	2	0.69
Chrysopogon spp.	-	Poaceae	Young shoots	5	1.73
Cymbopogon spp.	-	Poaceae	Young shoots	5	1.73
Elaeagnus angustifolia	Russian Olive	Elaeagnaceae	Leaf/seed	2	0.69
Ephedra gerardiana	Soom	Ephedraceae	Stem/shoot/ root	23	7.96
Ephedra intermedia	Soom	Ephedraceae	Stem/shoot/ root	25	8.65
Ferula narthex	Sup	Umbelliferae	young shoots	11	3.81
Fraxinus xanthoxyloides	-	Oleaceae	All parts	5	1.73
Fraxinus hookeri	Kasunar	Oleaceae	Leaf	15	5.19
Haloxylon griffithii	-			5	1.73
Indigofera gerardiana	-	Leguminosae	Leaf	4	1.38
Juniperus	Chili	Cupressaceae	Leaf	3	1.04
Lonicera sp.	Ash	Caprifolaceae	Flower/leaf	2	0.69
Olea ferruginea	Kawo	Oleaceae	Leaf	28	9.69
Picea smithiana	Spruce	Pinacea	Leaf	2	0.69
Pinus gerardiana	Yunji	Pinaceae	Leaf	5	1.73
Pinus gerardiana	Chilgoza	Pinacea	Leaf	2	0.69
Pistacia khinjuk	Kakayown	Anacardiaceae	Leaf	23	7.96
Poa grass	-	Poaceae	All parts	5	1.73
Polygonum spp.	-	Polygoniaceae	Leaf	6	2.08
Quercus baloot	Holly Oak	Fagaceae	Leaf/seed	3	1.04
Rheum australe	Chontal	Polygoniaceae	young shoots	3	1.04
Rheum emodi	Jaro Chontal	Polygoniaceae	Leaf	2	0.69
Rheum webbianum	Chontal	Polygoniaceae	Leaf	3	1.04
Rosa webbiana	Jungli gulab	Rosaceae	Leaf	2	0.69
Thymus linearis	Tumoro	Labiatae	All parts	5	1.73
Thymus serpyllum	Tumoro	Labiatae	All parts	3	1.04
			Total	289	100.0

Food preferences

Food of Ladakh urial composed of different plant forms including herbs, shrubs and grasses. During present study, 36 plant species were recorded to have been consumed by the Ladakh urial in GB. The consumption of these species was confirmed through direct field observations (n=26), reports of local persons (n=4), shepherds and hunters (n=6; Table IV).

Among these plant species, Ladakh urial frequently used *Artemisia maritima* (n=53) with 18.34% of observations followed by *Olea ferruginea* (n=28, 9.69%) *Ephedra intermedia* (n=25, 8.65), *Pistacia khinjuk and Ephedra gerardiana* (n=23, 7.69%; Table IV). Out of total 36 plant species, 15 were consumed during summer (June to August), 10 in spring (April-May), six (6) in autumn (September-October) and five (5) in winter (February-March; Table V).

In winter season Ladakh urial moves from higher elevation to lower elevation due to heavy snowfall at higher elevation. However, statistically, there was a

non-significant difference between the number of plant species consumed during different seasons ($X^2=6.88$, $df=3$, $p=0.76$). Most of food plant species were found at the elevation range of 2600-3000m while minimum plant species were recorded from 4000 to 5000 m elevation range (Fig. 5).

Table V.- Seasonal variations in food preferences of Ladakh urial in Gilgit Baltistan during 2013.

Sessions	Months	No. of plant species consumed	% of consumption
Winter	Feb- Mar	5	14
Spring	Apr-May	10	28
Summer	Jun-Aug	15	42
Autumn	Sep-Oct	6	16
Total		36	100

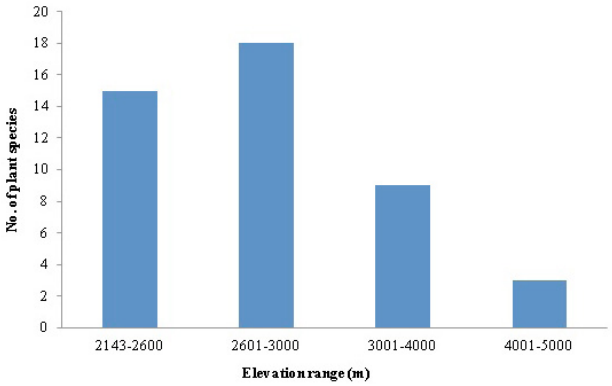

Fig. 5. Number of plant species consumed by Ladakh urial at different elevation ranges in GB.

The difference between the number of different plant species consumed at different elevation levels was significantly different ($X^2=11.8$, $df=3$, $p=0.008$). Moreover, a highly strong positive correlation ($r=0.99$, $p=0.008$) was obtained among the number of plant species consumed and population observed along different elevation classes in the area.

DISCUSSION

Gilgit Baltistan (GB) is located in the extreme North of Pakistan sandwiched among the highest peaks of Karakoram and Hindu-Kush in the north and those of western Himalayas in the south. It borders with Ladakh region of India which is the most potential habitat for Ladakh urial in India. This dramatic concentration of high mountains, provides an ecological backdrop for the floral and faunal species adapted to rugged, high mountains. The Ladakh urial was present with low densities in different habitat types of GB. Based on major vegetation classification of Roberts (1997) and Virk *et al.* (2003) identified several distinct ecological zones in GB.

Ladakh urial preferred montane dry sub-tropical scrub zone with 41.87% evidence of its presence (direct sightings, fecal pallets etc.) and alpine meadows/alpine scrub (21.14%), sub-alpine scrub zone (13.41%). A highly significant difference ($X^2=191.87$, $df=6$, $p=<0.001$) among the preference of different habitat types. The preferred habitats in the study area are open shrublands that provide ample food and may also help in the detection of predators. Besides, slopes of these habitats are somewhat moderate and easy to move around. Many authors have reported that the Ladakh urial occupy relatively open and low altitudes with gentle slopes along the main valleys (Lydekker and Dollman, 1985; Ranjitsinh, 1981; Schaller, 1977; Roberts, 1997; Raghavan and Bhatnagar, 2003).

Urial were also recorded in dry temperate coniferous forests (8.54%), agricultural lands (3.24%) and dry alpine zone/permanent snowfield (3.66%). Dry temperate coniferous forests and oak forests occurring in Nanga Parbat areas were occasionally used during winter season when heavy snow covered the open areas. These forests can provide food and shelter during heavy snow. Besides, some evidence of urial marauding agricultural lands was also recorded especially during winter season, when the high elevation areas experienced heavy snowfall and the urial descended in the vicinity of human habitations. Alpine zones and permanent snowfields were not commonly used by the urial in the study area. However, the available evidence suggested that these habitats were preferably used during summer (77.77%) than in any other season. Almost all available previous studies suggested that the urial remained confined to lower altitudes unlike other mountain ungulates (*e.g., Capra ibex sibirica* and *Pseudois nayaur*), that occur in more rugged remote mountains at high altitudes (Mallon, 1983; Schaller, 1977; Roberts, 1997; Raghavan and Bhatnagar, 2003). However, during summer, when these lower elevations become saturated with human beings and their livestock, consequently urial were pushed up towards higher mountainous elevations unwillingly. In some areas of Ladakh, they were reported to be restricted to higher elevation zones even during winter season (Raghavan and Bhatnagar, 2003).

Approximately >60% of the urial habitat area in GB is arid sub desert composed of barren lands with soils, sands and rocks without any vegetation cover. The remaining portion of habitat harbors scattered and stunted vegetation comprising small trees, shrubs, herbs and grasses. In some localities, *viz.,* Nanga Parbat, Nagar and Skardu, the urial were also observed and reported in dry temperate

coniferous and dry temperate evergreen oak forests where *Cedrus deodara, Picea smithiana, Abies pindrow, Pinus wallichiana, Pinus gerardiana, , Quercus baloot, Salix daphnoides* dominate among the vegetation between 2500 to 3800 m elevations. According to Khan and Zahler (2004), the vegetation is dominated by sagebrush or wormwood (*Artemisia*) above 1800 m, while scattered oak (*Quercus baloot*) and juniper (*Juniperus excelsa*) appear around 2100 m. At higher elevations (2500-3800 m), open pine forests (*Pinus wallichiana* and *P. gerardiana*), with juniper and patches of deodar (*Cedrus deodara*) and spruce (*Picea smithiana*) were also present. However, at further elevation, above 3800 m, woody vegetation is limited to juniper and shrubby Himalayan birch (*Betula utilis*) (Khan and Zahler, 2004).

The urial habitat use patterns confirmed their preference for intermediate slopes (51º-70º*; X^2=62.80, df=2, p=<0.001*) with smooth to sometimes broken terrain at southern aspects *(X^2=34.94, df=3, p=<0.001).* They occasionally used steep slopes or rocky terrain. Although, the urial were seen to be restricted to the middle elevation zones even during winter they preferred lower elevation zones. The gentle slopes (<50º) are not generally used by the urial as these slopes are usually exploited by human beings and their livestock while the steep slopes might not be preferred because of their hardness in the movement or scarcity of food. Urial preferred to stay in open areas, close to ridgelines and cliffs on the southern aspects and like other wild sheep, used speed to escape predators (Geist, 1971; Shackleton, 1997; Raghavan and Bhatnagar, 2003). On perceiving danger, they usually escape to the nearest ridgeline, possibly to enable the monitoring of predators (danger) from a safer distance and to keep them in sight. Due to the hunting pressure, probably, the flight distance of urial on sighting humans was extremely large (minimum distance being 150m, *pers. obs.*). The openness of the terrain makes urial conspicuous to predators including humans. They rarely use cliffs as escape terrain, and prefer speedy running towards ridgelines to escape danger (Geist, 1971).

Ladakh urial used various types of terrain including smooth, broken and rocky terrains differentially in the study area. Similar types of terrrain were used by these urial in Ladakh, India (Chundawat and Qureshi, 1999). However, during the present study, the rocky terrain was preferably used by the Ladakh urial with 48% of observations, followed by broken terrain (30%), and smooth terrain (22%) in all habitats except agricultural lands where it preferred smooth terrain. A highly significant difference *(X^2=26.65, df=2, p=<0.001)* between utilization of these terrains also confirmed that rocky terrains were usually preferred by urial, which may be due to the reason that these terrains may provide better shelters to these animals not only from predators but also from the extreme environmental events as these topographical features usually have natural shelters in the form of lee sides, crevices, gaps, crakes etc. Urial inhabits moderate to very arid habitats, especially grasslands, but they also occur in agricultural fields and woodland areas preferring very gentle slopes with smooth or broken terrain (Raghavan and Bhatnagar, 2003; Valdez, 2008). Schaller (1976) recorded that like all other urial species, the Ladakh urial prefers rolling but not precipitous terrains at low altitudes by penetrating the mountains along rivers.

Majority of urial were recorded at elevation range of 2600-3000 m above sea level, while minimum population was recorded from 4000 to 5000 m elevation range. A highly significant difference *(X^2=34.56, df=3, p=<0.001*) between the populations at different elevation ranges suggested that there was a differential pattern of elevation preference by urial in the study area. The results indicated that the urial preferred lower elevations and rarely ascended above 4000 m. This is perhaps due to the harsh climatic conditions and scarcity of the staple food at high elevations. Other factors *viz.,* competition with other mountain ungulates like markhor. Hunting pressure of snow leopard may also contribute in this regard. Mallon (1983) also suggested that, in Ladakh, the urial occur between 3000 and 4250 m elevation range.

Urial usually preferred lower middle elevations which are often accompanied by the huge human interference and pressure (Mallon, 1983; Shackleton, 1997; Raghavan and Bhatnagar, 2003). From April to late September habitat area is densely populated by human population and their livestock. To reduce this pressure, the urial, like other mountain sheep, are likely to undertake migrations to higher elevations during these months. Hence, they have to face either the human pressure or climatic/ecological pressures in higher elevations which results into the population decline of these animals in the area. Schaller (1976) also reported downward pushing of these animals by the snow in winter to branches of the Indus, near Astor, where man and his livestock, have taken most of their habitat, and downstream of Skardu the species is now virtually extinct.

Many other authors have also reported these disturbances to the Ladakh urial in other areas. In Ladakh, its habitat also coincides with areas of maximum human activity in terms of settlements, agriculture, pastoralism and development (Fox *et al*., 1991; Chundawat and Qureshi, 1999; Raghavan and Bhatnagar, 2003; Din *et al*., 2016). Livestock grazing and other human induced disturbances also affect the nutritional uptake of wild ungulates as they may spend more energy and time to escape from such disturbances and usually forced to

forage in low quality habitats instead of better habitats (Schaller, 1977; Din *et al*., 2016). Furthermore, increased developmental activities including construction of roads, dams, and military bases in these areas have consequently made the species more vulnerable to threats of poaching and habitat destruction (Fox *et al*., 1991; Chundawat and Qureshi, 1999; Raghavan and Bhatnagar, 2003).

Ladakh urial were found consuming different types of plants including herbs, shrubs, trees and grasses. About 36 plant species were found to be consumed by the Ladakh urial in GB. Among these, *Artemisia maritime*, *Olea ferruginea*, *Ephedra intermedia*, *Pistacia khinjuk* and *Ephedra gerardiana* were the most frequently consumed. In Ladakh, they have been reported to consume twenty-six different plant species, preferring *Polygonum plebium, Causinia thomsonii*, *Thermopsis* spp. and *Silene moorcroftiana* (Raghavan *et al*., 2003). Mallon (1983) has also reported that these urial depend on *Ephedra gerardiana, Artimesia* spp. and *Capparis spinosa*. The number of food plants consumed usually depends upon their availability. If the density of plants is low then more number of species would be required to fulfill nutritional requirements. There were seasonal variations in the number of plant species consumed by urial during different seasons. These seasonal variations in food preference of Ladakh urial depend on the availability and abundance of food plants during different seasons. In winter season Ladakh urial moves from higher elevations to lower elevations where different plant species are available hence differences in feeding occur. However, statistically, there was non-significant difference ($X^2=6.88$, $df=3$, $p=0.76$) among number of plant species consumed during different seasons.

There was a highly significant difference ($X^2=11.8$, $df=3$, $p=0.008$) between number of plants species consumed at different elevation levels because of their differential availability as the majority of food plant species were found at the elevation range of 2600-3000 while minimum plant species were recorded from 4000 to 5000 elevation range. Khan and Zahler (2004) also recorded that below 1800 m, most of the areas were usually barren and rocky deserts with little vegetation outside of villages except irrigated crops. While higher elevations were generally not preferred by the urial as they contained lower number of food plants and competition with other ungulates being higher. A strong positive correlation ($r=0.99$, $p=0.008$) between number of urial sightings and plant species consumed suggested that, the distribution and abundance of urial along different elevations was found strongly influenced by the availability of plant species to be consumed.

CONCLUSION

In conclusion, Ladakh urial preferably inhabit montane dry sub-tropical scrub habitat ranging between 2143m to 5000 m ASL. They preferably consume and depend upon the availability of different plant species especially *Artemisia maritime*, *Olea ferruginea, Ephedra intermedia, Pistacia khinjuk* and *Ephedra gerardiana*. However, the remaining urial population is facing severe threats in their habitat. The major threats are illegal hunting and habitat degradation by increasing trends in livestock grazing, wood, fodder and medicinal plant collection. Overpopulation and high dependence of local communities on livestock as the major economic source, directly or indirectly interfere with habitat and food of Ladakh urial. The livestock populations, especially goats and sheep which comprise the major portion, directly compete with the urial in almost all parts of the study area. These factors are destroying the natural habitat of urial. Despite the fact that the area is an ideal habitat; Ladakh urial population, as well as the area of occupancy have greatly been reduced over the last few decades.

ACKNOWLEDGMENTS

We are grateful to Wildlife Conservation Society (WCS) Pakistan providing financial support for this study. We are thankful to Haider Raza, Muhammad Jamil and Dr. Akbar (WCS); Haider Khan and Habib-ur-Rahman (Mountain Conservation and Development Programme Gllgit Baltistan) and Jaffar-ud-Din, Hussain Ali and Younus (Snow Leopard Foundation, Pakistan) for their assistance during field work. We express our gratitude to Muhammad Taj-ud-Din, Dr. Rafi-ud-Din and Burhan-ud-Din for their cooperation and support during field work.

Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Chundawat, R. and Qureshi, Q., 1999. *Snow leopard intensive management study report.* Wildlife Institute of India, Dehradun.

Din, M.S., Minhas, R.A., Khan, M., Ali, U., Bibi, S.S., Ahmed, B. and Awan, M.S. 2016. Conservation status of Ladakh urial (*Ovis vignei* vignei Blyth, 1841) in Gilgit Baltistan, Pakistan. *Pakistan J. Zool*., **48**: 1353-1365.

Festa-Bianchet, M., 1989. Seasonal dispersion of overlapping mountain sheep ewe groups. *J. Wildl. Manage.,* **50**: 325-330. https://doi.

org/10.2307/3801922

Fox, J.L., Nurbu, C. and Chundawat, R.S., 1991. The mountain ungulates of Ladakh, India. *Biol. Conserv.,* **58**: 167-190. https://doi.org/10.1016/0006-3207(91)90118-S

Geist, V., 1971. *Mountain sheep: A study in behavior and ecology*. University of Chicago Press, Chicago.

Khan, B., 2012. Biodiversity of Gilgit Baltistan: Potential, challenges and opportunities. *Wildl. Pak.,* **1**: 18-20.

Khan, M. and Zahler, P., 2004. Status and new records of Ladakh urial *(Ovis orientalis vegnei*) in Northern Pakistan. *Caprinae,* pp. 1-3.

Kittur, S., Sathyakumar, S. and Rawat, G.S., 2010. Assessment of spatial and habitat use overlap between Himalayan tahr and livestock in Kedarnath Wildlife Sanctuary, India. *Eur. J. Wildl. Res.,* **56**: 195-204. https://doi.org/10.1007/s10344-009-0302-3

Lydekker, R. and Dollman, J.G., 1985. *The game animals of the Indian Subcontinent*. International Books and Periodicals Supply Service, New Delhi

Mallon, D.P., 1983. The status of Ladakh urial (*Ovis orientalis vignei*) in Ladakh, India. *Biol. Conserv.,* **27**: 373-381. https://doi.org/10.1016/0006-3207(83)90091-5

Mallon, D.P., 1991. Status and conservation of large mammals in Ladakh. *Biol. Conserv.,* **56**: 101-119. https://doi.org/10.1016/0006-3207(91)90092-N

Raghavan, B. and Bhatnagar, Y.V., 2003. *Rapid Survey for the Endangered Ladakh urial* (Ovis vignei vignei) *in Leh District of Ladakh Trans-Himalaya*. Report submitted to the Wildlife Trust of India, New Delhi.

Raghavan, B., Bhatnagar, Y.V. and Qureshi, Q., 2003. *Interactions between livestock and Ladakh Urial (*Ovis vignei vignei*) in Jammu and Kashmir*. Final report submitted to the International Snow Leopard Trust.

Ranjitsinh, M.H., 1981. Himalayan fauna. In: *The Himalaya: Aspects of change* (ed. J.S. Lall). Oxford University Press, New Delhi.

Roberts, T.J., 1977. *Mammals of Pakistan*, 1st edn. Ernest Benn, London, pp. 361.

Roberts, T.J., 1997. *The mammals of Pakistan*, 2nd edn. Oxford University Press, Karachi.

Schaller, G.B., 1976. Mountain mammals in Pakistan. *Oryx,* **13**: 351-356. https://doi.org/10.1017/S0030605300014071

Schaller, G.B., 1977. *Mountain monarchs: Wild sheep and goats of the Himalayas*. University of Chicago Press, Chicago.

Schaller, G.B., 1979. *Stones of silence: Journeys in the Himalayas*. The University of Chicago Press, Chicago.

Shackleton, D.M., 1997. *Wild Sheep and Goats and their relatives*: *Status survey and conservation action plan*. IUCN/SSC Caprinae Specialist Group, IUCN, Switzerland and Cambridge, UK.

Valdez, R., 2008. *Ovis orientalis*. In: *IUCN 2013: IUCN red list of threatened species*, Version 2013.1. Available at: www.iucnredlist.org (Accessed: 02 October 2013).

Virk, A.T., Sheikh, K.M. and Marwat, A.H., 2003. *NASSD background paper: Biodiversity*. Northern Areas Programme, Gilgit, IUCN Pakistan.

Zain, O.F., 2010. A socio-political study of Gilgit Baltistan Province. *Pak. J. Soc. Sci.*, **30**: 181-190.