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PHYTOSOCIOLOGICAL ANALYSIS WITHIN THE RANGE OF GREY GORAL IN PAKISTAN AND AZAD KASHMIR

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Abstract

Phytosociological analysis of habitat, spread over some 5,000 km^2, exploited by almost half the global population of endangered Himalayan grey goral (*Naemorhedus goral*, order: Artiodactyla, sub-order: Ruminantia, family: Bovidae) was carried out using line transect method, two way ordination using TWINSPAN and Sorenson's coefficient of similarity. Study suggests a high overall species diversity (99; trees 22, shrubs 24, herbs 31, grasses 52) and in different stands (22–77). The canopy was fairly open and trees (3.80-44.42%), shrubs (6.20-68.73%) and herbs/grasses (9.89–59.54%) contributed different covers in different stands. Trees and shrubs constituted perennial layers, while herbs and grasses dry up during autumn and winter. *Pinus roxburghii* was indicator species of habitat. Most of the other species exhibited a low constancy, except *Dodonaea viscose* (77.28%), *Carissa opaca*, *Acacia modesta*, *Myrsine africana*, *Aristida cyanatha*, *Cynodon dactylon*. Eight vegetative communities were established, each having its own species composition and distributed in different tracts and shared high similarity indices. Habitat loss was not directly responsible for past population decline yet serious management and monitoring is required in the wake of expected increased grazing and wood cutting stresses.

Introduction

Habitat is a specific set of physical, biological and chemical conditions that surround an individual, a species or a community. It meets four important requirements of an animal species, i.e., food, water, shelter and space and is determined by the biological requirements of animal species. Macro- and micro-habitat selection is, thus, a reflection of the evolutionary position, body size and correlated feeding strategies of the species (Geist & Walther, 1974). Optimal habitat requirements for all the different factors are very rarely met and hence a species has to find an amicable adjustment with the existing conditions of its habitat. However, a species can not tolerate a departure in any of these biotic or abiotic conditions, if it exceeds its range of tolerance, when the condition acts as limiting factor and barrier to animal dispersal. Knowledge of habitat requirements of a species and their use is essential to enhance effective management of the species (Riney, 1982).

Ungulates modify their activity pattern (Owen-Smith, 1979), size and composition of social groups (Geist, 1967; Elsner-Schack, 1985) and feeding behaviour (Geist, 1974) in response to habitat variation and level of disturbance. Grazers, being unselective feeders, may show large groups in habitat having dominance of grasses, while browsers, being selective in feeding habit, live in smaller groups or as solitary individuals (Jarman, 1974) and hence browsers are more sensitive indicators of habitat quality than grazers (Owen-Smith, 1979; Pachlatko and Nievergelt, 1985). Grey goral is generally believed to fall between true sheep and goat has a mixed feeding habit and hence can potentially harvest herb and shrub layers.

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Almost half of the present global population of endangered Himalayan grey goral (*Naemorhedus goral*, order: Artiodactyla, sub-order: Ruminantia, family: Bovidae) survives under habitat conditions available in the area falling under territorial limits of Pakistan and the associated tracts of Azad Jammu and Kashmir (Anon., 1989). Very little is known about the type and status of goral habitat in this part of its distribution range. Habitat of this species is known from some casual remarks (Schaller, 1977; Prater, 1980; Mead, 1989; Roberts, 1997) and more careful studies conducted in protected areas (Mishra, 1993; Mishra & Johnsingh, 1996; Pendharkar, 1993; Pendharkar & Goyal, 1995; Anwar, 1989; Anwar & Chapman, 2000). Present study has designed on phytoecological analysis of wild habitat of this species, distributed over a wide area of Pakistan and Azad Kashmir (5,000 km^2 under specific goral habitat), to provide bench line information on its present status and to be used as reference point for future possible changes.

Materials and Methods

Study area: Pakistan and Azad Kashmir (24-37^{o}NL, 61-78^{o}E, 796,099 km^2, south Asia) is a land of geographic diversity, southern and eastern parts occupied by plain terrain, while mountains of varying heights are present in western and northern parts. Relatively drier mountain ranges are present in western (Hindu Kush) and northern (Karakorum) parts, while western reaches of the Great Himalayan Range run parallel but more southwardly to Karakorum. Northern Himalayan mountain ranges of Pakistan and Azad Kashmir falling at 700-2,500 m above sea line (asl) falling under administrative districts of Mardan, Buner, Kohistan, Masehra, Abbotabad, Rawalpindi and Azad Kashmir, are inhabited by the Himalayan grey goral and constitute area under study.

Most rocks are late Precambrian or early Palaeozoic, basically sedimentary giving loamy clay character, except for parts of Kohistan, which are Mesozoic and volcanic. Mountains are mostly steep to arduous with narrow valleys, generally associated with freshwater streams and lakes. Climate is temperate with four well defined seasons. Summers are harsh at lower altitudes (exceeding 40^o C in June-July) and winters at higher altitudes (touching -15^o C in December - January). Summer monsoons (July-August) are more frequent in southern and eastern parts, while winter precipitation is more in western and northern parts. Human population is very scattered in steep mountains, under goral habitat, mainly depending upon livestock grazing and subsistence farming in isolated fields.

Sampling: Fifty-one stands (tracts having relatively homogeneous phytohabitat conditions) were established over the distribution goral range (Fig. 1) and visited during spring and early summer (February-June) 2003 and 2004. Line intercept method was adopted for collection of vegetative data (Canfield, 1941). In each stand, 9-10 transects were randomly laid to include all possible microhabitat variation. Length of the 50-m long transect line touching a plant or passing through an imaginary plant canopy was recorded, along with its species. Total length of the transect line shared by plants of different species was worked out through regular pooling and percent cover of each plant species was worked out by dividing the total length occupied by each plant species by length of the transect line. Constancy appearance (number of transects having the species divided by total number of transects in stand) of each species was calculated, which was assigned one of the five constancy classes (class I= <21%, II= 2-40, III = 4-60, class IV = 61-80, V = >80: Muller-Dombois & Ellenberg, 1974). Representative specimen of each plant species were collected and identified by comparing with reference collection available at Herbarium, Quaid-i-Azam University, Islamabad, Pakistan., following the Flora of Pakistan (Nasir & Ali, 1972).

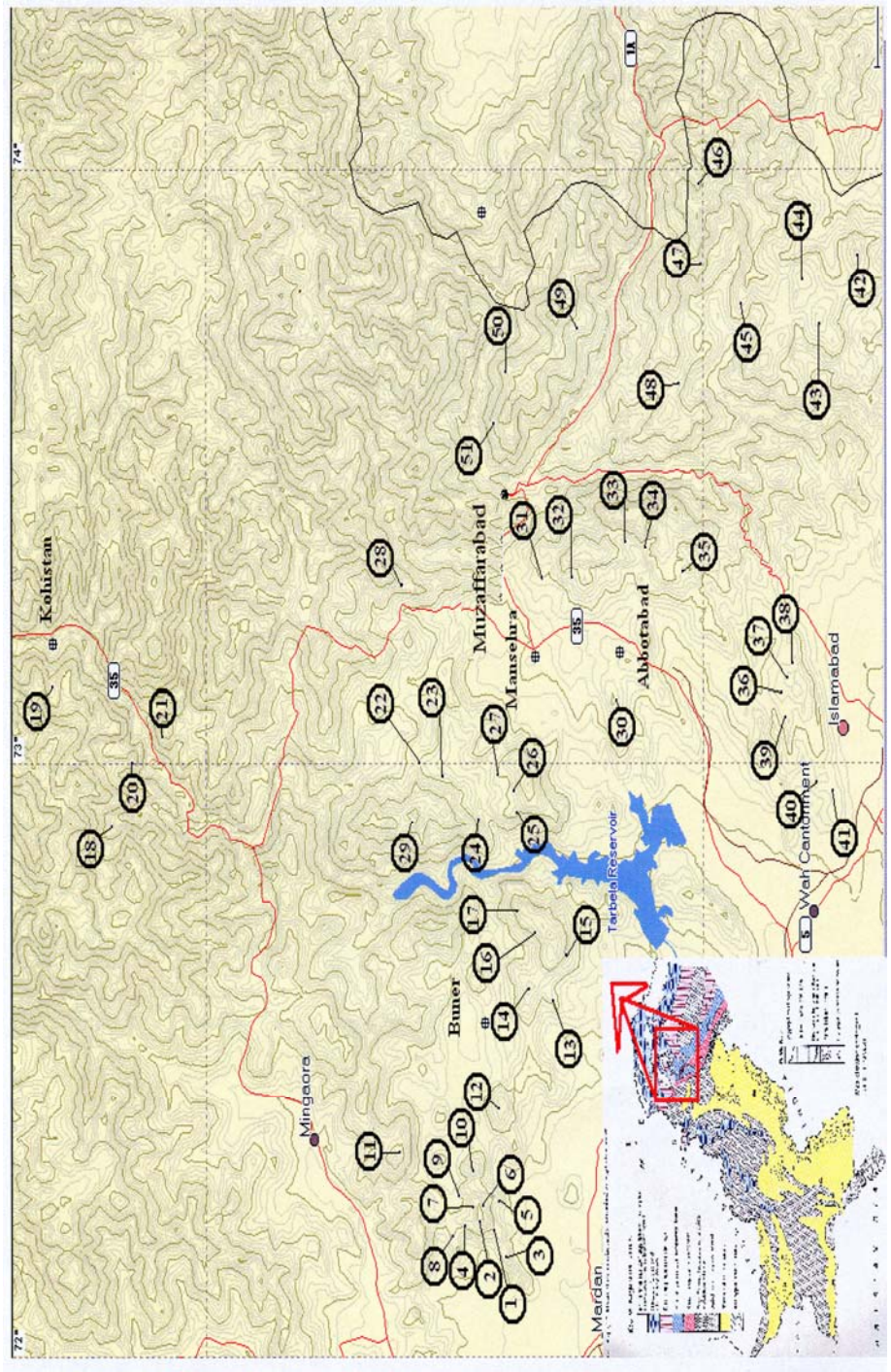

Fig. 1. The tentative locations of different stands used for the habitat studies on the grey goral.

Analysis: Data on absolute cover of 470 transect samples was analysed using two ways indicator species analysis, using TWINSPAN (a DOS based computer programme, PC version 1.21, 1992) and groups of transects having reasonable similarity in species composition were identified. Each group was recognized as a plant community and named after plant species contributing significant cover. Sorensen's coefficient of similarity (Ss) was calculated between different communities (Causton, 1988), as per formula:

$$Ss = \frac{2 \text{ X } \# \text{ common species X } 100}{\# \text{ species in community A } + \# \text{ species in community B}}$$

The similarity coefficient was used for development of community association dendrogram.

Results

General phytoecological features: Transect data on vegetative characters suggested 99 species for total goral habitat (Table 1). The number of species in different stands ranged between 22 (stand # 13) and 77 (stand # 33). Data on life forms of different species suggested that three definite vegetative layers were present. Tree layer was represented by 22 species and shrub layer by 24. Ephemeral herbs and grasses were represented by 52 species (31 herbs, 21 grasses). Trees and shrub layers were perennial, while herbs and grasses dried up during autumn and winter.

Most of species exhibited a low constancy of appearance. *Pinus roxburghii* was the most widely distributed species, which appeared in all the vegetative types (constancy class V) and appeared in 94.65% of transects. *Dodonaea viscosa* also exhibited a high constancy of appearance (77.28% of stands; class IV). Two species (*Carissa opaca* and *Acacia modesta)* shared constancy class III, and 6 others (*Myrsine africana, Aristida cyanatha, Cynodon dactylon, Themeda anathera, Grewia aptiva* and *Olea ferreuginea*) class II (21-40%), while 89 in class I (48 appeared in less than 10% of transects).

Overall cover ranged between 53.52 and 97.04% in different stands. Cover contributed by different layers also varied between stands, i.e., tree between 3.80-44.42%, shrubs 9.20-68.73%, and herbs and grasses 9.89-59.54% of the total cover.

None of the species individually claimed a very high vegetative cover in a stand. *Dodonaea viscosa* (28.79%) and *Pinus roxburghii* (25.94) are 2 species, which claimed more than 20% of cover in separate stands. For all other species cover remained below 20% and a majority of species claimed < 10% cover.

Vegetative communities: Ordination, through TWINSPAN, identified 8 vegetative communities (Fig. 2) for geographic distribution of communities) as described below:

1. *Acacia modesta* - *Dodonaea viscosa*: Association of 27 species, appearing in 6.59% (31) of transects and identified in 3 isolated stands of Mardan district located at 800 - 1750 m asl. Community had an average absolute cover of 89.97±3.21%, shared between 9 species of trees (37.42±7.19%), 3 shrubs (36.65±7.19%) and 14 herbs and grasses (28.90±3.11%).

Table 1. Vegetative cover (%) shared by different species in communities, established in the habitat of Himalayan grey goral distributed in different parts of Pakistan. *Habit: T = tree, S = shrub, H = herb, G = grass. ** numbers of communities correspond to text and stands to figure 1.

Species ↓ (Stand #)→	Habit*	Community**								Consistency (%), constancy class
		1 (2,5,8)	**2** (3,4,7)	**3** (1,3,6,9-17)	**4** (18-22,24-41)	**5** (44,47)	**6** (23,29,48-51)	**7** (46)	**8** (42)	
Pinus roxburghii	T	8.32	3.63	10.35	9.92	4.19	8.14	4.91	8.55	94.65, V
`Dodonaea viscosa	S	11.37	10.48	12.96	10.90					77.28,IV
Carissa opaca	S				5.38	6.13	6.95	2.88	1.71	50.33, III
Acacia modesta	T	12.48	10.69	8.28	3.53					44.60, III
Myrsine africana	S				6.30	0.60			1.71	39.87, III
Aristida cyanatha	H			3.15	1.20	0.60	0.33	3.55	8.55	27.62, II
Cynodon dactylon	G				0.66					27.39, II
Themeda anathera	G				2.54			0.17	0.85	25.17, II
Grewia optiva	T			0.36	0.08	2.39	4.43			24.50, II
Olea ferruginea	T	10.68	11.29		2.48					23.83, II
Monotheca buxifolia	S	3.61	0.40		1.72					20.49, I
Olea cuspidata	T	1.11			2.15					20.04, I
Rubus macilentus	S			1.08	1.70					19.15, I
Quercus incana	S	8.88	8.06	0.36	0.27					18.71, I
Chrysopogon serrulatus	G			6.57	1.78					18.71, I
Ficus palmata	S			6.48	1.18					18.71, I
Ziziphus nummularia	T				1.34	0.90	4.96			18.71, I
Arthraxon prionodes	G	1.25	3.23	0.02	0.06	6.13	4.17	1.52	4.27	18.48, I
Acer caesium (maple)	T				2.08					18.26, I
Brachypodium sylvaticum	G	1.25				5.98	6.82	3.38	8.55	18.04, I
Quercus baloot	T				2.48					18.04, I
Poa nemoralis	G				1.74					18.04, I
Arabidopsis thaliana	H	0.55				5.98	6.09	2.20	1.71	17.59, I

Table 1. (Cont'd.).

Species ↓ (Stand #)→	Habit*	Community**								Consistency (%), constancy class
		1 (2,5,8)	**2** (3,4,7)	**3** (1,3,6,9-17)	**4** (18-22,24-41)	**5** (44,47)	**6** (23,29,48-51)	**7** (46)	**8** (42)	
Agrostis stolonifera	G	1.11	3.02		0.05	5.83	3.31	1.69	4.27	17.37, I
Punica granatum	T				1.64		0.19			16.48, I
Bramia monnieri	H					4.63	6.88	5.58	1.71	16.26, I
Daphne oleoides	S			0.72	0.58	4.33	2.58			15.81, I
Cedrus deodara	T				2.43					15.59, I
Koeleria gracilis	H				0.03	3.74	6.88	6.09	1.71	15.59, I
Digitaria setigera	G				1.45					15.14, I
Ficus bengalensis	T					2.84	7.15	5.92	1.71	15.14, I
Kickxia ramosissima	H		0.20			4.63	5.36	4.91	6.84	13.81, I
Indigofera trifoliata	H			2.43						13.59, I
Juglans regia	T				2.45					13.59, I
Rumex hastatus	H				2.10			0.17	0.85	13.59, I
Kauser booty	H			9.18	0.13					13.26, I
Mallotus philippensis	S	5.69	9.48		0.66					12.92, I
Aesculus indica	T	0.14			1.48					12.69, I
Stipa sibirica	H		0.81				4.04	22.67	3.42	12.69, I
Chrysopogon aucheri	G				1.26					12.47, I
Ziziphus jujube	T	0.69	6.45	5.22						11.80, I
Morus alba	T				2.04		0.13			11.80, I
Sarcococca saligna	S				1.01					11.80, I
Digtaria ciliaris	G				0.98					11.58, I
Ranunculus arvensis	H				0.33	0.45	1.72			11.58, I
Ranunculus lactus	H					3.44	1.72	5.92	1.71	11.58, I
Heteropogon contortus	G				1.78					10.91, I

Table 1. (Cont'd.).

Species ↓ (Stand #)→	Habit*	Community**								Consistency (%), constancy class
		1 (2,5,8)	**2** (3,4,7)	**3** (1,3,6,9-17)	**4** (18-22,24-41)	**5** (44,47)	**6** (23,29,48-51)	**7** (46)	**8** (42)	
Poa pratensis	G				0.95	2.24			1.71	10.91, I
Cannabis sativa	H			5.22	0.17					10.69, I
Quercus dilatata	T				1.17					10.69, I
Polygonum aviculare	H	0.55			0.02		4.24	6.09	1.71	10.47, I
Solanum surattense	H		0.81			2.39	3.04	0.17	0.85	10.24, I
Dalbergia sissoo	T	6.93	8.87		0.01					10.02, I
Mentha longifolia	H			2.61	0.28					9.35, I
Gymnosporia royleana	S				0.62	0.60	0.53		1.71	9.35, I
Digitaria decumbens	G				1.18					9.13, I
Sorbaria tomentosa	S					3.74	3.57			9.13, I
Daphne mucronata	S		0.60		1.18					8.91, I
Chrysopogon echinulatus	G	7.91	2.82							8.69, I
Diospyros lotus	T	0.28			0.84	0.45	0.07			8.46, I
Saccharum rufipilum	G			0.99	1.10					8.91, I
Plantago lanceolata	H			5.67						8.46, I
Rubus fruticosus	S			4.41	0.06					8.46, I
Duchesnea indica	H			0.54	0.08	0.60	1.59			8.46, I
Berberis lycium	S				1.03	0.60		0.34		8.46, I
Valeriana stracheyi	H	0.69	0.40	0.01		4.04	0.26	1.69	4.27	8.46, I
Bauhinia variegata	T	0.97	8.06		0.69					8.24, I
Euphorbia helioscopia	H			3.15	0.25					8.02, I
Nasturtium officinale	H			0.99	0.55					8.02, I
Brachiaria ramosa	G	1.39				4.93		5.58	1.71	7.80, I
Veronica undulata	H				0.14	2.69		2.03	3.42	7.80, I

Table 1. (Cont'd.).

Species ↓ (Stand #)→	Habit*	Community**								Consistency (%), constancy class
		1 (2,5,8)	**2** (3,4,7)	**3** (1,3,6,9-17)	**4** (18-22,24-41)	**5** (44,47)	**6** (23,29,48-51)	**7** (46)	**8** (42)	
Poa araratica	G					4.04	0.79	3.55	8.55	7.80, I
Justicia adhatoda	S			2.07	2.87					7.13, I
Poa supina	G				0.14	3.44	1.92		1.71	7.13, I
Apluda mutica	G			0.81	0.35					6.90, I
Jasminum humile	S				0.63	0.60				6.68, I
Pinus wallichiana	T				0.49	0.30				6.68, I
Myosotis asiatica	H	9.29								6.01, I
Carthamus oxyacantha	H	1.11	5.65			0.60			1.71	6.01, I
Woodfordia fruticosa	S				0.36		0.26	0.17	0.85	6.01, I
Dichanthium annulatum	G	1.11	0.40			0.60	0.13	0.34		5.79, I
Cassia alata	S				0.62					5.79, I
Eulaliopsis binata	H				0.39					5.79, I
Buxus sempervirens	S				0.77					5.70, I
Thalictrum alpinum	H	1.11	0.81			2.39	0.26	1.86	0.85	5.56, I
Rosa brunonii	S				0.39					5.34, I
Polygonum barbatum	H			2.97						5.12, I
Poa spp.	H			2.61						5.12, I
Acacia nilotica	T				0.52					5.12, I
Eriophorum comosum	G	0.97	0.40			2.54	7	1.69	4.27	4.90, I
Flacourtia ramontchi	S				0.47					4.68, I
Aerua sanguinilenta	H		0.60		0.11	0.45	0.66	0.34		4.23, I
Rubus ellipticus	S				0.44					4.23, I
Agrostis canina	H	1.11	2.82							3.79, I
Daphne oleoides,	S							4.57	8.55	3.11, I
Cephalanthera longifolia	H				0.44					4.90, I
Euphorbia philippensis	H				0.32		0.33			2.00, I
Celtis australis	T			0.72						1.78, I

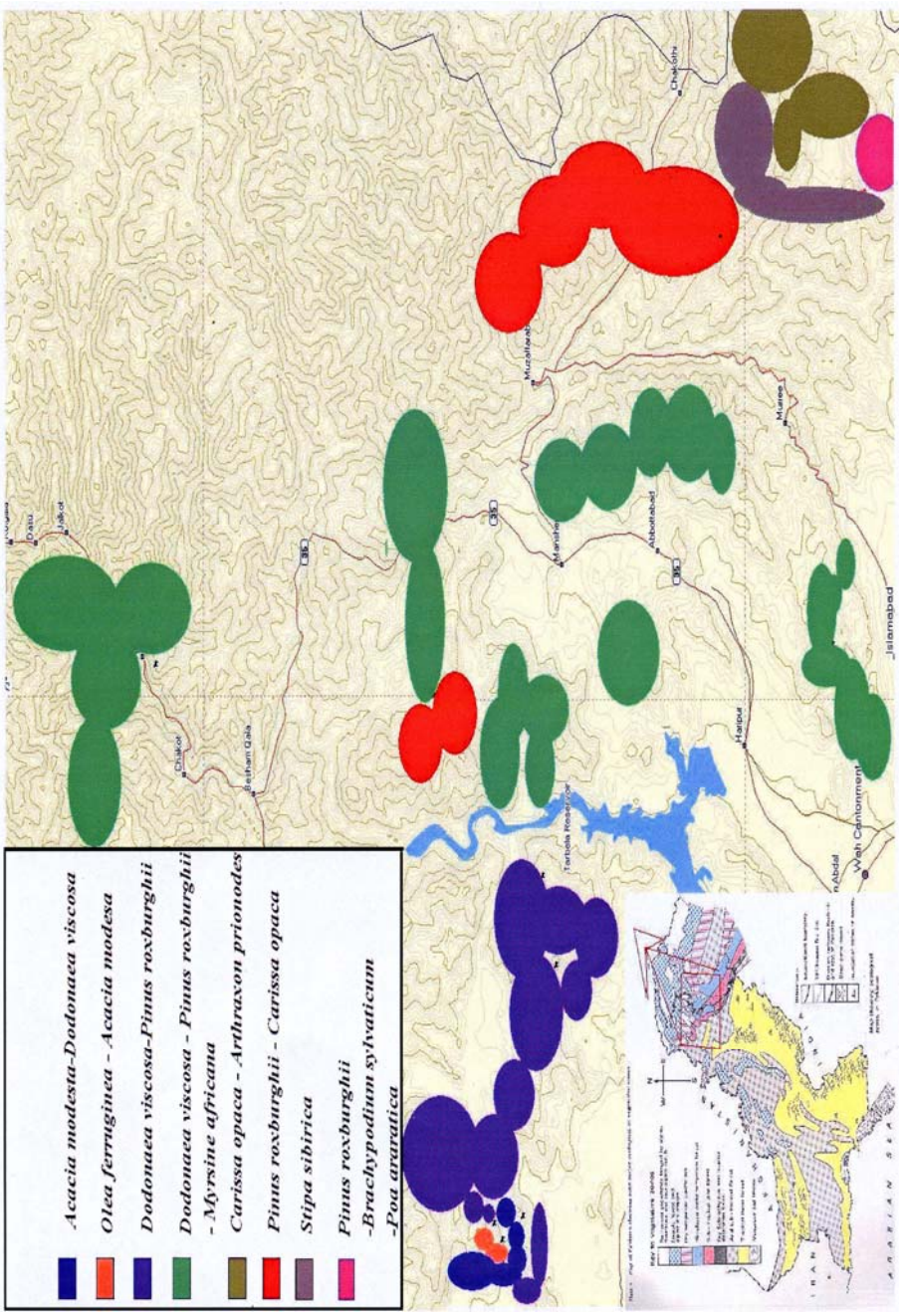

Fig. 2. Distribution of plant communities in the habitat of grey goral in study area.

2. *Olea ferruginea-Acacia modesta*: Association of 24 species appearing in 4.26% (20) transects in 3 isolated stands of Mardan district (650-11800 m asl), having an average absolute cover of 71.99±3.35%, shared between 6 trees (23.93±3.79%), 4 shrubs (25.51±2.31%) and 13 herbs and grasses (22.55±2.26%) species.

3. *Dodonaea viscose-Pinus roxburghii*: Community presented an association of 27 species, appearing in 15.11% (79) of transects having a comparatively wider distribution over a fairly continuous tract of Mardan and Buner districts 700 – 2600 m asl. Community held an average absolute cover of 85.08±7.34%, shared between 5 species of trees (40.84±3.45%), 7 shrubs (29.5±6.5%) and 16 herbs and grasses (14.73±4.28%).

4. *Dodonaea viscosa-Pinus roxburghii-Myrsine africana*: Community has been identified in 50.63% (238) of transects, showing a very wide and fairly continuous distribution (23 stands) at 800-2600 m asl from some part of Mardan but mainly from Buner district. Community presented an association of 73 species, with an average absolute cover of 85.6±1.82%, shared by 19 species of trees (33.12±2.15%), 21 shrubs (29.99±3.44%) and 33 herbs and grasses (22.56±1.44%).

5. *Carissa opaca-Arthraxon prionodes*: An association of 36 species, appearing in 4.04% (19) transects, represented community which appeared in 3 stands located in southern parts of Azad Kashmir at 1200 - 3000 m asl. Average absolute community cover of 82.62±0.29% was shared between 6 species of trees (9.30±2.55%), 7 shrubs (28.19±6.93%) and 23 herbs and grasses (45.12±9.11%).

6. *Pinus roxburghii-Carissa opaca*: Community presented association of 34 species, appearing in 12.76% (60) transects in 6 stands distributed over a wide and almost continuous tract in eastern flank of Mansehra and central parts of the Azad Kashmir at 1100-3000 m asl. The community had an average absolute cover of 84.10±2.15%, shared between 7 species of trees (17.15±6.60%), 5 shrubs (22.65±3.01%) and 22 herbs and grasses (44.30±7.00%).

7. *Stipa sibirica*: Community represented an association of 29 species, appearing in only 3.40% (16) of transects distributed in 2 isolated tracts of south-eastern parts of Azad Kashmir at 1300-2600 m asl. Community held an average absolute cover of 75.64±2.51%, distributed between 2 species of trees (6.5±2.7%), 5 shrubs (16.34±2.55%) and 22 herbs and grasses (52.80±2.75%).

8. *Pinusroxburghii-Brachypodium sylvaticum-Poa araratica*: Community presented an association of 31 species, appearing in very few (7, 1.48%) transects. It was identified from a single isolated stands present in the south-eastern parts of goral distribution range in Azad Kashmir, at 1100 - 2000 m asl and had an average absolute cover of 89.57%, shared by 2 species of trees (13.77%), 6 shrubs (20.49%) and 23 herbs and grasses (55.31%).

Community association: Association dendrogram developed from similarity index between different communities and TWINSPAN ordination (Fig. 3) suggested that all communities shared *Pinus roxburghii*, which was regarded as an indicator of the goral habitat. Total habitat was divided into 2 sub-types, each consisting of a group of 4 communities, sharing an association index of 31.15%. *Qurecus incana* worked as indicator species for this primary bifurcation. Indicator species was present in 14 stands located in comparatively eastern parts, while 37 stands, present in the western parts, did not hold the species.

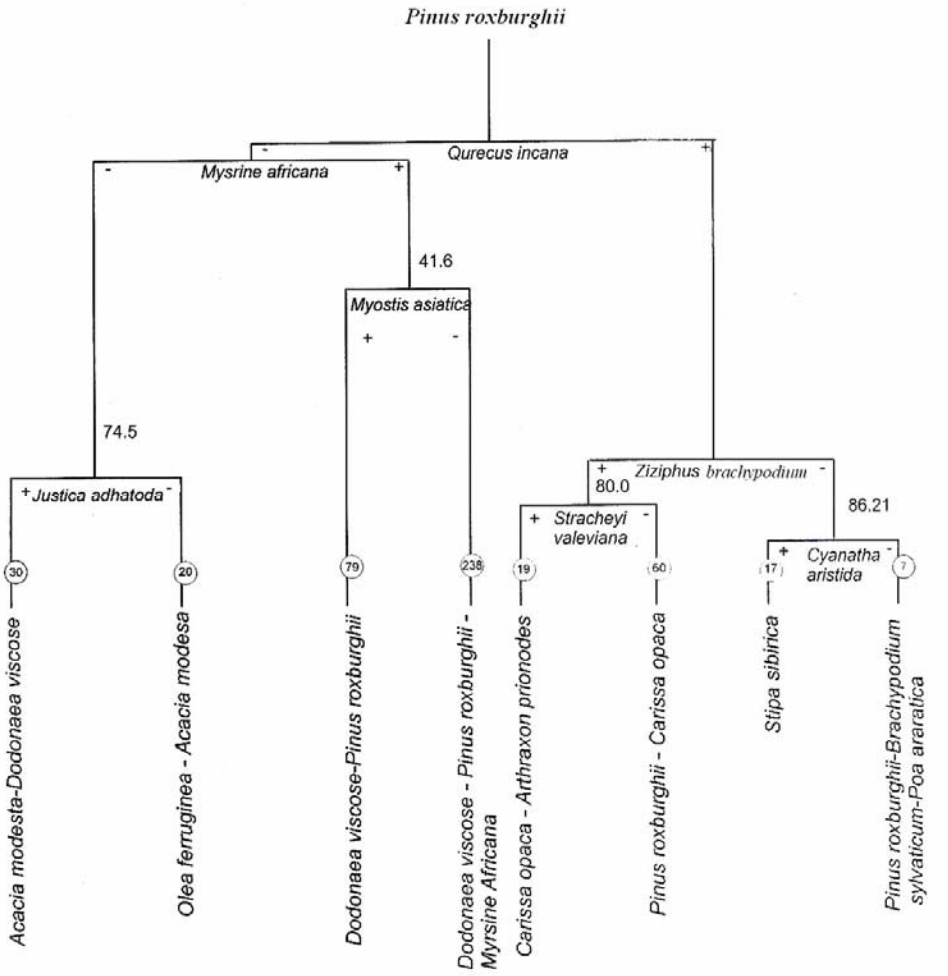

Fig. 3. Association dendrogram of the plant communities identified through TWINSPAN analysis in the grey goral habitat in Pakistan.

Sub-type sharing *Q. incana* was bifurcated into 2 groups, where *Ziziphus brachypodium* acted as an indicator species and shared a similarity index of 77.23%. Indicator species was present in 2 communities, distributed towards northern parts of distribution range of sub-type. *Valeriana stracheyi* was present in *Carissa opaca-Arthraxon prionoides* community, while indicator species was absent from *Pinus roxburghii-Carissa opaca* community, and shared an association of 80.0%. Community group with no representation of *Z. brachypodium* was separated on the basis of *Aristida cyanatha*, to separate 2 communities. *Stipa sibirica* community held indicator species and was distributed towards northern margin, while *Daphne oleoides-Poa supine-Pinus roxburghii* community did not hold indicator species and was represented by a single stand, located in south-eastern extremity of goral habitat. Two communities shared a very high similarity of 86.21%.

Sub-type not holding *Q. incana* was further bifurcated on the basis of distribution of *Mysrine africana*. Two groups, thus created, shared a relatively low similarity index (32.14%). Group of 5 stands located towards western parts did not hold indicator species, while other group of 32 stands did hold indicator species. Stands not holding *M. africana* was separated into two communities on the basis of *Justica adhatoda*. *Acacia modesta-Dodonaea viscosa* community held indicator species, while *Olea ferruginu-Acacia modesta* community was without the species. Two communities shared a high similarity index of 74.50%. Group of 2 communities holding *M. africana* was separated on the basis of distribution of *Myostis asiatica*. Two communities shared relatively low association index (41.6%). *Dodonaea viscosa-Pinus roxburghii* community was distributed over a wider tract (12 stands). *Dodonaea viscosa-Pinus roxbughii-Myrsine africana* community did not hold the indicator species and was distributed over a very wide tract (23 stands, 45%) in central and northern parts.

Discussion

Very few detailed studies are available on phyto-sociological analysis in habitat of Himalayan grey goral. Vegetative habitat essentially provides food to herbivores, like goral, and partly shelter, along with physical obstacles (Etchberger *et al*., 1989). It also governs size and composition of social groups and the activity pattern of animal species (Geist, 1974; Elsner-Schack, 1985). Knowing habitat requirements of a species and their relative exploitation is essential to enhance the human potentials for the effective management of the species (Riney, 1982; Pachlatko & Nievergelt, 1985).

General habitat of goral, in India, has been variously described through casual sighting records on species in certain tract/ tracts. Based upon such records goral is believed to be a cliff dweller (Schaller, 1977; Green, 1987; Heptner *et al*., 1989; Mead, 1989; Cavallini, 1992; Lovari & Apollonio, 1993) with a distribution range falling between temperate forests and Alpine pastures (Green, 1987), including tropical moist deciduous, pine subtropical forests and wet temperate and evergreen forests (Prater, 1965; Dang, 1968; Schaller, 1977; Green, 1981, 1987). Some detailed analysis of habitat of Himalayan grey goral has been conducted over 39 km^2 tract, falling under Majhatal Harsang Wildlife Sanctuary, India, using layer by layer analysis through quadrat sampling (Mishra, 1993; Mishra & Johnsingh 1996) through general visual impression carried about vegetative density and characters in different sampling areas; over 27.5 km^2 in Simbalbara Sanctuary, India (Pendharkar, 1993) and for 126 km^2 in Margalla Hills National Park, Pakistan (Anwar, 1989; Anwar & Chapman 2000). The present study appears to the first attempt towards a more detailed phytosociological analysis carried out in habitat of gorals over a wider area, spreading over 4,839 km^2 of potential habitat, distributed in Pakistan and Azad Jammu and Kashmir, using 470 transect samples collected from 51 stands. Study, however, has remained limited to the summer months and in years of comparatively higher precipitation. Further studies, carried out in other parts of year and in years having lower precipitation, may help in further understanding of habitat variability, available to this ungulate in area under present study.

Diversity: Present study suggests presence of a minimum of 98 plant species, which are distributed in different compositions in different areas under specific habitat of grey goral in Pakistan, indicating a reasonably good vegetative diversity. This diversity is equally reflected in trees (22 species), shrubs (24), herbs (31) and grasses (21). Two other studies

recorded 134 (54 tree, 44 shrub, 7 herb, 19 grass, 9 climber, 6 others) species from Simbalbara Sanctuary, India (Pendharkar, 1993) and 23 (5 tree, 13 shrubs, 5 grasses) for Margalla Hills National Park, Pakistan (Anwar, 1989). Present study has recorded 37 species from Goral habitat in Margalla Hills, attributable to a better sampling. Species diversity is expected to increase while moving towards eastern parts of Himalayan range, attributable to increasing precipitation and hence a higher diversity is expected for Simbalbara Sanctuary.

Stratification: Goral habitat has 3 well defined and regularly appearing vegetative layers, i.e., tree, shrub, herbs (and gasses), appearing in different combinations in different areas. Trees provide an open canopy, the cover ranging between 3.50 and 44.42% in different stands. Trees and shrubs are perennials and are available throughout the year, while herbs and grasses layer is provided by ephemerals, which mainly sprout in spring and/or monsoons and are almost dry during winter. No direct information is available on vegetative stratification in goral habitat, yet presence of herbs, shrubs and trees in lists of plant species, identified from goral habitat by Pendharkar (1993) and Anwar (1989) reflect presence of 3 well defined layers. Present findings go in partial conformity with Roberts (1997) suggesting that goral habitat has an open canopy. Grey goral has though been reported from the vegetation types having a close canopy, yet it appears to avoid such forests (Pendharkar, 1993).

Constancy: Majority of plant species appearing in goral habitat have a low constancy of appearance. Only one species (*Pinus roxbughii*) claims 94.65% constancy, and has appeared in all stands. *Dodonaea viscosa* is other species exhibiting a high (77.21%) constancy. Only 2 species (*Carissa opaca* and *Acacia modesta*) have shown 41-60% constancy, while another 6 appeared in 21-40% constancy class. Low constancy of appearance of most species indicates variability in vegetative habitat conditions in different parts of its distribution range. No comparative study is available on this aspect of grey goral habitat, but this suggests versatility in habitat and its potentials to maintain itself under future odds. Versatility of habitat is further supported through presence of a higher number of species (minimum 22, maximum 77) in a stand. Vegetative diversity and cover are directly correlated with precipitation and hence high level of species diversity is expected for this area, receiving moderate precipitation, yet vegetation remains under stress as precipitation is mainly received during monsoons.

Pinus roxburghii has appeared as an indicator species for goral habitat. Species has been previously associated with goral habitat in Pakistan by Roberts (1997) and in two previous studies on vegetative analysis of goral habitat (Anwar, 1989; Pendharker, 1993).

Cover: All stands share a common character of having a good vegetative cover (53.52 - 97.04%). Herbs and grasses contribute 9.81-59.54% of cover and major part of this cover is available for direct exploitation of goral during a sufficient part of year. This layer not only contributes a part to goral food, but can also ensure availability of chemical nutrients to other part of vegetative community through biogeochemical cycle. Shrubs layer, providing 9.20-68.78% cover, ensures year long availability of food and shelter for this human shy relatively small ungulate. Only other study which records absolute cover present in grey goral habitat (Anwar, 1989) suggests a vegetative cover of 29.66% (tree 6.11%, shrubs 9.46%, herbs 14.09%) for Margalla Hills National Park, Pakistan, which appears to fall short of that suggested by present study.

Vegetative Communities: Vegetative communities under the present study have been established on the basis of absolute/ relative vegetative cover, occupied by different plant species. This is a slight deviation from generally followed technique of establishing plant communities on importance value of species, giving equal importance to cover, density and constancy of appearance (Curtis & McIntosh, 1950). Basing communities on importance value is not very relevant, when phytosociological analysis of vegetative habitat of an animal species is attempted. It is only the vegetative cover, contributed by plants species, irrespective of density and constancy, which is exploited by animals for meeting its two basic requirements, i.e., food and shelter. Cover has been previously used in establishment of vegetative communities in studies on animal ecology (Goriup, 1983; Collins, 1983; Mian, 2003).

Present report appears to be the only report attempting a detailed community analysis based upon quantified data on distribution of cover, collected from 470 line transects in the area, holding almost half of the present global population of the species. Communities have been established through collection visual data on relative distribution of plants species (Pendharker, 1993; Mishra, 1993) or on cover, relative cover and relative frequencies of the plant species present in the goral habitat (Anwar, 1989; Anwar & Chapman, 2000).

Present phytosociological analysis has identified 8 plant communities distributed in habitat of Himalayan grey goral in Pakistan and Azad Kashmir. Two studies carried out in protected areas of India have identified 9 (Pendharkar, 1993) and 7 (Mishra, 1993) vegetative communities from goral habitat. Direct comparison of results of these studies with present one is difficult, as per difference in methods adopted for establishment of communities.

There is a pattern in distribution of different communities in area under present study. *Dodonaea viscosa–Pinus roxburghii–Myrsine africana* community is most widely distributed in central belt of goral range and persists in areas receiving moderate precipitation. *Dodonaea viscosa-Pinus roxburghii* is other community which runs over a fairly continuous area in western reaches of goral distribution. Two other communities i.e., *Acacia modesta-Dodonaea viscosa* and *Olea ferruginea-Acacia modesta*, have limited distribution in small patches present in extreme western parts. *Pinus roxburghii-Carissa opaca* is present in two isolated localities, a smaller patch in central tract along *Dodonaea viscose-Pinus roxburghii-Myrsine africana* community, while major part of this community is present over a rather continuous tract in eastern parts. Three other communities i.e., *Stipa sibirica, Carissa opaca-Arthaxon prionodes* and *Pinus roxburghii-Brachypodium sylvaticum-Poa araratica*, are present in limited tracts in extreme south-eastern parts of goral range.

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