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Phytosociological study on *Isodon rugosus* dominated communities in Khwazakhela district Swat, KPK, Pakistan

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Key words: *Isodon rugosus*, Phytosociology, Environmental variables, Ward's cluster analysis, NMS Ordination

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Abstract

The present study aimed to investigate the status of *Isodon rugosus* dominated communities in Khwazakhela swat. Various phytosociological attributes of all the recorded species were obtained. For quantitative analysis of vegetation a 4x4 m^2 quadrat was used and a total of ten stands were sampled. Five quadrats were taken randomly per stand. Descriptive information such as altitude and aspect of the sampling site were recorded. For classification and ordination of vegetation data Ward's Cluster Analysis and NMS (Non-metric Multidimensional Scaling) ordination was applied using PC-Ord software which results into the formation of four communities groups at 50% remaining information of the species. The highest values IVI, density/ha and cover/ha of *Isodon rugosus* was recorded in communities' group I while lowest value of IVI, density/ha and cover /ha was recorded in community group 3 which is due to the anthropogenic disturbance as observed during field survey.

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Introduction

Isodon rugosus is an aromatic branched shrub of Lamiaceae family. Its leaves are opposite ovate having notched margin and covered with dense small hairs on ventral side. This species is distributed throughout the northern region. The flowering period of this species is July to September and seeds ripening occur from august to October (Nasir and Ali, 1972).

Isodon rugosus is medicinally and ecologically an important plant species and locally use for the treatment of different types of diseases such as antiseptic, germicidal and cardiac stimulant (Singh, 1994). In Pakistan this species is locally used for toothache hypoglycemic, antdiarrheal bronchodilator fever (Ajmal *et al*., 2012), hypertension (Akhtar *et al*., 2013), antifungal (Rauf *et al*., 2012), antibacterial, phytotoxic (Rauf *et al*., 2012) as well as antioxidant (Janbaz *et al*., 2014). Besides various medicinal properties, it is also used for phytoremediation (Muhammad *et al*., 2013) of heavy metals polluted soil.

Plants association may be defined as stable plants groups in equilibrium with surrounding environment characterized by a certain dominant species which revealed a particular ecology. The presence of dominant species represents major trends in the local vegetation of an area and allowed ecologist to evaluate plants communities' dynamics (Barkatullah, 2012). Beside the soil chemical composition, topography, climatic condition, elevation man-made disturbance also exert a great impact on the distribution and reshaping of plants communities (Cousin and Eriksson, 2002; Chuangye *et al*., 2009). Unfortunately due to climatic fluctuation, high pressure of overgrazing animals, fodder demands for livestock, medicinal value and cutting for burning purposes the population of this medicinally and ecologically important species decreasing at an alarming rate in the area.

Different researchers conducted information on the Phytosociology of vegetation communities using advance multivariate analysis (Khan *et al.,* 2013) While, the data is mostly conducted on the overall vegetation or either on single tree species but less information's are available on the Phytosociology of shrubs species (Shariatullah, 2013; Ahmad *et al.,* 2016) though there is not found any information on the exploration of *Isodon rugosus* dominated communities in the published literature. Therefore in the present study an attempt was made to investigate the communities' structure and natural dynamics of *Isodon rugosus* in relation to environmental variables in Khwazakhela Upper Swat, Khyber Pakhtunkhwa, Pakistan.

Materials and methods

Study Area

Khwazakhela is the administrative subdivision of District Swat. It is situated in South East of Mingora at a distance of 23 Km. It contains seven wards, and further sub wards and union counsels. Climate of the study area is variable; the area is very cold in winter and pleasant in summer season. The study area is diverse in vegetation and home to several medicinally and ecologically important plants species.

Field Survey

In the spring of 2015, regular trips were arranged for sampling of *Isodon rugosus* dominated communities in Khwazakhela Upper Swat. The visited areas are Taroogay (St. 1), Toopsin (St. 2), Baboo (St. 3), Shalpin (St. 4), Chinkolai (St. 5), Shin Binkat (St. 6), Fatehpur (St. 7), Kotanai (St. 8), Doob (St. 9) and Jano (St. 10). Standard procedure was applied for sampling of communities following (Cottom and Curtis 1965).

Data Collection

Data was collected using a 4m x 4m quadrate and 5 quadrates were placed per stand. Inside each quadrate cover of individuals of every species was measured in cm and their number of individuals was counted. Elevation and aspect of the sampling site was also noted. The collected species were identified with the help of Flora of Pakistan (Nasir and Ali, 1972) and their dried specimens were deposited in the Herbarium University of Malak and.

Data Analysis

The data obtained were analyzed for phytosociological attributes (frequency, relative frequency (F3), density, relative density (D3), cover, relative cover (C3) and Importance values (IVI) following Mueller-Dombois and Ellenberg, 1974; Curtis and McIntosh, 1950).

Statistical analysis

The IVI data of the recorded species correspond to environmental variables was subjected to PC-Ord (version 5.10) for classification (Ward's Cluster Analysis and NMS ordination) which results into the formation of four vegetation association.

Results

Classification of vegetation (Ward's Cluster Analysis)

The Wards cluster analysis separate the data in to various clusters and four distinct plants communities are made at 50% remaining information of the species (Fig.1). The distribution of species in the sampled stands is shown in the two way cluster Dendrogram (Fig: 2). Based on the IVI mean values of the species the detail of resulted communities is summarized below.

Table 1. IVI mean values of *Isodon rugosus* and associated species.

Species	G 1			G 2			G 3			G 4		
	Mean	±	SE	Mean	±	SE	Mean	±	SE	Mean	±	SE
Acacia modesta Wall	2.4	±	0.1	3	±	0.6	0.8	±	0	2.3	±	0
Achyranthes bidentata Blume	0	±	0	0.5	±	0.5	0	±	0	0	±	0
Ailanthus altissima (Mill) Swingle	2	±	0.7	1.2	±	0.5	0	±	0	0	±	0
Ajuga bracteosa Wall. ex Benth.	1.2	±	0.6	0.3	±	0.3	0	±	0	0	±	0
Ajuga parviflora Benth.	0	±	0	2.1	±	0.5	0	±	0	0	±	0
Alnus nitida Endl.	0.5	±	0.5	0	±	0	0	±	0	0	±	0
Androsace baltistanica Y. Nasir	0	±	0	0.2	±	0.2	0	±	0	0	±	0
Artemisia scoparia Wildest. & Kit.	0.6	±	0.6	0.4	±	0.4	0	±	0	0	±	0
Asparagus gracilis Royle ex Baker	0.4	±	0.4	0	±	0	0	±	0	0	±	0
Asparagus officinalis L.	4.1	±	4.1	0	±	0	0	±	0	0	±	0
Astragalus graveolens Buch.-Ham.	0	±	0	2.6	±	2.6	0	±	0	0	±	0
Avena sativa L.	5.5	±	1.1	6.3	±	1.1	0	±	0	2.1	±	0
Berberis lyceum Royle.	5.6	±	2.4	9.4	±	1.4	12.7	±	0	4.4	±	0
Calendula arvensis L.	0	±	0	0.7	±	0.5	2	±	0	1.8	±	0
Calotropis procera (Wild) R.Br.	0	±	0	0.4	±	0.3	1.1	±	0	1.2	±	0
Cannabis sativa L.	0	±	0	0.3	±	0.3	0	±	0	0	±	0
Carbenia benedicta (L) Benth. Hk	0	±	0	0.2	±	0.2	0	±	0	0	±	0
Celtis australis L.	0	±	0	0.4	±	0.2	0	±	0	0	±	0
Chenopodium botrys L	0	±	0	0.8	±	0.8	0	±	0	13	±	0
Cirsium arvense (L.) Scop.	0	S	0	0.7	±	0.7	1.1	±	0	0	±	0
Clematis connate	0	±	0	0.4	±	0.3	0	±	0	0	±	0
Coix lachryma L.	1.1	±	0.2	0.7	±	0.4	0	±	0	0	±	0
Cotinus coggygria Scop.	0	±	0	0	±	0	0	±	0	7.4	±	0
Cynanchum arnottianum Wight.	0	±	0	0.4	±	0.4	0	±	0	0	±	0
Daphne mucronata Royle.	1.2	±	0.7	3	±	3	1.1	±	0	0	±	0
Debregeasia salicifolia (D. Don) Rendle	1.3	±	1.3	0	±	0	0	±	0	0	±	0
Delphinium vestitum Wall	0.5	±	0.5	0	±	0	0	±	0	0	±	0
Dodonaea viscosa (L.) Jacq.	0	±	0	0	±	0	0	±	0	2.4	±	0
Daphne papyracea Wall, ex steud.	0	±	0	0.3	±	0.3	0	±	0	0	±	0
Echinops echinatus Roxb.	0	±	0	0	±	0	2.1	±	0	0	±	0
Ficus carica L.	0.6	±	0.6	1.8	±	0.4	0.7	±	0	0.8	±	0
Fragaria vesca L.	1.4	±	0.5	2.3	±	0.6	2.1	±	0	0	±	0
Hedera nepalensis K. Koch	1.1	±	1.1	0.5	±	0.3	0.7	±	0	0	±	0
Hypericum patulum	0	±	0	0.2	±	0.2	0	±	0	0	±	0

Incarvillea emodi	0.3	±	0.3	0	±	0	0	±	0	0	±	0
Inula grandiflora Willd.	3.2	±	0.8	4.2	±	0.3	1.2	±	0	3.8	±	0
Isodon rugosus Wall. ex Benth.	18.3	±	1.9	17	±	1.9	16.1	±	0	16.9	±	0
Jasminium humlie L.	1.6	±	1.2	0	±	0	1.9	±	0	0	±	0
Maytenus royleanus (Wall. ex Lawson)	0	±	0	0	±	0	0	±	0	1.3	±	0
Maytenus wallichiana	0.5	±	0.5	0	±	0	0	±	0	0	±	0
Medicago sativa L	1.1	±	0.5	0.9	±	0.6	2	±	0	0	±	0
Mentha longifolia L.	0.3	±	0.3	0	±	0	0	±	0	0	±	0
Mentha spicata L.	0.6	±	0.3	0.7	±	0.5	0	±	0	0	±	0
Micromeria biflora (Ham.) Benth.	4.1	±	0.3	4.2	±	0.9	4.3	±	0	6.4	±	0
Morus alba L.	0	±	0	0.2	±	0.2	0	±	0	1.1	±	0
Myrsine africana L.	0	±	0	0.2	±	0.2	0	±	0	3.9	±	0
Olea ferruginea Royle	1.3	±	0.7	3.2	±	0.4	4.1	±	0	2.8	±	0
Oxalis corniculata L.	1.1	±	0.6	2.1	±	0.7	1.2	±	0	0	±	0
Parthenium hysterophorus L.	0.3	±	0.3	0.2	±	0.2	0	±	0	0	±	0
Pimpinella stewartii Dunn. Nasir.	0.4	±	0.4	0	±	0	0	±	0	0	±	0
Pinus roxburghii Sargent.	0	±	0	1.9	±	0.9	1.1	±	0	0	±	0
Plantago major L.	3.4	±	2.4	0.8	±	0.6	2.3	±	0	4.4	±	0
Quercu sbaloot griff.	0	±	0	0.1	±	0.1	0.7	±	0	0	±	0
Robus fruticosus L.	1.9	±	0.3	4.7	±	1.5	4.4	±	0	5.1	±	0
Rubus sanctus	0	±	0	0.4	±	0.4	0	±	0	0	±	0
Rumex dentatus L.	2.1	±	1.2	0.9	±	0.1	0.6	±	0	1.1	±	0
Rumex hastatus D. Don	9.6	±	1	2.3	±	0.7	3.3	±	0	0	±	0
Salvia moorcroftiana Wall. ex Benth.	1.2	±	0.6	0.9	±	0.5	1.2	±	0	2.1	±	0
Tagetes minuta L.	2.6	±	0.9	0.8	±	0.3	3.1	±	0	1.3	±	0
Taraxacum officinale Web.	0.9	±	0.5	0	±	0	1.6	±	0	1.6	±	0
Verbascum thapsus L.	0.6	±	0.6	1.8	±	0.6	1.2	±	0	1.1	±	0
Verbena officinalis L.	0.2	±	0.2	0.2	±	0.2		±	0	0	±	0
Vicia sativa L.	2	±	1.1	2.5	±	0.3	2.3	±	0	0	±	0
Zanthoxylum armatum DC.	0	±	0	2.2	±	1	2.8	±	0	1.7	±	0

Isodon rugosus-Rumex hastatus community

This group consists of 39 species in which the leading dominant species is *Isodon rugosus* (18.3%) while the co-dominant specie is *Rumex hastatus* (9.6%). Among the other species, the IVI of Berberis *lyceum* was (9.6%), *Avana sativa* (5.5%), *Carbenia benedicta* (4.1%), *Micromeria biflora* (4.1%), *Plantago Major* (3.4%), *Indegofera geradiana* (3.2%), *Tagetes minuta* (2.6%), *Acacia modesta* (2.4%), *Rumax dintatus* (2.1%), *Ailanthus altissima* (2%), *Jasminium humlie* (2%), *Rubus fruticosus* (1.9%), *Fragaria vesca* (1.4%), *Debregeasia salicifolia* (1.4%), *Olea ferruginea* (1.3), *Ajuga bracteosa* (1.2%), *Daphne mucronata* (1.2%), *Salvia moorcroftiana* (1.2%), *Hedera nepalensis* (1.1%), *Medicago sativa* (1.1%), *Oxalis corniculata* (1.1%), *Coix lachyma* (1.1%) the remaining species of this group showed less contribution.

Table 1. Correlation of NMS ordination axis with aspect and altitude.

Variables	Axis I	Remarks	Axis 2	Remarks
Altitude	0.051262	Ns	0.214322	Ns
Aspect	0.362334	Ns	0.156392	Ns

Isodon rugosus-Berberis lycium community

This community comprised of 49 species in which the leading dominant is *Isodon rugosus* with a (17%) while the co-dominant specie is *Berberis lyceum* (9.4%). Among the other species of this community, the IVI of *Avena sativa is* (6.3%), *Rubus fruticosus* (4.7%), *Inula grandiflora* and *Micromeria biflora* (4.2%), *Olea ferruginea* (3.2%), *Acacia modesta* and *Daphne mucronata* (3%),

Astragalus graveolens (2.6%), *Delphinium roylei* (2.5%), *Jasminium humlie* (2.5%), *Rumax hastatus* (2.3%), *Fragaria vesca* (2.3%), *Zanthoxylum armatum* (2.2%), *Ajuga parviflora* (2.1%) while the remaining species contributed less than2% IVI to this community.

Isodon rugosus- Berberis lycium community

In this community, a total of twenty nine species were found in association with *Isodon rugosus*, In which the ivi of the *Isodon rugosus* is (16.1%) while the co-dominant specie, *Berberis lycium*. contributed (12.7%) followed by *Rubus fruticosus* (4.4%), *Micromeria biflora* (4.3%), *Olea ferruginea* (4.1%), *Rumex hastatus* (3.3%), *Tagetes minuta* (3.1%), *Zanthoxylum armatum* (2.8%), *Plantago major* (2.3%), *Vicia sativa* (2.3%), *Fragaria vesca* (2.1%), *Echinops echinatus* (2.1%), *Medicago sativa* and *Calendual arvensis* (2.0%).

Table 3. Density/ha and cover/ha of Isodon rugosus and associated species in different communities.

Species	Density/ ha								Cover/ha			
codes	Group 1	Group 2	Group 3	Group 4	Group1	Group 2	Group 3	Group 4				
	Mean ± S E	Mean ± S E	Mean ± SE	Mean ± S E	Mean ± S E	Mean ± S E	Mean ± S E	Mean ± S E				
Acmo	117 ± 8	100 ± 22	25 ± 0	125 ± 0	2608 ± 561	4644 ± 767	3360 ± 0	2320 ± 0				
Acbi	0 ± 0	33.3 ± 33	0 ± 0	0 ± 0	0 ± 0	1116 ± 1116	0 ± 0	0 ± 0				
Aial	83 ± 36	45 ± 20	0 ± 0	0 ± 0	3600 ± 616	4828 ± 2037	0 ± 0	0 ± 0				
Ajbr	225 ± 113	55 ± 55	0 ± 0	0 ± 0	232 ± 118	89 ± 89	0 ± 0	0 ± 0				
Ajpa	0 ± 0	205 ± 40	0 ± 0	0 ± 0	0 ± 0	720 ± 28	0 ± 0	0 ± 0				
Alni	67 ± 67	0 ± 0	0 ± 0	0 ± 0	87 ± 87	0 ± 0	0 ± 0	0 ± 0				
Anba	0 ± 0	25 ± 25	0 ± 0	0 ± 0	0 ± 0	154 ± 154	0 ± 0	0 ± 0				
Arsc	0 ± 0	50 ± 50	0 ± 0	0 ± 0	0 ± 0	384 ± 384	0 ± 0	0 ± 0				
Asgr	25 ± 25	0 ± 0	0 ± 0	0 ± 0	231 ± 231	0 ± 0	0 ± 0	0 ± 0				
Asof	150 ± 0	0 ± 0	0 ± 0	0 ± 0	658 ± 658	± 0	± 0	0 ± 0				
asgra	0 ± 0	55 ± 55	0 ± 0	0 ± 0	0 ± 0	81 ± 81	0 ± 0	0 ± 0				
Avsa	542 ± 65	515 ± 77	0 ± 0	150 ± 0	2555 ± 185	2669 ± 331	0 ± 0	2600 ± 0				
Bero	317 ± 116	840 ± 283	525 ± 0	250 ± 0	5798 ± 1544	4115 ± 1126	7295 ± 0	4584 ± 0				
Caar	0 ± 0	115 ± 83	225 ± 0	200 ± 0	0 ± 0	267 ± 164	836 ± 0	730 ± 0				
Capr	0 ± 0	50 ± 29	100 ± 0	100 ± 0	0 ± 0	264 ± 164	880 ± 0	920 ± 0				
Casa	0 ± 0	87.5 ± 88	0 ± 0	0 ± 0	0 ± 0	137 ± 137	0 ± 0	0 ± 0				
Cabe	0 ± 0	250 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 2	0 ± 0	0 ± 0				
Ceau	0 ± 0	15 ± 10	0 ± 0	0 ± 0	0 ± 0	616 ± 378	0 ± 0	0 ± 0				
Chbo	0 ± 0	43.75 ± 44	0 ± 0	200 ± 0	0 ± 0	2434 ± 2434	0 ± 0	0 ± 0				
Ciar	0 ± 0	100 ± 100	75 ± 0	0 ± 0	0 ± 0	268 ± 268	1893 ± 0	0 ± 0				
Clco	0 ± 0	40 ± 24	0 ± 0	0 ± 0	0 ± 0	464 ± 284	0 ± 0	0 ± 0				
Cola	225 ± 0	225 ± 0	0 ± 0	0 ± 0	101 ± 101	76 ± 76	0 ± 0	0 ± 0				
Coco	0 ± 0	0 ± 0	0 ± 0	625 ± 0	0 ± 0	0 ± 0	0 ± 0	1341 ± 0				
Cyar	0 ± 0	68.75 ± 69	0 ± 0	0 ± 0	0 ± 0	147 ± 147	0 ± 0	0 ± 0				
damu	75 ± 0	0 ± 0	0 ± 0	0 ± 0	3627 ± 3627	0 ± 0	0 ± 0	0 ± 0				
Desa	83 ± 83	0 ± 0	0 ± 0	0 ± 0	1216 ± 1216	0 ± 0	0 ± 0	0 ± 0				
Deve	88 ± 88	0 ± 0	0 ± 0	0 ± 0	520 ± 520	0 ± 0	0 ± 0	0 ± 0				
Dovi	0 ± 0	0 ± 0	0 ± 0	50 ± 0	0 ± 0	0 ± 0	0 ± 0	13600 ± 0				
Dppa	0 ± 0	12.5 ± 13	0 ± 0	0 ± 0	0 ± 0	256 ± 256	0 ± 0	0 ± 0				
Ecec	0 ± 0	0 ± 0	50 ± 0	0 ± 0	0 ± 0	0 ± 0	8200 ± 0	0 ± 0				
Fica	50 ± 0	55 ± 12	25 ± 0	25 ± 0	4533 ± 4533	7220 ± 2754	3040 ± 0	2960 ± 0				
Frve	167 ± 92	280 ± 44	275 ± 0	0 ± 0	463 ± 102	382 ± 30	422 ± 0	0 ± 0				
Hene	63 ± 63	55 ± 34	50 ± 0	0 ± 0	304 ± 304	143 ± 90	360 ± 0	0 ± 0				
Hypa	0 ± 0	18.75 ± 19	0 ± 0	0 ± 0	0 ± 0	325 ± 325	0 ± 0	0 ± 0				
Inem	50 ± 50	0 ± 0	0 ± 0	0 ± 0	93 ± 93	0 ± 0	0 ± 0	0 ± 0				

Ingr	242	±	74	360	±	58	50	±	0	200	±	0	3513	±	1058	2454	±	627	4680	±	0	4890	±	0
Isru	2075	±	288	1820	±	176	1500	±	0	1775	±	0	2437	±	803	1846	±	147	1869	±	0	1500	±	0
Jahu	150	±	115	0	±	0	150	±	0	0	±	0	882	±	495	0	±	0	2133	±	0	0	±	0
Maro	0	±	0	0	±	0	0	±	0	125	±	0	0	±	0	0	±	0	4640	±	0	0	±	0
Mawa	13	±	13	0	±	0	0	±	0	0	±	0	5947	±	5947	0	±	0	0	±	0	0	±	0
Mesa	158	±	79	95	±	68	200	±	0	0	±	0	290	±	149	123	±	79	280	±	0		±	0
Melo	33	±	33	0	±	0	0	±	0	0	±	0	93	±	93	0	±	0	0	±	0	0	±	0
Mesp	42	±	22	45	±	30	0	±	0	0	±	0	369	±	216	331	±	202	0	±	0	0	±	0
Mibi	583	±	58	475	±	100	450	±	0	625	±	0	893	±	21	852	±	38	1116	±	0	1386	±	0
Moal	0	±	0	10	±	6	0	±	0	50	±	0	0	±	0	864	±	532	0	±	0	3000	±	0
Myaf	0	±	0	25	±	25	0	±	0	325	±	0	0	±	0	464	±	464	0	±	0	1834	±	0
Olfe	67	±	55	175	±	38	250	±	0	150	±	0	5307	±	4382	3852	±	766	3488	±	0	4413	±	0
Oxco	125	±	72	300	±	127	125	±	0	0	±	0	275	±	138	732	±	200	608	±	0	0	±	0
Pahy	75	±	0	37.5	±	38	0	±	0	0	±	0	596	±	596	384	±	384	0	±	0	0	±	0
Pist	150	±	0	0	±	0	0	±	0	0	±	0	138	±	138	0	±	0	0	±	0	0	±	0
Piro	0	±	0	65	±	27	25	±	0	0	±	0	0	±	0	4484	±	1348	10000	±	0	0	±	0
Plma	417	±	333	100	±	77	250	±	0	450	±	0	588	±	325	462	±	298	1144	±	0	1302	±	0
Quba	0	±	0	5	±	5	25	±	0	0	±	0	0	±	0	480	±	480	2400	±	0	0	±	0
Rofr	175	±	87	495	±	164	300	±	0	300	±	0	6853	±	4997	1571	±	597	3580	±	0	3833	±	0
Rusc	0	±	0	50	±	50	0	±	0	0	±	0	0	±	0	411	±	411	0	±	0	0	±	0
Rude	92	±	44	40	±	6	25	±	0	75	±	0	2526	±	1447	2624	±	873	1200	±	0	1307	±	0
Ruha	1175	±	210	285	±	116	400	±	0	0	±	0	1602	±	213	1397	±	430	995	±	0	0	±	0
Samo	92	±	46	50	±	24	75	±	0	150	±	0	1089	±	548	814	±	350	1973	±	0	1267	±	0
Tami	358	±	154	75	±	31	350	±	0	125	±	0	581	±	72	454	±	186	554	±	0	864	±	0
Taof	100	±	50	0	±		150	±	0	150	±	0	778	±	389	0	±	0	1213	±	0	1213	±	0
Veth	125	±	0	137.5	±	26	75	±	0	50	±	0	565	±	565	1373	±	361	2293	±	0	2760	±	0
Veof	0	±	0	25	±	25	0	±	0	0	±	0	0	±	0	170	±	170	0	±	0	0	±	0
Visa	300	±	173	360	±	60	300	±	0	0	±	0	387	±	195	551	±	29	553	±	0	0	±	0
Zaar	0	±	0	90	±	28	75	±	0	75	±	0	0	±	0	4346	±	1428	0	±	0	4560	±	0

The remaining specie which are found in this community and shared less IVI is given in table (1).

Isodon rugosus-Chenopodium botrys community

This community is represented by a single stand and comprised of 24 species in which the leading dominant species is *Isodon rugosus* (16.9%) followed by *Chenopodium botrys* (13.0%). Among the remaining 22 species of this community the IVI of *Cotinus coggygria* is (7.0%), *Micromeria biflora* (6.4%), *Rubus fruticosus* (5.1%), *Plantago major* (4.4%), *Berberis lyceum* (4.4%), *Myrsine africana* (3.9%), *Inula grandiflora* (3.8%), *Olea ferruginea* (2.8%), *Dodonaea viscosa* (2.4%), *Acacia modesta* (2.3%), *Salvia moorcroftiana* (2.1%), *Avena sativa* (2.1%). The remaining species of this community contributed less than 2% IVI.

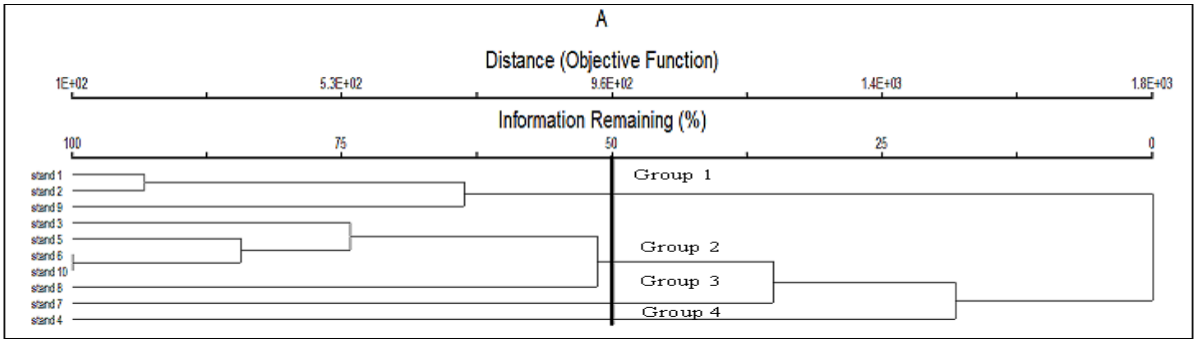

Fig. 1. Dendrogram results from Ward's cluster analysis communities made on 50% information remaining.

Ordination of vegetation communities

The data analyzed through ward's cluster analysis was also subjected to NMS for ordination in order to know about the pattern of vegetation associated with *Isodon rugosus* in different sampling stands. As the NMS ordination was run on the same data of IVI of the species and similar groups were obtained which are summarized in Fig (3). The results verify that Ordination and Cluster Analysis are two different methods though used for the same purposes. Ordination plot shows the rotation of different stands between NMS ordination axis (1, 2).

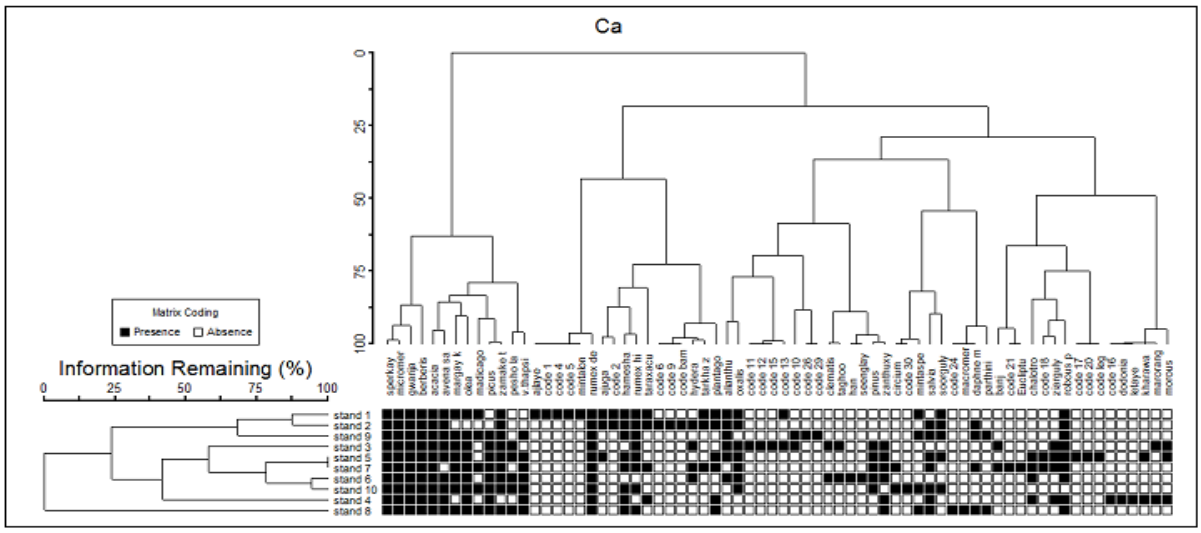

Fig. 2. Two way cluster dendrogram the dots showing the presence species in different plants communities.

Group 1 which comprised of three zones is positioned toward axis 2, while group 2 which is comprised of five stands is positioned in the lower portion of the plot toward axis 1. Similarly group 3 which comprised of a single stand is present in the top of ordination plot toward axis 1. Group 4 is also positioned toward axis 1 in the middle portion. The rotation of *Isodon rugosus* dominated stands showing irregular rotation between the ordination axes. The original data of altitude of the site and aspect was correlated with the NMS ordination axis (Axis 1, Axis 2) but it did not yield any significant relation with ordination axis at the given probability level (Table 3.1).

Density/ha and Cover/ha of Isodon rugosus dominated Communities

Group 1: Isodon rugosus-Rumex hastatus community

In this group the density/ha of *Isodon rugosus* was recorded as (2075 ± 288) individual/ha with a mean cover/ha of (2437 ± 803) cm, the density/ha of the co-dominant species *Rumex hastatus* was (1175 ± 210) individuals/ha and 1602 ± 213 cm cover/ha. Among the remaining species of this community the density/ha of *Micromeria biflora* was (583 ± 58) individuals/ha while its cover/ha was 893 ± 21 cm.

Group 2: Isodon rugosus-Berberis lycium community

Based on density/ha the dominant species of this community is *Isodon rugosus* (1820 ± 176) individual/ha and 1846±147 cm cover/ha followed by *Berberis lycium* (840±283) individuals/ha. The cover/ha of this species is 4115 ± 1126 cm.

Group 3: Isodon rugosus-Berberis lycium community

In this community group 3 the density/ha of Isodon rugosus is 1500 and cover /ha is 1869 cm while that of the co-dominant species *Berberis lycium is* 525 individual/ha with a mean value of 4584 cm cover/ha.

Group 4: Isodon rugosus-Micromeria Biflora community

Out of 24 species of this community, the mean value of density/ha of *Isodon rugosus* is 1775 and cover /ha is 1500 cm while the co-dominant species is *Micromeria biflora*. The mean density of this species is 625 individual/ha and 1386 cm cover/ha.

Discussion

In the present study Ward's agglomerative techniques was used for the analysis of *Isodon rugosus* dominated communities in Khwazakhela (Upper Swat). Based on importance values of species, Cluster Analysis separated data into four vegetation groups at 50 % remaining information of the species. All communities were dominated by *Isodon rugosus*.

The co-dominant species in community 1 was *Rumex hastatus,* in community 2, 3 *Barbers lyceum* while, in community 4 the co-dominant species was *Micromeria biflora*. Similar study was conducted by Hussain *et al*., (2003) while studying the vegetation of central Karakoram national park and reported six plants communities.

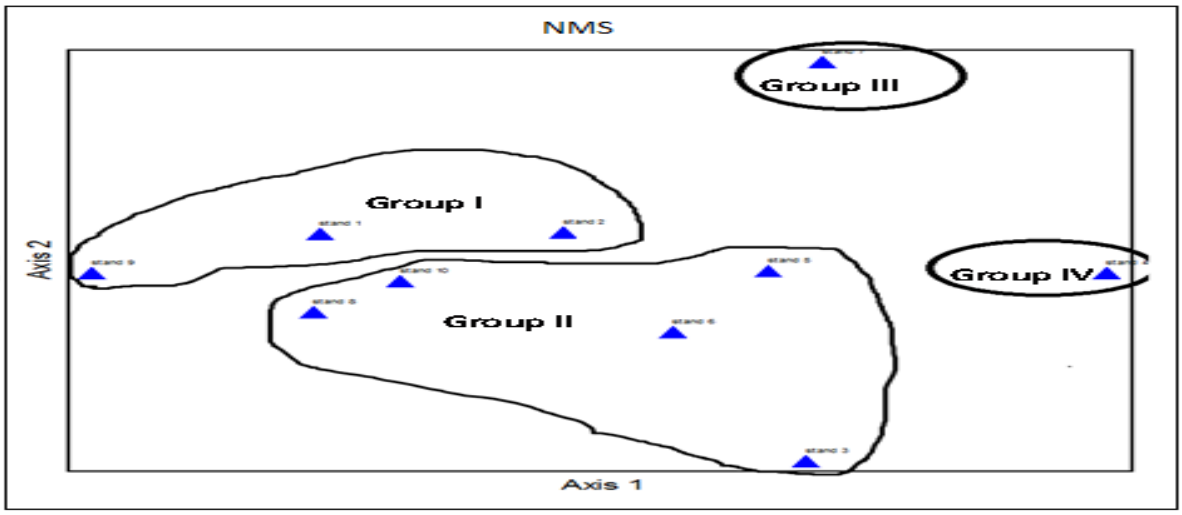

Fig. 3. NMS ordination plot showing the distribution of *Isodon rugosus* dominated communities.

Ahmed *et al.,* (2009) found 10 communities while studying *Olea ferruginea* forests in District Dir (Lower). Ahmed, (2009) recognized 4 vegetation communities of herbaceous plants by the application of advance multivariate techniques in Margalla Hills National Park, whereas Shaheen *et al*., (2011) used these techniques for the determination of structure diversity, vegetation dynamics Bagh (Kashmir). Shaheen and Shinwari, (2012) studied the phytodiversity and endemic richness of Karambar Lake vegetation of Chitral using TWINSPAN and DCA ordination for analysis. Khan *et al.,* (2011) used multivariate methods for the analysis of structure diversity of *Monotheca buxifolia* and associated vegetation of District Dir (Lower). The results obtained through Ward's cluster analysis also superimposed on NMS ordination axes. Our results is supported by Grieg-Smith, (1983) and Shaukat, (1985) who stated that that ordination and clustering are two basic techniques complementary to each other though applied fundamentally for different purposes.

In the present study a total of 70 species were found in *Isodon rugosus* dominated communities which shows that the vegetation of study area is diverse, though their distribution and importance values in different communities' groups was different. The IV of *Isodon rugosus* was found high in community group 1, followed by community 2, while in community 3, 4 it was found similar but a large difference is observed in the species composition in different groups. As in community 2, 52 species were found in association with *Isodon rugosus*. In community 1 it was 41, while 24 associated species were found in community group 4. Some species which found in all communities in association with *Isodon rugosus* are *Barberis lyceum, Indegofera geradiana, Tagetes minuta, Micromeria biflora, Olea ferruginea, Ficus carica, Plantago major, Rubus fruticosus, Rumex dentatus, Rumex hastatus, Salvia moorcroftiana, Verbascum Thapsus* are widely distributed in the study area.

Other species which are found rarely in the *Isodon* dominated communities require proper management for their conservation otherwise they will be loss in the future. Similar to the number of species composition the importance values, density/ha and cover/ha of *Isodon rugosus* was also different in different sampling stands. The importance value, density/ha and cover/ha of *Isodon rugosus* was high in community 1. Similarly the d/ha of *Isodon rugosus* was low in community group 3 and the lowest cover/ha was found in group 4. Some of the most important species which are found in association with *Isodon rugosus* are *Berberis lyceum*, *Indegofera geradiana*, *Accacia modesta*, *Ailanthus altissima, Rubus fruticosus, Olea ferruginea*, *Daphne mucronata* and *Parthenium hysterophorus*. Among these species *Berberis lyceum* is an important medicinal plant used for the treatment of different types of diseases. Other species such as *Indegofera geradiana, Tagetes minuta,* and *Olea ferruginea* are other important species used by the people of the area for fuels and other purposes purpose (Khan *et al*., 2011). Similarly *Ficus palmata* is also an associated species with *Isodon rugosus* that yield edible fruits but was rare in the forest. On the other hand *Dodonaea viscosa* was part of the associations that is the dominated species in open and hilly areas on lower elevation of Malakand division. *Partehnium hysterophorus* is also found in *Isodon* dominated communities' which is an invasive species and is a threat to the natural flora and particularly to *Isodon* and other important medicinal plants and their reduction can be controlled by an active but scrupulous intervention like enrichment and improvement planting (Khan *et al*., 2010; Siddique *et al*., 2012). The forest of *Isodon rugosus* were dominated by low growing, light loving species replacing upper canopy trees with high timber value *i.e. Olea ferruginea*, *Ficus carica*. These species is declining due to their timber and fruit value resulting in low species evenness and lower economic value of the forest. In the present study different important trees and shrubs were found in association with *Isodon rugosus* with very low ivi, density/ha and cover/ha.

The less contribution of these trees and shrubs species may be due to the highest demand for fuels and other purposes as reported by Khan *et al.,* (2011) and Shariatullah, (2013). It is suggested that elevation is one of the most important and basic controlling factor prevailed in the vegetation structure. In the present study the altitude and aspect data of different stands was correlated with the NMS ordination axis in order to know about the effect of altitude and aspect on the distribution of *Isodon rugosus* in different sampling stands but it did not yield any significant relationship with the NMS ordination axis. Hill and Gauch, (1980) and McCune and Grace, (2006) stated that the ordination is capable of yielding at least one basic gradient associated with the vegetation. Similar study was conducted by Rahman, (2012) and found significant relation of DCA ordination axis 1 with altitude. Shariatullah, (2013) found significant relationship of altitude with ordination axis while studying the community structure of *Justicia adhatoda* in Malakand division. Khan *et al.,* (2011) found significant correlation of Ordination axis with altitude, organic matter, soil pH, and nitrogen and magnesium contents while studying the vegetation of subtropical dry temperate forests of Pakistan. However our finding is in correlation with Khan, (2011) who reported the effect of environmental variables (topographic, edaphic and soil variables and did not found any significant correlations with the DCA ordination axes and argued that anthropogenic effect is responsible for the differences in the distribution of species in different communities. As the IVI, density/ha and cover/ha of *Isodon rugosus* was high in community the difference in the altitude was low in different community so the high density may be the less anthropogenic disturbance which was observed during field survey as compared to other communities. Beside the anthropogenic disturbance there are some other important environmental variables, for example, water holding capacity (WHC), soil moisture, calcium, magnesium, conductivity, salinity and soil depth, to be considered to explain the variability as reported by Palmer, (2005) and was not studied in the present study.

Beside this slope, soil texture, available nitrogen, potassium, organic matter, lime and soil moisture differences are also responsible for the differences in density, ivi, and cover as well as the distribution of the vegetation Zare *et al*., (2011).

Conclusion and recommendation

Isodon rugosus dominated communities are generally diverse in herb species while shrub and trees are minor associates. *Isodon rugosus* is a moisture loving species and mostly grows on north to north east aspect. Difference in IVI, density/ha, cover/ha of *Isodon rugosus* in different sampling stand is due to overgrazing and unsustainable use for fuels, fodders and medicinal purposes which will lead to the rapid decrease of *Isodon rugosus* in the area.

Further study is needed to explore the effect of edaphic variables on the distribution of this important species.

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