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STUDIES ALONG AN ALTITUDINAL GRADIENT IN *MONOTHECA BUXIFOLIA* (Falc.) A.D, FOREST, DISTRICT LOWER DIR, PAKISTAN

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Abstract

The present paper is about the species composition, diversity, equitability, richness and concentration of dominance of tree species along an altitudinal gradient of District Dir Lower Hindukush range of Pakistan. A total of 15 stands in *Monotheca buxifolia* (Falc.) A.D forests were analyzed at an elevation of 1370m to 1670m asl. The vegetation analysis showed that a total of six tree species existed and *Monotheca buxifolia* emerged as dominant tree species on all locations with IVI ranging between 62% to 100%. *Olea ferruginea* and *Acacia modesta* were reported in four stands as a second dominant species. At two locations *Quercus baloot* and *Punica granatum* were associated species with 14% and 35% of importance value respectively. *Ficus palmata* was notably found as a rare species in the study area. The total density ranged between 110 tree/ha^{-1} to 304 tree/ha^{-1}. Species diversity was ranged 0 to 0.36 and maximum diversity was reported at the elevation of 1370m and 1555m asl. Concentration of dominance and equitability values in some stands 1 to 1.70 were relatively high due to the presence of single species in the forests.

Introduction

Monotheca buxifolia is a broad leaved evergreen small tree belonging to the family Sapotaceae. This species is distributed in the mountains of Afghanistan and the main center is Northern Pakistan. After a gap of several hundred kilometers, it occurs again in Jebel al Akhdhar range of Northern Oman where it is dominated species of the semi-evergreen sclerophyllous woodland and in Southwest Saudi Arabia near Zahran al Janub (Shahina & Martin, 1998). In Pakistan it is commonly found in Gorakh Hills, Zhob, Loralai, Kohat, Drosh Chitral, Kala Chitta Hills, and Attock District (Nasir & Ali, 1972). The study area District Dir Lower (DDL) lies in sub tropical dry temperate areas of Pakistan (Champion *et al.*, 1965). This species is represented by either pure or mixed with *Olea ferruginea, Acacia modesta, Punica granatum, Ficus palmata* and *Quercus baloot* which is rarely found in association with this species (Champion *et al.*, 1965). At some locations, *Dalbergia sissoo* is also sporadically associated with *Monotheca buxifolia*.

Inspite of other species, *Monotheca buxifolia* is the most preferred species in hilly areas. It is mainly used as a fuel, fodder (browsed by camels and goats), small timber and notably used as a fence around cultivated fields and fruit gardens due to its thorny nature.

Monotheca buxifolia is of economic value for local mountain inhabitants, particularly in areas with rough terrain where conventional horticultural or agronomic cropping is limited (Al-Yahyai & Al-Nabhani, 2006). The fruit black berries locally called Gurguri is sold by the local inhabitants. It is considered to be very delicious fresh and dry fruit and have a market price of 40 to 50 rupees per kg. Ethnobotanically or medicinally fruit is laxative, digestive and is used in urinary tract diseases (Rashid & Sarfraz, 2009).

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Phytosociology and vegetation analysis of Pakistan forests have been reported by several workers Viz: Chaudhri (1960), Hussain (1969 a, b), Hussain & Qadir (1970), Naqvi (1976), Ahmed and Qadir (1976), Ahmed (1976, 1986, 1988), Hussain *et al.,* (1981), Amin and Ashfaq (1982), Beg and Khan (1984), Malik & Hussain (1987), Qadri (1986), Hussain and Illahi (1991), Hussain and shah (1989), Durrani and Hussain (2005), Ahmed and Naqvi (2005), Ahmed *et al.,* (2006), Wahab *et al.,* (2008), Ahmed *et al.,* (2009) and Siddiqui *et al.,* (2009).

Dir hills represent a great aesthetic treasure in Hindukush range of Pakistan. So far very little information exists on the ecological aspects of the forest communities and quantitative analysis of forest vegetation of the area (Ahmed *et al.,* 2009) and Siddiqui *et al*., (2009). Some ethnobotanical surveys on medicinal plants were conducted by Ali *et al*., (2007), Ali *et al*., (2008) and Asad *et al.,* (2009). However, no attention was paid to describe the altitudinal changes in forest about species composition, dominance-diversity and species richness of tree species in Pakistan.

Therefore, an attempt was made to investigate the variation in tree species composition along an altitudinal gradient of *Monotheca buxifolia* in District Dir Lower Pakistan.

Material and Methods

1. Study site: District Dir lower is located in the North-West Frontier Province of Pakistan . It lies in Hidukush range between 35° 10 to 35° 16 N Latitude and 71° 50 to 71° 83 E Longitudes. According to Ali *et al.,* (2008) the area once occupied by the state (5284 km²), now forms two districts of Pakistan - Upper Dir and Lower Dir (15,85km). These two districts are the part of Malakand Division. Panjkora River rises in the Hindukush Mountains and joins the Swat River near Chakdara. In the North of Dir lower are rugged mountainous peaks rising from 1100 to 3119 meter. Swat is located in the East while Afghanistan lies in the West.

A total of 15 forest stands were selected at different altitudes ranging from 1370m to 1670m asl, to examine the forest vegetation of *Monotheca buxifolia* (Table. 1).

2. Climate: The elevation of District ranges from 1200m to 2800m above sea level. The climate of the District largely depends on altitude. The closest meteorological station is situated at Dir upper. The climatic data of the station show that July is hottest month (15.67 to 32.52°C), while January and February are the coldest months and the temperature generally falls below freezing point. The mean maximum and minimum temperature are 11.22°C and 2.39°C. The winter season is from mid November to March. Relative humidity is higher in January, February, August and December (Wahab *et al.,* 2008). The study area receives highest rainfall in March 242.22 mm and lowest in July, October, and November (Anon., 1998). Snowfall starts from December to March and remains upto June and July on high mountains, adding to the beauty of the valley.

3. Methods: A large amount of descriptive information concerning Site parameters including elevation, slope, aspect and site description were recorded for each stand. Elevation was estimated by Altimeter (AM) as average of the higher and lower elevation of the stand. The slope was measured by Clinometer (CM) and aspect by compass. Global positioning systems (GPS) were used to estimate geographical coordinates (Table 1).

From various distance methods Point Center Quartered (P.C.Q) method of Cottam & Curtis (1956) was used to evaluate the quantitative vegetational composition of trees species in each stand.

Table 1. Characteristic features and dominant tree species of the study sites.

Forest Stands	Location	Latitude N	Longitude E	Altitude (m)	Slope	Aspect	Canopy	Dominant species
1	Porighar	34 º 71	71 º 82	1370	27 º	E	Open	1,2
2	Gidar	34 º 70	71 º 67	1375	12 º	E	Open	1
3	Shagokas	34º 65	71 º 60	1380	15 º	W	Moderate	1,6
4	Doda	34 º 70	71 º 68	1405	25 º	E	Open	1
5	Deere	34º 43	71º 53	1420	22 º	E	Open	1
6	Zaar	34 º 43	71 º 48	1422	10 º	E	Moderate	1,3
7	Gatko	34 º 71	71 º 81	1434	32 º	E	Open	1,5
8	Palosin	34 º 68	71 º 79	1440	18 º	E	Open	1
9	Chal Kamar	34 º 70	71 º 65	1455	20 º	SE	Open	1,5
10	Pingal	34 º 78	71 º 80	1555	26 º	E	Open	1,5
11	Manogay	34 º 70	71 º 77	1562	35 º	E	Open	1,5
12	Sur Kamar	34 º 70	71 º 80	1568	10 º	E	Open	1
13	Karapa	34 º 69	71 º 72	1625	18 º	W	Open	1,2,3
14	Kattan Lower	34 º 70	71 º 83	1660	22 º	W	Open	1,2,3,4
15	Kattan Upper	34 º 70	71 º 83	1670	13 º	E	Open	1,2,3

Species code: 1. *Monotheca buxifolia* (Falc.) A. DC., 2. *Olea ferruginea* Royle, 3. *Punica granatum* L., 4. *Ficus palmata* Forssk. 5. *Acacia modesta* Wall. 6. *Quercus baloot* Griff.

Fifteen PCQ point at each stand were systematically taken, while 1.5 meter circular quadrates were used for understorey species. In each PCQ point, all trees > 10 Dbh cm (diameter breast height) at 1.37m (about breast height) above the ground were individually measured.

The vegetation data was quantitatively analyzed for frequency, density, abundance, basal area and Importance value index according to the formula given by Curtis & McIntosh (1950) and Hussain (1989). The relative values (Relative frequency, relative density, and relative basal area) for each species were summed upto represent importance value index (IVI) in a particular stand (Curtis, 1959). Every species was ranked according to their importance values and the species with the highest importance value in the stand was considered as the dominant species.

The diversity index (H') was computed after Shannon & Weaver (1963) information theory function.

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where $\boldsymbol{p_i}$ is the fraction of individuals belonging to the *i*-th species.

Equitability or evenness (J) which describes the evenness of allotment of individuals among the species was calculated as the obseverd diversity as a proportion of maximal diversity in that area. It was calculated according to Pielou (1969) as:

$$\text{Equitability (J)} = H'/H_{max} = H'/\log S$$

Species richness or variety index (d) is the number of species as a function of the total number of individuals in the sample and was determined using the formula of Menhinick (1964) as follows:

$$D = S / \sqrt{N}$$

where S is equal to the number of species and N is the total number of individuals of all species.

Concentration of dominance (D) was calculated using Simpson's index (1949) as follows:

$$D = \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)},$$

where, n_i is the number of individuals of *i*th species and N is the total number of individuals.

Results

Details of sampling sites including geographical coordinates, altitudes, slope, aspects, canopy and dominant species were recorded (Table 1). Dominant tree species were encoded with numbers.

Out of 15 locations, 11 stands were east facing while 3 lie towards West. The slope ranged from 10 to 35 degrees. Due to low densities of trees canopy was open with the exception of stand 3 (1380m) and stand 5 (1422m), where moderate canopy was present.

The study area was represented by 6 tree species in the altitudinal range from 1370m (stand 1) to 1670m (stand 15) above sea level. The highest numbers of tree species were recorded from Zaar (Stand 6) with1660m asl.

Fig. 1. shows the total density of tree species which ranged between 110 trees/ha^{-1} (stand 5) to 304 trees/ha (Stand 6). Meanwhile total density of stand 1(1370m) and stand 14 (1660m) ranged between 214 to 225 trees/ha^{-1}. Stand 10 (1555m), stand 11 (1562m) and stand 12 (1568m) showed a continuous increase in density/ha^{-1} with increase in elevation, while stand 2 and 3 had similar number of individuals/ha^{-1}.

A slight change in density/ha^{-1} was observed in stand 4 (1405m) and stand 9 (1455m). Stand 5 (1420m) possessed the lowest value of density/ha among all stands.

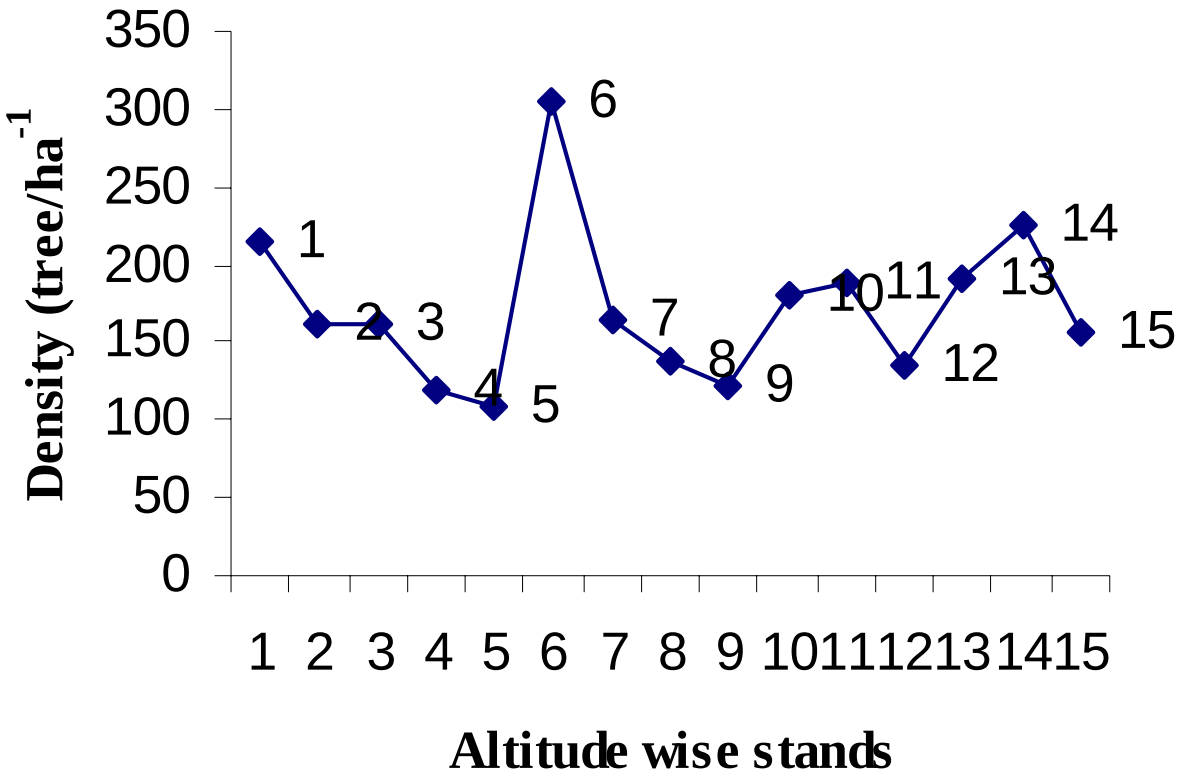

Fig. 1. Altitude wise changes in total density (trees/ha) of study area.

Altitudinal changes in IVI, density and diversity are set in Table 2, 3 and 4. On the basis of density, *Monotheca buxifolia* was the dominant tree species in all stands.

The density/ha ranged from 94 to 285 individuals/ha. Maximum density was recorded from stand 6 (1422m) elevation. Meanwhile minimum density of *Monotheca buxifolia* was obtained in stand 9 with 1455m height.

Olea ferruginea was the associated tree species at 4 locations both on the lowest and highest elevations. Minimum density of *Olea ferruginea* was reported in stand 15 (1670m) while maximum density 67 tree/ha was recorded in stand 1 (1370m) elevation. *Punica granatum* and *Acacia modesta* had the same distribution. Both species were reported at four locations (Table 1). The density of *Punica granatum* ranged between 19.1 (stand 6, 1422m) to 32 trees/ha^{-1} (stand 14, 1660m). Similarly 23 to 48 individuals/ha^{-1} of *Acacia modesta* were obtained from altitudinal range 1434m to 1562m above sea level. *Ficus palmata* and *Quercus baloot* were reported in Stand 3 (1380m) *&* Stand 14 (1670m) elevation respectively.

Dominance of tree species was found out by calculating the IVI and results were recorded (Table 3). The study indicated that *Monotheca buxifolia* was the most dominant species of all stands. Its minimum IVI was 62 (Stand 1) at an elevation 1370m, while 100% IVI was recorded in stand 4 (1405m), Stand 5 (1420m), stand 8 (1440m) and stand 12 (1568m) respectively.

On the basis of Importance value, *Olea ferruginea* was the second co-dominated tree species at four locations. Its IVI range from 17.7% to 37.56%. Similarly *Acacia modesta* was also reported the second associated tree species with 17 to 33% in 1434 to 1562 altitudinal ranges.

At 1380m elevation (Stand 3) *Quercus baloot* was associated with 35.34% IVI, while at elevation 1422m *Punica granatum* was co-dominant tree species with lowest (8.42%) importance value. *Ficus palmata* was reported from stand 14 (1660m) with 4% of importance value.

The value of species richness, species diversity, equitability and concentration of dominance are given in Table 4. Species richness and diversity along an altitudinal gradient ranged between (0.11-0.36) and (0-0.36) respectively. Maximum diversity (0.36) recorded at stand 1 (1370m) and stand 11 (1562m). Maximum species richness (0.36) recorded at stand 14 (1660m) where as minimum diversity of tree species were recorded from stand (4, 5, 8, and 12) respectively (Table 4).

Equitability (e) and Simpson's dominance showed reverse trend between 1568 to 1670m altitudes. In the present investigation the value of dominance and equitability ranged between 0.10 (Stand 14, 1660m) to 1.70 (Stand 2, 4, 5,8,12, 1380-1560m) elevation, while Simpson's dominance ranged between 0.62 (1625m) to 1 (Table 4).

Discussion

The range values of density and IVI of *Monotheca buxifolia* and associated species are presented in Tables 2 and 3 respectively. It is obvious that *Monotheca buxifolia* is the most dominant species in all sites. The comparative studies of the related parameters of other forests in Pakistan are studied by various workers. The total density of the present study for tree species was 110 to 304 individuals/ha with IVI ranged from 62% to 100%. Siddiqui *et al*., (2009) reported 41 to 667 trees/ha of *Pinus roxburghii* in lesser Himalayan and Hindukush range of Pakistan. Similarly 120 individuals/ha^{-1} with 26% IVI for *Acacia modesta* and 20 to 80 tree/ha were obtained for associated tree species from Shakarparian near Islamabad.

Table 2. Altitudinal wise changes in Values of IVI.

Stand/ Altitude (m)	*Monotheca buxifolia*	*Olea ferruginea*	*Punica granatum*	*Ficus palmata*	*Acacia modesta*	*Quercus baloot*
Site-1 (1370)	62.44	37.56	--	--	--	--
Site-2 (1375)	100	--	--	--	--	--
Site-3 (1380)	64.66	--	--	--		35.34
Site-4 (1405)	100	--	--	--	--	--
Site-5 (1420)	100	--	--	--	--	--
Site-6 (1422)	91.58	--	8.42	--	--	--
Site-7 (1434)	83.33	--	--	--	16.67	--
Site-8 (1440)	100	--	--	--	--	--
Site-9 (1455)	76.11	--	--	--	23.89	--
Site-10 (1555)	66.67	--	--	--	33.31	--
Site-11 (1562)	81.24	--	--	--	18.76	--
Site-12 (1568)	100	--	--	--	--	--
Site-13 (1625)	71.43	20.37	8.20	--	--	--
Site-14 (1660)	64.1	17.7	14.2	4	--	--
Site-15 (1670)	69.94	20.4	9.74	--	--	--

Table 3. Altitudinal wise changes in value s of density (tree/ha).

Stand/ Altitude (m)	*Monotheca buxifolia*	*Olea ferruginea*	*Punica granatum*	*Ficus palmata*	*Acacia modesta*	*Quercus baloot*
Site-1 (1370)	147.50	67.04	--	--	--	--
Site-2 (1375)	161.35	--	--	--	--	--
Site-3 (1380)	119	--	--	--		42
Site-4 (1405)	120.06	--	--	--	--	--
Site-5 (1420)	110.16	--	--	--	--	--
Site-6 (1422)	285.82	--	19.1	--	--	--
Site-7 (1434)	140.30	--	--	--	23.95	--
Site-8 (1440)	139.55	--	--	--	--	--
Site-9 (1455)	94.59	--	--	--	28.12	--
Site-10 (1555)	131.58	--	--	--	48.87	--
Site-11 (1562)	161.57	--	--	--	27.58	--
Site-12 (1568)	135.99	--	--	--	--	--
Site-13 (1625)	144.47	35.30	12.84	--	--	--
Site-14 (1660)	139.27	39.27	32.13	14.26	--	--
Site-15 (1670)	110.67	29.29	16.26	--	--	--

Wahab *et al*., (2008) described the values of density and IVI, ranging from 12 to 104 and 14% to 100% respectively. Ahmed *et al*., (1991) reported 24 to 924 with a mean of 266 individuals/ha^{-1} of *Pinus gerardiana* forest in Balochistan. Present values also within the range values of Hussain & Badshah (1998), Ahmed *et al*., (2009) and Ajaib *et al*., (2009).

The study revealed that Quercus baloot is the co-dominant species in one stand on (1370m) elevation. According to Champion *et al*., (1965) *Quercus baloot* forests are extensively distributed between 1200 to 2000m with *Olea ferruginea* and *Pistacia* below the dry coniferous forest and notably of *Pinus gerardiana* and *Cedrus deodara* in Dir, Chitral and other areas of Pakistan. In these forest *Quercus* species exhibited a clear dominance over other associated tree species. In the present study the comparative low value of *Quercus baloot* may be due to logging for fuel wood and other anthropogenic disturbances.

Table 4. Altitudinal wise changes in species richness (R), diversity (H"), equitability (J') and concentration of dominance (CD).

Stand/Altitude (m)	Species richness (d)	Diversity (H')	Equitability (J')	Simpson's dominance (D)
Site-1 (1370)	0.20	0.36	0.53	0.53
Site-2 (1375)	0.11	0	1.70	1
Site-3 (1380)	0.20	0.35	0.51	0.6
Site-4 (1405)	0.11	0	1.70	1
Site-5 (1420)	0.11	0	1.70	1
Site-6 (1422)	0.20	0.27	0.39	0.76
Site-7 (1434)	0.20	0.29	0.43	0.719
Site-8 (1440)	0.11	0	1.70	1
Site-9 (1455)	0.20	0.35	0.50	0.61
Site-10 (1555)	0.20	0.36	0.52	0.55
Site-11 (1562)	0.20	0.32	0.47	0.66
Site-12 (1568)	0.11	0	1.70	1
Site-13 (1625)	0.27	0.19	0.17	0.62
Site-14 (1660)	0.36	0.14	0.10	0.47
Site-15 (1670)	0.27	0.20	0.18	0.64

Acacia and *Olea* species are associated in four locations with relative low importance values. A similar result was also presented by Dastagir *et al*., (1999) from Mai Dhani Hills Azad Kashmir. He reported that *Acacia modesta* is a rare species associated with *Olea ferruginea* with lowest importance values of 6.06% and 15.16% at 800m. Malik and Hussain (1990) reported that *Acacia modesta* are distributed on the plains from 650 to 1000m in Kotli area, while Hussain *et al.,* (1993) reported that this species is the most abundant and widely distributed tree species of tropical dry deciduous forest of Swabi District exhibiting maximum Importance value, presumably due to the protection, as there was hardly any Acacia cover in the non protected sites in the same area.

Among the distribution pattern of the tree species in *Monotheca buxifolia* forests, most of the species were distributed contagiously and few species were quite randomly. Odum (1971) emphasized that contagious distribution is the most common pattern in nature. Greig-Smith (1957), Kershw (9173), Singh & Yadav (1974) and Kumar & Bhatt (2006) also reported contagious distribution pattern in foot hills forest in Garhwal Himalaya.

The vegetation of Pakistan varies due to the changes in altitude and climate (Hussain & Badshah, 1998). Species diversity, equitability, species richness and concentration of dominance of tree species along altitudinal gradient were recorded (Table 4). Diversity and Equitability ranged (0-.36) and (0.10- 1.70) respectively. The high and low value (0 and 1.70) in diversity index equitability is due to the presence of single species in the stand. Concentration of dominance and species richness showed irregular pattern.

No information for comparison is available in Pakistan besides the present work. From evergreen forest of Kumaun Himalaya, Rohit & Neelam (2008) obtained 3 to 9 tree species and the diversity was recorded 1.00 to -2.07 while the concentration of dominance ranged between 0.13 to 0.14. Similarly Geeta (2009) presented species richness varying from 1.0 to 1.3 and diversity value from 0 to 0.3. Equitability and concentration of dominance value ranged from 0.4 to 2.7 and 0.9 to 1.0 respectively. Tripathi *et al*., (2004) reported diversity of 0.198 corresponding to the population density

207 individals/ha^{-1} in Saddle peak forests in Andaman Island. It is clear from the above discussion that the present values are within the range of other studies carried were out by other workers.

Distribution and occurrence of species has been affected due to the anthropogenic disturbances, commercial exploitation, forest fire, overgrazing etc. Therefore these forests need proper management and protection.

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