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Growth behaviour, sex ratio and fruit output of *Juniperus excelsa* in Mastuj valley, District Chitral, Khyber Pakhtunkhawa, Pakistan

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Abstract

Study was conducted to examine growth behaviour, sex ratio and seed output of *Juniperus excelsa* in various parts of Mastuj valley, Khyber Pakhtunkhawa Pakistan. Average height, diameter and density of male, female and bisexual plants were determined. Seed output of female plants were found highest in Dodorghaz gol followed by Mastuj village and Ghuru gol. Number of fallen fruits were high in Dodorghaz gol followed by Mastuj village and Ghuru gol. Number of seedlings were high in Mastuj village followed by Ghuru gol and Dodorghaz gol. Soils were sandy loam and loamy sand with elements such as C, Ca, Mg, Si, Fe and K. These results strongly sustain genetically-determined sex ratios and a lack of major differences between males and females in growth behaviour and seed output which had been suggested by short-term studies elsewhere in the species' range.

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Introduction

Mastuj lies in between 36°-3′ north latitude and 72°-5′ east longitude towards the northeastern part of District Chitral bordering Northern areas and Afghanistan. The altitude of the area vary from 2200m-4000m. Climatically the area falls within dry temperate zone with mild summers and cold winters with snowfall. Topographically the area is bounded by mountains having scattered *Juniperus* forests. Ahmed *et al* (1990) sampled 60 monospecific stands of *Juniperus excelsa* at four locations in Balochistan and recorded density, basal area and height of individual. Soils were analysed for selected physical and chemical characteristics and the degree of disturbance due to logging and burning was also noted. Fisher and Gardner (1994) described the status and ecology of a *Juniperus excelsa* subsp. *Polycarpos* woodland in the northern mountains of Oman. Sarangzai (2000) described the population structure and natural regeneration potential of *Juniperus excelsa* in the northern Balochistan. Gauquelin *et al* (2002) studied the sex ratio and sexual dimorphism in *Juniperus thurifera*. Ali (2003) discussed issues and threats to Juniper forests in Chitral and provided recommendations for the conservation of these forests to avoid further degradation. Dar and Christensen (2003) recognized seven texa of *Juniperus* from the western Himalaya. Schulz *et al* (2003) studied cone morphology in *Juniperus* in the light of cone evolution in cupressaceae. Borghesio *et al* (2004) evaluated the conservation status of two *Juniperus* forests in south Ethiopia. Auken *et al* (2005) examined the emergence, mortality and growth of *Juniperus ashei*. Short term studies of *J. virginiana* in Ontario (Vasiliauskas and Aarssen, 1992) and in Alabama (Lawton and Cothran 2000) have shown a lack of major differences between males and females in growth rates, growth behaviour, sex ratio and seed output and suggested that the genetically-determined sex ratio was 1:1. However, it was not possible in those studies to determine the long-term survivorship of marked individuals and the effect that it may have had on the observed sex ratio, growth rates and growth behaviour. There have been frequent reports of inconstant sex expression in *Juniperus* species (Vasek 1966, Freeman et al. 1981, Lloyd and Bawa 1984, Jordano 1991), but there have been no long-term observations on the sex expression of *juniperus excelsa* individuals in natural populations. The objective of this research was to utilize long-term observations on associates of labeled individuals of *juniperus excelsa* to directly determine growth rates, growth behaviour, sex ratio and seed output of individual males, females and bisexual, constancy of sex expression, and resulting sex ratios.

Fig. 1. *Juniperus excelsa* M. Bieb. in Mastuj Valley, District Chitral.

Materials and methods

The study was conducted during August and November 2006. The approximate height, diameter, density and seed output of different sexes of *Juniperus excelsa* (Fig. 1) were measured. Diameter was measured as dbh at a height of 1.5 meters from the soil surface and density was calculated by using midpoint values. Seed output were known after using the formula:

SO = NFMi x NMi x NMj

SO = Seed output

NFMi = Number of fruits in minor branch

NMi = Number of minor branches

NMj = Number of major branches

A 24 x 24cm quadrat was used to count the number of fallen fruits and seedlings. Soils below and away from *Juniperus* were analyzed for elemental compositions and physio-chemical characteristics. The associated plant species of *Juniperus excelsa* were also noted.

Result and discussion

The study showed that in Mastuj village average maximum height were that of bisexual plants 248cm, followed by female plants 169.5cm and male plants 112cm. In Dodorghaz gol maximum height was observed in female plants 74.2cm, followed by bisexual plants 49cm and male plants 41.2cm. In Ghuru gol bisexual plants had maximum height 84.2cm, followed by female plants 66.5cm and male plants 59cm (Table 1). The maximum average diameter of different sexes of *Juniperus excelsa* in Mastuj village were female plants 20cm, bisexual plants 17cm and male plants 13cm. In Dodorghaz gol bisexual plants had maximum diameter 16cm, followed by female plants 13cm and male plants 10cm. In Ghuru gol female plants had 10.5cm, bisexual plants 9cm and male plants had 7cm diameters (Table 1). Density showed that female plants were dominants followed by male plants and bisexual plants in the area (Table 1).

Table 1. Growth behaviour and Sex ratio of *Juniperus excelsa* in Mastuj, District Chitral.

Parameter	Location	Mastuj		Dodorghaz gol	Ghuru gol
	Altitude	2300-2400m		2590-3300m	2290-3100m
	Habitat	Mesic		Dry	Stony & Dry
Height (cm)	Male Plant	Max	144	55	72
		Min	84	25	40
		Average	112	41.2	59
	Female Plant	Max	280	100	116
		Min	114	52.5	30
		Average	169.5	74.2	66.5
	Bisexual Plant	Max	480	55	96
		Min	96	43	72
		Average	248	49	84.2
Diameter (cm)	Male Plant	Max	17	12	9
		Min	9	7	4
		Average	13	10	7
	Female Plant	Max	28	15	15
		Min	12	9	7
		Average	20	13	10.5
	Bisexual Plant	Max	18	18	10
		Min	16	14	8
		Average	17	16	9
Density (mid point)	Male Plant	Max	15	5	25
		Min	5	5	15
		Average	10	5	20
	Female Plant	Max	25	25	35
		Min	15	15	15
		Average	20	20	25
	Bisexual Plant	Max	5	5	5
		Min	5	5	5
		Average	5	5	5

Table 2. Seed output of Female *Juniperus excelsa* in Mastuj, District Chitral.

Locality	Height (cm)			Diameter (cm)			Seed output			No. of Fruits within Quadrat	No. of Seedlings within Quadrat
	Max	Min	Average	Max	Min	Average	Max	Min	Average		
Mastuj	280	114	169.5	28	12	20	72000	3000	20640	147	16
Dodorghaz gol	100	52.5	74.2	15	9	13	85800	2160	23340	347	5
Ghuru gol	116	30	66.5	15	7	10.5	25920	117	5568	55	7

Table 3. Physico-chemical analysis of soils from study sites.

Sites	$CaCO_3$ %	OM %	N %	K %	pH	Ecx10³	TSS %	Clay %	Silt %	Sand %	Textural class
Mastuj village *Juniper*	5.75	2.82	0.141	95	7.4	0.23	0.073	13.6	32.0	54.4	Sandy loam
Mastuj village away *Juniper*	13.25	2.58	0.129	142	7.3	0.22	0.070	4.4	42.0	53.6	Sandy loam
Dodorghaz gol *Juniper*	12.50	2.27	0.113	114	7.6	0.10	0.032	2.4	18.0	79.6	Loamy sand
Dodorghaz gol away *Juniper*	12.75	2.20	0.110	95	8.2	0.12	0.038	10.4	26.0	63.6	Sandy loam
Ghuru gol *Juniper*	6.00	2.89	0.144	142	8.1	0.14	0.045	11.6	20.0	68.4	Sandy loam
Ghuru gol away *Juniper*	15.25	1.96	0.098	133	8.2	0.11	0.035	10.4	12.0	71.6	Loamy sand

Maximum average seed output was calculated in Dodorghaz gol 23340, followed by 20646 in Mastuj village and 5568 in Ghuru gol. Number of fallen fruits were also high in Dodorghaz gol 347, followed by 147 in Mastuj village and 55 in Ghuru gol. Number of seedlings were high in Mastuj village 16, followed by 7 in Ghuru gol and 5 in Dodorghaz gol (Table 2). The associated plant species with *Juniperus excelsa* in Mastuj village were *Cotoneaster affinis* var. *bacillaris, Hippophae rhamnoides, Mentha longifolia, Dicanthium annulatum, Sophora mollis, Rosa webbiana, Nepeta cateria, Berberis lycium, Saccharum spontaneum* and *Verbascum thapsus*. In Dodorghaz gol *Rosa webbiana, Astragalus psilocentros, Astragalus amberstianus, Artemisia brevifolia, Ephedra gerardiana, Berberis lyceum, Accantholimon longiscapum, Ribes orientalis, Cotoneaster nummularia, Cicer macranthum* and *Matricaria disciformis* were associated with *Juniper*. In Ghuru gol *Ephedra gerardiana, Artemisia brevifolia, Kracheninnikovia ceratoides, Acantholimon longiscapum, Otostegia limbata, Nepeta paulsenii, Astragalus psilocentros, Verbascum thapsus, Ribes orientalis, Polygonum glabrum, Rosa webbiana, Berberis lyceum* and *Echinops echinatus* were the associated species.

Soils below and away from *Juniperus excelsa* having elements such as Mg, Si, K, Ca and Fe in common with varying amounts. Carbon was present only in Mastuj village and in Dodorghaz gol below *Juniperus* soil. In Mastuj village the soils were sandy loam. In Ghuru gol the soils below the *Juniper* was sandy loam and loamy sand away from the *Juniper*. In Dodorghaz gol the soil below the *Juniper* was loamy sand and

away from the *Juniperus* the soil was sandy loam (Table 3).

In Pakistan *Junipeusr* forests are found in District Chitral, Gilgit, Kurum Agency, Kaghan valley and in Balochistan Province between altitude of 1800 and 4200 meters. *Juniperus* survive in harsh climatic conditions with 200 to 400 mm average precipitation with the majority being in the form of snow in winter. They grow on very poor soils, steep and screed slopes and sometimes even on the crevices of bare rocks. *Juniper* forests are vanishing rapidly from the mountains of Chitral because of over exploitation for domestic use and in some areas for commercial purposes (Ali, 2003).

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