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Full Length Research Paper

Assessment of status and biomass of *Swertia angustifolia* : a high value Himalayan medicinal plant

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Studies on population assessment and biomass variation in selected populations of *Swertia angus-tifolia* were undertaken in west Himalaya. Low population density across the surveyed populations indi-cates poor availability of the species in study area. Species showed random distribution and higher fre-quency of occurrence in most of the population, which is the indicator of better potential of the spe-cies in these sites. Density was positively correlated with biomass. The biomass showed peak value in senescence phase and thus has positive consequences of harvesting for the survival of the species.

Key words: Endangered, conservation, Himalaya, *Swertia angustifolia*, medicinal plant.

INTRODUCTION

Swertia, an important genus of family Gentianaceae, is distributed in the mountains of tropical Asia, Europe, America and Africa. About 32 species of *Swertia* occur in Indian Himalayan Region (IHR) of which 16 species are reported from northwest Himalaya (Garg, 1987). Among these, *Swertia angustifolia* Ham. ex D. Don (family Gentianaceae) is an erect annual herb, occurring between 600 - 2000 m asl in parts of west Himalaya, Nepal, Garhwal and Kumaon (Garg, 1987). The species is useful in the treatment of malarial fever and bronchial asthma and is used as a substitute of chirayita (*Swertia chirayita)* (Kiri-tikar and Basu, 1984; Ghosal et al., 1978). Besides these, the plant is also used as a blood purifier and febrifuge (Bhattacharjee, 2001). In addition to target species several other species of *Swertia* are also known for their medicinal value (Table 1).

Due to several adverse factors such as grazing and habitat destruction affecting the growth and survival, the species has become the endangered medicinal plant of west Himalaya (Samant et al., 1998). It also falls in the list of medicinal plants prioritized for conservation (Sastry and Chatterjee, 2000).The development of appropriate conservation strategies for threatened species requires details of occurrence, availability and distribution pattern in natural habitat. To date, the assessment of threat categories to species in IHR is mostly based on qualitative observations (Pangtey and Samant, 1988; Samant et al., 1993; 1996a, b; 1998a; Pandey and Well, 1997). Very few studies have used both qualitative and quantitative attributes for assessment of species status (Samant et al., 1996a; Airi et al., 1997; Airi et al., 2000; Bhatt et al., 2005; Bhatt et al., 2006). In the context of Himalayan medicinal plants only few studies considered both density and biomass (Table 2).

Population assessment in natural habitats is considered necessary for developing *in-situ* conservation strategies. This assumes significance in view of the fact that *S. angustifolia* is near endemic (Samant et al., 1998) in addition to possessing the aforementioned properties. Perusal of literature reveals that information on population dynamics of *S. angustifolia* is not available. Therefore the present investigation attempts to provide quantitative details of *S. angustifolia* through: (i) assessment of distribution patterns and quantum of availability of target species and (ii) analysis of variations in biomass among natural populations.

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Table 1. Medicinally important species of genus *Swertia.*

Species name	Altitude m asl	Parts used	Uses
Swertia chirayita (Roxb. ex Fleming) Karsten	1200-3000	WP	Blood purifier, skin disease, bitter tonic for fever, indigestion, laxative, anthelmentic, antidiarrhoetic, antiperiodic and bronchial asthma
Swertia alata (Royle ex D.Don) Cl.	1200-3500	WP	Infusion of plants used as tonic and febrifuge
Swertia ciliata D.Don ex G.Don	2700-4000	Lf	Used as substitute of Chirayita
Swertia paniculata Wall.	1500-3000	WP	Used as substitute of Chirayita
Swertia cordata Wall.	1800-3000	WP	Used as substitute of Chirayita
Swertia nervosa (G. Don) Wall.	3000-4000	WP	Used as substitute of Chirayita
Swertia tetragona Edgew ex Cl.	1900-3100	WP	Not known but due to bitter taste it is used as substitute of Chirayita
Swertia thomsonii Cl. ex Hook f. & T.	2700-4350	WP	The decoction of plant is used in head-ache and fever
Swertia speciosa Wall. ex Griseb	2670-4670	Rt	Used as substitute of Chirayita
Swertia kingii Hook.f	2940-4747	WP	Used as substitute of Chirayita
Swertia petiolata Royle ex D.Don	3800-5600	WP	Medicinal for gall disorder

WP: whole plant; Lf: Leaves; St: Stem; Rt: Root

MATERIALS AND METHODS

Seven populations of *S. angustifolia* were identified in different parts of Kumaon Himalaya (Snow view, Killburry, Jageshwar, Jalna, Deenapani, Majhkhali and Katarmal). Specific details of locations (altitude, latitude and longi-tude) of the populations were recorded using the hand held Global Positioning System (GPS) (Trimble Make) (Table 3). In each population, one 20 x 20 m plot was established and 15 (1 x 1m) quadrats placed randomly inside the plot. Individuals of all the species, that is, *S. angusifolia* and its associates, were recorded in all qua-drats. The pooled quadrat information was used to ana-lyze compositional features such as frequency, density, abundance and A/F ratio (Misra, 1968).

All the studied populations under investigation were visited during the active growing season (July to Septem- ber 2001-2002) for bio-mass estimation. Five randomly selected individuals from each population were harvested at two growth stages (flowering and senescence). The harvested individuals were carefully washed. Before re-cording the fresh weight of each individual, the water adhering to the surface was removed by pressing it care-fully on tissue paper. Thereafter the entire sample was oven dried at 80^oC to constant weight (Airi et al., 1997). Since the whole plant (*S. angustifolia*) possesses medicinal properties, the attempts were made to determine the biomass in two growth stages for the identification of best stage for optimum yield. Total biomass was obtained by multiplying individual dry weight with stand density of species in each phase that is, maturation and sene-scence phase (Airi et al., 1997; Bhatt et al., 2006).

An analysis of variance (ANOVA) was conducted on biomass data of different phenophases (flowering and senescence) . The least significant difference among means were separated by using Fisher's least significant difference (LSD; p<0.05) following Snede-cor and Cochran (1968).

RESULTS

Occurrence and availability

S. angustifolia grows well in dry southeast facing slopes under a mixed canopy of oak and pine. The density of *S. angustifolia* varied between 0.80 individual / m2 (Sa_1) to 1.95 individual / m2 (Sa_4). The frequency of occurrence was relatively better (55% - Sa_1 to 90% - Sa_5) and comparable to other associated species. The species largely prefers the southeast facing slope. The abun-dance to frequency (A/F) ratio of *S. angustifolia* revealed that species was distributed randomly in most of the populations (Sa_1, Sa_2, Sa_4 and Sa_6). Few other populations, Sa_3, Sa_5 and Sa_7 showed regular distribution patterns (Table 3).

The density of *S. angustifolia* is positively correlated with the above ground biomass (r = 0.819, P< 0.05), be-low ground biomass (r = 0.767, P< 0.05) and total bio-mass (r = 0.820, P< 0.05).

Variation in biomass

The variation in fresh weight during the maturation and senescence phase was not significant. Among popu-lations, Sa_4 with maximum fresh weight (maturation-13.05; senescence-11.48 gm), showed significantly more (p<0.05) fresh weight than the other populations. Likewise, while considering the total dry weight values, population Sa_4 continued to exhibit the maximum dry weight at maturation (4.05 gm) and senescence (4.23 gm) phases. These values were significantly higher than the values obtained for most of the other populations.

The values for above ground biomass were, in most cases, higher for senescence phase. During this phase the values varied between 2.48 to 6.63 gm/m^2. The value values of biomass during this phase were significantly higher in most populations (Sa_1, Sa_2, Sa_3 and Sa_6) as com pared to maturation phase. Similarly, in all the cases below ground biomass peaked in the senescence phase and values were significantly higher (p<0.05) than matu-ration phase, except population Sa_3.

In all the populations, the total biomass peaked during

Table 2. Earlier report on phytosociology and biomass of Medicinal plants.

Species	Studied parameter Density	Biomass	Working area	Reference
Allium stracheyi	+	+ (UGV)	UGV and NDBR	Uniyal et al., 2002; Maikhuri et al., 1998
Carum carvi	+	+ (UGV)	UGV and NDBR	Uniyal et al., 2002; Maikhuri et al., 1998
Dactylorhiza hatagirea	+	+ (UGV)	UGV, Indian trans Himalaya, NDBR and VOF	Uniyal et al., 2002; Kala, 2000; Maikhuri et al., 1998; Kala et al., 1998
Pleurospermum angelicoides	+	+ (UGV)	UGV and NDBR	Uniyal et al., 2002; Maikhuri et al., 1998
Bergenea stracheyi	+	+ (UGV)	UGV, Indian trans Himalaya and VOF	Uniyal et al., 2002; Kala, 2000; Maikhuri et al., 1998
Picrorhiza kurrooa	+	+ (UGV)	UGV, Indian trans Himalaya and VOF	Uniyal et al, 2002; Kala, 2000; Maikhuri et al., 1998
Podophyllum hexandrum	+	+(UGV, Pindari, Sundar dhunga)	UGV, Indian trans Himalaya, Pindari, Sunderdhunga and Kaphani	Uniyal et al, 2002; Kala, 2000;Airi et al., 1997
Rheum australe	+	+ (UGV)	UGV, Indian trans Himalaya and VOF	Uniyal et al., 2002; Kala, 2000
R. moorcroftianum	+	+ (UGV)	UGV and Indian trans Himalaya	Uniyal et al., 2002; Kala, 2000
Aconium heterophyllum	+	-	Hemkund, Kedarnath, Madmahas-hwar, Panwali Kantha, Tungnath	Nautiyal et al., 2003
A. viloceum	+	-	Hemkund, Kedarnath, and Panwali Kantha	Nautiyal et al., 2003
A. balfourii	+	-	Dayara, Hemkund, Kedarnath, Madmahashwar, Panwali Kantha, Tungnath and VOF	Nautiyal et al., 2003
Nardostachys jatamansi	+	+	Pindari and Sunderdhunga catchment	Airi et al., 2000
Dactylorhiza hatagirea	+	-	NDBR and VOF	Bhatt et al., 2005
Swertia chirayita	+	+	Kanchula, Kalaseer, Duggalbitha (Uttaranchal) Pullag and Dora(Himachal)	Bhatt et al., 2006

UGV= Upper Gori Valley; +=Studied conducted; - = Studied not conducted; NDBR= Nanda Devi Biosphere Reserve; VOF=Valley of Flower.

the senescence phase with a variation between 2.81 to 8.25 gm/m^2. The comparison of the biomass value at both the maturation and senescence phase revealed that most of the populations (Sa_1, Sa_2, Sa_3 and Sa_6) exhibit significantly more values of biomass at senescence phase (Table 4).

DISCUSSION

Studies on quantitative assessment play a vital role in the ecology of the species (Uniyal et al., 2002). It helps in determining the performance of populations under different sets of conditions and provides desired information about the specialized ecological requirements of a taxon (Kaul and Handa, 2001). The information, thus generated, has immense potential for contributing in conservation and management of rare threatened plant species (Synge, 1985; Hutchings, 1991). Low population density across the surveyed populations indicates poor availability of the species in study area. However, random distribution (4 populations) and higher frequency of occurrence is indicative that species have potential for better performance in these sites (habitats) in the region. It is observed that the whole plant of the species is used for medicinal properties (Mukherjee, 1953; Kirtikar and Basu, 1984) and, individuals are uprooted indiscriminately. It is reported that harvesting of the whole plant is more destructive than the harvesting of fruits, seeds or leaves in isolation (Sheldon et al., 1997). Furthermore, the removal of the entire plant before seed maturation ceases the possibilities of development of future regeneration (Sheldon et al., 1997).

Poor distribution of *S. angustifolia* across the sites and its localised distribution in specific pockets (habitats) reflect its endangered status. This has a conservation implication, as the species with specific habitat requirements have greater possibilities of extinction than the species with broad habitat range (Samant et al., 1996b). Since a minimum population size is required for long term viability of rare and endangered species (Cunningham and Saigo, 1999), the density of *S. angustifolia* increases up to certain altitudinal limit (1920 m) and decreases gradually

Table 3. Location and availability of *Swertia chirayita* in selected populations.

Population	Altitude (m asl)	Aspect	Species	Frequency (%)	Density (Individual/ m^2)	Relative Density (%)	A/F ratio	Habitat characteristics
Snow view Sa_1	2210	NE	*S. angustifolia*	55	0.80	0.95	0.026	Steep grassy slopes with *Q. leucotricho-phora*
			Associates					
			Poa annua	90	78.17	92.98	0.960	
			Anisomeles spp.	90	2.10	2.50	0.025	
			Blumea spp.	60	1.30	1.54	0.036	
			Others (4)		1.69	2.03		
			Total		84.06	100		
Killburry Sa_2	2200	SE	*S. angustifolia*	70	1.55	1.94	0.031	Steep grassy slopes with *Q. leucotricho-phora*
			Associates					
			Cenchrus spp.	85	72.94	91.07	1.00	
			Anaphalis spp.	25	1.70	2.12	0.270	
			Dryopteris spp.	70	1.55	1.94	0.031	
			Others (3)		2.35	2.93		
			Total		80.09	100		
Jageshwar Sa_3	2020	NW	*S. angustifolia*	75	0.9	0.7	0.016	Moist grassy slope with *Q. leucotricho-phora, Pinus rox-burghii* and *Myrica esculenta*
			Associates					
			Ferula spp.	95	116.78	93.32	1.290	
			Scutellaria spp.	55	1.05	0.83	0.034	
			Blumea spp.	80	3.40	2.72	0.053	
			Others (4)		3.00	2.43		
			Total		125.13	100		
Jalna Sa_4	1920	SE	*S. angustifolia*	75	1.95	1.34	0.034	Grassy slope with *P. roxburghii, Q. leu-cotrichophora* and *M. esculenta*
			Associates					
			Trichanthium spp.	95	132.41	91.18	1.46	
			Blumea spp.	70	3.90	2.69	0.070	
			Asparagus spp.	35	3.05	2.10	0.240	
			Others (3)		3.90	2.69		
			Total		145.21	100		
Deenapani Sa_5	1770	SE	*S. angustifolia*	90	1.5	1.26	0.018	Grassy slope with *P. roxburghii*
			Associates					
			Themeda anathera	100	108.74	91.88	1.080	
			Blumea spp.	80	2.30	1.94	0.035	
			Anaphalis spp.	80	2.80	2.37	0.040	
			Others (5)		3.0	2.55		
			Total		118.34	100		
Majkhali Sa_6	1700	SE	*S. angustifolia*	75	1.43	1.01	0.025	Steep slope with *P. roxburghii*
			Associates					
			Trichanthium spp.	100	131.96	93.79	1.310	
			Anaphalis spp.	40	1.35	0.95	0.070	
			Blumea spp.	85	2.17	1.45	0.030	
			Others (3)		11.77	2.80		
			Total		148.68	100		
Katarmal Sa_7	1200	NE	*S. angustifolia*	75	1.44	0.75	0.019	Gentle grassy slope with *P. roxburghii*
			Associates					
			Trichanthium spp.	95	132.11	92.42	1.380	
			Anaphalis spp.	80	2.0	1.41	0.029	
			Blumea spp.	25	3.10	2.16	0.401	
			Others (3)		4.29	3.26	-	
			Total		142.94	100		

Table 4. Biomass variation in different phenophases of *S. angustifolia.*

Population	Phenophases	Above ground biomass (gm/ m^2)	Below ground biomass (gm/ m^2)	Total biomass (gm/ m^2)
Sa_1	M	1.40	0.07	1.47
	S	2.86	0.45	3.31
Sa_2	M	3.53	0.32	3.85
	S	5.05	0.62	5.67
Sa_3	M	1.51	0.18	1.69
	S	2.48	0.33	2.81
Sa_4	M	7.46	0.46	7.92
	S	6.63	1.62	8.25
Sa_5	M	2.04	0.23	2.27
	S	2.82	0.42	3.24
Sa_6	M	2.52	0.13	2.65
	S	3.56	0.69	4.24
Sa_7	M	3.89	0.14	4.03
	S	3.80	0.61	4.41

M-maturation and S-senescence. LSD ($p<0.05$), for above ground biomass (0.89), below ground biomass (0.19), total biomass (1.09).

with further increase in altitude indicating its specific preference of altitude. This pattern of density-distribution for *S. angustifolia* correspond well with some reports on other species wherein it is said that the geographical distribution of the species is heterogeneous with the density attaining a peak near the center of its distribution range and lowering towards the margins (Hengeveld and Haeck, 1982; Brown, 1984). As far as density of the species is concerned, it showed positive correlation with above ground, below ground and total biomass. This has implications for propagation or cultivation of species. Probably, the chances of good crop pro-duction will increase through high density plantation. These findings are in tune with the reports that root/rhizome biomass is positively correlated with density (Pechakova et al., 1999).

In the case of medicinal plants, time of harvesting is critical because it needs to be related to availability of maximum biomass/ active components. In the present study most of the populations (4) showed significantly more biomass in the senescence phase. These findings have relevance for sustainable harvesting of the species. However, the finer details of the active principles availability in the two phenophases can be drawn out in light of proper phytochemical analysis. In such a situation it is recommended that plants should be harvested in the sensecence phase when most of the reproductive stages are completed.

The present data on population status and habitat preference would assist in the understanding of the ecology and development of the conservation plan with regard to the species. The study also recommends the collection of plant material in the senescence phase, which ultimately leads to sustainable utilization of the species. The Jalna population showed the highest bio- mass, therefore this population may be recommended as elite and propagules from this population can be used for mass propagation / cultivation

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