INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 3, Issue 3, July-September 2012: 189-198 www.ijcs.uaic.ro

ECOLOGICAL FEATURES AND CONSERVATION OF ARNEBIA EUCHROMA. A CRITICALLY ENDANGERED MEDICINAL PLANT IN WESTERN HIMALAYA

Koushalya Nandan SINGH[1*], Brij LAL[1], Gopi CHAND[1], Nagendra P. TODARIA[2]

[1] Biodiversity Division, Institute of Himalayan Bioresource Technology, CSIR, Palampur, 176061, Himachal Pradesh, India
[2] Forestry Department, HNB Garhwal University, Srinagar, Uttarakhand, India

Abstract

Arnebia euchroma (Royle ex Benth.) Johnston, commonly known as 'Ratanjot' is an important medicinal plant species and is found distributed in the western Himalaya at elevations ranging between 3200 - 4500 m above sea level. Considering its potent medicinal properties, cultural significance, declining population density and critically endangered status of this taxon, the present investigation was carried out for the assessment of its availability in the natural alpine landscapes of the Spiti cold desert of western Himalaya in Himachal Pradesh (India). We focused our study on its ecological features, population dynamics and performance in natural habitats, so as to formulate conservation plans. In order to achieve the objectives of the present study, a total of 620 areas were set by using a random sampling technique at six different locations where A. euchroma was found distributed naturally. The highest population density was recorded in undulating meadows (5.30 individuals/m^2) with a maximum circumference (4.18±1.80cm) at an elevation of 4240 m above sea level, with maximum frequency of occurrence (100%). Ecological surveys revealed that distribution was restricted in specific habitats rich in soil nutrients with high pH (8.025 - 8.37). The significance of the role of various ecological variables is explained in detail in the present paper. Habitat specificity, low population, and anthropogenic pressure justify the rarity status of this taxon in the Spiti valley. The authors discussed different implications to develop appropriate strategies for a long-term monitoring and sustainability of A. euchroma in the Spiti cold desert of western Himalaya.

Keywords: *Arnebia euchroma; ecological monitoring; conservation; sustainable use; western Himalaya.*

Introduction

A number of medicinal plants collected from the Indian Himalayan region (IHR) are highly threatened, due to their increasing demand for the pharmaceutical industry [1]. In IHR, about 1,748 species of medicinal value have been reported [2], contributing with 90% of the raw material from natural habitats for the herbal industry in India and for export [3]. The natural environment in Indian trans-Himalaya, one of the most important biological hotspots and ecologically fragile biogeographic zones in India [4] is also under tremendous stress. The Spiti cold desert, an integral part of the Indian trans-Himalaya is also under high pressure of over-

* Corresponding author: knsingh.ecology@gmail.com

exploitation of its natural resources, due to various socio-economic changes, the increase in demand and population [5]. The cold, arid region of Spiti harbors most of the endemic, threatened and rare plants. Several years of unscientific collection of valuable medicinal plants resulted in the depletion of their population in natural habitats [6].

The present article highlights the status of *Arnebia euchroma* (Royle ex Benth.) Johnston (Boraginaceae), a commercially valuable and critically rare medicinal plant, distributed naturally in the Spiti cold, arid zone of trans-Himalaya, in Himachal Pradesh (Fig 1). During 1998, that species was placed under the category of endangered plants [7]. However now it is included in the list of critically endangered, threatened plants for Himachal Pradesh [8], according to the latest IUCN categorization.

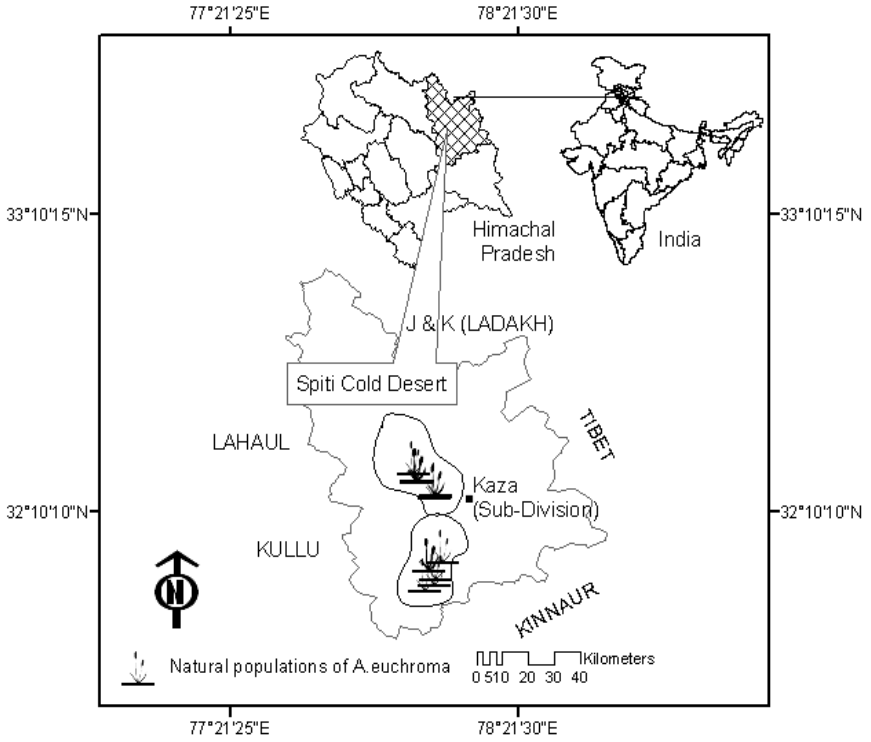

Fig. 1. Map showing natural distribution of *Arnebia euchroma* in the Spiti cold desert of trans-Himalaya

Out of the total 5 species of the genus *Arnebia*, only 3 are found in the Spiti cold desert of trans-Himalaya [9] and *A. euchroma* (syn. *Macrotomia perennis* Boiss) is the one that is used commercially on a large scale. The species is known as Dimok or Khamed in the Spiti valley and is famous by its trade name Ratanjot. It is distributed in dry areas, usually between 3300-4500 m of altitude, in alpine western Himalaya, western Tibet and Nepal [10]. *A. euchroma* is an erect, caespitose, perennial, hairy herb with many stems, arising from the axils of its basal leaves (Fig 2). Its reproductive cycle ranges from June to August. Its roots are purplish in color and are used in many herbal medicine preparations. Besides curing bodily aches [11], the species also possesses antimicrobial [12] and anti-HIV properties [13]. Considering its medicinal value, the declining population and its critical endangered status, it is imperative to take urgent measures for the conservation of *A. euchroma*. Studies on its population status and ecological attributes play a vital role to formulate the conservation plans [14] and are required to develop appropriate strategies for its long term monitoring and sustainable use. Important

available publications with significant information on the quantitative assessment of various medicinal plants in the Indian Himalayan Region [6, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25] reveal no records on the ecological status of *A. euchroma*. Thus, the present paper provides some quantitative details on population structure, ecological features, availability, and conservation implications of *A. euchroma* in the Spiti cold desert of western Himalaya.

Fig. 2. *Arnebia euchroma*: a critically endangered medicinal plant

Materials and Methods

Description of the Study Area

Extensive ecological surveys were conducted to estimate the population density of *A. euchroma* in the entire Spiti cold desert of western Himalaya, where it is found naturally distributed (Fig 3).

Fig. 3. Distribution of *Arnebia euchroma* in the dry landscape of the Spiti cold desert

Spiti, with an area of 5,582 sq km, is situated between 31°42′ - 32°58′N latitude and 77°21′ - 78°35′E longitude in the extreme North-East, in the state of Himachal Pradesh, India. Its average elevation is 4000 m above sea level. The study area is known for a considerable variation in temperature. Generally, July and August are recorded as the hottest months, when the maximum temperature in July and August goes up to 30.5^{0}C. January and February are the coldest months, when the lowest temperature fluctuates between -30.5^{0}C and -24.5^{0}C (Fig 4).

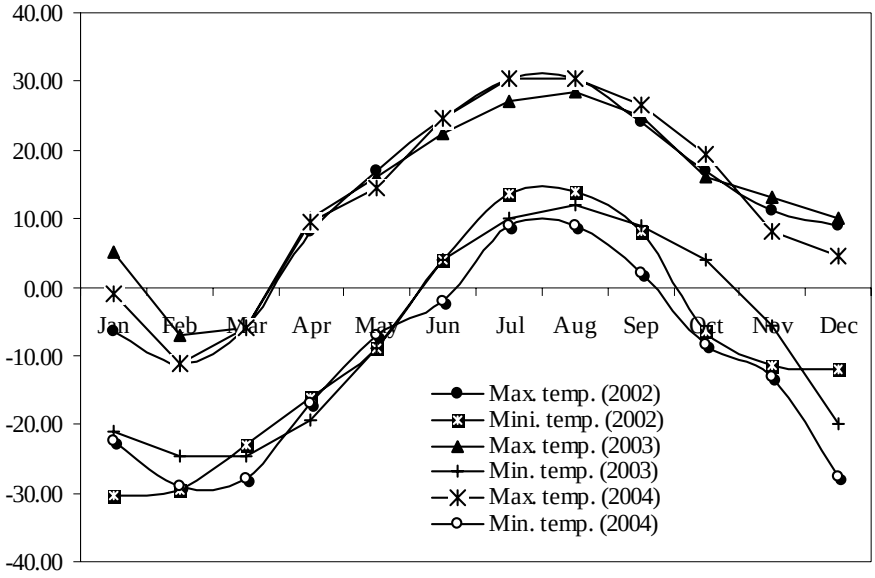

Fig. 4. Outline of temperature variation during the preliminary survey period in Spiti

Sampling Technique and Analysis

Natural distribution of *A. euchroma* in various landscapes was identified at six different locations, where the random sampling square method [26] was employed to study population structure. A total of 620 areas were set, sized 1×1 m, covering all sampling sites under investigation. The density (number of individuals/ m^2) and frequency (%) of the species were calculated [27]. The average value of plant circumference (cm) at ground level and the population density in each location were considered to explain the performance of species. Composite soil samples collected from natural habitats were analyzed for chemical constituents, by following standard methods [28]. Simple regression correlation (polynomial) was worked out to determine the correlation (*r*-value) among the mean values of studied parameters, in order to understand the interactions of the species with ecological variables, as described by Fowler *et al*. [29].

Results and Discussions

In total, six locations with varying number of natural habitats of *A. euchroma* were identified in the Spiti valley. The species generally grows in association, on open slopes with varying directions. However north was the most preferred part. Populations were found distributed between 3500 - 4250 m of elevation. However, the recorded slope of natural habitats was between 15 - 46 degrees. Random distribution of species in small fragmented patches suggests its patchy or scattered distribution. The population density of *A. euchroma* in most of

its natural habitats was low (0.14 - 2.88 individuals/ m^2). However, two habitats were found with higher densities, at 4050 m, in Lapcha Longpa (3.10 individuals/ m^2) and in the undulating meadows of Langza (5.30 individuals/ m^2), at 4240 m. A wide range of frequency of occurrence (4.55 - 100%) was observed. The highest frequency of species distribution was recorded in the undulating meadows of Langza and the dry slopes at Sagnam (100% each), followed by the bouldry slopes (95%) in the scrub land of Lapcha Longpa (Table 1). During the assessment of *Jurinea dolomiaea* in different habitats, at the alpine meadows of Kumaon Himalaya, Awasthi *et al.* [20] found the highest density and frequency in the undulating meadows and in the Chhota Bhangal area of western Himalaya, Uniyal *et al.* [19] also reported similar observations.

Table 1. Availability and status of *Arnebia euchroma* in Spiti cold desert

Location	*Major community*[§]	*Micro-habitat(s)*	*Altitude (m)*	*Aspect*[‡]	*Slope (degree)*	*Density*	*Frequency*	*Dominant associates*
Farka	Ae-Ct	Bouldry slope	3665	E	35	1.43	66.67	*Cousinia thomsoni* (80.95); *Heracleum thomsonii* (33.33)
	Ct-Ll	Scrub land	3525	N	25	0.44	22.22	*Cousinia thomsoni* (100); *Lindelofia longiflora* (77.78)
Sagnam	Ae-Cm	Dry slope	3850	SE	40	2.88	100.00	*Cicer microphyllum* (75); *Saussurea jacea* (25)
	Ht-Rs	Scree slope	3860	SE, NW	46	0.32	21.21	*Heracleum thomsonii* (85.71); *Rheum spiciforme* (84.62)
Telling	Ae-Sj-Ht	Scree slope	3700	E	45	1.20	60.00	*Saussurea jacea* (90); *Heracleum thomsonii* (80)
	Ho	Bouldry slope	3700	E	40	0.14	4.55	*Cousinia thomsoni* (31.82); *Hyssopus officinalis* (72.73)
Kibber	Ae	Undulating meadow	4200	NW	25	2.30	75.00	*Cousinia thomsoni* (45); *Heracleum thomsonii* (45)
	Ae-Am	Undulating meadow	4100	NE	35	1.57	50.00	*Artemisia maritima* (64.29); *Potentilla gerardiana* (42.86)
	Ht-Dh	Scrub land, loose dry soil	4250	NW	32	0.27	20.00	*Dracocephalum heterophyllum* (66.67); *Heracleum thomsonii* (100)
Langza	Ae-Ab-Dh	Undulating meadow	4240	NE	15	5.30	100.00	*Allium blandum* (50); *Dracocephalum heterophyllum* (50)
	Ae-Eg-Ac	Scrub land	4115	SW	30	2.15	76.92	*Asperula cynanchica* (53.85); *Ephedra gerardiana* (69.23)
	Dh-Ct	Loose dry soil	4250	W	25	1.67	13.33	*Cousinia thomsoni* (53.33); *Dracocephalum heterophyllum* (66.67)
Lapcha Longpa	Ae-Ct	Scrub land with bouldry slope	4050	NE, NW	40	3.10	95.00	*Cousinia thomsoni* (80); *Heracleum thomsonii* (40)

[§] Major communities are categorized on the basis of dominant species with frequency > 50%
Ab, *Allium blandum*; Ac, *Asperula cynanchica*; Ae, *Arnebia euchroma*; Am, *Artemisia maritima*; Cm, *Cicer microphyllum*; Ct, *Cousinia thomsoni*; Dh, *Dracocephalum heterophyllum*; Eg, *Ephedra gerardiana*; Ho, *Hyssopus officinalis*; Ht, *Heracleum thomsonii*; Ll, *Lindelofia longiflora;* Pg, *Potentilla gerardiana*; Rs, *Rheum spiciforme*; Sj, *Saussurea jacea*.
[‡]E, east; N, north; W, west; SE, south east; NE, north east; NW, north west; SW, south west.

Major plant communities (Table 1) were categorized in the present study, on the basis of higher frequency of occurrence (above 50%) of common species. The results revealed that some species grow in association with many other plants, preferring similar ecological environments. *Allium blandum, Artemisia maritima, Cicer microphyllum, Cousinia thomsoni, Dracocephalum heterophyllum, Ephedra gerardiana, Heracleum thomsonii, Hyssopus officinalis, Lindelofia longiflora, Potentilla gerardiana, Rheum spiciforme* and *Saussurea jacea* were the dominant associates of *A. euchroma* in various micro-habitats, like dry bouldry and scree slopes, undulating meadows and loose dry soil in the alpine scrub land.

Individuals of *A. euchroma* found in the natural habitats at Langza showed the maximum circumference (4.18 ± 1.80), followed by Lapcha Longpa (3.55 ± 1.67) (Table 2). However, the highest average density recorded in those locations was 3.04 individuals/ m^2 and 3.1

individuals/ m^2 respectively. The individuals with the lowest circumference were found at Telling (2.53 ± 1.12), with a low average population density of 0.67 individuals/ m^2 (Fig 5).

Table 2. Soil characteristics in natural habitats of *Arnebia euchroma* in Spiti cold desert

Population	*Farka*	*Sagnam*	*Telling*	*Kibber*	*Langza*	*Lapcha Longpa*
Circumference (cm)	2.91 ± 0.89	2.85 ± 1.17	2.53 ± 1.12	2.27 ± 1.15	4.18 ± 1.80	3.55 ± 1.67
Soil pH	8.025 ± 0.44	8.300 ± 0.260	8.245 ± 0.170	8.040 ± 0.420	8.210 ± 0.090	8.370 ± 0.040
EC (mmhos/cm)	0.139 ± 0.03	0.115 ± 0.040	0.165 ± 0.010	0.120 ± 0.040	0.160 ± 0.030	0.163 ± 0.004
OM (%)	4.65 ± 2.28	2.308 ± 0.360	2.290 ± 0.400	2.830 ± 1.300	4.000 ± 1.034	3.770 ± 0.380
N (kg/h)	218.28 ± 28.78	160.72 ± 29.07	181.3 ± 8.77	227.39 ± 125.13	235.2 ± 51.86	254.8 ± 55.44
P (ppm)	5.96 ± 4.94	14.65 ± 5.70	33.25 ± 19.18	17.00 ± 3.05	18.58 ± 5.88	19.13 ± 11.84
K (ppm)	120.00 ± 38.47	120.00 ± 62.85	172.50 ± 87.32	150.51 ± 57.9	166.67 ± 75.05	185.00 ± 91.92

EC - electrical conductivity; OM - organic matter; N - available nitrogen; P - phosphorus; K - potassium

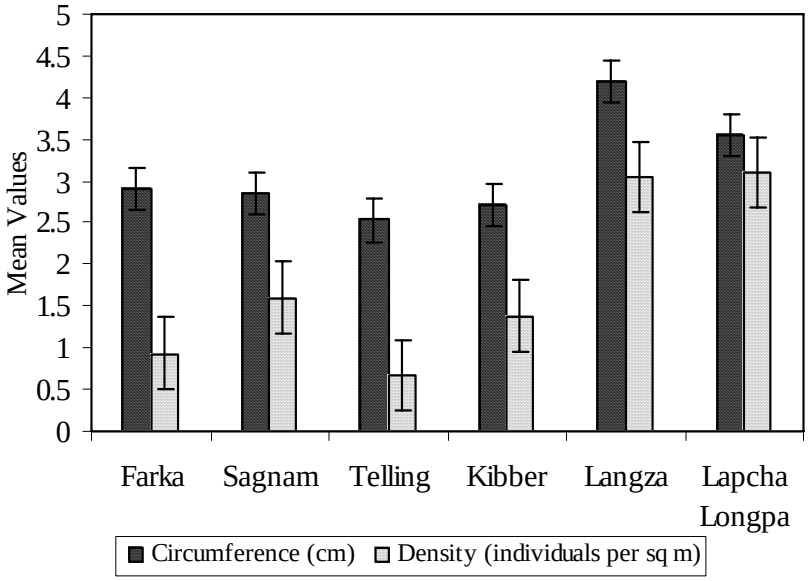

Fig. 5. Performance of *Arnebia euchroma* at different locations in Spiti

Among different phytosociological parameters, the high level of positive and significant correlation of population density was observed with the circumference of plants (r=0.936; p<0.01) and the frequency (r=0.882; p<0.05). However frequency and circumference were also correlated significantly (r=0.901; p<0.05). In the case of soil parameters, organic matter (r=0.840; p<0.05), the available nitrogen (r=0.869; p<0.05) and available phosphorus (r=0.772; p<0.1) significantly influenced the population density. Frequency also showed a high significant correlation with available nitrogen (r=0.986; p<0.01). Besides, organic matter (r=0.786; p<0.1) was the only soil parameter showing a positive influence on the circumference of individuals. Soil pH, however, did not have any significant correlation with density, due to non-significant variations in the pH values, but it is imperative to note that *A. euchroma* prefers alkaline soils, with a pH between 8.025 and 8.37 (Table 2) for its natural growth, development and distribution. Therefore a significantly positive correlation (r=0.823; p<0.05) of soil pH with frequency highlights its importance for the distribution of *A. euchroma* in natural landscapes.

Apart from soil properties, a significant effect of altitude on density (r=0.732; p<0.1) was also observed within its distribution range of 750 m. However, the slope also exhibited a similar trend with circumference (r=0.735; p<0.1). Supporting the observations of the present study,

Airi *et al.* [16] reported a significant positive relationship between the frequency and density of *Nardostachys jatamansi* and the altitude. Moreover, density also had a positive correlation with soil properties, such as organic carbon and nitrogen contents. Kala [6] also found an increasing pattern in the population density of a number of rare and endangered medicinal plants from lower alpine to higher alpine zones in the Indian trans-Himalaya.

According to Nayar and Shastry [30] over 113 plant taxa of endangered categories grow in Indian Himalaya, and are under the pressure of over exploitation and the destruction of their natural habitats [7, 8]. *A. euchroma* in Spiti is also facing similar threats. The extraction of roots by digging out whole plants indiscriminately causes low population densities and habitat degradation, which are major constraints for future regeneration. It is a usual practice in the Spiti valley to sell and use its roots as edible dye and medicine [9]. Local doctors (known as *Amchis* in western Himalaya) use the root extract in different indigenous medicines, prescribed for cough and for blood purification. Moreover, trampling by livestock was also noted as a major factor for the depletion of its population in natural habitats. In relation to these observations, Kala [6,17] highlighted that over-collection and grazing pressure are the disturbances most responsible for the low density and continuous decline of the wild populations of most of the rare and endangered medicinal plants in the Indian Himalayan region. Similarly, Bhatt *et al.* [21] also observed that frequent extraction and increased grazing pressure were mainly responsible for the low population status of *Dactylorhiza hatagirea* in central Himalaya.

During the surveys, some of the areas far from roads, local paths and human settlements, possessed healthy individuals with higher densities in undulating meadows (5.30 individuals/ m^2) and in the scrub land of bouldry slopes (3.10 individuals/ m^2). Considering species performance across localities, Langza and Lapcha-Longpa appeared to be the best in regard to the circumference of individuals, population density and frequency of occurrence.

The distribution in fragmented habitats and the wide variation in frequency of occurrence of *A. euchroma* suggested a high potential of the species to grow over large areas (Fig 6), but due to anthropogenic activities, it seemed unable to form large continuous distribution boundaries. Significant correlations of the density, frequency and circumference of *A. euchroma* with soil properties revealed that the taxon prefers nutrient rich soils with alkaline nature. Its preference for specific soil properties, with restricted distribution in fragmented patches, highlights an imperative mechanism, indicating that the rate of extinction of this species from the population available in fragmented patches, with specific habitat requirements, becomes faster than that of species with a continuous broad habitat range, because the ecological niches available for the survival of such plants are reduced [1, 18].

As with *A. euchroma* in the Spiti valley, restricted distribution and habitat specificity at higher elevations in Indian Himalayan regions have also been reported for various other threatened medicinal plants. In Kumaun, Airi *et al.* [15] studied the population structure of *Podophyllum hexandrum* and found its best performance in specific habitats with acidic soils. However during 2002, Airi *et al.* [16] also reported the occurrence of *Nardostachys jatamansi* in specialized habitats, at high altitudes in the Himalaya, ranging from 3000 to 5000 m. While exploring the natural habitats of *Aconitum balfourii, A. heterophyllum* and *A. violaceum* in Gharwal Himalaya, Nautiyal *et al.* [18] found restricted distribution of these species with very low population density. In the upper Gori valley, Uniyal *et al.* [14] also reported the specific habitat preferences of most of the threatened species, which were usually found in distinct landscape units or habitats. Apart from habitat specificity, it has also been revealed that most of the herbs from temperate regions are highly vulnerable to harvesting [31], where harvesting of a large number of medicinal plants from wild populations was reported to be unsustainable, leading to the reduction in their population status [32].

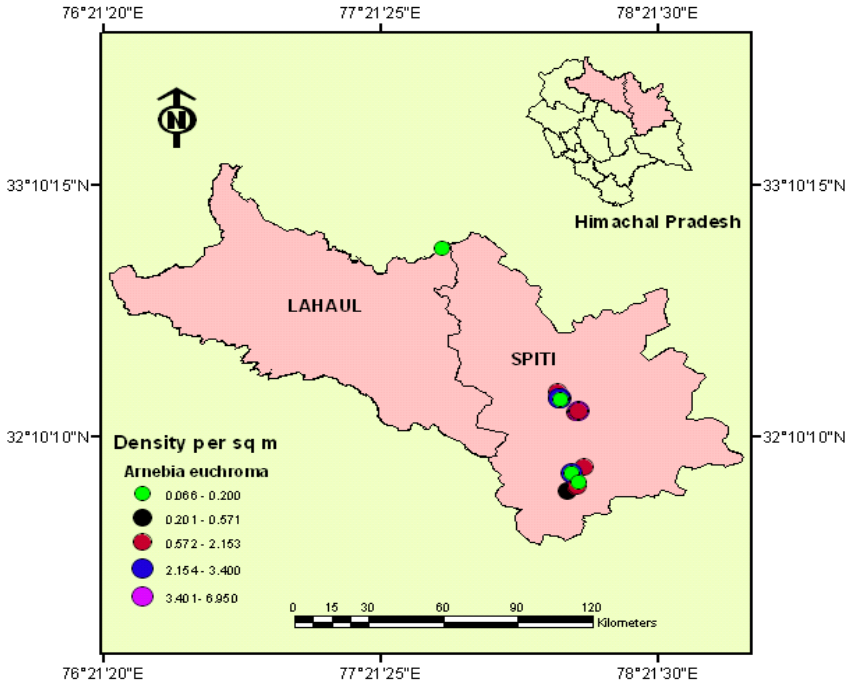

Fig. 6. Population density and distribution map of *Arnebia euchroma* in Spiti

Conclusions

Considering the ecological features and population status of *A. euchroma*, the present study suggests designing and implementing effective conservation programs for this critically endangered taxon in the Spiti cold desert of trans-Himalaya. It is imperative to study the local harvesting methods, the response of the species to specific harvesting techniques and the quantity harvested. That information is inadequately known for most of medicinal plant species. Authors support the recommendations of Kala [6] to notify the areas having natural populations of medicinally important threatened species as Medicinal Plant Conservation Areas (MPCA). The multiplication of those plants by using tissue culture techniques and conventional methods for their transplantation in natural habitats and niche areas of the species will be a significant initiative for its conservation. Local people and doctors should be made aware of the problems caused by injudicious harvesting of the plant roots. The development of specific agro-techniques for the species in the Spiti cold desert, to meet the requirements for raw materials for domestic use will help reduce the pressure on the existing populations of *A. euchroma* in its natural habitats.

Acknowledgements

This paper is dedicated to the fond memory of the late Dr. H. R. Negi, who inspired and guided the first author to carry out ecological researches in the Spiti area of western Himalaya. Authors are thankful to the Director and to Dr. R.D. Singh of the Institute of Himalayan Bioresource Technology, for providing the facilities and to the National Bioresource Development Board, Govt. of India for their financial support. The first author is also thankful to CSIR, New Delhi, for their award of Senior Research Fellowship.

References

[1] V. Tandon, *Need for CAMP for Lahaul-Spiti and Ladakh, the conservation of medicinal plants*, **Conservation Assessment and Management Plan Workshop for High Altitude Medicinal Plants of North West Himalayas** (editors D.K. Ved, V. Tandon), Foundation for Revitalization of Local Health Traditions, Bangalore, 1998.

[2] S.S. Samant, U. Dhar, R.S. Rawal, *Biodiversity status of a protected area of west Himalaya. 1-Askot Wildlife Sanctuary***, International Journal of Sustainable Development and World Ecology, 5,** 1998, pp. 194-203.

[3] D.K. Ved, A. Mudappa, D. Shanker, *Regulating export of endangered medicinal plant species-need for scientific vigour*, **Current Science, 75,** 1998, pp. 341-344.

[4] W.A. Rodgers, H.S. Panwar, **Planning a Protected Area Network in India**, Wildlife Institute of India, Dehra Dun, 1988.

[5] R. Misra, **Ecological Workbook**, Oxford and IBH, Calcutta, 1968.

[6] C.P. Kala, *Status and conservation of rare and endangered medicinal plants in the Indian trans- Himalaya*, **Biological Conservation, 93,** 2000, pp. 371-379.

[7] D.K. Ved, V. Tandon, **CAMP Report for High Altitude Medicinal Plants of Jammu-Kashmir and Himachal Pradesh**, Foundation for Revitalization of Local Health Traditions, Bangalore, India, 1998.

[8] * * *, **Threat Assessment and Management Prioritization of Selected Medicinal Plants of West Himalayan States**, Foundation for Revitalization of Local Health Tradition, Bangalore, India, 2003.

[9] B.S. Aswal, B.N. Mehrotra, **Flora of Lahaul-Spiti (a cold desert in North West Himalaya,** Bishen Singh Mehendra Pal Singh, Dehra Dun, India, 1994.

[10] O. Polunin, A. Stainton, **Flowers of the Himalaya**, Oxford University Press, New Delhi, India, 1984.

[11] O.P. Gupta, T.N. Srivastava, S.C. Gupta, D.P. Badola, *Ethnobotanical and phytochemical screening of high altitude plant of Ladakh-II*, **Bulletin of Medico-Ethnobotanical Research, 2,** 1981, pp. 67-88.

[12] C.C. Shen, Syu Wan-Jr., S.Y. Li, C.H. Lee, C.M. Sun, *Antimicrobial activities of naphthazarins from Arnebia euchroma*, **Journal of Natural Products, 65,** 2002, pp. 1857-1862.

[13] Y. Kashiwada, M. Nishizawa, T. Yamagishi, T. Tanaka, G.I. Nonaka, L.M. Cosentino, J.V. Snider, K.H. Lee, *Anti-AIDS agents, 18 sodium and potassium salts of caffeic acid tetramers from Arnebia euchroma as anti-HIV agents*, **Journal of Natural Products, 58,** 1995, pp. 392-400.

[14] S.K. Uniyal, A. Awasthi, G.S. Rawat, *Current status and distribution of commercially exploited medicinal and aromatic plants in upper Gori valley, Kumaon Himalaya, Uttaranchal*, **Current Science, 82**(10), 2002, pp. 1246-1252.

[15] S. Airi, R.S. Rawal, U. Dhar, A.N. Purohit, *Population studies on Podophyllum hexandrum Royle - a dwindling, medicinal plant of the Himalaya*, **Plant Genetic Resource Newsletter, 110,** 1997, pp. 29-34.

[16] S. Airi, R.S. Rawal, U. Dhar, A.N. Purohit, *Assessment on availability and habitat preference of Jatamansi - a critically endangered medicinal plant of west Himalaya*. **Current Science, 79**(10), 2000, pp. 1467-1471.

[17] C.P. Kala, *Indigenous uses, population density, and conservation of threatened medicinal plants in protected areas of the Indian Himalaya*, **Conservation Biology, 19,** 2005, pp. 368-378.

[18] B.P. Nautiyal, V. Prakash, R. Bahuguna, U. Maithani, H. Bisht, M.C. Nautiyal, *Population study for monitoring the status of rarity of three Aconite species in Garhwal Himalaya*. **Tropical Ecology, 43,** 2002, pp. 297-303.

[19] S.K. Uniyal, A. Kumar, Brij Lal, R.D. Singh, *Quantitative assessment and traditional uses of high value medicinal plants in Chhota Bhangal area of Himachal Pradesh, western Himalaya*, **Current Science, 91, 9,** 2006, pp. 1238-1242.
[20] A. Awasthi, S.K. Uniyal, G.S. Rawat, *Status and extraction patterns of Jurinea dolomiaea Boiss. (dhoop) in an alpine meadow of Kumaon Himalaya (Uttaranchal)*, **Indian Forester, 129,** 2003, pp. 589-595.
[21] A. Bhatt, S.K. Joshi, S. Gairola, *Dactylorhiza hatagirea (D.Don) Soo – a west Himalayan orchid in peril*, **Current Science, 89**(4), 2005, pp. 610-612.
[22] A. Bhatt, R.S. Rawal, U. Dhar, *Ecological features of a critically rare medicinal plant, Swertia chirayita, in Himalaya*, **Plant Species Biology, 21,** 2006, pp. 49-52.
[23] S.K. Ghimire, M. Doyle, Y.A. Thomas, *Conservation of Himalayan medicinal plants: harvesting patterns and ecology of two threatened species, Nardostachys grandiflora DC. and Neopicrorhiza scrophulariiflora (Pennel) Hong*, **Biological Conservation, 124,** 2005, pp. 463-475.
[24] A. Haleema, R.C. Gupta, M.A.A. Siddique, M.A. Bhat, I.T. Nazki, *Distribution, frequency, abundance, and density of Podophyllum hexandrum Royle in Anatanag and Srinagar districts of Kashmir Himalayas*, **The Journal of Plant Science Research, 22,** 2006, pp. 33-35.
[25] B. Singh, S.J. Phukan, B.K Sinha, V.N. Singh, S.K. Borthakur, *Conservation Strategies for Nepenthes Khasiana in the Nokrek Biosphere Reserve of Garo Hills, Northeast, India*, **International Journal of Conservation Science, 2**(1), 2011, pp. 55-64.
[26] C. Mishra, *Livestock depredation by large carnivores in the Indian trans-Himalaya: conflict perceptions and conservation prospects*, **Environmental Conservation, 24,** 1997, pp. 242-338.
[27] E.A. Phillips, **Methods of Vegetation Study**, Henry Holt, New York, 1959.
[28] H.L.S. Tandon, **Methods of Analysis of Soils, Plants, Waters and Fertilizers,** Fertilizer Development and Consultation Organization, New Delhi, 2001.
[29] J. Fowler, L. Cohen, P. Jarvis, **Practical Statistics for Field Biology**, John Wiley & Sons, New York, 1998.
[30] M.P. Nayar, A.R.K. Shastry, **Red Data Book of Indian Plants, vol. I-III,** Botanical Survey of India, Calcutta, 1987-1990.
[31] T. Ticktin, *The ecological implications of harvesting non-timber forest products*, **Journal of Applied Ecology, 41,** 2004, pp. 11-21.
[32] M.F. Pfab, M.A. Scholes, *Is the collection of Aloe peglerae from the wild sustainable? An evaluation using stochastic population modeling*, **Biological Conservation, 118,** 2004, pp. 695-701.

Received: March, 03, 2012
Accepted: August, 15, 2012