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P. K. SHARMA[1,*]
S. SARITA[1]
J. PRELL[2]

[1]*Department of Microbiology, CCS Haryana Agricultural University, Hisar 125 004, India*
[2]*Department of Soil Ecology, Rhineland Westfalen Technical University, Aachen, Germany*
**For correspondence.*
e-mail: pksharma@hau.ernet.in

Dactylorhiza hatagirea (D. Don) Soo – a west Himalayan orchid in peril

Dactylorhiza hatagirea (D. Don) Soo (family Orchidaceae), a high-value medicinal plant, is reported to occur in temperate to alpine regions (2500–5000 m asl) in India, Pakistan and Nepal. It is commonly known as Salem Panja (Kashmir) and Hatajari (Uttaranchal). It is a perennial herb, up to 60 cm in height, having palmately lobed, divided root tubers with broadly lanceolate leaves arranged more or less along the stem and rosy purple flowers. The tuber is used as nervine tonic, aphrodisiac and to relieve hoarseness[1]. Salep, obtained from tubers of *D. hatagirea*, is used as a sizing material in silk industry[2]. Economic potential of the species can be assessed on the basis of its high market value in different localities[3,4]. Also, the annual demand of the species is high (5000 tons)[5]. This leads to over-exploitation of the species from wild, particularly those not cultivated at commercial scale. *D. hatagirea* has been categorized as critically endangered[6] (CAMP status), critically rare[7] (IUCN status) and is listed under appendix II of CITES[8]. Besides these, being an orchid, *D. hatagirea* can be considered as an inherently slow-growing and poorly regenerating species because of pollinator specificity and requirement for mycorrhizal association. Thus it becomes more important from conservation point of view. Further the species is categorized as near endemic[9,10]. All these attributes call for conservation of the target species.

To formulate the conservation plan for a particular area and to understand the ecology of the species, studies on quantitative information play a vital role[8]. Since studies on extent of availability of high-value medicinal plants in wild are essential to develop appropriate strategies for their sustainable use[11], the present study focuses on assessment of quantum of availability of *D. hatagirea* in its natural habitats.

Six populations, namely Valley of Flowers (VoF), Nagtal, Pindari, Lata, Donidhar and Kedarnath in Uttaranchal Himalaya were selected for the study. Site characteristics of the species are presented in Table 1. Three belt transects (200 m long and 20 m wide) were laid in each population. Transects were divided into three strata (i.e. base, middle and top) and three plots (20×20 m) were marked in each strata. Fifteen (1×1 m) quadrats were laid randomly in every plot. Number of individuals of all the species was recorded in each quadrat. The target species was localized and not distributed uniformly. Hence the calculated density represents the density of the species in its habitats. Quadrat data were analysed for frequency, density, abundance, relative density (RD)[12] and abundance/frequency (A/F) ratio[13]. Data were pooled for plots in each site. To assess the difference among density of the species at different sites,

Table 1. Site characteristics of selected populations of *D. hatagirea*

Management status	Study site	Altitude (m)	Aspect	Latitude	Longitude	Habitat
Protected	Valley of Flowers	3360	North	30°40′N	79°37′E	Open grassy slopes
	Nagtal	3310	South	30°40′N	79°37′E	Sub-alpine forest gaps
Unprotected	Pindari	3540	NW	30°42′N	79°58′E	Open grassy slopes
	Lata	3680	SW	30°29′N	79°45′E	Open grassy slopes
	Donidhar	3800	NW	30°39′N	79°44′E	Open grassy slopes
	Kedarnath	3760	East	30°44′N	79°03′E	Open grassy slopes

Table 2. Phytosociological parameters of *D. hatagirea* in selected populations

Management status	Study site	Density* (indi/m^2)	Relative density (%)	A/F ratio	Dominant associate
Protected	Valley of Flowers	2.02	20.94	0.027	*Anemone tetrasepala* (23.33%); *Geranium wallichianum* (21.77%); *Heracleum* sp. (13.03%); *Polygonum polystachyum* (9.83%)
	Nagtal	2.19	7.00	0.040	*P. polystachyum* (16.63%); *G. wallichianum* (12.07%); *A. tetrasepala* (9.19%)
Unprotected	Pindari	1.27	12.85	0.021	*Selinum tenuifolium* (23.77%); *Danthonia cachmyriana* (16.23%); *G. wallichianum* (14.28%); *A. tetrasepala* (12.85%)
	Lata	1.13	15.25	0.020	*Anaphalis triplinervis* (23.67%); *G. wallichianum* (22.62%); *Potentilla atrosanguinea* (17.83%); *D. cachmyriana* (11.11%)
	Donidhar	1.89	23.94	0.024	*A. tetrasepala* (23.54%); *G. wallichianum* (22.49%); *P. polystachyum* (19.36%); *D. cachmyriana* (10.44%)
	Kedarnath	1.64	22.89	0.021	*A. tetrasepala* (29.22%); *Morina longifolia* (18.24%); *G. wallichianum* (15.06%); *D. cachmyriana* (14.55%)

LSD (0.41) shows least significant difference ($P < 0.05$).
*LSD only for density.

one-way analysis of variance (ANOVA) was performed using SYSTAT[14]. The relationship was tested for significance at $P < 0.05$.

The present study reveals that the density of *D. hatagirea* was higher in protected than the unprotected sites, whereas RD of the species follows the reverse trend. Density of *D. hatagirea* varied across the sites. It ranged between 1.13 indi./m^2 (Lata) and 2.19 indi./m^2 (Nagtal). Density of the species in VoF, Nagtal (both protected) and Donidhar (unprotected) was significantly higher ($P < 0.05$) than Lata and Pindari (both unprotected). However, density of the species in Nagtal was significantly higher ($P < 0.05$) than that at Kedarnath. Contiguous distribution of the species was recorded in all the populations. Species like *Anemone tetrasepala* (RD – 23.33% in VoF; 9.19% in Nagtal; 12.85% in Lata; 23.54% in Donidhar and 29.22% in Kedarnath), *Geranium wallichianum* (RD – 21.77% in VoF; 12.07% in Nagtal; 14.28% in Pindari; 22.62% in Lata; 22.49% in Donidhar and 15.06% in Kedarnath), *Heracleum* sp. (RD – 13.03% in VoF), *Polygonum polystachyum* (RD – 9.83% in VoF; 16.63% in Nagtal and 19.36% in Donidhar), *Selinum tenuifolium* (RD – 23.77% in Pindari), *Danthonia cachmyriana* (RD – 16.23% in Pindari; 11.11% in Lata; 10.44% in Donidhar and 14.55% in Kedarnath), *Potentilla atrosanguinea* (RD – 17.83% in Lata), *Anaphalis triplinervis* (RD – 23.67% in Lata) and *Morina longifolia* (RD – 18.24% in Kedarnath) were dominant associates of *D. hatagirea* (Table 2).

The results are comparable with those of earlier studies, which report density of *D. hatagiera* as 1.0–4.2 indi./m^2 in protected area and 0.475 indi./m^2 in unprotected area[8]. In unprotected sites, the low density is perhaps due to high extraction and increased grazing pressure.

Grazing and trampling by livestock adversely affect the above-ground plant parts and disturb the life cycle of the species. Grazing indirectly promotes plant growth and enhances vegetative reproduction as well as seed production of unpalatable species[15]. Among the dominant associates of *D. hatagirea*, *Anemone tetrasepala* (RD – 9.19–29.22%), *Anaphalis triplinervis* (RD – 23.67%)[16] and *Morina longifolia* (RD – 18.24%) (pers. obs.) are unpalatable, whereas *D. hatagirea* (RD – 7.0–23.94%) is a palatable species. This reflects pressure on the target species and makes the proliferation of unpalatable species easy. It becomes more important in view of the fact that wild populations of the species are declining continuously due to grazing pressure[17]. Another major associate, *Polygonum polystachyum* (RD – 9.83–19.36%) is considered as an overgrowing species which suppresses other native herbs[18,19]. The occurrence of this species as a major associate further endangers proliferation of the target species. Interestingly, in one of the study areas (VoF), *Cuscuta europeae* (a total stem parasite) has been reported to infest endangered medicinal species, including *D. hatagirea*[20].

The above-mentioned factors (grazing, trampling and weed proliferation) in the protected and unprotected areas may further have a negative effect on seed germination of the species. Also, in order to obtain the maximum quantity of dry tubers from the species, a large number of individuals are extracted, from the wild[8]. It appears that *D. hatagirea*, due to various forms of anthropogenic pressure and habitat depletion through encroachment by other species, is in danger. It would, therefore, be important to analyse management implications of such a scenario in protected as well as unprotected areas.

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ARVIND BHATT*
SOUMAI KANT JOSHI
SANJAY GAIROLA

Conservation of Biological Diversity Core, G. B. Pant Institute of Himalayan, Environment and Development, Kosi-Katarmal, Almora 263 643, India
**For correspondence.*
e-mail: arvin_bhatt@rediffmail.com

An *M* 5.2 earthquake occurs in Koyna region after 4½ years

Koyna, located near the west coast of India, is known to be the most significant site of artificial water reservoir triggered earthquakes. The activity started soon after the filling in of the reservoir in 1961 and during the last 44 years, an earthquake of M 6.3, 19 earthquakes of $M \geq 5$, about 170 $M \geq 4$ earthquakes, and several thousand smaller earthquakes have occurred. As far as $M \geq 5$ earthquakes are concerned, the site had been quiet for some time, the last earthquake of $M \geq 5$ having occurred on 5 September 2000.

In a detailed investigation, Gupta *et al.*[1] speculated as to how long triggered earthquakes would continue at Koyna. They concluded that a maximum credible earthquake for the region is M 6.8. So far, about one-half of the energy of an M 6.8 earthquake has been released. Considering that the region got activated soon after filling of the Koyna dam in 1961, the activity should continue for another 3–4 decades. However, there was no large enough intact fault segment left to cause an earthquake of M 6 like the one on 10 December 1967. At the same time, smaller earthquakes will continue to occur, governed by Kaiser effect, rate of loading, and duration of retention of high water levels. In another study, Gupta[2] pointed out that most of the earthquakes of magnitude 4 or larger have occurred in Koyna region following the high rate of loading soon after the monsoon months – September to December. Another peak of activity occurred during the unloading stage of the reservoir during the months of February–March.

The current seismic activity of M 5.2 on 14 March, and two earthquakes of $M > 4$ on 15 and 26 March occurred during the unloading period (Figure 1). The epicentral location of earthquakes of $M > 5$ in the Koyna–Warna region is shown in Figure 2. Figure 3 *a* shows the distribution of earthquakes of $M \geq 3$ since January 2003, and water levels in the reservoir. It may be noted in Figure 3 *a* that the enhanced activity during the month of March 2003 was associated with unloading of reservoir, and the same is the case with the enhanced activity in the month of March 2005 where there are several earthquakes of $M \geq 3$, two earthquakes of $M \geq 4$, and one earthquake of $M \geq 5$. It is in line with the earlier picture where it was noted that maximum number of earthquakes of $M \geq 4$ occurred in the month of September due to rapid loading of the reservoir, and another peak occurred in the month of February following unloading of the reservoir (Figure 3 *b* after Gupta[2]).

Another interesting thing to note is that most earthquakes exceeding M 5, which occur in the unloading phase, are close to the Warna reservoir. For example, nos: 17 and 18 in Figure 2 and the March 2005