Assessment of availability and habitat preference of Jatamansi – a critically endangered medicinal plant of west Himalaya

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Nardostachys jatamansi (D. Don) DC., a critically endangered rhizome-bearing medicinal plant, is restricted to specialized habitats in high altitudes of the Himalaya, ranging from 3000 to 5000 m asl. The plant is collected from natural habitats for local consumption and trade. The existing status of the species and variations in its performance in different habitats were studied in selected sites in Kumaun, west Himalaya. Dripping moss-laden rocks (frequency 40.7%, density 15.9 individual/m²) and moist boulders (frequency 25.9% and density 16.8 individual/m²) are the most preferred habitats of this plant. Generally, density and frequency had significant (P < 0.05) positive relationship with altitude. The mean density in two contrasting slopes differed significantly (P < 0.05), showing relatively higher density on west-facing slopes. Several biological and environmental features of the individual plants contributing towards wholesome below-ground biomass were identified. For example, among biological parameters, plant density (P < 0.01), plant height (P < 0.01) and above ground biomass (P < 0.01) were positively correlated. So were soil nitrogen (P < 0.05) and moisture content (P < 0.01) with below ground biomass.

Kumaun Himalaya. In spite of these attributes, the existing information of the species is inadequate, especially with regard to (i) frequency of its occurrence in natural habitat, (ii) quantitative data on its availability, and (iii) performance under different conditions.

Nardostachys (Family Valerianaceae) is a small herbaceous Himalayan genus, represented by two broad range endemic species, N. grandiflora DC. and N. jatamansi (D. Don) DC. in India. Until recently, the two species were considered synonymous. However, critical taxonomic evaluation has separated them. N. grandiflora has been reported to be scarcely occurring in certain localities (above 4000 m) of Kumaun and Sikkim Himalaya, whereas N. jatamansi is relatively common in Garhwal, Kumaun and Sikkim Himalaya between 3000 and 5000 m asl.

The underground part of N. jatamansi is used as a substitute for valerian and the extracts find use in over 26 Ayurvedic preparations. The root is also used for treatment of heart disease, high blood pressure and insomnia. The root and rhizome contain active compounds with carminative, sedative, antispasmodic and tranquilizing properties.

Information on taxonomy, general distribution, uses, conventional and in vitro methods of propagation of N. jatamansi are available. Also, the phytochemical properties have been investigated in detail. Considering the increasing demand for herbal drugs in general and Himalayan medicinal plants in particular, and consequent depletion of several species including N. jatamansi, it is imperative to initiate urgent steps for conservation. The present communication attempts to assess the status of occurrence and quantum of availability of N. jatamansi in the natural habitats of Kumaun Himalaya, essential for developing a conservation strategy.

The study area (30°6′–39°N lat. and 70°55′–80°E long.), located in Kumaun (west Himalaya), extends between 3100 and 4000 m asl and consists of three river catchments, viz., Pindari, Sunderdhunga and Kaphani. Usually the site remains snow bound from late October through April. The soil of the study area, a residue from crystalline rocks, is dark grey to dark brown and black and silty loam to loam in constitution.

Keeping in view the altitudinal range of its occurrence, the sampling was restricted to altitudes above 3000 m asl. The study area was divided into three arbitrary altitude zones < 3400 m (S1); 3401–3600 m (S2) and > 3600 m (S3). In each zone of a catchment, two sites (one each in east and west facing slopes) were identified. A total of 18 sample sites were identified. However, considering localized occurrence of the species, the sampling sites were established in areas of its availability. Therefore, all the estimates will be applicable for such sites where it occurs. The estimates cannot be extrapolated for entire area above 3000 m asl.

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Vegetation sampling was conducted through vertical belt transects (one in each site – 20 m wide and 150 to 200 m long) involving a total area of 0.3–0.4 ha. Three (20 × 20 m) plots (stands) were marked at three positions of each transect (viz. base, mid and top). Habitat characteristics of each plot were recorded. The detailed information on species performance was obtained from ten (1 × 1 m) randomly-placed quadrats in each plot. The data was analysed for frequency and abundance. The frequency of occurrence and abundance of the species in a particular habitat was determined as an indicator of its preference.

Data on morphological features (i.e. plant height, number of leaves, flowers, rhizome length, diameter, etc.) were collected from randomly-selected mature individuals (n = 10) of each site of a transect in July–August, 1998. Selected individuals (n = 5) were removed (whole) from the site and brought to the laboratory for biomass studies.

The substrate of *N. jatamansi* varied from dry rocky crevices to moss laden rock surfaces. The substrate samples (500–700 g) collected from different stands of a transect were dried in the sun for one week. Dried soil samples were packed in perforated polythene bags and stored at room temperature. Moisture content, pH and organic carbon were determined. Total nitrogen was determined by Kjeldhal technique, using Kjelplu-Pelicon unit for distillation.

Relationships between studied parameters were statistically tested using SYSTAT. Significant differences among means were separated using LSD mean separation test (P < 0.05).

The density patterns of *N. jatamansi* among different altitude zones exhibited a significant (P < 0.05) differ-
ence in mean density of two sites (on opposite slopes) in a particular altitude zone (Table 1). The mean density (25.6 individual/m²) at > 3600 m altitude zone on west facing slope (site S3W) was significantly high compared to all other sites. This suggests favourableness of the altitude (> 3600 m asl) and aspect (west) for species proliferation. The density of species showed significant increase (r = 0.462, P < 0.05) with altitude. This is in general agreement with the statement that altitude, to a large extent determines the vegetation pattern in the mountains. However, while comparing the distribution on two contrasting hill slopes (east and west), significantly higher increase in density (14.3–25.6 individual/m²) with altitude was revealed (r = 0.638, P < 0.05) on west-facing slope. Since the north and west-facing slopes in alpine zone of this region are broadly considered as relatively shady areas with low light and high moisture, the results suggest that the species prefers such conditions.

All the investigated (54) stands of *N. jatamansi* can be grouped under seven arbitrary habitat types (Figure 2). Considering frequency of occurrence in stands and relatively high mean density of individuals, dripping moss-laden rock (frequency 40.74%; density 15.9 individual/m²) followed by moist boulders (frequency 25.93% and density 16.75 individual/m²) are the most preferred habitats.

The substrate of *N. jatamansi* was invariably acidic (pH 5.69–6.02), with high mean organic carbon (6.21–9.46%) and nitrogen (0.56–0.78%) (Table 2) and comparable to the values reported for alpine soils of the region. In general, the higher elevation stands exhibited significant increase in nitrogen (r = 0.599, P < 0.001) and organic carbon (r = 0.892, P < 0.001). The density of *N. jatamansi* showed significantly positive correlation with some of the substrate components like organic carbon (r = 0.613, P < 0.01), moisture content (r = 0.611, P < 0.01) and nitrogen (r = 0.795, P < 0.001). In general, while comparing the means, the site on the west slope at the highest elevation (> 3600 m asl) showed high moisture content, organic carbon, and nitrogen, compared to low elevation (< 3600 m asl) sites on the east slope (Table 2).

Across sites, a considerable variation in mean biomass (above and below) of *N. jatamansi* (20.72–81.25 g/m²) was revealing (Table 3). The sites on west facing slopes had higher biomass (40.31–81.25 g/m²) and the mean biomass of two high elevation sites (> 3400 m asl) on this slope was significantly higher (P < 0.05) than that at the other sites (Table 3). Similar is the case of below ground biomass (9.84–30.64 g/m²).

### Table 1. Distribution pattern of *Nardostachys jatamansi* in three different catchments

<table>
<thead>
<tr>
<th>Site</th>
<th>Density (individuals/m²)</th>
<th>Site mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 E</td>
<td>9.17 (2.14)</td>
<td>6.57 (1.18)</td>
</tr>
<tr>
<td>S1 W</td>
<td>16.17 (3.62)</td>
<td>9.93 (2.57)</td>
</tr>
<tr>
<td>S2 E</td>
<td>9.17 (3.20)</td>
<td>12.03 (3.77)</td>
</tr>
<tr>
<td>S2 W</td>
<td>18.50 (7.45)</td>
<td>11.23 (2.76)</td>
</tr>
<tr>
<td>S3 E</td>
<td>17.93 (5.68)</td>
<td>7.20 (2.29)</td>
</tr>
<tr>
<td>S3 W</td>
<td>34.00 (9.46)</td>
<td>17.23 (4.92)</td>
</tr>
<tr>
<td>Catchment mean</td>
<td>17.49 (4.90)</td>
<td>15.12 (4.90)</td>
</tr>
</tbody>
</table>

S1, < 3400 m; S2, 3401–3600 and S3, > 3600; E, east facing slope and W, west facing slope. Value in parenthesis is relative density. LSD (0.05) for site mean and catchment mean are 3.57 and 5.98 respectively.

### Table 2. Soil characteristics of *Nardostachys jatamansi* in three different sites (values represent means of all catchments)

<table>
<thead>
<tr>
<th>Site</th>
<th>Moisture content (%)</th>
<th>pH</th>
<th>Organic carbon (%)</th>
<th>Nitrogen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 E</td>
<td>35.43</td>
<td>5.69</td>
<td>6.21</td>
<td>0.56</td>
</tr>
<tr>
<td>S1 W</td>
<td>37.67</td>
<td>5.97</td>
<td>6.80</td>
<td>0.61</td>
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<tr>
<td>S2 E</td>
<td>34.83</td>
<td>5.88</td>
<td>7.58</td>
<td>0.57</td>
</tr>
<tr>
<td>S2 W</td>
<td>39.81</td>
<td>6.02</td>
<td>7.97</td>
<td>0.62</td>
</tr>
<tr>
<td>S3 E</td>
<td>36.50</td>
<td>5.72</td>
<td>9.28</td>
<td>0.67</td>
</tr>
<tr>
<td>S3 W</td>
<td>39.89</td>
<td>5.70</td>
<td>9.46</td>
<td>0.78</td>
</tr>
<tr>
<td>LSD (&lt; 0.05)</td>
<td>3.95</td>
<td>0.98</td>
<td>1.31</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Site details as in Table 1.

### Figure 2. Habitat preference of *Nardostachys jatamansi* in selected sites of Kunaua Himalaya. MRC, Moist rocky crevices; DMLR, Dripping moss-laden rocks; MAS, Moist-alpine-slope; DRB, Dry rocky boulders; DAS, Dry alpine slope and DRC, Dry rocky crevices.
Table 3. Species performance in different sites of Nardostachys jatamansi (values represent means of all catchments)

<table>
<thead>
<tr>
<th>Site</th>
<th>Plant height (cm)</th>
<th>No. of leaves</th>
<th>Above ground</th>
<th>Below ground</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 E</td>
<td>10.68</td>
<td>12.17</td>
<td>10.88</td>
<td>9.84</td>
<td>20.72</td>
</tr>
<tr>
<td>S1 W</td>
<td>12.24</td>
<td>12.05</td>
<td>17.08</td>
<td>23.43</td>
<td>40.51</td>
</tr>
<tr>
<td>S2 E</td>
<td>12.61</td>
<td>13.26</td>
<td>13.49</td>
<td>13.18</td>
<td>26.67</td>
</tr>
<tr>
<td>S2 W</td>
<td>14.57</td>
<td>14.17</td>
<td>31.46</td>
<td>30.88</td>
<td>61.54</td>
</tr>
<tr>
<td>S3 E</td>
<td>11.28</td>
<td>11.36</td>
<td>15.28</td>
<td>18.79</td>
<td>34.07</td>
</tr>
<tr>
<td>S3 W</td>
<td>11.60</td>
<td>11.99</td>
<td>50.40</td>
<td>30.64</td>
<td>81.04</td>
</tr>
<tr>
<td>LSD (P &lt; 0.05)</td>
<td>3.75</td>
<td>5.33</td>
<td>13.19</td>
<td>9.16</td>
<td>16.34</td>
</tr>
</tbody>
</table>

Site details as in Table 1.

Increase in plant density (r = 0.60, P < 0.01), plant height (r = 0.389, P < 0.1) and above ground biomass (r = 0.706, P < 0.001) positively correlate with below ground biomass. This suggests that overall robustness of the individuals is an indicator of increased below ground biomass. Also, significant increase in below ground biomass was observed with increasing soil nitrogen (r = 0.510, P < 0.05) and soil moisture content (r = 0.575, P < 0.01). The advantage of high water and nutrient supply for rhizome and root production has also been reported elsewhere for related valerian species. Interestingly, unlike above ground biomass and density which show significant increase with altitude (r = 0.433, P < 0.05), below ground biomass does not show such relationship. This does not match with the observations on Podophyllum hexandrum, another rhizomatous medicinal plant of the region, which shows significant increase in below ground biomass at lower elevations.

Variations in response to environmental stresses are species specific and therefore must be considered while developing strategies for sustainable harvest and conservation. However, ecological implications can be meaningful if the correlations between secondary compounds (active ingredients), morphological and environmental parameters are also taken into consideration. Such type of information is presently lacking.

On the basis of the present investigations, it is concluded that (i) N. jatamansi is restricted to some specialized habitats and is subject to destructive harvesting (removal of root/rhizome) from the wild. In this context, the quantified data on its occurrence and availability and relationship of utilisable part (below ground biomass) with various biological and environmental parameters can be gainfully utilized for identification of potential habitats and expected yield per unit area. (ii) Ex situ conservation of the species assumes greater significance especially in a scenario when harvesting potential from the wild falls short of the demand for commercial exploitation. In this regard it will be pertinent to consider the specific preferred environmental edaphic requirement of the species before developing improved agrotechnologies for cultivation of the species.

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