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A case study on utilization and conservation of threatened plants in Sechu Tuan Nalla Wildlife Sanctuary, western Himalaya, India

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Abstract: During the course of surveys between 2016 and 2019 in the Sechu Tuan Nalla Wildlife Sanctuary, 37 species were reported of which, two critically endangered, 18 endangered, 13 vulnerable, four data deficient and one endemic to western Himalayas were recorded. All the species recorded are highly priced medicinal herbs. It also discussed the sustainable use and conservational approach adopted by the local people dwelling in the vicinity of the protected area for an endangered medicinal plant, Fritillaria cirrhosa D.Don.

Keywords: Endangered, endemic, Fritillaria cirrhosa, high altitude, Jangli lahsun, Pangi Valley, medicinal plants.

Abbreviations: STNWS—Sechu Tuan Nalla Wildlife Sanctuary | WS—Wildlife Sanctuary | GOI—Government of India | BSD—Herbarium of Botanical Survey of India, Northern Regional Centre, Dehradun | IUCN—International Union for Conservation of Nature | CAMP—Conservation Assessment and Management Prioritization | CITES—Convention on International Trade in Endangered species of Fauna and Flora | RDBIP—Red Data Book of Indian Plants | UT—Union territory.
INTRODUCTION

The biodiversity is deteriorating at faster rate and ecosystem services are greatly affected and are among one of the major issues encountered by humanity today (Piccolo 2017). Protected areas form the basis of biodiversity conservation worldwide and play a vital role in the rehabilitation of deteriorated natural habitat (Margules & Pressey 2000; Mashizi & Sharafatmandrad 2020). Assessment of threatened plant diversity of protected areas is essential for the protection and appropriate management of biodiversity. The study of protected areas offers plenty of scope for framing suitable management policies. These areas are important for the collection and documentation of scientific data on bio-resources which provide gateways for sustainable use and conservation. Several protected areas including national parks and wildlife sanctuaries have been evaluated for endemic and threatened plants throughout the country.

In this paper, we aim to highlight the sustainable approach towards the conservation and use of *Fritillaria cirrhosa* D.Don. (syn. *Fritillaria roylei* Hook.) by the people in and around the WS. *F. cirrhosa* D.Don is a threatened medicinal herb, flourishing well in high-altitude areas on grassy slopes (Image 2a–e) of western Himalaya of India (Jammu & Kashmir UT, Ladakh UT, Himachal Pradesh, and Uttarakhand), Afghanistan, and Pakistan. Local people of Pang valley call it ‘Jangli lahsun’ otherwise known as ‘Kakoli’ in other parts of the Himalayan region. Bulbs of this Himalayan medicinal herb has an international market and are highly priced (INR 8,000–20,000 /kg). Bulbs are chiefly used in traditional Ayurvedic and Chinese medicine system. The plant flourishes in the upper reaches of the two forest beats (Tuan and Sechu) of the WS. The bulbs are beneficial in the cure of rheumatism, cough, fever and many other ailments (Kirtikar & Basu 1984). The species is prized for its immense medicinal properties and constitutes an important part of many herbal formulations (e.g., Astavarga, Chyavanprash). The tribal populace harvests the plant from the wild and sell it to the buyers sometimes directly or at times through middlemen. These middlemen are either agents of pharmaceutical or ayurvedic companies or of wholesale raw material suppliers that connect the distant farmer to the buyer. As a result of its relentless exploitation from the wild, this medicinal herb has become endangered in the Indian Himalayan region. The population status of the medicinally important species has deteriorated to the extent that it has now been considered endangered in Western Himalaya (IUCN 2001; Kuniyal et al. 2015). There is an urgent need to address the declining population of this species and to take initiative for suitable conservation strategies along with sustainable utilization.

The distribution of published information on the conservation status of plants can be effective to increase the level of awareness among stakeholders. Therefore, in the present communication, we also aimed to bring a list of the number of threatened plants which are growing in wild in the wildlife sanctuary. This study also highlights some of the threatened plants grown by local people and forest department officials. Some gap areas and recommendations are also provided in the paper.

MATERIALS AND METHODS

Study area

Sechu Tuan Nalla Wildlife Sanctuary is a remote WS in the interior Himalaya in the Pangi tehsil of Chamba district of Himachal Pradesh, India (Image 1). It is home to many rare, endemic and threatened species of flora and fauna (GOI 2016). The WS was established in 1974 with a purpose of conservation of Brown Bear and Snow Leopard. However, it has also conserved over the years the rich floral wealth of the region. The flora is distinct with floral elements from temperate to alpine to cold desert biome. Several endemic and threatened plant species thrive and flourish in the region. This is due to the sustainable approach followed by the people inhabiting the eco-sensitive zone of WS, i.e., the Pangwals and the Bhots tribal communities. The sanctuary is in a very remote region with adverse climatic conditions and no proper road or telecom connectivity. People dwelling in these regions have no other option for their economic upsurge other than to market the local natural resources available. With the trending use of Ayurveda and traditional system of medicines in the modern-day world, there has been a gradual increase in demand of plant based Ayurvedic and medicinal products. The region being rich in medicinal plants especially highly priced Himalayan herbs is emerging as a supplier of raw materials.

Plant explorations and identification

Plant specimens were collected in the study site using a random sampling approach. Information on the uses of plants was collected from the local people inhabiting in the vicinity of the wildlife sanctuary. Informants comprised of 15 people from each village including elderly and younger ones. Local people were interviewed for the uses, cultivation practices and any potential threat to these species according to their perception.
The collected plant specimens were identified with the help of the herbarium (BSD) of Botanical Survey of India, Northern Regional Centre, Dehradun, Uttarakhand, India and other regional floras. Conservation status given in table 1 is as per Red List of plants in International Union for Conservation of Nature and Natural Resources (IUCN 2001), Conservation Assessment and Management Prioritisation (Ved et al. 2003), Convention on International Trade in Endangered (CITES, http://www-bsienvis-nic-in/Database/bsi_3949.aspx), Red Data Book of Indian Plants (Jain & Sastry 1980, 1984; Nayar & Sastry 1987, 1988, 1990; Rao et al. 2003) and recent literature (Rawat 2005; Rana & Samant 2010) on assessment of these plants in western Himalaya by various active and prominent researchers.

RESULTS

Overall, 37 threatened and endemic plant species (Table 1, image 3a–f) were found in the sanctuary and its environs. A total of two species, *Lilium polyphyllum* D.Don and *Saussurea costus* (Falc.) Lipsch. or 5.40% of taxa assessed were listed as Critically Endangered (CR) (Figure 1. Map of study area with collection sites in Sechu Tuan Nalla Wildlife Sanctuary in Chamba district, Himachal Pradesh, India.)
1). In the meantime, 18 (48.65%) of taxa were classified as Endangered (EN) and 13 (35.14%) were classified as Vulnerable (VU). Another four (10.81%) were listed as Data Deficient (DD) which means that there is inadequate data for appropriate assessment of conservation status to be prepared. As far as the frequency of occurrence in the study is concerned, out of 37 species, 28 (75.68 %) are infrequent while nine (24.32 %) are scarce in the study area.

DISCUSSION

Local people of Pangi valley call it Jangli lahsun otherwise known as kakoli in other parts of Himalayan region.

‘Praja’, the local indigenous governing body plays a major role in managing the local resources of the area. The Praja is a local institution comprising of at least a single member of every household in the village and acts as an administrative and social reforming body. The Praja appoints people of the village to keep an eye on any kind of illegal activity by outsiders that may destroy the plants in the wild. People or other tourists need to get themselves registered or to provide prior information at the village before entering the adjoining forest during the harvest season.

The systematic and phase-wise collection of bulbs of Jangli lahsun from the wild is allowed to only the inhabitants of hilly regions of the state (Badola & Butola 2004). However, no one can harvest the plant before the seed is set and dispersed; ensuring sufficient seed is available for germination for the next year. While collecting the bulb of the plant care is taken not to disturb the adjoining vegetation. Such simple yet powerful efforts by the locals have led to a very healthy population of the species in Tuan Forest beat of the WS. Therefore, these traditional practices keep a check on illegal means of exploitation of this plant species and have positive effects on its conservation. On the contrary, Sindhani Dhar, an inaccessible region of the WS from the Sechu beat was once home to a very healthy population of Jangli lahsun, which over the span of 4–5 years was ruined by outsiders from the adjoining regions. The plant was so badly exploited in the Sindhani region that the population once in thousands came to a scattered few plants. Habitat degradation has also led to substantial pressure on the wild population of _F. cirrhosa_ in many parts of western Himalaya. The population of the species in the western Himalaya has declined to an alarming situation (Chauhan et al. 2011). This decline is attributed to the uprooting of the whole individual at early growth stages before the seed sets. Bisht et al. (2016) cited some other factors such as early snowfall and frequent grazing by migratory animals in alpine meadows which affected the regeneration of the species. The species population has declined to the level that it has been put into the endangered category in western Himalaya (IUCN 2001; Kumar et al. 2011; Kuniyal et al. 2015; Bisht et al. 2016).

All the species of an ecosystem are important and equally contribute to stabilizing a particular ecosystem, and loss of a single species can have grave consequences. Therefore, regardless of medicinal or any other importance, all the species should be treated important for the preservation of biodiversity.

Positive approach through sustainable utilization coupled with conservation efforts

The traditional practices to keep check on illegal means of exploitation of this plant species have positive effects on its conservation. Probably the lacuna is that there is no such effective and efficient management plan existing in the area for cultivation of most other medicinal endangered plant species except for few. _Dioscorea deltaoida_ Wall. ex Kunth, _Picrorhiza kurroa_ Royle ex Benth., _Sinopodophyllum hexandrum_ (Royle) T.S.Ying, _Saussurea costus_ (Falc.) Lipsch. are being cultivated in the forest nurseries (Image 4). Both the extraction of the medicinal plants for household purpose by the local people and illegal destructive harvesting by outsiders is mainly from wild populations. As the socio-economic condition of the local inhabitants depends upon the natural resources available, cultivation of medicinal

![Figure 1. Number of species in various threat categories.](image-url)
| Name of species | Local name (if any) | Family | Habit | Locality with altitude | Collection no. | Cause | Occurrence in study area | Conservation Status as per IUCN, CAMP, RDBIP & Regional Publications |
|-----------------|---------------------|--------|-------|------------------------|----------------|-------|--------------------------|-----------------------------------------------|
| 1. Acer caesium Wall. ex Brandis | | Aceraceae | Tree | Saichu Dhar, 2,888 m | Puneet Kumar 127737 | Exploitation in the past for timber. | VU | Source |
| 2. Aconitum violaceum Jacquem. ex Stapf | | Ranunculaceae | Herb | Chasak Bhattori to Sechu, 3,696 m | Puneet Kumar 127624 | Over exploitation of medicinal roots. | EN | Source |
| 3. Aconitum heterophyllum Wall. ex Royle | | Ranunculaceae | Herb | Along Sindhmarh Nalla, 3,592 m | Puneet Kumar 127609 | Over exploitation of medicinal roots. | EN | Source |
| 4. Allium stracheyi Baker | | Alliaceae | Herb | Eco-sensitive zone around Hillu-Tuan, 3,272 m | Puneet Kumar 128034 | Exploitation of corms. | VU | Source |
| 5. Angelica glauca Edgew. | | Apiaceae | Herb | Eco-sensitive zone (on way to Chasak Bhatori), 3,453 m | Puneet Kumar 132603 | Over exploitation of medicinal rhizomes. | EN | Source |
| 6. Aralia cachemirica Decne. | | Araliaceae | Herb | Harbi Dhar, 3,457 m | Puneet Kumar 127305 | Very few individuals. Endemic to NW Himalaya. | VU | Source |
| 7. Arenaria neelgherrensis Wight & Arn. | | Caryophyllaceae | Herb | Pepe Nalla, Chasak Bhattori, 3,988 m | Puneet Kumar 127451 | Very few individuals. | DD | Source |
| 8. Berberis pseudoumbellata R. P. Parker | | Berberidaceae | Shrub | Harbi Dhar, 3,128 m | Puneet Kumar 127817 | Exploited for medicinal uses. | DD | Source |
| 9. Bergenia ciliata (Haw.) Sternb. | | Saxifragaceae | Herb | On way to Sidhani Dhar, 2,712 m | Puneet Kumar 127961 | Exploitation of medicinal rhizomes. | VU | Source |
| 10. Bergenia stracheyi (Hook. & Thomson) Engl. | | Saxifragaceae | Herb | Along Triund Nalha towards Chogalu Dhar, 3,551 m | Puneet Kumar 132519 | Exploitation of medicinal rhizomes. | VU | Source |
| 11. Bunium persicum (Boiss.) B. Fedtsch. | | Apiaceae | Herb | Eco-sensitive zone, Mujh village, 3,121 m | Puneet Kumar 128032 | Exploitation directly from wild, whole plant uprooted for seeds. | EN | Source |
| 12. Corallorhiza trifida Châtel. | | Orchidaceae | Herb | Sidhani Dhar, 3,469 m | Puneet Kumar 132562 | Limited distribution with few individuals (single locality in study area) in Western Himalaya. | EN, CITES Appendix II | Source |
| 13. Dactylorhiza hatagirea (D. Don) Soó | | Orchidaceae | Herb | Eco-sensitive zone near Sidhani, 3,544 m | Puneet Kumar 127643 | Exploitation of medicinal root-tubers. | EN, CITES Appendix II | Source |
| 14. Dioscorea deltoidea Wall. ex Kunth | | Dioscoreaceae | Climber | Harbi Dhar, 3,469 m | Puneet Kumar 127309 | Decline in population owing to over exploitation of medicinal/edible rhizome. Tough to cultivate commercially due to very slow growth. | EN, CITES Appendix II, Negative List of Exports | Source |
| 15. Epipactis helleborine (L.) Crantz | | Orchidaceae | Herb | On way to Sidhani Dhar, 2,712 m | Puneet Kumar 132591 | Exploitation directly from wild, whole plant uprooted for seeds. | VU, CITES Appendix II | Source |

**Table 1. Endemic and threatened species from Sechu Tuan Nalla Wildlife Sanctuary.**
| Name of species | Local name (if any) | Family | Habit | Locality with altitude | Collection no. | Conservation Status as per IUCN, CAMP, RDBIP & Regional Publications | Occurrence in study area | Cause |
|-----------------|---------------------|--------|-------|------------------------|----------------|-------------------------------------------------|------------------------|-------|
| 16. Eremurus himalaicus Baker | Piyau | Asphodelaceae | Herb | Sidhani Dhar, 2,991 m | Pune & Kumar 128011 (BSD) | EN, Endemic to Western Himalaya | Infrequent | Exploited for edible foliage roots. |
| 17. Ferula jaeschkeana Vatke | Kurash | Apiaceae | Herb | Along Triund Nalha, 3,207 m | Pune & Kumar 127872 (BSD) | EN | Infrequent | Exploited for medicinal uses. |
| 18. Fritillaria cirrhosa D. Don | Jangli Lahsun | Liliaceae | Herb | Along Triund Nalha towards Chogelu Dhar, 3,503 m | Pune & Kumar 128149 (BSD) | EN | Infrequent | Exploited for medicinal uses. |
| 19. Gymnadenia orchidis Lindl. | | Orchidaceae | Herb | Sidhani Dhar, 3,625 m | Pune & Kumar 132561 (BSD) | EN, CITES Appendix II | Infrequent | With very few individuals in study area. |
| 20. Hedysarum astragalooides Benth. ex Baker | Pepe Nalla, Chasakh Bhatori, 3,826 m | Fabaceae | Herb | Pune & Kumar 127422 (BSD) | DD | Infrequent | With very few individuals in study area. |
| 21. Hedysarum microcalyx Baker | | Fabaceae | Herb | Towards North of Bhatori Seri along Sindhmarh Nala, 3,693 m | Pune & Kumar 127557 (BSD) | VU | Infrequent | Over exploitation of medicinal. |
| 22. Hyoscyamus niger L. | Khurasani Ajwain | Solanaceae | Herb | Saichu Dhar, 2,868 m | Pune & Kumar 127755 (BSD) | VU | Infrequent | With very few individuals in study area. |
| 23. Dolomiae a mozacephala DC. | Dhoop | Asteraceae | Herb | Along Sindhmarh Nalla, 3,294 m | Pune & Kumar 127602 (BSD) | EN | Infrequent | Exploited for medicinal uses. |
| 24. Lilium polyphyllum D. Don | Ksheerkakoli | Liliaceae | Herb | Along Sindhmarh Nalla, 3,405 m | Pune & Kumar 127594 (BSD) | CR | Infrequent | Ayurvedic herb. Harvested for its bulbs. A whole plant is uprooted and disturbed. Of its total geographical distribution in Himalayan region, 80% is in India. |
| 25. Malaxis muscifera (Lindl.) Kurtze | Rshibhak | Orchidaceae | Herb | Towards north of Bhatori Seri along Sindhmarh Nala, 3,595 m | Pune & Kumar 127549 (BSD) | EN, CITES Appendix II | Infrequent | Ashtavarg herb. Corms medicinal. |
| 26. Meconopsis aculeata Royle | Veerbhusti | Papaveraceae | Herb | Pepe Nalla, Chasakh Bhatori, 3,740 m | Pune & Kumar 127468 (BSD) | EN | Scarce | Exploited for medicinal uses. Habitat destruction. |
| 27. Picrorhiza kurroa Royle ex Benth. | Kour | Plantaginaceae | Herb | Sidhani Dhar, 3,670 m | Pune & Kumar 132569 (BSD) | EN, CITES Appendix II and Negative List of Exports | Infrequent | Over exploitation of medicinal rhizomes. |
| Name of species | Local name (if any) | Family       | Habit | Locality with altitude | Collection no. | Conservation Status as per IUCN, CAMP, RDB/IP, Regional Publications | Occurrence in study area | Cause                                                                 |
|----------------|-------------------|--------------|-------|------------------------|----------------|---------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------|
| 28. *Sinopodophyllum hexandrum* (Royle) T.S. Ying | Bankakri | Berberidaceae | Herb | Along Jambu Nalla towards Ghatitar, 3,302 m | Puneet Kumar 127258 (BSD) | EN, CITES Appendix II and Negative List of Exports | Infrequent | Over exploitation from wild for its medicinal value. |
| 29. *Polygonatum cirrhifolium* (Wall.) Royle | Salam mishri | Convallariaceae | Herb | Sidhani Dhar, 2,716 m | Puneet Kumar 132577 (BSD) | VU | Infrequent | Ashtavarga herb Rhizomatous rootstock medicinal. |
| 30. *Polygonatum verticillatum* (L.) All. | Salam mishri | Convallariaceae | Herb | Along Triund Nalha towards Chogalu Dhar, 3,504 m | Puneet Kumar 132510 (BSD) | VU | Infrequent | Ashtavarga herb Rhizomatous rootstock medicinal. |
| 31. *Rheum spiciforme* Royle | Chukri or Revand cheni | Polygonaceae | Herb | Sidhani Dhar, 3,177 m | Puneet Kumar 132599 (BSD) | VU | Scarcity | Exploitation of medicinal rootstock. |
| 32. *Rheum webbianum* Royle | Chukri or Revand cheni | Polygonaceae | Herb | Pepe Nalla, Chasakh Bhatori, 3779 m | Puneet Kumar 132455 (BSD) | VU | Infrequent | Exploitation of medicinal rootstock. |
| 33. *Saussurea costus* (Falc.) Lipsch. | Kurth | Asteraceae | Herb | Towards North of Bhatori Seri along Sindhmarh Nalla, 3,677 m | Puneet Kumar 127501 (BSD) | CR, CITES Appendix I and Negative List of Exports | Infrequent | Indiscriminate collection (for its roots) and destruction of habitat. Few individuals in cultivation in the vicinity of villages. |
| 34. *Saussurea roylei* (DC.) Sch. Bip. | | Asteraceae | Herb | Sidhani Dhar, 3,959 m | Puneet Kumar 132553 (BSD) | DD | Infrequent | Whole plant is exploited for medicinal uses. |
| 35. *Taxus wallichiana* Zucc. | Rakhal | Taxaceae | Tree | On way to Sidhani Dhar, 2,879 m | Puneet Kumar 132587 (BSD) | EN, CITES Appendix II and Negative List of Exports | Infrequent | Over exploitation of medicinal bark. |
| 36. *Trollius govanianum* Wall. ex D. Don | Nag Chhatri | Trilliaceae | Herb | Sidhani Dhar, 3,240 m | Puneet Kumar 132532 (BSD) | EN | Scarce | Exploited for medicinal uses. |
| 37. *Trollius acaulis* Lindl. | | Ranunculaceae | Herb | Seen on way to Sidhani Dhar, 3,176 m | Puneet Kumar 132525 (BSD) | EN | Infrequent | Only three individuals seen in single locality near glacier. |

CR—Critically Endangered | EN—Endangered | VU—Vulnerable | DD—Data Deficient | BSD—Herbarium of Botanical Survey of India, Northern Regional Centre Dehradun.

Note: Due to sensitivity of critically endangered species we are not giving geo-coordinates here in this communication however, in case anybody required data for genuine research purpose can get information by contacting the corresponding author.
Image 2 (a–e). a—Fritillaria cirrhosa D. Don., growing in its natural habitat on alpine grassy slopes, single flower in inset | b—Three terminal solitary drooping flower’s top view | c—Inverted flower view to show stigma and anthers | d—Upright maturing capsules coming out of the withering floral parts | e—Bulb (arrowed), along with two uprooted young plants. © Puneet Kumar.
and aromatic plants should be encouraged among the farmers for their betterment. Though the local people have shown interest in the cultivation of these medicinal plants, the efforts turn out to be futile probably due to unscientific cultivation practices. The scientific community should come forward to help in improving the methods of cultivation presently employed by these farmers. Although many of the important medicinally
CONCLUSION

The study highlighted the sustainable approach of local people towards the use of resources around the WS. Local people and their efforts are the very essence that has conserved the floral heritage of the Great Himalaya over the centuries. Linking local communities to conservation programs for natural resources and management of forests can be the way forward to biodiversity protection and sustainable development. The study highlighted the sustainable approach of local people towards the use of resources around the WS.
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Articles

The Javan Leopard Panthera pardus melas (Cuvier, 1809) (Mammalia: Carnivora: Felidae) in West Java, Indonesia: estimating population density and occupancy
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