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# Ecological Assessment of Natural Populations of *Fritillaria cirrhosa* D. Don: A Critically Endangered Species from Indian North Western Himalaya of Global Significance

**Swaran Lata, Vivek Chauhan, Tanay Barman[1] and Rishabh Sharma**

*Silviculture and Forest Management Division, ICFRE-Himalayan Forest Research Institute*
*Conifer Campus, Panthaghati, Shimla-171 013, India*
*[1]Centre of Excellence on Sustainable Land Management, Indian Council of Forestry Research and Education,*
*New Forest, Dehradun-248 006, India*
*E-mail: swaranswaras86@gmail.com*

***Abstract*:** *Fritillaria cirrhosa* D. Don, locally known as Kakoli is a critically endangered and perennial plant belonging to the family Liliaceae with immense medicinal importance. It is a major constituent of *Ashtavarga* group. Thus, massive unsustainable extraction from the wild leads to its rapid habitat depletion. Therefore, the present study was carried out to understand the ecological status of this magnificent native species of the Himalaya. Extensive surveys were done following standard ecological methods in Himachal Pradesh. Seventeen natural populations were sampled and recorded 192 herbs from 44 families. Dominant families were Asteraceae, Polygonaceae, Ranunculaceae, etc. The richness of herbs ranged from, 29-51. The total herb density ranged from 11-23 Ind $ha^{-1}$. The density of *F. cirrhosa* ranged from 0.62-2.30 Ind $m^{-2}$. The highest density of *F. cirrhosa* was observed in Ritirard (2.30 Ind $m^{-2}$) and minimum in Kagaldhar (0.33 Ind $m^{-2}$). The species diversity of herbs ranged from 1.72-3.02. The concentration of dominance ranged from 0.0109-0.0835. Continued unsustainable overuse for its high demand in the market causes challenges to protect the species. Thus, proper management and regular monitoring is required. These findings can be used to guide government policies to safeguard this noteworthy species.

***Keywords*:** Ecological assessment, Diversity, Density, North western Himalaya, Critically endangered, Concentration of dominance

Environmental damage and depleting biodiversity by increasing human populations, demands and anthropogenic pressure on natural forests have also alarmed conservationists, particularly in the fragile Himalayas (Saraswat and Thakur 1998). The broadleaved, evergreen, and coniferous forests of the Himalayas are recognized as representative, natural, and distinctive ecosystems. The western Himalaya is a complex mountain ecosystem ranging from 300 to 6000 m amsl and has diverse biodiversity, amazing landscape and a challenging climate (Rana et al 2022). Himalayan ecosystem is a storehouse of great number of ecologically and socio-economically essential species (Barman et al 2021a). The young and vulnerable Indian Himalayan Region (IHR) is threatened by unsustainable extraction of natural resources, habitat degradation, overexploitation, and climate variability (Ved et al 2003, Rana and Samant 2010, Rana et al 2012). Therefore, the effort has been given to assess the natural populations of *Fritillaria cirrhosa* in the north-western Himalaya because there are no such datasets on the population ecology of the plant or poorly understood, which is a matter of concern. Continuous unsustainable harvesting of bulbs of *F. cirrhosa* due to its high demand in the pharmaceutical industry has resulted in rapid loss of the species' presence throughout the IHR (Chauhan et al 2011). Phytosociological studies will help to identify the species richness, diversity, density and dominance, which will further help to understand the dynamics of its forest vegetation. Thus, managing and conserving the species through an integrated approach is needed, which will further help to formulate specific strategies for the plant's *ex-situ* conservation.

*F. cirrhosa* comes under the family Liliaceae and it is the medicinal plant of the *Ashtavarga* group, which is perennial and critically endangered medicinal herb in the Himalayan region (Barman et al 2021b) and vulnerable globally according to the IUCN (www.iucnredlist.org), and locally known as Kakoli or Jungli Lahsun. The species is a glabrous, bulbous, 15-60 cm tall plant with a spotted stem. Bulbs are small in size with membranous scales on them. Within a brief period of time, typically from April to September, the plant undergoes both its vegetative and reproductive phases (Bisht et al 2016).

The fully matured bulbs (collected after 3 years) of *F. cirrhosa* are used traditionally in the cure of burns, stomachache, asthma, as a stimulant, and bronchitis (Singh and Rawat 2011). As an aphrodisiac, it is used in Indian Medicine System. In the *Ayurvedic* and *Unani* systems of medicine, the roots are used for healing wounds (Samant et al 1998). The bulbs boiled with the orange peel of this herb

and given to cure tuberculosis and asthma (Shaheen et al 2012). Conventionally *F. cirrhosa* is used for tuberculosis, and rheumatism and as a tonic in Jammu and Kashmir UT (Srivastava et al 1986). The powder of bulbs of *F. cirrhosa* is given with milk for body weakness in Uttarakhand, India (Bisht et al 2013). The dried bulb's powder is utilized in Pakistan to alleviate urinary tract infections and to soothe and soften the skin by blending it with butter (Khan et al 2013). Bulbs are also used for the treatment of milk deficiency, fever and hemorrhage (Kaul 2010). For bronchial disorder and pneumonia, it is also recommended in the Chinese medicine system (Zhang et al 2008). The bulbs of the species are also used to cure bronchial and ophthalmic disorder in Himachal Pradesh (Barman et al 2021b) and also used in making anticancerous drugs (Ping et al 1995).

Textural diversity in plant communities is closely linked to species richness, which is considered a crucial factor in both the structural and dynamic aspects of these communities (Van der Marrel 1996). Diversity is commonly alarmed with the sign of variability of natural communities and that's why the study of this species is helps to understand its structure, development, and composition (Li et al 2002). There is a shred of strong evidence that biodiversity and forest resilience are linked together in ecosystems (Folke et al 2004, Thompson et al 2009). Particularly, some species and groups of species carry out crucial activities in forests, making them necessary for the maintenance of all of the forest's functional processes and the long-term development of resilience (Diaz and Cabido 2001). There are no such studies regarding the population structure of *F. cirrhosa* have been done in the Indian northwestern Himalaya. Very less studies on population structure and dynamics have been done on other species (Devi et al 2019, Paul et al 2019, Barman et al 2021a, Rana et al 2022) in the north-western Himalaya. In view of the importance of *F. cirrhosa* as essential species of the temperate forest ecosystem of the Himalaya, the current study has been conducted to assess the population status of *F. cirrhosa* in the north-western Himalaya; and to formulate strategies for the policy makers for the conservation of the species.

## MATERIAL AND METHODS

**Study area:** The State Himachal Pradesh (30°37'50'' N to 33°21'11" N latitudes and 75°59'86" E to 79°07'22" E longitudes) is a part of Trans and North-Western Himalaya (Fig. 1). The study was conducted during 2017-2022 in Lahaul & Spiti (3345-3405 m), Kinnaur (3903 m), Chamba (3592-3712 m), Shimla (3253-3756 m), Sirmaur (3608 m) and Kullu (3150-3538 m) districts of Himachal Pradesh. Topographically, the territory of the state can be divided in three prominent zones, namely the Shiwaliks (Outer Himalaya), mid mountain (Inner Himalaya) and the alpine zones (Greater Himalaya). It is bordered by the autonomous territory of Tibet on the east, Panjab on the west and south-west, Haryana and Uttarakhand on the south-east and by Jammu and Kashmir Union Territory on the north. The whole territory of Himachal Pradesh is hilly region with the altitude ranging from 200 to 7000 m amsl, thus creates great variation in the climatic conditions. The state is blessed with by five major rivers like, Chenab, Yamuna, Ravi, Beas, and Sutlej, as well as numerous tributaries of these rivers. The state is well-regarded for having a healthy and varied climate. Due to different aspects and heights, it also sees significant differences in rainfall distribution and temperature distribution. Precipitation decreases from West to East and South to North. Light to dark brown and yellowish brown with sandy loam to silt and light to dark yellowish brown. The vegetation mainly comprises of tropical, sub-tropical, temperate, sub-alpine and alpine types. Tropical forests are dominated by broad leaved deciduous and evergreen species. Sub-tropical forests are dominated by deciduous broad leaved and ever green and coniferous forests. Temperate and sub-alpine forests are mainly dominated by broad leaved and coniferous species, and alpine meadows are dominated by alpine scrubs and herbaceous species.

**Population assessment and data analysis:** The physical characteristics of each habitat were used to identify them, and a hand-held Global Positioning System was used to obtain the geographic coordinates of each population. To sample a specific site or habitat where the target species were observed, a 30m x 30m plot was established. For the ecological assessment, a total of 20 quadrats, each measuring 1m x 1m, were randomly placed within the plot

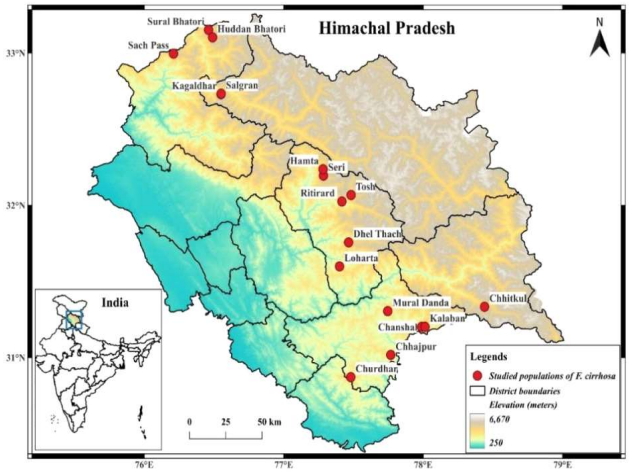


**Fig. 1.** Studied populations of *F. cirrhosa* in Himachal Pradesh

following standard ecological methods (Curtis and Mc Intosh 1950, Dhar et al 1997, Greig-Smith 1957, Misra 1968, Mueller-Dombois and Ellenberge 1974, Samant et al 2002, Samant and Joshi 2004) were followed. From each site, samples of each species were collected and identified with the help of flora and earlier publications (Aswal and Mehrotra 1994, Dhaliwal and Sharma 1999, Singh and Sharma 2006, Samant et al 2007, Samant 2015). Data analysis was performed on the data using MS Excel 2016. Species diversity (H') was calculated by using the Shannon-Wiener information index (Shannon and Wiener 1963) as follows.

$$H' = \sum_{i=1}^{S} pi \ln pi$$

Where, pi = the proportion of individuals of species i

The Concentration of dominance (Cd) was calculated using Simpson's index (Simpson 1949) as follows.

$$D = \Sigma (n/N)^2 \qquad D = \frac{\Sigma n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species

N = the total number of organisms of all species

(The value of D ranges between 0 and 1)

The total count of species was considered as species richness. Species richness was calculated as follow:

Richness = $S/\sqrt{n}$

Where, S = number of species; n = Total number of individuals of all the species

Density, abundance, frequency, relative frequency and relative density of the species were calculated as:

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats of occurrence}}$$

$$\text{Frequency} = \frac{\text{Number of quadrats in which species occurred}}{\text{Total number of quadrats}} \times 100$$

**Soil sampling and analysis:** Soil samples were collected from each studied plot. Soil was cored up to 20 cm depth. Five soil samples, four from the corners and one from the centre of each plot were collected, pooled and mixed properly to make a composite sample. The air-dried soil samples were assessed for further tests and analysis. Soil pH was measured using pH meter in 1:5 mixture of soil and distilled water. Organic carbon was analysed as described by Walkley and Black method (Walkley and Black 1934), available nitrogen by Kjeldahl method (Subbiah and Asiijah 1956), available phosphorus by Olsen's extraction method (Olsen et al 1954) and available potassium by flame photometer (Allen et al 1974, Jackson 1958).

## RESULTS AND DISCUSSION

**Spatial pattern and distribution:** Seventeen populations of *F. cirrhosa* were studied in Lahaul & Spiti, Shimla, Sirmaur, Chamba, Kinnaur, and Kullu districts of Himachal Pradesh. The open meadow habitat represented 11 sites, followed by Partial shade 6 sites between 3150-3903 meters. The slope of sampled sites ranged from $18^0$ to $37^0$. The highest slope was recorded from Mural Danda and Ritirard ($37^0$, each), followed by Kalaban and Chhitkul ($35^0$, each), Tosh ($34^0$) and minimum in Chanshal ($18^0$). Studied populations varied from aspect to aspect and highest populations were found in North-east aspect (9 sites) followed by North (6 sites) and South-east (2 sites) (Table 1).

**Species composition:** Total 192 herbs from 44 families were recorded from studied sites. Maximum species richness was observed in Sach Pass (69 species) followed by Kalaban, Kagaldhar, and Mural Danda. Dominant family was Asteraceae with 32 speices, followed by Polygonaceae, Ranunculaceae, Lamiaceae, Apiaceae, Boraginaceae and Rosaceae.

**Species richness and density:** The richness of herbs ranged from 29-51. The maximum value of richness was from Sach pass (69 species), followed by Kalaban, Mural Danda and the minimum was recorded from Sural Bhatori (33 species). The maximum total herb density was recorded from Kalaban (90.29 Ind $ha^{-1}$) followed by Sach Pass (83.51 Ind $ha^{-1}$), Kagaldhar and the minimum in Sural Bhatori (22.39 Ind $ha^{-1}$). The highest density of *F. cirrhosa* was in Ritirard (2.3 Ind $m^{-2}$), followed by Salgran, Kalaban and minimum in Kagaldhar (0.33 Ind $m^{-2}$) (Table 2).

**Species diversity (H') and concentration of dominance (Cd):** The H' of herbs was maximum recorded from Tosh (3.02) followed by Loharta, Kalaba), Ritirard and minimum in Chhajpur (1.72). The maximum Cd of herbs was from Dhel Thach (0.0835), followed by Ritirard, Chhajpur, Sural Bhatori and minimum in Huddan Bhatori (0.0109) (Table 2).

**Physicochemical properties of soil:** The the maximum value of pH was recorded from Salgran (6.45), followed by Mural Danda, Kagaldhar. The highest EC was observed at Mural Danda (162.2 S/m), followed by Kagaldhar (Salgran S/m. Organic Carbon ranged between 1.35-2.91%, with the maximum value of OC recorded at Kagaldhar followed by Mural Danda, Hamta. Total Nitrogen ranged from 165.2-288.5 Kg/ha, the maximum from Mural Danda (288.5 Kg/ha) followed by Kagaldhar and Salgran . Available phosphorous ranged from 3.82-11.68 Kg/ha and maximum was at Hamtay

Tosh. Available potassium ranged from 87.1-197.5 Kg/ha maximum at Mural Danda, followed by Kagaldhar, Tosh (141.8 Kg/ha) (Table 3).

***Corelation study***: The statistical analysis revealed a significant negative correlation between species richness and altitude ($R^2$ = 0.417,) (Fig. 2a) which signifies severe climatic conditions at the higher elevations or more anthropogenic pressure making unfavourable condition for natural regeneration. Positive correlation was found between density of *F. cirrhosa* with total density ($R^2$ = 0.082,) (Fig. 2b). Similar findings were observed by several researches in the Himachal Pradesh (Devi et al 2019, Barman et al 2021a, and Rana et al 2022). Significant positive correlation was found between species richness and total density ($R^2$ = 0.751) and positive correlation found between organic carbon with species richness ($R^2$ = 0.165) which states that organic carbon is essential for the growth and germination of the species. These findings are comparable with earlier reported studies in the Himalayan region (Paul et al 2019, Barman et al 2021, Singh et al 2021).

The north western Himalaya has been graced with a broad floristic variety of ecologically and economically significant species, which is essential for human life. The increasing demand and unsustainable extraction of the plant from the wild for its huge medicinal purposes causes population depletion from its natural ecosystem. It even has a significant effect on endemic and native flora found in the forests, raising the possibility of their extinction from their

**Table 1.** Site characteristics and associated herbs of *Fritillaria cirrhosa* D. Don populations in the studied sites

| Populations | Habitat type | Altitude (m) | Aspect | Slope (°) | Latitude (N°) | Longitude (E°) | Major associated species |
|---|---|---|---|---|---|---|---|
| Mural Danda | Open meadow | 3432 | East | 37 | 31° 18'15" | 77°44'44" | *Trillium govanianum, Angelica glauca* |
| Chhajpur | Open meadow | 3253 | North-east | 27 | 31° 01'00" | 77°46'04" | *Viola serpens, Meconopsis aculeata, Jurinea macrocephala* |
| Chanshal | Open meadow | 3756 | North-east | 18 | 31° 12'03" | 77°59'21" | *Aconitum violaceum, Morina longifolia* |
| Kalaban | Partial shade | 3355 | East | 35 | 31° 12'06" | 78° 00'47" | *Bergenia stracheyi, Arnebia benthamii* |
| Chhitkul | Partial shade | 3903 | North-east | 35 | 31° 19'59" | 78° 26'25" | *Dactylorhiza hatagirea, Aconitum heterophyllum, Picrorhiza kurrooa* |
| Churdhar | Open meadow | 3608 | South-east | 31 | 30° 52'14" | 77°28'51" | *Rheum australe, Sinopodophyllum hexandrum, Trillium govanianum,* |
| Kagaldhar | Partial shade | 3405 | North-east | 30 | 32° 43'47" | 76°33'01" | *Sinopodophyllum hexandrum, Dactylorhiza hatagirea* |
| Salgran | Partial shade | 3345 | North-east | 28 | 32° 43'59" | 76° 33'05" | *Sinopodophyllum hexandrum, Prunella vulgaris* |
| Sach Pass | Open meadow | 3592 | East | 33 | 32° 59'46" | 76°12'35" | *Aconitum heterophyllum, Rheum australe, Lilium polyphyllum.* |
| Sural Bhatori | Partial shade | 3712 | South-east | 29 | 33° 09'55" | 76°27'40" | *Dactylorhiza hatagirea, Rheum australe,* |
| Huddan Bhatori | Open meadow | 3654 | East | 32 | 33°06'11" | 76°29'23" | *Picrorhiza kurrooa, Sinopodophylum hexandrum, Dectylorhiza hatagirea* |
| Loharta | Open meadow | 3150 | North-east | 30 | 31° 35'53" | 77°24'00" | *kurrooa, Jurinea macrocephala* |
| Dhel Thach | Open meadow | 3538 | North-east | 23 | 31° 45'22" | 77°27'55" | *Trillium govanianum, Sinopodophyllum hexandrum,* |
| Ritirard | Open meadow | 3443 | East | 37 | 32° 01'29" | 77°25'02" | *Dactylorhiza hatagirea, Picrorhiza kurrooa, Silene gonosperma* |
| Tosh | Open meadow | 3393 | East | 34 | 32° 04'01" | 77°28'59" | *Jurinea macrocephala, Rheum australe, Dactylorhiza hatagirea* |
| Seri | Partial shade | 3472 | North-east | 25 | 32°11'40" | 77°17'05" | *Sinopodophyllum hexandrum, Thymus linearis* |
| Hamta | Open meadow | 3345 | North-east | 21 | 32°14'12" | 77°16'55" | *Dactylorhiza hatagirea, Sinopodophyllum hexandrum* |

particular ecosystem. Conducting appropriate ecological research and raising public awareness of the need to protect the biodiversity components of any biogeographic area are essential for the conservation of plant species and to understand forest dynamics (Barik and Adhikari 2012). There are many studies related to ecological studies carried out in the state of Himachal Pradesh (Pant and Samant 2012, Sharma and Samant 2013, Lal and Samant 2015, 2019, Adhikari et al 2018, Paul et al 2018 a&b, 2019, Devi et al 2019, Lal and Samant 2019, Lal et al 2020, Barman et al 2021, Rana et al 2022) but no such studies on the ecological status of *F. cirrhosa* has been done so far in Himachal Pradesh. *F. cirrhosa* is a common herb of the Himalayas' higher wet temperate and alpine forests. This plant species

**Table 2.** Population wise species richness, total density, species diversity and concentration of dominance

| Populations | Species richness | Total density (Ind/m$^2$) | Density of *F. cirrhosa* (Ind/m$^2$) | Species diversity | Concentration of dominance |
|---|---|---|---|---|---|
| Mural Danda | 57 | 61.11 | 1.63 | 2.84 | 0.0199 |
| Chhajpur | 36 | 40.6 | 0.7 | 1.72 | 0.0367 |
| Chanshal | 50 | 46 | 1.5 | 2.09 | 0.0296 |
| Kalaban | 61 | 90.29 | 1.73 | 3.00 | 0.0199 |
| Chhitkul | 54 | 54.7 | 0.83 | 2.46 | 0.0228 |
| Churdhar | 41 | 57.1 | 1.4 | 2.85 | 0.0267 |
| Kagaldhar | 54 | 64.42 | 0.33 | 2.51 | 0.0199 |
| Salgran | 39 | 44.6 | 1.8 | 1.94 | 0.0290 |
| Sach Pass | 69 | 83.51 | 0.83 | 2.13 | 0.0185 |
| Sural Bhatori | 33 | 22.39 | 0.47 | 2.64 | 0.0354 |
| Huddan Bhatori | 49 | 53.9 | 0.63 | 2.15 | 0.0109 |
| Loharta | 39 | 44.7 | 1.53 | 3.01 | 0.0281 |
| Dhel Thach | 45 | 57 | 1.2 | 2.57 | 0.0835 |
| Ritirard | 43 | 50.53 | 2.30 | 2.91 | 0.0369 |
| Tosh | 39 | 46.8 | 1.4 | 3.02 | 0.0350 |
| Seri | 46 | 51.1 | 1.6 | 2.51 | 0.0299 |
| Hamta | 49 | 49.3 | 0.9 | 2.64 | 0.0261 |

**Table 3.** Physico-chemical properties of soil in the studied populations

| Populations | pH | EC (S/m) | Carbon (%) | Nitrogen (Kg/ha) | Phosphorus (Kg/ha) | Potassium (kg/ha) |
|---|---|---|---|---|---|---|
| Mural Danda | 4.84 | 99.1 | 2.61 | 288.5 | 6.65 | 197.5 |
| Chhajpur | 6.22 | 128.4 | 1.35 | 175.6 | 8.91 | 122.0 |
| Chanshal | 5.95 | 70.8 | 1.89 | 201.4 | 8.72 | 87.1 |
| Kalaban | 6.25 | 162.2 | 2.31 | 218.2 | 6.41 | 129.1 |
| Chhitkul | 6.45 | 120.2 | 2.11 | 178.3 | 7.44 | 124,1 |
| Churdhar | 4.97 | 102.2 | 2.28 | 175.6 | 3.82 | 135.4 |
| Kagaldhar | 5.88 | 101.2 | 2.91 | 288.3 | 6.13 | 158.1 |
| Salgran | 4.72 | 105.6 | 2.11 | 250.8 | 9.95 | 141.1 |
| Sach Pass | 5.84 | 72.2 | 2.21 | 165.2 | 11.01 | 120.3 |
| Sural Bhatori | 4.21 | 108.7 | 1.72 | 169.0 | 9.52 | 127.1 |
| Huddan Bhatori | 4.81 | 105.3 | 1.86 | 170.3 | 9.12 | 135.4 |
| Loharta | 5.01 | 112.3 | 2.10 | 182.1 | 9.05 | 140.6 |
| Dhel Thach | 5.21 | 114.2 | 2.19 | 189.5 | 10.02 | 129.8 |
| Ritirard | 4.91 | 109.2 | 1.92 | 174.3 | 8.62 | 133.7 |
| Tosh | 5.13 | 113.5 | 2.14 | 192.1 | 11.07 | 141.8 |
| Seri | 5.02 | 115.2 | 2.01 | 190.7 | 11.04 | 139.5 |
| Hamta | 5.32 | 118.6 | 2.36 | 185.4 | 11.68 | 134.4 |

EC=Electrical conductivity

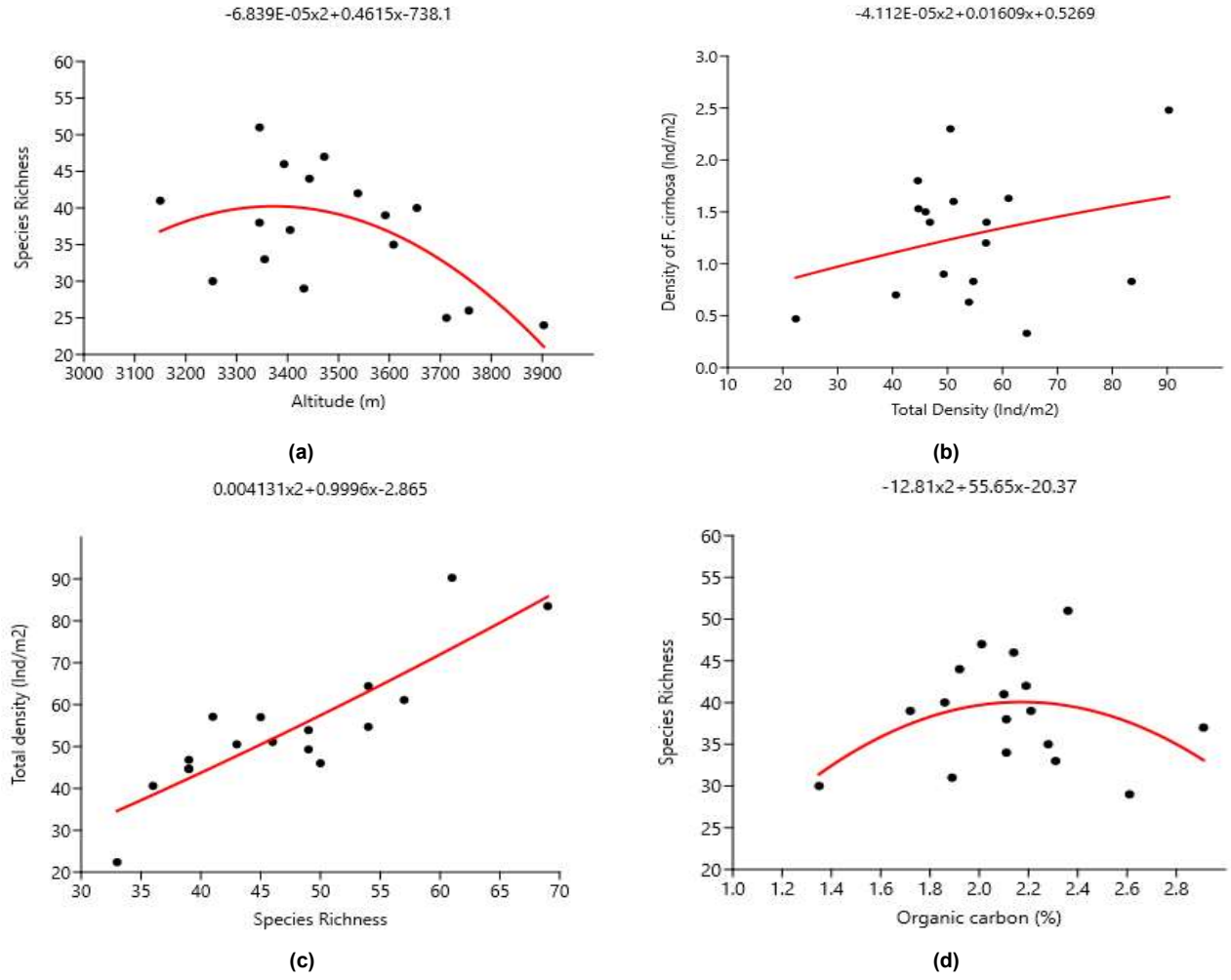


**Fig. 2 (a-d).** Relationship between (a) Altitude and species richness; (b) density of *F. cirrhosa* and total density; (c) Species density and total density; and (d) Species richness and organic carbon

produced bulbs that sold in markets for their high economic value due to its medicinal properties. The plant is a source of income for Himalayan tribes and an essential component of the ecosystem, customs, and lifestyle of Himachal Pradesh's tribes. In IHR, tribes and indigenous people are major ethnic groups known for their distinct traditions, cultures, and ways of life. A total of 192 herbs from 44 families were recorded from studied sites. The number of the species is less than the numbers reported from previous studies in Himachal Pradesh (Lal 2007, Rana and Samant 2009, Bhandari et al 2018, Rana et al 2022) and this is may be due to recent habitat loss or increased anthropogenic pressure. This phenomenon simply illustrates the conservation needs of forest biodiversity in the studied areas. The species diversity values are less compared with previously reported studies in Himachal Pradesh (Rana and Samant 2010, Lal and Samant 2015, Singh et al 2021, Barman et al 2021a), but comparable with Bisht et al (2016) in Dronagiri alpine meadow of Uttarakhand. The total herb density is very less than reported earlier studies (Singh et al 2021, Paul et al 2019, Rana et al 2022). This may be due to over-exploitation and increasing anthropogenic pressure on natural habitats.

## CONCLUSION

The protection of forest biodiversity remains a major challenge in the management of forest resources in the era of climate induced vulnerable ecosystems. Cultivating medicinal plants domestically can have dual benefits of enhancing the financial status of the regional inhabitants and thus promotes the preservation of biodiversity elements. To ensure the continued existence of *F. cirrhosa* in the wild, it is crucial to undertake conservation measures. Due to the medicinal benefits and critically endangered status of this herb, it is essential to prioritize both *in situ* conservation and *ex situ* cultivation. To achieve this, a population assessment using standard ecological methods should be conducted to quantify

the current stock of the species in its natural habitats throughout the Himalayan region. It is crucial that forest managers plant native, fire-resistant plants in appropriate, methodical ways, rigorously avoiding monotypic species. Additionally, they need to support effective control of invasive species, which eventually aids native species in thriving. Maintaining soil moisture also depends on having a thorough grasp of the dynamics and pattern of a forest's hydrology. By carefully planning ahead, the government may be able to lessen encroachments in forest regions. The research also offers in-depth details on the physical traits, richness, density, species diversity, concentration of dominance, and population ecology of *F. cirrhosa*. It is important to strictly prohibit the unscientific and illegal collection of the herb from its natural habitats. Implementing these strategies would aid in the conservation and sustainable availability of this valuable herb. The survival and ongoing existence of *F. cirrhosa* in the wild will necessitate collective efforts from a range of stakeholders.

## AUTHOR'S CONTRIBUTION

Conceptualization, draft manuscript editing, identification of flora and overall coordination were performed by SL. VC contributed in the writing of the draft manuscript, field data collection and data analysis, and preparation of tables and figures. TB contributed in research design, statistical analysis, editing and reviewing of the draft manuscript. Study area map was prepared by RS and also contributed in the preparation of the manuscript.

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