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Status of *Catamixis baccharoides* Thomson (a critically endangered plant) in Western Himalayas

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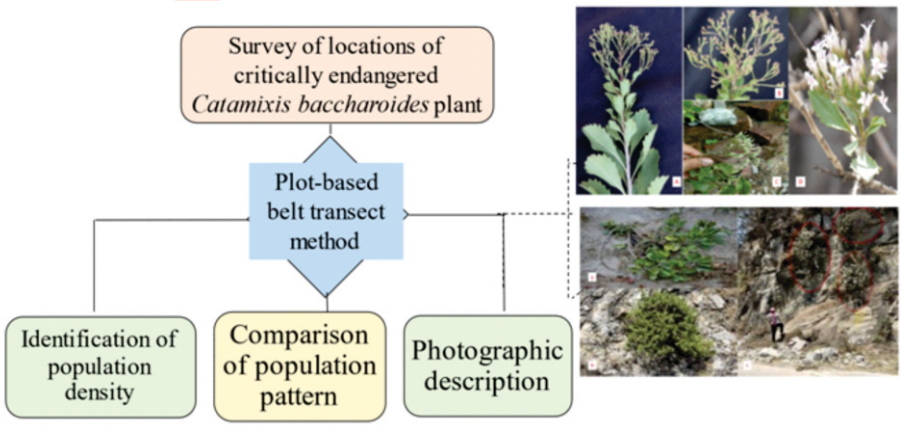
Abstract

Aim: The aim of the study is to provide current conservation status of IUCN listed critically endangered species, *Catamixis baccharoides*, and to study the population density of species in three major locations: Biyasi, Rajaji National Park near Mansa devi in Uttarakhand and Mohand in Uttar Pradesh.

Methodology: Two concurrent field surveys during April - May 2018 and March - May 2021, were conducted for population study of *Catamixis baccharoides*. Belt transect method was used for biomass evaluation of species at all three locations and sampling were done using transect path of 1000 m (20 m wide). Plants habit, morphology and phenology were described on the basis of field observation. Population density of the species in sample survey was determined and seeds were collected for germination test.

Results: The population of plant in first survey 2018 was compared with 2021 survey and other previous survey conducted by other authors, and observed that there was sudden decease in plant density from 11 plants to zero in Biyasi location and the population was steady in Mohand (6 plants) and Mansa Devi (24 plants) Rajaji National Park Haridwar. Seeds seem to be recalcitrant in nature.



Interpretation: *Catamixis baccharoides*, also known as "Vish-Patri", an endemic monotypic shrub of Asteraceae family and is categorized in critically endangered category under IUCN. The population of this species is declining at an alarming rate from its natural habitat in Uttarakhand and Uttar Pradesh. In Biyasi location Uttarakhand, the population of species had vanished due to anthropogenic disturbances and ignorance during Char Dham road project and is decreasing rapidly in other locations. However, the medicinal and economical vantage of *C. baccharoides* is yet unexplored so, there is a need to take necessary steps to conserve the species in its natural habitat.

Key words: Belt transect method, Conservation, Critically endangered, Monotypic

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Introduction

Biodiversity is essential for human survival, economic well-being and for the ecosystem structure, functioning and stability (Singh, 2002; Rana *et al.,* 2015; Karki *et al.,* 2017). Forests are important repositories of terrestrial biodiversity and play a key role in influencing socio-ecological and cultural attributes of human societies, including livelihood activities of societies living in those areas (Hermann, 2006). The anthropogenic disturbances create the fragmentations in natural ecosystems and has adversely affected the natural resources, structure and functioning of ecosystem (Bargali *et al.,* 2019). In a recent study, a concern was raised that the species, which are not important to humans and have restricted habitats, may likely to lose its survival in its natural habitat (Kress and Krupnick, 2022). *Catamixis baccharoides* Thomson a monotypic genus belongs to family Asteraceae, commonly known as 'Vishpatri' is also facing similar threat. It is critically endangered and habitat-specific shrub, endemic to forests of Central and North-West Himalaya in Sivalik hills (IUCN, 2014; Pundir, 2015; Srivastava *et al.,* 2016), which is an extension of the outer Himalayas and is formed of conglomerate and sandstone rocks (Chisholm, 1911).

The habitat of this species extends from Lower Sivalik of the Indian Western Himalayas to Western Nepal (Kitamura and Gould, 1982). Earlier it was placed in the Pertyeae tribe but revised to the subfamily Pertyoideae on the basis of molecular studies (Panero, 2008; Sharma and Painuli, 2011). The present botanical status is being described in Table 1. The species is reportedly distributed across Lower Sivalik in very limited populations and despite its critically endangered status, there are gaps in knowledge; such as ethnobotanical usage, phenology, natural germination and also its conservation status. A study was conducted to record its abundance in naturally growing condition by periodical surveys of the reported area of its distribution in Uttarakhand and Uttar Pradesh. The purpose of study was to determine threat and conservation status of this species and also to prepare a detailed description of this species in its natural habitat to generate base line biological information.

Materials and Methods

This status review has been gathered using citations from major platforms such as forestry journals, NeBio Conservation Biology, Science Direct, PubMed, Botanical Survey of India and various government reports based on Himalayan Biodiversity. For conservation status, earlier exploration or survey reports especially of Uttarakhand and Uttar Pradesh were used for comparison (Pundir, 2015; Srivastava *et al.,* 2016: Chandra *et al.,* 2017). *Catamixis baccharoides* belongs to phylum Magnoliophyta, class Magnoliopsida and order Asterales. Its taxonomical detail was ascertained using specimens and records from DD Herbarium, Dehradun (Table 1). The reconnaissance field surveys were conducted to investigate the species distribution in Lower Sivalik areas of Uttarakhand and Uttar Pradesh twice; April - May 2018 and March - May 2021. Sampling surveys were conducted in three locations; Biyasi, (Tehri Garhwal), Near Mansa Devi, Rajaji National Park, Haridwar and Mohand (Saharanpur) of Uttarakhand and Uttar Pradesh, respectively using the plot-based belt transect method to estimate the population density of plants (Buckland *et al.,* 2001). Both Mansa Devi and Mohand is a part of Rajaji National Park which is IUCN category II protected area. Sampling was conducted along the road using a straight transect path of 20 m wide and 1000 m long; making a plot size of 20 ha. Individuals of *C. baccharoides* occurring within the belt were identified (reference of the herbarium specimen available from DD Herbarium Dehradun) and counted whereas the plant sample including seeds, were collected. Plant and its habitat description were recorded along with its associate trees and woody shrubs. All biological descriptions of plants like habit, height, leaf, petiole, stem, root etc., were recorded and also photographed.

Phenological details like leaf emergence, flowering, fruiting and seed bearing were recorded. To ensure location accuracy, previously available coordinates were selected and explored. Seeds were collected for germination studies. Seeds were sown in nursery beds (soil), on paper towel in seed germinator and on Murashige and Skoog medium in sealed Petri dishes under *in vitro* condition. Temperature in germinator and in vitro condition were maintained at 25 ± 2°C. In nursery beds (soil), seeds were sown in first week of June and third week of July. Observation for germination was recorded from fifth day onwards of sowing experiments followed by a periodical observation on every third day and continued up to 45 days and data were converted into per cent. Based on the above study, photographic descriptive detail and population density of *C. baccharoides* in Uttarakhand state and Uttar Pradesh was prepared.

Results and Discussion

During the sampling survey, bushy specimens were found growing on edges as well as on vertical rock fissures on sandy hill cliffs at an elevation above 500 m (Fig. 1). The species was photographed, herbarium specimen was prepared confirmed through DD Herbarium, Dehradun.

Morphogenic description of *Catamixis baccharoides*: *C. baccharoides* is recognized as a bushy, vigorously branched shrub, upto 1.7 m tall, ascending in nature, and erect (Fig. 1). The stem is hard, turns dark brown to black at maturity, glabrous; branchlets are terete when young, white, silky pubescent, wrinkled or ridged, with conspicuous scars of fallen petiole bases. Leaves are densely arranged, simple, alternate, coriaceous, petiolate, 2 - 9 cm long, obovate and sometimes obovate - spathulate, decurrent on the petiole, cuneate to narrow at the base (Fig. 2). Leaf margins are serrate-dentate to crenate-serrate, glabrescent or sparsely pubescent near the base, leaf surface is glabrous or puberulous above on maturity, apex is round, dentate, prominently veined and dry veins are raised on both sides of leaf surfaces. Petioles are short, 0.4 cm to 0.8 cm long and sericeous (Fig. 2). The inflorescence is always terminal,

Table 1: Sample plot location and observation of Biyasi, Mohand and Rajaji National Park location

Location	Area (ha)	Latitude (N)	Longitude (E)	Total number of plants		Plants per ha	
				2018	2021	2018	2021
Biyasi (Tehri Garhwal)	20	30°04'10.9" 30°04'11.3" 30°04'11.8" 30°04'12.3"	78°30'58.6" 78°30'57.6" 78°30'57.1" 78°30'56.2"	11	0	0.55	0
Mohand (Saharanpur, Uttar Pradesh)	20	30°12'6" 30°12'07.1"	77°54'58" 77°54'58.3"	6	6	0.30	0.30
Rajaji National Park, Hardwar (Uttarakhand)	20	29°57'21.3" 29°57'25.2" 29°57'25"	78°09'56.2" 78°10'4.8" 78°10'5"	24	24	1.2	1.2

Sample area = length (1000 m) × breadth (20 m) = 20 ha

Fig. 1: (a, b) Bushes of *C. baccharoides* on rocky cliffs of Biyasi, Tehri, (Uttarakhand) and (c) Raja Ji National Park, Haridwar (Uttarakhand).

in corymbose panicle, inflorescence branches mostly glandular and occasionally dichotomously branched, capitulate; rachis is glandular-pubescent. Bracts and bracteoles are small, green to purplish, setaceous, uppermost bracteoles and outermost phyllaries placed to capitula base (Fig. 3).

Phyllaries are multiseriate, apex are acuminate to acute and shorter than the flower, often purplish; outer one is ovate or ovate-lanceolate; inner one is larger than outer one and linear-lanceolate. Capitula is homogamous, consisting of 5 - 7 florets per capitula, ligulate, 0.45 – 1.20 cm long, florets are mostly white, rarely yellow and bisexual (Fig. 3). Ligule limb is 4 – 5 mm long and spreading, apex is 5 - toothed; receptacle is convex, glabrous; Corolla tube is 3.6 – 5.2 mm long and up to 1 mm broad, linear-spathulate, toothed at apex; anther tube is bluish or purple-tinged and exserted, up to 3.2 mm long; anther are appendaged, narrowly triangular, apex subacute; Style 4 – 5 mm long, filiform, in shape; shaft glabrous; apices slightly rounded. Cypsela is either obovate or oblong-obovate or obconical, narrowly turbinate, up to 3.2 × 1.4 mm, sub-flattened, brownish, hairy, silky or sericeous; cypsela hairs in basal and sub-basal part are longer than upper pappus 2-seriate or sub-2-seriate; hairs are up to 8

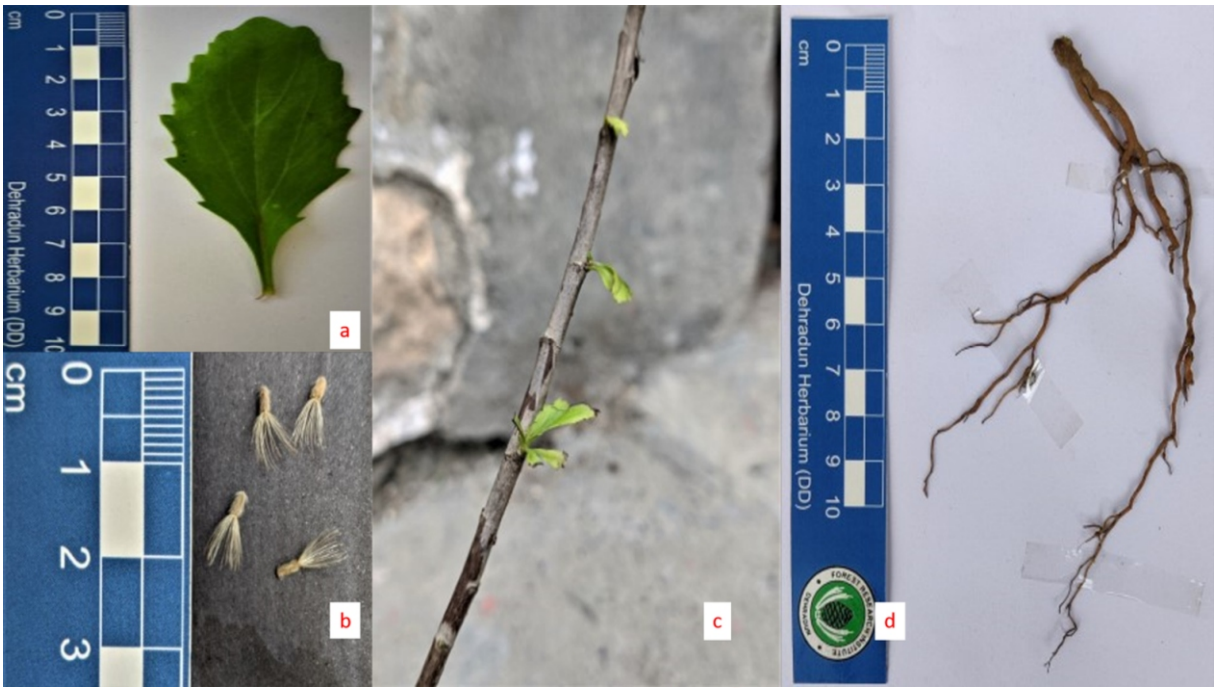

Fig. 2: (a) Mature leaf, (b) Seeds, (c) Stem with visible nodes and (d) Roots, of *Catamixis baccharoides.*

mm long, white, slender in shape, outer pappus is shorter (Fig. 2). The observations in our survey suggest that flowering in *C. baccharoides* starts in late spring *i.e.,* March and seed setting completes by May. The seeds are small and around 2 - 3 mm in size and with wings size ranges between 7 - 10 mm (Fig. 2). Pundir (2015) reported species is entomophilous, as few species of small insects have always been seen fluttering around the fertile branches even entering in a floral tube.

Ecological niche and distribution of *Catamixis baccharoides*: *C. baccharoides* grows on stony well drained soil, mostly found on rocky and sandy cliffs. Observation during survey revealed that associated vegetation was mostly shrubs like; *Pittosporum eriocarpum, Ischaemum angustifolium, Incarvillea emodi, Woodfordia fruticosa, Buddleja asiatica* and *Rumex hastatus*. Occasionally trees like *Desmodium oojeinense, Adina cordifolia, Aegle marmelos, Shorea robusta, Holoptelea integrifolia, Lannea coromandelica, Mallotus phillippensis, Acacia catechu, Rhus parviflora, Ficus glomerata, Syzygium cumini* were also found. Invasive species like *Lantana camara* were also encroaching the area. *C. baccharoides* is reported in seven localities of Lower Sivalik belts of Haryana, Himachal Pradesh, Uttarakhand and Uttar Pradesh (Fig. 4); three of the four locations comes under protected area, Rajaji National Park, Uttarakhand and in Sher Jung National Park, Himachal Pradesh (formerly known as Simbalbara National Park) (Kanjilal, 1928; Jain *et al.,* 2000; Rao *et al.,* 2003; Srivastava *et al.,* 2017), where it grows on steep rocky or sandy slopes at an altitude of 450 – 900 m (Fig. 1). Based on the observations from field visits and earlier reports, a species distribution map was prepared (Fig. 4). This map will serve as a baseline reference locations for future studies.

During the sampling survey, shrub specimens mostly growing on the vertical calcareous cliff were recorded in the sample plots. Observation made during the sampling survey in 2018 suggests that plant population in Biyasi was 11 plants per plot and 0.55 plants per ha, whereas in Mohand it was 6 plants per plot and 0.30 plants per ha and 24 plants per plot and 1.2 plants per ha in Mansa Devi, Haridwar (Table 1). This was low in comparison to plant density of 0.75 plants per ha in Biyasi and equal to 0.30 plants per ha in Mohand as compared to observation report of Chandra *et al.* (2017) conducted in 2016. If we compare our survey of 2018 with the report of survey during 1997-2001 by Pundir (2015); there was a significant decrease in bush numbers from 36 to 11 plants in Biyasi, 17 to 6 plants in Mohand and 60 to 24 plants in Mansa Devi (Rajaji National Park), Haridwar. In our subsequent survey of same locations in 2021, severe decrease in plant population was noted (Table 1). During the investigation at Mansa Devi, Haridwar, approximately 24 *C. baccharoides* bushes were observed with flowers and some flower buds in sample plot whereas, six bushes were observed in Mohand locality though no traces of this species were observed in Biyasi locality. A graph of the population of Biyasi over time using our observation and earlier records reveals a steady decline of individuals within population, which might be attributable to road development project. *C. baccharoides* is extremely endangered in this region, necessitating ongoing monitoring as well as conservation actions such as *in situ* restoration assisted by artificial introduction.

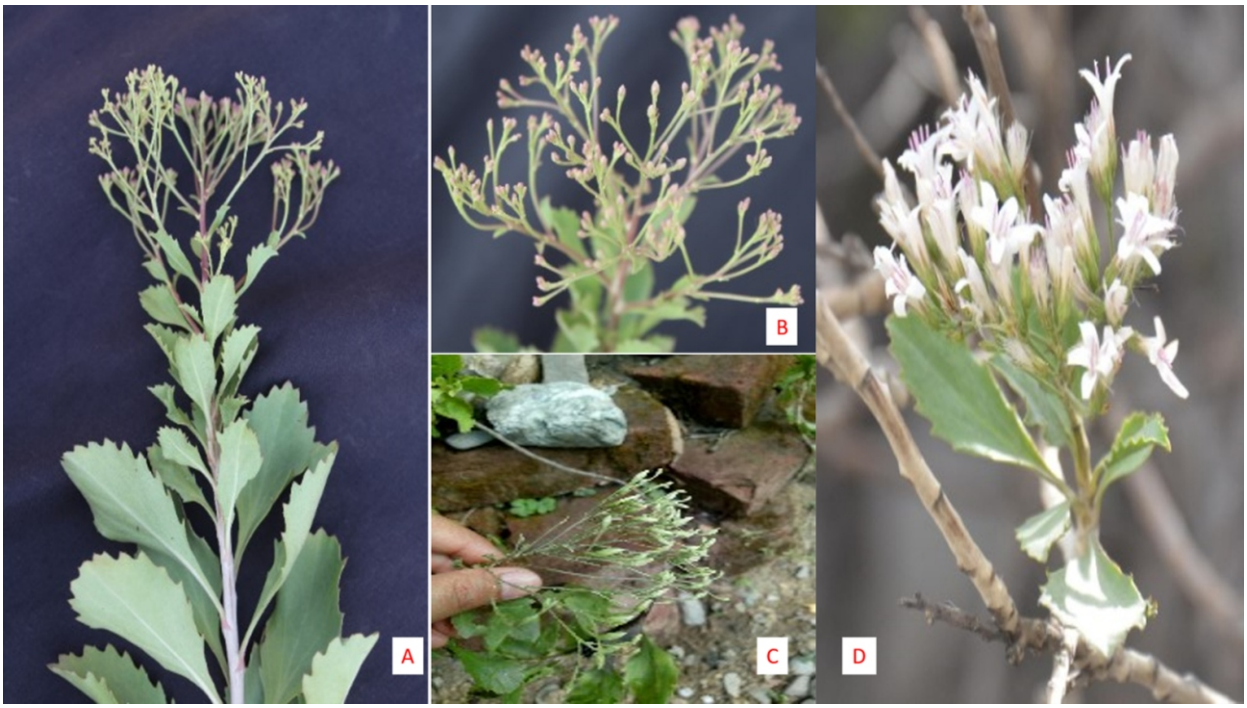

Fig. 3: Floret emergence and flowering; (A) Branch with floral buds, (B) Inflorescence, (C) Floral buds and (D) Flowers in panicle.

A careful survey for the same site is suggested in order to preserve the population, if any remains (Fig. 5). Before 2015, there was a continuous reduction in the number of plants in the RajaJi National Park region, but after 2015, the number of individuals has remained stable. This also happens to be the same year when RajaJi National Park was designated as a Tiger Reserve. The strong protective measures and limited anthropogenic activities in Tiger Reserve are most likely reason for stable populations over the period of years. The lack of fresh *C. baccharoides* recruits in both sites was the only cause for worry. Though, a few tiny plants were discovered in a land slide region outside of the sample plot near Mansa Devi in Haridwar, which indicates that the habitat is still suitable for young recruits. It is recommended that this species to be conserved *in situ* in all vulnerable areas.

Propagation: Propagation is an important tool for *in situ* or *ex situ* conservation of endangered species. Seed germination investigations revealed that seed germination in nursery bed (soil) was 8 % when sowed immediately and no germination was obtained in seed sowed during mid July. In seed germinator, germination rate was 20 % which increased further to 34 % under *in vitro* germination experiment. Srivastava *et al.* (2017) found seed germination between 45 – 60 % within 7 days of collection. The observation showed that seeds seem to lose viability quickly, so seeds dispersed during the month of May might fail to germinate due to subsequent absence of rain. This seems to be a likely cause of absence of natural regeneration in its habitat.

Notably, propagation of *C. baccharoides* with stem cuttings has been successfully attempted by several workers (Pundir, 2015; Srivastava *et al.,* 2016; Panwar *et al.,* 2018; Tomar and Kumar, 2020). Tomar and Kumar (2020) collected explants from Mohand (Saharanpur) and near Mansa Devi, RajaJi National Park, (Haridwar) and rooting was 57.5 % after 84 days of planting and 6000 ppm IBA exogenous treatment which was better than the result obtained by Srivastava *et al.* (2017) who found rooting of cuttings was 25 – 30 % after 60 days. Panwar *et al.* (2018) reported good *in vitro* seed germination and propagation from seeds. Shoots from *in vitro* germinated seedlings were cultured on half-strength MS media supplemented with 1.5 µl IBA and it generated 41.0 shoot number, 7.6 cm shoot length, and 100 % rooting in 30 days. It appears that *C. baccharoides* response to sexual as well as asexual propagation is fairly good and hence, *in situ* conservation can be done using standardized propagation methods.

Conservation status and threats: Poverty, population pressure, agricultural expansion and intensification and development of infrastructure has created as major threats to biodiversity and regeneration processes (Cardinale *et al.,* 2012; Baboo *et al.,* 2017). *C. baccharoides* grow in semi-arid conditions and are distributed in the Sivalik Hills of India, Kashmir Himalaya, and Nepal (Ahmad *et al.,* 2020). Earlier, the plant was common on calcareous cliffs and dry sandy steep or exposed rocky slopes, but later it was observed that the species started disappearing

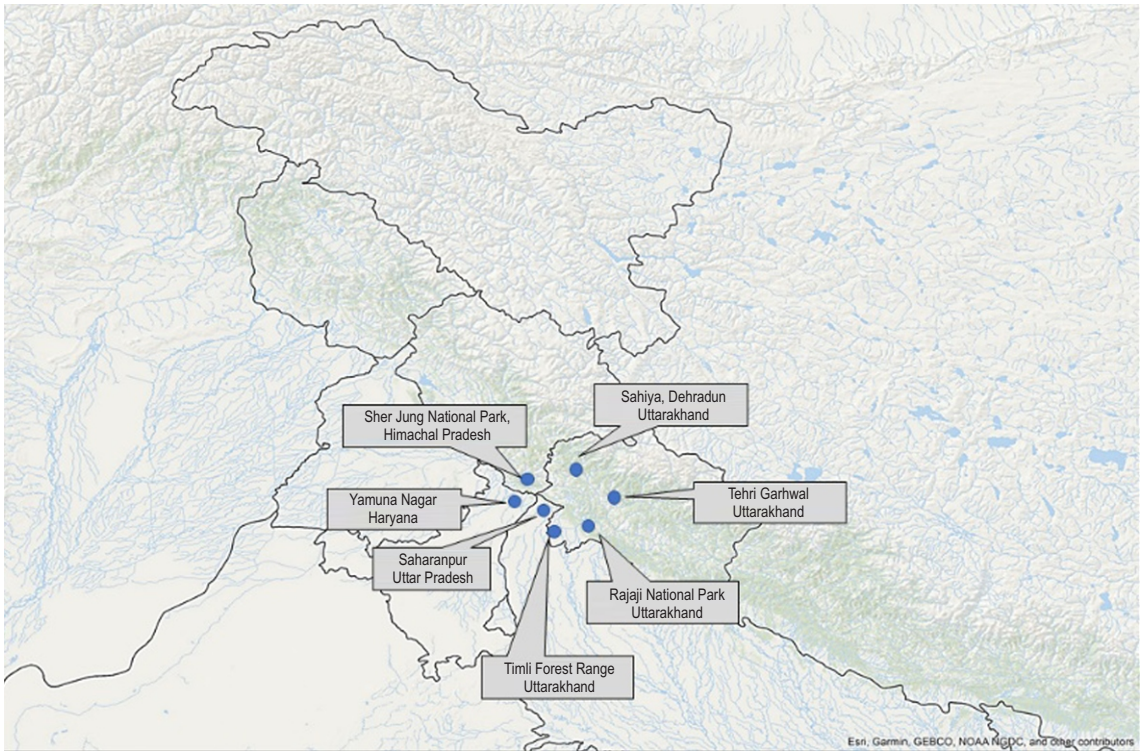

Fig. 4: Native distribution of *Catamixis baccharoides* in the Indian Himalayan Region (IHR). Source: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors.

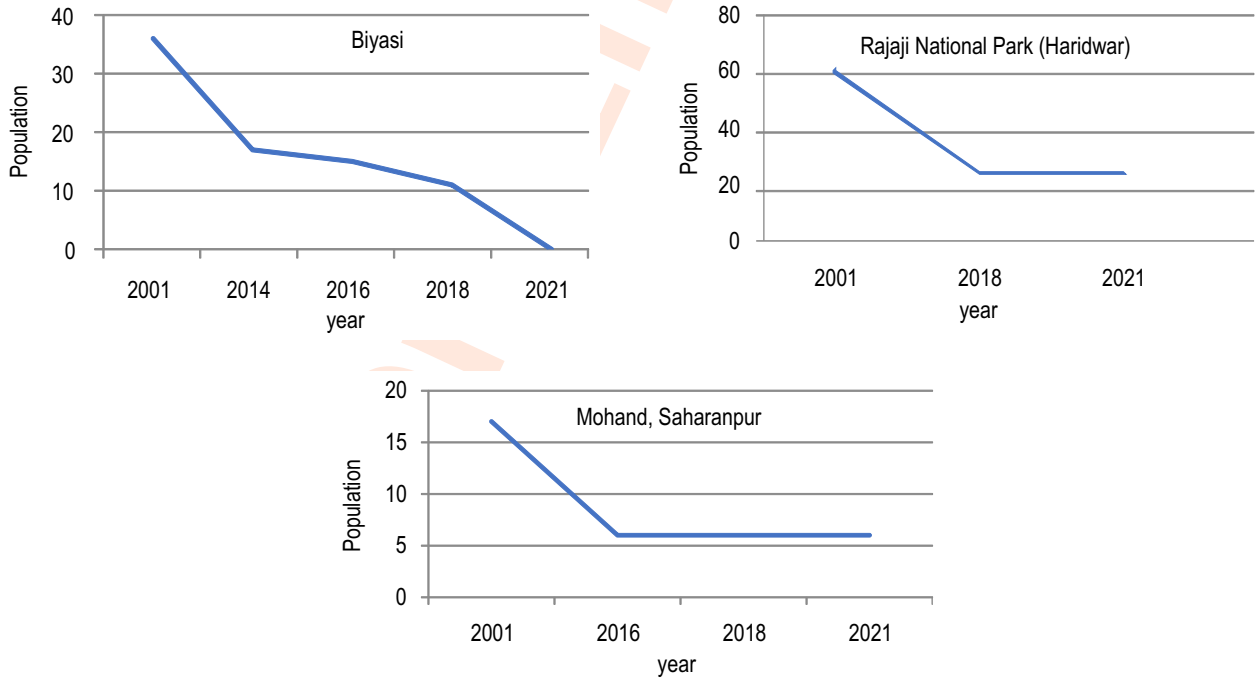

Fig. 5: Temporal variation in population of *C. baccharoides* at three places (Chandra *et al*., 2017; Pundir, 2015).

(Sharma, 2020). Soon the species became rare and later marked its presence in the vulnerable category of Red Data Book of Indian plants in 1997 (Pundir, 2015). Many theories reported about population decline in this species and some of them are; low seed viability (Katinas and Funk, 2020), low regeneration potential (Khanna, 2018) as well as poor natural regeneration of seeds (Panero, 2008). Though viability and regeneration potential are moderate if seeds were sown within 7 days (Srivastava *et al.,* 2017) but poor natural germination was evident in its natural habitat. Usually, recalcitrant types of seeds lose their germination with time, and their storage requires specific conditions. Reduced population size and obstructed gene flow due to habitat fragmentation result in poor fitness of species and impact may be on seed quality, germination or survival.

The other possible reasons could be the impact of climate change, tourism activity, habitat destruction due to serious disturbances in Sivalik hills; like hydro projects construction, indiscriminate quarrying, mining, cutting of hill slopes for constructing roads, and soil erosion. These factors appear to play important role in the rapid fall in its population (Barik *et al.,* 2018). This mostly happens due to its habit (bush) and also limited information about the status of this species. Such species due to ignorance, affected by human choice and are losing the race of survival (Kress and Krupnick, 2022). Therefore, the species is facing a high risk of extinction and necessary *ex situ* and *in situ* conservation steps should be taken to save the existence of this endemic species. Recently, under 'Char Dham highway project Uttarakhand', one native population of *C. baccharoides* vanished, now the existence of *C. baccharoides* is confined only to two locations, out of three locations studied.

C. baccharoides is indexed in the IUCN Critically Endangered (CR) category and its one out of three major habitats have vanished in Uttar Pradesh and Uttarakhand, therefore consistent efforts should be made to conserve the plant from extinction. The priority is its ecological mapping followed by conservation efforts in its natural habitat. There should be consideration of its ecological status while developing a construction project. A multidimensional approach is needed for conservation followed by domestic as well as biotechnological methods that could be provided to save this wild species from extinction. Hence, it is proposed to produce plants using all methods of propagation; through seeds, macro and micropropagation, and subsequently these plants should be conserved *in situ*. Further studies on molecular diversity and bar-coding, family relationships, and linkage mapping is also needed.

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Authors' contribution: R. Dhiman: Experiment conduct and MS writing; **A. Thakur:** Experiment design, data analysis and MS preparation; **S. Yadav:** MS writing and proof reading; **P.K. Verma:** MS writing and editing of MS.

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