

RESEARCH ARTICLE

Reassessment of population and conservation status of ‘critically endangered’ *Phlomoides superba* (Royle ex Benth.) Kamelin & Makhm. from the Lower Shiwalik foothills of Udhampur district of J&K (UT), India.

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Abstract:

Phlomoides superba (Royle ex Benth.) Kamelin & Makhm. is a critically endangered tuberous herb of the western Himalaya with a highly restricted distribution in India. The present study reassessed its population status and major threats in the Jallow and Khathil Gango localities of Udhampur district, Jammu and Kashmir. A total of approximately 412 individuals were recorded from the two sites. Populations occurring along roadsides, stream margins, and agricultural field boundaries were small and fragmented, whereas a comparatively large and vigorous population was observed in the relatively undisturbed habitat at Khathil Gango. Habitat destruction, agricultural expansion, residential development, and road widening were identified as the major threats. Although local communities are aware of the traditional medicinal and veterinary uses of the species, no active tuber harvesting was reported during the study. The findings highlight the importance of habitat protection, regular population monitoring, community participation, and integrated *in situ* and *ex situ* conservation measures for the long-term survival of *P. superba*.

Keywords: *Phlomoides superba*, critically endangered, population assessment, conservation, Udhampur, Khathil Gango, habitat degradation.

Introduction

Phlomoides superba (Royle ex Benth.) Kamelin & Makhm. (syn. *Eremostachys superba* Royle ex Benth.) is a critically endangered endemic species of the western Himalayan region, with a restricted distribution extending from eastern Afghanistan and Pakistan to the Indian Himalayan states of

Himachal Pradesh, Jammu and Kashmir, and Uttarakhand (Malik et al. 2014; Singh et al. 2022; Bhagat et al. 2025). It is a perennial tuberous herb belonging to the tribe Phlomoideae of the family Lamiaceae. The species bears conspicuous bright yellow flowers arranged in verticillasters, giving the plant its characteristic appearance and earning it the common name 'Golden Himalayan Spike'; it is locally known as 'Gajar moola' in Dogri and 'Ban mooli' in Hindi (Srivastava et al. 2017; Garg & Singh 2024; Bhagat et al. 2025). It is recognized for its diverse medicinal, veterinary, and ornamental significance. The tuberous roots have traditionally been utilized by indigenous and local communities for managing mastitis and enhancing milk production in cattle. In traditional healthcare practices, the roots are also used to alleviate several human health conditions, particularly disorders affecting the liver and digestive system, as well as gout (Koul et al. 1997, Verma et al. 2003 ; Pant and Pant 2011; Malik et al. 2014; Srivastava et al. 2017; Garg & Singh 2024).

The restricted distribution of *Phlomoidea superba* in the Indian Himalayan region, coupled with increasing anthropogenic pressures, poses a serious threat to its survival in the wild. Its populations have declined markedly due to overexploitation for medicinal purposes, habitat loss and fragmentation resulting from agricultural expansion and road widening, and grazing by wild animals (Garg & Singh 2024). In addition, the species has inherently low regenerative capacity, characterized by poor sexual reproduction, low seed set, and intrinsic seed dormancy under natural conditions. These reproductive constraints, together with the fragmentation and isolation of populations, may further promote inbreeding depression and are compounded by limited availability of effective pollinators (Garg & Rao 1997; Verma et al. 2003; Uniyal et al. 2012; Srivastava et al. 2017; Srivastava 2020). Based on conservation and threat assessments following IUCN criteria, Srivastava et al. (2017) categorized *P. superba* as an Endangered taxon while Bhagat et al. (2025) included it in critically endangered category with a declining population trend.

In India, *Phlomoidea superba* has a highly restricted distribution, with records from only ten localities as per earlier records. Of these, seven are situated in Jammu and Kashmir, two in Himachal Pradesh, and only one in Uttarakhand, including its type locality at Mohand (Srivastava et al. 2017). More recently four new localities are reported from J&K (Bhagat et al. 2025) raising total number to eleven localities. Thus, Jammu and Kashmir represents the principal known distributional range of the species within India. Among the known populations of *P. superba* in India, the population at Jallow Village, Udhampur, Jammu and Kashmir, has been reported to support the largest number of individuals, with an estimated population size of approximately 500 plants (Srivastava et al. 2017). Given the restricted distribution and ongoing conservation concerns surrounding this species, the present study was undertaken in the Jallow region and Khathil Gango locality of Udhampur to reassess the current population status of *P. superba* and to evaluate the prevailing anthropogenic and ecological threats that may influence its persistence and regeneration in the area.

Materials and Methods

Study area

The study was conducted at Khathil Gango locality and Jallow Village, Udhampur district, Jammu and Kashmir, India, located at 32.794900° N and 75.229420° E, at an elevation of approximately 640 m to 720m above sea level (Fig. 1). The site falls within the outer Himalayan landscape of the Udhampur region, which is characterized by predominantly hilly and undulating terrain, with a marked altitudinal gradient and a mosaic of forested, agricultural, and rural landscapes. The sub-Himalayan Shiwalik transition zones here provide the precise microclimate, soil composition, and open canopy conditions necessary to sustain the natural habitat of this rare species. These localities were selected as the study site because it supports one of the largest known populations of *Phlomoidea superba* in

the region.

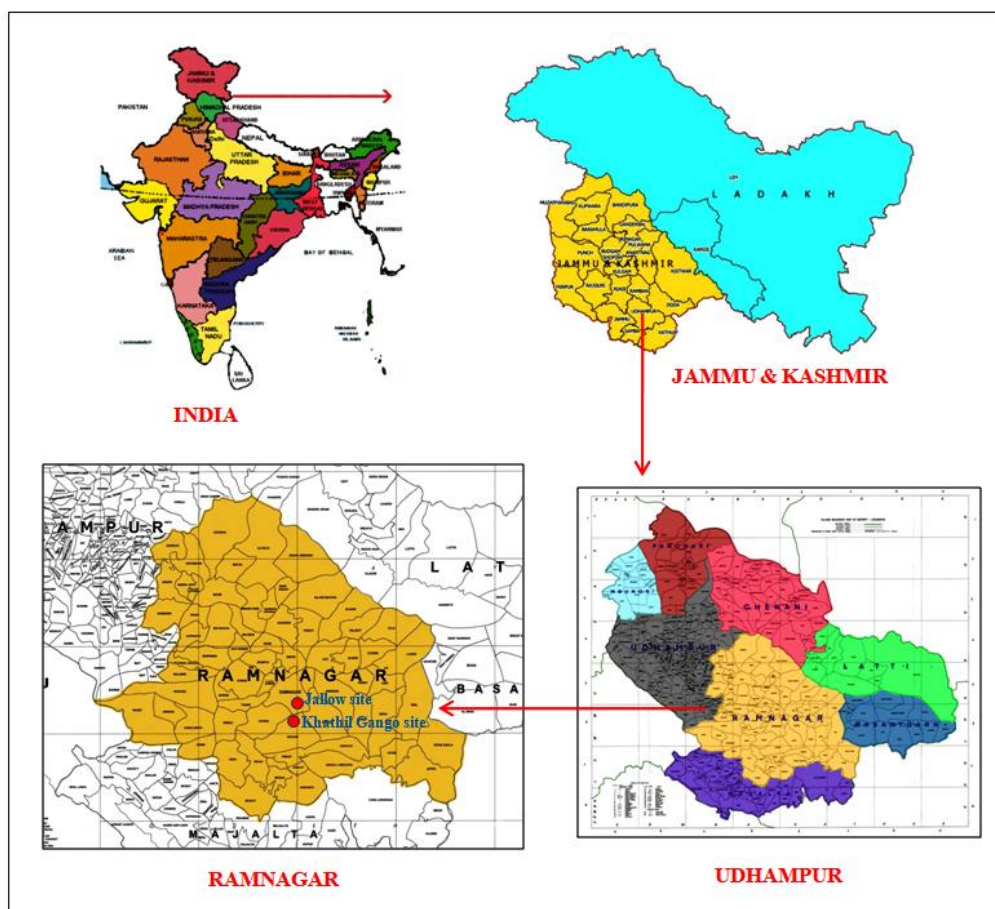


Fig. 1: Location map of study area (not upto scale)

Data Collection

Population assessment

A systematic field survey was conducted within a 2×2 km (4 km^2) assessment area which defines the species' total Area of Occupancy (AOO) centred on the known occurrence site of *P. superba* at Jallow and Khathil Gango areas of Udhampur during the months of March to June, 2025. Given the micro-endemic distribution and the highly threatened status of the species, a total census approach (exhaustive count) will be employed rather than statistical sampling. The area was thoroughly surveyed to identify all accessible individuals, and every mature plant encountered was counted to estimate the current population size. Geographic coordinates and elevation were recorded using a handheld GPS for the surveyed population. The identity of *P. superba* was confirmed through consultation of relevant taxonomic literature, regional floras, published studies, and the Plants of the World Online (POWO) database (Polunin & Stainton 1985; Verma et al. 2003; Uniyal et al. 2012; Srivastava et al. 2017). The resulting population estimate was compared with previously reported records to assess changes in population size and the current conservation status of the species. Field

surveys and direct observations were conducted to document existing and potential threats affecting the *P. superba* population and its habitat. Particular attention was given to anthropogenic and environmental pressures, including overgrazing, agricultural expansion, road construction, deforestation, habitat fragmentation, landslides, tourism-related disturbances, mining, and overexploitation.

Results and Discussion

Taxonomic description

Phlomoides superba is an erect perennial herb growing up to a height of 1.5 m. Stems are erect, hairy, and either branched or unbranched, arising from thick, woody, vertically oriented tuberous roots. Basal leaves are oblong to ovate, simple to pinnatipartite or pinnatisect, with crenate, lobed or serrated margins and sparse simple hairs on both surfaces; lamina measures 10–20 × 5–10 cm, with petioles up to 10 cm long, while cauline leaves are sessile and pinnatifid. Verticillasters are 5–17, distantly arranged, each comprising 6–14 bright yellow flowers and surrounded by white-lanate bracts. Bracts are ovate-lanceolate to lanceolate, 6–10 mm long, with spinulose margins. The calyx is broadly ovate-campanulate, 12–15 mm long, subcoriaceous, hairy, and bears teeth terminating in 1–2 mm long spines. The corolla is yellow, 25–30 mm long, bilabiate, with a villous, white-bearded upper lip and a lower lip subequal to or longer than the upper lip; the corolla tube is 0.5–1 cm long, included within the calyx and lacking an annulus. Nutlets are trigonous, approximately 7 × 3.5 mm, and brownish-black. Flowering and fruiting during March–May (Fig. 2 & 3).

Economic importance

Phlomoides superba has considerable ornamental value due to its attractive yellow flower spikes, which persist for nearly a month (Srivastava et al. 2017). The tuberous roots are traditionally used as a galactagogue to enhance milk production and to prevent mastitis and body swellings in livestock, particularly cattle and buffaloes (Koul et al. 1997; Verma et al. 2003; Pant & Pant 2011; Srivastava et al. 2017; Garg & Singh 2024; Bhagat et al. 2025). The tuberous roots are also used in traditional medicine for ailments associated with the liver, stomach, and gout (Srivastava et al. 2017). The root tubers are traditionally consumed by women as a folk remedy for infertility (Bhagat et al. 2025).



Fig. 2 (A-D): Plants of *Phlomoides superba* in its natural habitat

Population status

The present study conducted at Khathil Gango and Jallow locality revealed a total of 412 individuals of *P. superba* with 343 mature individuals and 69 young plants which are about to flower. *P. superba* populations were observed growing along the margins of a small stream, with a few scattered individuals occurring in the adjoining agricultural fields, particularly along the roadside and stream margins. The habitat is characterized by a gently sloping, rocky terrain with sandy loam soil. A comparatively large and contiguous population was recorded at the Khathil Gango site, where the species was predominantly distributed across exposed rocky terrain. Within the agricultural landscape (especially Wheat fields), the individuals are predominantly restricted to uncultivated areas, particularly along the boundaries separating adjacent fields and the margins of cultivated plots. Along the roadside and stream margins, *P. superba* occurs in association with a diverse assemblage of herbaceous and woody species, including *Ageratum conyzoides*, saplings of *Ficus carica*, *Cannabis sativa*, *Vicia* sp., saplings of *Mallotus philippensis*, *Lathyrus sativa*, *Euphorbia helioscopia*, *Justicia adhatoda*, *Torilis leptophylla*, and saplings of *Phoenix dactylifera*. These associated species represent a mixture of herbaceous vegetation and young woody plants characteristic of disturbed roadside and riparian habitats.



Fig. 3: *Phlomoides superba* in its natural habitat with geographic coordinates

The spatial distribution of *Phlomoides superba* at Khathil Gango and Jallow, Udhampur, revealed a distinctly localized and clustered population pattern within a heterogeneous landscape. Recorded individuals were concentrated primarily in semi-natural and relatively less disturbed patches interspersed among agricultural terraces, while additional occurrences were recorded toward the northern portion of the study area along the Ramnagar road. The distribution pattern indicates a restricted and fragmented occurrence of the species within the surveyed landscape, with agricultural expansion, settlement, and road infrastructure representing potential sources of habitat disturbance (Fig. 4)

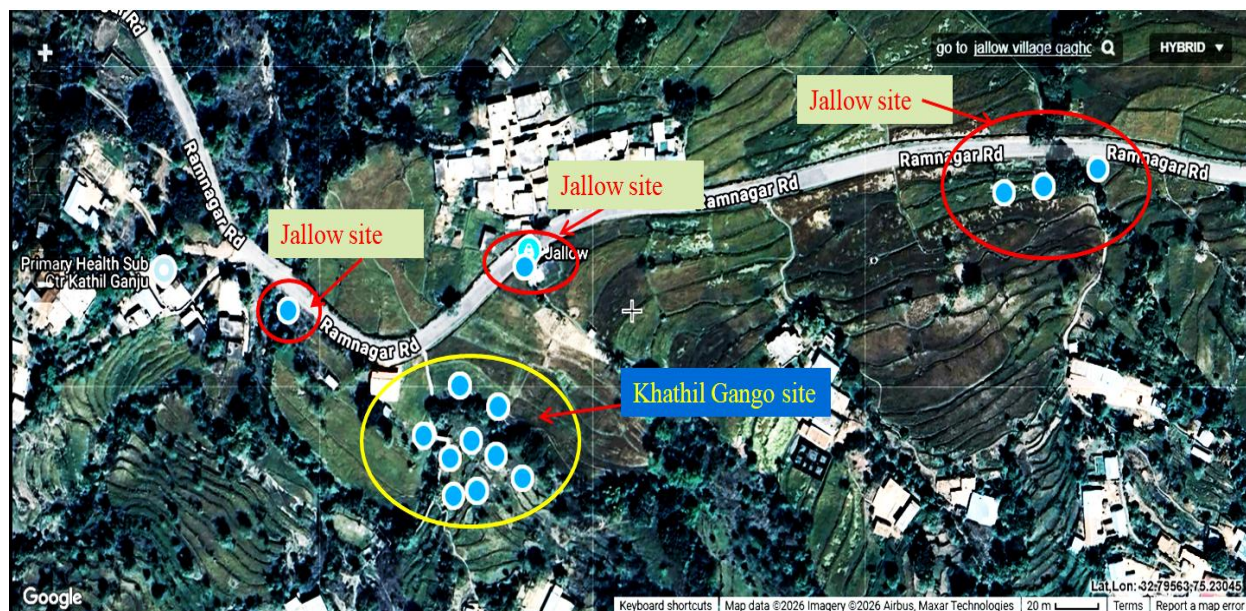


Fig. 4: Satellite image of study site showing spatial distribution of *Phlomoides superba*.

Srivastava et al. (2017) previously reported approximately 500 individuals of *Phlomoides superba* from Jallow village, comprising about 200 mature plants and more than 300 saplings. The population was distributed along stream margins and in adjoining wheat fields, covering an area of approximately 450 m². However, it remains unclear whether the locality surveyed by the authors falls within the present-day administrative or geographical limits of Khathil Gango village. In the present study, a total of approximately 412 individuals were recorded from the two localities, Jallow and Khathil Gango. Relatively small and scattered populations were observed in agricultural fields, along roadsides, and on stream margins, where the species may be increasingly affected by anthropogenic disturbances and habitat modification. In contrast, a comparatively large and contiguous population was recorded at the Khathil Gango site, occupying relatively undisturbed natural habitat away from roadsides and cultivated fields. This population appears to represent a more intact habitat for *P. superba* and may therefore be of particular significance for the conservation of the species. In addition to Jallow village, Srivastava et al. (2017) documented *P. superba* from six other localities in Jammu and Kashmir (Domel, Tara, Bal Shama, Suketor, Panj Grain, and Pouni), two localities in Himachal Pradesh (Gujreda and Kundian), and one locality in Uttarakhand (Mohand) while assessing the distribution and conservation status of the species (Table 1). More recently, Bhagat et al. (2025) reported four additional localities for *P. superba* in Jammu and Kashmir, namely Nand, Badla Denonion, Gahani Alna, and Seral Chowah (Table 1). These records contribute to the expanding knowledge of the species' distribution in the northwestern Himalayan region.

Table 1: Distribution of reported localities of *Phlomoides superba* in India, population size, and percentage decline

S.No	State	Locality	Habitat	Altitude amsl	Earlier population records (approx.)	Present population (approx.) in 2025	%age decrease in years till 2016 (approx.)	%age decrease in years till 2025 (approx.)
1	J&K	Jallow	On the edges of crop fields, sides of stream, undisturbed slightly rocky terrain	650 m	500 (Srivastava et al. 2017)	412 (current study) including nearby Khathil Gango site also	NA	18% in 9 years
2		Tara	On the edges of crop fields	450 m	122 (Verma et al. 2007) ; 70 (Srivastava et al. 2017)	Not Known	43% in 9 years	Not Known
3		Bal Shama	Adjacent to road side on the edges of crop fields	550 m	1022 (Verma et al. 2007) ; 450 (Srivastava et al. 2017)	Not Known	56% in 9 years	Not Known
4		Suketor	On the edges of crop fields	400 m	108 (Verma et al. 2007) ; 45 (Srivastava et al. 2017)	Not Known	58% in 9 years	Not Known
5		Panj Grain	Forest edges adjacent to crop fields	480 m	15 (Srivastava et al. 2017)	Not Known	NA	Not Known
6		Pouni	On the edges of crop fields	615 m	25 (Srivastava et al. 2017)	Not Known	NA	Not Known
7		Domel	On the edges of crop fields	580 m	400 (Koul et al. 1997) : 50 (Srivastava et al. 2017)	Not Known	87% in 20 years	Not Known
8		Nand	bunds of agricultural fields,	405-502 m	112 (Bhagat et al. 2025)	Not Known	NA	Not Known
9		Badla Denonio	bunds of agricultural	405-502	24 (Bhagat et al. 2025)	Not Known	NA	Not Known

		n	l fields	m				
10		Gahani Alna	bunds of agricultural fields	405-502 m	71 (Bhagat et al. 2025)	Not Known	NA	Not Known
11		Seral Chowa	Forest edges	405-502 m	123 (Bhagat et al. 2025)	Not Known	NA	Not Known
12	HP	Khundian	On the edges of crop fields	730 m	500 (Uniyal et al. 2012); 350 (Srivastava et al. 2017)	Not Known	30% in 4 years	Not Known
13		Gujreda,	Forest edges	570 m	22 (Uniyal et al. 2012) ; 14 (Srivastava et al. 2017)	Not Known	36% in 4years	Not Known
14	Uttarakhand	Mohand	Forest edges adjacent to roads	550 m	18 (Verma et al. 2007) : 3 (Srivastava et al. 2017)	Not Known	83% in 9 years	Not Known

Conservation status

The conservation status of *Phlomoides superba* has been assessed differently across previous studies, reflecting the species' restricted distribution and continuing population decline. Several authors have classified it as Vulnerable (Jain & Sastry 1980; Ved et al. 2003; Samant et al. 2007; Pant & Pant 2011), whereas other assessments have placed it in the Endangered category (Jain & Sastry 1984; Garg & Rao 1997; Verma et al. 2007; Panwar & Srivastava 2015; Panwar et al. 2015; Pundir 2015). Even more severe assessments have designated the species as Critically Endangered (Verma et al. 2007; Panwar 2014; Panwar et al. 2014; Bhagat et al. 2025), while earlier accounts described it as being on the verge of extinction (Som 1968; Rao & Garg 1994).

In recognition of its conservation concern, *P. superba* has been notified in the Gazette of India as a species threatened with extinction in the Union Territory of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand under Section 38 of the Biological Diversity Act, 2002 (Gowthami et al. 2021). The available literature further indicates that several members of the genus *Phlomoides* are experiencing severe population declines, with some species already considered extinct or facing a very high risk of extinction (Khan et al. 2022). Collectively, these findings highlight the urgent need for systematic population assessments, habitat monitoring, and targeted conservation measures for *P. superba* and other threatened taxa within the genus.

Threat factors responsible for population of *Phlomoides superba*

The majority of known populations of *P. superba* occur in close proximity to cultivated fields, roadsides, and other human-dominated landscapes, making the species particularly vulnerable to anthropogenic disturbances. Habitat loss and fragmentation resulting from the expansion of agricultural land, conversion of natural habitats, and road widening have substantially increased the pressure on its remaining populations. Additional anthropogenic threats include the extension of cultivation into natural habitats, livestock grazing, and the unsustainable harvesting of underground

tubers for medicinal and veterinary purposes (Srivastava et al., 2017; Bhagat et al. 2025). In particular, local communities and tribal groups reportedly excavate the root tubers of *P. superba*, which are subsequently mixed with livestock feed and administered for veterinary purposes, including the treatment of mastitis and as a galactagogue to enhance milk production (Bhagat et al. 2025).

Apart from direct anthropogenic pressures, several biological factors may further contribute to population decline. These include low reproductive and regeneration potential, poor fruit and seed set, and limitations in pollinator availability (Verma et al. 2003; Garg & Rao 1997; Uniyal et al. 2012; Srivastava et al. 2017; Bhagat et al. 2025). Insect infestation and herbivory or consumption of tubers by wild animals, particularly porcupines, wild boars, and rodents, may also adversely affect population establishment and persistence (Srivastava et al. 2017). The combined effects of habitat disturbance, unsustainable harvesting, grazing, reproductive constraints, and herbivory are likely to exert considerable pressure on the long-term survival of *P. superba*, particularly in populations occurring in highly disturbed habitats.

In the present study, a noticeable decline and fragmentation of *P. superba* populations were observed in habitats associated with field bunds and agricultural margins, roadsides, and stream banks. This decline may be attributed primarily to habitat degradation and destruction resulting from the expansion of cultivation, construction of residential structures, and road widening. In contrast, the relatively undisturbed habitat at the Khathil Gango site supported a comparatively large and healthy population, with numerous individuals exhibiting vigorous growth.

Interestingly, information obtained from local inhabitants during the field survey indicated that the root tubers of *P. superba* are currently not harvested for veterinary purposes, including the treatment of mastitis or as a galactagogue in livestock. Although local communities possess knowledge of the species and are familiar with its traditional veterinary and other uses, they reportedly refrain from extracting its tubers because of their awareness of its threatened conservation status. According to local informants, this awareness has been reinforced by earlier researchers who documented *P. superba* populations in the region and communicated the importance of its conservation to the local community. The apparent absence of tuber harvesting may, therefore, be an important factor contributing to the persistence of the relatively large population at Khathil Gango, where *P. superba* occurs luxuriantly in comparatively undisturbed habitat. This observation highlights the potential role of local ecological knowledge and community awareness in supporting the in-situ conservation of threatened plant species.

Conclusion

The present study indicates that natural populations of *Phlomis superba* are declining across several reported localities in India, primarily as a consequence of habitat loss, anthropogenic disturbance, and restricted regeneration. The species therefore requires strengthened conservation measures, integrating both in situ and ex situ approaches. Ex situ conservation efforts are already underway, with germplasm maintained at the Botanical Survey of India, Dehradun, and botanical gardens of institutions such as the University of Jammu. Propagated plants are also being distributed to institutions and individuals to support its wider conservation and cultivation (Srivastava et al. 2017).

The present observations further highlight the important role of local communities in the conservation of *P. superba*. Local inhabitants possess considerable knowledge of its traditional uses and are aware of its declining populations and conservation significance. Continued awareness and community participation should therefore form an integral component of future conservation programmes.

Further systematic surveys are required to locate previously unrecorded populations, reassess known localities, monitor population trends, and evaluate the current conservation status of the species. In parallel, phytochemical and pharmacological investigations are warranted to characterize the bioactive compounds underlying its ethnomedicinal properties and assess their potential for therapeutic applications. A coordinated approach combining population monitoring, habitat protection, ex situ propagation, scientific research, and community-based conservation will be essential for the long-term persistence of *P. superba* in its natural habitats.

Declarations

Competing interests: The authors have no competing interests to disclose.

Authors' contributions: **KK** (Kewal Kumar) devised the study, framed its draft, collected the data, and wrote the manuscript. **SK** (Sanjeet Kour) helped to design, draft and edit and critical revision of the manuscript. **YP** (Yash Paul) participated in field visits, compiling and interpretation of data. **FA** (Fraz Ahmed) and **BPS** (Bhekam Pal Singh) helped in finalizing the draft and critical revision of the manuscript before approval for final submission.

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