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A novel species of *Pedicularis* L. from alpine Himalaya, India

Mudasir Nazir BHAT[1,3], Bikarma SINGH[2,3,*], Misbah TABASSUM[1,3], Sonali KUMARI[1]

1. *CSIR Indian Institute of Integrative Medicine, Jammu 180001, Jammu and Kashmir, India.* ***2.*** *Botanical Garden, Plant Conservation and Agrotechnologies, CSIR National Botanical Research Institute, Lucknow 226001, Uttar Pradesh, India.* ***3.*** *Academy of Scientific & Innovative Research (AcSIR), Ghaziabad 201002, Uttar Pradesh, India.* [*]*Corresponding author's emails:drbikarma.singh@nbri.res.in, bikarma81@yahoo.co.in*

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ABSTRACT: The newly described *Pedicularis lolabiensis*, belonging to Ser. Semitortae Prain, recorded from Machil in the Lolab valley of Kashmir Himalaya, India. The distinguishing features that separate *P. lalabiensis* include annual habit, villous morphology, three whorl leaves, 18–30 flowered inflorescence, equal and unbeaked calyx, papillose coiled corolla, pinkish–white stamens, hook-shaped stigma, and monocolpate pollen grains. This novel species resembles to *P. oliveriana* Prain with terminal raceme inflorescence, and bracts elliptic, broad at the base, larger than the calyx, calyx with 5 unequal toothed, long staminal filaments pilose at insertion and distally villous. This species thrives in specific alpine Himalayan environments. Comprehensive population mapping and threat evaluation based on IUCN Red List Categories Criteria Version 2023.1 classified as Endangered.

KEY WORDS: Conservation, Himalayan endemic, IUCN status, novelty, *Pedicularis lolabiensis*, *Pedicularis oliveriana*.

INTRODUCTION

The genus *Pedicularis* L., with around 679 species globally (POWO, 2025), is the largest in family Orobanchaceae, with 352 species native to eastern Asia (Garg and Shukla, 2023). The highest representation of this genus is found in the subalpine and alpine regions of China, India, Bhutan and Myanmar (Bentham, 1846; Hooker, 1884; Husain and Garg, 2003; Garg and Shukla 2023; Zhang *et al*., 2024). China has 77% endemism within *Pedicularis* (Wolfe, 2005). In India, the *Pedicularis* comprises 84 species, 13 subspecies and 9 varieties, out of which 17 species, 4 subspecies, and 5 varieties are endemic to the Himalaya (Husain *et al*., 2010; Borah *et al*., 2020; Borah *et al*., 2020; Garg and Shukla, 2023). From Jammu and Kashmir (J&K), 9 species have been recorded from different pockets of Himalaya (Bhellum *et al*., 2016; Awasthi 1997). Most species are either annual or perennial herbs (Garg and Singh, 2015), characterised by corollas with basal tube and distal lips. Upper lip is compressed to form a galea containing the anthers and style, and the lower lip forms a wide, trifid labium (Singh *et al*., 2016; Tsoong, 1955). Being microhabitat-specific, the flowers of *Pedicularis* exhibit remarkable diversity and each species possesses a well-defined host-plant association (Garg and Husain, 2009; Garg, 2010).

The Indian Himalaya occupies a distinctive position, harboring over 11,157 species across 2,359 genera and 241 families (Singh *et al*., 2019). This region accounts for approximately 50% of India's total flora (Stainton 1988; Bhat *et al*., 2021). The state of Jammu and Kashmir, with elevations ranging from 250 to 8,000 meters above sea level (Awasthi, 1997), exhibits a remarkable range of vegetation, encompassing ecosystems from tropical to alpine zones. Dhar and Kachroo (1983) documented 5,056 taxa across 1,306 genera and 180 families (Singh *et al*., 1999; Dar *et al*., 2020). This mountainous region extends across three biogeographic provinces: upper Gangetic plain (7A), west Himalaya (2B), and cold arid regions (1C) (Singh *et al*., 2023). In the higher altitudes of the Indian Himalaya (> 2500 m. a.m.s.l.) are primarily treeless, dominated by flora such as *Betula* L., *Juniperus* L., *Ribes* L., *Bergenia* Moench., *Gentiana* Tourn. ex L., *Potentilla* L., *Primula* L., *Rheum* L., *Rhodiola* L., *Saussurea* DC., *Saxifraga* Tourn. ex L. and *Sedum* L., enriching region's botanical diversity (Sharma and Kachroo, 1981; Sharma and Jamwal, 1988; Bhellum and Singh, 2016; Singh *et al*., 2018; Thakur *et al*., 2020; Singh, 2021). Lolab Valley, nestled within the Kashmir Hills, has a historical legacy of minimal human settlements, safeguarding its forests from disturbances, particularly the heavy snowfall that distinguishes it from other parts of the state (Wali and Tiku, 1964; Haq *et al*., 2021). Much floristic work has been done, as evidenced by the floristic studies detailing plant uses (Stewart, 1916-1917; Rao, 1960; Javeid, 1966).

During 2018–2022, twelve field exploration tours were carried out in the temperate, subalpine and alpine regions of Kashmir Himalaya to investigate the floristic diversity of Pir Panjal Mountain with special reference to a comprehensive study of the family Orobanchaceae. While surveying the Lolab valley (34°41'46.07" N, 74°32'8.12" E, elev. 2300–3450 m a.m.s.l.), District Kupwara, two unusual populations of *Pedicularis* were recorded from Machil and its surrounding habitat with notable distinguishing and interesting characters. The scattered small population of this unidentified species was found to be growing in the open grassland of alpine vegetation (Machil Proper: 34°38'41"N, 74°25'47"E, elev.

Table 1. Comparison of delimiting characters between ***Pedicularis lolabiensis*** sp. nov. and ***P. oliveriana***.

Characters	***P. lolabiensis*** sp. nov.	***P. oliveriana***
Habit	annual plants, 15–30 cm tall	perennial plants, 15–20 cm tall
Stems	herbaceous, profusely branched, densely pubescent	herbaceous, less branched, sparsely pubescent
Leaves	whorls of 3, ovate to oblong, 2.5–7.5 × 1.3–2.5 cm	whorls of 3 or 4, oblong to lanceolate, 4.5 × 1.5 cm
Petioles	0.8–1.6 cm long, slightly hairy at base	short, densely hairy
Inflorescences	terminal, usually 18–30 flowered, peduncle hairy, 1.1–1.7 cm across	terminal spikes or racemes, 22-25 flowered, peduncle hairy
Bracts	oval, entire; lowermost bracts pinnatisect, foliaceous	narrow, serrate; lowermost bracts pinnatifid, leaf-like
Calyx	5–lobed, tubular, not beaked, ovate, 0.7–1.2 cm, equal, multicellular hairs along nerves, margin recurved	5–lobed, barely clefted, posterior lobes triangular, lateral lobes serrate, margins entire
Corolla	pinkish–white, tube 0.5–1.3 cm long, papillose surface, coiled horizontally, not a right angle	dark reddish purple, tube 0.6-0.7 cm long, not coiled, prominent two-lipped structure
Galea	stipitate, coiled horizontally, incurved, 0.4–0.5 cm long beak	ciliate, slender, S-shaped beak
Labium	deeply 3–lobed, 1.2–2.2 cm, papery, middle–lobe not prominent, recurved, not ciliate, entire	prominent 3–lobed, 0.85–0.95 cm, ciliate
Stamens	inserted near the base of corolla tube, filaments slightly pubescent, anthers pinkish–white, dorsifixed	inserted near the base, filaments densely pubescent and robust
Ovary	lanceolate, styles bent at upper middle part, inserted, stigmas hook–shaped, densely pubescent	lanceolate, styles straight at upper middle part, not inserted stigmas less hooked, glabrescent
Capsules	ovate to obovate, 0.5–1.2 × 0.4–0.6 cm, tapering inwards	compressed, oblong, 0.1 × 0.3 cm, apiculate
Pollen grains	monocolpate, fusiform	tricolpate

2,591 m a.m.s.l.; Machil Top: (34°39'47"N, 74°25'19"E, elev. 3,152 m a.m.s.l.). At first glance, the collected plant materials resemble the well-known *Pedicularis oliveriana* Prain of Ser. Semitortae Prai, but close examinations resulted in differentiations of plant growth, leaf characters, and unique flower morphology. After the critical examinations by herbarium consultation with housed protologue specimens of KASH, RRLH, BSD, ASSAM, CAL, LWG, DD, K, NY and PE (acronyms according to Thiers, 2019), comprehensive literature consultation on the genus *Pedicularis* (Bentham, 1846; Clarke, 1883; Hooker, 1884; Prain, 1890; Pennell, 1943; Li, 1948; Hurusawa, 1949; Yamazaki, 1988; Yang *et al*., 1998; Mill, 2001; Garg, 2009; Hussain *et al*., 2010; Mill, 2011) and subject expert advice on the morphological characters concluded that the species is novel. Therefore, it is described here as a novelty with detailed taxonomic characters, photographed and hand-made illustrations. A holotype herbarium specimen of the novel species is deposited CSIR-Indian Institute of Integrative Medicine (acronym RRLH).

TAXONOMIC TREATMENT

Pedicularis lolabiensis M.N. Bhat, B. Singh, M. Tabassum & S. Kumari, ***sp. nov.*** **Figs. 1–2**

Type**:** INDIA, Himalayan Region, Jammu and Kashmir (J&K), Kupwara district, Lolab valley, Machil, 34.6791465° N, 74.4059672 E, 2361 m a.m.s.l., 02 August 2022, *MN Bhat and Bikarma Singh* 52032 (holotype: RRLH).

Diagnosis**:** A species closely related to *P. oliveriana* Prain exhibits morphological similarities but can be distinguished by the following characteristics (**Table 1**): it is an annual species with a densely pubescent habit, 18-30 flowers, and has a tubular, non-beaked calyx. The corolla is coiled and measures 1.1–1.7 cm, the galea is coiled with an elongated beak. The filaments are sparsely pubescent, styles exhibit a curvature at the upper middle portion, and the stigmas are both inserted and pubescent. The capsules are ovate to obovate, measuring 0.5–1.2 × 0.4–0.6 cm, with a tapering apex. The pollen grains are monocolpate.

Description**:** Annual herbs, hemiparasitic, caespitose, 15–30 cm tall; tap roots stout, bifurcated 6–10 cm long, haustorial interconnection with host plant roots. Stems herbaceous, profusely branched, 3–4 branchlets, 10–15 × 0.5–1 cm, reddish green at maturity, pubescent when very young, glabrous at maturity; internodes 9–12 cm long, glabrous; branches decumbent, arise from axils of leaves, innermost ones erect, 3.2–4.5 cm long, outer ones decumbent or inclined, 5.5–7.5 cm long; young stem greenish, herbaceous, pubescent; older stems woody, slightly reddish brown, glabrous, turn brown after drying. Basal leaves opposite, petiolate. Stem leaves in whorls of 3, petiolate. Petioles 0.8–1.6 cm long, slightly hairy at base; lamina ovate to oblong, 2.5–7.5 × 1.3–2.5 cm, pinnatisect; midrib deconvoluted, slightly abaxially raised, adaxial surface glabrous, abaxial surface with minute white hairs, hairy in between pinnae; pinnae 10–13 pairs, linear, 1.2–2.2 cm long, sub–opposite, with base as broad as pinna, 6 or 7 times incised–dentate margins; margins obtuse with slight dentation at apex. Inflorescences terminal, 18–30 flowered, capitate fascicles; peduncles hairy, 8–12 cm long; bracts attached at base, stalked, 0.4–1.2 × 0.6–1.2 cm, upper and middle bracts oval, entire; lowermost bracts pinnatisect, foliaceous, base oblique, apex obtuse, glabrous, midrib

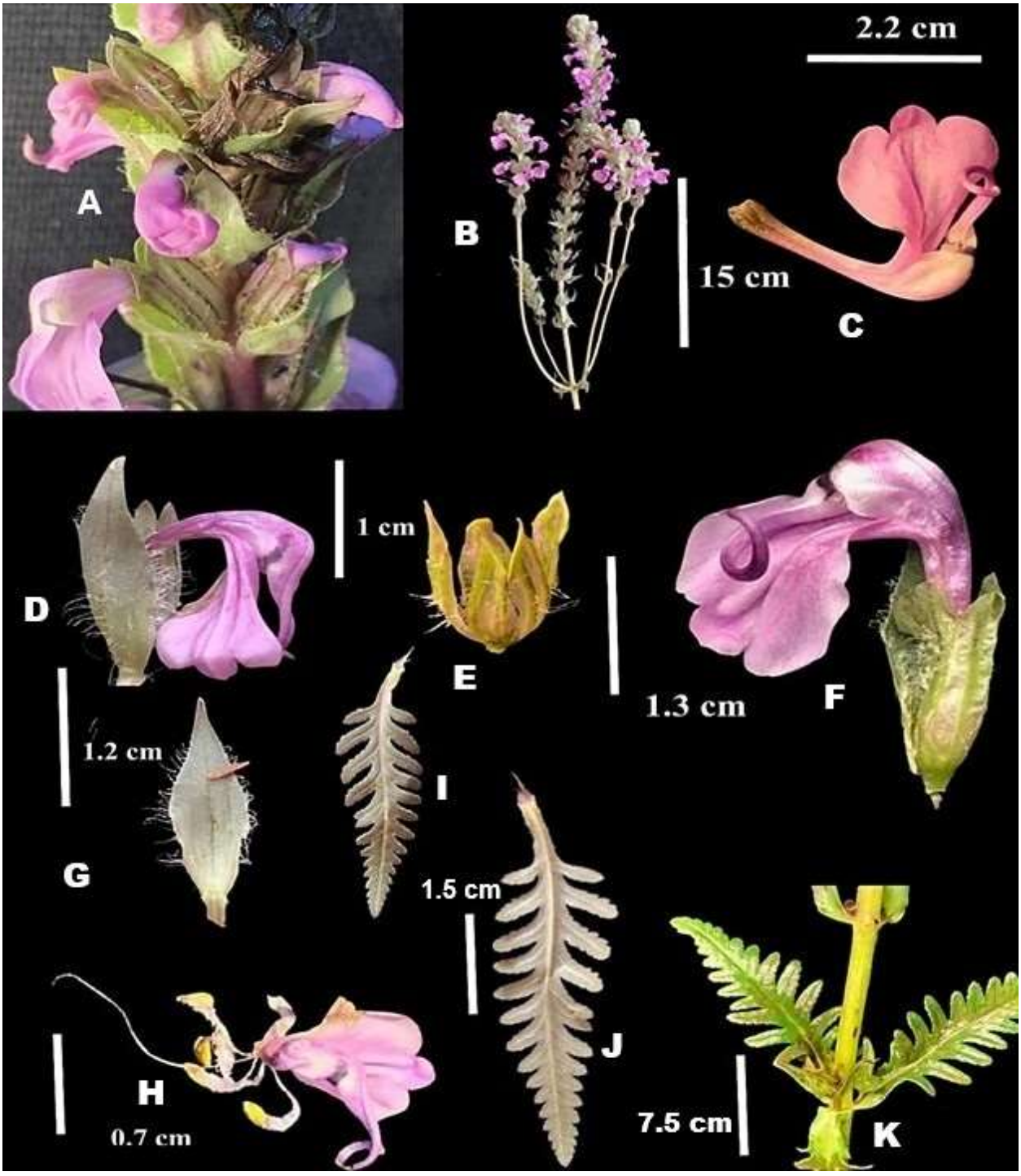

Fig. 1. ***Pedicularis lolabiensis*** sp. nov.: **A-B**. Inflorescence, **C**. Close view of petal, **D.** Side view of flower with hair, **E.** Close view of sepal, **F.** Complete view of flower, **G.** Bract, **H.** Insertion and attachment of stigma and stamen, **I.** Adaxial view of leaf, **J.** Abaxial view of leaf, **K.** Leaf arrangement..

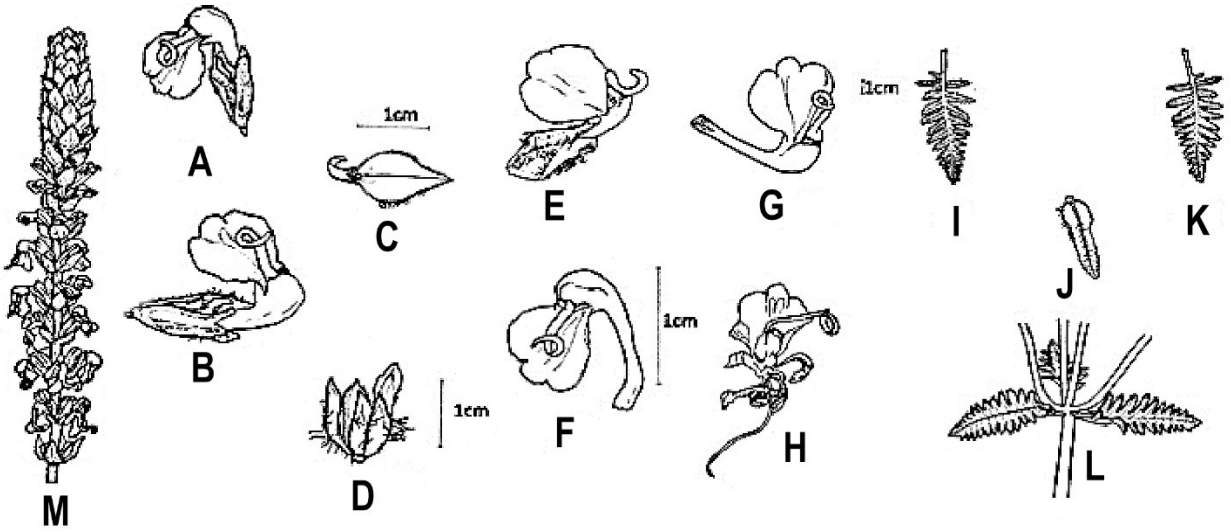

Fig. 2. Illustration of ***Pedicularis lolabiensis*** sp. nov. **A-B.** complete flower, **C.** bracts, **D.** calyx, **E.** dorsal part of flower, **F.** ventral part of flower, **G.** corolla, **H.** calyx, **I-L.** lamina and leaflets arrangement, **M.** Inflorescence

plicate. Flower pedicillate, erect, 1.1–1.7 cm long including pedicel, slightly incurved from sepal; pedicels minute, 1.5–2 mm long, glabrous. Sepals shallowly 5–lobed, not beaked, ovate, 0.7–1.2 cm long including lobes in tubes, 0.5–0.7 × 0.15–0.22 cm, oblique, slightly raised anteriorly, nerved, white hairy with multicellular hairs along nerves, 9–10 number, broad at base, inflated in middle, light purple green; lobes unequal, minute, 2–3 mm long, margin recurved, base acute, apex obtuse, with tufted hairs; anterior lobes dentate, pointed; lateral lobes ovate, entire obtuse; posterior lobes slightly bigger than anterior and lateral lobes, triangular obtuse. Petals pinkish-white; tubes cylindrical, 0.5–1.3 cm long, slightly light pink in upper half, dark pink below, with papillose surface. Galea pink, stipitate, acuate, 0.4–0.5 cm long, coiled horizontally not at right angle, inflated at anther bearing region; beak shorter than anther containing parts, incurved, obtuse, open dark pink, papillose; papillae stipitate, densely set, head glabrous, elliptic, acutely inclined; labium deeply 3–lobed, elliptic–ovate, 1.2–2.2 × 0.6–0.9 cm, thin, papery, glabrous, reticulately recurved, margins entire, base acute, apex obtuse; lateral lobes overlapping, broadly elliptic, three times larger than mid–lobes; lateral lobes overlapping, broadly elliptic, three times lesser than mid–lobe; mid–lobes obovate, 0.6–0.7 × 0.22–0.32 cm, upper parts in used, margins semi–circular, open obtuse, upper lobes purple, tinged at the base, projected above lower lobes, white ring at tip. Stamens inverted at base of corolla tube, 0.6–1.0 cm long; filaments densely pubescent, white flat. Anthers pinkish white, *ca* 0.1 × *ca* 0.2 cm long, dorsifixed, ovoid, base acute; pollen grain monocolpate, fusiform. Ovary lanceolate, 0.63–0.75 × 0.4–0.5 cm, open apiculate; styles bent at upper middle part, inserted, 0.15–0.22 mm long, pubescent at base, glabrous at open; stigmas minute, hook–shaped, bilobed, densely pubescent. Capsules ovate to obovate, 0.8–1.2 × 0.4–0.6 cm, papillose, apiculate at open, with persistent calyx in young.

***Etymology*:** The species epithet is named after its type locality, the picturesque 'Lolab Valley' in the Kupwara district of Jammu and Kashmir state, within the Himalayas, India. Encircled by snow-capped peaks, the valley is an integral part of the broader Himalayan region and is beloved locally for its serene natural beauty and tranquility.

***Phenology*:** Flowering begins in early August, and lasts till the first week of October, with fruiting initiating in mid–September.

***Habitat, ecology and associated plants*:** *P. lolabiensis* thrives in semi-shaded slopes within the open sub-alpine and alpine snow-clad pastures, flourishing at elevations ranging from 2300 to 3450 meters above mean sea level. Preferring a cold climate and coarse soils, the plant deeply penetrates its roots into the ground. The surrounding vegetation predominantly comprises of dominant herbs such as *Swertia kashmirensis* B.A. Bani, T. Islam & Khuroo, *Campanula cashmeriana* Royle, and *Podophyllum hexandrum* Royle and tree species *Cedrus deodara* (Roxb. ex D.Don) G.Don, *Abies pindrow* (Royle ex D.Don) Royle, *Pinus wallichiana* A.B. Jacks., *Acer caesium* Wall ex Brandis and *Betula utilis* D.Don. This newly discovered species exhibits hemi-parasitic traits, with host plants like *Sorbus foliolosa* (Wall.) Spach., *Matricaria chamomilla* L., *Gentiana robusta* King ex Hook.f., *Geum elatum* Wall. ex G.Don, and *Bistorta affinis* (D.Don) Greene in the study area.

***Distribution*:** *P. lolabiensis* exclusively inhabits the type locality within the Lolab Valley, situated at elevations ranging from 2500 to 3,450 m above mean sea level, within the sub-alpine and alpine pastures of the Kashmir

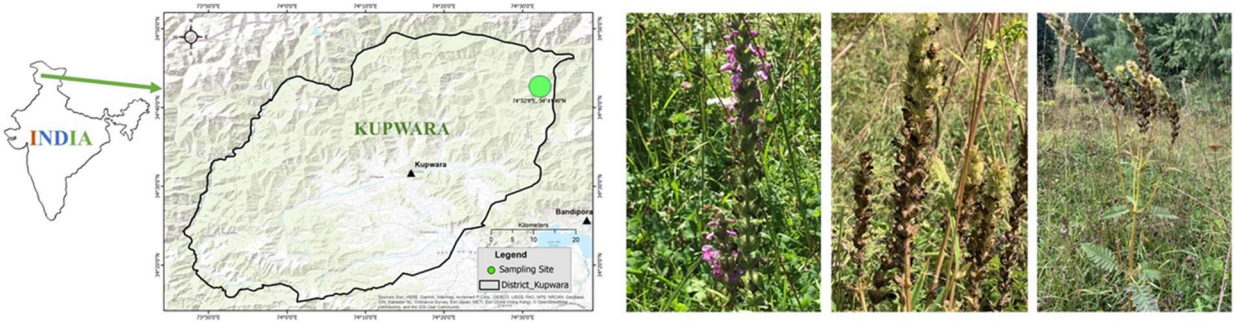

Fig. 3. Distribution map of ***Pedicularis lolabiensis*** Lolab valley of Kashmir Himalaya

Table 2. Population data of ***Pedicularis lolabiensis*** in the Lolab valley of Kashmir Himalaya, India and the hierarchical alpha-numeric numbering system of the criteria and sub-criteria (IUCN, 2024).

	Number Of Individuals								
Location	Machil Proper				Machil top (13 km from Machil)				Range
Year	2018	2019	2020	2021	2018	2019	2020	2021	
Mature	23	31	32	20	61	76	89	63	32–89
Seedling	8	11	9	5	12	13	15	2	2–15
Extent Of Occurence (Eoo) (Sq. Km)	13.5				Eoo Rating				EN
Area Of Occupancy (Aoo) (Sq. Km)	7.5				Aoo Rating				EN
IUCN Criteria (Ver.2023.1)	B1b(i,ii,iii,v)c(i,ii,iii,iv);C2a(i);D				IUCN Threat Rating				EN

Himalaya, India. It appears to be endemic to the Himalayan region, marking its distinct presence in this specific geographic area.

***Conservation status*:** *P. lolabiensis* documented solely first time from its type locality, Machil (Lolab valley, Kashmir Himalaya) and its surroundings during a comprehensive study of plant communities of Himalaya. While conducting extensive surveys in the Lolab valley and adjacent regions of Kashmir, within the Pir Panjal Mountain range, revealed the presence of 20–89 mature individuals and 2–15 young seedlings of *P. lolabiensis* over a four-year period during 2018–2021 **(Table 2)**. The species exhibits a distribution range of 2300 to 3,450 m (based on GPS points recorded during the survey). The Lolab valley, renowned for its snow-covered mountains, draws numerous tourists from June to August. Unfortunately, this influx of visitors disrupts the habitat, posing a threat to the newly discovered species, *P. lolabiensis*. Habitat fragmentation due to road construction, and developmental activities in and around the valley further contribute to the species' vulnerability. The cumulative impact of these factors, compounded by climate change, has led to a critically the low population size of this particular species in the Kashmir Himalaya. Guided by the IUCN Red List Categories Criteria version 2023.1 (IUCN 2024), the evaluation of *P. lolabiensis*'s conservation status was taken into account for study on the criteria B (geographic range), C (small population size), and D (restricted population). The extent of occurrence (EOO) for the species was measured at only 13.5 km^2, with an area of occupancy (AOO) less than 7.5 km^2. Notably, the recorded matured individuals were below 250 (20–89 individuals). Consequently, *P. lolabiensis* has been classified as endangered, under categories B1b(i,ii,iii,v)c(i,ii,iii,iv);C2a(i);D (**Table 2)**.

DISCUSSION

The Indian Himalaya is a mega-diversity center for hemiparasitic genus such as *Pedicularis* L., *Sapria* Griff., and *Rafflesia* R.Br. ex Gray. The novel species *Pedicularis lolabiensis*, Ser. Semitortae Prain, is distinguished from *P. oliveriana* through various morphological characteristics. Although, most of the species of this section of *Pedicularis* are annual, except *P. oliveriana* and *P. fotisowii* Regel. *Pedicularis lolabiensis* being an annual herbaceous plant, contrasts with the perennial nature of *P. oliveriana*, distinguishing them in terms of life cycle and ecological traits. Despite both the species reaching a height of 15–30 cm, *P. lolabiensis* displays a more extensively branched and densely pubescent stem in comparison to the less branched and sparsely pubescent stem of *P. oliveriana*. This discrepancy in stem morphology mirrors their different growth habits, with *P. lolabiensis* with more condensed and bushy morphology. The leaf structure also presents variations between these two taxa. The leaves of *P. lolabiensis* are characterized by its trifoliate arrangement, with a shape ranging from ovate to oblong, and dimensions of 2.5–7.5 × 1.3–2.5 cm. In contrast, *P. oliveriana* displays larger leaves, oblong to lanceolate in shape, and sometimes found in whorls of three or four. Moreover, the petioles of *P. lolabiensis* are long (0.8–1.6 cm) and exhibit a slight pubescence at the base, in

contrast to the shorter and densely pubescent petioles of *P. oliveriana*.

Another distinguishing feature lies in the structure of the inflorescence. *P. lolabiensis* commonly forms terminal inflorescences containing 18–30 flowers, with a hairy peduncle measuring 1.1–1.7 cm in diameter. In contrast the *P. oliveriana* develops denser spikes or racemes, typically bearing 22–25 flowers, and a peduncle measuring less than 1 cm in diameter. The calyx in *P. lolabiensis* is tubular, 5-lobed, and not beaked, with equal lobes and recurved margins, while *P. oliveriana* has a less clefted calyx with posterior lobes that are triangular and lateral lobes that are serrate.

The corolla in *P. lolabiensis* is pinkish-white with a horizontally coiled tube, adding a novel twist to the floral structure, whereas the corolla of *P. oliveriana* is dark reddish-purple, shorter, and lacks the coil, instead featuring a prominent two-lipped structure. The galea in *P. lolabiensis* is horizontally coiled with an incurved beak, as compared to the slender, S-shaped beak of *P. oliveriana*. The labium of *P. lolabiensis* is deeply three-lobed and papery, with a less prominent middle lobe, contrast with the shorter, and more prominent, and ciliate labium of *P. oliveriana*.

Stamens in *P. lolabiensis* are inserted near the base of the corolla tube with slightly pubescent filaments and pinkish-white anthers, while *P. oliveriana* features more robust and densely pubescent filaments. The ovary of *P. lolabiensis* is lanceolate with a bent style and hook-shaped stigma, whereas in *P. oliveriana*, the style is straighter and the stigma less hooked and glabrescent. Capsule shape and pollen type further distinguish the species: *P. lolabiensis* has ovate to obovate capsules tapering inward, with monocolpate, fusiform pollen grains, while *P. oliveriana* has compressed, oblong capsules with tricolpate pollen grains.

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