



Ophiorrhiza himadrica & *Ophiorrhiza bharat* (Rubiaceae), two new species from Arunachal Pradesh, India

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ABSTRACT: Two new species of *Ophiorrhiza* (Rubiaceae), *Ophiorrhiza himadrica* M.Khanal, D.Kumar & S.Sarkar, and *Ophiorrhiza bharat* M.Khanal, D.Kumar & S.Sarkar, are described and illustrated from Arunachal Pradesh, India, situated within the Eastern Himalaya Biodiversity Hotspot. *Ophiorrhiza himadrica* was discovered in a temperate mixed forest near Menchuka and shows morphological affinity with *O. medogensis* H. Li, whereas *O. bharat*, found in a subtropical evergreen forest near Hone village, resembles *O. ochroleuca* Hook.f. to some extent. Despite their superficial similarities with allied taxa, both species can be readily distinguished by a unique combination of vegetative and floral characters. Detailed morphological descriptions, diagnostic comparisons with closely related species, colour photographic plates, notes on phenology and habitat, biogeographical discussion, ecological differentiation, and preliminary conservation assessments are provided to facilitate accurate identification and to support future taxonomic and ecological research in the region.

KEY WORDS: Heterostyly, Himalayan, *Ophiorrhiza himadrica*, *Ophiorrhiza medogensis*, *Ophiorrhiza ochroleuca*, Ophiorrhizeae.

INTRODUCTION

The genus *Ophiorrhiza* L. (Rubiaceae: tribe Ophiorrhizeae, subfamily Rubioideae) comprises 384 accepted species worldwide (POWO, 2025), occurring predominantly in the wet tropical and subtropical forests of Asia, with its range extending to Malesia, Papuasia, Australia, and the South Pacific (Taher *et al.*, 2020). In India, the genus is notably diverse, with 47 species and 9 varieties previously documented across the subcontinent (Deb and Mondal, 1997), many of which are largely confined to the northeastern states and the Western Ghats (Hareesh and Sabu, 2022). Following a series of recent discoveries and taxonomic revisions, the number of species has risen to 64, including several recently described taxa, of which approximately 35 are considered potentially endemic (Deb and Mondal, 1997; Hareesh *et al.*, 2015, 2017; Hareesh and Sabu, 2018; Taher *et al.*, 2020; Chanu *et al.*, 2025). Members of the genus are typically perennial understory herbs, occasionally annuals, ranging from creeping forms to tall, erect shrubs with woody bases, and are characterised by succulent stems, slightly unequal opposite leaves, five-lobed gamopetalous and epigynous flowers, and laterally compressed, berry-like fruits containing numerous tiny rhomboidal seeds (Deb and Mondal, 1997; Taher *et al.*, 2020; Chanu *et al.*, 2025). *Ophiorrhiza* species are renowned for their remarkable morphological diversity,

ecological specialisation, and restricted distributions, making them significant from both taxonomic and conservation perspectives.

During field investigations conducted by the first author (MK) in March–May 2025 in Shi-Yomi district, Arunachal Pradesh, India, two distinct populations of previously undocumented species of *Ophiorrhiza* were encountered—one inhabiting the forest floor of a temperate forest near Menchuka, and the other from a subtropical evergreen forest near Hone village. Critical morphological examination revealed that these specimens do not match any known species of the genus *Ophiorrhiza*. Among them, *O. himadrica* appears morphologically allied to *Ophiorrhiza medogensis* H.Li, while *O. bharat* bears resemblance to *Ophiorrhiza ochroleuca* Hook.f. following a thorough comparison with type, protologue, relevant literature and examination of herbarium specimens, we herein describe both as new to science. Detailed morphological descriptions, high-resolution colour plates, and diagnostic comparisons with allied taxa are provided, along with notes on phenology, habitat, biogeographical discussion, ecological differentiation and preliminary conservation assessment.

MATERIALS AND METHODS

Populations of *Ophiorrhiza himadrica* and *O. bharat* were located during a floristic survey in the Shi-Yomi



district of Arunachal Pradesh, India. Sampling was carried out using the random sampling method. Field photographs were taken in their natural habitat using a Sony Alpha 6400 camera, while detailed dissection photographs were captured with a Samsung Galaxy A34 smartphone utilizing its macro camera features. Voucher specimens representing the observed range of morphological variation were collected, and three individuals from each population were selected for detailed morphological examination and herbarium preparation. Morphological observations and morphometric measurements were made from fresh materials dissected in the field using a steel scale and a digital caliper. Specimens were collected during a single field season from the type locality, and measurements were recorded from available flowering individuals encountered during the survey due to the limited population observed at the site. Geographical coordinates were recorded with a Garmin eTrex 32X GPS unit. Microscopic analyses of pollen morphology and seed surface characteristics were initially planned as part of the study. However, these investigations could not be carried out due to logistical constraints and limited access to specialized microscopy facilities during the study period. Future investigations incorporating detailed palynological and seed surface analyses using advanced microscopic techniques would be employed to provide additional taxonomic resolution and strengthen species characterization. Collected specimens were pressed in the field between newspaper and blotting sheets and dried using a wooden herbarium press. Voucher specimens were prepared following Alexiades (1996) and deposited at CAL (Holotype), ARUN & G. B. Pant National Institute of Himalayan Environment- North East Regional Centre Herbarium (Isotypes). A thorough review of relevant literature (Hooker, 1880; Li, 1980; Lo, 1990; Deb and Mondal, 1997; Bremer, 2000; Chen and Taylor, 2011; Hareesh et al., 2015, 2017; Bhuyan *et al.*, 2021; Hareesh and Sabu, 2022; Chanu *et al.*, 2025) and examination of specimens and digital images from several herbaria [APFH, ARUN, ASSAM, BSHC, CAL, LBG, BM, E, K, P] were undertaken for comparative analysis. Morphological terminology follows Beentje (2010). Conservation assessments were carried out according to the IUCN guidelines (IUCN, 2024).

TAXONOMIC TREATMENT

Ophiorrhiza himadrica M.Khanal, D.Kumar & S.Sarkar, *sp. nov.* **Figs. 1A–B & 2**

Type: INDIA. Arunachal Pradesh: Shi-Yomi district, on the way to Menchuka, 28°34'22.02'', N 94°09'08.69''E, 1968m, 13th April 2025, *Madhusudhan Khanal* 2112 (holotype: CAL; isotype: ARUN, G.B. Pant National Institute of Himalayan Environment - North East Regional Centre Herbarium)

Diagnosis: *Ophiorrhiza himadrica* M.Khanal, D.Kumar & S.Sarkar is readily distinguished from its close ally *O. medogensis* H. Li by its smaller habit (plants up to 30 cm tall vs. up to 60 cm tall), shorter stipules (0.9–1 mm, triangular, sparsely pubescent or glabrous with ciliate margins vs. 3–6 mm, subulate to filiform, lobed, and pubescent), and smaller, fewer-veined leaves (1.7–3.5 × 1–2.5 cm, 5–9-veined vs. 3.5–11.5 × 1.5–3.5 cm, 7–16-veined). The bracts are larger and oblanceolate (5–10 × 1–2 mm vs. 6–10 × 1 mm, lanceolate), and the calyx lobes are shorter and elliptic (1–1.3 mm vs. 3.5–6 mm, filiform). The corolla is slightly longer and glabrous externally (vs. puberulent), with a longer style in the long-styled morph (16–18 mm vs. 10–11 mm) and a shorter one in the short-styled morph (6–9 mm vs. 4–4.5 mm). The stigma in the long-styled flowers is smaller and ovate (1.5–1.7 mm vs. ca. 3.5 mm, linear to oblanceolate), while in the short-styled flowers it is oblong (2.9–3.1 mm). These characters together clearly distinguish *O. himadrica* from *O. medogensis* (Table 1).

Description: Erect to decumbent, perennial herbs up to 30 cm tall. Stem terete, slender, branched from the lower nodes, green to reddish-brown, villous throughout, especially along the younger portions; internodes 2–7 cm long. Indumentum composed of soft, simple, uniseriate, whitish to pinkish or translucent hairs, stem densely villous, hairs 0.4–0.8 mm long, spreading to slightly appressed, whitish to translucent, denser on nodes and younger internodes, becoming sparsely pubescent or glabrescent with age; outer surface of stipule sparsely pubescent with short erect hairs, margins ciliate. Leaves sparsely pubescent along the veins and margins adaxially, sparsely so abaxially, otherwise glabrous; stipules interpetiolar, 0.9–1 mm long, triangular, persistent; petiole slender, 1–1.5 cm long, greenish to reddish-brown, glabrous, slightly grooved adaxially; lamina 1.7–3.5 × 1–2.5 cm, ovate to oblong, chartaceous, base rounded, margin entire, apex obtuse to subacute, adaxial surface green, abaxial surface lighter, midrib prominent beneath, secondary veins 5–9 pairs, eucamptodromous, faintly impressed above, prominent below, tertiary venation reticulate and faint. Inflorescence terminal, corymbose, consisting of 2 to many flowers; peduncle 0.5–1 cm long, terete, glabrous, pinkish to green; bracts and bracteoles similar, 0.5–1 × 0.1–0.2 cm, oblanceolate to lanceolate, prominently nerved, apex acute, glabrous, persistent or rarely deciduous, overall inflorescence architecture compact, spreading in anthesis. Flowers complete, bisexual, actinomorphic, heterostylous, epigynous, 2.4–2.8 cm long, white, fragrant when fresh; pedicels 1–3 mm long, glabrous, pinkish to green, articulated below the ovary. Calyx gamosepalous, 5-lobed; tube forming a short hypanthium 1.2–2 × 2–2.5 mm, obovoid, slightly striated, bearing two short but prominent lateral wings, pinkish-white to greenish-white, glabrous; lobes 5, elliptic, 1–1.3 mm long, apex obtuse, glabrous, pinkish;

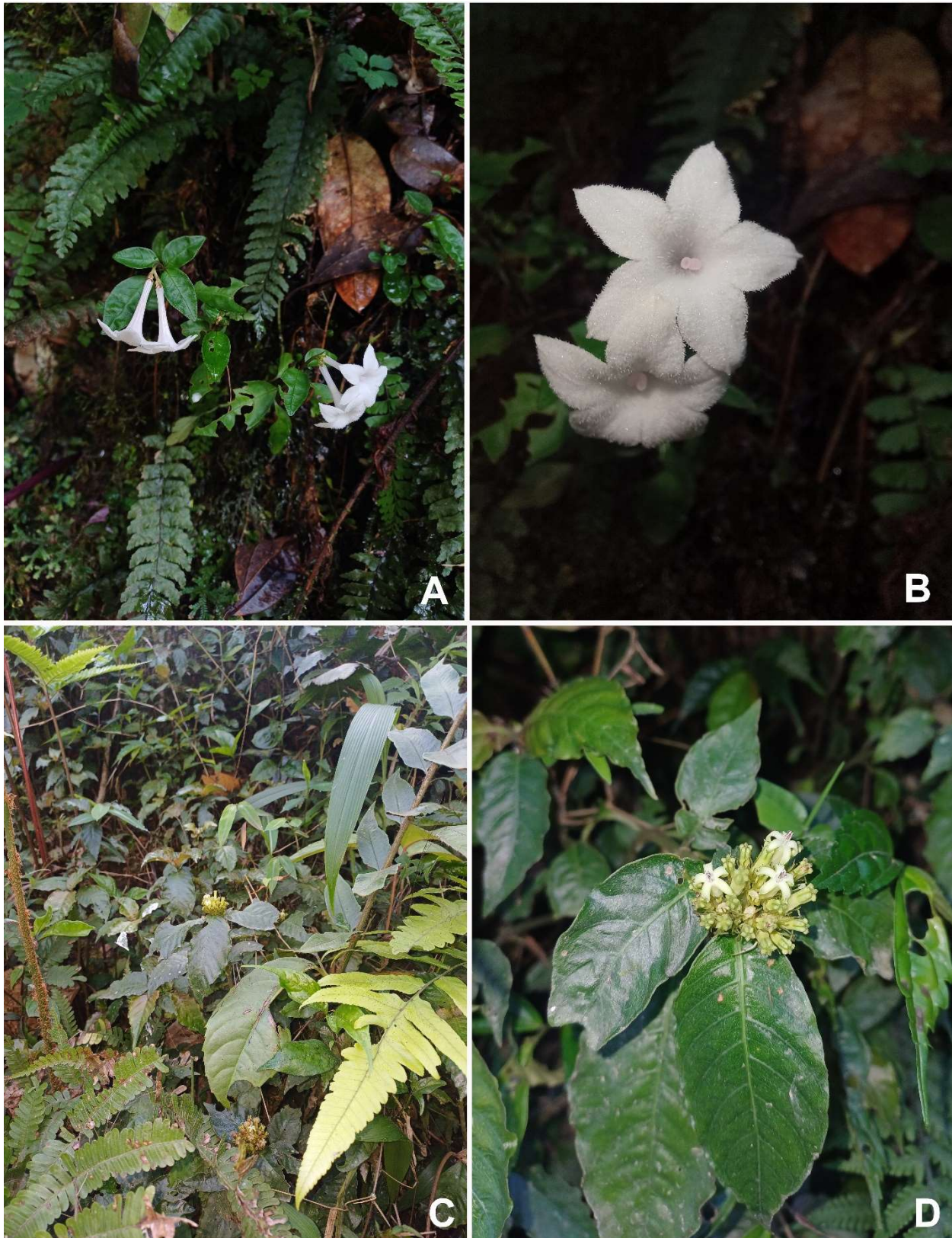


Fig. 1. Habitat photoplate of *Ophiorrhiza himadrica* & *Ophiorrhiza bharat*. **A.** Plants of *O. himadrica* in-situ. **B.** Close-up of flowers of *O. himadrica*. **C.** Plants of *O. bharat* in-situ. **D.** Close-up of inflorescence and flowers of *O. bharat*. (Photographs by Madhusudhan Khanal).

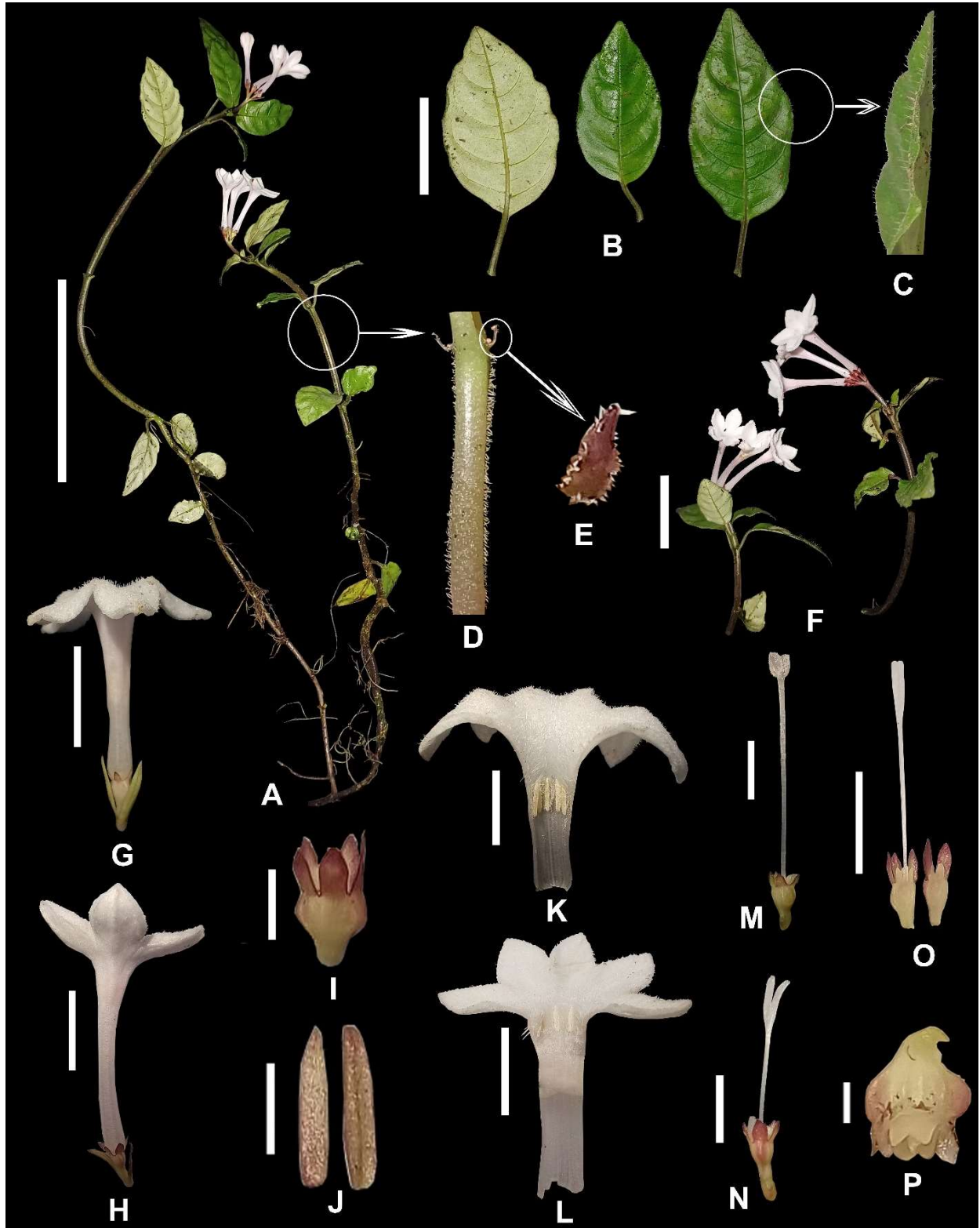


Fig. 2. Photoplate of *Ophiorrhiza himadrica*. **A.** Habit. **B.** Leaves (abaxial and adaxial view). **C.** Hairs on leaf. **D.** Texture of a stem. **E.** Stipule. **F.** Inflorescence. **G.** Long-styled flower. **H.** Short-styled flower. **I.** Calyx. **J.** Bracts. **K.** Split view of the corolla of a long-styled flower. **L.** Split view of the corolla of a short-styled flower. **M.** Carpel of long-styled flower. **N.** Carpel of short-styled flower. **O.** Dissected ovary. **P.** Hypanthium. **Scale bars:** **A.** 10 cm. **B.** 2 cm. **F.** 2.5 cm. **G.** 1 cm. **H.** 1 cm. **I.** 2 mm. **J.** 2 mm. **K.** 1 cm. **L.** 1 cm. **M.** 5 mm. **N.** 5 mm. **O.** 5 mm. **P.** 1 mm. (INDIA. Arunachal Pradesh. Shi-Yomi district, on the way to Menchuka, 28°34'22.02" N 94°09'08.69" E, 1968m, 13th April 2025, Dissections by Madhusudhan Khanal & photoplate by Shuvadip Sarkar).

**Table 1.** Morphological Comparison between *Ophiorrhiza himadrica*, *O. medogensis* & *O. medogensis* var. *shiyomiense*.

| Characters | <i>O. himadrica</i> | <i>O. medogensis</i> | <i>O. medogensis</i> var. <i>shiyomiense</i> |
|----------------------|--|---|--|
| Plant habit | ca.30 cm tall. | ca.60 cm tall. | ca.50 cm tall. |
| Stem | Base herbaceous, green to reddish-brown, villous. | Woody at base, densely villose. | Woody at base, green to pinkish green, pubescent. |
| Stipules* | 0.9–1 mm long, triangular, sparsely pubescent or glabrous. | 3–6 mm long, subulate to linear, pubescent. | ca. 10 mm long, subulate, pubescent. |
| Petiole | 1–1.5 cm long, glabrous. | 1–2 cm long, with dense pink pubescence. | 1–2.5 cm long, with dense pink pubescence. |
| Leaf blade | 1.7–3.5 × 1–2.5 cm, ovate to oblong, pubescent adaxially on margins/veins, sparsely on abaxial veins, 5–9 veined. | 3.5–11.5 × 1.5–3.5 cm, elliptic to ovate-lanceolate, pubescent on both surfaces, 7–16 veined. | 3.5–9 × 1.75–4 cm, elliptic or ovate to ovate-lanceolate, adaxially sparsely pubescent to pubescent, abaxially pubescent, 9–14 veined. |
| Bract* | 5–10 × 1–2 mm, oblanceolate, glabrous. | 6–10 × 1 mm, lanceolate, pubescent. | 10–13 × 1 mm, lanceolate, pubescent. |
| Peduncle | 0.5–1 cm long, glabrous. | 0.3–0.5 cm long, densely villose. | ca. 3 cm long, densely villose. |
| Flower | 2.2–2.8 cm long, white, heterostylous. | 2.0–2.5 cm long, white or with a pinkish tinge, heterostylous. | 2–2.4 cm long, whitish-green, heterostylous. |
| Pedicel | 1–3 mm, glabrous, pinkish-to-green. | 2–2.5 mm, densely villose, pale green. | 2–2.5 mm long, densely villose, pale green. |
| Hypanthium | 1.2–2 × 2–2.5 mm, pinkish-white to greenish-white, glabrous. | 1.5–2 × 2–2.5 mm, pale pink, densely pink-villose. | 1.5–2 × 2–2.5 mm, pale green, densely pink-villose. |
| Calyx lobes* | 1–1.3 mm long, elliptic, apex obtuse, pinkish, glabrous. | 3.5–6 mm long, filiform, apex acute, pale green to green, pubescent. | 3.5–6 mm long, filiform, unequal in length, apex acute, pale green to green, pubescent. |
| Corolla* | 2.4–2.8 cm long, white, glabrous outside; lobes 4–6 × 4–5 mm. | 1.8–2.0 cm long, white or with a pink tinge, puberulent outside; lobes 3.5–4 × 3.5–4 mm. | 1.8–2.0 cm long, pale yellow with green tinge towards the lobes, densely villose; lobes ca. 2 × 1.5 mm. |
| Long styled flower* | Style 16–18 mm long, glabrous; stigma 1.5–1.7 mm long, bifid, ovate. | Style 10–11 mm long, ciliate; stigma ca. 3.5 mm long, linear to oblanceolate. | Style 10–11 mm long, ciliate; stigma ca. 2 mm long, linear to oblanceolate. |
| Short styled flower* | Style 6–9 mm long, glabrous; stigma 2.9–3.1 mm long, oblong. | Style 4–4.5 mm long, pubescent; stigma 2–2.5 mm long, oblanceolate. | Style 4–4.5 mm long, ciliate; stigma 2–2.5 mm long, oblanceolate. |
| Biogeographic region | Eastern Himalaya (Arunachal Pradesh- Endemic) | Southern Tibet - Eastern Himalaya (restricted, Himalayan slopes) | Eastern Himalaya (Arunachal Pradesh- Endemic) |
| Elevation range* | 1900 to 2200 msl. | 1100 to 1700 msl. | 1100 to 1200 msl. |
| Habitat | Cool, mist-laden understory of temperate mixed forests, shaded stream banks, and moist ravines. | Sub-tropical broad-leaved forest or moist slopes near waterfalls. | Moist slopes near waterfalls. |
| Associated species | <i>Impatiens prainii</i> , <i>Henckelia lachenensis</i> , <i>Trifolium</i> sp., <i>Rubus</i> sp., <i>Goodyera foliosa</i> , <i>Selaginella</i> sp., etc. | <i>Amomum sericeum</i> , <i>Henckelia pumila</i> , <i>Elatostemma</i> sp., <i>Impatiens arguta</i> , <i>Pilea</i> sp., etc. | <i>Impatiens paramjitana</i> , <i>Impatiens arguta</i> , <i>Pilea</i> sp., etc. |

(* - key diagnostic features)

aestivation valvate, occasionally imbricate near the apex. Corolla sympetalous (gamopetalous), tubular, 2.2–2.6 cm long, white, externally glabrous, internally bearing a villous ring; corolla tube cylindrical, gradually widening toward the throat, lobes 5, 4–6 × 4–5 mm, ovate, pubescent within, apex acute, margin entire; aestivation imbricate. Stamens 5, epipetalous, inserted on the inner surface of the corolla tube, alternate with the lobes, filaments short, glabrous; anthers linear-oblong, 2.5–3 mm long, dorsifixed, introrse, pale yellow, dehiscing longitudinally. **Long-Styled Morph:** Villous ring situated at the middle of the corolla tube, followed by dense short pubescence towards the lobes and glabrous towards the base; stamens inserted at the middle of the corolla tube below the villous ring, included; anthers 2.5–3 mm long, linear-oblong, pale yellow; filaments 1.0–1.5 mm long, slender, glabrous; style 16–18 mm long, filiform, exerted beyond corolla throat, glabrous, white;

stigma bifid, ovate, 1.5–1.7 mm long, glabrous. **Short-Styled Morph:** Villous ring situated at the throat of the corolla tube, followed by dense pubescence towards the lobes and glabrous towards the base; stamens inserted at the throat of the corolla tube, exerted above the villous ring; anthers 2.5–3 mm long, linear-oblong, pale yellow; filaments 2.0–2.5 mm long, slender, glabrous; style 6–9 mm long, filiform, included within corolla tube, glabrous, white; stigma bifid, oblong, 2.9–3.1 mm long, glabrous. Fruit not seen. (**Figures 1A–B & 2**).

Etymology: The specific epithet *himadrica* originates from Sanskrit, where *hima* means “snow” and *adri* means “mountain.” The term “*himadrica*” refers to the Himalayas, the highest mountain range in the world and the type locality of the species.

Phenology: Flowering: April–May; fruiting: not observed.

Distribution: *Ophiorrhiza himadrica* is known only



from near Menchuka, Shi-Yomi district of Arunachal Pradesh, India.

Habitat: *Ophiorrhiza himadrica* thrives in the cool, mist-laden understory of temperate mixed forests in Shi-Yomi district, Arunachal Pradesh, at elevations between 1900 to 2200 m. It grows along shaded stream banks, moss-clad ravines, and forested roadside slopes where constant moisture and filtered light prevail. The species roots in humus-rich, loamy soil often blanketed with dense mats of mosses and decaying leaf litter, forming a soft, damp substrate. Plants occur in partial to deep shade beneath a closed canopy, often near trickling water or cascading falls that sustain a perpetually humid microclimate. The surrounding vegetation typically includes *Impatiens prainii* Hook.f., *Henckelia lachenensis* (C.B. Clarke) D.J. Middleton & Mich. Möller, *Trifolium* sp., *Rubus* sp., *Hedychium* sp., *Begonia* sp., *Elatostemma* sp., *Dryopteris* sp., *Goodyera foliosa* (Lindl.) Benth. ex C.B. Clarke, and *Selaginella* sp., among others, reflecting a rich, moisture-loving understory community. (Figures 1A–B & 2)

Note: Descriptions are based on specimens sampled during a single field season. Further collections across seasons and populations are required to document the full phenological cycle and population variation.

Ophiorrhiza bharat M.Khanal, D.Kumar & S.Sarkar, *sp. nov.* Figs. 1C–D & 3

Type: INDIA. Arunachal Pradesh: Shi-Yomi district, Hone village adjoining forested areas, 28°31'26.31" N 94°32'12.47" E, 1083m, 19th April 2025, *Madhusudhan Khanal* 2113 (holotype: CAL; isotype: ARUN, G. B. Pant National Institute of Himalayan Environment- North East Regional Centre Herbarium)

Diagnosis: *Ophiorrhiza bharat* M.Khanal, D.Kumar & S.Sarkar differs from its close ally *O. ochroleuca* Hook.f. by its smaller stature (erect herbs up to 60 cm tall vs. up to 100 cm tall), pubescent stem and petiole (vs. glabrous), and smaller, sparsely pubescent leaves (5–10 × 3–4.5 cm, sparsely pubescent vs. 3.5–22.5 × 1.5–10 cm, glabrous). The stipules are narrower and subulate (0.9–1.3 cm vs. 0.4–1.5 cm, linear-lanceolate), and the bracts are conspicuously larger (0.9–1.5 cm vs. minute). The inflorescence is terminal and trichotomously branched, forming a polychasial cyme, whereas in *O. ochroleuca* it is axillary or terminal and dichotomous to trichotomous helicoid. The peduncle is much shorter (3–6 mm vs. 3.5–10 cm), and the calyx lobes are distinctly longer and linear-lanceolate (4–5 mm vs. 0.8–1.2 mm, triangular). The corolla is shorter (8–9 mm vs. 1.2–1.8 cm) and glabrous externally, with a dense villous ring at the throat. *Ophiorrhiza bharat* bears homostylous flowers with a short style (2–2.1 mm) and an ovate stigma (ca. 1 mm), in contrast to the heterostylous condition in *O. ochroleuca*, clearly distinguishing it from its allied species.

Description: Erect, perennial herbs up to 60 cm tall.

Stem terete, slender, woody at base, greenish-brown, pubescent throughout, internodes 3–8 cm long. Indumentum of short, simple, eglandular hairs; densely pubescent to hirsute on stem, hairs 0.2–0.4 mm long, spreading to slightly ascending, pale brown to whitish, denser on younger portions; sparsely pubescent on both surfaces of leaves, more so beneath, hairs appressed to subappressed, 0.1–0.3 mm long, translucent to pale brown, veins hirsutulous, margins finely ciliolate; sparsely pubescent externally on stipules; margins of bracts and bracteoles minutely ciliolate, inner surfaces glabrous. Stipules interpetiolar, 0.9–1.3 cm long, subulate, apex acuminate, sparsely pubescent, persistent. Petiole slender, 0.4–1 cm long, green, pubescent, slightly canaliculate above; lamina 5–10 × 3–4.5 cm, elliptic-ovate to ovate-lanceolate, chartaceous, base attenuate, margin entire to slightly undulate, apex caudate; secondary veins 7–12 pairs, brochidodromous, prominent beneath, tertiary venation reticulate and faintly visible on both surfaces. Inflorescence terminal, trichotomously branched, forming a capitate, polychasial cyme of 8 to many flowers; peduncle 3–6 mm long, terete, glabrous, pinkish to green; bracts and bracteoles sub-similar, 0.9–1.5 cm long, linear-subulate, apex acute, green, persistent or often deciduous, giving the inflorescence a dense, rounded appearance. Flowers small, 0.8–1 cm long, complete, bisexual, actinomorphic, homostylous, epigynous, greenish-yellow, glabrous externally; pedicels 1–2 mm long, glabrous, green, articulated below the ovary. Calyx gamosepalous, 5-lobed to the base, lobes linear-lanceolate, 4–5 mm long, apex acute, glabrous, greenish-brown, aestivation valvate. Corolla sympetalous, tubular, 8–9 mm long, greenish-yellow, glabrous externally, tube cylindrical, gradually widened toward the throat, lobes 5, 3–4 × 1–1.2 mm, linear-oblong, strongly reflexed and recurved at anthesis, apex acute, slightly keeled and horned, margins entire, aestivation imbricate; inner surface densely pubescent, forming a villous ring at the throat followed by dense short pubescence below, glabrous toward the base. Stamens 5, epipetalous, inserted at about 3/4th the length of the corolla tube, alternate with the lobes; filaments 2.5–3 mm long, glabrous, adnate to the corolla; anthers 2–2.5 mm long, linear-oblong, dorsifixed, introrse, dehiscent longitudinally, pale yellow to creamy white, thecae parallel; pollen pale yellow. Gynoecium bicarpellary, syncarpous; ovary inferior, obovoid, 1.9–2.1 × 2.5–2.7 mm, glabrous, green, with a 0.5–0.7 mm long conspicuous whitish disc at the apex; locules 2, with numerous anatropous ovules on axile placentation; style filiform, 2–2.1 mm long, glabrous, white; stigma bifid, ovate, ca. 1 mm long, white. Nectariferous disc conspicuous, annular, fleshy. Fruit not seen. (Figures 1C–D & 3)

Etymology: The specific epithet '*bharat*' (from Sanskrit *bhārata*) refers to the traditional and constitutional name of India, honoring the country's rich botanical and cultural diversity.



Fig. 3. Photoplate of *Ophiorrhiza bharat*. **A.** Habit. **B.** Stem showing hairs and stipules. **C.** Stipules. **D.** Leaves (abaxial and adaxial view). **E.** Inflorescence. **F.** Bracts. **G.** Flowers in a cyme. **H.** views of a single flower. **I.** Calyx attached to the ovary. **J.** Split view of the corolla (inner view). **K.** Split view of the corolla (outer view). **L.** Carpel with calyx. **Scale bars-** **A.** 10 cm. **C.** 1 cm. **D.** 2 cm. **E.** 1.3 cm. **F.** 5 mm. **G.** 1.3 cm. **H.** 1.3 cm. **I.** 2 mm. **J.** 5 mm. **K.** 5mm. **L.** 2 mm. (INDIA. Arunachal Pradesh. Shi-Yomi, Hone village adjoining forested areas, 28°31'26.31" N 94°32'12.47" E, 1083m, 19th April 2025, Dissections by Madhusudhan Khanal & photoplate by Shuvadip Sarkar).

**Table 2.** Morphological comparison between *Ophiorrhiza bharat*, *O. ochroleuca* and *O. gajureliana*.

| Characters | <i>Ophiorrhiza bharat</i> | <i>O. ochroleuca</i> | <i>O. gajureliana</i> |
|----------------------|--|--|--|
| Plant habit | Herbs, ca.60 cm tall. | Herbs, ca.100 cm tall. | Subshrubs, 40–70 cm tall. |
| Stem* | Pubescent. | Glabrous. | Glabrous, above pubescent when young. |
| Stipules* | 0.9–1.3 cm long, subulate, sparsely pubescent. | 0.4–1.5 cm long, linear-lanceolate, glabrous. | 5–6 mm long, acuminate, persistent. |
| Petiole | 0.4–1 cm long, pubescent. | 1.5–4 cm long, glabrous. | 1–4.6 cm long, glabrous. |
| Leaf blade | 5–10 × 3–4.5 cm, elliptic-ovate to ovate-lanceolate, sparsely pubescent. | 3.5–22.5 × 1.5–10 cm, elliptic to elliptic-lanceolate, glabrous. | 9.5–14 × 6–7.3 cm long, ovate-lanceolate to nearly elliptic-lanceolate, glabrous. |
| Bract* | 0.9–1.5 cm long, linear-subulate, sparsely pubescent. | Minute, subulate, glabrous. | Absent. |
| Inflorescence* | Terminal, trichotomous polychasial cyme. | Axillary and terminal dichotomous or trichotomous helicoid cyme. | Uniparous helicoid. |
| Peduncle | 0.3–0.6 cm long, glabrous. | 3.5–10 cm long, pubescent. | 2–3 cm long, pubescent. |
| Pedicel | 1–2 mm long, glabrous. | 0.75–1 mm long, puberulous. | 0.2–0.3 cm long, glabrous. |
| Calyx* | Lobes 4–5 mm long, linear-lanceolate, glabrous. | Lobes 0.8–1.2 mm long, triangular, puberulous. | 2–2.2 × 2.2–2.3 mm, glabrous. |
| Flower* | 8–10 mm long, homostylous. | 6–14 mm long, heterostylous. | 2.3–2.5 cm long, homostylous. |
| Biogeographic region | Eastern Himalaya (Arunachal Pradesh- Endemic) | Eastern Himalaya – Indo-Burma region (widespread). | Eastern Himalaya (Arunachal Pradesh- Endemic). |
| Elevation range | 1000 to 1200 msl. | Sea level to 1200 msl. | 1800 to 2200 msl. |
| Habitat | Moist, partially shaded slopes and roadside cuttings within semi-disturbed sub-tropical forest margins | Moist stable forest interiors, often under closed canopy conditions of a tropical or sub-tropical forest | Subtropical to sub-temperate forest areas. |
| Associated species | <i>Terminalia myriocarpa</i> , <i>Henckelia pumila</i> , <i>Ophiorrhiza ripicola</i> , <i>Ophiorrhiza medogensis</i> var. <i>shiyomiensis</i> , <i>Impatiens arguta</i> , <i>Amomum arunachalense</i> . etc. | <i>Impatiens drepanophora</i> , <i>I. pseudolaevigata</i> , <i>Ophiorrhiza debiana</i> , <i>Tacca</i> sp., <i>Pilea</i> sp. etc. | <i>Ophiorrhiza harrisiiana</i> , <i>Ophiorrhiza pauciflora</i> , <i>Osbeckia nepalensis</i> etc. |

(* - Key diagnostic features)

Phenology: Flowering: April–May; fruiting: not seen.

Distribution: *Ophiorrhiza bharat* is known only from the adjoining forested areas of Hone village, Shi-Yomi district of Arunachal Pradesh, India.

Habitat: *Ophiorrhiza bharat* inhabits partially disturbed subtropical forest margins and moist roadside banks, typically along shaded to semi-open streamside areas at 1000–1200 m above msl. It grows on clayey, humus-rich soil with good moisture retention but occasional light exposure. The species occurs amidst ground herbs and ferns, often forming scattered populations in moderately shaded microhabitats rather than under dense canopy cover. It grows in association with *Terminalia myriocarpa* Van Heurck & Müll.Arg., *Henckelia pumila* (D.Don) A.Dietr., *Ophiorrhiza ripicola* Craib, *Ophiorrhiza medogensis* var. *shiyomiensis* Hareesh & M.Sabu, *Impatiens arguta* Hook.f. & Thomson, *Dryopteris* sp., *Nephrolepis* sp., and *Amomum arunachalense* Hareesh & M. Sabu. etc. (**Figures 1C–D & 3**)

Note: The flowers of *Ophiorrhiza bharat* are distinctly homostylous, with the stigma positioned clearly below the anthers, both arising from the central portion of the corolla tube. The anthers are gamopetalous, being partially fused to the inner wall of the corolla tube, and extend above the stigma between the recurved petals. The absence of style dimorphism and the uniform floral form observed across individuals confirm the homostylous condition.

Homostyly is an uncommon feature within *Ophiorrhiza*, a genus otherwise characterized predominantly by distylous flowers. It has been reported in a few Indian taxa described from the Eastern Himalayas, such as *O. gajureliana* (Bawri *et al.*, 2024) and *O. meghalayaensis* (Hareesh *et al.*, 2017). Although *O. bharat* shares this floral condition, it differs markedly in vegetative and floral morphology—particularly in its denser indumentum, smaller and more clustered flowers, and distinct stipule and bract characters—indicating an independent evolutionary origin of homostyly within this lineage.

The occurrence of homostyly in *O. bharat* may represent an ecological adaptation to its disturbed, semi-open mid-elevation habitat, where pollinator activity is likely sporadic. The floral structure suggests a potential shift toward autonomous self-pollination, a strategy that may enhance reproductive assurance under variable environmental conditions. However, as the present description is based on limited flowering material from a single known population, additional collections from different seasons and nearby areas are required to confirm the stability of this condition and to document any intraspecific variation. Detailed reproductive and molecular studies would further clarify whether homostyly in *O. bharat* represents a derived adaptation or a case of convergent evolution within the Eastern Himalayan *Ophiorrhiza*.

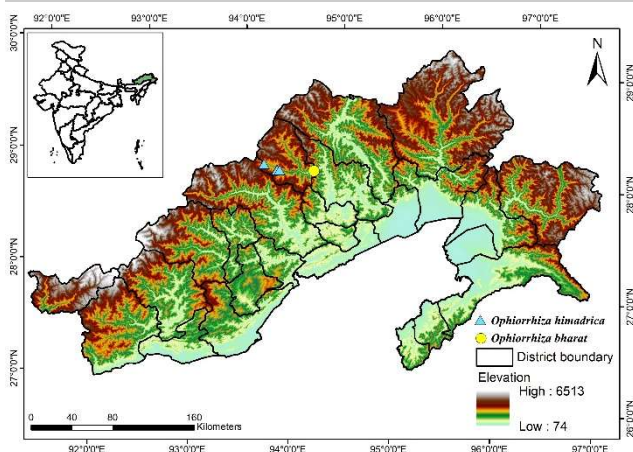


Fig 4. Distribution map of *Ophiorrhiza himadrica* & *Ophiorrhiza bharat* in Arunachal Pradesh.

DISCUSSION

Biogeographical discussion and ecological differentiation: The Eastern Himalaya, particularly Arunachal Pradesh and adjoining regions, represents one of the key centers of *Ophiorrhiza* diversity in India, where complex topography and humid subtropical to montane climates foster micro-endemism and ecological specialization (Deb and Mondal, 1997; Bawri *et al.*, 2024). Both *Ophiorrhiza himadrica* and *O. bharat* are restricted to this Eastern Himalayan biogeographic province (Rodgers and Panwar, 1988) but occupy distinct elevational and ecological zones, reflecting adaptive divergence under contrasting habitats.

Ophiorrhiza himadrica inhabits cool, shaded stream banks and moist ravines between 1900–2200 m in central Arunachal Pradesh. Its close ally *O. medogensis* H. Li—originally described from Medog, southeastern Tibet (Li, 1980) and recently recorded from Dibang Valley, Arunachal Pradesh (Hareesh and Sabu, 2022)—occurs at slightly lower elevations under denser canopy cover. Morphological distinctions mirror this ecological separation: *O. himadrica* bears fewer but larger, glabrous flowers with distylous morphs typical of cross-pollinated species, whereas *O. medogensis* shows denser indumentum and smaller, more numerous flowers adapted to relatively warmer, less humid forest strata.

At mid-elevations (1000–1200 m), *O. bharat* occurs on moist, semi-disturbed slopes and roadsides, while its close relative *O. ochroleuca* Hook.f. thrives in the shaded interiors of undisturbed evergreen forests (Hooker, 1880; Deb and Mondal, 1997; Hareesh and Sabu, 2022). *O. bharat*'s pubescent stem, compact polychasial cymes, and homostylous flowers suggest adaptation to fluctuating light, humidity, and low pollinator reliability, potentially allowing partial self-pollination.

These ecological and morphological contrasts demonstrate fine-scale niche differentiation within

Ophiorrhiza. *O. himadrica* exemplifies a high-elevation, moisture-dependent, distylous taxon, while *O. bharat* represents a low-elevation, disturbance-tolerant, homostylous one. Their restricted distributions and small populations highlight the influence of microenvironmental variation on speciation and underscore the need for continued surveys to document phenological variation, potential contact zones, and conservation requirements across the Eastern Himalaya.

Conservation status: *Ophiorrhiza himadrica* is currently known from four subpopulations in Arunachal Pradesh, with approximately 23 mature individuals observed under the shaded understory of moist evergreen forests. These habitats face increasing anthropogenic pressures such as fuelwood collection, small-scale logging, and shifting cultivation. A preliminary Area of Occupancy (AOO) of 16 km² was estimated using GeoCAT (Bachman and Moat, 2012). However, as adjacent forest tracts with similar habitats remain unsurveyed and long-term population data are lacking, its true range and abundance remain uncertain.

In contrast, *Ophiorrhiza bharat* is known from a single subpopulation in Arunachal Pradesh, where only 16 flowering individuals were recorded within an approximate AOO of 4 km². The population occurs near a tribal settlement and is directly threatened by ongoing road expansion and habitat modification. No fruiting individuals were observed during field visits, and data on its reproductive biology and dispersal remain unavailable.

Both *O. himadrica* and *O. bharat* are highly localized, small, and inconspicuous understory herbs, likely under-reported due to their diminutive size and seasonal visibility. The currently available information is insufficient to evaluate their extinction risk confidently, as required by the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee, 2024). Consequently, both species are best assessed as **Data Deficient (DD)**.

This provisional status emphasizes the urgent need for comprehensive field surveys across potential habitats, long-term monitoring of known populations, and studies on population structure, reproductive ecology, and habitat specificity. Such efforts will be essential for accurate reassessment of their conservation status and for implementing targeted in-situ and ex-situ conservation measures in the Eastern Himalaya.

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