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continued on the back inside cover

Cover: *Euphaea pseudodispar* shot at Kalindi River, Thirunelly, Wayanad district, Kerala. © Muneer P.K.



Taxonomy and threat assessment of *Lagotis kunawurensis* Rupr. (Plantaginaceae), an endemic medicinal plant species of the Himalaya, India

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Abstract: *Lagotis kunawurensis* Rupr. (Plantaginaceae), a rare plant species endemic to the Himalaya, is reported here after a gap of 50 years from Ladakh. This species has often been taxonomically misidentified and confused with *Picrorhiza kurroa*, an important medicinal plant of the Himalaya. The present study clarifies the taxonomy of *L. kunawurensis* by providing description and photo illustrations of diagnostic characters which will aid its proper field identification. Furthermore, the threat assessment of *L. kunawurensis* using the IUCN Red List of Threatened Species has been conducted based on the available occurrence records, and the species currently falls under the 'Near Threatened' category. This species is used for medicinal purposes by locals in the study area. As the species is simultaneously experiencing various kinds of threats and the known distribution range is relatively smaller, it is right time to develop conservation strategies for the sustainable utilization of this endemic medicinal plant species of the Himalaya.

Keywords: Biogeography, conservation, Ladakh, medicinal plant, *Picrorhiza kurroa*, status, uses.

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INTRODUCTION

Plants are crucial for the existence of life (Isbell et al. 2011). However, in recent times, plants are subjected to various threats such as habitat loss, over-exploitation, pollution, illicit trade (Tali et al. 2014; Ganie et al. 2019), and increasing stresses associated with climate change (Urban 2015; Hamid et al. 2020). These anthropogenic pressures on plant diversity are predicted to push Earth beyond the tipping points (Steffen et al. 2015; Bachman et al. 2017). In response to such grave concerns, the Target 2 of Convention on Biological Diversity (CBD) has called for assessment of threat status at regional, national, and global level to identify plant species which need immediate conservation. Empirical evaluation of threat status of biodiversity has emerged as an area of immediate research focus (Agnihotri et al. 2107; Tali et al. 2018; Ganie et al. 2019). Designation of current threat status of a species is crucial in assessing the risk of extinction, development of conservation policy, and drawing public attention towards these species, as well as their declining habitats (Burton 2003; Tali et al. 2018; Ganie et al. 2019).

The Himalaya, one of the global biodiversity hotspots, harbors about 10,000 plant species of which >3,100 are endemic to the region (Chitale et al. 2014). The Indian Himalayan region is rich in biodiversity, including prized medicinal plants (Tali et al. 2019; Dar & Khuroo 2020; Ganie et al. 2020). The genus *Lagotis* J. Gaertn. (Family: Plantaginaceae) has several species endemic to the Himalayan region (Stewart 1972; Lu 1992; Li et al. 2014). Four species of *Lagotis* have been recorded from the Himalaya (Stewart 1972) and two: *L. cashmeriana* (Royle) Rupr. and *L. kunawurensis* Rupr. are narrow endemic to the region. Stewart (1972) has recorded *L. kunawurensis* from Ladakh, Trans-Himalayan region in India; however, since then no other researcher (Kachroo et al. 1977; Polunin & Stainton 1984; Klimeš & Dickoré 2006; Behera et al. 2014) has reported this species from Ladakh. Recently, while carrying out botanical surveys to document the flora of Ladakh, specimens of a typical *Lagotis* species were collected from Sapi La, Kargil (Ladakh). After critical study of its morphological features, the species was identified as *Lagotis kunawurensis* Rupr. (Stewart 1972; Polunin & Stainton 1984). The later researchers, most likely, have taxonomically confused *L. kunawurensis* with *Picrorhiza kurroa*, another important medicinal plant of the Himalaya (*Lagotis kunawurensis*-efloraindia <https://sites.google.com/site/efloraofindia/species/mz/p/plantaginaceae/lagotis/lagotiskunawurensis>).

In an era of biodiversity crisis, the correct taxonomic identification and scientific information on the occurrence and population status of endemic species is urgently needed to undertake threat assessment, and thereafter develop appropriate conservation strategies (Chitale et al. 2104; Tali et al. 2018; Khuroo et al. 2020). In the backdrop of *L. kunawurensis* being a narrow endemic species, the present study aimed to resolve its taxonomic confusion and also for the first time undertake an empirical assessment of its threat status across the Himalaya based on IUCN Red List criteria (IUCN 2012).

MATERIALS AND METHODS

Study area

The Himalaya, covering an area of about 329,109.22 km², is located between 25.065–35.082 °N & 73.013–97.041 °E, along the northern boundary of India (Chitale et al. 2014). The climate is sub-alpine-temperate in western Himalaya, while it is sub-tropical to temperate in eastern Himalaya; whereas annual temperature and precipitation is on average 5 °C and 1,200 mm in western Himalaya, it is 10 °C and 3,500 mm in eastern Himalaya, respectively. The wide elevation gradient in the Himalaya ranging from 500–8,800 m results in a variety of ecosystems within short distances, from alluvial grasslands and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid-hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the treeline (Chitale et al. 2014).

The Trans-Himalayan region of Ladakh, the collection site of the present study, is located at the northwestern boundary of India between 21.095–37.083 °N & 72.066–78.041 °E. This region possesses a wide altitudinal gradient, land with diverse geological formations, resulting in the rich diversity of alpine and cold-desert flora (Nüsser & Dickoré 2002). The collection site namely, Sapi La is located in district Kargil of Ladakh at an altitude of 4,375 m, at 34.036 °N & 76.019 °E, and situated about 70 km towards the southwestern side of Kargil township.

Taxonomy

Standard herbarium methods (Bridson & Forman 1992) were used during collection, processing and preparation of the herbarium specimens. Voucher specimens have been deposited at the University of Kashmir Herbarium (KASH). Besides, an ethno-botanical survey was conducted in the study area to document the traditional use of this plant species. The survey usually started with the interview of elderly and experienced

members, locally known as 'Amchi' to collect information regarding medicinal uses of this plant species.

Record of operative threats

The operative threats (both direct and indirect) to plant species and their habitats were assessed during different seasons of the year at regular intervals of time following Ganie et al. (2019).

Threat assessment

Occurrence records for *Lagotis kunawurensis* were obtained from the Global Biodiversity Information Facility database (GBIF 2018) using the 'gbif' function from the 'dismo' package (<https://CRAN.R-project.org/package=dismo>) (Hijmans et al. 2017) and supplemented with the occurrence records from India Biodiversity Portal (IBP 2018), herbarium records (BSD, KASH) and field surveys.

Adopting the IUCN Red List Categories and Criteria, version 3.1 (IUCN 2012), we assessed the current threat status of the species based on the Criterion B; it takes into account the geographic range size as well as evidence of diminishing or fragmenting populations (Gaston & Fuller 2009; Cosiaux et al. 2018). The Criterion B is appropriate for assigning conservation status even when data is scarce and the geographic distribution of a species is known from only a few georeferenced herbarium records (Cosiaux et al. 2018). We used the ConR package (<https://CRAN.R-project.org/package=ConR>) (Dauby et al. 2017) implemented in R software (<https://www.R-project.org/>; R Core Team 2018) to calculate extent of occurrence (EOO) and area of occupancy (AOO) based on the occurrence records of the species. EOO was calculated by constructing a minimum convex polygon around all the known occurrences while AOO was estimated as the sum of occupied cells after superimposing the grid with cells of desired size (Dauby et al. 2017; Cosiaux et al. 2018; Lughadha et al. 2018). During the present study, the minimum AOO was estimated based on a standard grid cell of size 2 x 2 km (IUCN 2017). In addition, we also calculated the number of 'locations', as defined by IUCN (2017), with respect to the various types of threats, so that a single 'location' may involve more than one adjacent sub-populations.

RESULTS

TAXONOMIC DESCRIPTION

Lagotis kunawurensis Rupr., Sert. Tianschan. 64 1869.

Synonyms: *Gymnandra kunawurensis* Royle ex

Benth., Scroph. ind. 47, 1835.

Lagotis glauca var. *kunawurensis* (Royle) Hook. f., Fl. Brit. Ind. 5, 569, 1885

Plant herbaceous up to 23 cm tall; roots many, fibrous; basal leaves obovate-oblongate, with cuneate leaf base, dentate-denticulate margin and acute-rounded leaf apex, 6-8 cm long and 1.5-2.2 cm broad, petiolate, petiole creamy with reddish tinge, 6-8 cm in length; stem leaves ovate, sessile, 2-3 cm long and 1-1.5 cm broad; inflorescence spike, flowers pale mauve or blue, numerous; calyx spathe-like; corolla tube slender, zygomorphic, bracts numerous, overlapping; stamens 2, filament as long as corolla or shorter; anthers reniform, black in colour; ovary 2 locular, superior; stigma capitate, bilobed (Image 1).

Specimens examined: India, Ladakh, Kargil: Sapi La, 03 August 2017, Tariq, Aijaz, & Khuroo 1000129; 23 July 2019, Aijaz & Nazima 110991 (KASH); Himachal Pradesh, Lahaul: Rohtang pass, 04 August 1994, Murti & Singh 102923 (BSD).

Identification aid: In western Himalaya, there is a confusion regarding the identification between *Lagotis kunawurensis* and *Picrorhiza kurroa* (<https://sites.google.com/site/efloraofindia/species/mz/p/plantaginaceae/lagotis/lagotiskunawurensis>), therefore the comparison of the diagnostic characters between these two species is provided to facilitate their correct taxonomic identification (Table 1).

Flowering period: July-August.

Ecological note: The species grows in the cold desert alpine areas which experience high speed winds and also prone to landslides. Also, the species is over-exploited for local use by herbal healers and whole plant along with roots is extracted. During the present study, the species was recorded only at one site (i.e., Sapi La) in the

Table 1. Comparison of diagnostic characters between *Lagotis kunawurensis* and *Picrorhiza kurroa*.

Diagnostic characters	Species	
	<i>Lagotis kunawurensis</i>	<i>Picrorhiza kurroa</i>
Leaf a. Type b. Shape	Both basal and stem leaves present Basal leaves obovate-oblongate Stem leaves ovate, sessile	Only stem leaves present Absent Stem leaves spatulate to narrow elliptical with winged leaf stalk
Inflorescence a. Type b. Size	Spike Up to 15-20 cm long	Cylindrical head Up to 10 cm long
Flower a. Colour b. Stamens	Pale mauve or blue Short, not exerted	Purplish-blue Long, exerted



Image 1. *Lagotis kunawurensis* Rupr.: A—Habitat (Scale = 0.1mm) | B—Habit (Scale = 1mm) | C—Fibrous roots (Scale = 1.5 mm) | D—Inflorescence –spike (Scale = 6 mm) | E—Zygomorphic pale blue flowers (Scale = 8 cm) | F—Numerous overlapping bracts (Scale = 9 mm) | G—Obovate-lanceolate basal leaves (Scale = 6 mm) | H—Leaf with denticulate margins and acute-rounded leaf apices (Scale = 2 cm) | I—Sessile stem leaves (Scale = 8 mm). © Aijaz Hassan.

entire Ladakh region. The number of mature individuals at the collection site was about 250 individuals, thus represented by a small population size.

DISTRIBUTION

Global: Pakistan (Deosai, Baltistan); India (Drass, Rusi La, Sapi La and Zaskar in Ladakh, Jhow, Kunawur, Phaloot in Himachal Pradesh, Uttarakhand, and Sikkim); Nepal (Mechi, Gandaki Zone, Sagarmatha Zone, Koshi Zone, Thorung La, Manang, Karnali. Suli Gad); Bhutan

(Catalogue of life-<https://www.catalogueoflife.org>)

During the present study, the plant species was collected from Sapi La (4370 m.; 34.036 °N and 76.019 °E), in Kargil district of Ladakh, India (Figure 1).

Ethno-medicinal uses

The plant species, in particular roots, are used against abdomen cramps, inflammation, and brown phlegm. The plant is also used as liver tonic and to treat different types of fevers in the collection site of the present study.

Threat status

Empirical evaluation of the threat status revealed that the extent of occurrence (EOO) and area of occupancy (AOO) for *L. kunawurensis* is 2,78,896 km² and 88 km² respectively (Figure 1). Furthermore, the species is recorded from 24 unique localities, representing a total of 19 sub-populations from 20 different locations (sensu IUCN 2012) which are more than 10 locations that represent the upper most limits for the 'Vulnerable' (VU) category under sub-criterion 'a'. Therefore, *L. kunawurensis* is assigned under IUCN category of Near Threatened (NT) according to criterion B.

DISCUSSION

After Stewart (1972), *Lagotis kunawurensis* has not been reported from the Ladakh region (Kachroo et al. 1977; Polunin & Stainton, 1984; Klimeš & Dickoré, 2006; Behera et al. 2014), therefore the authenticity of its presence in this region was doubtful. However, the present study clearly demonstrates distribution of *L. kunawurensis* in the region. The species has been confused with similar-looking *Picrorhiza kurroa*, another important medicinal plant that grows in Ladakh. A detailed taxonomic description and photo illustrations of diagnostic characters, as worked out in the present study, will facilitate its easier field identification, which is crucial for its conservation and sustainable use.

The present study has revealed that *L. kunawurensis*

is currently Near Threatened (NT). Being narrow endemic to the Himalaya, rare distribution at high altitudes and smaller population size in the region makes the species highly vulnerable to contemporary land-use and climate changes (Rana et al. 2017). Ladakh region is recently experiencing climate change, which can impact both floral and faunal diversity of the region (Barrett & Bosek 2018). As *L. kunawurensis* is a narrow endemic species, thus considered more prone to extinction due to changing climate (Muthumperumal et al. 2020). In Ladakh, the species is mostly extracted by 'Amchis' (local herbal healers) for preparation of traditional medicine. Overexploitation for local use poses a serious threat to valuable wild medicinal plant species, and in turn endangers their habitats as well (Ganie et al. 2019). The medicinally important plant species is overharvested, in most cases illegally, from their wild habitats for trade in the national and international markets. This poses one of the biggest threats to the plant species (Ganie & Tali 2013). Worryingly, the species is extracted as a whole along with roots, that hinders its sexual (seeds) and/or asexual (rootstock) reproduction and which in turn results in reduction of population size and distribution (Tali et al. 2014). The species grows in landslide prone areas in the study area. Landslides are one of the major factors of habitat fragmentation (Dar & Naqshi 2002) and also play a major role in making the plant species vulnerable to local extirpation (Ganie et al. 2019). The landslides can lead to the competitive advantage for growth of other ruderal species due to changes brought

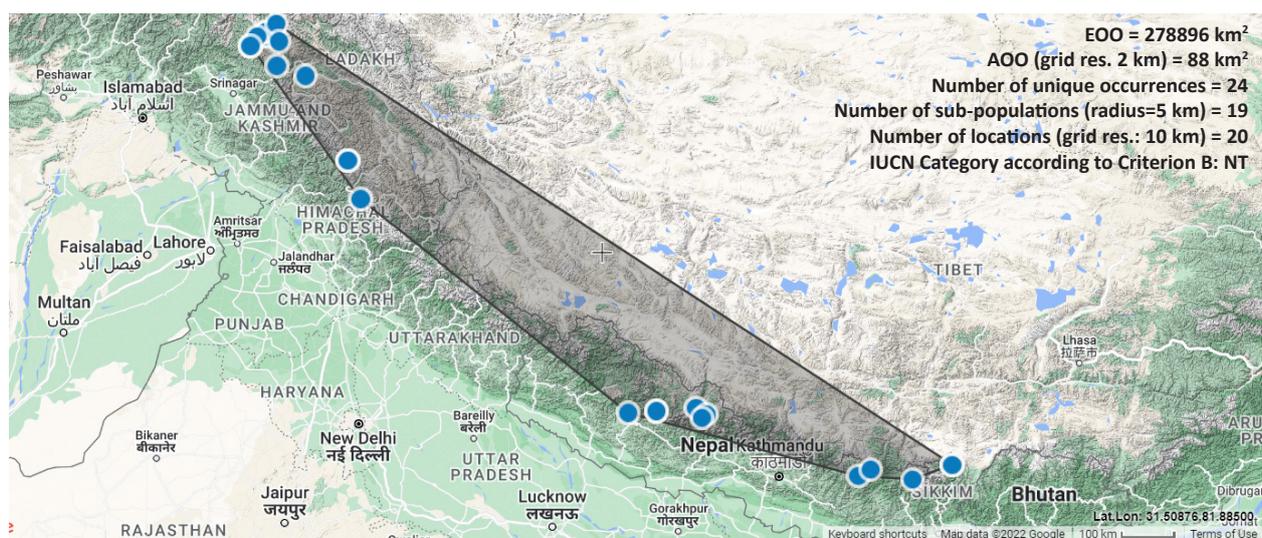


Figure 1. Result of the threat assessment for *Lagotis kunawurensis*. Blue dots represent the occurrence records for the target species, grey polygon the convex hull used for calculation of extent of occurrence (EOO). The inset (upper right black text) summarizes all the information calculated by the *IUCN.eval* function.

in physico-chemical properties of the soil, which in turn can render the natural habitat of endemic species unfavorable, and lead to their population decline (Tali et al. 2014; Ganie et al. 2019). If these threats continue to operate unchecked, the species is highly susceptible to become threatened in near future. To focus conservation action at a regional scale, it becomes necessary to prioritize these species in their natural distributional range (Nori et al. 2016).

Therefore, in an era of rapid land-use change and climate crisis, the results from present study have wide relevance in devising successful conservation strategies for this endemic species in high-altitude habitats of the Himalaya. Looking ahead, the present study can serve as an early warning for undertaking urgent efforts to conserve this important endemic medicinal plant species.

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Article

Identification of confiscated pangolin for conservation purposes through molecular approach

– Wirdateti, R. Taufiq P. Nugraha, Yulianto & Gono Semiadi, Pp. 21127–21139

Communications

The trade of Saiga Antelope horn for traditional medicine in Thailand

– Lalita Gomez, Penthai Siriawat & Chris R. Shepherd, Pp. 21140–21148

The occurrence of Indochinese Serow *Capricornis sumatraensis* in Virachey National Park, northeastern Cambodia

– Gregory McCann, Keith Pawlowski & Thon Soukhon, Pp. 21149–21154

Attitudes and perceptions of people about the Capped Langur *Trachypithecus pileatus*

(Mammalia: Primates: Cercopithecidae): a preliminary study in Barail Wildlife Sanctuary, India

– Rofik Ahmed Barbhuiya, Amir Sohail Choudhury, Nazimur Rahman Talukdar & Parthankar Choudhury, Pp. 21155–21160

Feather characteristics of Common Myna *Acridotheres tristis* (Passeriformes: Sturnidae) from India

– Swapna Devi Ray, Goldin Quadros, Prateek Dey, Padmanabhan Pramod & Ram Pratap Singh, Pp. 21161–21169

Population and distribution of Wattled Crane *Bugenerus carunculatus*, Gmelin, 1989 at lake Tana area, Ethiopia

– Shimelis Aynalem Zelelew & George William Archibald, Pp. 21170–21178

Waterbird assemblage along Punatsangchhu River, Punakha and Wangdue Phodrang, Bhutan

– Nima & Ugyen Dorji, Pp. 21179–21189

Freshwater fishes of the Chimmony Wildlife Sanctuary, Western Ghats, India

– P.S. Eldho & M.K. Sajeevan, Pp. 21190–21198

Butterflies of Eravikulam National Park and its environs in the Western Ghats of Kerala, India

– Kalesh Sadasivan, Toms Augustine, Edayillam Kunhikrishnan & Baiju Kochunarayanan, Pp. 21199–21212

The dragonflies and damselflies (Insecta: Odonata) of Shendurney Wildlife Sanctuary, southern Western Ghats, India

– Kalesh Sadasivan, Vinayan P. Nair & K. Abraham Samuel, Pp. 21213–21226

A pioneering study on the spider fauna (Arachnida: Araneae) of Sagar District, Madhya Pradesh, India

– Tanmaya Rani Sethy & Janak Ahi, Pp. 21227–21238

Taxonomy and threat assessment of *Lagotis kunawurensis* Rupr (Plantaginaceae), an endemic medicinal plant species of the Himalaya, India

– Aijaz Hassan Ganie, Tariq Ahmad Butt, Anzar Ahmad Khuroo, Nazima Rasool, Rameez Ahmad, Syed Basharat & Zafar A. Reshi, Pp. 21239–21245

The study of algal diversity from fresh water bodies of Chimmony Wildlife Sanctuary, Kerala, India

– Joel Jose & Jobi Xavier, Pp. 21246–21265

Review

A checklist of herpetofauna of Telangana state, India

– Chelmala Srinivasulu & Gandla Chethan Kumar, Pp. 21266–21281

Viewpoint

Comments on “The Dragonflies and Damselflies (Odonata) of Kerala – Status and Distribution”

– A. Vivek Chandran & K. Muhamed Sherif, Pp. 21282–21284

Short Communications

Landings of IUCN Red Listed finfishes at Chetlat Island of Lakshadweep, southeastern Arabian Sea

– Davood Nihal, N.M. Naseem, N. Abhirami & M.P. Prabhakaran, Pp. 21285–21289

First report of the termite *Glyptotermes ceylonicus* (Blattodea: Isoptera: Kalotermitidae) from India: an example of discontinuous distribution

– Edwin Joseph, Chinnu Ipe, Nisha P. Aravind, Sherin Antony & Jobin Mathew, Pp. 21290–21295

Authentic report of the emesine bug *Gardena melinarthrum* Dohrn, 1860 (Hemiptera: Heteroptera: Reduviidae) from India

– Sangamesh R. Hiremath, Santana Saikia & Hemant V. Ghate, Pp. 21296–21301

Reappearance of stomatopod *Gonodactylus platysoma* (Wood-Mason, 1895) after an era from the intertidal region of Chota Balu, South Andaman, India

– N. Muthu Mohammed Naha, Limaangnen Pongener & G. Padmavati, Pp. 21302–21306

Range extension of earthworm *Drawida impertusa* Stephenson, 1920 (Clitellata: Moniligastridae) in Karnataka, India

– Vivek Hasyagar, S. Prasanth Narayanan & K.S. Sreepada, Pp. 21307–21310

***Pelatantheria insectifera* (Rchb.f.) Ridl. (Orchidaceae): a new generic record for Eastern Ghats of Andhra Pradesh, India**

– V. Ashok Kumar, P. Janaki Rao, J. Prakasa Rao, S.B. Padal & C. Sudhakar Reddy, Pp. 21311–21314

Notes

New breeding site record of Oriental White Ibis *Threskiornis melanocephalus* (Aves: Threskiornithidae) at Thirunavaya wetlands, Kerala, India

– Binu Chullakattil, Pp. 21315–21317

Rediscovery of *Gardena melinarthrum* Dohrn from Sri Lanka

– Tharindu Ranasinghe & Hemant V. Ghate, Pp. 21318–21320

A report on the occurrence of the cicada *Callogaeana festiva* (Fabricius, 1803) (Insecta: Cicadidae) from Mizoram, India

– Khawhrling Marova, Fanai Malsawmdawngliana, Lal Muansanga & Hmar Tlawmte Lalremsanga, Pp. 21321–21323

New distribution records of two species of metallic ground beetles of the genus *Chlaenius* (Coleoptera: Carabidae: Chlaeniini) from the Western Ghats, India

– Duraikannu Vasanthakumar & Erich Kirschenhofer, Pp. 21324–21326

Report of *Euphaea pseudodispar* Sadasivan & Bhakare, 2021 (Insecta: Odonata) from Kerala, India

– P.K. Muneer, M. Madhavan & A. Vivek Chandran, Pp. 21327–21330

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