Why is it essential to critically study allied taxa while describing those new to science? A case study based on *Lepidagathis keralensis* (Acanthaceae)

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The effective conservation of a species is feasible only when its taxonomy and ecology are well understood. India is one of the top ten countries in the world, reporting several new species and is also recognized as a centre of plant extinction. The role of plant taxonomists in the country is considered crucial. This article discusses one of the most neglected taxonomic practices among Indian taxonomists while describing new taxa. It is done in the context of the field and detailed macro- and micromorphological studies of a newly described Lepidagathis Willd. (Acanthaceae) species from the lateritic plateaus of the Western Ghats in Kerala as an example. The taxonomy of Lepidagathis keralensis Madhus. & N.P. Singh is also discussed with an updated description and colour photographs for precise identification.

Keywords: Allied and new taxa, diagnostic characters, *Lepidagathis keralensis*, plant extinction, taxonomic practices.

THE description of new taxa is essential to synthesize and disseminate the available information on them to the world of science and promote research and understanding of their ecology, uses, evolutionary relationships, risk of extinction and conservation[1,2]. In the last five years, an average of 2377 species of vascular plants have been described as new each year[3]. Cheek *et al.*[1] reported 1942 species of plants and 1886 species of fungi described from different parts of the world in 2019, of which 36% of plants and 41% of fungi were from Asia. India is one of the top ten countries reporting the maximum number of new species globally. Mao *et al.*[4,5] reported 122 and 139 taxa of vascular plants described as new from India in 2020 and 2021 respectively. Lughadha *et al.*[6] estimated that 39% of all vascular plants – two-out-of-five – are threatened with extinction primarily owing to various anthropogenic activities, such as agriculture and aquaculture, overexploitation of biological resources, modification of natural systems, residential and commercial development, fast-spreading of invasive and other problematic species, pollution, climate change, energy production and mining and transportation. Furthermore, they have predicted that the ongoing rate of plant extinction is up to 500 times faster than that of the pre-Anthropocene era and reported that India is one of the major centres of plant extinction. To preserve and conserve biodiversity, it is essential to document the existence and distribution of biodiversity worldwide, especially in biodiversity-rich regions[7]. Taxonomists play a crucial role in documenting the biodiversity of any geographic region.

Venu and Sanjappa[8] argued that plant taxonomy could be complicated if undertaken without caution. They noted that essential taxonomic practices are sometimes neglected by Indian taxonomists when describing a new taxon, reporting rediscoveries, assessing IUCN conservation statuses, depositing types and vouchers, and publishing new combinations and typifications of plant names. This article discusses one such essential taxonomic practice that must be meticulously executed, with a case study in the genus *Lepidagathis* Willd. (Acanthaceae).

Describing species or infraspecific taxa (subspecies, varieties and forma) as new to science is one of the goals of a taxonomic researcher and typically results from critical taxonomic studies, as part of a flora, revision or monograph, based on field and herbarium specimens coupled with a thorough review of earlier published literature. The ability to recognize diagnostic characters of a taxon that allow it to be differentiated from its close relatives is one of the most significant skills required by a taxonomist specialized in a particular group of plants. Wood[9] proposed a classification of taxonomists along with the dichotomous key. The following categories were recognized: the over-cautious, the alternative, the idealogue (matrician and monophylist),

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the pragmatist (splitters and lumpers), the flora or monograph writers and the cherry pickers, primarily based on their approach to the description of new taxa. The International Code of Nomenclature for algae, fungi and plants provides the mandatory requirements for publishing a legitimate and correct name unambiguously between articles 29 and 45 (ref. 10). Thus, it is a prerequisite for plant taxonomists to have sound knowledge of the Code to publish an effective and valid name for a novel taxon.

While describing species or infraspecific categories, many essential steps must be followed before concluding that the taxon is new to science. First, a detailed description needs to be provided, based, wherever possible, on both freshly collected and herbarium specimens, representing the full range of the geographical distribution of the taxon, to document the total variation of micro- and macro-morphological characters. In some cases, the description of a novel taxon is based on one or two herbarium specimens. In such cases, it is essential to carry out field tour(s) to locate and assess the status of earlier collection(s) to study the taxon thoroughly.

Second, the morphological characters of the proposed new taxon must be compared with other taxa within the group globally to ensure that it has not been already described. In many cases, a novelty is confirmed by comparison only with taxa within a particular geographical area and without studies across the entire geographical distribution range or of all the known global taxa. This is one of the most common errors committed, which results in the description as a novelty of a taxon that has already been described. Comparisons should be made using specimens. A detailed study of related taxa is often given unequal priority when describing a new taxon. If the comparison of diagnostic characters is based only on the protologue or subsequent publications of allied taxa, ambiguities or errors may occur.

Third, a thorough scrutiny of protologue and a detailed examination of type specimen(s) of morphologically allied taxa must be undertaken before describing a new taxon. This step is often neglected since it involves a rigorous and time-consuming search. The type specimen(s) are not necessarily 'typical' of a species – they do not represent the complete range of variation within a taxon, but their examination is critical to ensure the correct application of names.

New species should not be described without citing the details of allied species[11]. Keys provided should work – they should be complete, without missing couplets or ending abruptly[12]. Tables detailing diagnostic characters should be carefully constructed to avoid the impression that trivial differences are equal in significance to those diagnostic characters that differentiate taxa. Finally, new taxa – as scientific hypotheses – should be scrutinized by scientific peers; they should not be published in non-peer-reviewed journals to avoid questioning and alternative opinions.

As part of an ongoing study on the 'Systematics of *Lepidagathis* Willd. (Acanthaceae) in India' funded by the Science and Engineering Research Board (SERB/CRG/2020/001605), Government of India, field explorations were conducted in the lateritic plateaus of Western Ghats in Kerala. During one of the explorations, plant materials of *Lepidagathis keralensis* Madhus. & N.P. Singh were collected from in and around its type locality, Madayippara, in Kannur district, Kerala[13]. A detailed description, including its morphological variation, has been prepared based on fresh specimens using Stemi 508 microscope coupled with Axiocam 208 colour camera (Zeiss, Germany). This detailed gross morphological study revealed that many morphological characters provided in the protologue[13] and subsequent publication[14] need to be emended and revised. This species has been referred to in the description of a recently described new species from the lateritic plateaus of the Western Ghats in Kerala, *Lepidagathis ananthapuramensis* V.S.A. Kumar *et al*. (ref. 15). The flowering and fruiting specimens of the species have also been collected and critically examined in the present study.

The objectives of this article are to: (i) present a revised and updated description of *L. keralensis* along with colour photographs, photomicrographs and lectotypification of the name and (ii) demonstrate the need for a detailed morphological study of allied taxa when describing those new to science with a case study along with emended potential differences between *L. keralensis* and *L. ananthapuramensis* based on the updated description in the present study.

Taxonomy of *Lepidagathis keralensis*

A stenoendemic species, *L. keralensis* was described by Madhusoodanan and Singh in 1992 based on fresh collection and herbarium specimens housed at University of Calicut, Malappuram (CALI) and Royal Botanic Gardens, Kew (K) from Madayippara and adjoining lateritic plateaus in the Kannur district of Kerala[13]. The present detailed macro- and micro-morphological study based on fresh and herbarium specimens of *L. keralensis* revealed that the original description of this species by Madhusoodanan and Singh[13] did not capture the full range of variation of this taxon. Thus, an updated description has been provided here, along with colour photographs and photomicrographs.

Lepidagathis keralensis Madhus. & N.P. Singh, *Kew Bull*., 1992, **47**(2), 301 (Figures 1 and 2).

Lectotype (designated here): India, Kerala, Kannur district, Madayippara, 50 m, 20.04.1988, *P.V. Madhusoodanan & E. Jayakumar* 11868 [K (K000939674, digital image)].

Perennial prostrate herb with woody rootstock, spreading up to 1 m long in diameter, rooting at basal nodes. Stems well-branched, four-angled, ash-coloured and glabrous when old, purplish-green and hairy at the nodes when young; internodes 1.2–14 mm long. Leaves sessile, opposite-decussate, lance-ovate to oblong, 4–10 × 1.5–2 mm, obtuse at base, entire at margins, acute to blunt-acuminate at apex in the vegetative leaves; inflorescence-producing branches

possess densely pubescent leaves with spinose apical process; eucamptodromous veins, midvein broad at base, lateral veins 2 or 3 pairs, conspicuous on the lower surface. Monochasial cyme or spike, compressed, linear, raised at terminal branches, 2–10 cm long, 2–30-flowered. Bracts: sterile bract 1, lance-ovate to narrowly elliptic, 7.4–8.5 × 1.6–2.1 mm, obtuse or truncate at base, glandular-hairy at margins, acute with a spinose apical process at apex, glandular-hairy throughout, midvein broad at base, eucamptodromous veins in first sterile bract, lateral veins two pairs; acrodromous veins in the rest of the sterile bracts, veins 3–5, conspicuous on both surfaces; fertile bract one, lance-ovate to elliptic-ovate, 7.1–9.1 × 1.7–2.6 mm, obtuse or truncate at base, glandular-hairy at margins, acute with spinose apical process at apex, glandular-hairy throughout, midvein broad at base, eucamptodromous veins at first fertile bract, lateral veins two pairs; acrodromous veins in the rest of the sterile bracts, veins five, conspicuous on both surfaces. Bracteoles two, narrowly elliptic, 4.8–6.6 × 0.9–1.4 mm, cuneate or obtuse at base, glandular-hairy at margins, narrowly acute with a spinose apical process at apex, glandular-hairy throughout, midvein broad at base, acrodromous veins three, conspicuous on both surfaces. Calyx five-lobed; lobes heteromorphic, glandular-hairy at margins, acute with a spinose apical process at apex, glandular-hairy throughout, acrodromous veins, conspicuous on both surfaces; anticous lobes two, unequal, overlapping, connate at base (one-quarter of their total length, i.e. 1.4–2.5 mm), lobes narrowly elliptic, dimorphic, 6.7–8.6 × 1.3–2.4 mm (large lobe) and 5.4–8.2 × 1.1–1.9 mm (small lobe), acrodromous veins, long lobe five-veined, short lobe three-veined; posterior lobe one, ovate, 7.6–9.88 × 2.2–4 mm, acrodromous veins, 5–7-veined; lateral lobes two, lanceolate to narrowly elliptic, 5.6–8 × 0.7–1.69 mm. Corolla bilabiate, 11.8–13.8 mm long, purplish-pink throughout the inside with yellow dots or patches on the palate; tube 5.86–8.6 mm long, cylindrical below for 3–4.8 mm long, glabrous inside, abruptly expanded above for 2.6–4.2 mm long, glabrous inside, retrorsely hairy outside; upper lip arcuate, 2.5–3.69 × 3.3–5.2 mm, entire at margins, minutely two-lobed (0.4–0.68 mm long) at apex, each lobe three-veined; lower lip three-lobed, having a membranous portion on either side of the centre

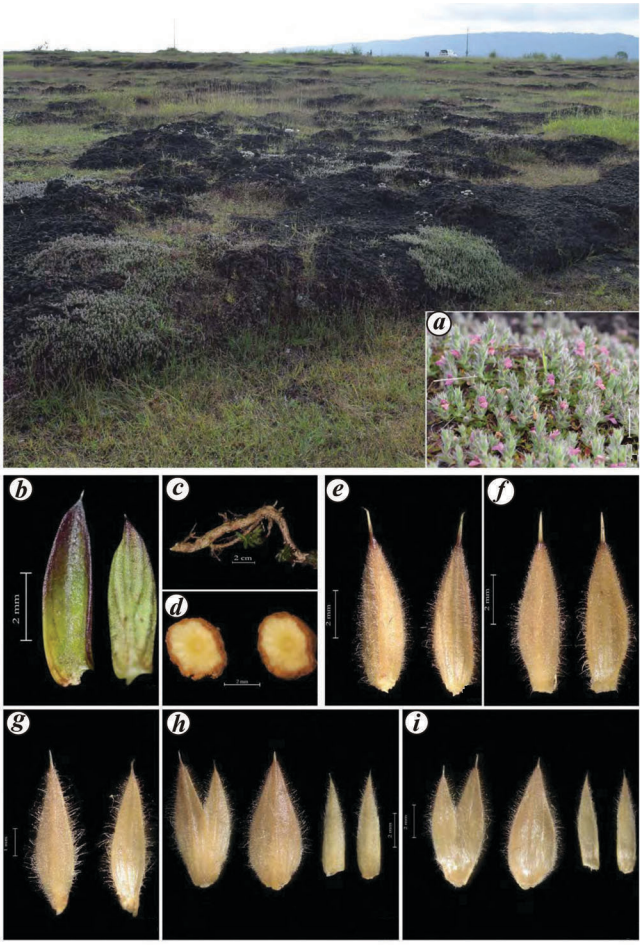

Figure 1. *Lepidagathis keralensis* Madhus. & N.P. Singh. ***a***, Habitat with plants as inset; ***b***, Leaf; ***c***, Stem – old; ***d***, Stem – cross-section; ***e***, Sterile bract; ***f***, Fertile bract; ***g***, Bracteoles; ***h***, ***i***, Upper (***h***) and lower (***i***) surfaces of calyx lobes.

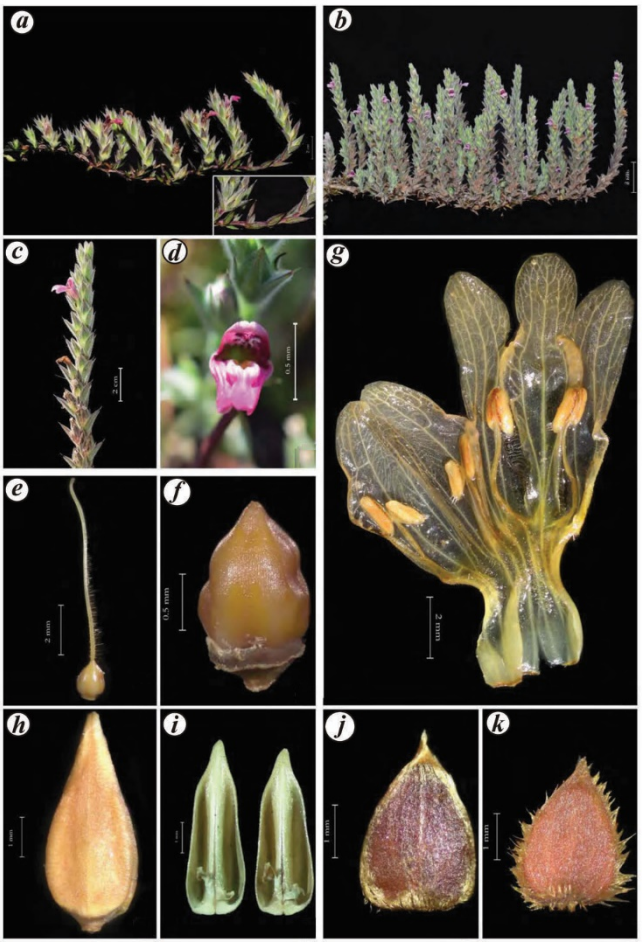

Figure 2. *L. keralensis* Madhus. & N.P. Singh. ***a–c***, Range of variation in inflorescence length with reproductive leaves; ***d***, Close-up view of flower showing lower lip; ***e***, Carpel; ***f***, Ovary with nectary disk; ***g***, Corolla – split open; ***h***, ***i***, Capsule – split open; ***j***, ***k***, Seed – dry and wet with hygroscopic golden hairs.

Table 1. Comparison of diagnostic characters between *Lepidogathis ananthapuramensis* and *Lepidogathis keralensis* as given by Biju *et al*.[15] with the present observations

Diagnostic characters	*L. ananthapuramensis*	*L. keralensis*	Present observations
Plant	Erect	Prostrate	This character is diagnostic. However, rarely *L. ananthapuramensis* grows as a decumbent herb (Figure 3 *b*).
Stems	4–6-sided, narrowly winged along the angles, purplish-brown, densely pubescent at the apex and sparsely pubescent towards the base	Quadrangular, more or less winged, always glabrous	In *L. ananthapuramensis*, six-angled stems are not seen in the present study. However, the stems of young branches are four-angled and old branches are almost circular in both species (Figures 1 *c*, *d* and 3 *c*). In *L. keralensis*, the younger branches are four-angled, purplish-green with hairs at the nodes. The indumentum on stems and branches is diagnostic.
Leaves	Pubescent, with 4–6 pairs of veins, acute or spinose-pointed at the apex	Glabrous, 1 or 2 pairs of veins, acute or blunt-acuminate at apex	In *L. keralensis*, the inflorescence-bearing branches has densely pubescent leaves with a spinose apical processes at apex (Figure 2 *a*), whereas the vegetative leaves are glabrous with acute to blunt-acuminate apices; lateral veins 2 or 3 pairs (Figure 1 *d*). The vegetative leaves are diagnostic.
Spikes	*c*. 10 cm long, 14–30-flowered	*c*. 2 cm long, 2–5-flowered	In *L. keralensis*, the length of spike ranges from 2 to 10 cm long with 2–30 flowers (Figure 2 *a* and *b*). This character has been erroneously described in the protologue[13]. It is not diagnostic.
Flowers	Sessile or subsessile	Sessile	*L. ananthapuramensis* produces sessile flowers. This character is not diagnostic.
Anthers	Hairy at the base and lateral sides, cream-coloured with purple shade	Sparsely hairy, purple to deep violet	The colour and hairy nature are similar in both species. This character is not diagnostic.
Nectary disk	Cupular	Annular	Generally, the disk in *Lepidagathis* species is more or less a same, but often differentiated with multiple synonymous terms such as 'annular', 'cupulate' or 'cupular', 'cup-shaped' and 'bowl' or 'flat bowl-shaped'. In the present study we describe this feature as cupulate (Figures 2 *e–f* and 3 *h*). This character is not diagnostic.
Capsules	Conical, 1–4-seeded	Conical, 2-seeded	Generally, the shape of the capsule in *Lepidagathis* is lance-ovoid to ovoid in face view. The capsule of *L. keralensis* has always one fertile seed, while the remaining three seeds are either immature or aborted (Figure 2 *h* and *i*). Only one fertile seed is noticed in both species, while the remaining three seeds are either immature or aborted (Figures 2 *h*, *i* and 3 *j*, *k*). This character is not diagnostic.
Seeds	Obliquely ovate, compressed, obtuse at apex, hairy	Oblong, flat, obtuse at apex, soft and hairy	In *L. keralensis*, the seed is ovoid in face view (Figure 2 *j*; which has been erroneously described as oblong in the protologue[13]), and sparsely clothed with hygroscopic golden hairs (Figure 2 *k*). According to Figures 2 *o* and 3 *i* of *L. ananthapuramensis*[15] and the present observations, the seeds are lance-ovoid and not compressed (Figure 3 *l* and *m*). The terms 'compressed' and 'flat' (*L. keralensis*) are synonymous. This character is not diagnostic.

of the palate with purplish-brown horizontal striations, 3.2–5.9 mm long, including lobes, lobe spreading at throat for 5.2–5.5 mm long; middle lobe slightly broader than the lateral lobes, oblong to suborbicular, 1.8–2.5 × 1.4–2 mm, entire, three-veined; lateral lobes oblong, 1.7–2.7 × 1.1–1.98 mm, three-veined. Stamens four, didynamous; filaments purple to white, glabrous; anticous (longer) filaments 3–3.7 mm; posticous (shorter) filaments 2.3–2.7 mm; anthers oblong-elliptic, divergent, 1.1–1.67 mm long, purple to white, sparsely hairy at base of the slit, scabrous at the connectives, longitudinally dehiscing. Ovary sub-globose, 1.3–1.6 × 0.9–1.16 mm, glabrous, two-loculed; ovules two in each locule; nectary disk cupulate; style 7.3–7.7 mm long, bristled-glandular-hairy; stigma bilobed. Capsules ovoid in face view, 4.6–5.7 × 1.8–2.5 mm, glabrous, green to yellowish-brown; seed one, fertile, ovoid in face view, 2.2–2.8 × 1.7–2.1 mm, flat, sparsely clothed with hygroscopic short white hairs on both surfaces.

Vernacular name: Paramullu (Malayalam).

Distribution in India: Kerala (Kannur district).

Flowering and fruiting: September–April.

Habitat: Grows on barren lateritic rocks.

Specimens examined: India, Kerala, Kannur district, Ezhimala, 10.09.1978, *P.V. Madhusoodanan & K. Swarupanandan* CU13451 (K000939675, digital image); Madayipara, 50 m, 20.04.1988, *P.V. Madhusoodanan & E. Jayakumar* K11868 (K000939674, digital image); Payangadi, 22.11.1988, *P.P. Sudhirkumar* CALI2599 (K000939677, digital

image); Pazhayangadi, 10.10.1988, *M. Sebastian* CALI1499 (K000939676, digital image); Madayippara, Near lake, way to Madayippara, 14.12.2011, *C. Pramod* 126913 (CALI109-017); Madayippara, *s.die*, *C. Pramod* 100009 (CALI109-016); Madayippara, S.N. School, 14.12.2011, *C. Pramod* 126911 (CALI109018); Madayippara, 60 m, 14.10.2021, *A.F.J. King & M.N. Pradeep* 12815, 12816, 12817 (Madras Christian College Herbarium, Chennai); Madayippara, 59 m, 27.12.2021, *G. Gnanasekaran & A.F.J. King* 12834 (Madras Christian College Herbarium, Chennai); Madayippara, near SN School, 28 m, 27.12.2021, *G. Gnanasekaran & A.F.J. King* 12835 (Madras Christian College Herbarium, Chennai).

Nomenclatural note: While describing the species, Madhusoodanan and Singh[13] cited a holotype (*Madhusoodanan* CU29323) specimen deposited at MH without (any details on isotype along with five paratype specimens (*Madhusoodanan* CU50407, *Madhusoodanan & Jayakumar* K 11868, *Madhusoodanan & Swarupanandan* CU13451, *Sebastian* CALI1499 and *Sudhir Kumar* CALI2599) at CALI and K. Consultation of the type section of MH for the holotype specimen revealed that it was missing or perhaps not deposited by the authors. Therefore, *P.V. Madhusoodanan & E. Jayakumar* 11868, one of the paratype specimens with the barcode K000939674 (K), has been designated here as the lectotype for the name in accordance with article 9.3 of the Code[10].

Case study

Lepidagathis ananthapuramensis was described from the lateritic plateaus of Kasargod district in Kerala based on two fresh gatherings along with colour photographs showing morphological characters of the new species and its allied species *L. keralensis* and providing the key to the species of *Lepidagathis* from Kerala[15]. Although the authors included colour photographs based on fresh specimens of *L. keralensis*, the diagnostic characters in the differentiating table were primarily sourced from either the protologue[13] or earlier published literature[14]. Furthermore, it is surprising that the authors had overlooked the work of Shaju *et al.*[16], which presents the erroneous identification of this new species as *L. clavata* Dalzell from Ananthapuram temple, the type locality of *L. ananthapuramensis*. An updated description of the species based on fresh and herbarium specimens is given below. Table 1 presents the differentiating diagnostic characteristics of *L. ananthapuramensis* and *L. keralensis* with detailed observations based on the present study.

Lepidagathis ananthapuramensis V.S.A. Kumar *et al.*, *Phytotaxa*, 2020, **460**, 269 (Figure 3).

Holotype: India, Kerala, Kasaragod district, Ananthapuram, 12.09.2019, *P. Biju & V.S. Anil Kumar* 7862 (TBGT).

Distribution in India: Kerala (Kasaragod district).

Flowering and fruiting: July–January.

Habitat: Grows on barren lateritic plateaus amidst grasses.

Specimens examined: India, Kerala, Kasaragod district, Ananthapuram temple, 103 m, 11.09.2018, *T. Shaju & Rijuraj* 77528 (TBGT, digital image); around Ananthapuram temple, 75 m, 14.10.2021, *A.F.J. King* 12818, 12819, 12820, 12821 (Madras Christian College Herbarium, Chennai); around Ananthapuram temple, 73 m, 29.12.2021, *G. Gnanasekaran & A.F.J. King* 12845 (Madras Christian College Herbarium, Chennai).

Emended diagnosis: A careful examination of plant materials of *L. ananthapuramensis* and *L. keralensis,* along with the pertinent literature, revealed that these two species could be differentiated from each other by the following characteristics: (i) Plant erect, rarely decumbent versus prostrate. (ii) Leaves 12–30 × 4–10 mm, truncate or subcordate at base, with a spinose process at the apex, densely pubescent on both surfaces; lateral veins 3–6 pairs versus 4–10 × 1.5–2 mm, obtuse at base, acute to blunt-acuminate at the apex, glabrous (densely pubescent with a spinose process at the apex in reproductive branches); lateral veins 2 or 3

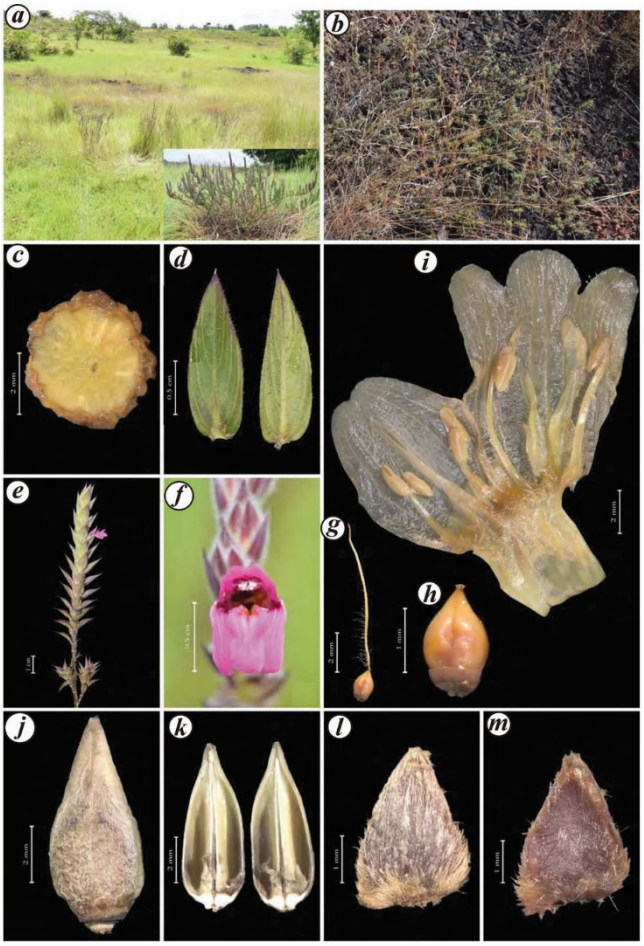

Figure 3. *Lepidagathis ananthapuramensis* V.S.A. Kumar *et al.* ***a***, Habitat with plants as inset; ***b***, Plant decumbent; ***c***, Stem – cross-section; ***d***, Leaf; ***e***, Inflorescence; ***f***, Flower close-up view of flower showing lower lip; ***g***, Carpel; ***h***, Ovary with nectary disk; ***i***, Corolla – split open; ***j***, ***k***, Capsule – split open; ***l***, ***m***, Seed – dry and wet with hygroscopic golden hairs.

pairs. (iii) Corolla 16.5–18 mm long with tube 9.3–10.9 mm long versus 11.8–13.8 mm long with tube 5.8–8.6 mm long. (iv) Stamens: anticous (longer) filaments 4.8–6.4 mm, posticous (shorter) filaments 2.9–4.2 mm; anthers 1.7–2.3 mm long versus anticous (longer) filaments 3–3.7 mm; posticous (shorter) filaments 2.3–2.7 mm; anthers 1.1–1.67 mm long. (v) Capsules 5.9–7.4 × 2–3.2 mm versus 4.6–5.7 × 1.8–2.5 mm.

Conclusion

This article highlights important steps to follow while describing a taxon new to science. Through critical examination of specimens, we demonstrate the significance and need for a detailed morphological study of not only the proposed new species but also of allied species to ensure accurate and reliable diagnostic characters for differentiating taxa. This should not rely on the literature alone; taxonomists should endeavour to examine specimens from across the range of distribution of taxa pertinent to the study to ensure that the variation in characters is fully documented.

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