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A further new species of *Isoglossa* (Acanthaceae) from the Eastern Arc Mountains of Tanzania

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Summary. *Isoglossa pareensis* I.Darbysh. & Hemp (Acanthaceae), from submontane moist forest at Mwala in the South Pare Mountains of northeastern Tanzania, is described and illustrated. This species is considered to be related to *I. gregorii* (S.Moore) Lindau and *I. punctata* (Vahl) Brummitt & J.R.I.Wood, which are widespread in the montane forests of eastern Africa, but it clearly differs from these species in inflorescence structure and indumentum and in anther morphology. Notes on the habitat requirements and extinction risk of this new species are provided; it is considered to be Vulnerable under IUCN criterion D2 because of its extremely limited range and a plausible future threat from wildfires. The recent discovery of the Critically Endangered acanthaceous herb *Asystasia masaiensis* Lindau at lower, drier elevations at the same site is also reported and the first known photograph of that species is reproduced

Key Words. Conservation, extinction risk, Isoglossinae, IUCN Red List, taxonomy.

Introduction

The genus *Isoglossa* Oerst. (Acanthaceae: Acanthoideae: Justicieae: Isoglossinae; Kiel *et al.* 2006; Manzitto-Tripp *et al.* 2021) currently comprises c. 70 species, distributed across the palaeotropics and subtropics, with centres of species richness in eastern and southern Africa (POWO 2022). It is currently delimited by having the combination of a bilabiate corolla with ascending-cochlear aestivation, two bithecous stamens that lack appendages on the thecae, 4-seeded stipitate capsules, and (usually) biporate pollen (i.e., with two compound apertures, each with the ecto- and endo-apertures both porate), circular in apertural view and with a pronounced interapertural "girdle" of tectate exine, termed "gürtelpollen" (Darbyshire *et al.* 2023). The limited molecular phylogenetic evidence currently available indicates that *Isoglossa* s.l. is paraphyletic, with monothecous genera of Isoglossinae arising out of it (McDade *et al.* 2021). However, clear synapomorphies to support the splitting of *Isoglossa* have not yet been identified, and further molecular data, including the use of Next Generation Sequencing techniques, is required before further decisions on generic delimitation in Isoglossinae can be made (Darbyshire *et al.* 2023).

In the *Flora of Tropical East Africa* account for *Isoglossa*, 26 species were documented in Tanzania, of which three were undescribed and poorly known due to incomplete material (Darbyshire *et al.* 2010). *Isoglossa* s.l. is noteworthy for including a significant number of narrowly range-restricted taxa, both in Tanzania and in wider tropical and southern Africa and Madagascar (Brummitt 1985; Darbyshire 2009; Darbyshire *et al.* 2010, 2011, 2021, 2023; Balkwill *et al.* 2017; Champluvier & Fischer 2020). Although the genus occurs in a range of habitats, many of these range-restricted species are endemic to specific mountain ranges. For example, the Eastern Arc Mountains of Kenya and Tanzania — well known for their exceptionally high biodiversity and endemism (Burgess *et al.* 2007; Gereau *et al.* 2016) — support seven endemic species of *Isoglossa*. These are *I. asystasioides* I.Darbysh. & Ensermu, *I. bondwaensis* I.Darbysh., *I. ixodes* Lindau and *I. oreacanthoides* Mildbr. from the Uluguru Mountains, *I. candelabrum* Lindau from the Taita Hills and East Usambara Mountains, *I. variegata* I.Darbysh. from the East Usambara and Nguru Mountains, and *I. ventricosa* I.Darbysh. from the southwestern-most extremity of the Eastern Arc in Lulanda Forest and the Mufindi Escarpment (Darbyshire 2009; Darbyshire *et al.* 2010).

Here, we report on a further new species of *Isoglossa* endemic to the Eastern Arc Mountains in Tanzania, found by the second author during ongoing ecological studies of forest biodiversity on East African mountains. The type locality for this new species, at Mwala in the South Pare Mountains of Kilimanjaro Region, Tanzania (Fig. 1), is of high botanical interest. A new orchid species, *Rhipidoglossum pareense* Cribb & Hemp, was documented recently from this site (Cribb & Hemp 2022), and the recently described *Asplenium arcumontanum* Hemp & N.R.Crouch (Aspleniaceae) occurs here and on the neighbouring North Pare and West Usambara Mountains (Hemp & Crouch 2018). Furthermore, the rare *Asystasia masaiensis* Lindau was encountered in the dry foothill savannas at Mwala at

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Fig. 1. Mwala, South Pare Mountains, Tanzania. **A** aerial view of submontane forest and associated habitats; **B** within the forest understorey with shaded rock outcrops; **C** ground fog within the forest, a major source of moisture at this site; **D** *Asystasia masaiensis* recorded from the dry foothill savannas at Mwala, collected as *A. Hemp* 7348. PHOTOS: A. HEMP.

700 m elevation in December 2019 (*A. Hemp* #7348; Fig. 1D). This latter species was previously known only from two collections from Mkomazi town to the south of the South Pare Mountains, and is assessed as Critically Endangered on the IUCN Red List (Vollesen in Darbyshire *et al.* 2010; Luke *et al.* 2015).

The new *Isoglossa* species was first collected in November 2017 when it was found primarily in fruit; the specimen was shown to the first author during a research visit to the Kew herbarium, and was found not to match any of the species documented in the *Flora of Tropical East Africa* (Darbyshire *et al.* 2010). Flowering material was later collected and the species was also grown from seed in the glasshouses at the University of Bayreuth where an additional herbarium specimen was made, allowing for confirmation that this is an undescribed species. Based on similarities in corolla and seed morphology, it is hypothesised to be allied to *Isoglossa gregorii* (S.Moore) Lindau and *I. punctata* (Vahl) Brummitt & J.R.I.Wood, which are both widespread in the mountains of eastern Africa, but the new species displays clear and consistent morphological differences such that they are unlikely to be confused.

Materials & Methods

This work is based on the study of both herbarium collections and live plants of the new species of *Isoglossa* from Mwala in the South Pare Mountains of Tanzania and from cultivated plants at the University of Bayreuth grown from seed collected from the type locality. The herbarium material was analysed and measured at K. Prior to dissection, a flower was soaked in Aerosol OT 5% solution; all other characters were measured on dry material. Herbarium abbreviations follow Thiers (continuously updated).

The species conservation (extinction risk) assessment follows the Categories and Criteria of the IUCN Red List (IUCN 2012) and the guidelines for their use (IUCN Standards and Petitions Subcommittee 2022).

Taxonomic Account

Isoglossa pareensis *I.Darbysh. & Hemp* **sp. nov.** Type: Tanzania, South Pare Mountains, Mwala, 28 Nov. 2017, *A. Hemp* 6953 (holotype K; isotypes B, NHT, UBT).

http://www.ipni.org/urn:lsid:ipni.org:names:77323326-1

Slender herbs 10 – 25 cm tall, trailing and rooting towards base, with decumbent leafy stems; stems green, with conspicuous cystoliths, angular (sulcate in dried material), with inconspicuous short pale retrorse or mixed antrorse and retrorse hairs mainly on two opposite sides, hairs more dense along the nodal line. *Leaves* ovate or proximal leaves ovate-elliptic, pairs somewhat anisophyllous, largest leaves 4.2 – 6 × 2.5 – 3.9 cm, each leaf with base broadly cuneate to obtuse or rounded or distal-most leaves shallowly cordate, margin entire, apex acute to shortly attenuate, surfaces largely glabrous except for antrorse multicellular hairs along midrib above and margin, or adaxial surface with scattered multicellular hairs appearing deflated in dry state; cystoliths linear, conspicuous in dry state; petiole 20 – 33 mm long, antrorse-pubescent along adaxial groove. *Inflorescence* a slender panicle-like thyrse 74 – 105 × 28 – 37 mm including primary peduncle 26 – 32 mm long, few-branched, the branches dichasial or partially monochasial; inflorescence axes shortly glandular-pubescent and eglandular-puberulous to -pubescent, glandular hairs 0.1 – 0.25 mm long, sometimes more dense on the secondary branches; bracts and bracteoles purplish, linear-lanceolate, 1.3 – 3.6 mm long, up to 0.5 mm wide. *Calyx* purple, lobes linear-lanceolate, 3.4 – 3.8 mm long in flower, 4.6 – 5.5 mm long in fruit, shortly glandular-pubescent and eglandular-puberulous. *Corolla* white suffused pink and with deeper pink markings on palate of lower lip, 10.5 – 11.5 mm long, pubescent externally mainly on dorsal side of tube; tube cylindrical, 6.7 – 7 mm long, with basal cylindrical portion ± 1.5 mm in diam., only slightly widened towards mouth where 2 – 2.3 mm in diam.; upper lip 2.7 – 2.8 mm long, apex 2-lobed for ± 1.6 mm, lobes somewhat reflexed; lower lip 3.6 – 4.7 mm long, with 3 lobes 2 – 2.8 mm long, palate somewhat raised with central furrow, lacking prominent herring-bone patterning, glabrous. *Stamens* inserted ± 4 mm from base of corolla tube; filaments free for 2.8 – 3 mm, glabrous; anthers barely exserted or held in corolla mouth, thecae slightly oblique to parallel, overlapping for half their length, upper theca 0.65 – 0.75 mm long, lower theca 0.6 – 0.7 mm long, muticous. *Pistil* glabrous; style ± 5 mm long; stigma shortly bilobed. *Capsule* stipitate with expanded fertile portion, 9.5 – 10.5 mm long, puberulous with eglandular and occasional glandular hairs; seeds subflattened, ± 3 × 2.7 mm, with elongate, minutely glochidiate tubercles particularly towards the rim Figs 2, 3 and 4.

RECOGNITION. *Isoglossa pareensis* is similar to *I. gregorii* in foliage and to both *I. gregorii* and *I. punctata* in corolla form and in having seeds with elongate, minutely glochidiate tubercles, but differs from both in the inflorescence being a panicle-like thyrse with pedunculate dichasial or monochasial cyme units (vs inflorescence a simple spike or, if branched, the branches being spiciform with (sub) sessile cyme units); in the anther thecae overlapping for c. half their length (vs thecae fully superposed to widely separated); in the capsule being puberulous with eglandular and occasional glandular hairs (vs capsule glabrous or occasionally with few eglandular hairs towards apex and/or with scattered glandular and/or long eglandular hairs); and in the inflorescence axes and calyces having a more dense indumentum including more numerous glandular hairs. It additionally differs from *I. gregorii* in having linear-lanceolate bracts, 1.3 – 3.6 × 0.3 – 0.5 mm (vs bracts elliptic, somewhat obovate or basal pairs ovate, (3.5 –) 4.5 – 14 × 0.7 – 6 mm) (Fig. 5; Table 1).

DISTRIBUTION. This species is known only from the South Pare Mountains of Kilimanjaro Region, northeast Tanzania.

ADDITIONAL COLLECTIONS STUDIED. TANZANIA. Kilimanjaro Region, South Pare Mountains, Mwala, 1700 m, fl. & fr., 17 Dec. 2019, *A. Hemp* 7355 (NHT, UBT); cult. at Univ. Bayreuth, fl., 13 June 2021, *A. Hemp* 8165 (K, NHT, UBT).

HABITAT & ECOLOGY. This species occurs in the herb layer of lower montane *Newtonia* forests between 1600 and 1700 m, with an underlying geology of gneisses (Geological survey of Tanzania, Quarter degree sheet 108, Hedaru) (Fig. 1). Dominant associated trees include *Newtonia buchananii* (Baker f.) G.C.C.Gilbert & Boutique (Fabaceae), *Pleiocarpa pycnantha* (K.Schum.) Stapf (Apocynaceae; newly recorded for South Pare), *Strombosia scheffleri* Engl. (Olacaceae), *Drypetes gerrardii* Hutch. (Putranjivaceae), *Syzygium micklethwaitii* Verdc. sensu stricto (Myrtaceae), *Dasylepis integra* Warb. (Achariaceae), *Xymalos monospora* (Harv.) Baill. ex Warb. (Monimiaceae), and *Myrsine melanophloeos* (L.) R.Br. ex Sweet (Primulaceae). The dense shrub layer in these forests is mainly composed of *Dracaena fragrans* (L.) Ker Gawl. (Asparagaceae), *Psychotria goetzei* (K.Schum.) E.M.A.Petit, *Chassalia parvifolia* K.Schum., *C. discolor* K.Schum. (all Rubiaceae), and *Maytenus acuminata* (L.f.) Loes. (Celastraceae).

Isoglossa pareensis grows on the shady forest floor together with many ferns, particularly *Asplenium gemmiferum* Schrad., *A. arcumontanum*, *A. erectum* Bory ex Willd., *A. elliottii* C.H.Wright (all Aspleniaceae), *Lomariopsis warneckei* (Hieron.) Alston (Lomariopsidaceae), and *Blotiella stipitata* (Alston) Faden (Dennstaedtiaceae). Other herbs belonging to the Acanthaceae include *Crossandra tridentata* Lindau and *Isoglossa lactea* Lindau subsp. *saccata* I.Darbysh. *Isoglossa pareensis* is not common within these forests; using data from 30 forest plots (A.

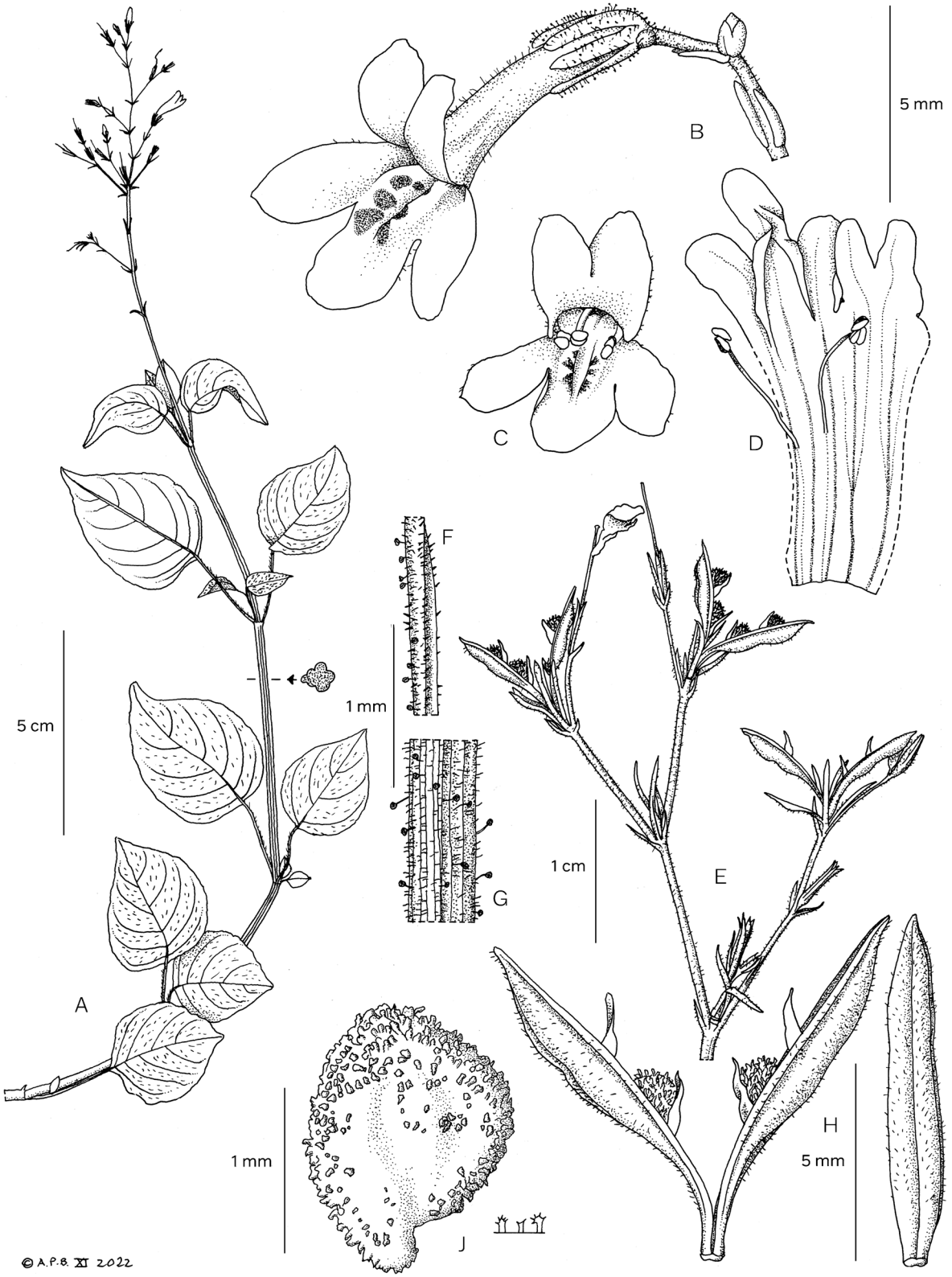

Fig. 2. *Isoglossa pareensis*. **A** habit, flowering branch; **B** flower in situ; **C** face view of corolla with stamens and stigma visible at mouth; **D** dissected corolla with stamens; **E** partial infructescence with mature capsules; **F** indumentum of calyx lobe, side view, external face to left; **G** indumentum of peduncle; **H** capsule with seeds, and dorsal view of capsule valve; **J** mature seed, with detail of sculpturing. **A** & **D** from *Hemp* 8165; **B** & **C** from photographs of plants in the field; **E** – **J** from *Hemp* 6953. DRAWN BY ANDREW BROWN.

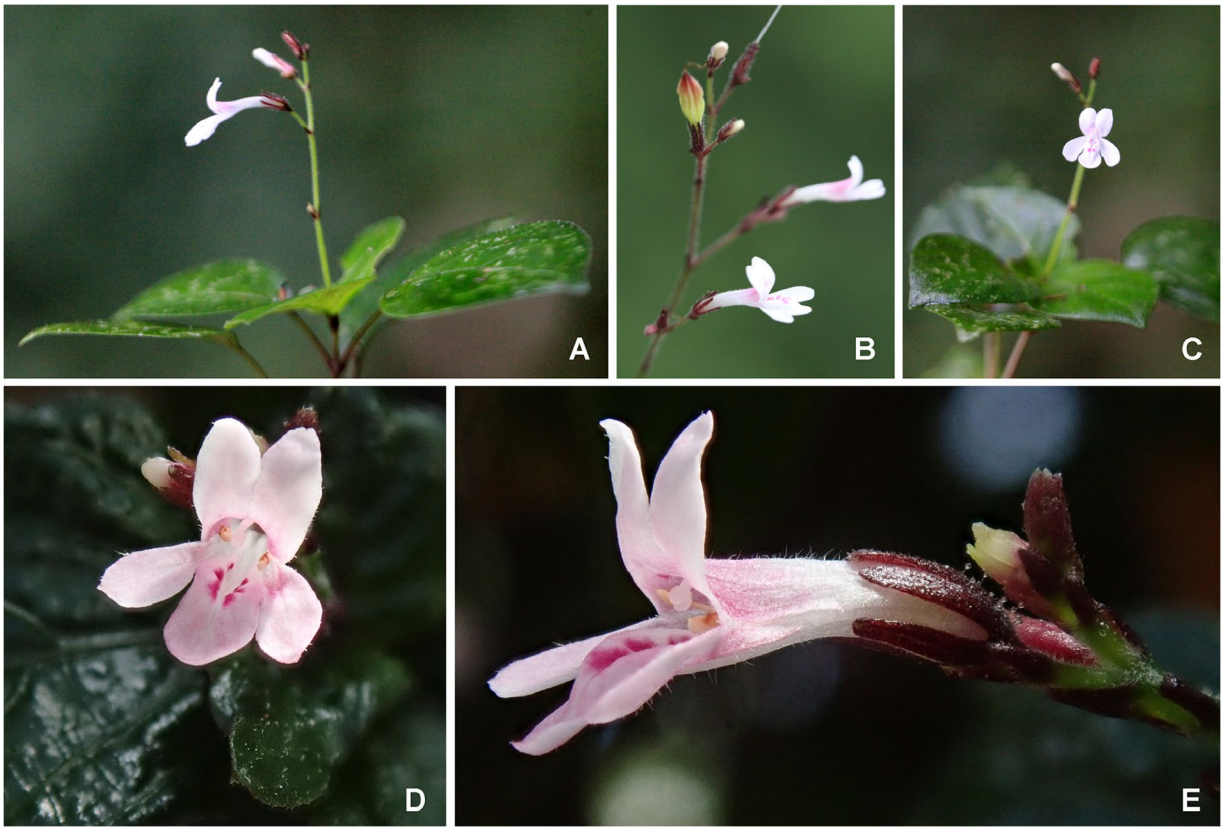

Fig. 3. *Isoglossa pareensis*. **A** – **C** in situ at Mwala, Tanzania, collected as *A. Hemp* 7355; **D** & **E** in cultivation at UBT. PHOTOS: **A** – **C** A. HEMP; **D, E** U. MEVE.

Hemp, unpubl. data) we estimate that it occurs in 13% of the area of Mwala with perhaps 10 – 20 individuals per 0.1 ha.

The climate at Mwala is humid and foggy. Mean annual rainfall is only about 700 mm; however, fog water interception provides more than two times this amount in addition (data of 5 years; A. Hemp, unpubl. data). Consequently, mean annual relative humidity is 94%. Mean annual temperature is 15.7°C with a minimum temperature of 8.7°C and a maximum temperature of 29.0°C. Because of the high humidity, tree trunks and branches are densely covered by mosses (30 – 50% coverage) and vascular epiphytes (5 – 10% coverage) (A. Hemp, unpubl. data).

CONSERVATION STATUS. This species is known only from the type locality, and using the recommended 2 × 2 km grid cell size for calculation, its Area of Occupancy is 4 km^2. However, the forest in which this species is found covers an area of c. 3.5 km^2, within which suitable habitat for the *Isoglossa* is estimated to be 1.2 km^2, and as noted above, it is not common here (A. Hemp, pers. obs.). The area where

Fig. 4. Fruits of *Isoglossa pareensis*. **A** fruit valve within calyx, showing dense glandular indumentum; **B** dehiscing capsule with seeds; **C** capsule valve showing immature seeds with glochidiate-tuberculate sculpture. Scale bars = 2 mm. PHOTOS: U. MEVE.

Fig. 5. *Isoglossa gregorii*. **A** habit of flowering plants; **B** inflorescence for comparison to *I. pareensis*; Ngozi, Tanzania. PHOTOS: I. DARBYSHIRE.

the species occurs is currently unprotected although it has been proposed as a Forest Reserve, and during the visit of the second author (A.H.) no illegal logging activities or other ongoing threats were observed. However, there is a plausible future threat from forest fires at this site; such events have been recorded from similar forest patches in the region and larger burning events can be highly damaging to the forest understorey (A. Hemp, pers. obs.). Given the extremely small range size and this plausible threat, *Isoglossa pareensis* is assessed as Vulnerable under criterion D2 – **VU D2**.

ETYMOLOGY. The species epithet "*pareensis*" denotes that this species is, so far as is known, endemic to the Pare Mountains of Tanzania.

NOTES. Although this species appears to be most closely allied to *Isoglossa gregorii* (Fig. 5) and *I. punctata* based on corolla and seed morphology, it is easily separated by the characters listed in the Recognition section and in Table 1, and the inflorescence form, in particular, is so different from those species that they are unlikely to be confused.

One further species from adjacent areas — *Isoglossa paucinervis* I.Darbysh. from the Eastern Arc Mountains (West Usambara, Ukaguru and Udzungwa) and Mt Kilimanjaro — could potentially be confused with *I. pareensis* because they share a similarly small stature, small leaves with few lateral veins, and an open, branched inflorescence with small bracts. However, *I. pareensis* is easily separated from *I. paucinervis* by a range of characters, including the capsule being puberulous (vs glabrous), the seeds having glochidiate tubercles (vs seeds with elongate but non-glochidiate tubercles), a markedly more slender corolla tube and a more dense inflorescence indumentum (see Darbyshire 2009; Darbyshire *et al.* 2010). We hypothesise that these two species are not closely related and that the resemblance between them is likely to be superficial. *Isoglossa paucinervis* is included in Table 1 for completeness.

To date, none of the *Isoglossa* species discussed in this paper have been sampled in molecular phylogenetic studies pertaining to Isoglossinae (Kiel *et al.* 2006; McDade *et al.* 2021), and so relationships based on morphology are speculative. In their study of Justicieae using five molecular loci (nrITS, *trnT-L* and *trnS-G*, *trnL-F* and *rps16* intron), McDade *et al.* (2021) documented two clades of *Isoglossa* s.l. within Isoglossinae. Included within *Isoglossa* Clade 1 were two species from Madagascar, one of which — *I.* aff. *justicioides* Baker — is from a group of Malagasy species that appear morphologically similar to *I. gregorii* and *I. punctata* (I. Darbyshire, pers. obs.). We could hypothesise, therefore, that *I. pareensis* may be resolved within *Isoglossa* Clade 1, but this needs to be tested with further molecular phylogenetic data, ideally using Next Generation Sequencing phylogenetic techniques to improve data resolution. With this in mind, a RADseq analysis of the tribe Isoglossinae is now being prepared to investigate the delimitation and evolutionary history of *Isoglossa* and its allies (C. A. Kiel & I. Darbyshire, in prep.).

Table 1. Main diagnostic characters for separation of *Isoglossa pareensis* from *I. gregorii*, *I. paucinervis* and *I. punctata*.

Character	*Isoglossa punctata*	*Isoglossa gregorii*	*Isoglossa pareensis*	*Isoglossa paucinervis*
Inflorescence form	spiciform or if (often) branched then branches spiciform with (sub)sessile cyme units	spiciform or if (more rarely) branched then branches spiciform with (sub)sessile cyme units	slender panicle-like thyrse with pedunculate dichasial or monochasial cyme units	slender panicle-like thyrse with pedunculate, mainly monochasial cyme units, or sometimes reduced to a simple 1 – 2-flowered cyme
Indumentum of inflorescence axes	two opposite lines of dense eglandular hairs, rarely with scattered glandular hairs	two opposite lines of dense eglandular hairs, sometimes with scattered glandular and/or long eglandular hairs	shortly glandular-pubescent and eglandular-puberulous to -pubescent	eglandular-puberulous to -pubescent, few glandular hairs occasionally present, or axes sometimes glabrous
Bract shape and size (mid-point of inflorescence axes)	triangular-ovate, 1.5 – 4.5 × 0.7 – 2.5 mm	elliptic to somewhat obovate, (3.5 –) 4.5 – 14 × 0.7 – 6 mm	linear-lanceolate, 1.3 – 3.6 × 0.3 – 0.5 mm	linear-lanceolate to narrowly elliptic or ovate, 1 – 11.5 × 0.3 – 6 mm
Indumentum of calyces, external surface	shortly ciliate, elsewhere glabrous or rarely with scattered longer glandular hairs	shortly ciliate or hairs more widespread, often with scattered longer glandular and/or long eglandular hairs	shortly glandular-pubescent and eglandular-puberulous	shortly ciliate, with or without scattered glandular and/or eglandular hairs on external surface
Corolla tube shape	(sub-) cylindrical to narrowly campanulate	(sub-) cylindrical	cylindrical	(sub-) campanulate to inflated
Anther thecae arrangement	superposed and widely separated	immediately superposed to widely separated	overlapping for half their length	usually superposed and separated by 0.5 – 1.5 mm
Capsule indumentum	glabrous or with minute eglandular hairs towards apex, occasionally with scattered longer glandular hairs	glabrous or with minute eglandular hairs towards apex, occasionally with scattered longer glandular and/or long eglandular hairs	puberulous with eglandular and occasional glandular hairs	glabrous
Seed sculpturing	with elongate, minutely glochidiate tubercles particularly towards rim	with elongate, minutely glochidiate tubercles particularly towards rim	with elongate, minutely glochidiate tubercles particularly towards rim	with elongate, appressed tubercles extending in length towards rim, lacking glochidia

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Declarations

Conflicts of interests/Competing interests The authors declare no conflicts of interest/competing interests.

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