

## *Ceropegia omissa* H. Huber (Apocynaceae: Asclepiadoideae) on the verge of extinction

Taxonomists seldom stumble upon rare species in explorations, and it is unlikely that they realize the rarity of the material immediately. At best, they could consider such materials interesting and call for greater scrutiny in the fixing of correct identities. One such collection was made while exploring the South Indian species of *Habenaria* Willd. (Orchidaceae) in Agasthyamalai hills, Tamil Nadu (TN), India. This plant was found growing in association with *Habenaria* and primarily identified as a species of *Ceropegia* L. The absence of tuberous roots and partial falling of leaf indumentum as the leaf ages truly placed the authors in predicament in fixing its identity with the accessible literature and available keys. The material was sent to Ulrich Meve (University of Bayreuth, Germany), an expert on the genus for opinion with a photo plate and notes prepared based on dissected fresh material. Meve in his reply stated that 'it cannot be named for now and might represent an undescribed species'. Based on our own assessment, we found the material was 'near comparable' with *Ceropegia evansii* McCann, *C. media* (Huber) Ansari and *C. santapau* Wadhwa & Ansari. While browsing through specimens at Kew, our attention was drawn to specimens (Wight 509 and s.n.) collected and annotated by Wight (1835) as *C. acuminata* Roxb. But Roxburgh's *C. acuminata* is very different and can be diagnosed by tuberous roots and the glabrous nature of leaves, the corolla tube and the outer corona and hairy corolla lobes. What had driven Wight to annotate it as *C. acuminata* is hard to guess. Hooker<sup>1</sup> referred this collection as doubtful novelty under *C. intermedia* var. *wightii* Hook. f. He never favoured presenting novelties based on dry specimens in some genera of Apocynaceae, which includes the genus *Ceropegia*. Yet, he gave accurate characterization, 'lanceolate acuminate leaves, broad glabrous corolla lobes and ciliated outer coronal lobes' to his new variety. Hooker's clarity on the taxon was further evident when he differed with Wight's annotation, *C. acuminata*, on all his three sheets, stating that slender petioles and strongly three-nerved base of the lamina are the diagnostic features of *C. acumi-*

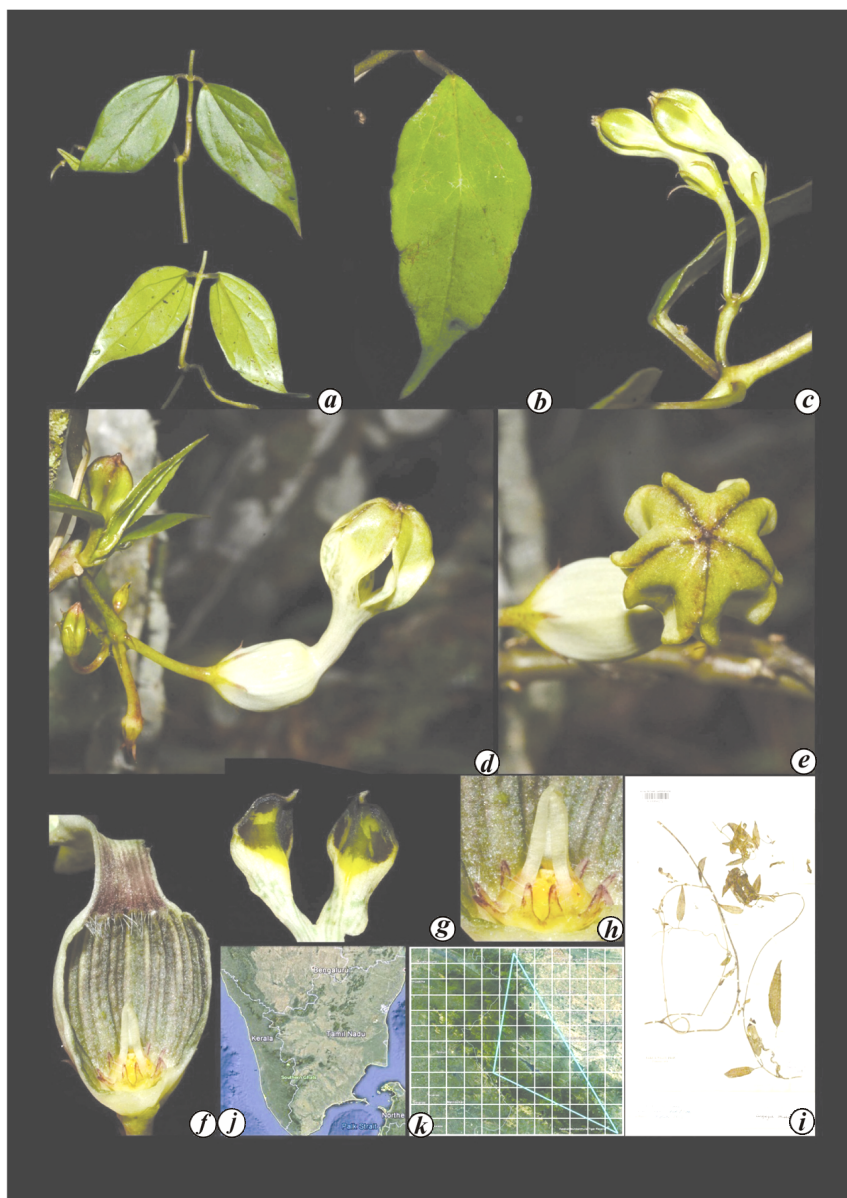
*nata* and are not seen in these specimens. These are distinctive features of var. *wightii* and differ from var. *intermedia*. Gamble<sup>2</sup> annotated the sheets as var. *wightii* and included the same in his *Flora of Presidency of Madras*. Huber<sup>3</sup> gave the species status appropriately and published as a replaced name, *Ceropegia omissa* H. Huber (since 'wightii' preoccupied, *Ceropegia wightii* Graham 1833). Ansari<sup>4</sup> accessed Wight's collections in his revision of Indian *Ceropegia*, and included a short description of species and illustration of corona. He cited two more specimens collected from Sengalgeri, Tirunelveli ('Tinnevely', TN). Till date, only seven specimens (all from TN) are available, four of them at Kew herbarium, London and three at Madras herbarium, Coimbatore. Nair and Nayar<sup>5</sup> probably could not access Wight's specimens (509 and s.n.), which were collected from the area covered in their flora and therefore did not include this species in their *Flora of Courtallum*. Sasidharan<sup>6</sup> reported this species from Chinnar Wildlife Sanctuary. Further, he gave the description of *C. intermedia* (flowers purplish, corolla lobes ciliate, outer corona cupular, five-lobed, inner corona lobes spatulate) under the name of *C. omissa*<sup>7</sup>. Nayar *et al.*<sup>8</sup> and Kambale and Yadav<sup>9</sup> claimed its distribution in Kerala based on Sasidharan's report. Unfortunately, there are no specimens of Sasidharan to ascertain its identity and distribution in Kerala.

The genus *Ceropegia* L. is represented by 61 taxa in India<sup>10</sup>. *Ceropegia omissa* is a narrow endemic, so far known only from TN and doubtfully from Kerala. Henry *et al.*<sup>11</sup> remarked it as rare. Nayar and Sastry<sup>12</sup>, and Rao *et al.*<sup>13</sup> designated it as 'Endangered' based on the literature and limited collections in herbaria. Albers and Meve<sup>14</sup> and Walter and Gillet<sup>15</sup> also evaluated it as 'Endangered'. The rarity is such that it is so far collected only on three occasions (Courtallum, 1835, Wight s.n. and 509; Sengalgeri, 1914, *s.coll.* 10875 and 1916, *s. coll.* 13540 & 13643), and now the present collection in 2014. The time gap between these collections is long and the collections are limited within 50 km radius. Aptly, Subbaiyan *et al.*<sup>16</sup> desig-

nated it as 'Endangered/Possibly Extinct'. Nayar and Sastry<sup>12</sup> sought for its rediscovery in other localities for its *in situ* conservation. Such extreme rarity took the taxon to near non-existential status. The description available in the literature is inadequate and floral details were never illustrated/photographed. Taking advantage of its fresh collection, we have provided a photo plate (Figure 1) of its habit in the field and its complete description.

**Taxonomy:** *Ceropegia omissa* H. Huber, Mem. Soc. Brot. 12: 67. 1957; Ansari, Fasc. Fl. India 16: 27, t. 15. 1984; Henry *et al.*, Fl. Tamil Nadu Analysis 2: 84. 1987; Jagtap & N.P. Singh, Fasc. Fl. India 24: 235. 1999. *C. intermedia* var. *wightii* Hook. f., Fl. Brit. India 4: 71. 1883; Gamble, Fl. Madras 2: 858. 1923. Type: India. Travancore, Coutrallum, *R. Wight* s.n. (lecto, K!).

Perennial twining herb. Rootstock fascicled, not tuberous. Stems slender, cylindrical, branched, ca. 5 m long, ca. 3 mm across, glabrous. Leaves simple, opposite; petioles 5–10 mm long; lamina ovate, ovate-lanceolate, linear-lanceolate, lanceolate, 2–6 × 1–2 cm, truncate to acute at base, acuminate at apex; petioles, margins, midrib below, hairy when young, becoming glabrous at maturity. Inflorescences extra-axillary, cymose, pedunculate; peduncles cylindrical, 8–10 mm long, glabrous; bract solitary, linear, 1–1.5 mm long, acute, glabrous; pedicels cylindrical, 5–10 mm long, glabrous. Calyx deeply five-lobed; lobes linear-subulate, 2–3 × 0.5 mm, acute, glabrous. Corolla ca. 3.2 cm long; tube 1.6–2 cm long, slightly curved; inflated at base, 6–8 mm long, mouth with a ring of white hairs, pale white with pale green bands; narrowed in the neck, glabrous, subcylindric and hardly dilated above, with purple bands at base and green bands towards apex; corolla lobes shorter than the tube, oblong-elliptic or oblong-ovate, 1–1.2 cm long, free near base and connate at tip forming dome-shape, glabrous, pale white at base and greenish-white above the middle; outer corona bowl-shaped, five-lobed; lobes further bilobed; lobules deltoid or linear, erect, ca. 0.6 mm long, ciliate, pale yellow with pink markings; inner corona lobes erect,



**Figure 1.** *Ceropogia omissa* H. Huber. **a**, Leaves dorsal and ventral sides; **b**, Leaf to show margin and petiole; **c**, Flower buds; **d**, Flowers; **e**, Top view of corolla lobes; **f**, Spilt-open corolla tube; **g**, Corolla lobes; **h**, Corona; **i**, Type at Kew (K000894272); **j**, Southern Western Ghats; **k**, Minimum convex polygon map.

alternate with outer corona, linear, 2.5–3 mm long, glabrous, whitish-cream. Pollinia yellow, waxy, subglobose or ovoid-globose, ca. 2 mm long, with pellucid margin, attached to corpusculum by dark brown, short, tubular caudicles. Follicles in pairs, slender, linear, ca. 8 cm long. Flowering and fruiting between September and December.

Distribution: Endemic to Tirunelveli district, TN.

Specimens examined: India, Tamil Nadu, Tirunelveli district, Agasthyamalai hills, 1489 m, 30 November 2014, K.

Prasad 006442 (BSID!); Coutrallum, 1835, *R. Wight* 509 (K!); Tirunelveli district, Sengalteri, 18 September 1914, *s.coll.* 10875 (MH!); 24 September 1916, *s.coll.* 13540; 26 September 1916, *s.coll.* 13643 (MH!).

Conservation status: Southern Western Ghats is a highly botanized area, but none could collect this species again, signifying its rarity even in its probable areas of occurrence. As the known habitat is in Agasthyamalais, a biosphere reserve area, there is little difficulty in conserving its populations. In total, 11

individuals were spotted on slopes of Agasthyakudam, and based on present and earlier collection sites, a map was prepared to calculate ‘extent of occurrence’ (EOO), which is less than 100 sq. km (Criterion B1) and ‘area of occupancy’ (AOO), which is less than 10 sq. km (Criterion B2). The known localities (Coutrallum, Sengalteri and Agasthyakudam) of this species all fall in southern Western Ghats and constitutes a single population, thus meeting the single location criterion. The quality of habitat has come down considerably due to failing monsoon in the area, thus fulfilling the sub-criteria (b: iii). Based on EOO and AOO, *C. omissa* is categorized here as ‘Critically Endangered’ [CR B1B2a,b(iii)] according to the IUCN guidelines<sup>17</sup>. There is a need for extensive exploration survey to locate newer populations of the species and assess its reproductive ecology to ensure its survival.

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## Soil organic carbon stock in agroforestry systems in western and southern plateau and hill regions of India

The rising level of carbon dioxide (CO<sub>2</sub>) in the atmosphere is a major concern, as scientific evidences show that it is the primary cause of global warming. CO<sub>2</sub> concentration is expected to double by the middle or end of the 21st century, with a temperature rise between 1.5°C and 4.5°C (ref. 1). The importance of agroforestry as a land-use system is receiving wider recognition not only in terms of agricultural sustainability, but also in issues related to carbon sequestration or climate change<sup>2</sup>. Trees in association with annual crops add carbon to both above- and belowground portions, through photosynthesis, and thereby increase the organic matter content of the soil<sup>3,4</sup>. Although it is generally assumed that agroforestry system has the potential to increase soil organic carbon (SOC) stocks<sup>5</sup>, and as reported by Nair<sup>6</sup>, very few studies have focused on soil layers deep inside<sup>7,8</sup>.

The present study was undertaken in 2015 under the National Innovations in Climate Resilient Agriculture Project to assess the SOC stock in existing agroforestry system in farmer's field from eight villages of Nashik and four villages of Thane district in Maharashtra, six villages of Chittoor district in Andhra Pradesh, and four villages each of Tumkur and Bellary districts in Karnataka,

under the western and southern plateau and hill regions. From each block, two villages were randomly selected to represent the whole block. In each village, transect walk was conducted during July and October 2015, with a hand-held GPS system and preliminary information was acquired on indigenous tree species, inter-crops, climatic data and soil type (Table 1). Soil samples were collected from the existing agroforestry system and crop fields from different soil depths (0–15, 15–30, 30–60 and 60–90 cm) with three replications; a total of 5–8 sampling sites were selected from each location in a zigzag manner and were mixed to prepare a composite sample for analysis. In Tumkur, SOC varied from 0.24% to 0.60% from one location to another. Similarly, in Bellary, it varied from 0.23% to 0.54%. In Thane and Nashik, the variation was 0.38–0.98% and 0.34–1.34% respectively. In Chittoor, SOC varied from 0.17% to 0.66%. Soil bulk density measurements were made using soil core sampler.

The soil samples were analysed to estimate organic carbon using the method of Walkley and Black<sup>9</sup>. SOC stock was calculated using the formula

$$\text{SOC stock (t ha}^{-1}\text{)} = \text{SOC} \times \text{BD} \times \text{SD} \times 10, \quad (1)$$

where SOC is the soil organic carbon (g kg<sup>-1</sup>), BD the bulk density (Mg m<sup>-3</sup>), SD the soil depth (m), and 10 is a conversion factor.

There are several scientifically acceptable evidences to support the positive influence of trees in enhancing SOC<sup>10,11</sup>. Table 2 presents the distribution of SOC in different soil depths. SOC content in agroforestry system was 1.02% in 0–15 cm depth over 0.96% under sole crop in Thane. Similarly, for 15–30 cm depth, SOC varied from 0.89% under agroforestry over 0.70% under sole crop. There was a decrease in SOC content with increase in soil depth. This might be due to the fact that turnover rate of fine roots decreases with increase in depth, which in turn affects the organic matter input in deep soil layers<sup>12</sup>. In Nashik, more or less similar results were obtained with SOC content under agroforestry system varying from 0.95% in 0–15 cm to 0.67% in 15–30 cm soil depth. While in case of sole crop, it was 0.74% in 0–15 cm and 0.60% in 15–30 cm depths. In Chittoor, SOC varied from 0.46% under sole crop to 0.55% under agroforestry system, while Tumkur and Bellary showed 0.64% and 0.57% SOC in agroforestry over 0.40% and 0.51% in sole crop in 0–15 cm soil depth respectively. When soil sampling was done up to 90 cm soil