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Hedyotis hamiguitanensis (Rubiaceae: Spermaceae), a new species from Mt. Hamiguitan, Davao Oriental, Philippines and its systematic position in *Hedyotis*

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Abstract. *Hedyotis hamiguitanensis*, from Mt. Hamiguitan, Davao Oriental, Philippines, is described, illustrated, and compared with two similar species, *H. whiteheadii* and *H. schlechteri*. This species is distinguished from congeneric Philippine species by its 5–12 cm long, compound, umbellate inflorescences, pendulous flowers, lanceolate to oblanceolate, thick, scabrid leaf blades with revolute margins. Its phylogenetic systematic position within the tribe Spermaceae is determined with a phylogenetic analysis using chloroplast (rps16, petD) and nuclear ribosomal (ITS, ETS) nucleotide sequence data.

Keywords: *Hedyotis*, Rubiaceae, Philippines, taxonomy.

INTRODUCTION

Hedyotis Linnaeus (1753: 101) is part of the *Hedyotis*-*Oldenlandia* complex, a taxonomically confusing group that was formerly placed in the tribe Hedyotideae, which is now part of tribe Spermaceae (Bremer 1996; Andersson and Rova 1999; Bremer and Manen 2000). The genus has long been controversial because of the lack of taxonomic delimitation and molecular data (Terrell and Robinson 2003). Recent phylogenetic analyses based on nuclear and plastid sequences of Asian-Pacific taxa from this group have identified 13 well-supported monophyletic genera (Neupane et al., 2015). Diagnostic characters such as habit, fruit type, seed form, and pollen type were compared to the phylogeny for characterizing the clades (Kårehed et al 2008; Groeninckx et al. 2009; Guo et al. B 2013; Wikström et al. 2013; Neupane et al. 2015). In the latest revision (Neupane et al. 2015), members of *Hedyotis* s.str. included species from Sri Lanka, India, SE China, Indo-Chi-

na, Malesia, Papuaia, Northwest Pacific, and Australia. The recent studies lack *Hedyotis* species occurring in the Philippines. *Hedyotis* is characterized by its habit –suffrutescent herbs, shrubs, or small trees –, its capsules with apex not protruding beyond the calyx lobes, the septicidal dehiscence usually followed by a partial apical loculicidal dehiscence that sometimes results in two semi-split valves and, the dorsiventrally compressed seeds (Wikström et al. 2013). The flowers have a pubescent corolla tube and pollen with 3–4 ecto-apertures, endoapertures shaped as an endocingulum and a tectum with a double reticulum pattern (Neupane et al. 2015). There are approximately 180 species in *Hedyotis* (Neupane et al. 2015), 36 of which occur in the Philippines (Pelser et al. 2011).

During fieldwork of the Thomasian Angiosperm Phylogeny and Barcoding Group (TAPBG) on Mt. Hamiguitan, Davao Oriental, Philippines, an interesting taxon was discovered. Two populations were observed, one in mossy forests and the other in pygmy forests on the same mountain. The collected material is morphologically similar to *Hedyotis whiteheadii* Merrill (1907: 303) and *H. schlechteri* Merrill & Perry (1945: 1), but detailed comparison showed that these two species differ from the newly collected material by their vegetative and inflorescence morphology. Therefore, a new *Hedyotis* species is here described and illustrated. We also included the new species in a maximum likelihood and Bayesian phylogenetic analysis of *Hedyotis* s.str. (sensu Neupane et al. 2015) based on chloroplast (*rps16*, *petD*) and nuclear ribosomal (ITS, ETS) nucleotide sequence data to elucidate its position within the genus.

MATERIAL AND METHODS

Hedyotis specimens were collected in the forests of Mt. Hamiguitan, Davao Oriental, Philippines, on 15 April 2017. Measurements, colors and other details given in the descriptions are based on field observations, herbarium specimens and reproductive parts preserved in 70% ethanol. Microscopic features were analyzed using a dissecting microscope (Olympus SZ2-ILST). Measurements were obtained using a metric vernier caliper. Character state terminology is based on Beentje (2010). *Hedyotis* specimens from different herbaria (A, CAHUP, K, PNH, PUH US, and USTH) were compared to our specimens. Additional specimens were examined on JSTOR Global Plants (<https://plants.jstor.org/>, accessed 18 May 2021). Herbarium specimens were deposited in USTH.

For the molecular data, DNA was extracted from silica gel-dried leaves using the DNeasy Plant Mini Kit

(Qiagen, Germany) following the manufacturer's protocol. The amplification protocol for nuclear and chloroplast regions follows Kårehed et al. (2008: 845) and Groeninckx et al. (2009: 111), respectively. The alignment file was downloaded from the supplementary data provided by Neupane et al. (2015). A total of 293 accessions were analyzed with the addition of 2 samples from this study, *H. hamiguitanensis* CB177051 and CB17036. The new sequences from plastid (*rps16*, *petD*) and nuclear (ITS) regions of *H. hamiguitanensis* produced during our investigation were deposited in Genbank (Genbank accession numbers MZ407950, MZ435801, MZ435799 for USTH016306 MZ407951, MZ435802, MZ435800 for USTH016305 respectively) Sequences were edited and pre-aligned using CodonCode Aligner v.4.0.4 (CodonCode Corporation, Dedham, MA) and subsequently aligned using MAFFT v.7 (Katoh and Standley, 2013). The alignment was manually adjusted using SeaView Sequence Aligner V.4 (Guoy et al., 2010). ML tree search was performed in RaxML-HPC Blackbox v. 8.2.12. while Bayesian inference was performed using MrBayes v.3.2 (Ronquist et al. 2012) with 15 million MCMC iterations. MrBayes and RaxML searches were conducted on the CIPRES Portal (Miller et al. 2010).

TAXONOMY

Hedyotis hamiguitanensis Santor, Santiago & Alejandro, **sp. nov.** (Figures 1, 2).

Type: Philippines, Davao Oriental, Pygmy forest in Mt. Hamiguitan, 16.7400° N, 1600 m, 126.1817° E, 15 Apr 2017, *Ordas, Alfeche & Zamudio* CB17051 (holotype, Accession numbers from USTH:USTH016306.1; isotypes: USTH016306.2, USTH016306.3).

Diagnosis

Hedyotis hamiguitanensis is similar to *H. whiteheadii* and *H. schlechteri* because of general leaf size ranging from 1.5–4 cm with 3–4 lateral nerves, densely hirsute petioles, and compound peduncled inflorescence, from which it can be distinguished by its lanceolate to oblanceolate, relatively thick leaves, scabrid surface, margins that are entire and revolute, stems, stipules, peduncle, pedicels with hirsute indumentum, inflorescence a compound, 5–12 cm long, umbel, and by the pendulous, 8–11 mm long flowers.

Description

Shrub 0.5–2 m tall. Stems terete, about 1–2 mm in diameter, olive green with maroon coloration on some

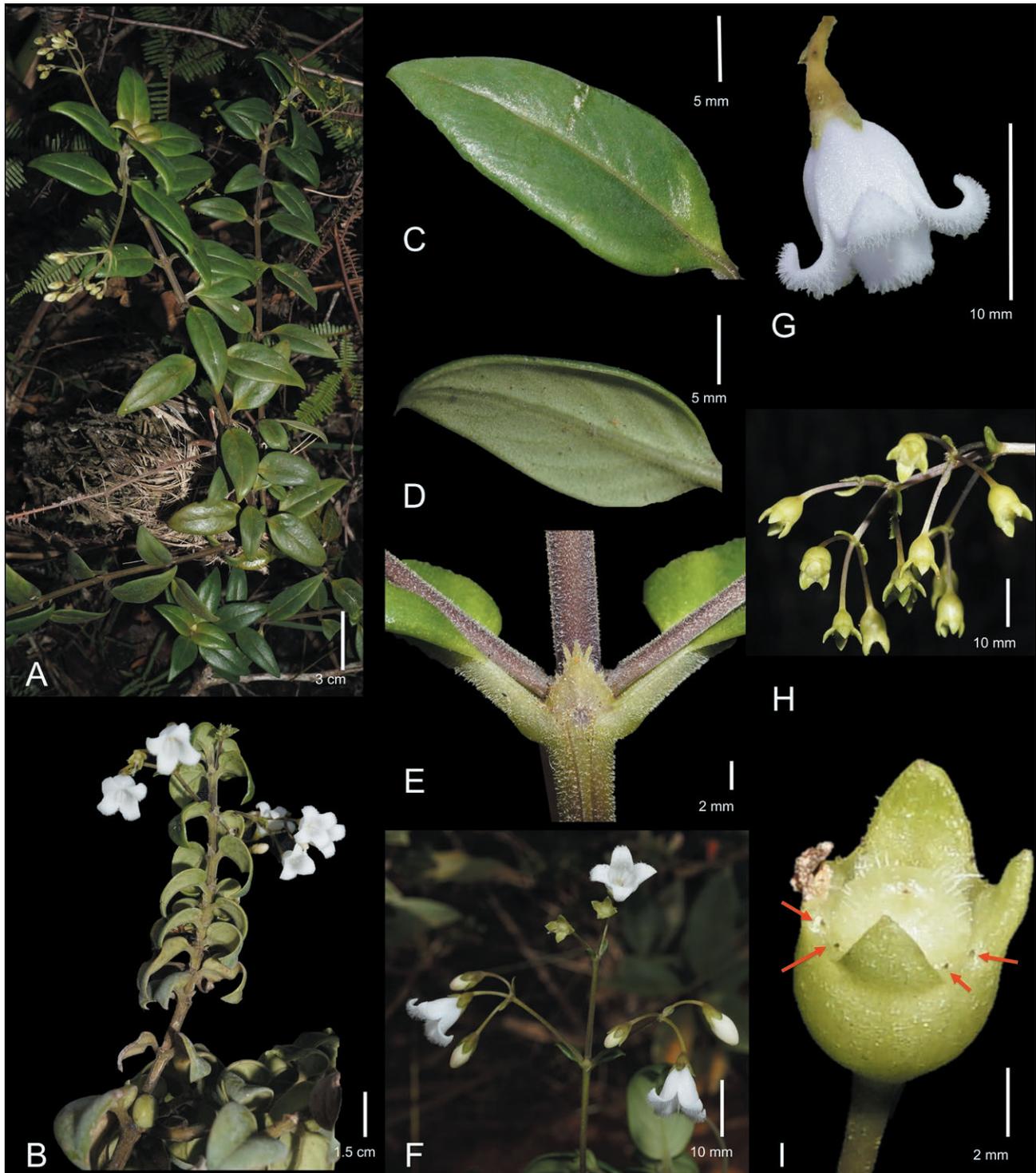


Figure 1. *Hedyotis hamiguitanensis*. **A.** Habit of CB17051 found in mossy forest at 1000 m elevation. **B.** Habit of CB17036 found in the pygmy forest of Mt. Hamiguitan at 1600 m elevation. **C.** Leaf adaxial surface. **D.** Leaf abaxial surface. **E.** Node, showing intrapetiolar stipule with lacinate teeth; stems, stipules and petioles are hirsute. **G.** Flower. **H.** Inflorescence. **I.** Fruit with 2 colleters at each calyx lobe sinus. Photos by N.K. Alfeche.



Figure 2. *Hedyotis hamiguitanensis*. **A.** Flowering and fruiting branch. **B.** Stipules. **C.** Inflorescence. **D.** Flower, lateral view. **E.** Flower, top view. **F.** Calyx and style. **G.** Opened Corolla showing stamens. **H.** Capsule. **I.** Dissected capsule showing the 2 locules. **J.** Seed. Illustrated by P.J.R. Santor.

parts, densely hirsute; internodes 1–5 cm long; branchlets sulcate, 1–2 mm in diameter. Stipules interpetiolar, triangular ovate, 2–4 × 3–4 mm, with 9–11 lacinia, hirsute. Leaves with petioles 1–5 mm long, subsessile in populations above 1600 m elevation, densely hirsute; blades lanceolate to broadly ovate, 1.5–3 × 0.8–1.5 cm, thinner leaves with margins recurved, thicker leaves with entire lamina recurved from the midrib; lamina scabrid on both surfaces, abaxial surface may appear densely hirsute on younger leaves, coriaceous, yellow-green to green on the adaxial surface, abaxial surface pale green when fresh, olive green to dark brown and brittle when dry, base subcordate to obtuse, apex attenuate to acute, lamina scabrid on both surfaces, abaxial surface may appear densely hirsute on younger leaves, thinner leaves with margins revolute; margins of thicker leaves revolute from the midrib; midrib distinct, canalliculate, sparsely to densely scabrid on the adaxial surface, sparsely scabrid on the abaxial surface; secondary veins 3 or 4 on each side of the midrib, obscure on thicker leaves, evident in thin leaves, tertiary venation not prominent. Inflorescence axillary, a compound umbel, 6–12 cm long in populations above 1000 m elevation, or 5–6.5 cm long in populations above 1600 m elevation, pendulous, hirsute; peduncle terete, 2–9 cm long, 0.2–0.5 mm in diam., hirsute; bracts ovate to lanceolate, 3–6 × 2–4 mm, apex attenuate, scabrid on the adaxial surface, hirsute or with bullate configuration on the abaxial surface, margins flat or revolute. Inflorescence cymose, 3(4)-flowered, 1–3 cm long, 3–5 mm in diameter, sparsely hirsute to glabrous; bracteoles ovate to lanceolate, 2–3 × 0.5–1.5 mm, apices acute. Pedicels terete, 10–30 mm long. Flowers 4-merous, pendulous, cupuliform, 8–11 mm long, white; . Calyx subcampanulate, 2–4 mm long, 3 mm in diameter; tube bell-shaped with constricted base, 1–1.5 mm long, sparsely hirsute to glabrous; lobes 1–2.5 mm long, apex attenuate, puberulous, 2–3 clavate indumentum located in the margin in between each calyx lobe. Corolla 6–11 mm long, glabrous, white; tube 4–6 mm long, pubescent inside; lobes lanceolate, 2–5 mm long, apex acute. Stamens 2.5–4.2 mm long, included, inserted at 2 mm; filaments 1–2 mm long, glabrous; anthers oblong, 1–2 mm long, dorsifixed. Style 6–7 mm long, glabrous, exerted 1.5–2.5 mm beyond corolla mouth. Capsules urceolate to ovoid, 3–4 × 2 mm, septicidal; calyx lobes persistent, 1.5 mm long. Seeds numerous, angular, dorsiventrally compressed, 0.5–0.7 mm long, black.

Etymology

The specific epithet is based on the type locality, Mt. Hamiguitan, Davao Oriental, Philippines.

Distribution and habitat

This new species is currently known only from its type localities. *Hedyotis hamiguitanensis* occurs in the mossy forest of Mt. Hamiguitan at c. 1000 m elevation, and in pygmy forest on Mt. Hamiguitan at c. 1600 m elevation.

Phenology

Hedyotis hamiguitanensis was observed flowering and fruiting in April.

Provisional IUCN Conservation assessment

This species was only collected at the type localities. Although two populations were found, few individuals were observed in the mossy and pygmy forest. The distribution range of this species remains unknown. Thus, the conservation status of *H. hamiguitanensis* is Data Deficient (DD) based on the IUCN (2019) categories.

Additional Specimens examined (paratypes)

PHILIPPINES. Davao Oriental: Mossy forest in Mt. Hamiguitan, 6.7400° N, 1000 m, 126.1817° E, 15 Apr 2017, *Ordas, Alfeche & Zamudio* CB17036 (USTH016305.1, USTH016305.2, USTH016305.3).

Phylogenetic Analysis

The phylogenetic analysis (Fig. 3) based on the combined nuclear (ITS, ETS) and plastid (*petD*, *rps16*) data revealed that *H. hamiguitanensis* is embedded within the *Hedyotis s. str.* clade (Neupane et al. 2015) and is sister to a clade consisting of *H. schlechteri* and *H. valetoniana* (BS=90, BPP=0.97), both from New Guinea. Although the two populations observed CB17051 and CB17036 showed differences in leaf size and thickness (Figure 1A&B), phylogenetic analysis revealed that both populations formed a monophyletic group (BS=100, BPP=1.00), supporting the view that these two populations belong to the same species and the morphological differences may be due to adaptation to environmental conditions (Fig. 3).

Discussion

Two samples representing *Hedyotis hamiguitanensis* Santor, Santiago & Alejandro were collected and analyzed. Field sample CB17051 *Ordas, Alfeche & Zamudio* was collected on the peak of Mt. Hamiguitan, Davao Oriental, at c. 1600 m elevation, while CB17036 *Ordas, Alfeche & Zamudio* was collected in the mossy forest at c. 1000 m elevation. The two collections have similar morphology in their vegetative and floral characters, but were different in terms of size, including plant height, leaf

Table 1. Comparative morphology between *H. hamiguitanensis* (CB177051, CB17036), *H. whiteheadii* and *H. schlechteri*

Characters	<i>H. hamiguitanensis</i>	<i>H. whiteheadii</i>	<i>H. schlechteri</i>
<i>Leaf</i>			
shape	lanceolate to oblanceolate	broadly ovate	broadly ovate
length (cm)	1.5-3	1.5-3	2-4
width (cm)	0.8-1.5	1-1.8	1-1.5
surface	adaxial: scabrid abaxial: scabrid/hirsute	glabrous on both surfaces	scabrid on both surfaces
lateral veins	obsolete	obscure	prominent
margin	revolute	revolute	planar
<i>Petiole</i>			
length (mm)	(0-) 1-5	1.5-2	5
<i>Stipules</i>			
surface	hirsute	hirsute	scabrid
<i>Inflorescence</i>			
type	compound umbel	compound cyme	compound cyme
length (cm)	5-12	2-3	5-6.5
<i>Flowers</i>			
direction	pendulous	erect	erect
flower length (mm)	8-11	5-6	5-7
Adaxial corolla lobe surface	hirsute	hirsute	glabrous

dimensions, degree of curvature of the leaf blade margins, petiole length, inflorescence length, and flower size. The size differences of the two samples can be attributed to different environmental conditions - elevation, amount of sunlight and availability of nutrients in the soil.

Hedyotis hamiguitanensis shares features with the allied species *H. whiteheadii*, notably the leaf blade 1.5-3 × 0.8-1.5 cm, the lamina thickness, the obscure lateral veins, revolute margins, and the hirsute stipules. However, *H. hamiguitanensis* found at c. 1000 m. altitude differs from *H. whiteheadii* in its lanceolate to oblanceolate leaves (vs. broadly ovate), scabrid leaf surfaces (vs. glabrous), compound umbels 5-12 cm long (vs. compound cymes 2-3 cm long), and significantly larger flowers 8-11 mm (vs. 5-6 mm). *Hedyotis hamiguitanensis* found at c. 1600 m. altitude also shares similar features with *H. schlechteri* with its scabrid leaf texture, inflorescences 5-6.5 cm long, and flowers up to 7 mm long. However, *H. hamiguitanensis* differs from *H. schlechteri* in the lanceolate to oblanceolate leaf blades (vs. broadly ovate), obscure lateral veins (vs. prominent), planar leaf margin (vs. revolute), hirsute stipules (vs. scabrid), 5-12 cm long inflorescences (vs. 5-6.5 cm), and larger flowers that are 8-11 mm long (vs. 5-7 mm).

Although the flower orientation was not mentioned in the protologue descriptions of *H. whiteheadii*

and *H. schlechteri*, the type specimens of *H. whiteheadii*, E.D.Merill 5783 (US 00137449 [image!]) and *H. schlechteri*, R.Schlechter 19761, (K000760468 [image!], K000760467 [image!]) exhibit an upward flower orientation. *Hedyotis hamiguitanensis* flowers, on the other hand, are pendulous. Table 1 provides a summary of the morphological differences between *H. hamiguitanensis*, *H. whiteheadii* and *H. schlechteri*.

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