



## *Hedyotis pubicaulis* (Rubiaceae), a new species from China

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(Manuscript received 20 August 2021; Accepted 3 January 2022; Online published 21 January 2022)

**ABSTRACT:** *Hedyotis pubicaulis*, a new species from China is described and photographed. It resembles *H. uncinella* in having herbal habit, tetragonal stem, sessile glomerate inflorescences, and dehiscent capsules, but it can be easily distinguished by having densely pubescent stem, truncate to triangular stipules with 6–14 bristles and only axillary glomerate inflorescence. The molecular phylogenetic analysis revealed that the new species was embedded in the genus *Hedyotis*. The new species is evaluated as Least Concern according to IUCN Red List Categories and Criteria.

**KEY WORDS:** *Hedyotis uncinella*, *Hedyotis-Oldenlandia* complex, Phylogeny, seed morphology, taxonomy.

### INTRODUCTION

The *Hedyotis-Oldenlandia* complex is one of the largest and taxonomically controversial groups in the tribe Spermacoceae of the family Rubiaceae. The complex was usually treated as a large genus of *Hedyotis* L. s.l. because of their similarities in mostly 4 corolla lobes, 4 stamens, and two-celled capsular fruits with a few to many small seeds (Lamarck, 1792; Willdenow, 1797; Roemer and Schultes, 1818; Steudel, 1821; Dutta and Deb, 2004). However, it was also separated into some small genera according to their habits, dehiscent or indehiscent fruits, and seed morphology (Roxburgh, 1820; Bremekamp, 1952). With the rapid development of modern molecular technique, most phylogenetic analysis based on multiple chloroplast and nuclear sequences revealed that the *Hedyotis-Oldenlandia* complex is polyphyletic and should be segregated into several small genera (Groeninckx *et al.*, 2009; Guo *et al.*, 2013; Wikström *et al.*, 2013; Neupane *et al.*, 2015; Gibbons, 2020; Xu *et al.*, 2021). Under this circumstance, the genus *Hedyotis* s. str. is typically characterized by its erect and robust herbs or shrubs and diplophragmous capsules, with the conserved type of *H. fruticosa* L. (Terrell and Robinson, 2003; Guo *et al.*, 2013). It is expected that *Hedyotis* s. str. may comprise approximately 150 species distributed mainly in the Asian-Pacific region (Wang, 2018; Jiang and Wang, 2021; Xu and Wang, 2021). To the best of our knowledge, there are about 82 *Hedyotis* s.l. taxa, of which 44 species belong to *Hedyotis* s. str., in China until now.

While examining the *Hedyotis* specimens from Guangxi and Yunnan, China, an interesting *Hedyotis* species came into our sights because of its hairy and tetragonal stem, axillary inflorescence and dehiscent capsular fruits. Successive field population investigation, as well as morphological comparison and molecular

phylogenetic analysis revealed that this plant is much different from other congeneric and morphologically similar species and represents a new species.

### MATERIALS AND METHODS

All morphological data in the description were collected from the specimens deposited at the herbarium of South China Botanical Garden, Chinese Academy of Sciences (IBSC). The seed morphology was observed using a scanning electron microscope (SEM, JSM-6360LV) under 25.00 KV accelerating voltage. The description of seed morphology followed Guo *et al.* (2011b).

The DNA extraction and PCR methods of the newly added taxa followed Guo *et al.* (2011a). Some other sequences included in the analysis were downloaded from GenBank (Table 1). SeqMan (DNASTAR Inc., Madison, WI, USA) was used to assemble sequences. Multiple sequence alignment was made using MAFFT v7.017 (Katoh *et al.*, 2002). Then obvious mismatch areas were manually adjusted according to Morrison (2006) and redundant sequences were cut off using Geneious v.8.0.2 (Kearse *et al.*, 2012). Bayesian inference (BI) analyses were conducted by MrBayes v 3.2.7 (Ronquist *et al.*, 2012) using ITS, *petD* and *rps16* sequences. It was carried out by MrBayes ver. 3.2.7 (Ronquist *et al.*, 2012), with GTR+G+I as the best-fitting nucleotide substitution model on basis of the AIC criterion (Nylander, 2004). The Markov chain Monte Carlo algorithm was run for 1 000 000 generations with four incrementally heated chains starting from random trees, sampling one out of every 100 generations. The initial 25% of the sampled trees were discarded as burn-in and a 50% majority-rule consensus tree was calculated from the remaining trees with nodal support summarized as posterior probabilities (PP). *Dentella repens* (L.) J.R. Forster & G. Forster and *Pentodon pentandrus* Vatke were selected as outgroups

**Table 1.** The taxa, vouchers and GenBank accession numbers of ITS, *rps16* and *petD* sequences for phylogenetic analysis.

Taxon	Voucher (Herbarium Code)	GenBank accession number		
		ITS	<i>rps16</i>	<i>petD</i>
<i>Dentella repens</i> (L.) J.R. Forst. & G. Forst.	Andersson 2262 (GB)	AM939440	AF333370	EU557693
<i>Pentodon pentandrus</i> Vatke	Dessein et al. 598 (BR)	AM939528	EU543066	EU557759
<i>Debia ovatifolia</i> (Cav.) Neupane & N. Wikström	Neupane 185 (ODU)	KP994262	KR005810	KR005749
<i>Dimetia ampliflora</i> (Hance) Neupane & N. Wikström	Rui-Jiang Wang 1147 (IBSC)	JX111198	JX111242	JX111086
<i>Dimetia auricularia</i> (L.) R.J. Wang	Rui-Jiang Wang 1185 (IBSC)	JF976476	JX111298	JF700053
<i>Dimetia capitellata</i> (Wall. ex G. Don) Neupane & N. Wikström	John H. Beaman 8630 (L)	HE657666	HE649796	HE657560
<i>Dimetia scandens</i> (Roxb.) R.J. Wang	Ming-Deng Yuan et al. 1386 (IBSC)	MW396584*	MW405417*	MW405431*
<i>Edrastima trinervia</i> (Retz.) Neupane & N. Wikström	Fagerlind 4338 (S)	HE657769	HE649907	HE657652
<i>Hedyotis acutangula</i> Champ. ex Benth.	Rui-Jiang Wang HA-02 (IBSC)	JX111197	JX111241	JX111085
<i>Hedyotis bracteosa</i> Hance	Shiu Ying Hu 10684 (A)	HE657736	HE649872	HE657621
<i>Hedyotis bodinieri</i> H. Lévl.	Rui-Jiang Wang 1253-1 (IBSC)	JF699910	JX111246	JF700059
<i>Hedyotis cantoniensis</i> F.C. How ex W.C. Ko	Rui-Jiang Wang 1250 (IBSC)	JF699912	JX111247	JF700061
<i>Hedyotis caudatifolia</i> Merr. & F.P. Metcalf	Xing Guo et al. 1269 (IBSC)	JF699916	JX111256	JF700065
<i>Hedyotis communis</i> W.C. Ko	Guo-Bin Jiang et al. 1137 (IBSC)	MT345064	MT792385	MT347604
<i>Hedyotis consanguinea</i> Hance	Rui-Jiang Wang 1254 (IBSC)	JF699923	JX111258	JF700071
<i>Hedyotis effusa</i> Hance	Rui-Jiang Wang 1268-1 (IBSC)	JF699933	JX111262	JF700083
<i>Hedyotis interrupta</i> G.B. Jiang & R.J. Wang	Guo-Bin Jiang et al. 1136-2 (IBSC)	MT345072	MT792393	MT347612
<i>Hedyotis longixserta</i> Merr. & Metcalf	Ming-Deng Yuan et al. YS60 (IBSC)	MW396584*	MW405424*	MW405435*
<i>Hedyotis matthewii</i> Dunn	Ming-Deng Yuan et al. YS236 (IBSC)	MW396582*	MW405427*	MW405438*
<i>Hedyotis nanlingensis</i> R.J. Wang	Ming-Deng Yuan et al. YS228 (IBSC)	MW396579*	MW405426*	MW405437*
<i>Hedyotis paridifolia</i> Dunn	Rui-Jiang Wang 1162 (IBSC)	JX111220	JX111272	JX111106
<i>Hedyotis platystipula</i> Merr.	Ming-Deng Yuan et al. YS348 (IBSC)	MW396580*	MW405429*	MW405440*
<i>Hedyotis prostrata</i> Blume	Guo-Bin Jiang et al. 1187 (IBSC)	MT345074	MT792396	MT347614
<b><i>Hedyotis pubicaulis</i></b> M.D. Yuan & R.J. Wang	Ming-Deng Yuan & Jiang-Ping Shu YS32 (IBSC)	MW396587*	MW405423*	MW405434*
<b><i>Hedyotis pubicaulis</i></b> M.D. Yuan & R.J. Wang	Ming-Deng Yuan et al. 1385 (IBSC)	MW396583*	MW405416*	MW405416*
<b><i>Hedyotis pubicaulis</i></b> M.D. Yuan & R.J. Wang	Ming-Deng Yuan et al. YS133 (IBSC)	MW396588*	MW405425*	MW405436*
<i>Hedyotis shenzhenensis</i> Tao Chen	Rui-Jiang Wang et al. 1262-2 (IBSC)	JF699952	JX111277	JF700102
<i>Hedyotis tenuipes</i> Hemsl.	Rui-Jiang Wang 1234-1 (IBSC)	JF699960	JX111280	JF700110
<i>Hedyotis tonggulingensis</i> G.B. Jiang & R.J. Wang	Guo-Bin Jiang et al. 1059-1 (IBSC)	MK562745	MT792398	MK694729
<i>Hedyotis uncinella</i> Hook. & Arn.	Rui-Jiang Wang 6306 (IBSC)	MZ326019*	MZ343058*	MZ468114*
<i>Hedyotis vachellii</i> Hook. & Arn.	T.W. Lau 057 (A)	HE657771	HE649909	HE657654
<i>Hedyotis xinyiensis</i> X. Guo & R.J. Wang	Rui-Jiang Wang 1182 (IBSC)	JF699970	JX111288	JF700120
<i>Hedyotis zhihaoana</i> H.C. Wang & X.L. Liu	Ming-Deng Yuan et al. YS287 (IBSC)	MW396589*	MW405428*	MW405439*
<i>Involucrella chereevensis</i> (Pierre ex Pit.) Neupane & N. Wikström	K. Larssen et al. 41491 (MO)	HE657737	HE649873	HE657622
<i>Involucrella coronaria</i> (Kurz) Neupane & N. Wikström	Xing Guo et al. 22-1 (IBSC)	JX111218	JX111270	JX111104
<i>Involucrella lithophila</i> M.D. Yuan & R.J. Wang	Sheng Chen YS49	MT793598	MW411058*	MT792383
<i>Leptopetalum biflorum</i> (L.) Neupane & N. Wikström	Rui-Jiang Wang 1146 (IBSC)	JF976479	JX111300	JF700055
<i>Leptopetalum pteritum</i> (Blume) Neupane & N. Wikström	Neupane 163 (ODU)	KP994274	KR005822	KR005759
<i>Oldenlandia corymbosa</i> L.	Xing Guo et al. SIN02 (IBSC)	JX111239	JX111306	JX111121
<i>Oldenlandia erecta</i> (Manilal & Sivar.) R.R. Mill	Ming-Deng Yuan et al. 1471-3 (IBSC)	MW396585*	MW405418*	MW405432*
<i>Scleromitron angustifolium</i> (Cham. & Schltdl.) Benth.	Neupane 108 (ODU)	KP994266	KR005814	KR005753
<i>Scleromitron diffusum</i> (Willd.) R.J. Wang	Xing Guo 51 (IBSC)	JF699932	JX111308	JF700081
<i>Scleromitron verticillatum</i> (L.) R.J. Wang	Xing Guo 66 (IBSC)	JF699969	JX111313	JF700119

\*indicating that the sequences are newly added.

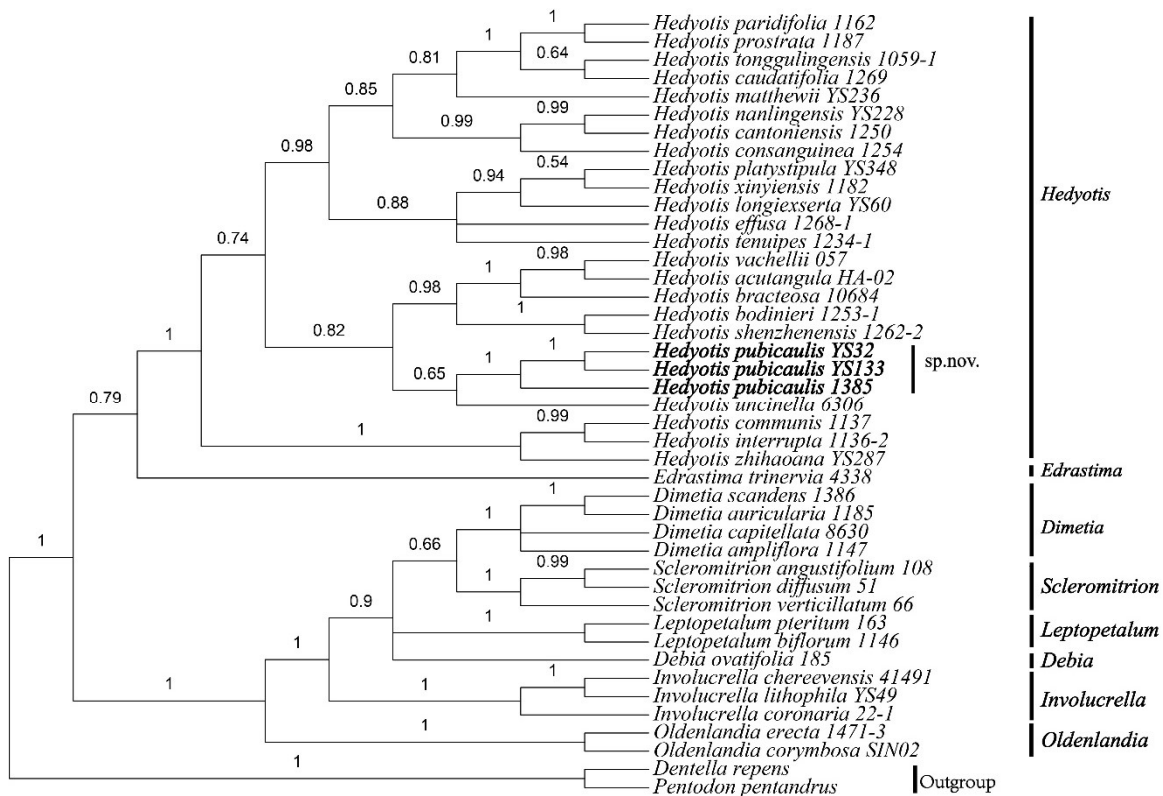


Fig. 1. MrBayes strict consensus tree derived from a combined analysis of ITS, petD and rps16, with posterior probability (PP) indicated above branches.

according to the previous studies (Guo *et al.*, 2013; Neupane *et al.*, 2015). The trees were adjusted by FigTree ver. 1.4.4.

## RESULTS

### Phylogenetic analysis

The phylogenetic analysis, based on nuclear ITS and two chloroplast DNA regions (*petD*, *rps16*), generated an almost identical tree to that of Guo *et al.* (2013). The three samples of *Hedyotis pubicaulis* from three subpopulations form an independent clade with robust support value (PP=1) and are phylogenetically close to *H. uncinella* with weak supported (PP=0.65) (Fig. 1 & Table 1).

## TAXONOMIC TREATMENT

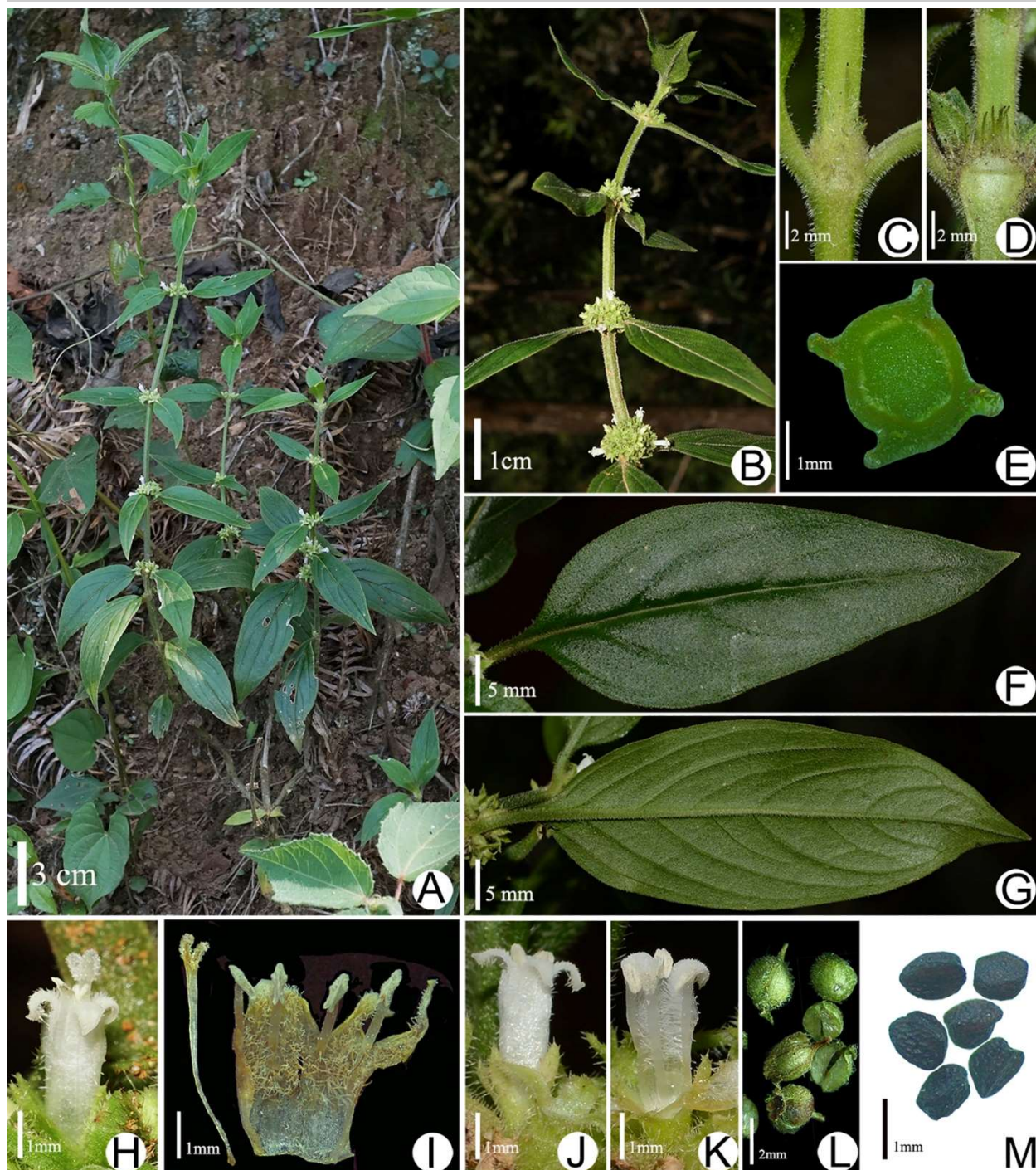
*Hedyotis pubicaulis* M.D. Yuan & R.J. Wang, *sp. nov.*

毛莖耳草 Figs. 2 & 3.

**Type:** CHINA. Yunnan Province: Dai Autonomous Prefecture of Xishuangbanna, Jinghong City, Gasa Town, Naban Village, roadside, 100°39' E, 22°09' N, 708 m elevation, short-styled flower, 11 November 2019, *Ming-Deng Yuan & Jiang-Ping Shu* YS32 (holotype IBSC! barcode 0859809; isotype IBSC, barcode 0859804).

**Diagnosis:** *Hedyotis pubicaulis* is similar to *H. uncinella* Hook. & Arn. but can be distinguished by its densely pubescent stems, truncate to triangular stipules with 6–14 bristles, axillary inflorescence and 2–3 mm long corolla tube.

**Description:** Perennial herbs, 15–60 cm tall. Stem erect, densely pubescent, usually unbranched, tetragonal and sulcate. Leaves opposite, 2.2–7.0 × 0.7–2.5 cm, elliptic to ovate, broadly cuneate to rounded at base, apex acuminate, blade papery, densely puberulent along veins; midrib obvious, concave adaxially and prominent abaxially; secondary veins 4–8 on each side; petiole to 1.0 cm long, puberulent. Stipules interpetiolar, 2–6 mm long including bristles, truncate to triangular, densely puberulent; bristles 6–14 at apex, 1.0–4.5 mm long. Inflorescence axillary, glomerate, sessile; bracts lanceolate or linear. Flowers heterostylous. Hypanthium funnelform, ca. 1.5 mm long, puberulent; lobes 4, narrowly triangular or ovate, ca. 1.5 mm long. Corolla white, campanulate, tube 2.5–3.5 mm long, sparsely pubescent abaxially, densely pubescent at throat and lobes; lobes 4, triangular or ovate, ca. 1.0 mm long, reflex. Stamens 4; filaments ca. 1.5 mm long; anthers slightly exserted, oblong, ca. 0.7 mm long. Stigma ca. 0.7 mm long, bilobed, clavate. Long-styled flowers: styles 3–4 mm long, stigma exserted completely; stamens adnate to sinus of corolla tube. Short-styled flowers: styles ca. 2.5



**Fig. 2.** *Hedyotis pubicaulis* sp. nov. **A:** Habit. **B:** Axillary inflorescences. **C & D:** Stipules with many bristles. **E:** Transverse section of the tetragonal stem. **F & G:** Adaxial and abaxial side of leaf blade, respectively. **H & I:** Long-styled flower and its longitudinal section, respectively. **J & K:** Short-styled flower and its longitudinal section, respectively. **L:** Septicidally dehiscent capsules. **M:** Seeds. (A–I: from Ming-Deng Yuan et al. 1385; J–M: from *Ming-Deng Yuan & Jiang-Ping Shu* YS32). Photos by the authors.

mm long, stigma extended to throat mostly; stamens adnate to the middle of corolla tube. Capsules 1.8–2.0 × 1.5–2.0 mm, ellipsoid to subglobose, densely puberulent, dehiscent at apex and then septicidally. Seeds numerous, angular, 0.8–1.0 mm long, testa reticulate.

**Phenology:** *Hedyotis pubicaulis* was observed in

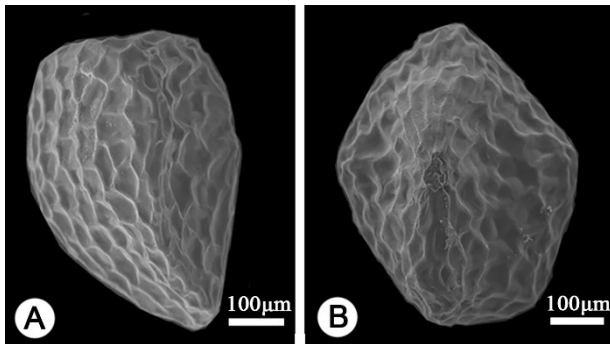
flowering between June and December and in fruiting between July and next January.

**Etymology:** The epithet refers to its densely pubescent tetragonal stem, which is an obvious character to distinguish the new species from other congeneric ones in China.

**Distribution and habitat:** *Hedyotis pubicaulis* is

**Table 2.** Morphological comparison among *Hedyotis pubicaulis* and its closely related species *Dimetia auricularia* and *H. uncinella*.

Characters	<i>Hedyotis pubicaulis</i>	<i>Dimetia auricularia</i>	<i>Hedyotis uncinella</i>
Habit	Perennial herbs	Perennial herbs	Perennial herbs
Stem	Tetragonal, densely pubescent	Cylindrical or slightly angled, densely hirtellous or glabrous	Tetragonal, hirtellous or glabrous
Leaves size	2.2–7.0 × 0.7–2.5 cm	1.0–10 × 1.0–3.5 cm	3.5–7.0 × 1.0–3.0 cm
Petiole length	0–10 mm	2–5 mm	0–10 mm
Leaves shape	Elliptic to ovate	Lanceolate, ovate-lanceolate or elliptic-lanceolate	Elliptic, ovate-oblong or oblong-lanceolate
Secondary veins	4–8 on each side	3–7 on each side	4–5 on each side
Stipules	Truncate to triangular, apex 6–14 bristles, densely puberulent	Truncate to triangular or elliptic, apically with 3–9 setae lobes, glabrous or hirtellous	Triangular to broadly triangular, marginally with 6–10 narrowly lanceolate lobes, densely hirtellous
Inflorescence	Axillary, glomerate	Axillary, glomerulate to congested-cymose	Terminal and axillary, capitate or glomerulate
Corolla	Campanulate, tube 2.0–3.0 mm long, sparsely pubescent abaxially, densely pubescent at throat and lobes	Tubular, tube 1.0–1.5 mm long, glabrous abaxially and lobes, densely pubescent in corolla tube	Tubular, tube 3.0–4.0 mm long, glabrous abaxially and lobes, densely pubescent at throat
Capsules	Elipsoid to subglobose, septically	Spherical to ovoid, indehiscent	Subglobose or broadly ovoid, septically

**Fig. 3.** Seed morphology of *Hedyotis pubicaulis* under SEM. **A:** Dorsal view. **B:** Ventral view. (from Ming-Deng Yuan et al. 1385).

widely distributed in Guangxi and Yunnan. It grows in the shady places of mountainous slopes and roadsides. The main associated species are *Melastoma malabathricum* L., *Gonostegia hirta* (Blume) Miq., *Commelina communis* L., *Dicranopteris pedata* (Houtt.) Nakaike.

**Additional specimens examined (paratypes):** CHINA.

**Guangxi:** Baise City, *Kuan-You Huang 30460* (GXMI), *Ming-Deng Yuan et al. YS133* (IBSC), *YS318* (long-styled flower, IBSC); Chongzuo City, *Ming-Deng Yuan et al. YS126* (IBSC), *YS332* (long-styled flower, IBSC), *Rui-Jiang Wang 375* (IBSC). **Yunnan:** Xishuangbanna Daizu Autonomous Prefecture, *Chi-Wu Wang 77434* (PE), *80451* (PE; IBSC), *Ming-Deng Yuan et al. YS286* (short-styled flower, IBSC), *Ming-Deng Yuan et al. 1426* (long-styled flower, IBSC), *Sheng-Ji Pei 10010* (KUN, HITBC), *11044* (KUN), *Wen-Tsai Wang 10404* (KUN); Honghe Hanizu Yizu Autonomous Prefecture, *Wei-Xin Liu 460* (HITBC), *De-Ding Tao 613* (KUN); Puer City, *Guo-Da Tao 49148* (HITBC; IBSC); Wenshan Zhuangzu Miaozu Autonomous Prefecture, *Ming-Deng Yuan et al. 1385* (long-styled flower, IBSC).

**Conservation status:** Based on the information from specimens and our field investigation, more than 15 wild subpopulations of *Hedyotis pubicaulis* were recorded in Guangxi and Yunnan, China. This species is a perennial and widely distributed herb and can generate numerous fertilized seeds and young seedlings every year. In addition, it has no any medicinal and ornamental value.

According to the IUCN Standards and Petitions Subcommittee (2019), the conservation status is evaluated as Least Concern.

## DISCUSSION

*Hedyotis uncinella* is not only morphologically similar to but also phylogenetically closed to *H. pubicaulis* in the present analysis, but in fact the relationships among the *Hedyotis* species has not been well resolved yet due to the insufficient data. A phylogenetic tree based on whole chloroplast genomes is expected to simulated in future. In addition, *Hedyotis pubicaulis* is also similar to *Dimetia auricularia* (L.) R.J. Wang in sharing herbal habit and axillary inflorescence, but it can be readily recognized by its densely pubescent and tetragonal stem, 2–3 mm long corolla tubes and dehiscent capsules (Table 2).

## ACKNOWLEDGMENTS

The study was supported by the general program of National Natural Science Foundation of China (Grant no. 31770217). We are indebted to Ms. Xiao-Ying Hu for SEM observation.

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