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# ***Hemipilia avisoides* (Orchidaceae), a new species from Sichuan Province, China**

Xue-Man Wang,  Ying Tang, Pei-Hao Peng, Hua Peng

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# 1 ***Hemipilia avisoides* (Orchidaceae), a new species**

## 2 **from Sichuan Province, China**

3 Xue-Man Wang<sup>1</sup>, Ying Tang<sup>2</sup>, Pei-Hao Peng<sup>2</sup>, Hua Peng<sup>3</sup>

4 <sup>1</sup> College of Earth Sciences, Chengdu University of Technology, Chengdu  
5 610059, Sichuan, China

6 <sup>2</sup> College of Tourism and Urban-rural Planning, Chengdu University of  
7 Technology, Chengdu 610059, Sichuan, China

8 <sup>3</sup> CAS Key Laboratory for Plant Diversity and Biogeography of East Asia,  
9 Kunming Institute of Botany, Chinese Academy of Sciences, Kunming  
10 650201, Yunnan, China

11 Corresponding author: Ying Tang ([sanxiaqutang@sina.com](mailto:sanxiaqutang@sina.com))

## 12 **Abstract**

13 A new orchid species, *Hemipilia avisoides*, is described from Songpan County  
14 and Maoxian County, Sichuan Province, China. Morphologically, it is most  
15 similar to *H. occidensichuanensis* ( $\equiv$  *Ponerorchis limprichtii*), but *H. avisoides*  
16 can be distinguished by the combination of its involute middle lip lobe that is  
17 smaller than the lateral lobes, pendulous lateral lip lobes, floral bracts that are  
18 always shorter than the ovary, a leaf that is appressed to substrate and is  
19 adaxially green with white veins and a solitary sheath at the stem base. The  
20 floral morphology of *H. avisoides* is also presented by utilising *in vivo* micro-  
21 CT scanning and 3D visualisation.

## 22 **Keywords**

23 Arid alley, Minjiang River Valley, Orchidinae, taxonomy

## 24 **Introduction**

25 The genus *Hemipilia* Lindl. *sensu stricto* (Orchideae, Orchidaceae) comprises  
26 ca. 10 species that are characterised by a protruding, tongue-like rostellum  
27 (Luo & Chen 2000; Chen et al. 2009). Nevertheless, molecular phylogenies  
28 revealed *Hemipilia* s.s. as monophyletic, but nested deeply within a strongly-  
29 supported clade that also included several species from closely-allied genera,

for example, *Ponerorchis* Rchb. f., *Amitostigma* Schltr. and the monotypic *Hemipiliopsis* (K. Y. Lang) Y. B. Luo & S. C. Chen (Luo 1999; Bateman et al. 2003; Jin et al. 2014, 2017; Tang et al. 2015). Given the fact that *Ponerorchis* and *Amitostigma* are paraphyletic, both Jin et al. (2014) and Tang et al. (2015) formally proposed to expand the circumscription of *Hemipilia*, although to a different extent. Here, we follow the treatment of *Hemipilia sensu latissimo*, in which seven sections were recognised (Tang et al. 2015).

During the field trip in 2013 to collect *A. physoceras* Schltr. in Minjiang River Valley, Songpan County, Sichuan Province, China, one of the authors (Y. Tang) collected another orchid that morphologically fits into the category of *Hemipilia s.l.* It had been temporarily identified as cf. *Ponerorchis limprichtii* (Schltr.) Soó in the previous study by Tang et al. (2015). However, this taxon in Songpan not only differs in the morphology of the labellum and leaf, but also diverges in DNA sequences, both of which suggest it as a potential new species (Tang et al. 2015). Here, we describe it in *H. sect. Hemipilia sensu* Tang et al. (2015) and present its floral morphology by utilising an *in vivo* micro-CT method.

## Methods

### Material collection

During our field investigation to Minjiang River Valley, Songpan, Sichuan, China in 7–9 June 2022, two populations of the new taxon with 12 flowering individuals were found. One population occurs at the same locality that was visited in 2013 by one of the authors (Y. Tang) and the other is ca. 11.2 km southwards in the Valley.

A total of four living individuals with intact flowers from the two populations were collected, each was packaged with soils and EPE pearl cotton in a plastic bottle and transported by air to the Key Laboratory of Stratigraphy and Paleontology, Ministry of Natural Resources for *in vivo* micro-CT scanning. After scanning, these individuals were pressed as specimens. The voucher specimens were deposited at the Herbarium of Sichuan University (SZ).

### Morphological observations

The morphological description of the new taxon was mainly based on living materials. The length and width of leaves and the height of the inflorescence were measured on seven living, flowering plants in the field. The morphology

of subterranean parts was described on the four plants collected (see Material collection). The morphology of a single flower was described mainly on the basis of the 3D mesh model reconstructed by micro-CT data.

## Micro-CT scanning and 3D Visualisation

X-ray Computed Tomography (CT) was completed at the Key Laboratory of Stratigraphy and Paleontology, Ministry of Natural Resources. One of the four living individuals collected (see Material collection) was finally selected for scanning and was then chosen as the holotype of the new taxon. Its inflorescence with the uppermost three flowers was scanned *in vivo* in a Nikon XTH 225ST CT scanner at a resolution of 18.6  $\mu\text{m}$  and X-ray of 90 kv and 70  $\mu\text{A}$ .

3D reconstructions were performed in the software VGSTUDIO MAX 3.0 with STL files being exported. For the 3D model of inflorescence, however, only the uppermost two flowers were reconstructed due to the trade-off between resolution and computing time. Acquired 3D mesh models were visualised and processed by the software GOM INSPECT PRO in GOM SUITE 3.1.1109.0.

## Results

### Taxonomic treatment

***Hemipilia avisoides* Y. Tang, X. M. Wang & H. Peng, sp. nov.**

Figs. 1A–D, 2 and 3; see also Data availability

**Type.** CHINA, Sichuan Province, Aba Tibetan and Qiang Autonomous Prefecture, Songpan County, 9 June 2022, Y. Tang, X. M. Wang & Y. T. Zhu 235 (holotype: SZ!); Songpan County, 9 June 2022, Y. Tang, X. M. Wang & Y. T. Zhu 236 (paratype: SZ!); Maoxian County, 1 June 1958, S. Y. Chen, Z. He, M. F. Zhong *et al.* 5078 (paratype: SZ!).

**Diagnosis.** Similar to *Hemipilia occidensichuanensis* Y. Tang & H. Peng ( $\equiv$  *Ponerorchis limprichtii* (Schltr.) Soó), from which *H. avisoides* can be distinguished by a set of characteristics: mid-lobe involute, suboblong in apical view, trapeziform when flattened, smaller than lateral lobes; lateral lobes pendulous; floral bracts 5 mm long, always shorter than ovary; leaf appressed to substrate, adaxially green with white veins; stem with one sheath at base (Fig. 1; Table 1).

**Description.** Terrestrial, erect herbs, 8.5–31 cm tall. Tubers oblong, 2.5 cm long, 0.8 cm in diameter, neck with few roots. Stem subterranean, 2.7–5 cm long, 0.2 cm in diameter, with one sheath at base. Sheath tubular, membranous, 1–2 cm long, pale yellow. Leaf appressed to substrate, solitary, cordate, ovate or elliptic, 3–6.5 × 2–5.5 cm, apex acute, slightly fleshy, glabrous, abaxially purple, adaxially green with white veins, occasionally also with purple spots. Inflorescence terminal, erect, 3–14 cm long, 1–21-flowered, glabrous, dark purple. Flowers not secund, plum or purple plum, fragrant; floral bracts connivent to ovary, elliptic, 5 × 2.6 mm, shorter than ovary, apex acuminate, glabrous, dark purple; ovary curved, cylindrical, 10.5 mm long including pedicel, 1 mm in diameter, glabrous, dark purple. Dorsal sepal erect, oblong, cymbiform, 4.5 × 2.6 mm, apex rounded, sometimes concave at each side of central vein below middle, glabrous; lateral sepals spreading, obliquely ovate, cymbiform, 5.6 × 3.6 mm, apex obtuse, glabrous. Petals erect, connivent with dorsal sepal and forming a hood, apex bending similar to holding a fist in the other hand, obliquely ovate, 4 × 2.8 mm, apex obtuse, glabrous. Labellum spreading, broadly ovate when flattened, 7.1 × 5.4 mm, 3-lobed below middle, spurred, base collar-like raised on each side of spur entrance, glabrous, tinged white at base, disc dotted with purple; lateral lobes pendulous, rhombic, 3.4 × 2.5 mm, apex truncate, margin slightly undulate; mid-lobe horizontal, involute, suboblong in apical view, 2.2 × 1.2 mm, trapeziform when flattened, apex rounded or sometimes apiculate; spur horizontal, straight or curved upwards, cuneate, 9 mm long, ventrally carinate along central axis, entrance 2.5 mm wide, apex swollen, obtuse, 2.7 mm wide; anther reclined, 2.8 mm long, 2-locular, locules parallel and closely spaced, aubergine; pollinia 2, sectile, ovate, 1.2 × 0.7 mm; caudicles cuneate, 1.2 mm long; viscidia 2, closely spaced, oblong, transparent, each enclosed within a separate bursicle; bursicles formed by folding of rostellar arms, oblong, 0.6 × 0.3 mm; rostellum median lobe triangle, 0.7 mm long, lateral lobes grooved; stigma ventral, lobes 2, divergent, lamelliform, 1.2 × 0.5 mm, with hairs at base; auricles 2, each placed laterally at base of anther, behind collar of labellum base, 0.5 mm long.

**Flowering.** Peaking in early June.

**Distribution and habitat.** *Hemipilia avisoides* is currently known from two localities in Songpan County, which are ca. 11.2 km apart along the Minjiang River Valley and one locality in Maoxian County according to the collection by S. Y. Chen et al. in 1958. Individuals of the new taxon occur under arid-valley shrubs and on moss-covered rocks (see Discussion).

**Etymology.** The epithet refers to the resemblance of flowers and

137 inflorescence of *Hemipilia avisoides* to wild geese that are flapping wings and  
138 flying in formation.

139 **Chinese name.** 雁字舌喙兰 (Chinese pinyin: yàn zì shé huì lán).

140 **Additional specimens examined.** *Hemipilia avisoides*: **CHINA, Sichuan**  
141 **Province, Aba Tibetan and Qiang Autonomous Prefecture**, Songpan  
142 County, 30 June 2013, Y. Tang 151 (KUN!).

143 *Hemipilia occidensichuanensis*: **CHINA, Sichuan Province, Ganzi**  
144 **Tibetan Autonomous Prefecture**, Kangding City, 18 June 2022, Y. Tang, X.  
145 M. Wang, W. Q. Yuan & Y. T. Zhu 237 (SZ!); Kangding City, 17 June 2017, Y.  
146 L. Peng, Q. Yu & L. L. Li THP-KD-1390 (CDBI!); Kangding City, 13 June 2014,  
147 Y. Tang 199 (KUN!); Luhuo County, 12 August 2005, D. E. Boufford, J. H.  
148 Chen, K. Fujikawa, S. L. Kelley, R. H. Ree, H. Sun, J. P. Yue, D. C. Zhang &  
149 Y. H. Zhang 34770 (A!); Xiangcheng County, 15 July 2004, D. E. Boufford, J.  
150 H. Chen, S. L. Kelley, J. Li, R. H. Ree, H. Sun, J. P. Yue & Y. H. Zhang 30764  
151 (A!); Daofu County, 10 June 1996, J. S. Yang 91-270 (IBSC!; PE!); Kangding  
152 City, 28 May 1981, Z. J. Zhao, J. B. Shi & D. G. Fan 114262 (SZ!); Xinlong  
153 County, 28 June 1974, Z. S. Qin 06383 (CDBI!); Xinlong County, 27 June  
154 1974, Z. S. Yu 06409 (CDBI!); Yajiang County, 15 June 1961, S. Jiang 05196  
155 (KUN!). **CHINA, Sichuan Province, Aba Tibetan and Qiang Autonomous**  
156 **Prefecture**, Xiaojin County, 21 May 1959, Xiao Jin Zu 0130 (SZ!); Xiaojin  
157 County, 21 May 1957, J. Zhou 34 (IBSC!); Maerkang City, 16 May 1957, X. Li  
158 71047 (PE!; SZ!). **CHINA, Gansu Province, Longnan City**, Wenxian County,  
159 12 May 2007, Bai Shui Jiang Cai Ji Dui 4839 (PE!); Wenxian County, 9 May  
160 2007, Bai Shui Jiang Cai Ji Dui 4514 (PE!); Wudu District, 15 June 1959, Z. Y.  
161 Zhang 4390 (WUK!); Wudu District, 5 June 1959, Z. Y. Zhang 3379 (WUK!);  
162 Wudu District, 30 May 1959, Z. Y. Zhang 3180 (PE!; WUK!). **CHINA, Gansu**  
163 **Province, Gannan Tibetan Autonomous Prefecture**, Zhouqu County, 27  
164 May 1999, Bailongjiang Exped. 1408 (PE!). **CHINA**, 1959, Chuan Jing A 0130  
165 (KUN!); July 1907, E. H. Wilson 1762 (specimen 2nd from left: AMES!).

166 **Conservation status.** *Hemipilia avisoides* seems narrowly distributed  
167 within the Arid valley in the upper reaches of Minjiang River (see Discussion),  
168 with few populations and individuals being found. The habitat of *H. avisoides*  
169 could be easily disturbed by people as it is close to roads and villages.  
170 However, further field investigations in Minjiang River Valley and areas nearby  
171 are necessary to assess the exact distribution and population status of *H.*  
172 *avisoides*. Therefore, we here temporarily assign *H. avisoides* to the category  
173 DD (Data Deficient) according to the International Union for Conservation of  
174 Nature (IUCN Standards and Petitions Committee 2022).



## Discussion

The new species *Hemipilia avisoides* has oblong tubers, two erect anthers, two stigmas that are beneath the rostellum and two sectile pollinia with viscidium each enclosed within a bursicle. These characteristics fit well into the category of the *Amitostigma* alliance or *Hemipilia s.l.* (Tang et al. 2015). *Hemipilia avisoides* has also a solitary, slightly fleshy leaf that is appressed to substrate, which is quite reminiscent of *Hemipilia s.s.* (Chen et al. 2009). However, the median rostellum lobe of *H. avisoides* never protrudes between anther cells like that of *Hemipilia s.s.*

Molecular phylogenies did, however, reveal a close relationship between *Hemipilia s.s.* and *H. avisoides* in a clade (figs. 1–3 in Tang et al. 2015, *H. avisoides* identified as *Ponerorchis cf. limprichtii*). The sister relationship between *P. limprichtii* ( $\equiv$  *H. occidentichuanensis*) and *H. avisoides* is also strongly supported in both nuclear and chloroplast trees (Tang et al. 2015), while they are most similar in morphology (see Taxonomic treatment and below). Moreover, *H. avisoides* and *P. limprichtii* each occupies a long branch in molecular trees, exhibiting considerable DNA sequence divergences (Tang et al. 2015).

Amongst the specimens of *P. limprichtii*, one collection by S. Y. Chen et al. in 1958 caught our attention for it was gathered from Maoxian County at an elevation of 1780 m, this being close to the localities where we discovered *H. avisoides*. The environment of that region differs from the alpine habitat that *P. limprichtii* usually favours. After careful examination, we believe that this specimen represents *H. avisoides* here described, although it was initially identified as *P. limprichtii*. We highlighted in Fig. 3 the key features, which facilitated our identification of the specimen. Nevertheless, rather than on living plants, some subtle features could faintly be observed on pressed specimens of *H. avisoides* and its similar species. For example, the three-dimensional structure of flowers would collapse once pressed and the colours of leaves would fade away when drying. This might obscure the discrepancies between *H. avisoides* and *P. limprichtii* or even other more distantly related species like *P. chusua* (D. Don) Soó. We hope that the 3D mesh model reconstructed in this study (see Data availability) would become helpful for recognising *H. avisoides* in future research.

*Ponerorchis limprichtii* is also distributed in Gansu Province, which is north of Sichuan Province. According to the vegetation regionalisation of China (Zhang 2007) and the information of specimens (see Additional specimens examined), the habitats of *P. limprichtii* in Gansu probably range

from arid-valley shrubs to deciduous broadleaved forests at an elevation between 1250 and 1850 m. Besides herbarium specimens, there are some photo records of *P. limprichtii* in Gansu, despite initially being assigned only to genus level or to other species by the photographers, on the web site of Plant Photo Bank of China, PPBC (in Chinese; see <http://ppbc.iplant.cn/tu/5920959> (by R. B. Zhu in Zhouqu County), <http://ppbc.iplant.cn/tu/5919232> (by R. B. Zhu in Wenxian County), <http://ppbc.iplant.cn/tu/5919279> (by R. B. Zhu in Wenxian County), <http://ppbc.iplant.cn/tu/7885080> (by X. J. Liu in Chengxian County) and the remaining photos in the albums of each plant). The plants shown in those photos have a subsquare mid-lobe that is obviously larger than the lateral lobes; therefore, we recognised them as *P. limprichtii*. Surprisingly, their leaves are green with white, reticulate venation, which mainly resemble those of *H. avisoides*. Another online photo of *P. limprichtii*, taken by S. L. Kelley in Luhuo County, Sichuan, showed a nearly uniformly green leaf ([http://hengduan.huh.harvard.edu/fieldnotes/specimens/search/specimen\\_detail.zpt?specimen\\_id=21330&full\\_image=skelley04179](http://hengduan.huh.harvard.edu/fieldnotes/specimens/search/specimen_detail.zpt?specimen_id=21330&full_image=skelley04179)). On the other hand, a few individuals of *H. avisoides* were observed in the field to possess conspicuously purple spots, along with white veins, on their leaves. We have also noticed that the lateral lobes of *P. limprichtii* in Gansu as shown in the PPBC photos are often pendulous. Taking these facts into account, the abovementioned cases render the diagnostic characteristics of *H. avisoides* seemingly cryptic.

According to the spatial delimitation of the Arid valley in the upper reaches of Minjiang River (Zheng et al. 2017), of the two *H. avisoides* populations we discovered, one is distributed within the range of the Arid valley and the other is closely situated next to the Arid valley. The locality of the collection by S. Y. Chen et al. in 1958 was not precisely recorded, but the elevation of 1780 m implied that the specimen was collected from the range of the Arid valley in that region. However, it is notable that, as climate changes, the spatial range of the Arid valley varies (Zheng et al. 2017). Focusing on vegetation type, based on our field observations, the vegetation where our collections of *H. avisoides* occurs could be classified into Form. *Sophora davidii* (Franch.) Skeels, Form. *Prunus tangutica* (Batal.) Korsh. and/or Form. *Ostryopsis davidiana* Decaisne, which are typical of arid-valley shrubs and span an elevation between ca. 1700 and 2500 m (Yang 2007). To sum up, the habitats of *H. avisoides* are mostly within the Arid valley in the upper reaches of Minjiang River. To our knowledge, other orchids in the same and sympatric habitats include *H. physoceras* (Schltr.) Y. Tang & H. Peng, *Habenaria acianthoides* Schltr. and *Cephalanthera erecta* (Thunb. ex A. Murray) Bl., although each of these species is more widely distributed overall. We believe



254 the ecological characteristics of these orchids, including *Hemipilia avisoides*,  
255 are worthy of future study.

## 256 **Data availability**

257 The 3D mesh model of the uppermost two flowers on an inflorescence and  
258 photos of the corresponding micro-CT-scanned individual of *Hemipilia*  
259 *avisoides*, are available on Zenodo via DOI:  
260 <https://doi.org/10.5281/zenodo.6832154>.

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270 Academy of Sciences, Dr Yang-Jun Lai from Institute of Botany, Chinese  
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## 277 **Author contributions**

278 **Xue-Man Wang**: Investigation; Writing – original draft; Writing – review &  
279 editing. **Ying Tang**: Conceptualisation; Investigation; Resources;  
280 Visualisation; Writing – original draft; Writing – review & editing. **Pei-Hao**  
281 **Peng**: Funding acquisition; Supervision. **Hua Peng**: Conceptualisation;  
282 Funding acquisition; Supervision.

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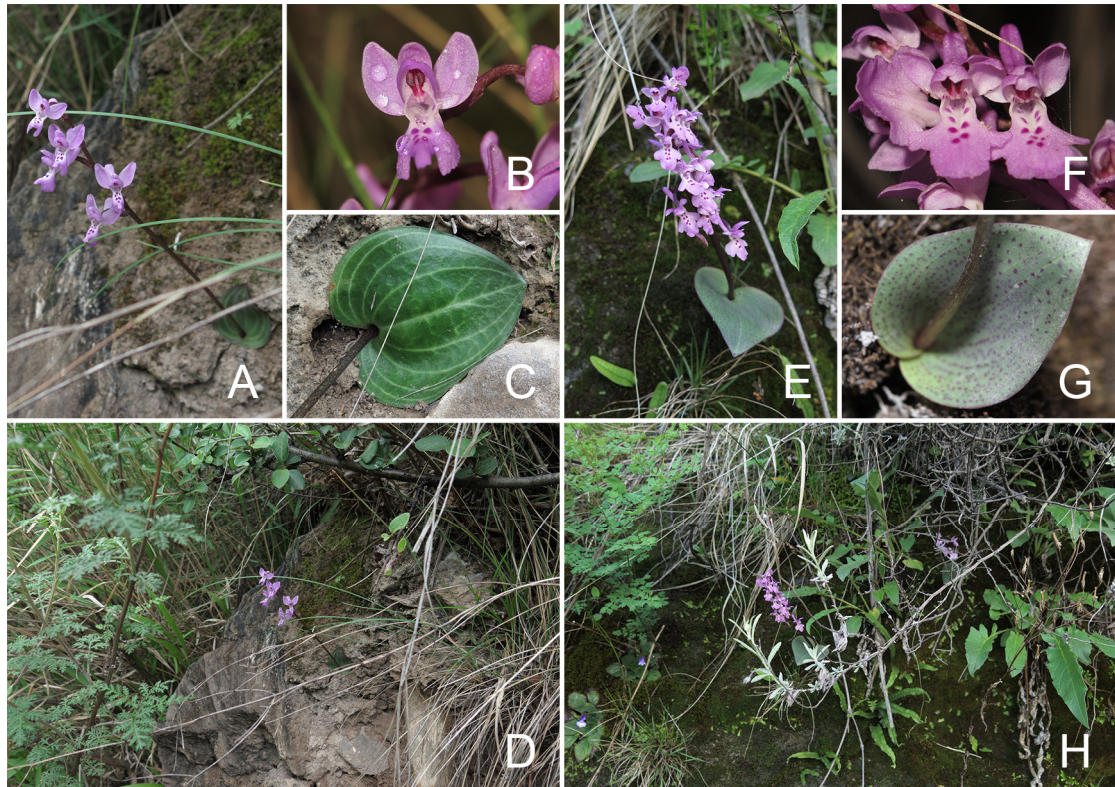
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324 **TABLE 1.** Comparisons in morphology between *Hemipilia avisoides* sp. nov.  
325 and similar *H. occidentichuanensis*.

Species	<i>Hemipilia avisoides</i>	<i>H. occidentichuanensis</i>
<b>Stem shape</b>	Subterranean, with 1 sheath at base	Partly subterranean, with 1 or 2 (or 3) sheaths at base
<b>Leaf position</b>	Appressed to substrate	Sub-basal
<b>Leaf colour adaxially</b>	Green with white veins, occasionally also with purple spots	Usually green with purple markings, sometimes nearly uniformly green or with white, reticulate venation
<b>Flora bract shape</b>	Elliptic, 5 mm long, always shorter than ovary	Lanceolate or ovate-lanceolate, lower ones nearly as long as ovary, gradually smaller upwards to shorter than ovary
<b>Dorsal sepal shape</b>	Oblong, apex rounded, sometimes concave at each side of central vein below middle	Suboblong, apex subacute
<b>Lateral lip lobe shape</b>	Pendulous, rhombic	Usually horizontal, auricular or transversely suboblong
<b>Middle lip lobe shape</b>	Involute, suboblong in apical view, $2.2 \times 1.2$ mm, trapeziform when flattened, smaller than lateral lobes, apex rounded or sometimes apiculate	Usually open and flat, subsquare, $4-5 \times 3-4$ mm, larger than lateral lobes, apex obtuse-rounded, sometimes slightly emarginate or shortly apiculate

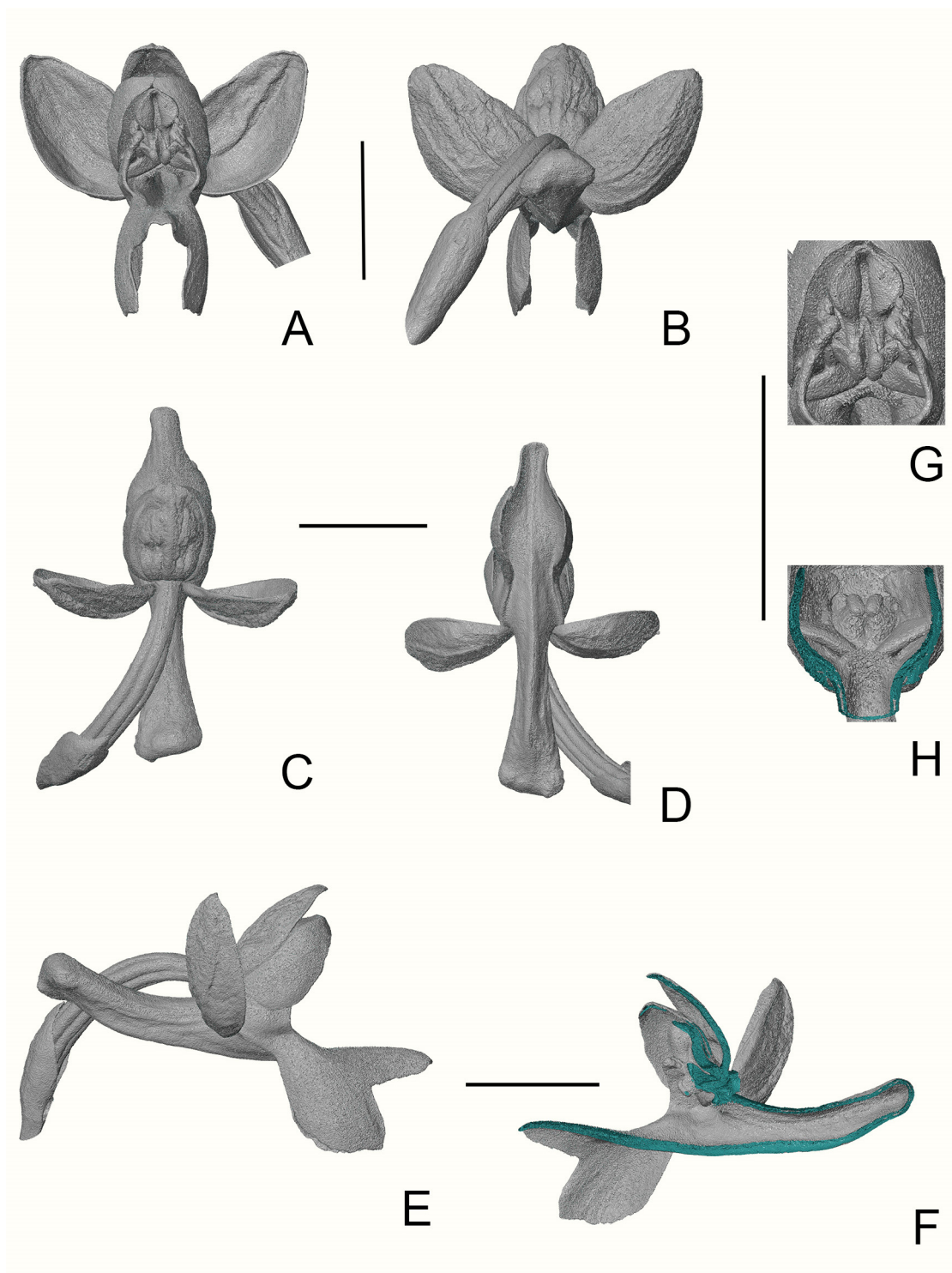
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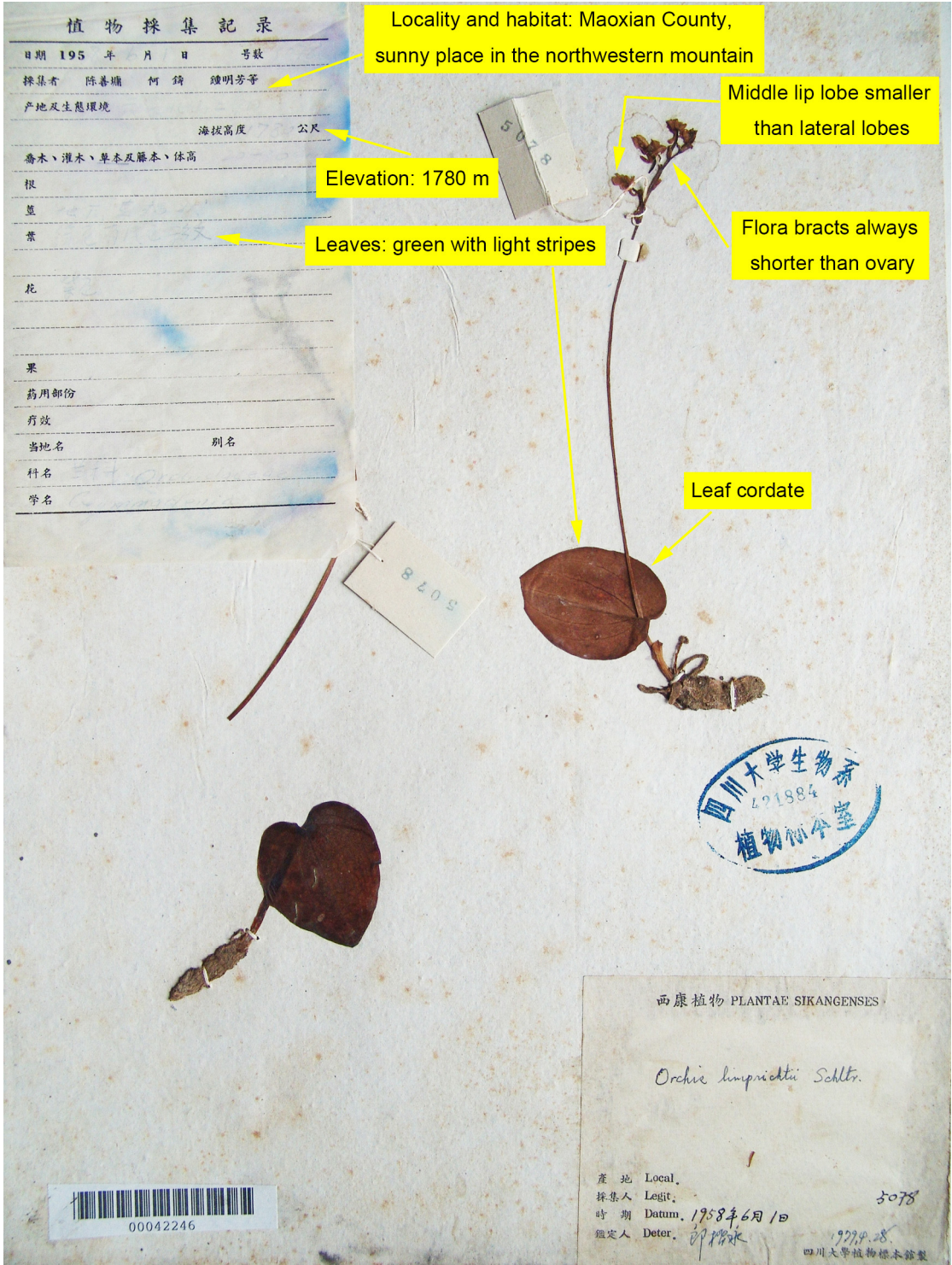
328 **Figure 1.** Comparisons between living plants of *Hemipilia avisoides* sp. nov.  
 329 and similar *H. occidentichuanensis* in the wild. **A–D**, habit, flowers, leaf and  
 330 habitat of *H. avisoides*; **E–H**, habit, flowers, leaf and habitat of *H.*  
 331 *occidentichuanensis*. Photographs A–H by Y. Tang.





**Figure 2.** Different views of *Hemipilia avisoides*, based on 3D mesh model reconstructed by micro-CT data. **A–E**, front, back, apical, ventral and right-side views of flower; **F**, left-side view of labellum that is split; **G**, **H**, front and ventral views of gynostemium. Scale bars, 5 mm.





**Figure 3.** Specimen of S. Y. Chen, Z. He, M. F. Zhong et al. 5078 (SZ!) identified as *Hemipilia avisoides* in this study. Key features, which would facilitate the identification of this specimen, are highlighted and arrowed in yellow.