**Taiwania 63(3)**: 235-240, 2018
*DOI: 10.6165/tai.2018.63.235*

# A new species of *Berberis* Sect. *Wallichianae* from Taiwan, *Berberis morii*

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(Manuscript received 9 May 2018; accepted 18 July 2018; online published 6 August 2018)

ABSTRACT: In a revision of *Berberis* Sect. *Wallichianae* in Taiwan and Luzon, the Philippines, two of the authors recognized 11 species from Taiwan, including three new species. This article recognizes a further new species, *Berberis morii*, and places it in the same clade with other species from Taiwan. Rather than reproduce all the observations that were made there, we simply note that Taiwan is an important center of endemism of *B.* Sect. *Wallichianae.* In comparing the floral structure and overall morphology of *B. morii* with similar taxa from Taiwan, China and India, a series morphological differences, both qualitatively and quantitatively, were noted. Phylogenetic analysis was also used to evaluate the endemicity of *B. morii*.

KEY WORDS: *Berberis*, Cloud forest, Flora of Taiwan, Hualien, New species, Mori Ushinosuke.

## INTRODUCTION

*Berberis* Sect. *Wallichianae* C.K. Schneid. in Taiwan exhibits both high species diversity as well as a high degree of endemism (Ahrendt, 1961; Yu and Chung, 2014, 2017). The morphologically diverse species are believed to have arisen from at least two dispersal events from continental Asia that may have undergone recent rapid speciation (Yu and Chung, 2014, Huang *et al*. 2018). Interestingly, more than half the species of Sect. *Wallichianae* are exclusively found in montane cloud forests, which are usually at mid to high elevations across Taiwan.

During an expedition to find *B. aristatoserrulata* Hayata and *B. brevisepala* Hayata in Hualien Hsien, Taiwan, where they were first collected by the Japanese ethnographer Mori Ushinosuke in 1910, a new species of *Berberis*, which we here name *B. morii,* was discovered (Harber, 2015, Yu and Chung, 2016). The colony of *B. moriii* consisted of four individuals growing among *Miscanthus sinensis* Andersson on the side of a disused and degraded logging trail in a cloud forest. All the plants were sterile, but their large and abaxially pruinose leathery leaves suggested that they were likely to be an undescribed species of Sect. *Wallichianae*. Also, *B. morii* was observed to possess adventitious roots, an unusual characteristic only documented from a few *Berberis* Sect. *Wallichianae* taxa. A cutting taken from one of the plants was successfully rooted using the techniques described in Browse (1992) and Harber (2010), and eventually flowered in cultivation.

An analysis of the morphology of the plant (Table 1), as well as its floral structure, confirmed it to be undescribed. *Berberis morii* has leaves that are somewhat similar in size, shape and margin to *B. dasyclada* Ahrendt, endemic to Arunachal Pradesh in northwest India, but are yellowish green as against the dark green of the latter. The color of mature stems and the flower structure of the two species are different. Moreover, *B. morii* is somewhat similar to some Taiwanese species (i.e., *B. aristatoserrulata* Hayata, *B. brevisepala* Hayata and *B. mingetsensis* Hayata) in its leaf shape, but differsfrom these in its upper leaf surface and floral structures (Yu and Chung, 2014). Of these Taiwanese species the one that is most similar in leaf surface and color is *B. aristatoserrulata*, whose leaves are mostly narrower, are rarely abaxially pruinose and have 16-30 serrations along the leaf margin. *Berberis morii* has a similar number of flowers per fascicle as *B. aristatoserrulata*, but a different flower structure (Fig. 1D, E; Table 1). A phylogenetic analysis was also utilized to determine the relationship of *B. moriii* to other species of Sect. *Wallichianae* in Taiwan and elsewhere; the results are reported below. *Berberis morii* was subsequently found at another site in Hualien Hsien (Mt. Wanwuta, shown as the upper asterisk in Fig. 1F), but again the plants were sterile. The holotype consists of the one branch that flowered in 2016. The cultivated plant produced many more flowers in 2017, but due to a lack of watering the flowers became desiccated. The plant has now recovered. Perhaps in the future an account of its fruit can be given.

## MATERIALS AND METHODS

### *Phylogenetic analyses*

A phylogenetic analysis was conducted based on three chloroplast DNA sequence regions, *rbcL*, *ycf6-psbM*, and *psbA-trnH*, used in Yu and Chung (2014). Total genomic DNA was extracted from silica-gel dried leaves following the manufacture's protocol for the Viogene Plant Mini Kit (Viogene, Taiwan). To amplify

**Table 1.** Morphological comparison of ***Berberis morii***, ***Berberis aristatoserrulata*** and ***Berberis dasyclada***.

| | ***B. morii*** sp. nov. | ***B. aristatoserrulata***[1] | ***B. dasyclada***[2] |
|---|---|---|---|
| **Vegetative** | | | |
| *Leaf adaxial surface* | Densely white pruinose | Pale green or sometimes pruinose | Paler, yellowish green |
| *Leaf abaxial surface* | Dull yellowish green | Dull green | Shiny, dark green |
| *Adventitious roots* | Yes | No | No |
| *Leaf margin serrations* | 5－12 | 16－31 | 12－18 |
| **Floral** | | | |
| *Shape of first sepal* | Ovate | Ovate | Lanceolate |
| *Pedicel length* | 9－15 mm | 16－26 mm | 10－12 mm |
| *Apex of anther* | truncate | short apiculate | entire |
| *Ovules* | Always 3 | 2－4 | 3－4 |

[1] Yu and Chung (2014); [2]Ahrendt (1961)

these markers, PCR-primers identical to those used in Yu and Chung (2014) were also applied. All chloroplast regions were PCR amplified in 20 μL reaction volume. The PCR program for *rbcL* started with 5 min at 96°C, followed by 35 cycles containing 60 s at 94°C, 60 s at 55°C, and 70 s at 72°C, and a final step of 5 min at 72°C. For both *ycf6-psbM* and *psbA-trnH*, the program started with 5 min at 96°C, followed by 35 cycles containing 40 s at 94°C, 40 s at 55°C, and 40 s at 72°C, and a final step of 5 min at 72°C. Sequence alignment was conducted by MUSCLE launched in MEGA5.05 (Tamura *et al*. 2011) under default parameters with subsequent manual adjustments. Indels and ambiguous regions were excluded in all phylogenetic analyses. Sequences generated in this study have been deposited in GenBank under the accessions MH713422 to MH713424 for *psbA-trnH*, *ycf6-psbM* and *rbcL*, respectively.

The cpDNA phylogeny was reconstructed based on maximum likelihood (ML) and Bayesian MCMC inference with sequence data partitioned. The best-fit substitution models for both analyses were determined by jMODELTEST (Posada 2008). The model GTR+I+G was selected for *rbcL*, HKY+G for *ycf6-psbM*, and HKY for *psbA-trnH*. The program RAxML-HPC2 v7.2.7-3 (Stamatakis *et al*. 2008) was used to reconstruct the ML topology with 1000 bootstrapping via the CIPRES Portals (http://www.phylo.org/index.php/portal/). For Bayesian MCMC inference, the consensus topology with posterior clade probability of each node was obtained by Mr. Bayes 3.0 (Ronquist and Huelsenbeck 2003) based on parameters set as follows: random starting tree, 8,000,000 generation runs with sampling occurring every 1000 generations with the first 25% of runs discarded as burn-in.

## RESULTS

### *Phylogenetic analyses*

Because both maximum likelihood and Bayesian analyses gave identical topologies, the best-scored maximum likelihood tree with support values of both ML and BI analyses are shown in Fig. 2. As the morphological evidence suggested, *Berberis morii* is positioned within the clade comprising all the Taiwanese species with ovate sepals. Its relationship to other non-Taiwanese Sect. *Wallichianae* species remains unclear, but the phylogeny revealed that *B. morii* differs in its DNA sequences from other species Sect. *Wallichianae* that have been subject to molecular analysis. Moreover, the current phylogeny again supports a single origin hypothesis for the species of Sect. *Wallichianae* in Taiwan and Luzon.

## TAXONOMIC TREATMENT

***Berberis morii*** Harber & C.C. Yu, ***sp. nov. Type***: **TAIWAN**: Cultivated; Hualian, Guangfu Logging Trail, 23°38'59.00"N, 121°19'34"E, 1576 m, 20 March 2016, *J. F. Harber & C. C. Yu 2016-01* (Holotype: HAST 141801!)

**森氏小檗 Figs. 1A－E & Fig. 3**

Shrubs, evergreen to 1. 4 m tall; mature stems purplish red turning pale brownish yellow, terete; spines 3-fid, concolorous, 0.6–2.4 cm. Leaves subsessile; blade abaxially densely white pruinose, adaxially dull yellowish green, lanceolate, lanceolate-ovate or lanceolate-elliptic, 5.5–9 × 2–3 cm, thickly leathery, midvein raised abaxially, slightly impressed or flat adaxially, lateral veining and reticulation largely obscure abaxially, inconspicuous adaxially, base attenuate, margin spinose with 5–12 widely spaced often coarse teeth on each side, apex acuminate, mucronate. Inflorescence a fascicle, 8 to 15–flowered; pedicels 9–15 mm; both bracts and bracteoles absent. Sepals in 3 whorls; outer sepals broadly ovate, sometimes with reddish stripe, 2 × 2 mm; median sepals broadly obovate or obovate-orbicular 4–4.25 × 3.5–4 mm; inner sepals obovate or obovate-elliptic, 6 × 3.75–4 mm; petals obovate 5.75 × 3.5–4 mm, base cuneate, glands contiguous, ovoid ca. 1 mm long, apex entire or slightly retuse, stamens 3.5 mm long, anther connective extending beyond thecae, truncate, pistil 3.5 mm long, ovules 3. Fruit unknown.

***Phenology****:* The flowering and fruiting season of *Berberis morii* in the wild is unknown. In cultivation it flowers in March and April.

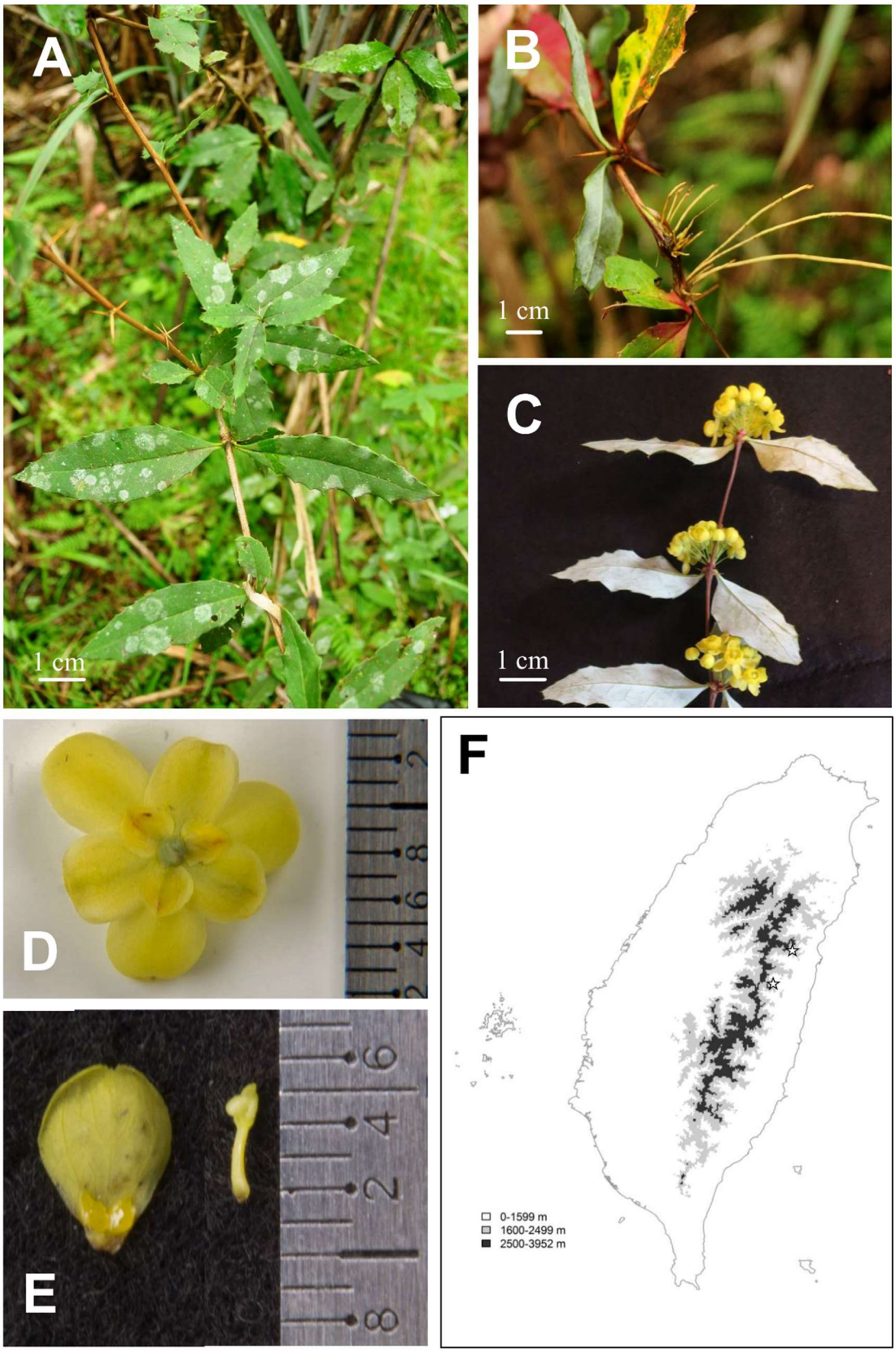


**Fig. 1**. ***Berberis morii*** Harber & C.C. Yu **A**. Plant in nature. **B**. Adventitious roots. **C**. Densely pruinose abaxial surface. **D**. Flower from plant in cultivation; abaxial view showing sepals. **E**. Petal with nectaries and stamen. **F**. Distribution of ***B. morii***.


**Fig. 2**. Best ML tree from analysis of three concatenated chloroplast markers. Numbers adjacent to the nodes indicate ML bootstrap support. (BS) BI posterior clade probabilities (PP). Well supported clades are denoted by thick line (BS > 50 and PP > 0.6).

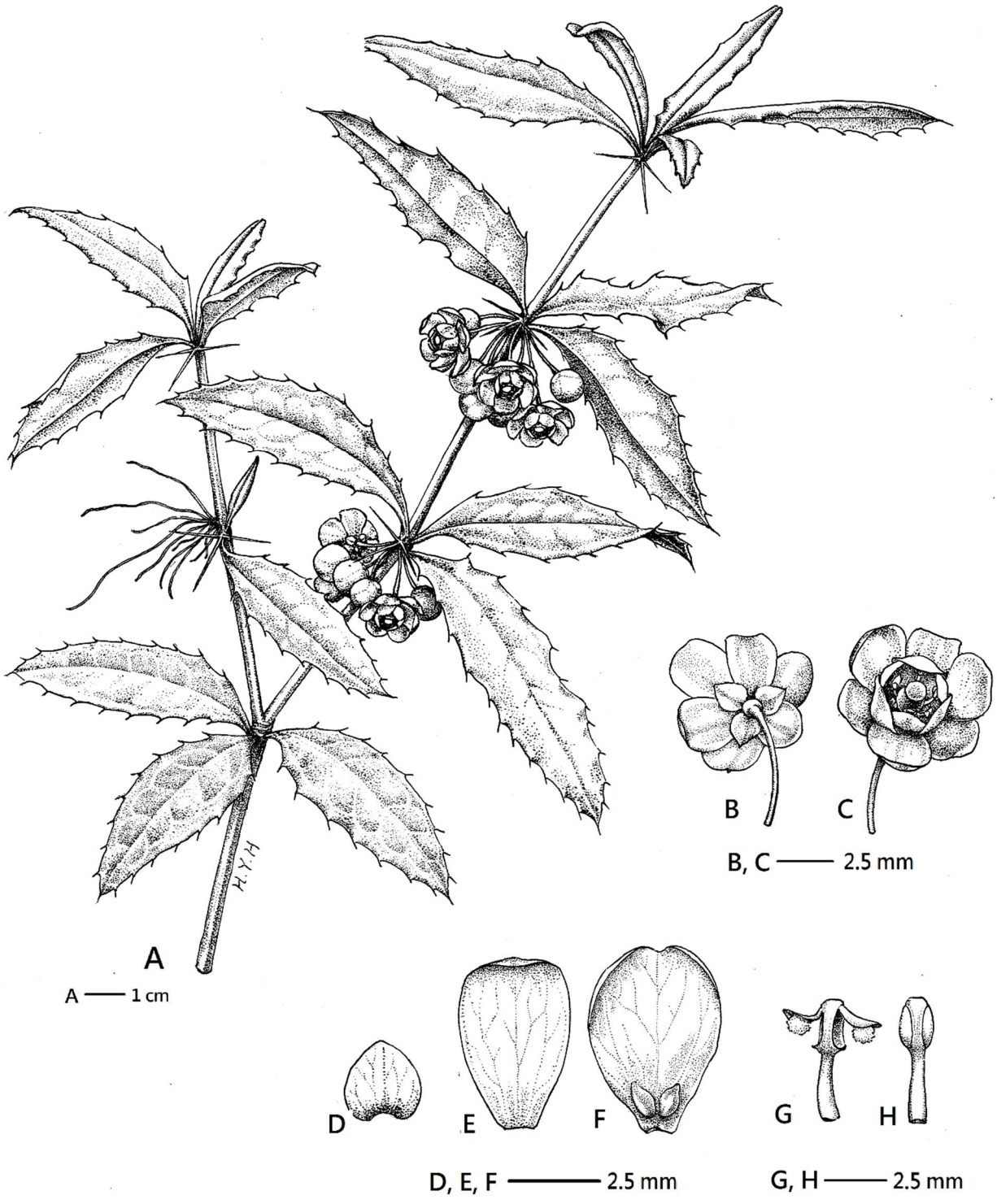


**Fig. 3**. ***Berberis morii*** Harber & C.C. Yu. **A**. Flowering branch. **B**. Flower, abaxial view. **C**. Flower, adaxial view. **D**. First whorl sepal. **E**. Inner sepals. **F**. Petal with pair of ovoid nectaries at base. **G**. Dehisced stamen. **H**. Stamen before dehiscence. Illustrations by Han-Yau Huang.

***Distribution & habitat****:* eastern Taiwan, Hualien Hsien; known from only two small colonies, one on the side of Guangfu Logging Trail at 1576 m, the second at the summit of Mt. Wanwuta (Fig. 1F).

***Etymology****: Berberis morii* is named for the Japanese ethnographer, Mori Ushinosuke, who was the first to collect plants in the area where *B. morii* was found.

***IUCN Red List category****: Berberis morii* is assessed as Data Deficient, according to IUCN (2012) criteria.

***Additional specimens examined****:* **TAIWAN**. Hualien: Guangfu Logging Trail, 1576 m, 9 April 2014, *J. F. Harber & C. C. Yu Guanmen Exped. 19* (E E00783683, TAI).

## ACKNOWLEDGEMENTS

We are grateful to the members of the National Taiwan University mountaineering club for assistance in collecting around the high mountains in Taiwan and Han-Yau Huang for preparing the handsome line drawings of *Berberis morii*. This study was supported by grants from the Ministry of Science and Technology (MOST) of Taiwan (MOST 106-2621-B-001-003-MY3) to K.F. CHUNG and funding from the National Geographic Society (GEFNE44-12) to Julian Harber.

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