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TWO NEW SPECIES OF *BOESENBERGIA* (ZINGIBERACEAE) FROM PALAWAN, PHILIPPINES

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Recent botanical explorations in the province of Palawan, Philippines, have resulted in the discovery of two new ginger species, namely *Boesenbergia eburnea* Docot and *Boesenbergia leonardocoi* Funak. & Docot, which are described and illustrated here, including information on their distribution, habitat, phenology, ecology and conservation status. Additionally, a key to *Boesenbergia* species in the Philippines is provided.

Keywords. *Boesenbergia alba*, *Caulokaempferia*, conservation status, deciduous, *Jirawongsea*.

Introduction

Boesenbergia Kuntze (1891) currently comprises c.82 species distributed mainly in Indo-Malaysia, with a few species exceptionally occurring in China, the Western Ghats of India, Indonesia, Nepal and the Philippines. Members of this genus usually inhabit the forest understorey, although some thrive in diverse habitats such as open plateaux and limestone formations near the sea (Mood *et al.*, 2014a, 2014b, 2018). *Boesenbergia* is mainly distinguished from related genera in the tribe Zingibereae by its distichous bracts, basipetalous flowering (flowers opening from the apex towards the base) and more or less saccate labellum (Smith, 1987; Larsen, 1997; Mood *et al.*, 2014a).

Larsen & Smith (1972) described a species, *Caulokaempferia alba* K.Larsen & R.M.Sm. (Fig. 1), noting that the flat labellum, crested anther, and absence of an androecial tube at the base of the labellum were atypical characters in *Boesenbergia*, most of whose species have a saccate labellum, an uncrested anther, and an androecial tube. Because of this, they described it in *Caulokaempferia* K.Larsen (1964) (= *Monolophus* Wallich, 1829 [as 1828]–1849) rather than in *Boesenbergia*, even though the flower is white and the ovary is trilocular (yellow and unilocular in most species of *Caulokaempferia*). Mood *et al.* (2014b) explained that these atypical characters mentioned by Larsen & Smith (1972) had already been documented by several authors (e.g. Valeton, 1918; Holttum, 1950) in *Boesenbergia* species such as *B. curtisii* (Baker) Schltr. and *B. rotunda* (L.) Mansf. before *Caulokaempferia alba* was described.

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FIG. 1. *Boesenbergia alba*. A, Habit; B, pseudostem, ligule and leaf base; C, flower; D, stamen and stigma. A, No voucher; B–D, *A.D. Poulsen* 2826 from Laos. (Photographs: A, H. Funakoshi; B–D, A. D. Poulsen.)

Larsen (1973, 2002) described five more species with these atypical characters in *Caulokaempferia*, two of which (*C. thailandica* K.Larsen and *C. violacea* K.Larsen & Triboun) are morphologically similar to *C. alba*. In 2002, Larsen divided *Caulokaempferia* into two groups: 1) yellow-flowered species with a unilocular ovary, and 2) whitish to violet-flowered species with a trilocular ovary. In 2008, Picheansoonthon *et al.* established the genus *Jirawongsea* Picheans. to formalise Larsen's second group of *Caulokaempferia*,

but in 2014, Mood *et al.* sank *Jirawongsea* in *Boesenbergia*, using evidence from molecular and morphological studies, and the combinations of the five *Jirawongsea* species in *Boesenbergia* were made accordingly (Mood *et al.*, 2014b).

Some of the atypical characters mentioned (e.g. flat labellum and crested anther) also occur in the Bornean *Haplochorema* K.Schum. (1899), which is basipetalous, like *Boesenbergia* (Larsen *et al.*, 1998). *Haplochorema*, however, can easily be distinguished from *Boesenbergia* by the ± deeply bilobed labellum (flower appearing quadrate with the lateral staminodes) and petaloid anther crest. Although some species, such as *Boesenbergia flavorubra* R.M.Sm., have a somewhat bilobed labellum, this is never held flat as in *Haplochorema* (Smith, 1982, 1987).

In the Philippines, there are two endemic species of *Boesenbergia*, the first of which was described by Ridley in 1909 as *Gastrochilus longipetiolata* Ridl. based on the collection *H.N. Whitford & J. Hutchinson* 9110 from Zamboanga Sibugay, Mindanao. Ridley (1909) noted that *Gastrochilus longipetiolata* resembled *G. longipes* King & Prain ex Ridl. in Indochina (= *Boesenbergia longipes* (King & Prain ex Ridl.) Schltr.), and as the epithet indicates, is characterised by the 5–9 cm long petiole. In 1926, Merrill combined *Gastrochilus longipetiolata* in *Boesenbergia* and described the second species, *B. macropoda* Merr., from Jolo Island in the province of Sulu, Mindanao, noting that it had an affinity to *B. javanum* (K.Schum.) Schltr. (= *B. curtisii*) from Indochina and Java.

During a botanical expedition in 2017–2018 in the province of Palawan, Philippines, specimens of at least two unknown taxa were collected. Their morphology is similar to species formerly placed in *Jirawongsea*. Examination and comparison of specimens, including types and protologues of known *Boesenbergia*, especially those distributed in the Philippines and neighbouring islands, led to the conclusion that the specimens represent two new species, which are described and illustrated below. Additionally, we provide information on their distribution, habitat, phenology and ecology; assessments of their conservation status; and a key to *Boesenbergia* species in the Philippines.

Material and Methods

Published morphological descriptions and herbarium specimens, including high-resolution images of specimens, from AAU, BM, E, FEUH, K, NY, UC, US and USTH of most similar species occurring in the Philippines and neighbouring islands were examined and compared with our recently collected specimens. The extent of occurrence (EOO) and area of occupancy (AOO) were calculated using the geospatial conservation assessment tool GeoCAT (Bachman *et al.*, 2011) to facilitate the assessment of the conservation status of the two new taxa using the International Union for Conservation of Nature (IUCN) criteria (IUCN Standards and Petitions Subcommittee, 2019). Furthermore, a distribution map of the specimens examined was generated in QGIS version 2.18 (Quantum GIS Development Team, 2016).

Taxonomic Treatment

Key to Boesenbergia *species in the Philippines*

1a. Petiole 15–20 cm long; flower red and pink _____ *B. macropoda*
1b. Petiole 2–9 cm long; flower white or lavender _____ 2

2a. Lamina pubescent beneath, smooth, base rounded _____ *B. longipetiolata*
2b. Lamina glabrous beneath, plicate, base obtuse _____ 3

3a. Pseudostem 3–25 cm; sheaths reddish brown; labellum and lateral staminodes white; throat of the labellum yellow; anther crest apex white _____ **B. eburnea**
3b. Pseudostem 8–40 cm; sheaths mid-green; labellum and lateral staminodes lavender; throat of the labellum dark violet; anther crest apex purplish _____ **B. leonardocoi**

Boesenbergia eburnea Docot, **sp. nov.**

Similar to *Boesenbergia alba* (K.Larsen & R.M.Sm.) Mood & L.M.Prince but differing by its lower stature (to 40 cm versus to 60 cm tall), the shape of the lobes of the ligule (subulate not ovate), the shape and texture of the lamina (narrowly ovate and plicate, not narrowly linear and smooth), the apex of the labellum (entire not ± bilobed), and the colour and apex of the anther crest (white and entire, not yellow and 4-lobed). – Type: Philippines, Luzon, Palawan, Brooke's Point, Barangay Malis, Mount Mantalingajan, 8°44′10.2′′N, 117°40′16.4′′E, 840 m, 27 ix 2018, *R.V.A. Docot, G.C.V. Gamus, L.C.P. Santiago, T.J.R. Pangilinan, D.K.P. Adesas, M.J.B. Grecia & N.A.J.C. Flores* 0189 (holo PNH; iso CAHUP, E, FEUH, L, USTH). **Figs 2, 3**.

Deciduous terrestrial herb, 9–40 cm tall, in loose clump. *Rhizome* subterranean, globular to subglobular, 2–4 cm in diameter, cream-yellow inside, faintly aromatic. *Pseudostem* 3–25 cm long; sheaths reticulate, glabrous, reddish green. *Ligule* deeply bilobed, lobes subulate, 8–15 × 3–5 mm, glabrous, membranous, reddish green. *Petiole* 2–5 cm long, canaliculate, glabrous, reddish green. *Lamina* narrowly ovate, 9–25 × 4–9 cm, glabrous on both sides, mid-green above, light green beneath, plicate, base obtuse, apex acuminate, margin entire. *Inflorescence* terminal, flowering basipetally; peduncle 8–10 mm long; floral bract ensiform, 20–30 × 5–13 mm, glabrous, greenish brown, glabrous on both sides, apex acute; bracteole ensiform, open to base, 17–21 × 3–6 mm, glabrous, basal half translucent white, apex 1- or 2-dentate; calyx tubular for half its length, 10–15 mm long, glabrous, translucent white, apex bidentate; corolla tube 4–5 cm long, glabrous, white; dorsal corolla lobe narrowly ovate, 25–30 × 5–10 mm, glabrous, white, apex acuminate and cucullate; lateral corolla lobes narrowly linear, 17–20 × 4–8 mm, glabrous, white, apex acute; labellum orbicular, held flat, petaloid, 30–40 × 35–40 mm, glabrous, white, throat yellow, margin more or less repand, apex rounded; lateral staminodes ovate, petaloid, 15–20 × 10–15 mm, glabrous, white, apex rounded; anther sessile, 7–9 × 4–5 mm, with few glandular hairs beneath, white; thecae c.2.5 mm wide, glabrous, white, dehiscence poricidal; anther crest ovate, c.3 mm long, glabrous, translucent white, apex rounded; style 5–6 cm long, glabrous, white; stigma orbicular, with spots,

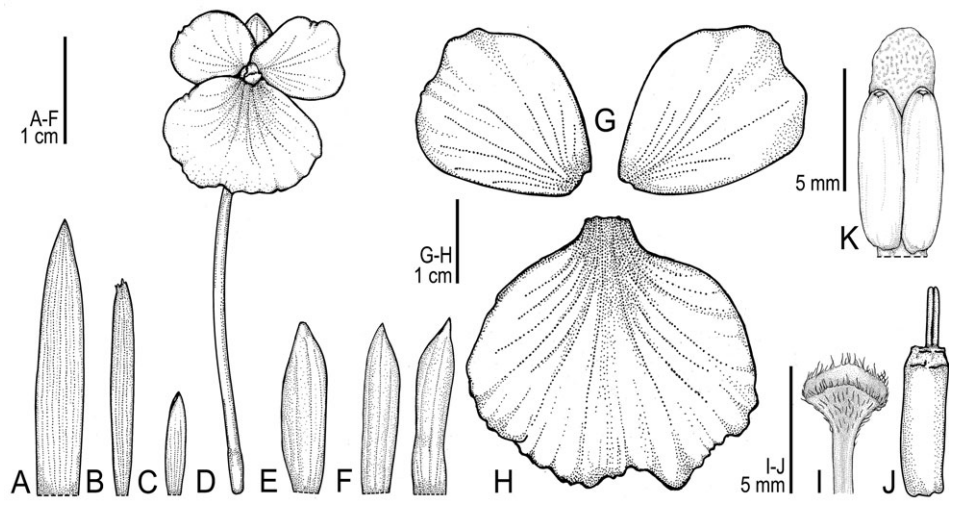

FIG. 2. *Boesenbergia eburnea* Docot, sp. nov. A, Bract; B, bracteole; C, calyx; D, flower, E, dorsal corolla lobe; F, lateral corolla lobes; G, lateral staminodes; H, labellum; I, stigma; J, ovary and epigynous glands; K, anther. All drawn from the type, *R.V.A. Docot* et al. 0189, by K. D. Gutierrez.

facing downwards, white, ostiole ciliate; epigynous glands two, linear, 3–4 mm wide, pale yellow; ovary subglobose, 30–32 × 15–20 mm, trilocular, placentation axile, glabrous, light green. *Fruit* elliptic-cylindrical, 20–25 × 8–10 mm, glabrous, light green; seed subglobose, 1–2 mm wide, brown.

Etymology. Latin, *eburneus* (white as ivory), referring to the white flowers.

Distribution and habitat. *Boesenbergia eburnea* is currently known only from Mount Mantalingajan, Brooke's Point, Palawan (see Fig. 6), growing on humid soil under semishaded forest at 800–1000 m.

Phenology and ecology. Flowering and fruiting occur between July and November. Our field observations indicate that the pollen of *Boesenbergia eburnea* is already dispersed at noon and the stigma faces downwards (Fig. 3D). This suggests that *Boesenbergia eburnea* may exhibit flexistyly, a floral mechanism that enhances outcrossing by the extreme curving of the style (Takano *et al.*, 2009), but more thorough field observations must be carried out over a period of time (e.g. 1−2 months) to strengthen this claim, which would be the first report of flexistyly in *Boesenbergia*.

Boesenbergia eburnea dies back to the rhizome and underground root tubers during the dry season. According to the Philippine Institute for Development Studies (2005), Palawan has two types of climate: the western side of the province has a dry season from November to April and is wet for the rest of the year (type I climate), whereas the eastern side has a short dry season from either December to February or March to May and with no

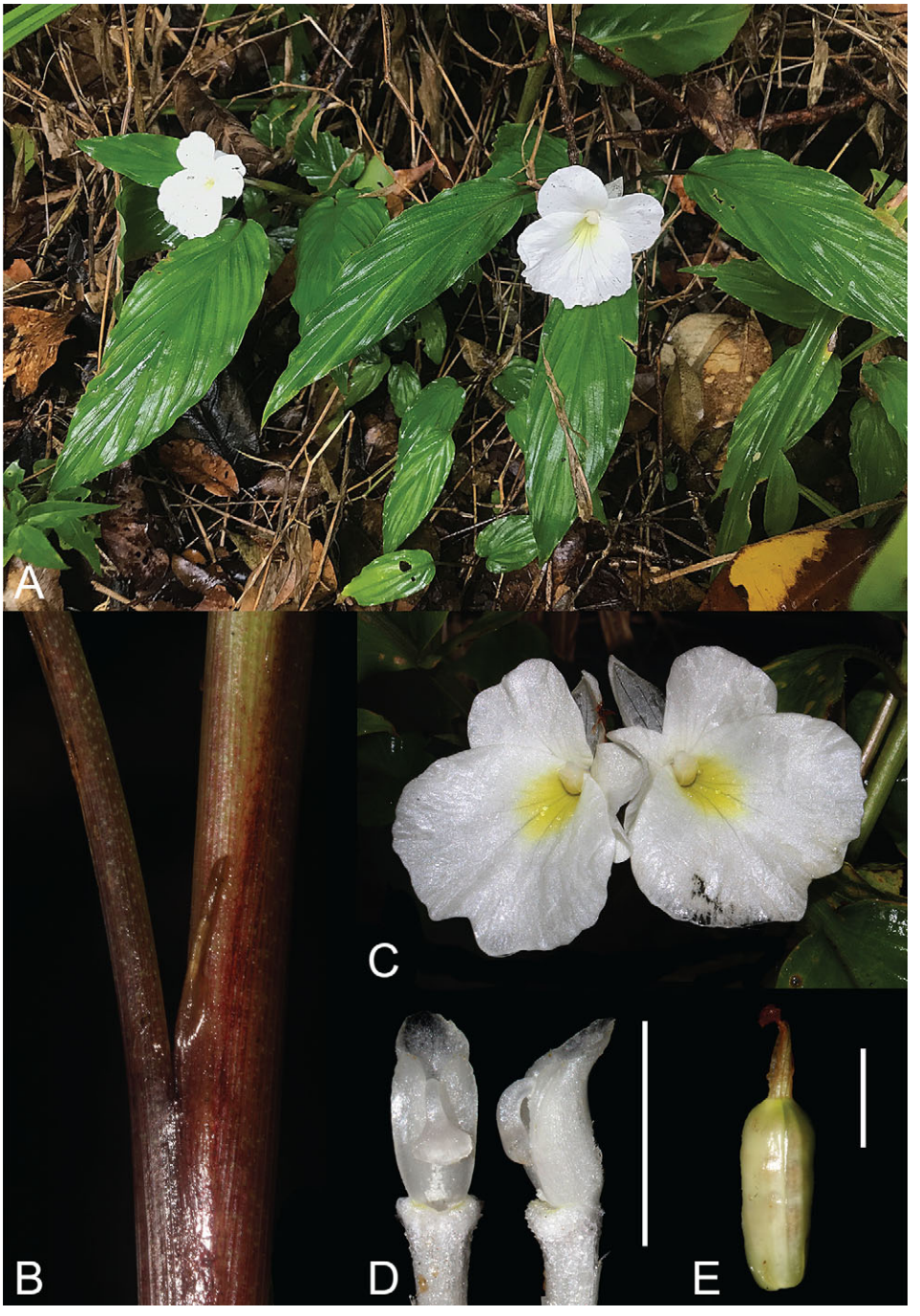

FIG. 3. *Boesenbergia eburnea* Docot, sp. nov. A, Habit; B, pseudostem, ligule and petiole; C, flowers; D, stamen (ventral and lateral views); E, fruit. Scale bars, 1 cm. All photographs of the type, *R.V.A. Docot* et al. 0189, taken by R. V. A. Docot.

pronounced maximum wet season (type III climate). *Boesenbergia eburnea* is distributed in the eastern side of the province and therefore seems to favour a type III climate. Deciduous species of *Boesenbergia* are usually distributed in northern Thailand, which has a marked dry season, whereas evergreen species are found mainly in Borneo, which has an extended wet season (Mood *et al.*, 2014a). The deciduous habit of *Boesenbergia eburnea* is thus an adaptation to the local climate, and it would be interesting to use molecular methods to reveal if its nearest relatives are found in similar climates in continental Asia.

Conservation status. Based on the *IUCN Red List Categories and Criteria* (IUCN, 2019), *Boesenbergia eburnea* is categorised as Critically Endangered [CN: B2ab(iii)]: B2: AOO is estimated to be less than 10 km^2 (total AOO is 9 km^2); a: severely fragmented or known from no more than one location (*B. eburnea* is known only from Mount Mantalingajan). *Boesenbergia eburnea* is within the Mount Mantalingajan Protected Landscape, which is currently being evaluated for selection as a UNESCO World Heritage Site. The population of *Bosenbergia eburnea* may decline significantly if the Palaw'an tribe in Brooke's Point does not regulate its collection for use as a medicinal plant. Additionally, the continuous conversion of forest into agricultural land (e.g. rice plantations) within Mount Mantalingajan can also contribute to the population decline of the species.

Vernacular name and use. Locally known as *kayadkad* (Palaw'an language) by the Palaw'an tribe in Brooke's Point, Palawan. The species is used by the locals to treat sore throat by boiling the base of the leafy shoot (*ubod*) and drinking the decoction.

Boesenbergia alba of Laos and Thailand is the most similar species, having a flat and white labellum with a yellow patch at the throat (Figs 1C, 3C). A garden collection (*A.D. Poulsen* 2826) of *Boesenbergia alba* at E from Laos (accession no. and qualifier: 20060807*A) has a bilobed labellum (Fig. 1C), a character that Larsen & Smith (1972) did not mention and a character never observed in *B. eburnea*. As mentioned in the *Introduction*, *Haplochorema* is distinguished from *Boesenbergia* by the ± deeply bilobed labellum. *Boesenbergia alba*, however, does not have the broad and petaloid anther crest that is common to most species of *Haplochorema*. Instead, the anther crest of *Boesenbergia alba* is 4-dentate and yellow (Fig. 1D), whereas it is entire and white in *B. eburnea* (Fig. 3D). In terms of the vegetative parts, both species have a bilobed ligule, but in *Boesenbergia eburnea* the lobes are subulate (Fig. 3B) and not ovate as in *B. alba* (Fig. 1B).

Before describing any new species of *Boesenbergia*, it is important to understand the existing two species in the Philippines, *Boesenbergia longipetiolata* (Ridl.) Merr. and *B. macropoda*. Unfortunately, the type of *Boesenbergia longipetiolata* cannot be located in any herbarium, indicating that it may have been lost, but a recent collection (*R.V.A. Docot* et al. 0241, FEUH) made near the type locality, Malanggas, Zamboanga Sibugay, is most likely of this species and differs from *B. eburnea* by its longer petiole (5–9 versus 2–5 cm long), smooth lamina (versus plicate), pubescent abaxial side of the lamina (versus glabrous) and rounded base of the lamina (versus obtuse).

The flowers of *Boesenbergia macropoda* were described as red and pink, whereas those of *B. eburnea* are white. In 1926, Merrill noted that *Boesenbergia macropoda* was allied to

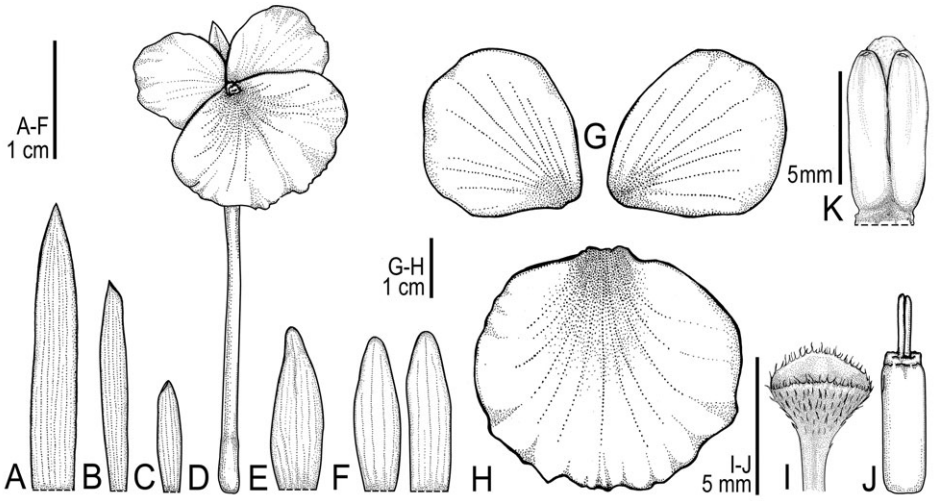

FIG. 4. *Boesenbergia leonardocoi* Funak. & Docot, sp. nov. A, Bract; B, bracteole; C, calyx; D, flower; E, dorsal corolla lobe; F, lateral corolla lobes; G, lateral staminodes; H, labellum; I, stigma; J, ovary and epigynous glands; K, anther. All drawn from the type, *R.V.A. Docot* et al. 0112, by K. D. Gutierrez.

B. curtisii, the morphology of which is very different from *B. eburnea* due to the much larger lamina and concave labellum.

Boesenbergia leonardocoi Funak. & Docot, **sp. nov.**

Similar to *Boesenbergia eburnea* Docot but differing by its taller habit (9–40 versus 20–60 cm tall), broader lamina (4–9 versus 5–13 cm wide), the colour of the labellum (lavender with dark violet patch at the throat, not white with yellow patch at the throat), the colour of the lateral staminodes (lavender not white) and the colour of the apex of anther crest (white not purplish). – Type: Philippines, Luzon, Palawan, Puerto Princesa City, Barangay Iwahig, Mount Thumbpeak (Mount Pulgar), 9°47′42.4′′N, 118°35′52.4′′E, 150 m, 2 x 2017, *R.V.A. Docot, S.G.S. Zamudio, J.A.D. Ordas, N.K.G. Alfeche, M.J.C. Arshed & J.C. Chavez* 0112 (holo PNH; iso L, NY, USTH). **Figs 4, 5**.

Deciduous terrestrial herb, 20–60 cm tall, in loose clump. *Rhizome* subterranean subglobular to oblong, 3–5 cm in diameter, cream-yellow inside, faintly aromatic. *Pseudostem* 8–40 cm long; sheaths reticulate, glabrous, green. *Ligule* deeply bilobed, lobes subulate, 9–20 × 3–5 mm, glabrous, membranous, yellow–green. *Petiole* 2–5 cm long, canaliculate, glabrous, green. *Lamina* narrowly ovate, 10–25 × 5–13 cm, glabrous on both sides, mid-green above, light green beneath, plicate, base obtuse, apex acuminate, margin entire. *Inflorescence* terminal, located between leaf sheaths, flowering sequence basipetally; peduncle c.2 cm long; floral bracts ensiform, 25–50 × 10–15 mm, glabrous, greenish brown, glabrous on both sides, apex

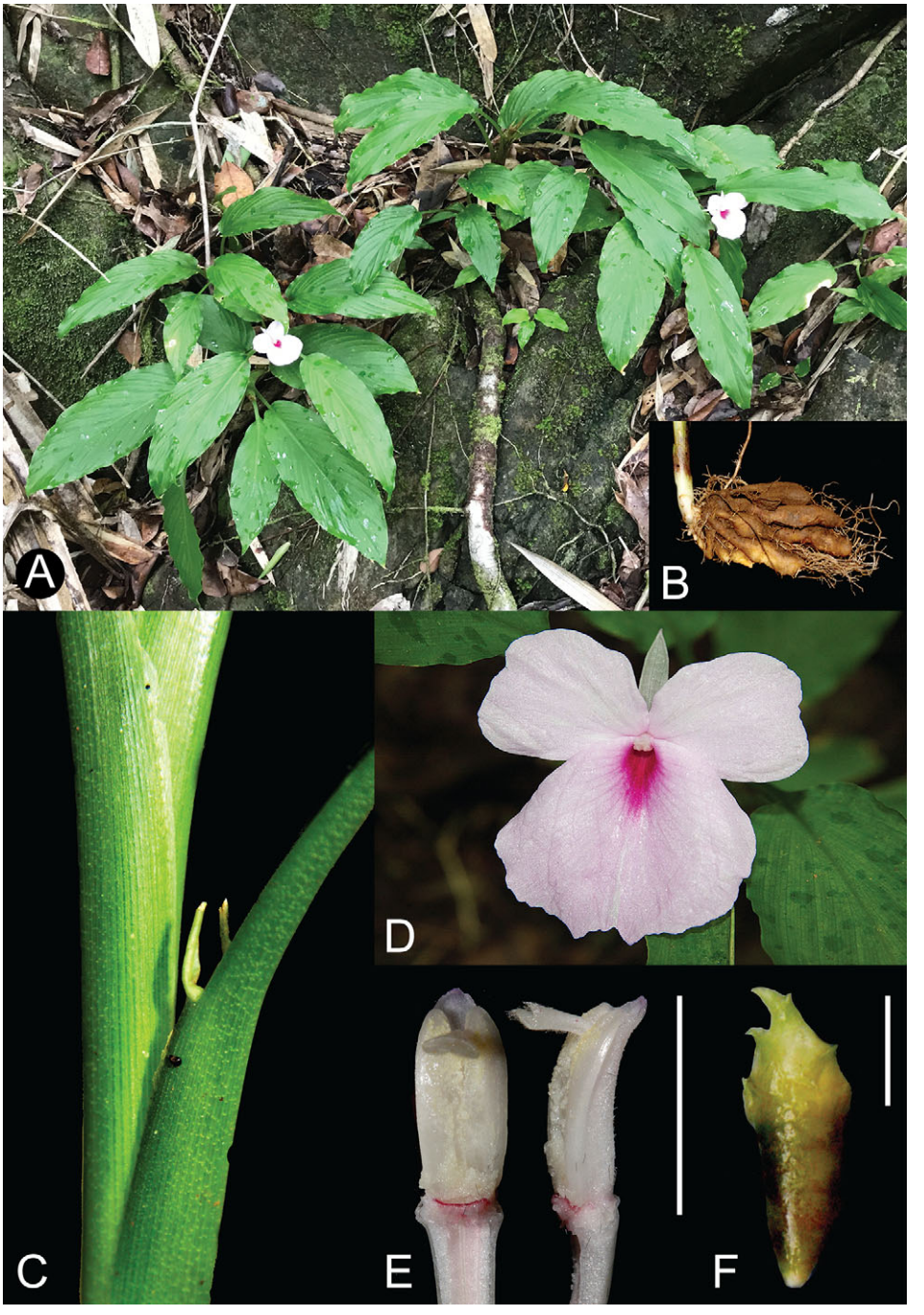

FIG. 5. *Boesenbergia leonardocoi* Funak. & Docot, sp. nov. A, Habit; B, root tubers; C, pseudostem and ligule; D, flower; E, stamen (ventral and lateral views); F, bulbil. Scale bars, 1 cm. A and E, the type, *R.V.A. Docot* et al. 0112. (Photographs: A, B and E, R. V. A. Docot; C, D and F, H. Funakoshi.)

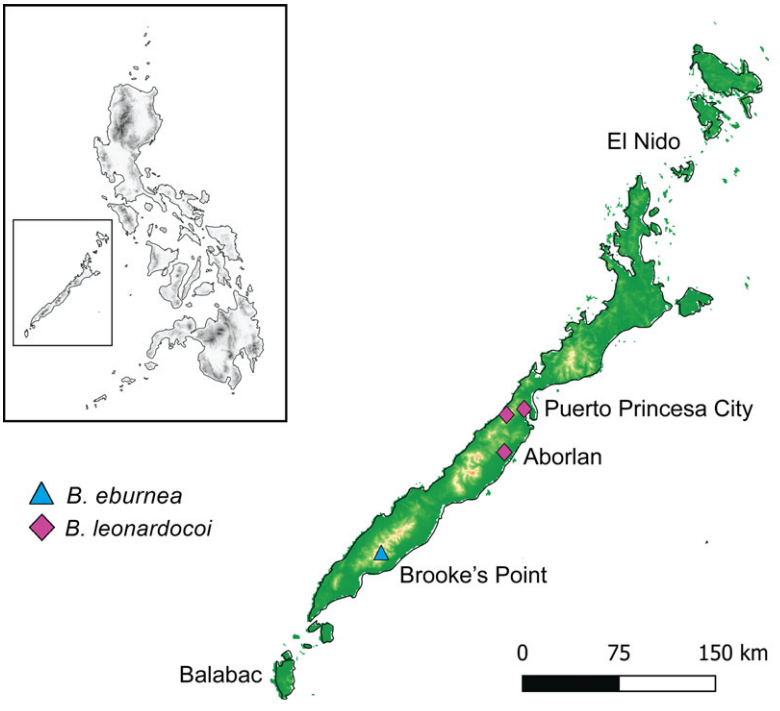

FIG. 6. Distribution of *Boesenbergia eburnea* and *B. leonardocoi* on the island of Palawan.

acute; bracteoles ensiform, 18–30 × 5–10 mm, glabrous, white, becoming greenish towards the acute apex; calyx tubular for half its length, 17–20 mm long, glabrous, white, apex acute; corolla tube 4–6 cm long, glabrous, white; dorsal corolla lobe narrowly ovate, 13–22 × 4–6 mm, glabrous, white, apex acuminate and cucullate; lateral corolla lobes narrowly linear, 18–22 × 2–4 mm, glabrous, white, apex acute; labellum orbicular, held flat, petaloid, 35–50 × 35–45 mm, glabrous, lavender, throat dark violet, margin more or less repand, apex rounded; lateral staminodes ovate, petaloid, 20–30 × 15–20 mm, glabrous, lavender, apex rounded; anther sessile, 9–12 × 5–6 mm, with few glandular hairs beneath; thecae c.3 mm wide, glabrous, white, dehiscence poricidal; anther crest ovate, c.1.5 mm long, glabrous, white, apex rounded and purplish; style 5–6 cm long, glabrous, white; stigma orbicular, with spots, facing downwards, white, the ostiole ciliate; epigynous glands two, linear, c.2–4 mm long, pale yellow; ovary subglobose to narrowly ovoid, 25–30 × 4–7 mm, placentation axile, glabrous, white. *Fruit* not seen.

Etymology. The species is named after Leonardo L. Co (1953–2010), one of the most distinguished botanists who devoted his life to elucidating the Philippine flora, and who in September 2004 first photographed the species during the 6th Flora Malesiana Symposium

TABLE. Comparison of the morphological characters of *Boesenbergia eburnea, B. leonardocoi* and *B. alba*

Morphology	*B. eburnea*	*B. leonardocoi*	*B. alba*
Leafy shoot (height)	9–25 cm	20–40 cm	30–60 cm
Sheath	Reddish brown	Mid-green	Mid-green
Ligule	Bilobed, the lobes subulate	Bilobed, the lobes subulate	Bilobed, the lobes ovate
Lamina attachment	Petiolate (2–6 cm long)	Petiolate (2–6 cm long)	Subsessile to petiolate (0.5–3 cm long)
Lamina			
Size	9–25 × 4–9 cm	10–25 × 5–13 cm	6.5–13 × 1.3–2 cm
Shape	Narrowly ovate	Narrowly ovate	Narrowly linear
Base	Obtuse	Obtuse	Rounded
Texture	Plicate	Plicate	Smooth
Calyx	1-dentate	1-dentate	2-dentate
Corolla	White	Lavender	White
Labellum			
Orientation	Flat	Flat	Flat
Shape	Orbicular	Orbicular	Orbicular
Apex	Entire	Entire	Entire to bilobed
Colour	White	Lavender	White
Colour of throat	Yellow	Dark violet	Yellow
Lateral staminodes	White	Lavender	White
Anther crest			
Length	c.3 mm	c.1.5 mm	c.4 mm
Colour	White	White	Yellow
Apex shape and colour	Rounded and white	Rounded and purplish	4-dentate and yellowish

excursion to the Talakiagan Watershed, Aborlan, Palawan (image available via *PhytoImages*, see Nickrent *et al.*, 2006–; Pelser *et al.*, 2011–).

Distribution and habitat. *Boesenbergia leonardocoi* is currently known from three locations in Aborlan and Puerto Princesa City, Palawan (Fig. 6), growing on rocky soil and in rock crevices along streams at 100–200 m.

Phenology and ecology. The flowering and fruiting seasons are throughout the months of July to November. Like *Boesenbergia eburnea*, this new species is deciduous and may also exhibit flexistyly (Fig. 5E). It reproduces asexually by bulbils (Fig. 5F), which are dispersed by the flooding stream during the rainy season.

Conservation status. Based on the *IUCN Red List Categories and Criteria* (IUCN, 2019), *Boesenbergia leonardocoi* is categorised as Endangered [EN: B1, B2ab(iii)]: B1: EOO is estimated to be more than 5000 km^2 (total EOO is 156.672 km^2); B2: AOO is estimated to be more than 500 km^2 (total AOO is c.12 km^2); a: severely fragmented or known from no more than five locations. Populations of *Boesenbergia leonardocoi* were all recorded within protected areas (e.g. Palawan Flora and Fauna Parcel 2). Although the observed populations are within protected areas, the populations of the species may decline significantly if mining activities and conversion of forest into residential and agricultural lands continue within these areas.

Additional specimen examined. PHILIPPINES. **Luzon**: Palawan, Puerto Princesa City, Barangay Irawan, Trail to Masagana Falls, 9°48′45.9′′N, 118°40′50.3′′E, 200 m, 1 vii 2018, *C.B.M. Domingo & R.V.A. Docot* PL18−008 (FEUH, USTH).

The two new species described above do not coexist; the collections seen occur at least 110 km apart and at different habitats and elevational ranges (shaded forest near streams at 100–200 m versus semishaded forest at 800–1000 m). Despite being morphologically very similar, they may easily be differentiated by the colour of the flower: *Boesenbergia eburnea* is white (Fig. 3C) whereas *B. leonardocoi* is lavender (Fig. 5D). Additionally, *Boesenbergia eburnea* is significantly shorter than *B. leonardocoi* (9–25 versus 20–45 cm long). Using the vegetative parts, it is also possible to distinguish the two species by the colour of the sheath: *Boesenbergia eburnea* is reddish brown (Fig. 3B) whereas *B. leonardocoi* is mid-green (Fig. 5C; see the Table for the full comparative morphology between the two species).

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