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Wei-Chih Chen, Chih-Chiang Wang,  Kun-Cheng Chang

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Reappraisal of *Nertera* (Rubiaceae) in Taiwan

Wei-Chih Chen¹, Chih-Chiang Wang², Kun-Cheng Chang³

1 Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung 912, Taiwan. **2** Department of Forestry, National Pingtung University of Science and Technology, Pingtung 912, Taiwan. **3** Department of Forestry and Nature Resources, National Chiayi University, 300 Syuefu Rd., Chiayi city 600, Taiwan.

Corresponding author: Kun-Cheng Chang (kcchang@mail.ncyu.edu.tw)

Abstract

Only one species in the genus *Nertera*, *N. granadensis*, had been identified in Taiwan. This study discovered that there are two additional species in the genus endemic to Taiwan: *N. nigricarpa* and *N. taiwaniana*. These species are both distinguishable from *N. granadensis* through an examination of their holotype and living individuals. *N. nigricarpa* is characterized by the unapparent or slightly convex leaf venation on the upper surface, spreading leaf margins, purple petals, black fruits, and dark-purple seeds with raised striate. *N. taiwaniana* has leaves with distinctly convex veins on the upper surface, undulated margins, yellowish-green petals, red fruits, and yellow-white seeds without striate.

Keywords

Nertera depressa, *Nertera granadensis*, *Nertera nigricarpa*, *Nertera taiwaniana*, Rubiaceae

27

28 **Introduction**

29 There are 16 known species in the genus *Nertera* Banks ex J. Gaertn. in the family
30 Rubiaceae in Australia, New Zealand, South America, Indonesia (Java), Mainland
31 China, Taiwan, and the Philippines (Ko 1999). Hayata (1908) first described *N.*
32 *nigricarpa* Hayata and reported that it is endemic to Taiwan and distributed at mid- to
33 high-altitudes across the island. Masamune (1938) first described *N. taiwaniana*
34 Masamune, which grows red fruits and was found only in the Jingshueiying area in
35 Southern Taiwan. However, *N. taiwaniana* has also recently been discovered in
36 Yuanyang Lake in Northern Taiwan and at Lijia Industry Road in Eastern Taiwan.
37 Yamamoto (1938, 1940) believed that *N. taiwaniana* in Taiwan and *N. depressa*
38 Banks & Sol. ex Gaertn. in the Philippines were the same species; therefore, he used
39 the term *N. taiwaniana* to refer to these two organisms. Chao (1978) described both *N.*
40 *depressa* and *N. nigricarpa* in the first edition of *Flora of Taiwan* and also treated *N.*
41 *taiwaniana* as being synonymous with of *N. depressa* in accordance with Yamamoto
42 (1938, 1940). Liu and Yang (1998) only recorded one species, *N. granadensis* (Mutis
43 ex L. f.) Druce, in the second edition of *Flora of Taiwan*, and treated *N. depressa* and
44 *N. nigricarpa* as synonymous.

45 Recently, we discovered populations of two species of *Nertera* in the field. We
46 collected the specimens to compare their morphology and the anatomy of their fruits.

47 According to the morphological comparison (Fig 1), we verified that the black-fruited
48 *Nertera* and the red-fruited *Nertera* native to Taiwan are of a different species.
49 *Nertera taiwaniana* has leaves with veins that are distinctly convex on the upper
50 surface and has undulated margins, yellowish-green petals, red fruits, and
51 yellow-white seeds without striate. *Nertera nigricarpa* is characterized by leaf
52 venation, which is unapparent or slightly convex on upper surface, spreading leaf
53 margins, purple petals, black fruits, and dark-purple seeds with raised striate. They are
54 distinguishable.

55 Furthermore, after comparing the lectotypes of (*Mutis s.n.*, LINN) and a live
56 individual growing in Central and South America by using the Naturalsita database,
57 we found that *N. granadensis*'s leaf is nearly fleshy, with unapparent veins, without
58 undulated margins, with an obtuse to acute apex and obtuse to shallowly truncated
59 base, and with red fruit that has no black spots. Therefore, *N. granadensis* is
60 morphologically distinguishable from *N. taiwaniana* and *N. nigricarpa*. The fruits of
61 both *N. granadensis* and *N. taiwaniana* are red, but the leaf of *N. taiwaniana*
62 possesses distinctly convex veins, undulated margins, an acute apex, a cordate or
63 truncated base, and fruits with black spots. We also compared the syntype of *N.*
64 *depressa* (*Daniel Solander s.n.*, WELT) and a live individual growing in Antarctica
65 (New Zealand). *Nertera depressa* possesses slightly fleshy leaves with unapparent

66 veins, no undulated margins, an acute apex, an obtuse or shallowly cordate base, and
 67 fruits that are red without black spots. In particular, the top hollow of *N. depressa*'s
 68 fruit is black. This characteristic is never found on the species native to Taiwan or in
 69 Central and South America. We were provided some *Nertera* specimens with
 70 orange-red fruits from Malaysia and the Philippines (Fig 2) that seemed similar to the
 71 *Nertera* populations with red fruits in Taiwan. Fruits from the Philippine and
 72 Malaysian specimens had no black spots on their surface, similar to the fruits of
 73 Taiwanese *N. taiwaniana*. These species are suspected to have a close phylogenetic
 74 relationship. The extraordinarily wide distribution of *N. granadensis* has been noted
 75 by botanists. We observed that the morphology of *Nertera* populations differed
 76 between regions. Further and more detailed research is necessary for classification.
 77 Considering the current evidence, we suggest that *N. nigricalpa* and *N. taiwaniana*
 78 remain classified as endemic in Taiwan.

79

80 **Key to species of *Nertera* in Taiwan**

- 81 1. Leaf vena distinctly convex on upper surface, undulated margins; yellowish-green
 82 corolla; red fruits..... *Nertera taiwaniana* Masamune
- 83 1. Leaf vena unapparent or slightly convex on upper surface, spreading margins;
 84 purple corolla; black fruits..... *Nertera nigricalpa* Hayata

85

86 **Taxonomic treatment**

87 **Nertera nigricarpa** Hayata in Journ. Coll. Sci. Univ. Tokyo 25(19): 115. 1908 (Fl.

88 Mont. Form.); Icon. Pl. Form. 7: 32. 1918; Chao in Fl. Taiwan 4: 315. pl. 1020.

89 *Nertera granadensis* auct. non Druce: Liu & Yang in Fl. Taiwan Second 4: 306.

90 *pro parte*.

91 Figs 1a, 1c, 1e, 1g, 3

92 A small repent herb. Branches slender, 5–20 cm long, glabrous. Leaves reniform

93 to broad-ovate or deltoid, papery to thick-papery, 6–13 mm long, 4–8 mm wide; apex

94 obtuse to acute, base cordate or truncate, margins entire, spreading; petioles 2–7 mm

95 long, veins 2–3-paired and unapparent on upper surface or slightly convex, veins

96 slightly impressed on lower surface; stipules lanceolate to triangular and membranous,

97 approximately 1.3 mm long and 0.9 mm wide. Flowers sessile, solitary, terminal,

98 approximately 1.5 mm long and 1.5 mm wide; calyx truncate, glabrous; corolla

99 purple-black, four lobes, lobes deltoid to ovate, approximately 0.6 mm long and 0.5

100 mm wide, apex acute; four stamens, anthers ovate, filaments approximately 0.4 mm

101 long; ovary ellipsoid, two-celled, each with one ovule; two styles, free, approximately

102 1 mm long. Fruit globose drupe, 3–5 mm in diameter, black at maturity; two seeds,

103 purple-black, ovate to long-ovate, approximately 2–3 mm long, approximately 1.7–2

104 mm wide, the outside striated.

105 Endemic species in Taiwan. At medium altitudes throughout the island.

106 **Specimens examined. Taiwan, Taipei,** Bunzangun, 6 Aug. 1938, *T. Nakamura*

107 673 (TAI); Mt. Chiamu, 11 May 1935, *N. Fukuyama* 19242 (TAI); Hsintien, 15 Dec.

108 2000, *Chen et al.* 3771 (TAIF); **Hsinchu:** Mt. Tapachienshan, 6 Sept. 1993, *C. L.*

109 *Huang* 71 (HAST); 1 Nov. 1996, *C. M. Wang* 2370 (TAIF); **Taichung:** Ssuyuan, 13

110 Jan. 2000, *Y. P. Cheng* 2950 (TAIF); Mt. Pahsien, 7 Aug. 1959, *T. I. Chung* 2697

111 (HAST); Mt. Amma, 20 Oct. 1957, *T. S. Liu* 197 (HAST); **Nantou:** Mayfeng to

112 Sungkang, 21 Jan. 1986, *C. I Peng* 9079 (HAST); Yuanfeng, 5 Jul. 2000, *Y. P. Cheng*

113 3253 (TAIF); Tunyuan to Yunhai, 20 May 1993, *C. C. Liao* 1299 (HAST);

114 Tatachiaanpu to Lulinshanchuang, 7 Aug. 1991, *W. P. Leu* 1208 (HAST); Kuankao to

115 Patungkuan, 4 Jul. 1985, *C. I Peng* 8181 (HAST); **Chiayi:** Shimeng Valley, 6 Feb.

116 2007, *K. C. Chang et al.* 3802 (TCF); Mt. Ali, 17 Dec. 1939, *Nakamura & Yamamoto*

117 4133 (TAI); 10 Oct. 1983, *C. I Peng* 6018 (HAST); **Kaohsiung:** Chungtzukuan, 19

118 Dec. 2000, *S. J. Yang* 29999 (TAIF); Chuyunshan, *H. L. Ho* 899 (HAST); **Pingtung:**

119 Mt. Peitawu, 23 May 1918, *E. Matuda* 1710 (TAI); 7 Feb. 1990, *C. I Peng* 13276

120 (HAST); 5 May 2004, *K. C. Chang* 2419 (CHIA); **Ilan:** Fanfan, 27 Aug. 1918, *E.*

121 *Matuda* 430 (TAI); Tananao, 21 Jul. 1929, *S. Suzuki* 628 (TAI); Mt. Chialoshan, 27

122 Sept. 1930, *S. Suzuki* 6220 (TAI); Mt. Chililo, 5 Aug. 1928, *S. Suzuki s. n.* (TAI); Mt.

123 Taiping, 25 Jul. 1929, *S. Suzuki* 920 (TAI); 26 Aug. 1962, *Kao et al.* 4961 (TAI); 2
 124 Mar. 1966, *Kao & Chuang* 4093 (TAI); 26 Aug. 1962, *M. T. Kao* 4691 (HAST);
 125 Chililo-Hsulawa, 16 Jul. 1932, *S. Suzuki* 7206 (TAI); Kiyanrawa, 25 Sept. 1930, *S.*
 126 *Suzuki* 6182 (TAI); **Hualien**: Hoping Logging Trail, 15 Apr. 2006, *S. W. Chung* 8489
 127 (TAIF); Mt. Chingshui, 9 Sept. 1939, *T. Nakamura* 3780 (TAI);
 128 Tailoku-Tailokutaishan, 15 Jun. 1933, *A. T. Hsieh s. n.* (TAI); Mt. Mukua, 7 Aug.
 129 1940, *T. Nakamura* 4526 (TAI); 23 Sept. 1984, *C. I Peng* 7269 (HAST); Tayulin, 17
 130 Oct. 2004, *J. H. Lii* 1135 (TAI); Mt. Lintien, 12 Feb. 1962, *J. M. Chao* 810 (TAI);
 131 **Taitung**: Siangyang, 18 Mar. 2006, *K. C. Chang & C. C. Wang* 3069 (TCF).

132

133 ***Nertera taiwaniana*** Masamune in Trans. Nat. Hist. Soc. Form. 28: 144. 1938.

134 *Nertera granadensis* auct. non Druce; Liu & Yang in *Flora of Taiwan* 2nd 4: 306.

135 *pro parte.*

136 *Nertera depressa* auct. non Banks & Sol. ex Gaertn; Yamamoto in Journ. Soc.

137 Trop. Agr. 10: 276. 1938, 12: 24. 1940. Chao in Fl. Taiwan 4: 315. *pro parte.*

138 Figs 1b, 1d, 1f, 1h, 4

139 A small repent herb. Branches slender, 5–15 cm long, glabrous. Leaves opposite,
 140 deltoid to ovate, membranous to papery, 4–12 mm long, 2–8 mm wide, the apex acute
 141 to acuminate, base cordate or truncate, margins entire, more or less undulate; petioles

142 1.5–6 mm long; veins 2 or 3 paired, distinctly convex on upper surface, unapparent on
 143 lower surface; the stipules triangular, membranous, approximately 1.5 mm long and
 144 1.5 mm wide. Flowers sessile, solitary, terminal, approximately 2 mm long and 1.8
 145 mm wide; calyx truncate, glabrous; corolla yellowish-green, four lobes, lobes deltoid
 146 to ovate, approximately 0.7 mm long and 0.6 mm wide, apex acute; four stamens,
 147 anthers oblong, filaments approximately 0.5 mm long; ovary ellipsoid, two-celled,
 148 each with one ovule; two styles, free, approximately 1 mm long. Fruit globose drupe,
 149 4.5–6.5 mm in diameter, red at maturity; seeds 2, yellowish-white, long-ovate to
 150 spathulate, approximately 2.5–3.5 mm long, approximately 1.5–2 mm wide, outside
 151 smooth.

152 Distribution: Philippines, Taiwan, Indonesia, Malaysia, Mexico, Panama, Chile,
 153 Peru, and Australia. Taiwan, on hillsides at medium altitudes in the eastern and
 154 southern parts of the island.

155 **Specimens examined. Taiwan, Pingtung:** Chunjih Hsiang, 30 Dec. 1999, *C. I*
 156 *Peng 17902* (HAST); Tahan Forest Road, 26 Jul. 2001, *Y. Y. Huang 554* (HAST);
 157 Chinshuiying, 23 Jun. 1999, *K. F. Chung 1348* (HAST); 18 May 2008, *K. C. Chang &*
 158 *C. C. Wang 4447* (TCF); 6 Jun. 2009, *K. C. Chang & C. C. Wang s. n.* (TCF); **Ilan:**
 159 Shenmihu, 28 Dec. 1987, *Y. M. Hsu 554* (TAI); Chialohu, 10 May 2002, *C. I Huang*
 160 *815* (HAST); Mt. Taiping, 22 Dec. 1995, *C. H. Chen 1519* (HAST); Mt. Fanpao, 17

161 Apr. 1996, C. C. Liao 1798 (HAST); **Taitung**: Mt. Sung, 30 Aug. 1932, S. Suzuki s. n.
 162 (TAI); 13 May 1988, S. Y. Lu 22900 (TAIF); Mt. Kutzulun, 20 Jul. 1937, H. Simizu
 163 3888 (*Nertera taiwaniana*, holotype: TAI!).

164

165 **Acknowledgements**

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 167 Ms P. F. Lu and Dr C. M. Wang for their assistance with the fieldwork. We thank the
 168 curators of the Herbaria CHIA, HAST, TAI, and TAIF for allowing us to study these
 169 specimens of *Nertera*. This manuscript was edited by Wallace Academic Editing.

170

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- 176 Ko WC (1999) *Nertera*: Rubiaceae. In: Lo HS, et al., editors. Flora Reipublicae
 177 Popularis Sinicae. Beijing, China: Science Press. Tomus 71(2):162-165. [in
 178 Chinese]
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183 Transactions of the Natural History Society of Formosa 28(176):138-44.
- 184 Yamamoto Y (1938) Observationes ad Floram Formosanam XXI. J Soc Trop Agric
185 10(2):274-80.
- 186 Yamamoto Y (1940) Materials for a flora of the South-Eastern Asia, including
187 Formosa and Ryu-Kyu, Soth-China, Malay Archipelago and others. III. J Soc Trop
188 Agric 12(2):243-50.
- 189

190 **Table 1.** Comparison of *Nertera nigricarpa* and *N. taiwaniana* in Taiwan.

	<i>Nertera nigricarpa</i>	<i>Nertera taiwaniana</i>
Leaf		
Vena	unapparent or slightly convex on upper surface	distinctly convex on upper surface
Margins	spreading	undulate
Flower		
Color	purple	yellowish-green
Fruit		
Color	black	red
Seed		
Color	dark-purple	yellow-white
Ornamentation	raised striate	not striate

191

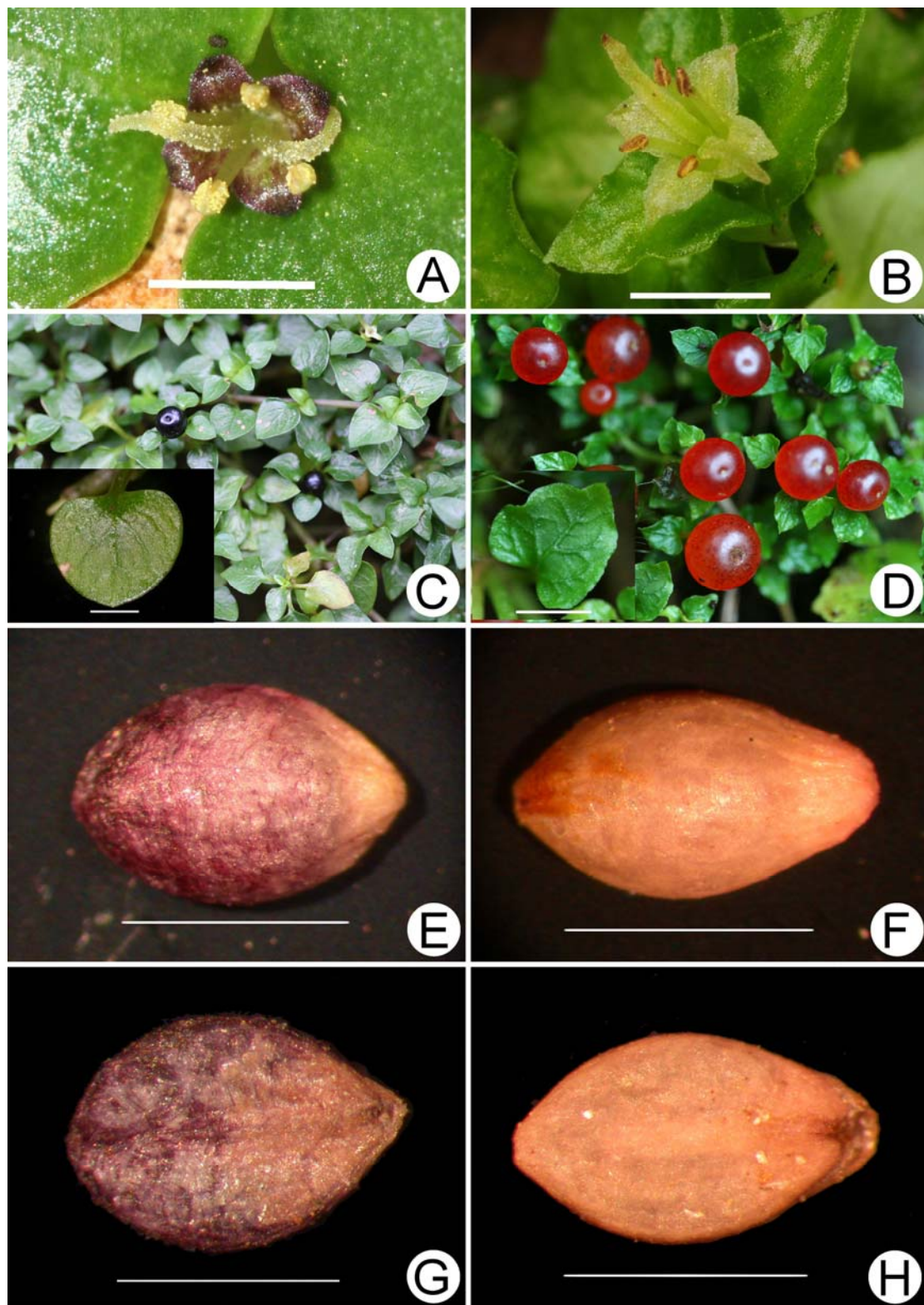
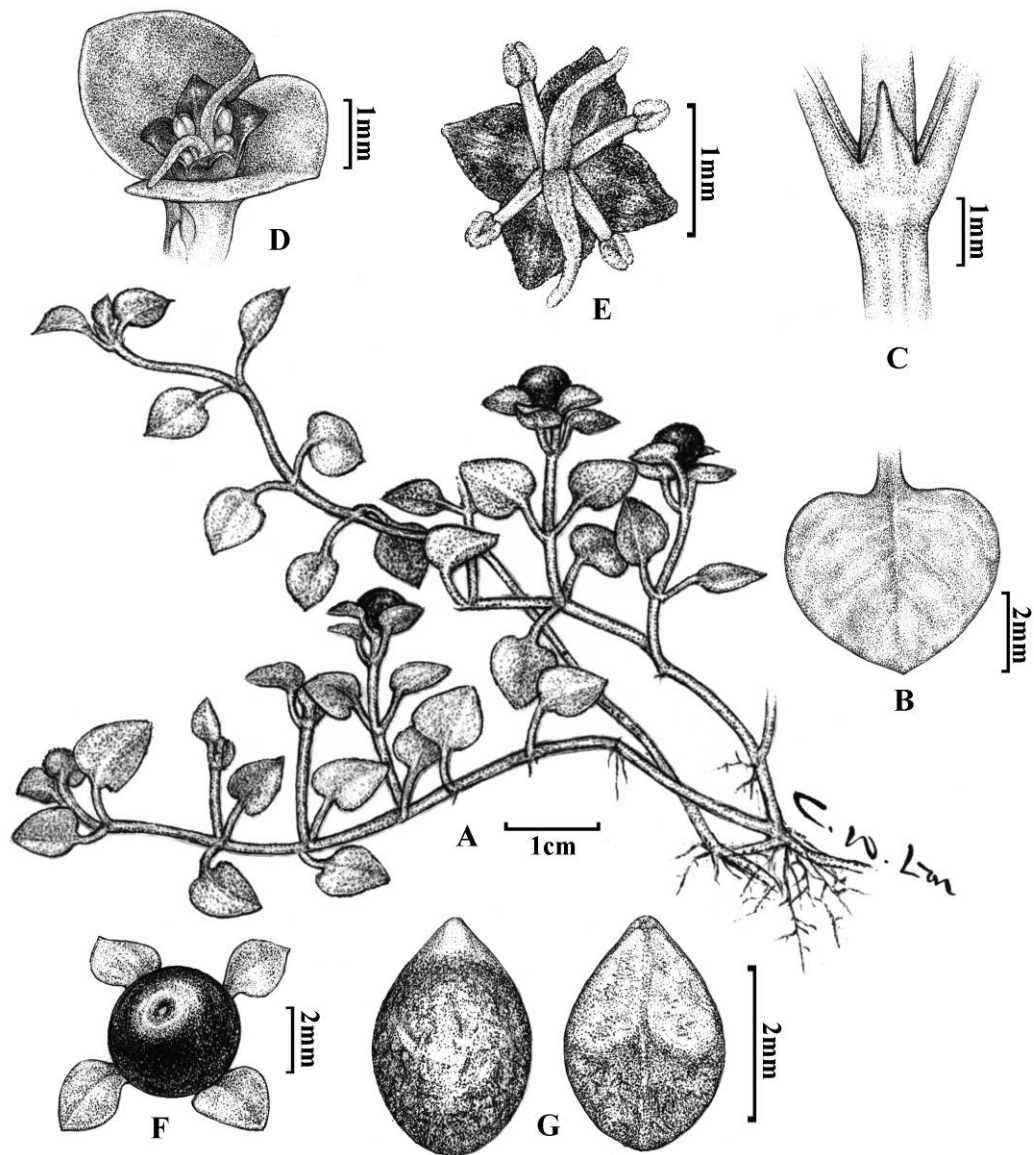


Figure 1. Photographs of *Nertera nigricarpa* Hayata and *N. taiwaniana* Masamune. **A** Flower of *N. nigricarpa*. **B** Flower of *N. taiwaniana*. **C** Fruits and leaf shape of *N. nigricarpa*. **D** Fruits and leaf shape of *N. taiwaniana*. **E** Top side of *N. nigricarpa* seed. **F** Top side of *N. taiwaniana* seed. **G** Underside of *N. nigricarpa* seed. **H** Underside of *N. taiwaniana* seed. Scale bars 2 mm.

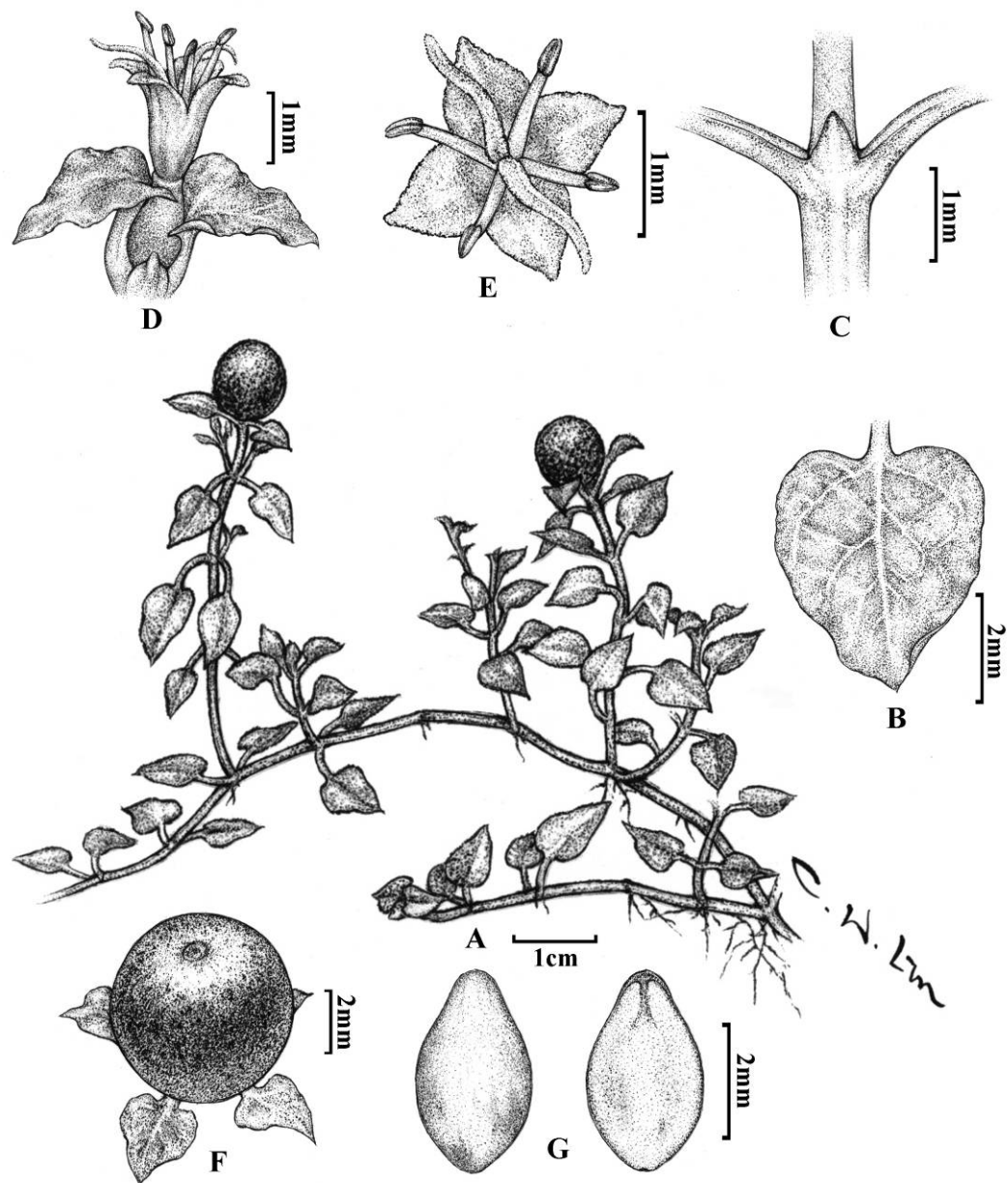


Figure 2. Photographs of *Nertera* species with orange-red fruits from the Philippines and Malaysia. **A** and **B** *Nertera* species from Mindanao, Philippines. **C** and **D** *Nertera* species from Mt. Kinabalu, Malaysia.



204 **Figure 3.** *Nertera nigricarpa* Hayata. **A** Habit, **B** leaf, **C** stipule, **D** inflorescence, **E**
 205 flower, **F** fruit, and **G** seeds.

206



207 **Figure 4.** *Nertera taiwaniana* Masamune. **A** Habit, **B** leaf, **C** stipule, **D** inflorescence,
 208 **E** flower, **F** fruit, and **G** seeds.