



Vaccinium paradoxum (Vaccinieae, Ericaceae), an unusual new species from sea cliffs on ultrabasic forest of Luzon Island, Philippines

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ABSTRACT: *Vaccinium paradoxum* is described as a new species of blueberry from the lowland ultrabasic forest of Northern Sierra Madre Natural Park, Luzon Island, Philippines. It resembles *V. halconense*, but differs by having shorter inflorescences, fewer flowers per inflorescence, a glabrous inner surface of the corolla, absence of anther spurs, and a glabrous style. *Vaccinium paradoxum* is unique among the currently known blueberries in Malesia by the presence of sessile glands borne on the pedicel and predominantly near the centre or scattered on the calyx lobes. It is also the only known Philippine *Vaccinium* to inhabit lowland ultrabasic forest on sea cliffs.

KEY WORDS: Blueberry, lowland ultrabasic forest, Malesia, taxonomy, Vaccinioideae, *Vaccinium halconense*.

INTRODUCTION

Northern Sierra Madre Natural Park (NSMNP) is the largest protected area in the Philippines and a tentative UNESCO World Heritage Site (UNESCO, 2006; DENR, 2015; van Weerd and Udo de Haes, 2010). The park is located on the east side of Luzon Island facing the Philippine Sea. It encompasses nine local jurisdictions in the province of Isabela *viz.* Cabagan, Dinapigue, Divilacan, Ilagan, Maconacon, Palanan, San Mariano, San Pablo, and Tumauini. This protected area comprises the most extensive continuous and intact tropical rainforest in the country, with a high level of genetic, species, and habitat diversity (van der Ploeg *et al.*, 2011; Brown *et al.*, 2013; DENR, 2015; Guingab, 2019; Biag and Santos, 2021). The forest assemblage at NSMNP is varied, such that 10 of the 12 forest formations known in the Philippines exist there (Fernando *et al.*, 2008). The forest of NSMNP is also an important source of sustenance for the indigenous people in the area, e.g., the Agta, the Kalingas, and the Paranans (DENR, 2015; Minter *et al.*, 2014).

The genus *Vaccinium* (Vaccinieae, Ericaceae) includes 450–500 species occurring worldwide except in Antarctica and Australia (Sleumer, 1966–1967; Argent, 2014). Species of *Vaccinium* predominantly grow in nutrient-poor habitats such as acidic, sandy, peaty, and high-humus soils (Vander Kloet, 1988). In the tropics, they also thrive in montane mossy forests, on exposed mountain ridges and grassland summits (Argent, 2019; Tamayo *et al.*, 2022), and rarely in coastal vegetation (Sleumer 1966–1967).

While conducting a herbarium specimen review towards a revision of Philippine *Vaccinium*, we

encountered an unusual specimen collected from the lowland ultrabasic forest of Palanan, Isabela Province. The locality of this specimen differs from that of all other *Vaccinium* species in the Philippines in inhabiting a low-elevation area near sea cliffs. Detailed examination of the specimen revealed several characters that are unique among Philippine *Vaccinium*. The specimen also does not fit well with any species circumscribed in the available treatments of *Vaccinium* within the larger area of Malesia (Sleumer, 1966–1967; Argent, 2019; Argent and Wilkie, 2020). On this basis, it became clear to us that the specimen represents an undescribed species of *Vaccinium*. Here we describe this *Vaccinium* species as new to science under a morphological species concept (Cronquist, 1978). This discovery raises the total number of *Vaccinium* currently recognized for the Philippines to 38.

MATERIALS AND METHODS

The description is based on a single dried herbarium specimens from A, CAHUP, and L. Dried flowers from herbarium packets were soaked in Pohl's solution for 15 minutes and dissected under an AmScope stereomicroscope of up to 64× magnification. The relevant taxonomic literature on Philippine and Malesian *Vaccinium* was also consulted (*i.e.*, Merrill, 1908; Copeland, 1930; Sleumer, 1966–1967; Argent, 2008, 2019; Argent and Wilkie, 2020; Co *et al.*, 2002; Salares *et al.*, 2018; Fritsch *et al.*, 2020; Tamayo *et al.*, 2021, 2022) including available online images of types and other specimens at Naturalis Biodiversity Center (<https://bioportal.naturalis.nl/>) and JSTOR Global Plants (<https://plants.jstor.org>).



TAXONOMIC TREATMENT

Vaccinium paradoxum M.N.Tamayo & P.W.Fritsch, *sp. nov.* **Fig. 1**

Type: PHILIPPINES. Luzon Island, Isabela Province, Municipality of Palanan, Digallorin (Digollorin), Divinisa camp site, Northern Sierra Madre Natural Park (NSMNP), forest on ultrabasic on steep sea cliffs opposite to campsite, epiphyte at ca. 20 m elevation, 4 June 1992, *ISU373* (holotype: A 02006775!; isotypes: CAHUP 61178!; L L2621498-image!).

Diagnosis: *Vaccinium paradoxum* resembles *V. halconense* Merr. by its leaf shape, leaf dimension, and flower color, but differs by having shorter inflorescences (1.3–3.5 cm vs. 5.0–7.0 cm), fewer flowers per inflorescence (5–8 vs. 10–15), glabrous inner surface of corolla (vs. pubescent), absence of anther spurs (vs. present), and a glabrous style (vs. pubescent). Moreover, the sessile glands borne on the pedicels and predominantly near the centre or scattered on the calyx lobes of *V. paradoxum* is a unique character among *Vaccinium* in Malesia (Fig. 2).

Description: **Habit** epiphytic, evergreen, multi-branched. **Branchlets** greyish brown *in sicco*, rounded in cross section, 2.5–7.0 mm wide, glabrous, lenticellate; perennating buds compressed-circular or oblong, 1.0–1.5 mm long; bud scales overlapping, glabrous. **Leaves** persistent on older branchlets, spirally and evenly arranged, condensed, overlapping, internodes 5–10 mm long; petiole brown *in sicco*, cylindrical, 4.0–7.0 × 1.5–2.5 mm, glabrous; leaf blade elliptic, with larger leaves on each branchlet 3.2–8.0 × 2.0–2.5 cm, coriaceous, green abaxially, reddish adaxially, glabrous, with minute punctae on both surfaces, midvein raised on both surfaces, secondary veins 4 to 6 on each side of midvein, first pair basal, the remainder along midvein, arc-ascending, obscure on both surfaces, tertiary veins obscure, base cuneate, margin entire, revolute, apex acute or obtuse, marginal glands slightly raised, 8 or 9 per side, scattered along the leaf blade margin, 0.3–0.5 mm wide. **Inflorescences** arising from the upper axil or terminal, racemose, developing beyond confines of perennating bud, glabrous, 1 per axil, peduncle 3.0–5.0 mm, rachis 1.0–3.0 cm long at anthesis, 5–8-flowered; peduncle and rachis ascending to slightly curved downwards, brown *in sicco*, obscurely ridged, terete, glabrous; bracts early caducous, reddish brown *in sicco*, non-foliaceous, planar or occasionally cucullate, ca. 5 mm long, triangular or obtuse, glabrous. **Pedicel** 5–20 × 0.3–0.7 mm at anthesis, terete, slightly spreading, glabrous, with sessile circular or irregularly-shaped glands; bracteolate, probably minute, attached on base of pedicel at junction with rachis, very early caducous. **Flowers** articulated at junction with pedicel, 8.8–11.2 mm long. **Hypanthium** dark brown *in sicco*, cupuliform, 0.8–1.2 × 1.3–1.5 mm, hirsute, hairs ca. 0.1 mm; calyx limb ca. 1.5 mm long; calyx lobes 5,

broadly triangular, 1.0–1.3 mm long, hirsute, margin entire, ciliolate, acute or obtuse, glands sessile, borne predominantly near the centre of the dorsal side of the lobes or randomly distributed, ca. 0.3 mm across. **Corolla** urceolate, gradually broadening towards apex, dark brown *in sicco*, 8–10 × 4–7 mm, glabrous on both surfaces; lobes 5, occasionally 6, glabrous, abaxial surface with minute papillae, 0.8–1.0 × 1.5–1.7 mm, acute to obtuse. **Stamens** 8 to 10, monomorphic, distinct, 4–4.5 mm long; filaments brown *in sicco*, straight, dilated at base, 2.5–2.7 mm long, white-lanate throughout, trichomes 0.4–0.5 mm long; anthers 1.5–1.8 mm long, cells 1.1–1.3 mm long, obscurely echinulate, tubules smooth, slightly parallel to diverging, slightly curved laterally, cylindrical, becoming broader distally, 0.4–0.5 mm long, pore oblique, spurs absent. **Ovary** 5- or 6-locular but appearing pseudo-10- or 12-locular with false partitions extending ca. 0.3 mm from inner wall; ovules in two columns per locule. **Disk** disciform, flat, non-bulky, 1.8–2 × 1.5–2 mm, with simple trichomes around the slightly raised attachment site of style, margin obscurely or non-ridged. **Style** slender, thin, 8–9 × 0.20–0.25 mm, glabrous; stigma truncate. **Fruit** unknown.

Distribution and Habitat: The new species is currently known only from the type locality in the lowland ultrabasic forest of NSMNP at ca. 20 m asl on sea cliffs.

Phenology: Flowering in June.

Etymology: The epithet “*paradoxum*” is from the Latin meaning, in part, puzzling or unusual. This is in reference to the unique presence of sessile glands borne on the pedicel and predominantly near the centre of the calyx lobes of the new species.

Conservation Status: The species is only known from its type specimen. The holotype was collected from a remote and rarely visited area at the eastern edge of Luzon Island. Because the data for this species is derived from a single collection, the extent of occurrence cannot be calculated. Although it is possible that this plant can be found within the stretch of the ultramafic forest in the vicinity of its type locality, its epiphytic habit may be one reason why this plant was overlooked. Thus, we propose to categorize the conservation status of this species as Data Deficient (DD) (IUCN Standards and Petitions Committee, 2022).

Although the locality of the new species is a protected area, NSMNP is gravely threatened by illegal logging, fuel-wood collection, slash and burn farming, and increasing residential settlements (DENR, 2015). Moreover, the eastern seaboard of Luzon Island is an immediate pathway of tropical storms from the Pacific Ocean during the monsoon season. Climate change has exacerbated the effects of Philippine storms, these having become stronger and more frequent in the last two decades (Cinco *et al.*, 2016). This change is a risk factor to the survival of all the species in NSMNP.

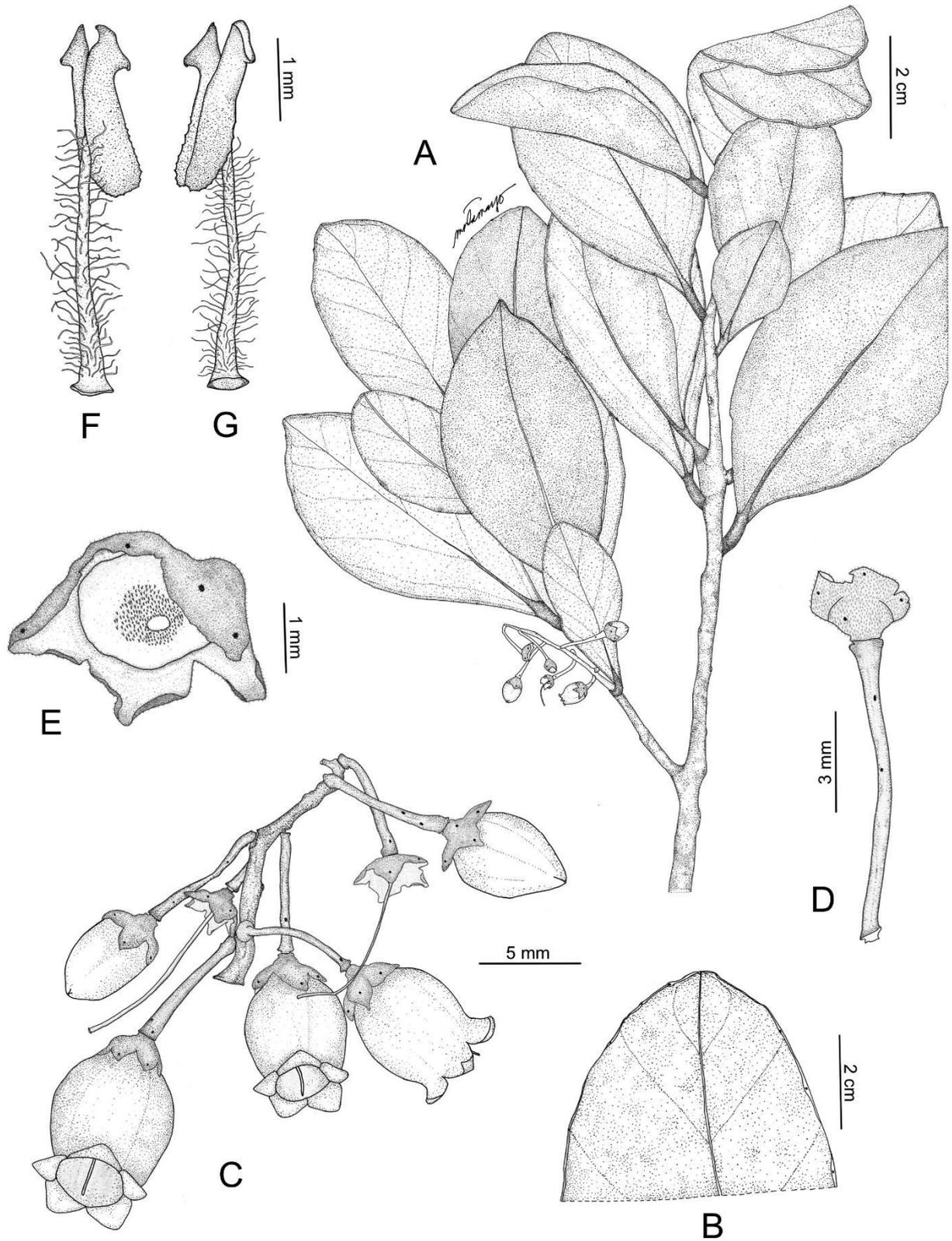


Fig. 1. *Vaccinium paradoxum*. A. Habit. B. Distal half of leaf showing marginal glands. C. Inflorescence. D. Pedicel and hypanthium. E. Oblique view of hypanthium showing calyx and disk. F. Dorsal view of stamen. G. Lateral view of stamen. Illustration by Maverick Tamayo. Based on the holotype.

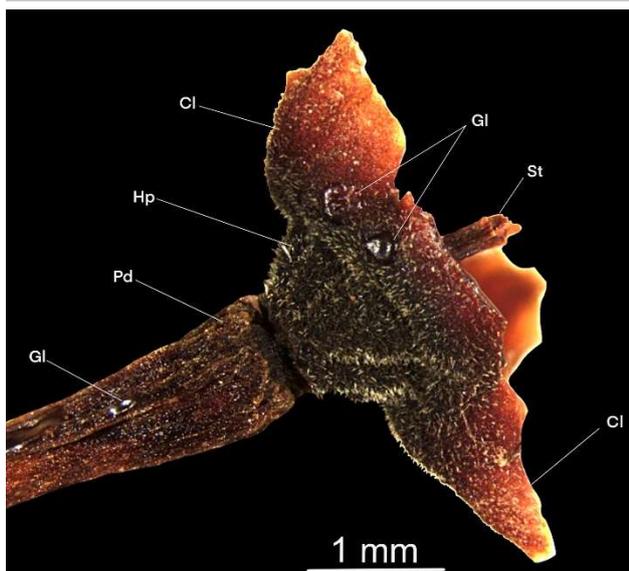


Fig. 2. *Vaccinium paradoxum*. Distribution of sessile glands borne on the pedicel and predominantly near the centre of the lobes. Legend: calyx lobes (Cl); glands (Gl); hypanthium (Hp); pedicel (Pd); style (St; broken). From the holotype.

Notes: *Vaccinium paradoxum* is here treated as a member of *V.* section *Bracteata* Nakai in Nakai and Koidzumi (1927) sensu Sleumer (Sleumer, 1966–1967), as exhibited by its multi-flowered racemose inflorescences, caducous bracts, absence of a membranaceous wing at the sinuses of the corolla, and anthers that open by short terminal pores.

In the artificial key to Philippine *Vaccinium* (Copeland, 1930), *V. paradoxum* best keys to *V. halconense* Merr. In addition to the characters mentioned in the diagnosis, *V. paradoxum* differs from this species by having longer petioles (4.0–7.0 mm vs. 3.0–5.0 mm), glabrous pedicels (vs. ferruginous-pilose), and a flat and non-bulky disk (vs. dome-shaped and bulky). In the key to the Malesian *Vaccinium* (Sleumer, 1966–1967), *V. paradoxum* best keys to *V. lageniforme* J.J.Sm., a species endemic to New Guinea. *Vaccinium paradoxum* differs from this species by having more flowers per inflorescence (5–8-flowered vs. 3–5-flowered), shorter hypanthium (0.8–1.2 mm vs. ca. 2 mm), a glabrous inner surface of the corolla (vs. pubescent), a disk with simple trichomes (vs. glabrous), and a slender style (vs. bottle-shaped).

In the key to the Bornean species of *Vaccinium* (Argent, 2019), *V. paradoxum* keys to *V. simulans* Sleumer but differs by having glands distributed along the leaf blade margin (vs. single pair at the base), longer pedicels (5.0–20.0 mm vs. 1.5–3.0 mm), a glabrous inner surface of the corolla (vs. pubescent), longer filaments (2.5–2.7 mm vs. ca. 1.8 mm), and an absence of anther spurs (vs. present).

In the sectional treatment of *Vaccinium* (Vander Kloet and Dickinson, 2009), *V. paradoxum* can be

accommodated as a member of *V.* section *Euepigynium* Schlechter by its evergreen habit, monomorphic perennating buds, one perennating bud per leaf axil, plinerved leaf blade venation, entire leaf blade margin, peduncle longer than pedicels, calyx tube completely fused to the ovary, and pseudo-10-locular ovary. However, the number of sections of the Malesian *Vaccinium* sensu Vander Kloet and Dickinson (2009) and their boundaries need further study because of the utilization of imprecisely defined characters that apparently overlap with other sections (Tamayo *et al.*, 2022), as well as unspecified placement of many of the species to section.

Vaccinium paradoxum is the only Philippine blueberry species found near coastal areas at a low elevation; all the other Philippine species are found at elevations ≥ 600 m. In Malesia, two *Vaccinium* species are documented near coastal areas, i.e., *V. kjellbergii* J.J.Sm. and *V. littoreum* Miq. (Sleumer, 1966–1967). An epiphytic habit is shared among the three species. However, *V. paradoxum* is distinct from *V. kjellbergii* by having glabrous inflorescence (vs. pubescent), early caducous bracts (vs. sub-persistent), a glabrous outer surface of the corolla (vs. pubescent), and an absence of anther spurs (vs. presence), and from *V. littoreum* by its longer pedicel (5.0–20.0 mm vs. 2.5–4.0 mm), absence of anther spurs (vs. presence), and disk with simple trichomes (vs. glabrous) (Sleumer, 1966–1967).

Additional specimens examined: *Vaccinium halconense* Merr. PHILIPPINES. Dumaguete (Cuernos Mountains), Negros Oriental Province, Negros Island. *A.D.E Elmer 9655*, March 1909 (NY 04204566!); vicinity of Tanculan, Bukidnon Province, Mindanao Island. *E. Fenix 26065*, July 1916 (NY 04204567!). *Vaccinium kjellbergii* J.J.Sm. INDONESIA. Sulawesi, Sulawesi Selatan, Malili, C. Celebes, Lampea. *G. Kjellberg 2068*, 8 August 1929 (L 0008066-image!). *Vaccinium littoreum* Miq. MALAYSIA. Dunga, Terengganu, Malaya. *E. Soepadmo & Mahmud 9100*, 29 April 1968 (NLU NLU0142191!). *Vaccinium simulans* Sleumer. MALAYSIA. Mt. Kinabalu, above Tenompok, near lodge. *J. and M.S. Clemens 29387*, 25 April 1932 (E E00438118-image!).

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LITERATURE CITED

- Argent, G. 2008 A checklist of Philippine Ericaceae. *Philipp. J. Syst. Biol.* **2**(1): 40–46.
 Argent, G. 2014 *Vaccinium utteridgei* (Ericaceae), a new species (sect. *Bracteata*) from Indonesian New Guinea. *Edinburgh J. Bot.* **71**(2): 189–192.



- Argent, G.** 2019 *Rigiolepis* and *Vaccinium* (Ericaceae) in Borneo. *Edinburgh J. Bot.* **76(1)**: 55–172.
- Argent, G. and P. Wilkie.** 2020 Six new species of *Vaccinium* (Ericaceae) from New Guinea. *Edinburgh J. Bot.* **77(3)**: 439–453.
- Biag, R.D. and G.J.D. Santos** 2021 Rubiaceae flora of Northern Sierra Madre Natural Park, Isabela, Luzon, Philippines: Species richness, distribution, and conservation. *Philipp. J. Sci.* **150(3)**: 907–921.
- Brown, R.M., C.D. Siler, C.H. Oliveros, L.J. Welton, A. Rock, J. Swab, M. van Weerd, J. van Beijnen, E. Jose, D. Rodriguez, E. Jose and A.C. Diesmos** 2013 The amphibians and reptiles of Luzon Island, Philippines, VIII: the herpetofauna of Cagayan and Isabela provinces, Northern Sierra Madre Mountain Range. *ZooKeys* **266**: 1–120.
- Cinco, T.A., R.G. de Guzman, A.M.D. Ortiz, R.J.P. Delfino, R.D. Lasco, F.D. Hilario, E.L. Juanillo, R. Barba and E.D. Ares** 2016 Observed trends and impacts of tropical cyclones in the Philippines. *Int. J. Climatol.* **36(14)**: 4638–4650.
- Co, L. L., D. Madulid and G. Argent** 2002 A new species of *Vaccinium* (Ericaceae) from the Philippines. *Edinburgh J. Bot.* **59(3)**: 373–376.
- Copeland, H.F.** 1930 Philippine Ericaceae, II: the species of *Vaccinium*. *Philipp. J. Sci.* **42**: 537–607.
- Cronquist, A.** 1978 Once again, what is a species? In: Knutson, L.V. (ed.), *Biosystematics in Agriculture*. Allenheld Osmin, Montclair, New Jersey, USA, pp. 3–20.
- Department of Environment and Natural Resources (DENR)** 2015 Biodiversity and watersheds improved for stronger economy and ecosystem resilience (B+WISER) program: Northern Sierra Madre Natural Park. Available from: <https://forestry.denr.gov.ph/b+wiser/index.php/sites/nsmnp> (accessed 02 March 2022).
- Fernando, E.S., M.H. Suh, J. Lee and D.K. Lee** 2008 Forest Formations of the Philippines. ASEAN-Korea Environmental Cooperation Unit (AKECU), Seoul, Korea. 232 pp.
- Fritsch, P.W., V.B. Amoroso, F.P. Coritico and D.S. Penneys** 2020 *Vaccinium hamiguitanense* (Ericaceae), a new species from the Philippines. *J. Bot. Res. Inst. Texas* **14(2)**: 281–287.
- Guingab, M.V.D.** 2019 Floral diversity of the lowland ultrabasic forest in the Northern Sierra Madre Natural Park, Isabela, Luzon, Philippines. *J. Biodivers. Environ. Sci.* **15(5)**: 113–124.
- IUCN Standards and Petitions Committee** 2022 Guidelines for Using the IUCN Red List Categories and Criteria. Version 15. Prepared by the Standards and Petitions Committee. <http://www.iucnredlist.org/documents/RedListGuidelines.pdf>. (accessed 18 February 2022).
- Merrill, E.D.** 1908 Philippine Ericaceae. *Philipp. J. Sci.* **3**, section C (Botany): 369–382.
- Minter, T., J. van der Ploeg, M. Pedrablanca, T. Sunderland and G.A. Persoon** 2014 Limits to indigenous participation: The Agta and the Northern Sierra Madre Natural Park, the Philippines. *Hum. Ecol.* **42(5)**: 769–778.
- Nakai, T. and G. Koidzumi** 1927 *Trees and Shrubs Indigenous in Japan Proper*, revised ed., I. Seibido Shoten, Tokyo. 714 pp.
- Salares, V.B., J.J. A. Obico, P. Ormerod, J.F. Barcelona and P.B. Pelsler** 2018 Taxonomic novelties from Cebu: a new species of *Vaccinium* (Ericaceae) and a new record of *Phaius* (Orchidaceae) for the Philippines. *Phytotaxa* **360(3)**: 255–262.
- Sleumer, H.** 1966–1967 Ericaceae: In: C.G.G.J. van Steenis (ed.), *Flora Malesiana*, Ser. 1, **6(4, 5)**: 469–914. Wolters-Noordhoff, Groningen, Netherlands.
- Tamayo, M.N., R.A.A. Bustamante and P.W. Fritsch** 2021 *Vaccinium exiguum* (Ericaceae, Vaccinieae), a new species from the ultramafic summit of Mt. Victoria, Palawan Island, Philippines. *PhytoKeys* **179**: 145–154.
- Tamayo, M.N., F.P. Coritico, V.B. Amoroso, D.S. Penneys, D.N. Tandang and P.W. Fritsch** 2022 *Vaccinium carmesinum* (Ericaceae), a new species of blueberry from Mt. Tago range, Mindanao Island, Philippines. *Phytotaxa* **533(3)**: 173–180.
- United Nations Educational, Scientific, and Cultural Organization (UNESCO)** 2006 Northern Sierra Madre Natural Park and outlying areas inclusive of the buffer zone. Available from: <https://whc.unesco.org/en/tentativelists/5037/> (accessed: 05 March 2022).
- Vander Kloet, S.P.** 1988 The genus *Vaccinium* in North America. Research Branch Agriculture Canada Publ. 1828, Ottawa, Canada. 218pp.
- Vander Kloet, S.P. and Dickinson, T.A.** 2009 A subgeneric classification of the genus *Vaccinium* and the metamorphosis of *V.* section *Bracteata* Nakai: more terrestrial and less epiphytic in habit, more continental and less insular in distribution. *J. Plant Res.* **122(3)**: 253–268.
- van der Ploeg, J., M. van Weerd, A.B. Masipiqueña and G.A. Persoon** 2011 Illegal logging in the Northern Sierra Madre Natural Park, the Philippines. *Conserv. Soc.* **9(3)**: 202–215.
- van Weerd, M. and H.A. Udo de Haes** 2010 Cross taxon congruence in tree, bird, and bat species distributions at a moderate spatial scale across four tropical forest types in the Philippines. *Biodivers. Conserv.* **19(12)**: 3393–3411.