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A new monocaulous species of *Virotia* (Proteaceae) from New Caledonia and a rare case of co-accumulation of nickel and manganese

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Abstract

Recent fieldwork has revealed a new species of *Virotia*, a genus of Proteaceae endemic to New Caledonia. This understory monocaulous shrub or tree was found in two nearby rainforests on ultramafic substrate in the Poro region. We report high concentrations of manganese (10,900 mg.g^{-1}) and nickel (2,900 mg.g^{-1}) in dry leaves of this species. This is one of the few cases of simultaneous hyperaccumulation of these metals in angiosperms. This rare micro-endemic species is given a conservation status of critically endangered due to the impact of nickel mining, fire and fragmentation on its habitat.

Introduction

The last complete taxonomic revision of the New Caledonian Proteaceae was carried out by Robert Virot as the second volume of the series "Flore de la Nouvelle-Calédonie et dépendances" (Virot 1968). His treatment included the genus *Macadamia* F.Muell. with six endemic species and the introduced *Macadamia ternifolia* F.Muell. from Australia. At the end of their authoritative work on Proteaceae, Johnson and Briggs (1975) published the genus name *Virotia* L.A.S. Johnson & B.G. Briggs with a five-line diagnosis and the combination for the type species, *Virotia leptophylla* (Guillaumin) L.A.S.Johnson & B.G.Briggs [= *Kermadecia leptophylla* Guillaumin, *Macadamia leptophylla* (Guillaumin) Virot]. They indicated that the genus included six species endemic to New Caledonia and possibly another one in north-eastern Queensland "assigned to *Virotia* in the absence of fruits". At the beginning of their final section on "New genera and specific combinations" where the name *Virotia* first appeared, they stated that "specific combinations are made here for type species only. Fuller details of the many characters relevant to relationships and taxonomy, as well as combinations for other species, will be provided elsewhere." Weston & Mast (in Mast *et al.* 2008) published much later combinations in *Virotia* for the five other species native to New Caledonia that Virot treated as *Macadamia*. The genus is considered as endemic to New Caledonia and forms a clade with *Athertonia* L.A.S.Johnson & B.G.Briggs (one species in Queensland) and *Heliciopsis* Sleumer (14 species in Southeast Asia) (Mast *et al.* 2008). Hopkins and Pillon (2020) described a seventh species, *Virotia azurea* H.C.Hopkins & Pillon, and clarified the boundaries between *Virotia francii* (Guillaumin) P.H.Weston & A.R.Mast and *Virotia leptophylla*. Field observations and collections made in 2022 (Munzinger and Bruy 2023) and later in the Poro area revealed a plant that did not fit into any existing taxon and is described here as new.

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Virotia poroensis Pillon, Bruy & B.Henry, *sp. nov.* (Figs 1, 2)

LSID: http://www.ipni.org/urn:lsid:ipni.org:names:77359143-1

Type: NEW CALEDONIA: Houailou, Poro, 21°19'01.7''S, 165°45'13.3''E, 310 m, 7 March 2024, *Pillon, Bruy & Traclet 1548* (fl.) (holo [prepared as three mounted sheets and one spirit collection]: NOU112668! [leaf apex], NOU112670! [leaf base & inflorescence], NOU112671! [mid-portion of a leaf], NOU011339 [flowers in spirit], iso: P!).

Diagnosis: This species is most similar to *Virotia angustifolia* (Virot) P.H.Weston & A.R.Mast and *Virotia azurea* H.C.Hopkins & Pillon as they have a similar unbranched architecture (Corner's model), large unlobed lanceolate leaves with short petiole, and beaked fruits. It differs from *V. angustifolia* in its leaves that are larger (64–95 vs 19–53 cm) and wider (11–24 vs 3–8 cm), and from *V. azurea* in the color of the flowers (pink vs. bluish), the leaf margin which is not wavy, and the shorter petiole (0–0.9 vs 1.5–3 cm).

Description: Slender, single-stemmed *shrub* or small *tree* up to 8 m high, following Corner's model of architecture, often with one or two reiterations, up to 30 cm in circumference at breast height. Bark rugose. *Leaves* clustered around the top of the shoot, simple, sessile or almost so, petiole 0–0.9 × 0.7–1.2 cm, blades oblanceolate, 64–95 × 11–24 cm; base narrowly cuneate or sometimes decurrent, symmetrical; apex broadly obtuse to triangular, often forming a large acumen; margins entire, slightly

Figure 1. *Virotia poroensis* Pillon, Bruy & B.Henry. A: Apical crown of leaves; B: unbranched trunk with an inflorescence(buds); C: inflorescence at anthesis; D: fruits fallen on the ground. A–B, D: pictures by Benoît Henry, C: picture of the holotype (*Pillon et al.* 1548) by Yohan Pillon.

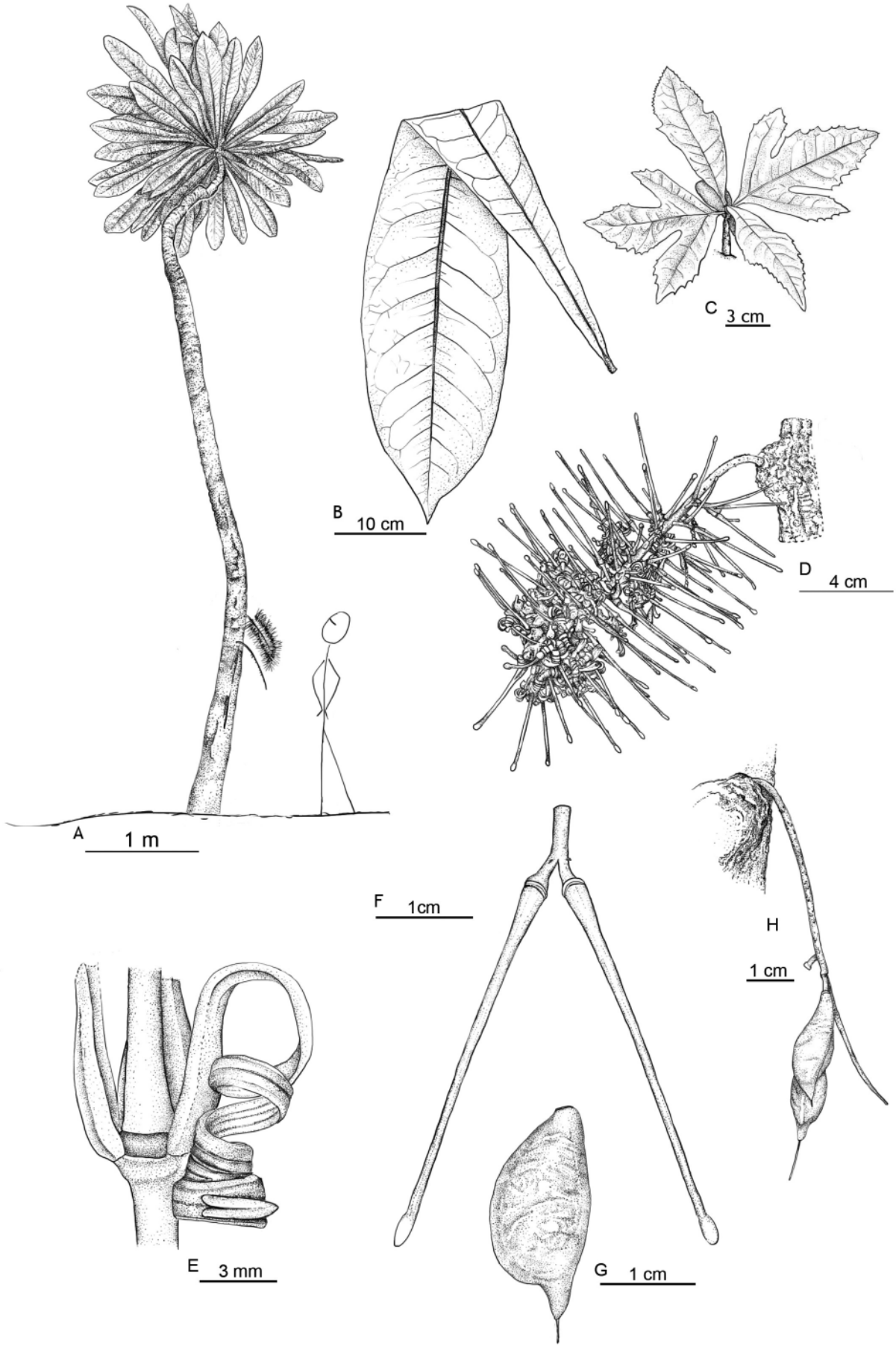

Figure 2. *Virotia poroensis* Pillon, Bruy & B.Henry. A: Plant habit; B: leaf; C: seedling; D: inflorescence (conflorescence), most flowers post-anthesis; E: base of a flower at anthesis with one tepal removed; F pair of flower buds; G: Fruit in lateral view; H: axis with two fruits. [B, D–E: *Pillon et al.* 1548, A, C, F–H: from pictures by Benoît Henry. Drawing: Laurence Ramon.

wavy and sinuate; both surfaces completely glabrous; midrib on upper surface flat or slightly indented to slightly raised towards the base, minutely ridged; prominent, rounded and longitudinally ridged beneath; secondary and higher order veins minutely prominent on both surfaces in dry material; towards the base of the blade; secondary veins almost at right angles (c. 80°) to the midrib, parallel to each other and connected by an intramarginal vein near the margins; in the middle and distal part of the leaf; secondary veins gradually at a narrower angle to the midrib (40–50° near the apex), either parallel or curved, branching and anastomosing further from the margins. *Seedlings* [from photographs]: cotyledons green above red below, first two leaves following cotyledons c. 10 cm long, opposite, trilobed, margin serrate on all three lobes; subsequent leaves simple, spirally arranged and serrate only on distal half. *Inflorescences*: axes inserted by 1–2 on the trunk, well below the leaves, ± horizontal; each a raceme of flower-pairs of total length 13–23 cm, including a common peduncle 2.5–4 cm long and bearing a few caducous bracts each 0.5–3.5 mm long; flowering part cylindrical, 8–9.5 cm diam., its central axis slender, 2–3 mm diam., slightly ridged longitudinally, quite densely hairy when young, later sparsely to moderately hairy (at 40×), the hairs short, reddish-brown, adpressed. *Flowers*: in pairs, the axis of each pair arising from the axil of a small, caducous, finely hairy bract c. 0.5 mm long. Common peduncle of each flower-pair 2–7 mm long, bearing 2 pedicels each (0.5) 2–4.5 mm long, common peduncle and pedicels together 6–11 mm long, slender, sparsely hairy, slightly ridged longitudinally; bracts inserted close to the base of the pedicels (or sometimes below, on the common peduncle), triangular, c. 0.5 × 0.2 mm, hairy; hairs on peduncle, pedicels and bracts 0.1 mm, reddish-brown, adpressed. Bud just prior to anthesis a straight slender tube 28–38 mm long, very narrow for most of its length, expanded into an ovoid tip, also slightly expanded at the base, pink; outer surface sparsely to moderately hairy (hairs minute, reddish, adpressed). Tepals post-anthesis split to or almost at base, tips of lobes only slightly broadened, curling helically, pink, their inner surface glabrous. Stamens: free part of the filament c. 0.5 mm long, barely distinct, each one inserted towards the base of the enlarged tip of a tepal; anthers 3 × 0.5–0.7 mm. Hypogynous disc a thin regular glabrous ring, height c. 0.8 mm. Gynoecium: ovary and style continuous and not readily distinguishable, cylindrical-conical, long and slender, 30–38 mm, 1–1.5 mm diameter at the base 0.6 mm at its narrowest subapical point, glabrous, pink, the distal 2.5–3 mm forming a slightly swollen pollen presenter, this glabrous and shiny black with longitudinal ridges. *Fruits* few (1–3) per infructescence, each borne on a thickened pedicel/peduncle 8–11 mm long, cylindrical, somewhat laterally compressed, crescent shaped or ventral part ± elliptic in outline, with a marked beak at the end of the dorsal margin, up to 3.2 cm long (including the 3 mm long beak) × up to 1.1 cm deep (between the midpoints of the ventral and dorsal margins), possibly up to 4 × 2 × 2 cm when ripe (based on photographs without scale); epicarp bright or dark shiny green to brown when ripe, glabrous; seeds 1 per fruit, ellipsoid in section.

Etymology: This species is named after the village and plateau of Poro, to which it appears to be restricted.

Distribution and habitat: This tall and slender shrub or tree is an understory plant in humid forest on ultramafic substrates. It has been found in two nearby forests in the Poro area between 50 and 310 m elevation (Figure 3).

Conservation status: This species was assessed on October 17th 2024 by the Red List Authority Flora of New Caledonia (Meyer *et al.* 2022) and was given a conservation status of Critically Endangered according to the IUCN criteria.

Other specimens examined: NEW CALEDONIA: Northern Province: Houailou, Poro, 21°19′01.7″S, 165°45′13.3″E, 310 m, 7 March 2024, *Pillon, Bruy & Traclet 1549* (fr.) (K!, NOU112673!, P!); ibid, 21°19′0.696″S, 165°45′14.364″E, 300 m, 17 April 2022, *Bruy & Munzinger 2276* (fl.) (NOU111992!).

Note on architecture: This species is an addition to the list of c. 182 monocaulous plant species native to New Caledonia (Bruy 2018).

Notes on metal accumulation: A leaf fragment from the holotype was washed in water, dried and then finely ground using a mortar, pestle, and liquid nitrogen. 30 mg of leaf powder was digested with 1.5 mL of 65% HNO_3 and 500 µL of 30% H_2O_2 in a Savillex PFA vial. The mixture was homogenised and left without cap at room temperature for 12 h to remove gas. The cap was then tightened and the sample was heated on a hot plate at 85°C for 48 h. The cap was unscrewed and the vial was heated at 84°C and evaporated until dry. After cooling, the residue was suspended in 3 mL H_2NO_3 (10%, w/w) and sonicated for 20 min using a Branson 2510 ultrasonic cleaner. The sample was then heated on a hot plate at 100°C for 10 min. After cooling, the sample was diluted 10 times with deionised water. A laboratory blank and a certified reference material for bush branches and leaves (NCS DC73349 from the National Analysis Center for Iron & Steel) were also prepared. The samples were then analysed using an inductively coupled plasma mass spectrometer (ICP-MS) at the OSU-OREME, University of Montpellier, France.

We obtained concentrations per dry mass in the leaf of 10900 $mg.g^{-1}$ for Mn, 2896 $mg.g^{-1}$ for Ni, and 141 $mg.g^{-1}$ for Co. Therefore, according to the accepted thresholds of van der Ent *et al*. (2013), *Virotia poroensis* qualifies as a hyperaccumulator of both Mn and Ni. Manganese hyperaccumulation is already well known in New Caledonian Proteaceae (Jaffré 1979), including the morphologically similar *V. angustifolia*, as well as *V. neurophylla* (Guillaumin) P.H.Weston & A.R.Mast, which holds the world record for Mn content (5.5%, Reeves *et al.* 2018). There are few cases of plants hyperaccumulating multiple elements, and dual hyperaccumulation of Mn and Ni has only been reported in species from New Caledonia (Reeves *et al.* 2018). These include *Denhamia fournieri* (Pancher & Sebert) M.P.Simmons (Celastraceae) (Jaffré *et al.* 2013), *Dendrophyllanthus fractiflexus* (M.Schmid) R.W.Bouman (Phyllanthaceae), *Kermadecia pronyensis* (Guillaumin) Guillaumin (Proteaceae), and *Hybanthus austrocaledonicus* (Vieill.) Melch. (Violaceae) (Gei *et al.* 2020).

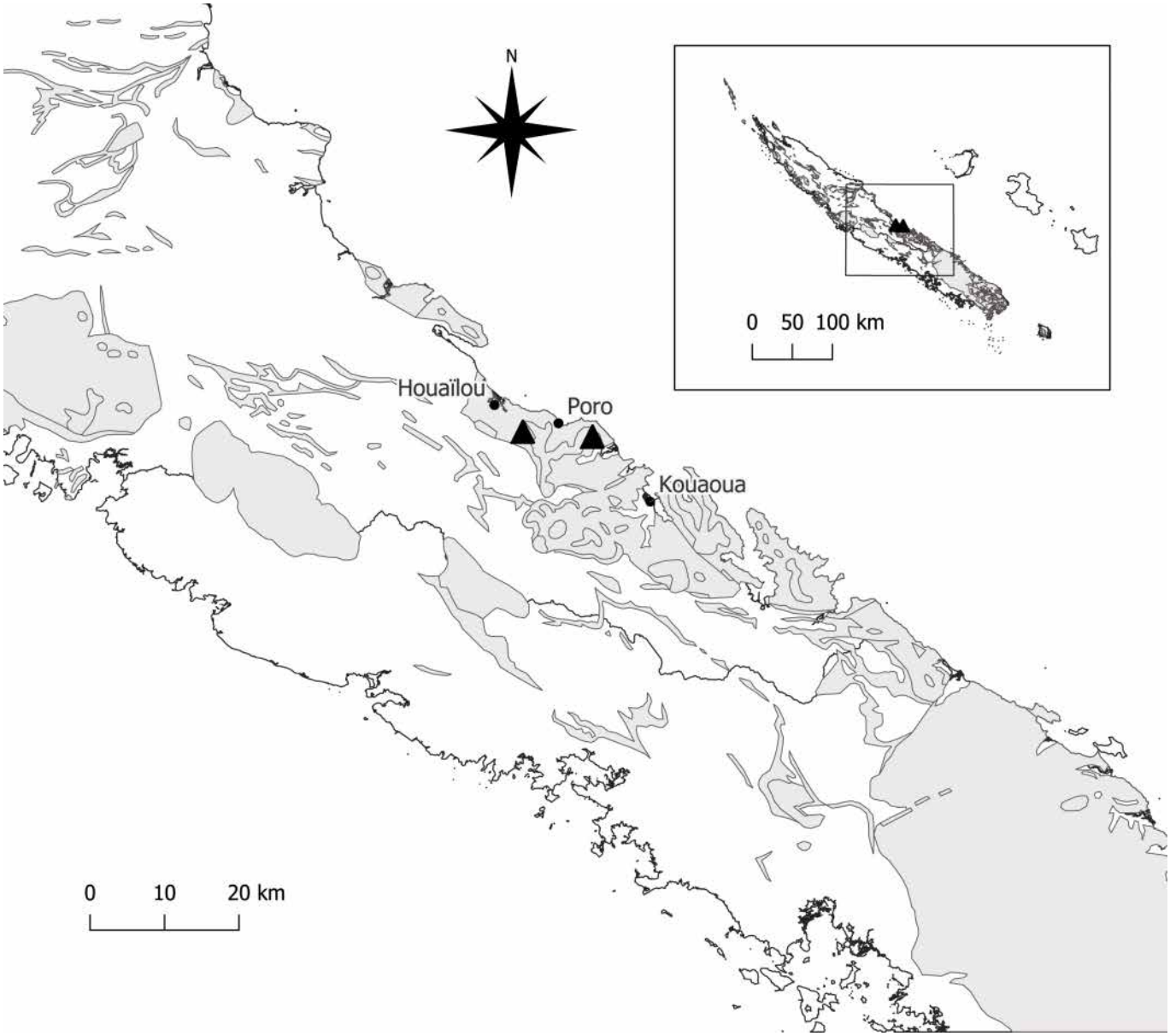

Figure 3. Distribution of *Virotia poroensis* Pillon, Bruy & B.Henry. Areas in grey indicate ultramafic substrates. The easternmost location is based on unvouchered field observations and photographs.

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