



**HAL**  
open science

# Morphological and anatomical investigation of New Caledonian graminoid *Dendrobium* (Orchidaceae) with the description of two new species

Marc Pignal, Jérôme Munzinger

## ► To cite this version:

Marc Pignal, Jérôme Munzinger. Morphological and anatomical investigation of New Caledonian graminoid *Dendrobium* (Orchidaceae) with the description of two new species. *European Journal of Taxonomy*, 2020, 633, pp.1-26. 10.5852/ejt.2020.633 . hal-02553080

**HAL Id: hal-02553080**

**<https://hal.umontpellier.fr/hal-02553080>**

Submitted on 24 Apr 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



## Research article

# Morphological and anatomical investigation of New Caledonian graminoid *Dendrobium* (Orchidaceae) with the description of two new species

Marc PIGNAL<sup>1,\*</sup> & Jérôme MUNZINGER<sup>2</sup>

<sup>1</sup>MNHN Paris, Département Systématique et Evolution, UMR 7205 MNHN/CNRS Origine Structure et Evolution de la Biodiversité, 16 Rue Buffon, C.P. 39, 75231 Paris cedex 05, France.

<sup>2</sup>AMAP, Université Montpellier, IRD, CIRAD, CNRS, INRAE, Montpellier, France.

\*Corresponding author: [marc.pignal@mnhn.fr](mailto:marc.pignal@mnhn.fr)

<sup>2</sup>Email: [jerome.munzinger@ird.fr](mailto:jerome.munzinger@ird.fr)

**Abstract.** Morphological characters support the description of two new species of Orchidaceae from New Caledonia: *Dendrobium butinii* M.Pignal & Munzinger sp. nov. and *Dendrobium letocartiorum* Munzinger & M.Pignal sp. nov. The lectotypes of *Dendrobium camaridiorum* Rehb.f. and *D. crassifolium* Schltr. are designated here. A leaf anatomical study was conducted and provided useful characters to distinguish the five New Caledonian graminoid Dendrobieae species. Two identification tools are provided: an anatomical key for sterile material of grass-like Dendrobieae and a morphological key for the New Caledonian graminoid *Dendrobium*. We propose preliminary conservation assessments with IUCN criteria for the new taxa.

**Keywords.** Orchidaceae, *Grastidium*, *Dendrobium*, *Biloba*, New Caledonia, taxonomy.

Pignal M. & Munzinger J. 2020. Morphological and anatomical investigation of New Caledonian graminoid *Dendrobium* (Orchidaceae) with the description of two new species. *European Journal of Taxonomy* 633: 1–26. <https://doi.org/10.5852/ejt.2020.633>

## Introduction

The New Caledonian flora is remarkable, both for its endemism, estimated at ca 75% (Morat *et al.* 2012), and for the presence of numerous primitive angiosperm groups (Lowry II 1998; Pouteau *et al.* 2015). Morat (1993) estimated that 5–10% of the flora remained undescribed, an interpretation supported by the ongoing description of one new endemic plant species on average per month (Gâteblé *et al.* 2018), including some in the Orchidaceae (Pignal & Munzinger 2011; Faria 2016). Many years ago, our colleague and friend Jean-Pierre Butin (Forest Service, Northern Province) brought to our attention some potentially new species of Orchidaceae. These belong to the genus *Dendrobium* Sw. and are characterized by long thin stems, and narrowly elliptical leaf blades evoking the Poaceae Barnhart, that we call therefore ‘graminoid’ species. Two New Caledonian species were known at that time to have this strange habit: *D. camaridiorum* Rehb.f. and *D. crassifolium* Schltr. Another graminoid *Dendrobium*, *D. uncarinatum* Kores (1989: 97) is now known to occur on the island. We quickly noticed that several herbarium specimens of graminoid *Dendrobium* did not match these three known species, and that

Hallé's annotations on herbarium sheets suggested two potential new species he provisionally named: *Dendrobium crassifomentum* Hallé in herb. and *D. crassiformatum* Hallé in herb. In order to clarify the taxonomy of New Caledonian graminoid *Dendrobium* and evaluate the status of the putative new species, we have undertaken a revision based on morphology of all material in P and NOU. As part of this study, we also examined leaf anatomy, which has provided very informative features for classifying members of *Dendrobium* s. lat. (Yukawa *et al.* 1992; Stern *et al.* 1994; Morris *et al.* 1996; Yukawa & Uehara 1996; Carlsward *et al.* 1997). The main objectives were to 1) clarify the taxonomy of graminoid *Dendrobium* in New Caledonia; 2) provide keys for sterile and fertile material; 3) evaluate how anatomical characters provide information about the placement of these new species in the three sections: *Dendrobium* Sw., *Grastidium* (Blume) J.J.Sm. (Smith 1905a: 348) and *Biloba* J.J.Sm. (Smith 1905b: 67), incl. *Monanthos* Schltr. (Schlechter 1912: 251).

## Material and methods

We examined 109 collections from LY, NOU and P. Herbarium acronyms follow *Index Herbariorum* (Thiers, continuously updated). In addition, we used several virtual collections: Global Plant initiative (<https://plants.jstor.org/>), e-ReColNat infrastructure (<https://www.recolnat.org/>) and Endemia association Website (<http://endemia.nc/>).

The anatomy of leaves of five graminoid taxa belonging to sections *Grastidium* and *Biloba* was studied. Most samples were taken from P and NOU herbaria, or from cultivated material available at several institutions (see Acknowledgements and Material examined). Dried leaves were rehydrated in boiling water, transversely sectioned by hand, bleached in 10% sodium hypochlorite for 5 min, washed and mordanted with acetic acid. The sections were then stained with methylene blue in saturated aqueous solution (5 min) and with Safranin (5 min), dehydrated by 95% alcohol and mounted with Euparal.

For the observation of small pieces of leaves using the Scanning Electron Microscope (SEM) Jeol of the 'Service Commun de Microscopie Électronique du MNHN', samples were cleaned with butanol, fixed on aluminium stubs and sputter-coated with gold.

In parallel of that work, IUCN status was evaluated by the New Caledonian Red List Authority (RLA-NC) and the results are reported there. Species phenology is based on both herbarium data and Christian Laudereau's precise observations.

## Results

### *Key to the graminoid species of Dendrobium in New Caledonia*

Grass-like stems. Inflorescences 1- or 2-flowered, exactly opposite the leaf blade.

1. Flowers non-resupinate. Inflorescences 1-flowered, lamina without any visible depression. Fruit sub-globose (*Dendrobium* sect. *Biloba*) ..... 2
  - Flowers resupinate. Inflorescences always biflorous, lamina with a visible depression, sometimes 'V'-shaped (Fig. 1R), in the lower third; fruit fusiform (*Dendrobium* sect. *Grastidium*) ..... 3
2. Stems bifaciate. Sepals 12 × 2–4 mm, lateral sepals triangular. Petals linear or slightly lanceolate, 11 × ca 1 mm. Lip red, carina, 3 ..... *D. letocartiorum* Munzinger & M.Pignal sp. nov.
  - Stems cylindrical or slightly flattened. Sepals 4–4.5 × 2.4–3 mm, lateral sepals triangular-ovate. Petals ovate, asymmetrical, ca 4 × 2 mm, lip white, carina, 1 ..... *D. unicardatum* Kores
3. Leafy stem thick, slightly fleshy, weakly flattened; lamina of leaf wide and short, 50–70 × 9–15 mm, ovate, coriaceous, fleshy ..... *D. crassifolium* Schltr.

- Leafy stem thin, terete, not fleshy; lamina of leaf narrow, 35–100 × 1.5–4 mm, slender, chartaceous and not crassulescent ..... 4
- 4. Leaf blade 45–100 × 4–5 mm; sepals and petals at least 30 mm long; adventive plantlets frequent; sepals attenuate ..... *D. camaridiorum* Rchb.f.
- Leaf blade ca 35–40 × 1.5–2 mm; sepals and petals < 10 mm long; adventive roots present, but plantlets absent; sepals triangular, abruptly narrowed forming an acumen ca 4 mm long .....  
..... *D. butinii* M.Pignal & Munzinger sp. nov.

**Taxonomic treatment**

Class Angiospermae Lindl  
Subclass Magnoliidae Takht.  
Super-Order Liliales Takht.  
Family Orchidaceae Juss.  
Genus *Dendrobium* Sw.

***Dendrobium unicarinatum* Kores**

Figs 1B, I–J, P, 2, 3H–I, 4A, 5H

*Allertonia* 5: 97 (Kores 1989). – *Dendrobium crassiformatum* Hallé ined. in herb. – **Type:** FIJI • Viti Levu, Mba Province, vicinity of Nandarivatu; 17 Nov. 1927; *Gillespie 3841*; holotype: AMES[AMES00243052].

**Etymology**

The epithet refers to the carina of the lip.

**Material examined**

NEW CALEDONIA – **Province Nord** • Mont Mandjelia, Pouébo; 20°23'51" S, 164°31'57" E; 21 Feb. 2016; fr.; *C. Laudereau 97*; NOU[NOU090363] • Cultivated in Nouméa; *C. Laudereau 172*; (original material data: Roches de la Ouaième; 20°38'22" S, 164°51'47" E, 6 Dec. 2016); NOU[NOU090377] • Roches de la Ouaième, Hienghène; 20°38'22" S, 164°51'47" E; 22 Oct. 2018; fr.; *C. Laudereau 1075*; NOU[NOU090364] • Ouane Batch, Pouébo; 20°30'35" S, 164°43'56" E; 23 Dec. 2018; *C. Laudereau 1112*; NOU[NOU090365] • Mont Mandjelia Pouébo; 20°23'51" S, 164°31'57" E; 24 Dec. 2018; fr.; *C. Laudereau 1156*; NOU[NOU090366] • Grande-Terre, Pouébo: Mont Mandjélia; [20°24'2" S, 164°31'42" E]; alt. 750 m; 7 Jun. 1979; *H.S. MacKee & Bégaud 36986*; P[P00118407] • Pouébo: Mont Mandjélia; [20°24'2" S, 164°31'42" E]; alt. 750 m; humid forest, schists, 26 Jan. 1980; *H.S. MacKee 37759 & Bégaud*; P[P00118408] • Roches de la Ouaième, on the crest; [20°38'17" S, 164°52'0" E]; alt. 765 m; 4 Nov. 2011; fr.; *J. Munzinger 6162, V. Hequet, A. Vandrot, Ph. Birnbaum & I. Pounds*; NOU[NOU063339] • Cascade La Guen; 20°37'0" S, 164°46'53" E; humid forest; st.; 21 Nov. 2010; *J. Munzinger 6401, P. Lowry, M. Callmander, H. Vandrot, T. & M. Teimpouene*; NOU[NOU063581]. – **Province Sud** • Mont Koghi; [22°10'55" S, 166°30'19" E]; alt. 500 m; humid forest; Jan. 1979; *H.S. MacKee 43003 & Labrissière*; P[P00118409] • Mont Pembai; [21°34'47" S, 165°49'59" E]; alt. 700 m; humid forest, schists; 31 May 1990; *H.S. MacKee 44925*; P[P00124752, P00124753].

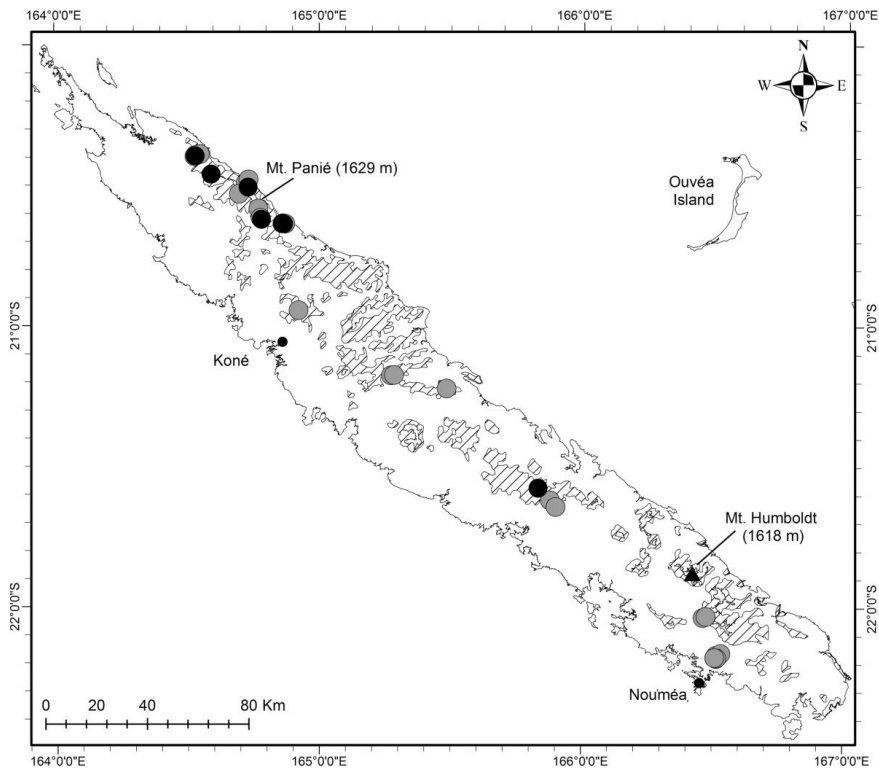
**Description**

Herb, epiphytic, erect. Roots whitish, ca 1–2 mm wide, at the base of the plant (axillary roots lacking). Stem erect, to 50 cm long, terete or slightly flattened, covered by the sheath of the oldest leaves, blades remaining only in the upper third of the adult stem. Internodes 25 mm long at the base of the stem. Leaves





Fig. 1. (see full caption on page 5)

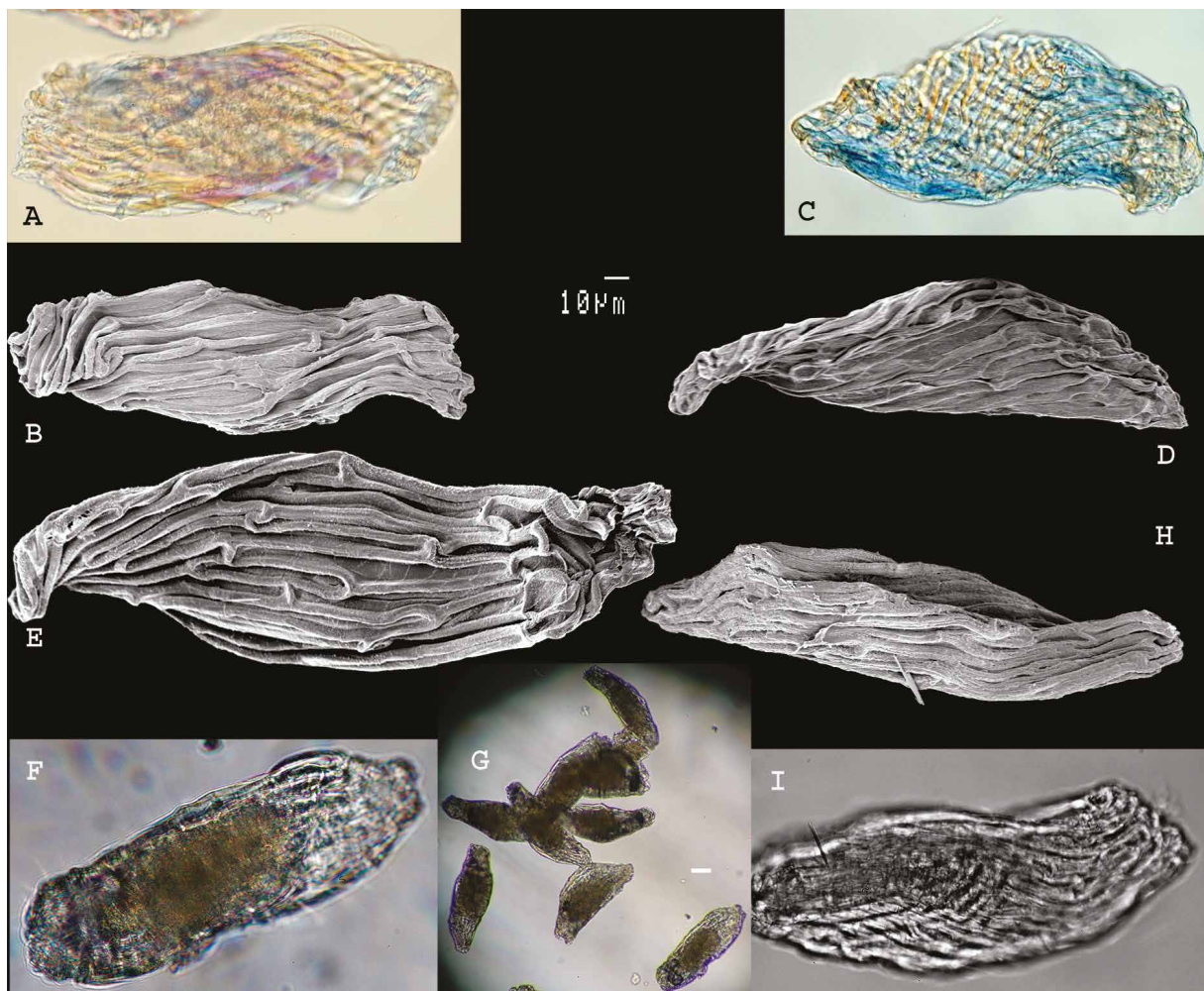


**Fig. 2.** Distribution of *D. uncarinatum* Kores in New Caledonia, based on herbarium specimens (●) and field observations (◐).

**Fig. 1. A–E.** Fruits. **A.** *D. butinii* M.Pignal & Munzinger sp. nov., loc. Colnett Mountain, Ouâ Ina or Wé Ina; image n°PA211592. **B.** *D. uncarinatum* Kores, cult. Nouméa (original data: Mandjélia Mount or Tidiélic Mount, 780 m); image n°PA118035. **C–D.** *D. letocartiorum* Munzinger & M.Pignal sp. nov., Mandjélia Mount or Tidiélic Mount, 780 m; image n°PA182815. **D.** Dehiscent fruit, cult. Nouméa (original data: mt Mandjélia or Tidiélic, 780 m); image n°PC061498. **E.** *D. camaridiorum* Rchb.f., Col des Roussettes, Bouirou; 5 Apr. 2015; image n°P4057147. **F–N.** Flowers. **F–G.** *D. letocartiorum* Munzinger & M.Pignal sp. nov., cult. Nouméa (original data: Mandjélia Mount or Tidiélic Mount, 780 m; 6 Dec. 2014); image n°PC061503. **G.** Cult. Nouméa; (original data: Mandjélia Mount or Tidiélic Mount, 780 m; 6 Dec. 2014); image n°PC061504. **H.** *D. butinii* M.Pignal & Munzinger sp. nov., Colnett Mount, Ouanebatch We Ina, 300 m; 20 Jan. 2018; image n°P1211262. **I–J.** *D. uncarinatum* Kores. **I.** Cult. Nouméa; 15 Nov. 2015; (original data: Roches de la Ouaieme, 800 m; 23 Oct. 2015); image n°PB157702. **J.** Teratological flower, cult. Nouméa; 30 Jul. 2015; (original data: Mandjélia Mount or Tidiélic Mount, 780 m; 25 Oct. 2014); image n°P7314192. **K–L.** *D. crassifolium* Schltr., cult. Nouméa; 27 Nov. 2015. **K.** Image n°PB270172. **L.** Image n°PB2700199. **M–N.** *D. camaridiorum* Rchb.f., Bopope, Piémont (versant sud) du Kantalupaik, *M. Pignal et al. 5165*. **N.** Cult. Nouméa; 13 Nov. 2014; image n°PB130988. **O–Q, S–T.** Habits. **O.** *D. crassifolium* Schltr., cult. Nouméa; before 1998; digitized analogue image s.n. **P.** *D. uncarinatum* Kores, Koghis Mountains, Bouo Mount, 680 m; 31 Aug. 2003; image n°P8311086. **Q.** *D. camaridiorum* Rchb.f., Vallée de la Tchamba; 15 Sep. 2003; image n°P9151456. **S.** *D. butinii* M.Pignal & Munzinger sp. nov., Vallée de la Amoâ Vaawe; 26 Feb. 2016; image n°P2260576. **T.** *D. letocartiorum* Munzinger & M.Pignal sp. nov., Mandjélia Mount ou Tidiélic Mount, 780 m; 24 Oct. 2018; image n°111258. **R.** Leaf of *D. camaridiorum* Rchb.f., *J. Munzinger et al. 6358*. A–L, N–S, T images by Christian Laudereau; M image by Jérôme Munzinger; R image by Peter P. Lowry.



green, shiny above. Blade  $49 \times 3$  mm. Midrib slightly prominent. Two lateral veins visible,  $< 1$  mm from the margin (see discussion of anatomy below). Secondaries prominent, convergent at the apex. Base slightly narrower. Apex rounded or emarginate and asymmetrical. Sheath striated in the upper half and ending by a beak opposite to the lamina and applied on the stem. Inflorescence very short, 1-flowered. Ovary non-resupinate. Floral buds white, flower white to bright yellow when open, fleshy. Tepals with a red terminal dot. Dorsal sepal triangular, 4.5 mm long, 3 mm wide at the base, with 5 nerves. Lateral sepals triangular-ovate, oblique, ca  $4 \times 2.4$  mm, with 8 nerves. Petals ovate, asymmetrical, ca  $4 \times 2$  mm, with 3 nerves. Lip white, entire, rectangular, ca  $4 \times 2.8$  mm, with 5–7 nerves, 3 on the carina and 2–4 lateral. Apex triangular, rounded to obtuse. Carina ca 1 mm wide. Column 1.8 mm high and 1.5 mm wide. Fruit globose, ca  $6 \times 9$  mm. Dried seed with transparent testa of  $217 \times 48$   $\mu\text{m}$ , fusiform, with extremity and base slender. Right extremity slightly spiral. Hydrated seed ovate, sacciform. Cells cubic to polygonal, with extremities rounded, ca  $48\text{--}100 \times 5$   $\mu\text{m}$ , with edges thick, roughly spiral, with smooth cellular walls. Embryo spherical, ca 12  $\mu\text{m}$  in diameter.



**Fig. 3.** Seeds, opening on the right. **A–B.** *D. camaridiorum* Rchb.f. **A.** LM. **B.** SEM (*H.S. MacKee* 14228). **C–D.** *D. butinii* M.Pignal & Munzinger sp. nov. **C.** LM. **D.** SEM (*M. Pignal* 2384). **E–G.** *D. letocartiorum* Munzinger & M.Pignal sp. nov. **E.** SEM. **F.** LM. **G.** SEM (*H.S. MacKee* 37760). **H–I.** *D. uncarinatum* Kores. **H.** SEM (*H.S. MacKee* 36986). **I.** LM (*H.S. MacKee* 44925). Scale bars: A–F, H–I = 10  $\mu\text{m}$ ; G = 30  $\mu\text{m}$ .

### Distribution and ecology

*Dendrobium uncarinatum* grows in Fiji and in New Caledonia dense humid forest (500–750 m), as an epiphyte on trunks (at the base or at several metres high) and can be very abundant, especially on palms. C. Laudereau (pers. comm.) separates two populations by habit and light exposition: the first erect and in sunny situations, the other pendulous, in shade.

### Taxonomic notes

In New Caledonia, *D. uncarinatum* can be easily identified by a cylindrical or slightly flattened stem, 1-flowered inflorescence and white, non-resupinate flowers. Leaf section shows *D. uncarinatum* to be the only graminoid New Caledonian *Dendrobium* having large, obvious and numerous (> 20) supernumerary fibre bundles on both sides, and having the largest vascular bundle in position 2.

### Phenology

Further observations are needed to determine the flowering and fruiting periods. In the available herbarium material, flowers were observed on cultivated plants (grown in New Caledonia) in January and in the field from February to March, and fruits in May to January.

### IUCN status

This species was not recognized in New Caledonia until now, and was evaluated as Data Deficient (DD) by the New Caledonian Red List Authority.

*Dendrobium camaridiorum* Rchb.f.  
Figs 1E, M–N, Q–R, 3A–B, 4Bb, 5A–B, 6

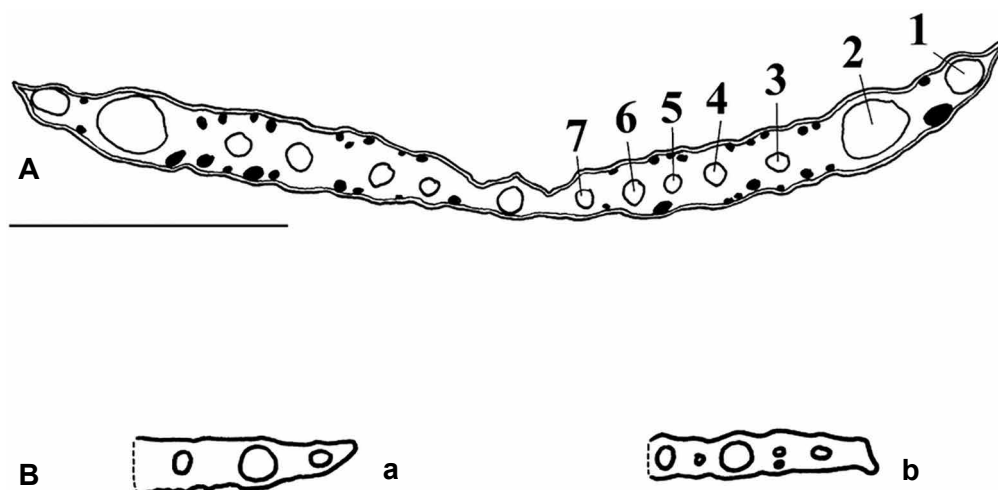
*Linnaea* 41: 89 (Reichenbach 1877). – **Type:** NEW CALEDONIA • Balade; *Vieillard 1332 (nec 1192)*; lectotype: W, **here designated**; isolectotype: P[P00124865]!

### Material examined

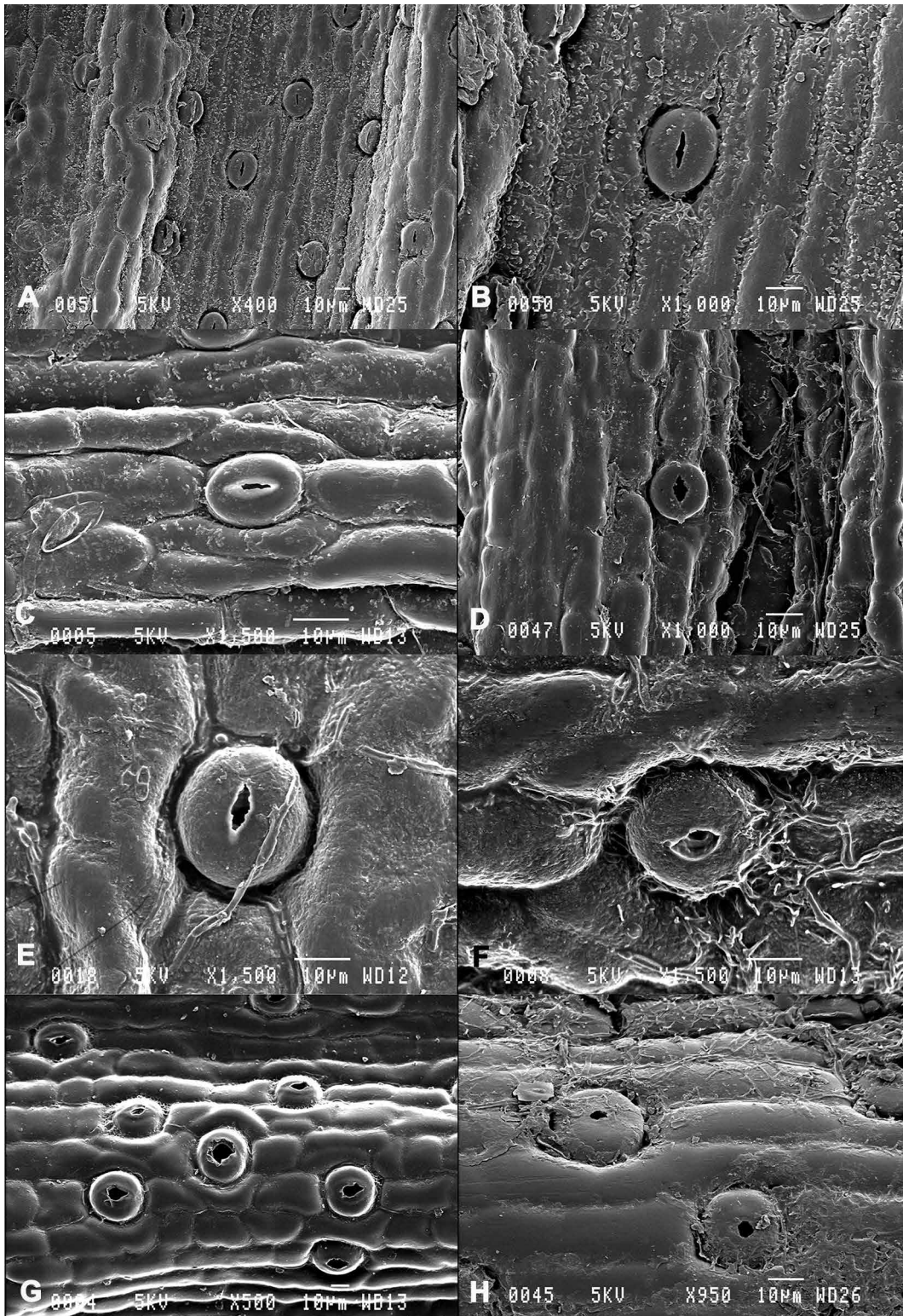
NEW CALEDONIA – *Deplanche 528bis*; P[P00124867, P00124868] • *Legand 4888*; P[P00124869] • s. loc., cultivated in Parc E. Liais, Cherbourg-en-Cotentin; 5 Apr. 2003; *M. Pignal 2046*; (original data: collected alive in 1985 in New Caledonia); P[P00777178]. – **Province Nord** • Haute vallée de la Tchamba; [21°1'55" S, 165°13'36" E]; alt. 100–200 m; gallery forest, near the river; 28 Dec. 1965; *H.S. MacKee 13753*; P[P00124850] • Haute vallée de l'Amoa (exploitation forestière Létocart); [21°0'2" S, 165°14'31" E]; alt. 300–500 m; humid forest; 13 Jan. 1966; *H.S. MacKee 14228*; P[P00124838, P00124849] • Haute Amoa; [20°58'24" S, 165°10'21" E]; alt. 50–100 m; humid forest; 20 Nov. 1967; *H.S. MacKee 17984*; P[P00124846, P00124874] • Haute Tchamba (exploitation forestière Létocart); [21°1'11" S, 165°13'46" E]; alt. 500 m; humid forest; 21 Nov. 1967; *H.S. MacKee 17991*; P[P00124872] • Mont Ignambi (north-east slope); [20°27'11" S, 164°35'50" E]; alt. 900 m; humid forest on schists; 8 Nov. 1971; *H.S. MacKee 24639*; P[P00124845] • Ponérihouen: east buttress of Mont Aoupinié; [21°11'0" S, 165°17'48" E]; alt. 700–850 m; humid forest on grauwackes; 28 Jun. 1972; *H.S. MacKee 25626*; P[P00124844] • Farino, Pic Vincent; [21°2'48" S, 165°10'8" E]; alt. 700 m; humid forest; 3 Mar. 1973; *H.S. MacKee 26374*; P[P00124843] • Haute Diahot, Tendé, exploitation forestière Frouin; [20°24'37" S, 164°31'19" E]; alt. 600 m; humid forest, micaschists; 26 Apr. 1976; *H.S. MacKee 31162*; P[P00124839] • Roche Ouaième; [20°38'35" S, 164°51'36" E]; alt. 850 m; maquis, schists; 22 Dec. 1977; *H.S. MacKee 34465 (leg. Cherrier)*; P[P00121154] • Monéo; [21°8'21" S, 165°27'51" E]; alt. 250 m; altered serpentine plateau, maquis; 25 Apr. 1979; *H.S. MacKee 36818*; P[P00124877] • Pouébo: Mont Mandjélia; [20°24'9" S, 164°31'28" E]; alt. 700 m; humid forest, micaschists; 8 Feb. 1981; *H.S. MacKee 38729 (leg. Bégaud)*; P[P00124870] • Mandjélia, forested slopes; [20°24' S, 164°32' E]; alt. 500 m; 20 Dec. 1981;



*G. McPherson 4531*; MO • Ponandou River Valley, forested slopes below Mont Inédète; 20°49'10" S, 165°11'18" E; alt. 550 m; 10 May 2002; *G. McPherson 18723*; MO • Cascade la Guen; 19 Nov. 2010; *J. Munzinger 6358*, *P. Lowry*, *M. Callmänder*, *H. Vandrot*, *T. & M. Teimpouene*; MO • Bopope, base of the Kantalupaik (south buttress), summit of the Inédète range; 20°51'7" S, 165°0'28" E; alt. 320 m; 28 Dec. 2017; fl.; *M. Pignal 5165*, *J. Munzinger & D. Bruy*; P[P01073021] • Balade; [20°18'56" S, 164°29'52" E]; s.d.; *E. Vieillard 1332*; P[P00124865] • Mont Görö Até; 21°1'42" S, 165°10'12" E; 19 Nov. 2002; *F. Tronchet 484*, *J. Munzinger*, *D. Létocart*, *I. Létocart*, *J.-P. Butin*, *A. Oddi & A. Obry*; P[P00354837, P00354120]. – **Province Sud** • Forest of ‘Mois de Mai’; [22°7'6" S, 166°38'48" E]; 13 Jun. 1951; *M.G. Baumann-Bodenheim 14050*; P[P00124861] • *ibid.*; 24 Jun. 1951; *M.G. Baumann-Bodenheim 14179*; P[P00124860] • Mont “Algaoné” [Algaoué], serpentine; [22°12'10" S, 166°31'40" E]; alt. 500 m; 19 Dec. 1950; *A. Guillaumin 7031 & M.G. Baumann-Bodenheim*; P[P00124859] • Mé Amméri; [21°39'34" S, 165°50'36" E]; alt., 700 m; 27 Nov. 1950; *A. Guillaumin 8647 & M.G. Baumann-Bodenheim*; P[P00124852] • *ibid.*; 27 Nov. 1950; *A. Guillaumin 8700 & M.G. Baumann-Bodenheim*; P[P00124851] • *ibid.*; 28 Nov. 1950; *A. Guillaumin 8744 & M.G. Baumann-Bodenheim*; P[P00124854] • *ibid.*; 28 Nov. 1950; *A. Guillaumin 8721*; P[P00124748] • *ibid.*; 28 Nov. 1950; *A. Guillaumin 8780 & M.G. Baumann-Bodenheim*; P[P00124853] • *ibid.*; 28 Nov. 1950; *A. Guillaumin 8882 & M.G. Baumann-Bodenheim*; P[P00124855] • *ibid.*; 29 Nov. 1950; *A. Guillaumin 8938 & M.G. Baumann-Bodenheim*; P[P00124856] • *ibid.*; 29 Nov. 1950; *A. Guillaumin 8969 & M.G. Baumann-Bodenheim*; P[P00124858] • *ibid.*; 30 Nov. 1950; *A. Guillaumin 9030 & M.G. Baumann-Bodenheim*; P[P00124864] • Forest of Rivière Bleue; [22°6'11" S, 166°38'0" E]; 22 Feb. 1951; *A. Guillaumin 10965 & M.G. Baumann-Bodenheim*; P[P00124857] • *ibid.*; *A. Guillaumin 10966a & M.G. Baumann-Bodenheim*; P[P00124863] • Mont Bario; [22°10'54" S, 166°30'18" E]; alt. 500 m; 20 Apr. 1951; *A. Guillaumin & M.G. Baumann-Bodenheim 12523a*; P[P00124862] • Farino: forest of Mépéou (Exploitation forestière Germain); [21°37'5" S, 165°46'35" E]; alt. 500 m; humid forest; 11 Feb. 1966; *H.S. MacKee 14412*; P[P00124848, P00124873] • Col d’Amieu: Mont Pembai; [21°34'36" S, 165°49'38" E]; alt. 500–600 m; humid forest; 10 Jun. 1973; *H.S. MacKee 26765*; P[P00124842] • *ibid.*; *H.S. MacKee 26766*; P[P00124841] • Port Boisé, associated to 30278; [22°20'58" S, 166°56'18" E]; 24 Jan. 1976; *H.S. MacKee 30672 (leg. Aymard)*; P[P00124840] • 4 km west of Mé Aoui; [21°25'27" S, 165°32'6" E]; alt. 600 m; humid forest, schists; 31 Oct. 1976; *H.S. MacKee 32173 (leg. Bégaud)*; P[P00124847] • Port Boisé; [22°20'59" S,



**Fig. 4.** Drawing of transverse sections of leaves of three graminoid species of *Dendrobium*. **A.** Total section of *D. uncarinatum* Kores (*H.S. MacKee 44925*). Vascular bundles are represented by empty circles and are numbered starting from the lamina margin, black spots indicate fibre bundles. **B.** Leaf margins sections, a. *D. letocartiorum* Munzinger & M.Pignal sp. nov. (*H.S. MacKee 37760*); b. *D. camaridiorum* Rchb.f. (*H.S. MacKee 24639*). Scale bar = 1 mm.

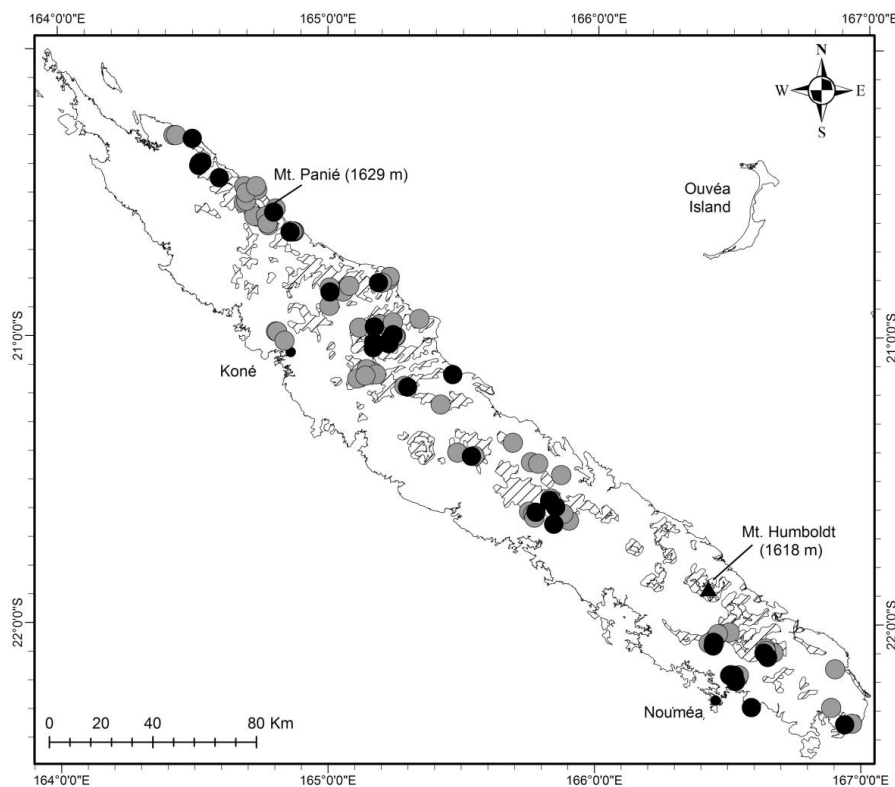


**Fig. 5.** Stomata (SEM). A–B. Type I: *D. camaridiorum* Rchb.f. (H.S. MacKee 14228). C. Type I: *D. butinii* M.Pignal & Munzinger sp. nov. (M. Pignal 2384). D. Type II: *D. butinii* M.Pignal & Munzinger sp. nov. (M. Pignal 2384). E. Type I: *D. crassifolium* Schltr. (H.S. MacKee 43781). F. Type II: *D. crassifolium* Schltr. (H.S. MacKee 43781). G. Type II: *D. letocartiorum* Munzinger & M.Pignal sp. nov. (H.S. MacKee 37760). H. Type II: *D. unicarinatum* Kores (H.S. MacKee 36986). Scale bars = 10 µm.

166°56'19" E]; 9 May 1978; *H.S. MacKee 35091* (leg. *Bégaud*); P[P00124878] • Paita: Tao; [20°34'24" S, 164°47'57" E]; 8 Apr. 1982; *H.S. MacKee 40310* (leg. *Bégaud*); P[P00121153] • Piste du Dzumac; [22°4'46" S, 166°26'34" E]; alt. 800 m; 16 Mar. 1985; *H.S. MacKee 42497* (leg. *Aymard*); P[P00124875] • Dzumac track; [22°4'2" S, 166°26'39" E]; alt. 900 m; humid forest, serpentine terrain; 20 Dec. 1985; *H.S. MacKee 42955* (leg. *Aymard*); P[P00124871] • Thy River valley, ca 12 air-km NE of Nouméa, rainforest near 400 m; [20°10'55" S, 166°31'19" E]; 8 Apr. 1979; *G. McPherson 1530*; P[P00124876]; MO • Mt. Rembai: above Col d'Amieu, forested slopes; [21°36' S, 165°51' E]; alt. 650–850 m; 9 May 1984; *G. McPherson 6542*; P[P00124876]; MO • Flanc du Mont Dore; [22°17'36" S, 166°35'17" E]; s.d.; *Musée Néocalédonien 394*; P[P00124866].

## Description

Epiphyte (also lithophytic), erect with graminoid habit. Roots whitish, ca 1–2 mm wide, at the base of the plant (axillary roots lacking, but sometimes with adventive rooted plantlets, ‘keikis’). Stems spindly, 20–70 cm long, cylindrical, covered by the sheaths of the oldest leaves, lamina remaining only from the upper middle to the upper third of the adult stem. Lamina narrow and long, 45–100 × 4–5 mm, apex attenuated, carrying a V-shaped depression under half of its length (Fig. 1R). Internodes 25–30 mm long at the base of the stem. Sheaths deeply furrowed, beak opposite to the lamina, flute-shaped. Inflorescences always 2-flowered. Ovary resupinate. Flower white, fragrant. Sepals long, narrow, attenuated, ca 35 × 2 mm. Petals long and narrow, equaling the sepals, 30 × 2 mm. Lip trilobate, lateral lobes rounded, median lobe ending as a point, the lip with orange deep within. Central carina proximal, without papillose hairs, edge slightly toothed. Dots yellow-orange on the mentum and the carina. Mentum 4 mm long. Column 3 mm long. Fruit fusiform, greenish yellow, ca 15 mm long and 8 mm in diameter. Dried seed with transparent testa about 191 × 54 µm, fusiform, with extremity and base truncate. Extremity strongly spiral. Hydrated seed ovate



**Fig. 6.** Distribution of *D. camaridiorum* Rchb.f., based on herbarium specimens (●) and field observations (◐).

sacciform. Cells cubic or with extremities rounded, elongate, ca  $57\text{--}100 \times 7.3\text{--}8.5 \mu\text{m}$ , edges thick with spiral orientation, cellular walls smooth. Embryo spherical ca  $10\text{--}11 \mu\text{m}$  in diameter (Fig. 3A–B).

### Distribution and ecology

The endemic plant is widespread in humid or gallery forests all over the main island ‘Grande-Terre’, from 50 to 900 m, but has not been observed in sclerophyll forest (west coast), or in the extreme north-west (Fig. 6).

### Taxonomic notes

*Dendrobium camaridiorum* produces numerous adventive plantlets (‘keikis’), which is not the case of *D. butinii* sp. nov. The long, attenuated leaves with a V-shaped depression on the blade surface are the easiest characters to observe in *D. camaridiorum*. It is distinguished from *D. butinii* sp. nov. by the white, very elongated sepals (shorter and green in *D. butinii* sp. nov.). Leaf anatomy shows *D. camaridiorum* very similar to *D. letocartiorum* sp. nov. (see details under *D. letocartiorum* sp. nov. below).

### Phenology

Flowers are observed throughout the year. It seems that the hours of opening (in the morning) and closing of the flowers (in the afternoon) are synchronous throughout the territory.

### IUCN status

*Dendrobium camaridiorum* is the most abundant species of the graminoid group in New Caledonia, and was evaluated as Least Concern (LC) by the New Caledonian Red List Authority.

### Typification

Vieillard’s numeration cannot be understood as true collection numbers (Morat 2010). Indeed, he often attributed the same number to different gatherings that he regarded as comprising a single species, however he confused many taxa, thereby generating some nomenclatural problems as many of his collections were chosen as types (see for example Pierre *et al.* 2014). Comparison of the material deposited at W with a specimen at P that clearly represents the same collection indicates that an error occurred in transcribing the number on the former, which is probably a fragment removed from the original specimen. Labels on the Paris specimen bear the number *Vieillard 1332*, whereas the sheet at W is numbered *1192*, which in fact corresponds to material of *Phyllanthus cornutus* Baill. (Euphorbiaceae Juss.). The material in Vienna consists of a stem fragment, several leaves, a single, dissected, immature flower, and a drawing of the Paris material. The latter is a tracing of the Paris plant (Hallé, pers. comm.). This interpretation is consistent with Reichenbach’s visit to P in April 1864 (*Paris Herbarium Visit Catalogue*). Paris’s material comprises a bud and a tuft of 3 stems, and is clearly conspecific with the fragmentary collection at W. We can reasonably assume that Reichenbach studied both P and W material, which would thus represent syntypes. We have selected the material at W as the lectotype as it clearly served as the basis of the description of the flower.

### *Dendrobium crassifolium* Schltr.

Figs 1K–L, O, 5E–F, 7

*Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie Heft 1*, 39: 75 (Schlechter 1906). – **Type:** NEW CALEDONIA – **Province Nord** • près “Ou-Hinna” [Oua Hinna]; alt. 900 m; 2 Jan.1903; *Schlechter 15603*; holotype: B (destroyed); lectotype: P[P00121168]!, **here designated**; isoelectotype: K[K001085479] photo seen, BM[BM000505888] photo seen).

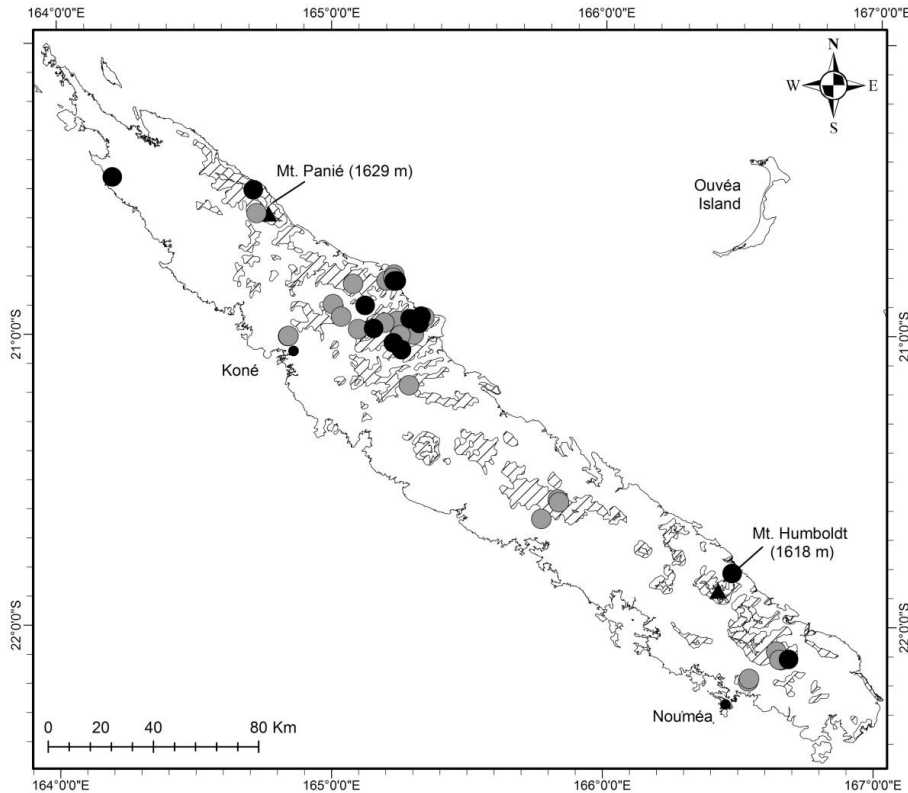


## Etymology

The epithet refers to the texture of the leaf.

## Material examined

NEW CALEDONIA – **Province Nord** • Haute vallée de la Tchamba; [21°1'56" S, 165°13'36" E]; alt. 100–200 m; gallery forest near the river; 28 Dec. 1965; fl.; *H.S. MacKee 13751*; P[P00124990] • Haute Tchamba; [21°3'23" S, 165°15'22" E]; alt. 50 m; gallery forest; 13 Nov. 1969; fl.; *H.S. MacKee 21172*; P[P00124992], P[P00124993], P[P00124994] • Plateau of the Dôme Tiébaghi; [20°27'37" S, 164°12'7" E]; alt. 500 m; 20 Jun. 1972; fl.; *H.S. MacKee 21337*; P[P00124991] • Touho, Ponandou; [20°49'12" S, 165°13'45" E]; alt. 10–100 m; forest on serpentine substrate; 2 Jan. 1973; *H.S. MacKee 26141*; P[P00124995] • Poindimié: Povila; [20°57'0" S, 165°17'16" E]; alt. 400–500 m; humid forest, schistose crest; 21 Mar. 1975; *H.S. MacKee 29892*; P[P00124996] • Touho: Ponandou; [20°49'11" S, 165°14'14" E]; alt. 30 m; gallery forest, schists; 22 Mar. 1975; *H.S. MacKee 29897*; P[P00124997] • Poindimié; [20°56'27" S, 165°19'39" E]; alt. 30 m; humid forest, schists; 14 Jun. 1976; fl., cult.; *H.S. MacKee 31399* (leg. Aymard); P[P00124998] • Haute Amoa: base du Mont Grandié; [20°58'59" S, 165°9'15" E] alt. 50 m; gallery forest, serpentine substrate; 25 Dec. 1976; fl.; *H.S. MacKee 32136*; P[P00124999] • Poindimié: Ndiambi; [20°57'57" S, 165°19'14" E]; alt. 200 m; 23 Nov. 1987; *H.S. MacKee 43781* (leg. Aymard); P[P00123284], P[P00354112 alc.] • Flowered in greenhouse in Nov. 1983; *P. Morat 5321* (original data: Bopope, Feb. 1977, collected by P. Morat); P[P00121169] • On the mountains at Ou-Hinna; [20°30'22" S, 164°42'55" E]; alt. 900 m; 2 Jan. 1903; fl.; *R. Schlechter 15603*; P[P00121168]. – **Province Sud** • Haute Yaté, Rivière Bleue; [22°6'46" S, 166°41'4" E]; alt. 200 m; humid forest, serpentine substrate; 1 Feb. 1985; *H.S. MacKee 42443* (leg. Bégau); P[P00125000] • On the



**Fig. 7.** Distribution of *D. crassifolium* Schltr., based on herbarium specimens (●) and field observations (●).

mountains at Ngoye; [21°49'8" S, 166°28'23" E]; alt. 300 m; 13 Nov. 1902; fl.; R. Schlechter 15277; LY[LY0562048].

### Description

Erect or downward arching epiphyte. Roots whitish, ca 1–2 mm wide, at the base of the plant (axillary roots lacking). Stems 20–100 cm long, robust. Sheaths of the oldest leaves not always covering the stem. Leaves dark green shiny above, lighter below, thick and coriaceous. Lamina shortly ovate to elliptic, 50–70 × 9–15 mm. Midrib visible, secondaries weakly visible. Lamina with a visible V-shaped depression printed around the lower third of the stem. Base abruptly narrowed, apex attenuate, emarginate, with two sub-equal lobes. Sheath striated in its entire length, with edge oblique, opposite to the lamina and applied to the stem. Inflorescence 2-flowered. Ovary resupinate. Flower yellow. Sepals triangular, 10 × 2.9 mm. Petals elliptical, 10 × 2.5 mm. Lip trilobed ca 6 × 5 mm. Lateral lobes with papillose hairs, median lobe with distinctive carina, extending into short papillate hairs. Edge slightly fimbriate. Mentum ca 3 mm. Column about 1.7 mm long. Fruit fusiform ca 8 × 10 mm long and 8 mm in diameter. Seed not seen.

### Distribution and ecology

This endemic species is found in a broad ecological range, quite commonly scattered in several places on the main island 'Grande-Terre' (Fig. 7), an epiphyte in humid or gallery forest. It grows from near sea level (10 m) to 900 m.

### Taxonomic notes

In New Caledonia, in the sect. *Grastidium*, *D. crassifolium* is the only species to have parts of the perianth rounded at the apex. *Dendrobium crassifolium* has the thickest leaves of the graminoid New Caledonian *Dendrobium*, it is also the only species having vascular bundles in two lines (vs one), more than 32 vascular bundles (vs < 30), and the largest vascular bundle with diameter < ½ the thickness of the leaf blade (vs > ¾ the thickness).

### Phenology

Flowering probably throughout the year (not observed in April).

### IUCN status

The species is common in New Caledonia and was evaluated as Least Concern (LC) by the New Caledonian Red List Authority.

*Dendrobium butinii* M.Pignal & Munzinger, sp. nov.

[urn:lsid:ipni.org:names:77209475-1](https://nbn-resolving.org/urn:lsid:ipni.org:names:77209475-1)

Figs 1A, H, S, 3C–D, 5C–D, 8, 9

### Diagnosis

*Dendrobium camaridiorum* Rehb.f. *affinis*, sed planta gracilior foliis minoris fastigiatisque cum vagina minus sulcata, radicibus axillaribus, sepalis brevioris acuminatisque, petalis brevioris angustiorisque. Lobus medius labeli frimbriatus papillosusque.

### Etymology

The species is dedicated to our good friend, Jean-Pierre Butin, an enthusiastic lover of botany, who first recognized and collected this taxon.



**Fig. 8.** *Dendrobium butinii* M. Pignal & Munzinger, sp. nov. *Butin s.n.* A. Habit. B. Sheath. C. Inflorescence. D. Flower. E. Lip. F. Dorsal sepal. G. Petal. H. Lateral sepal. I. Column. J. Fruit, profile. K. Fruit, face. L. Seed. Scale bars: A, C = 1 cm, B, E–I = 2 mm, D = 1 mm, J–K = 5 mm, L = 3.5  $\mu$ m (A–B, E–L, *J.-P. Butin s.n.* [P00157228], C–D from a picture of *J.-P. Butin*). Drawing by Agathe Haevermans.

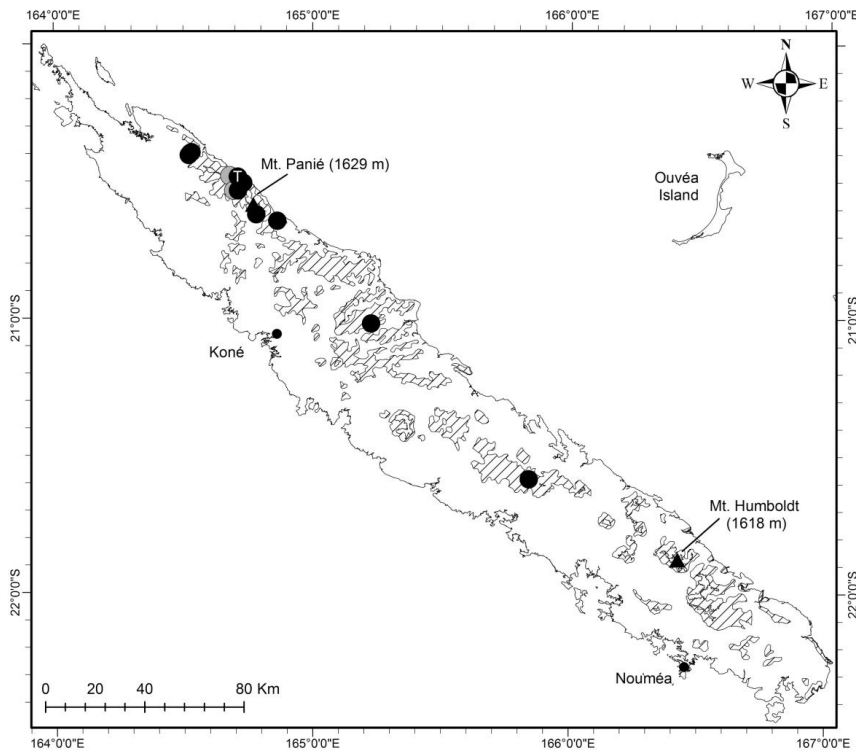


**Type material**

NEW CALEDONIA – **Province Nord** • s. loc.; 18 May 2001; fl.; *J.-P. Butin s.n.*; (original data: Mont Colnett 700 m, collected alive by J.P. Butin, 3 Oct. 1997); holotype: P[P00157228]!; clonotype: P[P00453885]! (see note).

**Paratypes**

NEW CALEDONIA – **Province Nord** • Cultivated in Koné; 7 May 2003; fl.; *J.-P. Butin s.n.*; (original data: Mont Colnett, collected by J.P. Butin); P[P00453886] • Mont Colnett; 20°29'17" S, 164°42'42" E; alt. 690 m; 10 May 2003; fl. & fr.; *J.-P. Butin s.n.*; P[P00777172, P00777173] • Amoa GR Tchamba, Poindimié; 20°59'2" S, 165°13'55" E; 13 Nov. 2016; fl. & fr.; *C. Laudereau 133*; NOU[NOU090367] • Colnett Oua Ina, Pouébo; 20°30'35" S, 164°43'56" E; 5 Jan. 2017; fr.; *C. Laudereau 256*; NOU[NOU090368] • Colnett Oua Ina, Pouébo; 20°30'38" S, 164°44'0" E; 2 Jan. 2018; *C. Laudereau 663*; NOU[NOU090369] • Poindimié, Povila, Nérupaawé Pic Amoa; 20°57'25" S, 165°17'27" E; 21 Oct. 2018; fl.; *C. Laudereau 1061* & *D. Szlachetko*; NOU[NOU090370] • Ouane Batch, Pouébo; 20°30'35" S, 164°43'56" E; 23 Oct. 2018; fr.; *C. Laudereau 1115* & *D. Szlachetko*; NOU[NOU090371] • Mont Colnett, east side; 20°29'13" S, 164°42'39" E; alt. 700 m; 3 Nov. 2003; fl. & fr.; *A. Mouly 101*; P[P00777175] • Tchamba valley; 21°0'13" S, 165°14'49" E; fr.; 23 Apr. 2004; *M. Pignal 2350*, *J. Munzinger*, *J.P. Butin*, *C. Létocart*, *I. Létocart* & *D. Létocart*; P[P02288380] • Tchamba valley; 21°0'34" S, 165°14'24" E; fr.; 24 Apr. 2004; *M. Pignal 2384*, *J. Munzinger*, *J.-P. Butin*, *C. Létocart*, *I. Létocart* & *D. Létocart*; P[P00777174].



**Fig. 9.** Distribution of *D. butinii* M.Pignal & Munzinger, sp. nov., based on herbarium specimens (●) and field observations (●), ‘T’ indicates the type collection.



## Description

Terrestrial or epiphytic herb with graminoid habit. Thin roots at the base of the plant, as well as along the stem, at the base of the nodes. Stems spindly  $400 \times 1.5\text{--}2$  mm. Internodes 1–1.5 cm long. Sheaths of the dried leaves covering all of the stem, not deeply furrowed, the part opposite to the stem showing a beak-like extension. Leaves with narrow lamina, ca 2 mm wide at the base and 35–40 mm long. Lamina with a visible V-shaped depression printed around the lower third of the stem. Inflorescence 2-flowered, emerging from a small sessile sheath. Ovary resupinate. Flowers: sepals triangular, greenish,  $9 \times 3$  mm, abruptly acuminate, acumen of the sepal 4 mm long. Petals linear, very narrow, greenish, ca  $7 \times 0.5$  mm. Lip yellow-green, trilobate, with small short papillate hairs on edges. Lateral lobes 1 mm wide, weakly carinate, each carina surmounted by the same small papillate hairs. Median lobe cordiform, 3 mm wide, ending in a central clearly distinguishable carina, laterally fimbriate, each fibre covered with small papillate hairs, ending by a tuft of thick long hairs. Internal face of the column with longitudinal reddish macules, 3 mm height, mentum showing a right angle with the ovary, 3 mm. Ovary ca 2 mm long, on a peduncle 12 mm long. Fruit ellipsoid, ca  $18 \times 4$  mm. Dried seed with transparent testa,  $208 \times 53$   $\mu\text{m}$ , fusiform with extremity and base attenuated. Extremity strongly spiralled. Hydrated seed elliptic sacciform. Cells cubic to polygonal, ca  $65 \times 4.6\text{--}6.6$   $\mu\text{m}$ , with spiral orientation. Edges thick, with spiral orientation, cellular walls smooth. Embryo spherical or elongate, about 8  $\mu\text{m}$  in diameter.

## Distribution and ecology

This endemic species has been located so far on one mountain (Mont Colnett) and in one valley (Tchamba) and appears restricted to humid forest of the North-East of the main island. *Dendrobium butinii* sp. nov. appears to occur in areas with the same ecological conditions as those of *D. uncarinatum*.

It can also occur in windy areas, as a lithophytic cushion plant on mossy micashists, in a dense population of cushion-like plants (Butin, pers. comm.). The species is known from 280 to 700 m elevation. The species has been observed also in the forest of Sailles (Thio) and Pénari (C. Laudereau, pers. comm.).

## Taxonomic notes

The material studied that we attribute to *D. butinii* sp. nov. clearly does not correspond to *D. minutiflorum* Kraenzl. (Kränzlin 1914: 84), which was considered an insufficiently known species by Hallé (1977) and was based on a single collection (*Sarasin 579*) that was probably destroyed in Berlin. According to the original description (Kränzlin 1914), *D. minutiflorum* has bilobed leaves that are 23 mm long and 6–7 mm wide, 2–3-flowered inflorescences, suggesting that this taxon would be closest to *D. isochiloides* Kraenzl. (Kränzlin 1894: 334) (= *Monanthos isochiloides* (Kraenzl.) Rauschert in Rauschert 1983: 455) and *D. erectifolium* J.J.Sm. (Smith 1908: 16) (= *Monanthos erectifolius* (J.J.Sm.) Rauschert in Rauschert 1983: 455). Hallé suggested this species might be related to members of sect. *Grastidium*, although the 3-flowered inflorescence would be very surprising inside this section. The ecological conditions in which the two taxa (*D. minutiflorum* and *D. butinii* sp. nov.) occur are also different: *D. minutiflorum* was collected at Yaté in extreme SE New Caledonia, at low altitude (100 m) in an area with ultramafic soil, whereas *D. butinii* sp. nov. grows between 450 and 700 m at sites with sedimentary substrates.

*Dendrobium butinii* sp. nov. matches the characters of the “fourth group” so called by Hallé (1977), characterized by having leaves along the stem, internodes hidden by leaf sheaths that are not imbricate and 2-flowered inflorescences on the leafy stems, opposite the lamina and developing from a small, sessile sheath. In New Caledonia this morphological group is represented by three species: *D. butinii* sp. nov., *D. crassifolium* and *D. camaridiorum*. This group is also remarkable by the presence of a ‘V-like’ central imprint on the leaves, always clearly present in *D. camaridiorum* and *D. crassifolium*, sometimes less apparent in *D. butinii* sp. nov. (Figs 1R, 8).

*Dendrobium camaridiorum* is the closest species to *D. butinii* sp. nov. Based on habit, *D. butinii* sp. nov. can be distinguished by its more spindly aspect, its smaller leaves, the presence of numerous adventive roots without adventive plantlets ('keikis') and its abruptly narrowed sepals.

Floral features, including the presence of papillose hairs on the lip and its fimbriate aspect, suggest a close affinity between *D. butinii* sp. nov. and *D. crassifolium*, although the hairs and fibres are much more developed in the latter species. *Dendrobium butinii* sp. nov. has thin leaves and vascular bundles in one line as *D. camaridiorum*, but differ by having vascular bundles  $< 15$  (vs  $> 22$ ), midrib not prominent (vs prominent), largest bundles in position 3(4–5) (vs 5(–6)) and presence of supernumerary fibre bundles (vs absence). *Dendrobium butinii* sp. nov., *D. camaridiorum* and *D. crassifolium* were all observed by the authors growing together on a single tree trunk in the Tchamba valley in NE New Caledonia.

### Phenology

Flowering and fructification periods need further observations. The fruits were observed from the field and in cultivation (in New Caledonia) in January, April to May, October to November. Flowering specimens were observed in January, April, May and October to November.

### IUCN status

Even if uncommon, *D. butinii* sp. nov. was evaluated as Least Concern (LC) by the New Caledonian Red List Authority, because no specific threat to the species or its habitat is known.

### Note

Unrecognised by the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.* 2018), the clonotype notion is used by numerous systematists working on groups which can be cultivated. By 'clonotype' we designate here all material originated from the individual which provided the holotype and isotypes. Thus, the collector of a clonotype and the collection date can be different from those of the 'type' material. According to the Code, this is a paratype, but it can be genetically equated to an isotype; thus we believe the clonotype notion should be accepted by the Code.

*Dendrobium letocartiorum* Munzinger & M.Pignal, sp. nov.

[urn:lsid:ipni.org:names:77209476-1](https://nomenclature.ipni.org/names/77209476-1)

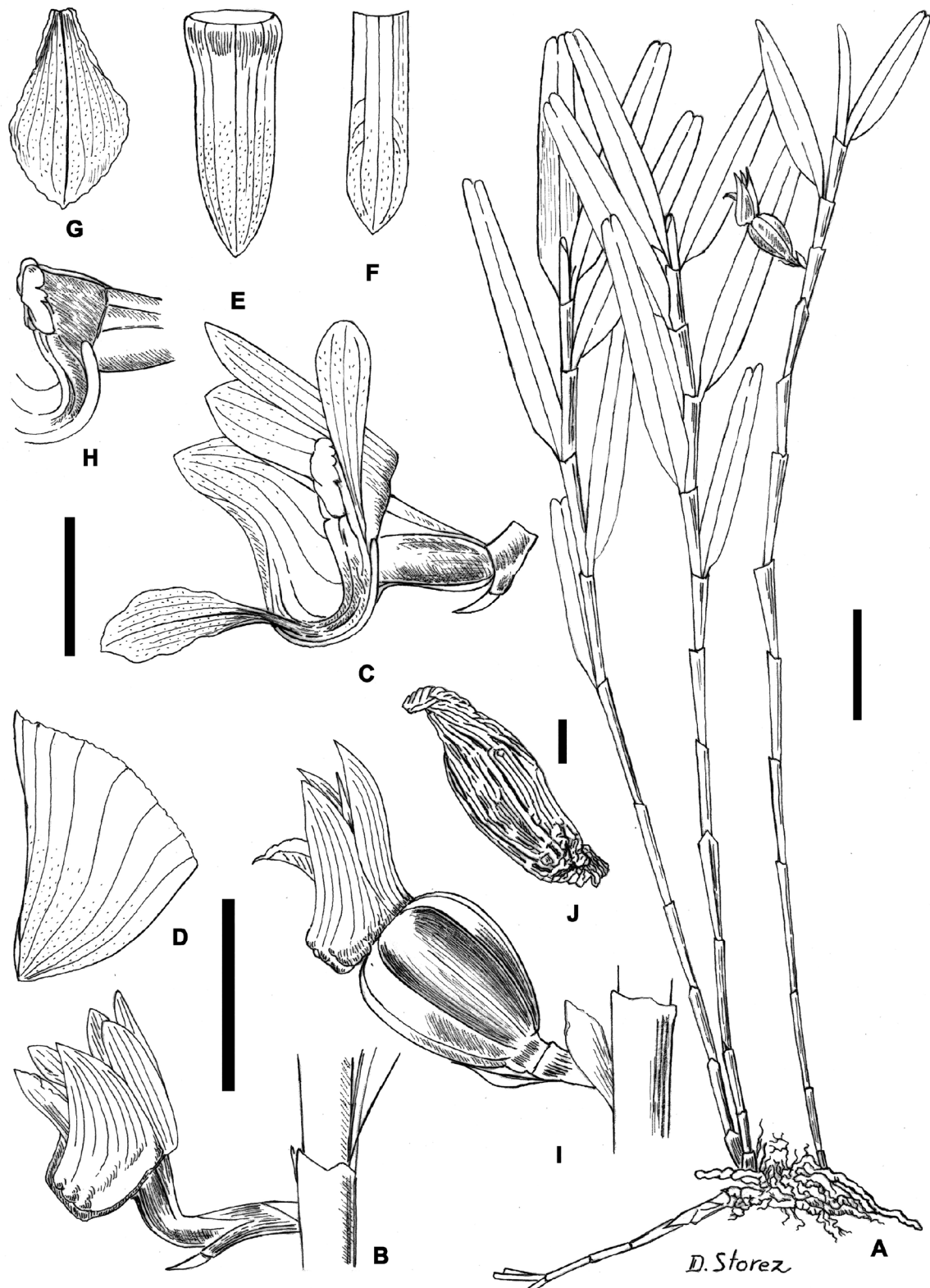
Figs 1C–D, F–G, T, 3E–G, 4Ba, 5G, 10, 11

### Diagnosis

*Dendrobium bilobo* Lindl. *affinis*, sed *foliorum rostratis vaginis (versus truncatas)*, *sine atropurpureis maculis labello, dorsali sepalo triangulari*,  $12 \times 2$  mm (*versus ovatum*  $4\text{--}5 \times 2\text{--}3$  mm), *lateralibus sepalis*  $12 \times 4$  mm (*versus*  $6.5 \times 4.5$  mm), *petalis linearis vel paulo lanceolata*,  $11 \times ca 1$  mm (*vs lanceolata*,  $3.5\text{--}4 \times 1.5\text{--}2$  mm), *gynostegio cum atropurpureis faciali interni maculis (vs pallide purpureis aut albis)*, *praecipue differt*.

### Etymology

The species is dedicated to our friends Irène and Daniel Létocart who collected and cultivated this plant in 1978–1980, providing H.S. MacKee with material for the first herbarium specimens, and also to the Létocart family, whose many members are active naturalists, creators of the Endemia website, and with whom we have made many field trips.



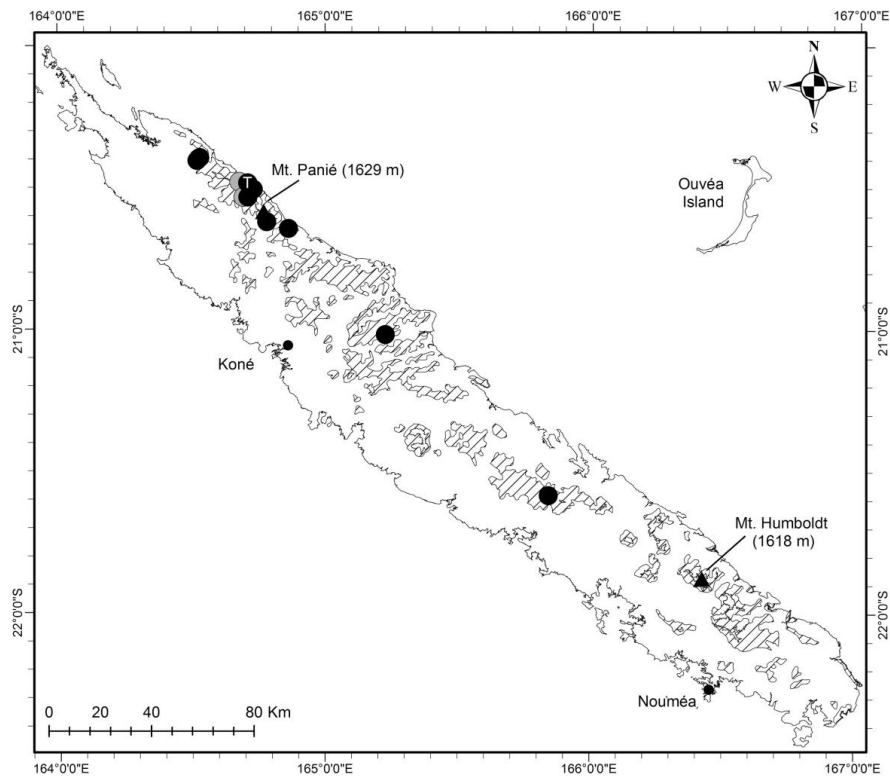
**Fig. 10.** *Dendrobium letocartiorum* Munzinger & M.Pignat sp. nov. **A.** Habit. **B.** Flower, profile. **C.** Flower, lateral sepal removed. **D.** Lateral sepal. **E.** Dorsal sepal. **F.** Petal. **G.** Lip. **H.** Column. **I.** Fruit. **J.** Seed. Scale bar: **A** = 2 cm, **B**, **I** = 1 cm, **C–H** = 5 mm, **J** = 40  $\mu$ m (*A.* Mouly 99, holotype [P00777176]). Drawing by Dominique Storez.

**Type material**

NEW CALEDONIA – **Province Nord** • Mont Colnett, versant Est; 20°29'13" S, 164°42'39" E; alt. 700 m; border zone between the altitude rainforest and the savanna of burns, schists; 3 Nov. 2003; fl. & fr.; *Mouly 99*; holotype: P[P00777176]!; isotypes: P[P00777177]!, NOU[NOU090448!]. – *Dendrobium crassifomentum* Hallé ined. in herb.

**Paratypes**

NEW CALEDONIA – **Province Nord** • Mont Colnett; alt. 720 m; 29 Oct. 2003; fl.; *Butin s.n.*; P[P00352883] • Mont Colnett; 20°29'17" S, 164°42'43" E; alt. 720 m; 10 May 2003; fl.; *Butin s.n.*; P[P00493892] • Mont Mandjelia, Pouébo, 20°23'51" S, 164°31'57" E; 10 Dec. 2016; *C. Laudereau 98*; NOU[NOU090376] • Mont Mandjelia, Pouébo, 20°23'51" S, 164°31'57" E; 23 Dec. 2016; *C. Laudereau 213*; NOU[NOU090375] • Colnett Oua Ina, Pouébo, 20°30'35" S, 164°43'56" E; 5 Jan. 2017; *C. Laudereau 239*; NOU[NOU090374] • Pouébo, Mont Mandjélia; 20°23'51" S, 164°31'57" E; 24 Oct. 2018; *C. Laudereau 1155*; NOU[NOU090373] • Mont Mandjélia; [20°24'2" S, 164°31'41" E]; 29 Sep. 1978; *H.S. MacKee 35761 (leg. D. Létocart)*; P[P00118401] • Tchamba; [21°1'22" S, 165°13'36" E]; 21 Dec. 1978; *H.S. MacKee 36261 (leg. D. Létocart)*; P[P00118403] • Haute Diahot: Tendé; [20°24'28" S, 164°31'17" E]; alt. 700 m; humid forest, micaschists; 12 Dec. 1979; *H.S. MacKee 37117*; P[P00118404] • Pouébo, Mont Mandjélia; [20°24'2" S, 164°31'41" E]; alt. 750 m; humid forest, schists; 26 Jan. 1980; *H.S. MacKee 37760 (leg. Bégaud)*; P [P00118405] • Pouébo, Mont Mandjélia; [20°24'2" S, 164°31'41" E]; alt. 750 m; 14 Mar. 1980; *H.S. MacKee 37908 (leg. D. Létocart)*; P[P00118402] • ibid.; 20 Dec. 1980; *H.S. MacKee 38198 (leg. D. Létocart)*; P[P00118406] • Roches Ouaième; alt. 950 m; 14 Jun. 2005, *J. Munzinger 2915, Y. Pillon & J.-P. Butin*; NOU[NOU007988] • Mandjélia; 2 Dec. 2006; bt. fr.; *J. Munzinger 4016, D. Létocart, I. Létocart, R. Amice & O. Chapelle*; NOU[NOU017301] • Mont



**Fig. 11.** Distribution of *D. letocartiorum* Munzinger & M.Pignal sp. nov., based on herbarium specimens (●) and field observations (●), ‘T’ indicates the type collection.



Panié; [20°37'27" S, 164°46'56" E]; *J. Munzinger 4326, H. Blaffart, M. Wanguene, O. Chapelle & J. Tiavouane*; NOU[NOU018878] • Dawenia, west buttress of Colnett; 20°32'15" S, 164°41'39" E; 14 Nov. 2010; *J. Munzinger 6290, Ph. Birnbaum, M. Callmander, I. Pounds, J.-P. Butin & H. Vandrot*; NOU[NOU063469]. – **Province Sud** • Col d'Amieu: Mt. Pembai; [21°35'20" S, 165°50'30" E]; alt. 800 m; humid forest, schists; 15 Apr. 1976; fr.; *H.S. MacKee 31229 (leg. Bégaud)*; P[P00118400].

### Description

Erect epiphyte. Roots whitish, ca 1–2 mm wide, at the base of the plant (axillary roots lacking). Stems reaching 60 cm long, slightly flattened, completely covered by the sheaths of the old leaves, lamina remaining only in the upper half, yellow-orange on dry material. Internodes ca 25 mm long at the base of the stem. Leaves spirally arranged, dark shiny green above, light green below (fide collectors' notes), ca 75 × 7 mm. Midrib impressed on adaxial surface, very prominent on abaxial surface. Two lateral nerves very conspicuous, < 1–2 mm from the margin (see discussion of anatomy below), numerous prominent smaller nerves visible, all convergent at the apex. Base narrow, forming a flattened pseudopetiole. Extremity emarginate, asymmetrical, the two lobes often diverging. Sheath striated in its upper half and ending in a beak opposite to the lamina and applied on the stem. Inflorescence 1-flowered, emerging through a slit of the foliar sheath. Pedicel 3.5 mm long. Ovary ca 3 mm long, non-resupinate. Bract acuminate, 2–3 mm long. Flower pale green to yellow, ca 12 mm long. Dorsal sepal triangular, 12 × 2 mm. Lateral sepals triangular, 12 × 4 mm at the base, with 7 nerves. Petals linear or slightly lanceolate, 11 × ca 1 mm. Lip entire, red, approximately elliptic, margin thin and undulate, 10 mm long and 3 mm wide, obscurely tricarinate. Mentum, 3 mm long. Column, 2.5 mm high and 2 mm wide with a fimbriate margin. Fruits very few despite an abundant flowering, yellow-greenish to brown when mature, ovoid, 8 mm in diameter, with base slightly narrower. Bracts persistent. Dried seed with transparent testa, ca 267 × 86 µm, fusiform, with extremity slender and base truncate, extremity strongly spiraled. Hydrated seed ovate, sacciform. Cells cubic or with extremities rounded, elongate, ca 43–110 × 7.3–10.2 µm, with thick edges, spiral orientation and smooth cellular walls. Embryo spherical elongate, ca 6–7 µm wide, inserted in the lower 2/3 of the testa.

### Taxonomic notes

*Dendrobium letocartiorum* sp. nov. has always slightly flattened stems. The species has affinities with *D. bilobum* Lindl., but the flower is bigger and the lip does not have a dark red spot on the adaxial surface. Leaf anatomy shows that *D. letocartiorum* sp. nov. is very similar to *D. camaridiorum*, having thin leaves, 24–28 vascular bundles in one line and largest bundle in position 5(–6). They only differ by the margins in transverse section, which are obtuse in *D. letocartiorum* sp. nov. and truncate in *D. camaridiorum* (Fig. 4B).

### Phenology

Flowering and fructification periods need further observations. The fruits were observed in the field and in cultivation (in New Caledonia) during the months of January, May, July, October, November and December and flowering specimens are from May and November.

### Distribution and ecology

This endemic species occurs on the main island, in the central chain and on the Panié range in North-East coast. It grows on edges of humid forest, and also on rocks as a lithophyte and is known from 700–800 m a.s.l. The species has been observed also in Plateau de Dogny (Sarraméa) (C. Laudereau, pers. comm.)

**Table 1.** Anatomical features of graminoid New Caledonian *Dendrobium* Sw. Ratio BVL / L: ratio of the diameter of the largest vascular bundle / width of the lamina. Stomata types (I & II) follow the definitions in Yukawa *et al.* (1992).

<i>Dendrobium</i>	<i>butinii</i> sp. nov.	<i>crassifolium</i>	<i>camaridiorum</i>	<i>letocartiorum</i> sp. nov.	<i>unicarinatum</i>
Number of vascular bundles	14–15	33	27–29	27–29	15
Vascular bundles alignment	One line	Two lines	One line	One line	One line
Position of the largest vascular bundle	3(–4)	6	(4–5)–6	(5)–6	2
Ratio BVB/L	> 0.75	< 0.5	> 0.75	> 0.75	> 0.75
Fibre bundles	Few on abaxial	None	None	Few on abaxial	Numerous on both faces
Midrib in transverse section	Not prominent	Not prominent	Prominent	Prominent	Prominent
Marge in transverse section	Rounded or acute	Acute	Truncate	Acute	Acute
Stomata type	Type I & II	Type I & II	Type I	Type II	Type II

### IUCN status

This species is currently known from only four locations in New Caledonia, based on herbarium specimens. *Dendrobium letocartiorum* sp. nov. was evaluated as Near Threatened (NT) by the New Caledonian Red List Authority, considering the species apparent rarity and the low threat to its habitat.

### Anatomical characters

Analysis of the leaf sections of the five species discussed in the present paper shows that they present strong differences between samples, especially regarding the number of vascular bundles (VB). We assigned a number to each VB, starting from the margin of the lamina (Fig. 4), and observed that the position of the larger VBs is stable and has a diagnostic value for the species, as has the ratio of the size of the larger VBs compared to the thickness of the lamina. Vascular bundles exhibit little variation within a species but can be very different between species. Differences were also seen in the alignment of the VBs, which are in two lines in *D. crassifolium*, but in only one line in all other species studied. Differences were also observed in the size of VBs number 2 of *D. crassifolium* which are symmetrically situated on each side of the lamina and are larger than the others. The presence of fibre bundles was also a remarkable character, especially in *D. uncarinatum*. Table 1 summarizes these anatomical characters for each species, which were also used to prepare an identification key to distinguish sterile material of graminoid *Grastidineae* species from New Caledonia.

### Key based on leaf anatomy (transverse section) to the graminoid species of *Dendrobium* in New Caledonia

1. Leaves thick, vascular bundles in two parallel lines, very numerous (> 32), largest with diameter < ½ the thickness of the leaf blade ..... *D. crassifolium* Schltr.
- Leaves thin, vascular bundles in one line, less numerous (< 30), largest with diameter > ¾ the thickness of the leaf blade ..... 2

2. Vascular bundles < 15, midrib prominent or not, largest bundles in position 2 or 3(–4–5) ..... 3
  - Vascular bundles > 22, midrib prominent, largest bundle in position 5(–6) ..... 4
3. Supernumerary fibre bundles numerous on both sides (> 35), large (Fig. 4A), largest vascular bundle in position 2, midrib prominent in leaf section ..... *D. unicarinatum* Kores
  - Supernumerary fibre bundles only on abaxial side, few (< 15), small, largest vascular bundle in position 3(–4–5), midrib not prominent in leaf section .....  
 ..... *D. butinii* M.Pignal & Munzinger sp. nov.
4. Margins obtuse in transverse section (Fig. 4Ba) .....  
 ..... *D. letocartiorum* Munzinger & M.Pignal sp. nov.
  - Margins truncate in transverse section (Fig. 4Bb) ..... *D. camaridiorum* Rchb.f.

## Discussion

The group of graminoid *Dendrobium* is taxonomically artificial, because it includes species of two sections, *Grastidium* and *Biloba*, which do not seem to be phylogenetically related. However, species in this group are characterized by a morphological resemblance and share ecological constants. It is not uncommon for several species of them to meet in the field on the same porophyte.

### *Dendrobium unicarinatum*

While preparing his treatment of Orchidaceae for the *Flore de Nouvelle-Calédonie*, Hallé (1977) identified two new taxa in Paris's herbarium, but the material was too poor to enable a complete description. Over the last several years, additional material has become available and careful comparison with collections from the Pacific Islands together with the precise descriptions in the *Flora Vitiensis Novae* (Kores 1991) show that a part of the material represents a species previously known from Fiji, *D. unicarinatum*. The other part of the material corresponds to the new taxon *D. letocartiorum* sp. nov. *Dendrobium unicarinatum* was included by Kores (1989) in sect. *Monanthos*, although he mentioned its vegetative resemblances with members of sect. *Grastidium*, especially *D. carnicarinum* Kores (1989: 92). While some minor macromorphological differences can be observed (such as apex of the blade and sheath extremity), we doubt they are taxonomically significant. In fact, *D. unicarinatum* has the same type of sessile inflorescence sheath found in species of sect. *Grastidium*. On the other hand, several important differences in floral characters can be seen. For example, *D. unicarinatum* has solitary non-resupinate flowers with an entire lip, while sect. *Grastidium* is characterised by consistently 2-flowered inflorescences, resupinate flowers, and a trilobate and often fimbriate lip.

Morris *et al.* (1996) gave anatomical features that characterize *Grastidium* and *Bilobum* (which he considered as sections of the former *Dendrobium* subg. *Xerobium* Schltr. (Schlechter 1914: 242, 249)), in particular the absence of fibre bundles and a homogeneously seriate leaf margin in *Grastidium* vs the presence of bundles on both adaxial and abaxial surfaces and heterogeneous seriation in *Biloba*. We have noted the presence of fibre bundles on both surfaces in the leaves of *D. unicarinatum*, which suggest a placement in sect. *Biloba* rather than in sect. *Grastidium*. In *D. butinii* sp. nov. and *D. letocartiorum* sp. nov. (the latter species included in sect. *Biloba* on the basis of floral characters), we found leaf fibre bundles only on the adaxial surface. All five species studied here showed homogeneous seriation. Our observations suggest that these two characters are in fact of limited taxonomic value, and that the importance attached to them by Morris *et al.* (1996), whose observations were based on only one species for each section, is not justified.

Yukawa *et al.* (1992) identified two types of stomata in *Dendrobium*, a Type I, elliptical in shape with a slit-like opening and gradually sloping slides; and a Type II, circular in shape with a round to spindle-shape opening and steep sides. Based on their sample, these authors found all sections of *Dendrobium*

to have one or the other type of stomata, except *Grastidium*, which exhibited both types. Members of sect. *Biloba* were reported to have Type II stomates, and our observations of *D. unicarinatum* and *D. letocartiorum* sp. nov. agree with these results (Fig. 5G–H). Our study also confirms the presence of both types within *Grastidium*, with Type I stomata in *D. camaridiorum* (Fig. 5A–B), and the surprising presence of both types of stomata in *D. crassifolium* and *D. butinii* sp. nov. (see Fig. 5C–F).

Molecular phylogenies based on chloroplast DNA restriction site analysis (Yukawa *et al.* 1993) and *rbcL* sequence data (Yukawa *et al.* 1996) have shown *Dendrobium* to be para- or polyphyletic, and have pointed out the need of further investigations to clarify systematic relationships among Dendrobieae Pfitzer (Pfitzer 1889; Pridgeon *et al.*, 2014). Results from an analysis of the Internal Transcribed Spacers (ITS) led Clements (2003) to propose the sub-tribe Grastidiinae which includes most of the species considered by Hallé (1977) as belonging to *Dendrobium*, *Ephemerantha* P.F.Hunt & Summerh. (Hunt & Summerhayes 1961: 102), *Cadetia* Gaudich. (in Freycinet 1826–1829: 422, t. 33) and *Diplocaulobium* Kraenzl. (Kränzlin 1910: 331).

These proposals were rejected in Pridgeon *et al.* (2014) and would have brought the total number of genera in New Caledonia to 13, an excessive number considering the relatively small differences between the taxa. In line with the international consensus view of a broad concept of *Dendrobium* (Adams 2011; Schuiteman 2011; Chase *et al.* 2015; Pridgeon *et al.* 2014) we have classified all taxa in this paper under *Dendrobium*.

## Acknowledgements

We particularly wish to thank the late Gérard G. Aymonin and Jacques Florence for corrections of the Latin diagnosis, Pete Lowry for scientific points of view and English corrections and Djane Vasconcelos for the final English review. We are also indebted to the late Elisabeth Lopez (Service des cultures, MNHN), and the late Pierre Poulain (Parc E. Liais, Cherbourg-en-Cotentin), who provided living material and helped with growing plants. Scanning electron microscope pictures were taken at the ‘Service de microscopie électronique du MNHN’. Thanks to Daniel and Irène Létocart, Jean-Pierre Butin, Christian Laudereau, David Bruy, Arnaud Mouly and Gordon McPherson for help in the field, sharing observations or providing material, and to all collectors cited in the studied material. IRD and MNHN gave access to the collections in the framework of the RECOLNAT National Research Infrastructure (ANR-11-INBS-0004). Thanks to the New Caledonian Red List Authority, especially Christian Laudereau for his precise phenological observations and the Endemia association, especially Shankar Meyer, for sharing data and IUCN status assessments. The authors warmly thank the two anonymous reviewers whose proposals have greatly improved the manuscript.

## References

- Adams P.B. 2011. Systematics of Dendrobieae (Orchidaceae), with special reference to Australian taxa. *Botanical Journal of the Linnean Society* 166: 105–126. <https://doi.org/10.1111/j.1095-8339.2011.01141.x>
- Carlswald B.S., Stern W.L., Judd W.S. & Lucansky T.W. 1997. Comparative leaf anatomy and systematics in *Dendrobium*, sections *Aporum* and *Rhizobium* (Orchidaceae). *International Journal of Plant Sciences* 158: 332–342. <https://doi.org/10.1086/297445>
- Chase M.W., Cameron K.M., Freudenstein J.V., Pridgeon A.M., Salazar G.A., Van den Berg C. & Schuiteman A. 2015. An updated classification of Orchidaceae. *Botanical Journal of the Linnean Society* 177: 151–174. <https://doi.org/10.1111/boj.12234>



- Clements M.A. 2003. Molecular phylogenetic systematics in the Dendrobiinae (Orchidaceae), with emphasis on *Dendrobium* section *Pedilonum*. *Telopea* 10: 247–298.  
<https://doi.org/10.7751/telopea20035619>
- Faria E. 2016. Diversité du genre *Corybas* Salisb. (Orchidaceae, Diurideae) en Nouvelle-Calédonie. *Adansonia sér.* 3 38: 175–198. <https://doi.org/10.5252/a2016n2a4>
- Freycinet L.D. 1826–1829. *Voyage autour du Monde, exécuté sur les corvettes de SM l'Uranie et la Physicienne, etc. Navigation et Hydrographie, première partie, et Atlas*. Pillet Aîné, Paris.
- Gâteblé G., Barrabé L., McPherson G., Munzinger J., Snow N. & Swenson U. 2018. One new endemic plant species on average per month in New Caledonia, including eight more new species from Ile Art (Belep Islands), a major micro-hotspot in need of protection. *Australian Systematic Botany* 31: 448–480.  
<https://doi.org/10.1071/SB18016>
- Hallé N. 1977. Orchidacées. In: Aubréville A. & Leroy J.-F. (eds) *Flore de la Nouvelle-Calédonie et Dépendances*: 1–565. Muséum national d'histoire naturelle, Paris.
- Hunt P.F. & Summerhayes V.S. 1961. Notes on Asiatic Orchids III. *Taxon* 10: 101–110.  
<https://doi.org/10.2307/1217855>
- Kores P.J. 1989. A precursory study of Fijian Orchids. *Allertonia* 5: 1–222.  
Available from <https://www.jstor.org/stable/23188211> [accessed 15 Apr. 2020].
- Kores P.J. 1991. Orchidaceae. In: Smith A.C. (ed.) *Flora Vitiensis Nova: a New Flora of Fiji (spermatophyte only)*: 321–576. National Tropical Botanical Garden, Lawai, Kauai, Hawaii.
- Kränzlin F.W. 1894. Orchidacea Papuanae. *Österreichische Botanische Zeitschrift* 44: 333–338.  
<https://doi.org/10.1007/BF01794849>
- Kränzlin F.W. 1910. Orchidaceae-Monandrae-Dendrobiinae. Pars. 1. In: Engler A. (ed.) *Das Pflanzenreich Regni vegetabilis conspectus*: 1–331. Engelmann, Leipzig.
- Kränzlin F.W. 1914. Orchidaceae von Neu-Caledonien und den Loyalty-Inseln. In: Sarazin F. & Roux J. (eds) *Nova Caledonia*: 84. Kreydel's Verlag, Berlin & Wiesbaden.
- Lowry II P.P. 1998. Diversity, endemism, and extinction in the Flora of New Caledonia: a review. In: Peng C.-I. & Lowry II P.P. (eds) *Rare, Threatened, and Endangered Floras of Asia and the Pacific*: 181–206. Institute of Botany, Academia Sinica, Monogr. Ser. No. 16, Taipei.
- Morat P. 1993. Our knowledge of the flora of New Caledonia: endemism and diversity in relation to vegetation types and substrates. *Biodiversity Letters* 1: 72–81. <https://doi.org/10.2307/2999750>
- Morat P. 2010. Les botanistes récolteurs en Nouvelle-Calédonie de 1774 à 2005. *Adansonia, sér.* 3 32: 159–216. <https://doi.org/10.5252/a2010n2a1>
- Morat P., Jaffré T., Tronchet F., Munzinger J., Pillon Y., Veillon J.-M. & Chalopin M. 2012. Le référentiel taxonomique Florical et les caractéristiques de la flore vasculaire indigène de la Nouvelle-Calédonie. *Adansonia sér.* 3 34: 177–219. <https://doi.org/10.5252/a2012n2a1>
- Morris M.W., Stern W.L. & Judd W.S. 1996. Vegetative anatomy and systematics of subtribe Dendrobiinae (Orchidaceae). *Botanical Journal of the Linnean Society* 120: 89–144.  
<https://doi.org/10.1111/j.1095-8339.1996.tb00483.x>
- Pfitzer E. 1889. Orchidaceae. In: Engler A. & Prantl K. (eds) *Die natürlichen Pflanzenfamilien nebst ihren Gattungen und wichtigeren Arten, II.6*: 52–218. Engelmann, Leipzig.

- Pierre A.-H., Le Moguédec G., Lowry II P.P. & Munzinger J. 2014. Multivariate morphometric analysis and species delimitation in the endemic New Caledonian genus *Storthocalyx* (Sapindaceae). *Botanical Journal of the Linnean Society* 176: 127–146. <https://doi.org/10.1111/boj.12199>
- Pignal M. & Munzinger J. 2011. Une nouvelle espèce de *Microtatorchis* (Orchidaceae, Vandeeae, Aeridinae) en Nouvelle-Calédonie, et une clef d'identification pour les Aeridinae aphyllés du territoire. *Adansonia sér.* 3 33: 183–190. <https://doi.org/10.5252/a2011n2a2>
- Pouteau R., Trueba S., Feild T. & Isnard S. 2015. New Caledonia: A Pleistocene refugium for rainforest lineages of relict angiosperms. *Journal of Biogeography* 11: 2062–2077. <https://doi.org/10.1111/jbi.12581>
- Pridgeon A.M., Cribb P.J., Chase M.W. & Rasmussen F.N. 2014. *Genera orchidacearum*, Vol. 6. Oxford University Press, Oxford.
- Rauschert S. 1983. Beitrag zur Nomenklatur der Orchidaceae. *Feddes Repertorium. Zeitschrift für Botanische Taxonomie und Geobotanik* 94: 433–471.
- Reichenbach H.G. 1876. Orchidiographische Beiträge. *Linnaea* 41(1): 17–98.  
Available from <https://www.biodiversitylibrary.org/page/123722#page/18/mode/1up> [accessed 15 Apr. 2020]
- Schlechter R. 1906. Beiträge zur Kenntnis der Flora von Neu-Kaledonien. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 39(1): 1–274.  
Available from <https://www.biodiversitylibrary.org/page/213837#page/1> [accessed 15 Apr. 2020].
- Schlechter R. 1912. XXXIX. Orchidaceae novae et criticae. *Repertorium Specierum Novarum Regni Vegetabilis, Beihefte* 1: 248–254.
- Schlechter R. 1914. Die orchidaceen von Deutsch-Neu-Guinea. *Repertorium Specierum Novarum Regni Vegetabilis, Beihefte* 1.  
Available from <https://www.biodiversitylibrary.org/item/28953#page/6/mode/1up> [accessed 15 Apr. 2020].
- Schuiteman A. 2011. *Dendrobium* (Orchidaceae): To split or not to split? *Gardens' Bulletin Singapore* 63: 245–257.  
Available from <https://www.biodiversitylibrary.org/page/43627168> [accessed 15 Apr. 2020].
- Smith J.J. 1905a. Die Orchideen von Java. In: Brill E.J. (ed.) *Flora von Buitenzorg*. Leiden. <https://doi.org/10.5962/bhl.title.86938>
- Smith J.J. 1905b. Die orchideen von Ambon. Landsdrukkerij. <https://doi.org/10.5962/bhl.title.86926>
- Smith J.J. 1908. Vorläufige Beschreibungen neuer papuanischer Orchideen. *Bulletin du Département de l'Agriculture aux Indes Néerlandaises. Buitenzorg* 19: 1–39.
- Stern W.L., Morris M.W. & Judd W.S. 1994. Anatomy of the thick leaves in *Dendrobium* section *Rhizobium* (Orchidaceae). *International Journal of Plant Sciences* 155: 716–729. <https://doi.org/10.1086/297210>
- Thiers B. Continuously updated. *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium.  
Available from <http://sweetgum.nybg.org/science/ih/> [accessed 15 Apr. 2020].
- Turland N.J., Wiersema J.H., Barrie F.R., Greuter W., Hawksworth D.L., Herendeen P.S., Knapp S., Kusber W.-H., Li D.-Z., Marhold K., May T.W., McNeill J., Monro A.M., Prado J., Price M.J. & Smith G.F. (eds). 2018. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Koeltz Botanical Books, Glashütten.

Yukawa T. & Uehara K. 1996. Vegetative diversification and radiation in subtribe Dendrobiinae (Orchidaceae): evidence from chloroplast DNA phylogeny and anatomical characters. *Plant Systematics and Evolution* 201: 1–14. <https://doi.org/10.1007/BF00989048>

Yukawa T., Ando T., Karasawa K. & Hashimoto K. 1992. Existence of two stomatal shapes in the genus *Dendrobium* (Orchidaceae) and its systematic significance. *American Journal of Botany* 79: 946–952. <https://doi.org/10.2307/2445006>

Yukawa T., Kurita S., Nishida M. & Hasebe M. 1993. Phylogenetic implications of chloroplast DNA restriction site variation in subtribe *Dendrobiinae* (Orchidaceae). *Lindleyana* 8: 211–221.

Yukawa T., Ohba H., Cameron K. & Chase M. 1996. Chloroplast DNA phylogeny of subtribe *Dendrobiinae* (Orchidaceae): insights from a combined analysis based on rbcL sequences and restriction site variation. *Journal of Plant Research* 109: 169–176. <https://doi.org/10.1007/BF02344542>

*Manuscript received: 12 September 2019*

*Manuscript accepted: 3 December 2019*

*Published on: 23 April 2020*

*Topic editor: Frederik Leliaert*

*Editor-in-Chief: Koen Martens*

*Desk editor: Connie Baak*

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum national d'histoire naturelle, Paris, France; Meise Botanic Garden, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands; Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; Real Jardín Botánico de Madrid CSIC, Spain; Zoological Research Museum Alexander Koenig, Bonn, Germany; National Museum, Prague, Czech Republic.