Four new species in the endemic genus *Rhodocolea* Baill. (Bignoniaceae) from Madagascar

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ABSTRACT
A recent review of the Malagasy Bignoniaceae for the *Catalogue of the Vascular Plants of Madagascar* has enabled us to discover new species in most genera in the family. In this part of a series of publications detailing the necessary taxonomic changes, we provide descriptions of four new species in the endemic Malagasy genus *Rhodocolea*: *R. humbertii* Callm. & Phillipson, *R. magnifica* Callm. & Phillipson, *R. parvifoliolata* Callm. & Phillipson and *R. ranirisonii* Callm., Phillipson & L.Gaut. Each of the new species is provided with line drawings, a discussion of its morphological affinities and a conservation threat analysis based on the IUCN Red List Categories and Criteria.

KEY WORDS
Bignoniaceae,
Coleeae,
Rhodocolea,
Madagascar,
endemism,
conservation status,
new species.

RÉSUMÉ
Quatre nouvelles espèces dans le genre endémique Rhodocolea *Baill. (Bignoniaceae) de Madagascar.*
Une révision récente de la famille des Bignoniaceae pour le *Catalogue des plantes vasculaires de Madagascar* nous a permis de découvrir de nouvelles espèces dans la plupart des genres. Dans cette partie d'une série de publications décrivant les

MOTS CLÉS
Bignoniaceae,
Coleeae,
Rhodocolea,
Madagascar,
endémisme,
statut de conservation,
espèces nouvelles.

changements taxonomiques nécessaires, nous décrivons quatre nouvelles espèces du genre endémique malgache *Rhodocolea*: *R. humbertii* Callm. & Phillipson, *R. magnifica* Callm. & Phillipson, *R. parvifoliolata* Callm. & Phillipson, et *R. ranirisonii* Callm., Phillipson & L.Gaut. Chaque nouvelle espèce est décrite avec des dessins au trait, une discussion sur les affinités morphologiques ainsi que l'évaluation préliminaire du statut de conservation de chaque espèce suivant les catégories et les critères de l'UICN.

INTRODUCTION

Madagascar is the second largest centre of Bignoniaceae diversity in the world after South America with about 70 currently accepted published species (many with numerous varieties) in nine genera. The first and only comprehensive taxonomic treatment for Madagascar was published by Perrier de la Bâthie (1938a, b), who recognized 54 species and numerous varieties and forms. Subsequently 17 additional species have been described: five by Capuron (1960, 1970), one by Gentry (1977) and 11 by Zjhra (2006).

The genera present in Madagascar are divided between two tribes based primarily on the dehiscence of the fruit: Coleeae (indehiscent) and Tecomeae (dehiscent) (Zjhra *et al.* 2004). Within the Malagasy Coleeae, the Malagasy endemic *Rhodocolea* has been regarded as the basal genus (Gentry 1976; Zjhra *et al.* 2004), but a comprehensive phylogenetic analysis is not available. The genus *Rhodocolea* Baill. can be easily distinguished from the other members of the Coleeae in Madagascar (*Colea* Bojer ex Meisn, *Ophiocolea* H. Perrier, *Phyllarthron* DC and *Phylloctenium* Baill.) by its opposite compound leaves, bilocular stamens and smooth oblong fleshy indehiscent fruit.

A recent review of the Malagasy Bignoniaceae for the *Catalogue of the Vascular Plants of Madagascar* (Madagascar Catalogue 2011) has enabled us to clarify and refine taxon delimitations and has lead us to discover new species in most genera in the family. We intend to produce a series of publications detailing the necessary taxonomic changes. In this article, we provide descriptions of four new species of the genus *Rhodocolea*.

MATERIAL AND METHODS

We have examined all the available material of *Rhodocolea* from the major herbaria with relevant collections, including those in Antananarivo (TAN and TEF), Geneva (G), Georgia University State (GAS), Kew (K), St. Louis (MO), Paris (P) and Wisconsin (WIS). Historical collections lacking geographic coordinates were post-facto georeferenced as accurately as possible, using the "Gazetteer to Malagasy Botanical Collecting Localities" (Schatz & Lescot 2005) and other sources (these are placed in square brackets in the citation of material examined in the taxonomic treatment that follows). Species distributions were mapped on the five bioclimatic zones of Madagascar (after Cornet 1974; adapted by Schatz 2000), using ESRI ArcView 3.3 software (2000). Each species is provided with preliminary risk assessments based on the IUCN Red List Categories and Criteria (IUCN 2001). Calculations of the area of occupancy (AOO), extent of occurrence (EOO) and number of subpopulations were based on the methods presented in Callmander *et al.* (2007).

SYSTEMATICS

Genus *Rhodocolea* Baill.

1. ***Rhodocolea humbertii*** Callm. & Phillipson, sp. nov. (Fig. 1)

Haec species a congeneris foliis compositis 25-33 cm longis petiolo incluso, inflorescentia cauliflora sat parva atque calyce grandi denticulato facile distinguitur.

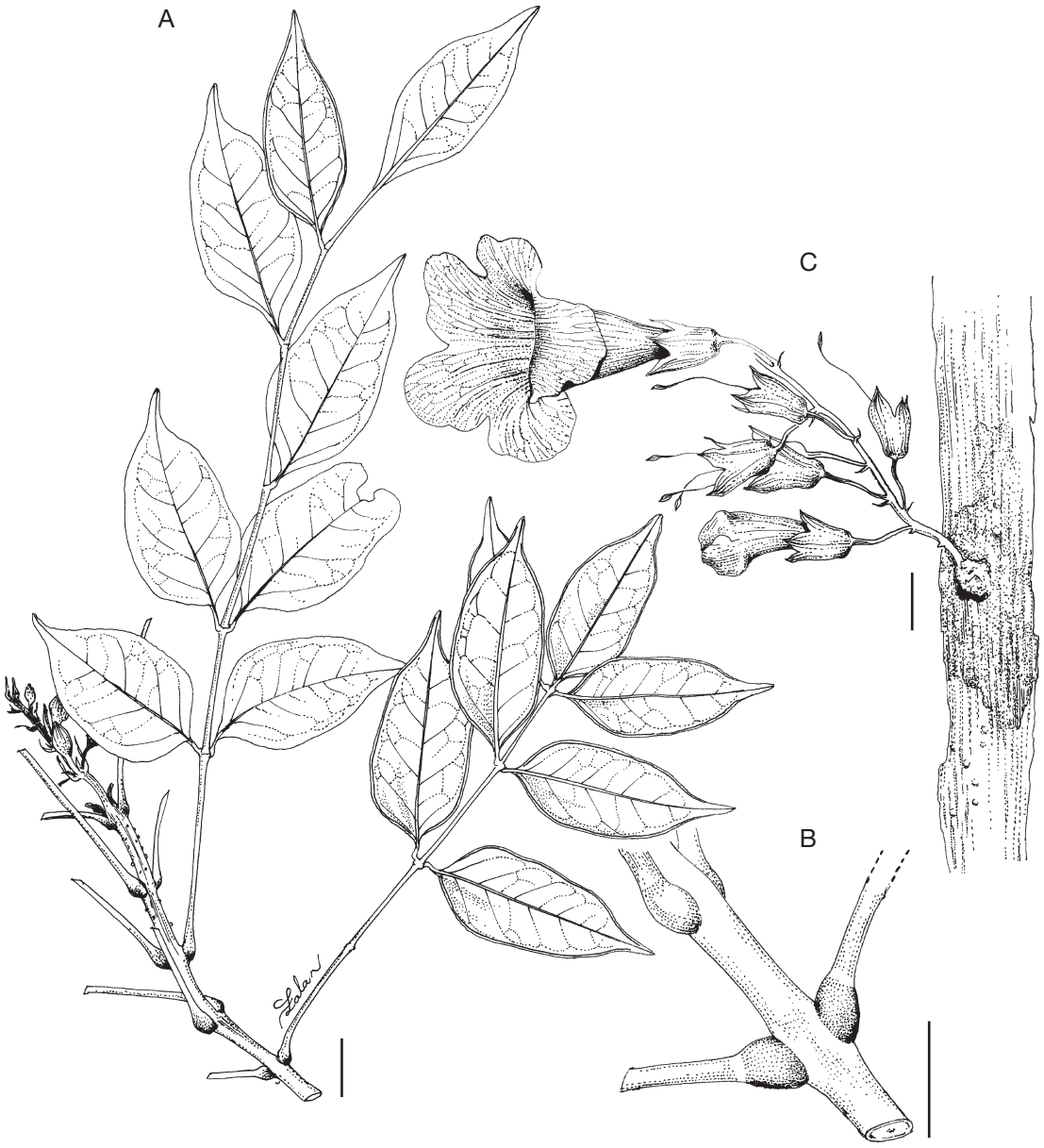

FIG. 1. — *Rhodocolea humbertii* Callm. & Phillipson: **A**, branch; **B**, detail of base of petioles; **C**, cauliflorous inflorescence. *Humbert & Capuron 24210* (holotype, P). Scale bars: A, 2 cm; B, C, 1 cm. Drawing Roger Lala Andriamiarisoa.

TYPUS. — **Madagascar**. Prov. d'Antsiranana, vallée de l'Andalangy, affluent de l'Andraronga (bassin de la Bemarivo du Nord-Est), 14°18'S, 49°43'E, 12-14.XI.1950, fl., *Humbert & Capuron 24210* (holo-, P [P00730612]!; iso-, B, K!, G [G00303502]!, MO[MO05033701, 3640192]!, NY, PRE, TAN, WAG).

PARATYPI. — **Madagascar**. Prov. d'Antsiranana, vallée de l'Antsahabe, affluent de la Lokoho, 14°27'S, 49°50'E, 10-11.III.1950, fl., *Humbert 23345* (MO [MO3600880], P[2 sheets]). — À l'ouest de la rivière Manantenina, pentes orientales du Massif de Marojejy, 100-300 m, 14°29'S, 49°49'E, 14-15.IV.1949, *Humbert 23407*

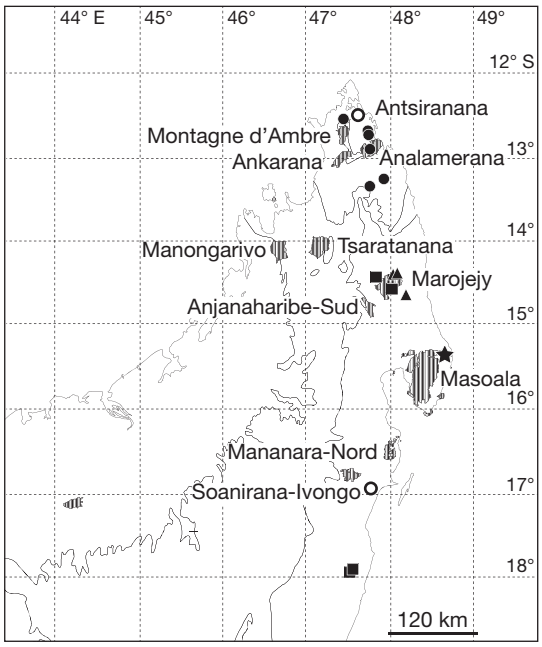

FIG. 2. — Distributions of the *Rhodocolea* new species mapped on the bioclimatic zones of Madagascar (after Cornet 1974; see Schatz 2000): *R. humbertii* Callm. & Phillipson (▲), *R. magnifica* Callm. & Phillipson (■), *R. parvifoliolata* Callm. & Phillipson (★), and *R. ranirisonii* Callm., Phillipson & L. Gaut. (●).

(P). — Vallée inférieure de l'Androranga, affluent de la Bemarivo (nord-est) aux environs d'Antongondriha, Mont Anjenabe, 14°17'S, 49°46'E, 3.XI.1950, fl., *Humbert & Capuron 24056* (MO [MO05033703], P). — Vallée de l'Andalangy, affluent de l'Androronga (bassin de la Bemarivo du Nord-Est), 14°18'S, 49°43'E, 12-14.XI.1950, fl., *Humbert & Capuron 24213* (MO [MO3640193], P).

DESCRIPTION

Tree up to 10-15 m tall; dbh > 25 cm. Leaves imparipinnate, 25-33 × 10-12 cm (including petiole); rachis canaliculate, 0.2-0.3 cm in diam., dark green or straw-yellow when dried, glabrous; nodes slightly swollen, not conspicuous; petiole 5-7 cm long. Leaflets generally (7-)9-13; blade ovate, (5-)7(-9) × (2.5-)3(-3.5) cm, chartaceous, darker on the upper surface, glabrous; base shortly attenuate; apex acuminate, the acumen *c.* 10 × 4-6 mm; margins entire; midrib and secondary veins prominent on the both surfaces, reticulation visible; petiolule length 3-5 mm (lateral leaflets), up to 30 mm (terminal leaflets). Inflorescence, cauliflorous or terminal, a raceme up to *c.* 12 cm long, with 6-4 nodes each bearing 3-2 flowers; axis fine, patent, cylindric, *c.* 1 mm diameter, drying dark brown; bracts narrowly triangular, *c.* 3 × 1 mm, glabrous, persistent; peduncle < 5 mm long; pedicel 2-3 cm long with a pair of minute persistent glabrous bracteoles at the base. Calyx campanulate, puberulent, 1.5-2 × 1.5-1 cm, 5-lobed, with 5 prominent veins; lobes triangular, *c.* 4 × 4 mm, acute. Corolla tubular with 5 spreading lobes, *c.* 5.5 × 4 cm, pale pink [*fide* notes on *Humbert 23345*]; tube *c.* 3.5 × 1 cm, interior vinous, rather abruptly narrowed to *c.* 3 mm diameter in the basal 1/4; lobes rounded *c.* 1.5 × 1 cm; stamens 4, 2.2 cm long, filament densely pubescent at base, anthers *c.* 2 mm long, 2-locular; style 2.5 cm long, stigma laterally flattened, shortly bilobed. Fruit unknown.

DISTRIBUTION AND ECOLOGY

Rhodocolea humbertii is endemic to the mid-elevation evergreen humid forests around the Marojejy massif in northwestern Madagascar (Fig. 2), but is not known from within the Marojejy National Park.

CONSERVATION STATUS

With an EOO of 83 km², an AOO of 27 km² and 5 subpopulations, none of which situated within the protected area network, *Rhodocolea humbertii* is assigned a preliminary status of Critically Endangered (CR B1ab[iii]).

REMARKS

Rhodocolea humbertii can be easily recognized by its long compound leaves (25-33 cm including petiole), rather small cauliflorous inflorescence (8-12 cm long) and by it large denticulate calyx (1.5-2 × 1-1.5 cm). Another new species described below, *R. parvifoliolata* growing the littoral forests of Masoala also bears similar large calices but the leaves and leaflets are much smaller in the latter (leaves: [6-]10-13 × 3-4.5 cm; leaflets: 2.5-1.5 × 1-0.6 cm in *R. parvifoliolata* vs. leaves: 25-33 × 10-12 cm; leaflets: [5-]7[-9] × [2.5-]3[3.5] cm in *R. humbertii*).

FIG. 3. — *Rhodocolea magnifica* Callm. & Phillipson: **A**, inflorescence; **B**, leaf. *Humbert & Saboureau 31418* (holotype, P). Scale bars: A, 1 cm; B, 2 cm. Drawing Roger Lala Andriamiarisoa.

2. ***Rhodocolea magnifica***
Callm. & Phillipson, sp. nov.
(Fig. 3)

Haec species Rhodocoleae perrieri Capuron *tantum comparabilis, sed ab ea inflorescentiis per axem longum (vs. ad nodos parvos corticis) dispositis atque flore tubulari (vs. subcampanulato) in lobos 5 profundos (6-15 mm vs. < 5 mm) fisso distinguitur.*

Typus. — **Madagascar**. Prov. Antsiranana, partie occidentale du massif du Marojejy (NE) de la vallée de l'Ambatoharanana au bassin supérieur de l'Antsahaberoka, 1200 m., 14°18'S, 49°33'E, 9.XI-2.XII.1959, fl., *Humbert & Saboureau 31418* (holo-, P[00568714]!; iso-, G [G00303501]!, K!, P[P00722273, P00722274]!, MO [MO3640197]!, TAN!).

Paratypi. — **Madagascar**. Prov. Antsiranana, Atsinanana, Betampona PA, 17°53'24"S, 49°13'48"E, XII.1962, fl., *Bosser 16985* (G, MO [MO3601159], K, P, TAN). — Marojejy PA, along the trail to the summit of Marojejy Est, N of Mandena, 14°27'S, 49°46'E, 100-300 m, 27.XI.1989, fl., *Miller & Randrianasolo 4637* (MO [MO3767660], P, TAN). — Toamasina, Atsinanana, Betampona PA, 17°55'S, 49°13'E, 300-400 m, 23.II.1953, fl., *Réserves Naturelles 5901* (G, MO [MO3601128], P, TAN). — Atsinanana, Betampona PA, Rendrirendry, 17°55'S, 49°12'E, 14.XII.1955, *Réserves Naturelles 7406* (P, TEF).

Description

Unbranched tree to 8 m. Leaves imparipinnate, 50-60 × 20-30 cm (including petiole); rachis and petiole subcylindric, flattened and narrowly winged (*c.* 0.1 cm wide) on the upper surface, ribbed below yellow-brown when dried, glabrous, *c.* 0.6 cm in diameter but narrowing to the apex; nodes conspicuously swollen; petiole 13-16 cm long. Leaflets 9-11; blade elliptic, (12-)15-19 × 6-7 cm, sub-coriaceous, darker on the upper surface, glabrous; base cuneate; apex acuminate, the acumen 6-8 × 5-9 mm; margins entire, slightly revolute when dry; midrib, secondary and tertiary veins prominent below, visible above, reticulation visible on the lower surface; petiolule length *c.* 1 mm (proximal leaflets), up to 10 mm (basal leaflets), up to 35 mm (terminal leaflet). Inflorescence cauliflorous and on the younger growth just below the leaves, a raceme 16-23(-45) cm long, with 6-10 nodes each bearing a pair of opposing bracts both subtending a fascicle of 1-5 flowers; axis stout, ascending, flattened, *c.* 3 mm diameter, drying dark brown; bracts ovate-lanceolate, the largest (near the base) < 20 × 8 mm, with conspicuous peltate glands on the abaxial surface, often caducous before anthesis; pedicel 15-20 mm with a pair of persistent glabrous spatulate bracteoles at the base. Calyx broadly infundibuliform, puberulent, 0.8-1 × 0.6-0.8 cm, shallowly 5-lobed, with 5 conspicuous veins; lobes broadly triangular, *c.* 2 × 5 mm, acute ending in a short mucro. Corolla tubular with 5 spreading lobes, 2-4 × 1.2-2 cm, dull yellow; tube 2.5 × 1 cm, interior purple-brown with golden yellow marks; lobes rounded *c.* 7 × 8 mm; stamens 4, 1.8 cm long, filament densely pubescent at base, anthers *c.* 2 mm long, 2-locular; style 1.9 cm, stigma laterally flattened, shortly bilobed. Fruit unknown.

Etymology

The species epithet refers to the magnificent large flowers and long inflorescences of the new species, a unique and remarkable combination in the genus.

Distribution and ecology

Rhodocolea magnifica grows in the north-eastern humid montane forests in Marojejy National Park and in the lowland forests in Betampona Reserve (Fig. 2).

Conservation status

With an EOO of 5508 km^2, an AOO of 45 km^2 and 3 subpopulations, two of which situated within protected areas (Betampona, Marojejy), *Rhodocolea magnifica* is assigned a preliminary status of Vulnerable (VU B1ab[iii]).

Remarks

Rhodocolea magnifica is most similar to *R. perrieri* Capuron. The new species differs from the latter by its inflorescences which are arranged on a long lax inflorescence (16-23 cm) along or just below the leaves (vs. in dense clusters on the trunk); flowers tubular divided into 5 deep lobes (0.7 × 0.8 cm) (vs. subcampanulate with 5 recurved short lobes, < 5 mm long). *Rhodocolea magnifica* is only known from evergreen montane forest near the Marojejy National Park and Betampona Reserve, while *R. perrieri* grows in littoral

FIG. 4. — *Rhodocolea parvifoliolata* Callm. & Phillipson: **A**, flowering branch; **B**, details of a leaf; **C**, base of petioles; **D**, flower. **A**-**C**, *Bernard, Rahajasoa & Rabe 94* (isotype, TAN); **D**, *Bernard, Rahajasoa & Rabe 94* (holotype, P). Scale bars: A, 1 cm; B, 5 mm; C, 3 mm; D, 2 cm. Drawing Roger Lala Andriamiarisoa.

forests near Sambava. The collections at MO were annotated by A.H. Gentry with the unpublished name *R. campanulata* (*Bosser 16985*, *Humbert 31418*, *Miller 4637* and *Réserves Naturelles 5901*).

3. ***Rhodocolea parvifoliolata***
Callm. & Phillipson, sp. nov.
(Fig. 4)

Haec species a congeneris foliis parvis acuminatis, calyce grandi atque floribus grandibus rubris saepe in inflorescentiam subsessilem cauliflorum 4- ad 10-florum dispositis distinguitur.

Typus. — **Madagascar**. Prov. Antsiranana, Antalaha, Masoala PN, Ambohitralalana (Cap-Est), forêt Tanandavahely, 0-15 m, 15°18'S, 50°29'E, 9.XII.2004, fl., *Bernard, Rahajasoa & Rabe 94* (holo-, MO!; iso-, G [G00340048]!, K!, P[00568716]!, TAN!, WIS!)

Description
Treelet 2.5 m, mature branching pseudo-dichotomous. Leaves imparipinnate, (6-)10-13 × 3-4.5 cm (including petiole); petiole 2-3.5 cm long, *c.* 0.1-0.2 cm in diameter, brown when dried, glabrous, canaliculate; rachis articulate, canaliculate, glabrous. Leaflets generally (9-)11-13; blade acuminate, 1.5-2.5 × 0.6-1 cm discolorous, dark brown on the upper surface, beige on the lower one, subcoriaceous, glabrous; apex acuminate, the acumen *c.* 5 mm long; margin entire; midrib and secondary veins prominent on the both surfaces, base asymmetric, shortly attenuate at the base, sub-sessile. Inflorescence a raceme, terminal on young growth, or cauliflorous, 4-7 cm long, 4-5 flowered; pedicel 2-3 cm, glabrous; calyx narrowly funnel-shaped, 0.7 × 1.5 cm, venation visible, 5-lobed and with 5, conspicuous veins ending at the acute apex; corolla tubular, with five sub-equal spreading lobes, 4 × 5 cm; tube *c.* 3.5 × 1.5 cm; lobe 1.3 × 1.6 cm; stamens 4, *c.* 3 cm in length, anthers *c.* 2 mm, 2-locular; style *c.* 3.5 cm long stigma laterally flattened, shortly bilobed. Fruit unknown.

Etymology
The species epithet refers to its leaves with numerous leaflets which are markedly smaller than those of any other known species in the genus.

Distribution and ecology
Rhodocolea parvifoliolata is endemic to littoral forest on the Masoala peninsula in North-East Madagascar (Fig. 2).

Conservation status
With 1 collection known, an AOO of 9 km^2 and only 1 subpopulation in a protected area, *Rhodocolea parvifoliolata* is assigned a preliminary status of Vulnerable (VU D2).

Remarks
Rhodocolea parvifoliolata is a highly distinctive species and cannot be confused with any other known species. It can be recognised by its pinnate leaves composed of numerous small acuminate leaflets (1.5-2.5 × 0.6-1 cm), large calyx (1.5-2 mm) and large corolla (*c.* 5 × 4 cm), and inflorescences borne either in a subsessile cauliflorous fascicle, or a short lateral few-flowered raceme in the upper leaf axils.

4. ***Rhodocolea ranirisonii***
Callm., Phillipson & L.Gaut., sp. nov.
(Fig. 5)

Haec species Rhodocoleae boivinii (Baill.) H.Perrier *et* R. telfairiae (Bojer ex Hook.) H.Perrier *similis, sed ab eis inflorescentia brevi laxa paniculata, calyce dentibus parvis 5 coronato atque corolla 2.0-2.5 cm longa distinguitur.*

Typus. — **Madagascar**. Prov. Antsiranana, Daraina, Forêt de Binara, camp I, 600 m, 13°15'S, 49°37'E, 4.XI.2001, fl., *Gautier & Ravelonarivo 4031* (holo-, G [G00007239]!; iso-, K!, MO!, P!, TEF!, WIS!).

Paratypi. — **Madagascar**. Prov. Antsiranana, Andrafiabe, Sahafary, 12°34'49"S, 49°26'55"E, 191 m, 26.VII.2004, fl., *Guittou et al. 47* (CNARP, MO [MO04880566], P, TAN). — Collines et plateaux calcaires de l'Analamera, vallée de l'Analabe, affluent du Rodo, 12°48'S, 49°27'E, 50 m, I.1938, *Humbert 19231* (G, P). — Forêt de Sahafary, environs de Diégo-Suarez, 12°35'S, 49°27'E, XI.1970, fl., *Keraudren-Aymonin & Aymonin 25649* (G, MO, P, TAN). — Daraina, forêt d'Ambohitsitondroina, 13°08'S, 49°27'E, 285 m, 19.I.2001, fr., *Ranirison & Nusbaumer 1098* (G, P, TEF, WIS). — Vohémar, versant SO de la forêt d'Ampondrabe, à 2 km au sud-ouest du village de Tsaratanana, 12°57'50"S, 49°41'38"E,

FIG. 5. — *Rhodocolea ranirisonii* Callm., Phillipson & L.Gaut.: **A**, flowering branch; **B**, immature fruit. **A**, *Rakotonandrasana et al. 980* (paratype, TAN); **B**, *Ranirison & Nusbaumer 1098* (paratype, G). Scale bars: A, 1 cm; B, 4 mm. Drawing Roger Lala Andriamiarisoa.

500 m, 8.II.2005, fl., *Rakotonandrasana et al. 980* (CNARP, MO, P, TAN). — Commune Antsahampano, Fkt. Andranotsimaty, forêt classée de Ambohipamba Montagne d'Ambre, 12°26'34"S, 49°08'44"E, 400 m, 21.XI.2001, fl., *Randrianaivo et al. 792* (MO, P, TAN WIS).

Description

Tree 5-10 m. Leaves imparipinnate, 15-22 × 9-13 cm (including petiole); petiole 5-6 cm long, *c*. 0.2 cm in diameter, glabrous, canaliculate. Leaflets 9-11, (4-)6-7 × (1.5)2.5-3 cm, blade elliptic, sub-coriaceous, glabrous, base rounded, apex acuminate, the acumen *c*. 10 mm long; margin entire; midrib and secondary veins prominent on the both surfaces; petiolule 5 mm (proximal leaves) to 10 mm (basal leaves), brownish, shining on the upper surface, glabrous. Inflorescence a raceme, 6-8 × 8-10 cm, with *c*. 20 flowers; calyx 5-lobed, 6-4 × 3-2 mm, greyish, with 5 mucros, 1.5 mm; corolla tubular, pinkish with 2 yellow lines in the inner part of the throat, 35-20 × 18-6 mm, 5-lobes, rather abruptly narrowed to *c*. 2 mm diameter in the basal ¼; lobes rounded *c*. 8-5 × 5-4 mm large, sparsely covered with short trichomes; stamens 4, 10 mm in length, anthers *c*. 1.5 mm, 2-locular; style 15 mm. Fruit an indehiscent oblong berry, reddish, pendant, *c*. 3 × 0.8 cm.

Etymology

This new species is named in honour of Patrick Ranirison, who has collected fruiting specimens of the new species, as a mark of recognition of Patrick's important contribution to a project that has gathered over 3500 collections in the hitherto poorly collected Loky-Manambato (Daraina) region. This complete inventory led to the discovery of many new species and has catalysed the conservation of the unique, highly-threatened Loky-Manambato forests. Laurent Gautier, leader of this project, who collected the type specimen, joins us as a co-author of this species.

Distribution and ecology

Rhodocolea ranirisonii grows in the dry forests of Daraina in Antsiranana Province (DIANA Region) (Fig. 2).

Conservation status

With an EOO of 1907 km^2, an AOO of 45 km^2 and 5 subpopulations, one of which situated within a protected area (Analamera), *Rhodocolea ranirisonii* is assigned a preliminary status of Endangered (EN B1ab[i, iii] + B2ab[i, iii]).

Remarks

Rhodocolea ranirisonii most closely resembles two other species in Madagascar: *R. boivinii* (Baill.) H.Perrier and *R. telfairiae* (Bojer ex Hook.) H.Perrier. The new species differs from both by its inflorescence: a short (6-8 cm) loose panicle (vs. a long [20-30 cm] narrow panicle in *R. boivinii* and compound cymes, 12 cm long in *R. telfairiae*); flowers with a calyx bearing five small teeth (*c*. 2 mm long) (vs. longer teeth [*c*. 5 mm] in *R. boivinii* and the teeth absent or rudimentary in *R. telfairiae*); a corolla 2-2.5 cm long (vs. 4.5-5 mm in both of the other species). *Rhodocolea ranirisonii* grows in the dry northern parts of the country, while *R. boivinii* is known from the evergreen lowland forests of the Sambirano and west of Marojejy, and *R. telfairiae* is known from the central highlands.

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