



Rinorea spongiocarpa and *Rinorea dimakoensis* (Violaceae), new threatened species of forest trees from East and South Regions of Cameroon and Gabon

Gaston Achoundong¹ & Martin Cheek²

Summary. Two tree species are described as new to science: *Rinorea spongiocarpa* Achound. sp. nov. (placed in *Rinorea* [unranked] Brachypetalae) and *R. dimakoensis* Achound. sp. nov. (placed in *Rinorea* [unranked] Illicifoliae). Both species occur in Cameroon, south of the Sanaga river, the first from South and East Regions, occurring in evergreen forest from Ngovayang and Lolodorf across the southern plateau to the Dja forest. The second extends also to Gabon, occurring in Cameroon in the northern part of East Region in semi-deciduous forest towards the interface with woodland habitats in the Dimako-Bertoua area. The two species are mapped and illustrated, and their affinities and conservation status according to the 2012 IUCN categories and criteria are discussed. Both *R. spongiocarpa* and *R. dimakoensis* are threatened with extinction due to habitat destruction, both are assessed as Vulnerable.

Key Words. conservation, hydro-electric projects, Vulnerable.

Introduction

In the course of revising the species of Violaceae of Africa, mainly in preparation for the account of the Violaceae for the “*Flore du Cameroun*”, the first author has, with collaborators, published 17 new species to science for this group (Achoundong & Onana 1998; Achoundong & Bos 1999; Achoundong & Bos 2001; Achoundong 2003; Achoundong & Cheek 2003; Achoundong & Cheek 2005; Achoundong & Bakker 2006; Achoundong *et al.* 2021). The new species published here have previously been referred to under provisional names (Achoundong 1996; Achoundong 1997; Amiet & Achoundong 1996; Achoundong 2000; Bakker *et al.* 2006). In this paper, these two provisional species names are formally published to validate these names.

The most recent studies of the phylogeny and classification of African *Rinorea* Aubl. are set out by Wahlert (2010), Wahlert & Ballard (2012) and van Velzen *et al.* (2015). However, the classification of Brandt (1914) has still not been formally replaced.

The genus *Rinorea* is pantropical, with 210 species currently accepted by Plants of the World Online (POWO, continuously updated, accessed April 2022). Africa is the most species-diverse continent for *Rinorea* with 110 – 150 species (van Velzen *et al.* 2015). *Rinorea* species are forest understorey shrubs or small trees. Morphologically, in continental Africa, they are characterised by having alternate, simple leaves, often

with petioles of different lengths on the same stem and a usually long, curving apical bud (in the Neotropics and Madagascar, some species e.g. *Rinorea* sect. *Pubiflora* Wahlert & H.E. Ballard have opposite leaves). The flowers are often green, dull yellow, or shades of white and are usually markedly zygomorphic (rarely appearing more or less actinomorphic). There are three sets of petals in *Rinorea*: an anterior petal (also known as the lower or ventral petal), two lateral petals and two posterior petals. These are likely homologous to the three sets of petals in other strongly zygomorphic genera of Violaceae, such as *Viola* L. (Wahlert 2010).

The anterior petal is larger than the other petals, and often modified, with taxonomically important, often diagnostic characters. The androecium has a staminal tube which is also zygomorphic: the anterior (lower or ventral) side is longer and entire, while on the dorsal side of many of the African species, the staminal tube is generally shorter and incised with a V-shaped cleft. The fruits are typical of the family: hard, dry tricoccal, septicial capsules with parietal placentation.

Rinorea are ecologically important and diverse in African forests, often with several sympatric species in one forest. For example, ten species were recorded in a few square kilometres of the Mefou Proposed National Park near Yaoundé (Achoundong in Cheek *et al.* 2011). The most species diverse area is in the

¹ IRAD-Cameroon National Herbarium, BP 1601, Yaoundé, Cameroon.

² Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, UK. e-mail: m.cheek@kew.org

littoral plain in the polygon bounded by Edea-Kribi, Bella and Bipindi. Many species are range-restricted, found in such small areas that they are at risk of extinction from forest clearance. *Rinorea dewitii* Achound., *R. fausteana* Achound., *R. simoneae* Achound., and *R. thomasii* Achound., are all assessed as threatened in the *Red Data Book of the Flowering Plants of Cameroon* (Onana & Cheek 2011) and all but the first can be found on the IUCN Red List (iucnredlist.org) e.g., *Rinorea thomasii* (Darbyshire & Cheek 2004a; Cheek 2017; Darbyshire & Cheek 2004b). In neighbouring Gabon, the recently published *Rinorea calcicola* Velzen & Wieringa is also range-restricted and of conservation concern (van Velzen & Wieringa 2014). Cameroon has the highest species-diversity for the genus in tropical Africa with 53 species listed (Onana 2011), followed by Gabon, with 46 species (Sosef *et al.* 2006). However, the superficial similarity between species has made identification difficult for taxonomists, e.g., 194 specimens of *Rinorea* are listed as unidentified to species for Gabon in Sosef *et al.* (2006).

African *Rinorea* species are of great interest to entomologists, being important larval food plants of the butterfly genus *Cymothoe* (the gliders). Twenty-eight species of *Cymothoe* are known to feed on *Rinorea*, of which 18 are strictly monophagous, six are oligophagous and three feed on up to six species of *Rinorea* (Amiet 1997; Amiet 2000; Amiet & Achoundong 1996).

Materials & Methods

Fieldwork by the first author was mainly carried out in Cameroon from 1987 – 1996 in connection with his doctoral studies of *Rinorea* (Achoundong 1997). Specimens were collected using the patrol method (e.g. Cheek & Cable 1997). All specimens cited have been seen. Herbarium citations follow *Index Herbariorum* (Thiers continuously updated). Specimens were studied online, on loan from or at BR, K, P, WAG and YA principally by the first author. We also searched JSTOR Global Plants (<https://plants.jstor.org/>; accessed April 2021) for additional materials. Taxonomic authorities follow the International Plant Names Index (IPNI 2021), and nomenclature follows Turland *et al.* (2018). The conservation assessment was made using Bachman *et al.* (2011) following the categories and criteria of IUCN (2012). Herbarium material was examined with a Leica Wild M8 dissecting binocular microscope fitted with an eyepiece graticule. Measurements were made from rehydrated material. The terms and format of the description follow the conventions of Beentje & Cheek (2003) and Achoundong *et al.* (2021). Post-facto georeferences for specimens without coordinates were obtained from Google Earth. (https://www.google.com/intl/en_uk/earth/versions/).

Results: Taxonomy

Rinorea spongiocarpa Achound. sp. nov., the first of the two species described below is placed in *Rinorea* [unranked] Brachypetalae because it is closely similar to *R. gabunensis* Engl. and *R. leiophylla* M.Brandt which are placed in this group on molecular grounds (Wahlert & Ballard 2012; van Velzen *et al.* 2015) and because it fits the description of this group: alternate leaves, six ovules per ovary, cymose inflorescence, anthers sessile on the border of the staminal tube.

Rinorea dimakoensis Achound. sp. nov. the second species described, is placed in *Rinorea* [unranked] Illicifoliae on molecular grounds (Wahlert & Ballard 2012; van Velzen *et al.* 2015) and because it fits the description of the group: alternate leaves, six ovules per ovary; cymose inflorescences, sepals clearly ribbed fanwise; staminal tube sinuate between insertion of anthers, tube without a free margin or a lobed margin subtending anthers. Further data are given on Illicifoliae in Wahlert *et al.* (2020).

1. *Rinorea spongiocarpa* Achound. sp. nov. Type. Cameroon, South Region, Ebolowa, “Hill facing village of N’Kolandom, in primary forest on slope, Alt. c. 700 m, 2.48N, 11.10E”, fl. 20 Feb. 1975, J. J. F. E. de Wilde 7985 (holotype WAG; isotypes BR, K000593339, P, YA).

<http://www.ipni.org/urn:lsid:ipni.org:names:77308122-1>

Rinorea spongiocarpa ined. Achoundong (1996: 536 – 544; 1997: 193 – 198); Amiet & Achoundong (1996: 465); Onana (2011: 151).

Tree or shrub 2 – 6 (– 12) m high; stems glabrous. *Leaf-blades* leathery to thickly papery, glossy, dark green above, pale yellow-green beneath, elliptic, ovate to narrowly oblong, 14 – 30 × 11 – 6 cm, apex acuminate, base cuneate to attenuate, lateral nerves 9 – 12, on each side of the midrib, tertiary nerves subscalariform, leaf margin crenate, glabrous; petiole 5 – 7 cm long. *Inflorescence* a terminal panicle up to 7 cm long, lateral ramifications constituted by few-flowered cymes of 5 – 7 flowers each. Bracts triangular, 1.5 × 2 mm, median nerve raised, conspicuous. *Flowers* yellow or yellow-white, zygomorphic, 4 – 5 (– 6) × 3 – 4 (– 5) mm. *Sepals* purple, unequal, triangular to elliptic 2 × 3 mm, apex rounded. *Petals* yellow, unequal, anterior (lower) petal oblong 6 × 2 mm, spreading, not or barely revolute at maturity, lateral and posterior petals smaller, 3 – 4 mm long, distal half strongly revolute. *Androecium* zygomorphic, 3.5 – 5 mm long, staminal tube 1 – 2.5 mm long, staminal filaments short, extending from the tube rim, anthers subsessile, thecae 2 mm long, outer surface puberulent, connective appendage 2 mm long, red, decurrent deeply on the anther thecae, thecae appendage entire, not bifid. *Gynoecium* up to 5.3 mm

long. Ovary subglobose, 1.5×1 mm, glabrous, style straight, enlarged at the base, 3.5 mm long. *Fruit* subglobose-ovoid, 30×20 mm surface smooth, lacking ribs, fruit wall c. 3 mm thick, six-seeded. *Seeds* white, tetrahedral, $9 - 10 (- 11) \times 9 - 10 \times 5 (- 6)$ mm, drying pale brown, glossy. Fig. 1.

RECOGNITION. Similar to *Rinorea parviflora* Chipp in that the fruits are subglobose (in most species the fruits are 3-angular), having a thick mesocarp (in almost all other members of the genus the mesocarp is thin), differing in that the abaxial surface of the leaf blade lacks glands, the staminal tube of the flower is not free (the stamens arise from it), and that the inflorescence branches are many-flowered (vs glandular, staminal tube free, and 1 – 2-flowered respectively).

DISTRIBUTION. Cameroon. The species is restricted to the area of the Dja Forest (from Mbalamayo to Abong Mbang) in East Region, extending westwards to Ngovayang and Ebolowa-Lolodorf in Littoral Region. (Map 1).

SPECIMENS STUDIED. CAMEROON. East Region, Alat Makay, Dja National Park, fl. 23 Feb. 1987, *Achoundong* 1411 (P, YA); Timbe II, near Abong-Mbang, fl. 20 Jan. 1990, *Achoundong* 1562 (P, YA); Dja National Park., fl. 25 April 1993, *Lejoly & Sonké* 154 (BR, YA); Dja National Park, Mekas, fl. 10 Jan. 1995, *Sonké* 1385 (BR, YA); Mekas, fr. 26 May 1995, fr. *Sonké* 1548 (BR, YA); **South Region.** Ebolowa, Hill facing village of N’Kolandom hill, in primary forest on slope, fl. 20 Feb. 1975, *J. J. F. E. de Wilde* 7985 (holotype WAG; isotypes BR, K000593339, P, YA); Nkoladom village, S of Ebolowa, fr. 10 Sept. 1989, *Achoundong* 1495, (K000593338, WAG, YA); *ibid.*, fl. fr. Sept. 1992, *Achoundong* 1951 (YA); *ibid.*, *Achoundong* 1952 (YA); *ibid.*, *Achoundong* 1953 (YA); Bongolo I, 30 km on Ebolowa-Lolodorf road, fl., 14 Sept. 1989, *Achoundong* 1501, (K, YA); *ibid.*, fl., fr., 14 Sept. 1989, *Achoundong* 1501 (K000593337, P, YA); Avobengon village, 24 km S of Djoum, $12^{\circ}55'E$, $2^{\circ}40'E$, fl., 22 Dec. 1990, *Achoundong* 1598 (YA); *ibid.*, fl., 22 Dec. 1990, *Achoundong* 1632 (YA); *ibid.*, fl. 22 Dec. 1990, *Achoundong* 1700 (P, YA); *ibid.*, fl. 10 April 1991, *Achoundong* 1760 (K000593336, WAG, YA); *ibid.*, imm.fr. *Achoundong* 1802 (K000593335, YA); Medjap, near Djoum, st. 20 May 1990, *Achoundong* 1681 (P, YA); Mill Hill, Lolodorf, Sept. 1992, *Achoundong* 1974 (YA); Bibondi near Ngovayang, NW of Lolodorf, fl., 4 March 1993, *Achoundong* 2017 (YA); *ibid.*, *Achoundong* 2024 (YA); Mezese, fr. 24 May 1993, *Achoundong* 2066, (YA); Mezese, fr. 16 Sept. 2004, *Achoundong* 2335 (YA, WAG); Ebiememeyong, fl., Jan. 1993, *Achoundong* 2338 (YA).

HABITAT. *Rinorea spongiocarpa* is widespread in dense lowland evergreen forest from Lolodorf and Ngovayang at the edge of the littoral plain through the Dja forest of the Cameroon Congolese forest zone (in the sense of Letouzey 1985), which is characterised by *Gilbertiodendron dewevrei* and *Sterculia subviolacea*. It occurs at an altitudinal range of 400 – 700 m. *Rinorea spongiocarpa* does not occur

in the littoral plain itself and is completely absent from the semi-deciduous forest of the South Cameroon Plateau.

CONSERVATION STATUS. *Rinorea spongiocarpa* is only known from the border of Littoral Region at Ngovayang and Lolodorf to the Dja Forest area of adjoining East Region (Map 1). On the basis of the specimen records cited above, we calculate the total extent of occurrence of *Rinorea spongiocarpa* as 25,295 km². However, within this fairly large area, there are currently only nine scattered locations known and the global area of occupation is calculated as only 44 km² using the IUCN-preferred cell size of 4 km². Surveys for plant conservation management in forest areas north, south and west of the range of distribution of this species have resulted in many thousands of specimens being collected and identified, but failed to find any additional specimens of *Rinorea spongiocarpa* (Cheek 1992; Cable & Cheek 1998; Cheek *et al.* 2000; Maisels *et al.* 2000; Chapman & Chapman 2001; Tchoutou 2004; Harvey *et al.* 2004; Cheek *et al.* 2004; Cheek *et al.* 2010; Harvey *et al.* 2010; Cheek *et al.* 2011). Although there are still poorly sampled forest locations with intact natural habitat in Cameroon, it is likely that the known range of *Rinorea spongiocarpa* is close to the actual. Only one location for the species occurs in a designated protected area: the Dja forest. The species appears absent from the largest protected area in South Region, the Campo-Ma’an National Park. Despite being formally unprotected, forest at several of the known locations appears mainly intact (Google Earth imagery viewed 29 Oct. 2021), with forest entirely or largely removed only in two or three locations, apparently due to small-holder agricultural operations near roads. *Rinorea spongiocarpa* is therefore here assessed, on the basis of the ten or less locations, small known area of occupation and threats described above, as Vulnerable, VU B2ab(iii). Another example of a range-restricted endemic species in the same range and habitat is *Kupeantha spathulata* (A.P.Davis & Sonké) Cheek (Cheek *et al.* 2018a), which is also assessed as Vulnerable (Rokni *et al.* 2017).

ETYMOLOGY. The name of this species was coined by Amiet who inspired and supervised the doctoral research of the first author on *Rinorea*. “spongiocarpa” derives from the appearance of the fruit, which is not 3-angled as in most species of the genus, but subspherical, appearing inflated and spongy (even though it is hard).

NOTES. In herbarium collections, specimens belonging to this species appear similar to those of two other species: *Rinorea gabunensis* and *R. leiophylla* with which *R. spongiocarpa* has long been confused. The species have separate ranges. *Rinorea gabunensis* and *R. leiophylla* occur exclusively in the littoral plain whereas *R. spongiocarpa* is restricted to forest inland in the Cameroon “congolese forest” zone. The three species are distinguished as follows:

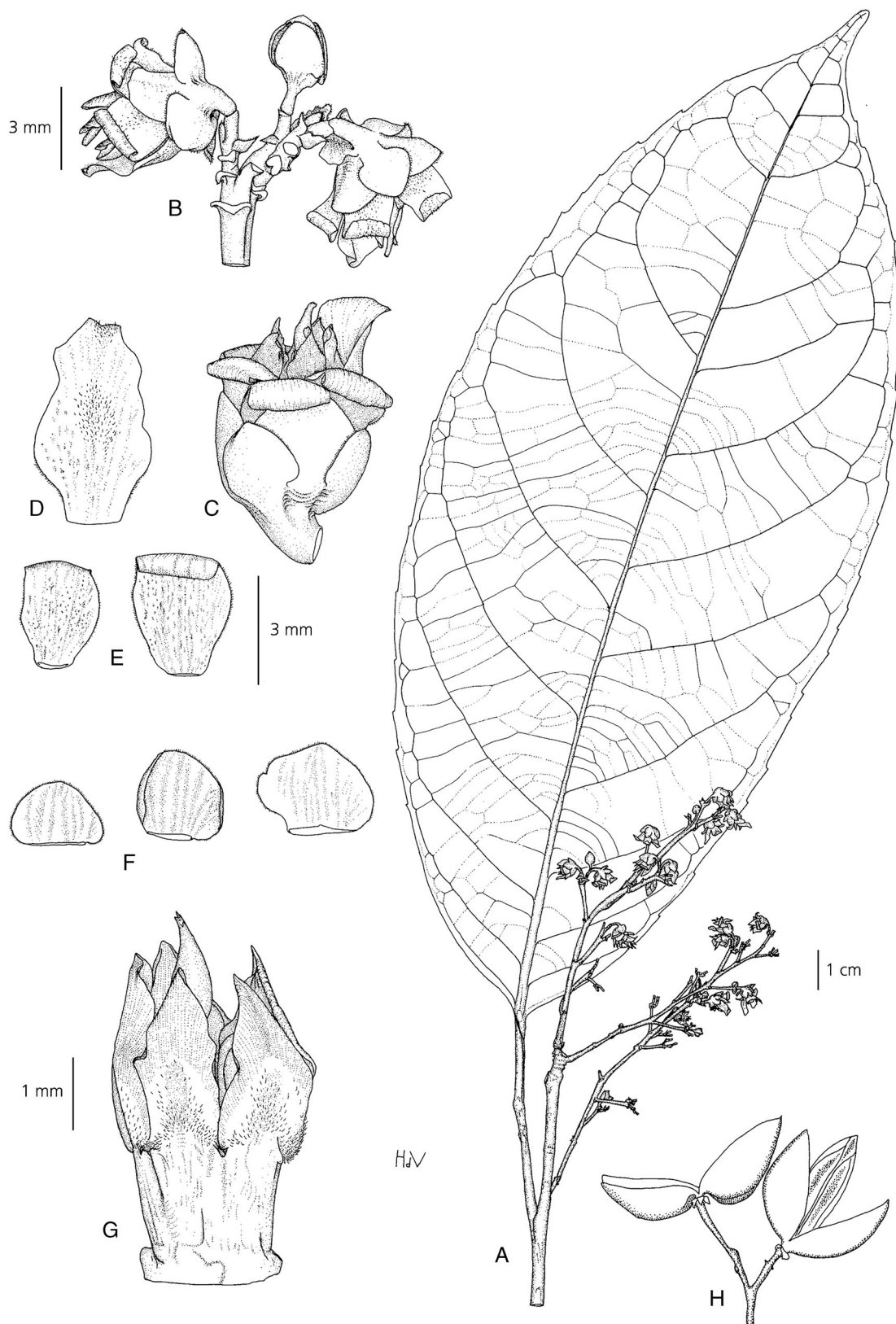
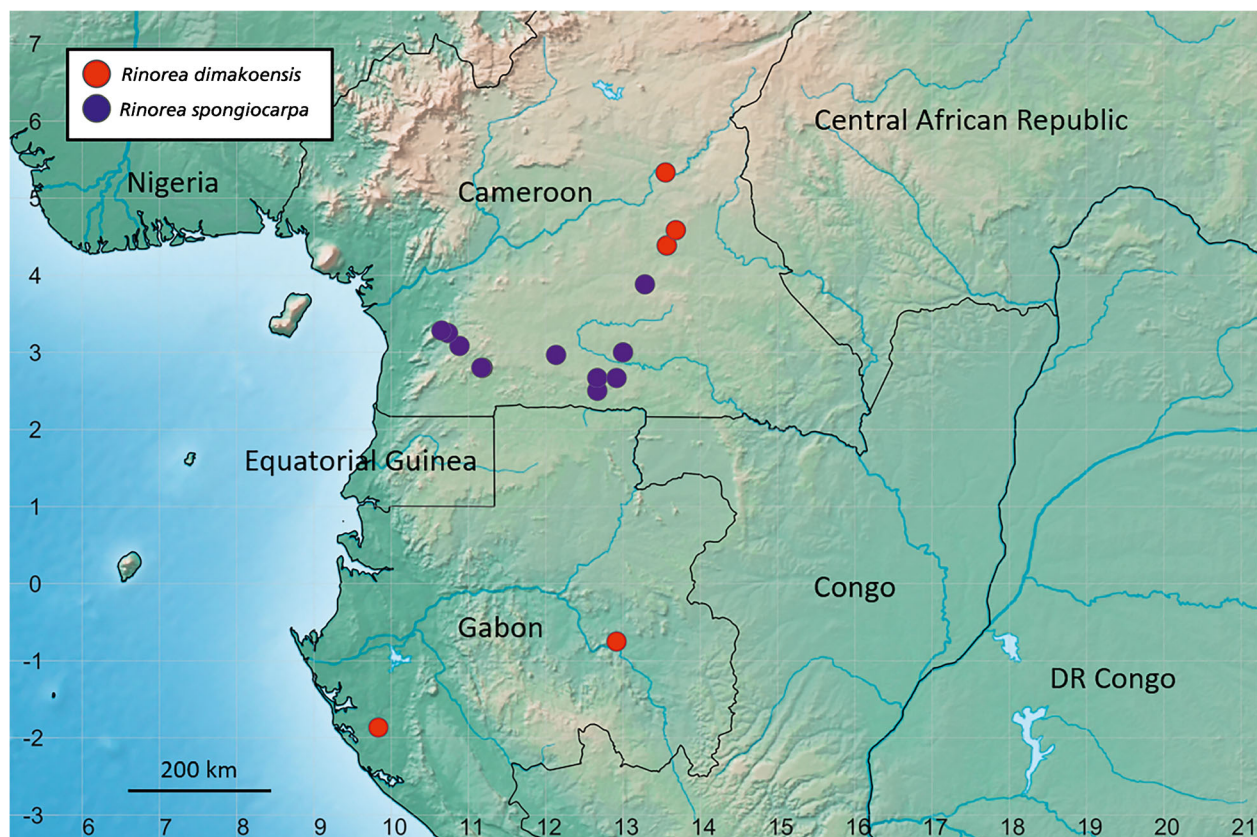


Fig. 1. *Rinorea spongiocarpa*. A habit, flowering stem; B portion of inflorescence with two open flowers and one flower in bud; C flower, note the spreading anterior petal; D anterior petal; E lateral and posterior petals; F sepals; G androecium, side view; H fruit, mature. From J. J. F. E. de Wilde 7985 (holotype, WAG). DRAWN BY J. M. (HANS) DE VRIES.



Map 1. Global distributions of *Rinorea spongiocarpa* and *R. dimakoensis*.

1. Small shrub of less than 5 m high; partial-inflorescences (secondary branches) of the inflorescence uniparous; fruit ribbed.....*Rinorea gabunensis*
1. Small tree up to 12 m high; partial-inflorescences (secondary branches) of the inflorescence biparous; fruit smooth (not ribbed).....2
2. Leaves glandular on abaxial surface; staminal tube with free margin.....*Rinorea leiophylla*
2. Leaves not glandular on abaxial surface; staminal tube margin not free.....*Rinorea spongiocarpa*

2. *Rinorea dimakoensis* Achound. sp. nov. Type. Cameroon, East Region, Dimako, rive droit de la riv. M Bonda, fl. fr. 18 Jan. 1960, *Letouzey* 2663 (holotype P00123533; isotypes P00123534; P00123535; P00123536; P00123537; P0012358; P00123539; YA).

<http://www.ipni.org/urn:lsid:ipni.org:names:77308123-1>

Rinorea dimakoensis Achound. ined. Achoundong (1996: 544); (1997: 156); Amiet & Achoundong (1996: 466); Bakker *et al.* (2006); Onana (2011); van Velzen *et al.* (2015); Wahlert (2010); Wahlert & Ballard (2012).

Tree or shrub up to 12 m tall; stems glabrous. *Leaves* thickly coriaceous, dark green above, blades elliptic, ovate to

narrowly oblong, 10 – 30 × 6 – 18 cm, apex acuminate, base rounded, obtuse or attenuate, lateral nerves 8 – 10 on each side of the midrib, leaf margin acutely serrate, glabrous; petiole 3 – 6 cm long. *Inflorescence* terminal or subterminal panicle 8 – 12 × 2 – 7 cm, lateral branches with 2 – 5-flowered cymes; bracts ovate 1.5 – 2 × 1 – 2 mm, rounded at the summit, median nerve conspicuous. *Flower* yellow, zygomorphic, 4 – 5 (– 6) × 3 – 4 (– 5) mm. *Sepals* unequal, triangular to elliptic orbicular, 2 × 3 mm, apex rounded or emarginate. *Petals* yellow, unequal, oblong, 6 – 7 × 2 – 4.2 mm, lateral and dorsal petals smaller, anterior (lower) petal bigger, straight, not revolute at maturity. *Androecium* zygomorphic, 3.5 – 5 mm long. Staminal tube 0.5 mm long, tube margin not free, anthers sessile on the rim of the staminal tube; staminal thecae 2 mm long, connective subelliptic, c.

2 mm long, apex rounded, thecae base decurrent slightly, thecal appendage entire (not bifid). *Gynoeceum* 3 mm long. Ovary glabrous, subglobose, 1 mm long, style 2 mm long. *Fruit* ovoid, 3.5 × 3 cm, longitudinally 3-ribbed, 6-seeded. Seeds tetrahedral, 8 × 5 mm. Fig. 2.

RECOGNITION. *Rinorea dimakoensis* Achound. is similar to *R. ilicifolia* Kuntze, in the shape and size of the leaves which are leathery and robustly toothed at the margin, however in *R. dimakoensis* the leaves are wider (6 – 18 cm vs 3 – 9 cm) and the spines are shorter (<0.5 mm long vs 1 – 2 mm long), the pedicels, flowers and fruits are longer and/or larger, reaching 4.5 mm, 7 × 4 mm, and 3.5 cm long respectively (vs 1 mm, 3.5 – 4 × 3 – 4 mm, and 1.2 – 1.6 cm long and the sepals have only the midrib raised and partly rib-like, not with multiple raised longitudinal ribs.

DISTRIBUTION. Cameroon & Gabon. The species is globally endemic to a narrow area on the South Cameroon Plateau of East Region, extending from Dimako in the south to the Lom-Pangar in the north and crossing into Gabon (Map 1), however it is suspected that the range may be larger.

SPECIMENS STUDIED. CAMEROON. East Region. South Dimako, MBonda R., fl. fr. 10 Aug. 1987, *Achoundong* 1878 (P, YA); Confluence du Lom et du Pangar, fl. date unknown, *Achoundong* 3033 (WAG, YA); S of Dimako, MBonda R., fl. fr. 18 Jan. 1960, *Letouzey* 2663 (holotype P00123533; isotypes P00123534; P00123535; P00123536; P00123537; P00123538; P00123539; YA); Ndemb II, 55 km along Ndemba road, st. 17 Nov. 1955, *Nana* 343 (P, YA); 60 km on Bertoua Road, Essengue II path, st. 18 Feb. 1956, *Nana* 489 (YA).

GABON. c. 30 km NE of Lastoursville, forest exploitation on right bank of Ogooue R., fl. 11 April 1990, *Breteler* 9868 (BR barcode BR00000565803; MA sheet No. 841394); Rabi, Shell oil concession, c. 300 m SSW of Rabi 46, fl. fr. 23 Nov. 1989, *W. J. J. E. de Wilde* 9675 (BR sheet number 2034648; LBV; WAG sheet number 1870759).

HABITAT. *Rinorea dimakoensis* is globally restricted to forest at up to 720 m alt. The distribution range of this species falls within the transition from forest to grassland in Cameroon, with forest mainly along drainage lines interdigitating with grassland on better-drained areas. The species is completely absent from semi-deciduous forest in the adjoining Centre Region, e.g. in the Yaoundé and Bafia areas. It is also completely absent from Cameroon coastal (littoral) evergreen forest, but extends far into Gabon.

CONSERVATION STATUS. Five locations are mapped for *Rinorea dimakoensis* (Map 1). However, three additional locations are thought to exist but require confirmation and documentation. Moreover, the species has been lost at its former northernmost location which has now been inundated (viewed on Google Earth 29 Oct. 2021) by the reservoir behind the Lom-Pangar

hydro-electric dam, which was completed in 2017. It is to be hoped that searching in surviving suitable habitat in the area might discover additional individuals but this is not certain. Forest at the remaining locations in Cameroon appears to have been shrinking and has been degraded over recent years, probably due to urbanisation, and the demand for fuel in neighbouring Dimako and Bertoua, towns along the transnational highway that links Douala, and Bangui, the major artery for the Central African Republic. The two locations in Gabon seem more secure and forest is under much less pressure. On the basis of the specimen records cited above and the likely but so far unsubstantiated locations referred to above, we estimate the total extent of occurrence of *R. dimakoensis* as 119,962 km² (including the Lom-Pangar site) and the global area of occupation is calculated as only 20 km² using the IUCN-preferred cell size of 4 km². There are currently only five extant locations known but another three suspected. It is possible that further additional locations will be found (especially within Gabon) within the extent of occurrence, and that this itself might be extended since this area of Cameroon is less well surveyed than that of the main forest zone (see references cited under *R. spongiocarpa*). We here assess *R. dimakoensis* on the basis of the data given above, as Vulnerable, VU B2ab(iii). Another example of a range-restricted endemic species with a similar range is *Allophylus bertoua* Cheek (Cheek & Haba 2016).

ETYMOLOGY. The species is named after the Dimako locality in East Region, where the first fertile specimen representing this species was collected in 1960 by Letouzey.

NOTES. *Rinorea dimakoensis* appears both closely similar and related to *R. ilicifolia*. The Gabonese specimens cited had been identified as *R. ilicifolia*. From field observations it appears that *R. dimakoensis* differs in the shape and size of the habit, the structure of the leaf margin, the architecture of the inflorescence and the habitat.

This close similarity probably constitutes one of the reasons why this species has not been recognised previously. Since discriminating characters are mainly located in mature flowers, it was not easy for botanists formerly to separate this species. *Rinorea dimakoensis* is also similar to *R. keayi* Brenan. In fact, the type specimen of this species, collected by Letouzey, was first identified as *Rinorea* aff. *keayi*. However, in *R. dimakoensis* leaf margins are so not spiny as those of this species and the lamina is not glandular beneath.

Discussion

Documented global extinctions of plant species are increasing (Humphreys *et al.* 2019) and recent estimates suggest that as many as two fifths of the world's

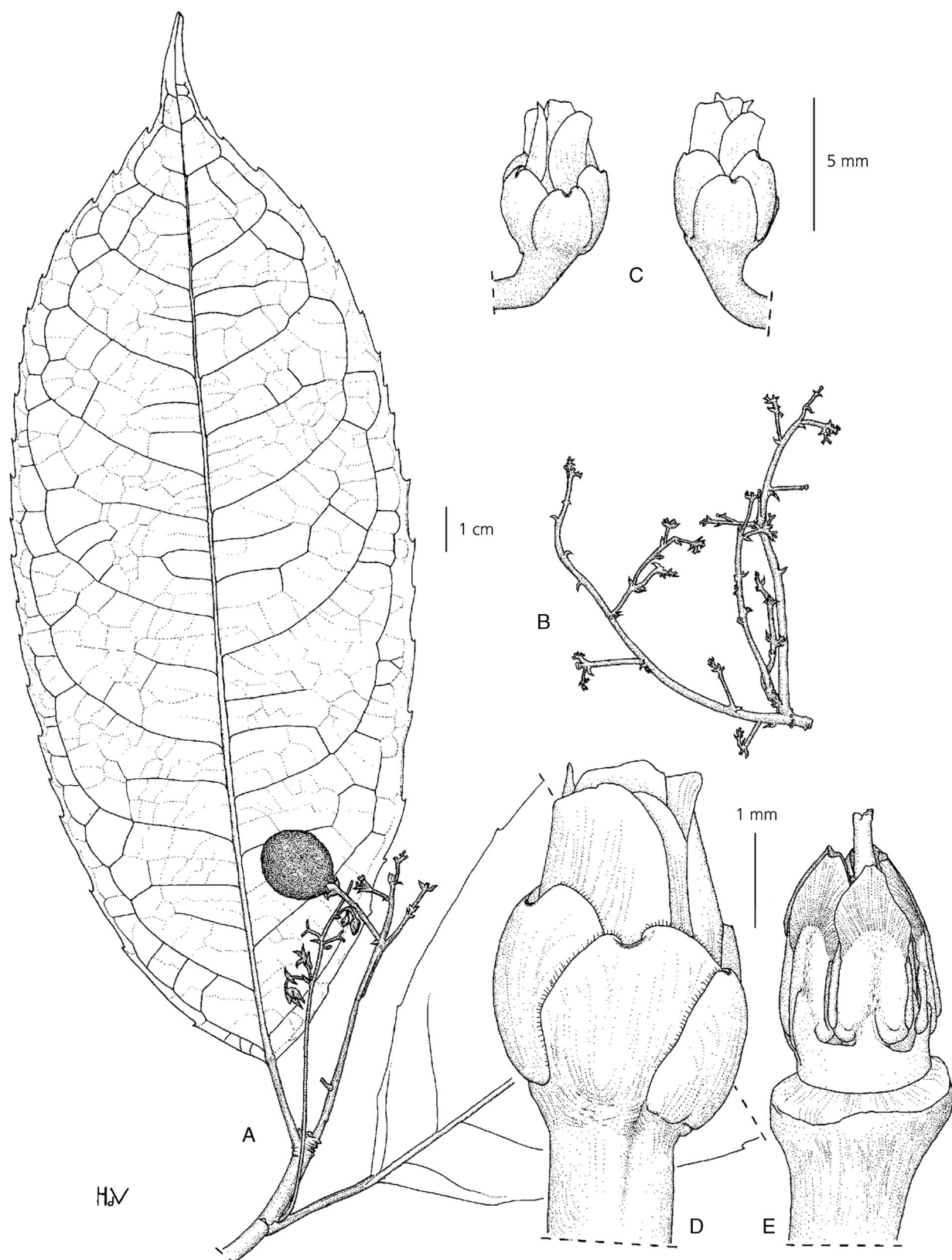


Fig. 2. *Rinorea dimakoensis*. A habit, fruiting stem; B portion of infructescence axis; C two flowers, side view; D flower, side view; E androecium, side view. A, C – E from Achoundong 3033 (WAG, YA), B from Letouzey 2663 (holotype P). DRAWN BY J. M. (HANS) DE VRIES.

plant species are now threatened with extinction (Nic Lughadha *et al.* 2020). Cameroon has the highest documented number of plant species extinctions of any country in tropical Africa (Humphreys *et al.* 2019). The endemic Cameroon species *Oxygyne triandra* Schltr. and *Afrothismia pachyantha* Schltr. are among those now known to be globally extinct (Cheek & Williams 1999; Cheek *et al.* 2018b; Cheek *et al.* 2019) and recently two species of *Pseudohydrosme* (Moxon-Holt & Cheek 2021; Cheek *et al.* 2021a) have been shown to be extinct in adjoining Gabon. In some cases, species appear to have become extinct even before they are known to science, such as *Vepris bali* Cheek (Cheek *et al.* 2018c) and *Monanthotaxis bali* (Cheek *et al.* 2022a), both also in Cameroon. Even areas known to be of high conservation value have been slated for development, threatening the species they contain with extinction, e.g. the Ebo forest in Cameroon (Lovell 2020).

About 2000 plant species new to science are published each year, with Cameroon contributing more than any other tropical African country in 2019 (Cheek *et al.* 2020). New species to science from Cameroon are being published steadily (Alvarez-Aguirre *et al.* 2021; Cheek & Onana 2021; Cheek *et al.* 2017, 2021b, 2021c, 2022b), even new genera to science (Litt & Cheek 2002; Cheek *et al.* 2003, 2018a). Only when such species as *Rinorea spongiocarpa* and *R. dimakoensis* (this paper) are formally known to science are they fully visible and only then can extinction risk assessments be accepted by IUCN allowing the possibility of measures being taken to protect them (Cheek *et al.* 2020).

Efforts are now being made to delimit the highest priority areas in Cameroon for plant conservation as Tropical Important Plant Areas (TIPAs) using the revised IPA criteria set out in Darbyshire *et al.* (2017). This is expected to help avoid the global extinction of additional endemic species such as the *Rinorea* species published in this paper which it is intended will be included in the future TIPAs.

Acknowledgements

The first author thanks IRAD-National Herbarium of Cameroon (YA) for support in his retirement that has enabled him to continue and finalise his taxonomic research on Violaceae of Cameroon for the *Flore Du Cameroun*. The Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NOW), Institut de Recherche pour le Développement (IRD) and Royal Botanic Gardens, Kew have supported the cost of visits by the first author to the European herbaria of BR, BM, K, P and WAG. The first author is particularly grateful to Jos van der Maesen, Frans Breteler and Eric Chenin at these institutions. He also thanks colleagues at Wageningen for retrieving and transmitting the excel-

lent figures that illustrate this paper, drawn by J. M. (Hans) de Vries. Xander van der Burgt is thanked for making the map. This paper was completed as part of the Cameroon TIPAs (Tropical Important Plant Areas) project at RBG, Kew, which is supported by players of People's Postcode Lottery. Formal Red Listing of these two tree species, once they are formally published, will be supported by the John S. Cohen Foundation.

Declarations

Conflicts of interest. The authors declare no conflicts of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Achoundong, G. (1996). Les *Rinorea* comme indicateurs des grands types forestiers du Cameroun. In: L. J. G. van der Maesen, X. M. van der Burgt & J. M. Van Medenbach-de Rooy (eds), *The Biodiversity of African Plants*, pp. 536 – 544. Kluwer Academic Publishers, Dordrecht. https://doi.org/10.1007/978-94-009-0285-5_69
- ____ (1997). *Rinorea du Cameroun, systematique Biologie, Ecologie, Phytogéographie*. Thèse Université Yaoundé I, Yaoundé.
- ____ (2000). Les *Rinorea* et l'étude des refuges forestiers en Afrique. In: M. Servant & S. Servant-Vildary (eds), *Dynamique à long terme des écosystèmes forestiers intertropicaux*, pp. 19 – 29. Mémoire UNESCO, Paris.
- ____ (2003). Novitates Gabonenses 45. Une nouvelle espèce de *Rinorea* (Violaceae) du Gabon. *Adansonia n.s.* 25: 211 – 215.
- ____ & Bakker, F. T. (2006). Deux nouvelles espèces de *Rinorea*, série *Ilicifoliae* (Violaceae) du Cameroun. *Adansonia*, sér. 3, 28 (1): 129 – 136.

- ____ & Bos, J. J. (1999). Novitates Gabonenses: 37. Espèces nouvelles de *Rinorea* (Violaceae) du Gabon. *Adansonia* 21 (1): 125 – 131.
- ____ & ____ (2001). Deux espèces nouvelles de *Rinorea* (Violaceae) du Congo et du Gabon. *Adansonia* 23 (1): 155 – 159.
- ____ & Cheek, M. (2003). Two new species of *Rinorea* (Violaceae) from Western Cameroon. *Kew Bull.* 58: 957 – 964. <https://doi.org/10.2307/4111209>
- ____ & ____ (2005). Two further new species of *Rinorea* (Violaceae) from Cameroon. *Kew Bull.* 60 (4): 581 – 586. <https://www.jstor.org/stable/25070244>
- ____ & Onana, J. (1998). *Alexis zygomorpha* (Violaceae): a new species from the Littoral Forest of Cameroon. *Kew Bull.* 53 (4): 1009 – 1010. <https://doi.org/10.2307/4118897>
- ____, van der Burgt, X. & Cheek, M. (2021). Four new threatened species of *Rinorea* (Violaceae), treelets from the forests of Cameroon. *Kew Bull.* 76: 705 – 719. <https://doi.org/10.1007/s12225-021-09987-8>
- Alvarez-Aguirre, M. G., Cheek, M. & Sonké, B. (2021). *Kupeantha yabassi* (Coffeae-Rubiaceae), a new Critically Endangered shrub species of the Ebo Forest area, Littoral Region, Cameroon. *Kew Bull.* 76: 735 – 743. <https://doi.org/10.1007/s12225-021-09982-z>
- Amiet, J.-L. (1997). Spécialisation trophique et premières états chez les *Cymothoe*: implications taxonomiques (Lepidoptera, Nymphalidae). *Bull. Soc. Entomol. France* 102: 15 – 29.
- ____ (2000). Les premiers états des *Cymothoe*. Morphologie et intérêt phylogénique (Lepidoptera, Nymphalidae). *Bull. Soc. Entomol. France* 106: 349 – 390.
- ____ & Achoundong, G. (1996). Un exemple de spéciation trophique chez les Lepidoptères: les *Cymothoe* camerounaises inféodées au *Rinorea* (Violacées) (Lepidoptera, Nymphalidae). *Bull. Soc. Entomol. France* 105 (5): 449 – 466.
- Bachman, S., Moat, J., Hill, A. W., de la Torre, J. & Scott, B. (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys*. 150: 117 – 126. <https://doi.org/10.3897/zookeys.150.2109>
- Bakker, F. T., van Gernerden, B. S. & Achoundong, G. (2006). Molecular systematics of African *Rinorea* Aublet. (Violaceae), pp. 33 – 44. In: S. A. Ghazanfar & H. J. Beentje (eds), *Taxonomy and ecology of African plants, their conservation and sustainable use*. Royal Botanic Gardens, Kew.
- Beentje, H. & Cheek, M. (2003). Glossary. In H. J. Beentje (ed.), *Flora of Tropical East Africa*. Balkema, Lisse.
- Brandt, M. (1914). Übersicht über die afrikanischen Arten der Gattung *Rinorea* Aubl. *Bot. Jahrb. Syst.* 51: 405 – 418.
- Cable, S. & Cheek, M. (1998). *The Plants of Mt Cameroon, a Conservation Checklist*. Royal Botanic Gardens, Kew.
- Chapman, J. & Chapman, H. (2001). *The Forests of Taraba and Adamawa States, Nigeria an Ecological Account and Plant Species Checklist*. University of Canterbury, Christchurch.
- Cheek, M. (1992). *A Botanical Inventory of the Mabeta-Moliwe Forest*. Royal Botanic Gardens, Kew.
- ____ (2017). *Rinorea simoneae*. *The IUCN Red List of Threatened Species* 2017: e.T110087540A110087542. <https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T110087540A110087542.en>. [Downloaded 9 May 2021].
- ____ & Cable, S. (1997). Plant Inventory for conservation management: the Kew-Earthwatch programme in Western Cameroon, 1993 – 96, pp. 29 – 38. In: S. Doolan (ed.), *African Rainforests and the Conservation of Biodiversity*. Earthwatch Europe, Oxford.
- ____ & Haba, P. (2016). Spiny African *Allophylus* (Sapindaceae): a synopsis. *Kew Bull.* 71: 57. <https://doi.org/10.1007/S12225-016-9672-3>
- ____ & Onana, J. M. (2021). The endemic plant species of Mt Kupe, Cameroon with a new Critically Endangered cloud-forest tree species, *Vepris zapfackii* (Rutaceae). *Kew Bull.* 76: 721 – 734. <https://doi.org/10.1007/s12225-021-09984-x>
- ____, Alvarez-Aguirre, M. G., Grall, A., Sonké, B., Howes, M.-J. R. & Larridon, I. (2018a). *Kupeantha* (Coffeae, Rubiaceae), a new genus from Cameroon and Equatorial Guinea. *PLoS ONE* 13(6): e0199324. <https://doi.org/10.1371/journal.pone.0199324>
- ____, Darbyshire, I. & Onana, J. M. (2022a). *Monanthotaxis bali* (Annonaceae) a new Critically Endangered (possibly extinct) montane forest treelet from Bali Ngemba, Cameroon. *BioRxiv* <https://doi.org/10.1101/2022.07.04.498636>
- ____, Etuge, M. & Williams, S. A. (2019). *Afrothismia kupensis* sp. nov. (Thismiaceae), Critically Endangered, with observations on its pollination and notes on the endemics of Mt Kupe, Cameroon. *Blumea* 64 (1): 158 – 164. <https://doi.org/10.3767/blumea.2019.64.02.06>
- ____, Feika, A., Lebbie, A., Goyder, D., Tchiengue, B., Sene, O., Tchouto, P. & Burgt, X. van der (2017). A synoptic revision of *Inversodicraea* (Podostemaceae). *Blumea* 62: 125 – 156. <https://doi.org/10.3767/blumea.2017.62.02.07>
- ____, Gosline, G. & Onana, J.-M. (2018c). *Vepris bali* (Rutaceae), a new critically endangered (possibly extinct) cloud forest tree species from Bali Ngemba, Cameroon. *Willdenowia* 48: 285 – 292. <https://doi.org/10.3372/wi.48.48207>
- ____, Harvey, Y. & Onana, J.-M. (2010). *The Plants of Dom, Bamenda Highlands, Cameroon, A Conservation Checklist*. Royal Botanic Gardens, Kew.
- ____, ____ & ____ (2011). *The Plants of Mefou Proposed National Park, Yaoundé, Cameroon, A Conservation Checklist*. Royal Botanic Gardens, Kew.

- _____, Molmou, D., Magassouba, S. & Ghogue, J.-P. (2022b). Taxonomic revision of *Saxicolella* (Podostemaceae), African waterfall plants highly threatened by Hydro-Electric projects. *Kew Bull.* 77: 403–433. <https://doi.org/10.1007/s12225-022-10019-2>
- _____, Ndam, N. & Budden, A. (2021b). Notes on the threatened lowland forests of Mt Cameroon and their endemics including *Drypetes burnleyae* sp. nov., with a key to species of *Drypetes* sect. *Stipulares* (Putranjivaceae). *Kew Bull.* 76: 223–234. <https://doi.org/10.1007/s12225-021-09947-2>
- _____, Nic Lughadha, E., Kirk, P., Lindon, H., Carretero, J., Looney, B., Douglas, B., Haelewaters, D., Gaya, E., Llewellyn, T., Ainsworth, A. M., Gafforov, Y., Hyde, K., Crous, P., Hughes, M., Walker, B. E., Forzza, R. C., Wong, K. M. & Niskanen, T. (2020). New scientific discoveries: plants and fungi. *Plants, People Planet* 2: 371–388. <https://doi.org/10.1002/ppp3.10148>
- _____, Onana, J. M. & Chapman, H. M. (2021c). The montane trees of the Cameroon Highlands, West-Central Africa, with *Deinbollia onanae* sp. nov. (Sapindaceae), a new primate-dispersed, Endangered species. *PeerJ* 9: e11036. <https://doi.org/10.7717/peerj.11036>
- _____, Onana, J. M. & Pollard, B. J. (2000). *The Plants of Mount Oku and the Ijim Ridge, Cameroon, a Conservation Checklist*. Royal Botanic Gardens, Kew.
- _____, Pollard, B. J., Darbyshire, I., Onana, J.-M. & Wild, C. (2004). *The Plants of Kupe, Mwanenguba and the Bakossi Mountains, Cameroon: A Conservation Checklist*. Royal Botanic Gardens, Kew.
- _____, Tchiengué, B. & van der Burgt, X. (2021a). Taxonomic revision of the threatened African genus *Pseudohydrosme* Engl. (Araceae), with *P. ebo*, a new, critically endangered species from Ebo, Cameroon. *PeerJ* 9:e10689. <https://doi.org/10.7717/peerj.10689>
- _____, Tsukaya, H., Rudall, P. J. & Suetsugu, K. (2018b). Taxonomic monograph of *Oxygyne* (Thismiaceae), rare achlorophyllous mycoheterotrophs with strongly disjunct distribution. *PeerJ* 6, e4828. <https://doi.org/10.7717/peerj.4828>
- _____ & Williams, S. (1999). A Review of African Saprophytic Flowering Plants, pp. 39–49. In: J. Timberlake & S. Kativu (eds), *African Plants. Biodiversity, Taxonomy & Uses. Proceedings of the 15th AETFAT Congress at Harare*. Zimbabwe.
- _____, _____, & Etuge, M. (2003). *Kupea martinetegei*, a new genus and species of *Triuridaceae* from western Cameroon. *Kew Bull.* 58: 225–228. <https://doi.org/10.2307/4119366>
- Darbyshire, I. & Cheek, M. (2004a). *Rinorea faustearia*. *The IUCN Red List of Threatened Species* 2004:e.T46185A11034817. <https://doi.org/10.2307/IUCN.UK.2004.RLTS.T46185A11034817.en>. [Downloaded 9 May 2021].
- _____ & _____ (2004b). *Rinorea thomasii*. *The IUCN Red List of Threatened Species* 2004: e.T46186A11034916. <https://doi.org/10.2307/IUCN.UK.2004.RLTS.T46186A11034916.en>. [Downloaded 1 May 2021].
- _____, Anderson, S., Asatryan, A., Byfield, A., Cheek, M., Clubbe, C., Ghrabi, Z., Harris, T., Heatubun, C. D., Kalema, J., Magassouba, S., McCarthy, B., Milliken, W., Montmollin, B. de, Nic Lughadha, E., Onana, J.-M., Saidou, D., Sârbu, A., Shrestha, K. & Radford, E. A. (2017). Important Plant Areas: revised selection criteria for a global approach to plant conservation. *Biodivers. Conserv.* 26: 1767–1800. <https://doi.org/10.1007/s10531-017-1336-6>
- Harvey, Y., Pollard, B. J., Darbyshire, I., Onana, J.-M. & Cheek, M. (2004). *The Plants of Bali Ngemba Forest Reserve, Cameroon. A Conservation Checklist*. Royal Botanic Gardens, Kew.
- _____, Tchiengue, B. & Cheek, M. (2010). *The plants of the Lebialem Highlands, a conservation checklist*. Royal Botanic Gardens, Kew.
- Humphreys, A. M., Govaerts, R., Ficinski, S. Z., Lughadha, E. N. & Vorontsova, M. S. (2019). Global dataset shows geography and life form predict modern plant extinction and rediscovery. *Nature Ecol. Evol.* 3.7: 1043–1047. <https://doi.org/10.1038/s41559-019-0906-2>
- IPNI (2021, continuously updated). *The International Plant Names Index*. Available from: <http://ipni.org/> [Accessed March 2018].
- IUCN (2012). *IUCN red list categories: Version 3.1*. IUCN Species Survival Commission, Gland and Cambridge.
- Letouzey, R. (1985). Notice de la carte phytogéographique du Cameroun au 1: 500,000.
- Litt, A. & Cheek, M. (2002). *Korupodendron songweanum*, a new genus of Vochysiaceae from West-central Africa. *Brittonia* 54 (1): 13–17. [https://doi.org/10.1663/0007-196X\(2002\)054\[0013:KSANGA\]2.0.CO;2](https://doi.org/10.1663/0007-196X(2002)054[0013:KSANGA]2.0.CO;2)
- Lovell, R. (2020). Timber ! The threat to Cameroon's Ebo Forest. <https://www.kew.org/read-and-watch/ebo-forest-cameroon> [Accessed 5 May 2021].
- Maisels, F. G., Cheek, M. & Wild, C. (2000). Rare plants on Mt Oku summit, Cameroon. *Oryx* 34: 136–140. <https://doi.org/10.1017/s0030605300031057>
- Moxon-Holt, L. & Cheek, M. (2021). *Pseudohydrosme bogneri* sp. nov. (Araceae), a spectacular Critically Endangered (Possibly Extinct) species from Gabon, long confused with *Anchomanes nigritianus*. *Aroidiana* 44 (1): 110–131.
- Nic Lughadha, E., Bachman, S. P., Leão, T. C., Forest, F., Halley, J. M., Moat, J., Acedo, C., Bacon, K. L., Brewer, R. F., Gâteblé, G. & Gonçalves, S. C. *et al.*, (2020). Extinction risk and threats to plants and fungi. *Plants, People, Planet* 2 (5): 389–408. <https://doi.org/10.1002/ppp3.10146>
- Onana, J.-M. (2011). *The vascular plants of Cameroon, a taxonomic checklist with IUCN Assessments*. Royal Botanic Gardens, Kew.

- ____ & Cheek, M. (2011). *Red data book of the flowering plants of Cameroon, IUCN global assessments*. Royal Botanic Gardens, Kew.
- Plants of the World Online (continuously updated). Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/?f=accepted_names&q=Vepris [Accessed 1 Nov. 2021].
- Rokni, S., Davis, A. P., Cheek, M. & Sonké, B. (2017). *Argocoffeopsis spathulata*. *The IUCN Red List of Threatened Species* 2017: e.T110079511A110079513. <https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T110079511A110079513.en>. [Downloaded 30 Oct. 2021].
- Sosef, M. S. M., Wieringa, J. J., Jongkind, C. C. H., Achoundong, G., Azizet Issembé, Y., Bedigian, D., Van Den Berg, R. G., Breteler, F. J., Cheek, M. & Degreef, J. (2006). Checklist of Gabonese Vascular Plants. *Scripta Bot. Belg.* 35.
- Tchoutou, M. G. P. (2004). *Plant Diversity in a Central African rainforest: implications for biodiversity conservation in Cameroon*. Wageningen University, Wageningen.
- 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/ih/> [Accessed March 2021].
- 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*. *Regnum Veg.* 159. Koeltz Botanical Books, Glashütten. <https://doi.org/10.12705/Code.2018>
- van Velzen, R. & Wieringa, J. J. (2014). *Rinorea calcicola* (Violaceae), an endangered new species from south-eastern Gabon. *Phytotaxa* 167 (3): 267 – 275. <https://doi.org/10.11646/phytotaxa.167.3.5>
- ____, Wahlert, G. A., Sosef, M. S. M., Onstein, R. E. & Bakker, F. T. (2015). Phylogenetics of African *Rinorea* (Violaceae): Elucidating Infrageneric Relationships using Plastid and Nuclear DNA Sequences. *Syst. Bot.* 40 (1): 174 – 184. <https://doi.org/10.1600/036364415X686486>
- Wahlert, G. A. (2010). *Phylogeny, biogeography, and a taxonomic revision of Rinorea (Violaceae) from Madagascar and the Comoro Islands*. Ph.D. Thesis. Ohio University, Athens.
- ____ & Ballard, H. E. (2012). A phylogeny of *Rinorea* (Violaceae) inferred from plastid DNA sequences with an emphasis on the African and Malagasy species. *Syst. Bot.* 37: 964 – 973. <https://doi.org/10.1600/036364412X656392>
- ____, Gilland, K. E. & Ballard, H. E. (2020). Taxonomic revision of *Rinorea ilicifolia* (Violaceae) from Africa and Madagascar. *Kew Bull.* 75 (1): 12, 1 – 15. <https://doi.org/10.1007/s12225-020-9866-6>

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.