Phytotaxa 167 (3): 267–275
www.mapress.com/phytotaxa/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.167.3.5

Rinorea calcicola (Violaceae), an endangered new species from south-eastern Gabon

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Abstract

Rinorea calcicola, endemic to south-eastern Gabon, is described as a new species. Its most striking characteristic is the laminate fruit, a character so far only known for *R. zenkeri*. *Rinorea calcicola* has a limited distribution and appears to be restricted to limestone outcroppings. We have assessed it as endangered—EN B1ab(ii,iii,iv,v)—according to IUCN criteria. Morphological affinities of *R. calcicola* are discussed, and a key to *R. zenkeri* and the Gabonese species of *Rinorea* with textured fruits is given. The new species is one of many endemic species from the same region, and we recommend that a study of their distribution and ecology is undertaken to inform conservation planning. Because of the presence of so many narrow endemic species in the region, we suggest that the area be considered for protected status.

Introduction

Rinorea Aublet (1775: 235 & pl. 93) is a genus of about 280 species distributed across the tropics, with the majority of species growing in sub-Saharan Africa (Engler 1921, Taton 1969, Hekking 1988, Achoundong 2000, Ballard *et al.* 2014). Species of *Rinorea* are considered to be important bioindicators for forest typification as they are often locally abundant and different species of African *Rinorea* are characteristic for different forest types (Achoundong 1996, 2000, Adomou *et al.* 2006, Mwavu & Witkowski 2009, Tchouto *et al.* 2009, Djuikouo *et al.* 2010). In addition, African *Rinorea* species are ecologically significant as larval host plants for *Cymothoe* (Nymphalidae) butterflies, of which at least 32 species are highly specialised on particular species of *Rinorea* (Fontaine 1982, Amiet & Achoundong 1996, Amiet 1997, 2000, McBride *et al.* 2009, van Velzen *et al.* 2009, 2013).

During the last decade 12 new species have been described from Cameroon, Gabon and the Republic of the Congo (Achoundong & Bos 1999, 2001, Achoundong 2003, Achoundong & Cheek 2005, Achoundong & Bakker 2006). However, despite these efforts, a large number of species remain to be described (Achoundong 1996).

On a recent collecting trip to Gabon, Wieringa collected (*Wieringa et al. 5991*) a *Rinorea* with strikingly lamellate fruits. It was growing near Lastoursville where the Ogooué River cuts through a plateau. Along the slope from the plateau to the Ogooué River, a small limestone layer is exposed which is precisely where *Wieringa et al. 5991* was gathered. The plants were quite abundant on the slope just below the nearly vertical limestone outcrop. Before our discovery, *Rinorea zenkeri* Engler (1902: 146) from Cameroon was the only species of *Rinorea* species known to bear a lamellate fruit. As the Gabonese population clearly differed in leaf and androecium characters from *R. zenkeri*, we soon concluded that the material represented an undescribed species. Here, we describe *Rinorea calcicola* on the basis of morphological characters, and compare this new taxon with similar *Rinorea* species from Gabon and Cameroon.

Accepted by Hans-Joachim Esser: 10 March 2014; published: 14 May 2014

Materials & Methods

After preliminary examination of the putative new species from Lastoursville (*Wieringa et al. 5991*), we have scrutinized all specimens filed under *Rinorea* at WAG in an attempt to find additional material that might belong to the same taxon. Special attention was given to specimens with lamellate or verrucose fruits and to those bearing similarities to *Wieringa et al. 5991* in vegetative morphology.

The selected specimens were subsequently examined by light microscopy in search of differentiating morphological characters. Flowers, when available, were rehydrated before being measured and dissected.

A conservation assessment (IUCN 2001) was performed using the conservation assessment tools developed by Moat (2007). The Area of Occupancy (AOO) was calculated using the sliding scale as suggested by Moat.

Results

Inspection of all *Rinorea* specimens at WAG revealed two additional specimens belonging to the same taxon as *Wieringa et al. 5991* from Lastoursville. The first is a specimen with lamellate fruits from Franceville *(de Wilde et al. 9923*). This specimen was erroneously identified as *R. laurentii* De Wildeman (1920: 170) (Sosef *et al.* 2006) which is a taxon with smooth surfaced fruits from Mogandjo in the Democratic Republic of the Congo. The second is a flowering specimen from Lastoursville (*Breteler & de Wilde 785*). This specimen was erroneously identified as *R.* cf. *dentata* (Palisot de Beauvois 1807: 11) Kuntze (1891: 42) (Sosef *et al.* 2006), which is a widespread species with farinose fruits (Hawthorne & Jongkind 2006). A discussion of the affinities of the new species, as well as a key to Gabonese species of *Rinorea* with textured fruits, is given in the discussion after the description below. A key to all species of *Rinorea* in Central Africa is urgently needed, but is beyond the scope of this study.

Taxonomy

Rinorea calcicola Velzen & Wieringa, *sp. nov.* (Fig. 1)

Rinorea calcicola resembles *Rinorea zenkeri* with which species it shares the character of laminate fruits, but it has elliptic to obovate leaves and a thyrsoid inflorescence instead of obovate leaves with a racemose inflorescence.

Type:—GABON. Ogooué-Lolo: c. 4 km E of Lastoursville, old secondary forest next to limestone rockface, 0°48.25' S, 12°45.92' E, 330 m, 19 January 2008 (in fruit), *J.J. Wieringa, P.H. Hoekstra, R. Niangadouma & J.-N. Boussiengui 5991* (holotype WAG!; isotypes LBV, WAG! (2×) & 5 others to be distributed!).

Shrub up to about 2 m high; young branchlets pubescent. Cuspis/stipule 2–7 mm long, outer surface pubescent over the central area, margins ciliate. Leaves: petiole 6–12 mm long, 1.0–1.8 mm in diameter, adpressed pubescent; blade elliptic to obovate, 7–30 × 3–10 cm, papyraceous–coriaceous, acuminate at apex, rounded to cuneate at base, glabrous but below with hairs in the axils of the secondary veins, glossy, dark green above, pale green beneath, margin shallowly serrate, bearing lignified teeth; midrib pubescent and prominent below, above with a narrow prominent ridge that is often flanked by parallel grooves (grooves only present when dried), both midrib and grooves sparsely pubescent; secondary veins 11–13 pairs, anastomosing 1–4 mm from the margin, glabrous to sparsely pubescent at base below. Inflorescence terminal, thyrsoid, c. 5 cm long, pubescent, budscale at base consisting of a reduced leaf with two reduced stipules, all three bearing an apical tooth; lateral branches decreasing in length towards the apex, basal ones up to c. 2 cm long, with up to c. 20 flowers; bracts triangular, decreasing in size to the apex of the inflorescence, c. 1–4 × 0.4–1.5 mm and topped with a tooth. Flowers zygomorphic, 4–5 × 3–4 mm, pedicel 1–1.5 mm long, pubescent; sepals triangular or ovate, 1.2 × 1.5–2 mm, sparsely pubescent with ciliate margins, pale greenish yellow with brown-red margin and apex, (1–)2–3(–4) with a (sub-)apical tooth; petals five, 3–4 mm long, pale yellow, often with a nail-like tooth at or just below the apex, posterior (adaxial) petals two, ovate, concave, rarely with a tooth, lateral petals two, ovate to bell shaped, usually with a tooth, anterior (abaxial) petal bell shaped, longitudinally folded, apex emarginate, inner surface hairy below the apex, outer surface with an often pubescent longitudinal ridge topped by a subapical tooth; androecium 3 mm long, staminal tube 1–1.5 mm long, up to 0.3 mm thick, glabrous, adaxially discontinuous except for a 0.1 mm high ridge and sometimes a velum connecting to the adaxial filament, margin regularly undulate; stamens diadelphous; adaxial filament ± free, c. 3 mm

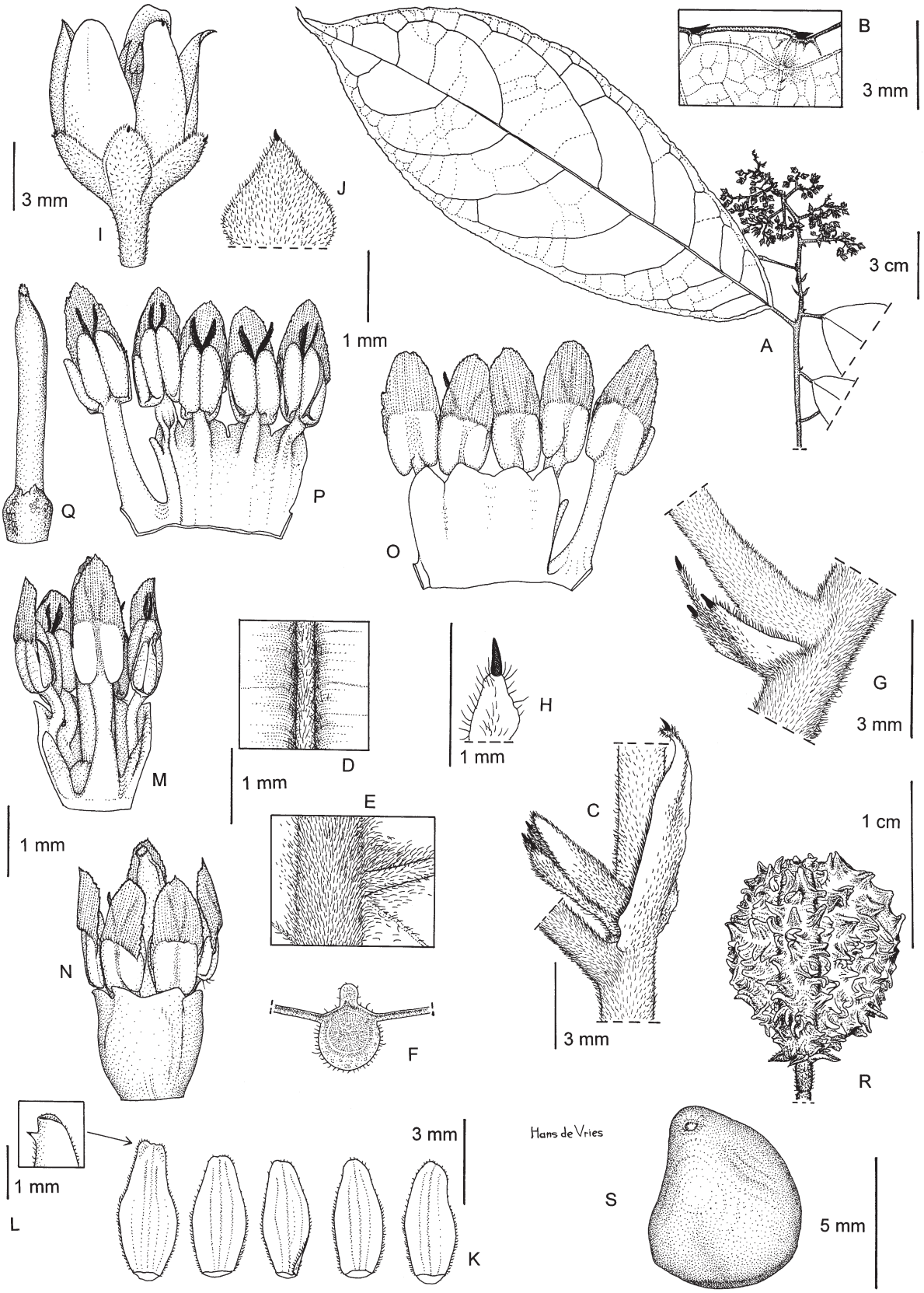

FIGURE 1. *Rinorea calcicola*. A. Flowering branch. B. Detail of leaf margin with teeth. C. Detail of leaf insertion with axillary bud and stipule. D. Detail of midrib area of the leaf blade from above. E. Detail of the midrib area of the leaf blade from below. F. Cross-section of leaf around the midrib G. Budscale/reduced leaf with 2 stipules at base of inflorescence. H. Bract at top of inflorescence. I. Flower. J. Sepal from outside. K. Petals from inside, most left is posterior petal, from there clockwise the other 4. L. Detail of apex of posterior petal, side view. M. Androecium from the adaxial side. N. Androecium from the abaxial side. O. Androecium from outside. P. Androecium from inside. Q. Ovary and style. R. Fruit, side view. S. Seed. A–Q based on *Breteler & de Wilde 785* (WAG); R–S based on *Wieringa et al. 5991* (WAG). Illustrator: Hans de Vries.

long, flattened, other 4 filaments inserted on the inner surface of the staminal tube, c. 2 mm long, flattened, anthers 1 mm long, connective scale red in dried flowers, ovate, c. 1 mm long, base decurrent on the upper half of the anthers, thecae with two ligulate connective appendages of c. 0.5 mm long; gynoecium flask-shaped, glabrous, ovary part developing black cork spots, style extending just beyond the connective appendices, ovary 1-loculate, with c. 6 ovules, placentation parietal. Fruit a capsule, obovoid-triangular, c. 13–17 × 9–12 mm, surface with lamellate corky protrusions of 1–3 mm long, up to 6-seeded; seeds tetrahedric, acutely angled, 5–6 mm long, smooth, grey or brown, dorsal faces concave, inner faces flat or concave.

Distribution:—SE Gabon, upper Ogooué River (Fig. 2).

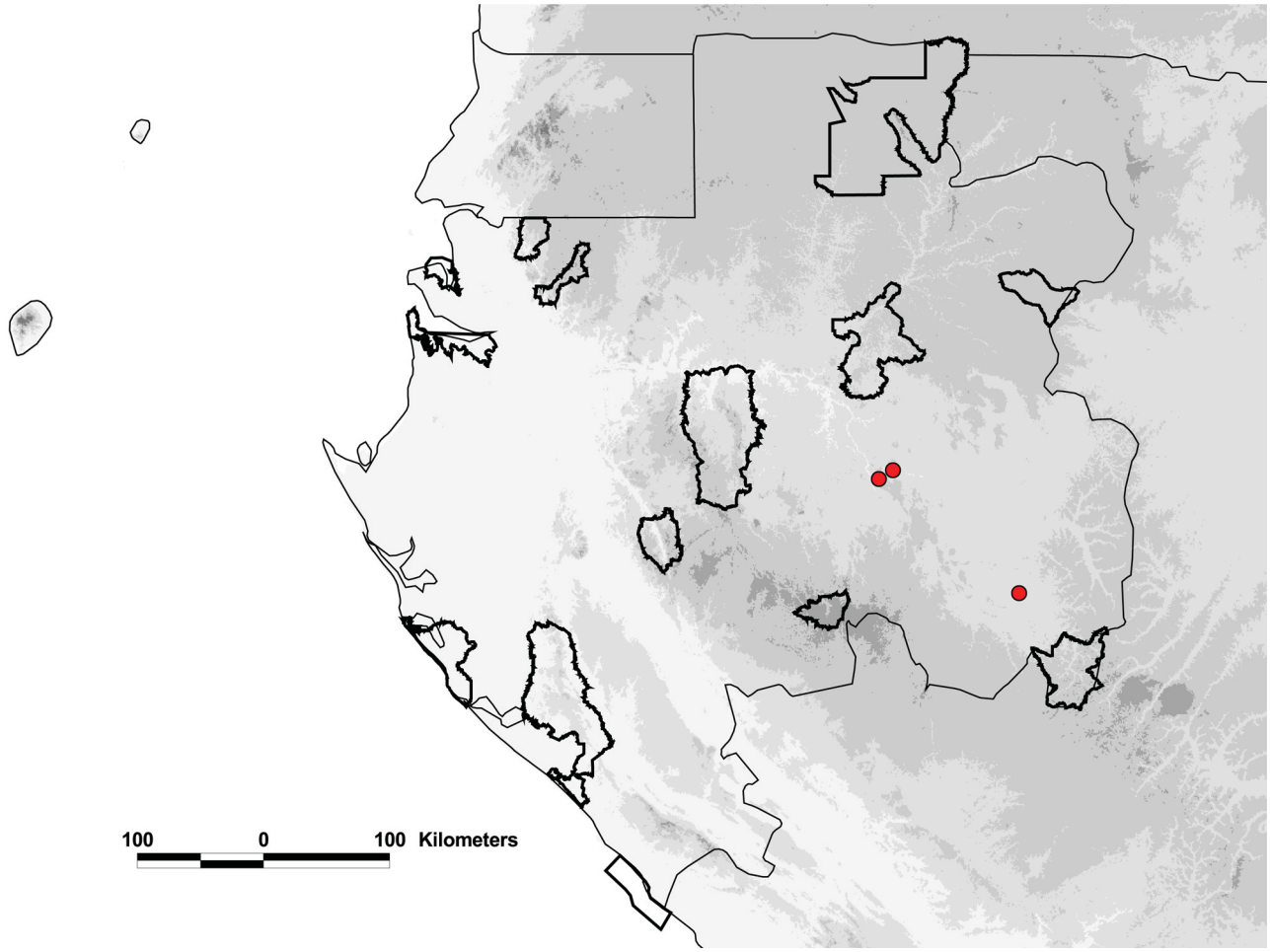

FIGURE 2. Distribution of *Rinorea calcicola* (red dots) including outlines of the National Parks in Gabon.

Habitat & Ecology:—Old secondary forest along the upper Ogooué River, 250–420 m elevation, on limestone (see discussion). Flowers observed in September, buds in December, fruits in December and January.

Etymology:—The epithet *calcicola*, meaning "living on chalk", refers to its assumed association with limestone (see below).

Conservation:—We assess *Rinorea calcicola* as Endangered, EN B1ab(ii,iii,iv,v), according to IUCN standards (IUCN 2001) and want to emphasise that further research may result in a status of Critically Endangered (CR). At present, *R. calcicola* is only known from three collections, with two localities being fairly close together (13 km apart) that we consider to belong to the same population. Three localities are just enough to calculate both an EOO and an AOO. The EOO of 884 km^2 falls within the Endangered range, while the AOO (cell size 14 × 14 km) of 616 km^2 indicates Vulnerable. We have used the sliding scale for grid cell size because we consider the 2 × 2 km grid cell size as advocated by IUCN in general far too small for botanical data from areas with relatively low sampling like Gabon. A grid cell size of 2 × 2 km would have resulted in a AOO of 12 km^2, being only slightly above the limit for Critically Endangered (CR). However, if we assume this species to be restricted to limestone, its actual AOO might be even less than 1 km^2, because the total amount of limestone in south-eastern Gabon is very

limited (Delorme 1979). One of the two known populations, that of Lastoursville, is under serious threat from local agriculture; when *Wieringa et al. 5991* was collected in 2008, slash-and-burn cropping fields were less than 100 metres away, while the label of *Breteler & de Wilde 785* from 1978 reads "Forest edge bordering local plantation". Other parts of the limestone strip may be a little further away from the agriculture front, but the species is only present in patches and does not occupy the full limestone strip. The locality SE of Franceville does not seem to be under any specific threat at the moment. Further research should establish whether the species is present on other limestone outcrops in the region.

Notes:—The most characteristic feature of *Rinorea calcicola* is the lamellate fruit. This character is shared only with *R. zenkeri*, which is a Cameroon endemic restricted to semi-deciduous forests (Achoundong 1996). Whereas *R. zenkeri* has obovate leaves with a cordate base and a racemose inflorescence, *R. calcicola* has elliptic to obovate leaves with an obtuse to cuneate base and a thyrsoid inflorescence. Another morphological peculiarity of *R. calcicola* is the strict diadelphous stamen arrangement. Whilst other *Rinorea* species with well-developed staminal tubes may have some free stamens, they are never as consistently diadelphous as those of *R. calcicola*. We initially selected *Breteler & de Wilde 785,* previously identified as *R.* cf. *dentata*, as possibly conspecific with the type collection (*Wieringa et al. 5991)* based on the shared character of relatively dense pubescence on the underside of the leaf midrib. On closer examination, the staminal tube morphology appeared to be different from that of *R. dentata* confirming that *Breteler & de Wilde 785* did not represent that species. Taking into consideration the vegetative similarities of *Breteler & de Wilde 785* with the two other collections of *R. calcicola* and the proximity of the collection locality to *Wieringa et al. 5991*, we concluded that all three collections represent the same taxon. This is further corroborated by one ovary of *Breteler & de Wilde 785* which has dark spots which we interpret as developing cork lamellae. Also, the very young buds of *de Wilde et. al. 9923* compare well with the flowers of *Breteler & de Wilde 785*, although the staminal tube is not yet developed and the young petals have more pronounced teeth than those of open flowers. As conspecific status of the fruiting and flowering material described here cannot be fully confirmed due to the lack of available fully developed flowers and fruits on the same individual, we have decided to designate *Wieringa et al. 5991* as the type collection, in contrast to the traditional type assignment of flowering material.

Additional material examined (paratypes):—GABON. Haut-Ogooué: falls in the Djoumou River, c. 7 km SE of Franceville on the road to Ndoumou, secondary high forest, ± 350–420 m, 1°41' S, 13°40' E, 6 December 1989 (in fruit and young floral buds), *J.J.F.E. de Wilde et al. 9923* (WAG!, LBV, 6 duplicates to be distributed!); Ogooué-Lolo: c. 10 km along the road from Lastoursville to Mékouyi, forest edge bordering local plantation, ± 250 m, 0°52'S 12°40'E, 25 September 1978 (in flower), *F.J. Breteler & J.J.F.E. de Wilde 785* (BR, C, LBV, MO, P, WAG!).

Discussion

According to the most recent classification of African *Rinorea* (Brandt 1914), the new species falls within *Rinorea* subgenus *Tubulosae* Brandt (1914: 406) (staminal tube present), section *Violanthus* Engler (1902: 133) (paniculate inflorescences and tetrahedric seeds), subsection *Dentatae* Engler (1902: 133) (staminal tube margins free, herbaceous sepals and petals, flowers > 4 mm long). Morphologically, *R. calcicola* has affinities with *R. zenkeri* and *R. dentata* based on fruit and leaf characters, respectively (see notes).

Many African *Rinorea* are larval host plants for at least 32 *Cymothoe* (Nymphalidae) butterflies, many of which are monophagous (Fontaine 1982, Amiet & Achoundong 1996, McBride *et al.* 2009, van Velzen *et al.* 2013). However, given the extreme rarity of *R. calcicola*, there is some doubt that it can sustain a monophagous *Cymothoe* species, although if that is the case, then the associated species of *Cymothoe* will be rare as well and probably is not yet known to science. It seems however more likely that *R. calcicola* is host to an oligophagous species that feeds on several species of *Rinorea*. In Cameroon, the hypothesised allied species *R. zenkeri* and *R. dentata* are larval host plants for the relatively oligophagous *Cymothoe coccinata* (Hewitson 1874) as well as some other closely related butterfly species (Amiet & Achoundong 1996). As *C. coccinata* is geographically widespread and also occurs in Gabon, one might expect its larvae to feed on *R. calcicola*. Because the herbarium material of *R. calcicola* shows characteristic caterpillar damage, at least one butterfly species is feeding on it, and this merits further research.

It appears that *Rinorea calcicola* is a biogeographically restricted species endemic to south-eastern Gabon. The type locality is just below a limestone outcrop near Lastoursville, while the flowering paratype *Breteler & de Wilde 785* is found 13 km from the type on the same slope between the Ogooué River and the plateau where a limestone seam is present (Delorme 1979), although no direct reference to limestone is given on its label. This area is known for many limestone outcrops and caves (Delorme 1979), but because the limestone is present mostly as seams, the total area where it is outcropping is very limited, and it can hardly be a coincidence that the second record from the Lastoursville area also lies in the zone where the limestone seam is present. The fruiting paratype *de Wilde et al. 9923* was found at the falls in the Djoumou River, indicating an outcrop of harder rock. Regrettably, we have not been able to establish if that is limestone as well, but we consider it likely. Limestone is quite rare in Gabon, and the fact that two of the collections are from a zone where limestone is exposed, and the third probably is as well, suggests that *R. calcicola* may be associated with limestone. However, this hypothesis clearly needs further substantiation by additional collections and geological data. In any case, the narrow distribution confirms reports of *Rinorea* species associated with particular forest types (Achoundong 1996), further validating their value as bioindicators for forest typification. In the few hours that were spent exploring the type collection site, several rare plant species were collected. Some of them, like *Anisotes macrophyllus* (Lindau 1894: 60) Heine (1966: 189), we consider to be associated with limestone as well. We recommend that botanical collectors target these rare limestone areas in Gabon because it is likely that they harbour a distinct flora which is poorly understood and under collected.

The distribution pattern of *Rinorea calcicola* coincides with that of a large number of other local endemics to this part of Gabon as recently discussed by Wieringa & Mackinder (2012). Although this area is one of the earliest areas in Gabon to become explored (van der Maesen & Wieringa 2013), still half of these species have only been recognised in the past decades, the most recent ones being *Dichapetalum inaequale* Breteler (2003: 9), *Trichoscypha debruijnii* Breteler (2004: 109), *Platysepalum bambidiense* van der Maesen (2010: 166) and *Hymenostegia elegans* Wieringa & Mackinder (2012: 145). *Rinorea calicola* is the 25th species to add to this list, and thus supplies further evidence for the importance of the region for biodiversity. Although *R. calcicola* might be more restricted than most other local endemics due to its association with limestone, it would be most useful for conservation planning to analyse the general pattern of these endemic species. It is worth noting that all these species occur outside the current system of National Parks, and lack legal protection. *Hymenostegia elegans* has been formally assessed as Vulnerable (VU) (Wieringa & Mackinder 2012), the other endemics lack formal conservation status assessments. Using herbarium collection distribution records, we carried out a preliminary range-based conservation assessments of the 21 other endemics for which herbarium records are available (see Wieringa & Mackinder 2012). Based on AOOs using the sliding scale, five of these species are classified as Critically Endangered (CR), seven as Endangered (EN), two as Vulnerable (VU) and seven as Data Deficient (DD), which we predict, when more data become available, will qualify for a category of threat as well. For the six species with enough records for calculating an EOO, the EOO results were the same as those for AOO, except one VU became EN. Pending formal conservation assessments of these endemics and a more general floristic analysis to determine areas in need of conservation (e.g. using Relative Floristic Resemblance; Wieringa & Sosef 2011) their distribution may nevertheless justify the creation of a new National Park.

Conclusions

A morphologically distinct species of *Rinorea* new to science has been discovered in a limestone area near Lastoursville, Gabon. Due to its habitat requirements this species is rare and assessed as Endangered (EN) according to the criteria of IUCN (2001). It may be the larval host plant to a species of *Cymothoe* butterfly. Future fieldwork should be focussed on the limited limestone locations of SE Gabon. The area around Lastoursville is rich in local endemics that warrant further analyses and possibly establishment of a new National Park.

Key

Below, we provide a key to the Gabonese species of *Rinorea* with verrucose, farinose or lamellate fruits, in addition to *R. zenkeri* from Cameroon. Despite the fact that species with such textured fruits do not form a natural group (Wahlert & Ballard 2012), we have produced a key with the aim to aid identification of these species when found in fruit.

1. Leaf base cordate; inflorescence bracts 3–10 mm long, covered with long hairs up to 1 mm 2
- Leaf base obtuse to cuneate; inflorescence bracts 1–4 mm long, glabrous or covered with short hairs < 0.1 mm 3
2. Inflorescence a raceme with undivided secondary ramifications; fruit lamellate..... ***R. zenkeri***
- Inflorescence a panicle with secondary ramification divided in threes; fruit verrucose..... ***R. curtirama*** Achoundong & Bos (1999: 128)
3. Lower leaf surface without glands; inflorescence terminal 4
- Lower leaf surface covered with glands; inflorescence usually axillary ..... ***R. verrucosa*** Chipp (1923: 293)
4. Leaves obovate, with densely dentate margins; filaments glabrous; fruits farinose or lamellate..... 5
- Leaves elliptic, with coarsely dentate margins; filaments hairy; fruits verrucose..... ***R. cerasifolia*** Brandt (1913: 118)
5. Fruits farinose; staminal tube continuous, all filaments inserted on the inner side of the staminal tube; midrib below sparsely covered with hairs..... ***R. dentata***
- Fruits lamellate; staminal tube discontinuous, adaxial filament free, other filaments inserted on the inner side of the staminal tube; midrib below densely covered with hairs ..... ***R. calcicola***

Acknowledgements

We are grateful to Hans de Vries for the excellent detailed drawing of *Rinorea calcicola* and for his contribution to our discussions on the floral morphology. Ton de Winter (Naturalis) directed the second author to the limestone outcrop near Lastoursville and he and Benoît Fontaine (MNHN) kindly provided the speleological map of the Lastoursville region. Barbara Mackinder (Kew) and Marc Sosef (Meise) provided useful comments on the draft manuscript, and we would like to thank Gregory Wahlert as well for a thorough review. Two of the three collections of *R. calcicola* were made during expeditions undertaken by WAG in cooperation with the National Herbarium of Gabon (LBV), part of the IPHAMETRA institute of CENAREST. We would like to thank IPHAMETRA for all help provided during our numerous missions. We would also like to thank Precious Woods that has provided logistic support for many missions to the Lastoursville area, including the one that led to the discovery of the new species described here.

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