




Addressing the *Vepris verdoorniana* complex (Rutaceae) in West Africa, with two new species

Martin Cheek¹ , Jean-Michel Onana², Shigeo Yasuda¹, Poppy Lawrence³, Gabriel Ameka⁴ & Greta Buinovskaja⁵

Summary. *Vepris verdoorniana* (Rutaceae) has long been regarded as a widespread and variable species occurring from Guinea to Gabon. Recent evidence has shown that the original material from the type locality in Cameroon consists of two different species, *V. verdoorniana* in the strict sense, endemic to Lower Guinea (Cameroon, Gabon and C.A.R. in W-C Africa) and *V. letouzeyi* Onana, which was thought to occur from Guinea to Cameroon. In this paper we show that the West African (Upper Guinea) material previously referred to as *V. letouzeyi/V. verdoorniana* is separate morphologically from that in Cameroon (Lower Guinea). In fact the West African material referred to comprises two distinct species, here described as *V. occidentalis* Cheek & Onana (Guinea to Ghana, but probably extending to Benin) a tree of lowland marginal dry evergreen and semi-deciduous forest, and *V. fer* Cheek, a species restricted to four mainly lower submontane forest locations on iron substrates in Liberia and Sierra Leone (also Upper Guinea). *Vepris occidentalis* is here assessed as Least Concern due to its wide range and high frequency, whilst *V. fer* is assessed as Endangered due to the low number of locations and threats from iron ore mining projects. Both new species are illustrated and mapped.

Key Words. Arcelor Mittal, conservation assessments, endangered, Gola, iron substrate, mining natural products, *Teclea*.

Introduction

Vepris Comm. ex A.Juss. (Rutaceae-Toddaliaceae), is a genus with 86 accepted species, 22 in Madagascar and 65 in Continental Africa with one species extending to Arabia and another endemic to India (Plants of the World Online, downloaded 25 May 2018). Four new species were recently described from Cameroon (Onana & Chevillotte 2015; Cheek *et al.* 2018a) and one more is in press (Onana *et al.* 2019), taking the total in Cameroon to 22 species, the joint highest number for any country. Many of these 22 species are endemic to western Cameroon (SouthWest Region and NorthWest Regions of Cameroon) and several are threatened (Onana & Cheek 2011). Western Cameroon is the most species-diverse area for vascular plants per degree square in tropical Africa and contains several refugia areas (Barthlott *et al.* 1996; Cheek *et al.* 2001).

In continental Africa, *Vepris* are easily recognised. They differ from all other Rutaceae because they have digitately (1 –) 3 (– 5)-foliolate (not pinnate) leaves, and unarmed (not spiny) stems. The genus consists of

evergreen shrubs and trees, predominantly of tropical lowland evergreen forest, but with some species extending into submontane forests and some into drier forests and woodland. *Vepris* species are often indicators of good quality, relatively undisturbed evergreen forest since they are not pioneers (Cheek, Onana pers. obs. 1992 – 2016).

Species of *Vepris* in Africa extend from South Africa, e.g. *Vepris natalensis* (Sond.) Mziray, to the Guinean woodland in the fringes of the Sahara desert (*V. heterophylla* (Engl.) Letouzey). Mziray (1992) subsumed the genera *Araliopsis* Engl., *Diphasia* Pierre, *Diphasiopsis* Mendonça, *Oricia* Pierre, *Teclea* Delile, and *Toddaliopsis* Engl. into *Vepris*, although several species were only formally transferred subsequently (e.g. Cheek *et al.* 2009; Onana & Chevillotte 2015). Mziray's conclusions were confirmed by the molecular phylogenetic studies of Morton (2017) but sampling was limited, identifications appeared problematic (several species appear simultaneously in different parts of the phylogenetic trees) and more molecular work would be desirable. Morton studied about 14 taxa of *Vepris*,

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¹ Science, Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, UK. e-mail: m.cheek@kew.org

² Faculté des Sciences de l'Université de Yaoundé I, BP 812, Yaoundé, Cameroon.

³ Biosciences, College of Life and Environmental Sciences, University of Exeter, Exeter, EX4 4QD, UK.

⁴ Herbarium, Botany Department, University of Ghana, P.O. Box 55, Legon, Ghana.

⁵ Herbarium, Botany Department & Trinity Centre for Biodiversity Research, School of Natural Sciences, Trinity College Dublin, Dublin 2, Ireland.

mainly those from eastern Africa. Nevertheless, characteristics of some of the former genera are useful today in grouping species. The “araliopsoid” species have subglobose, 4-locular fruit with 4 external grooves; the “oricoid” species are apocarpous in fruit; the fruits of “diphasioid” species are laterally compressed in one plane, bilocular and bilobed at the apex; while “tecleoid” species are unilocular in fruit and 1-seeded, lacking external lobes or grooves. There is limited support for these groupings in Morton’s study,

Due to the essential oils distributed in their leaves, and the alkaloids distributed in their roots, several species of *Vepris* have traditional medicinal value (Burkill 1997). Burkill details the uses, essential oils and alkaloids known from five species in west Africa: *V. hiernii* Gereau (as *Diphasia klaineana* Pierre), *V. suaveolens* (Engl.) Mziray (as *Teclea suaveolens* Engl.), *V. afzelii* (Engl.) Mziray (as *T. afzelii* Engl.), *V. heterophylla* (Engl.) Letouzey (as *T. sudanica* A.Chev.) and *V. verdoorniana* (Exell & Mendonça) Mziray (as *T. verdoorniana* Exell & Mendonça) (Burkill 1997: 651 – 653). Research into the characterisation and antimicrobial and anti-malarial applications of alkaloid and limonoid compounds in *Vepris* is active and ongoing, although sometimes published under generic names no longer in current use, e.g. Wansi *et al.* (2008). Applications include as synergists for insecticides (Langat 2011). Cheplogoi *et al.* (2008) and Imbenzi *et al.* (2014) respectively list 14 and 15 species of *Vepris* that have been studied for such compounds.

The most recent revision of the African Toddalieceae was by Verdoorn (1926), who recognised 49 taxa in the genera now included in *Vepris*. Her revision underpinned subsequent Flora accounts. In the account for *Conspectus Florae Angolensis*, Exell & Mendonça (1951) evidenced that she had mistakenly attributed the name *Teclea grandifolia* Engl. (now *Vepris grandifolia* (Engl.) Mziray) for which the type is Angolan, to another, undescribed species diagnosed by pedicellate flowers and axillary inflorescences, for which they published the new name *T. verdoorniana* Exell & Mendonça. Verdoorn (1926) had cited three specimens for her “*Teclea grandifolia*” from Cameroon (*Staudt* 472, 493 and *Mildbraed* 9234) and one from Sierra Leone (*Barter* s.n.). Exell & Mendonça (1951) selected one of these, *Staudt* 472 (K) as type. In the second edition of *Flora of West Tropical Africa*, Keay (1958) recognised three species of *Teclea* in West Africa, separating *T. verdoorniana* from *T. afzelii* Engl. and *T. sudanica* A.Chev. (now *V. heterophylla*) by the possession of inflorescences both axillary and terminal, hairy, to 4 cm long, (vs all axillary, glabrous, to 2.5 cm long), petioles often winged and leaflets sessile (vs non-winged, leaflets petiolulate). Letouzey followed this delimitation in *Flore du Cameroun* (1963) and pointed out that the *Mildbraed* specimen is from C.A.R.

Onana & Chevillotte (2015) showed that since Verdoorn (1926), authors had unwittingly included more than one species in *Vepris verdoorniana*. Onana & Chevillotte (2015) linked *Staudt* 493, which has winged, not terete petioles, with additional specimens from Southwest Region Cameroon and described them as *V. letouzeyi* Onana, showing that it is a diphasioid, not a tecleoid species. They gave *V. letouzeyi* the range formerly attributed to *V. verdoorniana*, i.e. Guinea to Gabon, that is occurring in both Upper Guinea (Guinea to Ghana) and Lower Guinea (Nigeria to Congo Republic).

These two phylogeographic units are separated by the Dahomey Gap (see e.g. Demenou *et al.* 2017). *Vepris verdoorniana*, differentiated among other characters by terete petioles and based on the type *Staudt* 472, was now shown to be restricted to the Cameroon coastal plain (Onana & Chevillotte 2015), Bioko, Gabon and C.A.R.

However, comparison of the West African (that is, Upper Guinea) material attributed to, or attributable to, *Vepris verdoorniana* by the definition of Keay (1958) shows that it is morphologically separate from both *V. verdoorniana* and *V. letouzeyi* of Lower Guinea. The Upper Guinean (Guinea to Ghana, possibly Benin) winged-petiole material considered to be *V. letouzeyi* in Onana & Chevillotte (2015) is a different taxon, named below as *V. occidentalis*. Further, a second undescribed taxon is present in Upper Guinea, which had also been included in *Teclea verdoorniana* by Keay (1958). The species represented by *Barker* 1181 (K!) has opposite leaves, nearly glabrous inflorescences and very large, pitted fruits. It occurs in the Gola Forest of Sierra Leone near the border with Liberia and in Liberia at the southern end of Mt Nimba and in the Putu Hills. This species is here termed *V. fer* Cheek.

Here we present a key and table of characters (Table 1) separating the taxa of the *Vepris verdoorniana* complex based largely on morphology. We also present a key and table of characters (Table 2) to all the tecleoid (unilocular) West African (Upper Guinean) species and present a synopsis of the species with descriptions, illustrations and conservation assessment of the two new species to science.

Approximately 2000 new flowering plant species are described each year (Willis 2017), adding to the estimated 369,000 already known to science (Nic Lughadha *et al.* 2016) although this total is disputed (Nic Lughadha *et al.* 2017). Evidence based conservation assessments exist for about 21 – 26% of these species, and 30 – 44% of these assessments rate the species concerned as threatened (Bachman *et al.* 2018). Widespread species tend to have already been discovered, so that many newly discovered species are those that are range-restricted and so more likely to be threatened, e.g. *Vepris bali* Cheek (Cheek *et al.* 2018a). This makes it imperative to discover and

Table 1. Characters distinguishing the species of the *Vepris verdoorniana* complex (data for *V. verdoorniana* sensu stricto and *V. letouzeyi* from Onana & Chevillotte 2015).

Characters	<i>Vepris verdoorniana</i>	<i>Vepris letouzeyi</i>	<i>Vepris fer</i>	<i>Vepris occidentalis</i>
Geography	Cameroon, Bioko, C.A.R., Gabon	SW Region Cameroon	Sierra Leone & Liberia	Guinea to Ghana, possibly Benin
Petiole	terete (rarely slightly canaliculate)	canaliculate	canaliculate	laterally winged
Gland dots on lower surface of leaflets observed with naked eye	fine black dots, conspicuous	fine black dots, conspicuous	fine black dots, conspicuous	dots concolorous with blade, not conspicuous
Stamen number	4	8	4	4
Carpel number	1	2	1	1
Fruit shape & dimensions (cm)	narrowly ovoid 1.2 × 0.4	bilobed 2 – 2.75 × 1 – 1.5	ellipsoid (0.6 –) 1.1 – 1.5 × (0.4 –) 0.5 – 0.6 (– 0.8)	ovoid-ellipsoid 0.6 – 0.8 (– 0.9) × 0.4 – 0.6 (– 0.7)
Phyllotaxy	alternate (rarely subopposite at some nodes)	alternate	opposite (rarely alternate)	alternate
Inflorescence indumentum	densely yellow pubescent	densely yellow pubescent	inconspicuously and sparsely yellow hairy	densely yellow pubescent

publish such species so that they can be assessed, and, if merited, conservation actions taken to reduce their extinction risks, such as through designating and implementing Important Plant Areas (Darbyshire *et al.* 2017).

Materials and Methods

This study is based on herbarium specimens. All specimens seen by the authors are indicated “!”. Herbarium citations follow Index Herbariorum (Thiers continuously updated), nomenclature follows Turland *et al.* (2018) and binomial authorities follow IPNI (continuously updated). Material of the suspected new species was compared morphologically with material of all other African *Vepris*, principally at K, but also using material and images from BM, BR, FHO, G, GC, HNG, P and YA. Specimens at WAG were unavailable during the period of study due to building work, and but low resolution images of specimens were viewed on the Naturalis website (<https://bioportal.naturalis.nl/>). Specimens referred to in Aké Assi (2001) are held privately in Ivory Coast and are not accessible at present. The main online herbarium used during the study apart from that of WAG was that

of P (<https://science.mnhn.fr/all/search>). Points were georeferenced using locality information from herbarium specimens. The map was made using ArcMap version 10.5, with additional layers showing protected areas (IUCN & UNEP-WCMC 2017) and lakes (Esri 1992). The conservation assessment was made using the categories and criteria of IUCN (2012). Herbarium material was examined with a Leica Wild M8 dissecting binocular microscope fitted with an eyepiece graticule measuring in units of 0.025 mm at maximum magnification. The drawing was made with the same equipment using a Leica 308700 camera lucida attachment.

Results

We present tables and keys separating the two new taxa from those with which they have previously been included. The species treatments that follow are presented in the order of the taxa in Table 1 above, beginning with *Vepris verdoorniana* under which name all four taxa treated in this paper were previously known (hence the “*Vepris verdoorniana* complex”, followed by *V. letouzeyi*, recently segregated from the former, followed by the two new species.

Table 2. Characters distinguishing the West African (Guinea to Ghana) tecteleoid (unilocular) *Vepris* species.

Characters	<i>Vepris afzelii</i>	<i>Vepris heterophylla</i>	<i>Vepris fer</i>	<i>Vepris occidentalis</i>
Phyllotaxy	alternate	alternate	fully opposite (rarely alternate)	alternate
Petiole	canaliculate	terete	canaliculate	laterally winged
Inflorescence length (cm)	to 2.5	to 2.5	2.4 – 5.4	to 3.6
Inflorescence indumentum	glabrous	glabrous	sparsely hairy	densely hairy
Leaflets petiolulate or sessile	petiolulate	petiolulate	sessile	sessile
Fruit length (cm)	0.7 – 0.8	0.8 – 0.9	(0.6 –) 1.1 – 1.5	0.6 – 0.8 (– 0.9)

Key to the species of the *Vepris verdoorniana* complex

1. Petiole terete, not (rarely slightly) canaliculate or winged; fruits narrowly ovoid with persistent style **1. *Vepris verdoorniana***
 1. Petiole winged or canaliculate; fruits ellipsoid or bilobed, lacking persistent style 2
 2. Petioles with lateral wings, widest near the apex; leaflets with oil glands not visible to the naked eye on the abaxial surface (concolorous); fruits 0.8 cm long **4. *Vepris occidentalis***
 2. Petioles canaliculate, without lateral wings; leaflets with oil glands visible with naked eye as black dots on abaxial surface; fruits 1.1 – 2.75 cm long 3
 3. Leaves opposite (rarely alternate); inflorescence sparsely and inconspicuously hairy; fruit ellipsoid 1.1 – 1.5 × 0.5 – 0.6 cm; stamens 4 **3. *Vepris fer***
 3. Leaves alternate; inflorescence densely yellow pubescent; fruit bilobed 2 – 2.75 × 1 – 1.5 cm; stamens 8 **2. *Vepris letouzeyi***
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Key to the tectleoid (unilocular) species of West African *Vepris*

1. Petioles laterally winged; inflorescences densely hairy. ***Vepris occidentalis***
 1. Petioles terete or canaliculate; inflorescences glabrous or sparsely hairy 2
 2. Leaves fully opposite (rarely alternate); leaflets sessile; inflorescence sparsely hairy; fruit > 1 cm long, pits, deep, conspicuous ***Vepris fer***
 2. Leaves alternate; leaflets petiolulate; inflorescence glabrous; fruit < 1 cm long, pits absent or inconspicuous 3
 3. Petioles canaliculate; young stems and inflorescences drying black; plants of humid, submontane forest ***Vepris afzелиi***
 3. Petioles terete; young stems and inflorescences drying pale brown or grey; plants of dry, wooded grassland. ***Vepris heterophylla***
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Synopsis of the species of the *Vepris verdoorniana* complex

- 1. *Vepris verdoorniana*** (Exell & Mendonça) Mziray (1992: 76); Heller & Cheek in Cheek *et al.* (2004: 396). Type: Kamerun, Johann Albrechtshöhe (now Cameroon, Kumba), fl. 1896, *Staudt* 472 sheet 2 (lectotype formally designated here, K000094280!). *Teclea verdoorniana* Exell & Mendonça (1951: 270); Letouzey (1963: 118); Keay (1958: 689)

DISTRIBUTION. Cameroon, Gabon, C.A.R., Bioko.

HABITAT. Lowland evergreen forest.

CONSERVATION STATUS. Provisionally assessed here as Near Threatened since c. 12 locations are known, the area of occupancy is estimated as 48 km² (using the 4 km² cells recommended by IUCN 2012) with threats being the clearance of forest habitat at seven or eight of those locations.

ETYMOLOGY. Named in honour of Inez Clare Verdoorn (1896 – 1989), South African botanist noted for her numerous taxonomic revisions.

LOCAL NAMES. None known.

LOCAL USES. None known.

NOTES. The type number indicated by Exell & Mendonça (1951), *Staudt* 472, K, consists of two sheets each with a different species. That labelled sheet 2 (K000094280!) is

selected here as the lectotype of *Vepris verdoorniana* since, having e.g. terete petioles, it is consistent with the concept of *V. verdoorniana* in the sense of Onana & Chevillotte (2015), while sheet 1 (K000094281!) has short, winged petioles and appears to be *V. letouzeyi*, a species already known to have been collected at the same location by the same collector (*Staudt* 493).

- 2. *Vepris letouzeyi*** Onana, in Onana & Chevillotte (2015: 117). Type: Cameroon, Southwest Region, Mundemba, Fabe Rd, fr. 22 Nov. 1986, *Nemba* & *Thomas* 335 (holotype YA0060230!; isotype MO).

DISTRIBUTION. Southwest Region, Cameroon.

REPRESENTATIVE SPECIMEN EXAMINED. CAMEROON, Southwest Region, Kumba “Kamerun, Johann Albrechtshöhe” [now Cameroon, Kumba], fl. 1896, *Staudt* 493 (K00094288!).

HABITAT. Lowland evergreen forest.

CONSERVATION STATUS. Endangered B2 ab(iv) since three locations are known, none of which are in protected areas, and all are near towns or villages and so at risk of clearance for small-scale agriculture (pers. obs. Cheek 2006). Area of occupancy is estimated as 12 km² using the standard IUCN preferred 4 km² cells.

ETYMOLOGY. Commemorating René Letouzey, founder of the Etude de la Flore du Cameroun programme, *Flore du Cameroun* series and the National Herbarium of Cameroon (Onana *et al.* 2017).

LOCAL NAMES. None known.

LOCAL USES. None known.

NOTES. *Staudt* 493, assigned to this species by Onana & Chevillotte (2015), was amongst the original material of *Vepris verdoorniana* (see above under that species and in introduction). Here we also assign sheet 1 of *Staudt* 493 to this species (see under *V. verdoorniana* above).

The protologue indicates that this species has 8-stamened male flowers and bilocular, apically bilobed fruits, characteristic of the “diphasoid” *Vepris* species, completely distinct from the 4-stamened, 1 locular, non-lobed “tecleoid” species that comprise the rest of the *Vepris verdoorniana* complex.

3. *Vepris fer* Cheek sp. nov. Type: Sierra Leone, Kenema Distr., Ganta Chiefdom, Gola Forest Reserve, fl. fr. 23 April 1965, *Fox* 124 (holotype K000875068!; isotype SL n.v.).

<http://www.ipni.org/urn:lsid:ipni.org:names:77198957-1>

Teclea verdoorniana sensu Keay (1958: 689) pro parte quoad *Barker* 1181 (K!); sensu Adam (1975: 1494, fig 771).

Dioecious (probably) tree or shrub. 7 – 9 m tall, circumference (girth) to 30 cm. Trunk features unknown. *Leafy stems* terete, 2.5 mm diam., internodes 1.8 – 10 cm long, pale grey-brown, with sparse longitudinal ridges and scattered, slightly raised, elliptic or orbicular lenticels (0.25 –) 0.4 – 0.75 (– 0.9) × (0.2 –) 0.4 – 0.5 mm, becoming most conspicuous in the second and third internodes from the apex, glabrous. *Leaves* opposite (rarely alternate — part of one short fruiting stem on *Fox* 124, K), trifoliolate, petioles canaliculate, 2.2 – 4.5 (– 7) × 0.1 cm, glabrous, slightly swollen at base. *Leaflets* oblong-elliptic or elliptic, subequal, the lateral leaflets $\frac{2}{3}$ to the same length as the median; median 6.9 – 16.6 × 2.5 – 6.9 cm, laterals 6.5 – 13.5 × 2.4 – 4.5 cm; acumen 0.8 – 1.8 × 0.28 – 0.45 cm, apex rounded; base of leaflet subsessile gradually decurrent into an indistinct, narrowly winged petiolule (0.2 –) 0.5 – 0.6 (– 0.75) cm long. Lateral nerves 11 – 15 on each side of the midrib, arising at c. 80° from the midrib, connecting towards the margin and forming a looping inframarginal nerve, sometimes with a further, weak parallel nerve between the margin and the looping secondary nerve; intersecondary nerves 1 (– 3) between and parallel, each pair of secondary nerves, connecting with the marginal nerve, almost as thick as the secondary nerves; tertiary and quaternary nerves

conspicuous, raised, forming a loose reticulum; oil glands visible to the naked eye on lower surface, black, 0.125 mm diam., 600 – 1100 per cm², both surfaces glabrous.

Inflorescence axillary, 70 – 100-flowered, subtended by leaves, often caducous, 2.4 – 5.4 cm long, axis very sparsely and inconspicuously hairy, hairs 0.05 mm long, patent. Peduncle (1 –) 7 – 17 mm long, sometimes branching from near the base; bracts narrowly oblong, densely yellow-hairy, 0.6 – 1 mm long. Pedicel terete, glabrous, 1 – 1.5 mm long, accrescent in fruit, (0.3 –) 0.5 (– 0.8) × 0.1 – 0.15 cm. *Male flowers* cream-coloured or greenish-white, c. 2.5 × 3 mm at anthesis; calyx shallowly cup-shaped, 0.2 – 0.3 × 1.2 mm, with 4 shallow, broadly triangular lobes c. 0.2 × 0.7 mm, glabrous, oil glands not conspicuous. *Petals* 4, free, ovate-oblong (1.5 –) 1.7 – 2 × 0.7 – 0.8 mm, apex acute, glabrous, oil glands not conspicuous. *Stamens* white, 4, free, anthers partly exerted above petals; filaments cylindrical 1.8 × 0.2 mm, apex geniculate, narrowing; anthers elliptic, 4-celled, 0.7 – 0.8 × 0.5 mm. *Pistillode* ovoid (proximal half) – cylindrical (distal half), 1 mm long, 0.5 mm wide (proximal half), 0.2 mm diam. (distal half), apex rounded, sparsely hairy, hairs spreading, bristle-like, 0.1 mm long. *Female flowers* unknown. *Infructescences* 2 – 6, on leafy stems, axillary, each c. 2 – 3 cm long and wide, 1 – 5-fruited, peduncle 0.1 cm. Fruit ripening yellow, surface deeply pitted (*J. G. Adam* 27597), ellipsoid-ovoid (0.6 –) 1.1 – 1.5 × (0.4 –) 0.5 – 0.6 (– 0.8) cm, apex acute to obtuse, base rounded to truncate, surface pits dense, conspicuous, elliptic 0.4 – 0.6 (– 1) mm long, fruit wall c. 2 mm thick, 1-locular, 1-seeded (*Adam* 1975: Planche 771). Fig. 1.

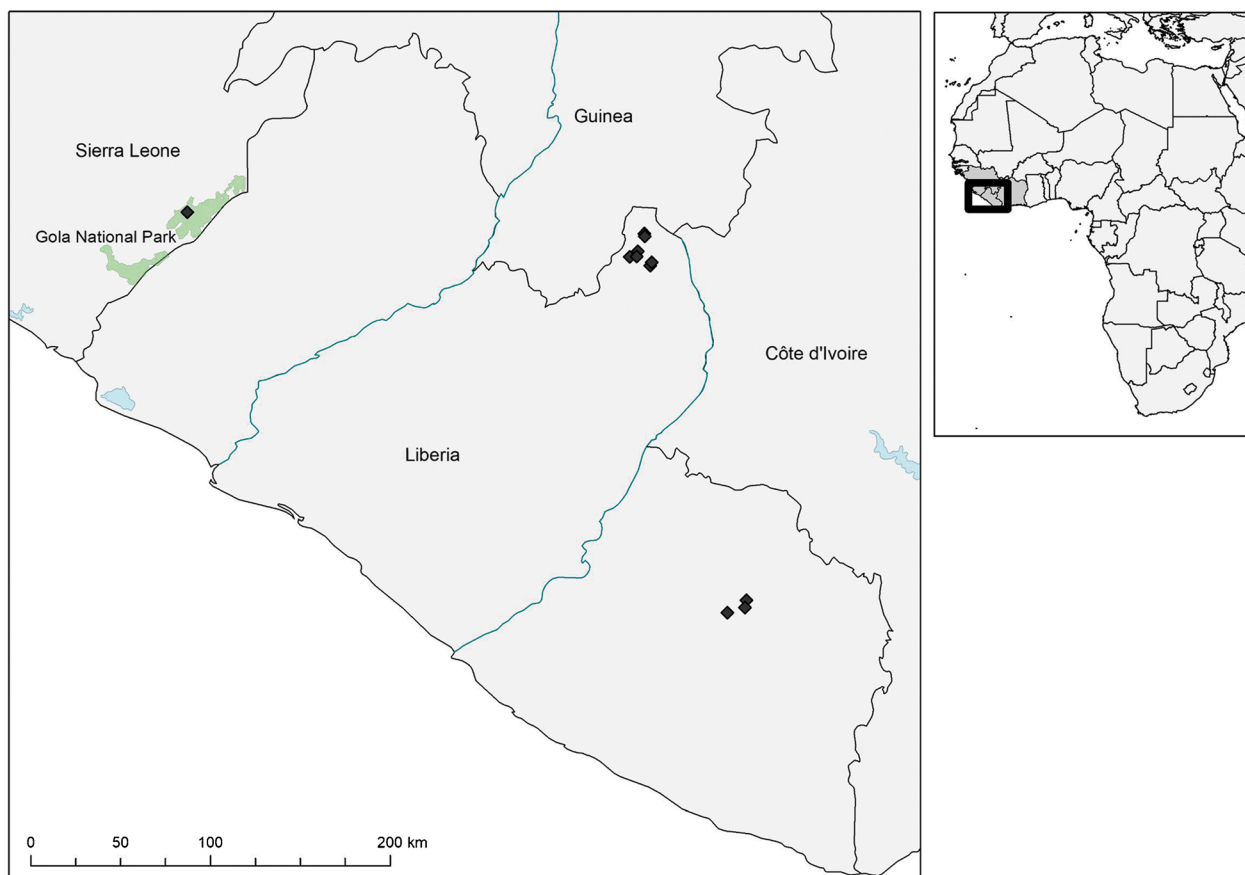
RECOGNITION. Differing from *Vepris verdoorniana* in the canaliculate (not terete) petioles, the ovoid-ellipsoid, conspicuously and deeply pitted fruits (not narrowly ellipsoid, pits absent or inconspicuous), leaves opposite (not usually alternate).

DISTRIBUTION. Sierra Leone, Gola Forest and Liberia, Mount Bele (=Mt Bili), Mount Tokadeh area and Putu Hills. Map 1.

SPECIMENS EXAMINED. SIERRA LEONE. Gola Forest Reserve, Geuta Chiefdom, Kenema distr., on red brown gravel soil – flat ground, fl. fr., 23 March 1965, *Fox* 124 (K000875068!). **LIBERIA. Mt. Nimba: Mt Bélé,** Mt Bili, 25 Dec. 1951, fl., *A. Barker* 1181 (K000875067!, P06600558!), fr., 17 May 1973, *J. G. Adam* 27597 (P02143761!, BR0000019425542!); Mt Bele, 7°25'2"N 8°35'31"W, 617 m, st., 20 May 2010, *Hawthorne* DBSL16 (FHO!); Mt Bele, 7°25'1"N 8°35'42"W, 690 m, st., 20 May 2010, *Hawthorne* DBSL15 (FHO!); Mt Bele, 7°25'0"N 8°35'27"W, 573 m, st., 20 May 2010, *Hawthorne* EPSL22 (FHO!); Road to Zotarpa from Grassfield, opposite Mt Bele, 7°25'19"N 8°35'20"W, 546 m, st., 4 June 2010, *Hawthorne* EPHT20



Fig. 1. *Vepris fer*. A habit, stem showing abaxial leaf surfaces and male (possibly abnormally contracted) inflorescence; B habit, fruiting stem, adaxial leaf surfaces; C detail of leaf-blade showing raised surface gland dots (abaxial surface); D detail of junction of canaliculate petiole with subsessile leaflets, including transverse section of petiole (left); E male flowers, side view; F pistillode, side view; G pitted fruit with pedicel. All from Fox 124 (K). DRAWN BY ANDREW BROWN.



Map 1. Global distribution of *Vepris fer* in West Africa.

(FHO!); **Yuelliton DSO**, 7°33'40"N 8°37'49"W, 766 m, st., 28 May 2010, *Hawthorne* EPSL30 (FHO!); **West Gangra** close to Villi River, 7°32'56"N 8°38'55"W, 549 m, st., 24 April 2010, *Hawthorne* EPHT06 (FHO!); Mt Gangra DSO site, 7°32'52"N 8°37'40"W, 695 m, st., 14 May 2010, *Hawthorne* EPSL20 (FHO!); **Mt Beeton**, approx 3 km S from Bonlah, 7°32'48"N 8°39'32"W, 626 m, st., 3 May 2010, *Hawthorne* EPSL11 (FHO!); **Bentor Area**, 7°30'29"N 8°40'4"W, 591 m, st., 29 Nov. 2011, *Hawthorne* PSSL07 (FHO!); Bentor to Gbapa footpath, 7°30'19"N 8°39'43"W, 651 m, st., 29 Nov. 2011, *Hawthorne* PSHT14 (FHO!); **Tokadeh**, close to steel ladder, 7°26'40"N 8°39'35"W, 658 m, st., 20 April 2010, *Hawthorne* EPVB02 (FHO!); Mt Tokadeh, 7°27'42"N 8°40'36"W, 791 m, st., 21 April 2010, *Hawthorne* DBPM01 (FHO!); SW of stock pile 2 by proposed road, 7°27'4"N 8°39'53"W, 622 m, st., 7 May 2010, *Hawthorne* DBSL10 (FHO!); Tokadeh — along old haul road, 7°26'50"N 8°40'3"W, 776 m, st., 17 May 2010, Mt Zorwu (Tokadeh), 7°28'18"N 8°39'48"W, 779 m, st., 25 Nov. 2011, *Hawthorne* PSHT12 (FHO!); *Hawthorne* EPHR02 (FHO!); **Vayampa**, next to road in community forest, approx 3 km before 7°26'38"N 8°42'9"W, 481 m, st., 15 May 2010, *Hawthorne* DBPF03 (FHO!); 2 km E of Vayampa nr road, 7°26'16"N 8°41'54"W, 494 m, st., 1 Nov. 2011, *Hawthorne* PSUS01

(FHO!); **Putu Hills**: Mt Ghi (Putu W) ridge, 5°39'37"N 8°12'48"W, 504 m, st., 28 Nov. 2010, *Hawthorne* EPHT02 (FHO!); David's town to Mt Montröh, 2.5 km NW of David's Town, 5°43'21"N 8°7'7"W, 239 m, st., 15 Dec. 2010, *Hawthorne* EPSL10 (FHO!); Panwloh to Mt Montröh, 2 km N of Panwloh Town and S of Mt Montröh ridge, 5°41'10"N 8°7'29"W, 239 m, st., 16 Dec. 2010, *Hawthorne* EPFL07 (FHO!);

HABITAT. Undisturbed submontane evergreen forest; (239 –) 480 – 790 m alt. "On red brown gravel soil – flat ground" (Fox 124). The lower boundary of submontane forest is often taken as the 500 m contour in the Guinea Highlands (e.g. Cheek & Williams 2016).

CONSERVATION STATUS. *Vepris fer* is known from three fertile specimens at two locations, Gola and Mt Bili. However, 20, (see list above) sterile plot voucher specimens are also known, 17 from Mt Bili and neighbouring Mt Tokadeh locations, and three also from a disjunct location in eastern Liberia, the Putu Hills.

The Sierra Leone location is within the Gola National Park which is protected. At Gola the species seems to be extremely rare. Botanical surveys in the Gola Forest in recent years by Hawthorne (FHO, pers. comm.), Cuni-Sanchez (Dec. 2012), and in March and

Oct. 2013 by Momoh, Saradugu, Swaray (SL), van der Burgt and Lopez-Poveda (K) produced no additional specimens of *Vepris fer* to the sole unlocalised collection at that location by Fox in April 1965.

All three of the Liberian locations are planned or active open cast iron-ore mines which have or are due to annihilate the known sites for the species (Arcelor Mittal 2013; Deady & Gunn accessed 2018; Mount Bele Resources 2012). In fact the plot voucher specimens were all collected for Environmental Impact Assessments (EIs) for mining projects at these sites.

At Mount Bele, Adam (1975) reported that this species (as *Teclea verdoorniana*) is locally common in the understorey at the base of the mountain and nearby. This is consistent with the large number (17) of plot vouchers collected by Hawthorne & Marshall there and in the neighbourhood. However, this location and neighbouring areas all appear to be either operating or prospective open-cast iron mines. Plotting a sample of seven of the 17 voucher records on 2018 CNES/Airbus imagery dated 31 Dec. 2017, accessed via Google Earth 6 Sept. 2018 showed that two fall in the Mount Bele Resources (MBR) project, a prospective iron ore mining concession of 55.8 km² with potential for 1.58 billion tonnes of iron ore, situated close to four other iron ore projects and producing mines at the southern end of Mt Nimba: operated by Arcelor Mittal, BHP Billiton and Hummingbird (Mount Bele Resources 2012). The remaining 12 voucher specimens all map onto one of these, the Arcelor Mittal Mount Tokadeh Project (which includes Mts Yuelliton and Gangra), just to the west of Mount Bele. Of these 12 points, three have been open-cast mined in the last 5 years, while nine still have natural vegetation although several of these are close to the edges of pits and infrastructure. The mining footprint is expected to expand until closure in 2034 (Arcelor Mittal 2013) so the survival of the currently intact sites is in doubt.

The Putu Iron Ore Mining project, based in Grand Gedeh county in SE Liberia, is currently owned by the Russian steelmaker Severstal and has an exploration tenement of 425 km² in the Putu Hills consisting of two parallel ridges c. 15 km long, running SSW-NNE. The ridgetops are in the range 450 – 600 m alt., rising from plains 200 – 300 m alt. The three voucher records are from the ridgetop and flanks. It is estimated that the project offers 2.37 billion tons of iron ore. Although the project is temporarily closed, there is little doubt that it will be re-opened once iron ore prices improve (<https://www.thornycroft.co.za/Gru/2018-4-15/putu-iron-ore-mining-in-liberia.html>). Currently the hills are covered in intact lowland evergreen forest with only small areas cleared during the exploration phase of the project (Digital Globe imagery dated 12/2016 viewed in Google Earth 6 Sept. 2018)

Of the four known locations, only one, the Gola Forest Reserve (Sierra Leone), is protected.

Using the georeferenced specimens cited in this paper, the area of occupancy (AOO, 44 km²) and extent of occurrence (EOO 27,691 km²) have been calculated using GeoCat (Bachman *et al.* 2011).

Given the continued loss of plants of this species at the Mont Tokadeh site, and the impending losses at Mount Bele and Putu Hills locations, we here assess *Vepris fer* as Endangered EN B1+B2a,b(iii).

ETYMOLOGY. Named (French noun in apposition) for the iron substrate on which this species usually occurs.

LOCAL NAMES. Samakin (Ganta: Fox 124, K).

LOCAL USES. None known.

NOTES. The description above is based on both the specimens cited and on the description of Adam (1975) which is derived solely from Adam 27597.

Mount Bele is the southern tip of the extensive Nimba Mountain range for which Adam completed the Flora (Adam 1975). Notably his specimen is the only record of the genus recorded in his extensive work on the main range of Nimba.

Initially we connected *Barter* s.n. (Sugar Loaf Mt, Sierra Leone) with this taxon since it has a canaliculate petiole and similar aspect.

However, it differs from our taxon in that it has alternate only leaves, much more densely hairy inflorescences, a long and well-defined petiolule to the median leaf, and many more secondary nerves per leaflet. The identity of this specimen remains uncertain.

Vepris fer is unique in West Africa (Senegal-Ghana) for the combination of large (>1 cm long) fruit which is 1-seeded, with conspicuous large-pits, and the regularly opposite leaves. *Vepris bali* Cheek of the Cameroon Highlands (Cheek *et al.* 2018a) is the only other *Vepris* species in W-C Africa with regularly opposite leaves. That species however has bilocular ovaries and 8 stamens, and long petiolules (not unilocular, 4 stamens, sessile leaflets).

The inflorescence of the type specimen shows scarring on the main axes suggesting damage early in development. This may account for the discrepancy in dimensions of the male inflorescences between *Barker* 1181 (c. 5 cm long, long internodes) and that of the type (3.5 cm long, more congested, possibly stunted).

The disjunction between Gola and Nimba locations is about 220 km, and between Nimba and the Putu Hills c. 180 km. It is likely that this is not due to under-sampling in the surviving habitat between these locations but due to the preference of the species for submontane forest. This disjunct pattern is seen in other submontane forest species in the Guinea Highlands e.g. *Trichilia djalensis* A.Chev., and the more recently discovered *Isoglossa dispersa* I.Darbysh. (Darbyshire *et al.* 2011), *Brachystephanus oreacanthus* Champl. (Champluvier & Darbyshire 2009),

Gymnosiphon samoritourei Cheek (Cheek & van der Burgt 2010), *Psychotria samoritourei* Cheek (Cheek & Williams 2016) and *Keetia futa* Cheek (Cheek *et al.* 2018c). Extensive surveys in two other submontane forested iron outcrops (Simandou in Guinea, and Tonkolili in Sierra Leone, respectively van der Burgt *et al.* 2012; Clark *et al.* 2011), both also iron ore projects, has failed to discover this species, suggesting that its range is no more extensive than that recorded in this paper.

Although fertile specimens are not known from the Putu Hills location, they agree closely in gland dot size, colour and density, in the unusual opposite leaves with those from the other three locations.

The inclusion by Keay (1958) of *Barker*1181 (*Vepris fer*) with its opposite leaves, from the high rainfall southernmost outliers of Mt Nimba in Liberia, as *Teclea* (*Vepris*) *verdoorniana* together with the alternate-leaved material from lower rainfall habitats in West Africa treated in this paper as *V. occidentalis*, was followed by other authors, such as Adam (1975) and Hawthorne & Jongkind (2006). In fact, these species differ from each other in numerous major characters (see Table 1).

While several species of *Vepris* sometimes have subopposite leaves, *V. fer* seems to be consistently fully opposite in its phyllotaxy, with the exception of a section of one stem bearing infructescences where the placement of leaf scars indicate that the phyllotaxy is alternate. This may be a case of stage-dependent variation in phyllotaxy as occurs in the threatened *V. felicis* Breteler which bears opposite leaves at the fertile stem apex of flowering stems but wherein nodes distant from the stem apex are alternate (Cheek pers. obs.; Cheek 2017).

Among other recently discovered new species of plant from Sierra Leone and/or Liberia which are range-restricted and threatened by development projects are *Allophylus samoritourei* Cheek (in Cheek & Haba 2016), *Gilbertiodendron tonkolili* Burgt & Estrella (in de la Estrella *et al.* 2012), *Ledermanniella yiben* Cheek (in Cheek *et al.* 2017a), *Inversodicraea liberia* Cheek (in Cheek *et al.* 2017b) and even a new genus to science *Lebbiea* Cheek (Cheek & Lebbie 2018).

4. *Vepris occidentalis* Cheek & Onana sp. nov. Type: Ghana, Mampong-Akwapim, fr. 16 March 1977, *Ankoma-Ayew* in GC 46141 (holotype K000875057!; isotype GC).

<http://www.ipni.org/urn:lsid:ipni.org:names:77197425-1>

Teclea grandifolia sensu Aubréville (1936: 92, fig. 163) non Engl.

Teclea verdoorniana sensu Keay (1958: 689); Hall & Swaine (1981: 303).

Vepris verdoorniana sensu Aké Assi (2001: 110 – 115); Hawthorne (1990: 165); Hawthorne & Jongkind (2006: 706); Akoègninou *et al.* (2006: 914).

Dioecious (probably) shrub or small tree 4 – 10 (– 15) m tall, “trunk 10 cm diam., dark brown, basally peeling off in scales, higher up smooth and with large pale grey spots” (*Leeuwenberg* 3905, K). *Leafy stems* terete, 2 – 3 (– 4) mm diam. at lowest leafy node, pale greenish grey, internodes (0.3 –) 1 – 6.2 (– 6.7) cm long with longitudinal ridges and elliptic slightly raised convex white lenticels (0.25 –) 0.35 – 0.5 (– 0.65) × (0.2 –) 0.25 – 0.4 (– 0.5) mm, surface glabrous. Apical leaf bud densely appressed hairy, hairs 0.2 mm long, pale brown. *Leaves* alternate, trifoliolate; petiole 2 – 4 cm long, with strongly developed patent wings from the adaxial margins, wings widest near the distal end, 0.3 – 0.5 (– 1) mm wide, the combined width of the wings often exceeding the width of the central, non-winged part of the petiole (Fig. 2E); in dried specimens wings usually revolute, glabrous; adaxial surface of central non-winged portion of petiole with thinly scattered simple hairs 0.1 – 0.3 mm long, extending along the leaflet midribs; densely pubescent at junction of leaflets with petiole (Fig. 2E). *Leaflets* equal or subequal, the lateral leaflets sometimes only $\frac{2}{3}$ the size of the median; narrowly elliptic or elliptic-oblong, median (7.8 –) 8 – 15.4 (– 16.6) × (2.3 –) 2.4 – 5 (– 5.8) cm; laterals 5.2 – 13.2 (– 13.6) × (1.5 –) 1.9 – 3.8 (– 5.0) cm, base cuneate, slightly asymmetrical with lateral leaflets, tapering gradually to the junction with the petiole, petiolules indistinct; acumen 0.2 – 1.2 cm long, apex acute; lateral secondary nerves 15 – 23 on each side of midrib, arising at 50 – 80° from midrib, the distal part of the nerves looping upwards to the nerve above (brochidodromous) connected by fine tertiary nerves to an infra-marginal nerve (Fig. 2C); intersecondary nerves 1 – 4 between secondaries, parallel to the secondaries and almost as well-developed; quaternary nerves, visible to the naked eye, not uniting to form a reticulum; oil glands 0.05 – 0.1 mm diam., c. 100 – 600 per cm², appearing as raised discs only on the abaxial surface, concolorous, not visible with the naked eye. *Inflorescences* axillary, 1.3 – 3.6 cm long, flowers 10 – 15 (female) arranged in 2 – 4-flowered fascicles along the main axis and the shorter basal branches, bracts narrowly triangular 0.1 – 0.5 mm long, axes and bracts densely puberulent (c. 50% cover), hairs 0.2 mm long. *Pedicels* 0.5 – 2 × 0.4 mm, indumentum as inflorescence. *Calyx* tube 0.1 – 0.2 × 0.7 – 1.1 mm; lobes 4, broadly triangular, c. 0.25 × 0.5 mm, apex obtuse, indumentum as pedicel, oil glands not conspicuous. *Petals* 4, white, free to base, lanceolate or narrowly elliptic, 2.4 – 3.1 × 0.7 – 1.1 mm, apex acute, slightly hooded, margins slightly involute, glabrous, oil glands not conspicuous. *Male*

flowers. Stamens 4, exerted beyond petals, erect; filaments cylindrical 2.2 – 3 × 0.1 mm, curving inward towards apex; anther two-celled, elliptic, c. 0.8 × 0.6 mm, medifixed. Pistillode pyriform, 1.5 × 0.75 mm, contracting to 0.3 mm diam. in the distal two-thirds, apex rounded, base with petal-opposed cavities; surface with spreading bristle-like hairs 0.2 – 0.3 mm long. Female flowers 10 – 20% larger than the males; ovary broadly ellipsoid, 1.5 × 1.3 mm, stipe c. 0.2 × 0.5 mm; style cylindrical or dilating towards apex, 0.25 × 0.3 mm; stigma irregularly disc-like 0.2 – 0.3 × 0.8 mm. Fruit orange or red when ripe, ellipsoid, 0.6 – 0.8 (– 0.9) × 0.4 – 0.6 (– 0.7) cm, apex and base rounded, surface drying wrinkled, oil cavities elliptic, 0.5 mm long, usually slightly raised, convex; 1-seeded. Fig. 2.

RECOGNITION. *Vepris occidentalis* differs from all species within its range, and from *V. verdoorniana*, in the strongly laterally winged petioles (not terete), and by the oil glands on the lower surface of the leaflets being concolorous, not visible to the naked eye, (not black, conspicuous to the naked eye). It further differs from the last species in the ellipsoid fruits (not narrowly ovoid).

DISTRIBUTION. Guinea, Ivory Coast, Ghana, probably Benin (see note below). Map 2.

SPECIMENS EXAMINED. GUINEA-CONAKRY (GUINEA).

Coyah Prefecture: Near Kouriya, near rd from Coyah to Kindia, 9°45'29.03"N, 13°18'7.19"W, 270 m, st., 11 Oct. 2016, *X. M. van der Burgt* 2074 (K001243856!).

LIBERIA. Lofa, North Lorma National Forest, 8°01.53'N, 9°43.88'W, 408 m, fl. 24 Nov. 2005, *C. C. H. Jongkind* 6889 (P04757389!, WAG1413490!, G!).

IVORY COAST.

Abidjan, Lamto, st.16 Jan. 1969, *Hainard* 173 (G!); *ibid.*, Sous-Préf. Tiassale, Lamto, st. 20 Jan. 1969, *Poecilot* 3812CI (G!); *ibid.* Res. du Lamto, fl. 25 March 1989, *Gautier-Beguín* 1181; *ibid.*, fr. 4 June 1989, *Gautier-Beguín* 1346 (G!); **Sous-Préf. Bouna, PN Comoé Sud,** 29 May 1991, *Poecilot* 4438 CI (G!); **Daloa,** 8 – 10 km to the E of st., 5 – 6 March 1962, *L. Bernardi* 8468 (P06600570!); st., 1932, *M. Aubréville* 795 (P06600566!); fl. fr., 29 April 1936, *M. Aubréville* 2365 (P06600567!); Fôret de Bouaflé, c. 40 km E of Daloa, along rd to Bouaflé, c. 200 m, imm. fr., 13 April 1962, *A. J. M. Leeuwenberg* 3905 (K000875063!, four sheets: L.2127875!, L.2127876!, WAG1413501, WAG1413502! BR0000019425610 image!); **Near Brafouedi,** 75 km NW of Abidjan, in a grove, c. 100 m, fr., 24 April 1959, *A. J. M. Leeuwenberg* 3341 (K000875062!, WAG1413493! BR0000019425603 image!); **Bouaké,** c. 70 km W of, Fôret Classée Matiemba, c. 25 km S of Béoumi, 5 km SE of Ando, fr., 27 May 1963, *W. J. J. O. de Wilde* 92 (K000875058!, P06600565!, WAG1413497!); **Kakpin,** 8 km N of, on sandy soil, fl., 18 April 1968, *C. Geerling & J. Bokdam* 2543 (K000875065!, two sheets: WAG1413503!, WAG1413504! BR0000019425573 im-

age!); Forêt du Bandama, st., 26 Sept. 1982, *M. Miège* 1438 (P00805680!); **Specimens cited in Aké Assi (2001),** and held in a non-registered, private herbarium in Ivory Coast, not available for examination: Région de Tiassalé, Fôret de la Kassa, 21 Oct. 1950, *Aké Assi* 1109; Entre M'Bahiakro et Ouellé, Fôret de la Baya, 7 Sept. 1951, *Mangenot, Miège et Aké Assi* 1360; Entre Dabou et Sikensi, rocher de Brafouedi, 18 Dec. 1954, *Aké Assi* 2684; Fôret de l'Agbo, 25 Sept. 1957, *Adjanooun* 1919B; Fôret de Bouaflé, 25 Sept. 1962, *Aké Assi* 6533; Région d'Adzopé, Mont Mafa, 14 March 1967, *Aké Assi* 9537. **GHANA. Near Ejun,** 240m, fl. fr., April 1928, *C. Vigne* 1100 (BM!, FHO!, K000875134!); **Volta River Reserve,** 500 m, fl., Feb. 1937, *C. Vigne* 4350 (FHO!); Volta River Reserve, fl., April 1931, *Moor* 2343 (FHO!); Sapuwsu F. R., Akosombo, fl., 12 March 1977, *Hall & Swaine* GC 46138 (P06600529!), two sheets: WAG1413486!, WAG1413496!, BR0000019425665!); Sapuwsu F. R., Akosombo, imm. fr., 12 March 1977, *Hall & Swaine* GC 46139 (P06600564!); Asafo Hills near town of Atimopku at Adomi Bridge on Volta R., 6°15'22.5"N 0°6'07.5"E, 280 m, st., Plot voucher AKWAC1 (K000875076!); **Agogo, Ashanti Akim,** imm. fr., April 1928, *F. R. Irvine* 952 (FHO!, two sheets: K000875060!, K000875061!); **Akwapim,** fl., April 1929, *F. R. Irvine* 1155 (K000875059!); Mampong-Akwapim, fr., 16 March 1977, *Ayew* GC 46141 (K000875057!, P06600555!); **Kwahu Nteso** to Ankoma, bank of R. Asuboni, fl., 17 Jan. 1968, *Enti & Hall* GC 37546 (FHO!, K000875056!); **Aburi Scarp,** gully at foot of above rd, fl., 27 Feb. 1961, *J. K. Morton* A4136 (K000875064!, WAG1413485!); **Berekuso,** on slope 2 km E of village, fr., 15 June 1978, *J. B. Hall* GC 47012 (K000875066!, WAG1413484!).

HABITAT. Drier evergreen and semi-deciduous forest types, often on shallow soils over rock at the boundary with savannah (woodland); 100 – 500 m alt.

Vepris occidentalis is listed (as *Teclea verdoorniana*) as one of 13 characteristic species of Southern marginal type forest (Hall & Swaine 1981: 83 – 87). Associated species include *Lecaniodiscus cupanioides* Planch., *Hildegardia barteri* (Mast.) Kosterm., *Dialium guineense* Willd., *Nesogordonia papaverifera* (A.Chev.) N.Hallé and *Drypetes floribunda* Hutch. This forest type, as its name suggests, is marginal to the south of the main block of forest in SW Ghana, and interfaces with "Savannah" (woodland). Surviving forest is principally on thin soil over rock. Rainfall is 1000 – 1250 mm p.a. Hall & Swaine (1981: 302, map 580), also map this species, at lower frequency, in Dry Semi-Deciduous Forest on the northern boundary of the main Ghana forest block, in a line proceeding south eastwards from the boundary with Ivory Coast, towards the Akosombo dam of Lake Volta. Rainfall is 1250 – 1500 mm p.a. Hall & Swaine equate this vegetation type unequivocally with the

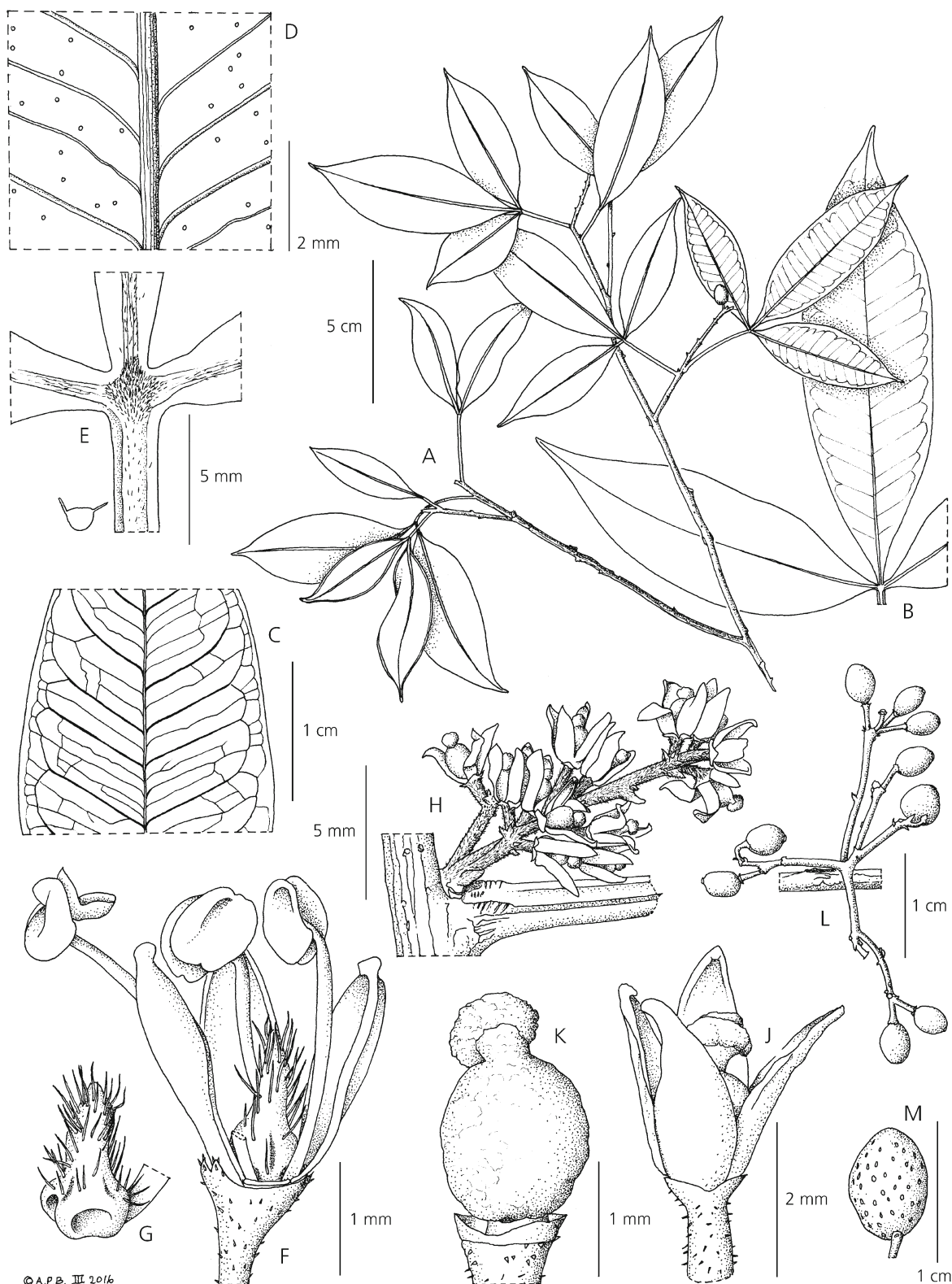
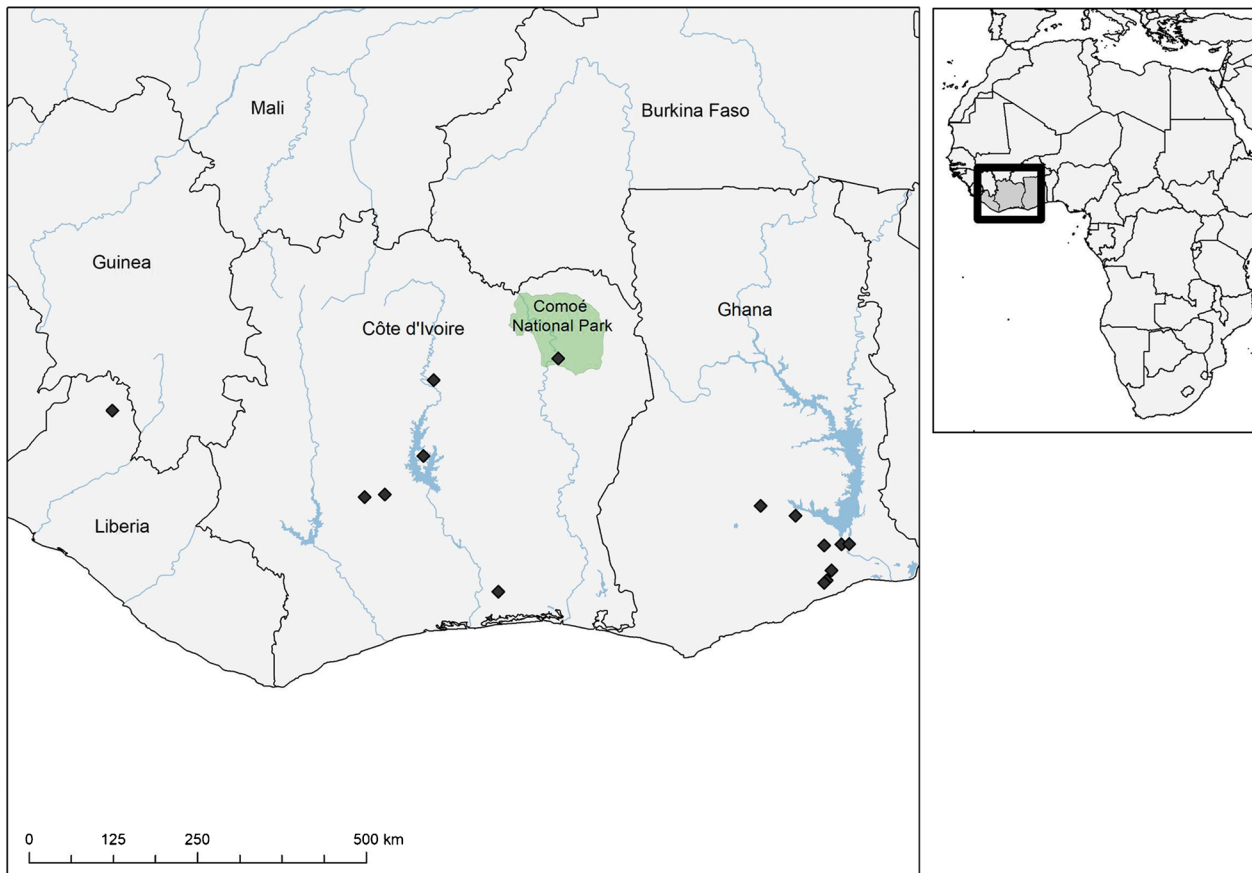


Fig. 2. *Vepris occidentalis*. A habit, small-leaved specimen; B habit, large-leaved specimen; C venation, adaxial surface leaflet; D oil glands on abaxial leaflet surface; E leaf portion, junction of leaflets with distal portion of the winged petiole, with transverse section of petiole; F male flower, with petal and stamen removed to display pistillode; G detail of pistillode, showing proximal staminal concavities centre and left, and right portion of staminal filament; H female inflorescence; J female flower; K female flower, petals removed, showing stipitate pistil; L infructescence with immature fruits; M mature fruit, showing surface oil glands. A, C, D, L from *Leeuwenberg* 3341; B, E, H – K from *Geerling & Bokdam* 2543; F, G from *Vigne* 1100; L from *Leeuwenberg* 3405. DRAWN BY ANDREW BROWN.



Map 2. Global distribution of *Vepris occidentalis* in West Africa.

“forêt dense semi-décidue” of Aubréville (1938). Aubréville surmised that before the advent of agriculture it had stretched far to the north, covering what is now “Guinean savanna” (woodland). Guillaumet & Adjanohoun (1971) name this vegetation “Forêt à *Aubrevillea kerstingii* et *Khaya grandifoliola*”, and Chatelain *et al.* (2011) map the occurrence of *V. occidentalis* in Ivory Coast. However, we have not been able to verify all their 22 points for this species. The westernmost outliers of *V. occidentalis* occur in the northernmost, drier part of Liberia and in east-central Guinea.

It is likely that the easternmost extent of this species occurs in Benin, since Akoègninou & Yédomonhan in Akoègninou *et al.* (2006) list *Vepris verdoorniana* in that country citing *Houngnon* 3659 from Misséssinto. However, we have not been able to view this specimen to confirm the identification, so do not include it in Map 2, although we consider it feasible, even likely. Akoègninou & Yédomonhan give the distribution of this taxon as in their phytogeographic zones 3 (Ouémé) and 4 (Kouffo), in the southern part of Benin, just inland of the coastal belt. This is semi-deciduous forest receiving rainfall of 900 – 1200 mm (Akoègninou *et al.* 2006). No *Vepris* species is recorded from Togo (Brunel *et al.* 1984), but it is quite possible that *V. occidentalis* occurs there but has been

overlooked since there are records immediately to the west in Ghana, and it appears to be present to the east in Benin (see above). Benin appears to be the eastern limit of the species since, although Nigeria is well studied for trees (e.g. Keay 1989), there are no records attributable to the species there.

Tarenna agnata Cheek has a partly overlapping distribution to that of *Vepris occidentalis*, also occurs in Dry Semi Deciduous Forest in Ghana, extending into Ivory Coast, but is much rarer, being known from fewer points and is considered possibly extinct (Cheek *et al.* 2015).

CONSERVATION STATUS. *Vepris occidentalis* has a large range (EOO = 6,191,100 km², AOO = 120 km²), and we have been able to verify records from 16 locations. Chatelain *et al.* (2011) map 22 points for Ivory Coast alone, but we have not been able to verify all of these records. However, if confirmed, the number of locations of this species may be much higher, potentially exceeding 30, on which basis the AOO was calculated.

Relatively little of the original 2,360 km² of the Ghanaian Southern Marginal Type of forest, (the habitat in which this species is most frequent in Ghana), is today covered by forest (Hall & Swaine 1981: 85), and of this area only 93 km² (4%) is within

the 10 reserved areas within this type (Hall & Swaine 1981: 69). In the last 35 years, several of these reserves have been largely destroyed by fire (Hawthorne pers. comm.). Generally speaking, good quality forest in Ghana only exists in reserves.

Much of the original lowland forest in Côte d'Ivoire has been destroyed or degraded over the last few decades and deforestation rates are still high (Bongers *et al.* in Poorter *et al.* 1994: 87 – 98) In Ivory Coast this species seems to be protected only in the Comoé NP.

Given the large range, and large numbers of recorded locations we here assess this species as Least Concern. However, further study may well show that *Vepris occidentalis* has been lost from many of the sites at which it has been recorded, in which case it will need to be reassessed as Near Threatened, potentially even as Vulnerable under criterion B (low AOO and severely fragmented) and/or criterion A (reduction in population).

ETYMOLOGY. Signifying “western”: this is the most western forest tree species of *Vepris* currently known.

LOCAL NAMES & USES. Niepé: *Bernardi* 8468; Dzézé: *Aubréville* 795; Jwebiribi, (Twi): *Irvine* 1155; Atuhon, (Ashanti): *Irvine* 952, *Vigne* 1100. Used as chewsticks (for dental hygiene): *Irvine* 952 Chewsticks, bark bitter, chewed to cure cough: *Irvine* 1155

NOTES. This paper was partly prompted by attempts to name material (*van der Burgt* 2074) from Guinea as an element of a project to delimit the areas of highest priority for plant species conservation using the Important Plant Areas criteria of Darbyshire *et al.* (2017). The Guinea material cited fitted the concept of *Vepris (Teclea) verdoorniana* used in the *Flora of West Tropical Africa*, but not that of Onana & Chevillotte (2015) prompting further investigation.

Vepris occidentalis is unusual as a newly described species in having a large range (Guinea to Ghana, possibly extending to Benin), appearing relatively common and frequent in much of that range, and so not being of high conservation concern, as is the case with *Karima scarciensis* (Scott Elliot) Cheek (Cheek *et al.* 2016) which has a similar range. In contrast, most recently discovered species within this area are much more range-restricted and in consequence, threatened with extinction. Examples are *Kindia gangan* Cheek (Cheek *et al.* 2018b), *Talbotiella cheekii* van der Burgt (van der Burgt *et al.* 2018), *Keetia susu* Cheek, *K. abouabou* Cheek (Cheek *et al.* 2018c), *Macropodiella cussetiana* Cheek & Ameka (2016) and *Striga magnibracteata* E. B. Fischer & I. Darbysh. (Fischer *et al.* (2011)).

Many of the uses ascribed to *Teclea verdoorniana* by Burkill (1997) pertain to this species, insofar as the material derived from Ghana and Ivory Coast. However, uses ascribed to this same species from Sierra Leone and Uganda must relate to other species of

Vepris since *V. occidentalis* is not known from those countries.

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References

- Adam, J. G. (1975). Flore descriptive des monts Nimba, Pt. 4. *Mém. Mus. Natl. Hist. Nat.* XXV.
- Akoègninou, A., van der Burg, W. J. & van der Maesen, L. J. G. (2006). Rutaceae. In: A. Akoègninou & H. Yèdomonhan (eds), *Flore Analytique du Bénin*, pp. 910 – 916. Backhuys Publishers, Contonou & Wageningen.
- Arcelor Mittal (2013). Nimba Western Range Iron Ore Project Liberia. <https://liberia.arcelormittal.com/~media/Files/A/ArcelorMittal-Liberia/reports-and-presentations/phase-2-esia/aml-phase-2-project-outline.pdf>. Accessed Sept 2018.
- Aké Assi, L. (2001). Rutaceae. In: Flore de la Côte d'Ivoire: catalogue systématique, biogéographie et écologie 2. *Boissiera* 58: 110 – 115.
- Aubréville, A. (1936). Rutaceae. In: *La Flore Forestière de la Côte d'Ivoire* 2: 83 – 94. Larose Éditeurs, Paris.
- (1938). La forêt coloniale. *Ann. Acad. Sci. Colon., Paris* 9: 1 – 245. <https://doi.org/10.2307/1787233>.

- Bachman, S., Moat, J., Hill, A., 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>.
- _____, Nic Lughadha, E. M. & Rivers, M. C. (2018). Quantifying progress towards a conservation assessment for all plants. *Conserv. Biol.* <https://doi.org/10.1111/cobi.13071>.
- Barthlott, W., Lauer, W. & Placke, A. (1996). Global distribution of species diversity in vascular plants: towards a world map of phytodiversity. *Erdkunde* 50: 317 – 327. <https://doi.org/10.1007/s004250050096>.
- Brunel, J. F., Hiepko, P. & Scholz, H. (1984). Flore analytique du Togo: Phanérogames. *Englera*, Vol. 4. Berlin & Eschborn, Berlin. <https://doi.org/10.2307/3776742>
- Burgt, X. M. van der, Haba, P. K., Haba, P. M. & Goman, A. S. (2012). *Eriosema triforum* (Leguminosae: Papilionoideae), a new unifoliolate species from Guinea, West Africa. *Kew Bull.* 67: 263 – 271. <https://doi.org/10.1007/s12225-012-9357-5>.
- _____, Molmou, D., Diallo, A., *et al.* (2018). *Talbotiella cheekii* (Leguminosae: Detarioideae), a new tree species from Guinea. *Kew Bull.* 73: 26. <https://doi.org/10.1007/s12225-018-9755-4>.
- Burkill, H. M. (1997). *The Useful Plants of West Tropical Africa*. Vol. 4, families M – R. Royal Botanic Gardens, Kew.
- Champluvier, D. & Darbyshire, I. (2009). A revision of the genera *Brachystephanus* and *Oreacanthus* (Acanthaceae) in tropical Africa. *Syst. Geogr. Pl.* 79(2): 115 – 192.
- Chatelain, C., Aké Assi, L., Spichiger, R. & Gautier, L. (2011). Cartes de distribution des plantes de Côte d'Ivoire. *Boissiera* 64: 187.
- Cheek, M. (2017). *Vepris felicitis*. The IUCN Red List of Threatened Species 2017: e.T65064584A65064590. <https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T65064584A65064590.en>. Accessed May 2018.
- _____ & Ameka, G. (2016). *Macropodiella cussetiana* (Podostemaceae) a new species from Côte d'Ivoire. *Kew Bull.* 71(2). <https://doi.org/10.1007/s12225-016-9634-9>.
- _____ & Burgt, X. M., van der (2010). *Gymnosiphon samoritourenus* (Burmanniaceae) a new species from Guinea, with new records of other achlorophyllous heteromycotrophs. *Kew Bull.* 65: 83 – 88. <https://doi.org/10.1007/s12225-010-9180-9>.
- _____, _____, Momoh, J. & Lebbie, A. (2017a). *Ledermanniella yiben* sp. nov. (Podostemaceae), Critically Endangered at the proposed Yiben Reservoir, Sierra Leone. *Kew Bull.* 72: 31. <https://doi.org/10.1007/s12225-017-9699-0>.
- _____, Challen, G., Lebbie, A., Banks, H., Barberá, P. & Riina, R. (2016). Discovering *Karima* (Euphorbiaceae), a New Crotonoid Genus from West Tropical Africa Long Hidden within *Croton*. *PLoS ONE* 11(4): e0152110. <https://doi.org/10.1371/journal.pone.0152110>.
- _____, Feika, A., Lebbie, A., Goyder, D., Tchiengue, B., Sene, O., Tchouto, P. & van der Burgt, X. (2017b). 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. (2018a). *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>.
- _____ & Haba, P. M. (2016). Spiny African *Allophylus* (Sapindaceae): a synopsis. *Kew Bull.* 71: 55. <https://doi.org/10.1007/S12225-016-9672-3>.
- _____ & Lebbie, A. (2018). *Lebbiea* (Podostemaceae-Podostemoideae), a new, nearly extinct genus with foliose tepals, in Sierra Leone. *PLoS ONE* 13(10): e0203603. <https://doi.org/10.1371/journal.pone.0203603>.
- _____, Lopez Poveda, L. & Molmou, D. (2015). *Tarenna hutchinsonii* (Rubiaceae) redelimited, and *T. agnata* described from W Africa. *Kew Bull.* 70: 12. <https://doi.org/10.1007/S12225-015-9560-2>.
- _____, Mackinder, B., Gosline, G., Onana, J. M. & Achoundong, G. (2001). The phytogeography and flora of western Cameroon and the Cross River-Sanaga River interval. *Syst. Geogr. Pl.* 71: 1097 – 1100. <https://doi.org/10.2307/3668742>.
- _____, Magassouba, S., Howes, M. R., Doré, T., Doumbouya, S., Molmou, D., Grall, A., Couch, C. & Larridon, I. (2018b). *Kindia* (Pavetteae, Rubiaceae), a new cliff-dwelling genus with chemically profiled colleter exudate from Mt Gangan, Republic of Guinea. *PeerJ* 6: e4666. <https://doi.org/10.7717/peerj.4666>.
- _____, _____, Molmou, D., Doré, T. S., Couch, C., Yasuda, S., Gore, C., Guest, A., Grall, A., Larridon, I., Bousquet, I. H., Ganatra, B. & Gosline, G. (2018c). A key to the species of *Keetia* (Rubiaceae - Vanguerieae) in West Africa, with three new, threatened species from Guinea and Ivory Coast. *Kew Bull.* 73: 4. <https://doi.org/10.1007/s12225-018-9783-0>.
- _____, Oben, B. & Heller, T. (2009). The identity of the West-Central African *Oricia lecomteana* Pierre, with a new combination in *Vepris* (Rutaceae). *Kew Bull.* 64: 509 – 512. <https://doi.org/10.1007/s12225-009-9135-1>.
- _____, Pollard, B. J., Darbyshire, I., Onana, J. M. & Wild, C. (2004). *The Plants of Kupe, Mwanenguba and the Bakossi Mts, Cameroon. A Conservation Checklist*. Royal Botanic Gardens, Kew.
- _____ & Williams, T. (2016). *Psychotria samoritourei* (Rubiaceae), a new liana species from Loma-Man

- in Upper Guinea, West Africa. *Kew Bull.* 71: 19. <https://doi.org/10.1007/S12225-016-9638-5>.
- Cheplogoi, P. K., Mulholland, D. A., Coombes, P. H. & Randrianarivelosia, M. (2008). An azole, an amide and a limonoid from *Vepris uguenensis* (Rutaceae). *Phytochemistry* 69: 1384 – 1388. <https://doi.org/10.1016/j.phytochem.2007.12.013>.
- Clark, R., van der Burgt, X., Banks, H., et al. (2011). A synopsis of *Pseudovigna* (Leguminosae: Papilionoideae) including a new species, *P. sulaensis*, from Sierra Leone. *Kew Bull.* 66: 589. <https://doi.org/10.1007/s12225-011-9314-8>.
- Darbyshire, I., 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., de Montmollin, B., Nic Lughadha, E., Onana, J. M., Saidou, D., Sarbu, 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>.
- _____, Pearce, L. & Banks, H. (2011). The genus *Isoglossa* (Acanthaceae) in west Africa. *Kew Bull.* 66: 425 – 439. <https://doi.org/10.1007/s12225-011-9292-x>.
- Deady, E. & Gunn, G. (date unknown). *The Potential for Iron Ore in Liberia*. British Geological survey with the Liberian geological survey. Ministry of Lands, Mines & Energy. https://www.bgs.ac.uk/lgs/downloads/Liberia_ironore_brochure_lowres.pdf (accessed 6 Sept. 2018).
- Demenou, B. B., Doucet, J.-L. & Hardy, O. J. (2017). History of the fragmentation of the African rain forest in the Dahomey Gap: insight from the demographic history of *Terminalia superba*. *Heredity* 120(6): 547 – 561. <https://doi.org/10.1038/s41437-017-0035-0>.
- Esri ArcWorld Database [computer file] (1992). Environmental Systems Research Institute, Redlands, C. A.
- de la Estrella, M., van der Burgt, X. M., Mackinder, B. & Hawthorne, W. D. (2012). *Gilbertiodendron tonkolili* sp. nov. (Leguminosae-Caesalpinioideae) from Sierra Leone. *Nordic J. Bot.* 30(2): 136 – 143. <https://doi.org/10.1111/j.1756-1051.2012.01357.x>.
- Exell, A. W. & Mendonça, F. A. (1951). Rutaceae. In: *Conspectus Florae Angolensis* 1: 265 – 275. Ministério do Ultramar junta de Investigações Coloniais, Lisbon.
- Fischer, E., Darbyshire, I. & Cheek, M. (2011). *Striga magnibracteata* (Orobanchaceae) a new species from Guinée and Mali. *Kew Bull.* 66: 441 – 445. <https://doi.org/10.1007/s12225-011-9296-6>.
- Guillaumet, J.-L. & Adjanohoun, E. (1971). La végétation de la Côte d'Ivoire. *Mem. O.R.S.T.O.M.* 50: 157 – 263
- Hall, J. B. & Swaine, M. D. (1981). *Distribution and ecology of vascular plants in a tropical rain forest. Forest vegetation in Ghana. Geobotany*, Vol. 1. Dr W. Junk Publishers, The Hague.
- Hawthorne, W. (1990). *Field Guide to the Forest trees of Ghana*. NRI. Overseas Development Administration, London.
- ____ & Jongkind, C. (2006). *Woody Plants of Western African Forests: A guide to the forest trees, shrubs and lianes from Senegal to Ghana*, pp. 706 – 707. Royal Botanic Gardens, Kew.
- Imbenzi, P. S., Osoro, E. K., Aboud, N. S., Ombito, J. O. & Cheplogoi, P. K. (2014). A review on chemistry of some species of genus *Vepris* (Rutaceae family). *J. Sci. Innov. Res.* 3: 357 – 362.
- IPNI (continuously updated). *The International Plant Names Index*. <http://www.ipni.org/>. Accessed Aug 2018.
- IUCN (2012). *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. IUCN, Gland and Cambridge. Available from: <http://www.iucnredlist.org/>. Accessed Jan 2017.
- ____ & UNEP-WCMC (2017). *The World Database on Protected Areas (WDPA)* [On-line], November 2017 (version 3.1). UNEP-WCMC, Cambridge. Available at: www.protectedplanet.net.
- Keay, R. W. J. (1958). Rutaceae. In: R. W. J. Keay (ed.), *Flora of West Tropical Africa* 1: 683 – 689. Crown Agents, London.
- ____ (1989). *Trees of Nigeria*, 2nd ed. Clarendon Press, Oxford.
- Langat, M. K. (2011). Flindersiamine, a Furoquinoline Alkaloid from *Vepris uguenensis* (Rutaceae) as a Synergist to Pyrethrins for the Control of the Housefly, *Musca domestica* L. (Diptera: Muscidae). *J. Kenya Chem. Soc.* 6: 9 – 15.
- Letouzey, R. (1963). Rutaceae. *Flore du Cameroun* 1. Muséum Nationale D'Histoire Naturelle, Paris.
- Morton, C. M. (2017). Phylogenetic relationships of *Vepris* (Rutaceae) inferred from chloroplast, nuclear, and morphological data. *PLoS ONE* 12: e0172708. <https://doi.org/10.1371/journal.pone.0172708>.
- Mount Bele Resources (2012). *Mining as a Motor for Liberia*. <https://www.developingmarkets.com/sites/default/files/Robert%20McKendrick%20Mount%20Bele%20Presentation%20LIS%20VI.pdf> (accessed: 09/2018).
- Mziray, W. (1992). Taxonomic studies in *Toddalieceae* Hook.f. (Rutaceae) in Africa. *Symb. Bot. Upsal.* 30: 1 – 95.
- Nic Lughadha, E., Bachman, S. P. & Govaerts, R. (2017). Plant Fates and States: Response to Pimm & Raven. *Trends Ecol. Evol.* 32: 887 – 889. <https://doi.org/10.1016/j.tree.2017.09.005>.
- ____, Govaerts, R., Belyaeva, I., Black, N., Lindon, H., Allkin, R., Magill, R. E. & Nicolson, N. (2016). Counting counts: Revised estimates of numbers of accepted species of flowering plants, seed plants, vascular plants and land plants with a review of other recent estimates. *Phytotaxa* 272: 82 – 88. <https://doi.org/10.11646/phytotaxa.272.1.5>.

- Onana, J. M. & Cheek, M. (2011). *Red Data Book of the Flowering Plants of Cameroon*. Royal Botanic Gardens, Kew.
- _____, _____ & Chevillotte, H. (2019). Additions au genre *Vepris* Comm. ex A.Juss. (Rutaceae-Toddalieceae) au Cameroun. *Adansonia* 41(5): 41 – 52. <https://doi.org/10.5252/adansonia2019v41a5> <http://adansonia.com/41/5>.
- _____, Chevillotte, H. (2015). Taxonomie des *Rutaceae – Toddalieceae* du Cameroun revisitée: découverte de quatre espèces nouvelles, validation d'une combinaison nouvelle et véritable identité de deux autres espèces de *Vepris* Comm. ex A. Juss. *Adansonia*, sér. 3, 37: 103 – 129. <https://doi.org/10.5252/a2015n1a7>
- _____, Mbome M. J. & Mekembom, Y. N. (2017). The North-South Synergy: The National Herbarium and Limbe Botanic Garden experience. In: I. Friis & Henrik Balslev (eds), *Tropical plant collections Legacies from the Past? Essential Tools for the Future? Proceedings of an international symposium held by The Royal Danish Academy of Sciences and Letters in Copenhagen, 19th – 1st of May, 2015*. *Sci. Dan., Ser. B, Biol.* 6: 117 – 139.
- Plants of the World Online (2018). downloaded 5 Nov. 2017, http://www.plantsoftheworldonline.org/?f=accepted_names&q=Vepris.
- Poorter, L., Bongers, F., Kouamé, F. N. & Hawthorne, W. D. (eds) (1994). *Biodiversity of West African forests. An Ecological Atlas of Woody Plant Species*. CABI Publishing, Wallingford.
- 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 Jan. 2018.
- 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.
- Verdoorn, I. C. (1926). Revision of African Toddalieceae. *Bull. Misc. Inform., Kew.* 9: 389 – 416 <https://www.jstor.org/stable/4118639>.
- Wansi, J. D., Mesaik, M., Chiozem, D. D., Devkota, K. P., Gaboriaud-Kolar, N., Lallemand, M.-C., Wandji, J., Choudhary, M. I. & Sewald, N. (2008). Oxidative Burst Inhibitory and Cytotoxic Indoloquinazoline and Furoquinoline Alkaloids from *Oricia suaveolens*. *J. Nat. Prod.* 71(11): 1942 – 1945. <https://doi.org/10.1021/np800276f>.
- Willis, K. (2017). *The state of the world's plants report — 2017*. Royal Botanic Gardens, Kew.

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