

Justicia gigantophylla (Acanthaceae), an endangered litter-gathering species from southern Cameroon

Harry J. Smith^{1,*}, Con Moran², Olivier Lachenaud^{3,4} & Iain Darbyshire¹

¹Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, UK

²School of Medicine, College of Medicine and Health, University College Cork, Ireland

³Botanic Garden Meise, Nieuwelaan 38, 1860 Meise, Belgium

⁴Université Libre de Bruxelles, Boulevard du Triomphe, 1050 Brussels, Belgium

*Corresponding author: harry.smith@kew.org

Background and aims – The taxonomic status of *Duvernoia gigantophylla* Lindau from southern Cameroon is considered in relation to the wider *Justicia extensa-laxa* complex of tropical Africa. Its unusual litter-gathering habit (currently unique in Acanthaceae) is also discussed.

Methods – This study was based on normal practices of herbarium taxonomy and morphological analysis. All relevant protocols were followed in the production of the conservation assessment and selection of the lectotype.

Key results – A new combination *Justicia gigantophylla* (Lindau) H.J.Sm. & C.Moran is proposed for this narrowly endemic and endangered species, which is re-instated, with a new description and conservation assessment. A basic key to the wider *J. extensa-laxa* complex is presented. *Justicia gigantophylla* is assessed as Endangered (EN B1ab(iii)+2ab(iii)) according to the 2012 criteria of IUCN and a new lectotype is also designated.

Keywords – Cameroon; Acanthaceae; *Justicia*; litter-gathering; species complex; conservation.

INTRODUCTION

With 500 species (almost certainly an underestimate), *Justicia* L. s. lat. is the most species-rich genus within the Acanthaceae family (Vollesen in Darbyshire et al. 2010). Recognized as one of world's 'megagenera' (Frodin 2004), the sheer scale and morphological diversity of *Justicia* continues to pose significant challenges to taxonomists, with comprehensive treatments being unavoidably complex and difficult to produce. Over the last two centuries, hundreds of species and several whole genera have been moved in and out of *Justicia*; most accounts treating only particular geographic regions and taxonomists disagreeing on whether to take a broad or narrow approach to the genus overall (Graham 1988). The taxonomic intricacy of *Justicia* extends to the

Justicieae tribe, which has been described as 'the most taxonomically difficult group in Acanthaceae' (Kiel et al. 2017) and which continues to resist clarity even with contemporary molecular methods.

This study focuses on a small group of African species of *Justicia*, the *J. extensa* T.Anderson-*J. laxa* T.Anderson complex (Anderson 1863). The species within this complex are rainforest understory perennial herbs and shrubs occurring across the "Guineo-Congolian" forest belt (White 1983), extending from Guinea in the west to Kenya in the east and to northern Angola in the south. The complex is currently divided into two widespread species: *J. extensa* and *J. laxa* (Heine 1963, 1966; Vollesen in Darbyshire et al. 2010). Each of these species has several nomenclatural synonyms, a result of formerly segregated taxa having been subsumed

within the two more broadly circumscribed species. *Justicia laxa* is listed as of Least Concern (LC) on the IUCN Red List of Threatened Species, and although not on the formal Red List, *J. extensa* has also been assessed as of Least Concern following the IUCN (2012) criteria (Cheek et al. 2004).

However, preliminary studies of the large volume of herbarium material available for this group (c. 900 specimens at K, P, BR and WAG alone) have revealed a large range of morphological variation within each species, with at least some of this variation separable into discrete taxa. Some of these entities also appear to have a restricted range and so may be of high conservation significance yet, as with many cryptic species, they are currently hidden within widespread species of low perceived conservation value. Besides Champluvier's unpublished efforts to unravel the complex within Central Africa (annotated specimens seen at BR and K), the exact relationships between and within these species are yet to be fully resolved. This study aims to begin that process by providing a basic key to the *J. extensa-laxa* complex and by resurrecting *Duvernoia gigantophylla* Lindau with a new combination in *Justicia*; a particularly distinct and highly threatened member of the group hitherto obscured by an incomplete taxonomy.

MATERIAL AND METHODS

This study is based on detailed morphological studies of herbarium material, using specimens held at BR, BRLU, K, P, and WAG (herbarium abbreviations following Thiers continuously updated) as well as digitised type material seen on JSTOR. Data on distribution, ecology and nomenclature were taken from specimen labels and from field observations by Martin Cheek, one of the most recent collectors of the species. The geographical coordinates for each specimen were databased and error-corrected where necessary. Specimen data was imported into SimpleMappr (Shorthouse 2010) and used to produce distribution maps. The online tool GeoCAT (<http://geocat.kew.org/>, Bachman et al. 2011) was used to calculate the area of occupancy (AOO) and extent of occurrence (EOO). Both figures were then used alongside the IUCN red list categories (IUCN 2012) to produce a full conservation assessment for *J. gigantophylla*. Due to the limited material available, floral measurements were based on a total of three flowers (taken from Cheek 17553 and Letouzey 4095). These were two whole, dried flowers and one dissected flower, which was first rehydrated using Aerosol OT 5%

solution. Nomenclature adheres to the protocols of Turland et al. (2018) and binomial authorities to IPNI (continuously updated). All cited specimens have been seen by the authors.

RESULTS

Preliminary key to the *Justicia extensa-laxa* complex

Based on the preliminary results of this study, *J. laxa* is provisionally separated into three taxa of which *J. gigantophylla* is the most distinctive and discrete. *J. gigantophylla* is separated ahead of a full revision due to its highly threatened position and consequent need for formal recognition. The closely related *J. extensa* complex will likely also warrant subdivision following further investigation.

Justicia gigantophylla (Lindau) H.J.Sm. & C.Moran, **comb. nov.**

Duvernoia gigantophylla Lindau, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie*. 49: 406 (Lindau 1913). – **Type**: Cameroon, South Dist., bei Fenda, 58 km E Kribi, 1910–1911, *Mildbraed 5841* (holotype B†; hololectotype: HBG, barcode HBG502243, **designated here**; isolectotypes: P, barcode P00434952, HBG, barcode HBG502552).

Figs 1–4

Erect, single-stemmed herbs of 0.5–2 m; monopodial growth characteristic of litter-gathering habit; stem medium to dark green with swollen nodes, sparsely pubescent towards apex, soon glabrescent, the apex with short internodes and leaves forming a pseudo-rosette. Leaves slanting upwards, arranged forming a funnel (Cheek pers. obs.), oblong-ob lanceolate, thinly leathery (*Bos 3667*), medium green above, pale green beneath; 15–40 cm long, 5–15 cm wide, base amplexicaul and tightly clasped around stem, basal margins raised, forming a saucer, short internodes towards stem apices of opposite-decussate pairs forming a pseudo-rosette, occasionally base subcordate with very short petiole ± 1 cm, distal quarter of blade corrugated along the midrib (fig. 1B) margins entire, apex cuspidate, ± 13–20 pairs of lateral veins, glabrous on both surfaces except for short, sparse hairs on abaxial veins; tertiary veins laxly reticulate and conspicuous on the lower surface; cystoliths inconspicuous even in dried material. Inflorescence a terminal, paniculate thyrse (5–)10–25 cm long, 3.5–15 cm wide, comprising a series

Preliminary key to the *Justicia extensa-laxa* complex

1. Ovary and capsule pubescent..... *J. extensa* agg.
 - 1'. Ovary and capsule glabrous..... 2
 2. Leaves (sub)sessile, blade oblanceolate, 20–40 cm long, with 15–20 pairs of lateral veins; calyx lobes broadly ovate, 3–6 mm wide with adjacent lobes overlapping with margins adpressed, forming a star shape to the calyx in cross section..... *J. gigantophylla*
 - 2'. Leaves petiolate, petioles 2–10 cm long, blade elliptic or ovate, 10–25 cm long, with up to 12 pairs of lateral veins; calyx lobes lanceolate or linear-lanceolate, up to 2.5 mm wide, not or barely overlapping and not forming a star shape in cross section..... 3
 3. Panicles oblong and contracted, 2–5 cm wide, bracts linear-lanceolate, < 1 cm long. “*J. pyramidata*”
 - 3'. Panicles more lax, 9–15 cm wide, bracts foliaceous, ovate, 2–4 cm long..... *J. laxa*
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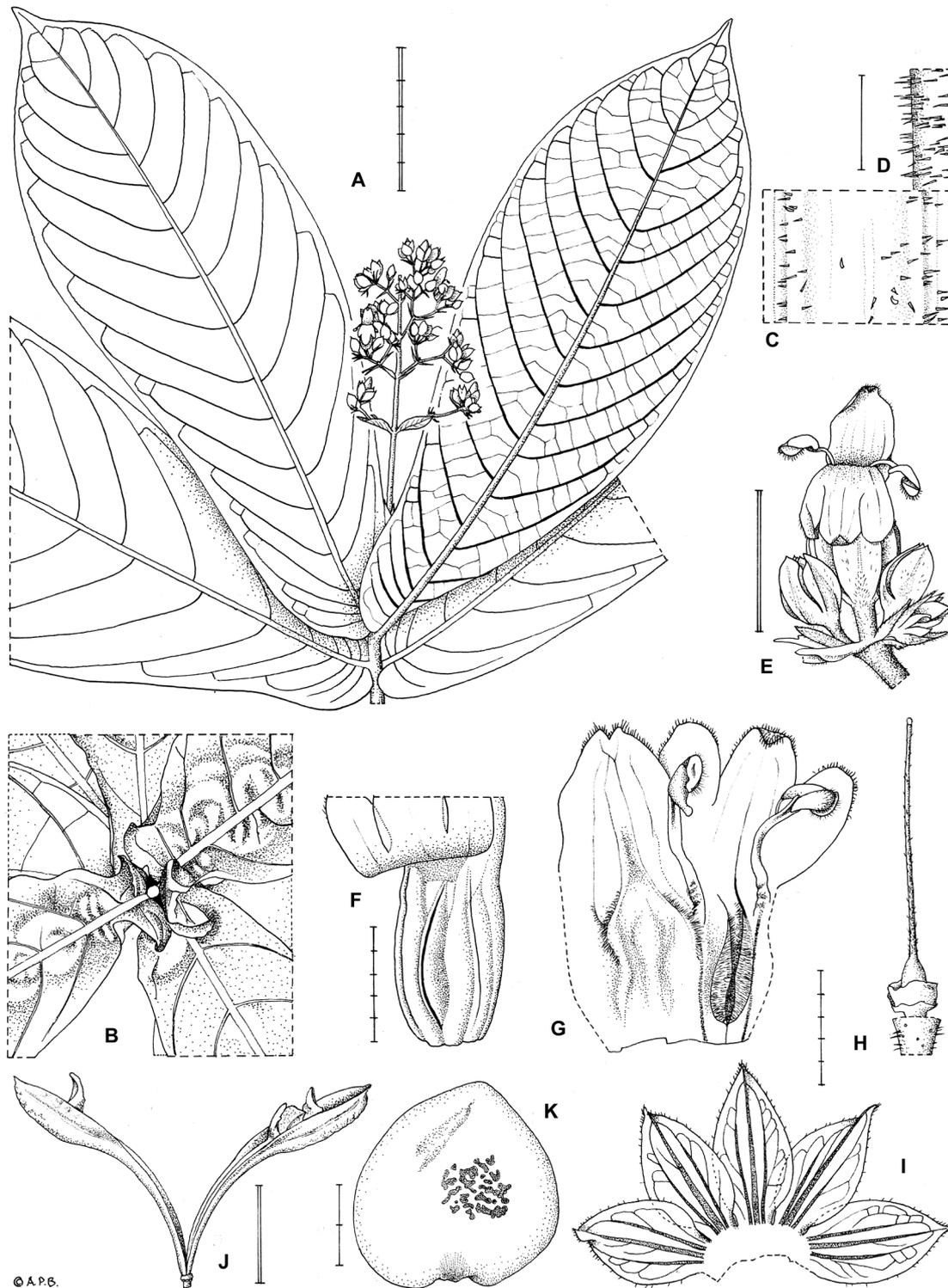


Figure 1 – *Justicia gigantophylla*. **A**. Upper part of plant with inflorescence (lacking terminal portion); artificially enlarged to avoid being obscured by right-side leaf. **B**. View of leaves (from photograph) in live plant from above to show puckering of young leaf surfaces and undulate leaf margins. **C**. Indumentum on axial midrib. **D**. Indumentum on pedicels/peduncles. **E**. Flower, face view, and neighbouring buds on lateral branch of inflorescence. **F**. Anterior face of corolla tube (with lobes raised) to show deep median and shallower lateral inflations. **G**. Corolla, cut and opened – the deep median inflation (on the right) is lined with inside as well as at its margins. **H**. Disc, ovary, style and stigma. **I**. Calyx, cut and opened, inner surface. **J**. Fruit, dehisced, with one immature seed in situ. **K**. Mature seed – pattern indicated is present over both surfaces. **A**, **C**–**I** from *Cheek 17553* (K). **B** from field photograph by M. Cheek (see fig. 2). **J** and **K** from *Letouzey 4095* (K). Scale bars: single bar = 1 mm; graduated single bar = 2 mm and 5 mm; double bar = 1 cm; graduated double bar = 5 cm. Drawn by Andrew Brown.

of open to rather dense dichasial cymes; inflorescence axes shortly antrorse-pubescent; bracts along main inflorescence axis linear-lanceolate, 0.3–1 cm long, 0.1–0.3 cm wide (at midpoint of inflorescence), lowermost bracts often larger and more leaf-like, antrorse-pubescent, bracteoles of same shape as bracts but smaller; cymes 1.7–6 cm long, pedicels 0.1–0.5 cm long. Calyx pale green with wine-red margin, deeply divided into five subequal suborbicular to broadly ovate lobes, 0.3–0.6 cm long, 0.3–0.6 cm wide, obtuse to faintly acute at apex, glabrous or with median vein sparsely antrorse-pubescent, strongly reduplicate with adjacent lobes overlapping and margins adpressed, forming a star shape to the calyx in cross section. Corolla 13–14 mm long (base of tube to tip of upper lip), minutely pubescent to glabrous externally and with short hairs on the margin of upper lip, conspicuously hairy within corolla tube; rugula (stylar furrow) present on dorsal side of tube and extending onto upper lip, with fringe of hairs in lower portion; tube 7–8 mm long, c. 4.5 mm broad, slightly ventricose above basal constricted portion of ± 1 mm; upper lip held erect, 5–7 mm long, c. 3.5 mm broad, somewhat hooded in situ, broadly ovate when flattened, apex emarginate, lower lip deflexed, 5–7 mm long, c. 6 mm broad, conspicuously 3-lobed for ± 3 mm, palate without conspicuous “herring-bone” venation. Stamens exerted, filaments \pm

3.5 mm long inserted ± 1.7 mm below corolla mouth, thecae offset by ± 0.5 mm, upper theca ± 1.5 mm long, pubescent on external side, with minute, rounded appendage, lower theca ± 1.5 mm long, glabrous, with ± 0.5 mm long ivory to cream-yellow appendage, blunt at the tip, stamens diverging at maturity. Ovary glabrous, c. 1 mm long, style 10.5–11.5 mm long, dark reddish-brown, strigose to glabrous, stigma short,



Figure 2 – Field photograph (by M. Cheek) of *J. gigantophylla* in lowland evergreen forest (Cheek 17553).

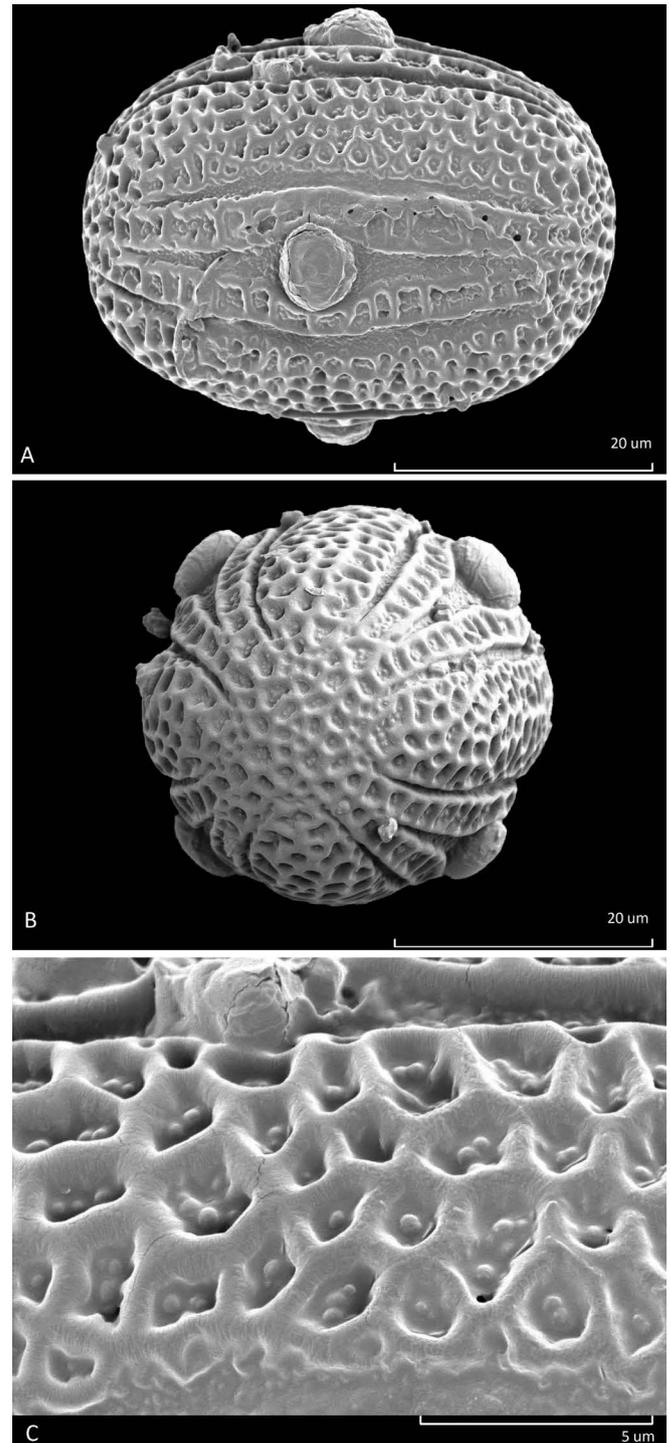


Figure 3 – SEM images of *J. gigantophylla* pollen. **A.** Apertural view. **B.** Polar view. **C.** Detail of interapertural exine. Material used: Cheek 17553.

lighter in colour (creamy yellow), minutely 2-lobed. Capsule 4-seeded, ± 3 cm long, glabrous, upper fertile portion ± 1.5 cm long, lower sterile stipe ± 1.5 cm. Seeds 0.3–0.5 cm in diameter, golden-brown, discoid, in face-view sub-orbicular, rugulose. – Figs 1 & 2.

Pollen prolate, 4-colporate, 8-pseudocolpate; $P = 39\text{--}46$ μm , $E = 25\text{--}34$ μm , $P/E = 1.15\text{--}1.5$; colpi and pseudocolpi approximately equal in length or pseudocolpi somewhat longer, extending to near the poles but not meeting; pori prominent, ± 6.5 μm wide; colpi and pseudocolpi microverrucate, interapertural and polar exine reticulate with microverrucate lumina. – Fig. 3.

Distribution – Africa: Cameroon. Known only from a small area of South Cameroon Region around the resort and port town of Kribi and inland to Bipinde. – Fig. 4.

Other specimens examined – CAMEROON. Bipinde, 1898, *Zenker 1840* (K, P); between Fenda, (60 km ESE of Kribi) and River Kienke, 22 Jan. 1962, *Letouzey 4095* (K, P, YA); Njabilobe (54 km ESE Kribi); 2 km W village, 12 Mar. 1963, *J. & A. Raynal 10386* (P, YA); Ebemwok (55 km W Ebolowa), SE of the village, 13 Mar. 1963, *J. & A. Raynal 10448* (P, YA); 15km SSE of Zingui (50 km to the SE of Kribi), 14 Mar. 1968, *Letouzey 9027* (K, P, YA); about 16 km. from Kribi, Lolodorf road, 18 Jan. 1969, *Bos 3667*



Figure 4 – Distribution maps of *J. gigantophylla* (top: long range; bottom: close range).

(P, WAG); about 15 km SE of Kribi, Kienke For. Res, at Bidou II, 30 Jun. 1969, *Bos 4949* (P, WAG); 38 km by road north of Akom II which lies on the Kribi-Ebolowa Rd. 22 Mar. 2014, *Cheek 17553* (K, YA,); Massif de Ngovayang, village de Ngovayang, 9 Jun. 2015, *Droissart et al. 1906* (BRLU); Ngovayang Massif, village of Atog Boga, 1 Sep. 2015, *Droissart et al. 2089* (BRLU); Massif de Ngovayang, au-dessus du village d'Atog-boga, 2 Sep. 2015, *Texier et al. 9* (BRLU); same locality, 3 Sep. 2015, *Texier et al. 14* (BRLU).

Habitat, ecology and phenology – Litter-gathering understory herb found mostly at roadsides and within forest clearings, sometimes near streams. Atlantic Equatorial Coastal Forests (White 1983). Mostly at elevations between c.300–900 m. Flowering occurs during rainy season between May/June and September/October.

Conservation assessment – A full IUCN conservation assessment is in press (Smith in press), which gives this species the current status of Endangered - EN B1ab(iii)+2ab(iii). This is based on the limited EOO of < 5,000 km² (3,427 km²) and AOO of < 500 km² (44 km²), the small and fragmented number of locations, and the imminent/currents threats of open-cast mining, logging and population growth in the immediate vicinity of the known locations.

Uses – Thus far, there are no described uses for this taxon, though its close relatives *J. laxa* and *J. extensa* are known for their economic and medicinal value. Both species are used as fish poisons throughout their native range in West Africa, and *J. extensa* is reportedly used as a treatment for a wide range of ailments; from headaches to epilepsy (Burkill 1985).

Notes – *Justicia gigantophylla* is based on Lindau's (1913) *Duvernoia gigantophylla* (see Discussion). It is clearly related to *J. laxa* T.Anderson, which it closely resembles in characters of the inflorescence, corolla, and anthers, but can be immediately separated by its oblanceolate, sessile or very shortly petiolate leaves that clasp the stem to form litter-gathering rosettes. The leaves are also larger than in *J. laxa* and usually bear more lateral veins, and the calyx lobes are much wider, with the margins adpressed to one another, forming a star shape in cross-section. *J. laxa* has more elliptic, regularly spaced leaves with a longer petiole, and narrowly lanceolate calyx lobes that are held flat.

Due to limited suitable material available for study, the pollen description for *J. gigantophylla* presented here is based on a single accession, *Cheek 12553*. The 4-colporate, 8-pseudocolpate reticulate pollen of that specimen is very similar to that reported for *J. extensa*, except that it is 4-aperturate whereas *J. extensa* is 3-aperturate (Graham 1988; Kiel et al. 2017). 3-colporate, 6-pseudocolpate pollen (as in *J. extensa*) is hypothesized to be synapomorphic for Justicieae as a whole (Kiel et al. 2017). However, aperture number is variable within the justicioids and it is clear that aperture number has evolved homoplastically across this clade (Kiel et al. 2017). Whilst pollen grains with 2 or 3 apertures are the most commonly encountered, some New World justicioids have up to 6 apertures, and 4-aperturate grains have been reported in several justicioid taxa, such as *Anisotes guineensis* Lindau (Baden 1981). Given this variation and homoplasy, pollen characters appear to be of limited taxonomic within the justicioids

at the generic level. However, a more exhaustive study of the pollen morphology of the *J. laxa*-*J. extensa* complex may, nevertheless, prove to be useful in species delimitation, particularly if aperture number proves to be consistent within species.

The lectotype selected here is one of two sheets of *Mildbraed 5841* held at HBG; the voucher in far superior condition is the one selected here. An image of the specimen is accessible at http://www.herbariumhamburgense.de/herbarsheets/disk_batch01/medium/HBG-502243.jpg

DISCUSSION

Taxonomic history and position of the species

Justicia gigantophylla was first described in 1913 by Gustav Lindau under the name *Duvernoia gigantophylla* and noted by the author for its resemblance to *J. extensa*, which Lindau also transferred to *Duvernoia* Nees. *Duvernoia* was first described from South Africa (*D. adhatodoides* E.Mey. ex Nees) but subsequently much expanded by Lindau. Despite Lindau's confidence in *Duvernoia*, its validity as a genus was challenged by Burkill & Clarke (1900) in the *Flora of Tropical Africa* (FTA) who noted that Lindau appeared to have circumscribed *Duvernoia* based on one character; that of the lack of tubercles on the smooth bands of the pollen. Burkill & Clarke (1900) wrote "we find the group contrary to nature itself; it appears not a genus, but a handful of species taken at random from every part of the genus *Justicia* (in a very wide sense)". Consequently, Burkill & Clarke moved all known species of *Duvernoia* into *Justicia*. Most recent treatments have followed this decision (e.g. Lebrun & Stork 1997; Scotland & Vollesen 2000; Vollesen in Darbyshire et al. 2010, 2015; Manning & Goldblatt 2014).

However, Lindau continued to uphold *Duvernoia* post-FTA and although *Duvernoia gigantophylla* was first collected in 1898 it was not described until 1911, nearly a decade after Clarke's FTA treatment. *Duvernoia gigantophylla* has not been covered in any subsequent floristic treatment. It is not mentioned in the *Flora of West Tropical Africa* (Heine 1963), which only extends as far east as the former 'British Cameroons' (modern-day Northwest and Southwest Cameroon Regions), i.e. outside the range of *D. gigantophylla*, which is only known from the South Cameroon Region. Similarly, Heine (1966) in *Flore du Gabon* did not discuss *D. gigantophylla* in relation to *J. extensa* or *J. laxa*. The name is entirely omitted from modern checklists of the vascular plants of Cameroon (Onana 2011, 2013) or of continental Africa (Lebrun & Stork 1997; Klopper et al. 2006; African Plants Database 2018). *Duvernoia gigantophylla* has therefore been left untreated, neither synonymized nor transferred, and essentially lost to science for over 100 years.

Since the first collection of this species in 1898 and the subsequent type specimen of 1911, no more specimens were collected until the 1960s (all of which were then mis-identified as either *J. extensa* or *J. laxa*). In most herbaria, this species has effectively been synonymised under *J. laxa* s. lat., due mainly to it having glabrous ovaries/capsules, the primary characteristic used by Burkill & Clarke (1900) and Heine (1963, 1966) to differentiate *J. laxa* from *J. extensa*

(the latter having pubescent ovaries/capsules). Some of the earliest specimens of *D. gigantophylla* (e.g. *Zenker 1840*) were labelled as “*Justicia andersonii* Lindau”, a name that was subsequently applied in 2004 to other specimens of this species by D. Champluvier (then of BR) who agreed that this species is distinct from *J. laxa*. However, *J. andersonii* is an unpublished manuscript name and would in any case be an illegitimate later synonym of *D. gigantophylla* (the name *J. andersonii* has already been published for two other species: *Justicia andersonii* Ramamoorthy from India and *Justicia andersonii* Wassh. from Brazil). The rediscovery of this species in 2014 and again in 2015, and observations on its unusual litter-gathering habit, prompted the re-examination of its taxonomic status which has led to its resurrection and transfer to *Justicia* here.

Recent molecular phylogenetic studies (Kiel et al. 2017, 2018) have demonstrated that *Justicia* s. lat. is highly paraphyletic and have outlined the need for serious re-evaluation and revision of the generic delimitation within the “justicioid” lineage. However, as the sampling in those studies was insufficient to reach firm conclusions on revised generic circumscriptions, a broadly circumscribed *Justicia* will remain for the immediate future, but it also seems likely that it is only a matter of time before major updates are implemented. What is clear from the results of Kiel et al. (2017) is that *Duvernoia sensu* Lindau is polyphyletic. Included in their sample are both *J. extensa* and *J. aconitiflora* (A.Meeuse) Cubey, the latter taxon being one of the two species previously treated in *Duvernoia* s.s. (see Manning & Getliffe-Norris 1995) and closely allied to the type species *D. adhatodoides* E.Mey. ex Nees (= *J. adhatodoides* (E.Mey ex Nees) V.A.W.Graham). *Justicia extensa* and *J. aconitiflora* are resolved as not closely related in this phylogeny. Hence, even if *Justicia* s. lat. is eventually broken up into segregate genera and *Duvernoia* is resurrected, the name *D. gigantophylla* will not stand. Therefore, it is appropriate that this species is transferred to *Justicia* s. lat. pending future generic recircumscription.

Besides the progress made with *J. gigantophylla*, it is clear that further work is necessary to resolve the *J. extensa-laxa* complex with any satisfaction. Molecular analysis would be a helpful addition here and may offer a logical and informative next step in the study of this group.

Litter-gathering habit

The distinctive litter-gathering habit of *J. gigantophylla* immediately separates it from the non-litter gathering species with clearly petiolate leaves seen across the rest of the *J. extensa-laxa* complex. The large leaves are tightly clasped around the stem and, due to the short internodes towards the stem apices, the opposite-decussate pairs form together a pseudo-rosette which creates a basket-like effect that collects humus and leaf litter from the forest. This habit appears to be unique in Acanthaceae though it has evolved in many different families (Zona & Christenhusz 2015; Lachenaud & Jongkind 2013) and may represent a remarkable case of convergence. The precise role of this adaptation remains unclear for *J. gigantophylla*, though in other litter-gathering plants commensal organisms are believed to utilise the

caught debris as food and/or housing, whilst the host plant benefits from nutrients as this debris is broken down (Zona & Christenhusz 2015). Litter-gathering plants such as this are surprisingly understudied, especially as far as Africa is concerned. It appears that they are often gregarious, with a strong tendency for several litter-gathering species to grow together (Lachenaud & Jongkind 2013). The reasons for this are unclear, but the litter-gathering habit may represent an adaptation to nutrient-poor soils. Nutrients might also be absorbed by the stem epidermis, or by underground roots as debris is washed away to the base of the plant (Hawthorne 2013). Cheek et al. (2008) described *Psychotria kupensis* (Rubiaceae), another litter-gathering shrub from Central Africa. Much like *J. gigantophylla*, this species was noted by the author for gathering forest litter in “funnel-like” rosettes, which indeed remains preserved in some herbarium specimens. Cheek et al. suggest that this litter-gathering form may benefit the plant through the uptake of “nutrient-enriched rainwater that percolates down from the funnel” (Cheek et al. 2008: 244); it is likely that a similar process occurs in *J. gigantophylla*.

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