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Phyllopentas flava (Rubiaceae), a New Morphologically Heterodistylous and Functionally Dioecious Species from Madagascar

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Abstract—A new species of the Afro-Malagasy genus *Phyllopentas* Kårehed & B. Bremer, ***Phyllopentas flava*** Razafim., T. Andriam. et Kårehed, is described and illustrated. This plant is restricted to the Itremo region in southeastern Madagascar and is distinct morphologically from the other species of the genus by its pubescent, narrowly ovate to narrowly elliptic leaves, grey-whitish and thickly hairy midribs and secondary veins on the lower surfaces of leaves, and functionally dioecious and heterodistylous flowers. Summaries of distribution, phenology, habitat, and ecology are given and a conservation assessment is also provided.

Keywords—Functional dioecy, heterodistyly, Knoxieae, *Phyllopentas*, Rubiaceae.

New generic circumscriptions of the tribe Knoxieae in the subfamily Rubioideae (Rubiaceae) have recently been established based on a recent molecular phylogenetic study by Kårehed and Bremer (2007). The members of Knoxieae are herbs, shrubs, or small trees generally characterized by a combination of the following characters: fimbriate, colletertipped stipules, terminal inflorescences, and five-merous, heterostylous flowers with unequal calyx lobes, sometimes enlarged and foliaceous. The tribe has a Paleotropical distribution with its center of species diversity in mainland Africa. In Madagascar, tribe Knoxieae sensu Kårehed and Bremer (2007) is currently believed to be represented by five of its 19 presently recognized genera: *Carphalea* Juss. (six species), *Otiophora* Zucc. (two species), *Pentanisia* Harv. (one species), *Pentas* Benth. (one species), *Phyllopentas* Kårehed & B. Bremer (five species), and *Triainolepsis* Hook. f. (ca. 14 species).

During a 2004 field collecting expedition led by the first author in the Itremo Region within the District of Ambatofinandrahana, Region of Amoron'i Mania, and Province of Fianarantsoa (Madagascar), an unknown species of the Afro-Malagasy genus *Phyllopenta*s was found. While this species does not fit any of the five described Malagasy species of the genus, its overall morphology matches the undescribed "*Pentas flava*" mentioned by Verdcourt (1953: 354). "*Pentas flava*" was considered by Verdcourt (1953) to be a new species, but he did not formally describe it pending better material. The name "*Pentas flava* Homolle MS" (annotation on *Decary 13215* (P!)) was listed by Verdcourt (1953) under the new species, and we therefore choose this epithet "*flava*" for this new species. In Kårehed and Bremer (2007), *Pentas flava*, represented by one specimen (*Andriamihajarivo et al. 410*!, TAN, erroneously cited as *ATH 211*), was resolved as sister to a Malagasy clade of *Phyllopentas* containing *P*. cf. *austroorientalis*, *P. ionolaena* subsp. *madagascariensis*, and *P. mussaendoides*. This further confirms the position of our new species in *Phyllopentas*.

Materials and Methods

The present study is based on the examination of 15 specimens of *Phyllopentas flava* available at the herbaria at P and TAN (abbreviations after Holmgren et al. 1990). Eco-geographical data were collected from specimen labels. The measurements provided in the description were taken from herbarium specimens. The georeferenced specimen data were imported into the geographic information software ArcView™ 3.3 to calculate area occupancy (AOO) and extent of occurrence (EOO) for *P. flava*. We used the AOO and EOO figures together with field observations to propose a conservation ranking status based on the IUCN red list categories and criteria (IUCN 2001).

Taxonomic Treatment

Phyllopentas flava Razafim., T. Andriam. et Kårehed, sp. nov.—TYPE: MADAGASCAR. Fianarantsoa Province, Amoron'i Mania Region, Ambatofinandrahana District: Lovokaloha, à l'ouest du barrage de Marosahona, au bord de la Rivière d'Akaifirina, 20°29′58″ S, 46°51′37″ E, ca. 1,411 m, 02 November 2004 (pistillate fl., fr.), *Andriamihajarivo et al. 410* (holotype: TAN!; isotypes, MO, P).

Species haec endemica in regione Itremo foliis anguste ovatus ad ellipticus et dense pubescentibus necnon floribus functionale dioeciis et morphologice heterodistylis distinguenda ab aliis speciebus in Madagascar *Phyllopentas*.

Herbs or shrubs, 0.50–1 m tall, entirely and densely pubescent. Stems ca. 1 cm diam., terete, pubescent, brown-blackish when dry. Leaves narrowly ovate to narrowly elliptic, membranaceous, pubescent, 4.5–8 × 0.95–2 cm, acuminate at apex, cuneate at base, margin entire; lower surfaces grey-whitish, midribs prominent, secondary veins 5–7 pairs, tertiary venation reticulate; upper surfaces darker, midribs prominent, secondary veins distinct, tertiary veins indistinct; petioles 0.5–0.8 cm long, pubescent, semiterete. Stipules 0.3–0.7(–1) cm long, linear, fimbriate, green, pubescent. Inflorescences terminal, trichotomous (dichotomously branched at the base of the primary inflorescences), lax, 4–7 cm long, pubescent, pedunculate; bracts solitary at the base of each pedicel, 6–1.2 mm long, linear, pubescent. Flowers functionally dioecious and morphologically heterodistylous, 5-merous, pedicellate, ca. 67% of them with one enlarged calyx lobe, ca. 33% without enlarged calyx lobe; pedicels 2–4 mm long, pubescent; calyx tubes 3–5 mm long, calyx lobes very unequal, the nonfoliaceous ones filiform, 4–8 mm long, pubescent, the foliaceous one spathulate or elliptic to oblong, 1–2 × 0.5–0.8 cm, pubescent, margins entire, with brochidodromous venation, apex acuminate, light purple. Functionally pistillate flowers shorter than the functionally staminate, corolla tubes 2–2.4 cm long, pale yellow, inside and outside pubescent, the lobes

4–5 mm long; styles 2–2,3 cm long, bifid, pubescent, the stigmatic lobes 1.5–2 mm long; ovaries ovate, bilocular, the well-developed ovules numerous in each locule, the placentation axile; stamens 5, without pollen grain, the filaments 0.8–1 mm long, dorsifixed, pubescent, inserted at the throat of the corolla tube and below stigmatic lobes, the anthers 2.3–2.8 mm long. Staminate flowers larger than pistillate flowers; corolla tubes 2.5–3.2 cm long, pale yellow, inside and outside pubescent, the lobes 3–4 mm long; stamens 5 with functional pollen grains, exserted, the filaments 4.2–5.5 mm long, pubescent, dorsifixed, inserted at the throat of the corolla tube, the anthers 2.3–2.9 mm long, glabrous, 19–21 mm long, inserted between 1/3 to ½ of the corolla tube from the throat; styles 20–24 mm long, the stigmas 1.1–2 mm long, bifid, the ovary conical, bilocular, containing reduced ovules. Fruits from the functionally pistillate flowers 3–6 × 3–6 mm, capsular, obtriangular, ribbed, beaked, dehiscent, ornamented by persistent calyx lobes, splitting into four valves in the beak, pubescent; seeds numerous, reduced staminodes. Seeds ca. 0.5 mm long, irregularly globose or tetrahedral. Fruits from the functionally staminate flowers not seen. Figure 1A-K.

Etymology—The epithet "*flava*" refers to the color of the corollas of this species.

Vernacular Name—None have been recorded.

Phenology—Flowering November to April; fruiting possibly December to June.

Distribution—The species is found in Itremo, District Ambatofinandrahana, Region Amoron'i Mania, and Province Fianarantsoa, Madagascar.

Habitat and Ecology—The species grows at edges of the evergreen sclerophyllous forests, growing along streams or rice fields; humid or subhumid conditions, at 1,200–1,800 m altitude.

IUCN Conservation Status—*Phyllopentas flava* is only known from two regions, Itremo and Ambatofinandrahana, with an area of occupancy (AOO) of 300 km^2 and an extent of occurrence (EOO) of 1,364 km^2. However, it occuppies areas that have been fragmented and parts of them have been severely destroyed by frequent fires. In other words, there is a continuing decline in its EOO, AOO, and the quality of its habitat. Consequently, it is likely that the number of its subpopulations and possibly also that of its mature individuals have declined or disappeared in some of its highly fragmented habitat. Therefore, we consider the species Endangered EN B1a,b(i,ii,iii,iv,v)+2a,b(i,ii,iii,iv,v) (IUCN 2001).

Additional Specimens Examined—MADAGASCAR. Fianarantsoa Province: Région Amoron'i Mania, District Ambatofinandrahana, environ d'Ambatofinandrahana, bord du ruisseau, Janv. 1964 (staminate fl.), *Bosser 18804* (TAN); Itremo Massif, 213 km, SW (BRG208°) of Antananarivo, forest remnant in river valley, at edge of evergreen sclerophyllous forest (with *Uapaca* sp.), 20°34'39.72"S, 46°34'53.22" E, 1,600 m, 29 October 1997 (pistillate fl.) *Davis et al. 1013* (P, TAN); unknown locality, unknown date, *Decary 13215* DSCN 581–2 (P); bord de torrent, 11 November 1939 (staminate fl.), *Decary 15175* DSCN583–4 (P); environs d'Ambatofinandrahana, bord du ruisseau, 1,600–1,800 m, 23 February1938 (staminate fl.), *Decary 13259* DSCN585–7 (P); Montagne à l'Ouest d'Itremo, 1,500–1,700 m, 17–22 January and 18–22 April 1955, data unknown (staminate fl.), *Humbert 28332* DSCN563–5 (P); Montagne à l'ouest d'Itremo, bois des pentes occidentales sur gneiss et quartzites, 1,500–1,700 m, 17–22 January and 2–18 April 1955 (staminate fl.), *Humbert 29926* DSCN552–3 (P); near the Col d'Itremo (West of Ambositra), stream valley in native woodland, with *Uapaca bojeri* and *Chrysalidocarpus decipiens* palms, on quartz, 20°34'26" S, 46°34'46" E, 1,580 m, 25 November 1993 (staminate fl.), *DuPuy et al. 666* DSCN576–8 (P, TAN); Itremo Massif, along Ambalaranagolana creek, ca. 1 km NNE of bridge on road to the Col d'Itremo, forested area right along creek bed, 20°34'31"S, 46°34'50" E, 1,540 m, 9 November 2002 (pistillate fl. & fr.), *Lowry et al. 5862* DSCN570–2 (P, TAN); Itremo Massif, on route national 35, 19 km W of Ambatofinandrahana, SW facing rocky slope with deep gully, 20°34'00" S, 46°42'40" E, 1,250 m, 11 March 1992 (pistillate fl.), *Phillipson et al. 3848* (TAN, P).

Key to all Six Described Malagasy Species of *Phyllopentas*

1. Inflorescences or infructescences head-like ..... *P. austroorientalis*
1. Inflorescences or infructescences not head-like 2
2. Herbs to 35 cm tall ..... *P. decaryana*
2. Herbs or shrubby herbs 70 cm to 5 m tall 3
3. Inflorescences sessile ..... *P. hirtiflora*
3. Inflorescences pedunculate 4
4. Leaves densely pubescent, the midribs and secondary veins of the lower surfaces of leaves thickly hairy, grey-whitish when dry; petioles 5–8 mm long ..... *P. flava*
4. Leaves not densely pubescent, the midribs and secondary veins of the lower surfaces of leaves not thickly hairy, not grey-whitish when dry; petioles at least 10 mm long 5
5. Leaves narrowly elliptic, corolla tubes ca.10 mm long ..... *P. madagascariensis*
5. Leaves elliptic to elliptic-oblong, corolla tubes 22–30 mm long ..... *P. mussaendoides*

Discussion

Phyllopentas flava is distinct from the other species of *Phyllopentas* in its pubescent, narrowly ovate to elliptic leaves. The functionally staminate and pistillate flowers are found on separate plants; the former are brevistylous and larger than the pistillate flowers that are longistylous. In the brevistylous, staminate flowers, the styles are located between 1/2 and 2/third of the corolla tube and below the attachment point of the filaments. The anthers contain pollen grains, whereas the ovaries contain reduced ovules. In contrast, the longistylous, pistillate flowers have styles as long as the corolla tubes. The stigmatic lobes and ovaries are well developed and the former are exserted beyond the corolla lobes; the anthers contain no pollen grain. Based on the above information, we conclude that *P. flava* is a morphologically heterodistylous and functionally dioecious species. The other Malagasy *Phyllopentas* are reported to be hermaphroditic and heterodistylous species, which are common in Rubiaceae, especially the subfamily Rubioideae (e.g. Robbrecht 1988). However, functionally dioecious and heterodistylous species seem to be rarely reported in the family. This latter has been reported in three distantly related genera: the genus *Antirhea* (*Antirhea borbonica*, Litrico et al. 2005) in the tribe Guettardeae (subfamily Cinchonoideae); the genus *Chassalia* (e.g. *Chassalia corallioides* (Cordem.) Verdc., Pailler et al. 1998) in the tribe

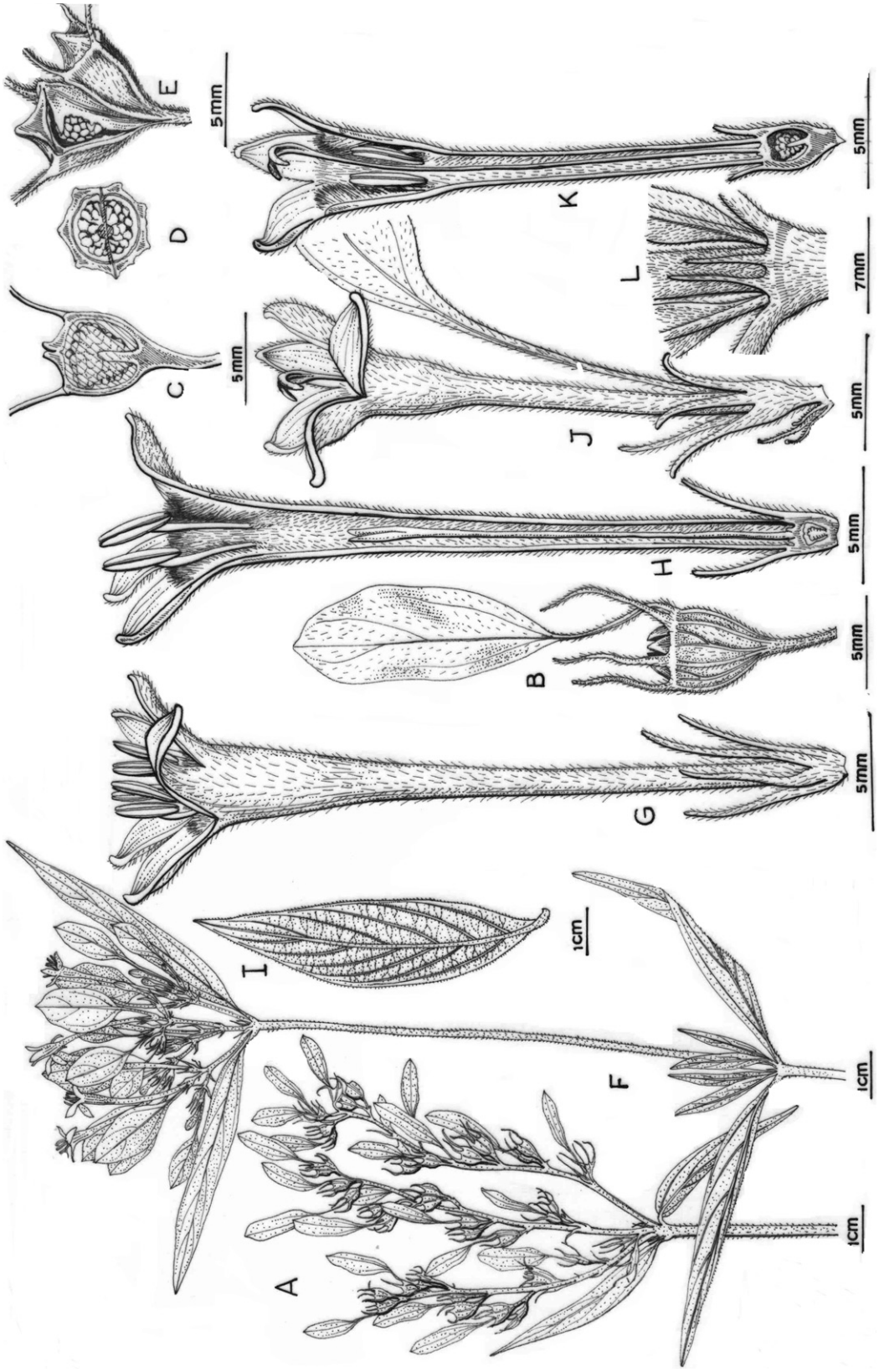

FIG. 1. *Phyllopentas flava* Razafim., T. Andriam., & Kårehed. A. Fertile branch with mature infructescences. B. Mature fruit showing longitudinal ridges, persistent and unequal calyx lobes, of which one is enlarged, and dehiscing beak. C. Longitudinal section of an immature fruit and its pedicel. D. Transversal section of an ovary. E. A Mature, dissected capsular fruit. (A-E drawn from *Philippson 3848*, TAN). F. Fertile branch with mature inflorescences. G. A functionally staminate flower with exserted anthers and unequal calyx lobes. H. Longitudinal section of a staminate flower showing the insertion of the filaments at the throat of the corolla tube, exserted anthers, a brevistylous, bifid stigma, and reduced ovules. I. An upper view of a leaf (G-I drawn from *Du Puy et al. 666*, TAN). J. A functionally female pistillate flower with an exserted stigmatic lobe, unequal calyx lobes and one enlarged calyx lobe. K. Longitudinal section of a pistillate flower showing the insertion of the filaments at the throat of the corolla tube, inserted anthers, a longistylous, bifid stigma, and well-developed ovules. L. A Node with fimbriate stipules (J-K drawn from *Andriamihajarivo et al. 410*, TAN).

Palicoureeae (subfamily Rubioideae); and more recently in the genus *Mussaenda* (e.g. *Mussaenda pubescens* Dryand, Li et al. 2010) in the tribe Mussaendeae (subfamily Ixoroideae). Functional dioecy was assumed to have been evolved from heterodistyly for the two latter species.

The specimen *Decary 5427* (P!) was listed by Verdcourt (1953) as *Pentas flava* Homolle MS; however the herbarium sheet is actually labeled *Pentas micrantha* Baker and annotated as such by Verdcourt. We confirm that this specimen belongs to the latter species, which is now the sole *Pentas* species found in Madagascar. We choose *Andriamihajarivo et al. 410* (TAN) over *Decary 13215* (P), seen by Verdcourt (1953), as holotype because it is more complete and has mature pistillate flowers.

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