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***Gladiolus mariae* (Iridaceae), a new species from fire-free shrubland in the Kounounkan Massif, Guinea**

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Abstract: *Gladiolus mariae* Burgt (*Iridaceae*), a new species from Guinea, West Africa, is described and illustrated. The new species is placed in *Gladiolus* sect. *Decorati* Goldblatt and compared with the nine species already known from that section. Flowering plants stand 28–160 cm high with 1–6 bright orange flowers, opening one at a time. The ecology of the new species is discussed in detail, and a description of the vegetation in the region is provided. *Gladiolus mariae* is at present known only from two uninhabited sandstone table mountains in the Kounounkan Massif, Forécariah Prefecture. About 210 plants were found, on rocky soils at altitudes of 650–1100 m. The majority of plants, about 160, were found in fire-free shrubland, in five patches of 1–4 ha each, dominated by fire-sensitive plant species, but grasses are infrequent. *Gladiolus mariae* seems vulnerable to grassland fires. The area of occupancy is 28 km². The species is assessed to the IUCN category Endangered.

Key words: *Gladiolus*, *Gladiolus* sect. *Decorati*, Guinea, *Iridaceae*, new species, submontane vegetation, taxonomy, West Africa

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Introduction

The Kounounkan Massif is situated in Forécariah Prefecture in western Guinea and is the south-eastern section of an expanse of sandstone plateaus occupying much of Coyah, Kindia and Dubreka Prefectures. The Kounounkan Massif is an area of mixed primary and secondary closed forest with natural and man-made savannah and farmbrush (Barnett & al. 1994). The lower slopes of the southern plateau of the Kounounkan Massif are covered in lowland evergreen rain forest. The precipitation in the region is about 2600 mm/y (L'Hôte & Mahé 1995), with a six-month dry season, conditions sufficient to support rain forest (Bond & al. 2005; Oliveras & Malhi 2016; Staver & al. 2011). However, the vegetation on the

southern plateau consists of 12 km² of sparsely wooded submontane grassland, and only 2 km² of submontane forest (grassland and forest at over 800 m altitude), in sheltered sites and along streams (measured on imagery of 3 May 2016 on Google Earth 2018). The grasslands are frequently burned during the annual dry season (see historic imagery on Google Earth 2018), but the submontane forests are normally free of fire. The boundaries between the submontane grasslands and the submontane forests in the Kounounkan Massif are generally abrupt; woody plant cover changes instantly from a few % in sparsely wooded submontane grassland to 100% in submontane forest. Transitions between tropical forests and savannas are frequently quite abrupt, as opposed to a gradual gradation in tree cover (Oliveras & Malhi 2016).

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The southern plateau of the Kounounkan Massif is a sandstone table mountain of 14 km² surrounded by vertical cliffs up to 400 m high. The summit of the table mountain is at 1180 m, while the surrounding plains to the west, south and east are at 50–100 m altitude. The southern plateau is uninhabited and there are no foot-paths; the plateau is not suitable for cattle raising because it is impossible to bring cattle there. The southern plateau is separated from the northern plateau by a kilometre-long and several-hundred-metre-deep canyon. The northern plateau has several small villages and the land is used for small-scale cattle raising and farming. North of the Kounounkan Massif is another sandstone plateau, the Benna Plateau. This plateau was visited by the French botanist Henri Jacques-Félix in the 1930s. From the collections made there and deposited in the Paris herbarium (P), he described several new species, for example *Cailliella praeurpticola* Jacq.-Fél. (*Melastomataceae*; Jacques-Félix 1938) and *Rhytachne perfecta* Jacq.-Fél. (*Poaceae*; Jacques-Félix 1954). Both species are endemic to the sandstone plateaus. Three endemic species of the sandstone plateau region were recently discovered: the tree *Talbotiella cheekii* Burgt (*Leguminosae*; Burgt & al. 2018), the monotypic herb *Kindia gagan* Cheek (*Rubiaceae*; Cheek & al. 2018a) and the small tree or shrub *Keetia susu* Cheek (*Rubiaceae*; Cheek & al. 2018b).

The Kounounkan Massif and the surrounding lowland rain forest are proposed by Kew's Tropical Important Plant Areas (TIPAs) Project (Darbyshire & al. 2017) to become a new protected area. To realize this, the Kew Herbarium and the National Herbarium of Guinea are studying the area and liaising with the Guinean government. A botanical expedition to the southern plateau of the Kounounkan Massif was undertaken in September 2016 by two of the authors of this paper (XvdB and PMH). One of the first collections made, immediately on arrival, was a species of *Gladiolus* L., with attractive bright orange flowers. On another expedition, in December 2017, a second population of the same species was found, and fruits and seeds were collected. A third population was found in October 2018 on an uninhabited table mountain 10 km to the west, with a size of 2.6 km², covered in forest and a few patches of open vegetation. The species is evidently new and is described here.

The largest genus of *Iridaceae*, *Gladiolus*, includes over 270 species (Goldblatt & al. 2014; International Plant Names Index 2018), and occurs in Africa, Madagascar, Mediterranean Europe and the Middle East as far east as Afghanistan. The genus is centred in southern Africa (Goldblatt 1996). Ten species of *Gladiolus* occur in West Africa, from Togo westward. Four of these species are endemic to West Africa, including the new species described here. All species in the genus *Gladiolus* are perennial herbs, with corms, a simple or sometimes branched aerial flowering stem, 3 sheathing cataphylls and 1–8 foliage leaves. The flowers are arranged in an inclined or erect spike, each flower sessile and subtended

by a pair of opposed bracts; the flowers have 6 unequal tepals, 3 stamens, filaments inserted at the base of the upper part of the perianth tube, usually at the point where the tube widens, and a style divided into 3 stigmatic branches. The fruit is a capsule; the seeds are broadly winged (Goldblatt 1996).

Material and methods

The expedition to the study area in which the new species was found was planned using Google Earth (2018) imagery. For successive expeditions, several localities with comparable habitats were selected on Google Earth; the occurrence of the new species was confirmed in most of these localities. All vegetation types present in the study area were visited. Herbarium collections were immediately dried overnight on a portable gas dryer. Photos of plants and vegetation types were taken with a Nikon Coolpix AW 110 and an Olympus Tough TG5. Research permits were obtained in advance of the expeditions, and export permits for the herbarium and seed collections were obtained for their export (see Acknowledgements).

The collections were compared with the revision of *Gladiolus* in tropical Africa by Goldblatt (1996). The International Plant Names Index (2018) was consulted for newly published names; no names additional to those in Goldblatt (1996) were found that could apply to the collections. Herbarium collections from HNG, K and P were studied (herbarium codes according to Thiers 2019+). The P herbarium holds the most extensive collection of historic specimens from Guinea. All herbarium specimens cited have been studied by the authors. All flowers from the type collection were carefully observed with a light microscope, using strong light from below, in order to study the internal features of the flower. A flower from *Burgt* 2207 was dissected.

Results and Discussion

Gladiolus mariae Burgt, sp. nov. – Fig. 1, 2.

Holotype: Guinea, Forécariah Prefecture, southern plateau of Kounounkan Massif, 09°33'N, 12°51'W, 910 m, fl., 25 Sep 2016, X. M. van der Burgt & P. M. Haba 2012 (K001243991; isotypes: HNG, P, PRE, WAG).

Diagnosis — *Gladiolus mariae* morphologically resembles *G. sudanicus* Goldblatt. *Gladiolus mariae* plants are 28–160 cm tall with 7–11 foliage leaves and 1–6 flowers (vs 15–20 cm tall with 4 or 5 leaves and 2 or 3 flowers in *G. sudanicus*). The outer bract of the flower is 40–110 mm long (vs 20–25 mm long in *G. sudanicus*). The perianth tube is 39–50 mm long (vs 16–20 mm long in *G. sudanicus*); the tepals are 28–36 mm long and bright orange (vs 16–24 mm long and pale to deep pink in *G. sudanicus*).



Fig. 1. *Gladiolus mariae* – A: habit of flowering plant; B: flowers; C: fruiting plant; D: fruit. – Origin: A from *Burgt & Haba 2012* (type gathering); B from *Burgt 2207*; C, D from *Burgt 2161*. – All photographs by Xander van der Burgt.



Fig. 2. *Gladiolus mariae* – A: flowering plant; B: detail of leaf; C: base of plant showing corm and 3 cataphylls; D: upper part of plant with an open flower and a flower bud; E: upper part of fruiting plant with 5 mature fruits; F: mature, open fruit with seeds; G: detail of dotted epidermis of fruit; H: seeds. – Origin: A–D from Burgt & Haba 2012 (type gathering); E–H from Burgt 2161. – Drawing by Lucy T. Smith.

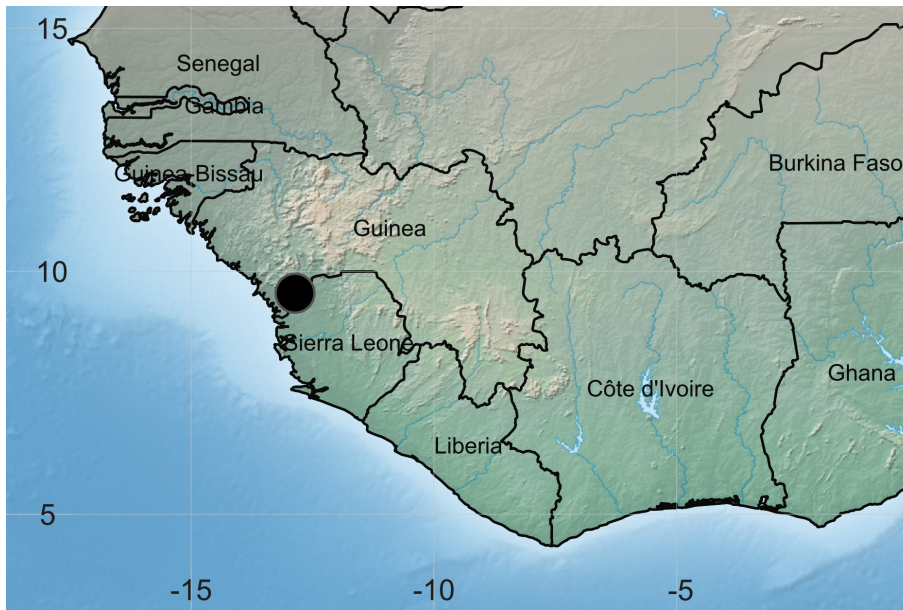


Fig. 3. Distribution of *Gladiolus mariae* in West Africa (●).

Description — Plants 28–160 cm tall. *Corm* 2–4 cm in diam.; *tunics* with netted veins. *Stem* unbranched, 2–7 mm in diam. at base, 1–3 mm in diam. just below inflorescence. *Cataphylls* 3, completely sheathing stem, brown to pale yellowish brown, 3–31 cm long. *Foliage leaves* 7–11, lower part sheathing, upper part 4–21 mm wide, midvein and margins prominent, pale green, usually a single vein near each margin also prominent and pale green; *lower leaves* reaching to apex of spike; *upper leaves* progressively shorter, reaching just below base of inflorescence, mostly sheathing. *Spike* erect, with 1–6 flowers; *bracts* green, outer bract 40–110 × 12–18 mm, inner bract 30–50 × 6–12 mm. *Flowers* bright orange, lower 3 tepals each with a light yellow-green median streak outlined in white and dark orange, upper 3 tepals each with a white streak. *Perianth tube*: proximal part erect, tubular, 18–25 mm long, distal part arching over and widening, 8–11 mm long; *tepals* lanceolate, outer tepals 34–46 × 12–15 mm, inner tepals 34–46 × 14–25 mm. *Stamens* unilateral, arcuate; *filaments* 25–30 mm long, exerted 17–19 mm from perianth tube; *anthers* yellow, 6–7 mm long, with apiculate appendages c. 1 mm long. *Ovary* ellipsoid, 8–10 × 2.5–3 mm; *style* 40–52 mm long, dividing opposite centre of anthers, branches c. 5 mm long, widening toward apex, edges dark orange. *Capsules* light brown when dry, ellipsoid, triangular in cross-section, 23–38 mm long, outside densely dotted with dark brown spots 0.1–0.3 mm in diam. *Seeds* up to 150 per fruit, in 6 rows, golden brown, elliptic to oval, 8–11 × c. 6 mm, broadly winged.

Phenology — *Gladiolus mariae* flowers in September–October and fruits in November–December.

Distribution — *Gladiolus mariae* is at present known only from two uninhabited sandstone table mountains

in the Kounounkan Massif in Forécariah Prefecture, Guinea (Fig. 3). Sandstone plateaus elsewhere in the region are inhabited by farmers and cattle herders, and most of the original vegetation there has been modified by fire. If the species originally occurred elsewhere in the sandstone plateau region, then it may still survive there, in rock crevices on vertical sandstone cliffs.

Habitat and ecology — *Gladiolus mariae* occurs on sandstone, on rocky soils; altitude 650–1100 m, in three vegetation types. Most plants were found in open fire-free

shrubland vegetation (Fig. 4, 5). The species was also found in rock crevices on vertical sandstone cliffs; and occasionally in sparsely wooded submontane grassland, in sheltered sites where dry-season fires do not occur every year (Fig. 6).

On uninhabited table mountains in the Kounounkan Massif occur a few patches of open shrubland vegetation, characterized by up to 75% shrub cover with a herbaceous understorey, surrounded by submontane forest with 100% small tree and liana cover but with few herbs in the understorey. Open shrubland vegetation blends gradually into submontane forest; sharp boundaries are absent (Fig. 4). Most plants of *Gladiolus mariae* were found in five patches of open shrubland vegetation, of 1–4 ha each, at 650–950 m altitude (Fig. 5). This vegetation is dominated by several species of shrubs 0.5–3 m tall, which are not resistant to fire, and which are endemic to Guinea or occur as well in only one or two other countries (African Plant Database 2018; Lisowski 2009): *Cailliea praerupticola*, *Dissotis leonensis* Hutch. & Dalziel, *Dichaetanthera echinulata* (Hook. f.) Jacq.-Fél. (all *Melastomataceae*), *Fegimanra afzelii* Engl. (*Anacardiaceae*) and *Kotschya uniflora* (A. Chev.) Hepper (*Leguminosae*). Two perennial *Cyperaceae* shrubs are also dominant: the widespread and fire-resistant *Afrotrilepis pilosa* (Boeckeler) J. Raynal and the rare and fire-sensitive *Microdracoides squamosa* Hua. In this fire-free habitat they are more luxuriant than in annually burned grassland; their woody stems standing to about 70 cm tall. *Poaceae* are infrequent in this open shrubland vegetation, which is remarkable because they are the most abundant family in terms of species richness and % cover in sparsely wooded submontane grassland in the Kounounkan Massif. Among the few *Poaceae* species present in open shrubland vegetation are *Rhytachne perfecta* (Fig. 5), endemic to the Kounounkan Massif, and *Schizachyrium radicosum* Jacq.-Fél., endemic to Guinea.



Fig. 4. Submontane forest and shrubland vegetation at 850 m altitude in the Kounounkan Massif. Both vegetation types are dominated by species that are not resistant to fire. The shrubland vegetation blends gradually into the surrounding submontane forest. – Photograph taken on 25 Sep 2016 by Xander van der Burgt.



Fig. 5. Inside the submontane shrubland vegetation of Fig. 4. *Gladiolus mariae* occurs abundantly in this vegetation type. The vegetation is dominated by shrubs that are not resistant to fire: *Cailliola praerupticola* (in flower), *Dissotis leonensis* (both Melastomataceae) and *Microdracoides squamosa* (Cyperaceae). Grasses (Poaceae) are infrequent; the only grass visible is *Rhytachne perfecta*, front and centre right. – Photograph taken on 27 Nov 2017 by Xander van der Burgt.



Fig. 6. Submontane wooded grassland vegetation in the Kounounkan Massif. *Gladiolus mariae* was collected on this 1020 m high hill and was also observed there, growing on vertical sandstone cliffs. In some years the vegetation on the hill is not subject to the annual dry season fires because it is separated from the main plateau by a narrow, 350 m long canyon. – Photograph taken on 7 Feb 2019 by Xander van der Burgt.

In Afromontane shrubland, fire has often favoured the spread of grasses at the expense of the shrubs (White 1983: 49). Anthropogenic fires are usually ignited in the dry season when lightning-ignited fires would not normally occur (Archibald & al. 2012) and have a large influence on species composition and structure of the vegetation (Bond & al. 2005; Staver & al. 2011).

These patches of open shrubland vegetation are assumed to be unaffected by natural as well as anthropogenic fires, because they are dominated by fire-sensitive plant species, and because they are remote and surrounded by vertical rock cliffs and submontane forest, protecting the shrubland from the annual fires in the nearby sparsely wooded submontane grasslands. Three soil samples of 3–8 kg each, taken in three different shrubland vegetation patches with abundant *Gladiolus mariae*, contained no charcoal at all, although many wood pieces were present. The patches of fire-free shrubland vegetation in the Kounounkan Massif (Fig. 4, 5) may represent some of the last remaining non-forest vegetation unaffected by anthropogenic annual dry-season fires in Guinea.

Conservation status — *Gladiolus mariae* is a very rare species, so far collected only by the present authors, and only found abundantly in fire-free vegetation in a few uninhabited areas. The species is at risk of be-

coming extinct in the wild. *Gladiolus mariae* is known from three collections and six observations from two table mountains in the Kounounkan Massif. The extent of occurrence is 28 km²; but is not used in the assessment because it contains mostly lowland forest habitat unsuitable for the species. The area of occupancy is also 28 km², calculated from a reference scale of 2 × 2 km cells. Despite searches elsewhere in the Kounounkan Massif, the species has not yet been found outside the nine known sites. Nevertheless, if the species occurs elsewhere in the Kounounkan Massif, the area of occupancy will remain below the Endangered category thresholds of the IUCN criterion B2.

The species was found in three vegetation types, each with different fire regimes, and the number of locations is therefore three. Continuous decline was observed in all three vegetation types, in quality of habitat and in number of mature individuals. *Gladiolus mariae* was found most abundantly in five patches of fire-free shrubland. There is a high risk of humans igniting these last remaining patches of fire-free shrubland vegetation. Vegetation on vertical sandstone cliffs may also be subject to fire, ignited by sparks from grassland fires. In sparsely wooded submontane grassland, which is the most common habitat type on plateaus in the Kounounkan Massif, *Gladiolus mariae* is relatively rare and is mostly found in sheltered sites where

Table 1. Important differences between the ten species in *Gladiolus* sect. *Decorati* (data of the nine species already known from the section are from Goldblatt 1996).

| Species | Distribution | Plant height (cm) | Number of leaves | Leaf width (mm) | Number of flowers | Outer bract length (mm) | Tepal colour | Tepal length (mm) |
|--|--|-------------------|------------------|-----------------|-------------------|-------------------------|---|-------------------|
| <i>Gladiolus decoratus</i> Baker | Tanzania, Malawi, Mozambique | 45–80 | 4 or 5 | 8–18(–24) | 5–9 | 25–40(–50) | bright orange-red or dark red | 40–55 |
| <i>Gladiolus grantii</i> Baker | Tanzania | 30–45 | 4 or 5 | 4–7 | 5 or 6 | 33–38 | white to cream, fading to pale salmon or pink | 28–30 |
| <i>Gladiolus lithicola</i> Goldblatt | Ethiopia | (8–)12–28 | 2–4 | (2–)3–4 | (1 or) 2 or 3 | (15–)30–35 | lavender or mauve | 18–20 |
| <i>Gladiolus mariae</i> Burgt | Guinea | 28–160 | 7–11 | 4–21 | 1–6 | 40–110 | bright orange | 34–46 |
| <i>Gladiolus mirus</i> Vaupel | Ivory Coast, Nigeria, Cameroon, Gabon | 40–80 | 4 or 5 | (3–)6–9 | 5–15 | 20–30(–40) | pink to red-purple | 30–35 |
| <i>Gladiolus oligophlebius</i> Baker | DR Congo, Zambia, Tanzania, Malawi | 40–80 | 4 or 5 | 8–18(–24) | (2–)5–9 | 25–40(–50) | pale to deep pink | 38–45 |
| <i>Gladiolus salmoneicolor</i> P. A. Duvign. & Van Bockstal ex Córdova | DR Congo | (14–)30–60 | 5 or 6 | 4–6 | 5–7 | (15–)18–25 | white to salmon- coloured | 18–20 |
| <i>Gladiolus serenjenis</i> Goldblatt | Zambia | 15–25(–40) | 5 or 6 | (2–)3–4 | 3–6 | 15–20(–25) | pink | 18–20 |
| <i>Gladiolus stenolobus</i> Goldblatt | Tanzania | c. 75 | c. 8 | 3–4 | c. 14 | 14–25(–35) | reddish purple | c. 33 |
| <i>Gladiolus sudanicus</i> Goldblatt | Sudan, Ethiopia | 15–20 | 4 or 5 | 5–9 | 2 or 3 | 20–25 | pale to deep pink | 16–24 |

the fires do not occur every year, which indicates that the species is vulnerable to fire. There is a risk that *Gladiolus mariae* will be threatened by horticultural collectors; coordinates of the three collections are therefore provided only to the nearest minute. Other threats, such as predation, have not been observed.

Approximately 210 individuals were counted; 160 plants in fire-free shrubland, 20 plants on vertical sandstone cliffs and 30 plants in sparsely wooded submontane grassland. Many of the sandstone cliffs in the Kounounkan Massif could not be surveyed for this species. Therefore, the number of mature individuals is presumably higher than 250. The Kounounkan Massif was surveyed for this species in 2016–2019 for 25 days, which is sufficient to enable an estimate that the number of mature individuals is probably lower than 2500. There are three subpopulations, in each of which a collection was made together with several observations. The number of mature individuals is probably lower than 250 in each of the three subpopulations. *Gladiolus mariae* is here assessed to the IUCN (2012, 2017) category Endangered: EN B2ab(iii,v); C2a(i).

Eponymy — *Gladiolus mariae* is named after Maria Alvarez Aguirre, the wife of XvdB.

Remarks — *Gladiolus mariae* is here placed in *G. sect. Decorati* Goldblatt. The spelling of the sectional epithet (originally “*Decoratus*”) is here corrected according to Turland & al. (2018: Art. 21.2). The nine species already known from the section are large, medium-sized or rarely small plants, unbranched, leaves lanceolate to linear, spike erect, outer bracts 14–40(–50) mm long, perianth tube often as long as or longer than bracts, flowers large, (25–)35–90 mm long, often red with white marks, perianth tube (8–)15–40 mm long, tepals unequal, and anthers with apiculate appendages (Goldblatt 1996; Table 1). The nine species already known from the section are compared with the new species in Table 1. These nine species have 2–6 leaves; all species already known in the genus have 1–8 leaves (Goldblatt 1996). *Gladiolus mariae* has 7–11 leaves (11 leaves on *Burgt* 2207 at K), more than any other species in the genus. *Gladiolus mariae* has bright orange flowers, slightly out of the range of colours of the nine species already known in *G. sect. Decorati* (Table 1). The species with the most similar flower colour is *G. decoratus* Baker, which has bright orange-red or dark red flowers (Goldblatt 1996). The species already known from the section have an outer flower bract to 40(–50) mm long (Goldblatt 1996), whereas *G. mariae* has a much longer outer flower bract, which is also very variable in length, 40–110 mm long (Table 1), so that the corolla may be shorter than the bract. *Gladiolus mariae* plants have 1–6 flowers. Only a single flower is open at a time. Plant height generally increases with the number of flowers. Most mature plants have 1 or 2 flowers, while plants with 5 or 6 flowers are rare.

Seeds of *Gladiolus mariae* were collected from 50 plants. For conservation reasons, less than 20% of available seed was collected. These seeds are stored at Kew’s Millennium Seed Bank and at the seed bank of the National Herbarium of Guinea. Data on the seed collection of *G. mariae*, such as numbers of viable seeds and germination test results, will become available on the internet (Millennium Seed Bank Partnership 2018).

A second rare species of *Gladiolus* occurs in the Kounounkan Massif: *G. chevalierianus* Marais. This species is placed in *G. sect. Acidanthera* (Goldblatt 1996). Flowering collections of these two species may be separated by the flower colour and the length of the perianth tube. The flowers of *G. chevalierianus* are pale yellowish green, the perianth tube is 60–70 mm long and the tepals are c. 20 × 5 mm. The fruits of both species are densely dotted outside with dark brown spots 0.1–0.3 mm in diam. Fruiting collections may be separated by the month of collecting: *G. mariae* fruits in November–December, whereas *G. chevalierianus* fruits in June–July. The other eight West African species of *Gladiolus* do not have densely spotted fruits.

Additional specimens examined — GUINEA: FORÉCARIAH PREFECTURE: southern plateau of Kounounkan Massif, 09°34’N, 12°52’W, 960 m, fr., 3 Dec 2017, X. M. van der Burgt 2161 (B, BR, G, HNG, K, MO, P, PRE, SERG, WAG); table mountain W of Gbara village, 09°32’N, 12°57’W, 650 m, fl. & young fr., 19 Oct 2018, X. M. van der Burgt 2207 (B, BR, HNG, K, MO, P, WAG).

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