

Notes on *Atriplex*, *Oxybasis* and *Dysphania* (Chenopodiaceae) in West-Central Tropical Africa

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Background and aims – The indigenous representatives of Chenopodiaceae in tropical Africa are still insufficiently studied. Some genera, especially *Atriplex* L., *Oxybasis* Kar. & Kir. and *Dysphania* R.Br. (subfam. Chenopodioideae), are difficult to diagnose and are often confused with other native or alien taxa.

Methods – The morphological characters of *Atriplex*, *Oxybasis* and *Dysphania* were reviewed using specimens from the herbaria B, BM, BR, BRLU, E, G, K, LE, MHA, MW, P, and W.

Key results – A new species *Atriplex congolensis* Sukhor. is described from the highlands of D.R.Congo and illustrated. It was previously cited as *A. hastata* L. (now *A. prostrata* Boucher ex DC.) and is the only species of *Atriplex* sect. *Teutliopsis* Dumort. emend. Sukhor. in tropical Africa. A morphological comparison of all *Atriplex* representatives encountered in Africa (*A. chenopodioides* Batt., *A. congolensis* Sukhor., *A. davisii* Aellen, *A. nilotica* Sukhor., *A. patula* L., *A. prostrata* Boucher ex DC., and *A. verreauxii* Moq.) is provided. All records of the rare native *Dysphania congolana* (Hauman) Mosyakin & Clemants in mountainous tropical Africa are mapped using previously known and re-identified locations. *Oxybasis chenopodioides* is newly reported for D.R.Congo. The lectotype of *Chenopodium glaucum* L. subsp. *congolanum* Hauman (*Dysphania congolana*) is designated. It is pointed out that *D. congolana* cannot be considered a close relative to any American taxon despite morphological similarities.

Key words – *Atriplex congolensis*, *Atriplex* sect. *Teutliopsis*, West-Central Tropical Africa, Chenopodiaceae, *Dysphania congolana*, *Oxybasis chenopodioides*.

INTRODUCTION

The Chenopodiaceae is a large family within the order Caryophyllales. It comprises ~ 1600 species and is divided into ~ 110 genera (Sukhorukov 2014, Hernández-Ledesma et al. 2015). It is mostly distributed in the arid regions of the World. The exact number of the family's representatives in Africa is still unknown, but according to our investigations, the number of indigenous and alien species may reach at least 300, including the largest genera *Caroxylon* Thunb. (~ 60 spp.), *Atriplex* L. (40 spp.), *Chenopodium* L. s.str. (25 spp.), and *Suaeda* Forssk. (20 spp.). Only a few Chenopodiaceae species are found in West-Central Tropical Africa (Hauman 1951), in contrast to arid territories in the northern, eastern and southern parts of the continent with high taxonomic richness. The most common chenopodiaceous species distributed in West-Central Tropical Africa (Burundi, Central African Republic, Cameroon, D.R.Congo, Equatorial Guinea, Gabon, Republic of Congo, and Rwanda) is the American *Dysphania ambrosioides* (L.) Mosyakin & Clemants (Baker

& Clarke 1909, Renier 1948, Hauman 1951, Cavaco 1963, Fernández-Casas 1994, Fernández-Casas & Morales-Valverde 1995), previously placed in the genus *Chenopodium*.

Taxonomy of the indigenous representatives of the family in Africa is still insufficiently studied. In the past decade, taxonomic revisions were only prepared for the genera *Sarcocornia* A.J.Scott in Southern Africa (Steffen et al. 2009, 2010) and *Atriplex* in East Tropical Africa and the Mascarene Islands (Sukhorukov 2012, 2013). However, some genera, especially *Atriplex* and *Dysphania* (subfam. Chenopodioideae), are difficult to diagnose and are often confused with other native or even alien taxa (Sukhorukov 2012). In the present article, the amendments to Chenopodiaceae in West-Central Tropical Africa concern both genera. A closer look at a single *Atriplex* species collected in D.R.Congo and previously identified as *Atriplex hastata* or '*Atriplex* sp.' (Hauman 1951) revealed that it is a new species from *Atriplex* sect. *Teutliopsis* described in the present article. Additionally, we have discovered new, previously misidentified, specimens of *Dys-*

phania congolana, a rare species hitherto known only from a few collections (Hauman 1949, 1951, Brenan 1954, Friis & Gilbert 2000), as well as a misidentified specimen of *Oxybasis chenopodioides*, hence newly reported for D.R.Congo.

MATERIAL AND METHODS

Morphological characters were studied using the material available in the herbaria B, BM, BR, BRLU, E, G, K, LE, MHA, MW, P, and W. However, collections of *Atriplex* and *Oxybasis* from West-Central Tropical Africa were found in BR only, and the specimens of *Dysphania congolana* are present in BR, E, K and P. Standard herbarium techniques were used. The cross-sections of the fruits of *Atriplex congolensis* were made by hand and examined using a light microscope (Mikmed-1, Biolam). The images of the bract-like cover were prepared using Carl Zeiss Axiovision camera. Geographical areas follow Brummit (2001).

RESULTS AND DISCUSSION

In his revision of Chenopodiaceae in the former Belgian Congo, Hauman (1951) accepted two *Atriplex* taxa: '*Atriplex hastata* L.' (now *A. prostrata* Boucher ex DC.) and '*Atriplex* sp.' The former was found to be a record based on misidentification (2 below), and the latter proved to represent a new species (1 below). *Chenopodium congolanum* (now in *Dysphania*) seems to be more common than previously thought (3 below).

1. A new *Atriplex* species from West-Central Tropical Africa

A thorough revision of *Atriplex* specimens collected in West-Central Tropical Africa shows that they all have the same morphology, and that they distinctly differ from *A. prostrata* (*A. hastata* auct. non L.) and its relatives within *Atriplex* sect. *Teutliopsis*. This justifies the description of a new species, *Atriplex congolensis*.

The new species is the only representative of *Atriplex* sect. *Teutliopsis* in tropical Africa (see also Sukhorukov 2012). This section comprises at least 26 representatives (*A. Sukhorukov*, unpubl. res.) mainly distributed in temperate Eurasia and littoral zones of North America. According to the molecular results, it seems to be monophyletic except for *A. oblongifolia* Waldst. & Kit. (Kadereit et al. 2010). The most significant characters of this section are the annual life history, leaves with isolateral or bifacial anatomy, a C₃ photosynthetic pathway (Moser 1934, Winter 1981, Sukhorukov 2006), partially caducous leaf indumentum consisting of bladder hairs (Sukhorukov 2006), clusters comprising both male and female flowers (Kondorskaya 1984), herbaceous bract-like covers enclosing the fruit (Sukhorukov 2006), and an evident seed dimorphism (Iljin 1936, Sukhorukov 2006). Some members of *Atriplex* sect. *Teutliopsis* are widely distributed ruderal plants, e.g. *A. patula*, *A. micrantha* C.A.Mey., and *A. prostrata* (Welsh 2003, Schwarz 2003, Sukhorukov 2006, 2014). The majority of the representatives originate in the steppes and semi-deserts of Asia, with secondary distribution areas in the coastal zones of Europe

and North America (Sukhorukov 2006). Several species of this section are found in Africa (*A. chenopodioides*, *A. congolensis*, *A. davisii*, *A. nilotica*, *A. patula*, *A. prostrata*, and *A. verreauxii*), and some of them have been misidentified for a long time (Sukhorukov 2010, present article). The majority of the African species occurs in Northern Africa, representing a Mediterranean extension of the Eurasian area of the section (Sukhorukov 2006). Exceptions are *A. nilotica*, an endemic of the Upper Nile valley (Sukhorukov 2010), and *A. chenopodioides*, restricted to Algeria, Morocco, and the southern part of Spain. Only two endemic species occur south of the Sahara: *A. congolensis* and *A. verreauxii*. The narrow endemic *A. congolensis* belongs to the montane element of the Katanga flora. The Afromontane character of parts of Katanga, especially on the high plateaus, is well known (Lisowski et al. 1971) though not frequently mentioned. The South African *A. verreauxii* obviously represents a further migration of the section southwards. In table 1 we present the differences in morphology and distribution pattern between all African species of *Atriplex* sect. *Teutliopsis*, along with taxonomic remarks.

Morphologically, *A. congolensis* is similar to *A. nilotica* from Egypt, but it differs in having leaf blades with slightly hastate (not clearly lobate or serrate-dentate) lobes, a less dense and interrupted inflorescence and a lower number (up to 6) of female flowers in each cluster.

Atriplex congolensis Sukhor., sp. nov.

Atriplex sp. (Hauman 1951: 10). – Type: D.R.Congo, Katanga [prov.], Saya (NNE of Likasi), alt. 1150 m, sol salé en voie d'assèchement [saline soil, drying out], 9 Nov. 1971, Thoen 4972 (holo-: BR, barcode BR0000015983534). Fig. 1.

Annual, branched from the base, with the ascendant branches up to 70(–100) cm. Leaves semi-appressed to the stem, with petioles to 2 cm long, blades to 35 × 25 mm, green or grayish, thick, oblong, ovoid or almost rhombic, entire or serrulate or slightly hastate, upper leaves oblong and entire. Inflorescence leafy at base, branched, with slightly interrupted flower clusters consisting of both male and female (5–10) flowers; bract-like cover triangular or rhombic-triangular, 2.5–7 mm, with two lobes; its segments connate to ¼, usually with large (to 2 mm long) 2–6 dorsal appendages (fig. 2). Fruit one-seeded, seed either brown or black; pericarp of fruits with brown seed 15–30 µm thick, colourless, 1–3-layered, the outer layer of smooth cells intermixed with scattered spongy cells; pericarp of fruits with black seed 10–18 µm thick, 1(–2)-layered, composed of spongy cells; brown seeds 1.5–1.8 × 1.8–2.0 × 0.6–0.7 mm, flattened, seed-coat testa 10–12 µm thick, smooth in outline (at cross-sections), outer cell walls of its cells without depositions of tannin-like substances (vertical stalactites); black or reddish-black seeds 1.3–1.5 × 1.3 × 0.4–0.5 mm, flattened or slightly convex, seed-coat testa 20–25 µm thick, smooth or wavy in outline, outer cell walls of its cells with vertical stalactites.

Additional specimens examined – **D.R.Congo**: Katanga [prov.], Saya, alt. 1100 m, 3 Jun. 1970, *Symoens* 13499 (BR, barcode BR000004850059); the same place, 11 Jul. 1971, *Symoens* 14084 (BR, barcode BR0000048500066; young plants in early vegetative stage only); Katanga [prov.], Mulungwishi, [without

Table 1 – Morphological features and distribution patterns of African representatives of *Atriplex* sect. *Teutliopsis*.

The identification of the representatives of this section requires a combination of the morphological characters. The most important features for identification are noted in the column with the heading Taxonomic remarks.

Species	Most valuable morphological characters	Distribution pattern in Africa	Taxonomic remarks
<i>A. chenopodioides</i>	plant to 2 m tall; leaves semi-orbicular or broadly ovate; inflorescences large (to 50 cm), flower clusters interrupted; bract-like covers rhombic, their segments connate in the lower half, with small dorsal appendages near the base or the middle	Northern Africa (Morocco, Algeria)	the species is easily recognized by leaf shape and bract-like covers with numerous appendages
<i>A. congolensis</i>	plant to 70(–100) cm; leaves ovoid, rhombic or oblong, with two inconspicuous lobes; inflorescences to 20 cm, flower clusters interrupted; bract-like covers triangular or rhombic-triangular, their segments connate in the lower quarter, with large (to 2 mm) dorsal appendages near the base or the middle	West-Central Tropical Africa (highlands in the southern part of D.R.Congo)	previously published as unnamed species (Hauman 1951). It is easily recognized by lower leaves with two inconspicuous lobes
<i>A. davisii</i>	plant to 2 m tall; leaves hastate; flower clusters interrupted; bract-like covers rhombic or orbicular, their segments connate to half way, with small dorsal appendages located in the middle or at the tip of segments	Northern Africa (the species reaches its southern limits in Egypt)	it is often misidentified with <i>A. prostrata</i> or <i>A. patula</i> (Sukhorukov 2010). The species is easily recognized by its small bract-like covers (to 5 mm in diameter) being fused for half of its length
<i>A. nilotica</i>	plant to 2 m tall; leaves rhombic or oblong, clearly lobate or sinuate; inflorescences very dense, clusters not interrupted, with up to 20 female flowers; bract-like covers triangular or rhombic-triangular, their segments connate to 1/3, with appendages in the middle part	Northern Africa, endemic of the Nile valley (Egypt). Possibly in Northeast Tropical Africa (Sudan) as well	it was previously misidentified as <i>A. patula</i> or <i>A. prostrata</i> ; it is a very distinct taxon due to its large and dense inflorescences
<i>A. patula</i>	plant up to 50(–80) cm tall; branches usually horizontally spreading, sometimes ascending; leaves oblong to rhombic, entire or with two lateral lobes directed upwards; flower clusters interrupted; bract-like covers rhombic, their segments connate to half way, with appendages near the middle	Northern Africa (scattered along the coast of the Mediterranean Sea, as ruderal or littoral plant)	although the species has been recorded for Southern Africa, all the specimens we examined from that area belong to <i>A. verreauxii</i> . The diagnostic characters of <i>A. patula</i> are stems with spreading branches and bract-like covers with elongated lateral angles
<i>A. prostrata</i>	plant to 80 cm tall; branches spreading or ascending; leaves triangular or ovate; inflorescence branches often drooping; clusters interrupted; bract-like covers triangular or ovoid, their segments almost free or connate to 1/3, smooth or with small appendages near the base	Northern Africa; all examined specimens from Egypt belong to other species (mostly <i>A. nilotica</i>)	the exact distribution pattern in Northern Africa should be further investigated. The species is characterized by hastate leaves, drooping inflorescence branches and triangular bract-like covers with almost free segments
<i>A. verreauxii</i>	plant to 1.5 m tall; stem distinctly flexuous; leaves mostly thick, lanceolate or oblong, entire or with two lobes; inflorescences interrupted; bract-like covers triangular, their segments almost free or connate to 1/3 without or with small dorsal appendages	Southern Africa (Republic of South Africa)	further study of the variability in <i>A. verreauxii</i> is required to determine if it is conspecific with <i>A. flexuosa</i> Moq., in which case the latter name (Moquin-Tandon 1840) would take precedence over the former (Moquin-Tandon 1849). <i>A. verreauxii</i> has a flexuose stem, lobate leaves and large interrupted inflorescences (similarly to <i>A. littoralis</i>).



Figure 1 – Holotype of *Atriplex congolensis* Sukhor. sp. nov. [Thoen 4972 (BR0000015983534)].

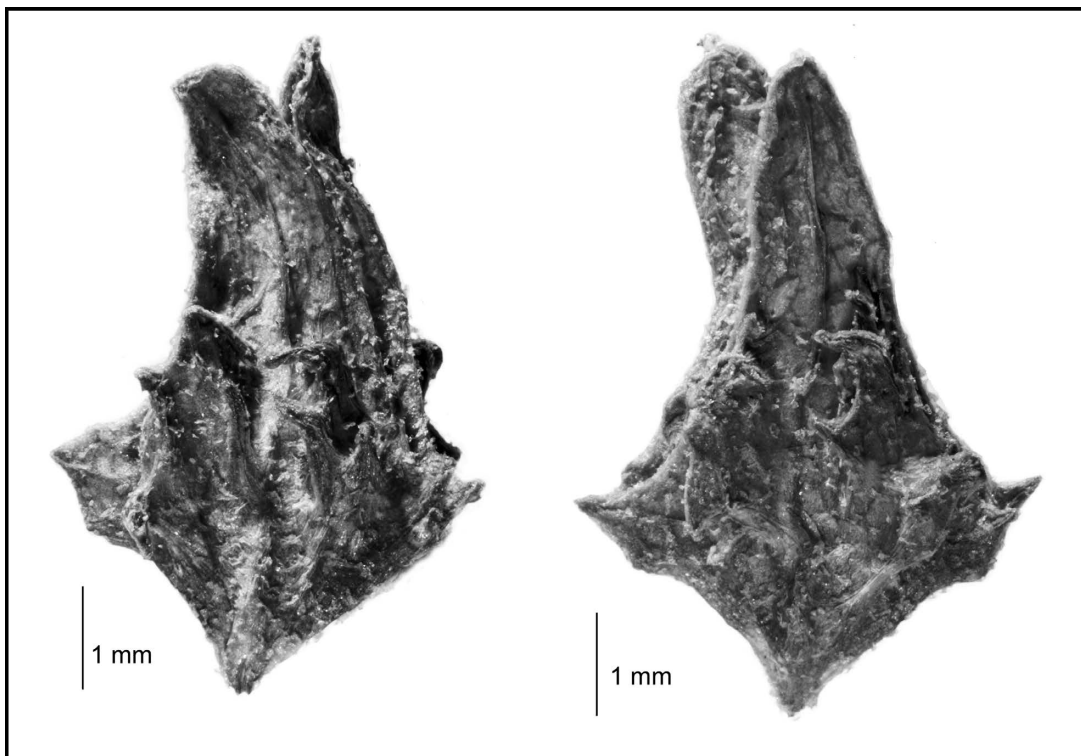


Figure 2 – Variability of bract-like cover shape in *Atriplex congolensis*. From Thoen 4972 (BR0000015983534). Scale bar: 1 mm.

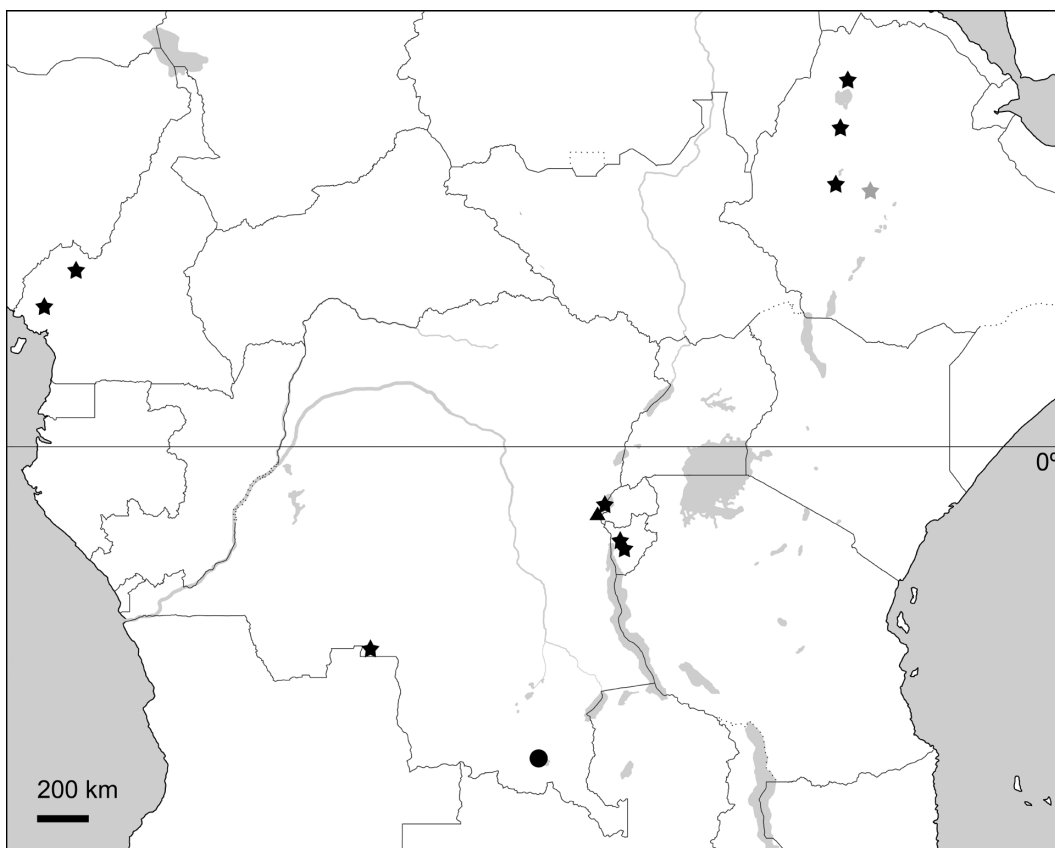


Figure 3 – Distribution of *Atriplex congolensis* (dot), a new record of *Oxybasis chenopodioides* in D.R.Congo (triangle) and all known records of *Dysphania congolana* (black asterisks based on the examined specimens; grey asterisk – an additional record from Ethiopia cited in Friis & Gilbert 2000).

date], *Van Den Branden* 211 (BR, barcodes BR000004850080 & BR000004850097), cited as “*Atriplex* sp.” in Hauman (1951).

Ecology and elevation – Saline soils at altitudes 1000–1500 m.

Distribution – The species is currently known from south-eastern D.R.Congo (Katanga province) only, in the locations situated close to each other and mapped as one dot (fig. 3). New records are possible from ecologically similar areas in Zambia.

Conservation status – *Atriplex congolensis* is given a preliminary Red List status of Vulnerable [VU]. The species is endemic to Katanga and known from four specimens representing three subpopulations. The extent of occurrence (EOO) of *Atriplex congolensis* cannot be estimated because all specimens were collected more than forty years ago (chenopods are often missed by the collectors) and do not represent records of presence. Its area of occupancy (AOO) is estimated to be between 4 to 12 km² (which falls within the limits for Critically Endangered or Endangered status under the criterion B2). The three subpopulations represent one to three locations (sensu IUCN 2014), which is the upper limit for Critically Endangered or Endangered status under the subcriterion ‘a’ of criterion B2. The species is known from saline soils at 1000–1500 m elevation with no current threat known, but its AOO is very restricted. Moreover, the known localities are situated in a region with high mining activity and increasing population pressure on the vegetation. Faucou et al. (2010) indicated that most endemic plants found in Katanga could be considered as threatened. We thus anticipate that this unpredictable degradation in the quality of its habitat could drive *Atriplex congolensis* to CR or EX in a very short time. For that reason, we assigned to *Atriplex congolensis* a preliminary status of VU D2.

2. First record of *Oxybasis chenopodioides* for D.R.Congo

Specimen seen – Congo Belge [D.R.Congo, South Kivu prov.], bords du lac [lake margin] [Kivu], Kabare, 28 Aug. 1914, Dr. *Bequaert* 5479 (BR, barcodes BR0000014849725 & BR0000014849732). Fig. 3.

The specimen cited as ‘*A. hastata*’ by Hauman (1951) was studied in BR. This identification was previously considered ambiguous (Brenan 1954), and the specimen is actually *Oxybasis chenopodioides* (L.) S.Fuentes, Uotila & Borsch (≡ *Chenopodium chenopodioides* (L.) Aellen). This species is native and widely distributed in the northern deserts and steppes of temperate Asia. It is naturalized in Burundi (Reekmans 1980), Kenya and South Africa (Sukhorukov 2014), where it was probably introduced by migratory birds (Sukhorukov 2014).

3. *Dysphania congolana* in West-Central Tropical Africa and notes on its taxonomic position

Dysphania congolana was described from D.R.Congo, and relatively few additional specimens were collected in West-Central (Cameroon, Burundi) and Northeast Tropical Africa (Ethiopia). However, we discovered that some of the specimens in BR, E, K and P labelled as *Chenopodium ambrosioides* or *C. procerum* were misidentified and belong to

D. congolana. This suggests that this species might be more common than previously thought. It prefers humid grasslands, woodlands, and disturbed habitats at altitudes 900–2600 m, and therefore belongs to the montane element of the flora, like the newly described *Atriplex congolensis*.

Dysphania congolana (Hauman) Mosyakin & Clemants (Mosyakin & Clemants 2008: 429). – *Chenopodium glaucum* L. subsp. *congolatum* Hauman (Hauman 1949: 447 & 1951: 9). – *Chenopodium congolatum* (Hauman) Brenan (Brenan 1956: 166). – Type: [D.R.Congo] Tshibinda, 1932, *Scaetta* 1223 (lecto-: BR, barcode BR00000887004, **designated here**; isolecto-: BR, barcode BR00000886920). The lectotypification is needed because two authentic specimens with the same label are present.

Additional specimens (fig. 3) – Burundi: Muramvya, forêt de Buragana, alt. 2200 m, défrichement récent [deforestation area], abondant [abundant], 19 Nov. 1966, *Lewalle* 1280 (BR, barcode BR0000016051928) sub *Chenopodium ambrosioides*; Bujumbura, Ndahangwa, alt. 900 m, sous bananiers [under banana trees], 25 Oct. 1967, *Lewalle* 2137 (BR, barcode BR0000016051171), sub *Chenopodium ambrosioides*; prov. Muramvya, Buragana, 3°18’S 29°32’E, Carrefour de Ryarusera, bord ruisseau, jachère [riverlet margin, fallow field], 28 Apr. 1982, *Reekmans* 11051 (BR, barcode BR0000016053465, K) sub *Chenopodium procerum*; prov. Citega, Gisozi, jachère postculturelle [fallow field], 3°34’S 29°41’E, alt. 2000 m, 13 May 1982, *Reekmans* 11227 (BR s.n.) sub *Chenopodium procerum*.

Cameroon: Bamenda division, Jakiri, inside Fulani cattle-pound where earth trampled hard, above and to west of village on path to Fara, a few plants mostly trodden by cattle, alt. 2000 m, 18 Feb. 1958, *Hepper* 2079 (B, BR, barcode BR0000016051898, K, P, barcode P 04942330); [Southwest region] Bakossi Mts., Kumba, alt. 3000 ft, glassland, 16 Apr. 1961, *Swarbrick* 2362 (E) sub *Chenopodium ambrosioides*.

D.R.Congo: [Sud-Kivu prov.] Idjiwi Island, alt. 1680 m, 24 Feb. 1939, *Loveridge* 587 (BR, K).

Ethiopia: Gondar, 1850, leg. *Rochet d’Héricourt* 9 (P, barcodes P 04942338 & P 04942331); Shewa [zone], Bako [Baco], alt. 1650 m, Sept. 1969, *Mogk* 321 (K) sub *Chenopodium ambrosioides*; Gojam Region, 5 km on the track towards Sekela, alt. 2550 m, 27 May 1980, *Thulin & Hunde* 3970 (K).

The genus *Dysphania* has been segregated from *Chenopodium* (Kadereit et al. 2010, Fuentes-Bazán et al. 2012) only recently using molecular phylogeny, with clear support of carpological results (Sukhorukov & Zhang 2013). It comprises c. 50 representatives with the diversity centers in Australia, South and Central America and Pan-Himalaya (Sukhorukov 2014, Sukhorukov et al. 2015). There are five native *Dysphania* species in Africa: *D. botrys* (L.) Mosyakin & Clemants (≡ *Chenopodium botrys* L.) in Northern Africa, *D. procera* (Hochst. ex Moq.) Mosyakin & Clemants (≡ *Chenopodium procerum* Hochst. ex Moq.) in Southern, Eastern and Northeastern Africa, *D. schraderiana* (Schult.) Mosyakin & Clemants (≡ *Chenopodium schraderianum* Schult., *Chenopodium foetidum* Schrad. nom. illegit.) with a similar distribution area in Africa, *D. congolana* (≡ *Chenopodium congolatum* (Hauman) Brenan) in West-Central, East and Northeast Tropical Africa, and *D. pseudomultiflora* (Murr) Verloove & Lambinon (≡ *Chenopodium pseudomultiflorum* (Murr) Uotila) in the southern part of the continent. However, the number of alien *Dysphania* representatives of American or Australian origin almost equals that of native species.

Table 2 – The differences between *Dysphania congolana* and the morphologically similar *D. ambrosioides*.

Species	Life history	Leaves	Segments of bract-like cover	Fruit and seed (after Sukhorukov & Zhang 2013)
<i>D. ambrosioides</i>	annual or perennial erect herb	covered with abundant curved hairs and yellow glands	fused to half way	pericarp smooth, in upper part with glandular hairs; seed embryo horizontal or occasionally vertical
<i>D. congolana</i>	annual with prostrate or ascending branches	covered with white glands	free	pericarp with reticulate ultrasculpture, without glandular hairs; embryo vertical

The most common is the American *D. ambrosioides* (\equiv *Chenopodium ambrosioides* L.), widely distributed elsewhere in the tropics and subtropics (Aellen 1928, Uotila 1988, Sukhorukov 2014), and a South American species, *D. multifida* (L.) Mosyakin & Clemants (\equiv *Chenopodium multifidum* L. \equiv *Roubieva multifida* (L.) Moq.), spreading in the coastal regions of Northern and Southern Africa (e.g. Maire 1962, Simón 1996, A. Sukhorukov, unpubl. res.). The two other alien species, *D. carinata* (R.Br.) Mosyakin & Clemants (\equiv *Chenopodium carinatum* R.Br.) and *D. pumilio* (R.Br.) Mosyakin & Clemants (\equiv *C. pumilio* R.Br.), are of Australian origin and are known in Southern Africa (Brenan 1954, 1988).

Despite the fact that *Dysphania congolana* is a well-recognizable taxon with lobate or sinuate leaves, in contrast to other native genus members with pinnatifid or pinnatisect leaves, it is sometimes confused with the alien *D. ambrosioides* due to the similar leaf shape. Here we provide the most significant differences between *D. congolana* and *D. ambrosioides* (table 2).

A molecular phylogeny of *Dysphania* remains unavailable at present. However, here we postulate that *D. congolana* is not closely related to any American member of the genus due to a different set of the carpological characters shared between almost all American *Dysphania* species and contrasting with Old World species (Sukhorukov & Zhang 2013, Sukhorukov 2014). For instance, the presence of glandular hairs on the pericarp of Brazilian *D. minuata* (Aellen) Mosyakin & Clemants, previously considered as a close relative of *D. congolana*, may be the most valuable feature contradicting the placement of both taxa into *Chenopodium* section *Margaritaria* Brenan (Simón 1996). However, it should be pointed out that, compared to other African species of *Dysphania*, *D. congolana* appears to be a remarkable taxon with respect to its morphology (Brenan 1956, Friis & Gilbert 2000) and fruit structure (Sukhorukov 2014).

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