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First record of *Amaranthus crassipes* subsp. *warnockii* (I.M.Johnst.) N.Bayón (Amaranthaceae) outside of the Americas, with nomenclatural notes

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Background: The genus *Amaranthus* is taxonomically complex because of its high morphological variability, which led to nomenclatural confusion, misapplication of names and misidentifications. Unfortunately, floristic and taxonomic studies on this genus are still incomplete. A population of *Amaranthus crassipes* subsp. *warnockii* was discovered in Monastir Governorate, Tunisia, representing the first record for both the Tunisian and the African floras, as well as the first one outside of its American native distribution area.

Objectives: The main aim of the present study was to record *Amaranthus crassipes* subsp. *warnockii* (I.M.Johnst.) N.Bayón in Tunisia and Africa for the first time. Morphological characters and ecological data were provided. Clarification about the typification of the names *Amaranthus crassipes*, *A. warnockii* and *Scleropus amaranthoides* was also presented.

Methods: The work was based on field surveys, analysis of relevant literature and examination of specimens preserved in the herbaria GH, HAL, P, RO, NY, US and the Herbarium of the Faculty of Pharmacy of Monastir (Monastir University).

Results: Nomenclatural notes were provided for Schlechtendal's *A. crassipes* (lectotype at HAL, designated by Henrickson in 1999 but here corrected according to Art. 9.10 of the ICN); Schrader's *Scleropus amaranthoides* [a superfluous and illegitimate name (Arts. 52.1 and 52.2 of the ICN) and regarded as a homotypic synonym of *A. crassipes* s.str.]; and Moquin-Tandon's *Scleropus amaranthoides* [an invalid name (Art. 36.1a of the ICN)].

Conclusion: *Amaranthus crassipes* subsp. *warnockii* is an alien species in Tunisia, growing in human-made habitat on clayey and sandy substrates within ruderal vegetation where it can be considered a casual. We hope that in the future continuous monitoring of the population will take place, to verify the possible naturalisation and spread of this taxon in Tunisia. If the latter happens, actions for eradication of the plants are needed.

Keywords: African flora; alien species; *Amaranthus*; Monastir city; Tunisia.

Introduction

The genus *Amaranthus* L. (Amaranthaceae Juss.) comprises 65–70 species of which approximately half are native to the Americas (see e.g., Mosyakin & Robertson 1996; Iamonico 2015a). Some American species are used as ornamentals, food or medicines and are able to escape from cultivation, negatively impacting the agricultural systems through a reduction in both productivity and crop quality (see Iamonico 2010, 2015a; Das 2016).

Amaranthus is a taxonomically complex genus due to its high phenotypic variability, which has resulted in the current nomenclatural confusion and

misapplication of several names (see e.g., Costea et al. 2001; Bayón 2015; Iamonico 2014a, 2014b, 2016a, 2016b, 2016c, 2020a, 2020b, 2020c; Iamonico & Palmer 2020).

According to Le Floc'h et al. (2010) and Iamonico (2015b) nine *Amaranthus* species occurred in Tunisia. More recently two further species were found, i.e. *A. palmeri* S.Watson (Iamonico & El Mokni 2017) and *A. spinosus* L. (Iamonico & El Mokni 2019) and a new species – *A. tunetanus* Iamonico & El Mokni – was described from Monastir Governorate, central Tunisia (Iamonico & El Mokni 2018). The total number of Tunisian species belonging to the genus *Amaranthus* is now 12.

As part of an ongoing investigation on the Tunisian *Amaranthaceae* sensu lato (Sukhorukov et al. 2016; Iamonico & El Mokni 2016, 2017, 2018, 2019), we found a population identifiable as *Amaranthus crassipes* Schltdl. subsp. *warnockii* (I.M.Johnst.) N.Bayón, which represents the first record for both the Tunisian and the African floras, as well as the first indication of the species out of the Americas. Morphological notes and data on the habitat are presented here and the typification of the linked names is clarified.

Material and Methods

The work is based on field surveys, analysis of relevant literature and examination of specimens preserved at GH, HAL, P, RO, NY and US (acronyms according to Thiers 2022) and in the personal collection of one of the authors (R. El Mokni) deposited in the herbarium of the Faculty of Pharmacy of Monastir, Monastir University (not listed in *Index Herbariorum*). The articles cited throughout the text follow the Shenzen Code (Turland et al. 2018).

Results and Discussion

Notes on the typification of *Amaranthus crassipes* sensu stricto

Amaranthus crassipes was validly described by Schlechtendal (1831: 757–758) through a detailed description and a morphological comparison with *A. polygonoides* L., which was considered by Schlechtendal (1831) as the most similar species. The provenance ('*In locis paludosis ad rivulos insulae Sti. Thomae*') was also provided.

Henrickson (1999: 787) indicated the holotype for *Amaranthus crassipes* sensu stricto in a specimen preserved at HAL collected by C. Ehrenberg. Bayón (2015: 318) specified the barcode of this specimen (HAL076208), as well as the locality and date of collection ('Isla Vírgenes: St. Thomas Island, 1826–1828'). However, Schlechtendal (1831: 757–758) did not cite any holotype and, according to Arts. 9.1, 9.3 and 9.4 of the ICN, a lectotypification would be necessary (see also the considerations given by McNeill 2014). On the basis of Art. 9.10 of the ICN, Henrickson's use of the term 'holotype' (which precedes Bayón's publication, see Art. 10.5 of the ICN) is an error to be corrected to lectotype.

Notes on the typification of *Amaranthus warnockii*

Johnston (1944: 153–154) validly proposed *Amaranthus warnockii* by a detailed description (in Latin), a morphological comparison with the related *A. crassipes*, and a list of examined specimens. In particular, the author reported 'COAHUILA: 1 mi. [1.6 km] southeast of Ocampo, silty plain near mogote, *Johnston 8886* (TYPE, Gray Herb.)'. According to HUH Index of Botanists (2013 onwards), Grey Herbarium and types are preserved at GH, whereas further material is kept in many other American and European herbaria. Johnston's statement 'Gray Herb.' would therefore refer to a GH specimen. We traced just one specimen at GH (barcode GH00037034) bearing three plants and the following original label: 'MEXICO: western Coahuila | *I.M. Johnston no. 8886* | Sept. 8, 1941 | *Amaranthus warnockii* n sp | a mile S.E. of Ocampo low place near mogote on plain'. Since no further sheets were found at GH, GH00037034 is the holotype of the name *Amaranthus warnockii*, as correctly reported by both Henrickson (1999: 788) and Bayón (2015: 319).

Notes on the name *Scleropus amaranthoides*

Schrader (1835: 5) proposed *Scleropus amaranthoides* as a replacement name of *Amaranthus crassipes*, which was listed as synonym. A short diagnosis was given in a note ('*Character essentialis. Flores monoici. Mas. Cal. 5phylli foliola ovato-oblonga, inaequalia, exteriora carinata. Cor. 0 ...*'). According to Arts. 52.1 and 52.2 of the ICN, *Scleropus amaranthoides* is a superfluous and illegitimate name since the valid *Amaranthus crassipes* was cited in synonymy. Therefore, the type of *Scleropus amaranthoides* is that of *Amaranthus crassipes* (homotypic synonyms). Note that Henrickson (1999: 787) listed the name *Scleropus amaranthoides* as synonym of *Amaranthus crassipes* var. *crassipes* stating 'Type: unknown'; so, he probably did not examine Schrader's protologue and wrongly considered *Scleropus amaranthoides* as a heterotypic synomyn.

Moquin-Tandon (1849: 271–272) listed *Scleropus amaranthoides* as a synonym of the new proposed combination *Scleropus crassipes* (Schrad.) Moq. reporting '*Scleropus amaranthoides* Schrad. l.c.' where 'l.c.' (=

loco citato) refers to the previous listed name, i.e. '*Amaranthus crassipes* Schlecht. in Linnaea 6: 757, n. 278 (1831)'. However, Schlechtendal (1831: 757–758) did not cite the name *Scleropus amaranthoides*. Moquin-Tandon (1849) intended to synonymyse *S. amaranthoides* with *S. crassipes*, but he inadvertently published a new name ('*Scleropus amaranthoides* Schrad. ex Moq.'). According to Art. 36.1a, this name is invalid from a nomenclatural point of view.

Taxonomic Treatment

Amaranthus crassipes

Amaranthus crassipes Schltdl. in Linnaea 6: 757–758 (1831) subsp. ***crassipes*** = *Euxolus crassipes* (Schltdl.) Hieron. in Bol Acad. Nac. Sci. 4: 13 (1881) = *Scleropus amaranthoides* Schrad. in Index Sem. Hort. Acad. Gottingen.: 5 (1835), *nom. superfl. et illeg.* (Arts. 52.1 and 52.2 of the ICN) = *Scleropus crassipes* (Schltdl.) Moq. in Prodr. [DC.] 13(2): 271 (1849). Type: U.S.A., Virgin Islands: 'in locis paludosis ad rivolus ins. [insulae] St. Thomas, 1826–1828', *Ehrenberg s.n.* (HAL076208, lecto.!, designated by Henrickson 1999: 787 as 'holotype', here corrected according to Art. 9.10 of the ICN). Image of the lectotype available at http://141.48.4.202/djatoka/jacq-viewer/viewer.html?rft_id=hal_0076208&identifiers=hal_0076208.

– *Scleropus amaranthoides* Schrad. ex Moq. in Prodr. [DC.] 13(2): 271 (1849), nom. inval. pro syn. of *Scleropus crassipes* (Art. 36.1a of the ICN).

Description

Herbs 100–400(–500) mm tall, monoecious, annual (therophyte). *Stems* erect, ascending or decumbent, glabrous, green or reddish, branched. *Leaves* green, orbicular or ovate, 10–50 × 10–15 mm, glabrous, margins usually entire, apex obtuse to slightly emarginate with apical mucro, base cuneate, petiolate, with veins more or less prominent on the abaxial surface. *Synflorescences* arranged in axillary glomerules 4–10-flowered, 4–10 mm in diameter, with axes much thickened becoming indurate at fruiting stage. *Floral bracts* 1, ovate-deltoid, 0.5–1.5 × 0.5−1.0 mm, about half the length of the perianth, membranaceous with median vein light green, apex acute-mucronate, margin entire, glabrous. *Staminate flowers* with 5 tepals, equal to each other, lanceolate, 1.0–1.5 × 0.5–1.0 mm, with median vein visible, apex acute; stamens 3(5). *Pistillate flowers* with usually 5 tepals, lanceolate (1.2–2.0 × 0.2–0.4 mm), connate in the proximal $^1/_5$, spatulate with the distal part expanded, hyaline distally; stigmas 2(3), 0.7–0.8 mm long. *Fruit* indehiscent, subglobose to ellipsoidal, 1.4–2.0 × 1.2–1.7 mm, shorter than the perianth, verrucose at maturity in the distal part. *Seeds* ovoid to lenticular, 0.9–1.4 mm in diameter, dark brownish to reddish (often reddish at the margins), shiny.

Iconography

Bayón (2015: 320, Fig. 28).

Vernacular names

Clubfoot amaranth, spreading amaranth, tropical spreading amaranth (Mosyakin & Robertson 2003).

Distribution

Native to Colombia, the Caribbean (Aruba, Bahamas, Cayman Islands, Cuba, Dominican Republic, Haiti, Jamaica, Leeward Island, Netherland Antilles, Puerto Rico, Turks and Caicos Islands, Winward Island), North México, southern U.S.A. (Alabama, Arizona, Florida, Louisiana, New Mexico, South Carolina, Texas), and Venezuela; alien to South México, Perù and Trinidad & Tobago (see POWO 2022 and literature therein). Outside of the Americas, the taxon is recorded in Europe in Great Britain (Clement & Foster 1994), and in Asia in Japan (Randall 2017) and Pakistan (Jamshed et al. 2018); there is also a doubtful record for southern Italy, but it was never confirmed (see Iamonico 2015a). Concerning Pakistan, Jamshed et al. (2018) did not specify the subspecies but, on the basis of the picture given (Jamshed et al. 2018: 3, Fig. 2), the leaves are clearly ovate and green, and the plant is identifiable as the subsp. *crassipes*.

Taxonomic notes

On the basis of the classification proposed by Mosyakin and Robertson (1996), *Amaranthus crassipes* sensu lato is a species belonging to the subgen. *Albersia* (Kunth) Gren. & Godr. sect. *Pentamorion* (G.Beck) Mosyakin & K.R.Robertson, which would include taxa with indehiscent fruits and five tepals. *A. crassipes* sensu lato can be easily distinguished from all the other members of the sect. *Pentamorion* by its peculiar axes of the synflorescences, which appear much thickened and becoming indurate at fruiting stage. The more similar *Amaranthus* species is *A. scleropoides* Schrad., which was included by Mosyakin and Robertson (1996) in the sect. *Pyxidium* Moq. (this section comprises taxa of subgen. *Albersia* with dehiscent fruit). In fact, the main difference between *A. crassipes* sensu lato and *A. scleropoides* refers to the fruit, which is, respectively, indehiscent with surface verrucose in the distal part, and dehiscent with surface smooth or verrucose in the proximal part (see Bayón 2015: 319, 357).

Representative specimens examined

ANTIGUA. **North Sound:** weed in fallow, 6 Apr. 1937, *Box 573* (NY1373779). BAHAMAS. **Little Exuma:** Mr Bowe's farmland on south edge of William town, 23 Apr. 1975, *Correll & Correll 44848* (NY01373732). BARBADOS. **Christ Church:** Chaucery Lane, 30 Jul. 1906, *Dash 360* (US01884380). COLOMBIA. **La Guajira:** Uribia, en los bordes y cauce del arroyo en la salida hacia Maicao, 29 Mar. 1962, *Saravia et Johson 324* (US03541795). CUBA. **La Habana:** Cojimar, 24 Aug. 1910, *Britton 154* (NY1036594). DOMINICAN REPUBLIC. **Valverde:** El Maguenal, Jaibon, Mao, alt. 100 m, 2 Feb. 1974, *Liogier 21195* (NY1373790). GUADALUPE. **Anse-Bertrand:** alt. 10 m, 7 Nov. 1937, *Stehlé 2515* (P05002553). HAITI. **Dep. du Sud:** Trémé, 30 Jun. 1980, *Peeters 80/60* (P04944386); Plaine d'Aquin, début route 44 vers Flamand, en zone paturée, 6 Jul. 1980, *Sastre et Polynice 7341* (P04944385). **Massif de la Selle:** 2 km al este de Petionville, alt. 200–240 m, 14 Jun. 1985, *Zanoni et al. 35236* (NY1373768). JAMAICA. Grounds of St. Benedict's School east of Harbour View, open waste ground, alt. 25–50 ft. [7.6–15.3 m], 13 Aug. 1963, *Proctor 23937* (NY1373776). PUERTO RICO. **Montalva:** roadside, 2–4 Mar. 1915, *Britton et al. 4876* (US00707046); **Island of Celebra:** waste places, 3–12 Mar. 1906, *Britton 154* (NY1036594). TURKS AND CAICOS ISLANDS. **South Caicos:** 14–16 Dec. 1907, *Wilson 7643* (NY1373730). VENEZUELA. **Lara:** Savanas around Barquisimeto, May 1925, *Saer 206* (US 0354180). U.S.A. **Arizona:** Pima County, Cabeza Prieta National Wildlife Refuge, José Juan Tank (Represo), and artificial dirt charco on San Cristobal Wash, 1.2 km W of the western boundary of Organ Pipe Cactus National Monument, 14 Sept. 1992, *Felger 92-713* (US03540276); **Florida:** 1842–1849, *Rugel 31* (US03540289). VIRGIN ISLANDS. **St. Thomas Island**: shore of harbour, 8–9 Feb. 1913, *Britton et al. 475* (US00707047). SAINT CROIX. West Indies Lab Compound, open bare rocky soil, alt. 5 m, 11 Jan. 1972, *Fosberg 53930* (NY1373756).

Amaranthus crassipes

Amaranthus crassipes Schltdl. subsp. ***warnockii*** (I.M. Johnst.) N.Bayón in Ann. Missouri Bot. Gard. 101: 319 (2015). Type: México, Coahuila, W. Coahuila, 1 mi. [1.6 km] SE of Ocampo, silty plain near mogote, 8 Sept. 1941, *Johnston 8886* (GH-00037034, holo.!). Image of the holotype at https://plants.jstor.org/stable/viewer/10.5555/al.ap.specimen.gh00037034?loggedin=true.

Diagnostic features

Subsp. *warnockii* differs from subsp. *crassipes* by the leaves, which are obovate to oblanceolate, 6–10 mm wide (vs 10–15 mm), and green-glaucous on the abaxial surface (vs green, never glaucous) (Figure 1).

Figure 1. *Amaranthus crassipes* subsp. *warnockii* from Monastir Governorate; A, plant; B, details of two floral glomerules. Photographs: R. El Mokni.

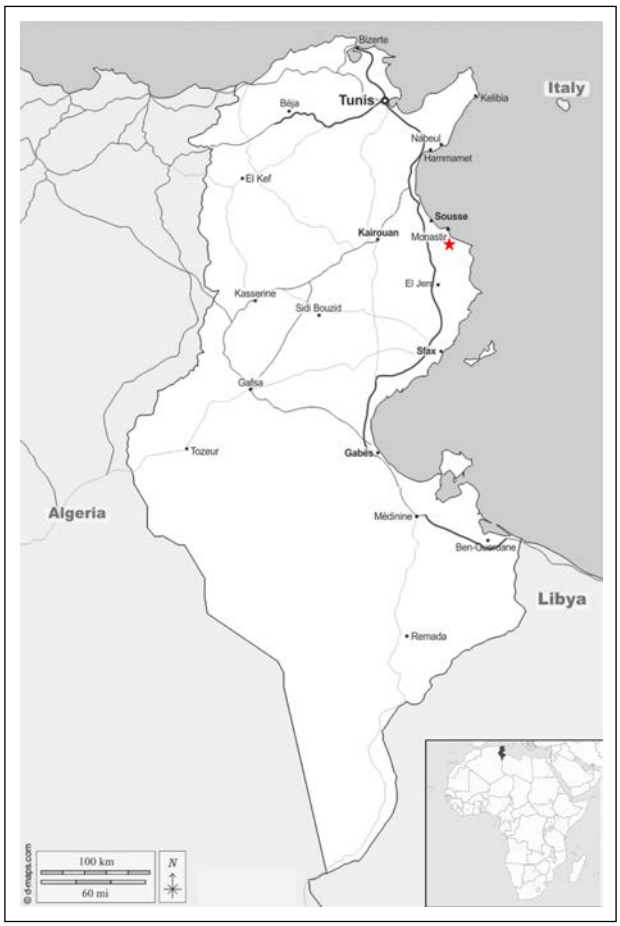

Figure 2. Distribution of *Amaranthus crassipes* subsp. *warnockii* in Tunisia.

Vernacular name

Warnock's amaranth.

Phenology in Tunisia

Flowering time October–November; fruiting time November–December.

Distribution

U.S.A. (SE Texas) and Mexico (E Chihuahua, E Coahulia). Not recorded outside of the Americas up to the present paper (see e.g., Bojian et al. 2003; Mosyakin & Robertson 2003; Palmer 2009; POWO 2022 and literature therein; African Plant Database version 3.4.0).

Habitat and distribution in Tunisia

Human-made habitat on clayey and sandy substrates within ruderal vegetation (almost similar to native habitat and vegetation, which consists of open areas and matorral, see Bayón 2015: 319). *Amaranthus crassipes* subsp. *warnockii* is restricted in Tunisia to one locality of Monastir city at alt. 8 m (Figure 2). The population found covers an area of about 100 m^2. The taxon is an alien for Tunisia and Africa and can be considered as casual.

Representative specimens examined

MÉXICO. **Coahuila:** W. Coahuila, 1 mi. [1.6 km] SE of Ocampo, silty plain near mogote, 8 Sept. 1941, *Johnston 8886* (GH00037034). TUNISIA. **Monastir:** Monastir city, 35°45'39"N, 10°49'52"E, on clayey and sandy substrates in ruderal vegetation, alt. about 8 m, 8 Oct. 2019, *El Mokni s.n.* (HFLA!, *Herb. R. El Mokni*). U.S.A. **Texas:** Hudspeth Co. Gypsum Flat: 10 Oct. 1944, *Waterfall 5842* (NY3363738); near Rio Grande, common and abundant, low places, 8 Aug. 1919, *Hanson 822* (US03540282).

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

DI conceived the research, searched pertinent literature and specimens for the typification purposes, and prepared the first draft of the manuscript; REM carried out field surveys, checked the manuscript and gave further considerations.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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