United States Department of Agriculture | Agricultural Research Service | Beltsville Area Beltsville Agricultural Research Center | Beltsville, Maryland 20705

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SUBJECT: Return of Amaranth Loans with Key to Cultivated and Similar Species

TO: Curators

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Introduction

A study on the taxonomy of *Amaranthus* evolved as a result of not being able to identify more than 1,200 voucher specimens received from the USDA germplasm repository in Ames Iowa. The study was also terminated by the Agricultural Research Service in May 1996. Please accept my apologies for returning the specimens without a publication.

As a status report, a tentative taxonomic key to cultivated species is provided to curators who made loans available (Ames, Miami, Missouri, and the National Arboretum). Nearly 1,000 specimens were employed in this study, which included 25 types from MO, and review of microfishe photographs of Linnaeus types. Most species of the genus were represented. A character list in DELTA format was created, and approximately 10 species items were coded. My intent was to provide a key to all species of *Amaranthus*, but the focal point has been to identify USDA germplasm collections.

Approximately half (600) of the 1200 collections from Ames Iowa that were employed in my study, now at the National Arboretum (NA), were annotated since most had not been identified to species. Specimens from the Missouri Botanical Gardens (MO) were annotated only if I disagreed with the previous identification. I was not able to review the specimens from Miami University, which were specimens previously annotated by Sauer.

As an explanation for the annotations, I present the following key to the cultivated and related weedy species, and a discussion.

Key

1. Tepals 3; flower clusters often globose, especially in leaf axils below the terminal spike..... **A. tricolor**
1. Tepals 5; flower clusters in elongated or cylindrical spikes..... 2

2. Leaf axillary spines present..... **A. spinosus**
2. Leaf axillary spines absent..... 3

3. Tepals strongly clasping the pyxidium, incurved to erect at maturity, or slightly recurved at apex; excurrent midrib of bract about equal to the tepal length..... 4
3. Tepals erect to recurved in fruit, not clasping the pyxidium;

length of bracts including the excurrent midrib usually much exceeding the length of tepals..... 5

4. Midrib on tepals strong, raised or keeled..... **A. congesta**
4. Midrib on tepals not raised, except in the upper half, or sometimes scarcely evident..... **A. dubius**

5. Bracts with their awns more than 1.5 times as long as the pyxidium..... 6
5. Bracts with their awns bracts less than 1.5 times as long as the pyxidium..... 12

6. All tepals obtuse or emarginate (excluding excurrent awn if present), oblong to obovate..... 7
6. Only the inner tepals obtuse or emarginate, or all tepals acute, linear to elliptic, or nearly oblong..... 8

7. Tepals entire to denticulate at apex; midrib and lamina portion of bract united towards the apex to form an excurrent awn; leaves mucronate or aristate..... **A. wrightii**
7. Tepals erose to retuse at apex; excurrent awn primarily from the thick and prominent midrib; leaves entire at apex, or weakly mucronate..... **A. retroflexus**

8. Floral parts--the awns, rachilla and tepals--recurved in fruit; florets of spikelet racemose or paniculate; inflorescence usually branched at base, each branch elongate with dense clusters of florets, thickest at base..... 9
8. Floral parts erect to spreading in fruit; florets contracted together into spikelike clusters, or cymose to paniculately arranged on a divaricately branched rachilla; inflorescence usually pinnately branched, often bare at base of branches..... 10

9. Plants dioecious..... **A. palmeri**
9. Plants monoecious..... **A. hybridus ssp. quitensis**

10. Inflorescence branches stiffly ascending to divaricate; florets usually in verticillate cymose clusters, in each cluster florets mostly erect on a horizontal, divaricately branched rachilla; floral bracts usually divergent in fruit with the pyxidia often visible below the middle; seeds white or dark reddish to black, or sometimes pale yellow, or both dark (reddish-brown) and pale (yellowish) on the same plant, nearly spherical with a broad rugose margin..... **A. hybridus ssp. hypochrondriacus**
10. Inflorescence branches spreading to divaricate, stiff or flexuous; florets usually in continuous spikes, in each cluster florets nearly sessile but pointing in various directions, erect or spreading in fruit with the pyxidia mostly concealed by the tepals except near apex; seed always dark, reddish to black, compressed-lenticular, smooth throughout..... 11

11. Bracts with a wide midrib, filling up most of the bract from near mid region to apex; florets mostly erect; inflorescence mostly branched at base; spikes relatively few, rigid, straight, thickest at base.... **A. hybridus ssp. powellii**
11. Bracts with a uniform narrow midrib; florets mostly spreading; infloresence usually with numerous pinnately branched flexuous spikes, not notably thicker at base..... ..... **A. hybridus ssp. hybridus**

12. Tepals nearly obovate, recurved or plicate; pyxidium not constricted below apex (Fig. 12N in Hunziker 1943)..... 13
12. Tepals nearly linear to oblanceolate, erect; pyxidium constricted below apex..... 14

13. Inflorescence catkinlike, of uniform thickness..... ..... **A. hybridus ssp. caudatus**
13. Inflorescence of many globular clusters of spikelets..... ..... **A. hybridus ssp. edulis**

14. Spikelets in dense thyrsoid (globose) clusters along a main inflorescence branch; branches of inflorescence mostly arising at base of infloresence, the branches ascending to erect; styles spreading from swollen pyxidial lobes (Fig. 12M in Hunziker 1943; Fig. 387 in Flora D'Italia 1982) that form a relatively long neck from their basal constriction, similar to the pyxidium of *A. dubius*, the pyxidium bladdery, deflated in part; seed white..... **A. hybridus ssp. paniculatus**
14. Spikelets in short to long racemelike clusters, nearly sessile; inflorescence mostly pinnately branched along a main axis; styles mostly filiform, erect, meeting rather abruptly with pyxidium to form a short to nearly obsolete neck from basal constriction, the pyxidium turgid, not particularly deflated (Fig. 388 in Flora D'Italia 1982; Fig. 10H in Townsend, Flora Zambesiaca 1988; Sauer 1311-A in Fig 5 of Sauer 1950); seed white or dark or both..... **A. hybridus ssp. cruentus**

Proposed Nomenclature for A. hybridus complex

Amaranthus hybridus L. ssp. **caudatus** (L.) Spjut *ined.*

Amaranthus hybridus L. spp. **cruentus** (L.) Thellung, Fl. adv. Montpell. 204, 1912

Amaranthus hybridus L. ssp. **edulis** (Spegazz.) Spjut *ined.*

Amaranthus hybridus L. ssp. **hypochondriacus** (L.) Thellung, Fl. adv. Montpell. 204, 1912

Amaranthus hybridus L. ssp. **hybridus**

Amaranthus hybridus L. ssp. **paniculatus** (L.) Spjut *ined.*

Amaranthus hybridus L. ssp. **powellii** (S. Wats.) Spjut *ined.*

Notes

Because a great deal of confusion exists in *Amaranthus* taxonomy, I proposed to lump the grain amaranths under the wild relative *A. hybridus*. The subspecies taxon is employed rather than variety to maintain usage of the familiar epithets. Unfortunately, some of the name combinations do not exist; thus, these are referred to as being unpublished (*ined*).

I generally agree with Townsend (1977, 1980) and Brenan (1981) in treating *A. caudatus* as a distinct species from the rest of the *A. hybridus* pack; however, molecular studies have suggested that "*A. caudatus*" is not that distinct from "*A. hypochondriacus*", compared to *A. cruentus*. It might be noted that *A. hypochondriacus* employed in these molecular studies may be *A. hybridus* ssp. *quitensis*; much of what Sauer regards *A. hypochondriacus* is, in my opinion, his *A. quitensis*. Moreover, Sauer (1967) indicated that *A. caudatus* may have been derived from *A. quitensis*, thus, the closer relationship between ssp. *hypochondriacus* and ssp. *caudatus* seen in the molecular studies is perhaps not all that surprising.

The distinction between *A. hybridus* ssp. *paniculatus* and *A. hybridus* ssp. *cruentus* is also supported by molecular data; however, the nomenclatural identifications for ssp. *paniculatus* and ssp. *cruentus* may need to be reversed on the NA specimens, or another name may have to be found for those identified ssp. *paniculatus*. My determinations were based on information in Linnaeus (1763), Sauer (1950, 1967), and from study of the Ames collections. The type for *A. cruentus* is reportedly from China, whereas that of *A. paniculatus* is apparently from Mexico (Linnaeus 1763). Sauer (1950, 1967) also recognized an "atypical" "Mexican race"; however, the Mexican collections exhibit a great deal of morphological variability, compared to considered homogenity among the Ames germplasm collections from the Old World. Thus, I concluded that the Mexican race probably belonged to ssp. *paniculatus*, while most of the Old World collections were probably ssp. *cruentus*. I do not consider the differences based on inflorescence color reliable for distinguishing these subspecies as indicated in Flora d'Italia (1982), and by Linnaeus (1763).

Contrary to my determinations, both Townsend (1977) and Sauer (1967) considered the type of *A. paniculatus* to be identical with that of *A. cruentus*. While the types appear similar, they are not identical; for example, the type of *A. cruentus* has an inflorescence similar to that seen in a voucher for PI-451710, whereas the inflorescence of *A. paniculatus* is more like that of a voucher for AMES 2201. Although I have identified these accessions as *A. cruentus*, and consider them intermediate in inflorescence characteristics, the characteristics of the pyxidia cannot be seen in the photographs of the Linnaeus types; therefore, closer study of the types seems necessary. A good example of the differences in the pyxidia is evident from the illustrations in Flora d'Italia (1982), exemplifying also an accurate representation of their differences in relative size, not mentioned in the key. Moreover, Linnaeus (1763) indicated the plant of *A. paniculatus* to be larger than that of *A. cruentus*, thus, I suspect this may also correlate with size differences in their pyxidia. It should also be recognized that my interpretation is the reverse of what is shown in Flora d'Italia (1982).

Coons (1977) concluded that *A. hybridus* is not distinct from *A. quitensis*

based on a quantitative analysis of characters mentioned by Sauer (1950) in his (Sauer 1950) illustrations and descriptions of the species; however, the characteristic recurved tepals as noted by Sauer (1967) is not evident in his (Sauer 1950) illustration. Coons (1977) did not evaluate this character. Additionally, the tepals of ssp. *quitensis* are often plicate in contrast to the turgid tepals of ssp. *hybridus*.

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