

Taxonomic recovery of the species in the *Chenopodium neomexicanum* (Chenopodiaceae) complex and description of *Chenopodium sonorensis* sp. nov.

Author(s): Nuri Benet-Pierce and Michael G. Simpson

Source: The Journal of the Torrey Botanical Society, 144(3):339-356.

Published By: Torrey Botanical Society

<https://doi.org/10.3159/TORREY-D-16-00013.1>

URL: <http://www.bioone.org/doi/full/10.3159/TORREY-D-16-00013.1>

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

Taxonomic recovery of the species in the *Chenopodium neomexicanum* (Chenopodiaceae) complex and description of *Chenopodium sonorensis* sp. nov.¹

Nuri Benet-Pierce² and Michael G. Simpson

Department of Biology, San Diego State University, San Diego, CA 92182

Abstract. We utilize fruit and seed morphology to help clarify the taxonomy of the *Chenopodium neomexicanum* complex. All previously synonymized taxa are recovered, and one new species within this complex, *Chenopodium sonorensis* Benet-Pierce & M. G. Simpson, is described. For all members of the complex we present a descriptive characterization. We include a dichotomous key for members of this species complex, integrating both reproductive and vegetative characters.

Keywords: Chenopodiaceae, *Chenopodium*, *Chenopodium neomexicanum*, *Chenopodium flabellifolium*, fruits, seeds

The genus *Chenopodium* of the Chenopodiaceae (=Amaranthaceae s.l. in Angiosperm Phylogeny Group 2016) had been traditionally treated as containing approximately 100–150 species worldwide (Willis 8th ed. 1973, Mabberley 3rd ed. 2008), but a recent molecular phylogenetic study of the family demonstrated that *Chenopodium* as traditionally circumscribed is not monophyletic (Kadereit *et al.* 2010). Additional studies (Fuentes-Bazán *et al.* 2012a, b) instituted major changes for the genus by transferring several clades of species formerly treated in *Chenopodium* to the genera *Blitum* L., *Chenopodiastrum* S. Fuentes, Uotila, & Borsch, *Lipandra* Moq., and *Oxybasis* Kar. & Kir, with the rest remaining in *Chenopodium* s.s. These studies have also confirmed the segregation of glandular chenopods to the genus *Dysphania* by Mosyakin and Clemants (2010). The taxa from North America discussed in this paper are all included in *Chenopodium* s.s. (which we subse-

quently refer to as simply *Chenopodium*), a clade of worldwide distribution of around 100 species.

A historically important genus and food staple for indigenous communities in the Americas, *Chenopodium* is now enjoying new popularity as a major pseudograin. In North America, as elsewhere, *Chenopodium* species have been plagued by misidentifications, and taxa of the genus have gone through many divergent treatments for well over 100 years. The number of species in North America in particular remains largely unresolved because of highly variable vegetative features (often considered the result of as yet unproven instances of hybridization), similar leaf characteristics across taxa, and scarcity of diagnostic morphological characters for delimitation of many species. These issues have contributed to synonymy and the elimination of many historic taxonomic entities. Leaf structure and seed coat surface sculpturing may allow segregating *Chenopodium* plants into broad groups (Standley 1916, Wahl 1954, Mosyakin and Clemants 1996, Clemants and Mosyakin 2003). However, characters employed in the past have yielded inconclusive results for some lower rank entities, and few morphological characters have been established to distinguish many taxa within these wide assemblages.

Because the early-formed, primary leaves in this genus often abscise before fruiting, it is rare to find both mature fruits and primary leaves in herbaria specimens, adding to the difficulty in delineating *Chenopodium* taxa. In addition, elucidation of the taxonomy of the group has been worsened by a certain lack of interest in these often underappreciated “weeds” that has resulted in relatively scant collecting and study. Consequently, the North

¹ We offer our most sincere thanks and appreciation to the curators of the following herbaria for allowing us to examine and sample material including type specimens, and for the use of their images: ASC, ASU, ARIZ, BM, BRIT, BYU, CAS-DS, CDA, CHSC, DES, G (with special consideration of the Paul Aellen collection), G-DC, GH, JEPS, K, MO, NMC, NYBG, OBI, P, PAC, RM, RSA-POM, SD, SDSU, SRSC, TEX-LL, UC, UNLV, UNM, US, and UTEP. We thank Lee M. Simpson for acquiring most of the images.

² Author for correspondence, E-mail: nuribpierce@gmail.com

doi: 10.3159/TORREY-D-16-00013.1

©Copyright 2017 by The Torrey Botanical Society

Received for publication March 19, 2016, and in revised form September 14, 2016; first published June 30, 2017.

America taxa have imprecise identification keys and incomplete treatments. Recent molecular studies have recommended that more morphological work may be needed to assist molecular research (Fuentes-Bazán *et al.* 2012b).

Wahl (1954), a well-known *Chenopodium* expert, recognized the importance of fruit characters in the taxonomy of the genus, stating, "Examination of any significant amount of material offers convincing evidence that characters exhibited by the fruits ... are of primary significance in separating 'interbreeding populations.' This is evident because of the relative distinctness between the fruits of individual species and because other characters are correlated with these fruit differences, not to mention the general acceptance of reproductive characters as of inherently greater diagnostic value than vegetative ones." (p. 3)

The use of fruits and seeds can be particularly critical in classifying and identifying *Chenopodium* taxa, as opposed to vegetative features, which are frequently quite similar across taxa. A number of new ultrastructural fruit characters have been recently investigated with success for their taxonomic value across *Chenopodium* s.l. (Sukhorukov and Zhang 2013). Here we aim to integrate both fruit and seed characters as well as aspects of vegetative morphology, all of which may result in a more robust method of identifying and describing the taxonomic entities of *Chenopodium* in North America.

In this paper we focus on the taxonomy of what Crawford (1973, 1974) first alluded to as the "*Chenopodium neomexicanum* complex," a group of six previously named species in which flavonoid chemistry is a unifying feature (Crawford 1973, 1974, 1977; Crawford and Evans 1978; see Table 1). Members of the complex are generally ill-smelling, have leaves that are triangular to ovate and mostly entire (except for basal lobes), have fruits with an adherent pericarp, and represent a large group of North American Western species.

Standley (1916) in his North American Flora, described the majority of the taxa of the *C. neomexicanum* complex, these being *Chenopodium arizonicum* and *C. neomexicanum* by means of type specimens that were collected in the United States, and *Chenopodium palmeri*, *Chenopodium flabellifolium*, and *Chenopodium parryi*, based on type specimens collected in Mexico, and of which he offered no information on distribution in

Mexico (Table 1). Standley (1916) used differences in their fruits as an integral part of his species description and has excellent, although brief, descriptions for these taxa, two of which he reviewed again in his 1917 treatment of the Chenopodiaceae of North America (Standley 1917).

Taxonomic treatments of groups of the *C. neomexicanum* complex have been few. In his brief comments on Standley's 1916 treatment, Macbride (1918) concluded that one species, *C. neomexicanum*, was indistinguishable from *Chenopodium paniculatum* Hook. [= *C. petiolare* Kunth], a South American taxon that also has triangular ovate leaves. However, the plasticity of leaf characters in *Chenopodium* makes resemblances in leaf morphology dubious, and our examination of fruits shows that *C. neomexicanum* and *Chenopodium petiolare* Kunth are quite distinct from one another (Fig. 4A). Macbride agreed with Standley that *C. palmeri* was a legitimate species, but did not comment on any the other three species of Standley (Table 1).

Subsequently, Aellen (1929) described *Chenopodium lenticulare* Aellen from plants collected in Texas. In addition, and with regard to Standley's species, Aellen and Just (1943) recognized only *C. arizonicum* in this complex. They considered *C. neomexicanum* to be the same as *Chenopodium watsonii* f. *glabrescens*, *C. palmeri* as *Chenopodium berlandieri* Moq. subsp. *eu-berlandieri* Aellen, and *C. parryi* as *C. arizonicum* (Table 1). They did not comment on *C. flabellifolium*. The type designated by Aellen for his *C. watsonii* f. *glabrescens*, is one of Standley's *C. neomexicanum* fully accepted syntypes. *Chenopodium berlandieri* Moq. and its varieties are very distinct entities. Their pericarp can be more aptly described as honeycombed-pitted, because its reticulations, usually golden and shiny, give some depth to it by covering the pits, and appearing as a white dot in the center. This is an important characteristic of the fruit of *C. berlandieri* and subspecies (Fig. 4B). *Chenopodium watsonii* A. Nelson is also a very different taxon, with overall dull white pitted pericarp, very occasionally darkish with no varieties accepted (Fig. 4C).

Wahl, in a publication (1954) and in specimen annotations, recognized *C. neomexicanum* and *C. palmeri* of the complex. He considered *C. arizonicum* to be a synonym of *C. palmeri* and *C. lenticulare* to be a synonym of *C. neomex-*

Table 1. Taxonomic comparison of taxa of the *Chenopodium neomexicanum* complex, listed chronologically by author(s).

Standley 1916	McBride 1918	Aellen 1929, Allen and Just 1943	Wahl 1954 and annotations	Reed 1969	Crawford 1973, 1978; Crawford and Evans 1978	Walters 1988	Clemants and Mosyakin 2003
<i>C. arizonicum</i> Standl.		<i>C. arizonicum</i> Standl.	= <i>C. palmeri</i> Standl.	<i>C. berlandieri</i> Moq.	= <i>C. neomexicanum</i> Standl.		
<i>C. flabellifolium</i> Standl.		<i>C. flabellifolium</i> Standl.*	<i>C. flabellifolium</i> Standl.*		<i>C. flabellifolium</i> Standl.		
<i>C. neomexicanum</i> Standl.	= <i>C. paniculatum</i> Hook	= <i>C. watsonii</i> A. Nelson f. <i>glabrescens</i> Aellen	<i>C. neomexicanum</i> Standl.	<i>C. neomexicanum</i> Standl.	<i>C. neomexicanum</i> Standl.	<i>C. neomexicanum</i> Standl.	<i>C. neomexicanum</i> Standl.
<i>C. palmeri</i> Standl.	<i>C. palmeri</i> Standl.	= <i>C. berlandieri</i> Moq. subsp. <i>eu-berlandieri</i> Aellen	<i>C. palmeri</i> Standl.	= <i>C. berlandieri</i> Moq.	= <i>C. neomexicanum</i> Standl.	<i>C. n. var. palmeri</i> (Standl.) Walters	
<i>C. parryi</i> Standl.		= <i>C. arizonicum</i> Standl.	= <i>C. neomexicanum</i> Standl.		= <i>C. neomexicanum</i> Standl.		
		<i>C. lenticulare</i> Aellen	= <i>C. neomexicanum</i> Standl.	= <i>C. neomexicanum</i> Standl.	= <i>C. neomexicanum</i> Standl.		

* Or *Chenopodium inamoenum* Standl. or *Chenopodium opulifolium* Schrad. ex DC.

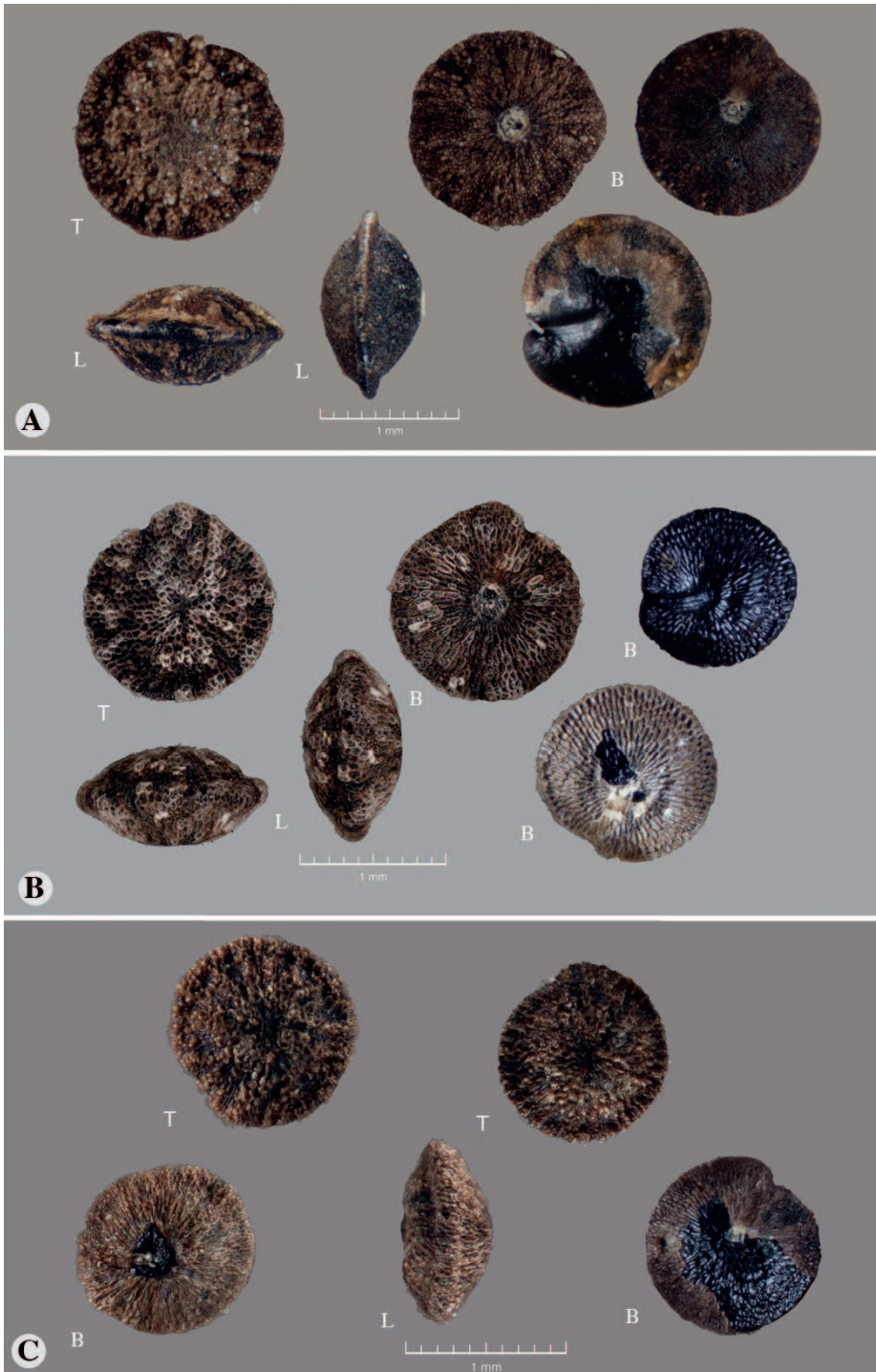


Fig 1. (A) *Chenopodium lenticulare* Aellen. Fruits/seeds > 1.5 mm in diameter, shaped as a double bowler hat; margin flat wide, in top view; papillae large, alternating radial markings cream and brown above; pericarp thin; papillae elongated and collapsed brownish to very dark brown below. Seed coat smooth. (Top two from LL 39893! Bottom left from TEX 173167! Bottom center from SRSC Powell 6385! Bottom right from SRSC 7349!). (B) *Chenopodium neomexicanum* Standley. Fruits/seeds ~ 14 mm in diameter; pericarp

icanum (Table 1). Occasionally, Wahl recognized *C. flabellifolium*, but in other instances he considered *C. flabellifolium* a synonym of either *Chenopodium opulifolium* Schrad. ex DC. or of *Chenopodium inamoenum* Standley. *Chenopodium parryi* was not mentioned (Table 1).

Reed (1969), in the *Flora of Texas*, recognized only *C. neomexicanum* of the species in this complex. He treated *C. arizonicum* and *C. palmeri* as synonyms of *C. berlandieri* and *C. lenticulare* as a synonym of *C. neomexicanum* (Table 1).

Crawford (1973) and Crawford and Evans (1978) recognized only *C. neomexicanum* and *C. flabellifolium* of the complex, with Crawford (1973) treating *C. arizonicum* and *C. palmeri* as synonyms of *C. neomexicanum*, as he did with all the other species of the complex (Crawford 1977; Table 1). Walters (1988) recognized only *C. neomexicanum* within the complex, and treated *C. palmeri* as a variety of *C. neomexicanum* (Table 1); Finally, the most recent treatment of *Chenopodium* by Clemants and Mosyakin (2003) also accepts only *C. neomexicanum* within the complex; the other four species originally described by Standley (1916) are not mentioned (even in synonymy), nor is *C. lenticulare* Aellen considered (Table 1).

Given the great disparity in treatments within the *C. neomexicanum* complex (Table 1), we felt a new study was warranted in order to clarify the taxonomy of the group. Our focus has been to conduct a detailed study of fruit morphology and to propose a classification primarily based on those features, given that fruits have proven to be highly diagnostic. The high plasticity or absence in specimens of many vegetative features in *Chenopodium* makes attempting to identify them without fruit and seed features highly subjective. Our treatment here is strongly supported by characteristics of the fruit and seed, which are relatively stable and diagnostic (see Benet-Pierce and Simpson 2014). We have also heavily utilized

fruit characters to recognize and describe what we deem to be a new species in the complex.

Materials and Methods. We sampled and examined specimens at the following herbaria, where the bulk of North American collections of *Chenopodium* are housed: ARIZ, ASC, ASU, BM, BRIT, BYU, CAS-DS, CDA, CHSC, DES, G (with special consideration of the Paul Aellen collection), G-DC, GH, JEPS, K, MO, NMC, NYBG, OBI, P, PAC, RM, RSA-POM, SD, SDSU, SRSC, TEX-LL, UC, UNLV, UNM, US, and UTEP (abbreviations after Thiers [continuously updated]; see Appendix 1 for list of specimens examined). We have studied and sampled all type specimens, most specimens cited in the original descriptions, and many others wherever possible.

Mature fruits of the *C. neomexicanum* complex are lenticular, almost always with the embryo horizontally oriented (rarely vertically oriented within a given specimen), small but variable in size (ranging 0.6–1.8 mm in diameter), and exhibit different shapes, including the presence or absence of an equatorial margin, as observed in either side or top view. All these characters may be observed in mature fruits with a field lens at 20 \times , but preferably with a dissecting microscope having magnifications up to 40 \times to 200 \times . The dry pericarp varies in thickness, texture, color/color pattern, and sculpturing, with the latter ranging from smooth to highly pitted. Usually, the fruit wall, adherent to the seed in members of this complex, is variously papillate immediately at maturity, but these papillae may dry and collapse, remaining as a series of papillae, pits, or reticulations that take different forms depending on age. These sculpturing features may also vary on the side of the fruit (upper versus lower). In this complex, as in *Chenopodium* in general, fruit features are among the most informative of characters.

Herbarium sheets of all studied specimen vouchers were either photographed or scanned at

alveolate-pitted overall. Upper with larger alveoli, alternating cream and dark gray bands, somewhat conical below with pericarp of smaller papillae and fewer cream color patches. (Left top and bottom, and center top and bottom, from RM 392085! Far right, top and bottom from ARIZ 320840!). (C) *Chenopodium arizonicum* Standley. Fruit/seed \sim 1 mm in diameter, margin thick; pericarp uniformly gray, or brownish even very dark brown; alveoli medium size, usually with alternating radial bands above, light and dark brown near margin in top view; smaller, more elongated alveoli below. (Top left and right, and bottom left and center, from Holotype US 497569! Bottom right from ARIZ 361255!). Abbreviations: B = bottom view; L = lateral view; T = top view.

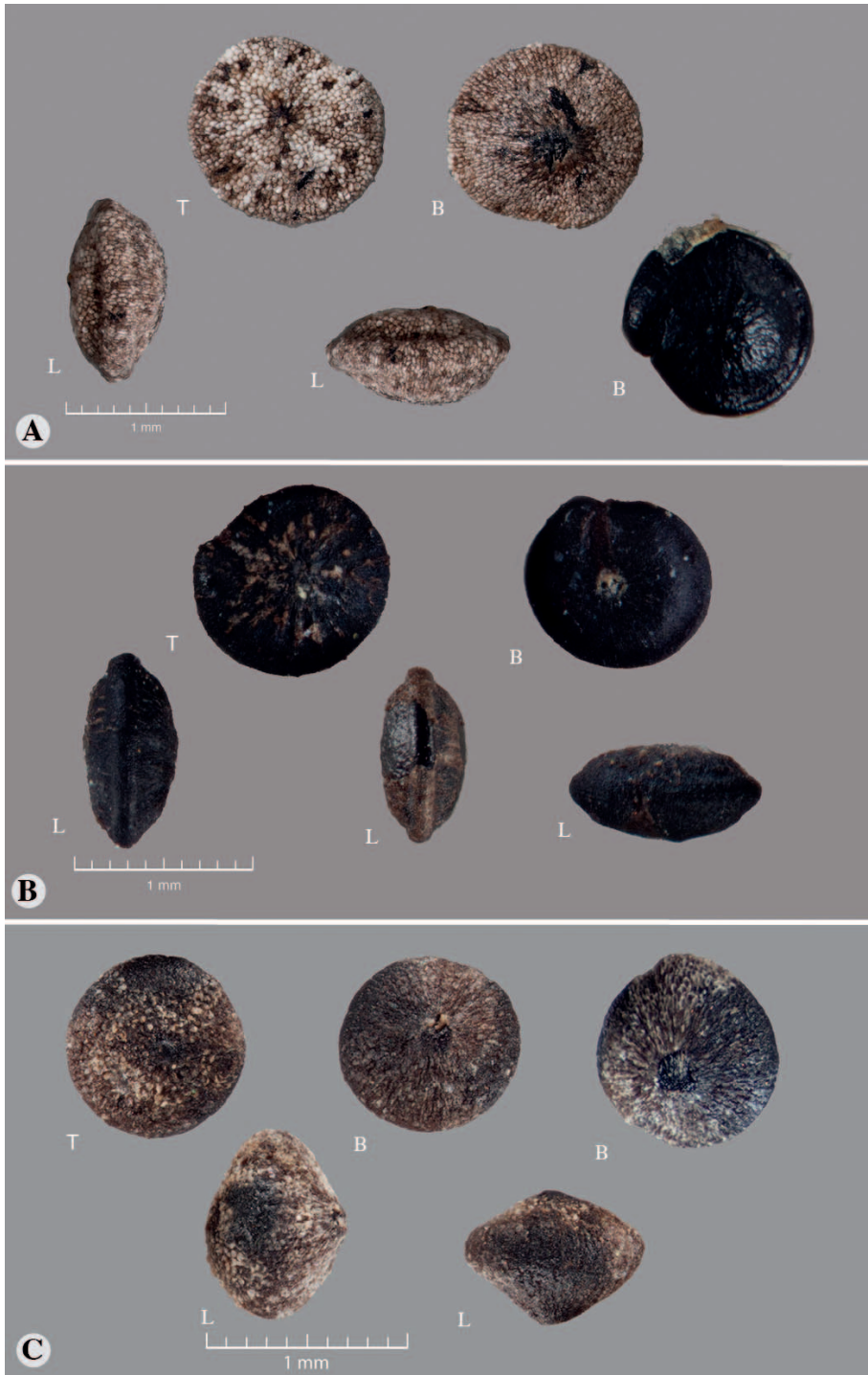


Fig. 2. (A) *Chenopodium flabellifolium* Standley. Fruit/seed ~ 1 mm in diameter; pericarp with large papillae that do not collapse at maturity; papillae mostly whitish with brown spots above, smaller elongated and browner below. (Top left and right, and bottom left and center from SD S.Vanderplank 080324-21! Bottom right SD 77939!). (B) *Chenopodium palmeri* Standley. Fruit/seed ~ 0.8 mm in diameter, lenticular; margin thick in side view, wide and evident from top and bottom sides; pericarp adherent, frequently smooth, usually

high resolution. Fruits were removed and placed on a labeled microscope slide affixed with double-stick tape. All slide collections are housed at the SDSU Herbarium. Fruits and seeds were photographed using at high resolution using a Visionary Digital BK Plus Lab System (Dun, Inc. Palmyra, VA). Qualitative and quantitative observations of fruits and seeds, as well as of vegetative features, were studied and compared. In total, we examined and/or sampled over 300 specimens of the *C. neomexicanum* complex.

All species of the *C. neomexicanum* complex have fruits with adherent pericarps, but very occasionally the pericarp detaches. We have added an image of one of these fruits for each one of the species' images shown in order to be able to illustrate the seed coat. We also have aimed to use the best images to show the dry pericarp, but in order to include a good fruit margin image we often needed to add an image of a fruit with the most evident margin as well. There are many more high-resolution images of fruits and specimens on our website, including the images illustrated here <http://www.sci.sdsu.edu/plants/chenopodium>.

Results. DESCRIPTIONS. We found that all six species of the *C. neomexicanum* complex can be diagnosed from one another, primarily based on fruit and seed characteristics and substantiated with vegetative characters. The following are descriptions and diagnostic characterizations of these six species, plus a description and diagnosis of a new species within the complex. Only size, pericarp adherence, and seed coat markings had occasionally been mentioned before for most of these species.

Chenopodium lenticulare Aellen. Erect annual, to 7 dm tall, with faint or no odor. Branched almost from base, branches spreading, ascending. Leaf blades deltoid to rhombic-ovate, lobes rounded, obtuse 0.8–2.6 cm long; upper leaves smaller, broadly lanceolate or oval, entire, lobes obtuse. Fruit very large, > 1.5 mm in diameter, equatorial margin in top view in excess of 0.2 mm all around, giving the appearance of a “double bowler-hat” shape in side view; pericarp semiadherent and

mottled with very narrow elongated papillae below, adherent with larger collapsed ones above, with scattered bands of large cream papillae interspaced with brown ones. Seed coat smooth. Distribution: USA: Texas and New Mexico; MEXICO: Coahuila. Type collected in Austin, Texas, 1918, *M. S. Young 708* (Holotype US 1104677! Isotype G 4925!); Paratypes: Texas: Jeff Davis County, thin soil along rocky ledges and ravines, 2100 m, Davis Mountains, Oct. 3, 1926, *E. J. Palmer 31874* (TEX 296862!); Jeff Davis County, wet open ground, flats among foot-hills of Davis Mountains, Oct. 6, 1926, *E. J. Palmer 31986* (G 4924!).

Chenopodium lenticulare has only a faint odor if at all, and its seed coat is smooth, putting into question if it really belongs in this complex. However, the pronounced equatorial margin is consistent with a unifying character in this group. Fruits of *C. arizonicum* are somewhat similar to those of *C. lenticulare* in markings above, but differ in size, shape, and pericarp color patterning (see below). The fruit in the type specimen of *C. lenticulare* was in relatively good condition, enabling good comparisons with other collections. This species is quite abundant in Texas (Figs. 1A, 5 & 6).

Chenopodium neomexicanum Standley. Erect annual, to ~ 7 dm, ill-scented. Strict or sparsely branched from base, with branches strongly ascending. Leaf-blades campanulate or broadly rhombic-ovate; lobes obtuse or rounded, 0.8–1.8 to 3cm long; upper leaves smaller, entire, ovate or oblong, apex obtuse-round to acute. Fruit large, to 1.5 mm in diameter; pericarp adherent, broadly pitted, grayish to black with cream-colored bands above, usually with a thin equatorial margin in side view. Seed coat reticulate. Distribution: USA: Arizona, New Mexico, and Texas; MEXICO: Chihuahua and Sonora. Type collected along Mineral Creek, Sierra County, New Mexico, 2250 m elevation, September 26, 1904, *O. B. Metcalfe 1413* (Holotype US 498188!).

Chenopodium neomexicanum seems to be more abundant in Arizona than anywhere else (Figs. 1B, 5 & 6)

←
very dark or black, occasionally with a few brownish radial lines above and below. (Top left and right, and bottom left and far right, from ARIZ 314981! Bottom center SD 153963!). (C) *Chenopodium parryi* Standley. Fruit/seed \lesssim 0.8 in diameter, globose; pericarp above of small uniformly whitish papillae, below darker brown. (Top right from Holotype US 48299! All others from US 397864!). Abbreviations: B = bottom view; L = lateral view; T = top view.

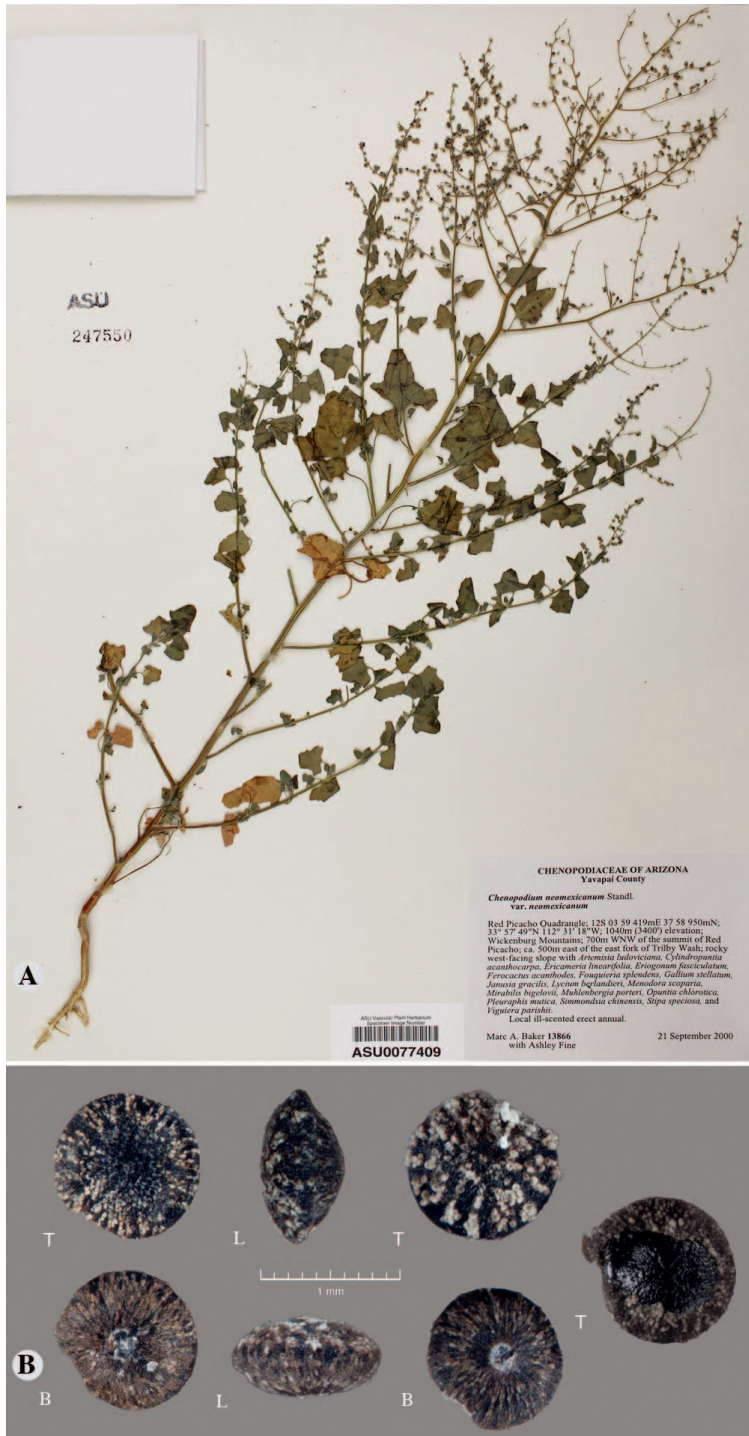


Fig. 3. *Chenopodium sonorensis* Benet-Pierce & M. G. Simpson (A) Holotype specimen: ASU 247550! B. Fruit/seed ~ 1 mm in diameter. Pericarp of papillae collapsed and plump, in white and dark (occasionally brown) radial bands, with thin profuse brown papillate radial bands below. (Top and bottom left and far right SD 95413! Top left center, side view ASC 69236! Top far right and bottom center right and bottom right DES 68899!). Abbreviations: B = bottom view; L = lateral view; T = top view

Chenopodium arizonicum Standley. Erect annual, to 3–6 dm tall, ill-scented. Profusely branched above, reddish; branches ascending but spreading at the base. Leaf blades triangular to rhombic-ovate, 0.7–1.6 cm long, central lobe large, mostly acute or occasionally obtuse, upper blades ovate to lanceolate, elliptic, lobes obtuse or acute, mostly entire. Fruit ~ 1 mm in diameter, flat above, with thick equatorial margin in side view; pericarp adherent, thick, gray or brown, with medium-sized papillae, mostly collapsed, of alternating black and brown radii near the margin above (sometimes quite subtly) and uniform brown or grayish below. Lower pericarp surface with smaller, elongate, collapsed papillae and a reticulate seed coat. Distribution: USA: Mountains of southwestern New Mexico and southeastern and central Arizona; MEXICO: Sonora. Type collected in the Santa Rita Forest Reserve, Arizona, in 1903, *David Griffiths 5982* (Holotype US 497569!). (Fig. 1C, 5, 6).

Chenopodium flabellifolium Standley. Erect annual, to 3 dm tall, ill-scented. Branches ascending. Leaf blades flabelliform to broadly round or rhombic, broader than long, to 1.3 cm, entire or faintly double lobed or dentate, lobes obtuse; upper leaf-blades smaller, occasionally lanceolate, apex obtuse to acute. Fruit 1–1.2 mm in diameter, lenticular, with round faces above and below and a thick margin in side view. Pericarp with inflated papillae that do not collapse at maturity, these whitish above and darker, smaller, and more elongated below. Seed coat rugose. Type collected on San Martin Island, Baja California, March 12, 1897, *T. S. Brandegee s.n.* (Holotype UC 116454!). No fruits present on type. Distribution: MEXICO: San Martin Island, Baja California.

Chenopodium flabellifolium is an extreme endemic found only in the island of San Martin off the west coast of Baja California in Mexico, and has been proposed for protection (Vanderplank and Mata 2010). Some work has been done trying to determine its closest relatives (Crawford 1977, Crawford and Evans 1978), given its extremely narrow range. One of the most discriminating characters of *C. flabellifolium* is its flabelliform leaf, in which the central lobe is reduced. Even though the type specimen for *C. flabellifolium* and its duplicates did not have fruits, there are many recent (and not so recent) collections that we were able to examine of this taxon. Its fruit differs from

other members of the *C. neomexicanum* complex in that the papillae of the pericarp remain mostly intact at maturity, both above and below (Fig. 2A, 5, 6).

Chenopodium palmeri Standley. Erect annual, to 8 dm tall, ill-scented. Branches strongly erect, ascending. Leaf blades broadly triangular to rhombic-ovate, 0.8–1.9 cm long, with basal lobes; upper leaf blades smaller, lanceolate, entire, apex usually broadly obtuse. Fruit lenticular, small, 0.7–1 mm in diameter, with thick and clearly delimited equatorial margin as seen from above and below; pericarp adherent, smooth or with minute papillae, black, occasionally with few brown marks above and below. Seed coat smooth to rugose. Distribution: USA: southern Arizona; MEXICO (where most common): Sonora, Coahuila, Chihuahua, and Baja California. Type collected at Hacienda San Miguel, southwestern Chihuahua, Mexico, in 1885, *Edward Palmer 9* (Holotype US 48302!).

Chenopodium palmeri is usually a large plant, but its fruits are among the smallest in the complex; the dry pericarp usually smooth and black. Occasionally tough, the pericarp shows scattered brown marks above and below. Fruits of *C. palmeri* have the characteristic equatorial margin of all species in this complex. Although *C. palmeri* had been described as a species occurring only south of the border, we have examined some USA specimens that, although having fruits smaller and somewhat lined below than those of Mexico (resembling *Chenopodium sonorensis*; see below), still appear to be closest to *C. palmeri*. Additional collections of *C. palmeri* will be of great help to resolve this apparent variation (Fig. 2B, 5, 6).

Chenopodium parryi Standley. Erect or spreading annual, to 1.5 dm tall, ill-scented. Profusely branched from the base. Leaf blades triangular to rhombic, 0.5–1.5 cm long with obtuse basal lobes; upper blades triangular to oblong, entire, apex acute. Fruit globose, ~ 0.8 mm in diameter. Pericarp adherent, papillate; very small whitish papillae above, darker below. Seed coat rugose. Type collected in the region of San Luis Potosí, Mexico, in 1878, *C. C. Parry & E. Palmer 780* (Holotype US 48299!). Distribution: MEXICO: Coahuila, Nuevo Leon, San Luis Potosí, Veracruz.

Chenopodium parryi Standley differs from all taxa in usually having smaller, more triangular leaves and a very small fruit with hardly any equatorial margin. Some specimens had been

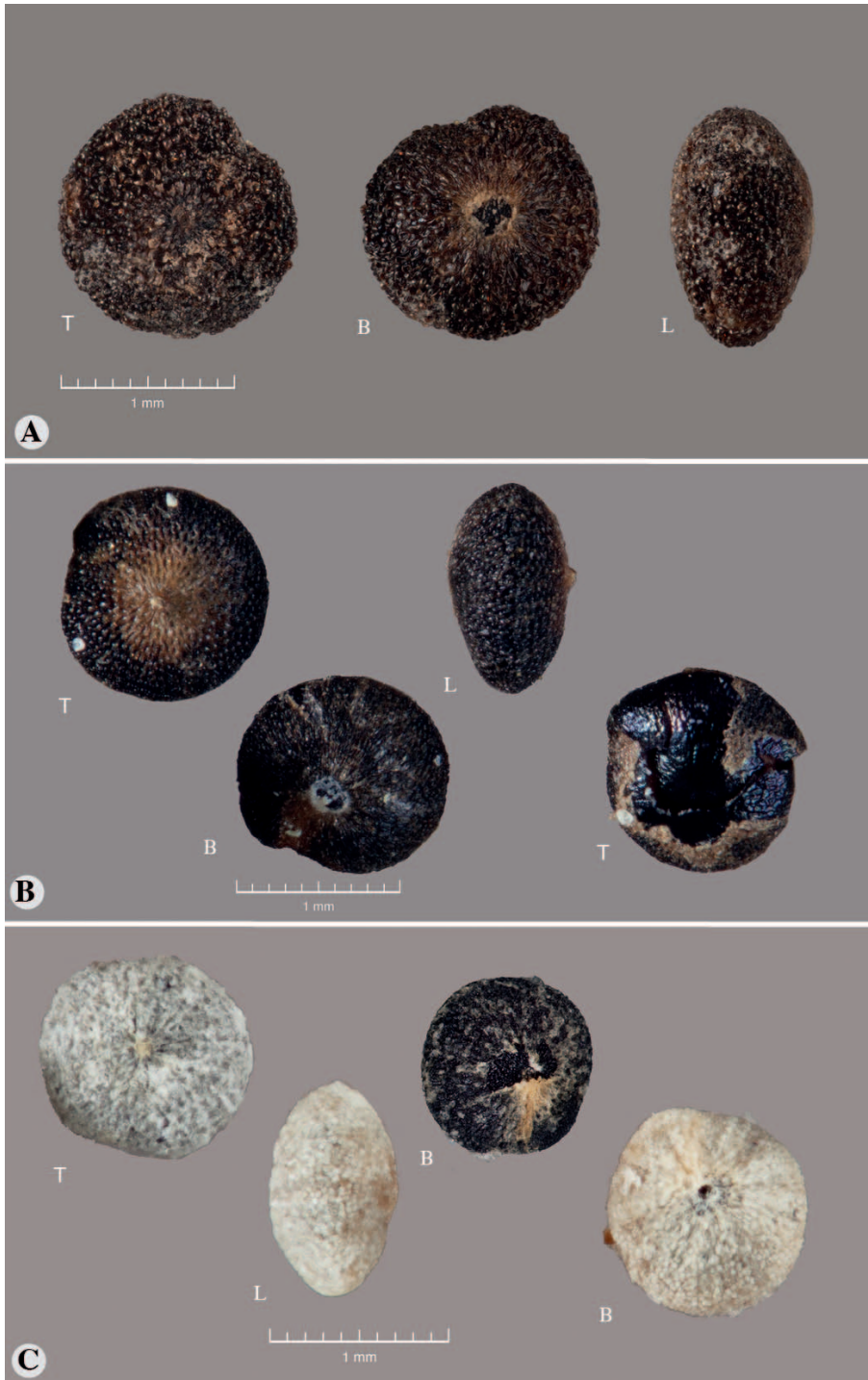


Fig. 4. (A) *Chenopodium petiolare* Kunth [*C. paniculatum* Hook.]. Pericarp adherent; papillae very congested, dark brown overall, rather closer in appearance to other taxa with true honey-comb pitted pericarp. (GH Bauchtien 27, Bolivia!). (B) *Chenopodium berlandieri* Moq. Pericarp true honeycombed-pitted, margin not thick in side view. (CDA 35033!). (C) *Chenopodium watsonii* A. Nelson [*Chenopodium olidum* S. Watson; *Chenopodium dacoticum* Standley], occasionally identified as *Chenopodium sonorensis*. Pericarp pitted, whitened overall (Left three images from RM 301563! Top right, with very rare darker pericarp from US 1651276!).

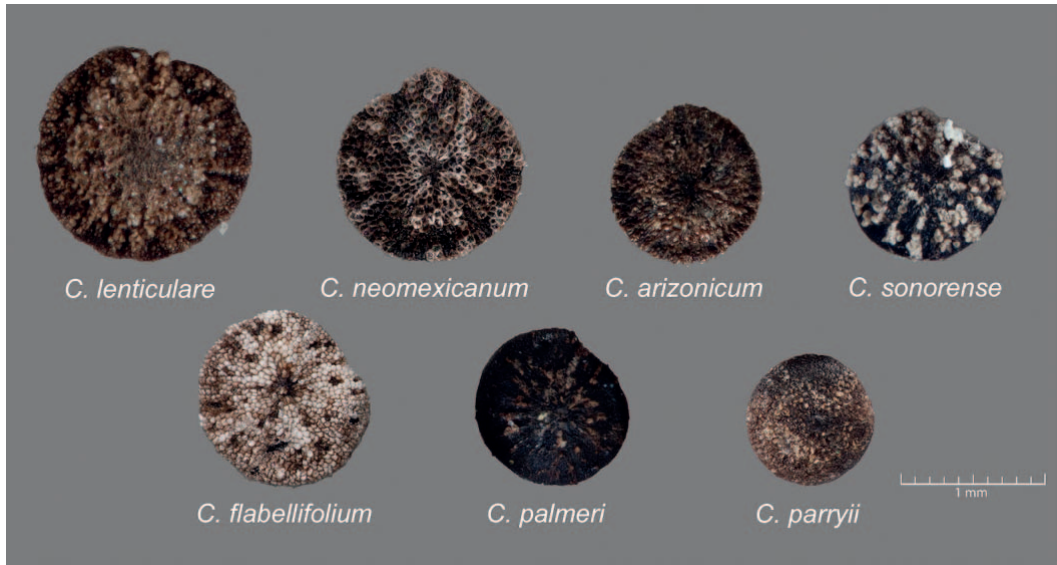


Fig. 5. Comparison of fruits of the seven members of the *Chenopodium neomexicanum* complex, all magnified to the same scale.

identified in the past as *Chenopodium carnosulum* Moq., but the latter is a taxon of the frigid shores of Patagonia with no records in North America (Benet-Pierce and Simpson 2010). We have seen a number of specimens from north and central Mexico that correspond to *C. parryi*. Here we document the fruits, which were in relatively good condition in the type specimen, enough to evaluate the taxon with the help of duplicate collections (Fig. 2C, 5, 6).

NEW SPECIES. During the course of these studies, we became convinced of an entity that we feel belongs to the *C. neomexicanum* complex, but differs from all known members. We think it should be treated as a new species, below. Note that the latitude, longitude, and/or elevations cited below that are estimated from specimen label information are indicated with an asterisk (*); otherwise we list label information exactly. See Fig. 6 for map of localities.

Chenopodium sonorensis Benet-Pierce & M. G. Simpson, *sp. nov.* (Fig. 3A, B). Type: USA, Yavapai County, Arizona: Wickenburg Mountains, 700 m West, North-West of the summit of Red Picacho, ~ 500 m east of the east fork of the Trilby wash, rocky west facing slope with *Artemisia ludoviciana*, *Cylindropuntia acanthocarpa*, *Ericameria linearifolia*, *Eriogonum fasciculatum*, *Ferocactus acanthodes*, *Fouquieria splendens*, and others, local ill-scented erect annual; Red Picacho

Quadrangle; 12S 03 59 419mE 37 58 950mN, 33°57'49"N, 112°31'18"W, 1,040 m (3,400 ft) elevation; September 21, 2000, *Marc A. Baker 13866 with Ashley Fine*. (Holotype: ASU 247550! Isotype: ASC 69236!).

Representative Paratypes. USA, GILA COUNTY, ARIZONA: SW rim of Parker Creek Canyon; Habitat: Chaparral 33.7645°N, -110.9843°W, Elevation: 920 m (3,000 ft*); September 9, 1989, *Frank Farrugia 1514 with Nicole, Luke, & Nate Hertzfeld* (ASU 270549!). USA, MARICOPA COUNTY, ARIZONA: Tonto National Forest, Usery Mountains along trail to Wind Caves, just below caves; 33°28.65'N, -111°35.84'W, Elevation: 1,070 m (3,600 ft*); July 1, 2004, *Landrum 10942 et al.* (ASU 250703!, NYBG Landrum 10942! ASU 256541!). Tonto National Forest, Superstition Wilderness Area, Reavis Trailhead, at the end of forest road 212, ~ 2.5 m S of Hwy. 8; desert grassland habitat dissected by wide canyons, associated with *Canotia*, *Cercocarpus*, *Agave*, plants scattered along sides of trail; 33.5567°N, -111.228609°W*, Elevation 1,095 m (3,600 ft), February 12, 1992, *Kathleen C. Rice 1079* (ASU 189640!). Javelina Mountain (Sand Tank Range). Barry M. Goldwater Air Force Range, northeast side of the mountain; 32°44'42.0"N, -112°21'19.0"W, Elevation 70 m (230 ft); Herb- age stinks like rotten fish; small localized popula-

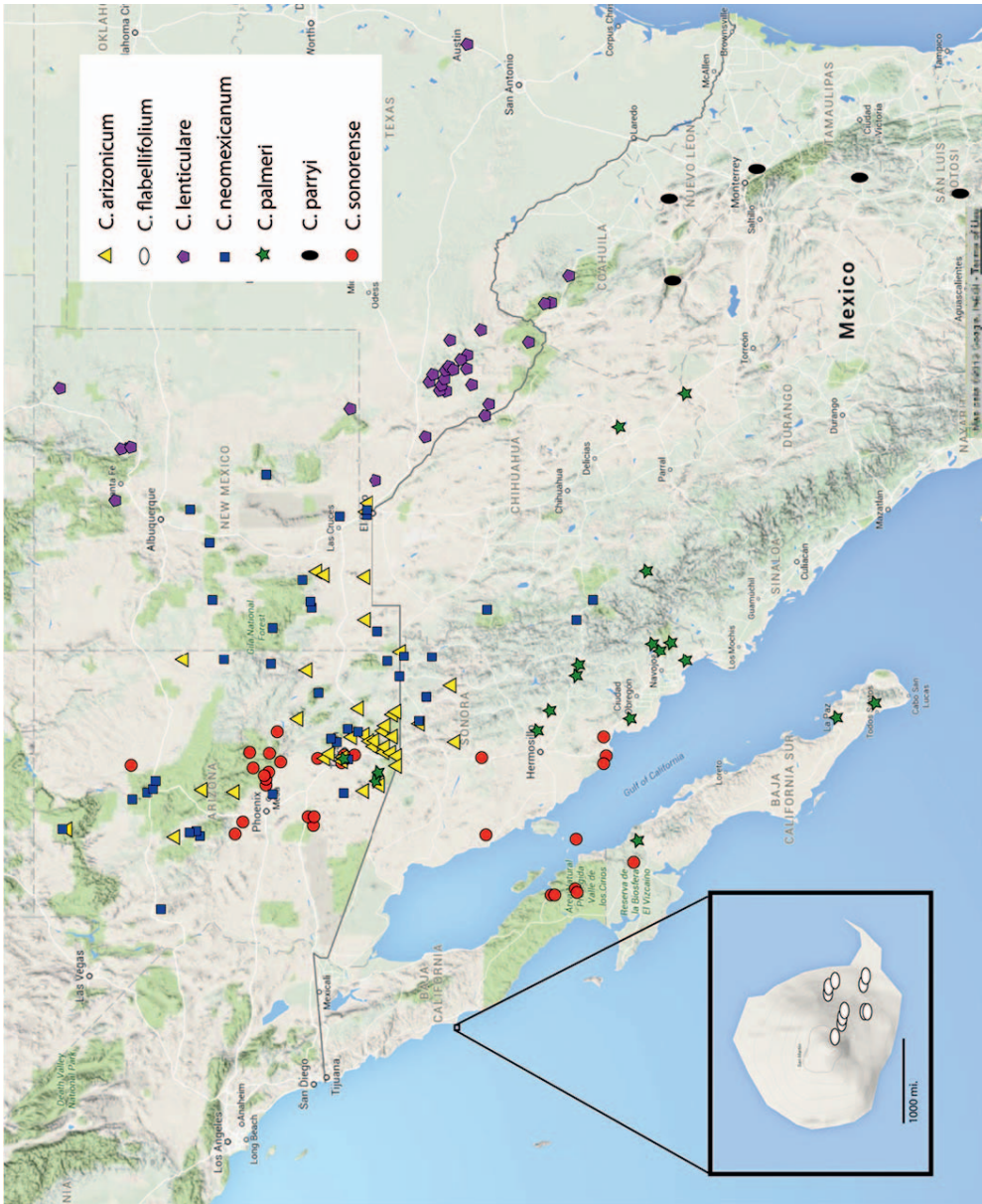


Fig. 6. Map, showing the distribution of the seven members of the *Chenopodium neomexicanum* complex.

- tions. December 2, 2000. *R.S. Felger* 00-63, *C. Bowden*, *B. Broyles*, *L. Wilson*, & *J. Maurer* (ARIZ 361032!). SW of Lake Pleasant Regional Park; Limestone cliff just below Chalky Springs; 33.836°N, -112.2777°W*, Elevation: 477 m* (1,565 ft); November 24, 1973 *Elinor Lehto* 17880 (ASU 59181!). Tonto National Forest; Superstition Wilderness Area; Boulder Creek Trailhead; directly across Highway 88 from Canyon Lake Marina to Trail 103; 103, 33.52°N, -111.45°W*, Elevation: 670.5 m (2,200 ft); January 25, 1992 *Kathleen C. Rice* 995 with *Charlotte Christie* (ASU 189844!). USA, PIMA COUNTY, ARIZONA: Saguaro National Monument, steep rocky north slope on Sweetwater Trail, smells like sardines; 32.2732°N, -111.1480°W*, Elevation 1,122 m (3,680 ft); September 9, 1989, *C.D. Bertelsen* 89-578 with *R.J. Rondeau* (UCR 68449!). San Xavier Indian Reservation, S of Tucson, flat wash area and rocky slopes of a small hill, S of Black Mountain; 32.6833°N, -111.055°W*, Elevation: 838 m (2,750 ft); September 3, 1984, *S.D. Boyd & L. LaPre et al.* (UCR 38500!). Tumamoc Hill. North slope above laboratory grounds. In shade of *Cercidium microphyllum*. 32.2143°N, -111.00558°W* Elevation: 944 m* (3,097 ft); *R.M. Turner* 82-22 (ARIZ 240300! SD 119154!) USA, PINAL COUNTY, ARIZONA: Tonto National Forest, Superstition Wilderness Area, Peralta Trailhead, 7 mi. N of US Hwy. 60 on Forest Road 77, Trail 102, associated with *Rhus ovata*, *Simmondsia chinensis*, *Quercus turbinella*; 33.378°N, -111.3639°W*, Elevation: 986 m (3,235 ft); March 13, 1992, *Kathleen C. Rice* 1140 (ASU190416!). Superstition Wilderness Area; Miles Ranch Trailhead near Paradise Spring; Forest Road 287; ~ 12 miles from US Highway 60 turnoff to Magma Copper Mine; Trail 271. 33.42940°N, -111.07°W*, Elevation: 1,219 m (4,000 ft); September 20, 1992 *Kathleen C. Rice* 1464 et al. (ASU 190220!). Superstition Wilderness Area; Massacre Grounds. Forest Rd 78 ~ 1 mile to turnoff to S; Associated with *Ambrosia*, *Dodonea viscosa*, *Encelia farinosa*, *Lycium*, *Quercus turbinella*. 33.4601°N, -111.4743°W*, Elevation: 731.5 m (2,400 ft); March 8, 1992 *Kathleen C. Rice* 1130 (ASU191405!) Antelope Peak 15' Quad.; Table Top Mountain; basin on summit of peak. Basalt substrate, Occasional. With *Opuntia phaeacantha*, *Fouquieria*, *Muhlenbergia*, *Yucca arizonica*, *Canotia holocantha*. 32.7606°N, -112.1260°W*, Elevation: 1,250 m (4,100 ft); September 3, 1981 *M. Butterwick* (ASU 213858!). Tonto National Forest; Picketpost Mountain Quad. Hewitt Canyon up from FS Road 1904, about two miles north of Roblas Butte; Habitat Saguaro-Palo Verde community, dacite tuff 20-40% slopes; 33°20.505'N, -111°13.401'W*, Elevation: 753 m (2,470 ft); October 16, 2008. *Elizabeth Makings* 3137 with *Andy Casillas* (DES 68899!). Sonoran Desert National Monument. Table Top Mountain, along trails in foothills to west of mountain. Basalt boulder field with fine-grain silty soil, Mixed desert scrub. 32°44'27.7"N, -112°08'22.7". Elevation: 868 m (2,847 ft); January 17, 2002. *R.S. Felger* 02-46 with *B. Broyles* (ARIZ 365275! ARIZ 374684!). MEXICO, SONORA: Cañon de las Barajitas, Sierra El Aguaje, ~ 18 km NW of San Carlos, side canyon; canyon bottom among rugged rhyolitic walls with *Cordia sonora*, *Fouquieria splendens*, *Hyptis emoryi*, *Lysiloma candida*, *Olneya tesota*. 28°03'36.6"N, -111°11'38.9" W, Elevation: 70 m (230 ft); February 17, 1995, *R.S. Felger* 95-175 with *Michael F. Wilson* (TEX 450791! ARIZ 375342!). Foothills at south end of Sierra Libre; 12.3 miles south of La Palma on MEX. Hwy 15, (at km marker 190) then 0.8 miles east of Hwy on Rd to Microondas Avispas. 28°29'N, -111°11'38.9"W, Elevation: 320 m (100 ft); October 3, 17, 1985, *R.S. Felger* 85-1090 with *Frank W. Reichenbacher* (ARIZ 257505!). MEXICO, BAJA CALIFORNIA: Municipio Ensenada, Sierra de La Libertad, south of Bahía de Los Ángeles, between Arroyo La Bocana y Campo El Rodeito of the eastern side of the Sierra, NW of Rancho San Pedro in a flat area en route to the higher sierra; 28.5134°N, -113.557°W, Elevation: 1,100 m (3,608 ft); October 3, 2012, *Jon Rebman* 25140 (SD 223592!). Sierra de San Borja, few seen in gravelly soil at the summit of Cerro Santa Marta; 28°54'N, -113°37'W, Elevation: 1,450 m (4,757 ft); June 9, 1962, *Reid Moran* 9769 (SD 560691! SD 600571!). Sierra de La Libertad along the trail between El Rodeo and Las Cuevitas; in canyon and on surrounding rocky slopes on the South side of Cerritos. Geology: volcanic substrates mostly basalt. Vegetation: Sonoran Desert, Central Desert subregion, with *Celtis pallida*, *Dodonea viscosa*, *Brahea armata*, *Cyllindropuntia cholla*, and *C. alcahes*. Annual; rare. 28.5155°N, -113.602°W, October 26, 2009. *Jon Rebman* 18668 (SD 202555!), Sierra Guadalupe: West of Mulege: south of the ex-mission de Guadalupe at

Table 2. Species of the *Chenopodium neomexicanum* complex recognized in this study.

Species	Source
<i>C. arizonicum</i> Standley	North American Flora, Vol. 21, pp. 19. 1916
<i>C. flabellifolium</i> Standley	North American Flora, Vol. 21, pp. 19. 1916
<i>C. lenticulare</i> Aellen	Feddes Repert. Spec. Nov. Regni Veg. 26: 31–64, 119–160. 1929
<i>C. neomexicanum</i> Standley	North American Flora, Vol. 21, pp. 19. 1916
<i>C. sonorensis</i> Benet-Pierce & M. G. Simpson	This publication. 2017
<i>C. palmeri</i> Standley	North American Flora, Vol. 21, pp. 19. 1916
<i>C. parryi</i> Standley	North American Flora, Vol. 21, pp. 21. 1916

E-base of Cumbre de San Pedro. 26°53'31"N, –112°23'44"W. Elevation: ~ 600 m (~ 1,968 ft), September 27, 1998 (SD 142985!); Sierra de La Libertad: at the edge of the mesa along the cliff above Arroyo el Paraiso; along the trail between the abandoned Rancho El Paraiso and the abandoned rancho Las Cuevitas. Annual; common along trail. *J. Rebman 17293* (SD 194568!); La Libertad 1062: Sierra de la Libertad, Palmar E El Rancho site 478. 28.4908°N, –113.596°, Elevation: 1,144 m (3,753 ft). October 10, 2009, *M. Salazar 5106 w. H. Riemann, W. Clark, and L. Delgado* (SD 208352!); Common under shrubs, Rancho San Antonio, east side of Sierra San Francisco 27°34'N, –113°01'W, Elevation: 1,050 m (3,445 ft). *R. Moran 23813* (SD 127323! & SD 95413!).

English Diagnosis. *Chenopodium sonorensis* is similar to *C. arizonicum* in the size of the fruit, but differs in that its leaves are round-ovate, sometimes with the center lobe sinuate with squarish and frequently double basal lobes. The dry pericarp is usually black or brown with white papillate markings above and profusely lined with minute papillae below. *Chenopodium sonorensis* is similar to *C. flabellifolium* in having larger papillae, some of which do not collapse, but differs in that its leaves are hardly ever flabelliform. It differs from all others in the complex by its mostly squarely lobed leaves and dry pericarp characteristics.

Description. Plant an erect annual, ~ 3–4 dm high, ill-scented. Stems slender, sparsely branched, branches ascending, weak. Leaves alternate, yellowish-green, farinose; leaf-blades 0.6–1.5 cm long, round-ovate, ovate to lanceolate, elliptic, or triangular, usually with squarish, lateral basal lobes, occasionally sinuate in the often reduced central lobe, apex obtuse or rounded; upper blades smaller, triangular, elliptic, or lanceolate, entire, usually with prominent squarish double basal lobes, these rounded, apex obtuse or acute.

Inflorescences in narrow, paniculate spikes. Flowers ~ 1 mm in diameter. Perianth uniseriate; calyx synsepalous, distinct to near base; lobes apically obtuse, farinose abaxially. Stamens five, distinct, whorled, antisepalous, yellowish; filaments terete; anthers laterally dehiscent, dithecal, sub-basifixed. Gynoecium with two stigmas. Fruit, lenticular, ~ 1.1 (1.0–1.2) mm in diameter, seed embryo horizontal, equatorial margin thick in side view; fruit wall adherent, papillate. Papillae large, often not collapsed, radially white or blackish above, occasionally even faintly so and fuzzy dark with minute, elongated papillae usually collapsed, forming alternating brown or whitish lines below. Seed coat black, rugose (Fig. 3B).

Distribution and Habitat. *Chenopodium sonorensis* occurs as scattered populations in Gila, Maricopa, Pima, Pinal, and Yavapai Counties in Arizona, and in Sonora and Baja California in Mexico.

Phenology. *Chenopodium sonorensis* appears to flower as early as May, and is in fruit from late June to September.

Etymology. The epithet “*sonorensis*” is Latin for “from Sonora,” as it occurs in the Sonora desert region of the USA and Mexico.

Suggested Common Name. Sonora goosefoot.

Key. See Appendix 2.

Note that *Chenopodium sonorensis* had on occasion also been identified as *Chenopodium fremontii* f. *farinosa* Wahl, but these identifications were never consistent, as other *Chenopodium* specimens have been identified to this taxon as well.

Discussion. The species of the *C. neomexicanum* complex accepted here (Table 2) can be characterized as mostly foul smelling plants, the leaves generally ovate with two basal lobes, and the fruits with a pericarp adherent to the seed. These plants remain understudied and have been deemed uncommon (Crawford 1973). Leaf mor-

phology in *Chenopodium* is often confusing, both because it is often invariant between species and because of the abscission of the basal, primary leaves generally prior to fruit maturation.

We have found that fruits and seeds of *Chenopodium* exhibit a stable and unique combination of characters corresponding to both known and previously unrecognized taxonomic entities. Because these reproductive features are more reliable than vegetative characters, they provide great taxonomic assistance and can be used with success in conjunction with the general architecture and vegetative characters of the plant. We confirm that fruits and seeds are actually needed for accurate identifications. However, we have been extremely cautious to only recognize entities for which we had ample specimens. We recommend that in using fruit and seed features, care be taken to sample only dry, mature, and well-developed fruits, as immature and unviable fruits may not be effective for identification purposes.

We have been able to recover and now recognize all of the original historical species of Standley (1916), plus *C. lenticulare* of Aellen (1929) and our herein described *C. sonorensis* in circumscribing what we continue to refer to as the *C. neomexicanum* species complex (see Table 2). All seven of these species are somewhat restricted in distribution and often sympatric to one another (Fig. 6); they may also be rare, given their limited past collections. It is to be expected that molecular work will eventually reveal evolutionary relationships for these species and the validity of this complex. However, at present we believe these should be recognized as separate entities given the evidence cited here. For example, the relationships of *C. flabellifolium* take on a new significance with the recognition here of *C. sonorensis*, which also occurs in many places in the Baja California peninsula as well as mainland Mexico and Arizona (Fig. 6). *Chenopodium sonorensis* is somewhat similar to *C. flabellifolium* in leaf morphology, having a somewhat reduced central lobe, but differing in the basal lobes and central lobe being mostly still very differentiated and with some teeth in the central lobe and only very seldom flabelliform. It is also similar in fruit morphology, as the pericarp has some noncollapsed papillae as well. These similarities may indicate a close relationship of the two species, but phylogenetic analyses will be needed to verify this.

Our continuing research, of which this paper is just a section, includes hundreds of samples, aided by the fact that *Chenopodium* is traditionally such a heavy seeder. Our most heartfelt gratitude is given to the enlightened individuals and governments that fund, maintain, and curate herbarium collections. We hope that with more reliable identifications there will be renewed focus and interest on this important genus. We thank our anonymous reviewers who helped in making this a better paper and Dr. A. Michael Powell & S. Powell for their indefatigable assistance in securing collections from Texas.

Literature Cited

- AELLEN, P. 1929. Beitrag zur Systematik der *Chenopodium*-Arten Amerikas, vorwiegend auf Grund der Sammlung des United States National Museums in Washington, D.C. I, II. Feddes Rept. Spec. Nov. Regni Veg. 26: 31–64, 119–160.
- AELLEN, P. AND T. JUST. 1943. Key and synopsis of the American species of the genus *Chenopodium* L. Amer. Midl. Nat. 30: 47–76.
- ANGIOSPERM PHYLOGENY GROUP. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Bot. J. Linn. Soc. 181: 1–20.
- BENET-PIERCE, N. AND M. G. SIMPSON. 2010. *Chenopodium littoreum* (Chenopodiaceae): a new goosefoot from dunes of south-central coastal California. Madroño 57: 64–72.
- BENET-PIERCE, N. AND M. G. SIMPSON. 2014. The taxonomy of *Chenopodium desiccatum* and *C. nitens* sp. nov. J. Torrey Bot. Soc. 141: 161–172.
- CLEMANTS, S. E. AND S. L. MOSYAKIN. 2003. *Chenopodium* Linnaeus, Sp. Pl. 1: 218, pp. 275–299. In Flora of North America Editorial Committee [ed.], Flora of North America. Vol. 4, Magnoliophyta: Caryophyllidae, Part 1. Oxford University Press, New York, NY.
- CRAWFORD, D. J. 1973. Morphology, flavonoid chemistry and chromosome number of the *Chenopodium neomexicanum* complex. Madroño 22: 185–195.
- CRAWFORD, D. J. 1974. The validity of *Chenopodium glabrescens* (Chenopodiaceae). The Southwest. Nat. 19: 249–255.
- CRAWFORD, D. J. 1977. On the relationships of *Chenopodium flabellifolium* and *C. inamoenum*. Madroño 24: 63–64.
- CRAWFORD D. J. AND K. A. EVANS. 1978. The affinities of *Chenopodium flabellifolium* (Chenopodiaceae). Evidence from seed coat surface and flavonoid chemistry. Brittonia 30: 313–318.
- FUENTES-BAZÁN, S., G. MANSION, AND T. BORSCH. 2012a. Towards a species level tree of the globally diverse genus *Chenopodium* (Chenopodiaceae). Mol. Phylogenet. Evol. 62: 359–374.
- FUENTES-BAZÁN, S., P. UOTILA, AND T. BORSCH. 2012b. A novel phylogeny-based generic classification for *Chenopodium* sensu lato, and a tribal rearrangement of Chenopodioideae (Chenopodiaceae). Willdenowia 42: 5–24.

- KADEREIT, G., E. V. MAVRODIEV, E. H. ZACHARIAS, AND A. P. SUKHORUKOV. 2010. Molecular phylogeny of Atripliceae (Chenopodioideae, Chenopodiaceae): implications for systematics, biogeography, flower and fruit evolution, and the origin of C4 photosynthesis. *Amer. J. Bot.* 97: 1664–1687.
- MABBERLEY, D. J. 2008. *Mabberley's Plant-Book: A Portable Dictionary of the Higher Plants, Their Classification and Uses*, 3rd ed. Cambridge University Press, Cambridge, UK.
- MACBRIDE, J. F. 1918. New and otherwise interesting plants, mostly North American Liliaceae and Chenopodiaceae. *Contrib. Gray Herb. Harv. Univ. New Ser.* 3: 1–22.
- MOSYAKIN, S. L. AND S. E. CLEMANTS. 1996. New infrageneric taxa and combination in *Chenopodium* L. (Chenopodiaceae). *Novon* 6: 398–403.
- REED, C. F. 1969. *Chenopodium*, pp. 26–51. In C. L. Lundell and L. Benson [eds.], *Flora of Texas*. Vol. 2, Part I. Texas Research Foundation, Renner, TX.
- STANDLEY, P. C. 1916. *Chenopodium*, pp. 19. In *North American Flora*. Vol. 21, Part 1. New York Botanical Garden, New York, NY.
- STANDLEY, P. C. 1917. *Chenopodium*, pp. 412–420. In *The Chenopodiaceae of the North American Flora*. *Bull. Torrey Bot. Club* 44: 411–429.
- SUKHORUKOV, A. P. AND M. ZHANG. 2013. Fruit and seed anatomy of *Chenopodium* and related genera (Chenopodioideae, Chenopodiaceae/Amaranthaceae): implications for evolution and taxonomy. *PLoS ONE* 8: e61906. doi:10.1371/journal.pone.0061906.
- THIERS, B. [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. Retrieved April 17, 2017 from the New York Botanical Garden. <<http://sweetgum.nybg.org/science/ih/>>.
- VANDERPLANK, S. AND S. MATA. 2010. Threats to an extreme endemic: *Chenopodium flabellifolium* (Amaranthaceae) on Isla San Martín. *Crossosoma* 36: 50–56.
- WAHL, H. A. 1954. A preliminary study of the genus *Chenopodium* in North America. *Bartonia* 27: 1–46.
- WALTERS, W. T. 1988. Relationship between isozymic and morphologic variations in the diploids *Chenopodium fremontii*, *C. neomexicanum*, *C. palmeri* and *C. watsoni*. *Am. J. Bot.* 75: 97–105.
- WILLIS, J. C. 1973. *A Dictionary of the Flowering Plants and Ferns*, 8th Ed. Revised by H. K. Airy Shaw. Cambridge University Press, Cambridge, UK.

Appendix 1

List of all specimens examined in the study, cited by collector, collection number, and herbarium accession number. Note that for *Chenopodium sonorensis*, specimens cited below were not listed as paratypes because of some uncertainty in identification.

- Chenopodium arizonicum*:** *Anderson s.n.* 590036; *Vandevender 1601* (SDSU 20964); (ARIZ 44090); *Baker 14217* (ASU 239277); *Vandevender 2013-282* (SDSU 20966); *Benson 8951* (RSA 279712); *Blumer 3585* (GH, MO 46171, UC 153635); *Buegge 1074* (ASU 231615, UCR 162228); *Carnahan 571* (ARIZ 421859); *Carnahan 682* (ARIZ 421686); *Vandevender 87-332* (ARIZ 271595); *Carnahan 703* (ARIZ 421668); *Carnahan 730* (ARIZ 421829); *Carnahan 731* (ARIZ 429830); *Wandevender s.n.* (ARIZ 201341); *Warnock 14277* (TEX 296857); *White 4695* (ARIZ 118667, US 2132420); *Wooton 1911* (US 660988); *Worthington 20044* (UTEP 43479); *Worthington 27275* (UNM 92874); *Worthington 9192* (UTEP 72678); *Worthington s.n.* (UTEP 1424); *Worthington 27168* (UTEP 56411).
- Chenopodium flabellifolium*:** *Brandegee s.n.*, 12 March 1897 (UC 116454 [Holotype], UC 1395472 [Isotype], UC 178873 [Isotype], US 694735=00102534 [Isotype]); *Moran 10497* (DS 501986, SD 54280, UCR 58732); *Moran 18449* (SD 77939); *Moran 21210* (CAS 597785, SD 86968); *Moran 27243* (SD 102437); *Thorne 61597* (UCR 43832); *Vanderplank 080628-1*; *Vanderplank 083211-32*; *Vanderplank 70225-12*; *Vanderplank 80028-1*; *Vanderplank 80324-32*; *Vanderplank 80528-1*.
- Chenopodium lenticulare*:** *Arsene 20708* (TEX); *Carr 23521* (TEX 210715); *Chauvin 3BD151-F7* (UNM 110976); *Chauvin C063-F21* (UNM 104974); *Correll 14008* (BRIT); *Correll 24416* (LL 39893); *Cory 26308* (GH); *Henrickson 15070* (TEX 173167); *Hinckley 3334* (US

2003724); *Hinckley 617* (BRIT); *Hinckley s.n.* (TEX 296859); *Hinckley s.n.* (TEX 296860); *Hinckley s.n.* (TEX 296861); *Keough 297* (SRSC); *Keough 41* (SRSC); *Larke 350* (SRSC); *Larke 560* (SRSC); *Lott 5174* (TEX 441386); *Lott 5559* (SRSC); *Palmer 31874* (K 49, TEX 296862 [Paratype]); *Palmer 31986* (G 4924, 4926 [Paratype]); *Powell 6385* (SRSC); *Powell 7057* (SRSC); *Powell 7312* (SDSU 21435); *Powell 7331* (SDSU 21432); *Powell 7333* (SDSU 21439); *Powell 7336* (SDSU 21440); *Powell 7343* (SDSU 21444); *Powell 7349* (SDSU 21434); *Powell 7351* (SDSU 21455); *Powell 7353* (SDSU 21453); *Powell 7360* (SDSU 21442); *Powell 7367* (SDSU 21452); *Riskind 238* (TEX 447226); *Sperry 255* (US 1684297 [plant at left]); *Stewart 1646* (GH); *Tharp 3386* (TEX 39891); *Warnock 1118* (SRSC 35636, US 1726087); *Warnock 21355* (SRSC); *Warnock 98* (SRSC 35635); *Waterfall 7774* (GH); *Wooton s.n.* (UNM 18419); *Worthington 1856* (UTEP 36806); *Young 708* (US 1104677=00102548 [Holotype], G 4925 [Isotype]).

***Chenopodium neomexicanum*:** *Alexander 202* (ASC 17145); *Arsene 18504* (US 1033838); *Barr 67-307* (ARIZ 166609); *Bedker 1456* (UNM 40591); *Blumer 1906* (DS 46433, GH, K 386, MO 46171, NMC 9324, RM 168326, UC 153635); *Blumer 39* (GH, NY); *Butterwick 4081* (ASU 113286); *Christie 1203* (ASC 85422); *Clarke 1003-25* (UCR 130306); *Crawford 474d* (RM 392069); *Crawford 552* (ASU 168254, CAS 351054, NY 990903, PAC, RM 392086); *Crawford 722* (NY, RM 392085); *Crawford 726a* (RM 392186); *Crawford 727* (RM 392187); *Crawford 728* (OBI 54088, RM 392084); *Crawford 747d* (PAC 84661); *Darrow 1124* (ARIZ 10214); *Felger 922* (ARIZ 303392); *Goldman 572* (DES 58879); *Gould 4606* (ARIZ 47181); *Hodgson 15908* (DES 56977 [plants at left]); *Hutchins 3311* (UNM 41321); *Jones 24809* (CAS 173248); *Laferriere 1048* (UCR 64219); *Martin s.n.* (ARIZ 322250); *Mathey 680* (UNM 61441); *Meltcalf 1413* (US 498188=00102553 [Holotype] CAS 85887 [Isotype], G 1413 [Isotype], MO 46392=216264 [Isotype], NMC 9317 [Isotype], NY 000324318 [Isotype], UC 851063 [Isotype], UNM 209 [Isotype], US 890281 [Isotype]); *Pinkava 13698* (ASU 14456); *Reina 2007-820* (SDSU 20935); *Reina 2010-980* (SDSU 20931); *Roll 470* (SDSU 21471); *Rothrock 747* (GH, MO 46419); *Schultz 3029* (ASC 92236);

Thornber s.n. (ARIZ 44074); *Thornber s.n.* (ARIZ 44192); *Toumey s.n.* (GH); *Townsend s.n.* (P 4971820); *W 17540* (TEX 39889); *Wahl 21826* (ARIZ 182619, ASC 21650, GH, PAC 27563); *Wahl 21900* (ASC 21652, PAC 82326, RM 288549); *Wahl 21925* (PAC 82327, RM 288548); *White 4443* (ARIZ 118669); *Wooton s.n.* (NMC 9319); *Wooton s.n.* (UNM 18816); *Worthington 13394* (NY 990905, UTEP 30651); *Worthington 16999* (UTEP 36802); *Worthington 17540* (UTEP 36803); *Worthington 25214* (UTEP 53613); *Worthington 5325* (UTEP 12188); *Worthington 9065* (UTEP 19863); *Zimmerman s.n.* (ASC 68073).

***Chenopodium palmeri*:** *Campbell 281* (TEX 173169); *De la Luz 8700* (HCIB 13371, SD 147056); *Dominguez 1790* (SD 147057); *Dominguez 349* (HCIB 1053); *Felger 1090* (ARIZ 283280); *Felger 1416* (ARIZ 257562, RSA 346148, SD 125075, TEX 173166); *Gentry 20481* (ARIZ 360879, US Gentry 20481); *Hodgson 23491* (DES 72283); *Jones 28610* (DS 233379, MO 1013003, UC 479239); *Knobloch 507* (PAC 27312); *Moran 21379* (SD 88092); *Palmer 9* (US 48302=00102561 [Holotype], GH 00037183 [Isotype], UC 116451 [Isotype]); *Provance 9542* (UCR 140927); *Rea 1268* (SD 175077); *Rebman 9664* (SD 153963); *Sanders 9439* (ARIZ 314981, RSA 626057, TEX 173161, TEX 173162, UCR 82625, 84345); *Sperry 255* (US 1684297 [plant at right]); *Vandevender 1063* (ASU 208349); *Vandevender 1381* (ARIZ 315137, TEX 175163); *Vandevender 659* (ARIZ 280125); *Vandevender 717* (UCR 57656); *Vandevender 951* (ARIZ 314982, TEX 173164, UCR 84289); *Wiggins 316* (ARIZ 161409, DS 295747, LL 173168, RSA 478632, UC 721843, 1635323, 1892870).

***Chenopodium parryi*:** *Ball 5508* (US 1794626); *Palmer 1151* (US 43865); *Palmer 310* (US 397864); *Parry 780* (GH, K 134 [Isotype], P 4992042 [Isotype], US 48299=00102562 [Holotype]); *Pinkava 5809* (ASU 66521); *Schmee s.n.* (P 4970774); *Seaton 184* (GH 257654, US 43863).

***Chenopodium sonorensis*:** *Felger 1063* (ARIZ 264084, SD 125074, TEX 173165); *Landrum 10923* (ASU 250600); *Landrum 11420* (ASU 258233); *Makings 3495* (ARIZ 278710, MO 6295840); *Shallert 1868* (BRIT); *Wiggins 6045* (DS 228536, US 1635323).

Appendix 2

Dichotomous key for the species of the *Chenopodium neomexicanum* complex.

1. Fruit small, ~ 0.8 mm or less in diameter
 2. Leaf-blades broadly rhombic-ovate, 1.5–2.5 cm long; fruit lenticular; pericarp smooth, mostly black
..... *C. palmeri*
 - 2'. Leaf-blades small, triangular, 0.5 cm. long or less, fruit globose; pericarp finely papillate, whitish
or light brown. *C. parryi*
- 1'. Fruit 1 mm or more in diameter
 3. Fruit ~ 1 mm in diameter, margin thick in side view (~ 0.15–0.2 mm)
 4. Leaf-blades triangular-ovate with distinguishable central and lateral lobes
 5. Leaf blades triangular to rhombic-ovate, central lobe long; lobes simple, obtuse; pericarp
of collapsed papillae above *C. arizonicum*
 - 5'. Leaf blades triangular, central lobe short; lobes mostly double, squarish; pericarp of
mostly inflated papillae above *C. sonorensis*
 - 4'. Leaf blades flabelliform, with central and basal lobes barely distinguishable . . . *C. flabellifolium*
 - 3'. Fruit 1.2–1.6 mm in diameter, margin thin in side view (~ 0.1 mm)
 6. Plants strict or sparsely branched from base, branches strongly ascending; leaf blades
campanulate; fruit margin narrow in top view, pericarp broadly pitted, grayish
..... *C. neomexicanum*
 - 6'. Plants heavily branched from above base, branches spreading, ascending; leaf
blades deltoid to rhombic-ovate; fruit margin wide in top view; pericarp papillate,
mottled brown. *C. lenticulare*