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THE TAXONOMY OF *CHENOPODIUM HIANS, C. INCOGNITUM,* AND TEN NEW TAXA WITHIN THE NARROW-LEAVED *CHENOPODIUM* GROUP IN WESTERN NORTH AMERICA, WITH SPECIAL ATTENTION TO CALIFORNIA

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ABSTRACT

In our search to document the fruits of *Chenopodium* L. taxa in North America to assist identifications, and after demonstrating fruits to be stable and diagnostic, we here focus on the some of the "narrow-leaved" group taxa prevalent in the western part of the continent. For this study, we sampled and classified, employing fruit characters as the leading criteria for categorization, more than 500 herbarium collections of *Chenopodium* of western North America, with a special focus on California. We concentrated only on taxa with fruits with adherent pericarp and lanceolate to lance-ovate, entire, un-lobed, or basally lobed leaves. Here, we recommend the recognition anew of *C. incognitum* Wahl as a separate species from *C. hians* Standley and 10 new species of *Chenopodium* in California and nearby states of western North America. The recognition of these taxa contributes to an ongoing study of the taxonomy of native *Chenopodium* in California, where an in-depth local taxonomic treatment of the genus has never before been presented. Our classification is supported both by biogeographical distribution and morphological characters. Taxonomic keys are provided.

Key Words: California, Chenopodiaceae, *Chenopodium*, fruits, North America, taxonomy.

Comprehensive phylogenetic analyses (Fuentes-Bazán et al. 2012a, b) have provided a revised classification of *Chenopodium* L. *s.l.,* recognizing six independent lineages: *Chenopodium s.s.,* the largest and most diverse clade, *Blitum* L., *Chenopodiastrum* S. Fuentes, Uotila, & Borsch*, Dysphania* R.Br., *Lipandra* Moq., and *Oxybasis* Kar. & Kir. These molecular studies are congruent with morphological features as well. However, *Chenopodium s.s.* includes many incompletely defined and poorly known taxa, reaffirming its reputation as a difficult genus and more recently again, as a very challenging group to resolve taxonomically (Sukhorukov *et al*. 2018).

The notorious difficulty in distinguishing *Chenopodium* using vegetative characters stems both from the early dehiscence of the plant's primary leaves, which are often shed prior to fruiting and absent in many collections, and from a plant architecture that varies considerably with environmental factors. These two issues are further complicated by the high plasticity of the leaves, to the point that different taxa often appear vegetatively similar with few other characters that can aid in identification. Therefore, the assessment of observable differences in vegetative characters has remained a highly subjective activity. In addition, many *Chenopodium* species are also of intermittent or episodic appearance (Jellen et al. 2011, Benet-Pierce, personal observations), fairly rare, and poorly known. It is still inconclusive if species of *Chenopodium* are highly dependent on colonizing disturbed habitat only and disappear after more established plant species have gained a permanent foothold, or if they also occupy a specialized ecological niche in a climax community (Ladyman 2006).

All these difficulties have not made *Chenopodium* particularly popular among botanists; thus, comprehensive treatments of *Chenopodium* in North America have been few. Standley (1916, 1917) produced probably the most extensive and thorough of the early *Chenopodium* treatments. Standley (1917) described many new species of the genus from Arizona, New Mexico, and Nevada, but he then admitted:

> "It is unfortunately true that the North American species are still poorly understood, and that a wholly satisfactory arrangement of them is apparently not to be secured at present"
>
> (pp. 413).

This outlook was further supported in Aellen's (1929) seminal *Chenopodium* study, which he entitled only a "Contribution. . ." and by Aellen and Just (1943), who indicated its incomplete nature in stating:

> "Obviously many American records will have to be added in the future."
>
> (pp. 47).

Similarly, Wahl (1954) called his major study solely "A Preliminary study of the Genus *Chenopodium* in North America" and he mostly focused on eastern North American species. While Wahl did add two new species, *Chenopodium incognitum* Wahl and *C. foggii* Wahl, to his taxonomic treatment and did collect in California, there was scant additional examination of *Chenopodium* in the state. In addi-

tion, most of Standley's (1916, 1917) species were never confirmed as occurring in California.

The next, and most recent comprehensive treatment of *Chenopodium,* is that in the Flora of North America (Clemants and Mosyakin 2003). This treatment brought new clarity to the genus. However, without presenting new criteria for their evaluation, many taxa were placed in synonymy (e.g., *C. incognitum* see below), and the descriptions of most recognized entities were left still too vague to permit precise identifications.

Except for our very recent studies (Benet-Pierce and Simpson 2010, 2014, 2017), no other native North American *Chenopodium* species had been described in the last 50 yrs, even with an enormous number of collections. Instead of additions, some taxa that had previously been described and named, fell into synonymy, such as *Chenopodium incognitum,* which has generally been viewed as a synonym of *C. hians* Standl. (e.g., Clemants and Mosyakin 2003). Many of the species in the *C. neomexicanum* Standl. complex, described by Standley and Aellen had also taxonomically disappeared, in part due to the difficulty that botanists had to tell the plants apart conclusively. We showed this was rectifiable with the use of fruits and seeds (Benet-Pierce and Simpson 2017).

Standley and Aellen were both well aware of the importance of fruit characters to aid on the discrimination and description of species, as they used fruit and seed traits in their descriptions. Wahl, in particular, insisted on the importance of fruit characters considering them "of primary significance in 'separating interbreeding populations'. This is evident because of the relative distinctiveness between the fruits of individual species and because other characters are correlated with these fruit differences . . ." (Wahl 1954)

(p.3).

Historically though, very few traits of fruits and seeds of *Chenopodium* had been known or described in the earlier treatments or by the botanists that followed. The intensive sampling of fruits and seeds in our ongoing study of *Chenopodium* taxonomy has shown us that there are a great number of characters with sufficient diagnostic features to be able to characterize taxonomic entities in the genus. These characters have the necessary stability and diagnostic power that *by themselves* can sufficiently assist or even permit the identification of taxa. This has been an unexpected and extraordinary discovery, the equivalent of the lucky find of a Rosetta Stone for this difficult genus, in which the vegetative characters are so challenging to assess. This new perspective has great potential for improving *Chenopodium* taxonomy and it is not surprising new species in California are only now being brought to light.

Improving the taxonomy of *Chenopodium* will provide a more accurate categorization of range of biodiversity, which will aid in the efforts of other scientists (e.g., those working on the DNA sequencing of *C. berlandieri* Moq). This widely distributed taxon, reportedly twice domesticated in the North American continent and part of native eastern North American crop complex, is considered a critical potential genetic resource for adaptive improvement the South American crop quinoa (*Chenopodium quinoa* Willd.), which has worldwide importance (Jarvis et al. 2017; Brenner et al. 2019).

With our ongoing goal of clarifying the taxonomy of *Chenopodium* of the western North America, where so many species occur, we here focus on employing fruit characters, in addition to vegetative features, on a group treated before under the designation "narrow-leaved". This term was applied to four to seven species by workers in the complex (Crawford and Reynolds 1974; Crawford 1975; Crawford and Julian 1976; Crawford and Wilson 1979; La Duke and Crawford 1979) referring to taxa with marginally entire, unlobed or basally lobed, lanceolate or lance-ovate leaves. We have used fruits as the primary classification tool, as they provide the best characters for recognizing independent taxonomic entities. Once diagnosed, these entities can be correlated with vegetative features and biogeographic ranges. These morphological studies are a necessary preamble to future molecular and phylogeographic studies in the complex.

Of the species generally included in this narrow-leaved group, we concentrate here only on the species with an adherent pericarp, which have been identified in California and most western states as *Chenopodium hians* Standley*, C. incognitum* Wahl (if recognized), or often as *C. atrovirens* Rydberg plants with adherent pericarp. The pericarp, when adherent, is highly informative, yielding a number of diagnostic features; thus, it is beneficial to begin by segregating these taxa. Of the other species traditionally included in this group, *Chenopodium inamoenum* Standley (considered by some to be synonymous with *C. leptophyllum* (Moq.) Nutt. ex. S.Watson and very occasionally with *C. hians*) has linear leaf blades and much smaller sized fruits. Thus, we have provisionally grouped *C. inamoenum* into to what we now call the *C. leptophyllum* aggregate, a loose assemblage of entities with free or adherent pericarp, fruits smaller than 7 mm and linear leaf blades, to be studied at a later date. *Chenopodium atrovirens* Rydberg (occasionally identified as *C. hians*) and *C. pratericola* Rydberg, both with more ovate but entire and basally lobed leaves, do not have an adherent pericarp; these taxa will also be the focus of study at a later date, when taxa with non-adherent pericarp will be treated. *Chenopodium pratericola* Rydb. is here defined under an aggregate classification as well, as we are seeing that it has been used as an umbrella category for more that one taxon. The remaining species with a non-adherent pericarp, *Chenopodium desiccatum* A. Nelson, has been treated already (Benet-Pierce and Simpson 2014). The study for this paper excludes all taxa with toothed leaves, among these *Chenopodium album* L. and *C. strictum* Roth,

which have been rather loosely classified in North America and are in need of extensive taxonomic work. Using fruit characteristics may prove highly advantageous to improve the taxonomy of these widespread taxa as well.

Methods

Fruits were examined of more than 550 *Chenopodium* herbarium collections from western North America (with emphasis on California) of members of the "narrow-leaved" complex, but with an adherent pericarp. These comprised specimens identified as *Chenopodium hians, C. incognitum*, or *C. atrovirens* with an adherent pericarp (noting that some previous workers considered pericarp adherence to be variable in the latter species). Specimens were obtained from herbaria at ALA, ARIZ, ASC, ASU, BABY, BM, BRIT, BRY, CAS/DS, CDA, CHSC, COLO, DAV, DES, G, GH, ID, JEPS, K, MO, MONT, MONTU, NMC, NY, OBI, ORE, OSU, P, PAC, RENO, RM, RSA/POM, SBBG, SD, SDSU, TEX, UBC, UC, UCR, UNM, UNLV, US, UTEP and WTU (Thiers 2019). Around 280 specimens were from the western United States, but outside California, and a larger number (around 300) from California alone. We also widely collected across eastern California, where all of these species occur (see Figs. 1–6, below). Photographs were taken of all herbarium specimens examined; high-resolution scans were made of some specimens on loan to the San Diego State University Herbarium (SDSU).

Fruits were removed and placed on double-stick tape affixed to a labeled microscope slide, all housed at SDSU. Fruits were studied under a high-powered (40x) dissecting microscope and qualitatively evaluated for differences in size, shape, color, and sculpturing pattern. As the study progressed, groupings were made of specimens with highly similar fruit morphology. This was done only after many specimens were comparatively examined in order to establish stable and continuously occurring differences and similarities in pattern and form, while considering natural variability as well. In addition, fruits from the type specimens of *Chenopodium hians* and *C. incognitum* (see below) were similarly examined for comparison with those from other specimens. The fruits of examined specimens were subsequently classified as belonging to either of the aforementioned taxa or as being unique and representing a new taxon.

After the classification by fruit morphology was well established, vegetative characterizations of specimens were made for all designated taxa. These included evaluation of stems, including stem diameter, height and branching pattern, and of leaves, both primary leaves (those arising basally mostly from the primary axis, but often missing in a specimens) and secondary leaves (those arising from more apical, secondary branches) when present. Similarities were noted among vegetative features of a given taxon and descriptions were made. We emphasize that our classification is based above all on fruit differences, as they have proven to be robust in segregating taxa adequately. Extreme caution was made to describe only what we believe to be well-supported entities.

From the establishment of these taxonomic entities, we proposed to designate ten of these as species new to science. For all taxa, the fruits were photographed in top, bottom, and side views using a Visionary Digital BK Plus Lab System high-resolution photomicroscope (Dun, Inc. Palmyra, VA). Type specimens were selected and imaged for the ten new taxa (Figs. 1–3). Formal names and descriptions are presented below in the Results section. A website has been developed for *Chenopodium* in North America which now incorporates the narrow-leaved species included in this paper. This website provides images of numerous additional specimens and fruits for examination of features within taxa (Benet-Pierce 2014 onwards; https://plants.sdsu.edu/chenopodium).

Results and Discussion

The fruits from the type specimens of the described taxa within the narrow-leaved and adherent pericarp group, *C. hians* and *C. incognitum,* were unfortunately not in very good condition. The examination of many specimens was necessary before their fruit features could be fully characterized and employed for classification. As mentioned earlier, *C. incognitum* has been considered a synonym of *C. hians* in recent treatments. However, we have determined that these two species are well differentiated, both in their fruits and vegetative characters. After studying hundreds of collections, we here document the diagnostic fruit for each taxon, their vegetative features, and their geographical distribution. We have also posted numerous specimen images online, so that their vegetative and fruit characteristics can be easily appreciated (Benet-Pierce 2014 onwards; http://www.sci.sdsu.edu/plants/chenopodium/index.html). We note that only two years after having been able to fully delimit *Chenopodium incognitum* from *C. hians*, we found the first fruit with an almost completely intact pericarp of the former in the packet of a duplicate collection saved by Paul Aellen at (G), many years before Wahl had designated a simultaneous collection as the type for that species. We had found no intact fruits earlier at the National Herbarium (US). In addition to its different fruit morphology, and vegetative aspect, *C. incognitum* appears to have a different and much wider geographic range than *C. hians* (see species descriptions below). Both species are well illustrated on our website.

With the firm diagnosis of these two described taxa, it became evidently clear that most of the California specimens that had been previously identified as *C. hians*, *C. incognitum,* or *C. atrovirens*

FIG. 1. A. Type specimen; B. Fruit images, with top of fruit image at left, bottom below and side view with bottom below at right; C. Map of geographical distribution for each taxa. Top row: Designated Type of *Chenopodium aureum* CAS 342155 Howell 24151 duplicates at CAS, G & RSA herbaria. Fruit images from SDSU 22226, Benet- Pierce & J. P. Pierce 665 & side view SDSU 22230 Benet-Pierce & J. P. Pierce 669. Map: CA, ID & NV. Center row: Designated Type *C. brandegeeae* SDSU 19747, Benet-Pierce & J.P. Pierce 336. Fruit images SDSU 19726, N.B. Pierce & J.P. Pierce 319. Map: CA: San Diego County, CA. Bottom row: Designated Type *C. eastwoodiae* John H. Thomas 9772, DS 577435. Fruit images SDSU 22005 Benet- Pierce & J. P. Pierce 403 El Dorado Co. CA. Map: CA: El Dorado, Mono and Tulare counties.

FIG. 2. A. Type specimen; B. Fruit images, with top of fruit image at left, bottom below and side view with bottom below at right; C. Map of geographical distribution for each taxa. Top row: Type specimen of *C. hians* Standley, US 687056 P. C. Standley 8129. Fruit images GH Porter & Porter 9491 Albany Co, WY with many duplicate specimens. Map: US: AZ, CO, MT, NM, NV, UT, WY and in British Columbia and the Yukon Territory in Canada. Center row: Designated Type *C. howellii,* CAS 217242 John Thomas Howell 11900 Lassen Co. CA. Fruit images WTU 20545 Morton E. Peck 15489 (DS 171540!) Lakeview Co. OR. Map: CA: Alpine, El Dorado, Lassen, Modoc, Mono, Plumas, Siskiyou and Tulare counties. NV: Washoe & Carson City. OR: Lakeview County. Bottom row: Type specimen of *C. incognitum* Wahl, US 689661 Standley & Bollman 11012, Rio Arriba Co. NM. Fruit images G 20594 Dup. coll. of Standley & Bollman 11014, Rio Arriba Co., NM. Map: US: AZ, CA, CO, ID, MT, NM, NV, OR, UT WA and WY in British Columbia, CAN.

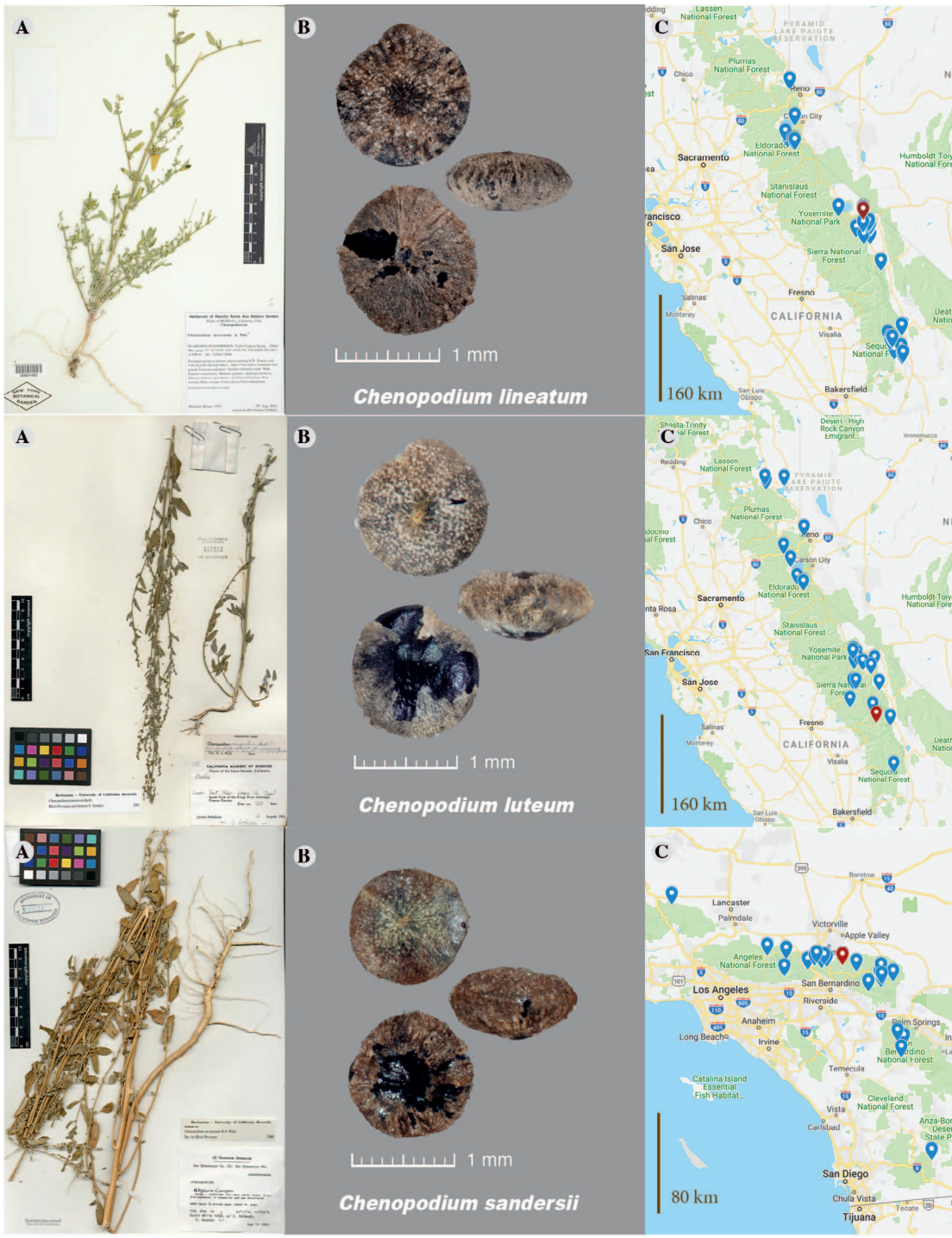

FIG. 3. A. Type specimen; B. Fruit images, with top of fruit image at left, bottom below and side view with bottom below at right; C. Map of geographical distribution for each taxa. Top row: Designated Type for *C. lineatum* NY 801483 M. Honer 1476 Mono Co (RSA-POM 680706!) CA. Fruit images: RENO 24425 M. Williams 72-71-1, Washoe Co. NV (CAS 637629!) Side view: Benet- Pierce & J. P. Pierce # 358 (SDSU 21937!) Map CA: Alpine, El Dorado, Inyo, Mono, and Tulare counties. Center row: Designated type for *C. luteum,* CAS 457912 Javier Peñalosa 2121, Fresno Co. CA. Fruit images SDSU 21993 Benet-Pierce & J. P. Pierce 391, 2011, El Dorado Co. CA Map: CA: El Dorado, Fresno, Inyo, Lassen, Mono, and Tulare counties. Bottom row: Designated Type *C. sandersii* UCR 100144 Scott White 1852 & C. McGaugh & K. Beanan, San Bernardino Co. CA. Fruit images: RSA 628598 A.C. Sanders 14964, San Bernardino CA (UCR 83371!) Map: CA: LA, Riverside, San Bernardino and San Diego counties.

FIG. 4. A. Type specimen; B. Fruit images, with top of fruit image at left, bottom below and side view with bottom below at right; C. Map of geographical distribution for each taxa. Top row: Designated Type of *C. simpsonii* UCR 132956 A. Sanders 14159, San Bernardino, CA. Fruit images: SD 257942 S. M. Leininger 274, San Diego Co. CA. Map: CA: Los Angeles, Riverside, San Bernardino and San Diego counties. Center row: Designated Type for *C. twisselmannii* PAC 81227, grown from fruits CAS 637604 Howell & True, 43934; duplicate PAC 82867, Tulare Co. CA. Fruit images CAS 390819 coll. P.H. Raven7914, Fresno Co. CA. Map: CA: High altitude meadows in Fresno, Inyo, Kern and Tulare counties. Bottom row: Designated Type for *C. wahlii* CAS 438720 Peter H. Raven 16726 dups. GH, RSA, SD and UC, San Bernardino Co. CA. Fruit images Coll. J. Hirshberg 2527, SD 235121, and 2526, SD 235120, San Diego Co CA. Map: CA LA, Riverside, San Bernardino, San Diego, and Tulare counties.

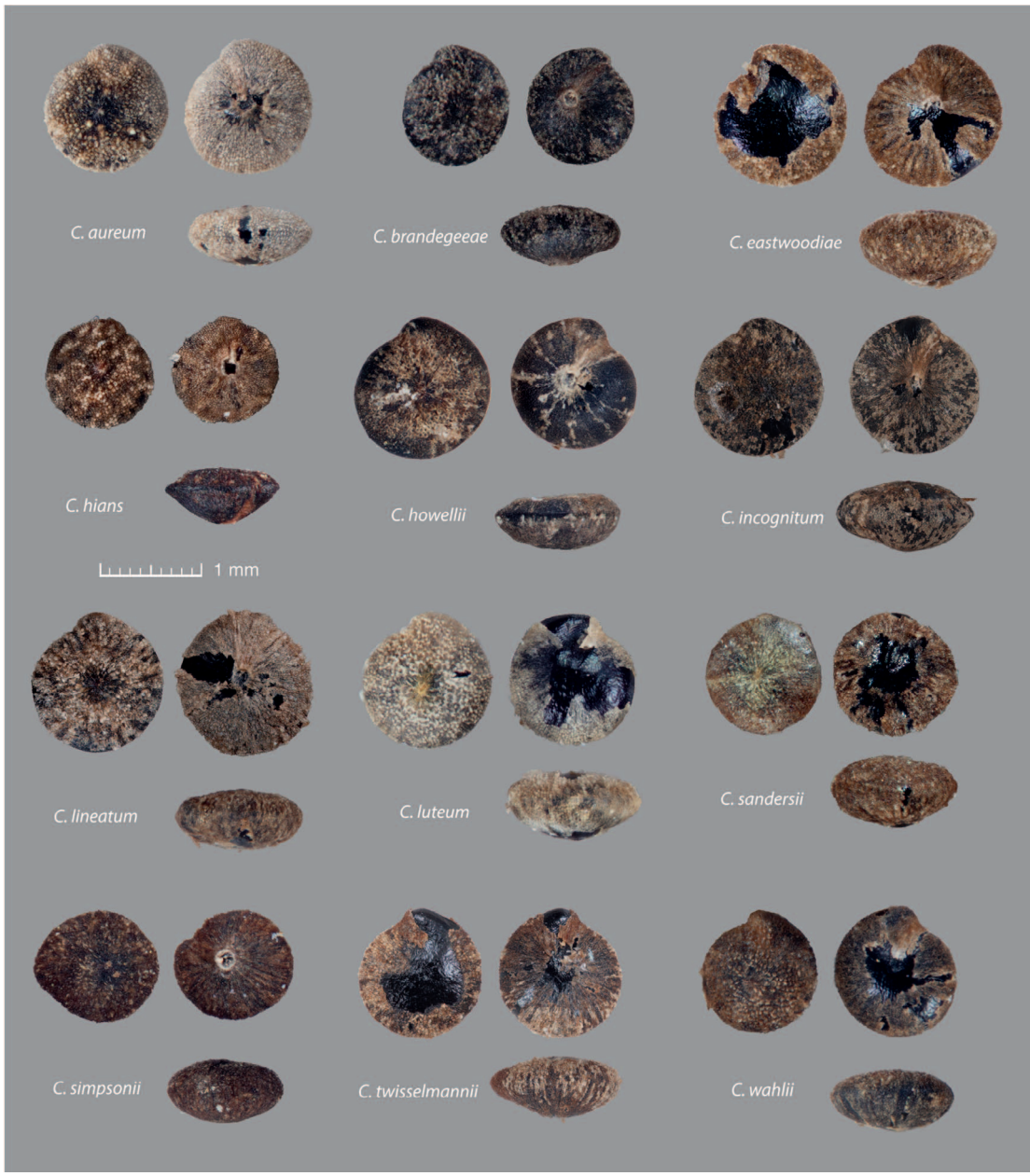

FIG. 5. Fruit images for all the taxa treated in this paper. For each taxon: top of fruit at upper left, bottom at upper right and side view with the top facing upward, below at right.

with adherent pericarp did not fit our diagnoses for those taxa. This is not surprising, given that new species continue to be described for California and given the taxonomic neglect that *Chenopodium* has suffered. Thus, in addition to recovering *C. incognitum* as a species separate from *C. hians,* we recognize here an additional 10 new species of the genus in California and geographically close western states. The absence of detection of these new taxa in the past can partially explain the high rate of misidentifications of *Chenopodium* specimens in California and the generally misleading sense of much higher intraspecific variation in the genus. Ertter (2000), in her article *Floristic surprises in North America North of Mexico*, argues convincingly that new plant discoveries are still rather common place in the continent and specifically that the exploration and discovery of plants in California is still in ongoing. This seems particularly true for the genus *Chenopodium*, often neglected and underappreciated, and

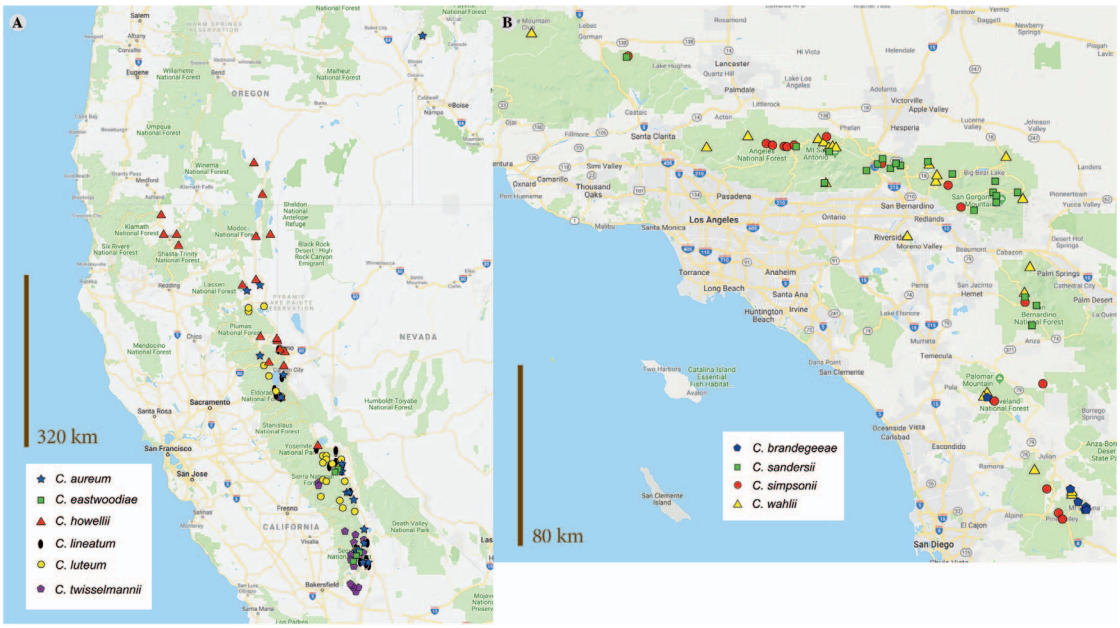

FIG. 6. Geographical distribution maps for all new taxa in this paper. A. Geographical distribution of taxa occurring in northern and eastern CA, ID, NV and OR. B. Geographical distribution of taxa present in southern California.

generally viewed as weeds with the potential for being highly invasive.

As discussed earlier, *Chenopodium* fruits vary in size (diameter), outline shape in face view (oval to round), level of compression as seen in side view (from lenticular to oblate to conical), three-dimensional shape of both the basal face (adjacent to the attachment of the hilum) and upper face (apical or stylar, frequently evident as the sepals open), sculpturing and degree of shine of the seed coat, presence, shape, and thickness of a marked equatorial margin, and characteristics of the pericarp, fundamentally its adherence to the seed, but also its color, pattern, shine, and sculpturing (texture). (Note that the apical pistillate flower of many *Chenopodium* species is larger than lateral fruits. We have occasionally used these apical fruits, when the lateral fruits were unavailable, but did not consider their size.) As this paper deals exclusively with species with an adherent pericarp, its features are of paramount importance. The pericarp is quite diverse, and its characteristics add to other features, especially fruit size, shape, and equatorial margin, offering considerable assistance in identification.

The pericarp is membranous and before maturation most pericarp characters are obscure. Even with the benefit of a vast number of collections, the intact mature fruits of some species were difficult to obtain. Often we worked with less than optimal fruit material, particularly in historical collections. However, taken as a whole, herbarium collections yielded an incredible wealth of material that made possible evaluation of the characteristics and natural variability of both the plants and the fruits, and of their appearance under different circumstances of maturity, integrity, and decay. As mentioned above, this was particularly important, as the fruit of type specimens of previously described species was generally poor and often partially destroyed (see Benet-Pierce 2014 onwards for images of these). For the species in California, we mostly found intact fruits in relatively new collections. Although fruit character differences may be subtle, once established, they have led us to what we now consider to be different taxonomic entities. Our classifications appear to be well corroborated by both vegetative characters and biogeographical distribution.

Our new taxa descriptions are based on the available specimens to date for a given group. Due to the difficulties of collecting *Chenopodium*, these descriptions may certainly be improved in the future. However, the study of historical specimens of *Chenopodium,* more than five thousand *Chenopodium* specimens across taxa country wide, and over 400 from western North America, including California for this study alone, also has contributed significantly to our understanding of the group, and in our opinion, to the specimens' actualization and increased usefulness as well.

Caution must be exercised when dealing with any of the characters employed here, in that there are always fruits and seeds in every plant that are unviable or deformed. Exceptions based on fruits being defective, have to be allowed as well. For example, some fruits may have lost the pericarp in a species with a normally adherent pericarp. Or, occasionally the pericarp is mostly white and very difficult to differentiate. Or, fruits are rarely oblate

when they are typically conical and vice versa. Or, fruits may often become flatter with age. Too early or very late collections present a problem, as fruits may be immature or decay with age. However, *Chenopodium* is a heavy seeder, which has been advantageous in both old and fresh collections.

We did not consider using scanning electron (SEM) microscopy for our work, as we found sufficient characters that we could easily see with a stereomicroscope and chose to employ the largest number of samples possible to be able to draw firmer conclusions about the vegetative characters, something impractical for SEM. In fact, the elucidation and characterization of color patterns, impossible with SEM, has given us even more characters. We believe that our methods have provided a more reliable path to species identification. SEM may become useful later to confirm or reject affiliations, just as molecular work will be needed to assess phylogenetic relationships.

Previously Described Taxa

Chenopodium hians Standley, N. Amer. Fl. 21(1): 16. 1916. (Fig. 2, top row).—TYPE: USA, New Mexico, Rio Arriba Co., Jicarilla Apache Reservation, near Dulce; elevation 2150 to 2470 m, *Paul C. Standley 8129* (Holotype US 687056!).

P.C. Standley segregated *C. hians* from *C. leptophyllum* due to its foul odor and described it in 1916. We have examined the three specimens Holotype US 687056, US 689474 and US 393385 mentioned by him (Standley 1917), and they all correspond to *C. hians*. This species has never been in doubt, Aellen having added more collections, most of them corroborated by us, with confirmed occurrences in AZ, CO, MT, NM, NV, UT, WY in the U.S. and in British Columbia and the Yukon Territory in Canada (see map in Fig. 2). *Chenopodium hians* plants are seldom branched, 2–3 (up to 4) dm tall. Leaves are unlobed, to 2.5 cm long x ca. 0.5 cm wide. The fruit is small, conical below, with a highly patterned pericarp of minute brown and white papillae. Very rarely, the pericarp is very dark brown, and smooth with a flatter fruit, but with the same patterned pericarp (US 689474, *Standley & Bollman 10764*). We have confirmed that these two fruit types occur on the same plants, but very seldom (see Benet-Pierce 2014 onwards for images).

Wahl recognized another entity that he found different enough from *C. hians,* occurring in the West, *C. incognitum* (below), while acknowledging that the plants in California of *C. hians* "may consist of more than one recognizable taxon" Wahl (1954, pp. 21) and recommended further study Wahl (1954, pp. 22). Our study confirms this, and many sheets annotated by Wahl as deserving separate recognition, are now being reclassified.

Chenopodium incognitum Wahl (Fig. 2, bottom row).—TYPE: New Mexico, Rio Arriba Co., Pine Woods Vicinity of Brazos Canyon, *P.C. Standley P.C. & Bollman 11012*, Holotype US 689661! Isotype: G 20594! Duplicate collection *Standley & Bollman 11014* (G Standley & Bollman! US 689663!).

Herbert A. Wahl (1954) described *C. incognitum* as large plants "3–12 dm tall, branched from base; lf blade ovate to deltoid-ovate 1.5 to 3.5 cm long, unlobed or with basal lobes, pericarp attached to seed and margin rounded." He chose his type from one of Aellen designated specimens of *Chenopodium standleyanum* Aellen, identified as such when he believed it was also present in the West and to which it resembles. *Chenopodium standleyanum,* however, has a non-adherent pericarp and does not occur in the West. Wahl ascribed many paratypes for *C. incognitum*, and he listed it as occurring in CA, CO, NM, OR, UT, and WY.

Wahl's description, albeit appropriate, is very brief. Over the years, the identity of *C. incognitum* was in doubt and the name taxonomically disappeared, remaining as synonymous with *C. hians*. The emphasis on unwarranted synonymy has been a common, but disastrous problem for *Chenopodium* taxonomy. Well-delimited taxa have been disregarded when many botanists were unable to distinguish them adequately. We hope to remedy this somewhat by posting many images of every taxon in our website, so researchers can be made well aware of them.

We here confirm the identity of *C. incognitum* Wahl, as different from *C. hians* Standley with plants branched from base, leaves broadly elliptic or trullate, and we document a much broader distribution, having confirmed a great number of Wahl's records and in addition many more in AZ, ID, MT, NV, WA in the U.S. and to British Columbia in Canada. We believe that *C. incognitum,* with such an extensive distribution, should be fully recognized; it may eventually be found to comprise some local varieties. Its fruits are large (~1.4 mm), oblate and have a pronounced equatorial margin. The pericarp is initially dark with yellow/ gold spots, but ages into a dark brown-dark red or brown with yellow cream spots or lines. Many images of both plants and fruits, may be seen in our website (Benet-Pierce 2014 onwards) and many more records are very likely to be found in many herbaria.

New Taxa

The paucity and incomplete nature of the taxonomic treatments of *Chenopodium* in North America have particularly affected California, as no separate examination of taxa or monographic treatment exists for such a large and rich area for this important genus, other than a very general and brief listing of some described species. Traditionally, the main obstacle to more aptly classifying *Chenopodium* has been the fundamental difficulty in conclusively verifying variability within taxa. The diagnostic power of fruit and seed morphology has added a whole new dimension for doing so. The classification

of the fruits with adherent pericarp most associated with *C. hians, C. incognitum,* or *C. atrovirens*, sampled from plants of California and from adjoining areas has yielded a number of new species, and now these entities can be segregated and treated.

We describe below these new taxa and their geographic ranges, noting that in the Golden State *Chenopodium* has played us something like a practical joke. Just as brown colors seem to predominate in the pericarp in the *C. neomexicanum* complex (Benet-Pierce and Simpson 2017), with this trend continuing with *C. hians*, the fruits and seeds of the new California taxa show, in addition to brown, mostly gold and yellow tones. We have placed a great number of images of specimens and fruits in our website (Benet-Pierce 2014 onwards) to illustrate the characters, including pericarp colors, of these species. The following proposed taxa all have very different fruits (Fig. 5). In some cases there is some geographical range overlap (Fig. 6), but their vegetative aspect is also quite distinct. Dichotomous keys to these taxa and the rest of *Chenopodium* in California appear in Appendices 1 and 2, below.

Chenopodium aureum Benet-Pierce, sp. nov. (Fig.1, top row).—TYPE: USA, California, Inyo Co., Big Pines Lake Trail, 8600–9000 ft (2600–2750 m), *John Thomas Howell 24151*, 16 August 1947 (Holotype CAS 342155! Isotypes: G 24151!, RSA 44538!).

Representative paratypes. USA, California, Inyo Co., desert slopes near Big Pine Creek at foot of trail to Big Pine Lakes, elevation 8500 ft (2590 m), *Roxana S. Ferris 8976* (DS 229804! NY 3337062!). Inyo Co., south side of Wonoga Peak, elevation 9000–9500 ft (2743–2995 m). *John Thomas Howell 26287* (CAS 356884!). Lassen Co., east of Highway 139, southeast of Eagle Lake. Small, seasonally moist rocky clay flat with burned pine and juniper, elevation 5680 ft. (1731 m.) *B. Corbin 1114*, 2 Oct 2002 (NY 652205! right specimen only). Lassen Co., Horse Lake, *Ynez Whilton Winblad s.n.* (CAS 226930!). IDAHO: Washington Co., sagebrush grass zone at border of Douglas fir and ponderosa pine, Brownlee Ranger Station, elevation 4350 ft (1326 m), *E. B. Caswell 82* (ID 24601!).

Description. Erect weak reddish annual, usually 4–5 dm high, sparsely branched from base. Leaf blades trullate and basally lobed ca. 2 cm long by .5 cm wide, base cuneate and apex acute. Upper leaves elliptic to lanceolate, ca. 1.3 cm long x 0.4 (–0.3) cm wide, entire and slightly farinose. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 30 cm long, with sessile flowers ca.1 mm in diameter. Fruits round, lenticular in side view, ca. 1.2 mm in diameter x 0.5 mm thick, acute equatorial margin with pericarp adherent of very tiny papillae golden-beige with some large whitish spots, very shiny.

English diagnosis. *Chenopodium aureum* differs from *C. luteum* in that the latter is a more robust plant with longer secondary leaves and larger, oblate fruits, with yellow pericarp and larger papillae overall (~30 micrometers), not the very minute papillae (~15 micrometers) and shiny golden-beige pericarp of *C. aureum*.

Distribution and habitat. *Chenopodium aureum* occurs as scattered populations in sagebrush country. California: Inyo, Lassen, Mono, Sierra, and Tulare counties. Nevada: Carson City. Idaho: Washington Co.

Phenology. *Chenopodium aureum* appears to flower in July, and is in fruit from August to September.

Etymology. The epithet "*aureum*" is Latin for gold or gleaming. The pericarp of this taxon appears golden and particularly shiny, this golden shine accounting for the epithet name.

Suggested common name. Golden goosefoot

Chenopodium brandegeeae Benet-Pierce, sp. nov. (Fig. 1, center row).—TYPE: USA, California: San Diego Co., Palomar Mountain Campground, Palomar Mountain State Park, off Hwy 76, *Benet-Pierce 336* with J. P. Pierce, 15 October 2010, elevation 5196 ft. (1584 m); (Holotype SDSU 19747!).

Representative paratypes. USA, California: San Diego Co., Laguna Mountains, disturbed area in Burnt Rancheria Campground, *Bell 360*, elevation 6000 ft (1830 m); (SD 144539! & UCR 138368!). San Diego Co., disturbed road edge, Cleveland National Forest, Laguna Recreation Area, near Storm Canyon viewing platform, on east side of Hwy S-1, 0.25 mile north of El Prado campground; geology: granitic; *J. Hirshberg 1228,* (SD 208785!). San Diego Co., Palomar Mountain Campground, Palomar Mountain, elevation 5106 ft (1584 m), *Benet-Pierce 329* (SD 19738!). San Diego Co., Cleveland National Forest, Laguna Recreation Area, Desert View picnic area on Hwy S-1, 1/2 mile NE of Mount Laguna Post Office and store, disturbed vegetation, island in center of picnic area, elevation 5909 ft (1800 m), *J. Hirshberg 1229* (SD 208784!).

Description. Erect large annual, 3–10 dm high, sparsely branched. Leaf blades, elliptic or lanceovate, occ. lobed, ca. 4.5 cm long x ca. 1.6 cm wide. Upper leaves lanceolate, narrowly elliptic, 0.9–0.7 cm long, occ. falcate, base cuneate, apex obtuse or widely acute and slightly farinose. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 15 cm. long, with sessile flowers ca.1 mm in diameter. Fruits lenticular, ca. 1 mm in diameter x ca. 0.5 mm thick, margin acute; pericarp shiny brown or when mature randomly mottled brown and black, very shiny. Seed coat black.

English diagnosis. *Chenopodium brandegeeae* is similar to *C. hians* in being a thin upright plant, but differs in it being usually a taller plant with larger lobed leaves and lenticular fruits. The fruits, when mature, have a very shiny black and brown pericarp, and are not conical. It differs from *C. whalii* Benet-Pierce in that *Chenopodium brandegeeae* is usually thinner, taller, and a more upright plant with very distinct fruits having shiny pericarp, often reddish brown particularly when young, and papillate, black, and brown when mature.

Distribution and habitat. *Chenopodium brandegeeae* occurs as scattered populations in disturbed habitats and favors previously burnt areas in San Diego Co., CA.

Phenology. *Chenopodium brandegeeae* appears to flower late July, and is in fruit from late August to November.

Etymology. Named for Mary Katharine Brandegee (1844—1920), an American botanist known for her comprehensive studies of flora in California and curator of the CAS herbarium.

Suggested common name. Brandegee's goosefoot.

Chenopodium eastwoodiae Benet-Pierce, sp. nov. (Fig.1, bottom row). —TYPE: USA, California, Mono Co., gravelly road bank about 3.5 miles up Rd Creek from Tom's place, elevation 8000 ft (2438 m), common co-occuring species include *Pinus contorta* Douglas ex. Loudon ssp. *latifolia* (Engelm. S.Watson) A.E.Murray, *Artemisia tridentata* Nutt., *Cercocarpus ledifolius* Nutt., and *Populus tremuloides* Tidestr. *J. H. Thomas 9772*, 14 September 1961 (Holotype: DS 577435! CAS-BOT-BC 460965).

Representative paratypes. USA, California: El Dorado Co. Grass Lake 3rd pull out entrance, elevation 9840 ft (2997 m), *Benet-Pierce & J.P. Pierce* 403, 2011(SDSU 22005!). El Dorado Co., Grass Lake, 1st turn out, elevation 9833 ft. (2997 m), *Benet-Pierce & J. P. Pierce* 401 (SDSU 22003!). El Dorado Co., Grass Lake, 3rd pull out entrance, elevation 9833 ft. (2997 m), *Benet-Pierce & J. P. Pierce* 406 (SDSU 22008!). Tulare Co., stringer on the southwest side of Big Meadow, small, dense, roadside colony on loam and decomposed granite, elevation 8150 ft. (2484 m), Jeffrey pine forest, *Twisselmann 15985* (CAS 593848! 637682!).

Description. Erect large branched annual 8–12 dm high, bright green and reddish at maturity. Leaf blades broadly lance-ovate and basally lobed, ca. 3 cm long x 1.2 cm wide, base cuneate and apex narrowly obtuse, entire. Upper leaves elliptic to long narrowly elliptic leaves 3.5 x ca. 0.8 cm. Inflorescences terminal and axillary panicles of glomerate spikes ca. 45 cm. long, with sessile flowers ca.1 mm in diameter. Fruits very large, 1.4 mm in diameter x 0.8 mm thick, round, oblate, but slightly flatter above, margin round, pericarp adherent, thick lined, reddish brown to whitish gray or yellow gray color.

English diagnosis. *Chenopodium eastwoodiae* appears to be a rare plant, characterized by very large oblate fruits with a distinctively thick pericarp of raised papillate bands when mature. It differs from *C. lineatum* Benet-Pierce, which has a much smaller and rather flat fruit and one in which the pericarp color bands are present from the beginning and mostly colored and hardly raised. *Chenopodium eastwoodiae* is similar to *C. incognitum* in the large lobed primary leaves, but it differs in that the secondary leaves are longer and slender, and its fruits larger and with very different pericarp to *C. incognitum*.

Distribution & habitat. California: El Dorado, Mono, and Tulare counties.

Phenology. *Chenopodium eastwoodiae* appears to flower in July, and is in fruit from August to early September.

Etymology. Named in honor of Alice Eastwood (1859—1953), a prolific collector and researcher of the California Flora, curator of the CAS herbarium, and author of more than 310 scientific papers.

Suggested common name. Eastwood's goosefoot.

Chenopodium howellii Benet-Pierce, sp. nov. (Fig. 2, center row). —TYPE: USA, California, Lassen Co., 5 miles north of Horse Lake on road to Alturas, *J. T. Howell 11900*, 10 June 1934 (Holotype CAS 217242! Isotype DS 230139!).

Representative paratypes. USA, California: Lassen Co., burnt area near Hallelujah Junction, west of Hwy 395 and south of Hwy 70, elevation 4900 ft. (1493 m), *Williams 74-L-36* (CAS 637594! 637696! RENO 24591!). Nevada: Washoe Co, Rancho San Rafael, NW Reno, near Evans Creek, north of Mc Carran, dry hillside, *Williams 85-295-2 & A. Tiehm*. (RENO 24398! 68666!). Oregon: Lake Co., dry field, Lakeview, elevation 4802 ft. (1464 m), *M. E. Peck 15489* (DS 171540! WTU 20545!). Lake Co., Paisley, elevation 4369 ft. (1332 m.), *J. S. S. Elder 1915* (OSU 3596!).

Description. Erect to decumbent, smallish plant, branched from base, 3–4 dm tall. Branches all ending around the same height at maturity. Leaf blades narrowly elliptic, rarely lobed, few ca. 1.5 (2) cm long x $\leq$0.7 cm wide, base slightly cuneate to obtuse, apex narrowly round. Upper leaves narrowly elliptic, but slightly smaller, entire. Inflorescences narrow paniculate spikes, flowers ca. 1 mm in diameter. Fruits ca. 1.2 mm in diameter x ca. 0.6 mm thick, lenticular, but convex below, with equatorial margin round. Pericarp adherent, brown with diagnostic, protruding whitish to creamy spots.

English diagnosis. *Chenopodium howellii* is a smallish plant uniformly branched from base with a fairly northwestern distribution, unlike any other in this group. Further collections along the northern California border and adjacent states will help to establish those limits. Similar to *C. aureum* in that its secondary leaf blades are narrowly elliptic, it is a much more profusely branching plant, with most of its branches getting to approximately the same height. The pericarp is to a degree similar in color to *C. incognitum*, but *C. howellii* it is smaller more compact plant and of very different appearance to *C. incognitum*.

Distribution & habitat. California: Alpine, El Dorado, Lassen, Modoc, Mono, Plumas, Siskiyou, and Tulare counties. Nevada: Washoe & Carson City counties. Oregon: Lakeview Co.

Phenology. *Chenopodium howellii* appears to flower in late June, and is in fruit from August to early September.

Etymology. Named in honor of botanist and taxonomist John Thomas Howell (1903—1994), founder of the RSA herbarium, curator of CAS herbarium.

Suggested common name. Howell's goosefoot

Chenopodium lineatum Benet-Pierce, sp. nov. (Fig. 3, center row). —TYPE: USA, California, Mono Co., Glass Mountain Region, Taylor Canyon Spring, perennial spring in narrow canyon running S-N, pumice soil with rhyolite outcrops above, open *Pinus jeffreyi* woodland with grazed *Artemisia tridentata*/*Purshia tridentata* scrub, with *Populus tremuloides, Mimulus guttatus* DC., *Aquilegia formosa* Fisch. ex. DC., and others, occasional on road edges by stream, elevation 7400 ft. (2256 m), *M. Honer 1476*, 25 August 2001 (Holotype: NY 801483! Isotype: RSA 680706!).

Representative paratypes. California: Alpine Co., Hope Valley Wilderness Reserve, elevation 7300 ft. (2225 m.), *Benet-Pierce 400* with J.P. Pierce (SDSU 22002!). El Dorado Co., Echo summit on road to Placerville, elevation 7382ft (2250m), *John Thomas Howell 15297* (CAS 271772!). Inyo Co., Pinyon belt, Sage Flat to Olancha Pass, elevation 7000 ft. (2134 m), *John Thomas Howell 26662* (CAS 361702!). Inyo Co., Pinyon belt, Sage Flat to Olancha Pass, elevation 7000 ft. (2134 m), *John Thomas Howell 26663* (CAS 361926! left plant only). Mono Co., north shore of Convict Lake between northeastern and western ends of the lake, elevation 7600 ft. (2316 m), *G. D. Barbe 3435*, with J.T. Howell & T.C. Fuller (CDA 0014803!).

Description. Erect small to medium size sparse plant, gray green, branched, 5–7 dm high. Leaf blades lanceolate, few lobed, ca. 2 cm long x $\leq$0.9 cm wide, base cuneate, apex obtuse or acute, entire. Secondary leaf blades elliptic or narrowly elliptic, ca. 1–3 cm long x 0.4–1.6 cm wide, apex acute, base cuneate. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 25 cm long, flowers sessile, ca. 1 mm in diameter. Fruits ca. 1.2 mm in diameter x 0.6 mm thick, lenticular, somewhat flat above and below, with a strongly acute equatorial margin. Pericarp adherent, with alternating dark brown colored radii or lines perpendicular to the equatorial margin both above and below, brown and light cream to white, these very salient lines in the pericarp giving the name to this taxon.

English diagnosis. *Chenopodium lineatum* is probably the easiest plant to identify by its fruit, as its shape is unusually flat with most a uniformly and persistent marked pericarp of brown radii from the center to the mostly acute margin. Very abundant in Mono and Inyo counties, this species differs from the sympatric species *C. eastwoodiae* in that *Chenopodium lineatum* is a weaker smaller plant and has thinner leaves and its pericarp, appears always lined, not only at late maturity like *C. eastwoodiae;* it differs from *C. luteum* that has a very distinctive yellow pericarp.

Distribution & habitat. California: Alpine, El Dorado, Inyo, Mono, and Tulare counties. Nevada: Washoe Co.

Phenology. The species appears to flower in July, and is in fruit from August to early September.

Etymology. The fruit pericarp shows very distinct lines, like radii, that give it its name, *lineatum***.**

Suggested common name. Mono goosefoot.

Chenopodium luteum Benet-Pierce, sp. nov. (Fig. 3, top row). —TYPE: USA, California, Fresno Co, Lower Tent Meadow, Copper Creek Trail, south fork of Kings River drainage, elevation 7600 ft. (2316 m), *J. Peñalosa 2121*, 16 August 1961 (Holotype: CAS 457912!).

Representative paratypes. California: Fresno Co., Laurel Creek, elevation 9000 ft. (2743 m) *P. H. Raven 6160* (note by Wahl about deserving separate recognition), (CAS 390823!). Fresno Co., Simpson Meadow, Middle Fork of Kings River, elevation 6000 ft. (2438 m), *J. T. Howell 33781* (CAS 457875! TEX Howell 33781!). Fresno Co., Mono Hot Springs, elevation 6500 ft. (1981 m), *P. H. Raven 6137* (note by Wahl about deserving separate recognition) (CAS 390821!). Inyo Co., Sierra Nevada, Independence Creek Canyon, gravelly roadside, Onion Valley Road, elevation 8000 ft. (2439 m), *M. DeDecker 3350* (CAS 637595! RSA 624714!). Mono Co., Glass Mountain region, along FS Rd 3S01 (paralleling power line – E of Deer Springs), approximately 1000 m W of Benton Crossing Rd., 200 m west of cattle tank, gently east sloping outwash alluvium of dry canyon, soil mixed decom-

posed granite and pumice gravel, with *Purshia tridentata* (Pursh) DC., *Artemisia tridentata*, *Ephedra viridis* Coville, and occ. *Pinus monophylla* Torr. & Frém, area evidently grazed, common in road edges and in scrub, elevation 7120 ft. (2170 m) (UC 1787084! RSA 697299!). Mono Co., eastern Sierra Nevada mountains, Convict Creek, UC Sierra Nevada Aquatic Research Lab, Mt Morrison Rd, 0.8 mi NW of intersections with Hwy 395, annual, common along the entrance road and in open site in sagebrush scrub, with *Eriogonum baileyi* S.Watson, *Gayophytum diffusum* Torr. & A.Gray, elevation 7070 ft. (2155 m), *A. Howald 2632* (UCR 224279!).

Description. Erect medium size plant, simple or branched, 2–9 dm high, dark green. Leaf blades trullate very occasionally unlobed, ca. 2.8 cm long x ca. 1 cm wide, base cuneate to obtuse, apex narrowly obtuse or acute. Upper blades lanceolate, elliptic, or narrowly elliptic, ca. 1–1.6 cm long x 0.9 to 0.6 cm wide, entire. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 25 cm long; flowers sessile, ca.1 mm in diameter. Fruits ca. 1.2 mm in diameter, oblate to conical, ca. 0.7 mm thick; pericarp weakly adherent, frequently semi-adherent, from solid pale yellow to aging darker yellow.

English diagnosis. *Chenopodium luteum* appears to be common in two forms, either simple one-stemmed or multi-stemmed, both with lobed primary leaves and a characteristic fruit shape from oblate to occasionally conical with uniformly yellow pericarp. Further collections in Fresno County should help to determine if there are two varieties here. In primary leaf shape, *C. luteum* is reminiscent of some plants of *C. aureum*, but stems of the former are not reddish or weak, being a stronger plant overall with a very distinct fruit, particularly in its yellow pericarp and oblate to conical shape.

Distribution & habitat. California: El Dorado, Fresno, Inyo, Lassen, Mono, and Tulare counties.

Phenology. The species appears to flower in July, and is in fruit from August to early September.

Etymology. Latin *luteum*, meaning yellow. The pericarp of this taxon appears yellow.

Suggested common name. Yellow goosefoot.

Chenopodium sandersii Benet-Pierce, sp. nov. (Fig. 3, bottom row). —TYPE: USA, California, San Bernardino Co., Cleghorn Canyon, occasional, roadsides and open sandy areas (e.g., drainage ways) in chaparral and oak shrub lands, elevation 4600 ft. (1402 m), *Scott White 1852* with C. McGaugh & K. Beaman, 10 September 1993 (Holotype: UCR 100144!).

Representative paratypes. California: Riverside Co., San Jacinto Mountains, Idyllwild, S.E. part of town near Saunders Meadow, west end of Tahquitz View Dr, toward Crestwiew Dr. Rural residential area with houses on large lots, vacant lots and remnant dry yellow pine forest with *Pinus coulteri* D.Don, *Pinus lambertiana* Douglas, *P. jeffreyi*, *Quercus wislizeni* A. DC., *Q. kelloggii* Newb., *Q. chrysolepis* Liebm., *Arctostaphylos pringlei* Parry, *Ceanothus leucodermis* Greene, and others, scarce erect annual on road edge, elevation 5600 ft. (1707 m), *A. C. Sanders 40837* (UCR 242672!). San Bernardino Co., San Bernardino Mountains, along a dirt road just SW of the Cottonwood Guard Station, slopes W. of Silverwood Lake, thinned chaparral (fire break), with *Quercus wislizeni*, elevation 3600 ft. (1100 m), *A. C Sanders 15194* (UCR 113577!). San Bernardino Co., San Bernardino Mountains, Cleghorn Ridge, along FS road 2N 47 between FS road 3N22 and Hwy 138 near Silverwood Lake, steep sided granitic ridge with chaparral and lower margins of yellow pine forest, elevation 4500 ft. (1372 m), *A. C. Sanders 14765* (UCR 81809!). San Bernardino Co., San Bernardino Mountains, dry chaparral and oak covered slopes S of Silverwood Lake, along FSR 2N59 ca. 2 miles E. of Cottonwood station, W of FSR 2N43 from Cedar Pines Park, under power lines, decomposed granite soil, an uncommon annual on the road shoulder 0.4 m. W of 2N43, elevation 3700 ft. (1150 m), *A. C. Sanders 14964* (RSA 628598!; UCR 83371!). San Bernardino Co., San Gabriel Mountains, mouth of Shade Canyon, north fork Lytle Creek, silt loam flat in the sun, elevation 3419 ft. (1042 m), *Louis C. Wheeler 10731* (BRIT *Wheeler 10731*! RSA 602945!).

Description. Large and erect plant, branched or occasionally one stemmed, ca. 5–7 dm tall, yellowish green. Leaf blades lance-ovate ca. 2–3.5 cm long x 1–1.2(1.5) cm wide, very rarely with basal lobes, base cuneate and apex obtuse or acute, entire. Upper blades elliptic, ca. 1–2 cm long x 0.7 cm wide, base cuneate, apex acute. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 45 cm long, flowers sessile, ca. 1 mm in diameter. Fruits conical below, with flatish cone tip, or occ lenticular ca.1 mm in diameter x ca. 0.6 mm thick, with acute equatorial margin. Pericarp semi-adherent, weak, often lost below at the center of the cone or completely, with dark yellow to brown faint color lines.

English diagnosis. *Chenopodium sandersii* is a large plant, similar to some large specimens of *C. incognitum*, but only when the primary leaves are present. Otherwise, secondary leaves are very long lance-ovate in *C. sandersii* and broadly elliptic in most *C. incognitum*. The fruit of *Chenopodium sandersii* is also very characteristic, being small, conical, with a semi-adherent pericarp, and not larger oblate and with a strongly adherent brown and golden to reddish pericarp as *C. incognitum*.

Distribution & habitat. California: Los Angeles, Riverside, and San Bernardino counties.

Phenology. The species appears to flower in late June, and is in fruit from August to early September.

Etymology. Named in honor of Andrew Sanders (1953–), southern California botanist, curator of the UCR herbarium, and prolific collector of *Chenopodium*.

Suggested common name. Sander's goosefoot.

Chenopodium simpsonii Benet-Pierce, sp. nov.* (Fig. 4, top). —TYPE: USA, California, San Bernardino Co., San Bernardino Mountains, Mill Creek Canyon, FSR 1N12 (toward Morton Peak and Warm Spring Canyon), 0.1–0.25 m above Mill Creek Rd., moist roadside seep in chaparral on mountains slopes, annual, scarce on roadside, elevation 3300 ft.(1006 m), *A. C. Sanders 14159,* 12 July 2008 (Holotype: UCR 132956!).

Representative paratypes. California: Los Angeles Co., San Gabriel Mountains, Kratka ridge, elevation7001 ft. (2134 m), *Sharon Dougherty s.n.,* 7 September 2001 (UCR 176994!). San Bernardino Co., San Bernardino Mountains, Cleghorn Canyon, elevation 4400 ft. (1341m), *Scott D. White 1783A*. Los Angeles Co., Kratka Ridge, Los Angeles National Forest, Waterman Mtn., mixed conifer forest, elevation 6800 ft. (2073 m), *Sharon Dougherty s.n.,* 18 September 1997 (UCR132651!). San Bernardino Co., San Bernardino Mountains, Cleghorn Canyon, elevation 4400 ft. (1341 m), *Scott D. White 1783B* (UCR 162964!). San Diego Co., Palomar Mountain, 500′ south of the Palomar Mountain Volunteer Fire Department, 950′ South East of the Canfield and East Grade Rd (S-7) intersection, mixed coniferous forest, burned October 2007, decomposed granite, south facing slope, *Suzann M. Leininger 274* (SD 257942!). San Diego Co., southwest of Combs peak canyon off Chihuahua/Lost Valley Rd, just northwest of Sky Oaks Field Station, on BLM lands, chaparral/oak woodland with *Adenostoma fasciculatum* Hook. & Arn., *A. sparsifolium* Torr., *Quercus agrifolia* var. *oxyadenia* (Torr.) J.T.Howell, *Q.* ×*acutidens* Torr., *Cercocarpus betuloides* Nutt., and *Lonicera subspicata* var. *denudata* Rehder, geology: mostly schist substrates, erect annual, rare, elevation 4610 ft. (1405 m), *Jon. P. Rebman 20327*, with J. Schlachter, L. Aerne Hains & volunteers (SD 209644!). San Diego Co., Cuyamaca Peak, elevation 6512 ft. (1986 m), *Frank F Gander 6508* (SD 22874!). San Diego Co., Pine Valley, elevation 3737 ft. (1139 m), *Frank F Gander 4465* (SD 18748!).

Description. Erect annual, ca. 7 dm high, branched, side branches weak. Leaf blades petiolate, narrowly lanceolate, entire ca. 2 cm long x ca.1 cm wide, base cuneate and apex acute, rarely lobed. Upper blades narrowly elliptic, ca. 2 cm long x ca. 0.4 cm wide, apex and base acute. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 25 cm long, flowers sessile, ca. 1 mm in diameter. Fruits oblate to occasionally conical, ca. 1.2 mm in diameter x ca. 0.6 mm thick, with round or occasionally acute equatorial margin. Pericarp adherent, thick, brown with a pattern of alternating faint reddish or yellow lines, from the center to the margin, the lines becoming faint with age.

English diagnosis. *Chenopodium simpsonii* is the only species in this group to have narrowly lanceolate leaves that are rarely lobed. Some of the specimens that have been identified as *C. pratericola* have lanceolate leaves as well, but the pericarp is always non-adherent in these. We have very strong evidence that the adherence of the pericarp is of paramount taxonomic importance in *Chenopodium*.

Distribution & habitat. California: Los Angeles, Riverside, San Bernardino, and San Diego counties.

Phenology. The species appears to flower in late June, and is in fruit from August to early September.

Etymology. Named in honor of southern California botanist, taxonomist, and Professor of Botany at San Diego State University, Michael G Simpson (1953–)

Suggested common name. Simpson's goosefoot.

Chenopodium twisselmannii Benet-Pierce, sp. nov. (Fig. 4, center row). —TYPE: USA, California, Tulare Co., Kern Plateau, Monache Jeep Trail about 4 miles north of Blackrock Guard Station on way to Monache Meadows, elevation 8700 ft. (2652 m), *John Thomas Howell 43934*, with G. H. True, 20 September 1967 (Holotype: CAS 637604! Isotype: PAC 81227!)

Representative paratypes. California: Kern Co., Landers Meadow, disturbed soil near dwellings, sandy/gravelly, *Allium* sp., *Eriastrum* sp., *Eriogonum* sp., *Phacelia sp., Pinus sabiniana* D.Don, *P. monophylla*, elevation 6754 ft. (2059 m) *Benet-Pierce 465* with J. P. Pierce (SDSU 20536!). Kern Co. Kern Plateau, on road to Bartolas Country, east of Little Canell Meadow, elevation 7200 ft. (2195 m), *John Thomas Howell 41850* with G. H. True (CAS 637689!, 593843!, the latter of which Wahl noted on the specimen as perhaps an undescribed var.; PAC 81033!). Kern Co., Kern Plateau, southwest end of Big Meadow just east of Cherry Hill Road; elevation 7800ft (2377 m), *John Thomas Howell 47177* with G. H. True (CAS 637602!). Tulare Co., Kern Plateau, Monache Jeep Trail about 4 miles north of Blackrock Guard Station on way to Monache Meadows,

* At the insistence of the first author and against the reservations of the second, *Chenopodium simpsonii* will bear its name in honor of Professor Michael G. Simpson as a tribute and great personal appreciation for his excellence in scientific and human mentorship, his unwavering encouragement, and his support both academic and institutional for the first author, without which this and recent contributions to the advancement of *Chenopodium* taxonomy would not have been possible.

elevation 8700 ft. (2652 m), *John Thomas Howell 43933* with G. H. True (CAS 637603! PAC 81229!). Tulare Co., Kern Plateau, Monache Jeep Trail about 3.8 miles north of Blackrock Guard Station, small rather dense colony growing in disturbed loamy decomposed granite in a forest opening along a broad ridgetop, red fir forest, elevation 8800 ft. (2682 m), *Ernest C. Twisselmann 13760* (CAS 593832! 637620!; USDA Kernville *Twisselmann 13760*!). Tulare Co., Kern Plateau, Piute Mountains, Brown meadow, plant well branched from the base, rather bushy, leaves dark green, growing in sandy soil under ponderosa pines, rare, elevation 7550 ft. (2301m), *E. C. Twisselmann 3192* (CAS 406154! 593823!). Tulare Co., Kern Plateau, summit of Bald Mountain, common in disturbed metamorphic rock and gravel, at the base of the lookout tower, open summit above Jeffrey pine forest, elevation 9430 ft. (2874 m), *E. C. Twisselmann 16006* (CAS 593827! 637618! G 61435!). Tulare Co., Kern Plateau, North Meadow jeep road on the west side of Sherman Peak, scattered colony growing in loam, along a little-used primitive road, Jeffrey pine forest, elevation 8600ft (2621 m), *E. C. Twisselmann 14669* with E. McMillan (CAS 593880!).

Description. Erect, large annual, branched from base, ca. 11 dm tall. Leaf blades petiolate, narrowly lance-ovate, mostly unlobed, ca. 2.5 cm long x ca. 1 cm wide, base cuneate to obtuse and apex obtuse, entire. Secondary leaf blades narrowly oblong, ca. 3–2 cm long x ca. 0.7 cm wide, apex and base obtuse to acute. Inflorescences terminal and axillary panicles of glomerate spikes, ca. 60–40 cm long, flowers sessile, ca. 1 mm in diameter. Fruits conical, ca.1.2 mm in diameter x ca. 0.7 mm thick, with marked equatorial margin. Pericarp adherent, orange brown to golden yellow from the center of the abaxial cone to the margin, brown half way as it ages.

English diagnosis. *Chenopodium twisselmannii* is similar to *C. incognitum* in that it is large plant with mostly unlobed leaves, but differs in that its leaves are narrowly lanceolate and mostly unlobed and its fruit is conical. It differs from *C. wahlii* in its conical fruit and much taller height and from *C. brandegeeae*, which is similar in size, by its larger and conical fruit and more profuse vegetative habit.

Distribution & habitat. California: High meadows in Fresno, Inyo, Kern, and Tulare counties.

Phenology. The species appears to flower in late June, and is in fruit from August to early September.

Etymology. Named in honor of botanist and cattle rancher Ernest Christian Twisselmann (1917–1972), authority on southern San Joaquin Valley flora and author of The Flora of Kern County.

Suggested common name. Twisselmann's goosefoot or High Meadow goosefoot.

Chenopodium wahlii Benet-Pierce, sp. nov. (Fig. 4, bottom). —TYPE: USA, California, San Bernardino Co., San Bernardino Mountains, dry road shoulders north of Lake Arrowhead, elevation 5000 ft. (1524 m), *Peter H. Raven 16726*, 17 September 1961 (Holotype: CAS 438720! Isotypes: SD 53090! RSA 155844! GH *Raven 16726*! UC 234690!)

Representative paratypes. California: Los Angeles Co., San Gabriel Mountains, north of Prairie Fork, 1/4 mile SE of Blue Ridge Lookout, loose unstabilized soil from mica schist, south slope of the ridge, Elevation 8400 ft. (2560 m), *Louis C. Wheeler 6320* (SD 230206! RSA 608296! TX *Wheeler 6320*!). Riverside Co., San Jacinto Mountains, head of the west fork of Snow Creek, with *Eriogonum* sp., elevation 7800 ft. (2377 m), *Louis C. Wheeler 6138* (RSA 597521! OBI 70667! BRY 392764! BM *Wheeler 6138*!). Riverside Co., San Jacinto Mountains on loose roadside soil, 1-mile n. of Idyllwild, elevation 5500 ft. (1676 m), *H. E. Wahl 21803* (SD 82781!). San Bernardino Co., San Bernardino Mountains, Pacific Crest Trail from Mission Springs to Onyx Summit, Jeffrey pine forest with *Abies concolor* (Gordon & Glend.) Lindl. ex. Hildebr., *Arctostaphylos patula* Greene and others on decomposed granite soil with boulders on mountain slopes, ca. 1 mile W of Coon Creek jumpoff, N slope of peak, elevation 8588 ft. (2561 m), *A. C. Sanders 19508* with White & L. Lubinsky (UCR 94176!). San Diego Co., Cleveland National Forest, 6 miles NW of Mount Laguna Post Office via Sunrise Hwy, at the edge of access road to Pioneer Mail Picnic area off S-1, elevation 5250 ft. (1610 m), *Jerilyn Hirshberg 2527* (SD 325121!).San Diego Co., roadside and clearing, Laguna Mountains, 6 miles sw of Mount Laguna, elevation 5738 ft. (1749 m), *Herbert A. Wahl 21810* (GH *Wahl 21810*! NY 3336125! RSA 229874!). San Diego Co., Pine Valley, Palomar Mountain, elevation 3737 ft. (1140 m), *Frank F. Gander 6204* (SD 22067!).

Description. Erect annual, branched, 4–8 dm tall. Leaf blades petiolate, narrowly elliptic, rarely lobed, ca. 2.8 cm long x ca. 0.9–1.5 cm wide, base cuneate, round, to obtuse and apex obtuse, round, or widely acute, entire. Upper blades narrowly elliptic, elliptic, to lanceolate, ca. 1.6 cm long x 0.6 cm wide, apex and base widely acute or round. Inflorescences terminal and axillary panicles of glomerate spikes ca. 40 cm long, flowers sessile, ca. 1 mm in diameter. Fruits slightly conical below, $\leq$1.1 mm in diameter x 0.5 mm thick, with acute equatorial margins. Pericarp adherent brown to occasionally with random yellow spots, turning all brown with age.

English diagnosis. *Chenopodium wahlii* is similar to *C. twisselmannii* in its narrowly elliptic leaf blades, but *C. wahlii* is a much smaller and thinner plant with a very distinct fruit. It differs from the geographically nearby taxa, *C. incognitum* and *C. sandersii,* in the shorter, narrowly elliptic leaves and fruit with a thin brown pericarp. It differs as well from *C. brande-*

geeae, which is a larger plant with a very distinct black and brown fruit pericarp.

Distribution & habitat. California: Los Angeles, Riverside, San Bernardino, San Diego, and Tulare counties.

Phenology. The species appears to flower in late June, and is in fruit from in September and October.

Etymology. Named in honor of H. A. Wahl (1900—1975), botanist, taxonomist, and faculty member at Pennsylvania State University for over 40 yr. Scientific authority on the taxonomy of the genus *Chenopodium*.

Suggested common name. Wahl's goosefoot.

Conclusions

Based on the clear correspondence between fruit and vegetative morphology (Benet-Pierce and Simpson 2014, 2017), we have presented a partial taxonomic treatment of western North American *Chenopodium* in this possibly artificial "narrow-leaved group". We determined these taxonomic entities first from characterization of fruit morphology, followed by correlation with vegetative features of the species.

We have employed more than 550 specimens, constituting a very high percentage of all specimens of this group collected in California and other western North American states, and we have provided as detailed descriptions as possible from the specimens at hand.

As a result of these studies, we have reached important conclusions in going forward with the taxonomy of *Chenopodium*. First, most *Chenopodium* taxa are clearly diagnosed by details of their fruit and seed morphology. Fruits are at present the most definite basis for identification, as they are more constant than vegetative characters. The majority of specimens cannot be identified adequately without fruit or seed until taxa have been extensively studied and described in detail. Even then, fruits appear to be needed as confirmation due to the well-documented vegetative plasticity in the genus. Second, most *Chenopodium* plants are not as variable as assumed in the past. Each taxon has a distinctive vegetative aspect that can be readily appreciated once classified into viable taxonomic units based on fruit morphology. Even if the vegetative characters alone cannot definitively identify taxa now, the use of fruits will allow for greatly improved and more detailed descriptions, permitting vegetative characters to be more reliably correlated, perhaps especially as additional collections are obtained in the future. Third, *Chenopodium* is much more speciose than previously thought. While some taxa are constrained to small and localized areas, others are much more widespread. This paper covers but just a fraction of what we believe is the as yet un-described *Chenopodium* diversity present in North America. More taxa are likely to be added now that fruit and seed features have been firmly established as stable and diagnostic complementing vegetative features. Of course, the taxonomy of *Chenopodium* will be further strengthened by molecular phylogenetic studies.

Finally, we note that early treatments of *Chenopodium* taxonomy in North America were incomplete. But we hope that with both stable and diagnostic fruit features, the task of studying, describing, and engaging in more encompassing treatments of this genus can become less subjective and, hopefully, a less frustrating undertaking. *Chenopodium* will greatly benefit by additional, extensive taxonomic work focusing on fruit and seed morphology in every region of the country, if not the world, where plants of this important, but misunderstood genus are still present. It is our wish that with improved identifications and descriptions, *Chenopodium* will also be better understood and appreciated for future protection and conservation.

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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 Repertorium Specierum Novarum Regni Vegetabilis 26:31–64, 119–160.

Aellen, P. and T. Just. 1943. Key and synopsis of the American species of the genus *Chenopodium* L. American Midland Naturalist 30:47–76.

Benet-Pierce, N. 2014. *Chenopodium* taxonomy of North America. San Diego State University, San Diego, CA. Website: https://plants.sdsu.edu/chenopodium. [Accessed 14 May 2019].

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. Journal of the Torrey Botanical Society 141:161–172.

Benet-Pierce, N. and M. G. Simpson. 2017. Taxonomic recovery of the species in the *Chenopodium neomexicanum* complex and description of *Chenopodium sonorense* sp. nov. Journal of the Torrey Botanical Society 144:339–356.

BRENNER D. M., BOCKELMAN H. E., AND WILLIAMS, K. A. 2019. North American wild relatives of grain crops *in* S. Greene, K. Williams, C. Khoury, M. Kantar, and L. Marek (eds) North American Crop Wild Relatives, Volume 2. Springer, Berlin.

CLEMANTS, S. E. AND N. BENET-PIERCE. 2012. *Chenopodium*. Pp. 638–642 *in* B. G. Baldwin, D. H. Goldman, D. J. Keil, R. Patterson, T. J. Rosatti, and D. H. Wilken (eds.), The Jepson manual: vascular plants of California, 2nd edition. University of California Press, Berkeley, CA.

CLEMANTS, S. E. AND S. L. MOSYAKIN. 2003. *Chenopodium*. Pp. 275–299 *in* Flora of North America Editorial Committee (eds.), Flora of North America. Vol. 4, Magnoliophyta: Caryophyllidae, part 1. Oxford University Press, New York, NY.

CRAWFORD, D. J. 1975. Systematic relationships in the narrow-leaved species of *Chenopodium* of the western United States. Brittonia 27:279–288.

CRAWFORD, D. J. AND E. A. JULIAN. 1976. Seed protein profiles in the narrow-leaved species of *Chenopodium* of the western United States: taxonomic value and comparison with distribution of flavonoid compounds. American Journal of Botany 63:302–308.

CRAWFORD, D. J. AND J. T. REYNOLDS. 1974. A numerical study of the common narrow-leaved taxa of *Chenopodium* occurring in the Western United States. Britonnia 20:398–410.

CRAWFORD, D. J. AND H. D. WILSON. 1979. Allozyme variation in several closely related diploid species of *Chenopodium* of the western United States. American Journal of Botany 66:237–244.

ERTTER, B. 2000. Floristic surprises in North America north of Mexico. Annals of the Missouri Botanical Garden 87:81–109.

FUENTES-BAZÁN, S., G. MANSION, AND T. BORSCH. 2012a. Towards a species-level tree of the globally diverse genus *Chenopodium* (Chenopodiaceae). Molecular Phylogenetics and Evolution 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.

JARVIS, D. E., Y. S. HO, D. J. LIGHTFOOT, S. M. SCHMÖCKEL, B. LI, T. J. BORM, ... , AND N. M. KHARBATIA. 2017. The genome of *Chenopodium quinoa*. Nature 542:307–313.

JELLEN, E. N., B. A. KOLANO, M. C. SEDERBERG, A. BONIFACIO, AND P. J. MAUGHAN. 2011. *Chenopodium*. Pp. 35–61 *in* C. Kole (ed.) Wild crop relatives: genomic and breeding resources. Springer, Berlin.

LA DUKE, J. AND D. J. CRAWFORD. 1979. Character compatibility and phyletic relationships in several closely related species of *Chenopodium* of the western United States. Taxon 28:307–314.

LADYMAN, J. A. R. 2006. *Chenopodium cycloides* A.Nelson (sandhill goosefoot): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Website: http://www.fs.fed.us/r2/projects/scp/assessments/chenopodiumcycloides.pdf [accessed 14 October 2010].

STANDLEY, P. C. 1916. *Chenopodium*. P. 19 *in* North American Flora, vol. 21, part 1. New York Botanical Garden, New York, NY.

STANDLEY, P. C. 1917. *Chenopodium*. The Chenopodiaceae of the North American Flora. Bulletin of the Torrey Botanical Club 44: 411–429.

SUKHORUKOV, A. P., M. V. NILOVA, A. A. KRINITSINA, M. A. ZAIKA, A. S. ERST, AND K. A. SHEPHERD. 2018. Molecular phylogenetic data and seed coat anatomy resolve the generic position of some critical Chenopodioideae (Chenopodiaceae – Amaranthaceae) with reduced perianth segments. PhytoKeys 109:103–128.

THIERS, B. 2019. Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. New York, NY. Website: http://sweetgum.nybg.org/science/ih/ [accessed 12 May 2010].

WAHL, H. A. 1954. A preliminary study of the genus *Chenopodium* in North America. Bartonia 27:1–46.

APPENDIX 1

KEY TO THE *CHENOPODIUM* SPECIES OF CALIFORNIA

MODIFIED FROM CLEMANTS AND BENET-PIERCE (2012)

1. Primary leaf blades generally 2-lobed or entire
   2. Primary leaf blade length generally $<1.7 \times$ width, most leaves deltate, triangular, ovate-oblong, or widely ovate
      3. Pericarp adherent to seed
         4. Plant scented, most primary leaf blades ovate-oblong to widely ovate; fruit $>$ 1 mm not horizontally depressed; scarce, mostly Central Valley . . . . . *C. vulvaria*
         4′. Plant not scented, most primary leaf blades deltate or occ ovate-oblong; fruit horizontally depressed on one side, <0.8 mm; relatively common NV & eastern CA . . . . . *C. nevadense*
      3′. Pericarp free from seed
         5. Most primary leaf blades deltate, triangular, or elliptic with prominent basal lobes; seed black
            6. Plant erect, reddish in age, few-branched distally; seed in side view lenticular, margin thick, square . . . . . *C. fremontii*
            6′. Plant compact, rounded, dull green in age, many-branched distally; seed in side view rhomboidal, margin obtuse. . . . . *C. incanum var. occidentale*
         5′. Most primary leaf blades ovate-oblong to elliptic and only some primary leaf blades with basal lobes; seed coat generally reddish-brown . . . . . *C. atrovirens*

2′. Primary leaf blade length generally >1.7 × width, most leaf blades linear, narrowly lanceolate to widely ovate, oblance-ovate, narrowly to broadly elliptic, or trullate
7. Primary leaf blade length generally 4-many × width, linear, narrowly lanceolate, lanceolate to lance-ovate
8. Pericarp adherent to seed; plant generally branched from base; primary leaf blade linear or narrowly lanceolate;
9. Primary leaf blade linear, generally <3 mm wide; fruit ≤ 0.7 mm . . *C. leptophyllum* aggregate
9′. Primary leaf blade narrowly lanceolate, generally ≥3.5 mm wide, fruit ~1mm; S. CA . . . . . *C. simpsonii*
8′. Pericarp free from seed; plant with long acaulescent stem, primary leaf blade lance-ovate . . . . . *C. pratericola* aggregate
7′. Primary leaf blade length 1.7–4 × width, narrowly elliptic to broadly elliptic, narrowly lanceolate to lanceolate, trullate to widely trullate, widely lance-ovate to widely ovate, or oblance-ovate
10. Pericarp free from seed; plant prostrate or nearly so
11. Stems procumbent; primary leaf blade trullate; seed lenticular in side view, seed coat rugose, not shiny; coastal sand dune habitat . . . . . *C. littoreum*
11′. Stems decumbent; primary leaf blade narrowly elliptic; seed flat in side view, seed coat tessellate and very shiny; sage brush habitat. . . . . *C. nitens*
10′. Pericarp adherent to seed; plant erect
12. Plant regularly ≤5 dm
13. Plant weakly branched, stems reddish at different height levels at maturity; primary leaf trullate and lobed; pericarp golden & shiny . . . . . *C. aureum*
13′. Plant many branched from base, stems not red, usu all ending at same height at maturity, primary leaf blade narrowly elliptic, rarely lobed; pericarp brown or black color with white protuberances . . . . . *C. howellii*
12′. Plant regularly ≥5 dm;
14. Primary leaf blades unlobed or occ lobed, narrowly elliptic, lanceolate or narrowly lance-ovate
15. Primary leaf blades occasionally lobed, narrowly elliptic, narrowly lanceolate to broadly lanceolate
16. Plant usually 5–8 dm, leaf blades gen narrowly elliptic or broadly lanceolate; fruit lenticular in side view
17. Plant many branched from base; leaf blades narrowly elliptic to broadly lanceolate; fruit equatorial margin obtuse, pericarp usu brownish; So CA . . . . . *C. wahlii*
17′. Plant thinly branched; leaf blades broadly lanceolate to lanceolate; fruit equatorial margin acute; pericarp with brown radii from the center to the margin; El Dorado, Mono, Inyo and Tulare counties . . . . . *C. lineatum*
16′. Plant usually to 11 dm, leaf blades narrowly lance-ovate; fruit conical in side view; high meadows, Fresno, Kern & Tulare Co. . . . . *C. twisselmannii*
15′. Primary leaf blades unlobed, elliptic or lance-ovate
18. Plant simple or branched; primary leaf blades lance-ovate; secondary leaf blades elliptic; fruit distally conical in side view, margin acute, pericarp golden brown; so. CA . . . . . *C. sandersii*
18′. Plant thinly branched; primary leaf blades elliptic or lance-ovate; secondary leaf blades occ falcate; fruit lenticular in side view, pericarp black and gold markings, very shiny; San Diego Co. . . . . *C. brandegeeae*
14′. Primary leaf blades usually lobed, trullate, broadly elliptic or broadly lance-ovate
19. Plant usually ≥8 dm; fruit lenticular or oblate; pericarp golden or reddish brown or cream
20. Primary leaf blades broadly lance-ovate; fruit oblate in side view, margin rounded, >1.4 mm in diameter in side view, pericarp thick, striped either brown, cream, or reddish in color; El Dorado, Mono and Tulare counties . . . . . *C. eastwoodiae*
20′. Primary leaf blades broadly elliptic or trullate; fruit lenticular in side view, margin acute, ~1.2 mm in diameter; pericarp golden-brown or reddish brown with cream color papillae markings; widespread in western North America . . . . . *C. incognitum*
19′. Plant usually ≤8 dm; fruit wide-oblate, pericarp yellow; El Dorado, Fresno, Inyo, Lassen, Mono counties. . . . . *C. luteum*

1′. Primary leaf blades 2-lobed and toothed
21. Pericarp adherent
22. Pericarp light gold color, honey-combed pitted at 20x magnification . . . . . *C. berlandieri*
23. Style base not yellow in fruit; seed 1–1.3 mm diam. . . . . var. *sinuatum*

23′. Style base yellow in fruit; seed 1.2–1.5 mm diam . . . . . var. *zschackei*
22′. Pericarp brown, papillate at 20×. . . . . *C. strictum* aggregate
21′. Pericarp free from the seed
24. Plant to 1 m; inflorescence branches straight; flower clusters generally in axillary and terminal branched panicles . . . . . *C. album* aggregate
24′. Plant to 2 m; inflorescence branches ± curved or pendent; flower clusters in axillary and terminal panicles of spikes . . . . . *C. missouriense*

Appendix 2

Chenopodium Taxonomic Key based on Fruit characters for Taxa in this Paper

1. Fruit conical or slightly conical below
2. Fruit conical below, golden-brown or reddish-brown
3. Pericarp golden-brown
4. Fruit ≤ 1 mm pericarp semi-adherent . . . . . *C. sandersii*
4′. Fruit ~1.2 mm pericarp adherent . . . . . *C. twisselmannii*
3′. Pericarp reddish-brown with scattered white papillae . . . . . *C. hians*
2′. Fruit slightly conical below, pericarp uniformly brown in color. . . . . C. *wahlii*
1′. Fruit lenticular or oblate
5. Fruit lenticular in shape
6. Fruit convex on both sides, pericarp very shiny
7. Pericarp golden. . . . . C. aureum
7′. Pericarp brown and black colored . . . . . C. brandegeeae
6′. Fruit convex or flat below, pericarp dull
8. Fruits convex below, flat above; pericarp with white protuberances or lines . . . . . C. howellii
8′. Fruits flat below and above; pericarp with brown radii. . . . . C. lineatum
5′. Fruit oblate in shape
9. Pericarp thick
10. Fruit diameter ≥ 1.4 mm, pericarp striped in age. . . . . C. eastwoodiae
10′. Fruit diameter ≤ 1 mm, pericarp striped early . . . . . C. simpsonii
9′. Pericarp thin
11. Fruit ~1mm pericarp semi-adherent, yellow . . . . . C. luteum
11′. Fruit ≥ 1.2 mm pericarp strongly adherent, golden and brown . . . . . C. incognitum