

A RECONSIDERATION OF CARDAMINE CURVISILIQUA
AND C. GAMBELLII AS SPECIES OF
RORIPPA (CRUCIFERAE)

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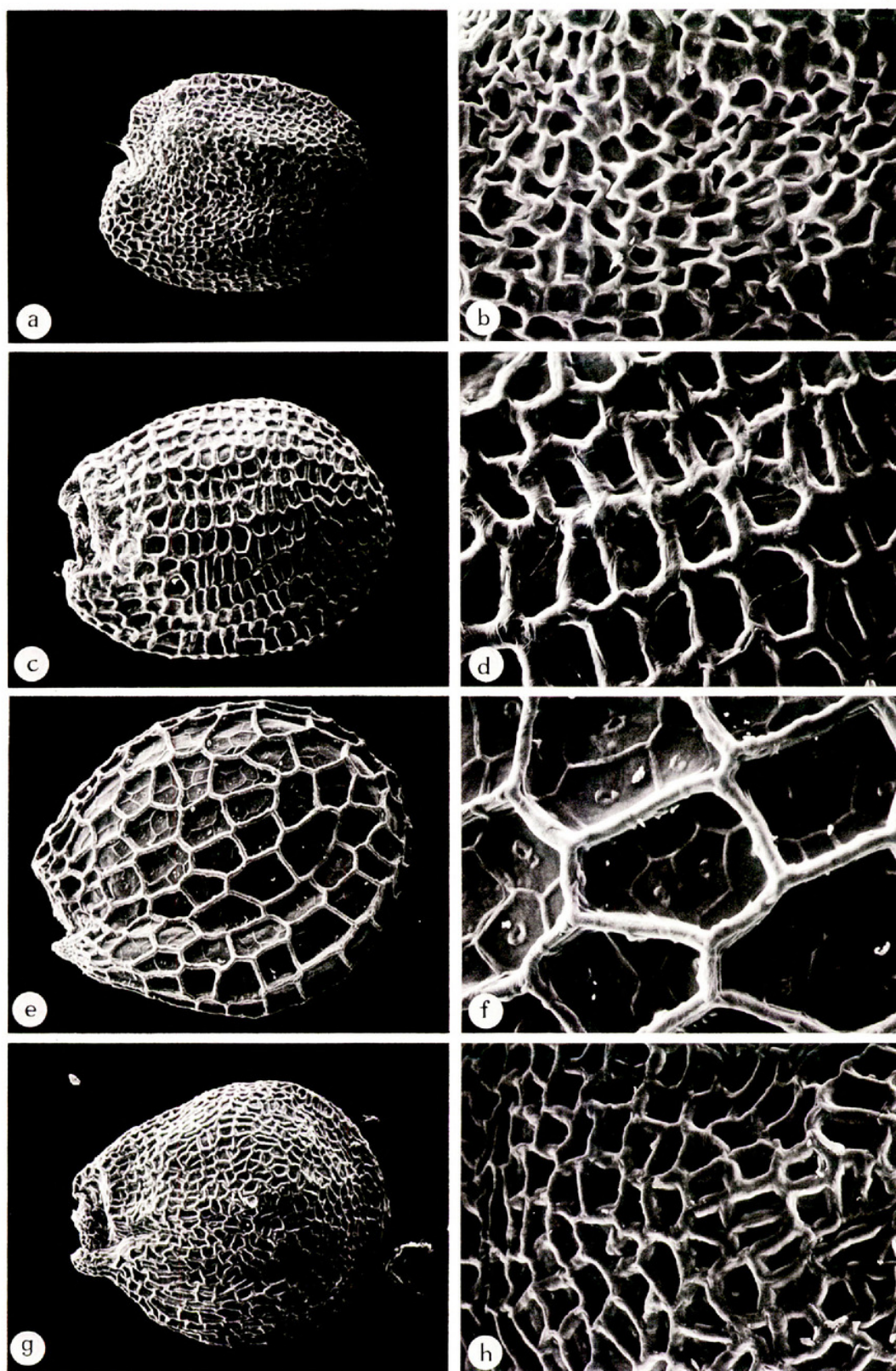
The generic status of *Nasturtium* is evaluated, and an argument supporting its union with *Rorippa* is presented. The new name *R. floridana* and the new combination *R. gambellii*, based on *Cardamine curvisiliqua* and *C. gambellii*, respectively, are proposed. A key to the white-flowered species of *Rorippa* that grow in North America is given.

One of the most frequently encountered problems in the systematics of the Cruciferae (Brassicaceae) is whether or not generic status should be given to a small group of species that, on the basis of morphology, form a marginal portion of a larger genus. Where sharply defined discontinuities exist, such peripheral groups are usually recognized as independent genera. However, if the differences between the marginal groups and the larger genus break down, whether locally or on a worldwide basis, then the taxonomy of the complex is best treated by not recognizing the smaller species groupings as segregate genera. A case in point involves *Rorippa* Scop. and *Nasturtium* R. Br.

Many authors (e.g., Coode & Cullen, 1965; Fernald, 1950; Stuckey, 1972; Valentine, 1964) who recognize both *Nasturtium* and *Rorippa* distinguish the former by its white petals, its lack of median nectaries, and its coarsely reticulate seeds. *Rorippa* has yellow petals, well-developed median nectaries, and variously sculptured (usually not coarsely reticulate) seeds. However, an examination of many species of *Rorippa* from the Southern Hemisphere reveals that these character sets break down in various combinations, and that none of the other alleged differences between the two genera holds together either. For example, *R. laurentii* Jonsell (Madagascar) has white flowers, median nectaries, and striate seeds (Jonsell, 1979); *R. gigantea* (J. D. Hooker) Garnock-Jones (Australia, New Zealand) has white flowers, median nectaries, and coarsely reticulate seeds (Garnock-Jones, 1978; Hewson, 1982); and almost all of the South American species have white flowers, no median nectaries, and colliculate seeds (Martínez-Laborde, 1985). It is evident that there are no solid grounds to support the maintenance of *Nasturtium* as a genus distinct from *Rorippa*.

Jonsell (1968) followed Schulz (1936) in uniting *Nasturtium* and *Rorippa* and in placing some species of the former in sect. *Cardaminum* (Moench) DC. Schulz, however, adopted *Nasturtium* for the combined genus, instead of the

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Scanning electron micrographs of seeds of *Rorippa*: a, b, *R. floridana* (Curtiss 24, GH); c, d, *R. microphylla* (Knowlton s.n., 25 July 1911, NEBC); e, f, *R. nasturtium-aquaticum* (Cory 1619, GH); g, h, *R. gambellii* (Bingham s.n., 1886, GH). a, c, e, g, $\times 38$; b, d, f, h, $\times 140$.

Comparison among *Rorippa floridana*, *R. microphylla*, and
R. nasturtium-aquaticum.

CHARACTER	TAXON		
	<i>R. floridana</i>	<i>R. microphylla</i>	<i>R. nasturtium-aquaticum</i>
Seeds			
Color	Light or yellowish brown	Reddish brown	Reddish brown
Arrangement in locule	Uniseriate	Uniseriate	Biseriate
Length (mm)	0.65–0.85(–0.9)	(0.8–)1–1.2	(0.8–)0.9–1.1(–1.2)
Width (mm)	0.42–0.65	(0.6–)0.7–0.84(–0.9)	(0.6–)0.7–0.9(–1)
Reticulation size	Minute	Moderate	Coarse
No. of areolae per side	400 to 500	75 to 150 (to 175)	25 to 50 (to 60)
Fruit width (mm)	1–1.5	1–1.5	2–3
Emergent leaves			
Petiole base	Not auriculate	Auriculate	Auriculate
No. of lateral lobes (pairs)	1 or 2 (or 3)	(1 or) 2 to 4 (or 5)	1 to 4 (to 6)
Chromosome number (<i>n</i>)	16	32	16

earlier-published *Rorippa*. His sect. *Cardaminum* included the watercress, *R. nasturtium-aquaticum* (L.) Hayek (as *N. officinale* R. Br.), as well as two African and two North American species. Both North American species were originally described in *Cardamine* L. and were treated later in *Nasturtium* (see below). They are transferred in this paper to *Rorippa*, where they are more appropriately placed.

The taxonomic history of both *Cardamine curvisiliqua* Shuttelw. and *C. gambellii* S. Watson, hereafter *Rorippa floridana* Al-Shehbaz & Rollins and *R. gambellii* (S. Watson) Rollins & Al-Shehbaz, respectively, has been discussed previously at some length (Rollins, 1960, 1978) and need not be repeated here. *Rorippa floridana* is endemic to Florida, where it grows in lakes and springs in Brevard, Citrus, Clay, Collier, Columbia, Dade, Duval, Gilchrist, Hillsborough, Lake, Levy, Manatee, Marion, Seminole, Sumter, Taylor, Volusia, and Wakulla counties. Plants of *R. floridana*, *R. microphylla* (Boenn. ex Reichb.) Hylander, and *R. nasturtium-aquaticum* produce only simple leaves on deeply submersed stems and pinnate leaves on emergent ones (Michaelis, 1976; Rollins, 1978). The production of simple or pinnate leaves can be controlled by manipulating the depth at which a given plant is grown (Rollins, 1978). These three species are indistinguishable in the submersed state, but they can be identified easily when emergent parts have mature fruits.

Rorippa floridana has previously been recognized as *Cardamine curvisiliqua* (Small, 1933), as "undoubtedly a minor variant" of *C. pennsylvanica* Muhlenb. ex Willd. (Patman, 1962, p. 200), and as *R. microphylla* (Clewett, 1985; Godfrey & Wooten, 1981; Rollins, 1978; Wunderlin, 1982). The species does not belong

to *Cardamine* because it does not have the elastically dehiscent fruits, the usually spirally coiled valves, or the narrowly winged replum margin that are unique to that genus. *Rorippa floridana* differs from *R. microphylla* in several features of its seeds (see FIGURE), in its emergent leaves, and in its chromosome number (see TABLE). Consistent chromosome counts of $2n = 64$ have been reported for *R. microphylla* from Canada (Mulligan, 1964), Sweden (Jonsell, 1963), Germany (as *Nasturtium officinale*; Tischler, 1935), England (as *N. uniseriatum* Howard & Manton; Howard & Manton, 1946), and Denmark, England, Holland, Ireland, and Scotland (as *N. officinale*; Manton, 1935). *Rorippa floridana* (as *C. curvisiliqua*) has $2n = 32$ (Rollins & Rüdénberg, 1977).

Seeds of *Rorippa floridana* are smaller in size and have much smaller and far more numerous areolae on each side than those of *R. microphylla* and *R. nasturtium-aquaticum* (see FIGURE). Seeds of the last species are unusual in that their areolae are subdivided by a low understory of reticulum, the units of which contain circular thickenings (see FIGURE, f). These probably correspond to stomata. To our knowledge, such a peculiar pattern of seed sculpture has not been recorded elsewhere in the Cruciferae. The areolae in *R. gambellii* are somewhat intermediate in size and number between those of *R. floridana* and *R. microphylla*.

Perhaps the earliest known collection of *Rorippa microphylla* from the New World was made by W. Boott in 1861 in Waltham, Massachusetts (Green, 1962). The species has not been collected from any of the southeastern states, whereas *R. nasturtium-aquaticum* is naturalized in all of them. Apparently the oldest specimens of *R. floridana* were collected by Leavenworth in 1836 from Tampa Bay (Gray, 1880; McVaugh, 1947; Torrey & Gray, 1840) and by Rugel in 1843 from St. Marks. Evidently the native *R. floridana* was well represented in several herbaria long before *R. microphylla* was recorded for North America.

The following key is provided to aid in the identification of the indigenous and naturalized North American white-flowered species of *Rorippa*:

- A. Lateral leaf lobes with 3 to 5 (to 7) teeth; inflorescences bracteate, the bracts toothlike to filiform and to 3 mm long, sometimes much larger, leafy, and pinnate, always adnate to pedicels; fruiting pedicels conspicuously flattened beneath at attachment to rachis. *R. gambellii*.
- A. Lateral leaf lobes entire or repand; inflorescences ebracteate; fruiting pedicels not flattened.
 - B. Petioles of emergent leaves not auriculate at base; seeds yellowish brown, usually < 0.9 mm long and < 0.65 mm wide, minutely reticulate, with 400 to 500 minute areolae on each side. *R. floridana*.
 - B. Petioles of emergent leaves minutely to coarsely auriculate at base; seeds reddish brown, usually > 0.9 mm long and > 0.65 mm wide, moderately to coarsely reticulate, with 25 to 175 areolae on each side.
 - C. Mature fruits 1–1.5 mm wide; seeds uniseriately arranged in each locule, moderately reticulate, with 100 to 150 (to 175) areolae on each side. *R. microphylla*.
 - C. Mature fruits 2–3 mm wide; seeds biseriately arranged, coarsely reticulate-foveolate, with 25 to 50 (to 60) areolae on each side. *R. nasturtium-aquaticum*.

Rorippa floridana Al-Shehbaz & Rollins, nom. nov. Based on *Cardamine curvisiliqua* Shuttelw. ex Chapman, Fl. South. U.S. 605. 1887. LECTOTYPE

(here designated): in uliginosis subsalsis ad fluv. St. Marks, prope St. Marks, Florida, *Rugel s.n.*, April–May, 1843 (isoelectotypes, GH!). The specific epithet *curvisiliqua* would become a later homonym if transferred to *Rorippa* because of the existence of *R. curvisiliqua* (W. J. Hooker) Bessey ex Britton, Mem. Torrey Bot. Club **5**: 169. 1894.

Nasturtium stylosum Shuttelw. ex O. E. Schulz in Engler & Prantl, Nat. Pflanzenfam. ed. 2. **17B**: 553. 1936; non *N. stylosum* (DC.) O. E. Schulz ex Cheesman, Trans. & Proc. New Zealand Inst. **43**: 179. 1911.²

Putative interspecific hybridization between *Rorippa floridana* (as *R. microphylla*) and *R. nasturtium-aquaticum* has been suggested previously (Rollins, 1978). It is likely that the hybrids are more common than is presently known. However, very little can be said about them, and only future field and experimental work can verify these assumptions.

Rorippa gambellii (S. Watson) Rollins & Al-Shehbaz, comb. nov. Based on *Cardamine gambellii* S. Watson, Proc. Amer. Acad. Arts **11**: 147. 1876. TYPE: California, Santa Barbara, *Gambell s.n.* (holotype, GH!; isotype, GH!).

Nasturtium gambellii (S. Watson) O. E. Schulz, Bot. Jahrb. Syst. **66**: 98. 1933.

Specimens of *Rorippa gambellii* in the Gray Herbarium were annotated by one of us (R. C. R.) as early as 1957, but the new combination was never published. Watson (1895) suggested that the spelling of *gambellii* should be changed to *gambelii* because the plant was named after Gambel, not Gambell. However, the original spelling is retained here.

The distribution of *Rorippa gambellii* is based primarily on old collections, the majority of which were made in the nineteenth century. The species apparently occupied marshy or aquatic habitats in southern California (Los Angeles, San Bernardino, and Santa Barbara counties) and occurred disjunctly in the Valley of Mexico. Areas near Santa Barbara and San Bernardino have been searched on two different occasions, but no plants of the species have been found. Likely habitats have mostly been obliterated by urbanization. The same despoiling of habitat seems to have occurred in Mexico. It now appears possible that *R. gambellii* is extinct.

Both glabrous and pubescent forms are known (Rollins, 1960; Watson, 1876), but this variation is apparently insignificant.

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²Schulz (1936) had recognized both *Nasturtium stylosum* Shuttelw. and the earlier homonym above as distinct species. The earlier homonym, which was transferred to *Rorippa* (as *R. stylosa* (DC.) Allan, Fl. New Zealand **1**: 188. 1961; non *R. stylosa* (Pers.) Mansf. & Rothm. Repert. Spec. Nov. Regni Veg. **49**: 276. 1940), is now known as *R. gigantea* (J. D. Hooker) Garnock-Jones.

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