

A NEW SUBSPECIES OF *CLARKIA CONCINNA*
(ONAGRACEAE) FROM MARIN COUNTY, CALIFORNIA

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ABSTRACT

A new self-pollinating subspecies, *Clarkia concinna* subsp. *raichei*, is described from the California coast north of San Francisco Bay. It is interfertile with the other subspecies, *C. concinna* subsp. *concinna* and subsp. *automixa*, but differs in having less deeply lobed petals, more completely united sepals, shorter stature, and earlier flowering time.

Clarkia (Onagraceae) exhibits a diverse array of floral morphologies and petal pigmentation patterns (MacSwain et al. 1973; Gottlieb 1989). Some of the most unusual flowers in the genus are found in section *Eucharidium* Lewis & Lewis, which includes *C. concinna* (Fischer & C. Meyer) E. Greene and *C. breweri* (A. Gray) E. Greene (Lewis & Lewis 1955). These two species are characterized by large trilobed petals, four rather than eight stamens, and a long floral tube that adapts them to pollination by long-tongued Lepidoptera or Diptera (MacSwain et al. 1973). *Clarkia concinna* occurs in northern and western California from Del Norte to Butte and Santa Clara Counties. The widely distributed, outcrossed subsp. *concinna* has large showy flowers, is protandrous, and has a very long style with the stigma exerted well beyond the anthers. Smaller-flowered, self-pollinated populations from the South Coast Ranges, which lack protandry and have anthers positioned adjacent to the stigma, have been described as subsp. *automixa* (Bowman 1987). A new subspecies, also self-pollinated but differing from subsp. *automixa* in stature and in floral morphology, is described here.

METHODS

Plants were grown from seed obtained from five populations of the three subspecies of *C. concinna*. Collections and localities were: subsp. *raichei*, Allen and Ford 1239 (type locality); subsp. *automixa*, Gottlieb 8701 (Santa Clara Co., Stevens Canyon Rd) and Gottlieb 8702 (Santa Clara Co., Soda Springs Canyon Rd); subsp. *concinna*,

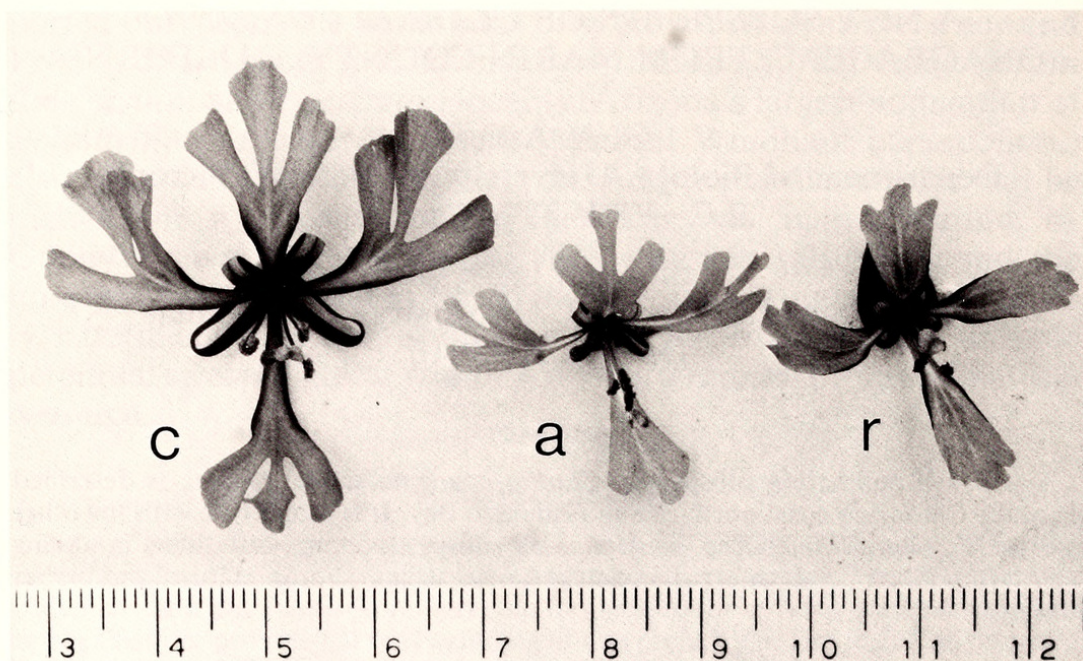


FIG. 1. Representative flowers of *Clarkia concinna*: c = subsp. *concinna* (Gottlieb 8740), a = subsp. *automixa* (Gottlieb 8701), r = subsp. *raichei* (Allen and Ford 1239).

Gottlieb 8740 (Sonoma Co., Hwy 128 w of Conn Dam) and Weeden 146 (Marin Co., 0.8 km W of summit, Lucas Valley Rd). One collection (Weeden 146, subsp. *concinna*) was obtained by random cross-pollination of 6–7 plants derived from the original field-collected seed; all other seeds were from field-collected populations. Seeds were germinated in moistened vermiculite, transplanted into 2-inch pots, and grown to flowering size in the greenhouse. Mature fully expanded petals and other floral parts were measured on at least 40 flowers from 20 plants of each population. Herbarium specimens at DAV, UC, JEPS, and CAS were also examined, to confirm conclusions reached from measurements made on these populations.

Pairwise crosses were made between individuals of each subspecies, and pollen stainability in lactophenol-aniline blue was determined in the parents and in the F_1 hybrids to estimate infertility. Chromosome counts for subsp. *raichei* were made from root tips of newly germinated seedlings fixed in 3:1 ethanol:acetic acid and stained with leuco-basic fuchsin as described by Allen (1984).

RESULTS

The most conspicuous morphological differences among the flowers of the three subspecies are summarized in Table 1. *Clarkia concinna* subsp. *raichei* and subsp. *automixa* both possess floral attributes associated with self-pollination: relatively small petals, anthers at the same height as the stigma, and absence of protandry. The

TABLE 1. FLORAL CHARACTERS OF THE THREE SUBSPECIES OF *CLARKIA CONCINNA*, DETERMINED FROM POOLED SAMPLES OF PLANTS GROWN FROM SEED. Overall means and standard deviations are calculated from means for individual plants; ranges are the extremes found for individual flowers. Anther-to-stigma distance = style length - (filament length + floral tube length). All units are mm.

	Subsp. <i>concinna</i>		Subsp. <i>automixa</i>		Subsp. <i>raichei</i>	
	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range
Petal length	25.4 \pm 2.5	19.0-30.5	18.4 \pm 2.0	13.5-23.5	19.4 \pm 0.6	17.5-21.5
Midlobe length	10.5 \pm 1.5	7.5-14.0	5.6 \pm 1.0	2.5-8.5	2.9 \pm 0.4	1.0-4.5
Lateral lobe length	7.2 \pm 1.2	4.5-9.5	3.0 \pm 0.6	1.0-5.0	1.2 \pm 0.4	0-2.5
Style length	30.0 \pm 2.0	25.5-34.0	24.7 \pm 1.8	19.0-29.5	24.6 \pm 0.9	22.0-27.0
Floral tube length	17.3 \pm 1.5	13.0-21.0	15.8 \pm 1.3	11.5-20.0	14.6 \pm 0.3	13.5-15.5
Anther-to-stigma distance	4.5 \pm 1.2	1.5-7.0	0.6 \pm 1.2	0-5.5	1.0 \pm 0.5	0-2.5
Midlobe/total length	0.41 \pm 0.03	0.33-0.50	0.30 \pm 0.04	0.16-0.45	0.15 \pm 0.02	0.06-0.22

TABLE 2. POLLEN VIABILITY OF SUBSPECIES OF *CLARKIA CONCINNA* AND THEIR F₁ HYBRIDS. Determinations were made from 500 pollen grains per plant.

Taxon or F ₁ hybrid	Number of plants sampled	Percent stainability of pollen ($\bar{x} \pm SD$)
<i>automixa</i> (Gottlieb 8701)	5	96.9 \pm 2.4
<i>concinna</i> (Gottlieb 8740)	6	96.9 \pm 1.8
<i>raichei</i> (Allen and Ford 1239)	6	95.9 \pm 1.8
<i>automixa</i> \times <i>raichei</i>	5	80.4 \pm 4.3
<i>raichei</i> \times <i>automixa</i>	6	77.5 \pm 6.0
<i>concinna</i> \times <i>automixa</i>	4	73.0 \pm 0.7
<i>concinna</i> \times <i>raichei</i>	9	77.2 \pm 1.6
<i>raichei</i> \times <i>concinna</i>	3	81.9 \pm 3.1

petals of subsp. *raichei* are similar in overall length to those of subsp. *automixa*, but have much shorter middle and lateral lobes (Table 1, Fig. 1). In subsp. *raichei* the middle lobe of the petals typically constitutes 10–20% of the total length, and the lateral lobes are often indistinct on one or more petals; in subsp. *automixa* the middle lobe of the petal generally constitutes 20–40% of total petal length, and the lateral lobes are well-marked and separated from the middle lobe by deep sinuses. The shape of the middle lobe is also an important distinguishing feature. The maximum width of the middle petal lobe relative to the width at the “neck” of the lobe is greatest in subsp. *concinna*, intermediate in subsp. *automixa*, and smallest in subsp. *raichei* (Fig. 1). In subsp. *concinna* and to some extent in subsp. *automixa*, the middle lobe of the lower petal of each flower curves upward, possibly directing the angle of approach of pollinators. This trait is absent in subsp. *raichei*.

The dimensions given in Table 1 are representative for early to mid-season flowers on healthy well-grown plants. However, petal size in *C. concinna* is affected by environment, flower position, and plant phenological stage. We observed smaller petals on late flowers, on laterally positioned flowers, and on small plants. Bowman (1987) gave a petal length of 8–12(–17) mm for subsp. *automixa*; this is often typical of field-collected subsp. *raichei* also, but under favorable conditions both subspecies have much larger petals (Table 1).

The subspecies also differ in other characteristics. In subsp. *raichei*, the relatively short, broad sepals are deflexed $< \frac{1}{3}$ of the distance from the base, and are united for the upper $\frac{2}{3}$ of their length to give the “boat-shaped” calyx characteristic of many other species of *Clarkia*. In the other two subspecies, the sepals are longer and narrower, deflexed at or just below the midpoint, and united only near the tip. The subspecies also differ in overall growth form; subsp. *raichei* is compact and usually less than 1 dm tall, whereas vigorous

plants of subsp. *automixa* and subsp. *concinna* are generally much taller.

Vigorous F_1 progenies were obtained from all combinations of parental subspecies. In comparison with the parents, F_1 plants showed a moderate decrease of 14% to 24% in percentage of stainable pollen (Table 2), suggesting relatively little genetic divergence. *Clarkia concinna* subsp. *raichei* is diploid, with the same chromosome number ($2n = 14$) as in other taxa of section *Eucharidium*. The subspecies evidently differ little in chromosome arrangement, the most frequent cause of hybrid sterility between *Clarkia* species (Lewis 1973). The F_1 plants were fertile, and most were able to set substantial amounts of seed by self-pollination.

CONCLUSIONS

Clarkia concinna subsp. *raichei* is a localized self-pollinating race of *C. concinna* that is morphologically and geographically distinct from subsp. *automixa*, and probably arose separately from it. F_1 hybrids between all pairs of the three subspecies show a similar decrease in pollen fertility, suggesting that genetically the three taxa are about equally divergent from one another. Their infertility indicates that they are not separated by any major chromosome rearrangement. *Clarkia concinna* subsp. *raichei* is an early-flowering plant of dwarf stature that occurs in exposed habitats, and is presently known only from a single locality in Marin County. No other populations of this subspecies have been found, although subsp. *concinna* occurs nearby, in less exposed habitats further inland. We have designated the new taxon subsp. *raichei* in honor of Roger Raiche (Botanical Garden, University of California, Berkeley), who discovered it.

TAXONOMY

Clarkia concinna (Fischer & C. Meyer) E. Greene subsp. ***raichei*** G. Allen, V. Ford & L. Gottlieb, subsp. nov.—TYPE: California, Marin Co., 1.1 km S of Tomales on Hwy 1, on steep NW-facing talus slope between milepost markers 43.88 and 44.40, 13 Apr 1988, *Allen and Ford 1239* (holotype, DAV; isotypes, JEPS, MO, RSA).

Flores non proterandri; petala 10–22 mm longa, parvilobata, lobo medio 1–4 mm longo, lobis lateralibus brevioribus interdum indistinctis; sepala in parte $\frac{2}{3}$ distali deflexa connata.

Annual, stems ascending to erect, 0.5–2 dm tall, often branched. Leaves elliptic to ovate, 1–3 cm long, 5–10 mm wide, entire, reddish beneath. Flowers erect in bud, sessile. Sepals narrowly lanceolate,

8–14 mm long, 1–1.5 mm wide, deflexed $\frac{1}{4}$ to $\frac{1}{3}$ of distance from base, remaining united for upper $\frac{2}{3}$ of length. Petals bright pink, 10–22 mm long, with three short lobes, the middle lobe 1–4 mm, the lateral lobes often present only as a shoulder on the middle lobe. Stamens 4, approximately equal, surrounding the style. Stigma obscurely 4-lobed, receptive as anthers mature. Chromosome number $2n = 14$.

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