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Clover from Shasta County, California, U.S.A.**

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Trifolium piorkowskii (Fabaceae, Papilionoideae), a New Clover from Shasta County, California, U.S.A.

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ABSTRACT. A new species of clover is described, allied to *Trifolium fucatum* Lindl. and *T. depauperatum* Desv. *Trifolium piorkowskii* Rand. Morgan & A. L. Barber (Fabaceae, Papilionoideae) is an extremely rare clover that is apparently endemic to Shasta County, California, U.S.A. This new species differs from all other members of the *T. fucatum* complex in calyx and floral morphology, leaflet shape and markings, foliaceous stipules, and smooth seed coat. It also differs in range and habitat and has an eccentric nuclear ribosomal DNA ITS profile. *Trifolium piorkowskii* differs from the *T. depauperatum* complex in its relative robustness, leaf shape and markings, larger corolla size, the large acuminate involucre lobes, consistently forked calyx teeth, and larger seeds.

Key words: California, Fabaceae, IUCN Red List, Papilionoideae, *Trifolium*, U.S.A.

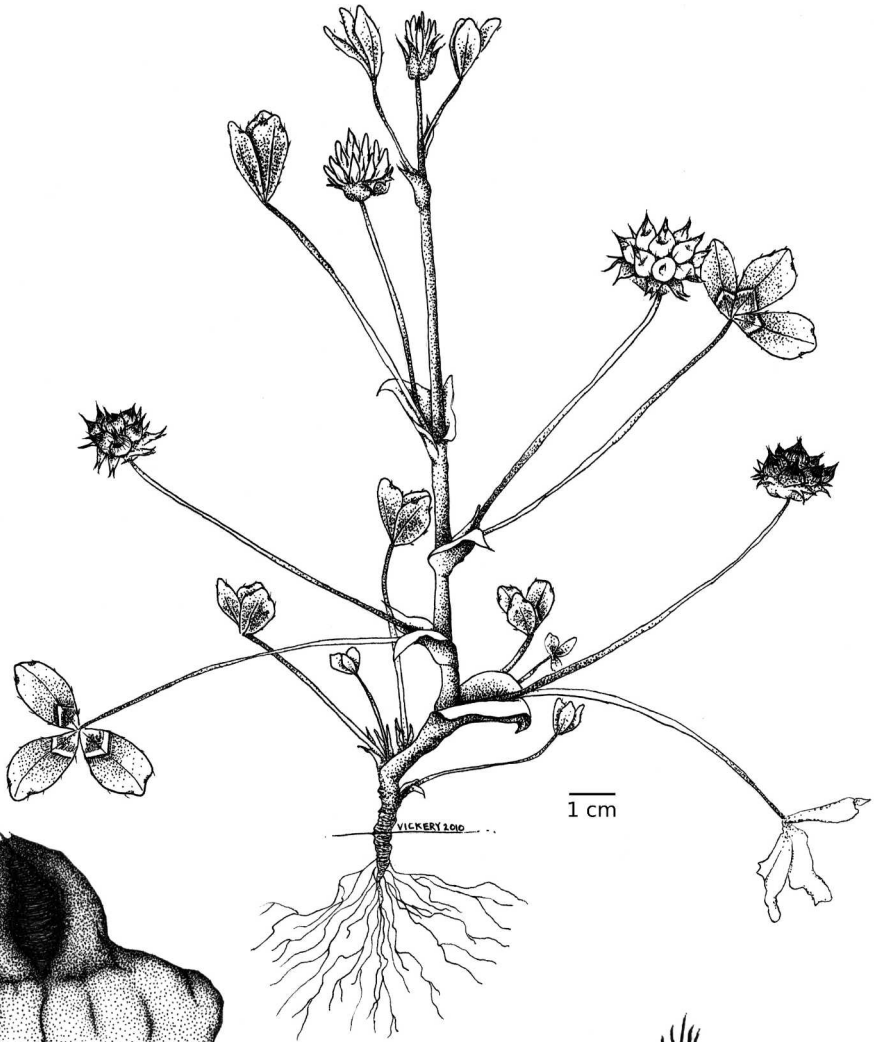
The *Trifolium fucatum* Lindl. complex is endemic to the lowland portions of the California floristic province. Despite its limited range and relative rarity, this group has proved to consist of a surprising number of discrete segregate taxa, each unique in ITS signature, morphology, habitat, and range. A study of this complex began in 1994, and it soon became clear that one of these segregates, *T. piorkowskii* Rand. Morgan & A. L. Barber, differed radically from all others in the group. The apparent sister-relationship of this species to the rest of the *T. fucatum* complex was later supported by a very distinctive ITS profile and by equally compelling morphological evidence based on a large-scale, common-garden study in 2008, in which over 100 accessions of *T. fucatum* s.l. were compared. *Trifolium piorkowskii* is described herein as a new species.

Trifolium piorkowskii Rand. Morgan & A. L. Barber, sp. nov. TYPE: U.S.A. California: Shasta Co., in a vernal pool, pasture field, ca. 250 yd. S of barn (& 300 yd. SW of barn), ca. 1/4 mi. S of Coleman Canal, 2.8 air mi. WSW of Darah Springs State Fish Hatchery, ca. 12 air mi. ENE of Cottonwood, 12 May 2003, L. Ahart & J. Dittes 10151 (holotype, JEPS; isotypes, CDA, CHSC, HSC, MO, MU, UCSC). Figure 1.

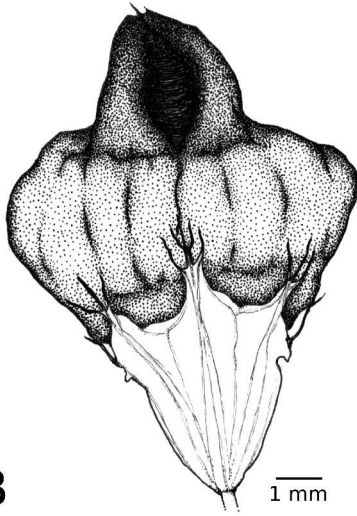
Haec species *Trifolio fucato* Lindl. affinis, a quo stipulis foliaceis, foliolis medianis non profunde lobatis, calycis tubo elongato plerumque plus quam 10-nervi ac dentibus regulariter furcatis, corollae tubo magnopere inflato atque seminibus testa laevi differt.

Glabrous annual clover, 7–20(–30) cm tall, erect or ascending, sparsely leafy, with 0 to 8 primary branches from base, rarely any secondary branches; stems ca. 5–15 cm (to 80 cm in cultivation), to 3.5 mm diam.; free portion of stipule lanceolate, herbaceous, entire, 1 cm; adnate basal portion of stipule with a dark purple spot. Petioles to 8(–12) cm, often with reddish blush distally; peduncles 5–15 cm, with reddish blush proximally and ca. equal to the subtending petiole. Leaflets 3, oblanceolate, at least those subtending the first inflorescence(s) shallowly 3- to 5-lobed and appearing erose; adaxial surface with a unique color pattern of faint pale stippling in distal 2/3; faint, thin, bicolored chevron near base; leaflets often developing a reddish wash extending from center toward margins but not obscuring the pale chevron (or entire leaf becoming red-purple on both surfaces when sun-stressed); largest leaflets to 2.8 × 1.9 cm; lateral veins ending in short marginal bristle. Inflorescences subglobose, with involucre 1.2–2.9 cm wide, with 3 to 16 flowers (generally 9 to 13) in 2 (1 to 3) whorls; involucre

A



B



C

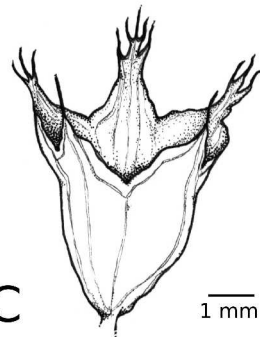


Figure 1. *Trifolium piorkowskii* Rand. Morgan & A. L. Barber. —A. Fertile habit. —B. Calyx showing teeth with floret removed. —C. Dry floret and calyx. Drawn from cultivated greenhouse plants (propagated from the type locality, L. Ahart & J. Dittes 10151), University of California, Santa Cruz, 2008.

consisting of 6 to 8 acuminate foliaceous lobes, entire-margined but often \pm split at apex. Calyx membranous, campanulate, 5–8 mm; tube 2.5–4 mm, with 5 principal nerves and 5 to 9 faint intermediate nerves; calyx teeth 5, acuminate to linear, the 3 lower

teeth 1–2.5 mm, each 3- to 5-forked and darker than the rest of the calyx, the upper 2 teeth shorter and often unbranched; flower buds pink in proximal 1/2, cream-colored in distal 1/2; corolla 1.1–1.3 cm, free distal portion ochroleucous at anthesis, the tube

portion pink or white depending on nighttime temperature, and much longer than the free banner; corolla tube partially enclosing the tiny wings and keel, the latter with an inconspicuous small pinkish spot on either side; style ca. 1.5 mm; ovules 2. Fruit a pod, 6 mm, including a 2 mm stipelike base, reticulately veined, translucent, indehiscent, remaining enclosed within the inflated corolla tube; seeds 0 to 2 per pod, 2.5 mm, gray-brown with blackish mottling; seed coat smooth.

Distribution and habitat. *Trifolium piorkowskii* occurs in the low foothills of the Cascade Range and upper Sacramento Valley in southern Shasta County and possibly in adjacent portions of Tehama County in northern California, at ca. 300–800 m. It occupies a habitat unlike that of any of the other *T. fucatum* segregates, preferring shallow vernal depressions on volcanic flats, or the banks of intermittent or perennial watercourses flowing through open rocky grassland, often with scattered blue oaks (*Quercus douglasii* Hook. & Arn.), or in transitional habitats with scattered chaparral and conifers at higher elevations. The species is evidently rare even within its limited range; the entire remaining population (of likely several thousand individuals) is currently known from two locations, one in the vicinity of the recently discovered type locality. While several herbarium specimens exist from other sites, Morgan and Piorkowski found no plants at any of these historical sites during searches in 1995 and 1996. At least one of the older collection sites was inundated by the Shasta Reservoir in 1941. A solitary plant was found at a new location off Ash Creek Road in 1997 (R. Morgan 4951). Seeds were collected from this plant and from plants at the type locality (UCSC seed accession numbers T414 and T413, respectively). Unlike most of its relatives, this species does not appear to occur in habitats subject to severe grass competition and, consequently, does not depend on grazing or other forms of periodic soil disturbance for its survival.

IUCN Red List category. *Trifolium piorkowskii* can be considered rare due to the very small and reduced number of locations. The habitat is vulnerable due to possible threats from livestock grazing, increasing human presence, and concomitant land-use changes. According to IUCN Red List criteria (IUCN, 2001) the new species is evaluated as Critically Endangered, qualified as CR B2bc(iii,iv,v). This assessment is based on the area of occupancy being estimated at less than 10 km²; continuing decline in habitat, locations, and number of mature individuals; and likely extreme fluctuations in

number of mature individuals (yearly fluctuations across several orders of magnitude are the norm for annual *Trifolium* L. species).

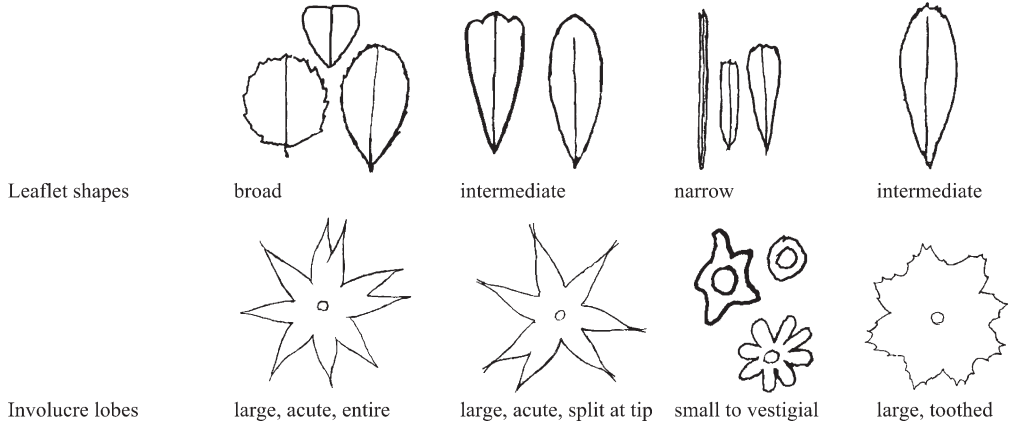
Phenology. *Trifolium piorkowskii* has been observed to flower in April and May. Flowers remain open only one day, after which the corolla tube becomes extremely inflated and retains its shape as it dries. Color is at first ochroleucous, then white (or uniformly soft pink if nights are chilly), eventually turning to pale tan and gradually to deep, rusty brown when dry, contrasting with the whitish calyx. The texture of the dry corolla is also distinctive, becoming tough, opaque, and papery rather than thin, translucent, and fragile as in other members of the *T. fucatum* complex.

Etymology. *Trifolium piorkowskii* is named in memory of Jeffrey M. Piorkowski (1961–2006), in gratitude for many years of assistance and support, including his assistance in locating this and other rare California clovers. Two vernacular names have been suggested: maverick clover in reference to the species' eccentric geographic range, morphology, and genotype; and marshmallow clover for the soft, inflated white flower heads.

Discussion. The differences between *Trifolium piorkowskii* and all other members of the *T. fucatum* complex are sufficient to place the new species in a basal or sister-clade relationship to the rest of the group. Of the many undescribed or unrecognized clover taxa known to the authors, this is easily the most distinctive species, both morphologically and genetically. In a large common garden experiment in 2008 and 2009, we measured 25 morphological traits in 102 accessions of *T. fucatum* s.l. from across California. In these trials, plants from our two accessions of *T. piorkowskii* exhibited a consistently unique suite of traits. The most conspicuously different features (exhibited in no other accessions) were the extreme inflation of the corolla tube, the elongated > 10-nerved calyx tube, foliaceous stipules, the regularly forked calyx teeth, the smooth seed coat, and the shallowly lobed middle leaves (see Fig. 1). Accessions of *T. piorkowskii* also exhibited statistically significant differences in phenology, leaf proportions and markings, cotyledon measurements, branching habits, floral markings, and measurements of inflorescence size (data from these trials to be published separately but available from the authors). The first collection of *T. piorkowskii* dates from 1894 (Baker & Nutting s.n.). Since that time, specimens of this species have been annotated with nearly every basionym available in the *T. fucatum* group (five

Table 1. Principal characters distinguishing four similar taxa of *Trifolium* L.

	<i>T. fucatum</i> s.l.	<i>T. piorkowskii</i>	<i>T. depauperatum</i> s.l.	<i>T. jokerstii</i>
Flower color at anthesis	white to yellow	white to pink	white to deep purple	golden yellow
Stems (max. diameter)	stout (4–8 mm)	intermediate (3.5 mm)	thin (2 mm)	intermediate (3 mm)
Indument	glabrous	glabrous	glabrous	calyx hairy
Stipules	± hyaline, entire	foliaceous, entire	foliaceous, entire	± hyaline, toothed
Lower calyx lobe	entire to irregular forks	regularly forked	entire	entire or forked
Calyx nerves	10	>10	5	5
Total teeth per calyx ¹	5 (rarely to 10) ²	11 to 14	5	5 to 7
Calyx tube (mm)	1–2	3–4	ca. 1	4–5
Number of ovules	2 to 6 ²	2	2 to 6 ²	2
Relative seed size ³	large (~3 mm)	large (~2.5 mm)	small (~1.5 mm)	large (~3 mm)
Seed coat	rough	smooth	lumpy or wrinkled	relatively smooth
Pod	dehiscent/indehiscent ²	indehiscent	indehiscent ⁴	indehiscent
Cotyledon blade ³	long, broad 9–11 × 5.9–6.9 mm	long, narrow 8.7–11 × 4.4–5.6 mm	short, narrow	long, narrow
Cotyledon petioles ³	short (4–13 mm)	long (12–18 mm)	unknown	long (13–25 mm)
Corolla size	medium to large 10–20 mm ²	medium 11–13 mm	small 4.5–9 mm	medium 10–15 mm
Breeding system	selfing to outcrossing ²	selfing	generally selfing	outcrossing

¹ Total number of ultimate bristle-tipped divisions on all five calyx lobes.² Dependent on the taxon.³ For *T. fucatum* Lindl. and *T. piorkowskii* Rand. Morgan & A. L. Barber, numbers are taken from common garden experiments; for *T. depauperatum* Desv. and *T. jokerstii* Vincent & Rand. Morgan, numbers are taken from the literature.⁴ With the exception of *T. depauperatum* var. *amplectens* (Torr. & A. Gray) Rattan.

basionyms have been published, all currently in synonymy under *T. fucatum*).

Two morphological variants are known for *Trifolium piorkowskii* that correspond to the two populations studied to date (Darah Springs and Ash Creek Road). Intra-taxon variability is nearly universal in California clovers, even among self-pollinating species like *T. piorkowskii*. These two forms differ markedly in cotyledon size, early stipule venation, phenology, and branching habit (one has a suppressed leader stem). This self-pollinating species is the only member of the *T. fucatum* complex to be consistently ignored by pollinating insects in common garden tests (other presumably selfing species have had occasional

insect visits in these tests). Nevertheless, the potential for outcrossing is indicated by one case of hybridization, apparently with the large-flowered North Coast Range member of the *T. fucatum* complex (Middle Creek Station, 31 May 1905, A. A. Heller s.n. [UC] 631104; this site was subsequently flooded by the Shasta Reservoir).

Genetically, *Trifolium piorkowskii* differs from its nearest relatives at 13 to 28 bp positions within the ITS region, in contrast to the typical one to six positions (Ellison et al., 2006). In fact, the ITS data (supported by 67 further samples of *T. fucatum*) appear to suggest a closer relationship to the *T. depauperatum* Desv. complex, despite the over-

whelming morphological affinity with the *T. fucatum* complex. *Trifolium piorkowskii* thus may be seen as an evolutionary link between the two groups. Indeed, this close relationship between *T. fucatum* s.l. and *T. depauperatum* s.l. has long been recognized, both complexes sharing several specialized features that include inflated corolla tubes, very short calyx tubes, and roughened seed coats (interestingly, *T. piorkowskii* itself is the only exception to the last two of these characters). The *T. fucatum* and *T. depauperatum* complexes have been historically combined, first by Nuttall (1848) as *Trifolium* subsect. *Physoanthes* Nutt., later by Lojaccono (1883) as *Trifolium* sect. *Physosemium* Lojac., then by McDermott (1910) as *Trifolium* sect. *Vesiculeae* McDermott. Nevertheless, *T. piorkowskii* keys readily in all references to *T. fucatum* (not *T. depauperatum*), and no collections have been annotated as *T. depauperatum*.

Some features of *Trifolium piorkowskii* are also similar to those of *T. jokerstii* Vincent & Rand. Morgan. Both are fairly small but showy annuals with open growth habit, long petioles and peduncles, relatively long calyx tube, inflated corolla, large, relatively smooth dark seed with black spots, and indehiscent pod with two ovules; both are narrow endemics of the upper Sacramento Valley in California. However, *T. jokerstii* has bright yellow, outcrossing flowers, a hairy calyx with larger teeth (only one of which is sometimes forked), variable leaf markings, lacinate fused involucre lobes, toothed stipules, and genetic markers that link it to the *T. barbigerum* Torr. complex. Table 1 details the differences between *T. piorkowskii*, *T. fucatum* s.l., *T. depauperatum*, and *T. jokerstii*.

Paratypes. U.S.A. **California:** Shasta Co., Shingle Creek, along Hwy. 44, ca. 1 mi. S along right-of-way of

Pacific Gas Pipeline, 25 Apr. 1990, *D. W. Taylor 10668* (JEPS); Redding, 11 Apr. 1911, *J. W. Blankinship s.n.* (JEPS); Anderson, Wildcat Rd. & Ash Creek Rd., 7 May 1983, *W. S. Lennon s.n.* (CAS, JEPS, RSA); near Middle Creek Station, 31 May 1905, *A. A. Heller s.n.* (UC); Morley's Station, 22 May 1894, *M. S. Baker & F. Nutting s.n.* (UC).

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