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PHYSARIA VITULIFERA, A TETRAPLOID SPECIES OF CRUCIFERAE

BY WILLIAM A. WEBER* AND JAMES L. BREWBAKER

Two species of the genus *Physaria*, family Cruciferae, are indigenous to Boulder County, Colorado. *Physaria australis* (Payson) Rollins is limited in its occurrence in the Boulder area to one or two isolated colonies on west-facing outcrops of shales of the Pierre formation at about 1700 m. altitude about four miles north of Boulder. Elsewhere in Colorado this species occurs most abundantly in the westernmost tier of counties, ranges north and east across the Red Desert of Wyoming, and enters Colorado again on the eastern side of the Rocky Mountains, penetrating as far south as Boulder County. *Physaria vitulifera* Rydberg is the more abundant species in the Boulder area, found on gravel sand and gravel loam soils of dry, sunny, usually south-facing slopes in the foothill canyons from 1800 m. to about 3000 m. altitude. *P. vitulifera* is endemic in the area between the Clear Creek and St. Vrain Creek drainages east of the Continental Divide. Both species occupy pioneer habitats. Their geographic ranges and ecological niches do not overlap. *P. vitulifera* is further isolated from *P. australis* by its earlier flowering period in comparable situations and altitudes. (See Fig. 1.)

Physaria australis and *P. vitulifera* are morphologically quite distinct. The former has numerous entire, fleshy basal leaves, 2-8 cm. long, with obovate, obtuse blades and broad petioles. The siliques are highly inflated, with shallow basal and apical sinuses, equal above and below, the locules being 6-10 mm. long. *P. vitulifera* has a few elongate, relatively thin basal leaves, 3-6 cm. long, the margins of which are deeply and broadly incised, oblanceolate to spatulate in outline with narrow petioles. The siliques are not highly inflated but somewhat angular, the sinuses unequal, the apical sinus broad, deep, and open, the locules being 4-8 mm. long (see Fig. 2, A and B).

Cytological studies of these species were begun in the spring of 1948. Young flowers of each species were fixed in Carnoy's fluid and were washed and stored in 70% alcohol. Belling's iron-aceto-carmin was used for making smears of young anthers. Drawings were made of microspore mother cells undergoing meiotic division, and of mitotic division in the developing pollen grains. The cytological study confirms Rollins' count (1939) of $n = 4$ for *Physaria australis* (see Fig. 3). *P. vitulifera* was found to be tetraploid with $n = 8$, the first known occurrence of this condition in the genus. Chromosome counts were made of individuals from several populations in Boulder County; in each instance, the tetraploid number was found

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see Fig. 4). Herbarium specimens documenting the counts are preserved in the University of Colorado Herbarium.

According to Rollins, the Colorado physarias fall into two groups of closely related species. *P. didymocarpa*, *P. condensata*, and *P. australis* comprise a primitive group with evolutionary tendencies culminating in *P. australis*. Only *P. australis* of this group enters Colorado. *P. vitulifera*, *P. floribunda*, *P. acutifolia*, and *P. Oster-*

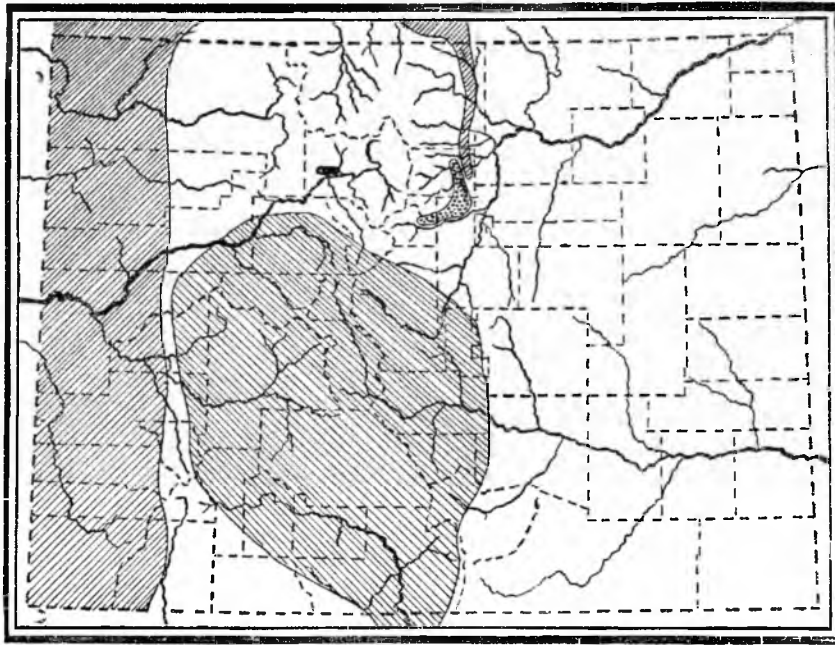


FIGURE 1. Approximate Colorado distribution of the species of *Physaria* discussed in this paper.



houtii comprise a more advanced group. In certain respects *P. australis* appears to connect the two groups. *P. australis*, *P. floribunda*, and *P. acutifolia* were found by Rollins to have four chromosome pairs.

Inasmuch as the tetraploid *P. vitulifera* and the diploid *P. australis* now occupy adjacent areas, the origin of the former from the latter or from the latter's successional ancestor might be postulated. This hypothesis, however, would imply a similar origin for the other diploid species, to which *P. vitulifera* is more closely

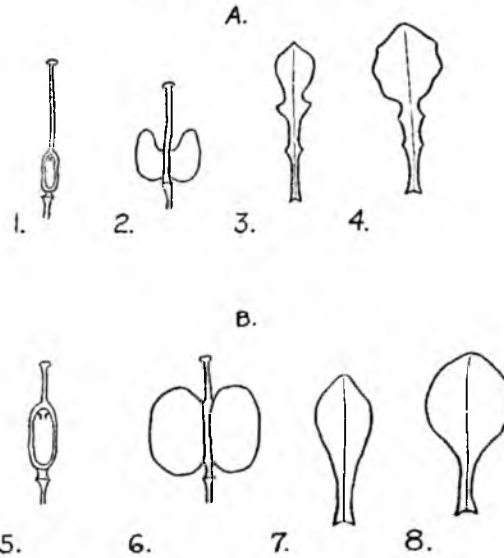


FIGURE 2. A. *Physaria vitulifera* Rydb.: 1, replum $\times 1\frac{1}{2}$; 2, silique $\times 1$; 3, immature leaf $\times \frac{1}{2}$; 4, mature leaf $\times \frac{1}{2}$. From Weber 13823.

B. *Physaria australis* (Payson) Rollins: 5, replum $\times 1\frac{1}{2}$; 6, silique $\times 1\frac{1}{2}$; 7, immature leaf $\times \frac{1}{2}$; 8, mature leaf $\times \frac{1}{2}$. From Weber 13867, 13864.

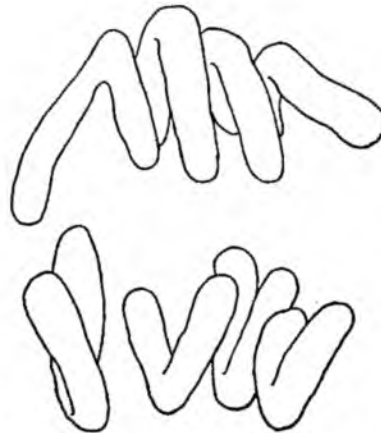


FIGURE 3. Anaphase chromosomes in developing pollen grain of *Physaria australis* (Payson) Rollins. $\times 4000$.

related morphologically. According to Rollins, the closest relatives of *P. vitulifera* are *P. floribunda* and *P. Osterhoutii*; "as a biological entity, the boundaries of *P. vitulifera* are seemingly well defined; however, recent connections with its relatives are strongly indicated." It therefore seems more logical to look to the other mem-

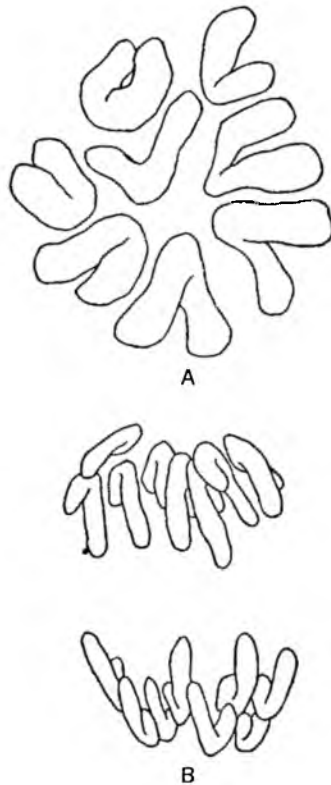


FIGURE 4. A. Configuration of chromosomes at first meiotic metaphase; *Physaria vitulifera* Rydberg. $\times 2900$.

B. Anaphase chromosomes in developing pollen grain of *Physaria vitulifera* Rydberg. $\times 2400$.

bers of the floribunda group for the origins of *P. vitulifera* than to the australis group, with which *P. vitulifera* bears little morphological relationship.

Physaria Osterhoutii Payson may reasonably be omitted from consideration at the present time. This species, known only from a few collections made at Kremmling and Sulphur Springs in Grand County, possesses characteristics connecting *P. vitulifera*, *P. floribunda*, and *P. acutifolia*. Rollins maintained this species with

hesitation, since it differs from *P. vitulifera* by minor features only. Future investigation may reveal the biological identity of this form and demonstrate whether or not *P. Osterhoutii* has played a part in the origin of the tetraploid under discussion.

If we accept Rollins' analysis of morphological relationship, it appears improbable that *P. vitulifera* arose by autopolyploidy from *P. australis*. A second possibility is an allopolyploid origin involving *P. australis* and *P. floribunda* or prototypes. However, the very close morphological relationship of *P. vitulifera* to the floribunda group alone makes a third alternative more plausible. The third possibility is that *P. floribunda* or its successional predecessor once ranged farther north and east than it does at the present time; that this population gave rise to an autotetraploid race on the northeastern periphery of its range; and that the tetraploid persisted in the area while the diploid was driven subsequently farther south and west. Since no irregularities have been discovered in the meiosis of the tetraploid, it may be concluded that *P. vitulifera*, whatever its origin, has now achieved the status of a functional allopolyploid.

LITERATURE CITED

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