MASON, C. T. 1952. A systematic study of the genus Limnanthes. Univ. Calif. Publ. Bot. 25:455–512.

————. 1959. A hybrid among the perennial gentians. Brittonia 10:40–43.

MUNZ, P. A. 1959. A California flora. Univ. Calif. Press. Berkeley.

PECK, M. E. 1941. A manual of the higher plants of Oregon. Binford and Mort, Portland.

CHROMOSOME COUNTS IN THE SECTION SIMIOLUS OF THE GENUS MIMULUS (SCROPHULARIACEAE). IV.

BARID B. MUKHERJEE AND ROBERT K. VICKERY, JR.

This report[1] on the determination of chromosome numbers in the section *Simiolus* of the genus *Mimulus* is part of a long range investigation into the evolution of species in *Mimulus* (Vickery, 1951). The chromosome numbers and configurations presented in this article indicate a lack of cytological differentiation between several of the currently accepted species (Pennell, 1951) of the section *Simiolus*. Also they reveal the presence of aneuploidy in different populations of two other species, and, lastly, they fill an important gap in the previously indicated (Mukherjee and Vickery, 1959) polyploid series that extends from North to South America.

Essentially the same method of bud fixation was employed as in the previous investigation (Mukherjee and Vickery, 1959), i.e., fixation in two parts absolute ethanol to one part glacial acetic acid saturated with ferric acetate, followed by staining of the anthers in iron-aceto-carmine. Work now in progress indicates that there may be possible improvements in this schedule. Each chromosome number determination is based on counts from an average of approximately eight pollen mother cells. Camera lucida drawings were made for three or four figures for each count and, in addition, photomicrographs were taken of many of the configurations. Herbarium specimens of each culture have been or will be deposited in the Garrett Herbarium of the University of Utah (UT).

---

[1] This work was supported by the National Science Foundation. Part of it was included in the dissertation of the senior author submitted to the Faculty of the University of Utah in partial fulfillment of the requirements for the Ph.D. degree.

The authors wish to thank the following people who made this study possible by so kindly gathering seeds or living plants for them: Lawrence Beane, Martin Brown, Annetta Carter, Norman V. Chamberlain, Jens Clausen, John L. Creech of the Plant Introduction and Exploration Division of the United States Department of Agriculture, William M. Hiesey, Richard W. Holm, Carl L. and Laura C. Hubbs, David D. Keck, Oliver Norwell, George T. Oberlander, the late Francis W. Pennell, Carl W. Sharsmith, G. Ledyard Stebbins, Jr., H. J. Venema, Delbert Wiens, and Ira L. Wiggins.

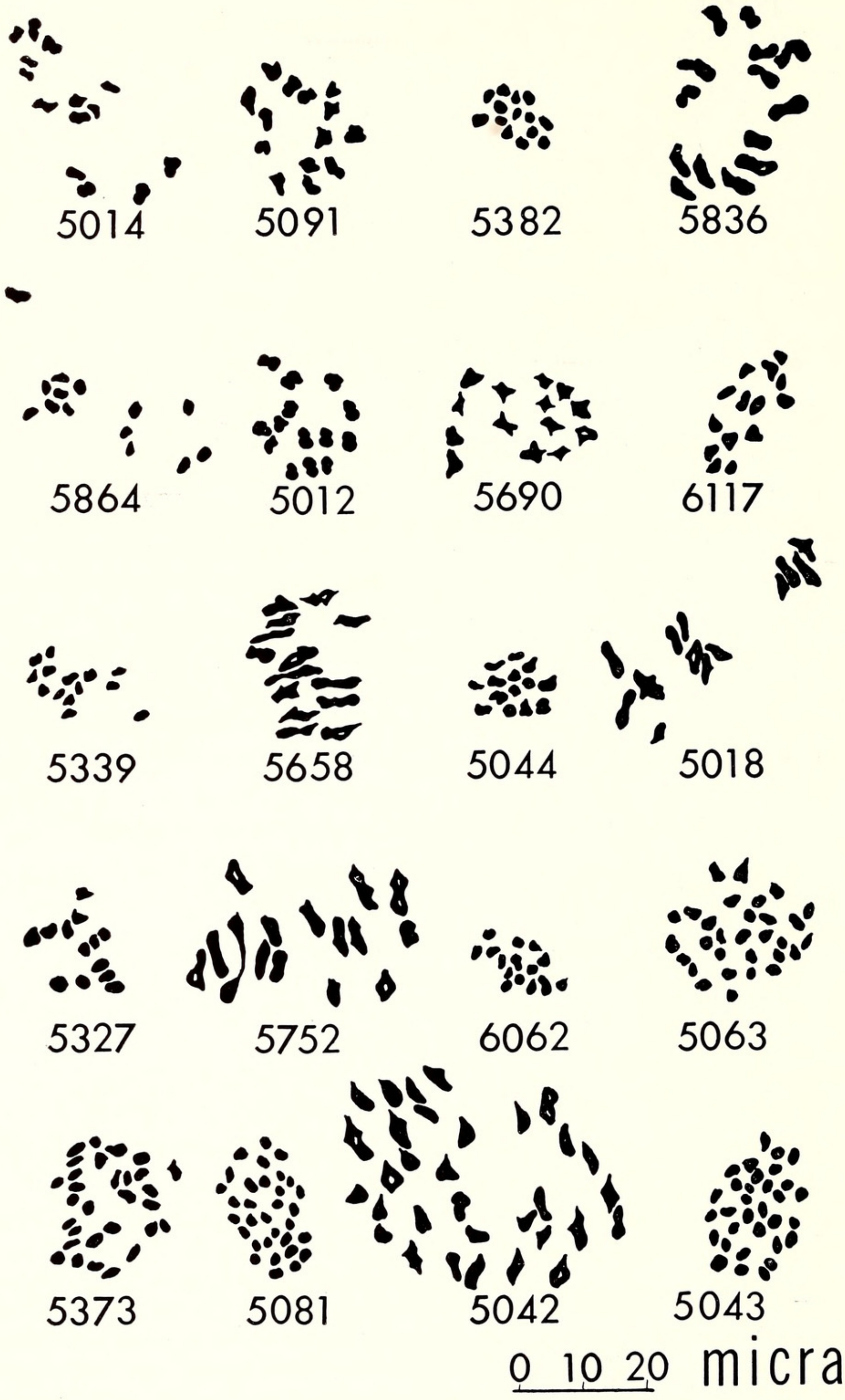

FIG. 1. Meiotic chromosomes of *Mimulus*: *M. guttaus*, 5014, 5091, 5382, 5836, 5864; *M. tilingii* var. *tilingii*, 5012, 5690, 6117; *M. laciniatus*, 5339; *M. laxus*, 5658; *M. nasutus*, 5044, 5018, 5327; *M. platycalyx*, 5752; *M. glabratus* var. *utahensis*, 6062; *M. glabratus* var. *fremontii*, 5063, 5373; *M. tigrinus*, 5081; *M. luteus*, 5042, 5043. All cells are in or near second metaphase except 5382, 5836, 5012, 5690, 5658, 5018, and 5752, which are in first metaphase. (Camera lucida drawings as reproduced, = × 840).

A total of thirty-three cultures was studied during the present investigation (see table 1). They include representatives of ten species and varieties of the section *Simiolus*: *Mimulus guttatus* DC., *M. tilingii* Regel var. *tilingii*, *M. laciniatus* Gray, *M. nasutus* Greene, *M. laxus* Pennell, *M. platycalyx* Pennell, *M. glabratus* var. *utahensis* Pennell, *M. glabratus* var. *fremontii* (Benth.) Grant, *M. tigrinus* hort., and *M. luteus* L.

All fifteen cultures of *M. guttatus* were found to have n=14 chromosomes. The configurations were regular and similar to those previously observed for other cultures of *M. guttatus* (Vickery, 1955; Muhkerjee, Wiens, and Vickery, 1957; Mukherjee and Vickery, 1959) and, therefore, only a few of the camera lucida drawings of *M. guttatus* chromosomes were included in figure 1. The fifteen cultures examined represent much of the geographical range of *M. guttatus* (see table 1) and much of its morphological and physiological diversity as well. Morphologically the cultures differ from each other in the average height of the plants, shape of the leaves, amount and distribution of anthocyanin pigmentation, and in the size of the flowers. Physiologically they differ in growth rates, time and speed of flowering, and time and speed of maturing seeds. Cytologically the only detectable difference observed among the fifteen cultures was the presence of marked chromosome stickiness under the present fixation schedule in two of the annual races. Despite the wide range of morphological and physiological differences between the various cultures, they all exhibit apparently similar karyotypes.

The chromosome numbers of six cultures of *M. tilingii* var. *tilingii* from the Sierra Nevada (see table 1) were found to be n=14 as in *M. guttatus*. *Mimulus tilingii* var. *tilingii* is related to *M. guttatus* on the basis of morphology (Hitchcock, Cronquist, Ownbey and Thompson, 1959), but is separated from it by strong crossing barriers (Vickery, 1956). The chromosome configurations of the six cultures were regular and similar to those of *M. guttatus* and to our first *M. tilingii* var. *tilingii* count (Vickery, 1955), but differed in number from our more recent report of n=15 for a Utah population of *M. tilingii* var. *tilingii* (Mukherjee and Vickery, 1959). The populations studied represent much of the morphological diversity present in *M. tilingii* var. *tilingii* in the Sierra Nevada (table 1).

Mimulus laciniatus and *M. laxus*, species that are genetically closely related to *M. guttatus* (Vickery, 1956, and unpublished), were found to have n=14 chromosomes as does *M. guttatus*. The karyotypes of the three species are apparently indistinguishable. *Mimulus laciniatus* is morphologically strikingly different from *M. guttatus*, whereas *M. laxus* is closely similar. Probably *M. laciniatus* should be treated as a variety of *M. guttatus*, while *M. laxus* should be considered as synonymous with *M. guttatus*.

The chromosomes of three cultures from widely scattered populations (see table 1) of *M. nasutus* were counted. Two of the cultures have n=13 chromosomes and the third has n=14, which confirms the previous de-

Table 1. Chromosome Counts in Mimulus, Section Simiolus

$n=14$ *M. guttatus* DC.

- Barry Summit, Humboldt County, California, altitude 3,400 feet, *Keck 6007* (5005).
- Yosemite Junction (rocky creek), Tuolumne County, California, altitude 1300 feet, *Hiesey 560* (5006).
- Lee Vining Canyon, Mono County, California, altitude 8000 feet, *Clausen 2039* (5014).
- Kern River, Kern County, California, altitude 1000 feet, *L. Bean,* April 16, 1949 (5085).
- Botanic Garden strain, Hortus Cluj, Romania (5091).
- Rio Santo Thomas, Baja California, Mexico, altitude ca. 20 feet, *C.* and *L. Hubbs,* spring 1950 (5382).
- San Dimas Canyon, Los Angeles County, California, altitude 1500 feet, *R. K. Vickery, Jr.,* September 29, 1950 (5678).
- Hugh's Canyon, Salt Lake County, Utah, altitude 6000 feet, *N. Chamberlain,* spring, 1952 (5836).
- Skagg's Springs, Sonoma County, California, altitude ca. 50 feet, *R. Holm,* spring, 1951 (5864).
- Old Mine, Big Cottonwood Canyon, Salt Lake County, Utah, altitude 7650 feet, *Vickery 683* (5961).
- Neff Canyon, Salt Lake County, Utah, altitude 5500 feet, *D. Wiens,* September 6, 1956 (5995).
- Moab, Grand County, Utah, altitude 4100 feet, *Vickery 762* (6080).
- Cane's Spring, San Juan County, Utah, altitude 5800 feet, *Vickery 763* (6081).
- Ledgemere, Big Cottonwood Canyon, Salt Lake County, Utah, altitude 5100 feet, *Vickery 880* (6082).
- East Creek, Morgan County, Utah, altitude 5700 feet, *Vickery 883* (6083).

$n=14$ *M. tilingii* Regel var. *tilingii*

- Slate Creek (near Carnegie Transplant Garden), Mono County, California, altitude 10,000 feet, *Clausen 2075* (5012). (In flower at time 6120, 6121, 6122 were collected in bud.)
- Budd Lake, Tuolumne County, California, altitude 10,250 feet, *C. W. Sharsmith,* September 13, 1950 (5690).
- Tributary to Slate Creek (near Carnegie Transplant Garden), Mono County, California, altitude 10,050 feet, *Vickery 1379* (6117).
- Slate Creek (near Carnegie Transplant Garden), Mono County, California, altitude 10,000 feet, *Vickery 1382* (6120). (Light green, large leaves.)
- Same locality—*Vickery 1383* (6121), dark green, medium sized leaves.
- Same locality—*Vickery 1384* (6122), dark green, small leaves.

$n=14$ *M. laciniatus* Gray

- Lake Eleanor road, Tuolumne County, California, altitude 4200 feet, *Vickery 179* (5339).

$n=14$ *M. laxus* Pennell

- Yreka, Siskiyou County, California, altitude 3000–3200 feet, *Pennell 26163* (5658).

$n=14$ *M. nasutus* Greene

- Hasting's Reservation, Monterey County, California, altitude 1500 feet, *Stebbins 701* (5044).

$n=13$ *M. nasutus* Greene

- San Augustine Pass, Dona Ana County, New Mexico, altitude 4500 feet, *O. Norwell,* October 30, 1946 (5018).
- Wild Cat Creek, near Yosemite Junction, Tuolumne County, California, altitude 475 feet, *Vickery 168* (5327).

n=15 *M. platycalyx* Pennell
Crystal Lakes Reservoir, San Mateo County, California, altitude 800 feet, *G. Oberlander,* April, 1951 (5752).
n=15 *M. glabratus* var. *utahensis* Pennell
Johnson Pass, Tooele County, Utah, altitude 5800 feet, *D. Wiens,* October, 1956 (6062).
n=30 *M. glabratus* var. *fremontii* (Benth.) Grant
Whipple Mountains, San Bernardino County, California, collected April 21, 1940. U.C. 667,449 (5063).
Kakernot Springs, Alpine Creek, Brewster County, Texas, *Cory 53186,* May 18, 1946 (5373).
n=32 *M. tigrinus* hort.
Garden seed from the "Carlos Thays" Botanic Garden, Buenos Aires, Argentina (5081).
n=32 *M. luteus* L.
Vicinity of Illapel, Coquimbo, Chile, altitude 6200 feet, *Plant Introduction and Exploration Division (U.S.D.A.) no. 144,535* (5042).
n=30+0, 1, or 2 *M. luteus* L.
Vicinity of Illapel, Coquimbo, Chile, altitude 2000 feet, *Plant Introduction and Exploration Division (U.S.D.A.) no. 144,536* (5043).

termination by G. L. Stebbins, Jr. (personal communictation) for the same culture. The n=13 cultures exhibit partial crossing barriers with *M. guttatus,* whereas the n=14 culture crosses readily with *M. guttatus* (Vickery, 1956, unpublished). The cytologic and crossing results suggest to us that *M. nasutus* as presently described (Grant, 1924, and Pennell, 1951) includes at least two different entities. The proper naming of these entities must await further investigation and a detailed study of the taxonomic literature and type specimens of *M. nasutus* and and its relatives.

Culture 5752, which was found to have n=15 chromosomes, was identified as *M. platycalyx* with some misgivings. Although the plants clearly exhibit Pennell's main key character of "fruiting calyces being fully as wide as long," yet the corolla throats are open and not filled by "a palate nearly closing orifice" (Pennell, 1951). Furthermore, Pennell had described *M. platycalyx* as occurring in the "southern Sierra Nevada from Mariposa to Tulare County, California," whereas the plants from which culture 5752 were grown came from the Crystal Lakes region of the outer Coast Ranges of California. However, even if this culture does not properly belong to *M. platycalyx*, it does represent an entity that is distinct from *M. guttatus* on the basis of morphology, crossing behavior (Vickery, 1956, in press), and cytology. Here again a sound taxonomic decision must await further critical study of this entity and the literature.

The culture of *M. glabratus* var. *utahensis* (6062) from the Stansbury Mountains near the Great Salt Lake had n=15 chromosomes as did culture 5265 from the population at Bicknell, Wayne County, Utah (Mukherjee, Wiens, and Vickery, 1957). In contrast, the population from the shore of Mono Lake at the western edge of the Great Basin has n=14 chromosomes (Vickery, 1955). Perhaps *M. glabratus* var. *utahensis* also consists of two morphologically similar but cytologically different entities as does *M. nasutus,* although corroborative crossing data is not yet available.

Two cultures of *M. glabratus* var. *fremontii* from southern California and Texas were found to have n=30 chromosomes, although some of the plants of culture 5063 were observed to have as few as n=26 chromosomes. This chromosome number fills an important gap in the polyploid series connecting the Great Basin form, *M. glabratus* var. *utahensis,* n=14 and n=15, with the South American *M. glabratus* var. *parviflorus* (Lindl.) Grant, n=45, and its ally *M. pilosiusculus* HBK., n=46 (Mukherjee and Vickery, 1959). *Mimulus glabratus* var. *fremontii* is approximately intermediate in appearance between the other two varieties. It is 5 to 15 centimeters in height, whereas *M. glabratus* var. *utahensis* varies from 10 to 50 centimeters, and *M. glabratus* var. *parviflorus* is nearly prostrate. The leaves and flowers of *M. glabratus* var. *fremontii* are smaller than those of *M. glabratus* var. *utahensis* but larger than those of *M. glabratus* var. *parviflorus.* A broader cytogenetic and taxonomic study of the *Mimulus glabratus* complex of species is now being undertaken.

The culture of *M. tigrinus* from the Botanic Garden of Buenos Aires, Argentina, was found to have n=32 chromosomes. This count agrees with the previous reports of Brozek (1932), Sugiura (Darlington and Wylie, 1955) and the authors (1959).

Chromosome counts obtained for two different cultures of *M. luteus* tend to support the previously indicated relationship of the horticultural species, *M. tigrinus,* to this wild species (Mukherjee and Vickery, 1959). Culture 5042 has n=32 chromosomes on the basis of two plants studied whereas culture 5043 was variable on the basis of the five or six plants examined. Of the twenty-three cells studied eleven had n=30 chromosomes, six had n=31 and six had n=32. The cause of the variability was not clear from the data obtained. Perhaps accessory chromosomes are involved. Tentatively, the chromosome number for this culture appears to be n=30+0, 1 or 2. The two cultures of *M. luteus* are morphologically similar, but are distinguishable on the basis of flower markings and the general growth habits of the plants.

In conclusion, this survey of chromosome numbers in section *Simiolus* has verified previously published counts for *M. guttatus* (n=14), *M. tilingii* var. *tilingii* (n=14, *M. glabratus* var. *utahensis* (n=15) and *M. tigrinus* (n=32). It has shown that two species that are genetically closely related to *M. guttatus, M. laciniatus* and *M. laxus,* have n=14 chromosomes also. In contrast, the culture, tentatively assigned to *M. platycalyx,* which is morphologically closely related to *M. guttatus* but genetically partially separated from it, has n=15 chromosomes. *Mimulus nasutus* appears to consist of two entities, one with n=14 chromosomes that is genetically closely related to *M. guttatus,* and the other with n=13 chromosomes that is genetically partially isolated from *M. guttatus* and from the n=14 form of *M. nasutus. Mimulus glabratus* var. *fremontii* was found to have n=30 chromosomes, which neatly fills an important gap in the polyploid series of *M. glabratus* var. *utahensis*, n=15, to *M. glabratus* var. *parviflorus*, n=45. Lastly, one race of South American *M. luteus* has n=32 chromosomes, as had been previously reported for its horticultural derivatives, but the other race apparently has n=30+0, 1, or 2.

Department of Genetics and Cytology
University of Utah, Salt Lake City

Literature Cited

BROZEK, A. 1932. Mendelian analysis of the "red- orange-yellow" group of flower colors in Mimulus cardinalis Hort. Preslia 11:1–10.

DARLINGTON, C. D. and A. P. WYLIE. 1955. Chromosome atlas of flowering plants. Allen and Unwin Ltd. London. 519 pp.

GRANT, A. L. 1924. A monograph of the genus Mimulus. Ann. Missouri Bot. Gard. 11:99–388.

HITCHCOOK, C. L., A. CRONQUIST, M. OWNBEY and J. W. THOMPSON. 1959. Vascular plants of the Pacific Northwest. Univ. Wash. Press, Seattle. 516 pp.

MUKHERJEE, B. B. and R. K. VICKERY, JR. 1959. Chromosome counts in section Simiolus of the genus Mimulus (Scrophulariaceae). III. Madroño 15:57–62.

MUKHERJEE, B. B., D. WIENS, and R. K. VICKERY, JR. 1957. Chromosome counts in Section Simiolus of the genus Mimulus (Scrophulariaceae). II. Madroño 14:128–131.

PENNELL, F. W. 1947. Some hitherto undescribed Scrophulariaceae of the Pacific States. Proc. Acad. Phila. 99:155–199.

————. 1951. *In* Illustrated Flora of the Pacfic States by LeRoy Abrams. Stanford Univ. Press. Vol. III, pp. 688–731.

VICKERY, R. K., Jr. 1951. Genetic difference between races and species of Mimulus. Carnegie Institution of Washington Year Book 50:118–119.

————. 1955. Chromosome counts in section Simiolus of the genus Mimulus (Scrophulariaceae). Madroño 13:107–110.

————. 1956. Data on interracial and interspecific hybridization in the section Simiolus of the genus Mimulus (Scrophulariaceae). Utah Acad. Proc. 32:45–64.

————. 1959. Barriers to gene exchange between the species of the Mimulus *guttatus* complex. Evolution 13:300–310.

FLOWERING RESPONSES IN PHACELIA SERICEA AND P. IDAHOENSIS[1]

GEORGE W. GILLETT

In the study of variation in the *Phacelia sericea* complex [*P. sericea* (Graham) A. Gray subsp. *sericea*; *P. idahoensis* Henderson; and intermediates], experimental cultures of *P. sericea* subsp. *sericea* and of *P. idahoensis* could not be brought into flower under actual or simulated summer conditions. In these cultures, the daily photoperiod was extended by incandescent lights, when necessary, to between 16 and 20 hours. Later cultures were brought into flower, however, by simulating the fall conditions of the natural environment to the extent of materially reducing

[1] Supported by grant G–3886, National Science Foundation.