NOTES ON THE SOMATIC CHROMOSOMES OF THE SEVEN-CHROMOSOME GROUP OF FRAGARIA

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INTRODUCTION

In continuing the work of MANGELSDORF and EAST (1927) and of ICHIJIMA (1926) on the collection of *Fragaria* at the BUSSEY INSTITUTION, it was thought desirable to make a more detailed study of the somatic chromosomes. The different *Fragaria* species have been found to fall into three groups according to their chromosome number by LONGLEY (1926), and by ICHIJIMA (1926). The basic chromosome number for the genus is seven. The species thus far reported in the diploid group are: *Fragaria vesca* (a number of varieties), *F. californica*, *F. mexicana* and *F. bracteata*. Five more species are now to be added to this group.

MATERIAL AND METHOD

Plants of the above mentioned species used are from the stock described by MANGELSDORF and EAST (1927). The following additional diploid species are under study: *Fragaria collina*, *F. maxima*, *F. nilgerrensis*, and two other species as yet unidentified. Another plant received from Albert Etter in California under the name of *F. Duchesnea* has fourteen somatic chromosomes. He states that it came originally from China. It corresponds very closely to our specimens of *F. nilgerrensis*.

Fragaria collina Ehrh. The description of EHRHART (1792) is brief: "Calyx fructus erectus. Folia acute serrata, utrinque pubescentia." "Serraturae ovato-lanceolatae; extima proximis brevior. Pubescentia petiolorum patentissima, pedunculorum erecta." The leaflets are longer in comparison to width and more acute than is found in the other seven-chromosome species. The petioles are moderately long. The leaves are

somewhat thinner than those of *F. virginiana*. The flowers are white, hermaphroditic and rather small; but larger than those of the *vesca* type. It is indigenous to central Europe. Our plants were obtained from Vilmorin, Andrieux and Company, Paris.

F. maxima is very similar to *F. collina*. The leaves are possibly somewhat larger, but the general appearance is much the same. The plants are believed to have come from the botanic garden at Tiflis, Russia.

F. nilgerrensis Schlecht. In leaf and flower shape this species shows a similarity to certain varieties of the 28-chromosome species, *F. chilensis*. The leaflets are obovate, of moderate size, with a heavy pubescence especially below and on the leaf-stalk. The flowers are large; the petals white with a pink blush. The scapes are short, carrying three to four flowers. The stamens are much shorter than the large receptacle. These plants came to us from the UNITED STATES DEPARTMENT OF AGRICULTURE and were originally obtained from Vilmorin Andrieux and Company who say of them:

"This form is close to *Fragaria nilgerrensis*; it has the same foliage and the same small white fruits with darker seeds, but it is more vigorous, and the fruits might be considered as edible, whereas in the type their taste is unpleasant."

It is a native of India and Southeastern Asia, in mountainous and temperate regions.

Fragaria sp. (FPI 64856). Plants under this label were received from Mr. G. M. DARROW of the UNITED STATES DEPARTMENT OF AGRICULTURE last year. He states that they "were grown from seed which Mr. DORSETT purchased in a market in Hingan, Manchuria, the fruits having been gathered in the hills nearby."

The plants somewhat resemble the *collina* type, but the leaflets are much less acute and the scapes are much shorter. The leaves are darker green than those of either *F. vesca* or *F. collina*. The flowers are of moderate size and are white, tinged with yellow at the base of each petal.

Fragaria sp. (429) Two Hawaiian species were kindly sent to us by Doctor A. J. MANGELSDORF. The one given the stock number 429 proved to be diploid. The flowers are similar to those of *F. vesca*, being small and white. The scapes are about the same length as the leaf stalks. The fruit is white, almost acute in shape. The seeds are prominent and are straw-colored. The leaves are large, the margins coarse-toothed. They are scantily pubescent and moderately thin in texture. The leaf stalk is heavily pubescent.

EXPLANATION OF PLATES

The first 22 figures show methaphase chromosomes; the last six show prophases. All are taken from somatic divisions in the root tips.

PLATE 1

FIGURE 1.—*F. vesca* (from Ecuador).

FIGURE 2.—*F. mexicana*.

FIGURE 3.—*F. bracteata*.

FIGURE 4.—*F. collina*.

FIGURE 5.—*F. maxima*.

FIGURE 6.—*F. sp.* (FPI 64856).

FIGURE 7.—*F. Duchesnea*.

FIGURE 8.—*F. Californica*.

FIGURE 9.—*F. nilgerrensis*.

Root tips were fixed in Flemming's strong and weak solutions good results being obtained with both. Other fixatives such as Bouin's solution, its modification by Allen, Carnoy's solution, etc., proved unsatisfactory, although ICHIJIMA reports good results with Allen's formula. The sections were cut from 6 to 8 microns thick, usually the latter. Haidenhain's iron-haematoxylin was used in staining. All drawings were made with the aid of the camera lucida, using a 1.5 mm. Spencer apochromatic objective; tube length 160 mm. Figures 23 to 29 were drawn with a $\times 10$ ocular, the rest with an $\times 18$.

SIZE RELATIONSHIPS AMONG THE CHROMOSOMES

An attempt was made to find constant differences in chromosome shape. Similar shapes were found in many cells, but they apparently were not confined to chromosomes of the same relative length. Two chromosomes of about the same length in a cell often show a striking similarity in shape (See figure 7).

The only difference among the chromosome pairs that remains at all constant is that of relative length. Even size differences are not always clearly apparent. The small size of the chromosomes, their shape, and often their position, make an estimate of length difficult. On the whole the chromosomes of the different species are very similar considering their wide geographic distribution, the diversity of their morphological characters, and their breeding behavior.

The seven pairs can be arranged into an evenly graded series. Measurement with an ocular micrometer of fourteen metaphase plates gives the following average lengths in microns: 1.7; 1.5; 1.4; 1.3; 1.2; 1.0; 0.9. It is usually easy to distinguish the two shorter ones and at least the longest pair. The measurements with the ocular micrometer were checked from the drawings by the use of a scale made with a camera lucida from a stage micrometer at the same magnification as the drawings.

ASSOCIATION OF CHROMOSOME HOMOLOGS

Somatic association of homologs seems to be most complete in the *Diptera* (METZ 1916). It has, however, been noted in numerous plant genera (STRASBURGER, CL. MÜLLER, STOMPS, NEWTON, OVERTON and others). The most recent observation that has come to my attention is that on *Zea mays* by FISK (1927). She seems to have found much the same situation in her material that is evident in *Fragaria*. While pairing is unmistakable it is far from universal. What may be seen in *Fragaria* is a frequent association of chromosomes not only of equal or nearly equal length, but very

PLATE 2

FIGURES 10-19.—The chromosomes of the first nine figures are here arranged in pairs according to length.

FIGURE 20.—*F. nilgerrensis*, showing end-to-end arrangement of the chromosomes. Fifteen chromosomes can be counted.

FIGURE 22.—*F. sp.* (429).

FIGURES 23-25.—*F. nilgerrensis*, showing the tendency for association in the prophase.

Figures 24 a and b are from the same cell.

FIGURES 26 and 27.—*F. collina*.

FIGURE 28.—*F. vesca*. None of the prophase figures (23-28) show the complete chromosome complement.

often of similar shape. In some cells this can be seen for all of the chromosomes (figure 22), more often for four or five pairs. Occasionally no pairing can be detected. These observations are based on an examination of well over a hundred metaphase plates. The first nine figures were not selected to show pairing. The relationship may be either end-to-end or parallel.

Figure 20 gives the suggestion of a continuous end-to-end arrangement, but if this is the normal occurrence it is a stage of very short duration. There was also evidence of an end-to-end arrangement in *Zea mays*. "Many cells were found in which a number of the chromosomes were arranged end-to-end as though they had just been separated by the segmentation of a spirem." (FISK 1927, p. 58).

An examination of the prophases for "pairing" is complicated by the facts that the chromosomes are not in a convenient position for observation and that they do not differentiate as clearly as in the metaphase. I did not find the sort of association here as reported by STOMPS (1911) working on *Spinacia oleracea* and by NEWTON (1924) on *Galtonia*; but there is some evidence of attraction as shown in figures 23 to 29. This association seems to be due not to a mechanical attachment holding over from an early spireme stage but to a mutual affinity.

The writer wishes to acknowledge the kind help and guidance of Doctor E. M. EAST in carrying on the *Fragaria* studies. Thanks are also due Doctor A. J. MANGELSDORF and Professor M. CHRISTOFF for assistance during the early part of the work.

SUMMARY

1. Five new species, *Fragaria collina*, *F. maxima*, *F. nilgerrensis* *F. sp.* (FPI 64856) and *F. sp.* (429) are added to the diploid group with 14 somatic chromosomes.
2. The somatic metaphase chromosomes form a graded series according to length.
3. Association of homologs in the somatic tissue is evident in all of the species of this group.

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