CHROMOSOME RACES IN *CARDAMINE PRATENSIS* IN THE BRITISH ISLES

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Introduction

Cardamine pratensis L. is a highly variable species in its morphological characters, particularly in the type of flower. The prevailing type of flower is single, but some forms occur bearing completely sterile double flowers, with all the floral parts, except the calyx, petaloid. Another sterile double variant was recorded by Blackburn (1922) in which the flower resembles that of the double form of *Arabis caucasica* in that each flower repeats itself several times by a median bud ("Arabis type"). In 1923 she also noted, in Northumberland, the occurrence of a "semidouble" type, in which the ovary becomes swollen and bursts into a double or an incompletely fertile flower.

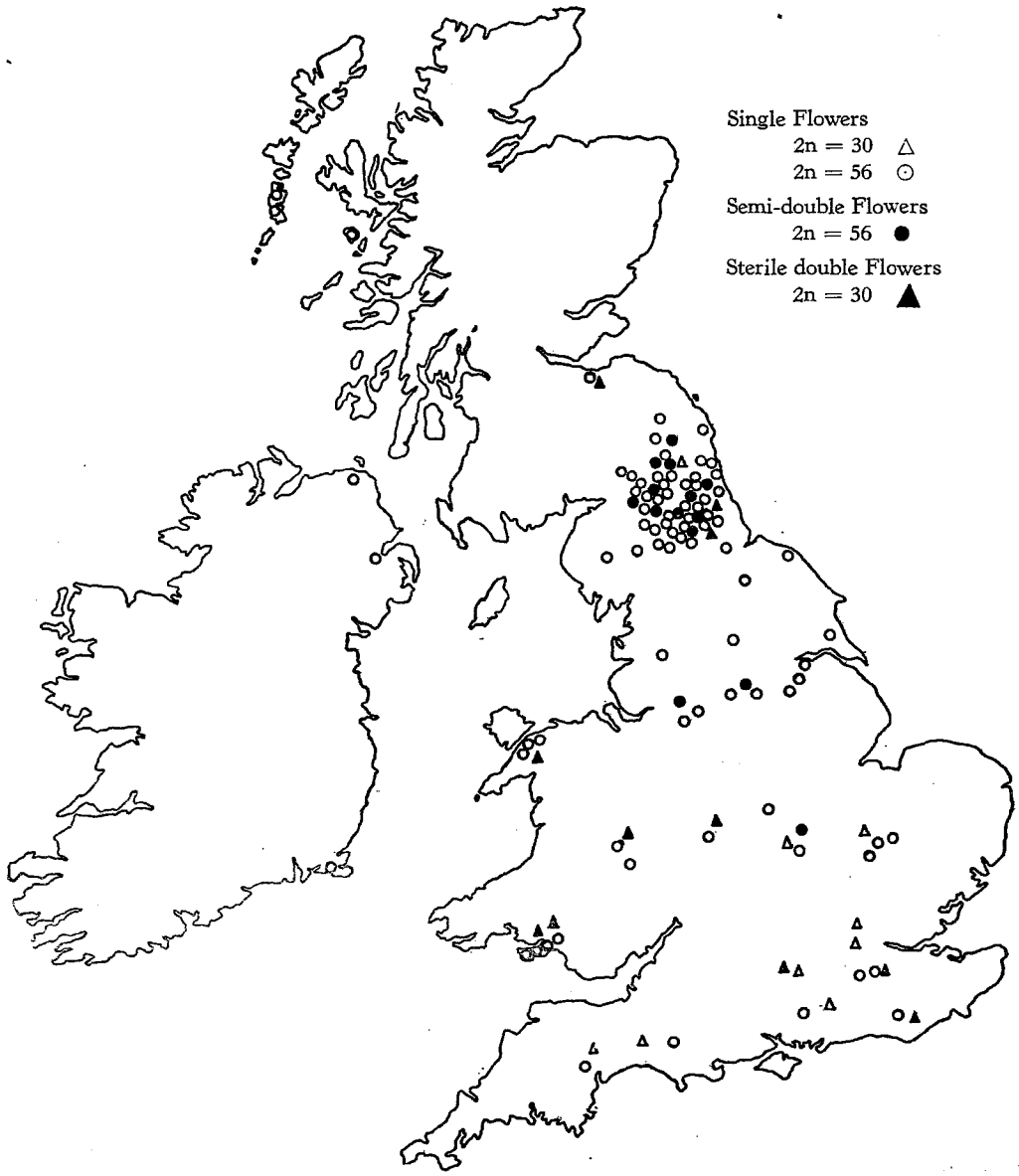
Early chromosome counts for the species were $2n = 32$ and $2n = 64$ by Manton (1932) for material collected from Cambridge and Southport respectively. Lawrence (1931) gives a count of $2n = 30$ for material obtained from the grounds of the John Innes Horticultural Institution. Flovik (1940) in his cytological survey of the Spitzbergen flora listed the species among those found in the polyploid form only ($2n = 64$). Guinochet (1946) recorded three chromosome numbers for material from the Jura Mountains: $2n = 16$, $2n = 30$ and $2n = 40$. Lövkvist (1946) reported several counts for material collected from Southern Sweden. These were: $2n = 30$, 56, 60, 64, 68, 72 and 76 with a few of $2n = 58$ and 84. Banach (1950) gave a similar long list of numbers for Polish plants. Howard (1948) gave counts of $2n = 56$ for material collected from Cambridge and Cheshire. The present author (1948), working on the chromosome numbers and geographical distribution of the species in the British Isles, found only two chromosome races: $2n = 56$ and $2n = 30$.

The distribution map given in 1948 included 70 plants and it showed the restriction of the $2n = 30$ plant to the south and the prevalence of $2n = 56$ all over the country. My request for more material brought the number of investigated plants up to 113, obtained from 100 different localities, belonging to 31 vice-counties. The following account contains a more complete distribution map, a cytological study of the chromosome races and details of the relation between the different types of double flowers and the chromosome numbers.

Results and Discussion

Geographical Distribution

Of the total number of plants only 19 gave counts of $2n = 30$, the rest of the material having a complement of $2n = 56$. No other chromosome race was found in the British Isles by me. Recently Mr. D. E. Allen has suggested that the $2n = 64$ count, originally made by Professor Manton for a plant from the Southport dunes, represents a third chromosome race which is readily distinguishable morphologically (*Yearbook B.S.B.I.*, **1952**, 56). The distribution map shows but one exception to the rule that the race with single flowers and lower chromosome number is restricted to the south. The exceptional plants were found in a wood in Northumberland in two different years. They may well have been due to accidental introduction with young trees since *Lilium martagon* was



found in the same wood and its presence certainly suggests planted, rather than natural, woodland. For the same reason—planting—the northern localities of the 2n = 30 sterile doubles may not be significant as most of them were from gardens. The northern and wider distribution of the 2n = 56 race and the virtual restriction of 2n = 30 to the southern unglaciated regions of Britain may furnish another example of a polyploid race able to invade new regions in which its diploid relation cannot survive.

Cytological Differences

The 2n = 30 plants had either a single, sterile double, or "Arabis type" flower. A comparison between the somatic chromosome complements of the three types did not show any obvious differences either in shape or in size of chromosomes (Fig. 1 a). Among members of the same complement shape and size differences were few. In length the

chromosomes measured about 1 μ. Constrictions, seldom visible, were mainly subterminal or median, with a few submedian ones. There was, however, a longer pair measuring 2 μ which seemed always to have a median constriction. In meiosis of the single flowers, a large diamond-shape bivalent with a median attachment was always clear and would correspond with the longest pair of somatic chromosomes (Fig. 1 b). Multivalents were found in about 2·5 per cent of cases and were either tri- or quadrivalents.

The results of anaphase separation were nearly always equal. These results agree with Lawrence's (1931) description, from which he concluded that the species is an allotetraploid.

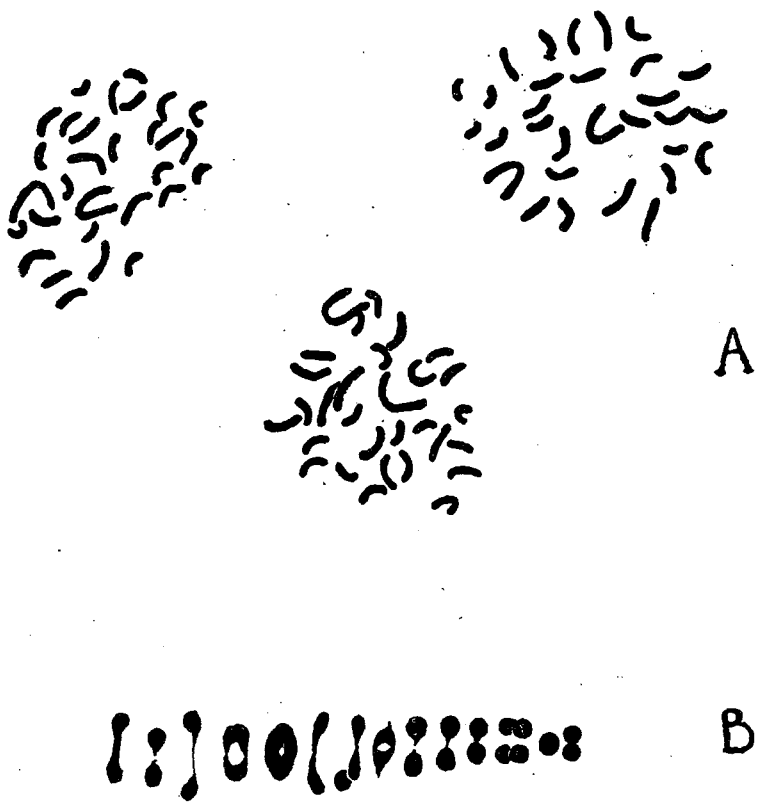


Fig. 1. (a) Somatic chromosomes of 2n = 30 of a single, double and " Arabis " type; (b) Meiotic chromosomes of a single 2n = 30.

Plants with 2n = 56 had either single or semidouble flowers. The study of somatic and meiotic plates of the two types (*see* Fig. 2 a and b) showed no major differences.

The differences in size and shape among the chromosomes of the same complement were also few, and may be correlated with those found in the 2n = 30 plants. However, owing to the smallness of the chromosomes, it was not possible to identify them individually and thus one could not judge the amount of similarity between the two races. The result of meiotic anaphase separation in 2n = 56 was also equal. This race may be considered an aneuploid of an octoploid. Whether it is an auto- or allopolyploid of the 2n = 30 race one cannot decide unless the meiotic behaviour of a hybrid and of an artificially produced 2n = 60 is examined. Except for the aneuploidy, the case is similar to that

of *Nasturtium microphyllum* (*uniseriatum*) which proved to be an allopolyploid, rather than an autopolyploid, of *N. officinale* (Manton & Howard 1946). In such cases, smallness of the chromosomes makes it difficult to consider the lower percentage of multivalents as a definite criterion of allopolyploidy, although the high fertility of the 2n = 56 race is suggestive. Morphological differences between the two chromosomes races were quite notable and will be dealt with statistically in a following study.

Type of Flower

From the cytological data it was clear that doubleness of flower was of a different type in the two chromosome races. All sterile doubles including the Arabis type, were 2n = 30, while all semidoubles were 2n = 56.

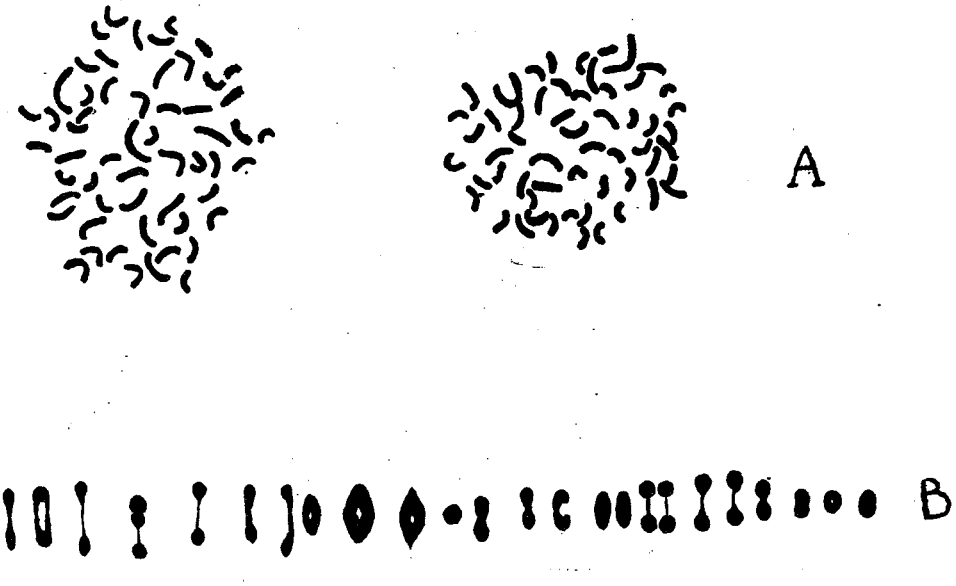


Fig. 2. (a) Somatic chromosomes of 2n = 56 of a single and semi-double type; (b) Meiotic chromosomes of a 2n = 56.

This may perhaps be considered as some indication that there is a genetic cause for all types of doubleness. Both sterile doubles and the Arabis type occurred without change under varying environmental conditions and were always vegetatively reproduced by the usual leaf buds, but in case of semidoubles, it was noticed that the proliferation occasionally, but not always, disappeared under greenhouse conditions in the following years, and some seeds were produced. It may be suggested that there is a physiological factor controlling the appearance of the semi-double condition.

SUMMARY

(1) The variability of the species is indicated and a short review of literature on the chromosome number given.

(2) Three aspects of the British races are discussed, geographical distribution, cytological differences and type of flower.

(3) No chromosome races except 2n = 30 and 2n = 56 were found in the 113 plants examined.

(4) The distribution map supports the conclusion that the 2n = 30 race is almost restricted to the southern unglaciated part of the country, and thus suggests the superiority of the 2n = 56 race in invading new territory.

(5) A cytological comparison between the two races indicates that there is not sufficient evidence to determine the type of polyploid relationship between them.

(6) Doubleness of flower in both races is thought to have a genetical cause. In the 2n = 56 race some unknown physiological factor may render it capable of setting seed. Both the cytological aspect and the subject of the physiologi cal control of semi-doubleness are in need of further investigation.

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