CYTOTAXONOMIC STUDIES IN THE GENUS SYMPHYTUM IV. CYTOGEOGRAPHIC INVESTIGATIONS IN SYMPHYTUM OFFICINALE L.

Th. W. J. GADELLA and E. KLIPHUIS

Instituut voor Systematische Plantkunde, Utrecht

SUMMARY

106 populations of *Symphytum officinale* were cytologically investigated. The distribution of white-flowered diploids and white- and purple-flowered tetraploids in Europa is discussed. The authors present a hypothesis which aims to give an explanation for the observed differences in distribution pattern.

1. INTRODUCTION

The wide-ranging and variable species *Symphytum officinale* L. was subjected to cytological investigations by various authors. Four cytotypes appear to occur: 2n = 24, 36, 40, 48.

The number 2n = 24 has been reported by GADELLA & KLIPHUIS (1967a, b; 1969, 1970) and by SKALIŃSKA *et al.* (1971). STREY (1931) and LAANE (1969) were able to demonstrate the occurrence of plants with the number 2n = 36. Strey, who studied plants of garden origin, made the remark that *S. officinale* presents very serious difficulties with regard to the correct identification of its chromosome number. The plants investigated by Laane originated from Norway. In spite of many chromosome counts neither the present authors nor SKALIŃSKA *et al.* (1971) were able to confirm the results obtained by Strey and Laane. The number 2n = 36 could not be found in plants collected in their natural habitats, but experimental hybridization between plants with 2n = 24 and 2n = 48 resulted in the formation of hybrids with 2n = 36 (GADELLA & KLIPHUIS 1969). Also the hybrid *S.* × *uplandicum*, which is rather common in southern Scandinavia, is often characterized by the number 2n = 36.

The number 2n = 40 was counted repeatedly in Dutch plants by the present authors (GADELLA & KLIPHUIS 1963, 1967b, 1971) and in Icelandic plants by LÖVE and LÖVE (1956). This cytotype, however, will be left out of consideration in this paper, since it differs, at least in the Netherlands, both in morphology and in ecological preference from diploid (2n = 24) and tetraploid (2n = 48) plants (GADELLA & KLIPHUIS 1967b).

Tetraploid plants (2n = 48) have been reported from Romania (TARNAVSCHI 1948), from Poland by SKALIŃSKA *et al.* (1971) and from various other European countries (GADELLA & KLIPHUIS 1963, 1967 a and b; GADELLA, KLIPHUIS & KRAMER, 1970; GADELLA 1972).

Morphological descriptions of the various cytotypes have been given by GADELLA & KLIPHUIS (1967b).

Artificial hybrids between the three cytotypes were made in order to provide a better insight into their breeding and taxonomic relationships (GADELLA & KLIPHUIS, 1969, 1971). These studies showed that a complicated series of relationships exists, not only between the cytotypes of *S. officinale*, but also between on the one hand these intraspecific variants of *S. officinale* and *S. asperum*, a Caucasian species on the other.

The geographic distribution of the various cytotypes of *S. officinale* had not been studied previously. For that reason the present authors decided to undertake combined phytogeographic and cytological studies with the object of testing the applicability of cytology to the solution of phytogeographic problems. This new and promising field of study, termed cytogeography, was excellently reviewed and discussed in general terms by FAVARGER (1967). Since cytotaxonomists generally limit their studies to differences in chromosome numbers and base their conclusions on a comparative examination of a very large number of individuals from various populations in the entire area of the taxon concerned, the results obtained in *S. officinale* seem to be suitable for cytogeographic investigations.

They are presented here, together with an hypothesis which aims at giving an explanation for the observed differences in distribution pattern.

2. MATERIAL AND METHODS

Plants from 106 populations were collected in Europe, 63 of which in the Netherlands and 43 in other European countries: Austria, Belgium, Czechoslovakia, France, W. Germany, E. Germany, Great Britain, Hungary, Italy, Norway, Romania, Yugoslavia.

As a rule 5–10 plants from each population were dug up and transferred to the experimental garden. For cytological methods see GADELLA & KLIPHUIS (1967b).

Voucher specimens of all the plants studied were deposited in the Herbarium of the State University of Utrecht.

3. RESULTS

The distribution of the two cytotypes is given in *fig. 1* (the Netherlands) and *2* (Europe).

From these maps the following conclusions may be drawn:

a. the diploid cytotype (2n = 24) does not seem to be as common as the tetraploid. This holds true both for the Netherlands and for other European countries, but it seems that it occurs more frequently in E. than in W. Europe. The diploid cytotype is white-flowered, not only in the Netherlands but also in all other European populations studied so far.

b. The tetraploid cytotype occurs throughout the range of *S. officinale*. Tetraploid plants are white- or purple-flowered. The populations sometimes con-

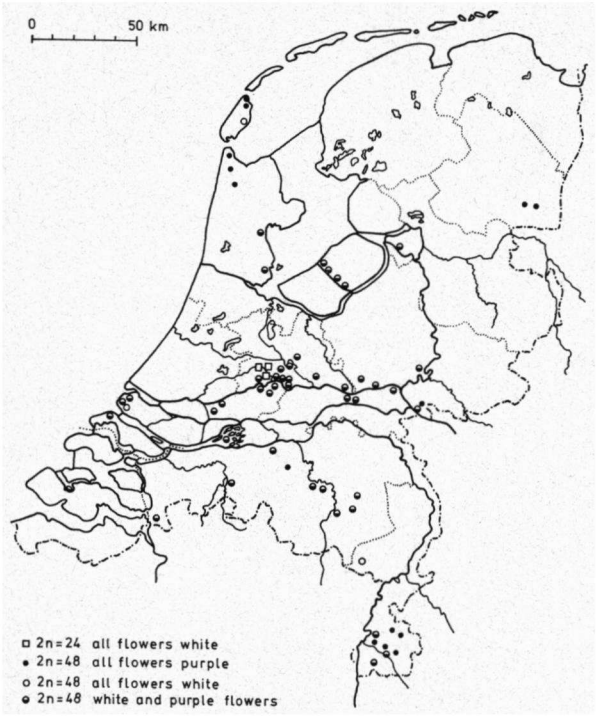

Fig. 1. The distribution of the diploid and tetraploid plants of *Symphytum officinale* L. in the Netherlands.

sist entirely of white-flowered or of purple-flowered individuals, but mixed populations in which white- and purple-flowered individuals occur in various proportions are also found. Mixed populations are very common in Western Europe, but in Eastern Europe they seem to be entirely absent. This confirms the observations made by STEVEN (1851) and POPOV (1953), who did not report white-flowered individuals from E. Europe.

4. DISCUSSION

From crossing experiments it became clear that white- and purple-flowered tetraploids are interfertile (GADELLA & KLIPHUIS 1969). In this connection it is interesting to note that crosses between two light purple-flowered tetraploid individuals (originating from two different localities in the Netherlands) yielded the following results: from 27 nutlets harvested, 24 F^1 plants turned out to be purple-flowered and 3 F^1 plants white-flowered.

A strong barrier between diploids and tetraploids exists. Hybrids from crosses between diploid plants and purple-flowered tetraploid plants could never be obtained. Only twice a hybrid with the chromosome number $2n = 36$ was obtained by crossing white-flowered tetraploids and diploids. At IJsselstein, the

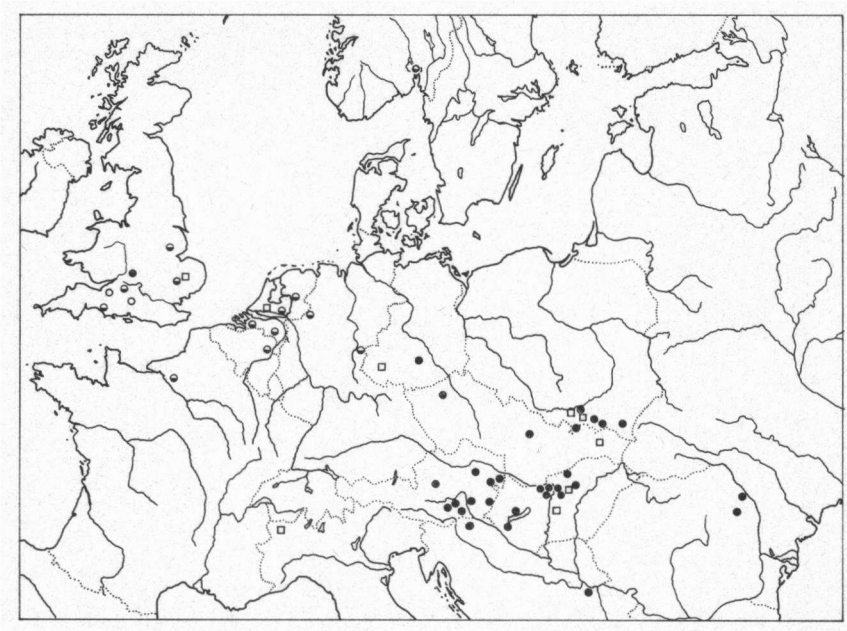

Fig. 2. The distribution of diploid (□) and tetraploid plants of *Symphytum officinale* L. in Europe. In E. Europe all tetraploid populations are purple-flowered (●), whereas in W. Europe "mixed" (◒) populations are abundant. Tetraploid white-flowered (○) populations seem to be rare and are restricted to W. Europe.

Netherlands, a large population consisting of diploids and tetraploids was found: 46 plants were studied cytologically, with the follo ing results: 16 white-flowered individuals (2n = 24); 18 white-flowered individuals (2n = 48); 12 purple-flowered individuals (2n = 48). No triploids were found. In Poland SKALIŃSKA *et al.* (1971) arrived at the same conclusion after studying a population near Biezanów. In a meadow a mixed population of diploids and tetraploids was found, but no triploids proved to occur. This population, however, differed from that near IJsselstein in the absence of white-flowered tetraploids.

WICKENS (1969) revised the species of the genus *Symphytum* in Turkey and adjacent areas. Of the 33 species recognized for the genus 27 species occur in this area and represent all sections of the genus. In fact in the Caucasus and Turkey the genus shows its greatest morphological diversity and is represented by the majority of its species. This may indicate that the centre of differentiation of the genus is situated in this area. If this supposition is correct, the European species, and especially *S. officinale*, spread from this centre over the larger part of Europe. In order to give an explanation of the facts presented here, the follow ing hypothesis was drawn up:

1. from the centre of differentiation two forms of *S. officinale* expanded their areas in a northeily and westerly direction:

a. the diploid form of *S. officinale*,

b. the purple-flowered tetraploid form of *S. officinale*.

2. The diploid cytotype is still represented in a number of scattered localities throughout Europe (probably more frequent in E. than in W. Europe). The tetraploid purple-flowered form is still very frequent throughout Europe.
3. In W. Europe a new cytotype arose as a result of the doubling of the chromosome number of the white-flowered diploid plants: the white-flowered tetraploids.
4. In W. Europe the white-flowered and purple-flowered tetraploids hybridized on a very large scale, resulting in large populations with both white and purple flowers.

The authors are fully aware that this hypothesis is a rather tentative one, but it is very difficult to give a satisfactory explanation for the differences in distribution and for the reproductive barriers observed. At any rate, more populations, especially in E. Europe, should be studied more in detail before further conclusions can be drawn.

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