ACTA SOCIETATIS
BOTANICORUM POLONIAE
Vol. 58, nr 2: 179-184
1989

Problematic octaploid forms and a new chromosome number in the genus *Achillea* L., 2n = 126

JANINA DĄBROWSKA

Department of General Botany, Institute of Botany, Wrocław University, ul. Kanonia 6/8, 50-328 Wrocław, Poland

(Received: September 21, 1988. Accepted: November 2, 1988)

Abstract

Among the offspring of a problematic form of *Achillea* sp., a 2n = 126 seedling which probably arose as the result of fusion of unreduced octo- and hexaploid gametes (72 + 54) was found along with seedlings having an octaploid chromosome number (2n = 72). Putative paths leading to the formation of problematic octaploid forms and plants with 126 chromosomes are discussed.

Key words: *Achillea L., chromosome number, polyploids*

INTRODUCTION

The genus *Achillea* L. is a polyploid complex (× = 9). When Ehrendorfer (1952) was starting cytotaxonomic studies on the genus *Achillea* L. in the U. S. A., he wrote about the forms classified as *A. millefolium* L. s.l.: "These general features of the races of *Achillea millefolium* – high local variability, little consistent morphological differentiation over larger areas, many modifications and few effective barriers to wide and often introgressive gene flow – account for the many difficulties which bar the way to a satisfying taxonomic classification and make the complex a real "crux botanicorum"."

Problematic *Achillea* L. populations which cannot be assigned to known di-, tetra-, hexa- or octaploids can be found in Poland (Dąbrowska 1973, 1982).

The objective of this paper is to discuss the origin of problematic octaploid forms, different from *A. pannonica*, and of a 2n = 126 (14 ×) form found in their offspring.

MATERIAL AND METHODS

The study was conducted on problematic forms of *Achillea* which were collected in Ludgierzowice (formerly in the Trzebnica district) and transplanted to the Wrocław collection. Seeds collected from these plants were sown in Petri dishes. Upon germination, the dishes were placed in a refrigerator for 2 days. Low temperatures (a few degrees above zero) cause the chromosomes to contract, facilitating counting (Filutowicz 1956). Slides prepared from root apical meristems using the squash method were stained with 2% orcein and photographed in a Zeiss Nf microscope.

RESULTS AND DISCUSSION

In 1976, I found numerous seedlings with a chromosome number 2n = 72 and one 2n = 126 (Fig. 1) among the offspring of a problematic form from Ludgierzowice, plant no. 37004. The number 2n = 72 characterizes the octaploid species *Achillea pannonica*, but plant no. 37004 and its offspring are not identical with that species.

The following questions arise: 1) What is the origin of the octaploid plant no. 37004 which is not morphologically identical with the octaploid species, *Achillea pannonica?* 2) How can the occurrence of a 2n = 126 (14 ×) seedling among the offspring of the octaploid plant no. 37004 be explained?

1. In addition to problematic forms, both hexaploid (*A. millefolium* L. s.str.) and octaploid (*A. pannonica*) forms occur in Ludgierzowice. It is therefore possible that octaploid forms which are not identical to *A. pannonica*, such as plant no. 37004, may arise in the following manner:

a) If *A. pannonica* (8 ×, 2n = 72) and *A. millefolium* L. s.str. (6 ×, 2n = 54) occur in the observed area, and if the latter species produces unreduced gametes, then:

$$\begin{array}{l} \;\;36z \\ \underline{+\,54nz} \\ \;\;90 \dashrightarrow 45\,z + 27\,z = 72 \end{array}$$

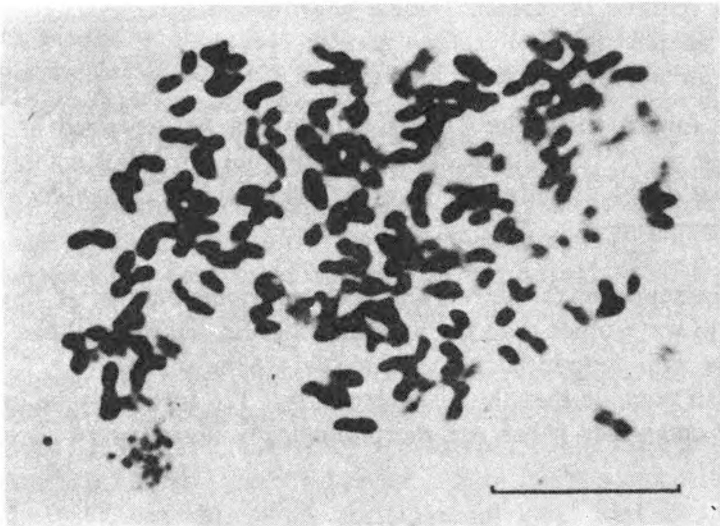

Fig. 1. A new chromosome number in the genus *Achillea* L., 2n = 126, scale = 10 μm

$$\begin{array}{l} \ 36z \\ +\ 27z \\ \hline \ 63 \dashrightarrow 36\,zs + 36\,zs = 72 \text{ where,} \end{array}$$

27 z – is a reduced gamete of *A. millefolium* L. s.str. (3 ×),
36 z – is a reduced gamete of *A. pannonica* (4 ×),
45 z – is reduced gamete of a decaploid (5 ×),
54 nz – is an unreduced gamete of *A. millefolium* L. s.str. (6 ×),
36 zs – is a reduced gamete of a septaploid (which has various gametes, among which 36 is possible).

b) If the tetraploid *A. collina* (4 ×, 2n = 36) occurs even sporadically in the observed area and produces unreduced gametes, then:

$$\begin{array}{l} \ 36\,nz \\ +\ 54\,nz \\ \hline \ 90 \dashrightarrow 45\,z + 27\,z = 72 \\ \qquad\qquad \text{or: } 45\,z + 18\,z = 63 \dashrightarrow 36\,zs + 36\,zs = 72 \end{array}$$

$$\begin{array}{llll} \ 36\,nz & \ 36\,z & \ 18\,z & \ 18\,z \\ +\ 36\,nz & +\ 36\,nz & +\ 54\,nz & +\ 27\,z \\ \hline \ 72 & \ 72 & \ 72 & \ 45 \dashrightarrow 45\,nz + 27\,z = 72, \text{ where} \end{array}$$

18 z – is a reduced *A. collina* gamete (2×),
36 nz – is an unreduced *A. collina* gamete (4×),
45 nz – is an unreduced pentaploid gamete (5×).

2. The formation of the 2n = 126 form can be explained as follows:
gamete n = 72 (unreduced, from the maternal no. 37004 octaploid plant)
+ gamete n = 54 (unreduced, from the hexaploid: *A. millefolium* L. s.str.)

2n = 126 (14×)

It can be supposed that forms with a chromosome number of 2n = 126 can also arise in ways other than the hypothetical one described above, e.g. from septaploids with unreduced gametes (63 nz + 63nz = 126).

It is also possible that the discovered 2n = 126 form may be involved in producing octaploids which are morphologically unsimilar to *A. pannonica*:

63 z
+ 27 z

90 -----------→ 45 z + 27 z = 72
or: 45 z + 18 z = 63 -----------→ 36 zs + 36 zs = 72,

where: 63 z – is a reduced gamete of form 2n = 126 (14×).

Plants with unreduced gametes have already been observed in yarrow (Tyrl 1969, 1975). I have found unreduced pollen grains in a diploid yarrow from Hungary, *A. asplenifolia* (Dąbrowska 1973). Androshchuk (1984) has found such pollen grains in *Achillea submillefolium* (tetraploid) and *A. nobilis* (diploid).

Septaploids have also already been found among yarrow (Oświecimska 1966, Tyrl 1975, Dąbrowska 1986 – unpubl.) as well as pentaploids (Schneider 1958, Oświecimska 1966, Oświecimska and Gawłowska 1967, Hiesey and Nobs 1970, Zaborsky in: Májovský et al. 1970, Tyrl 1975, Gervais 1977, Androshchuk 1984).

In 1986, this author (unpubl.) found septaploids identified as the hexaploid *Achillea distans*. They could have been the result of crossing with an octaploid having reduced gametes (27 z + 36 z = 63).

The occurrence of unreduced gametes in the genus *Achillea* L. is not uncommon. A population of tetraploids (*Achillea millefolium* L. s.l.) was found in western Oregon by Tyrl (1969) among which 30% of 110 plants produced unreduced gametes. On continuing his observations in North America, Tyrl (1975) found more populations of tetraploids producing unreduced gametes in various amounts (23.5%, 43%, 19.2%, 24.6%, 24.2%). In the south-western part of British Columbia he found unreduced gametes in a population of hexaploids and in nearby tetraploids. Septaploids and octaploids were among the hexaploids mentioned above.

Tyrl (1975) has come to the conclusion that the occurrence of hexaploid populations among tetraploids which produce unreduced gametes, and the presence of singular plants with variable numbers of chromosomes among tetraploid plants having some tetraploid gametes indicates that functional, unreduced gametes may help bring about an increase in the number of chromosomes in the genus *Achillea* L. Hexaploids can arise in a population of tetraploids through the union of $2\times$ and $4\times$ gametes. Octaploids can be formed by the fusion of $2\times$ and $6\times$ gametes. Backcrosses of these octaploids with the surrounding hexaploids can lead to the formation of septaploids. Another way leading to septaploids is the crossing of tetraploids with unreduced gametes with reduced gametes of hexaploids (Tyrl 1975).

The variation within the genus *Achillea* L. can thus be influenced not only by the breaking of crossing barriers between the higher levels of polyploidy (Ehrendorfer 1959a), the occurrence of cytotypes within a single taxon (e.g. di- and tetraploid forms – Ehrendorfer 1959b, Dąbrowska 1971, 1973, 1977, 1982, 1989), but also by the formation of unreduced gametes.

REFERENCES

Androshchuk A. F., 1984. Kariologicheskoe i tsitogeneticheskoe issledovanie roda tisyachelistnik. In: Tisyachelistniki. Sitnik K. M., Androshchuk A. F. et al. (eds.), Naukova Dumka, Kiev.

Dąbrowska J., 1971. Korelacja między liczbą chloroplastów w komórkach szparkowych, a poziomem poliploidalności czternastu taksonów *Achillea* L. Herba Polon. 17: 200-208.

Dąbrowska J., 1973. Studia systematyczno-geograficzne rodzaju *Achillea* L. w Polsce ze szczególnym uwzględnieniem Śląska oraz obserwacji dotyczących form azulenowych i bezazulenowych. D. Sc. Thesis, Wrocław University. Manuscript.

Dąbrowska J., 1977. Obserwacje kariologiczne szesnastu taksonów *Achillea* L. występujących w Polsce i na obszarach sąsiednich. Herba Polon. 23: 225-233.

Dąbrowska J., 1982. Systematic and geographic studies of the genus *Achillea* L. in Poland with special reference to Silesia. Acta Univ. Wratislav. No 419, Pr. Bot. XXIV.

Dąbrowska J., 1989. The chromosome numbers of several taxa of the genus *Achillea* L. Acta Soc. Bot. Pol. 58: 163-177.

Ehrendorfer F., 1952. Cytotaxonomic studies in *Achillea*. Carnegie Institution Year Book 51: 125-131.

Ehrendorfer F., 1959a. Differentiation-hybridization cycles and polyploidy in *Achillea*. Cold Spring Harbour Symp. Quant. Biol. 24: 141-152.

Ehrendorfer F., 1959b. *Achillea roseo-alba* Ehrendf., spec. nov. eine hybridogene, di- und tetraploide Sippe des *Achillea millefolium* – Komplexes. Österr. Bot. Z. 106: 363-368.

Filutowicz A., 1956. Cytologiczne podstawy selekcji odmian poliploidalnych i jej metodyka. In: Rola poliploidów w naturze i hodowli roślin. Zesz. Probl. Post. Nauk Rol. 1: 83-90.

Gervais C., 1977. Cytological investigation of the *Achillea millefolium* complex (*Compositae*) in Quebec. Can. J. Bot. 55: 796-808.

Hiesey W. M., Nobs M. A., 1970. Genetic and transplant studies on contrasting species and ecological races of the *Achillea millefolium* complex. Bot. Gaz. 131: 245-259.

Májovský et al., 1970. Index of chromosome numbers of Slovakian flora (part I). Acta F.R.N. Univ. Comen. Bot. 18: 1-26.
Oświecimska M., 1966. Zmienność zawartości olejku lotnego i azulenów w zielu krwawnika. Cz. V. Korelacja między ploidalnością i obecnością prochamazulenu. Diss. Pharm. Pharmacol. 18: 199-209.
Oświecimska M., Gawłowska J., 1967. Pomocnicze metody oznaczania taksonów zbiorowego gatunku *Achillea millefolium* L. s.l. Cz. I. Herba Polon. 13: 3-11.
Schneider I., 1958. Zytogenetische Untersuchungen an Sippen des Polyploid-Komplexes *Achillea millefolium* L. s.lat. Zur Phylogenie der Gattung *Achillea*. I. Österr. Bot. Z. 105: 111-158.
Tyrl R. J., 1969. Cytogeography of *Achillea millefolium* in Western Oregon. Brittonia 21: 215-223.
Tyrl R. J., 1975. Origin and distribution of polyploid *Achillea* (*Compositae*) in Western North America. Brittonia 27: 187-196.

Oktoploidalne formy problematyczne i nowa liczba chromosomów u rodzaju Achillea L., 2n = 126

Streszczenie

W potomstwie problematycznej formy *Achillea* sp., oprócz siewek o oktoploidalnej liczbie chromosomów ($2n = 72$) znaleziono siewkę o $2n = 126$, powstałą prawdopodobnie w rezultacie połączenia gamet niezredukowanych okto- i heksaploidu ($72 + 54$). Przedyskutowano domniemane drogi powstawania problematycznych form oktoploidalnych oraz rośliny o 126 chromosomach.