# Cytology

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(1958–1970). It comprises investigations on the karyology, morphology, geographical distribution and ecology of *Antennaria carpatica* s. str., *A. villifera* and, partially, *A. lanata*. The results of our cyto-embryological studies were previously published (Urbańska 1959, Urbańska-Worytkiewicz 1961, 1962, 1962a, 1965, 1967, 1967a, 1967b, 1968, 1969); observations on the embryology of *Antennaria carpatica* s. str. from the Alps and the Pyrenees remained unpublished.

## 2. Cytology

### 2.1 *Material and methods*

Material for the present study consisted of plants collected in North Scandinavia, the Tatra Mountains, the Alps and the Pyrenees. The voucher specimens were deposited at the Institute of Special Botany, Swiss Federal Institute of Technology, Zurich; some of them were also forwarded to the Botanical Department of the Tromsø Museum, Tromsø, Norway.

Scandinavian plants and the material from the Tatra Mountains were fixed in their natural habitats. Fixation of the material from the Alps and the Pyrenees was mostly performed in the experimental garden of the Botanical Institute, University of Neuchâtel, where the plants were transferred from their alpine localities. The root tips were left for 3–4 hours in a 0.05% aqueous solution of colchicine. Subsequently, they were fixed in acetic alcohol (1 : 3) with a small addition of ferric acetate and acetocarmine. The squashes were stained with lacto-propionic orcein.

For the analysis of karyotype, *Antennaria carpatica* s. str. from 6 localities in the Tatra Mountains, 10 localities in the Alps and a single locality in the Pyrenees was selected (Table 3). It should be noted that plants with tomentose and non-tomentose upper surface of the rosette leaves were studied separately; however, no evident differences in the chromosome morphology were found. Likewise no differences of karyotype occurred between staminate and pistillate plants.

As far as *Antennaria villifera* is concerned, 15 clones were studied; 6 of them represented the tetraploid cytotype whereas 9 were hexaploid (Table 2).

For the studies on the chromosome morphology, 8–12 well-spaced metaphase plates of each plant were observed. In addition, we have measured chromosomes in incomplete plates; however, the results are not included into the material presented in the resp. tables. As a criterion for the same degree of contraction of the chromosomes the length of the SAT-chromosomes

Table 2

List of habitats of Antennaria villifera selected for the karyotype analysis

| No of fixation | Place of origin | Altitude a. s. l. | 2n |
|---|---|---|---|
| 4/68N | Troms, Nordreisa: Gaetkuot'aivit, N slope | c.800m | 28 |
| 6/68N | Troms, Nordreisa: Gaetkuot'aivit, N slope | c.900m | 28 |
| 7/68N | Troms, Nordreisa: Gaetkuot'aivit, NW slope | c.1000m | 28 |
| 10/68N | Troms, Nordreisa: Gaetkuot'aivit, W slope | c.1000m | 28 |
| 12/68N | Troms, Nordreisa: Javreoaiv'vit, NE slope | c.1000m | 28 |
| 14/68N | Troms, Kåfjord: Guolas'javre, between Gåd'dečårro and Sinaivarri | c.800m | 28 |
| 1/68N | Troms, Nordreisa: Vuoddujåkka | c.700m | 42 |
| 2/68N | Troms, Nordreisa:between Vuoddujåkka and Gaetkuot'aivit | c.750m | 42 |
| 8/68N | Troms, Nordreisa: Gaetkuot'aivit, N slope | c.850m | 42 |
| 11/68N | Troms, Nordreisa: Gaetkuot'aivit, the top ridge | 1020m | 42 |
| 13/68N | Troms, Kåfjord: Guolas'javre, Gåd'dečårro | c.800m | 42 |
| 15/68N | Troms, Kåfjord: Sinaivarri, S slope | c.850m | 42 |
| 16/68N | Troms, Storfjord: Paras, E slope | c.800m | 42 |
| 18/68N | Troms, Storfjord: Paras, NE slope | c.950m | 42 |
| 19/68N | Troms, Storfjord: Paras, SE ridge | c.950m | 42 |

was used. In *Antennaria carpatica* s. str. where two types of the SAT-chromosomes occur, the length of smaller SAT-chromosomes was checked. Measurements were performed on camera lucida drawings at the magnification 4000 ×. The accepted accuracy was 0.25 μ.

The length of the two arms was measured separately for each chromosome. Subsequently, modal and average values for the length of each type of chromosomes were calculated. It should be emphasized that the length of the satellite region was included into the measurements as the differences in morphology of the SAT-chromosomes are well pronounced in the two species. The results of the metaphase analysis were compared with the prophase in order to check the structural differences occurring between the resp. types of chromosomes.

Table 3

List of habitats of Antennaria carpatica s. str. selected for the karyotype analysis

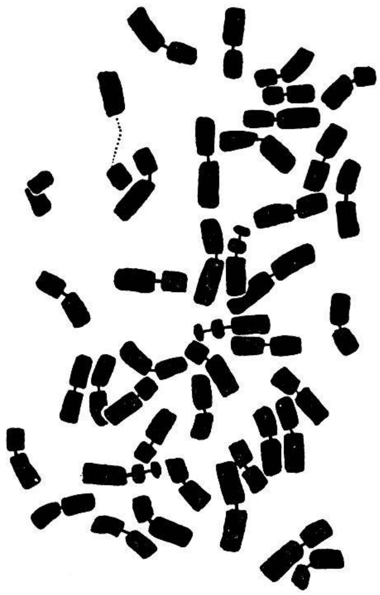
| No of fixation | Place of origin | Altitude a. s. l. | 2n |
|---|---|---|---|
| | I. the Tatra Mts: | | |
| 1/69T | the cirque Kocioł Mięguszowiecki | c.1850m | 56 |
| 2/69T | NWWslope of Żabie - over the Valley of Morskie Oko | c.1750m | 56 |
| 3/69T | near the pass Przełączka pod Żabią Czubą | c.1800m | 56 |
| 4/69T | Pośrednia Turnia, NE ridge | c.1900m | 56 |
| 5/69T | Gąsienicowa Turnia, S steep rocky slope | c.2000m | 56 |
| 6/69T | Pass Zmarzła | c.2100m | 56 |
| | II. the Alps: | | |
| 67-927 | the Bernese Alps: Oberaarsee | c.2350m | 56 |
| 67-937 | the Bernese Alps: Oberaarsee | c.2200m | 56 |
| 67-940 | the Fribourg Alps: Kaiseregg | 2100m | 56 |
| 67-876 | the Pennine Alps: Simplon, Kaltwasser | c.2320m | 56 |
| 4/69A | the Pennine Alps: l'Etherolla over Veyssonaz | c.2400m | 56 |
| 67-938 | the Pennine Alps: Mt. Rouge | c.2450m | 56 |
| 67-935 | the Pennine Alps: Riffelberg | c.2600m | 56 |
| 6/69A | the Rhaetian Alps: Nufenenpass | c.2400m | 56 |
| 26/67AM | the Maritime Alps: Cime de Mercantour, over the valley of Boréon | c.2775m | 56 |
| 67-936 | the Bergamo Alps: Val di Scalve, Passo di Vivione | c.2200m | 56 |
| | III. the Pyrenees: | | |
| 68-1197 | Vallée des Planès | c.2400m | 56 |

## 2.2 *Chromosome numbers*

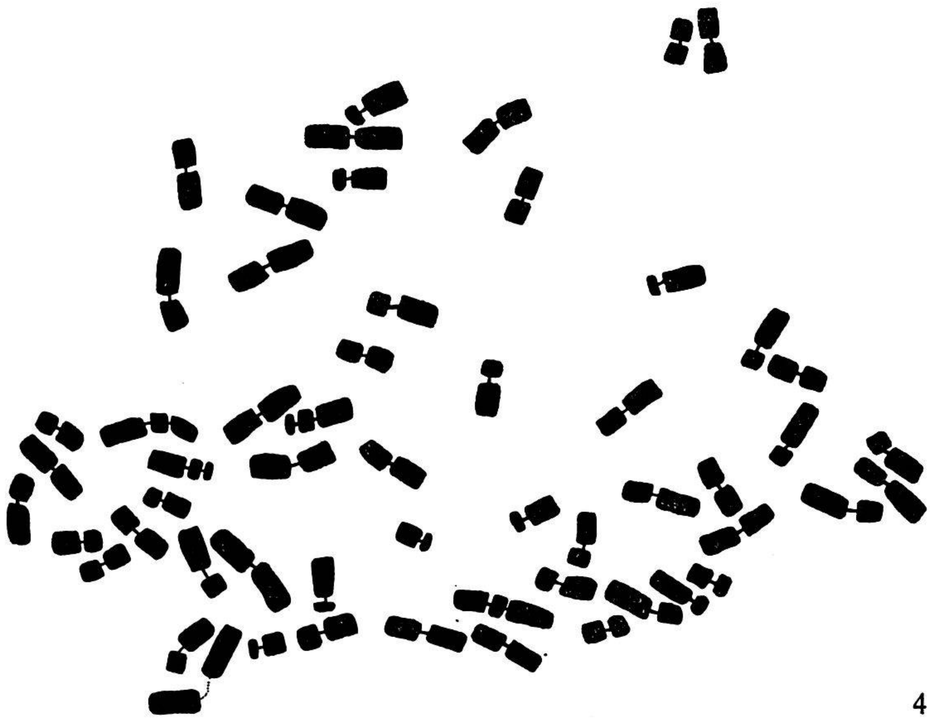
The *Antennaria carpatica* complex shows a karyological differentiation within the range of its distribution. First reports concerning the chromosome number of this group were given by Bergman (1935) who found a hexaploid, 40–42chromosomic cytotype in North Sweden. The present author's investigations carried out in Scandinavia led to reveal not only the hexaploid but also a tetraploid, 28chromosomic type (Urbańska-Worytkiewicz 1967, 1967a, 1967b). These results were recently confirmed by ENGELSKJØN and KNABEN (in press); they are also in accordance with the author's further cytological studies dealing with the Scandinavian material collected in 1968 (Figs. 2, 3, 27, 30).

The two above described cytotypes of *Antennaria villifera* do not only occur in European part of its arctic range; recently, ZHUKOVA (1968) found tetra- and hexaploid plants in the Chukotchka Peninsula. In accordance

2



3



4

Figs. 2–4. Root-tip metaphases. 2. Tetraploid *Antennaria villifera*, $2n=28$. 3. Hexaploid *A. villifera*, $2n=42$. 3. *A. carpatica* s.str., $2n=56$. C. 2200 ×.

with the present author's observations, she noted a notable morphological similarity occurring between the two types.

The results of the Russian author are particularly interesting in view of the fact that the Chukotchka Peninsula represents the easternmost limit of the range of *Antennaria villifera*. The occurrence of these same cytotypes in two opposite parts of the range seems to have an evolutionary value.

*Antennaria carpatica* s. str. shows a higher level of polyploidy. In the Tatra Mountains, the Alps and the Pyrenees the same octoploid chromosome number 2n=56 was found (Urbańska 1959, Urbańska-Worytkiewicz 1961, 1962, 1962a, 1965, 1967, 1968, 1968a; Figs. 4, 31).

When compared to other arctic-alpine groups in the European flora, the *Antennaria carpatica* complex represents a less frequent pattern of polyploid differentiation: higher polyploids occur in Central and Western Europe whereas lower polyploids were found exclusively in the North.

Cytological data concerning the American representatives of the complex are still inadequate. The only chromosome number reported for *Antennaria pulcherrima* from Canada is 2n=63 (Löve and Solbrig 1964). In view of the fact that *A. pulcherrima* has rather a regular pollen and is supposed to be a sexual species (Porsild 1965) it would be interesting to know its chromosome numbers from the whole area of distribution.

*Antennaria lanata* has not been studied cytologically hitherto. According to the measurements of the pollen diameter performed by the present author on some plants from British Columbia and Alberta, it seems to be a tetraploid type (Fig. 13). Further investigations in this respect are required.

### 2.3 *Analysis of the karyotype*

*Antennaria villifera* 2n=28, 42

Tetraploid cytotype. The length of chromosomes within the set of 28chromosomic *Antennaria villifera* ranges from 2.50 μ to 5.00 μ. 14 chromosome pairs are presented in Fig. 5. The comparison of morphology and size of chromosomes led to distinguish 4 groups among these 14 pairs. Their short description is given below:

(a) the smallest (2.47–2.49 μ) chromosomes with median centromere (Pairs XIII and XIV);

(b) chromosomes with submedian centromere (Pairs III, IV, V, VI, VII, IX, X, XI and XII);

(c) the biggest (4.26–4.98 μ) chromosomes with submedian centromere (Pairs I and II);

(d) SAT-chromosomes with submedian centromere (Pair VIII). The diameter of the satellite usually equals that of the chromosome arms; it corresponds also to the length of the shorter arm (Tables 4, 5).

Thus, the tetraploid set of *Antennaria villifera* consists of metacentric chromosomes. A special attention should be paid to a remarkable similarity occurring between some pairs of chromosomes. These types are: IX and X, XI and XII as well as XIII and XIV (Tables 4, 5). The length differences observed in most of the other pairs did not exceed 0.27 μ, except Pair I where an average length difference amounted to 0.72 μ. The most characteristic pair of the set was that of the SAT-chromosomes; it should be noted that the length of their arms corresponds to that of Pairs IX and X (Tables 4, 5).

The results of the present investigations are in favour of GUSTAFSSON's hypothesis concerning the somatic chromosome number 2n=28 as a tetraploid within the genus *Antennaria* (GUSTAFSSON 1947). The pronounced similarity occurring between some pairs of chromosomes in *Antennaria villifera* might be explained by doubling of a 14chromosomic type. On the other hand, the differentiation observed within the tetraploid set permits to assume that it represents an ancient cytotype in which the phylogenetic processes of length alteration could have proceeded at various speeds in the respective chromosomes; accordingly, some of them might have remained unaltered, whilst in the others, structural changes might have taken place. In view of this, tetraploid *Antennaria villifera* should be classified as a paleopolyploid type, according to the nomenclature proposed recently by FAVARGER (1961).

Hexaploid cytotype. The range of length variability of the chromosomes in hexaploid *Antennaria villifera* corresponds to that of the tetraploid type; it comports 2.50 μ to 5.25 μ. As in the tetraploids, metacentric chromosomes occur in the hexaploid set; among them three SAT-chromosomes could be observed (Figs. 3, 6, 30, Tables 6, 7).

The frequency of chromosomes belonging to the definite types deserves a special mention. Out of the 15 types distinguished according to their morphology, 12 comprised three chromosomes whereas three others consisted of chromosome pairs. This karyotype was established as a result of measurements performed on 74 metaphase plates belonging to plants from 8 localities in North Norway (Tables 6, 7). In addition, a deviating karyotype was found in the material from Gaetkuot'aivit, Troms (clone No. 2/68). In this particular set, type I consisted of a chromosome pair whereas type VI was represented by a single chromosome (Table 8). A comparison of the two karyotypes found in hexaploid *A. villifera* is given in Table 9.

Further interesting details were found in the course of a comparative morphological study on chromosomes occurring in tetra- and hexaploid sets.

Table 4

**A. villifera; variability of chromosome length in tetraploid type: results of measurements of the particular types of chromosomes in 63 plates (length in μ)**

| Pair | Longer arm | | | | | | | | | | Shorter arm | | | | | | | | | Satellite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 3.25 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.50 | 0.75 | 1.00 |
| I | - | - | - | - | - | 1 | 4 | 113 | 8 | 1 | - | - | - | - | - | 9 | 115 | 1 | - | - | - | - |
| II | - | - | - | - | 1 | 123 | 1 | 1 | - | - | - | - | - | - | 2 | 120 | 3 | 1 | - | - | - | - |
| III | - | - | - | - | 10 | 108 | 7 | 1 | - | - | - | - | - | 1 | 119 | 6 | - | - | - | - | - | - |
| IV | - | - | - | - | 2 | 120 | 4 | - | - | - | - | - | 2 | 123 | 1 | - | - | - | - | - | - | - |
| V | - | - | - | - | 9 | 113 | 4 | - | - | - | 6 | 117 | 3 | - | - | - | - | - | - | - | - | - |
| VI | - | - | 4 | 1 | 119 | 2 | - | - | - | - | - | - | 7 | 118 | 1 | - | - | - | - | - | - | - |
| VII | - | - | 2 | 2 | 120 | 2 | - | - | - | - | - | 6 | 118 | 2 | - | - | - | - | - | - | - | - |
| VIII | - | 1 | 1 | 2 | 121 | 1 | - | - | - | - | 1 | 119 | 5 | 1 | - | - | - | - | - | 6 | 118 | 2 |
| IX | - | - | 4 | 7 | 114 | 1 | - | - | - | - | 2 | 120 | 3 | 1 | - | - | - | - | - | - | - | - |
| X | - | 1 | 2 | 9 | 106 | 8 | - | - | - | - | - | 124 | 2 | - | - | - | - | - | - | - | - | - |
| XI | 3 | 9 | 112 | 2 | - | - | - | - | - | - | - | 3 | 117 | 6 | - | - | - | - | - | - | - | - |
| XII | 2 | 4 | 119 | 1 | - | - | - | - | - | - | - | 19 | 101 | 7 | - | - | - | - | - | - | - | - |
| XIII | - | 117 | 7 | 2 | - | - | - | - | - | - | 3 | 5 | 117 | 1 | - | - | - | - | - | - | - | - |
| XIV | 2 | 118 | 5 | 1 | - | - | - | - | - | - | 1 | 9 | 116 | - | - | - | - | - | - | - | - | - |

Table 5

The chromosome length within the tetraploid set of Antennaria villifera; a comparison between the modal values and the average values (length in μ )

| Pair | Mo | | | | M | | | |
|---|---|---|---|---|---|---|---|---|
| | Longer arm | Shorter arm | Satellite | Total length | Longer arm | Shorter arm | Satellite | Total length |
| I | 2.75 | 2.25 | - | 5.00 | 2.77 | 2.21 | - | 4.98 |
| II | 2.25 | 2.00 | - | 4.25 | 2.25 | 2.01 | - | 4.26 |
| III | 2.25 | 1.75 | - | 4.00 | 2.24 | 1.75 | - | 3.99 |
| IV | 2.25 | 1.50 | - | 3.75 | 2.25 | 1.49 | - | 3.74 |
| V | 2.25 | 1.00 | - | 3.25 | 2.24 | 0.99 | - | 3.23 |
| VI | 2.00 | 1.50 | - | 3.50 | 1.98 | 1.48 | - | 3.46 |
| VII | 2.00 | 1.25 | - | 3.25 | 1.99 | 1.24 | - | 3.23 |
| VIII | 2.00 | 1.00 | 0.75 | 3.75 | 1.98 | 1.01 | 0.74 | 3.73 |
| IX | 2.00 | 1.00 | - | 3.00 | 1.97 | 1.00 | - | 2.97 |
| X | 2.00 | 1.00 | - | 3.00 | 1.98 | 1.00 | - | 2.98 |
| XI | 1.50 | 1.25 | - | 2.75 | 1.47 | 1.25 | - | 2.72 |
| XII | 1.50 | 1.25 | - | 2.75 | 1.48 | 1.23 | - | 2.71 |
| XIII | 1.25 | 1.25 | - | 2.50 | 1.26 | 1.23 | - | 2.49 |
| XIV | 1.25 | 1.25 | - | 2.50 | 1.25 | 1.22 | - | 2.47 |

Table 6

A. villifera; Variability of the chromosome length in hexaploid type: results of measurements of the particular chromosomes in 74 metaphase plates (length in μ)

| Type | Longer arm | | | | | | | | | | Shorter arm | | | | | | | | Satellite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 0.50 | 0.75 | 1.00 |
| I | - | - | - | - | - | - | 1 | 16 | 200 | 5 | - | - | - | - | - | 2 | 13 | 207 | - | - | - |
| II | - | - | - | - | - | - | - | 221 | 1 | - | - | - | - | - | 1 | 12 | 18 | 191 | - | - | - |
| III | - | - | - | - | 1 | 2 | 10 | 206 | 3 | - | 18 | 198 | 3 | 3 | - | - | - | - | - | - | - |
| IV | - | - | - | - | 5 | 6 | 136 | 1 | - | - | - | - | - | - | 19 | 129 | - | - | - | - | - |
| V | - | - | - | - | 2 | 5 | 141 | - | - | - | - | - | 7 | 139 | 2 | - | - | - | - | - | - |
| VI | - | - | - | - | 1 | 19 | 124 | 4 | - | - | 9 | 132 | 5 | 2 | - | - | - | - | - | - | - |
| VII | - | - | - | - | 14 | 200 | 5 | 3 | - | - | - | - | - | 2 | 16 | 197 | 7 | - | - | - | - |
| VIII | - | - | - | - | - | 217 | 1 | 4 | - | - | - | - | - | 13 | 206 | 3 | - | - | - | - | - |
| IX | - | - | - | 1 | 14 | 196 | 5 | 6 | - | - | 1 | 5 | 8 | 203 | 4 | 1 | - | - | - | - | - |
| X | - | - | 1 | 6 | 9 | 202 | 4 | - | - | - | - | 3 | 16 | 186 | 15 | 2 | - | - | - | - | - |
| XI | - | - | - | 9 | 16 | 191 | 6 | - | - | - | 1 | 213 | 5 | 3 | - | - | - | - | 1 | 218 | 3 |
| XII | - | - | - | 7 | 8 | 182 | 20 | 5 | - | - | 16 | 202 | 4 | - | - | - | - | - | - | - | - |
| XIII | - | - | - | 6 | 30 | 179 | 5 | 2 | - | - | 8 | 194 | 13 | 5 | 2 | - | - | - | - | - | - |
| XIV | - | 6 | 18 | 176 | 19 | 3 | - | - | - | - | 1 | 18 | 192 | 9 | 2 | - | - | - | - | - | - |
| XV | 2 | 7 | 196 | 11 | 6 | - | - | - | - | - | 3 | 17 | 201 | 1 | - | - | - | - | - | - | - |

Table 7

The chromosome length in the typical hexaploid set of Antennaria **villifera: a comparison between the modal values** and the average values (length in μ)

| Type | Mo | | | | M | | | |
|---|---|---|---|---|---|---|---|---|
| | Longer arm | Shorter arm | Satellite | Total length | Longer arm | Shorter arm | Satellite | Total length |
| I | 2.75 | 2.50 | - | 5.25 | 2.71 | 2.48 | - | 5.19 |
| II | 2.50 | 2.50 | - | 5.00 | 2.50 | 2.44 | - | 4.94 |
| III | 2.50 | 1.00 | - | 3.50 | 2.25 | 0.98 | - | 3.23 |
| IV | 2.25 | 2.00 | - | 4.25 | 2.18 | 1.96 | - | 4.14 |
| V | 2.25 | 1.50 | - | 3.75 | 2.23 | 1.49 | - | 3.72 |
| VI | 2.25 | 1.00 | - | 3.25 | 2.22 | 0.99 | - | 3.21 |
| VII | 2.00 | 2.00 | - | 4.00 | 1.99 | 1.98 | - | 3.97 |
| VIII | 2.00 | 1.75 | - | 3.75 | 2.01 | 1.73 | - | 3.74 |
| IX | 2.00 | 1.50 | - | 3.50 | 2.01 | 1.48 | - | 3.49 |
| X | 2.00 | 1.50 | - | 3.50 | 1.95 | 1.49 | - | 3.44 |
| XI | 2.00 | 1.00 | 0.75 | 3.75 | 1.96 | 1.01 | 0.75 | 3.72 |
| XII | 2.00 | 1.00 | - | 3.00 | 2.01 | 0.98 | - | 2.99 |
| XIII | 2.00 | 1.00 | - | 3.00 | 1.96 | 1.01 | - | 2.97 |
| XIV | 1.50 | 1.25 | - | 2.75 | 1.49 | 1.24 | - | 2.73 |
| XV | 1.25 | 1.25 | - | 2.50 | 1.21 | 1.22 | - | 2.43 |

Table 8

Variability of the chromosome length in deviating karyotype of hexaploid Antennaria villifera from Gaetkuot'aivit, Troms: results of measurements in 12 metaphase plates (length in μ)

| Type | Longer arm | | | | | | | | | Shorter arm | | | | | | | | Satellite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 0.50 | 0.75 | 1.00 |
| I | - | - | - | - | - | 1 | 2 | 20 | 1 | - | - | - | - | - | 1 | 2 | 21 | - | - | - |
| II | - | - | - | - | - | - | 31 | 5 | - | - | - | - | - | - | 1 | 2 | 33 | - | - | - |
| III | - | - | - | - | - | 2 | 34 | - | - | 3 | 28 | 4 | 1 | - | - | - | - | - | - | - |
| IV | - | - | - | - | 5 | 27 | 4 | - | - | - | - | - | 1 | 1 | 31 | 3 | - | - | - | - |
| V | - | - | 1 | 1 | 2 | 30 | 2 | - | - | - | - | 3 | 28 | 4 | 1 | - | - | - | - | - |
| VI | - | - | - | - | 1 | 8 | 3 | - | - | 1 | 9 | 1 | 1 | - | - | - | - | - | - | - |
| VII | - | - | - | - | 36 | - | - | - | - | - | - | - | - | 2 | 34 | - | - | - | - | - |
| VIII | - | - | - | - | 35 | 1 | - | - | - | - | - | - | 1 | 32 | 2 | 1 | - | - | - | - |
| IX | - | - | - | 2 | 31 | 3 | - | - | - | - | - | 3 | 30 | 3 | - | - | - | - | - | - |
| X | - | - | - | 8 | 26 | 1 | 1 | - | - | - | 2 | 3 | 26 | 4 | 1 | - | - | - | - | - |
| XI | - | - | - | 2 | 33 | 1 | - | - | - | 2 | 29 | 4 | 1 | - | - | - | - | 1 | 34 | 1 |
| XII | - | - | 1 | 1 | 29 | 4 | 1 | - | - | 3 | 29 | 2 | 2 | - | - | - | - | - | - | - |
| XIII | - | - | 1 | 2 | 32 | - | 1 | - | - | - | 31 | 3 | 2 | - | - | - | - | - | - | - |
| XIV | - | 4 | 32 | - | - | - | - | - | - | - | 3 | 30 | 2 | 1 | - | - | - | - | - | - |
| XV | 4 | 31 | 1 | - | - | - | - | - | - | - | 2 | 33 | 1 | - | - | - | - | - | - | - |

Table 9

Hexaploid A. villifera: frequency of particular chromosome types in a typical set as well as in a deviating one (modal values of the chromosome length in $\mu$)

| Longer arm | Shorter arm | Satellite | Total length | Number of chromosomes | |
|---|---|---|---|---|---|
| | | | | Typical set | Deviating set |
| 2.75 | 2.50 | - | 5.25 | 3 | 2 |
| 2.50 | 2.50 | - | 5.00 | 3 | 3 |
| 2.50 | 1.00 | - | 3.50 | 3 | 3 |
| 2.25 | 2.00 | - | 4.25 | 2 | 3 |
| 2.25 | 1.50 | - | 3.75 | 2 | 3 |
| 2.25 | 1.00 | - | 3.25 | 2 | 1 |
| 2.00 | 2.00 | - | 4.00 | 3 | 3 |
| 2.00 | 1.75 | - | 3.75 | 3 | 3 |
| 2.00 | 1.50 | - | 3.50 | 3 | 3 |
| 2.00 | 1.50 | - | 3.50 | 3 | 3 |
| 2.00 | 1.00 | 0.75 | 3.75 | 3 | 3 |
| 2.00 | 1.00 | - | 3.00 | 3 | 3 |
| 2.00 | 1.00 | - | 3.00 | 3 | 3 |
| 1.50 | 1.25 | - | 2.75 | 3 | 3 |
| 1.25 | 1.25 | - | 2.50 | 3 | 3 |

Some notably similar types were found in both forms; their modal and average values as well as the resp. frequency are presented in Table 10. Pairs: II, III, VI, VIII, IX, X, XI and XIV of the tetraploid set had exactly corresponding types in the hexaploid form. It should be emphasized that the SAT-chromosomes, the most characteristic pair of the tetraploid set and the three SAT-chromosomes found in the hexaploids showed identical modal values and their average values differed only in 0.21 $\mu$.

Thus, out of the 14 pairs representing the karyotype of tetraploid *Antennaria villifera*, only two were missing in the hexaploid set; on the other hand, three types found in the hexaploids had no exactly corresponding pairs in the tetraploid form.

The results of the present investigations confirm the author's previous observations on microporogenesis in *Antennaria villifera* from North Scan-

Table 10

Antennaria villifera: frequency of particular chromosome types in tetra- and hexaploid set (length in μ)

| Type | Tetraploid set | | | Hexaploid set | | |
|---|---|---|---|---|---|---|
| | Mo | M | Number of chromosomes | Mo | M | Number of chromosomes |
| I | 5.00 | 4.98 | 2 | 5.25 | 5.19 | 3 |
| II | 4.25 | 4.26 | 2 | 4.25 | 4.14 | 2 |
| III | 4.00 | 3.99 | 2 | 4.00 | 3.97 | 3 |
| IV | 3.75 | 3.74 | 2 | 3.75 | 3.72 | 2 |
| V | 3.25 | 3.23 | 2 | 3.25 | 3.21 | 2 |
| VI | 3.50 | 3.46 | 2 | 3.50 | 3.49 | 3 |
| VII | 3.25 | 3.23 | 2 | 3.50 | 3.44 | 3 |
| VIII | 3.75 | 3.73 | 2 | 3.75 | 3.72 | 3 |
| IX | 3.00 | 2,97 | 2 | 3.00 | 2.97 | 3 |
| X | 3.00 | 2.98 | 2 | 3.00 | 2.99 | 3 |
| XI | 2.75 | 2,72 | 2 | 2.75 | 2.73 | 3 |
| XII | 2.75 | 2.71 | 2 | - | - | - |
| XIII | 2.50 | 2.49 | 2 | - | - | - |
| XIV | 2.50 | 2.47 | 2 | 2.50 | 2.43 | 3 |
| | - | - | - | 3.75 | 3.74 | 3 |
| | - | - | - | 3.50 | 3,23 | 3 |
| | - | - | - | 5.00 | 4.94 | 3 |

dinavia (Urbańska-Worytkiewicz 1967a). The occurrence of trivalens as well as variable and incomplete chromosome pairing found in the hexaploids could be explained by the fact that the resp. types mostly comprised three chromosomes. This particular frequency, in connection with a notable similarity of the chromosome types occurring within the tetra- and hexaploid sets permits to infer a close mutual relationship between the two cytotypes. This is in favour of our hypothesis concerning a putative origin of a hexaploid *Antennaria villifera:* it seems probable that it could have derived from a tetraploid form with a part of an unreduced gamete.

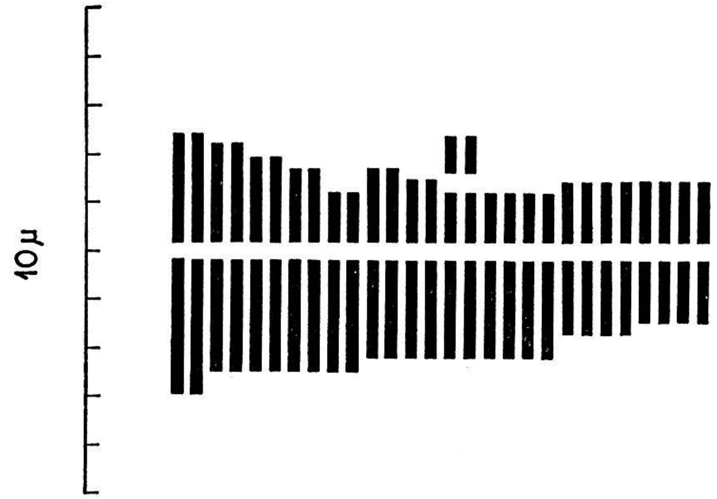



Fig. 5. Chromosome complement of tetraploid *Antennaria villifera.*

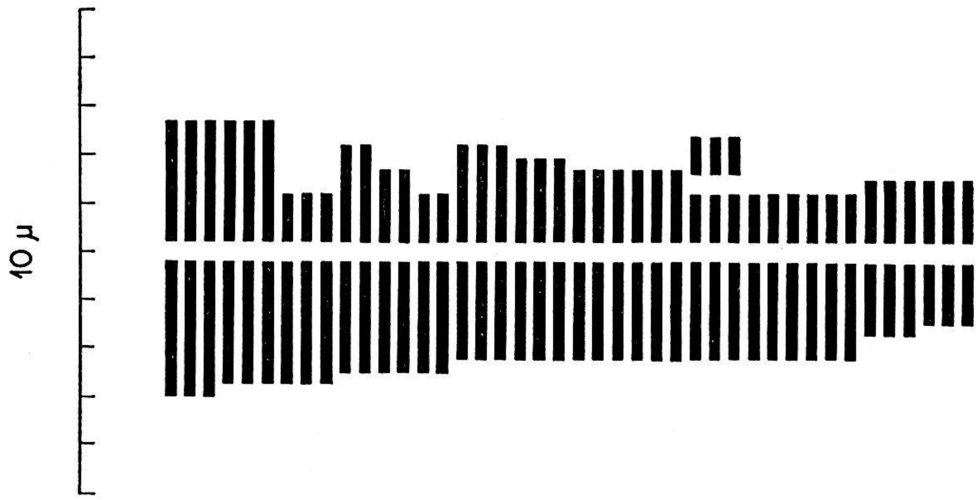



Fig. 6. Chromosome complement of hexaploid *Antennaria villifera.*

*Antennaria carpatica* s. str. 2n=56

As it was noted above, *A. carpatica* s. str. represents the same level of polyploidy within its whole range of distribution: in all plants studied from the Tatra Mountains, the Alps as well as from the Pyrenees, an octoploid chromosome number 2n=56 was invariably found.

The length of the chromosomes within the octoploid set ranged from 1.69 μ to 5.02 μ. The chromosomes were mostly metacentric; however, four pairs of acrocentric chromosomes also occurred in studied material. In this respect *Antennaria carpatica* s. str. differs from *A. villifera* whose sets consist exclusively of chromosomes with median or submedian centromeres.

It should be noted that the identification of some of the homologous chromosomes presented serious difficulties in view of the fact that some morphological types were sometimes represented by more than one pair. These identical pairs found in the material from the Tatra Mountains were: Pairs XV and XVI, XXII and XXIII, XXV and XXVI (Tables 11, 12, Fig. 7). In the plants from the Alps, the frequency of identical types was somewhat different: one type was represented by four pairs (XX–XXIII); in addition, Pairs XV and XVI as well as XI and XII were almost impossible to distinguish from each other (Tables 13, 14, Fig. 8). The highest frequency of exactly corresponding types was observed in a single population studied from the Pyrenees: as many as 11 pairs were grouped into similar types (Pairs XII–XIII, XV–XVI, XVIII–XIX, XX–XXII, XXIV–XXV). Moreover, type XXIII comprised five chromosomes instead of two pairs. Unfortunately, lack of a comparative material from the Pyrenees renders impossible any definite conclusion concerning this deviation (Tables 15, 16, Fig. 9).

The most characteristic components of the octoploid set, occurring invariably in all of the studied metaphase plates, were three pairs of chromosomes. One of them was a pair of the smallest (1.68–1.71 $\mu$) chromosomes with a subterminal centromere. The index (S.A./L.A.) comported 0.34–0.35. Two other pairs consisted of SAT-chromosomes. In view of their characteristic morphological differences a detailed description is given below.

SAT-chromosomes occurring within the octoploid set were divided into three well-defined regions: the long arm region (L.A.) extending from the distal end of the long arm to the centromere; the short arm region (S.A.) extending from the centromere to the secondary constriction; the short arm region "S" extending from the secondary constriction to the distal end of the satellite. The two types are presented in Fig. 10.

The first pair of SAT-chromosomes had a submedian centromere. The index values comported 0.57 in the material from the Tatra Mountains as well as from the Pyrenees; in the plants from the Alps the resp. value was slightly lower (0.54). The length of the satellite was about a half of the short arm (0.50–0.76 $\mu$). The secondary constriction was mostly conspicuous; in some cases, however, the satellite was adpressed to the short arm.

The second pair of SAT-chromosomes showed a quite different morphology. The index values ranged from 0.38 to 0.40. The length of the short arm was nearly the same as in the first type; by contrast, the long arm was much longer than that of the first pair. The resp. length differences between the two pairs amounted to 0.84 $\mu$.

The most remarkable characteristic was the length of the "S" region. Its average values were established as 1.50 $\mu$ in the material from the Tatra

Table 11

Variability of the chromosome length of Antennaria carpatica s. str. from the Tatra Mts: results of measurements in 54 metaphase plates (length in μ)

| Pair | Longer arm | | | | | | | | | Shorter arm | | | | | | | | | | | Satellite | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| I | - | - | - | - | - | 1 | 2 | 102 | 3 | - | - | - | - | - | - | - | - | 2 | 104 | 2 | - | - | - | - | - | - | - | - |
| II | - | - | - | - | - | - | 1 | 106 | 1 | - | - | - | - | - | 3 | 2 | 102 | 1 | - | - | - | - | - | - | - | - | - | - |
| III | - | - | - | - | - | 1 | 5 | 97 | 5 | - | - | - | - | 1 | 2 | 104 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| IV | - | - | - | - | - | - | 3 | 103 | 2 | - | - | 5 | 100 | 2 | 1 | - | - | - | - | - | - | - | - | - | 2 | 104 | 1 | 1 |
| V | - | - | - | - | - | 2 | 2 | 100 | 4 | - | - | - | 1 | 4 | 95 | 8 | - | - | - | - | - | - | - | - | - | - | - | - |
| VI | - | - | - | - | - | 8 | 97 | 3 | - | - | - | - | - | - | 5 | 102 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| VII | - | - | - | - | 1 | 4 | 101 | 2 | - | - | - | - | - | 1 | 103 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| VIII | - | - | - | - | - | 6 | 96 | 5 | 1 | - | - | 5 | 101 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| IX | - | - | - | - | 1 | 2 | 104 | 1 | - | 1 | 106 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| X | - | - | - | 1 | 5 | 98 | 4 | - | - | - | - | - | - | - | 3 | 99 | 4 | 2 | - | - | - | - | - | - | - | - | - | - |
| XI | - | - | - | - | 2 | 100 | 4 | 2 | - | - | - | - | 1 | 2 | 103 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| XII | - | - | - | - | 8 | 97 | 3 | - | - | - | - | - | 2 | 101 | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XIII | - | - | - | - | 3 | 105 | - | - | - | - | - | 7 | 98 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XIV | - | - | - | - | 4 | 101 | 2 | 1 | - | - | 3 | 103 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XV | - | - | 4 | 4 | 98 | 2 | - | - | - | - | - | - | 1 | 2 | 102 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| XVI | - | - | - | 3 | 103 | 2 | - | - | - | - | - | - | - | 2 | 99 | 7 | - | - | - | - | - | - | - | - | - | - | - | - |
| XVII | - | - | 2 | 4 | 97 | 5 | - | - | - | - | 1 | 4 | 100 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XVIII | - | - | 1 | 1 | 104 | 2 | - | - | - | - | - | 1 | 105 | 2 | - | - | - | - | - | - | - | 106 | 2 | - | - | - | - | - |
| XIX | - | - | 2 | 4 | 101 | 1 | - | - | - | - | - | 107 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XX | - | - | 2 | 106 | - | - | - | - | - | - | - | - | 3 | 2 | 100 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| XXI | - | 2 | 5 | 94 | 5 | 2 | - | - | - | - | - | - | 4 | 101 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| XXII | - | 2 | 3 | 101 | 3 | - | - | - | - | - | - | - | 105 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXIII | - | 2 | 5 | 99 | 2 | - | - | - | - | - | - | 2 | 102 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXIV | - | - | 3 | 100 | 5 | - | - | - | - | - | 4 | 101 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXV | - | 4 | 102 | 2 | - | - | - | - | - | - | - | 7 | 99 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXVI | 1 | 2 | 97 | 7 | 1 | - | - | - | - | - | - | 4 | 103 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXVII | 1 | 2 | 104 | 1 | - | - | - | - | - | 1 | 2 | 102 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XVIII | - | 6 | 98 | 3 | 1 | - | - | - | - | 30 | 76 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Table 12

The chromosome length within the set of A. carpatica s. str. from the Tatra Mts: a comparison between the modal values and the average values (length in u)

| Pair | Mo | | | | M | | | |
|---|---|---|---|---|---|---|---|---|
| | Longer arm | Shorter arm | Satellite | Total length | Longer arm | Shorter arm | Satellite | Total length |
| I | 2.50 | 2.50 | - | 5.00 | 2.49 | 2.50 | - | 4.99 |
| II | 2.50 | 2.00 | - | 4.50 | 2.50 | 1.98 | - | 4.48 |
| III | 2.50 | 1.75 | - | 4.25 | 2.49 | 1.75 | - | 4.24 |
| IV | 2.50 | 1.00 | 1.50 | 5.00 | 2.49 | 0.99 | 1.50 | 4.98 |
| V | 2.50 | 1.50 | - | 4.00 | 2.49 | 1.50 | - | 3.99 |
| VI | 2.25 | 1.75 | - | 4.00 | 2.23 | 1.74 | - | 3.97 |
| VII | 2.25 | 1.50 | - | 3.75 | 2.24 | 1.50 | - | 3.74 |
| VIII | 2.25 | 1.00 | - | 3.25 | 2.25 | 0.99 | - | 3.24 |
| IX | 2.25 | 0.50 | - | 2.75 | 2.24 | 0.50 | - | 2.74 |
| X | 2.00 | 1.75 | - | 3.75 | 1.99 | 1.76 | - | 3.75 |
| XI | 2.00 | 1.50 | - | 3.50 | 2.01 | 1.49 | - | 3.50 |
| XII | 2.00 | 1.25 | - | 3.25 | 1.98 | 1.25 | - | 3.23 |
| XIII | 2.00 | 1.00 | - | 3.00 | 1.99 | 0.99 | - | 2.98 |
| XIV | 2.00 | 0.75 | - | 2.75 | 2.00 | 0.74 | - | 2.74 |
| XV | 1.75 | 1.50 | - | 3.25 | 1.74 | 1.49 | - | 3.23 |
| XVI | 1.75 | 1.50 | - | 3.25 | 1.74 | 1.51 | - | 3.25 |
| XVII | 1.75 | 1.00 | - | 2.75 | 1.74 | 0.99 | - | 2.73 |
| XVIII | 1.75 | 1.00 | 0.50 | 3.25 | 1.74 | 1.00 | 0.50 | 3.24 |
| XIX | 1.75 | 0.75 | - | 2.50 | 1.73 | 0.75 | - | 2.48 |
| XX | 1.50 | 1.50 | - | 3.00 | 1.49 | 1.48 | - | 2.97 |
| XXI | 1.50 | 1.25 | - | 2.75 | 1.50 | 1.25 | - | 2.75 |
| XXII | 1.50 | 1.00 | - | 2.50 | 1.50 | 1.00 | - | 2.50 |
| XXIII | 1.50 | 1.00 | - | 2.50 | 1.48 | 1.00 | - | 2.48 |
| XXIV | 1.50 | 0.75 | - | 2.25 | 1.50 | 0.74 | - | 2.24 |
| XXV | 1.25 | 1.00 | - | 2.25 | 1.24 | 0.99 | - | 2.23 |
| XXVI | 1.25 | 1.00 | - | 2.25 | 1.26 | 0.99 | - | 2.25 |
| XXVII | 1.25 | 0.75 | - | 2.00 | 1.24 | 0.74 | - | 1.98 |
| XXVIII | 1.25 | 0.50 | - | 1.75 | 1.25 | 0.44 | - | 1.69 |

Table 13

Variability of the chromosome length of Antennaria carpatica s. str. from the Alps: results of measurements in 86 metaphase plates (length in μ)

| Pair | Longer arm | | | | | | | | | | Shorter arm | | | | | | | | | | | Satellite | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| I | - | - | - | - | - | 2 | 5 | 164 | 1 | - | - | - | - | - | - | - | - | 1 | 8 | 162 | 1 | - | - | - | - | - | - | - | - |
| II | - | - | - | - | - | 3 | 8 | 155 | 5 | 1 | - | - | - | - | 2 | 7 | 160 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| III | - | - | - | - | - | 1 | 4 | 162 | 5 | - | - | 3 | 2 | 163 | 4 | - | - | - | - | - | - | - | - | - | - | 3 | 6 | 161 | 2 |
| IV | - | - | - | - | - | - | 2 | 170 | - | - | - | - | - | 2 | 2 | 164 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| V | - | - | - | 1 | 1 | 2 | 166 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 167 | 2 | - | - | - | - | - | - | - | - | - |
| VI | - | - | - | - | 4 | 4 | 156 | 7 | 1 | - | - | - | - | - | 1 | 6 | 160 | 4 | 1 | - | - | - | - | - | - | - | - | - | - |
| VII | - | - | - | - | 4 | 8 | 159 | 1 | - | - | - | 1 | 5 | 162 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VIII | - | - | - | - | 1 | 9 | 156 | 6 | - | - | 1 | 3 | 160 | 8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| IX | - | - | - | - | 2 | 163 | 5 | 2 | - | - | - | - | - | - | 1 | 4 | 161 | 6 | - | - | - | - | - | - | - | - | - | - | - |
| X | - | - | - | - | 9 | 158 | 4 | 1 | - | - | - | - | - | 7 | 161 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| XI | - | - | - | - | 1 | 167 | 4 | - | - | - | - | - | 1 | 164 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XII | - | - | - | - | 4 | 166 | 2 | - | - | - | - | - | 2 | 169 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XIII | - | - | - | 3 | 6 | 158 | 5 | - | - | - | - | 7 | 162 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XIV | - | - | - | 5 | 161 | 6 | - | - | - | - | - | - | - | - | - | 2 | 170 | - | - | - | - | - | - | - | - | - | - | - | - |
| XV | - | - | 2 | 2 | 163 | 4 | 1 | - | - | - | - | - | - | 1 | 3 | 167 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| XVI | - | - | - | 9 | 156 | 7 | - | - | - | - | - | - | - | 1 | 3 | 164 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| XVII | - | - | 1 | 8 | 160 | 2 | 1 | - | - | - | - | 1 | 3 | 162 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XVIII | - | - | - | 4 | 165 | 3 | - | - | - | - | - | 6 | 21 | 143 | 1 | - | - | - | - | - | - | 1 | 167 | 4 | - | - | - | - | - |
| XIX | - | - | 1 | 7 | 156 | 8 | - | - | - | - | - | 5 | 163 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XX | - | - | 1 | 169 | 2 | - | - | - | - | - | - | - | - | 4 | 167 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXI | - | 3 | 1 | 162 | 4 | 2 | - | - | - | - | - | - | 1 | 4 | 164 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| XXII | - | - | 9 | 156 | 7 | - | - | - | - | - | - | - | - | 8 | 160 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| XXIII | - | 1 | 2 | 166 | 3 | - | - | - | - | - | - | 1 | 2 | 7 | 162 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXIV | - | 1 | 6 | 158 | 5 | 1 | 1 | - | - | - | - | - | 2 | 170 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXV | - | 6 | 162 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | 164 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXVI | - | 1 | 167 | 4 | - | - | - | — | - | - | 2 | 1 | 8 | 154 | 6 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXVII | 4 | 7 | 159 | 1 | 1 | - | - | - | - | - | 1 | 6 | 163 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| XXVIII | - | 5 | 161 | 4 | 3 | - | - | - | - | 40 | 126 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Table 14

The chromosome length of Antennaria carpatica s. str. from the Alps: a comparison between the modal values and the average values (length in µ)

| Pair | Mo | | | | M | | | |
|---|---|---|---|---|---|---|---|---|
| | Longer arm | Shorter arm | Satellite | Total length | Longer arm | Shorter arm | Satellite | Total length |
| I | 2.50 | 2.50 | - | 5.00 | 2.49 | 2.49 | - | 4.98 |
| II | 2.50 | 1.75 | - | 4.25 | 2.51 | 1.74 | - | 4.25 |
| III | 2.50 | 1.00 | 1.75 | 5.25 | 2.50 | 0.99 | 1.73 | 5.22 |
| IV | 2.50 | 1.50 | - | 4.00 | 2.48 | 1.48 | - | 3.96 |
| V | 2.25 | 2.25 | - | 4.50 | 2.24 | 2.24 | - | 4.48 |
| VI | 2.25 | 1.75 | - | 4.00 | 2.24 | 1.75 | - | 3.99 |
| VII | 2.25 | 1.00 | - | 3.25 | 2.23 | 0.99 | - | 3.22 |
| VIII | 2.25 | 0.75 | - | 3.00 | 2.24 | 0.75 | - | 2.99 |
| IX | 2.00 | 1.75 | - | 3.75 | 2.01 | 1.75 | - | 3.76 |
| X | 2.00 | 1.25 | - | 3.25 | 1.99 | 1.25 | - | 3.24 |
| XI | 2.00 | 1.00 | - | 3.00 | 2.00 | 1.01 | - | 3.01 |
| XII | 2.00 | 1.00 | - | 3.00 | 2.00 | 1.00 | - | 3.00 |
| XIII | 2.00 | 0.75 | - | 2.75 | 1.99 | 0.74 | - | 2.73 |
| XIV | 1.75 | 1.75 | - | 3.50 | 1.74 | 1.74 | - | 3.48 |
| XV | 1.75 | 1.50 | - | 3.25 | 1.75 | 1.49 | - | 3.24 |
| XVI | 1.75 | 1.50 | - | 3.25 | 1.75 | 1.50 | - | 3.25 |
| XVII | 1.75 | 1.00 | - | 2.75 | 1.74 | 1.00 | - | 2.74 |
| XVIII | 1.75 | 1.00 | 0.50 | 3.25 | 1.75 | 0.95 | 0.50 | 3.20 |
| XIX | 1.75 | 0.75 | - | 2.50 | 1.75 | 0.75 | - | 2.50 |
| XX | 1.50 | 1.25 | - | 2.75 | 1.50 | 1.24 | - | 2.74 |
| XXI | 1.50 | 1.25 | - | 2.75 | 1.50 | 1.25 | - | 2.75 |
| XXII | 1.50 | 1.25 | - | 2.75 | 1.50 | 1.23 | - | 2.73 |
| XXIII | 1.50 | 1.25 | - | 2.75 | 1.50 | 1.23 | - | 2.73 |
| XXIV | 1.50 | 1.00 | - | 2.50 | 1.50 | 1.00 | - | 2.50 |
| XXV | 1.25 | 1.25 | - | 2.50 | 1.25 | 1.25 | - | 2.50 |
| XXVI | 1.25 | 1.00 | - | 2.25 | 1.25 | 0.99 | - | 2.24 |
| XXVII | 1.25 | 0.75 | - | 2.00 | 1.23 | 0.74 | - | 1.97 |
| XXVIII | 1.25 | 0.50 | - | 1.75 | 1.26 | 0.43 | - | 1.69 |

Table 15

Variability of the chromosome length of Antennaria carpatica s. str. from the Pyrenees (Vallée des Planès): results of measurements in 12 metaphase plates (length in µ)

| 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | - | 1 | 19 | 4 | - | - | - | - | - | - | - | - | 2 | 21 | 1 | - | - | - | - | - | - |
| - | - | - | - | - | - | 5 | 18 | 1 | - | - | - | - | 1 | 1 | 21 | 1 | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | 1 | 2 | 21 | 1 | - | - | - | 1 | 23 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | 1 | 22 | 1 | - | 1 | 4 | 18 | 1 | - | - | - | - | - | - | - | - | - | - | 2 | 22 |
| - | - | - | - | - | - | 20 | 2 | 2 | - | - | - | - | - | - | 2 | 18 | 4 | - | - | - | - | - | - | - | - |
| - | - | - | - | - | 2 | 19 | 3 | - | - | - | - | - | - | 2 | 21 | 1 | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 1 | 2 | 21 | - | - | - | - | 1 | 22 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | 3 | 20 | 1 | - | - | 17 | 6 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 1 | 7 | 4 | - | - | - | - | - | - | - | 1 | 9 | 2 | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 3 | 19 | 2 | - | - | - | - | - | - | 1 | 2 | 20 | 1 | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 2 | 21 | 1 | - | - | - | - | - | - | - | 2 | 20 | 2 | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 1 | 21 | 2 | - | - | - | - | - | - | 17 | 5 | 2 | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 2 | 20 | 1 | 1 | - | - | - | 1 | 22 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | 1 | 5 | 18 | - | - | - | - | - | 2 | 21 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 1 | 23 | - | - | - | - | 1 | 22 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | 2 | 22 | - | - | - | - | - | - | - | - | - | 20 | 4 | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | 24 | - | - | - | - | - | - | - | 1 | 2 | 21 | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | 3 | 18 | 2 | 1 | - | - | - | - | 1 | 19 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | 1 | 23 | - | - | - | - | - | - | 2 | 20 | 2 | - | - | - | - | - | - | - | 23 | 1 | - | - | - |
| - | - | 1 | 2 | 20 | 1 | - | - | - | - | - | 3 | 19 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | 1 | 22 | 1 | - | - | - | - | - | - | - | 2 | 20 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| - | - | 2 | 19 | 2 | 1 | - | - | - | - | - | - | - | 21 | 2 | 1 | - | - | - | - | - | - | - | - | - | - |
| - | - | 2 | 21 | 1 | - | - | - | - | - | - | - | 1 | 23 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | 2 | 18 | 4 | - | - | - | - | - | 1 | 2 | 20 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | 10 | 2 | - | - | - | - | - | - | 3 | 9 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | 1 | 21 | 2 | - | - | - | - | - | - | - | 1 | 20 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | 3 | 19 | 1 | 1 | - | - | - | - | - | - | - | 22 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| - | 1 | 21 | 2 | - | - | - | - | - | - | 1 | 20 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | 1 | 20 | 3 | - | - | - | - | - | 7 | 16 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Table 16

The chromosome length of Antennaria carpatica s. str. from the Pyrenees (Vallée des Planès): a comparison between the modal values and the average values (length in μ)

| Mo | | | | M | | | |
|---|---|---|---|---|---|---|---|
| Longer arm | Shorter arm | Satellite | Total length | Longer arm | Shorter arm | Satellite | Total length |
| 2.50 | 2.50 | - | 5.00 | 2.53 | 2.49 | - | 5.02 |
| 2.50 | 1.75 | - | 4.25 | 2.46 | 1.73 | - | 4.19 |
| 2.50 | 1.25 | - | 3.75 | 2.57 | 1.24 | - | 3.81 |
| 2.50 | 1.00 | 1.75 | 5.25 | 2.50 | 0.95 | 1.73 | 5.18 |
| 2.25 | 2.00 | - | 4.25 | 2.31 | 2.01 | - | 4.32 |
| 2.25 | 1.75 | - | 4.00 | 2.26 | 1.74 | - | 4.00 |
| 2.25 | 1.00 | - | 3.25 | 2.21 | 1.00 | - | 3.21 |
| 2.25 | 0.50 | - | 2.75 | 2.23 | 0.58 | - | 2.81 |
| 2.00 | 1.75 | - | 3.75 | 1.95 | 1.72 | - | 3.67 |
| 2.00 | 1.75 | - | 3.75 | 1.99 | 1.75 | - | 3.74 |
| 2.00 | 1.75 | - | 1.75 | 2.03 | 1.77 | - | 3.80 |
| 2.00 | 1.25 | - | 3.25 | 2.01 | 1.34 | - | 3.35 |
| 2.00 | 1.00 | - | 3.00 | 2.01 | 1.00 | - | 3.01 |
| 2.00 | 1.00 | - | 3.00 | 1.93 | 0.99 | - | 2.92 |
| 2.00 | 0.75 | - | 2.75 | 1.99 | 0.75 | - | 2.74 |
| 1.75 | 1.50 | - | 3.25 | 1.73 | 1.54 | - | 3.27 |
| 1.75 | 1.50 | - | 3.25 | 1.75 | 1.46 | - | 3.21 |
| 1.75 | 1.00 | - | 2.75 | 1.76 | 1.03 | - | 2.79 |
| 1.75 | 1.00 | 0.75 | 3.50 | 1.74 | 1.00 | 0.76 | 3.50 |
| 1.75 | 1.00 | - | 2.75 | 1.71 | 0.98 | - | 2.69 |
| 1.50 | 1.25 | - | 2.75 | 1.50 | 1.25 | - | 2.75 |
| 1.50 | 1.25 | - | 2.75 | 1.52 | 1.29 | - | 2.81 |
| 1.50 | 1.25 | - | 2.75 | 1.48 | 1.23 | - | 2.71 |
| 1.50 | 1.00 | - | 2.50 | 1.52 | 0.94 | - | 2.46 |
| 1.50 | 1.00 | - | 2.50 | 1.54 | 0.93 | - | 2.47 |
| 1.25 | 1.00 | - | 2.25 | 1.26 | 1.02 | - | 2.28 |
| 1.25 | 1.00 | — | 2.25 | 1.25 | 1.02 | - | 2.27 |
| 1.25 | 0.75 | - | 2.00 | 1.26 | 0.77 | - | 2.03 |
| 1.25 | 0.50 | - | 1.75 | 1.27 | 0.44 | - | 1.71 |

Table 17

Antennaria carpatica s. str.: a comparison of frequency of particular chromosome types in the material from the Tatra Mts, the Alps as well as from the Pyrenees (modal values of length in $\mu$)

| Longer arm | Shorter arm | Satellite | Number of chromosomes | | |
|---|---|---|---|---|---|
| | | | Tatra Mts | Alps | Pyrenees |
| 2.50 | 2.50 | - | 2 | 2 | 2 |
| 2.50 | 2.00 | - | 2 | - | - |
| 2.50 | 1.75 | - | 2 | 2 | 2 |
| 2.50 | 1.50 | - | 2 | 2 | - |
| 2.50 | 1.25 | - | - | - | 2 |
| 2.50 | 1.00 | 1.75 | - | 2 | 2 |
| 2.50 | 1.00 | 1.50 | 2 | - | - |
| 2.25 | 2.25 | - | - | 2 | - |
| 2.25 | 2.00 | - | - | - | 2 |
| 2.25 | 1.75 | - | 2 | 2 | 2 |
| 2.25 | 1.50 | - | 2 | - | - |
| 2.25 | 1.00 | - | 2 | 2 | 2 |
| 2.25 | 0.75 | - | - | 2 | - |
| 2.25 | 0.50 | - | 2 | - | 2 |
| 2.00 | 1.75 | - | 2 | 2 | 5 |
| 2.00 | 1.50 | - | 2 | - | - |
| 2.00 | 1.25 | - | 2 | 2 | 2 |
| 2.00 | 1.00 | - | 2 | 4 | 4 |
| 2.00 | 0.75 | - | 2 | 2 | 2 |
| 1.75 | 1.75 | - | - | 2 | - |
| 1.75 | 1.50 | - | 4 | 4 | 4 |
| 1.75 | 1.00 | 0.75 | - | - | 2 |
| 1.75 | 1.00 | 0.50 | 2 | 2 | - |
| 1.75 | 1.00 | - | 2 | 2 | 4 |
| 1.75 | 0.75 | - | 2 | 2 | - |
| 1.50 | 1.50 | - | 2 | - | - |
| 1.50 | 1.25 | - | 2 | 8 | 6 |
| 1.50 | 1.00 | - | 4 | 2 | 3 |
| 1.50 | 0.75 | - | 2 | - | - |
| 1.25 | 1.25 | - | - | 2 | - |
| 1.25 | 1.00 | - | 4 | 2 | 4 |
| 1.25 | 0.75 | - | 2 | 2 | 2 |
| 1.25 | 0.50 | - | 2 | 2 | 2 |

Table 18

Seed development in Antennaria villifera Boriss.

| Locality | Herbarium | Stigma | Number of heads | Total number of florets | Number of achenes |
|---|---|---|---|---|---|
| I. Scandinavia*: | | | | | |
| Lule Lappmark: Gallivarre<br>2. VIII. 1936<br>G. Björkman | UPS | short | 5 | 244 | 1<br>% 0.41 |
| Nordland, Sörfold: Boaimac, riksgrensa<br>7. VII. 1954<br>W. Apold, G. Brodal, O. Skifte | TROM | short | 5 | 232 | 1<br>% 0.43 |
| Troms, Balsfjord: Hattevarre<br>17. VIII. 1934<br>P. Benum | TROM | short | 6 | 330 | 4<br>% 1.39 |
| Troms, Storfjord: Skibotndalen, Rippovarre<br>15. VIII. 1936<br>P. Benum | TROM | short | 6 | 267 | 7<br>% 2.62 |
| Troms, Skjervøy: Vaddas, Lohtana<br>28. VII. 1937<br>Y. Mejland | O | short | 6 | 348 | 15<br>% 4.37 |
| Troms, Målselv: Alappen<br>J. M. Norman | UPS | short | 6 | 251 | 11<br>% 4.38 |
| II. Kolguyev: | | | | | |
| Insula Kolguyev (typus locality ?)<br>1902<br>R. Pohle | HEL | short | 6 | 248 | 28<br>% 11.29 |
| III. Siberia: | | | | | |
| Yakutsch: Buckar<br>23. VIII. 1898<br>H. Nilssen | S | short | 5 | 227 | 31<br>% 13.66 |
| Jenisey, Dudinka<br>VIII. 1876<br>J. R. Sahlberg | LE | short | 6 | 272 | 46<br>% 16.91 |

* all other studied specimens had no seeds.

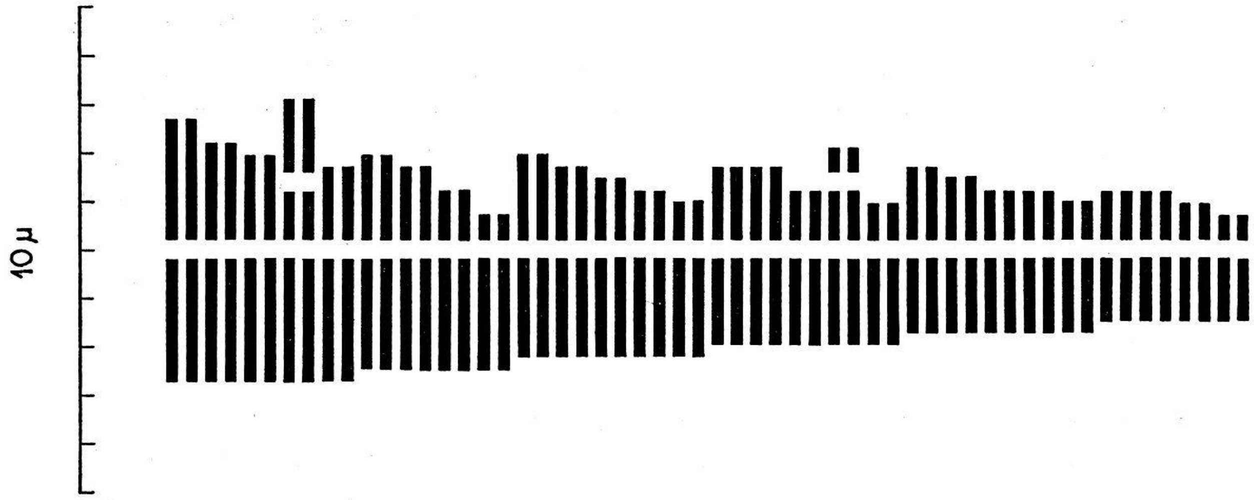



Fig. 7. Chromosome complement of *Antennaria carpatica* s. str. from the Tatra Mountains.

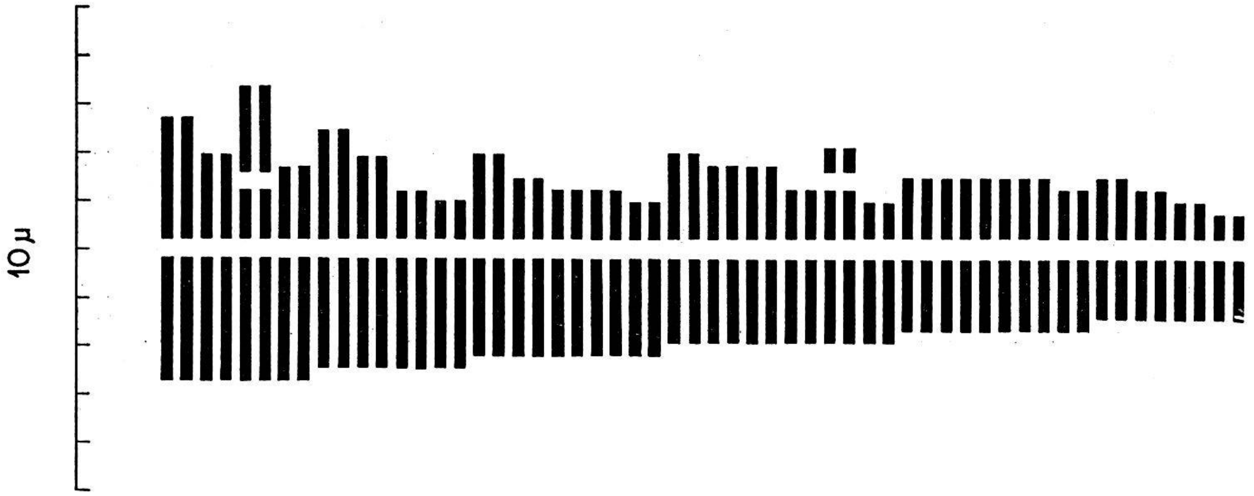



Fig. 8. Chromosome complement of *Antennaria carpatica* s. str. from the Alps.

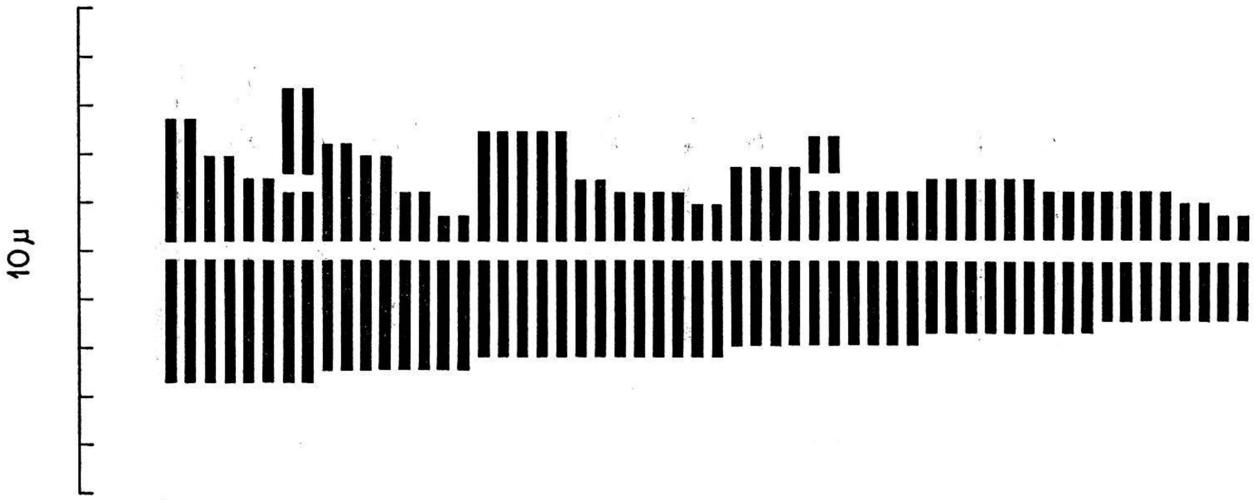



Fig. 9. Chromosome complement of *Antennaria carpatica* s. str. from the Pyrenees.

Mountains and 1.73 μ in all other plants. Thus, the big "satellite" was about three times longer than the small one occurring in the first pair.

A comparative morphological study of the material from the Tatra Mountains, the Alps and the Pyrenees revealed a rather high degree of similarity occurring between the resp. karyotypes. Most of the chromosome types could be recognized in all of the studied plates; the three characteristic pairs described above occurred invariably in the octoploid set. It should be noted that the materials from various mountain groups differed from one another in some details: certain types of chromosomes occurred exclusively in one groupe whereas in the others they were missing (Tables 17, 18). The frequency of some morphological types was also variable. On the whole, however, the length differences occurring between the particular chromosomes in the studied material did not exceed 0.25 μ.

The above results point to close relationship between the octoploid plants of *Antennaria carpatica* s. str. from various parts of its range. It seems probable that they might have a common origin. The octoploid type could have arisen as an allopolyploid or autopolyploid form; however, the polyploidization was an evolutionary step preceeding the structural changes of the chromosomes e. g. translocations or terminal deficiences. On the other hand, certain differences occurring in the material from separated mountain groups permit to assume that further processes of karyotype differentiation could have taken place independently in the Tatra Mountains, the Alps and the Pyrenees.

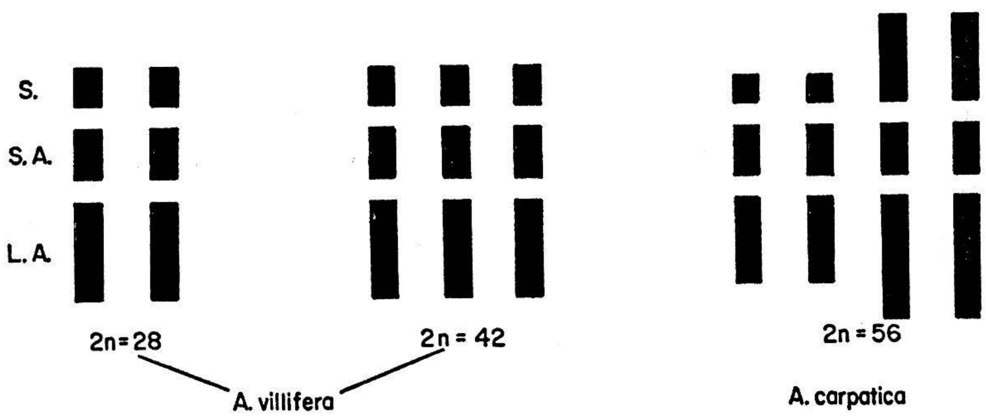



Fig. 10. Diagrammatic representation of SAT-chromosomes occurring in *Antennaria villifera* as well as in *A. carpatica* s. str.