A cytotaxonomic study on Bulgarian Anthemis species

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RÉSUMÉ

KUZMANOV, B., N. N. THIN & S. GEORGIEVA (1981). Etude cytotaxonomique des espèces bulgares du genre Anthemis. *Candollea* 36: 19-76. En anglais. résumé français.

Quarante-sept populations sauvages de vingt-deux espèces d'*Anthemis* bulgares ont subi une étude caryologique. Le nombre et la morphologie chromosomique de 13 espèces ont été examinés pour la première fois et leur signification pour la taxonomie des endémiques de Bulgarie et des Balkans est discutée, de même que les caractéristiques évolutives du genre.

ABSTRACT

KUZMANOV, B., N. N. THIN & S. GEORGIEVA (1981). A cytotaxonomic study on Bulgarian Anthemis species. *Candollea* 36: 19-76. In English, French abstract.

Forty-seven native populations of twenty-two *Anthemis* species occuring in Bulgaria have been studied karyologically. Chromosome number and morphology have been analysed in 13 species for the first time. Their significance for taxonomy, especially of Bulgarian and Balkan endemics, is discussed and the general evolutionary pattern of the genus is considered.

Introduction

Twenty-seven native species of two subgenera and five sections of *Anthemis* occur in Bulgaria (THIN, 1980a; see Table 1, Maps 1-14). Seventeen species are perennials and ten are biennials and annuals. They grow mostly in

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pastures and meadows, on sandy and rocky habitats, on roadsides and on disturbed places by villages and towns, from sea level up to 2700 m in high mountains.

For this study seeds from native populations were collected (see Table 1) and germinated in Petri dishes (only in some cases root-tips were collected from plants reared in pots in greenhouses). Root-tips were fixed in Clarke, stained and squashed as described in the previous reports of the senior author (KUZMANOV & KOŽUHAROV, 1967, 1973; KUZMANOV, 1975). Camera lucida drawings are magnified from microscope and chromosome morphology is described after KUZMANOV & KOŽUHAROV (1967, with modification).

Results

Subgenus Anthemis Section Hiorthia (DC.) R. Fernandes

Anthemis argyrophylla (Hal. & Georg.) Velen., $2n = 4x = 36$ (Table 1.1, Table 2.1; Figs. 1-2, 56a; Map 1).

The species is known from only two localities in the Maritsa river valley on calcareous rocky places (a third unconfirmed locality is Belogradčik in Northwestern Bulgaria). It is a Bulgarian endemic and possibly a relict species in our flora. In the karyotype one pair of long metacentric, 14 pairs of submetacentric and 3 pairs of SAT-chromosomes were found (Table 2).

Anthemis regis-borisii Stoj. & Acht., $2n = 4x = 36$ (Table 1.2, Table 2.2; Figs. 3-4, 56c; Map 2).

The species is known from several close lying localities in Northwestern Bulgaria on sandy and rocky habitats. In the karyotype the following characteristic chromosomes were found: metacentric — 4 pairs of long, submetacentric — 10 pairs (one pair only shorter) and SAT — 4 pairs of acrocentric chromosomes.

Anthemis kuzmanovii Thin (= *A. montana* var. *macedonica* Griseb.), $2n = 4x = 36$ (Table 1.3, Table 2.3; Figs. 5-6, 57a; Map 3).

The species is widespread in several localities in Northern and Western Bulgaria. In the karyotype we found 3 pairs of metacentric, 12 pairs of submetacentric and 3 pairs of SAT-chromosomes.

Anthemis rumelica (Velen.) Stoj. & Acht., $2n = 4x = 36$ (Table 1.4, Table 2.4; Figs. 7-8, 57b; Map 1).

Anthemis rumelica is known from a number of localities in Southern and Eastern Bulgaria. The following characteristic chromosomes were found in the karyotype: 4 pairs of metacentric, 11 pairs of submetacentric and 3 pairs of SAT-chromosomes.

Anthemis tenuiloba (DC.) Stoj. & Acht., $2n = 4x = 36$ (Table 1.5, Table 2.5; Figs. 9-10, 56b; Map 4).

The species is rather common in Central and Southern Bulgaria. In the karyotype we found in both varieties 4 pairs of metacentric, 10 submetacentric and 4 pairs of SAT-chromosomes.

Anthemis hinkovae Thin, $2n = 4x = 36$, $2n = 36 + 3$ (Table 1.6, Table 2.6; Figs. 11-14, 55c; Map 3).

This species has been described recently (THIN, 1980b) from the Eastern Rhodope mountains and is known only from the type locality. The following characteristic chromosomes were found in the karyotype: metacentric — 3 pairs, submetacentric — 10 pairs three of them longer) and SAT — 5 pairs (one submetacentric and four acrocentric) of chromosomes. In some plants an aneuploid chromosome number was also found.

Anthemis cretica L., $2n = 4x = 36$ (Table 1.7, Table 2.7; Figs. 15-16, 55b; Map 1).

Anthemis cretica is recorded only from one single locality in Southeastern Bulgaria. The following characteristic chromosomes were found in the karyotype: 2 pairs of metacentric, 10 pairs of submetacentric and 6 of SAT-chromosomes (one pair submetacentric and 5 pairs of short acrocentric). The chromosome number agrees with the data given by DOWRICK (1952) (for *A. montana*) and KÜPFER (1974) (for *A. saxatilis*).

Anthemis carpatica Willd., $2n = 4x = 36$ (Table 1.8, Table 2.8; Figs. 17-18, 55a; Map 5).

In Bulgaria *A. carpatica* occurs in the high mountains mainly in Central and Southwestern parts. There are no significant differences between the three varieties studied karyologically. The chromosome number agrees with the data given by KÜPFER & FAVARGER (1967) and DELAY (1970). In the karyotype we found one pair of metacentric, 13 pairs of submetacentric (only one pair is of short chromosomes) and 3 pairs of SAT-chromosomes (the drawing in Fig. 17 refers to *A. carpatica* var. *subcarpatica* Nyar.).

Anthemis orbelica Pančić, $2n = 2x = 18$, $2n = 18 + 4$, $2n = 3x = 27$ (Table 1.9, Table 2.9; Figs. 19-24, 58c, 59a-b; Map 2).

The species is known mainly from the mountains in Southern Bulgaria up to 1600 m above sea level. In most of the populations of this species we found a diploid chromosome number, but in one (Rila — *BK-7921*) an aneuploid chromosome number appeared. In three of the populations the karyotype consists of: two pairs of metacentric, five pairs of submetacentric and two of SAT-chromosomes. In the plants from Rila we found plants with $2n = 22$ — one pair of acrocentric and one of SAT-chromosomes more (see Table 2). In

triploid plants there were one pair of metacentric, two pairs of submetacentric and one of SAT (submetacentric) chromosomes.

Anthemis stribrnyi Velen., $2n = 2x = 18$, $2n = 18 + 3$ (Table 1.10, Table 2.10; Figs. 25-28, 58a, 59c; Map 2).

The species is known from many localities in Southern Bulgaria. In the diploid plants *(BK-7918, 7919, 7920)* the karyotype was of one pair of metacentric, five of submetacentric and three pairs of SAT-chromosomes. Some plants of the Rhodope mountains *(BK-7920)* proved to be aneuploid with one pair of metacentric and a single acrocentric additional chromosomes.

Anthemis macedonica Boiss. & Orph., $2n = 2x = 18$ (Table 1.11, Table 2.11; Figs. 29-30, 58b; Map 2).

A. macedonica is recorded from a number of localities in Southern Bulgaria. The karyotype studied is of two pairs of metacentric, five of submetacentric and two of SAT-chromosomes.

Anthemis virescens Velen., $2n = 2x = 18$ (Table 1.12, Table 2.12; Figs. 31-32, 58d; Map 3).

This species is widespread in Southern and Eastern Bulgaria. In the karyotype we found: one pair of metacentric, six pairs of submetacentric and two pairs of SAT-chromosomes.

Subgenus Anthemis Section Anthemis

Anthemis arvensis L., $2n = 2x = 18$, $2n = 27$ (Table 1.13, Table 2.13; Figs. 33-36, 59d, 60b; Map 5).

The species is common over most of the country. Three populations we studied belong to subsp. *arvensis* and one to subsp. *incrassata.* In the last taxon a triploid chromosome number was found. The karyotype of the diploids is characterised by one pair of metacentric, six of submetacentric and two pairs of SAT-chromosomes. In the triploid plants a pair of metacentric, submetacentric and SAT-chromosomes and a single metacentric chromosome are added. The chromosome number $2n = 18$ agrees with data of WULFF (1937), MARTINOLI (1942), HARLING (1950), LÖVE & LÖVE (1956) and JASIEWICZ & MIZIANTY (1975) (the last being for plants from Bulgaria).

Anthemis auriculata Boiss., $2n = 2x = 18$ (Table 1.14, Table 2.14; Figs. 37-38, 60d; Map 6).

A. auriculata is known from three different floristic regions: Struma valley, Eastern Rhodope Mts. and Eastern Stara Planina (near Aitos). In all

four populations we studied a diploid chromosome number was found and the karyotype is characterised by one pair of metacentric, six of submetacentric and two of SAT-chromosomes.

Anthemis ruthenica M.B., $2n = 2x = 18$ (Table 1.15, Table 2.15; Figs. 39-40, 60c; Map 7).

A. ruthenica is common all over the country. The chromosome number agrees with the data of HARLING (1950), MAJOVSKI & al. (1970), MITSUOKA & EHRENDORFER (1972) and JASIEWICZ & MIZIANTY (1975) (the last for plants from Bulgaria). In the karyotype we found two pairs of metacentric, five of submetacentric and two of SAT-chromosomes.

Subgenus Anthemis Section Maruta (Cass.) Griseb.

Anthemis cotula L., $2n = 2x = 18$ (Table 1.16, Table 2.16; Figs. 41-42, 60a; Map 8).

This species is found all over the country. The chromosome number agrees with the data of other authors: WULFF (1937), DELAY (1947, 1968), HEISER & WHITTAKER (1948), HARLING (1950), MULLIGAN (1957), TAYLOR & MULLIGAN (1968), TUMADŽANOV & BERIDZE (1968), MAJOVSKI & al. (1970), YAVIN (1970), STRID (1971), FERNANDES & QUEIROS (1971), MITSUOKA & EHRENDORFER (1972), QUEIROS (1973), LÖVE & KJELLQUIST (1974). In the karyotype there are one pair of metacentric, six pairs of submetacentric and two of SAT-chromosomes. The differences with the karyotype described by FERNANDES & QUEIROS (1971) and MITSUOKA & EHRENDORFER (1972) are given in Table 3. If not due to technical reasons, they may plead for a certain polymorphism in the species.

Subgenus Cota (Gay ex Guss.) Rouy Section Anthemaria Dumort.

Anthemis macrantha Heuff., $2n = 2x = 18$ (Table 1.17, Table 2.17; Figs. 43-44, 61d; Map 9).

A. macrantha is known from a single locality in Central Western Bulgaria (reference data from Southeastern Bulgaria is unconfirmed). In the karyotype there are three pairs of metacentric, four of submetacentric and two of SAT-chromosomes.

Anthemis sancti-johannis Turrill, $2n = 2x = 18$ (Table 1.18, Table 2.18; Figs. 45-46, 61a; Map 9).

The species is one of the ten Bulgarian endemics of the genus (THIN, 1980a; Map 14) and is known from two separate floristic regions, Central Stara Planina and Rila mountain (there is a third unconfirmed record from

Slavjanka Mt.). The chromosome number agrees with the data given by DOWRICK (1952). In the karyotype we found one pair of metacentric, four of submetacentric and four pairs of SAT-chromosomes.

Anthemis parnassica (Boiss. & Heldr.) R. Fernandes, $2n = 2x = 18$ (Table 1.19, Table 2.19; Figs. 47-48, 61b; Map 6).

The species is known from a number of localities in Central and Southern Bulgaria. In the karyotype we have found one pair of metacentric, six pairs of submetacentric and two pairs of SAT-chromosomes.

Anthemis tinctoria L., $2n = 2x = 18$ (Table 1.20, Table 2.20; Figs. 49-50, 61c; Map 10).

A. tinctoria is a common plant in Bulgaria. The chromosome number agrees with the data of many authors (see BOLHOVSKIH & al., 1969; MOORE, 1973, 1977; MITSUOKA & EHRENDORFER, 1972; KUZMANOV & KOŽUHAROV, 1970 and KUZMANOV, 1975) for Bulgarian populations. In the karyotype we found one pair of metacentric, six pairs of submetacentric and two pairs of SAT-chromosomes (for the differences with Kuzmanov and Mitsuoka & Ehrendorfer, see Table 3).

Subgenus Cota Section Cota

Anthemis altissima L., $2n = 2x = 18$ (Table 1.21, Table 2.21; Figs. 51-52, 62a; Map 6).

The species is widespread in Southern Bulgaria. The chromosome number agrees with the data of KUZMANOV & GEORGIEVA (1977) for Bulgarian plants and of HARLING (1950), PODLECH & DIETERLE (1969), MITSUOKA & EHRENDORFER (1972). In the karyotype we found one pair of metacentric, six of submetacentric and two pairs of SAT-chromosomes.

Anthemis austriaca Jacq., $2n = 2x = 18$ (Table 1.22, Table 2.22; Figs. 53-54, 62b; Map 11).

The species is a common plant in the country. The chromosome number agrees with the data of KUZMANOV & KOŽUHAROV (1970) and KUZMANOV (1975) for Bulgarian plants and of HARLING (1950), MITSUOKA & EHRENDORFER (1972). In the karyotype we found seven pairs of submetacentric and two pairs of SAT-chromosomes.

Discussion

The twenty-two *Anthemis* species of two subgenera and five sections we studied provide data for the evolutionary pattern in the genus.

Polyploidy

In ten species polyploidy was found (eight tetraploid and two triploid cytotypes). All tetraploids belong to one section — *Hiorthia,* and this seems to be the only section in the genus where polyploidy had an evolutionary rôle (see BOLHOVSKIH & al., 1969; MOORE, 1973, 1977; MITSUOKA & EHRENDORFER, 1972).

In respect to morphological characters the section *Hiorthia* is the most primitive one — the species are mostly subshrubs and perennials with long conical receptacles, large and denticulate receptacle scales, in most species the achenes have a long, denticulate corona (THIN, 1980a). Evidently, polyploidy had a major evolutionary rôle in the group and it seems to be a paleopolyploidy in many cases. Polyploids may have evolved from ancient diploids in Asia Minor (the primary evolutionary centre of the genus (THIN, 1980a). In the Balkan Peninsula and Bulgaria, however, they appeared as primitive tetraploids *(Anthemis argyrophylla, A. rumelica, A. hinkovae, A. kuzmanovii)* as well as more recent types *(A. regis-borisii, A. tenuiloba, A. carpatica* and *A. cretica).* There are also some types which seem to have developed even more recently in this region — *A. virescens, A. stribrnyi, A. orbelica* and *A. macedonica,* but again they are restricted to a region close to Asia Minor (see Map 14).

Triploid types were found in two species — *Anthemis orbelica* (sect. *Hiorthia*) and *A. arvensis* (sect. *Anthemis*). This may well speak for a recent hybridization on both sections, but a cytogenetic study on the respective populations is needed.

Karyotypes and species to species differences

In all populations studied karyologically four major types of chromosomes were found: metacentric (one to three pairs in the different species), submetacentric (four to fourteen pairs in the polyploid types), acrocentric (in fact only one pair in *A. carpatica*) and SAT-chromosomes (of metacentric, submetacentric or acrocentric types and from two to six pairs in the different species).

In section *Hiortia* two species — *Anthemis hinkovae* and *A. kuzmanovii* have been separated on their morphological characters (THIN, 1980b). *Anthemis hinkovae* is closely related to *A. cretica.* Significant differences have been found in their karyotypes: both species have one pair of submetacentric SAT-chromosomes, but in *Anthemis cretica* satellites are on the short arm and in *A. hinkovae* on the long arm; of the acrocentric SAT-chromosomes *A. cretica* has five pairs and *A. hinkovae* four pairs; *A. cretica* has two pairs and *A. hinkovae* three pairs of metacentric chromosomes (see Table 2). *Anthemis kuzmanovii* is related to *A. tenuiloba* and *A. carpatica.* Also in their karyotypes differences were observed: *A. kuzmanovii* has three pairs of acrocentric SAT-chromosomes, as well as *A. carpatica,* but there are

four pairs in *A. tenuiloba; A. carpatica* has one pair of acrocentric chromosomes which is missing in the other two species. Metacentric chromosomes are three pairs in *A. kuzmanovii,* one in *A. carpatica* and four in *A. tenuiloba;* submetacentric pairs are respectively twelve in *A. kuzmanovii,* thirteen in *A. carpatica* and ten in *A. tenuiloba* (see Table 2). *Anthemis regis-borisii* has been related to *A. rumelica* and *A. tenuiloba* (FERNANDES, 1976). In the karyotypes we found some differences: four pairs of acrocentric SAT-chromosomes in *Anthemis regis-borisii;* three pairs of SAT (one submetacentric and two acrocentric) in *A. rumelica* and four acrocentric pairs in *A. tenuiloba;* submetacentric chromosomes are ten pairs in *A. regis-borisii* and *A. tenuiloba,* but eleven pairs in *A. rumelica* (see Table 2).

Anthemis stribrnyi, A. orbelica and *A. macedonica* have been considered by Stojanov and Achtarov (*in* STOJANOV & STEFANOV, 1948) as infraspecific taxa of *A. thracica* in opposition to HAYEK (1931) and FERNANDES (1976), who relate *A. stribrnyi* to *A. rumelica* and *A. macedonica* is considered in sect. *Anthemis.* In their karyotypes there are the following characteristic differences of SAT-chromosomes. There are three pairs (one metacentric and two acrocentric) in *A. stribrnyi,* two acrocentric in *A. macedonica* and *A. orbelica.* There are two pairs of metacentric chromosomes in *A. orbelica* and *A. macedonica,* but only one pair in *A. stribrnyi* (see Table 2).

Anthemis sancti-johannis is related to *A. tinctoria* and *A. parnassica.* In their karyotypes we found: SAT-chromosomes — four pairs (two submetacentric and two acrocentric) in *A. sancti-johannis,* two acrocentric in *A. parnassica* and *A. tinctoria,* four pairs of submetacentric in *A. sancti-johannis* and six pairs in *A. parnassica* and *A. tinctoria.*

It is evident that chromosome repatterning has been a major pathway in the evolutionary changes in *Anthemis.* As pointed out by MITSUOKA & EHRENDORFER (1972), this may well have led to genetical isolation and speciation.

General evolutionary pattern in the genus

The most primitive species of *Anthemis* are concentrated in Asia Minor (subshrubs and perennials with woody stock) — *Anthemis trotzkiana* Bunge, *A. orientalis* (L.) Deg., *A. iberica* M.B., *A. cassia* Boiss., *A. anthemiformis* (Freyn & Sint.) Grierson, *A. candicans* Boiss., *A. rhodensis* Boiss., etc. (GRIERSON & YAVIN, 1975; FEDOROV, 1961). The adaptive irradiation to the west has led to the formation of many endemics in the Balkan Peninsula (27 species after FERNANDES, 1976; THIN, 1980b). In their evolutionary changes the perennial type has enabled these species to overcome the setbacks of polyploidisation and the obligate outcrossing favours hybridization (MITSUOKA & EHRENDORFER, 1972). In all annuals with short genetic sequence the recombination system has been narrowed by chromosomal repatterning leading to genetic isolation (MITSUOKA & EHRENDORFER, 1972).

In correlation to this, most of the Bulgarian endemics (see Map 14) and the Balkan endemics are perennials which are more or less restricted to a

small region. Seven of the ten Bulgarian endemics are perennials and six of them are restricted to a single locality.

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Table 1. — Cytologically studied taxa

Taxa	*Populations and voucher number*
Subgenus Anthemis Section Hiorthia	
1. *A. argyrophylla*	1.1. Thracian plain, limestone rocks near Belovo. 15.10.1979. *BK-7955.*
2. *A. regis-borisii*	2.1. Black sea coast, sandy places by "Pobitite kamani". 8.8.1978. *BK-7925.*
3. *A. kuzmanovii*	3.1. Krajste region, Golo bardo Mt., near summit Ostrica. 15.6.1979. *BK-7957.*
4. *A. rumelica*	4.1. Tundza region, grassy places on the hill east of Ajtos. 15.9.1978. *BK-7950.* 4.2. Black Sea coast, on the rocks by "Kaleto" at estuary of the river Ropotamo. 10.9.1978. *BK-7951.*
5. *A. tenuiloba*	
5.1. var. *delicatula*	5.1. Thracian plain, grassy places near "Aida" at Haskovo mineral baths. 27.7.1978. *BK-7948.*
5.2. var. *radiata*	5.2. Strandza Mt., on rocks north of Malko Tarnovo. 12.9.1978. *BK-7949.*
6. *A. hinkovae*	6.1. Eastern Rhodopi Mts., on rocks by the river Arda near Madzarovo. 27.7.1978. *BK-7947.*
7. *A. cretica*	7.1. Central Stara Planina, on rocks at "Sinite kamani" near Sliven. 16.10.1978. *BK-7952.*
8. *A. carpatica*	
8.1. var. *balcanica*	8.1. Pirin Mt., on rocks of summit Todorka. 19.8.-1978. *BK-7940.*
8.2. var. *subcarpatica*	8.2. Central Stara Planina, on rocks of summit Mara-Gidik. 14.10.1978. *BK-7939.*
8.3. var. *cinerea*	8.3. Pirin Mt., on rocks of summit Dzengal. 21.8.-1978. *BK-7941.* 8.4. Rila Mt., on the way to chalet "Ribnite ezera". 27.9.1978. *BK-7942.*

9. *A. orbelica* .....
   - 9.1. Western Rhodopi Mts., at the river above Sestrimo. 26.8.1978. *BK-7922.*
   - 9.2. Western Rhodopi Mts., grassy places near Velingrad. 7.7.1978. *BK-7924.*
   - 9.3. Western Rhodopi Mts., grassy places near Sladova, distr. Velingrad. 12.7.1978. *BK-7923.*
   - 9.4. Rila Mt., grassy places near Partizanska poljana on the way to chalet "Ribni ezera". 27.9.1978. *BK-7921.*

10. *A. stribrnyi* .....
   - 10.1. Central Rhodopi Mts., on rocks near Smoljan. 29.7.1978. *BK-7919.*
   - 10.2. Western Rhodopi Mts., grassy places near Borino. 29.7.1978. *BK-7918.*
   - 10.3. Western Rhodopi Mts., near the dam "Vasil Kolarov", 1600 m. 29.7.1978. *BK-7920.*

11. *A. macedonica* .....
   - 11.1. Struma valley, on the hill Malkija Kozuh. 30.9.-1978. *BK-7916.*
   - 11.2. Struma valley, near Kresna. 2.10.1978. *BK-7917.*

12. *A. virescens* .....
   - 12.1. Eastern Stara Planina, on the pastures near Dobrovan. 29.7.1979. *BK-7958.*

Subgenus Anthemis Section Anthemis

13. *A. arvensis*
   - 13.1. subsp. *arvensis* .....
     - 13.1.1. Eastern Rhodopi Mts., on the hills near Javorovo. 28.7.1978. *BK-7935.*
     - 13.1.2. Western Stara Planina, on the way to Varsec. 25.7.1978. *BK-7938, 7939.*
     - 13.1.3. Central Stara Planina, grassy places around chalet "Krivan" near Gabrovo. 15.10.1978. *BK-7937.*
   - 13.2. subsp. *incrassata* ....
     - 13.2.1. Black Sea coast, on sand near Kiten. 10.10.-1978. *BK-7936.*

14. *A. auriculata* .....
   - 14.1. Tundza region, grassy places near Ajtos. 9.9.-1978. *BK-7956.*
   - 14.2. Struma valley, grassy places near Kulata. 29.9.1978. *BK-7943.*
   - 14.3. Struma valley, grassy places on the hill "Malkija Kozuh". 30.9.1979. *BK-7944.*
   - 14.4. Struma valley, on the hills near Kresna. 1.10.-1978. *BK-7953.*

15. *A. ruthenica* .....
   - 15.1. Western Rhodopi Mts., grassy places near Velingrad. 3.7.1978. *BK-7902-7905.*
   - 15.2. Sofia region, near Lokorsko. 15.7.1978. *BK-7906, 7907.*
   - 15.3. Belasica Mt., grassy places near Kolarovo. 25.7.1976. *BK-76326.*

15.4. Rhodopi foothills — by Momina klisura. 21.8.-1976. *BK-76324.*

Subgenus Anthemis Section Maruta

16. *A. cotula* .....
16.1. Central Rhodopi Mts., near Devin. 29.7.1978. *BK-7933.*
16.2. Rhodopi foothills — by Momina klisura. 21.8.-1976. *BK-76326.*

Subgenus Cota Section Anthemaria

17. *A. macrantha* .....
17.1. Osogvska Mt., by the river Mlacka. 23.9.1978. *BK-7946.*

18. *A. sancti-johannis* .....
18.1. Central Stara Planina, alpine meadows around chalet "Mazalat". 13.10.1978. *BK-7945.*

19. *A. parnassica* .....
19.1. var. *parnassica* .....
19.1. Struma valley, on the road near Kresna. 1.10.-1978. *BK-7912.*
19.2. var. *pallida* .....
19.2. Strandza Mt., near Stoilovo, North of Malko Tarnovo. 12.9.1978. *BK-7913.*

20. *A. tinctoria* .....
20.1. Thracian plain, on the road to Haskovo mineral baths. 27.7.1978. *BK-7908.*
20.2. Western Rhodopi Mts., near Velingrad. 14.7.-1978. *BK-7909.*
20.3. Western Rhodopi Mts., near Sestrimo. 26.8.-1978. *BK-7911.*
20.4. Krajste region, on hills between Klisura and Dragomirovo. 22.9.1978. *BK-7910.*

Subgenus Cota Section Cota

21. *A. altissima* .....
21.1. Thracian plain, near Stara Zagora. 6.9.1978. *BK-7926.*
21.2. Black Sea coast, near Mičurin. 2.9.1978. *BK-7928.*

22. *A. austriaca* .....
22.1. Thracian plain, near Sadovo. 21.7.1978. *BK-7914.*
22.2. Western Rhodopi Mts., near Velingrad. 14.7.-1978. *BK-7915.*
22.3. Tundza region, near Sliven. 17.10.1978. *BK-7954.*

Table 2. — Comparative chromosomal morphology

Taxon	2n	Types of chromosomes					
					SAT		
		M	SM	A	M	SM	A
Subgenus Anthemis Section Hiortia							
1. *A. argyrophylla*	36	1L	14 (8L, 5M, 1Sh)	—	—	—	1M, 2Sh
2. *A. regis-borisii*	36	4L	10 (9L, 1M)	—	—	—	4M
3. *A. kuzmanovii*	36	3M	12 (8L, 4M)	—	—	—	2M, 1Sh
4. *A. rumelica*	36	4M	11 (7M, 4Sh)	—	—	1L	2Sh
5. *A. tenuiloba*	36	4M	10M	—	—	—	4Sh
6. *A. hinkovae*	36	3M	10 (3L, 7M)	—	—	1L	4Sh
7. *A. cretica*	36	2L	10L	—	—	1L	1L, 3M, 1Sh
8. *A. carpatica*	36	1M	13M	1	—	—	3Sh
9. *A. orbelica*	18	2Sh	5Sh	—	—	—	2Sh
	18 + 4	2Sh	5Sh	1	—	—	2Sh + ½
	27	3M + ½	7M	—	—	1L	2Sh
10. *A. stribrnyi*	18	1M	5M	—	1M	—	2Sh
	18 + 3	2M	5M	1½	—	—	2Sh
11. *A. macedonica*	18	2L	5L	—	—	—	2L
12. *A. virescens*	18	1M	6 (3L, 3Sh)	—	—	—	2M
Subgenus Anthemis Section Anthemis							
13. *A. arvensis*	18	1M	6M	—	—	—	2Sh
	27	3 + ½M	7M	—	—	—	3Sh
14. *A. auriculata*	18	1Sh	6 (3M, 3Sh)	—	—	1Sh	1Sh
15. *A. ruthenica*	18	2Sh	5Sh	—	—	—	2Sh
Subgenus Anthemis Section Maruta							
16. *A. cotula*	18	1L	6 (3L, 3M)	—	—	—	2Sh
Subgenus Cota Section Anthemaria							
17. *A. macrantha*	18	3L	4L	—	—	—	2L
18. *A. sancti-johannis*	18	1M	4M	—	—	2M	2Sh
19. *A. parnassica*	18	1M	6M	—	—	—	2Sh
20. *A. tinctoria*	18	1M	6M	—	—	—	1M, 1Sh
Subgenus Cota Section Cota							
21. *A. altissima*	18	1M	6 (4L, 1M, 1Sh)	—	—	2L	—
22. *A. austriaca*	18	—	7M	—	—	—	2Sh

Abbreviations (types of chromosomes): M = metacentric, SM = submetacentric, A = acrocentric, SAT = chromosomes with satelites (see KUZMANOV & KOŽUHAROV 1967, with modification). Relative dimensions of the chromosomes: L = long, M = middle, Sh = short, ½ = a single chromosome.

Table 3. — Comparative chromosome morphology — reference data and our investigation.

Taxon	*Reference data*		*Reference*	*Our investigation*
1. *A. cotula*	Text:	M-SM: 7 pairs SAT-A: 2 pairs	1	
	Figure:	M: 1-2 pairs M SM: 5-7 pairs M SAT-A: 1-2 pairs M		M: 2 pairs L SM: 5 pairs (2L, 3M) SAT-A: 2 pairs SH
	Text.:	M: 3 pairs SM: 4 pairs SAT-A: 2 pairs	2	
2. *A. tinctoria*	Text:	SM: 7 pairs SAT-A: 2 pairs	2	M: 1 pair M SM: 6 pairs M SAT-A: 2 pairs (M, Sh)
	Text:	M: 3 pairs L SM: 4 pairs (3L, 1SH) A: 1 pair Sh SAT-A: 1 pair L	3	
	Figure:	M: 2 pairs M SM: 5 pairs M A: 1 pair Sh SAT-A: 1 pair L		
3. *A. altissima*	Text:	M: 1 pair SM: 6 pairs SAT-SM: 2 pairs	2	M: 1 pair M SM: 6 pairs (5L, M) SAT-SM: 2 pairs L
4. *A. austriaca*	Text:	M: 3 pairs SM: 4 pairs SAT-A: 2 pairs	3	SM: 7 pairs M SAT-A: 2 pairs Sh
	Figure:	SM: 7 pairs (4L, 3M) SAT-A: 2 pairs Sh		
5. *A. arvensis*	Figure:	M: 1 pair SM: 7 pairs SAT-A: 1 pair	4	M: 2 pairs SM: 5 pairs SAT-A: 2 pairs

1 = FERNANDES & QUEIROS, 1971; 2 = MITSUOKA & EHRENDORFER, 1972; 3 = KUZMANOV, 1975; 4 JASIEVICZ & MIZIANTHY, 1975. Abbreviations as in Table 2.

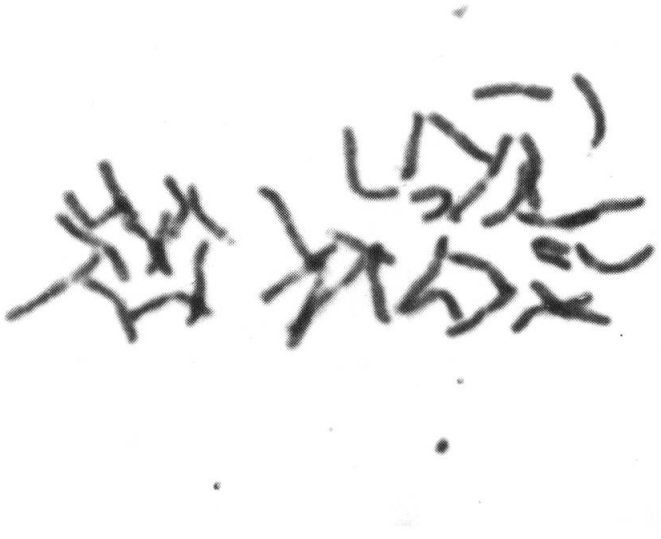
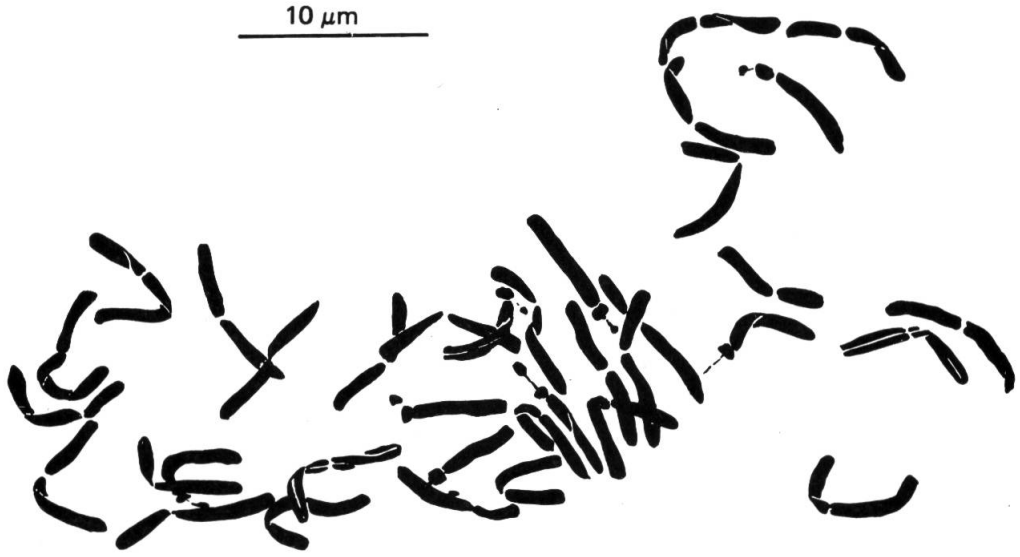


Fig. 1 — Drawings of mitotic root-tip cells of *A. argyrophylla.*
Fig. 2. — Microphotograph of mitotic root-tip cells of *A. argyrophylla.*



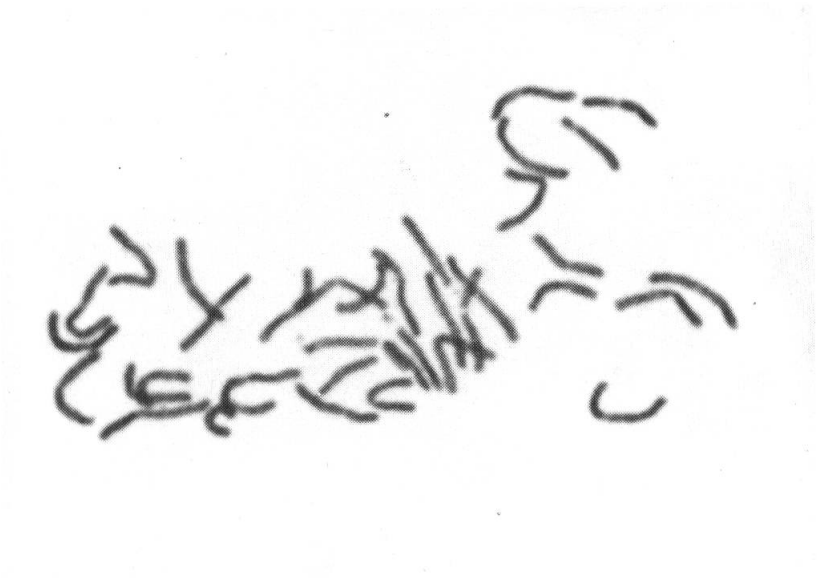


Fig. 3. — Drawings of mitotic root-tip cells of *A. regis-borisii.*
Fig. 4. — Microphotograph of mitotic root-tip cells of *A. regis-borisii.*

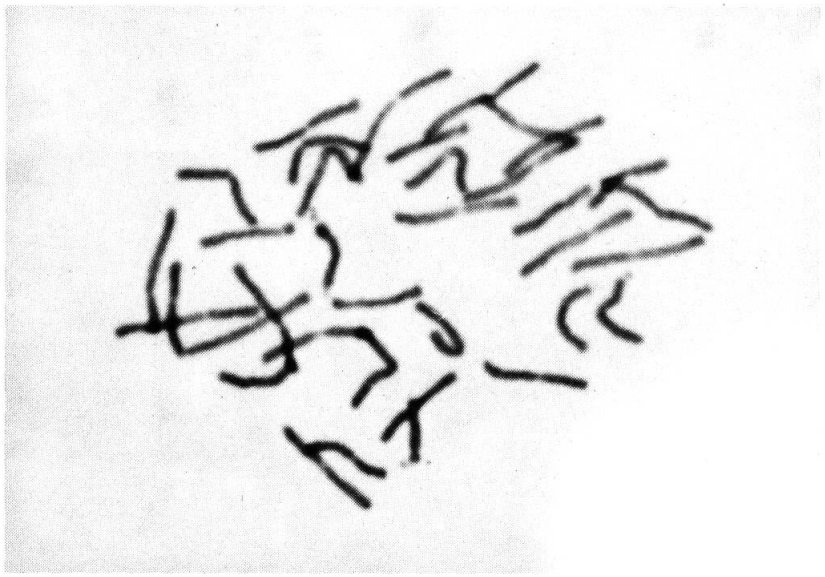
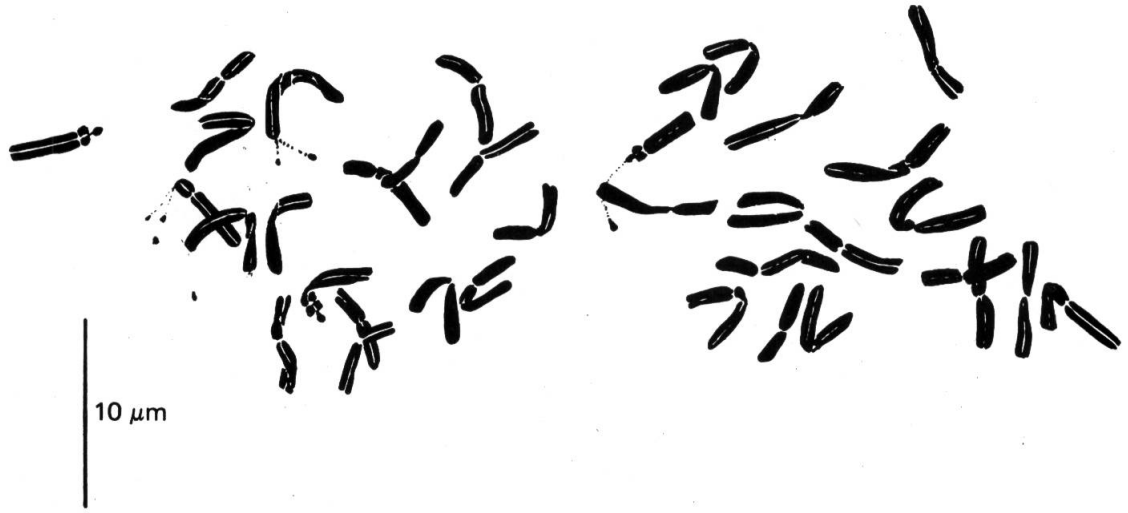


Fig. 5. — Drawings of mitotic root-tip cells of *A. kuzmanovii.*
Fig. 6. — Microphotograph of mitotic root-tip cells of *A. kuzmanovii.*



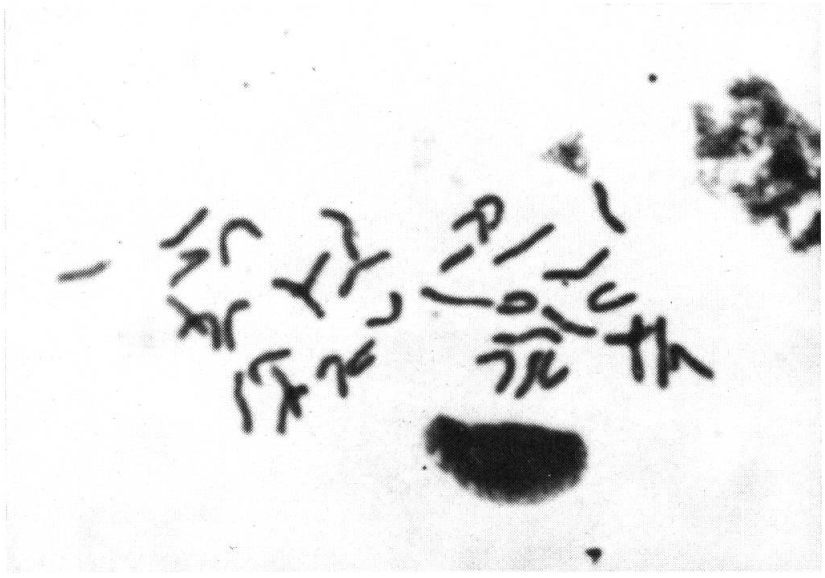
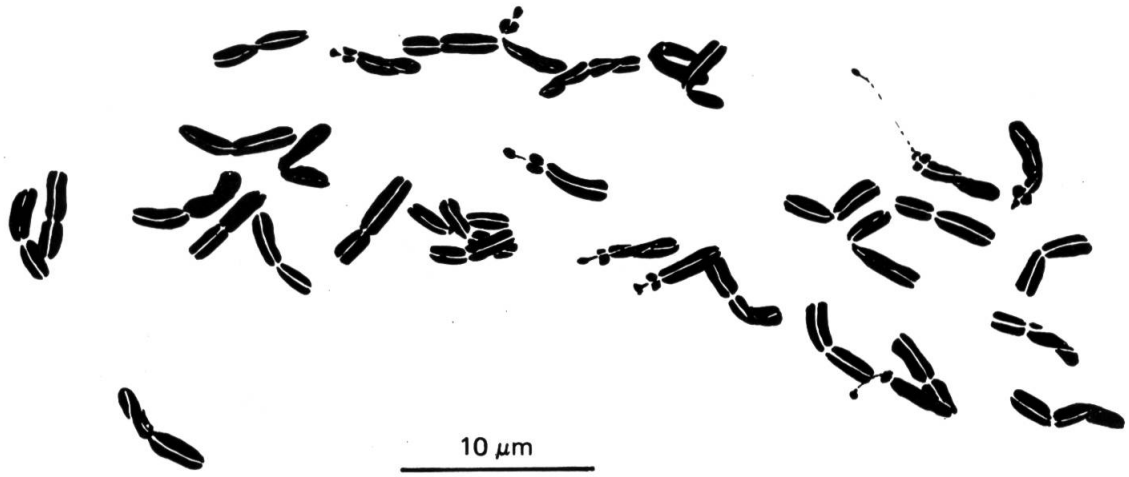


Fig. 7. — Drawings of mitotic root-tip cells of *A. rumelica.*
Fig. 8. — Microphotograph of mitotic root-tip cells of *A. rumelica.*



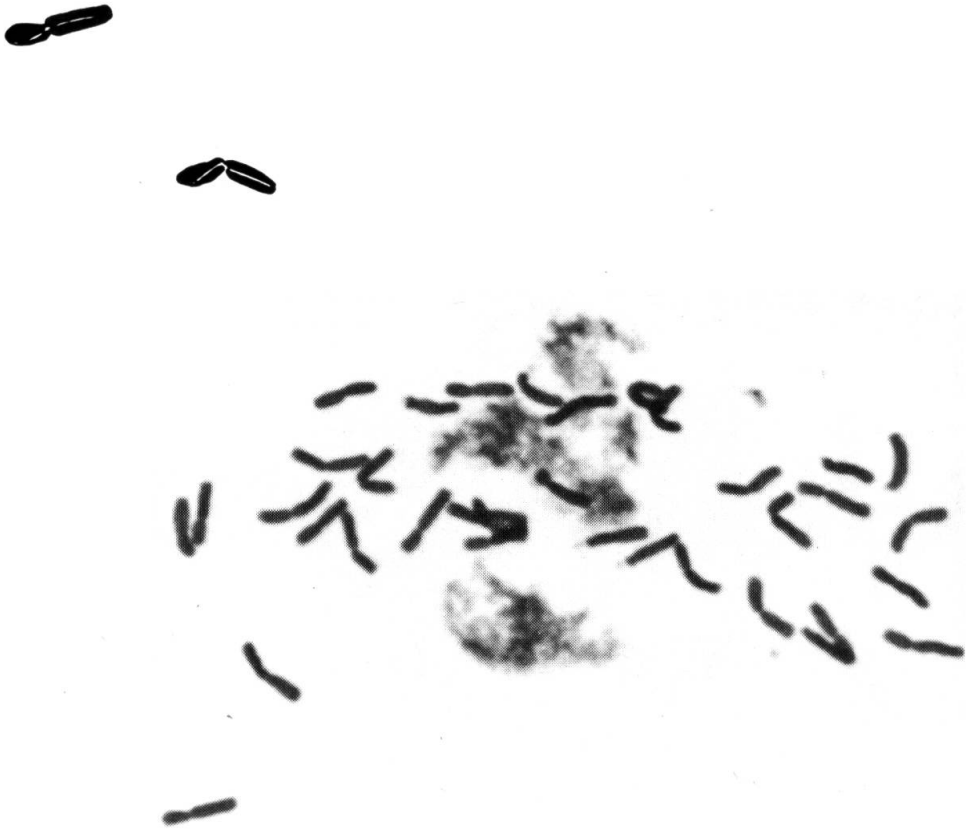


Fig. 9. — Drawings of mitotic root-tip cells of *A. tenuiloba.*
Fig. 10. — Microphotograph of mitotic root-tip cells of *A. tenuiloba.*

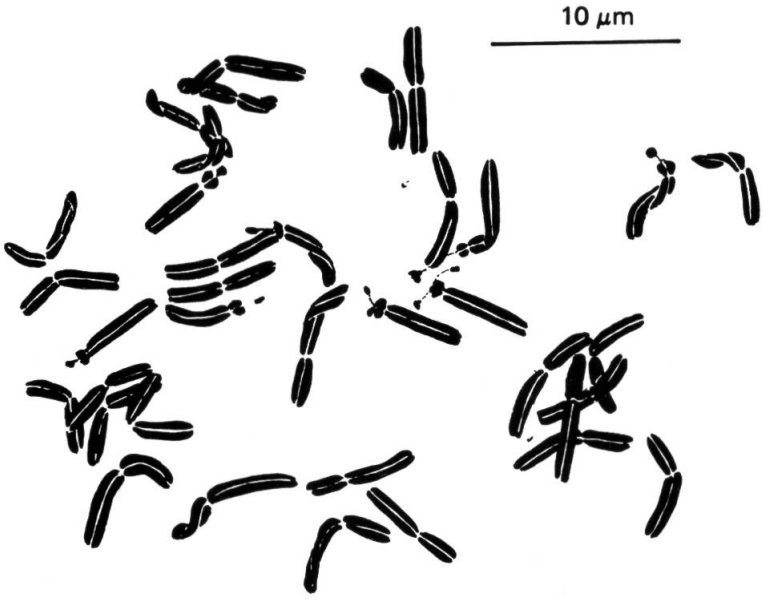
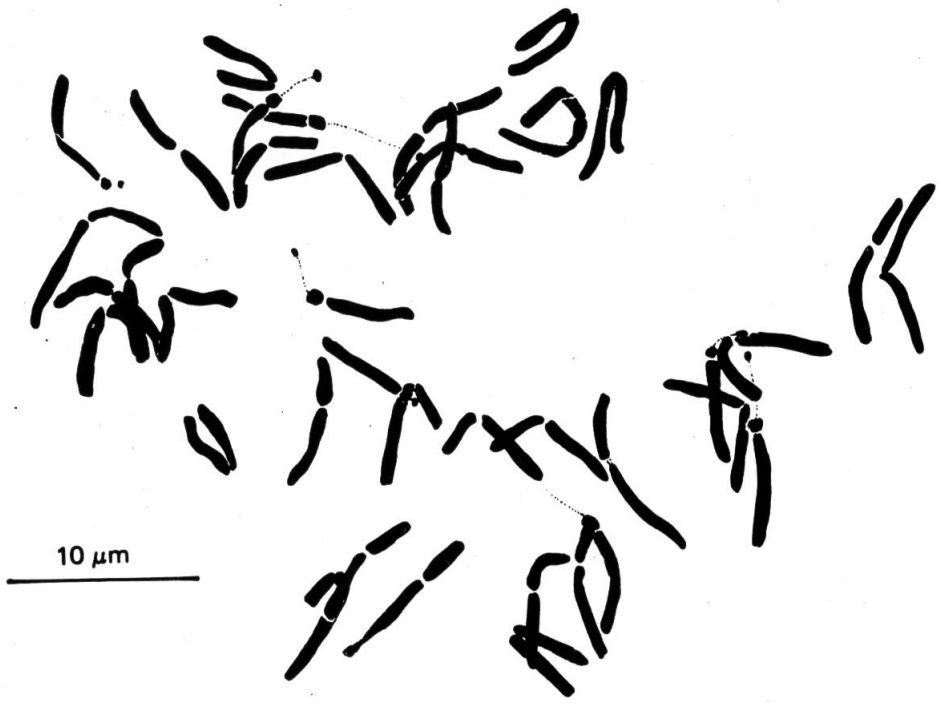


Fig. 11. — Drawings of mitotic root-tip cells of *A. hinkovae.*
Fig. 12. — Microphotograph of mitotic root-tip cells of *A. hinkovae.*



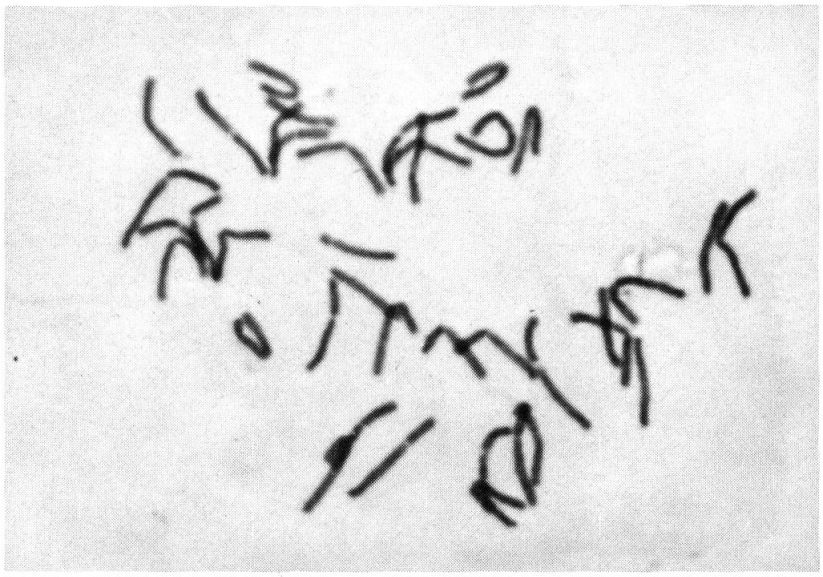
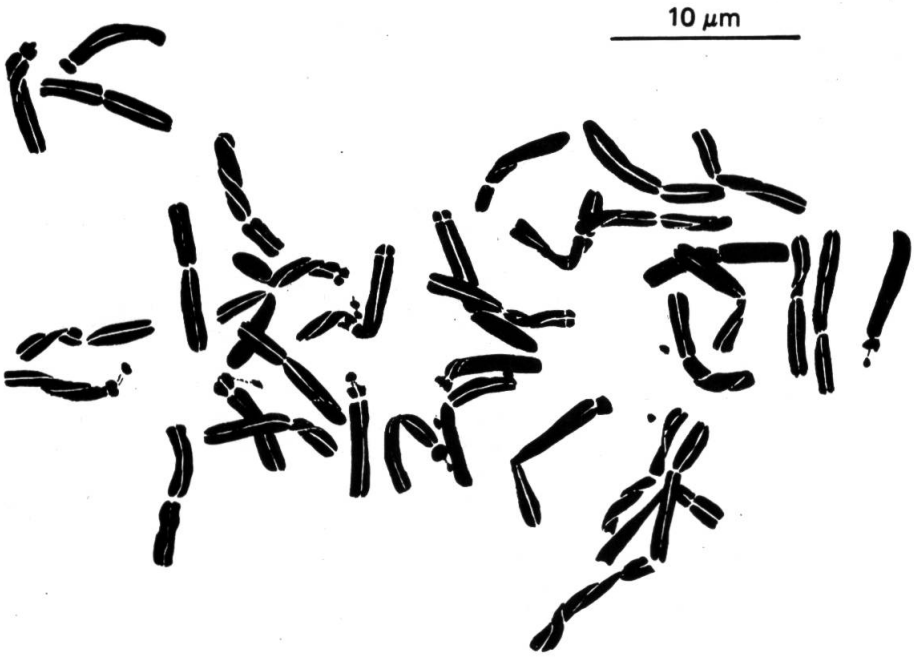


Fig. 13. — Drawings of mitotic root-tip cells of *A. hinkovae.*
Fig. 14. — Microphotograph of mitotic root-tip cells of *A. hinkovae.*



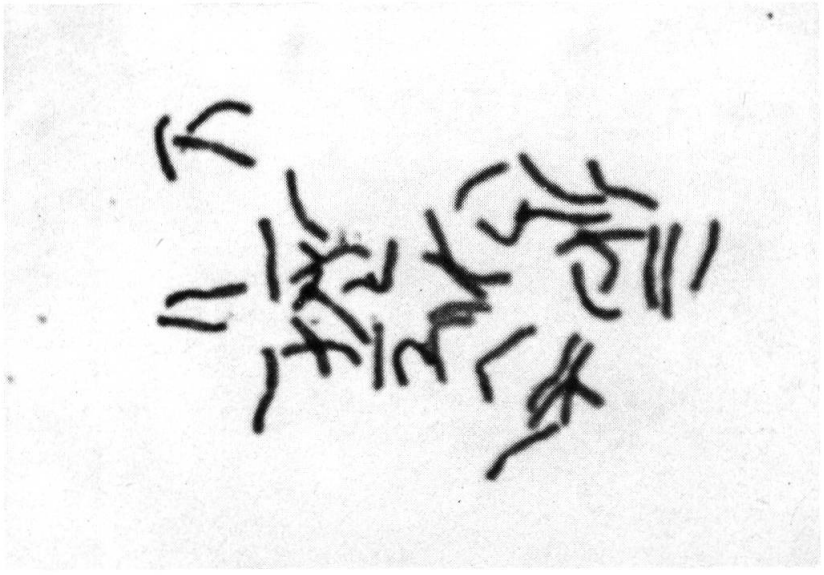
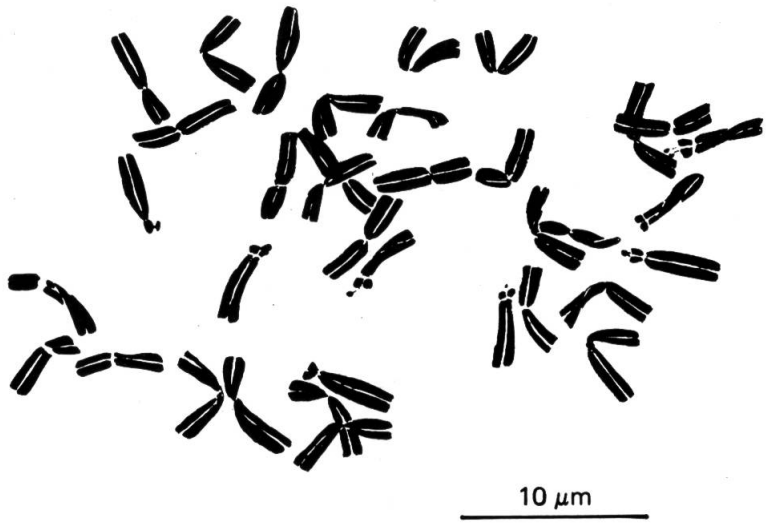


Fig. 15. — Drawings of mitotic root-tip cells of *A. cretica.*
Fig. 16. — Microphotograph of mitotic root-tip cells of *A. cretica.*



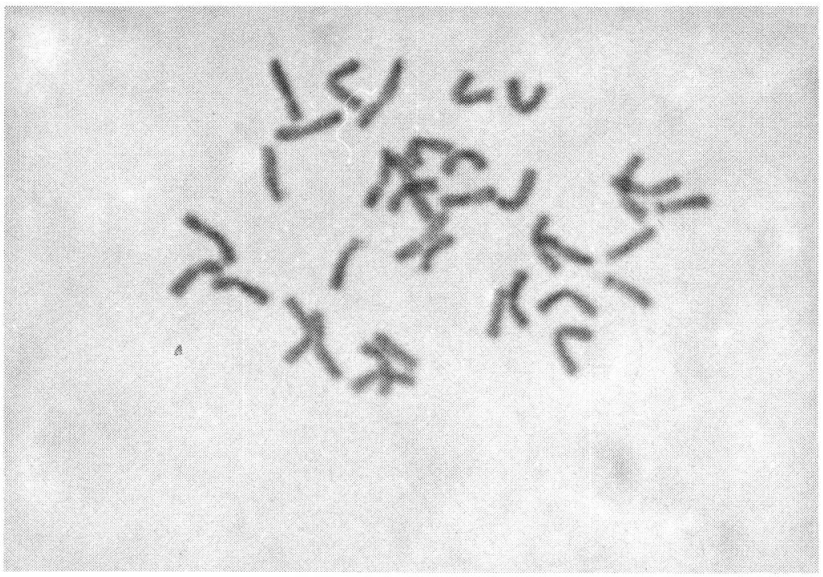


Fig. 17. — Drawings of mitotic root-tip cells of *A. carpatica.*
Fig. 18. — Microphotograph of mitotic root-tip cells of *A. carpatica.*

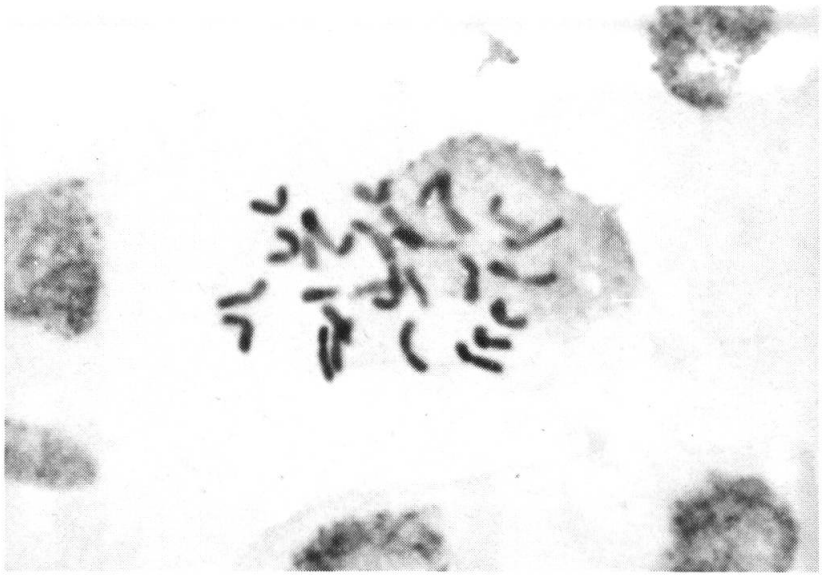
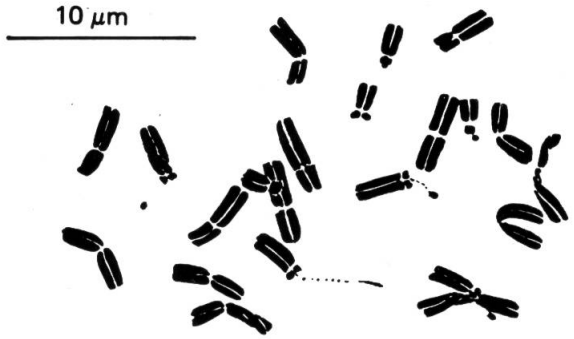


Fig. 19. — Drawings of mitotic root-tip cells of *A. orbelica.*
Fig. 20. — Microphotograph of mitotic root-tip cells of *A. orbelica.*



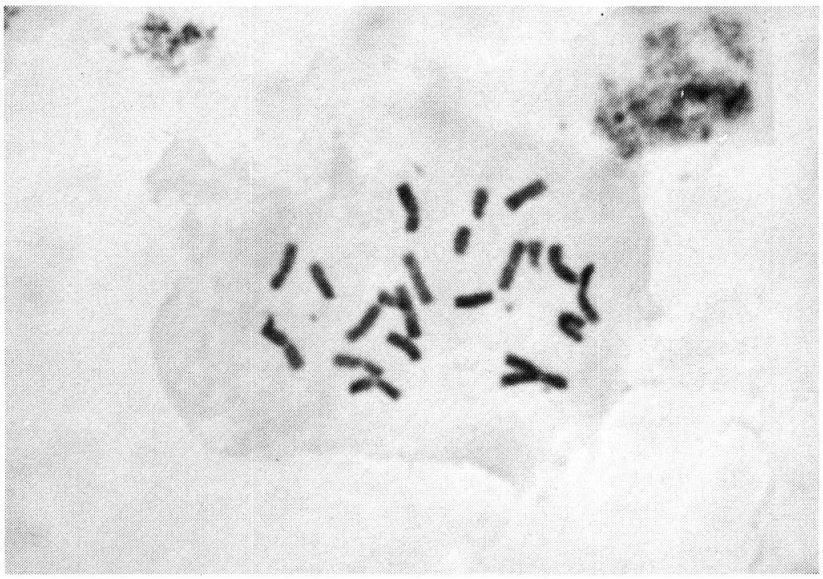


Fig. 21. — Drawings of mitotic root-tip cells of *A. orbelica.*
Fig. 22. — Microphotograph of mitotic root-tip cells of *A. orbelica.*

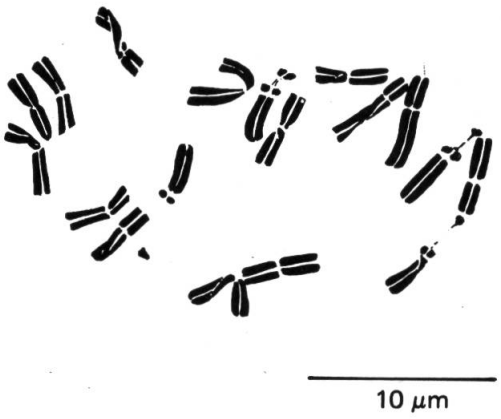
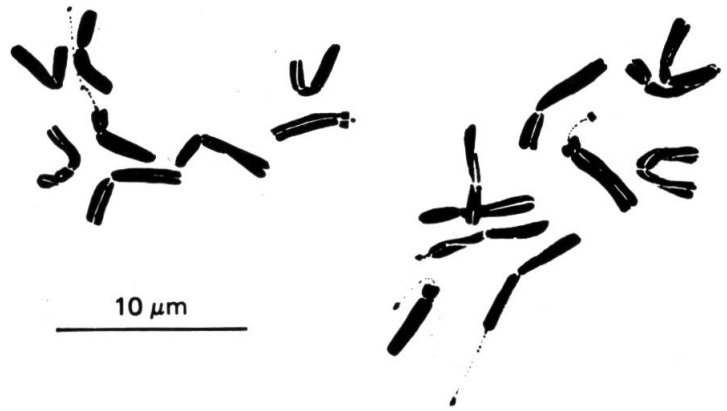


Fig. 23. — Drawings of mitotic root-tip cells of *A. orbelica.*
Fig. 24. — Microphotograph of mitotic root-tip cells of *A. orbelica.*



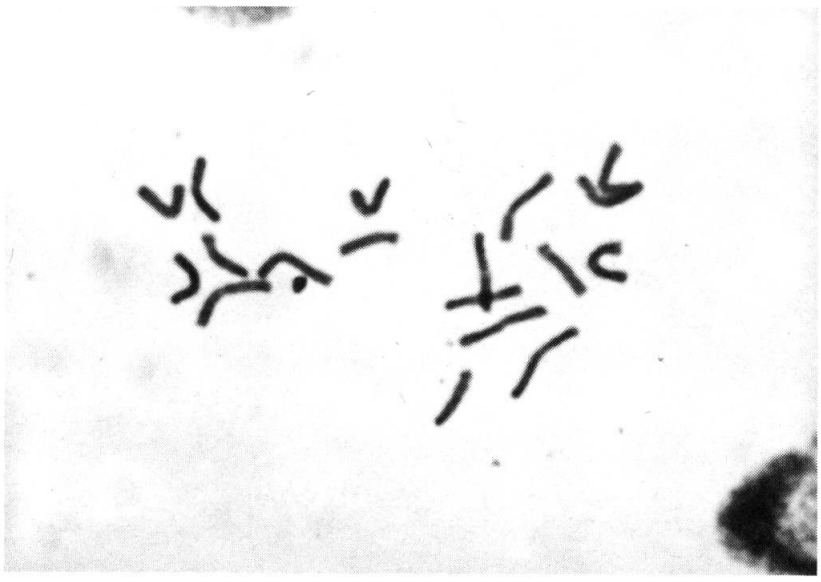


Fig. 25. — Drawings of mitotic root-tip cells of *A. stribrnyi.*
Fig. 26. — Microphotograph of mitotic root-tip cells of *A. stribrnyi.*

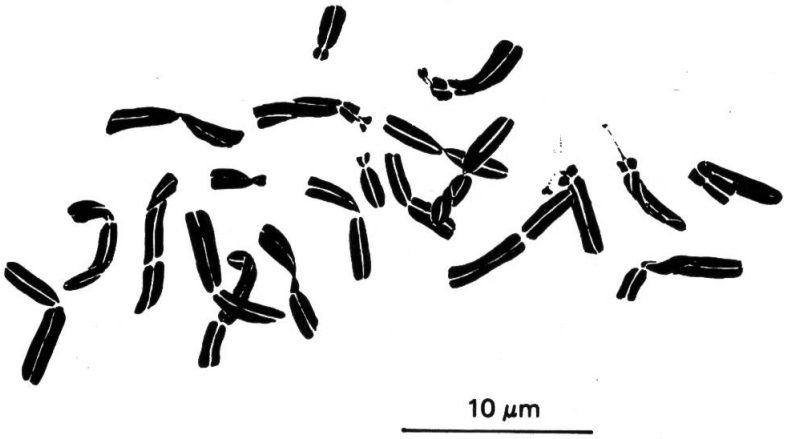
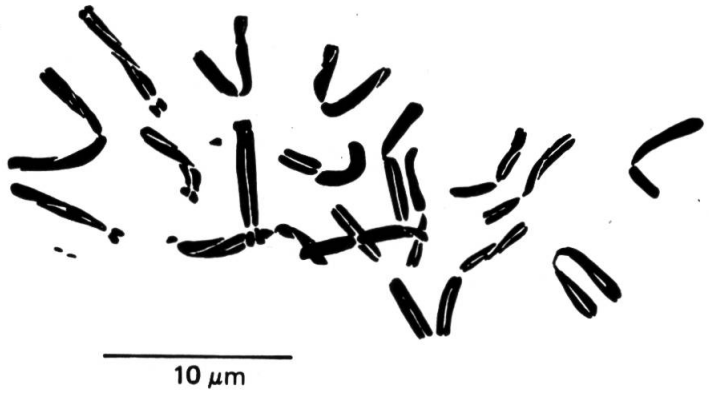


Fig. 27. — Drawings of mitotic root-tip cells of *A. stribrnyi*.
Fig. 28. — Microphotograph of mitotic root-tip cells of *A. stribrnyi*.



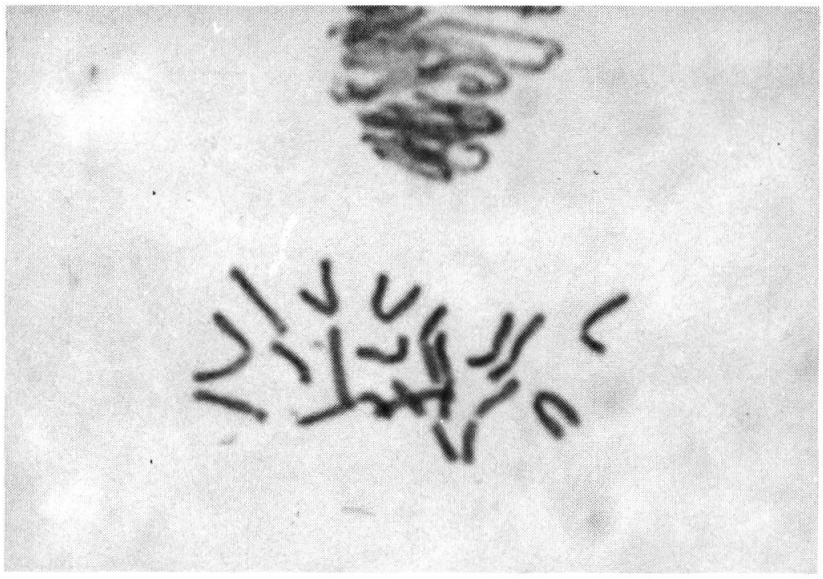


Fig. 29. — Drawings of mitotic root-tip cells of *A. macedonica.*
Fig. 30. — Microphotograph of mitotic root-tip cells of *A. macedonica.*

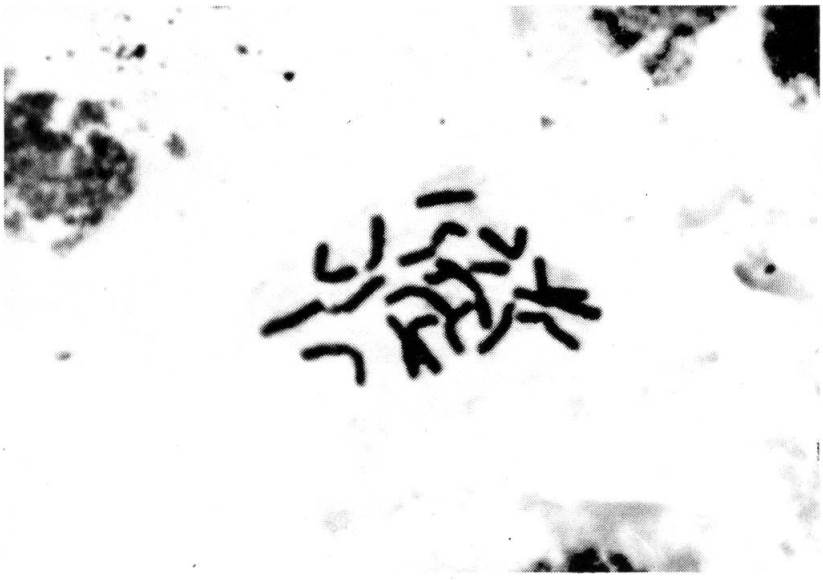
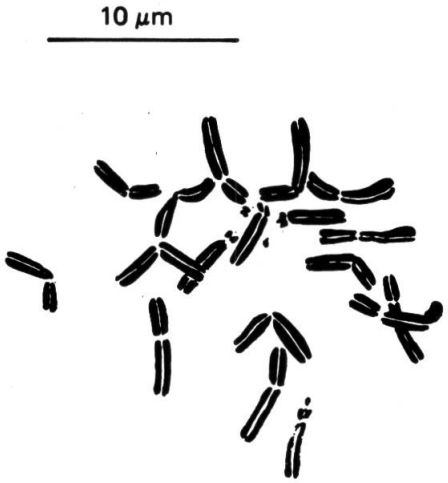


Fig. 31. — Drawings of mitotic root-tip cells of *A. virescens.*
Fig. 32. — Microphotograph of mitotic root-tip cells of *A. virescens.*



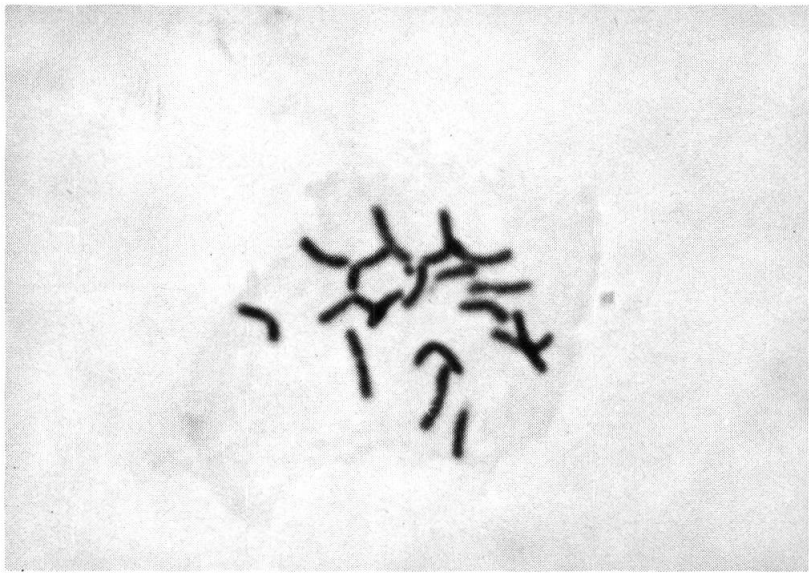


Fig. 33. — Drawings of mitotic root-tip cells of *A. arvensis.*
Fig. 34. — Microphotograph of mitotic root-tip cells of *A. arvensis.*

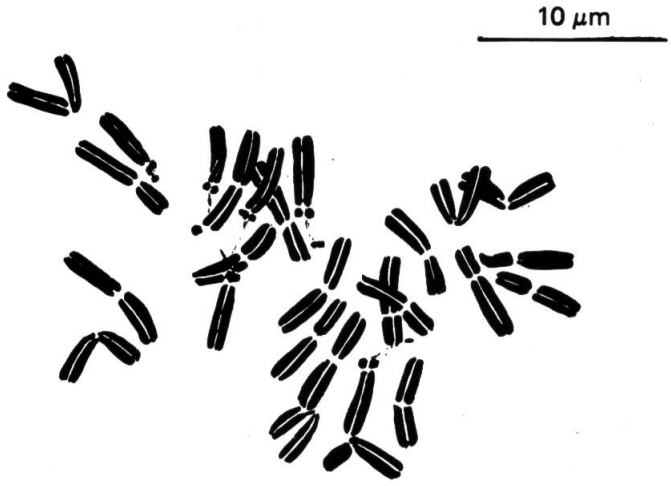


Fig. 35. — Drawings of mitotic root-tip cells of *A. arvensis.*
Fig. 36. — Microphotograph of mitotic root-tip cells of *A. arvensis.*

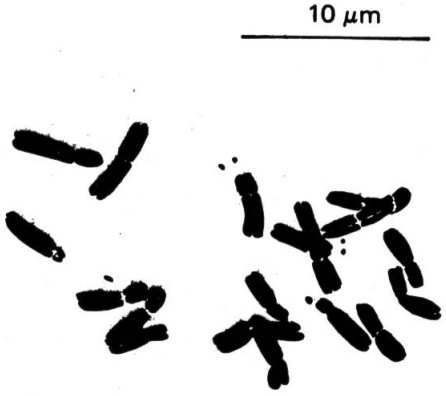
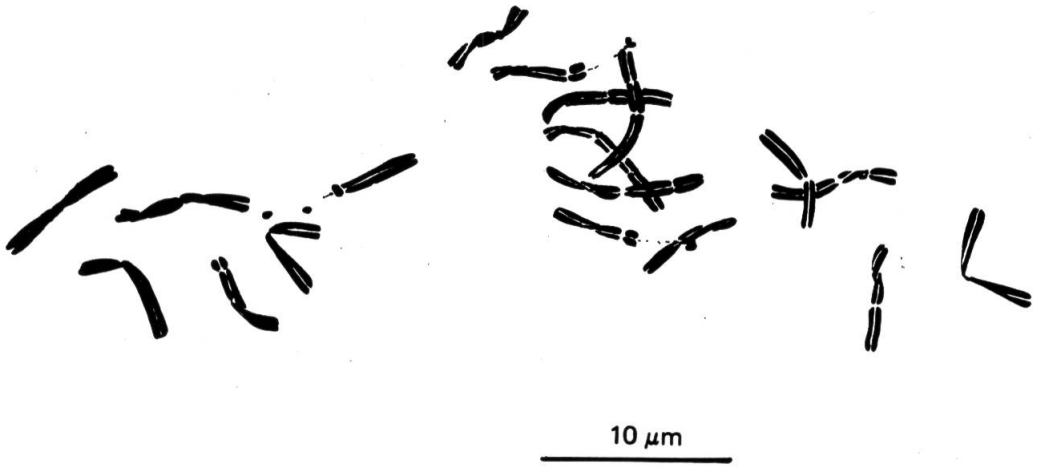


Fig. 37. — Drawings of mitotic root-tip cells of *A. auriculata.*
Fig. 38. — Microphotograph of mitotic root-tip cells of *A. auriculata.*

Fig. 39. — Drawings of mitotic root-tip cells of *A. ruthenica.*
Fig. 40. — Microphotograph of mitotic root-tip cells of *A. ruthenica.*



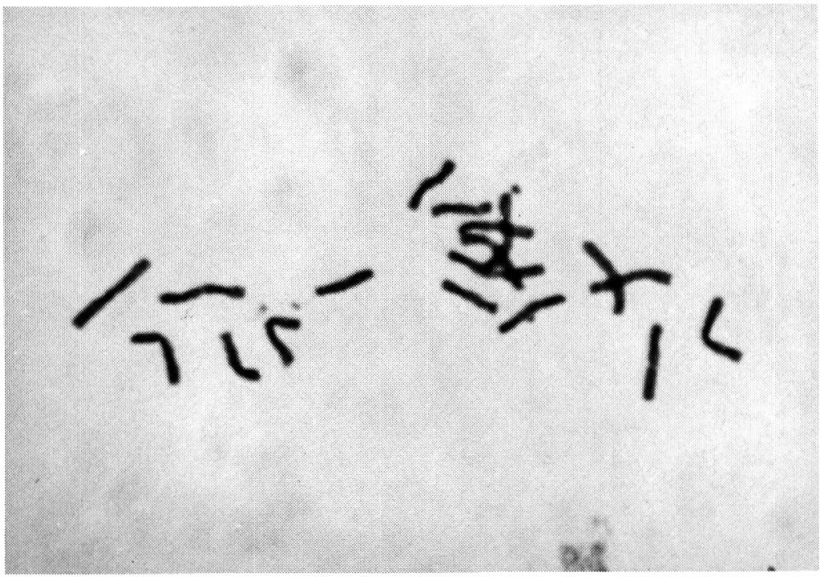
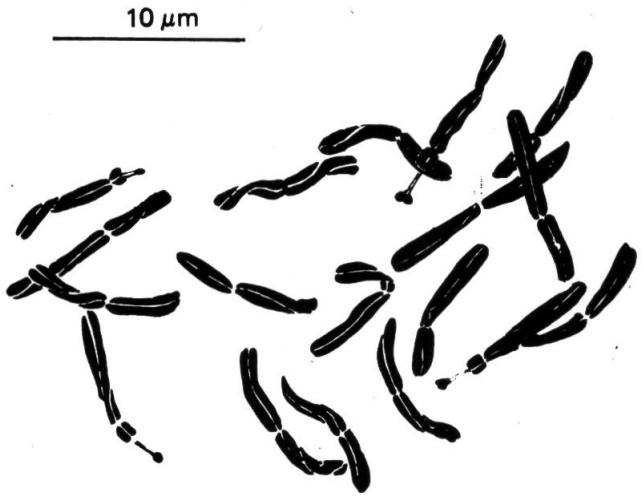


Fig. 41. — Drawings of mitotic root-tip cells of *A. cotula.*
Fig. 42. — Microphotograph of mitotic root-tip cells of *A. cotula.*



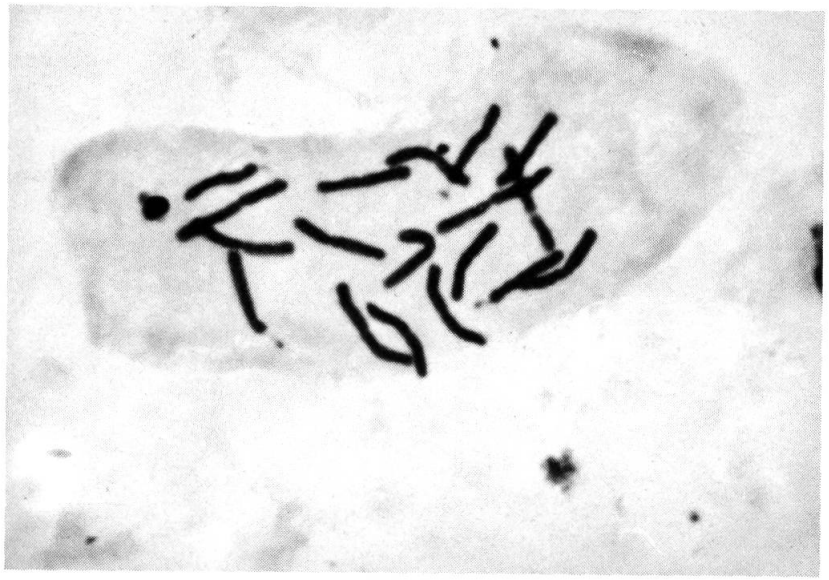
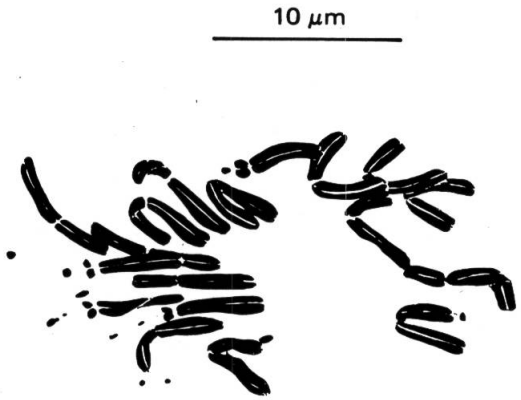


Fig. 43. — Drawings of mitotic root-tip cells of *A. macrantha.*
Fig. 44. — Microphotograph of mitotic root-tip cells of *A. macrantha.*



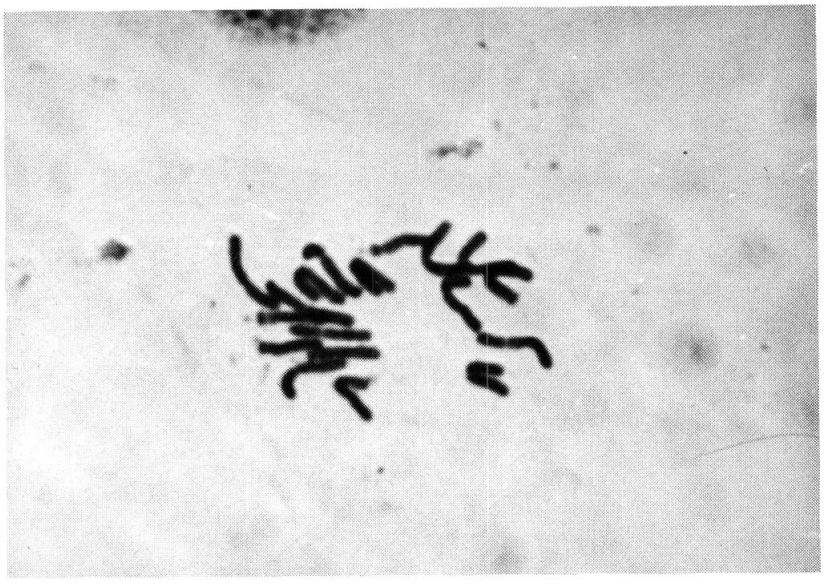


Fig. 45. — Drawings of mitotic root-tip cells of *A. sancti-johannis.*
Fig. 46. — Microphotograph of mitotic root-tip cells of *A. sancti-johannis.*

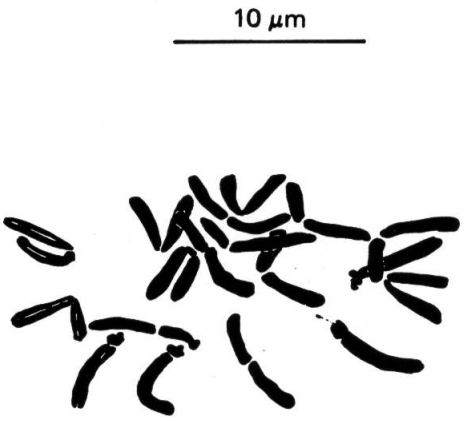
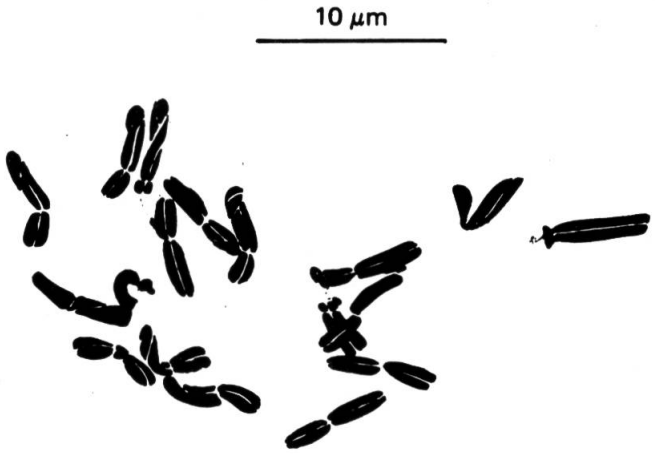


Fig. 47. — Drawings of mitotic root-tip cells of *A. parnassica.*
Fig. 48. — Microphotograph of mitotic root-tip cells of *A. parnassica.*



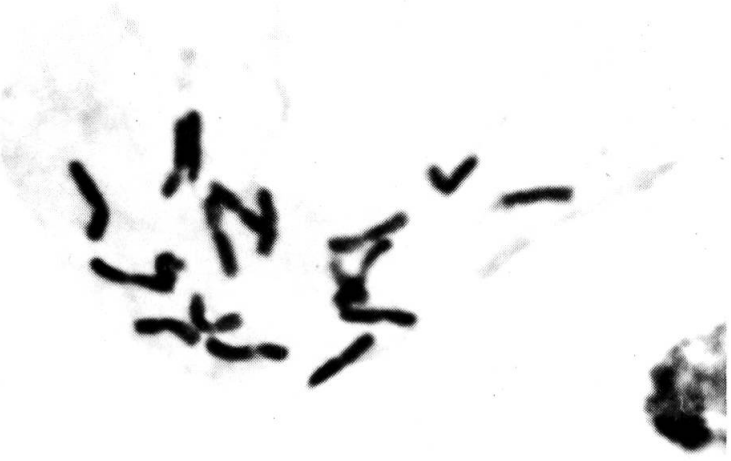
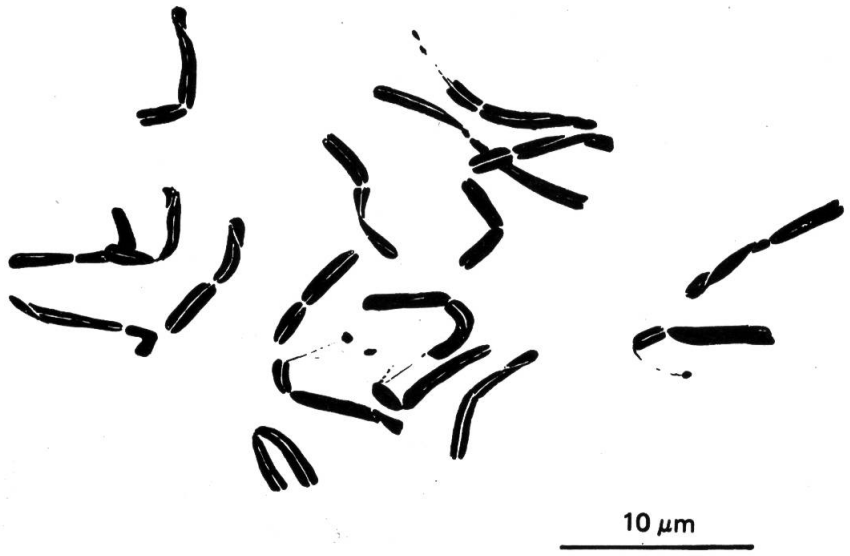


Fig. 49. — Drawings of mitotic root-tip cells of *A. tinctoria.*
Fig. 50. — Microphotograph of mitotic root-tip cells of *A. tinctoria.*



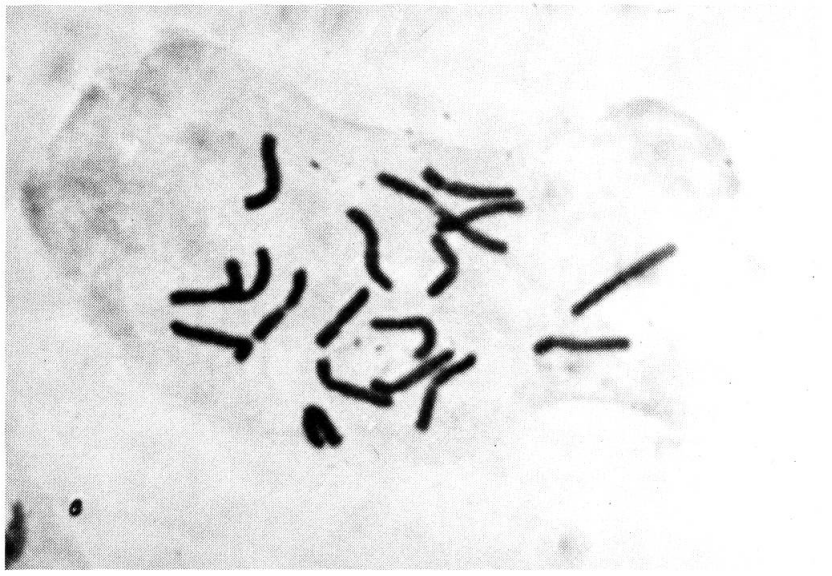


Fig. 51. — Drawings of mitotic root-tip cells of *A. altissima.*
Fig. 52. — Microphotograph of mitotic root-tip cells of *A. altissima.*

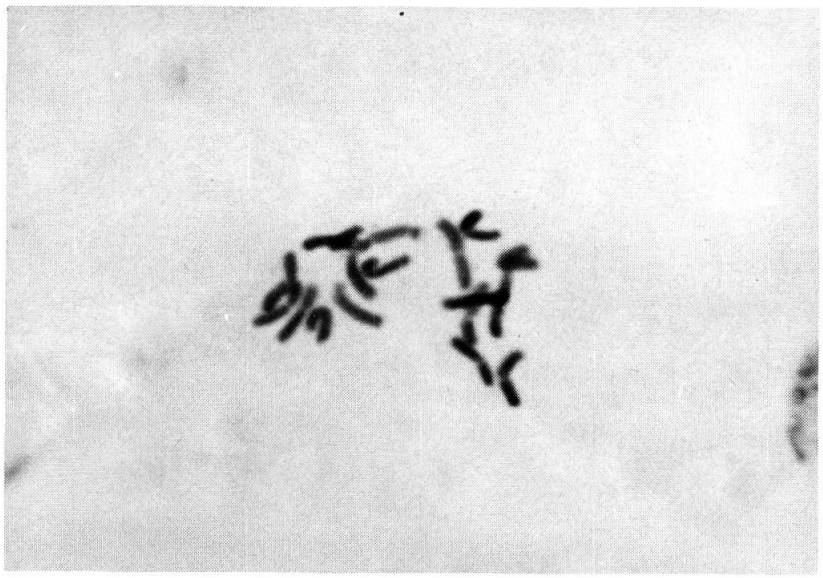


Fig. 53. — Drawings of mitotic root-tip cells of *A. austriaca.*
Fig. 54. — Microphotograph of mitotic root-tip cells of *A. austriaca.*

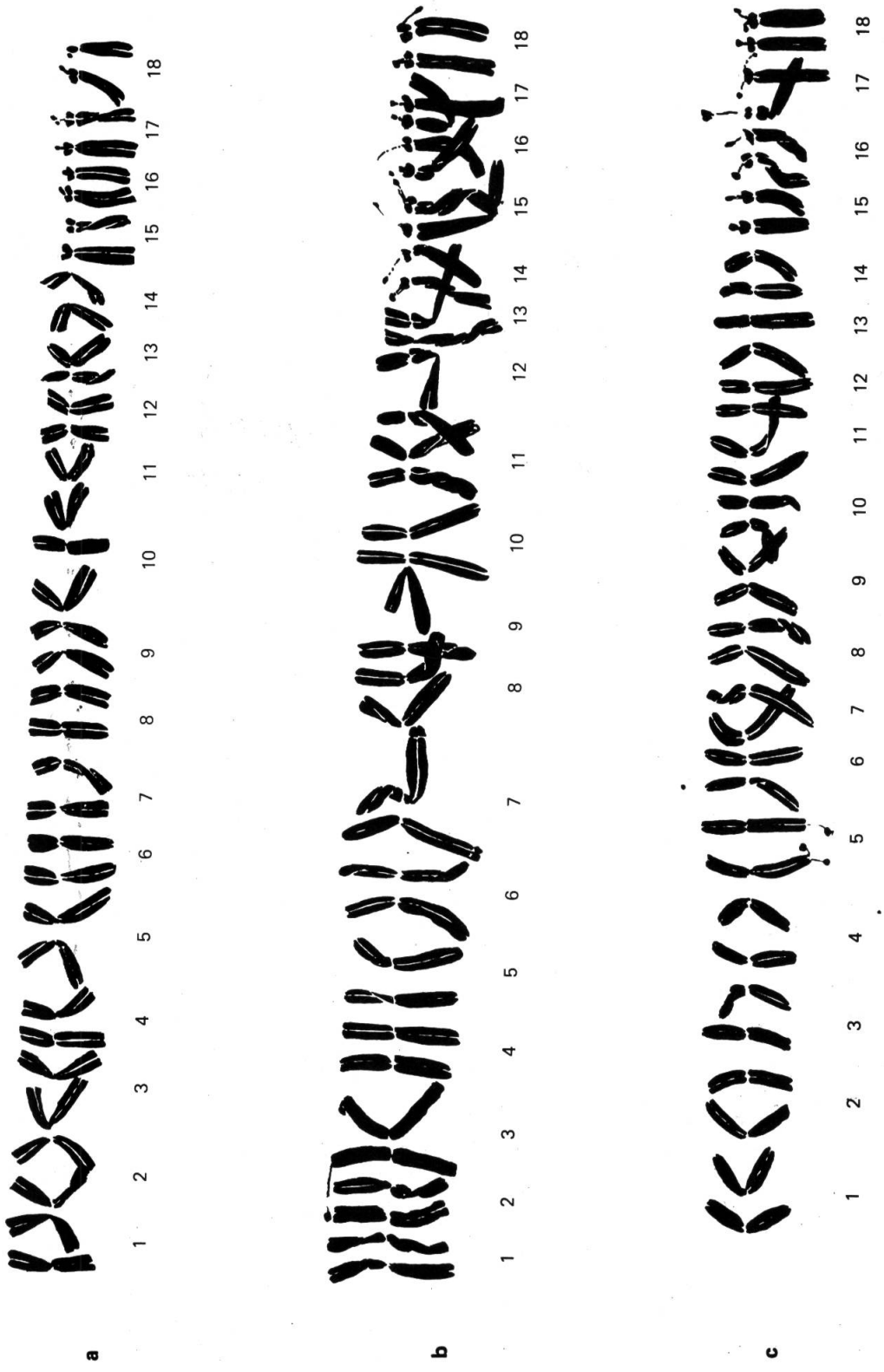


Fig. 55. — Karyograms of: **a**, *A. carpatica*; **b**, *A. cretica*; **c**, *A. hinkovae*.

Fig. 56. — Karyograms of: **a,** *A. argyrophylla;* **b,** *A. tenuiloba;* **c,** *A. regis-borisii.*

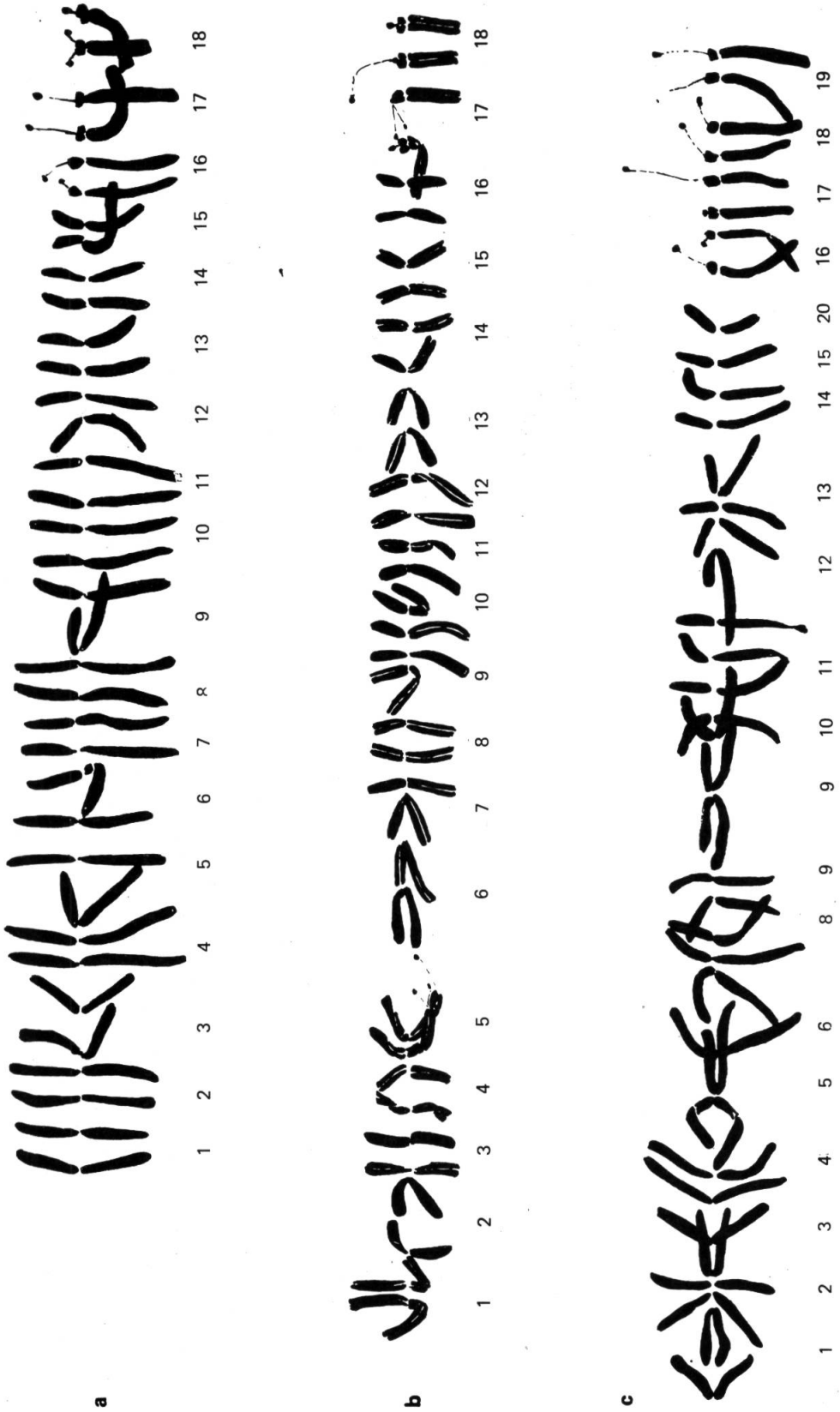


Fig. 57. — Karyograms of: **a**, *A. kuzmanovii*; **b**, *A. rumelica*; **c**, *A. hinkovae*.

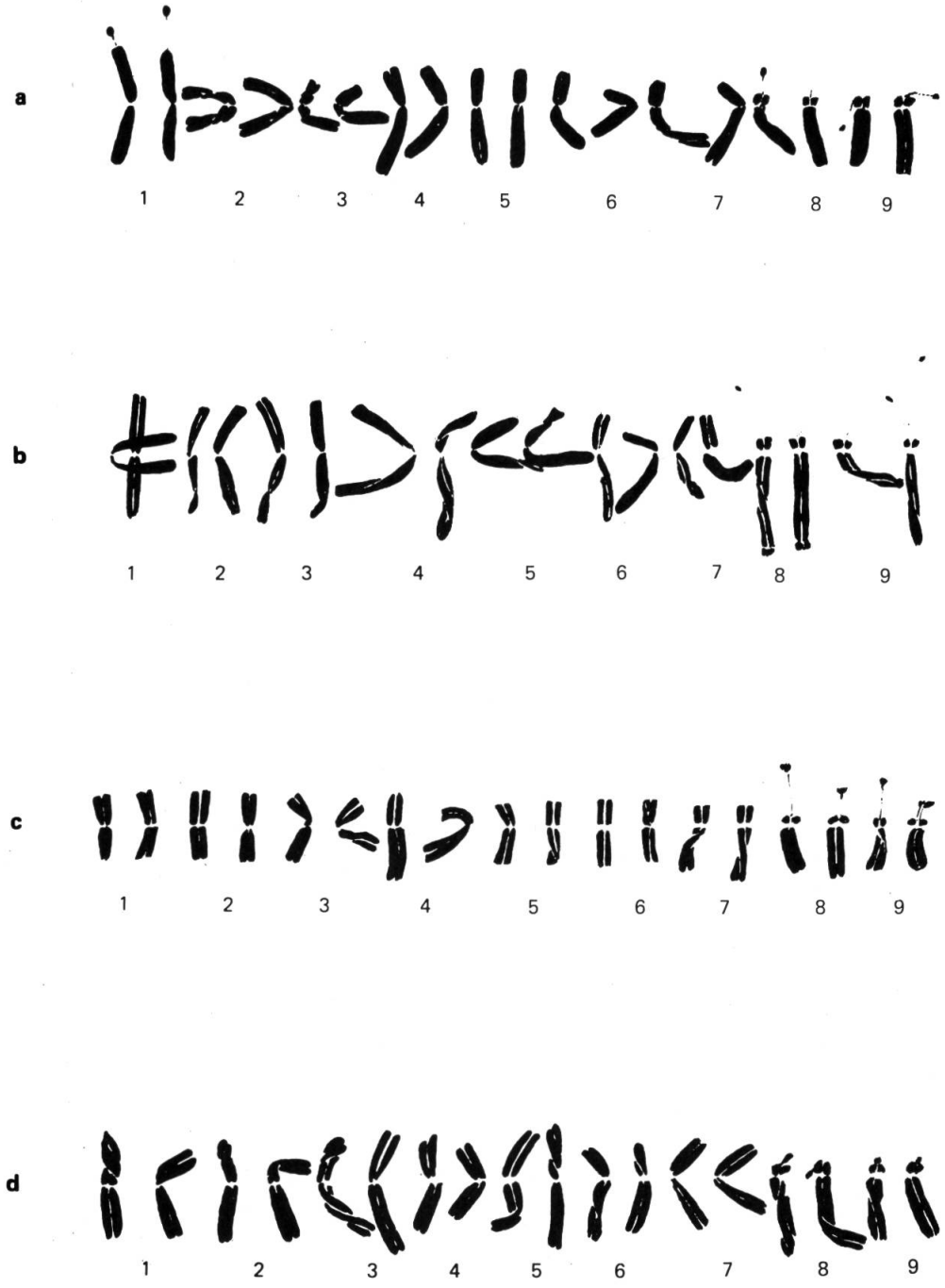


Fig. 58. — Karyograms of: **a,** *A. stribrnyi;* **b,** *A. macedonica;* **c,** *A. orbelica;* **d,** *A. virescens.*

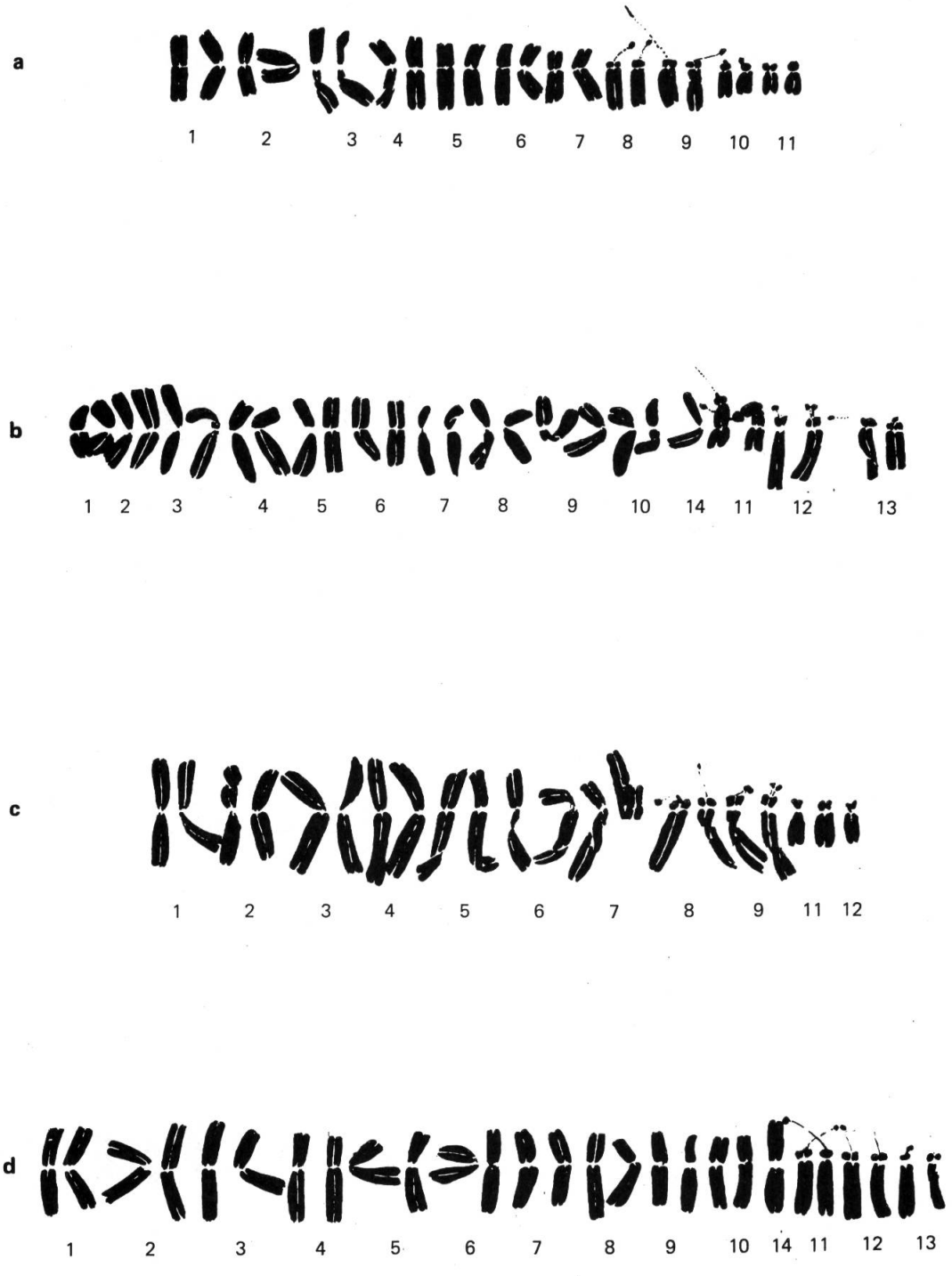


Fig. 59. — Karyograms of: **a-b,** *A. orbelica;* **c,** *A. stribrnyi;* **d,** *A. arvensis.*

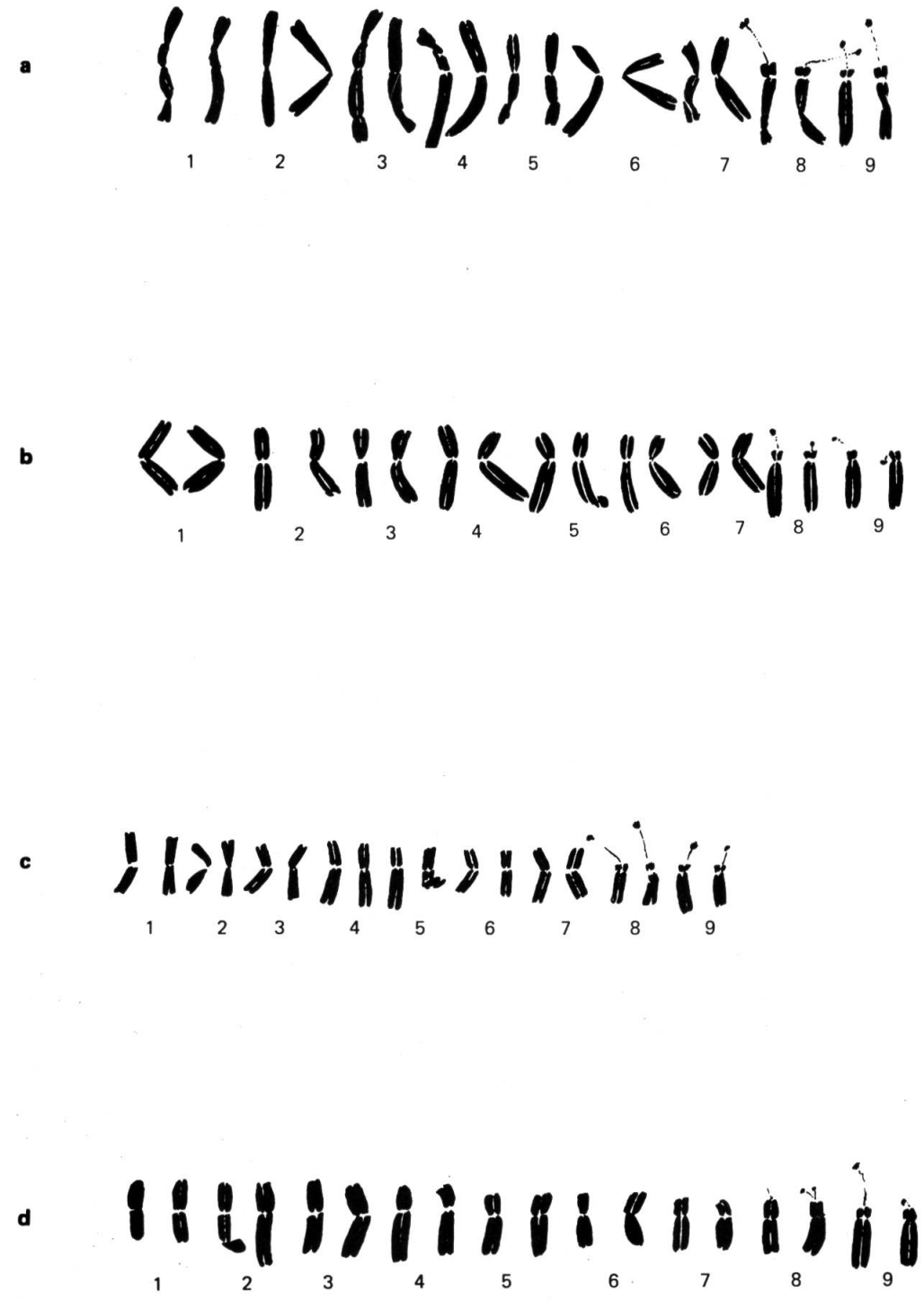


Fig. 60. — Karyograms of: **a**, *A. cotula;* **b**, *A. arvensis;* **c**, *A. ruthenica;* **d**, *A. auriculata.*

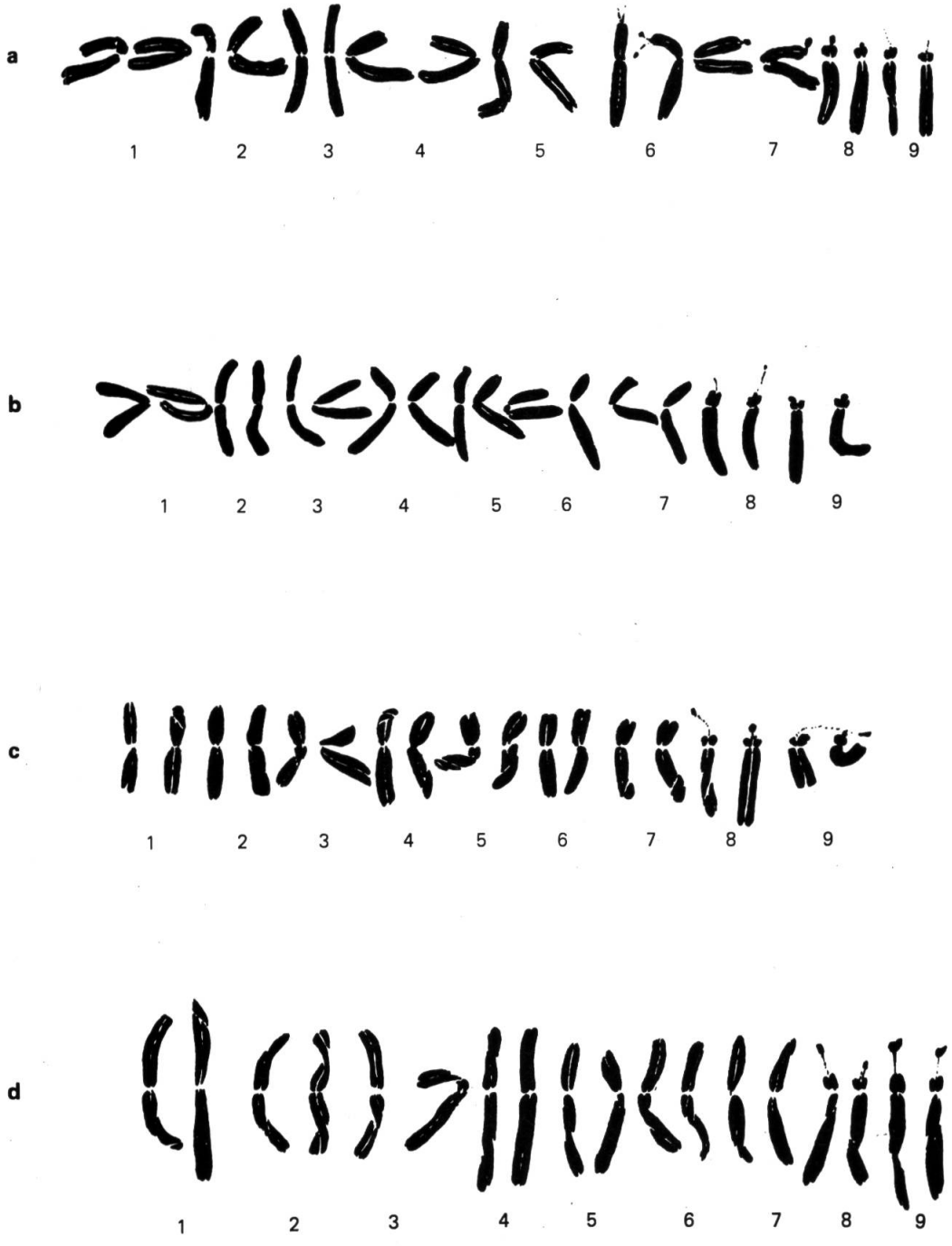


Fig. 61. — Karyograms of: **a,** *A. sancti-johannis;* **b,** *A. parnassica;* **c,** *A. tinctoria;* **d,** *A. macrantha.*

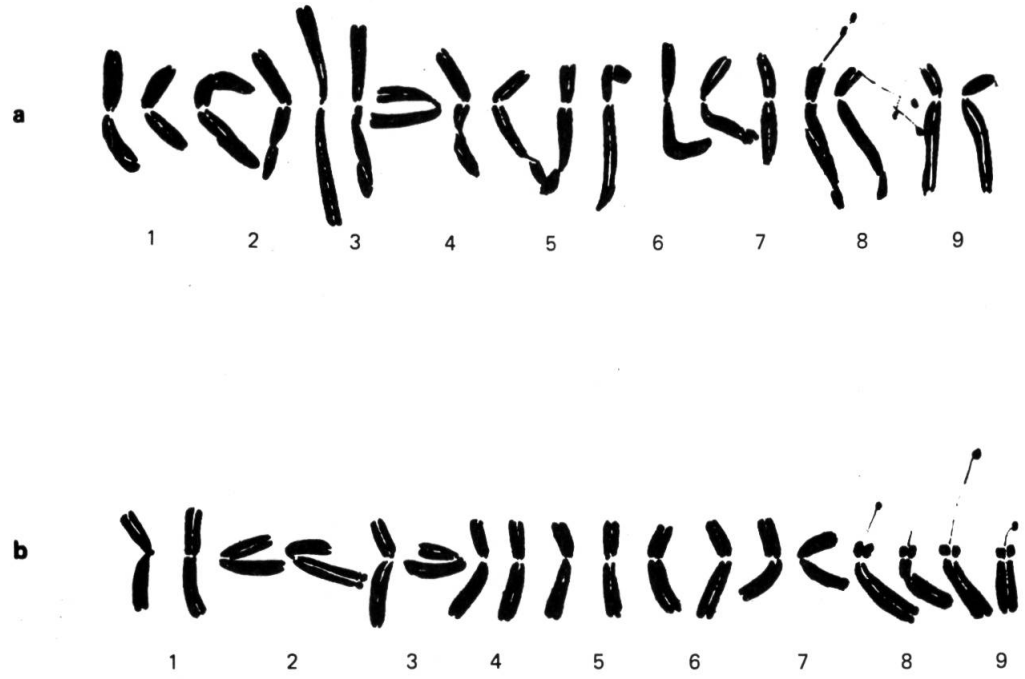


Fig. 62. — Karyograms of: **a,** *A. altissima;* **b,** *A. austriaca.*

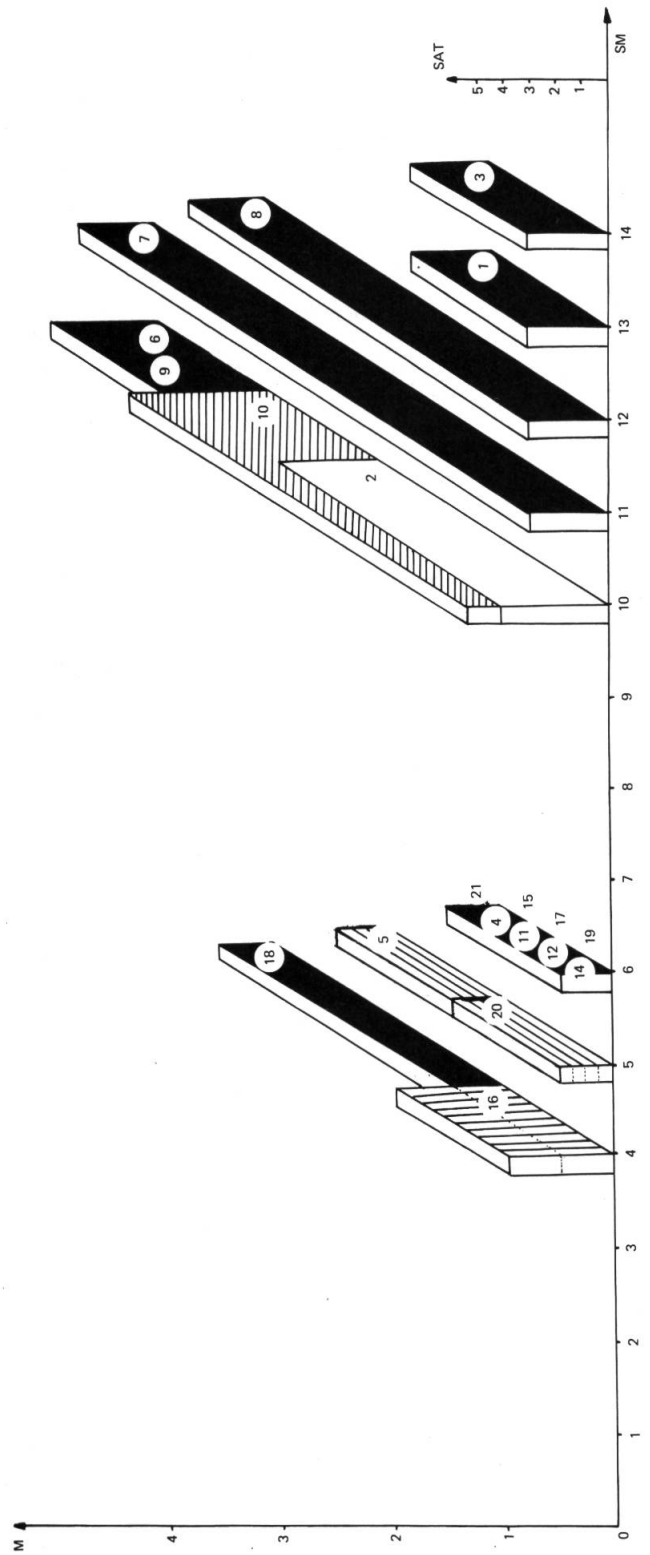
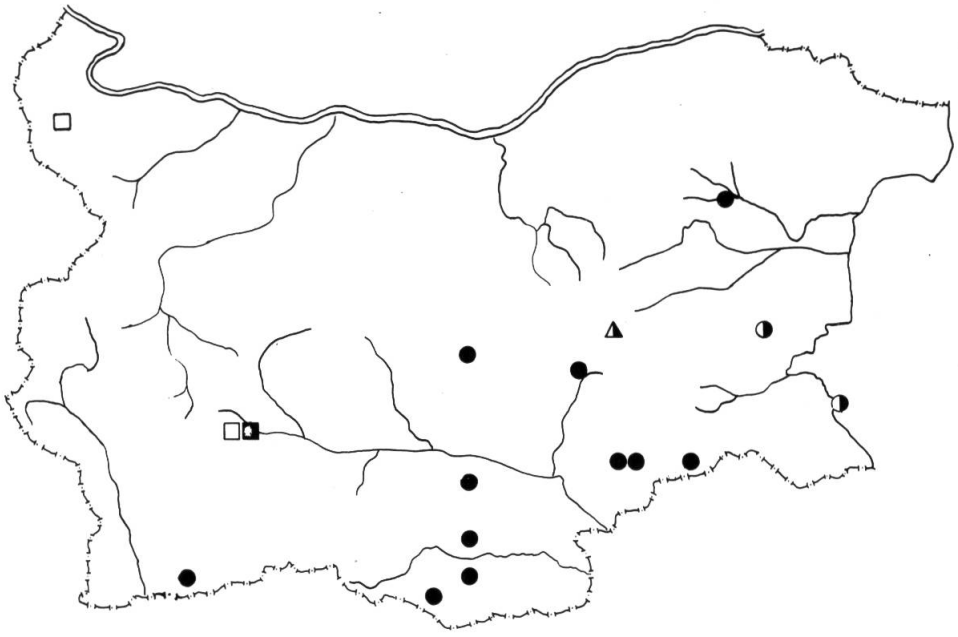
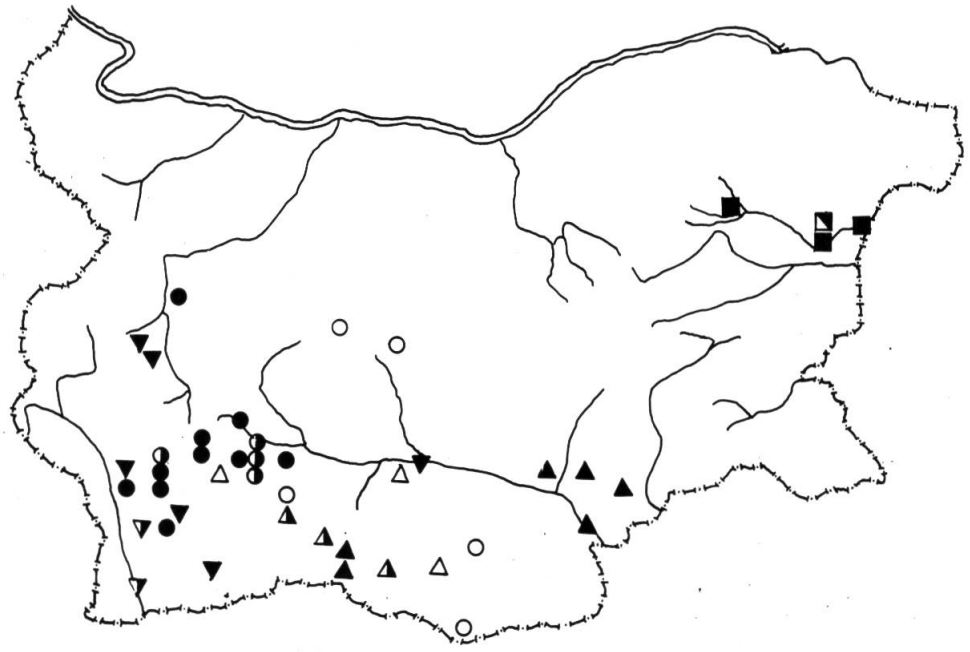


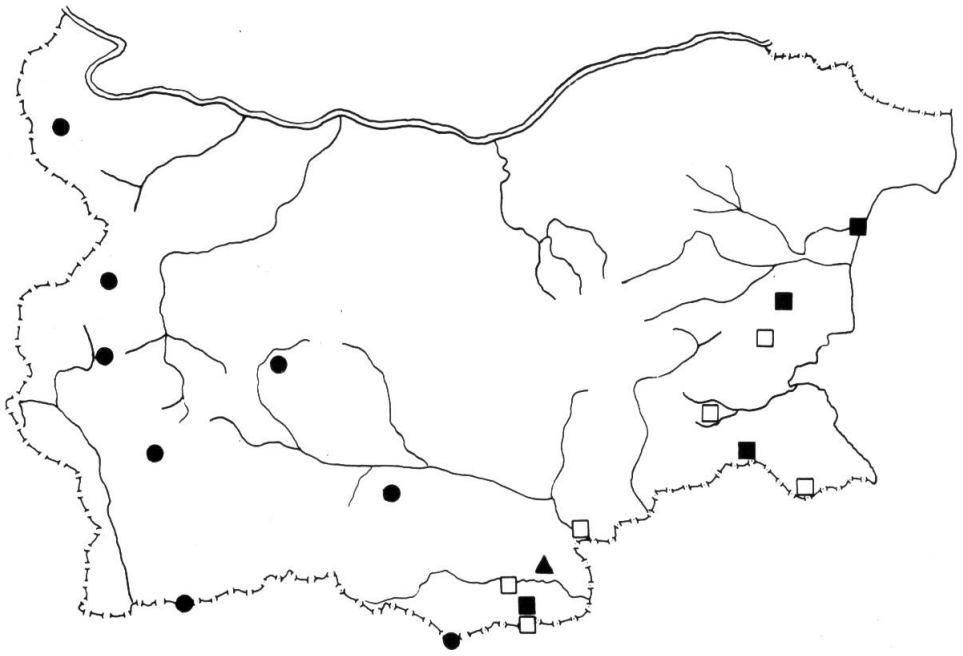
Fig. 63. — Three dimensional scheme for the correlations between the number of metacentric, submetacentric and SAT-chromosomes in the species *Anthemis* studied. M = metacentric, SM = submetacentric, SAT = chromosomes. **1,** *A. carpatica;* **2,** *A. hinkovae;* **3,** *A. argyrophylla;* **4,** *A. virescens;* **5,** *A. ruthenica;* **6,** *A. regis-borisii;* **7,** *A. rumelica;* **8,** *A. kuzmanovii;* **9,** *A. tenuiloba;* **10,** *A. cretica;* **11,** *A. arvensis;* **12,** *A. auriculata;* **13,** *A. orbelica* (same position as 12); **14,** *A. cotula;* **15,** *A. parnassica;* **16,** *A. sancti-johannis;* **17,** *A. tinctoria;* **18,** *A. macrantha;* **19,** *A. austriaca;* **20,** *A. stribrnyi;* **21,** *A. altissima;* **22,** *A. macedonica* (same position as 21).



Map 1. — Distribution of: ■ *A. argyrophylla;* ▲ *A. cretica;* ● *A. rumelica* (on maps 1-12 a solid mark (●) refers to documented localities, a not solid mark (○) to not documented localities and a half solid mark (◐) to populations studied cytologically).

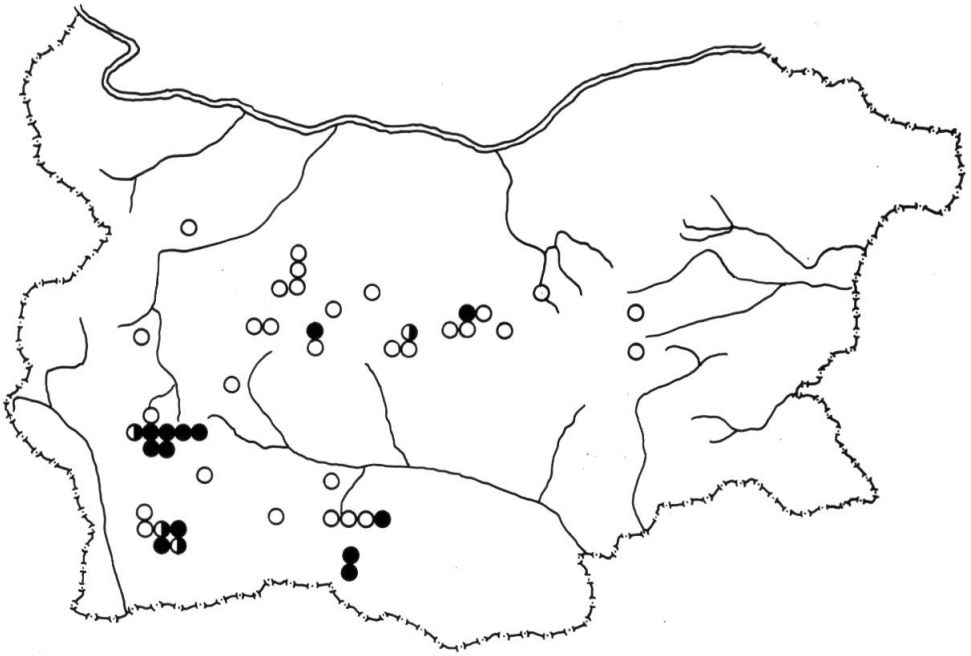


Map 2. — Distribution of: ● *A. orbelica;* ■ *A. regis-borisii;* ▲ *A. stribrnyi.*

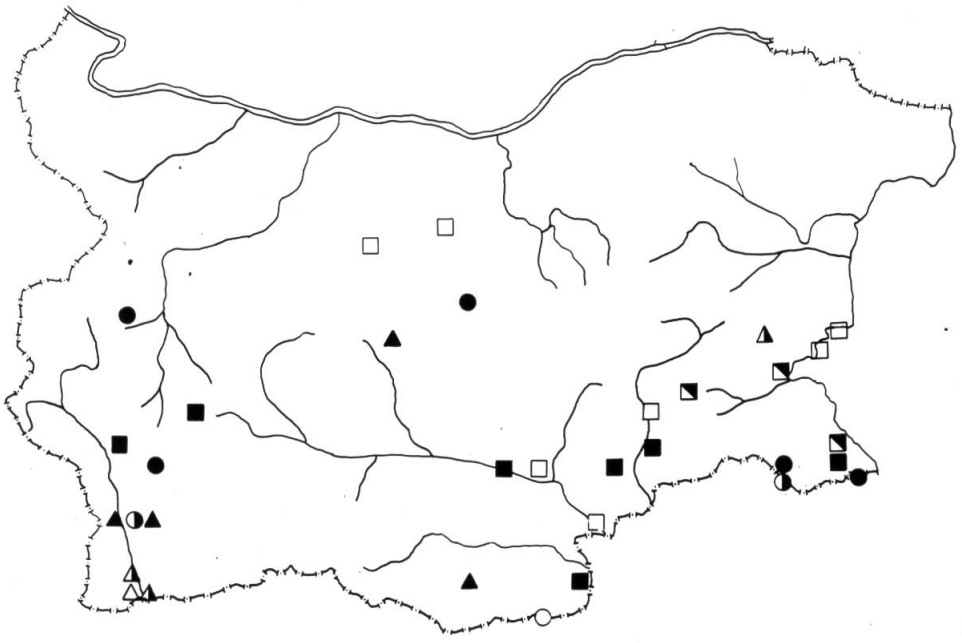


Map 3. — Distribution of: ● *A. kuzmanovii;* ■ *A. virescens;* ▲ *A. hinkovae.*

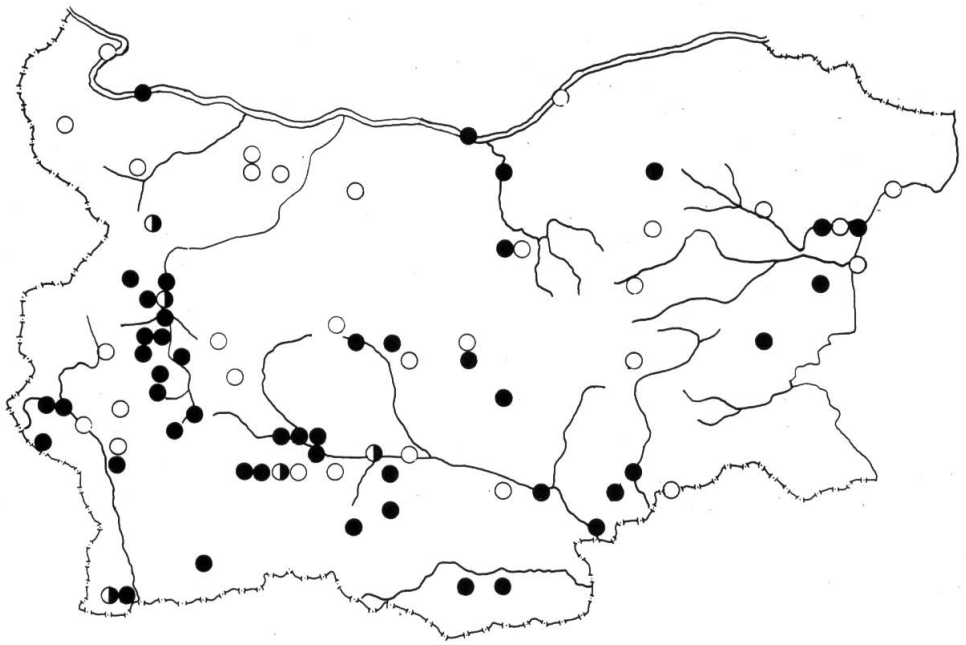
Map 4. — Distribution of: ● *A. tenuiloba.*



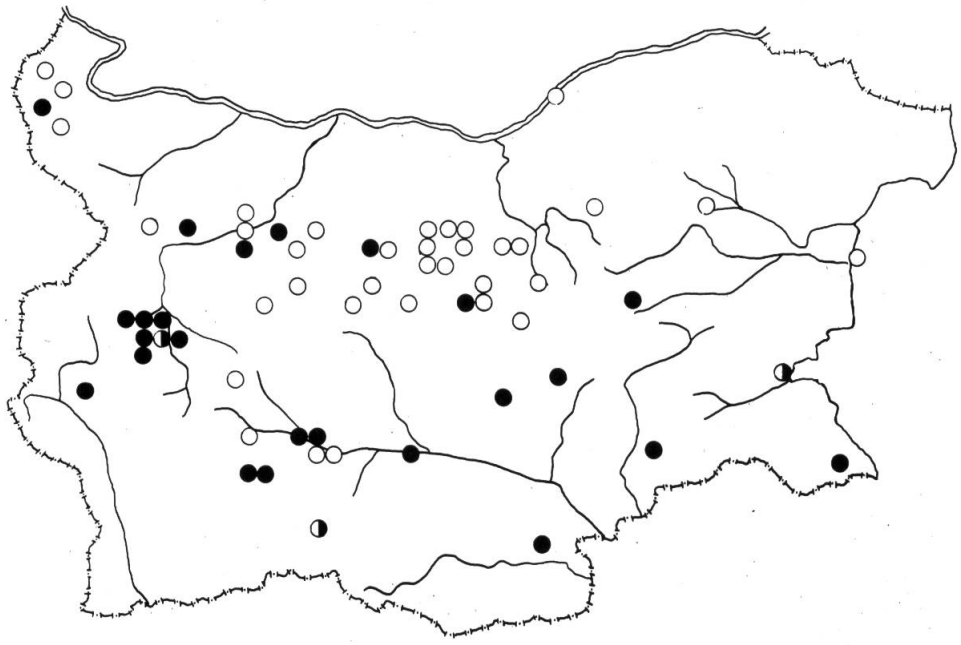
Map 5. — Distribution of: ● *A. carpatica.*



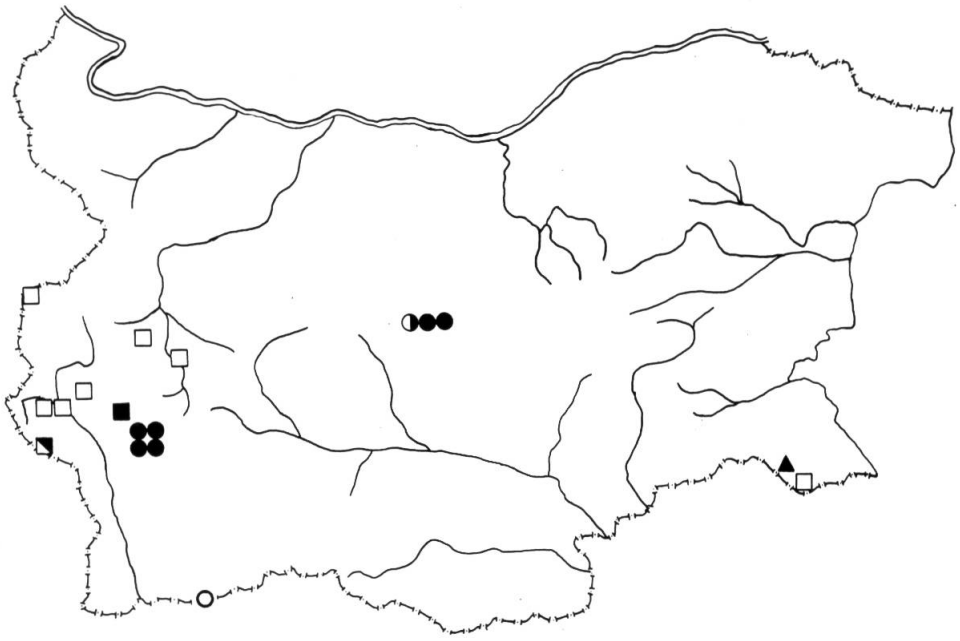
Map 6. — Distribution of: ● *A. parnassica;* ■ *A. altissima;* ▲ *A. auriculata.*



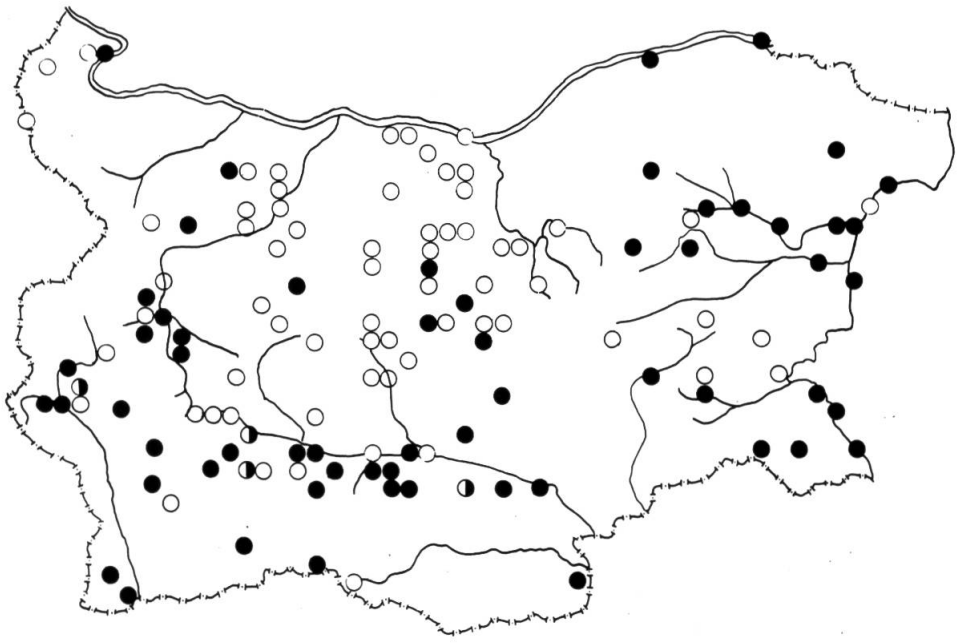
Map 7. — Distribution of: ● *A. ruthenica.*



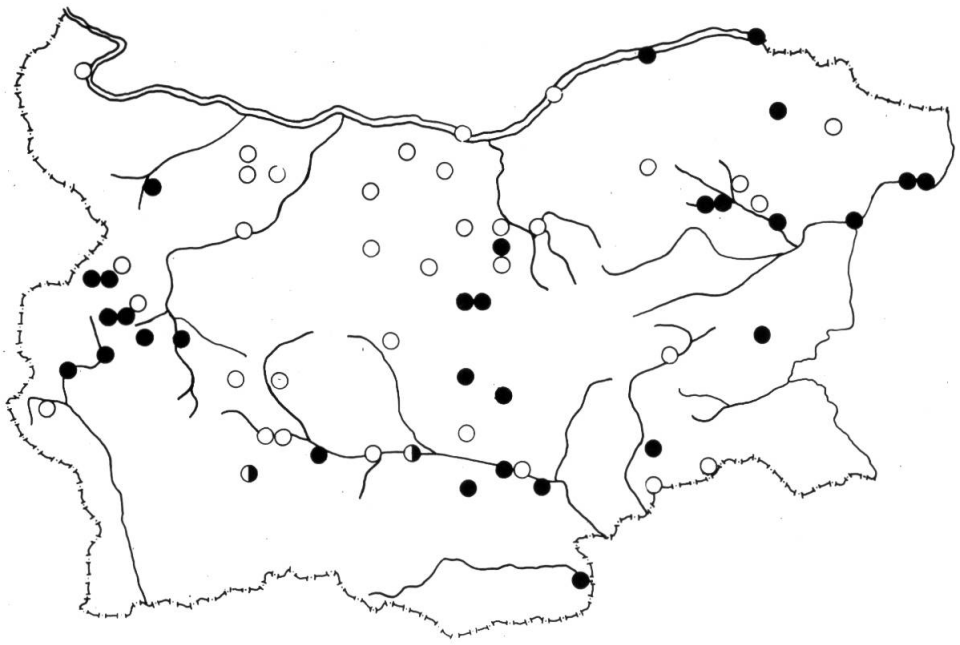
Map. 8. — Distribution of: ● *A. cotula.*



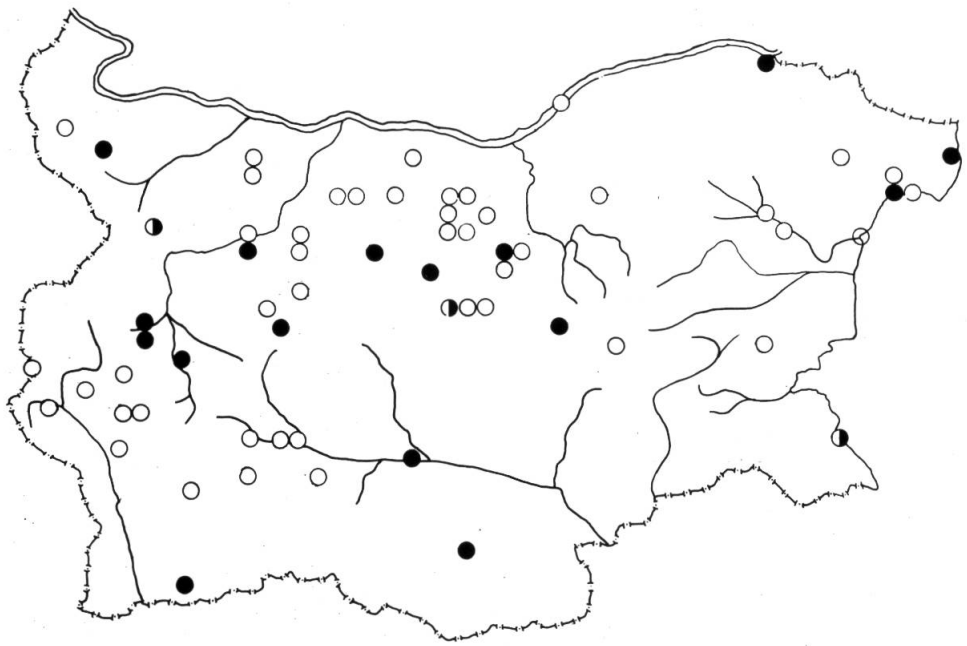
Map 9. — Distribution of: ■ *A. macrantha;* ▲ *A. jordanovii;* ● *A. sancti-johannis.*



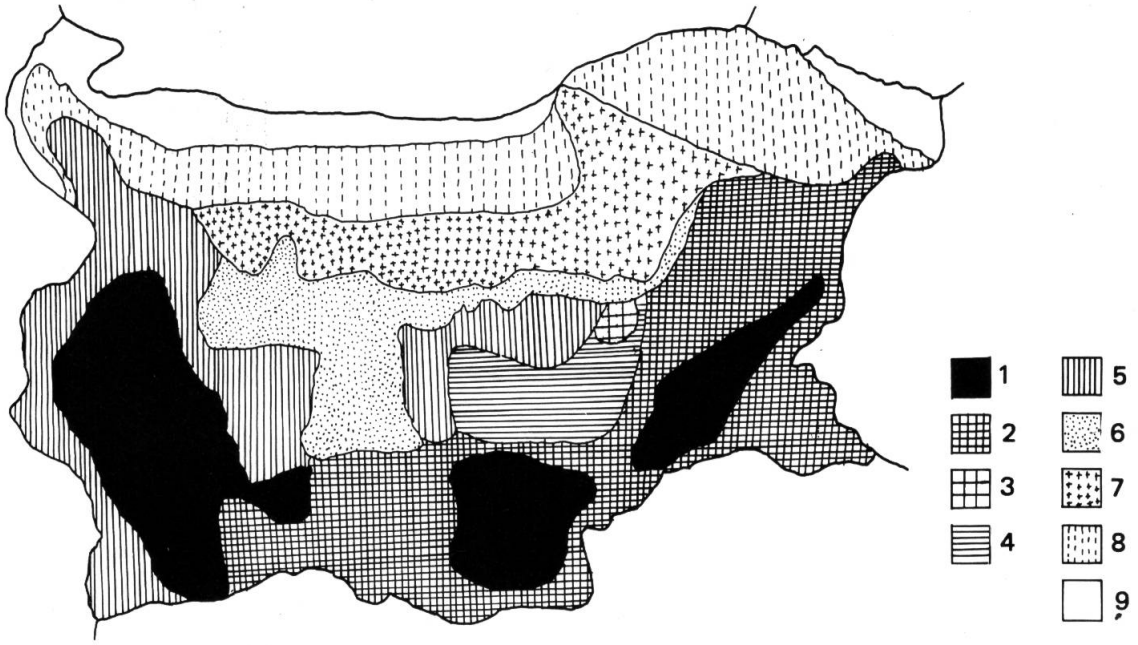
Map 10. — Distribution of: ● *A. tinctoria.*



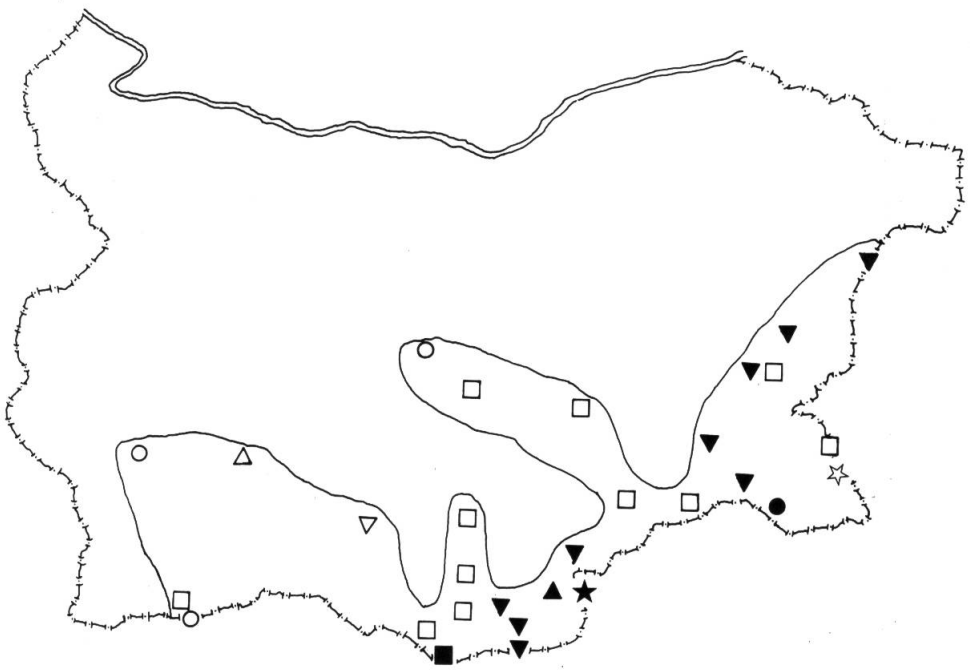
Map 11. — Distribution of: ● *A. austriaca.*



Map 12. — Distribution of: ● *A. arvensis.*



Map 13. — General distribution pattern of the 27 species of *Anthemis* in Bulgaria. The regions with: **1,** more than 8 species; **2,** with 8 species; **3,** with 7 species; **4,** with 6 species; **5,** with 5 species; **6,** with 4 species; **7,** with 3 species; **8,** with 2 species; **9,** with 1 species.



Map 14. — General distribution pattern of the Bulgarian endemic species of *Anthemis:* △ *A. argyrophylla;* ■ *A. bulgarica;* ▽ *A. gaudium-solis;* ▲ *A. hinkovae;* ● *A. jordanovii;* ★ *A. kitanovii;* ☆ *A. kitenensis;* □ *A. rumelica;* ○ *A. sancti-johannis;* ▼ *A. virescens* (data from THIN, 1980a).

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