

Chromosome Numbers of Some Representatives of the *Arabis hirsuta* Complex from Czechoslovakia

Chromozómové počty některých zástupců komplexu *Arabis hirsuta* z území Československa

Romana Czapik and Irena Novotná

CZAPIK R.¹⁾ et I. NOVOTNÁ²⁾ (1972): Chromosome numbers of some representatives of the *Arabis hirsuta* complex from Czechoslovakia. — Preslia, Praha, 44: 1–6. — Chromosome numbers are given of *Arabis planisiliqua* (PERS.) REICHENB., *A. sagittata* (BERTOL.) DC., *A. hirsuta* (L.) SCOP. s. str. and *A. hornungiana* SCHUR from 14 localities in Bohemia, Moravia and Slovakia. In *A. planisiliqua* and *A. sagittata* 16 somatic chromosomes were found, in *A. hirsuta* s. str. — 16 and 32, in *A. hornungiana* — 32. In addition some of their natural diploid, triploid and tetraploid hybrids were also examined. — ¹⁾ Department of Plant Cytology and Embryology, Institute of Botany, Jagellonian University, św. Jana 20, Kraków, Poland. ²⁾ Botanical Institute, Czechoslovak Academy of Sciences, Průhonice near Praha, Czechoslovakia.

Four species from the *Arabis hirsuta* complex were the object of the present studies: *A. planisiliqua* (PERS.) REICHENB., *A. sagittata* (BERTOL.) DC., *A. hirsuta* (L.) SCOP. s. str. and *A. hornungiana* SCHUR. The examined plants belonged to the natural populations from some Bohemian, Moravian and Slovakian localities. The plants were collected chiefly during our common field work in 1969 and the karyological data concerning this material are published here for the first time. It should be added that some plant material from five localities among 14 mentioned below was examined by us before and the results were included into one of the previous papers (CZAPIK et NOVOTNÁ 1967a, 1969; NOVOTNÁ et CZAPIK 1971). However, taking into account some problems connected with the sympatric occurrence of taxa (KLÁŠTERSKÝ et NOVOTNÁ 1962) and their cytological differentiation it seemed to be worth repeating the investigations there in the second season. In mixed populations interspecific hybrids were found and if it was possible their chromosome numbers were also determined. The discovery of natural hybrids between *A. sagittata* and *A. planisiliqua* was most interesting. They were known from our experiments only (NOVOTNÁ et CZAPIK 1971) and their occurrence in nature is very significant.

Methods

The chromosome numbers were determined on mitoses in flower buds of plants originating exclusively from natural habitats. The buds were fixed mainly in nature; in three cases only the fixation was made in the experimental field in Průhonice (the resp. plants were cultivated there from seeds collected in the wild and one individual was transplanted from the locality in the state of a rosette). The percentage of unstained pollen was established on fixed material by using the aceto-carmin test. A total 500 pollen grains were counted for each plant in the squashes prepared from unopened anthers of two flowers just before anthesis. Several plants were fixed from each population. The number of examined individuals depended chiefly on the existence of the material suitable to the cytological examination at the time of collection and was not connected with the number of individuals within the population. The voucher specimens are deposited in the Botanical Department of the National Museum in Praha (PR), Czechoslovakia.

Results and discussion

The main results of the karyological examinations are presented in the Tab. I where the chromosome numbers of plants from the particular populations as well as the number of examined individuals are given. The data were obtained from somatic metaphases. In addition meiosis was observed in PMCs of single tetraploid plants of *A. hirsuta* s. str. from Silická planina (two localities) and Čingova hora. The examination of the II division confirmed the chromosome numbers of these plants known from the somatic cells. The chromosome pairing was found in the plant from Silická planina above Gombasek. Apart from regular formation of 16 bivalents in some PMCs from 1 to 4 quadrivalents could be observed among chromosome pairs (cf. also CZAPIK 1971). The I division was also observed in PMCs of a specimen of *A. sagittata* from Silická planina above Jovice and in addition the I metaphase was found in the macrospore mother cells of a plant of *A. sagittata* from Zadielská dolina and *A. planisiliqua* from Čingova hora. The pairing was regular in diploid plants and 8 bivalents could easily be counted (Pl. II : A).

The degree of male sterility was checked in all plants recognized as natural hybrids. It amounted to 100 % in the tetraploid hybrids between *A. hirsuta* s. str. and *A. hornungiana* as well as in the triploid hybrids between *A. hirsuta* s. str. and *A. planisiliqua* or *A. sagittata*. As an exception 78% of unstained pollen grains were found in the sample of one triploid individual from Silická planina above Jovice determined as a hybrid. Thus this plant was characterized by the highest degree of the male fertility among triploids examined till now by us (0—4% in the previous investigated triploid hybrids, cf. CZAPIK 1971; NOVOTNÁ et CZAPIK 1971). The diploid natural hybrids between *A. planisiliqua* and *A. sagittata* showed dead pollen ranging from 45 to 81% in the present material (Pl. II: G). It should be mentioned that from 14 to 97% of unstained pollen grains was found in hybrids obtained after experimental crosses of these species (NOVOTNÁ et CZAPIK 1971).

Information concerning the origin of material and some further details is given below. The list of localities is ordered according to their geographic position from the West to East (Tab. I).

Origin of plants and their chromosome numbers

1. C. Bohemia: middle part of the Elbe valley, N. of the town Sadská, sandy ground along the bank of the river Elbe, c. 178 m a. s. l. Coll. authors 13. VI. 1969. Monospecific population of *A. hirsuta* s. str. Five tetraploid plants were collected. The same number was previously found in the cultivated material originating from this locality (CZAPIK et NOVOTNÁ 1969).

2. Moravia: Moravian Karst, southern slope of the hill Smrění jeslo, N. of the village Vilémovice near the town Blansko. Coll. authors 27. V. 1969. This monospecific population of *A. hirsuta* was also examined by I. Novotná in 1964 and 1968. Fourteen examined plants were tetraploid.

3. S. Moravia: hills Pavlovské vrchy near the town Mikulov, slope SW. of Mt Děvín. Seeds coll. A. ČERTKOVÁ and M. LHOŘSKÁ, 1968. *A. sagittata* plants cultivated in the experimental field in Průhonice, 1969. Four specimens labelled no 225/1 — 4 were diploid. It should be mentioned that A. Čertková collected herbarium specimens from this locality in 1962. In her material we could determine *A. sagittata*, *A. hirsuta* and their hybrids.

4. SW. Slovakia: the vicinity of the village Višňové, Eastern slope of the castle hill Čachtice near the town Nové Mesto nad Váhom. Seeds coll. P. Tomšovic, 1968. *A. sagittata* plants cultivated in the experimental field in Průhonice, 1969; most of them rested in the state of rosettes in that season. One plant examined was diploid.

5. W. Slovakia: E. of the village Omšenie near the town Trenčianské Teplice distr. Trenčín. Southern slope of the hill Baba, c. 379 m a. s. l. Coll. I. NOVOTNÁ 30. III. 1970. One plant *A. hirsuta* s. str. transplanted to the experimental field proves to be tetraploid.

Tab. 1. — Chromosome numbers (2n) of investigated plants (in brackets numbers of examined individuals are given)

Localities	Species				Interspecific hybrids between			
	<i>A. pla.</i>	<i>A. sag.</i>	<i>A. hir.</i>	<i>A. hor.</i>	<i>A. pla.</i> and <i>A. sag.</i>	<i>A. hir.</i> and <i>A. pla.</i>	<i>A. hir.</i> and <i>A. sag.</i>	<i>A. hir.</i> and <i>A. hor.</i>
1. Sadská	—	—	32 (5)	—	—	—	—	—
2. Smrčíní jeslo	—	—	32 (14)	—	—	—	—	—
3. Pavlovské vrchy	—	16 (4)	—	—	—	—	—	—
4. Čachtice	—	16 (1)	—	—	—	—	—	—
5. Omšenie	—	—	32 (1)	—	—	—	—	—
6. Vernár	—	—	32 (5)	32 (1)	—	—	—	32 (2)
7. Hranovnica	16 (2)	—	32 (7)	—	—	24 (1)	—	—
8. Čingova hora	16 (8)	—	32 (14)	—	—	—	—	—
9. Smižany	16 (2)	16 (1)	32 (9)	—	16 (4)	24 (1)	—	—
10. Ostrý vrch	—	—	32 (17)	—	—	—	—	—
11. Silická planina above Gombasek	—	—	32 (14)	—	—	—	—	—
12. Silická planina above Jovice	—	16 (14)	32 (26)	32 (1)	—	—	24 (3)	—
13. Zadielská planina	—	16 (8)	32 (20)	—	—	—	—	—
	—	—	16 (1)	—	—	—	—	—
14. Zadielská dolina	—	16 (5)	32 (1)	—	—	—	—	—

6. C. Slovakia: Eastern border of Nízke Tatry Mts., near the Vernár railway station. Coll. authors I. VI. 1969. Mixed populations of *A. hirsuta* s. str. and *A. hornungiana*. In five specimens of *A. hirsuta* s. str. and one *A. hornungiana* the tetraploid chromosome number was found. The same chromosome number for both taxa and their natural hybrids from this locality was published previously (CZAPIK et NOVOTNÁ 1969, NOVOTNÁ et CZAPIK 1971). No hybrids were found by the authors in 1969; Tab. 1 gives chromosome numbers of natural hybrids from the authors' collection of the year 1966.

7. C. Slovakia: Nízke Tatry Mts., at the bus stop "Hranovnické jezero" near the village Hranovnica. Coll. authors I. VI. 1969. This year seven tetraploid plants of *A. hirsuta* s. str. were found. It should be emphasized that the occurrence of mixed populations of *A. hirsuta* s. str. and *A. planisiliqua* as well as of the natural hybrids between these species was detected there by Klášterský and Novotná in 1963. The karyological data for *A. planisiliqua* ($2n = 16$) and interspecific hybrid ($2n = 24$) in the Tab. 1 concern the collection of the season 1963. The chromosome number of *A. planisiliqua* from this locality was published previously (CZAPIK et NOVOTNÁ 1967a).

8. C. Slovakia: Stratenská hornatina Mts., southern slope of the hill Čingova hora on the river Hornád. Mixed populations of *A. hirsuta* s. str. and *A. planisiliqua* were found here for the first time by I. Klášterský and I. Novotná in 1962. Fourteen plants of *A. hirsuta* s. str. collected by the authors 4. VI. 1969 were tetraploid, eight specimens of *A. planisiliqua* — diploid (Pl. II : I).

9. C. Slovakia: Stratenská hornatina Mts., slope of the hill along the river Hornád, c. 480 m a.s.l., SW. of the village Smížany. Mixed populations of *A. hirsuta* s. str., *A. planisiliqua* and *A. sagittata*. Coll. authors 4. VI. 1969. Nine plants of *A. hirsuta* s. str. ($2n = 32$), one plant of *A. sagittata* ($2n = 16$) and two plants of *A. planisiliqua* ($2n = 16$) were examined. In addition diploid and triploid hybrids were found there. Twenty four chromosomes were counted in a hybrid between *A. hirsuta* s. str. and one of the diploid species (*A. planisiliqua* or *A. sagittata*) which could not be recognized morphologically in a natural hybrid (cf. NOVOTNÁ et CZAPIK 1971). Four hybrids between *A. planisiliqua* and *A. sagittata* had 16 chromosomes (Pl. I, Pl. II: G, H) like their parental species.

10. C. Slovakia: Slovenské Rudohorie Mts., limestone quarry on the top of the hill Ostrý vrch, c. 760 m a.s.l., above the village Novoveská Huta near the town Spišská Nová Ves. Coll. authors I. VI. 1969. 17 specimens of *A. hirsuta* s. str. were tetraploid. The same chromosome number was established for eight plants in 1966 (CZAPIK et NOVOTNÁ 1969). In both years only *A. hirsuta* s. str. was found in this locality. It is worth mentioning that Klášterský and Novotná noted the occurrence of mixed populations of *A. hirsuta* s. str. and *A. sagittata* there in 1961.

11. S. Slovakia: Slovakian Karst, the plateau Silická planina above the village Gombasek. Coll. authors 29. V. 1969. Fourteen plants of *A. hirsuta* were checked; they were tetraploid. In 1963 Klášterský and Novotná collected four plants in this locality which had distinctly lower male and female fertility and were labelled as "*A. hornungiana*?". The progenies of these individuals were cultivated in Prúhonice and showed a wide range of variability in their morphological features as well as in their fertility. The whole population was characterized by an early period of vegetation. For this reason the plants collected by us in 1966 could not be fixed and the material was collected repeatedly in 1969. All specimens were identified as *A. hirsuta* s. str. but among them morphological types approaching *A. hornungiana* were also found. We supposed that the existence of mixed populations of *A. hirsuta* s. str. and *A. hornungiana* is highly probable in this locality.

12. S. Slovakia: Slovakian Karst, the plateau Silická planina, pasture above the village Jovice, c. 550 m a.s.l., Coll. authors 2. VI. 1969. Mixed populations of numerous representatives of *A. hirsuta* s. str. and *A. sagittata* and single individuals of *A. hornungiana* were found. In 26 specimens of *A. hirsuta* s. str. the number $2n = 32$ was determined (Pl. II: B, C, D), in 14 plants of *A. sagittata* — $2n = 16$ and in one plant of *A. hornungiana* — $2n = 32$. In addition 3 hybrids between *A. hirsuta* s. str. and *A. sagittata* with $2n = 24$ were examined karyologically. In 1966 a slight degree of karyological differentiation was found there in *A. hirsuta* s. str. for which $2n = 16$ and 32 was published (CZAPIK et NOVOTNÁ 1969). *A. sagittata* occurred in a small number of fruiting individuals unsuitable for fixation at that season and it was not examined karyologically. That was the reason why the material was supplemented by new collection in 1969. It also seemed desirable to enlarge the material in view of the fact that the third species — *A. hornungiana* collected there previously by Klášterský and Novotná could not be found by us in 1966.

13. S. Slovakia: Slovakian Karst, western part of the plateau Zadielská planina near the Jablonovský saddleback. Mixed populations of *A. hirsuta* s. str. and *A. sagittata*. Coll. authors 30. V. 1969. Eight diploid plants of *A. sagittata*, in addition to 20 tetraploid specimens and one

diploid individual of *A. hirsuta* s. str. could be examined. In 1966 only single representatives of both species were collected.

14. S. Slovakia: Slovakian Karst, Zadielská dolina valley, c. 350 m a.s.l. Southern slope of the valley near the village Zadiel. Mixed populations of *A. hirsuta* s. str. and *A. sagittata*. Coll. authors 30. V. 1969. The chromosome numbers — $2n = 32$ in one plant of *A. hirsuta* s. str. and $2n = 16$ in five plants of *A. sagittata*, could be determined.

General remarks

The present results are a further contribution to the karyology of the four species from the *Arabis hirsuta* complex in Czechoslovakia. The first data from this area were published by the authors (CZAPIK et NOVOTNÁ 1967a, b; NOVOTNÁ 1962; NOVOTNÁ et CZAPIK 1971) and MĚSÍČEK (1967). In our previous papers we have reported the number $2n = 16$ for *A. planisiliqua*, $2n = 16$ and exceptionally $2n = 24$ and 32 for *A. sagittata*. One chromosome number only — $2n = 32$ was given for *A. hornungiana* (CZAPIK et NOVOTNÁ 1969, MĚSÍČEK 1967). On the other hand, *A. hirsuta* s. str. was found to be cytologically differentiated; in adult plants cytotypes with $2n = 16$, 28 , 30 and 32 were revealed; the aneuploid numbers were also found in young seedlings (NOVOTNÁ 1962). The present karyological data are in accordance with our previous results as well as with the data from the literature (cf. BURDET 1967; CZAPIK et NOVOTNÁ 1967; TITZ 1966, 1969; MATVEJEVA et TICHONOVA 1969; $2n = 16$ for *A. planisiliqua* under the synonym *A. gerardii* BESS). However, the number $2n = 8$ published by BURDET for *A. hirsuta* s. str. and discussed by TITZ (1969) was not found in our material.

The interspecific hybrids studied in the course of the present studies had the ploidy levels known for the natural and experimental material (NOVOTNÁ et CZAPIK 1971). Triploid hybrids were found within mixed populations of *A. hirsuta* s. str. and *A. planisiliqua* or *A. sagittata*, tetraploid — *A. hirsuta* s. str. and *A. hornungiana*, diploid — *A. planisiliqua* and *A. sagittata**. Especially interesting were mixed populations in Smížany where three species were growing in the close neighbourhood: *A. hirsuta* s. str., *A. planisiliqua* and *A. sagittata* and triploid and diploid hybrids occurred. Such populations are especially suitable for the studies of the introgression and the degree of mutual crossability of taxa. In addition the occurrence of natural hybrids between *A. planisiliqua* and *A. sagittata* confirmed that they arose and survive also in nature, not only in experimental conditions.

The karyological differentiation of the examined species was not much pronounced in the material fixed in 1969. For instance the diploid number $2n = 16$ was noted only once in a plant of *A. hirsuta* s. str. from Zadielská planina; this cytotype was found by us in 7 plants from various localities in 1967. It is worth mentioning that in the present material two-years-old plants prevailed. It is highly probable that the cytological aberrants of the complex are badly adapted to the environmental conditions or at least less frequent among the biennial plants.

Acknowledgements

We wish to express our gratitude to the colleagues who kindly convey us the seeds from Pavlovské vrchy and Čachtice. The technical assistance of Miss Maria DOMAGALA by mounting the slides is also gratefully acknowledged.

* Note added in proofs: The occurrence of a diploid hybrid between *A. planisiliqua* and *A. sagittata* has been recently reported by TITZ (Österr. Bot. Zeitschr., Wien, 118: 353—390, 1970); the hybrid was collected in a natural habitat in Austria.

Předložené výsledky jsou dalším příspěvkem ke karyologii čtyř druhů komplexu *Arabis hirsuta* z území Československa. Karyologická diferenciacie jednotlivých druhů je různá. Jednotným počtem chromozómů se vyznačuje především *A. planisiliqua* ($2n = 16$), a také *A. hornungiana* ($2n = 32$) (srv. též MĚSÍČEK 1967). U *A. sagittata* jsme vedle počtu $2n = 16$ našli jen výjimečně $2n = 24$ a 32 (CZAPIK et NOVOTNÁ 1967). Naproti tomu *A. hirsuta* s. str. se vyznačuje větší diferenciací; u dospělých rostlin byly zjištěny následující cytotypy: $2n = 16, 28, 30, 32$ (CZAPIK et NOVOTNÁ 1969); v předložené práci $2n = 16, 32$. Aneuploidní počty byly také nalezeny u mladých semenáčků (NOVOTNÁ 1962). Počet $2n = 8$, publikovaný pro *A. hirsuta* BURDETEM (1967), jsme v našem materiálu nenalezli. Vznik a především výskyt cytologických aberantů závisí pravděpodobně na vnějších podmínkách. Stupeň ploidie u mezidruhových kříženců byl stanoven jak u kříženců přirozených, tak i umělých (NOVOTNÁ et CZAPIK 1971). Shrme-li výsledky dřívější a v předložené práci, je zřejmé, že triploidní kříženci byli zjištěni ve smíšených populacích druhů *A. hirsuta* a *A. planisiliqua* nebo druhů *A. hirsuta* s. str. a *A. sagittata*, tetraploidní při společném výskytu druhů *A. hirsuta* s. str. a *A. hornungiana*, diploidní v případě sympatrie druhů *A. planisiliqua* a *A. sagittata*. Na lokalitě JZ od Smižan byla nalezena smíšená populace tří druhů, *A. hirsuta* s. str., *A. sagittata* a *A. planisiliqua* a vedle nich — podle očekávání — kříženci: triploidní křížence z kombinace tetraploidní *A. hirsuta* s jedním ze dvou diploidních druhů (*A. planisiliqua* nebo *A. sagittata*) a dále diploidní kříženci z kombinace uvedených diploidních druhů. Diploidní křížence jsme znaly dosud jen z pokusných křížení; zjištění jejich přirozeného výskytu je důležitým poznatkem. Analýza zmíněné složité populace dává nové perspektivy našemu studiu křížitelnosti a možnosti introgrese uvnitř komplexu *A. hirsuta*.

References

- BURDET H. M. (1967): Contribution à l'étude caryologique des genres *Cardaminopsis*, *Turritis* et *Arabis* en Europe. — *Candollea*, Genève, 22 : 107—156.
- CZAPIK R. (1971): Notes on meiosis in *Arabis hirsuta* s. str., *A. sagittata* and their hybrids. — *Acta Biol. Cracov., Bot.*, Cracovie, 14 : 11—26.
- CZAPIK R. et I. NOVOTNÁ (1967a): Cyto-taxonomical and genetic problems of the *Arabis hirsuta* (L.) Scop. complex. I. — *Acta Biol. Cracov., Bot.*, Cracovie, 10 : 167—183.
- (1967b): *Arabis* L. — In: LÖVE Á.: IOPB chromosome number reports. X. — *Taxon*, Utrecht, 16 : 146—157.
- (1969): Cyto-taxonomical and genetic problems of the *Arabis hirsuta* complex. II. — *Acta Biol. Cracov., Bot.*, Cracovie, 12 : 35—56.
- KLÁŠTERSKÝ I. et I. NOVOTNÁ (1962): Komplex *Arabis hirsuta*. — *Preslia*, Praha, 34 : 387—393.
- MATVEJEVA T. C. et A. D. TICHONOVA (1969): *Arabis* L. — In: FEDOROV A. [ed.]: *Chromosome numbers of flowering plants*. — Leningrad.
- MĚSÍČEK J. (1967): *Arabis* L. — In: LÖVE Á.: IOPB chromosome number reports. XII. — *Taxon*, Utrecht, 12 : 341—350.
- NOVOTNÁ I. (1962): Untersuchungen über die Chromosomenzahl innerhalb *Arabis hirsuta* (Komplex). — *Preslia*, Praha, 34 : 249—254.
- NOVOTNÁ I. et R. CZAPIK (1971): Investigations on some hybrids from the *Arabis hirsuta* complex. — *Folia Geobot. Phytotax.*, Praha 419—440.
- TITZ W. (1968): Zur Cytotaxonomie von *Arabis hirsuta* agg. (Cruciferae). I. Allgemeine Grundlagen und die Chromosomenzahlen der in Österreich vorkommenden Sippen. — *Österr. Bot. Zeitschr.*, Wien, 115 : 255—290.
- (1969): Zur Cytotaxonomie von *Arabis hirsuta* agg. (Cruciferae). IV. Chromosomenzahlen von *A. sagittata* (Bertol.) DC. und *A. hirsuta* (L.) Scop. s. str. aus Europa. — *Österr. Bot. Zeitschr.*, Wien, 117 : 195—200.

Received January 26, 1971
 Recenzent: J. Měsíček

See also plates I.—II. in the appendix.

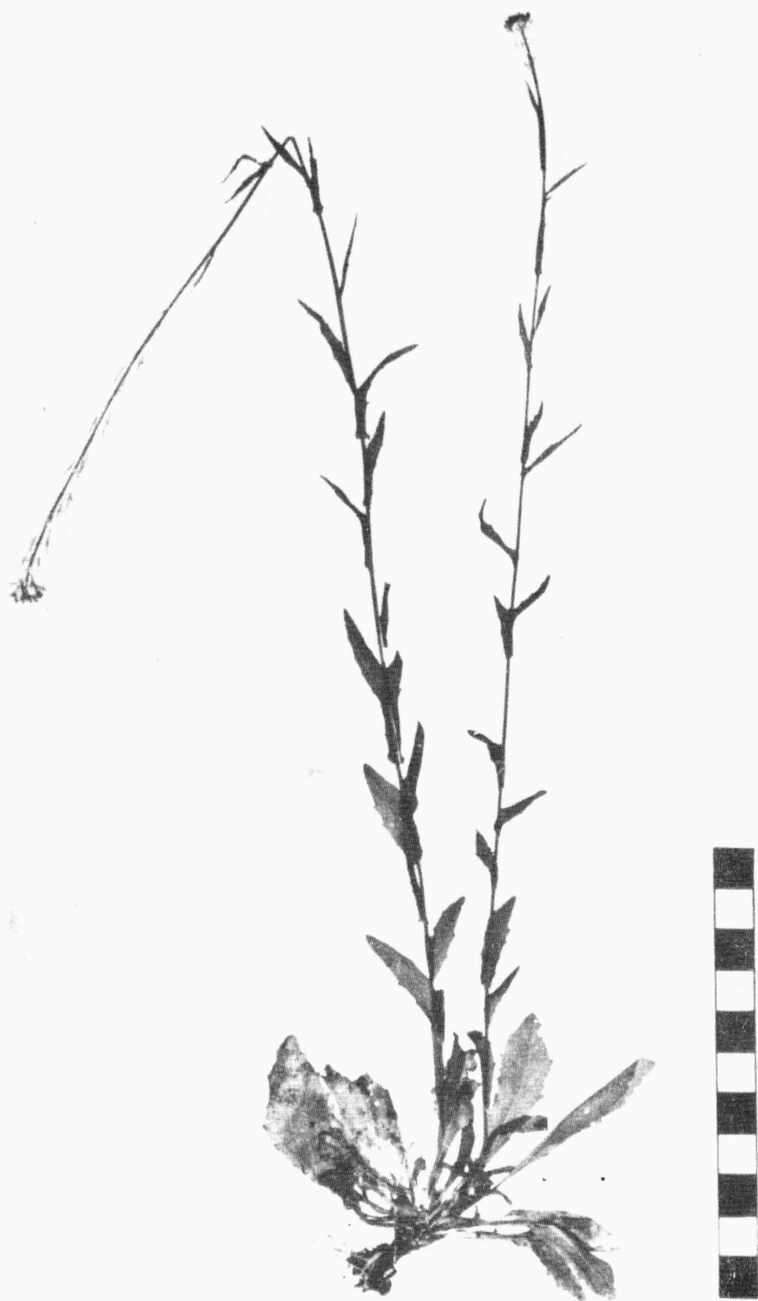


Plate I. - Natural diploid hybrid between *A. planisiliqua* and *A. sagittata* from the mixed population in Smižany [coll. 4. VI. 1969, ČS 32 (PR), Czechoslovakia]; scale in cm. — Photo: K. GREGOR.

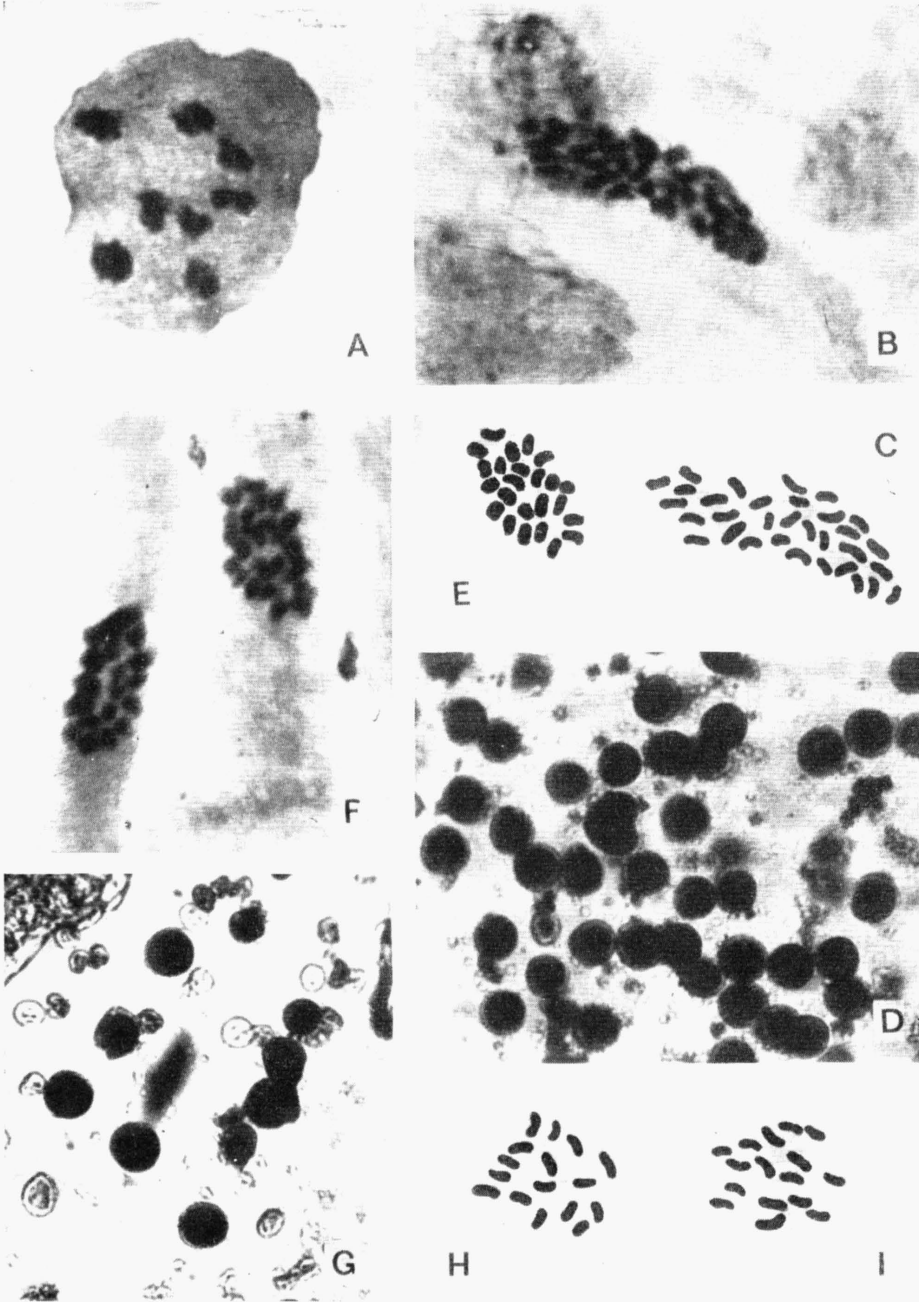


Plate II. — A: Eight bivalents in the diakinesis of *A. sagittata*; B, C: somatic metaphase of *A. hirsuta* s. str. (the same plate, $2n = 32$); D: well developed pollen grains of a tetraploid *A. hirsuta* s. str.; E, F: hybrid between *A. hirsuta* s. str. and *A. sagittata* (the same metaphase plate, $2n = 24$); G: pollen grains of a diploid hybrid between *A. planisiliqua* and *A. sagittata*; H: somatic metaphase of a hybrid between *A. planisiliqua* and *A. sagittata* ($2n = 16$); I: somatic metaphase of *A. planisiliqua* ($2n = 16$). — A — F: plants from Silická planina above Jovice; G — H: from Smižany; I: from Čingova hora. — G and D $\times 300$, the others $\times 2000$. — Photo: R. CZAPIK.