Further studies in chromosome numbers of Polish Angiosperms

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INTRODUCTION

This paper represents the continuation of our first contribution published in 1950. It gives the results of our further studies in chromosome numbers of the Polish Angiosperms. In view of a rather long time that has elapsed since our first report has been published, a considerable material has accumulated. It was therefore advisable to divide the results into two parts: the present study deals only with Monocotyledons, while the second — now in preparation — will give our results concerning the chromosome numbers of Dicotyledons. It should be added that some results obtained in the course of our work have been already published separately in the meantime. These results will be briefly summarized in due course.

Like previously, the plant material for our investigations originated exclusively from natural habitats. The determination of the chromosome numbers was based chiefly on the study of root-tip mitoses. In most cases the Navashin's fixative, sometimes diluted with an equal part of distilled water — in combination with Newton's gentian violet was used with good results.

Liliaceae

Colchicum autumnale L. ($2n = 38$). Studied by K. Satczek.

A perennial species occurring in Poland in meadows both in the plain and in lower mountain habitats.

It should be mentioned that various and highly controversial chromosome numbers were reported for this species prior to the detailed study of Leván (1940) dealing with several species of this genus. The correct number $2n = 38$ has been established for the first time by Leván on specimens of *C. autumnale* from the Botanical Gardens of Lund and Copenhagen. Since that time this chromosome number has been confirmed

by Sato (1942), Takenaka (1950) and recently by d'Amato (1955). Chromosome counts on plants from natural Central European habitats were not published hitherto.

The specimens for the present study originated from three habitats in southern Poland:

1. Valley of Harcza, near Czorsztyn.
2. Foreland of the Carpathian range, near Rzeszów.
3. Sudetic Mts, near Kudowa.

Although *Colchicum* has been considered as a difficult cytological material, root-tips fixed in Navashin's fixative at room-temperature contained a large number of well spaced metaphase plates in which the chromosome counts did not present special difficulties. The number found in the specimens from Poland is in accordance with the result of Leván.

Allium ursinum L. ($2n = 14$). Studied by H. Weisło.

This species occurs in Poland in shady woods. The specimens studied originated from the slope of Babia Góra (Western Carpathians). Their somatic chromosome number $2n = 14$ agrees with that previously given by Leván (1931, 1932) for plants from Sweden. The chromosomes are large bi-armed with median centromeres; one pair has trabants, like in the Swedish material. The same number has been found by Chodat (1925) and by Manton (1935, cited from Tischler, 1950).

Lilium martagon L. ($2n = 24$). Studied by H. Weisło.

A species common in lower mountain habitats and found rather rarely in the plain. The plants studied originated from the Tatra Mts (Łysanki), the Sudetic Mts (Kudowa), as well as from two habitats in the plain: Tunel, near Krakow, and Dolina Kluczwody, a jurassic valley near Krakow. The number 24 found in all plants studied is in accordance with the results of all previous authors (Tischler, 1950).

Majanthemum bifolium (L.) F. W. Schm. $2n = 36$. Studied by K. Sateczek.

A very common species occurring over all Poland in woods and in scrubs. In the mountains it ascends to the layer of *Pinus montana*. The material was collected in a variety of habitats extending from the north to the south of Poland:

1. Baltic coast, near Gdańsk-Wrzeszcz (N. Lat. c. $54^{\circ}25'$).
2. Sudetic Mts, near Szklarska Poręba (N. Lat. c. 51°).
3. Upper Silesia, near Taciszów (N. Lat. c. $50^{\circ}20'$).
4. Surrounding of Krakow, Dulowa (N. Lat. c. 50°).
5. Foreland of the Carpathian range near Maków Podhalański (N. Lat. c. $49^{\circ}45'$).

6. Pieniny Mts, way to Sokolica (N. Lat. c. $49^{\circ}30'$).

7. Tatra Mts, Valley of Biały (N. Lat. c. $49^{\circ}20'$).

In all plants studied the number $2n = 36$ was found. According to previous records, *Majanthemum bifolium* seems to be differentiated into a number of karyological races. The present results agree with those of Stenar (1935) and of Palmgren (1943, cited from Tischler, 1950). Other numbers however have been reported by Lawson (1913, cited from Tischler, 1950) who found $2n = 28$; by Dark (in Maude, 1939) — $2n = 38?$ as well as by Maude (1940) $2n = 42$, and by Löve and Löve, 1942 (according to Tischler, 1950) $2n = 42$.

Paris quadrifolia L. $2n = 20$. Studied by E. Pogan.

This species occurs in leafy woods and in scrubs over all Poland. The specimens studied originated from two habitats: Western Carpathians: way from Zawoja to Babia Góra, as well as from the central part of the Carpathian range (Beskid Niski), near Krynica. The number $2n = 20$ established in the course of the present study is in accordance with the results of previous investigations (Tischler, 1950).

Iridaceae

Iris pseudacorus L. ($2n = 24$). Studied by H. Wcisło.

This species is widely distributed in Poland, growing on banks of ponds and rivers and in marshes. The plants studied were collected in swampy meadows at Biezanów, near Krakow. Their somatic chromosome number is 24 (Fig. 1). The same results were obtained previously by Strasburger (1900), Miyake (1905) and by Longley (cited from Simonet, 1932). Studies of other authors however have revealed a well marked karyological differentiation within this species: the number 30 was found by Happel (in Maude, 1939); Ehrenberg (1945, cited from Löve and Löve, 1948) gave $2n = 30 - 32$, while Simonet (1932) reported $2n = 34$ for plants from France. In view of this differentiation, a more detailed study of wild populations of this species in Poland is planned in the future.

Juncaceae

Juncus trifidus L. ($2n = 30$). Studied by H. Wcisło.

The distribution of this species in Poland is restricted to the granitic part of the Tatra Mts, from the layer of *Pinus montana* to the alpine layer. The specimens studied were collected on granitic rocks near the path from the lake Morskie Oko to Czarny Staw (c. 1600 m o. s. l.). Their chromosome number ($2n = 30$) (Fig 2) is the same as that given by Löve and Löve (1944) for plants from the North.

Luzula nemorosa (Pall.) E. Mey. ($2n = 12$). Studied by H. Weisło.

A species which in Poland is common both in the plain and at lower altitudes in the mountains. The specimens studied originated from the slopes of Opalone in the High Tatra. The chromosome number $2n = 12$

Fig. 1—3. Root tip metaphase: 1. — *Iris pseudacorus* ($2n = 24$). 2. — *Juncus trifidus* ($2n = 30$). 3. — *Luzula nemorosa* ($2n = 12$) (c. 3000 $\times$).

(Fig. 3) found in the course of the present study, agrees with that previously established by Noronha-Wagner (1949) and confirmed by Michalska (1953) for two habitats in Poland.

Gramineae

Anthoxanthum odoratum L. studied by K. Kaczor.

This grass is widely distributed over all Poland, both in the plain and in the mountains. In the Tatra Mts its vertical distribution extends from the higher mountain layer to the alpine layer.

Östergren (1942) as well as Löve and Löve (1948) have recorded, in addition to the very common tetraploid type with 20 somatic chromosomes, also a much rarer form with only 10 chromosomes; this diploid type has been found in the Alps as well as in alpine regions of Scandinavia, Iceland and Greenland. According to Böcher and Larsen (1950) it occurs also in south Greenland and the Kola Peninsula. Our study has been undertaken in view of the cytological differentiation of this species suggesting the possible occurrence of the diploid type in the Tatra Mts. In the course of our work specimens from 20 natural habitats have been investigated. The results are summarized below:

- 1 lowland habitat in northern Poland (Baltic coast) — $2n = 20$.
- 8 lowland habitats in southern Poland — $2n = 20$.
- 7 habitats in the higher mountain layer of the Western Tatra (altitude 900 to 1040 m o. s. l.) — $2n = 20$.
- 4 habitats in the High Tatra (altitude 1580 to 1800 m o. s. l.) $2n = 10$.

The diploid type of *Anthoxanthum* has been described by Löve and Löve (1948, p. 105) as a new species *A. alpinum* L. a. L. Detailed comparative morphological studies of the two types, now in progress, will probably enable us to evaluate the taxonomical position of the diploid type from the High Tatra and will show whether it should be assigned to the new species *A. alpinum*.

Phleum Michelii All. (*P. hirsutum* Honck.) $2n = 14$. Studied by T. Michalski.

In addition to his previous study (1955) on *Ph. commutatum* Gaud. which proved to be represented exclusively by diploid biotypes in the Tatra Mts, the author investigated *Ph. Michelii* All., a species occurring only in the limestone part of the Tatra Mts, chiefly in the layer of *Pinus montana*. This species is likewise diploid ($2n = 14$). The same number has been found previously by Müntzing (1935) in one biotype from the collection of the Forage Crop Department of Svalöf.

Agrostis rupestris All. $2n = 14$. Studied by M. Skalińska.

A perennial grass, widely distributed in the High Tatra at higher altitudes, on steep slopes and in cracks of granitic rocks. It ascends to the highest mountain peaks.

The material studied originated from four habitats, situated in the layer of *Pinus montana* and in the alpine layer, in the north-western part of the High Tatra. The list of the habitats is given below:

Strain I. Valley of Pańszczyca, 1700 m o. s. l. (coll. S. Myczkowski).

Strain III. Slope below the pass Liliowe, c. 1800 m o. s. l.

Strain IV. Border of the lake Czarny Staw, c. 1630 m o. s. l.

Strain V. Pass Swinicka, on a grassy slope facing South (2050 m o. s. l.).

The four biotypes studied had the diploid chromosome number, $2n = 14$, however in all, with the exception of strain V, the occurrence of small accessory chromosomes (or fragments) could be stated in root-tip metaphases. These accessories represented very small bodies, their shape was almost spherical or slightly elongated; a centromere could not be discerned. Their width roughly corresponded to that of the arms of the normal chromosomes, while their length exceeded the width 1.5 to 2 times (Fig. 4 b, c, 32). These accessories could be observed in the metaphase plates in the number of 1 to 2 (exceptionally also 3). They occurred

in the three germ layers of the roots; their number seemed to be constant in one strain, while in the two other strains it manifested some degree of variation within the tissues of an individual (Table 1). This suggests that the transmission of these small accessories in mitotic divisions may be irregular.

Table 1

	Number of accessories in cells:				Total number of cells:
	0	1	2	3	
Number of cells:					
Strain I	—	16	—	—	16
Strain III	—	5	10	—	15
Strain IV	9	44	9	1	63
Strain V	20	—	—	—	20

The chromosome numbers of *Agrostis rupestris* have been studied only recently by S. O. Björkman (1951, 1954) and by G. Reese (1952). The latter author however found the tetraploid chromosome number ($2n = 28$) in a strain of *A. rupestris* from a locality in Stubai Alps, North Tirol. Björkman's investigations are based on an ample material of wild populations originating chiefly from the Alps and the Pyrenees; he studied also one strain from Poland as well as plants raised from seeds obtained from Botanical gardens. According to his results, all strains from the Alps have 28 chromosomes with the occasional occurrence of supernumeraries; on the other hand, in the Pyrenees this species is represented by two chromosomic types: the diploid with 14 chromosomes and the tetraploid with 28 chromosomes. Also the strain from Poland proved to be tetraploid. According to the information given me very kindly by Mr. Björkman, this tetraploid specimen was native in the High Tatra, in the surrounding of the lake Morskie Oko. Thus, it originated from the south-eastern part of the High Tatra, separated from the habitats of our diploid biotypes by two high mountain ridges. The results of Björkman and those of the present investigation have shown the occurrence of two chromosomic types in the High Tatra. A more detailed study of their distribution in this area is planned in the next future.

Calamagrostis epigeios (L.) Roth. ($2n = 56$).

Ammophila arenaria Link ($2n = 28$).

Ammophila baltica Link ($2n = 42$). Studied by A. Szwabowicz.

This study has been undertaken in order to elucidate the origin of *Ammophila baltica* which is regarded as an intergeneric hybrid between *Calamagrostis epigeios* and *Ammophila arenaria* (Hegi, 1906, Szaffer,

Kulczyński and Pawłowski, 1953). Therefore, the material for the present study originating from the Polish part of the Baltic coast, was collected exclusively from habitats in which the three forms were found together. It should be added that the distribution of *Ammophila arenaria* and *A. baltica* is limited to sand dunes at the sea coast whereas *Calamagrostis epigeios* occurs in a variety of habitats over all Poland.

Fig. 4—6. Root tip metaphases: 4. — *Agrostis rupestris* ($2n = 14$): a — plate without accessory chromosomes (Strain V); b — with one (Strain I) and c — with two accessories (Strain III) (c. 3500 $\times$). 5. — *Poa bulbosa* ($2n = 39$) (c. 3500 $\times$). 6. — *P. laxa* ($2n = 28$) (c. 3000 $\times$).

Hitherto the chromosome numbers of plants from the following habitats have been determined: 1. Międzyzdroje (N. Lat. $53^{\circ}55'$; E. Long. $14^{\circ}28'$), 2. Karwia (N. Lat. $54^{\circ}51'$; E. Long. $18^{\circ}12'$). 3. Jastarnia on the Hel peninsula (N. Lat. $54^{\circ}42'$; E. Long. $18^{\circ}36'$). The results of these investigations are given below.

Calamagrostis epigeios. In all plants from the three habitats the number $2n = 56$ has been found. According to earlier investigations however a polyploid differentiation occurs within this species. Nygren (1946) found in Scandinavian plants three chromosomic types: $2n = 28$, 42 and

56. In his opinion the hexaploids probably represent hybrids between the tetra- and the octoploids. Westergaard (1941, 1943, cited from Tischler, 1950) has established in his material the occurrence of two chromosomal types, the tetraploid and the octoploid. The tetraploid number solely has been reported by Nielsen (1939) and by de Litardière (1949, cited from Tischler, 1950). On the other hand, Avdulov (1931) gives for this species the somatic number c. 70.

Ammophila arenaria. In all plants originating from the three above habitats the somatic number 28 could be established. This species however seems to have, likewise, some degree of karyological differentiation. The tetraploid number has been found prior to our studies by Tischler (1934, cited from Tischler 1950), Wulff (1937) as well as by Guinochet (1943) who investigated two varieties of this species: var. *genuina* Briq. and var. *arundinacea* Husnot. Westergaard however (l. c.) has found besides the tetraploid type also an octoploid form with 56 somatic chromosomes.

Ammophila baltica. The chromosome number $2n = 42$ found in specimens of this putative hybrid in the three habitats suggests that this form really represents a cross-product between the octoploid biotypes of *Calamagrostis epigeios* and the tetraploid biotypes of *Ammophila arenaria* occurring in the same habitats. Further studies are in progress.

Deschampsia flexuosa (L.) Trin. ($2n = 28$). Studied by H. Wcisło.

This species occurs occasionally in a viviparous form. A single viviparous specimen has been collected near the bank of the lake Morskie Oko in the High Tatra (1410 m o.s.l.). Its chromosome number ($2n = 28$) is the same as that previously established for non-viviparous representatives of this species. This result is in accordance with the observations of Stählin (1929, p. 350). The number $2n = 28$ has been found, likewise by Hagerup (1939) who emphasized the wide distribution and the very great ecological range of this tetraploid species, as well as by Löve and Löve (1944). Specimens from Southwest Greenland and from Faroes recently investigated by Böcher and Larsen (1950) have the same chromosome number. It seems probable that this species is cytologically uniform within its wide area of distribution.

Poa L. studied by M. Skalińska.

Since our first publication two papers dealing with *P. alpina* L. (1952) and *P. nobilis* Skal. (1955) and one preliminary note (1954) have been published. In the present paper we give chromosome numbers of five further species of this genus as well as some supplementary data con-

cerning *P. alpina* and *P. nobilis*. The species investigated are grouped in sections according to the clasifcation given by Nannfeldt (1935, p. 28—29).

Triviales

P. trivialis $2n = 14$.

A perennial species widely distributed in Poland both in the plain and in lower mountain habitats. The specimens investigated were collected in the Tatra Mts at the border of a stream in the valley Olczyska (c. 900 m o.s.l.).

The diploid chromosome number of this species has been established previously for plants from other areas by Avdulov (1931), Åkerberg (1942) and Stählin (1929). Guinochet (1942/3) has described two chromosomic types in plants originating from the south-western Alps: var. *vulgaris* with 28 chromosomes and var. *sylvicola* with $2n = 14$.

Subbulbosae

P. bulbosa L. $2n = 39$.

Very few cytological studies of this species have been carried out hitherto, the results obtained however have revealed some degree of differentiation. According to the results of previous authors, the euploid numbers of this species range from the diploid ($2n = 14$, Guinochet 1942/3) through the tetraploid which seems to be most common ($2n = 28$ Armstrong, 1937 cited from Hartung, 1946, Åkerberg, 1942, Hartung, 1946) to the hexaploid ($2n = 42$, Hartung, 1946). Only in one case an aneuploid number has been reported hitherto ($2n = 45$, Åkerberg, 1942). The Polish specimens are likewise aneuploid ($2n = 39$, Fig. 5).

P. bulbosa in its viviparous form occurs in the Polish plain in rare and dispersed habitats. The material for the present study originated from an escarpment covered with gypsum debris in the gorge Skorocice near the lower course of river Nida (N. lat. c. $50^{\circ}20'$, E. Long. $20^{\circ}40'$). In this habitat *P. bulbosa* occurs abundantly. It has been collected in summer 1953 in the form of bulbils which germinated in spring 1954 after a resting period of several months. The young rootlets contained numerous metaphase plates with well spaced chromosomes; this enabled us to establish exactly the aneuploid number 39 in about 10 plants. The cytological uniformity of this large population suggests that it represents a single clone which has spread over this large area.

P. alpina L. var. *seminifera* L.

It has been mentioned previously (1952) that *P. alpina* is represented in the Tatra Mts by two forms, var. *seminifera* and var. *vivipara*, the

former being notably rarer than the latter. A new strain from the Western Tatra (south-eastern slope of Giewont, 1800 m o.s.l.) has been studied. Its chromosome number ($2n = 22$) is the same as that found previously in another non-viviparous strain originating likewise from the limestone part (cf. Skalińska 1952, p. 272). On the other hand in the High Tatra (on granitic soil) the occurrence of a strain with 33 chromosomes has been established.

Poa alpina L. var. *vivipara* L.

Our previous study revealed a high degree of cytological differentiation of the viviparous form in the Tatra Mts. The present investigation adds some new evidence concerning the ecological requirements and the altitudinal distribution of the already known chromosomic types. Accord-

Table 2
Poa alpina var. *vivipara*: list of habitats and chromosome numbers

Strain N.	Place of origin in the High Tatra	2n
Layer of subalpine forests		
203	Valley of the lake Morskie Oko; eastern border of the lake (c. 1420 m o.s.l.)	26
221	Valley of the lake Morskie Oko; lower part of the path to Czarny Staw (c. 1450 m)	26
Layer of <i>Pinus montana</i>		
222	Path from Czarny Staw over Morskie Oko to Rysy (c. 1650 m o.s.l.)	26
Alpine layer		
227	Path from Zmarzły Staw to the valley Kozia Dolinka (c. 1930 m o.s.l.)	33
254	Pass Liliowe (1952 m o.s.l.)	33
256	Below pass Waga (C.S.R.) among stones and scree, near the Tourist-house (coll. Z. Radwańska-Paryska) (c. 2260 m o.s.l.)	26

ing to our previous results, the viviparous biotypes of *P. alpina* occur on granitic soil in the High Tatra as two main types: with 26 and 33 (—35) somatic chromosomes. The latter represent the hardiest alpine ecotypes growing on granit in exposed habitats at high elevations; on the other hand, the strains with 26 chromosomes represent a mixture of subalpine and alpine ecotypes which occur not only on granit but also on limestone. In the course of the present study biotypes from six habitats in the High Tatra have been investigated. Their chromosome numbers are in agreement with our previous results (Table 2):

*Stoloniferae**P. granitica* Braun-Bl.

A perennial species occurring endemically in the High Tatra and in the Eastern Carpathians. In the course of the present study the chromosome numbers of seven strains originating from well separated habitats in the High Tatra have been determined (Table 3). A part of these results has been published in our preliminary report (Skalińska, 1954) in which the chromosome numbers of this species were given for the first time. *P. granitica* is a species with relatively high and aneuploid chromosome numbers. It manifests some degree of cytological differentiation, like other species of the Section *Stoloniferae* (*P. pratensis* L., *P. arctica* R. Br.); its chromosome number in the specimens studied by us hitherto ranges from 64 to 94 (Table 3, Fig. 8—11, 35). It should be added that the strains with relatively lower numbers (64—72) were found more frequently than the highest number $2n = 94$, found till now only in a single colony.

Table 3

Poa granitica: list of habitats and chromosome numbers

Strain N.	Habitats in the High Tatra	2n
229	Higher part of the path to pass Krzyżne (c. 1900 m o. s. l.)	72
199	Below the pass Kozia Przełęcz (c. 1800 m o. s. l.) (coll. S. Myczkowski)	94
200	Slope of Kozi Wierch above the valley Pusta Dolinka (1820 m o. s. l.) (coll. S. Myczkowski)	64
241	Path from the lake Zmarzły Staw to pass Zawrat (c. 1950 m c. s. l.)	67
250	Higher parts of the path from the pass Swinicka to the peak of Świnica (c. 2200 m o. s. l.)	64
251	Slope of Świnica, near the peak (c. 2250 m o. s. l.)	64
220	Slope of Mięguszowiecki (c. 1900 m o. s. l.) (coll. B. Pawłowski)	71

The representatives of this biotype differed from the average specimens of *P. granitica* also by some anatomical features: the size of the stomata and of the bulliform cells in the epidermis of their leaves was notably increased (Skalińska and Małecka, unpubl.); the pollen grains, likewise, were larger (Mean = 41.25μ) than those of the other biotypes (Means = 26.40μ to 27.0μ).

It should be emphasized that no intermediate numbers between 72 and 94 have been found hitherto. This detail may be of importance for the understanding of the possible mode of origin of this deviating high-chromosomic strain. Its unusually high chromosome number suggests that in its formation the process of chromosome summation resulting from facultative apomixis could have played a part. Our embryological studies of the seven strains — now in progress — have revealed in *P. granitica* a high degree of apomixis. Detailed results of these investigations will be published separately; it should be pointed out however that, according to the results already obtained, in this species the egg-cell is able of a parthenogenetic development while the formation of the endosperm requires fertilization, like in *P. pratensis* (Åkerberg, 1942). In accordance with this, in all strains studied, irrespective of their chromosome number, the ovules in unopened flower buds usually contained young embryos together with unfused polar nuclei. Only in rare instances the first divisions of the egg-cell may become delayed, favouring the possibility of its fertilization. In this way the increase of the chromosome number of the zygote could be achieved. The newly formed chromosomic type resulting from this process could be stabilized by apomixis. On the whole, the cytological differentiation of *P. granitica* seems to parallel other species of the Section *Stoloniferae* which, according to the opinion of Nannfeldt (1940) had originated from intersectional crosses.

P. nobilis Skal.

The present data supplement our studies in this viviparous species published recently (Skalińska, 1955). In the past year a number of new habitats of *P. nobilis* in the High Tatra have been found and the resp. biotypes have been investigated cytologically (Table 4). The present

Table 4

Poa nobilis: list of habitats and chromosome numbers

Strain N.	Habitats in the High Tatra	2n
219	Slope of Mt Mieguszowiecki (c. 1950 m o. s. l.) (coll. B. Pawłowski).	72
252	Pass Sucha Przełęcz, near the peak of Mt Kasprowy Wierch (c. 1960 m o. s. l.).	72
255	Below the pass Waga (C. S. R.), among stones and scree (c. 2260 m o. s. l.) (coll. Z. Radwańska — Paryska).	72
257	Near the peak of Lodowy (C. S. R.) (c. 2555 m o. s. l.) (coll. Z. Radwańska — Paryska).	72

results have shown once more the frequent occurrence of the somatic number 72 (Fig. 7), in accordance with our previous observations (l. c., p. 754). The other numbers found formerly (61—62, 76, 82) are notably rarer*.

Fig. 7—11. Somatic metaphase plates in root tips: 7. — *Poa nobilis* (Strain 255, $2n = 72$). 8. — *P. granitica* (Strain 251, $2n = 64$). 9. — *P. granitica* (Strain 241, $2n = 67$). 10. — *P. granitica* (Strain 220, $2n = 71$). 11. — *P. granitica* (Strain 199, $2n = 94$) (c. 3000 $\times$)

* Note added in proof: In the summer season 1956 four further strains found in new habitats of the High Tatra could be identified as *Poa nobilis*. Their chromosome numbers will be published later.

All new habitats listed in Table 4 are situated in the alpine layer. One of these habitats deserves special mention in view of its close vicinity to Mt. Kasprowy, where isolated plants could be found occasionally (cf. Skalińska, 1955, p. 758). It is probable that this natural rich habitat represents the place where from the resp. plants were dispersed in the form of bulbils.

P. pratensis L.

In spite of a very wide distribution of this species, the present study is restricted to four strains native in the Tatra Mts. They have been collected in habitats representing well marked differences in respect of edaphic conditions and altitude, with the aim to get some information concerning the intraspecific differentiation of biotypes in this area. On the whole, the range of diversity with regard to chromosome numbers is rather narrow (Table 5). The biotypes studied however are far from being uniform; after transplanting into the experimental field in Krakow, they manifested striking differences both in their vigour and their ability of development outside their natural habitats. The extremes are represented by two biotypes with approximately the same chromosome

Table 5
Poa pratensis: list of habitats and chromosome numbers

Strain N.	Place of origin	2n
164	A meadow above valley Olczyńska, bank of a stream, among stones (c. 1065 m o. s. l.).	74
173	Western (limestone) Tatra; grassy slope between Kobylarz and pass Siwarowa; layer of <i>Pinus montana</i> c. 1500 m o. s. l.).	c. 78
160	Western Tatra: valley Mułowa in the group of Czerwone Wierchy. Alpine layer (c. 1800 m o. s. l.).	c. 80
183	High Tatra: above the lake Zmarzły Staw, near the path to Zawrat; on granitic rocks. Alpine layer (c. 1800 m o. s. l.).	c. 80

numbers: the first (strain 183) originated from the granitic part of the Tatra Mts.; in nature it represented a small plant which maintained its general habit after transplanting and perished in the second year; the second (strain 160) collected in the limestone part of the Tatra Mts, represented likewise a small plant in its natural habitat, after transplanting however it developed into a vigorous and aggressive plant with abundant stolons and tall flowering stems.

Biotypes of *P. pratensis* from various areas have been studied cytologically by many authors (cf. Tischler, 1950). The relatively high

and aneuploid numbers found in the strains from the Tatra Mts roughly correspond to the highest numbers listed by Tischler. In specimens from the North the numbers are still higher.

Oreinos

P. laxa Haenke ($2n = 28$).

According to Nannfeldt (1935) the general area of distribution of this species extends from the Pyrenees, Corsica and the Apennines through the Alps, the higher parts of the Sudetic Mountains, and the Carpathians, viz. the Riesengebirge, Babiagora, the Tatra Mountains, Czarna Hora (?), the Rodna Mountains, the Transsilvanian Alps, and to Banatus (p. 57).

The specimens studied in the course of the present work originated chiefly from the High Tatra (12 habitats). In addition, one strain has been collected in the type-locality where from Haenke made the first description of this species, namely in the Sudetic Mountains, on the slopes of Śnieżka (= „Schneekoppe in the Riesengebirge”). All specimens studied proved to have $2n = 28$ (Fig. 6, Table 6). This number has been already mentioned in our previous papers (Skalińska, 1952, p. 256, 1954, p. 86). Chromosome numbers of this species from other areas are hitherto not available. It was particularly interesting to study its cytology on specimens from Central Europe in view of the occurrence in Scandinavia, Iceland and Scotland of a closely related species, *P. flexuosa* Sm. (*P. laxa* Hke, subsp. *flexuosa* (Sm.) (Hyl.) According to Nannfeldt (l. c.) this species represents a North European substitute for *P. laxa* (p. 55).

Nygren (1950) studied the cytology of *P. flexuosa* on Scandinavian specimens and found the number $2n = 42$. The same number occurs, according to the unpublished results of A. Löve, in Icelandic plants belonging to this species. In his studies in Arctic *Poa* Nygren emphasized the importance of a cytological examination of *P. laxa* from Switzerland; the resp. data however are still wanting. The present investigation has revealed the occurrence of a cytological difference between the North European *P. flexuosa* and *P. laxa* from the mountains of Central Europe.

Stenopoa

P. nemoralis L. ($2n = 28$).

This species has been included into our investigations in view of the fact that it shows a well marked karyological differentiation; its chromosome numbers, established by numerous authors (cf. Tischler, 1950) range from 28 to 56. Some degree of aneuploidy occurs in this species.

Table 6

List of habitats of *Poa laxa* ($2n = 28$).

Place of origin.

Sudetic Mountains:

Strain N

190

Slopes of Mt. Śnieżka (coll. J. Szweykowski).

Tatra Mts (High Tatra):

Layer of *Pinus montana*

174

Way from Hala Gąsienicowa to the lake Czarny Staw, at the bottom of Mały Kościelec, among granitic rocks (c. 1550 m o.s.l.)

212

Bank of the lake Czarny Staw, near the path to Granaty (c. 1600 m o.s.l.)

152

Path from the lake Czarny Staw over Morskie Oko to Rysy, among granitic blocks, near a patch of permanent snow (c. 1700 m o.s.l.)

135

Eastern slope of Żabie: path to the pass Owcza przełęczka, in cracks of granitic rocks (c. 1760 m o.s.l.)

Alpine layer

198

Path from the lake Zmarzły Staw to the pass Kozia przełęcz (c. 1800 m o.s.l.) (coll. S. Myczkowski).

154

Slope of Granaty, in cracks of granitic rocks (c. 2000 m o.s.l.)

244

Pass Zawrat (2159 m o.s.l.)

248

Path from the pass Świnicka przełęcz to the peak of Świnica — lower parts (c. 2100 m o.s.l.)

249

Higher parts of the same path, among granitic rocks (c. 2130 m o.s.l.)

171

Slope of Kościelec (c. 1900 m o.s.l.)

127

Pass Szpiglasowa (2114 m o.s.l.)

230

Below the pass Krzyżne (c. 2000 m o.s.l.).

A preliminary study has been carried out on two strains collected by Dr Z. Radwańska-Paryska in the Belan Tatra (Tatry Bielskie, C. S. R.): 1. Valley of Czarna Woda Rakuska (c. 1600 m o.s.l.), bank of a stream. 2. Border of a spruce forest in the Valley Do Siedmiu Żródeł (c. 1370 m o.s.l.). The two strains proved to be tetraploid ($2n = 28$).

Nardus stricta L. ($2n = 26$). Studied by J. Rychlewski.

The material of *Nardus stricta* for the present investigation originated from 22 natural habitats situated in various parts of Poland. 16 biotypes were native in the Tatra Mts at altitudes varying from 900 m to 1950 m o.s.l., 2 biotypes in the foreland of the Carpathian range, 2 biotypes in the neighbourhood of Krakow (southern Poland), 1 biotype in the neighbourhood of Częstochowa (central Poland), 1 biotype at the Baltic coast (northern Poland).

According to the results obtained hitherto, *Nardus stricta* represents in the whole area studied a karyologically uniform species. Its somatic chromosome number is 26 (Fig. 12, 33). Prior to the present study this species has been investigated cytologically only by Avdulov (1928,

1931); the results of the present study agree with his results. On the basis of morphological and anatomical features Avdulov expressed the opinion that *Nardus stricta* belongs to the group of grass species with the basic number $x = 7$. The number 26 had arisen by the loss of 2 chromosomes from the 28-chromosomic set (p. 249). Thus, *Nardus stricta* is a tetraploid in which 2 chromosomes are missing.

The manner of reproduction of this species seems to be particularly interesting. In 1923 J. de Coulon has reported parthenogenesis in *Nardus stricta*. The occurrence of partially or even totally aborted anthers, observed by this author in the strains from Switzerland supports his opinion. No further studies however have been carried out on this species since that time. In view of the considerable progress of knowledge concerning the phenomena of apomixis, a reinvestigation of this problem was advisable; therefore the present cytological and embryological study has been undertaken. The results already obtained have confirmed to some extent the results of Coulon. In all biotypes investigated from

12

13

Fig. 12—13. Root-tip mitoses: 12. — *Nardus stricta* ($2n = 26$) (3000 $\times$). 13. — *Festuca tatrae* ($2n = 14$) (c. 2700 $\times$).

a total of 24 habitats the abortion of the anthers has been invariably observed. Not a single strain was able to produce pollen. In all plants the contents of the anthers degenerates in early premeiotic stages; pollen grains have been never observed. In spite of this, apparently normal embryos could be found in numerous young ovules. This suggests that the resp. plants represent apomicts.

It should be emphasized that hitherto only one grass-species with completely aborted anthers has been described, namely the obligate apomict *Poa nervosa*. According to P. Grun (1951, 1952) *P. nervosa* is capable of a normal seed formation without any fertilization of either egg or polar nuclei. It seems evident that in *Nardus stricta*, likewise, the embryos are formed in the way of apomixis. Further embryological and cytological investigations, now in progress, will presumably throw light upon the type of apomixis in this species.

Festuca tatrae (Czakó) Degen ($2n = 14$) Studied by E. Bielecki.

This species occurring endemically in the Western Carpathians is found in the Tatra Mts. on limestone rocks in the higher mountain layer and the layer of subalpine forests (W. Szafer, St. Kulczyński, B. Pawłowski „Rośliny Polskie” 1953).

On the basis of its morphological and anatomical characters this species was first recognized by Czakó as *F. amethystina* L. var. *tatrae* Czakó (Saint-Yves 1913). Subsequently Degen gave it the rank of a separate species *F. tatrae* (Czakó) Degen (Szafer, Kulczyński, Pawłowski 1953).

The material for the present cytological study has been identified on the basis of the anatomical features given by the above authors. The specimens have been collected from two habitats in the Western Tatra and one habitat in the Belan Tatra (Tatry Bielskie, C. S. R.):

1. Limestone rocks near the way from Kalatówki to Hala Kondratowa (c. 1280 m o.s.l.)
2. Grass patches on limestone slopes over Hala Kondratowa (c. 1375 m o.s.l.)
3. Pass Czerwona Glinka, foot-hills of Belan Tatra (c. 1400 m o.s.l.) (coll. Z. Radwańska-Paryska).

All plants proved to be diploid: $2n = 14$ (Fig. 13, 34). On the other hand, *F. amethystina* is a tetraploid ($2n = 28$), according to the results obtained by Stählin (1929). Thus, in addition to the morphological and anatomical differences previously established by Czakó and Degen, the present study has revealed another important difference concerning the chromosome numbers of the two species.

Orchidaceae

Studied by E. Pogan and H. Weisło.

The family Orchidaceae is represented in the flora of Poland by 47 species. The chromosome numbers of 18 among them were established in the course of the present work. In general the chromosome counts were made on root-tip mitoses. Only in *Orchis morio* L. they were carried out on meioses in P. M. C's. Owing to great difficulties connected with the cultivation of specimens the best results were obtained from root-tip materials fixed in nature in the spring (May, June).

The analysis of the somatic metaphase plates is rather difficult: the chromosomes are crowded and in view of notable size differences the larger with distinct constrictions may be easily mistaken for two small chromosomes lying close together.

In the present paper only a preliminary study of the chromosome morphology is given. The investigations are being continued.

Diandrae.

Cypripedium L.

C. calceolus L. $2n = 20$.

This species is rare in the flora of Poland. It occurs in shady leafy woods and scrubs in isolated stands over all Poland in the plain as well as in the mountains. The specimens studied originated from two habitats: one from the Tatra Mts. (Łysanki, c. 1400 m o.s.l.) and the other from the plain in the vicinity of Tunel (N. L. c. $50^{\circ}30'$. E. long. c. $20^{\circ}15'$). The plants from the above habitats have the somatic chromosome number $2n = 20$. The chromosomes are very big; 16 have median or submedian constrictions and in 4 the constrictions are subterminal (Figs. 14, 36). In view of the large size of the chromosomes the study was performed on sections 18μ thick; in such sections a notable number of metaphase plates undamaged by the microtome knife could be found.

The number $2n = 20$ established on the material from Poland is different from that given by Francini (1931), who found 22 chromosomes of different size; among them two small chromosomes were present. In our material however such small chromosomes were never detected in undamaged metaphase plates. It is possible that the species *C. calceolus* manifests some degree of karyological differentiation (fragmentation?). In order to throw light upon this problem further studies dealing with the number of chromosomes and their morphology should be based on a larger material.

Monandrae

Traunsteinera Rchb.

T. globosa (L.) Rchb. = (*Orchis globosus* L.) $2n = 42$.

This species assigned previously to the genus *Orchis* has been recognized by Reichenbach on the basis of its flower structure as a new genus *Traunsteinera* (Vermeulen, 1947).

In the Polish flora *T. globosa* is a representative of the European-mountain element (Szafer, 1949). In Poland it occurs chiefly in mountain regions (the Tatra, Pieniny Mts, Sudetic Mts) and in addition in a few isolated habitats in the southern part of the Polish plain (Szafer, Kulczyński, Pawłowski, 1953).

The specimens for cytological investigations were collected in two habitats in the Pieniny Mts (a meadow near the way from Krościenko to Trzy Korony, — c. 600 m o.s.l.) and from Krościenko to Przehyba c. 1.100 m o.s.l.).

The somatic chromosome number ($2n = 42$) is in accordance with that given by Heusser 1938 (cited from Tischler, 1950).

The chromosomes are rather small with some size differences (Fig. 15).

According to Heusser (cited from Vermeulen, 1947) *T. globosa* closely resembles to the representatives of the subgenus *Euorchis* by the shape of its tubers as well as by its chromosome morphology.

Orchis L.

In general all species which are assigned to the genus *Orchis* can be divided into two groups:

I. Subgenus *Euorchis* Klinge.

II. Subgenus *Dactylorchis* Klinge.

They are distinguishable by a number of morphological characters and by their chromosome sets. The following species have been investigated cytologically:

I. Subgenus *Euorchis* Klinge

O. militaris L. ($2n = 42$) represents a species common in meadows, on slopes, and in wood clearings on the Polish plain and in lower mountain regions. The specimens studied were collected in clearings of the wood near Tunel. The somatic chromosome number ($2n = 42$) is in accordance with that previously given by Hagerup (1938), Heusser (l. c.) and Vermeulen (1949, cited from Tischler, 1950).

O. morio L. ($n = 18$) has a wide area of distribution in dry parts of meadows, slopes and scrubs in the plain and in lower mountain regions; only plants from a single habitat: a dry meadow in Biezanów near Kraków were studied. This species represents a rather difficult material for cytological studies. The chromosome number could be established only on the study of meioses in P. M. C's; the number $n = 18$ is in accordance with the results of Hagerup (1938) and Vermeulen (1947).

O. mascula L. $2n = 42$. This species occurs likewise in meadows, scrubs in the plain as well as in lower mountain regions. *O. mascula* is rather difficult for cytological studies. In spite of the fact that an ample material from 5 natural habitats from the Tatra Mts, Pieniny Mts, Zawoja has been originally collected, the chromosome number could be established only in plants from Maków Podhalański (foreland of the Carpathians range). The number $2n = 42$ confirms the results of previous authors (Hagerup, 1938; Vermeulen, 1949, cited from Tischler 1950).

The chromosomes of the three species studied are rather small, uniform in shape, but with some differences in their size (Figs. 16, 17, 18, 37). The same type of differentiation of the chromosome set occurs also in other species of the Subgenus *Euorchis* as was already emphasized by Heusser (l. c.).

Fig. 14—24. *Orchidaceae*: all Figs, except Fig. 17, represent root tip metaphases; Fig. 17 represents I metaphase in P.M.C.: 14. — *Cypripedium calceolus* ($2n = 20$). 15. — *Traunsteinera globosa* ($2n = 42$). 16. — *Orchis militaris* ($2n = 42$). 17. — *O. morio* ($n = 18$). 18. — *O. mascula* ($2n = 42$). 19. — *O. latifolia* ($2n = 80$). 20. — *O. maculata* ($2n = 40$). 21. — *Coeloglossum viride* ($2n = 42$). 22. — *Gymnadenia conopsea* ($2n = 40$). 23. — *G. odoratissima* ($2n = 40$). 24. — *Leucorchis albida* ($2n = 42$) (c. 2400 $\times$).

II. Subgenus *Dactylorchis* Klinge.

Orchis latifolia L. = *Dactylorchis majalis* (Rchb.) Vermln. ($2n = 80$) is a common species in Poland. The material originated from the following habitats: in the plain: wet meadows in Biezanów and Dulowa near Kraków; in mountain regions: the Tatra Mts (Way pod Reglami, c. 930 m o.s.l.), the Pieniny Mts (Valley of Harcza, c. 600 m o.s.l.), and in the range of Babia Góra (Markowe Szczawiny, c. 1150 m o.s.l.).

All specimens studied proved to have the somatic chromosome number $2n = 80$; the same number has been reported previously by Hagerup (1938) and Vermeulen (1938).

Orchis maculata L. = *Dactylorchis maculata* (L.) Vermln. ($2n = 40$) occurs in Poland in scrubs and meadows both in the plain and in lower mountain regions. Plants from the following habitats have been studied: Ojców near Kraków (in a jurassic valley), the Tatra Mts (Valley of Biały, c. 950 m o.s.l.; slope of Krokiew c. 950 m o.s.l.) the Pieniny Mts (slope of Sokolica, c. 700 m o.s.l.).

In all specimens studied the chromosome number $2n = 40$ has been established. The same number has been reported by Hagerup (1938) in addition to the number $2n = 80$ found by him in plants from Denmark. The relatively rare diploid form ($2n = 40$) determined by him as *O. maculata* var. *Meyeri* occurs only on limestone. It should be mentioned that all specimens studied from Poland originated from calcareous soils.

The chromosomes of the two species studied, belonging to the subgenus *Dactylorchis* are relatively small and rather uniform in size as well as in shape (Figs 19, 20, 38). This uniformity of the chromosomes within the group *Dactylorchis* shows, according to Vermeulen (1947) that the subgenus *Dactylorchis* represents a natural unit within the genus *Orchis*.

Coeloglossum Hartm.

C. viride (L.) Hartm. $2n = 42$

C. viride is common in Poland chiefly in mountain regions; the specimens studied were collected from three habitats in the Tatra Mts (Valley of Biały c. 950 m o.s.l.; Valley of Mała Łąka c. 900 m o.s.l.; slope of Kalacka Turnia c. 980 m o.s.l.) and in the Pieniny Mts (way from Krościenko to Trzy Korony c. 600 m o.s.l.). In all plants invariably the number $2n = 40$ was found, the same as that given previously by Richardson (1935, cited from Tischler 1950), Heusser (l. c.), Sokolovskaja and Strelkova (1940, cited from Tischler 1950), A. Löve and D. Löve (1944). The chromosomes of *C. viride* are rather small and uniform both in size as in shape (Fig. 21).

Gymnadenia R. Br.

G. conopea (L.) R. Br. $2n = 40$

In Poland this species is common in the Sudetic Mts and in the Carpathians in meadows and on rocky slopes; in the plain it is rarer. The specimens studied originated from 5 habitats (Table 7). All plants investigated had $2n = 40$. The same chromosome number was previously found for this species by Richardson (l. c.), Heusser (l. c.), Sokolovskaja and Strelkova (l. c.), Leliveld, 1941 (cited from Tischler 1950), Barber, 1942; Afzelius, 1943 (cited from Tischler 1950). Also a type with $2n = 80$ has been found by Sokolovskaja and Strelkova (l. c.), and by Heusser (l. c.).

Table 7
List of habitats of *Gymnadenia*

Species	Place of origin
<i>G. conopea</i> : ($2n = 40$)	Tatra Mts; Łysanki c. 1400 m o. s. l. Pieniny Mts; Sokolica c. 700 m o. s. l. Trzy Korony c. 850 m o. s. l. Western Carpathians, range of Babia Góra: two different habitats from the way Zawoja — Babia Góra through Czatoża.
<i>G. odoratissima</i> : ($2n = 40$)	Tatra Mts: Valley of Biały, c. 900 m o. s. l. Common Huciska in the Valley Chochołowska, c. 980 m o. s. l.

G. odoratissima (L.) Rich. $2n = 40$

This species grows in the limestone part of the Tatra Mts on rocky slopes and in meadows. In the plain it is very rare. The plants for our study were collected in 2 habitats (Table 7). Their chromosome number ($2n = 40$) is in accordance with that previously given by Heusser (l. c.).

Leucorchis E. Mey.

L. albida (L.) E. Mey. $2n = 42$

This species is rather common in mountain meadows in the Sudetic Mts and the Carpathians. Specimens from two habitats: the Tatra Mts (Way Pod Reglami c. 930 m o.s.l.), and the Pieniny Mts (Sokolica c. 700 m o.s.l.) have been studied. Their somatic chromosome number was $2n = 42$. The same number has been reported previously by Heusser (l. c.); A. Löve and D. Löve, 1944; A. Löve, 1950; Harmen, 1943 (cited from A. Löve 1950).

In the genera *Gymnadenia* and *Leucorchis* the chromosomes are rather small; their size and shape is approximately uniform within the plate (Figs. 22, 23, 24). The same type of somatic chromosomes is found in *Dactylorchis*.

Platanthera Rich.

P. bifolia (L.) Rich. $2n = 42$

This species occurs in clearings, in scrubs and light woods in the plain as well as in lower mountain regions. The specimens studied were collected in the Pieniny Mts (way from Szczawnica to Sokolica c. 600 m o.s.l.). The chromosome number $2n = 42$ found in the Polish material is in accordance with previous results (Afzelius, 1922; Richardson, l. c., Heusser l. c.).

P. chlorantha (Custer) Richb. $2n = 42$

P. chlorantha occurs in Poland in shady woods in the plain and in lower mountain habitats. In the material originating from the Pieniny Mts (way from Krościenko to Trzy Korony) the chromosome number $2n = 42$ has been established. The same number was given previously by Afzelius (1922), Richardson (l. c.), Heusser (l. c.), Matisson unpubl., cited from A. Löve and D. Löve, 1942; Hagerup 1947.

The chromosomes of the genus *Platanthera* are rather small with some differences in their shape and size (Figs. 25, 26, 39).

Epipactis Zinn. em. Sw.

E. latifolia (L.) All. $2n = 38$

This species occurs in Poland in woods, scrubs and in meadows. It is common in the plain as well as in lower mountain regions. *E. latifolia* represents an interesting example of intraspecific karyological differentiation. According to Weijer (1951) the basic number of this genus $x = 10$. Not only euploid but also aneuploid numbers are known however. In the material from Poland (one habitat Młynnik near Skała, N. L. c. $50^{\circ}10'$, E. long c. $19^{\circ}40'$), only one karyotype with aneuploid chromosome number $2n = 38$ has been found hitherto. The same number was previously given for this species by Barber (1942) and Hagerup (1947). In addition however Hagerup found also in his material originating from Denmark the euploid karyotype $n = 20$. On the other hand in Netherlands *E. latifolia* (= *E. helleborine* (L.) Cr. Wats and Coult.) is represented by the diploid ($n = 10$) as well as the tetraploid ($n = 20$) karyotypes (Weijer 1951). The former is notably rarer than the latter.

Fig. 25—31. *Orchidaceae* (cont.): 25. — *Platanthera bifolia* ($2n = 42$). 26. — *P. chlorantha* ($2n = 42$). 27. — *Epipactis latifolia* ($2n = 38$). 28. — *E. atropurpurea* ($2n = 40$). 29. — *Cephalanthera alba* ($2n = 36$). 30. — *Listera ovata* ($2n = 34$). 31. — *Neottia nidus avis* ($2n = 36$) (c. $2100\times$)

It should be added that in the species *E. leptochila* (= *E. latifolia* (L.) All. var. *leptochila* (Godf.) Mansf. — according to Tischler, 1950), Hagerup (1942) has established the number $n = 18$. It is possible that also in the flora of Poland karyotypes other than $2n = 38$ will be found in the course of further studies.

E. atropurpurea R a f. $2n = 40$.

In Poland this species is distributed both in the plain and in the mountains where it occurs chiefly in lower altitudes. It grows on stony slopes as well as in scrubs. The material was collected from 5 habitats (Table 8).

Table 8
List of habitats of *Epipactis atropurpurea*

Tatra Mts:

Mała Łąka Valley, c. 1000 m o. s. l.; border of a wood.

Kościeliska Valley, c. 1015 m o. s. l.; in a scrub at the bank of the stream.

Slope of Krokiew, c. 950 m o. s. l.; clearing of a wood.

Pieniny Mts:

Slopes of Sokolica, c. 700 m o. s. l.; in a scrub.

Klucze near Olkusz; in a scrub along the road.

E. atropurpurea seems to be karyologically uniform. Only one karyotype $2n = 40$ was found in the material from Poland in accordance with the results of other authors (Hagerup 1944, 1947; A. Löve and D. Löve, 1944).

Cephalanthera Rich.

C. alba (Cr.) Simk. $2n = 36$.

This species occurs in leafy woods in the plain and in lower mountain habitats. The plants studied were collected in the jurassic valley Saspowska near Ojców; they had $2n = 36$. The same number $n = 18$ was established for *C. alba* (= *C. grandiflora* (L.) S. F. Gray) by Barber (1942). On the other hand Hagerup (1947) reported for the species *C. Damasonium* (Mill.) Druce (= *C. alba* /Crantz/ Simk) the chromosome number $n = 16$.

The genus *Cephalanthera* is related with the preceding genus *Epipactis*. The chromosome morphology of these two genera shows a remarkable similarity. Their chromosome sets are distinctly differentiated into very large chromosomes with subterminal constrictions, chromosomes of medium size and small ones (Figs. 27, 28, 29, 40, 41, 42).

Listera R. Br.

L. ovata (L.) R. Br. $2n = 34$.

Studies of this species were based on a large material in view of the fact that different chromosome numbers have been reported previously.

The material originated from 12 habitats in the Tatra Mts and the Pieniny Mts, the Western Carpathians (Babia Góra) and the foreland of the Carpathians Range (Maków Podhalański). The list of habitats is given in Table 9.

Table 9

List of habitats of *Listera ovata*.

Foreland of the Carpathians Range:

Maków Pohalański; moist parts of a wood clearing.

Maków Pohalański; border of a wood.

Western Carpathians:

Babia Góra; mountain meadow on a slope, c. 1150 m o.s.l.

Pieniny Mts:

Sokolica; mountain meadow on a slope, c. 600 m o.s.l.

Way to Trzy Korony from Krościenko; border of a wood, c. 700 m o.s.l.

Valley of Harcza near Czorsztyn; clearing of a wood, c. 550 m o.s.l.

Tatra Mts:

Valley of Biały; border of a wood, c. 900 m o.s.l.

Valley Strążyska; wood in higher part of the valley, c. 950 m o.s.l.

Valley of Mała Łąka; a mixed wood, c. 1000 m o.s.l.

Valley Kościeliska; meadow near Hala Pisana, c. 1015 m o.s.l.

Łysanki; scrub near the peak, c. 1450 m o.s.l.

Slope of Krokiew; clearing of a wood, c. 950 m o.s.l.

All studied specimens proved to be karyologically uniform ($2n = 34$). In previous investigations dealing with specimens from other countries different chromosome numbers have been reported. These results are summarized below (Table 10).

Table 10

Chromosome numbers of *Listera ovata*

Sweden	$2n = 32$	Rosenberg 1912 (cited from Richardson 1933)
	$2n = 34, 36$	A. Löve and D. Löve, 1944
England	$2n = 34, 35, 36$	Richardson, 1933
Denmark	$2n = 38$	A. Löve and D. Löve, 1944
	$2n = 34, 36$	Hagerup, 1947
Belgium	$2n = 34, 35, 36, 37, 38$	Mac Mahon, 1936
France	$2n = 32$	Guignard, 1884, 1885 (cited from A. and D. Löve, 1944)
Germany	$2n = 32, 34$	Müller, 1912
	$2n = 34$	Hoffmann, 1930
Poland	$2n = 34$	the present study
Russia	$2n = 34,$ $n = 16, 17, 18$	Tuschnjakova, 1929

According to the results summarized in Table 10 *Listera ovata* shows a high degree of karyological differentiation; it is represented by 7 different chromosomic types: $2n = 32, 34, 35, 36, 37$ and 38 ; the number $2n = 34$ being particularly common. The number $n = 16$ given by previous authors (Guignard 1884, 1891, Rosenberg 1905, Müller 1912, Tuschnjakova 1929) has not been confirmed in the

course of later investigations and seems to be doubtful (Tischler 1950, p. 215).

In the genome of plants $n = 17$ Tuschnjakova (l. c.) found:

- 3 long bi-armed chromosomes (L)
- 2 somewhat smaller (M)
- 12 small chromosomes (S)

Richardson found on the other hand in plants with $2n = 34$:

- 3 pairs of long chromosomes (L)
- 1 pair of somewhat smaller (M)
- 13 pairs of small chromosomes (S)

one of which with trabants.

A detailed study of the morphology of chromosomes of *L. ovata* from Poland permitted to establish the same size-classes of chromosomes as have been reported previously by Richardson. It should be added however that in the Polish material the trabants have not been observed (Figs. 30, 43).

Neottia Adans.

N. nidus avis (L.) Rich. $2n = 36$.

N. nidus avis is common in shady woods of Poland. The root-tip material is rather difficult for cytological studies in view of the occurrence of an endotrophic mycorrhiza. In spite of the fact that a much larger material from a total of 8 habitats has been collected, the counts were possible only in specimens from two habitats: wood in Tunel in the vicinity of Kraków and the Pieniny Mts (slope of Trzy Korony c. 850 m o. s. l.).

The chromosome number $2n = 36$ agrees with the results of Modilewski 1918 and 1936 (cited from Tischler 1950), and of Barber (1942).

The chromosomes are differentiated both in respect of their size and their shape (Figs. 31, 44).

SUMMARY

This paper gives the results of further studies in chromosome numbers of Angiosperms native in Poland. The present investigations deal with Monocotyledons: chromosome numbers of 43 species, belonging to 28 genera have been established. Most of these numbers agree with the results of previous authors; some numbers however, chiefly among the *Gramineae*, are new or unknown hitherto for Central Europe.

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Explanation of Plates I and II

All figures represent microphotos of root-tip metaphases. The microphotos were taken with Leitz Makam combined with the Practiflex camera with the use of oil immersion lenses of Leitz and of Reichert ($\times 100$) and a Leitz periplan eyepiece $\times 10$. Their magnification is given below

Plate I.

Fig. 32—35. *Gramineae*: 32. — *Agrostis rupestris*, plate with one accessory chromosome (at 10 o'clock). (3000 $\times$). 33. — *Nardus stricta* (3000 $\times$). 34. — *Festuca tatrae* (c. 1800 $\times$). 35. — *Poa granitica*, strain 220 ($2n = 71$). (3000 $\times$).

Fig. 36—38. *Orchidaceae* (c. 1500 $\times$): 36. — *Cypripedium calceolus*. 37. — *Orchis militaris*. 38. — *O. latifolia*

Plate II.

Fig. 39—44. *Orchidaceae* (c. 1500 $\times$): 39. — *Platanthera bifolia*. 40. — *Epipactis latifolia*. 41. — *E. atropurpurea*. 42. — *Cephalanthera alba*. 43. — *Listera ovata*. 44. — *Neottia nidus avis*

Plate I

Plate II