Studies in chromosome numbers of Polish Angiosperms

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This paper gives the first contribution to the knowledge of chromosome numbers of Angiosperms from Poland. It is the result of a team work started in 1947 under the guidance of M. Skalińska by the staff of the Institute of Plant Anatomy and Cytology of the University of Krakow, with the cooperation of some students and junior research workers. Field studies on excursions were combined with cytological investigations of plant specimens collected in a variety of natural habitats chiefly in the southern parts of Poland. The determination of the numbers of chromosomes was based in most cases on the study of root-tip mitoses; sometimes however meioses were included in the studies. For a number of species, the results given here represent only a part, or a preliminary account of the investigations carried on by the contributors. Their names are given in the text. The results of their studies will be published separately in due course.

The purpose of our studies was not only to give the correct chromosome numbers of representatives of the Polish flora; we attempted at bringing the obtained results in connection with the geographic distribution, habitat and life form of the species studied. In the flora of Poland, studies in geographic distribution and ecology, chiefly if joined with the analysis of the geographic floristic elements of different putative provenance, may be important for the understanding of the past history of migration of some species; and they may throw some light upon the causes of a peculiar geographic distribution of biotypes with different chromosome numbers occurring within some species.

Our first report gives chromosome numbers of some species with a wide and discontinuous area of distribution; this allows us to compare our results with those obtained previously from other regions. On the other hand also rare species with very limited areas of distribution, among them a number of endemic species from the Tatra Mountains or some other extreme habitats, as well as some apomictic and viviparous species have been studied. In some instances the determination of chromosome numbers of plants belonging to the latter group was undertaken for the first time; it was therefore advisable to include some details concerning the localities and habitats of the plants studied.

MONOCOTYLEDONS

G r a m i n e a e.

Poa L. $x = 7$. Studied by M. Skalińska.

Poa alpina L. var. *vivipara* L. This grass is extremely common in the Tatra Mountains, both in the granitic and the limestone part. It occurs there in a variety of habitats and on different altitudes from the higher mountain layer to the alpine layer. In addition it grows in the Pieniny Mts. occurring there rather locally, chiefly on meadows. In the various habitats it shows a high degree of morphological diversity in general habit, height of the flowering stem, size and shape of the inflorescences, presence of anthocyanine etc. A preliminary investigation dealt with plants from 18 different habitats and altitudes ranging from 900 m. over sea level to 2300 m. in the Tatra and from two habitats in the Pieniny Mts at about 800 m. On the basis of this study the occurrence of at least six different chromosomic types chiefly with aneuploid numbers could be established. The following numbers have been found: $2n=22-23$, 26, 28, 33, 34, 35. Biotypes with the lower numbers (22-28) have been found more frequently in the limestone part of the Tatra, and the number 26 in Pieniny (below the peak of Trzy Korony) also on limestone. On the other hand the biotypes with higher numbers (33-35) seem to occur almost exclusively in the granitic part of the Tatra Mts.

Some of the numbers found by us in the Tatra and Pieniny Mts have been already reported for *Poa alpina* var. *vivipara* from other areas: Mü n t z i n g (1940) found the numbers 26 as well as 33 and 34 in two viviparous clones from Arosa (Switzerland);

the lower number 22 however has been reported by him only in a strictly sexual strain from Fürstenalp (M ü n t z i n g 1932). On the other hand higher numbers than those represented in the Polish material of *Poa alpina* var. *vivipara* studied till now, have been reported from the north and arctic: F l o v i k (1938, 1940) gives from Spitzbergen the numbers: $2n=44$, $42+4ff$, and B ö c h e r (1938) found on the Faeroes Islands viviparous clones with $2n=c.48$.

According to S z a f e r (1949, p. 187), *Poa alpina* is a representative of the arctic-alpine eurasiatic element of the Polish flora. The areas of such species are discontinuous, with one centre in the north and others in high mountains of Europe and Asia. A number of these species are regarded as species of mountain origin which presumably migrated n o r t h w a r d s in the Diluvium and proved able to colonize new territories in the arctic. The geographic distribution of the various chromosomic types of *Poa alpina* var. *vivipara* corroborates this assumption: lower numbers of chromosomes were found in clones occurring in the southern (mountain) part of its area, near their putative centre of origin, whereas clones with higher numbers occur in the north.

Poa granitica Br. Blanq. $2n = c. 80$.

P. granitica var. *vivipara* $2n = c. 80$.

This species with its viviparous form occurs in the alpine layer in the granitic part of the Tatra Mts. It differs from *P. alpina* by its general habit and form of inflorescences, as well as by the occurrence of underground runners. It shows a variable degree of vivipary. Specimens collected on the pass Wrota Chałubińskiego (2022 m.) proved to be high polyploids with aneuploid chromosome numbers like apomicts of *Poa pratensis* (M ü n t z i n g 1932).

Festuca L. $x = 7$. Studied by M. Piotrowicz.

Festuca ovina, var. *vivipara* L. $2n = 28, 35$.

The viviparous forms of *F. ovina* occur chiefly in the granitic part of the Tatra Mts. Their vertical distribution extends from the layer of *Pinus montana* to the alpine layer where they reach the highest peaks. In addition they have another centre on the slopes of Babia Góra in the Western Carpathians. Cytological studies have shown some degree of polyploid differentiation; hitherto two types: the tetraploid ($2n = 28$) and the pentaploid ($2n = 35$) have been found. The former (clones from 4 different habitats) seems to be confined to the layer of *Pinus montana* (e. g. around the lake Czarny Staw pod Kościelcem, elevation 1600—1680 m.). The latter occurs

both in the layer of *Pinus montana* (e. g. in the Valley of Five Polish Lakes 1700 m.) and in the alpine layer (e. g. on the slope of Mię-guszowiecki over Kazalnica at the elevation of about 2100 m.).

The polyploid differentiation occurring in *Festuca ovina* var. *vivipara* has been first studied by T u r e s s o n (1930, 1931), who in the material from Scandinavia and the Faeroes found three different chromosomic types with 21, 28 and 42 chromosomes respectively. According to F l o v i k (1940) a biotype with 49 chromosomes, possibly of hybrid origin, occurs in Spitzbergen. Contrasting with the results obtained in *Poa* investigations, in *Festuca ovina*, var. *vivipara* all formerly established chromosome numbers are euploid; the same is true for *Festuca* from the Tatra. It should be added that of the two chromosome numbers found in the present studies the pentaploid number $2n = 35$ has not been reported previously from other regions.

DICOTYLEDONS

P o l y g o n a c e a e

Polygonum L. $x = 10, 11$. Studied by H. Wcisło.

Polygonum viviparum L. $2n = c. 132$. This species is widely distributed in the Tatra Mts. where it occurs in a variety of habitats. Specimens for cytological investigation originated from the slopes of Miedziane and Rysy over the lakes Morskie Oko and Czarny Staw (layer of *Pinus montana* and alpine layer) and from different parts of the path leading from the lake Zmarzły Staw to the pass Zawrat (alpine layer). According to previous investigations this species represents a high polyploid: J a r e t z k y (1928) found $2n = c. 110$, F l o v i k (1940) gives the number $c. 100$ in his study of the flora of Spitzbergen, and according to Sokolovskaya and Strelkova (1938) the number in specimens from the Asiatic mountains is 83—88. In the specimens from the Tatra Mts. however a still higher number of chromosomes has been found, namely $c. 132$. In these high polyploids the reproduction takes place only through bulbils; a development of fruits and seeds could be never observed in spite of the abundant flowering.

Polygonum viviparum is a representative of the arctic-alpine eurasiatic element of the Polish flora (S z a f e r l. c.), with one centre in the north and other centres in mountain regions of Europe and Asia. It is regarded as a species of n o r t h e r n origin which

presumably migrated from the arctic tundra southwards to the European mountains in the Diluvial period. In the Tatra Mts. — far from the putative centre of origin of this species — polyploidy has attained a still higher degree than in plants occurring in the north.

Caryophyllaceae

Gypsophila L. $x = 17$. Studied by M. Skalińska.

Gypsophila repens L. $2n = 34$.

Gypsophila fastigiata L. $2n = 34$.

G. repens is a perennial species belonging to the European mountain element of the Polish flora. In the Tatra Mts. it occurs in cliffs of sunny limestone rocks. Its vertical distribution extends from the higher mountain layer to the layer of *Pinus montana*. The specimens investigated were collected in higher part of Skupniów Uplaz (about 1500 m.).

The chromosome number of the Tatra specimens agrees with that recently established by Favarger (1946) for plants from Switzerland.

G. fastigiata, a perennial calcicolous species widely distributed over the Polish plain, has the same number of chromosomes. The specimens investigated were brought from gypsum debris in the district of Kielce. The number of chromosomes of this species is reported here for the first time.

Ranunculaceae

Aquilegia L. $x = 7$. Studied by M. Skalińska.

Aquilegia vulgaris L. $2n = 14$. The specimens studied originated from higher parts of Dolina Bentkowska, a jurassic valley northwest of Krakow. The same number was found for this species by a number of authors (Levitsky, 1931, Skalińska 1928, Gregory 1941).

Delphinium L. $x = 8$. Studied by M. Skalińska.

Delphinium oxysepalum Borb. et Pax. $2n = 32$. A perennial dwarf high mountain species with a very limited area of distribution. According to Pawłowski (1933), it occurs endemically in the western part of the Central Carpathians, chiefly in the Tatra Mts. Its vertical distribution extends from the layer of *Pinus montana* upwards and its main centre is in the alpine layer, up to 2145 m. where it grows in cliffs of limestone rocks and among debris. It is rarer in the

granitic part of the Tatra being found only on soils with a low degree of acidity. Concerning the taxonomic position of this species, according to Pawłowski it belongs to the Series Montana Pawł. together with *D. montanum* D. C. from the eastern Pyrenees and *D. dubium* (Rouy et Fouc.) Pawł. from the Alps. The specimens investigated were collected in the Western Tatra near Wielka Turnia (about 1700 m.) on a steep slope covered with limestone debris. The number of chromosomes $2n = 32$ shows that *D. oxysepalum* is a tetraploid species.

Aconitum Tourn. $x = 8$. Studied by W. Leszczak.

Acanitum variegatum L. $2n = 16$.

Aconitum firmum Rchb. $2n = 32$.

These two species are common in the Tatra Mts; the diploid species *A. variegatum* however occupies a smaller area than the tetraploid *A. firmum*. The two species show also differences with regard to their vertical distribution. The former occurs in valleys and on slopes in the limestone part of the Tatra, ascending to the upper limit of the subalpine forests (about 1500 m). The latter occurs both in the limestone and in the granitic part of the Tatra; it has a vertical distribution which extends from the higher mountain layer upwards to the alpine layer where it is represented by dwarf forms. Specimens of *A. variegatum* were collected in 5 various habitats in the limestone part of the Tatra Mts. from elevations ranging from 900 m to 1500 m. Plants of *A. firmum* originated from 19 habitats in the granitic and limestone parts of the Tatra at various altitudes (900—2000 m). The number of chromosomes $2n = 16$ found in all plants of *A. variegatum* from the Tatra Mts. is the same as that established previously by Schaffer and La Cour (1934). The number of chromosomes of *A. firmum* has not been recorded formerly; it is tetraploid like the closely related species *A. napellus* L. (Levitsky, 1931, Schaffer and La Cour 1934); according to the opinion of Polish botanists (cf. Pawłowski), it should be considered as a separate species rather than a form within the species *A. napellus*.

Ranunculus Tourn. $x = 7, 8$. Studied by Z. Bauer.

R. alpestris L. $2n = 16$.

R. platanifolius L. $2n = 16$.

R. glacialis L. $2n = 16$.

The above three species have been studied on material from the Tatra Mts.

The occurrence of *R. alpestris* in Poland is limited to the Tatra Mts. where it is found frequently in cliffs of limestone rocks. Its vertical distribution extends from the higher mountain layer to the layer of *Pinus montana*. Three specimens from different altitudes were studied: from the valley of Biały (at about 950 m), from the layer of subalpine forests over Wantule (1500 m), and from the layer of *Pinus montana* on slopes of Małolączniak (1900 m). The number of chromosomes $2n = 16$ is the same as that established previously by L a n g l e t (1927) and by B ö c h e r (1938a) in materials from botanical gardens.

R. platanifolius which in Poland is found in the Tatra Mts. and also in the Western Carpathians on slopes of Babia Góra, has been studied from the following habitats: in the Tatra, from the higher mountain layer over Strążyska valley, from the layer of subalpine forests in the limestone part (peak of Łysanki, 1447 m), as well as from the layer of *Pinus montana* in the granitic part (slopes of Miedziane, at about 1600 m). In addition specimens from Babia Góra were studied. In all these plants invariably the number $2n=16$ could be established whereas, according to L a n g l e t (1927) the number is only $2n = 14$. It is possible that within this species there exist two different chromosomic races with 14 and 16 chromosomes; such a differentiation was found in the closely related species *R. aconitifolius* by G r e g o r y (1941) and occurs also in some other *Ranunculus* species according to this author.

R. glacialis occurs in Poland only in the granitic part of the Tatra Mts. where it is restricted to the alpine layer. The specimens studied were collected on granit rocks on the northern slope of Mały Kozi Wierch, near the pass Zawrat (elevation about 2100 m). Studies have shown the same number of chromosomes ($2n = 16$) as that found by L a n g l e t (1932) for specimens from Gr. St. Bernard (Switzerland), and by B ö c h e r (1938b) for plants from Ost-greenland; the same number is given by L ö v e and L ö v e (1944 in L. and L. 1948), with the addition however that, according to the unpublished results of S ö r e n s e n and W e s t e r g a a r d, also a tetraploid form of this species has been found in Greenland.

Ranunculus glacialis is, like *Poa alpina*, a species with a discontinuous area of distribution, with separate centres in high mountains of Europe and in the arctic. Concerning its origin, it is considered a m o u n t a i n species which migrated northwards (S z a f e r, l. c.). The occasional occurrence in the north of strains with higher chromosome numbers is in agreement with this assumption.

C r u c i f e r a e

Biscutella laevigata L. $2n = 18$. Studied by M. Skalińska.

In the flora of Poland, *B. laevigata* is the only representative of the genus. It belongs to the European mountain element and has its main centre in the Alps. In Poland it occurs in the limestone part of the Tatra Mts. and has also a few isolated centres in the plain. Its vertical distribution in the Tatra extends from the higher mountain layer to the alpine layer with the greatest condensation in the layer of *Pinus montana*. This species has been included into the present studies in view of the very interesting cytogenetic results of Manton (1934, 1937) on this species. Our material originated from a variety of habitats at different altitudes in the Tatra Mts. (from 900 m to 1700 m), and from one habitat in the plain. Some of the specimens were collected in the Tatra Mts. in relatively warm and sheltered places (valleys of Biały and Strążyska, 900—1000 m), others at much higher elevations (near Wielka Turnia 1600—1700 m) on exposed steep grassy slopes with limestone debris, where these plants occur together with alpine species (*Papaver Burseri*, *Clematis alpina*, *Viola alpina* Jacq., *Delphinium oxysepalum*). Plants from the plain were collected in an isolated centre near Olkusz on soil rich in lead and zinc. All plants from the above localities were diploid ($2n = 18$). This is the more interesting, as according to Manton, all forms of *Biscutella* from high elevations in central Europe are tetraploid ($2n = 36$) with the exception of one centre in the Austrian Alps where diploids have been found.

Cochlearia L. $x = 6, 7$. Studied by A. Bajer.

Cochlearia polonica Fröhl. $2n = 36$.

Cochlearia Tatray Borb. $2n = 42$.

The above two endemic biennial species are the only representatives of the genus in the Polish flora. *C. polonica* forms a few isolated spots in South Poland between Olkusz and the springs of river Biała near the Błędowska desert, where it has its main centre.

C. Tatray is a high mountain species with an area of distribution restricted to the granitic part of the Tatra. The plants studied originated from the pass Pod Chłopkiem (2311 m) near the peak of Mięguszowiecki (alpine layer) and from the Mięguszowiecki glacial cirque about 400 m lower.

The two endemic species are hexaploid. The basic number of *C. polonica* is 6, whereas *C. Tatray* has the basic number 7. The same two basic numbers have been found previously in other species of

Cochlearia, e. g. the tetraploid *C. officinalis* L. (Böcher 1938) $2n = 24$; (Crane and Gairdner 1923) $2n = 28$ and the diploid *C. groenlandica* L. (Flovik 1940) $2n = 14$.

It is interesting to note that the hexaploid *C. Tatrae* which occupies extreme habitats in the alpine layer is not a perennial, but a biennial plant with a normal sexual reproduction, in contrast to a large number of higher polyploid in which according to Gustafsson (1947) apomixis or vegetative propagation occurs frequently.

Cardamine L. $x = 8$. Studied by E. Banach.

Cardamine impatiens L. $2n = 16$.

Cardamine amara L. $2n = 16$.

Cardamine Opizii Presl. $2n = 16$.

Cardamine trifolia L. $2n = 16$.

Cardamine hirsuta L. $2n = 16$.

Cardamine flexuosa With. $2n = 32$.

Cardamine pratensis L. $2n = 30, 32, 44, 50, 76, 78$.

The above seven species of the genus *Cardamine* occurring in Poland form two distinct types: the first is represented by six species with constant and uniform chromosome numbers, the five first being diploid and the sixth having the tetraploid number, in agreement with the results previously obtained by Mantón (1932). The second type is represented only by *C. pratensis*, a species differentiated into a number of strains with euploid or aneuploid sometimes high chromosome numbers.

C. impatiens is an annual or biennial species widely distributed in Poland in damp woods and scrubs. In mountain regions it reaches the upper limit of the forests. The specimens studied have been collected in a mixed wood in the plain (Czarny Las, district of Jędrzejów, South Poland) and in a damp wood in the Carpathians near Nowy Sącz (elevation about 700 m).

C. amara is a perennial plant very common on moist meadows and borders of streams. It occurs over all Poland in the plain and in the mountains it is frequent chiefly at lower altitudes. The specimens studied originated from seven different habitats: four from valleys and slopes in the limestone part of the Tatra Mts., from the foreland of the Carpathian range near Maków Podhalański, from the vicinity of Krakow and from a damp meadow near Błędowska desert. In higher mountain regions this species is replaced by *C. Opizii*, its close relative. The vertical distribution of *C. Opizii* extends from the higher mountain layer to the layer of *Pinus montana*; it grows

there in borders of mountain streams, springs and among moss. The plants studied have been collected in eleven different habitats in the limestone and granitic part of the Tatra mountains at various elevations ranging from about 930 m. (Kościeliska valley) to 1800 m (slopes of Miedziane), and in addition from two habitats in woods over Czarna Hala (about 1150 m) in the Western Carpathians (Babia Góra).

C. trifolia is a perennial whose area of distribution in Poland is limited to woods and scrubs in the higher mountain layer in southern Poland. According to Schulz (1903), p. 313) this species should be regarded as a tertiary relict.

The plants investigated were collected in three habitats in the limestone part of the Tatra Mts.

C. hirsuta is an annual or biennial species, in Poland rather rare. It may be found in the plain and in the Carpathians where it reaches the layer of *Pinus montana* in isolated centres on meadows, borders of streams and in damp scrubs. The specimens studied were collected in damp scrubs on the border of a tributary of river Skawa near Maków Podhalański (foreland of the Carpathian range).

C. flexuosa which is closely related with the preceding species, is also annual or biennial. It is more common in Poland chiefly in shady damp woods; in the mountains it is found till to the layer of subalpine forests and it may also attain the layer of *Pinus montana* in the limestone part of the Tatra Mts. This tetraploid species could have arisen from the doubling of the chromosome set of the diploid *C. hirsuta*. The high degree of morphological similarity of these two species favours this assumption.

C. pratensis is a perennial which in the flora of Poland represents the holarctic geographic element. In Poland this species is widely distributed both in the plain and in the mountains where it occurs in the higher mountain layer, but may occasionally be found also in higher situations.

In view of the interesting results of cytological studies on this species in connection with the habitat recently obtained by Lövkvist (1947), the material for the present investigations has been collected from a variety of habitats in the plain, in the foreland of the Carpathian range, in the Tatra mountains, in the Western Carpathians (slopes of Babia Góra) and in the Pieniny Mts. The material studied till now shows a similar caryological differentiation as that found by Lövkvist, and the distribution of the various types also seems to be connected to some extent with their habitats. The

following chromosome numbers have been found: 30, 32, 44, 50, 76, 78. It should be added that, owing to the smallness of the chromosomes and technical difficulties in obtaining very well spaced chromosomes in somatic metaphases, some minor errors in counting cannot be excluded; in some plants however the numbers established from somatic plates have been checked by the studies of meioses, e. g. the number 44 which is not represented among the various types found by Lövkvis. On the other hand, in the Polish material no intermediate numbers between 50 and 76 have been found hitherto, although they occur in the Swedish material investigated ($2n = 56, 58, 60, 64, 68, 72$). In natural habitats in Poland the highest numbers of chromosomes (76, 78) were found in plants from Mydlniki near Kraków growing in ditches with floating water and in ponds. The number 44 has been established in plants from three habitats: one (near Krakow) by a ditch, about 20 cm. over the water level whereas two others, around Maków Podhalański, in relatively drier situations in scrub on the border of river Skawa. The numbers 32 and 30 were found in plants from higher and relatively dry parts of meadows in Biezanów, nr. Krakow and in the vicinity of Gliwice (Silesia). It is however interesting to note that the number 30 has been found also in a group of plants growing in overflowed areas around the springs of river Biała near the Błędowska desert. The investigations are being continued.

R o s a c e a e.

Potentilla L. $x = 7$. Studied by M. Skalińska.

Potentilla aurea L. $2n = 14$.

Potentilla heptaphylla L. (*P. rubens* Crantz, *P. opaca* L.)
 $2n = 14$.

Potentilla arenaria Borkh. $2n = 28$.

Potentilla argentea L. $2n = 42$ (Pieniny Mts); $2n = 35$ (Central Poland).

The genus *Potentilla* has been included in our studies in view of the high degree of intraspecific differentiation in the number of chromosomes occurring within some of its species.

P. aurea in Poland has an area of distribution confined to the Carpathians. It is a common plant in the Tatra Mts, where it occurs in the layer of subalpine forests, in the layer of *Pinus montana* and may be found also in the alpine layer. Specimens from the following habitats have been studied in the granitic part of the Tatra Mts: layer of *Pinus montana*: around Hala Gąsienicowa and Czarny Staw

(elevation 1567—1620 m) as well as in the Valley of Morskie Oko (about 1400 m); alpine layer: on a southern slope above the pass Zawrat (2159 m). Despite some morphological diversity shown by this species in various natural habitats, the number of chromosomes was 14 in all the above specimens. The same number of chromosomes has been reported previously for this species by the Japanese cytologist Shimotomai (1935).

P. heptaphylla which in Poland occurs in the plain and in lower mountain habitats is also a diploid species. The material originated from the Sąspowska valley near Ojców (cliffs of limestone rocks). The diploid chromosome number has been previously established in this species by A. and G. Müntzing (1941) and Hakansson (1946) for Swedish plants, as well as by Rütishauser (1948) for plants from Switzerland.

P. arenaria, a common species in Poland, has been collected for studies in two habitats in South Poland: on a sandy grassy slope near Krakow, and on soil with a relatively high content of lead and zinc, near Olkusz. The plants from the above habitats are tetraploid with $2n = 28$. This number is different from that found previously by Rütishauser (1943) in plants from Switzerland which are apomicts with 35 and 42 somatic chromosomes. In connection with these results the mode of reproduction of the Polish tetraploid biotypes deserves a special study.

P. argentea. Of this species which according to the results of Müntzing (1941) and Rütishauser manifests a high degree of intraspecific differentiation, hitherto only two biotypes have been studied: the first originated from the Pieniny Mts. and was a hexaploid with 42 somatic chromosomes; the second was collected in the vicinity of Warsaw in drier parts of a meadow and proved to be a pentaploid with 35 chromosomes. In view of the above results which showed the occurrence of cytological differences also in the Polish biotypes of *P. argentea*, the work will be continued.

Primulaceae.

Soldanella L. $x = 10$? Studied by K. Sateczek.

Soldanella carpatica Vierh. $2n = 40$.

Soldanella montana Willd.

ssp. *eumontana* Lüdi $2n = 40$

ssp. *hungarica* Lüdi, var. *major* (Neilr.) Vierh. $2n = 40$.

Of the above mentioned species, the first — *S. carpatica* has the widest distribution in the Tatra Mts. and occurs also in the

Western Carpathians (Babia Góra). Its vertical distribution in the Tatra Mts. extends from the higher mountain layer to the alpine layer. Plants for cytological examination have been collected from a variety of habitats at various elevations ranging from about 900 m to about 2000, in the granitic and limestone parts of the Tatra Mts. as well as in Western Carpathians. In specimens originating from 16 various habitats the number of chromosomes $2n = 40$ has been established on root tip material and in addition also meioses have been studied in some plants.

S. montana, ssp. *eumontana* which occurs in the Alps and in Polish flora is a representative of the European mountain element, is much rarer in the Tatra Mts. than *S. carpatica* and has here a more restricted area of distribution: it seems to be limited to the lower northern range and to occur in rather isolated places. The specimens studied were collected at rather low altitudes in the higher mountain layer in the range of Gubałówka (1123 m) and near Jaszczurówka (900 m). The number of chromosomes is the same as in *S. carpatica*, $2n = 40$.

S. montana ssp. *hungarica* whose area extends to the south-east outside Poland has a wider distribution in the Polish part of the Tatra Mts. than the ssp. *eumontana*; this form has been found by us both in the limestone and in the granitic parts, chiefly on borders of woods and in clearings of woods along the highroad leading from Zakopane to the valley of Morskie Oko in the High Tatra. It has been found also in the lower northern range near Bukowina (967 m). In general it seems to be limited in its vertical distribution to the layer of subalpine forests and does not ascend to the higher elevations where *S. carpatica* is being found. The number of chromosomes of this form, established on root tips of plants from 4 different habitats is also $2n = 40$.

The present studies give for the first time the chromosome numbers for the genus *Soldanella*. The relatively high number of chromosomes found invariably in all the three forms studied suggests that they represent polyploids, probably tetraploids with the basic number $x=10$. In the genus *Primula* Bruun (1932) has established the same basic number for some sections within the genus, and reported the somatic number $2n = 20$ and 40 for species from Himalayas, Tibet and China. The same somatic number $2n = 40$ has been found also by Wulff for two other representatives of *Primulaceae*: *Hottonia palustris* (1938) and *Anagallis arvensis* (1937).

Gentianaceae.

Gentiana L. $x = 9, 12, 13$. Studied by M. Skalińska.

Gentiana frigida Haenke $2n = 24$.

Gentiana verna L. $2n = 26$.

Gentiana Clusii Perr. et Song. $2n = 36$.

Gentiana punctata L. $2n = 36$.

Gentiana asclepiadea L. $2n = 36$.

Gentiana praecox Kern. $2n = 36$.

The above species are mountain plants and the specimens investigated originated chiefly from the Tatra Mts. Species which occur exclusively in the granitic part of the Tatra Mts. are: *G. punctata* and *G. frigida*, whereas *G. verna* and *G. Clusii* as well as *G. praecox* are found on limestone; the last species, *G. asclepiadea* occurs in both parts of the Tatra and it is also found in the Carpathians and on lower altitudes.

G. punctata is a perennial alpine species with a wide area of distribution in the high mountains of Europe. In the flora of Poland it represents the European mountain element. It occurs in the Tatra Mts. on grassy slopes, among rock debris usually in the layer of *Pinus montana* and in the alpine layer. Our studies were carried on on root tips of plants collected in three habitats in the High Tatra: on grassy slopes near the path leading from the lake Zmarzły Staw (1785 m) to the pass Zawrat (2159 m) in the alpine layer; above the lake Morskie Oko (1400 m) in the layer of *Pinus montana*; slopes of Mięguszwiecki above the lake Czarny Staw (about 2000 m) in the alpine layer. The number of chromosomes of this species ($2n = 36$) is reported here for the first time.

G. frigida is a dwarf perennial with a vertical distribution limited to the alpine layer in the Tatra Mts. The total area of distribution of this strictly calcifuge species is restricted to the alpine layer in the Alps of Stiria and the High Tatra. The plants for our studies were collected on the northern slope of Mały Kozi Wierch, below the pass Zawrat (alpine layer) at elevations ranging from about 1900 m to 2000 m, and on the northern slope of Miedziane (alpine layer) at about 2000 m. The number of chromosomes of this species ($2n = 24$) is reported here for the first time. It should be added that in some other species of *Gentiana* the number 26 has

been found; in view of this it was important to establish for *G. frigida* the exact number. It is different from that found previously in several other species by Scherer (1939) and Sakai (1934), and in *G. verna* studied by us (see below).

G. verna is a dwarf mountain perennial species with a very wide area of distribution which extends over Europe and parts of Asia; therefore in the Polish flora it is considered as a representative of the European-Asiatic mountain element. The vertical distribution of this species in the Tatra Mts. extends from the higher mountain layer to the alpine layer with the main centre in the layer of subalpine forests, occasionally however this species may be found in the lower mountain layer (below 950 m). Specimens for our studies originated from the following habitats in the limestone part of the Tatra: the valleys Strążyska, Kościeliska, Jaworzynka (higher mountain layer); slopes of Kopa Magóry (layer of subalpine forests, elevation about 1400 m). All plants investigated had $2n = 26$; the basic number $x=13$ agrees with that found by Sakai for the Japanese species *G. makinoi* (1934) and by Scherer (1939) for *G. pneumonanthe*. The same number has been also found by Sokolovskaja and Strelkova for *G. altaica* from Siberia (cited according to Darlington and Janaki-Amal 1945). Among the species of *Gentiana* investigated in the present study however, only *G. verna* has this number of chromosomes.

G. Clusii a perennial dwarf species is not as common in the Tatra Mts. as *G. verna*. It occurs in cliffs of limestone rocks and in soils rich in lime from the higher mountain layer upwards to the alpine layer. The chief centre of distribution of this strictly calcicolous species is confined to mountains in central southern Europe (limestone parts of the Alps, Jura and Schwarzwald, while in the Tatra Mts. it has a small isolated centre. Specimens from the following habitats have been studied: the valleys Strążyska and Jaworzynka (higher mountain layer); higher parts of the slopes of Kopa Magóry in cliffs of limestone rocks (about 1500 m) and of Skupniów Uplaz (about 1500 m) in the layer of *Pinus montana*. All plants investigated had $2n = 36$. The number of chromosomes of this species, reported here for the first time, suggests that *G. Clusii* is a tetraploid with the basic number $x = 9$. The same is true probably for the other species with the same number of chromosomes, viz. *G. punctata* (see above), *G. asclepiadea* and also the only annual species studied, a dwarf form of *G. praecox*.

G. asclepiadea is a perennial species with a wide area of distribution and a larger ecological range than the above mentioned species. It occurs chiefly in mountain regions of central and southern Europe and also in the Caucasus. It seems to be less exclusive in the selection of its habitat and it occurs on various soils and at different altitudes. In Poland it is found in the Tatra Mts. both on limestone and on granit; it occurs also in the Carpathians as well as near Ojców and Łysa Góra in the Holy Cross Mountains. Its vertical distribution in the Tatra extends from the lower mountain layer, where it is common in mixed forests and on borders of woods in valleys, up to the layer of subalpine forests; occasionally it may be found even higher, in the layer of *Pinus montana*. In the Carpathians it is found also at lower altitudes (submountain layer). The present investigation dealt with plants from the limestone part of the Tatra Mts. (a shady slope above the valley Strążyska at about 1100 m), as well as from the granitic part (border of a mixed wood near the valley of the lake Morskie Oko, at about 1400 m, layer of subalpine forests) and from the Carpathian near Sącz. In all plants studied the number $2n = 36$ could be established without difficulty in root tips; in the first specimen this number was first established in the study of meiosis. According to Wóycicki (1932) the number of chromosomes of this species is $2n = 32$. This number has been established by him for specimens from Zakopane on the basis of the study of meiosis. In view of the fact that the number 36 has been found by us not only in this species but also in three others, it seems probable that the number given by Wóycicki is incorrect.

G. praecox is the only annual species studied by us till now. This species manifests a high degree of intraspecific diversity both in morphology and ecology. Future work will probably show whether the numerous form within this species occurring in a variety of habitats and at different altitudes, have any cytological differentiation. Owing to the great technical difficulties in obtaining root tip material, the only form analyzed till now is represented by minute plants about 3 cm high growing among limestone rocks and on grassy slopes in a sunny situation on Skupniów Uplaz (about 1500 m). It is interesting to note that also these minute annual plants had the higher number of chromosome $2n = 36$, found in three perennial species, whereas the other perennials (*G. frigida* and *G. verna*) are diploids with 24 and 26 chromosomes. Thus the basic numbers in *Gentiana* are: 9, 12 and 13.

Valerianaceae.

Valeriana L. $x = 7, 8$. Studied by M. Skalińska.

Valeriana officinalis L. s. lato. $x = 7$.

V. officinalis L. s. str. (*V. exaltata* Mikan., *V. latifolia* Vahl.)
 $2n = 14$.

V. officinalis L. s. str. (a tetraploid form) $2n = 28$.

V. tenuifolia Vahl. (*V. angustifolia* Tausch.) $2n = 28$.

V. sambucifolia Mik. $2n = 56$.

The three above species are well defined morphologically on the European continent without intergrading forms frequently found in Great Britain (cf. Sprague, 1943, Skalińska, 1947).

In Poland the diploid *V. officinalis* s. str. has the widest area of distribution ranging from the Baltic coast in the north to the Carpathians in the south. The material for cytological investigations originated from a variety of habitats in different parts of Poland. Almost all specimens studied represented diploids; only plants from a single habitat in west-central Poland (near Nowe Miasto on river Warta) had the tetraploid number $2n = 28$. Diploids were found in the following habitats: Baltic coast: Rozewie, at the shore; Hel peninsula, in a mixed wood; East Prussia, border of the lake Kasajno; Białowieża, in the primeval forest; near Warsaw, in a wood; near Warsaw, under willow trees; near Puławy; near the lake Gopło; on meadows of Puszczykowo, near Poznań; on meadows, Czyżyny, near Kraków; on a slope near Kraków; in a peat moor in the Niepolomicka forest near Krakow; near Olkusz; along the valley of river Skawa; the valley of river Prądnik; in the Holy Cross Mountains, in lower situations; in Pieniny Mts, on a sunny slope; in Pieniny Mts, a damp and shady place under willow trees.

V. tenuifolia occurs only in the southern part of Poland, very locally in hilly regions on limestone, usually in shady places. Specimens from the following habitats were studied: from Bentkowska valley, north-west of Kraków, below a limestone slope; Zelejowa Góra near Chęciny (plateau of Little Poland); limestone hills over Kaziemierz on Vistula (Lublin plateau); near Sandomierz. All these plants are tetraploids.

V. sambucifolia in Poland is common chiefly in mountain regions in the south where it occurs in damp and shady habitats; its area

however extends northward from this main centre of distribution. Plants from the following habitats were studied: in the limestone part of the Tatra Mts: in the valleys Kościeliska (3 colonies) and Mała Łąka (higher mountain layer); in a subalpine forest above Przysłop Miętusi (about 1300 m); on the northern slope of Giewont (about 1400 m); in Western Carpathians: slopes of Babia Góra; in the vicinity of Kraków: Alnetum in the valley of Mników; in the plain: by the border of a stream in Jedlnia near Radom.

Previous investigations of Meurman (1925), Senjaninova (1927) and Runquist (1937) have already established the numbers of chromosomes of the above species; in the present study they are reported from the material from Poland, in connection with details of their distribution.

Valeriana tripteris L. $2n = 16$.

This species which occurs in the Alps and extends eastwards to the Carpathians and Transsylvania, is rather common in Poland in the Tatra Mts, as well as in the Western Carpathians and Pieniny Mts; in addition it is found as a mountain glacial relict also in some jurassic valleys in woods in south-western Poland. Specimens studied: from the limestone part of the Tatra Mts: Valley of Biały, Strążyska and Kościeliska (higher mountain layer); slopes of Kopa Magóry (layer of subalpine forests); from the granitic part: slopes of Miedziane (layer of *Pinus montana*); Western Carpathians: slopes of Babia Góra; on limestone slopes in jurassic valleys around Kraków: Bentkowska valley, Mników valley; valleys of Ojców. The number of chromosomes of this very uniform species was reported for the first time by Skalińska (1949).

Valeriana simplicifolia (Rchb) Kab. $2n = 16$. This species occurs in Poland on wet meadows, in swamps and peat bogs. Specimens studied: from the Tatra Mts. swamps in the valleys Kościeliska and Strążyska (higher mountain layer); a wet meadow in the valley of Mników, nr. Kraków; bog at a permanent spring near Błędowska desert. The number of chromosomes of this species $2n = 16$ has been established by Skalińska (1949).

In accordance with their chromosome numbers the two species should be assigned to the same section of the genus *Valeriana*, to which *V. dioica* belongs; in this last species the chromosome number was first established by Meurman (1925).

C o m p o s i t a e.

Hypochoeris L. $x = 4, 5$. Studied by M. Skalińska.

Hypochoeris uniflora Vill. $2n = 10$.

The area of distribution of this perennial species is restricted to the higher altitudes of the Carpathians (from the higher mountain layer to the alpine layer); it occurs on mountain meadows and grassy slopes. The specimens studied originated from slopes of Opolone (1700 m). This species is a diploid, with a very low basic number of chromosomes. The results obtained for this species are in sharp contrast with those obtained for the two other representatives of the same family, *Doronicum austriacum* and *Doronicum* (*Aronicum*) *Clusii*.

Doronicum L. $x = ?$ Studied by H. Weislo.

Doronicum austriacum Jacq. $2n = 60$.

This species is an alpine perennial, occurring in Poland in the Tatra Mts. with a vertical distribution ranging from the layer of subalpine forests to the layer of *Pinus montana*; it is also found in some parts of the Carpathians (Babia Góra). In addition, this mountain species occurs also in a few isolated habitats in the southern part of the Polish plain in scrubs and light forests where it is regarded as a mountain relict.

The root tip material of this species has been collected in the granitic part of the Tatra Mts., on slopes of Miedziane (about 1700 m, layer on *Pinus montana*) and on the border of a mixed wood near the lake Morskie Oko (layer of subalpine forests); and in the Western Carpathians (slopes of Babia Góra). Specimens from the plain originated from meadows in the vicinity of the Błędowska desert, near the springs of the river Biała. The number of chromosomes found in this species $2n = 60$ gives the first count not only for this species but in general for the genus *Doronicum*. This high number suggests that *D. austriacum* is a polyploid species, possibly a hexaploid with the basic number $x = 10$.

Aronicum Neck. $x = ?$ Studied by H. Weislo.

Aronicum Clusii All. $2n = c. 120$.

This species also represents an alpine perennial occurring in Poland in the Tatra Mts. where it is restricted to the granitic part, with a vertical distribution extending from the layer of *Pinus mon-*

tana upwards to the highest mountain peaks. The specimens studied originated from the alpine layer below the pass Zawrat (1900—2000 m.), and on the path leading from Szpiglasowa pass downwards to the Valley of the Five Polish Lakes; a third group of specimens has been collected on the slopes of Kościelec at the altitude of about 1700 m (layer of *Pinus montana*). Owing to the unusually high number of chromosomes found in this species and the entire lack of any previous data concerning the genus *Aronicum* the determination of the exact number presents serious difficulties. The work is being continued and problems of the reproduction of this high polyploid will be also taken into consideration.

Principal results

Among the species studied cytologically in the course of the present work the following have not been investigated previously, thus, their chromosome numbers are reported here for the first time:

	2n
<i>Poa granitica</i> Br. Blanq.	c. 80
<i>Gypsophila fastigiata</i> L.	34
<i>Delphinium oxysepalum</i> Borb. et Pax	32
<i>Aconitum firmum</i> Rchb.	32
<i>Cochlearia polonica</i> Fröhl.	36
<i>Cochlearia Tatrae</i> Borb.	42
<i>Soldanella carpatica</i> Vierh.	40
<i>Soldanella montana</i> Willd. ssp. <i>eumontana</i> Lüdi	40
ssp. <i>hungarica</i> Lüdi	40
<i>Gentiana frigida</i> Haenke	24
<i>Gentiana verna</i> L.	26
<i>Gentiana Clusii</i> Perr. et Song.	36
<i>Gentiana punctata</i> L.	36
<i>Gentiana praecox</i> Kern	36
<i>Valeriana tripteris</i> L.	16
<i>Valeriana simplicifolia</i> (Rchb) Kab.	16
<i>Hypochoeris uniflora</i> Vill.	10
<i>Doronicum austriacum</i> Jacq.	60
<i>Aronicum Clusii</i> All.	c. 120.

The following new numbers of chromosomes have been established in the present study for previously investigated species chiefly with polyploid or aneuploid differentiation:

Species:	Previous results (2n):	New numbers (2n):
<i>Poa alpina</i> L. var. <i>vivipara</i> L.	26, 33, 34 (Müntzing 1940) 44, 42+4ff (Flovik 1938) c. 48 (Böcher 1938)	22—23, 28, 35 (in addition to 26, 33, 34)
<i>Festuca ovina</i> L. var. <i>vivipara</i> L.	21, 28, 42 (Turesson 1930, 1931), 49 (Flovik 1940)	35 (in addition to 28)
<i>Polygonum viviparum</i> L. L.	c. 110 (Jaretsky 1928) c. 100 (Flovik 1940) 33—88 (Sokolovskaja and Strelkova 1938)	c. 132
<i>Ranunculus platanifolius</i> L.	14 (Langlet 1927)	16
<i>Cardamine pratensis</i> L.	32 (Manton 1932) 30 (Lawrence 1932) 30, 56, 58, 60, 64, 68 72, 76, 84 (Lövkvist 1947)	44, 50, 78 (in addition to 30, 32 and 76)
<i>Potentilla arenaria</i> Borkh.	35, 42 (Rütishauser 1943)	28
<i>Gentiana asclepiadea</i> L.	32 (Wóycicki 1932)	36

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REFERENCES.

- Böcher T. W. 1938a. Cytological studies in the genus *Ranunculus*. Dansk Bot. Ark. Vol. 9, p. 1—33.
- Böcher T. W. 1938b. Zur Zytologie einiger Arktischen u. borealen Pflanzen. Svensk Bot. Tidskr. Vol. 32, p. 346—361.
- Bruun H. G. 1932. Symb. Bot. Upsaliens. I. (cited from Darlington and Janaki-Ammal 1945).
- Crane M. B. and Gairdner A. E. 1923. Species crosses in *Cochlearia* with a preliminary account of their cytology. Journ. of Gen. 13, 187—200.
- Darlington C. and Janaki-Ammal. 1945. Chromosome atlas of cultivated plants. Allen and Unwin, London.
- Favarger C. 1946. Recherches caryologiques sur la sous-famille des Silenoidees Ber. d. Schweiz. Bot. Gesellsch. Bd. 56, p. 364—451.
- Flovik K. 1938. Cytological studies of arctic grasses. Hereditas 24. 265—376.
- Flovik K. 1940. Chromosome numbers and polyploidy within the flora of Spitzbergen. Hereditas 26. p. 230—240.
- Gregory W. C. 1941. Trans. Amer. Phil. Soc. New Series, 31 (cited from Darlington and Janaki-Ammal, 1945).
- Gustafsson A. 1947. Apomixis in higher plants III. Lund Univ. Arsskr. Bd. 43.
- Jaretsky R. 1928. Histologische und karyologische Studien an Polygonaceae. Jahrb. f. Wiss. Bot. 69, p. 357—490.
- Lövkvist B. 1947. Chromosome studies in Cardamine. Hereditas, 33, p. 421—422.
- Langlet O. 1927. Beiträge zur Zytologie der Ranunculaceae. Svensk Bot. Tidskr. 21, p. 1—17.
- Langlet O. 1932. Über Chromosomenverhältnisse und Systematik der Ranunculaceae. Svensk Bot. Tidskr. 26, p. 381—400.
- Levitsky G. A. 1931. The Karyotype in systematics. Bull Appl. Bot. Vol. 27.
- Löve A. and Löve D. 1948. Chromosome numbers in northern plant species. Reykjavik, 1948.
- Manton I. 1932. Introduction to the Cytology of the Cruciferae. Ann. Bot. 46. p. 509—536.
- Manton I. 1934. The problem of *Biscutella laevigata*. Zeitschr. f. ind. Abst. u. Vererb. 67, p. 41—57.

- Manton I. 1937. The problem of *Biscutella laevigata* II. Ann. of Bot. n. s. 1, p. 439—462.
- Meurman O. 1925. The chromosome behaviour in some dioecious plants. etc. Comment. biol. Helsingf. 2. p. 1—104.
- Müntzing A. 1932. Apomictic and sexual seed formation in *Poa*. Hereditas, 17. p. 131—154.
- Müntzing A. 1940. Further studies on apomixis and sexuality in *Poa*. Hereditas 26, p. 115—190.
- Müntzing A. and G. 1941. Some new results concerning apomixis, sexuality and polymorphism in *Potentilla*. Bot. Not. p. 237—278.
- Müntzing A. and G. 1945. The mode of reproduction of hybrids between sexual and apomictic *Potentilla argentea*. Bot. Not. p. 49—71.
- Pawłowski B. 1933. Studien über mitteleuropäische Delphinien aus der sog. Sektion *Elatopsis* I. Bull. Acad. Polon. des Sciences., p. 29—81.
- Runkvist E. 1937. Cytologische und morphologische *Valeriana* Untersuchungen. Hereditas. 23, p. 279.
- Rütishauser A. 1943. Konstante Art- u. Rassenbastarde in der Gattung *Potentilla*. Mitt. d. Naturf. Ges. Schaffhausen, Bd. 18. p. 111—134.
- Rütishauser A. 1948. Pseudogamie und Polymorphie in der Gattung *Potentilla* Archiv d. Julius Klaus-Stiftung. Bd. 23, 267—424.
- Schulz O. E. 1903. Monographie der Gattung *Cardamine*. Englers Bot. Jahrb. Bd. 32, p. 280—623.
- Skalińska M. 1928. Etudes sur la stérilité partielle des hybrides d'*Aquilegia*. Zeitschr. f. Ind. Abst. u. Vererb. Suppl. 2., p. 1343—72.
- Skalińska M. 1947. Polyploidy in *Valeriana officinalis* L. in relation to its ecology and distribution. Journ. Linn. Soc. London, Botany, 53, p. 159—186.
- Skalińska M. 1949. Cytological studies in Polish species of *Valeriana* (in the press).
- Schafer and La Cour. 1934. A chromosome survey of *Aconitum*. I. Ann. Bot. 48. p. 693—713.
- Sakai K. 1934. Studies on the chromosome numbers in alpine plants. Jap. Journ. of. Gen. 9. p. 226—230.
- Shimotomai N. 1935. Genetische u. cytologische Untersuchungen über die Pseudogamie bei *Potentilla*. Jap. Journ. of Gen. 11. p. 297—301.
- Scheerer H. 1939. Chromosomenzahlen aus der Schleswig-Holsteiner Flora. I. Planta 29. p. 636—642.

- Senjaninova M. 1925. Beitrag zur vergleichend-kariologischen Untersuchung des Linneons *Valeriana officinalis* L. Zeischr. f. Zellforsch. 5. p. 675—679.
- Sprague T. A. 1943. Field studies in *Valeriana officinalis* L. in the Cottswold Hills. Proc. Linn. Soc. Lond. Session 155. p. 93—104.
- Szafer W. 1949. Zarys geografii roślin. Warszawa.
- Turesson G. 1930. Studien über *Festuca ovina* L. II. Hereditas. 13. 177—184.
- Turesson G. 1931. Studien über *Festuca ovina* L. III. Hereditas 15. 13—16.
- Wóycicki Z. 1932. Nieco szczegółów z zakresu rozwoju pylników i pyłku u niektórych przedstawicieli rodzaju *Gentiana*. Acta Soc. Bot. Pol. 9. p. 7—30.