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Chromosome number and accessories in *Avena versicolor* Vill.

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Accessory chromosomes have been described in a number of plant species. They seem to be relatively frequent in the *Gramineae;* accessories in *Secale cereale* were the subject of detailed studies of Müntzing (1944, 1948) and of Lima-de-Faria (1955); the B chromosomes of *Zea Mays* were described by McClintock (1933), as well as by Darlington and Upcott (1941); other examples are: *Anthoxanthum aristatum* (Östergren, 1947), *Agrostis trinii* (Sokolovskaya, 1938), *Agrostis canina v. fascicularis* (Björkman, 1951), *Agrostis rupestris* (Björkman, 1954, Skalińska, unpubl.). In the course of the present work they have been found in root tips of the mountain grass *Avena versicolor* Vill. (*Avenastrum versicolor* (Vill.) Fritsch.).

The accessory chromosomes of *Avena versicolor* are in some respect similar to those of the above mentioned species: they differ distinctly from the normal chromosomes in the set by their shape and size; they manifested a high degree of constancy in root-tip cells of three plants in which accessories have been found, being present in cells of the three germ-layers (Table 2). In view of this fact suggesting their regular transmission in cell generations it seemed interesting to study their behaviour at mitosis, viz. their position and orientation in the metaphase plate. The importance of the position of the accessories during mitosis has been recently emphasized by Lima-de-Faria (1955).

In the present short report only results concerning mitosis are given. A study of the behaviour of the accessories during meiosis is planned in the next future. *Avena versicolor* however is an alpine species; the fixation of its flower buds in suitable stages of meiosis presents some difficulties in natural habitats and needs some experience.

Avena versicolor occurs abundantly on alpine meadows in the High Tatra. The material for the present study originated exclusively from natural habitats; the plant specimens were collected in the layer of *Pinus montana* and in the alpine layer at altitudes ranging from 1700 m to 2070 m o. s. l. (Table 1). In a total of 13 plants studied ten had the exactly diploid chromosome complement, while in three plants the occurrence of accessories in the number of one or two could be observed.

Chromosome number. The only previous record concerning the chromosome number of *Avena versicolor* is based on unpublished studies of Katterman, 1934 (Tischler, 1950). According to his results, the chromosome number of this species is very high (2n = 120 — 124). The origin of the specimens investigated by that author is difficult to trace. Therefore a re-investigation of this alpine species has been undertaken in the course of our studies dealing with chromosome numbers of Angiosperms from the Tatra Mts. Our results were entirely different from those of Katterman. To our great surprise, a much lower number has been found in all specimens of *Avena versicolor* from the High Tatra. The diploid number of this species is 14; in three plants the occurrence of one or two small accessory chromosomes could be stated in addition to the normal chromosome complement. Fig. 1 and 2 represent a root-tip metaphase with the exactly diploid number; Fig. 3—6 show the presence of accessories. The number n = 60 — 62 given by Katterman is difficult to explain. The assumption of a differentiation into geographic races with diploid and high polyploid numbers does not seem to be well founded. It seems more probable that the systematic determination of the specimens investigated by Katterman was erroneous and that the plants studied by him represented another species of the same genus. In this connection it should be added that a similar chromosome number (2n — c. 126) has been established recently by Reese (1953) for *Avena planiculmis*. This detail together with the results of the present study strongly suggest that the plants investigated by Katterman may belong in fact to the tall and robust mountain species *A. planiculmis*. As pointed out by Reese, such high polyploid numbers are very rare in the *Gramineae*. In the genus *Avena* the basic number is 7; most of its species represent either diploids or lower polyploids (tetra- and hexaploids).

According to the results of the present study, *A. versicolor* from the High Tatra is a diploid species. In somatic plates of three plants small accessory chromosomes occurring in the number of one in two plants and of two in the third have been detected. Their constant number in root-tip meristems of the respective plants shows that they are transmitted regularly in cell divisions.

Table 1

List of habitats of *Avena versicolor* in the High Tatra

Strain	Place of origin	Number of accessory chromosom.
I	Below the pass Liliowe, on a grassy slope (c. 1800 m o. s. l.)	2
II	SE slope of Kasprowy (c. 1700 m o. s. l.)	0
IV	Slope of Mt Beskid (c. 1800 m o. s. l.)	1
V	A meadow in the valley of Stawy Gąsienicowe, near the path to the pass Karb (c. 1700 m o. s. l.) one plant	1
	three plants	0
VI	SW slope of Skrajna Turnia (c. 2070 m o. s. l.); 3 plants	0
VII	Pass Świnicka (2050 m o. s. l.); 3 plants	0

Table 2

Number of accessory chromosomes in the three germ layers

Plants with accesso-ries	Plates Total	Without accessories			With 1 access.			With 2 access.		
		Derm.	Peribl.	Pler.	Derm.	Peribl.	Pler.	Derm.	Peribl.	Pler.
I	23	—	—	—	—	—	—	5	15	3
IV	28	—	—	—	7	21	—	—	—	—
V/1	20	—	—	—	3	13	4	—	—	—
Plants without accessories										
V/2	25	3	20	2	—	—	—	—	—	—
V/3	14	7	5	2	—	—	—	—	—	—
V/4	12	2	8	2	—	—	—	—	—	—
VI	13	5	7	1	—	—	—	—	—	—
VII	17	3	12	2	—	—	—	—	—	—

Accessory chromosomes. On the whole, the accessory chromosomes of the three plants represented the same type in respect of their shape and size. They consisted of a very short headlike part and a somewhat longer arm joined by a minute constriction representing probably the centromere. On the other hand, the normal chromosomes of the set are distinctly biarmed. A further difference concerns

the length: the accessories are notably shorter; their total length attains c. 2 μ, while that of the normal chromosomes ranges from 4.4 to 6.4 μ. In view of this remarkable size difference the accessories may be easily identified in well spaced metaphase plates (Fig. 3, 4).

The study of the occurrence of the accessories in the three plants was based on a total of 71 metaphase plates found in the three germ layers: dermatogen, periblem and plerome. In addition five other plants without accessories were studied in the same way. For the two plants with only one accessory the number of plates analyzed was 28 and 20 resp. The number of metaphase plates of the third plant, carrying two accessories, comported 23 (Table 2). This study led to establish that in all plates within an individual the number of accessories was exactly the same. The regular transmission of the accessories in cell generations gives evidence that their centromere is able to function. At the time of the congression of the chromosomes, also the accessories become included into the metaphase plate.

L i m a - d e - F a r i a (1955) has emphasized in a recent paper the importance of the position in the metaphase plate of the accessory chromosomes. The studies of M ü n t z i n g (1948) dealing with the position in the plate of the so-called „standard fragment" of *Secale cereale* have revealed that these accessory chromosomes tend to occupy a rather

T a b l e 3
Position of the accessory chromosomes in the plates

Plants with 1 accessory	Number of cells studied	Peripheral position		Central position
Plant IV	19	14		5
Plant V/1	20	15		5
Plant with 2 accessories		Peripheral Peripheral	Peripheral Central	Central Central
Plant I	10	4	3	3

central position; this favours their regular transmission at mitosis. The same is true of the chromosome derivative of *Secale*, studied by L i m a - d e - F a r i a (l. c.); it is not eliminated during the mitotic divisions. On the other hand, in *Zea Mays*, according to D a r l i n g t o n and U p c o t t (1941), the B chromosomes were usually found at the edge

of the plate; this may lead to irregularities at mitosis, owing to the weakness of the centromere.

The position of the accessory chromosomes in *Avena versicolor* has been studied in 49 cells. For this study only cells undamaged by the microtome knife could be used in view of a possible displacement of the chromosomes in the plate. The results summarized in Table 3 show a distinct prevalence of the peripheral position of the accessory chromosome in two plants carrying only one accessory. In the third plant — with two accessories — this prevalence is less marked; in three plates one of the two accessories is located in the centre while the second has a peripheral position; in three other cells both accessories are located centrally; the peripheral position of the two accessories was found in four cells.

In spite of the prevalence of the peripheral position of the accessories in the metaphase plates, their number in various meristematic cells of the three plants shows a remarkable constancy. In my opinion, for the understanding of their regular transmission in mitotic divisions not only their position — peripheral or central — but also their orientation should be taken into consideration. In most plates with a single accessory, its body is directed radially in the same way as are the arms of the normal chromosomes at the periphery of the plate (Fig. 3, 4); its headlike part is turned towards the centre, the longer arm outside. This orientation shows that it is included in the equatorial plate, irrespective of its peripheral position. Only in rare instances the longer arm had a more central position in the plate. On the other hand, the plates of the plant with two accessories, show a less regular orientation; one accessory or both may be found sometimes lying almost tangentially at the edge of the plate, their body being slightly bent (Fig. 5, 6). Such an orientation may lead perhaps to some degree of elimination, although till now our study failed to reveal any variability in the number of accessories within a single individual.

SUMMARY

Avena versicolor Vill. (*Avenastrum versicolor* (Vill.) Fritsch) from the High Tatra is a diploid species with 2n = 14. This number disagrees with the unpublished record of Katterman 1934 (Tischler, 1950) who found a much higher number (2n = 120 — 124) for plants of unknown origin.

The occurrence of 1 or 2 small accessory chromosomes in addition to the normal diploid complement has been established in meristem cells of three plants. Although the accessories tend to occupy a rather pe-

ripheral position in the metaphase plates, they are regularly transmitted in mitotic divisions.

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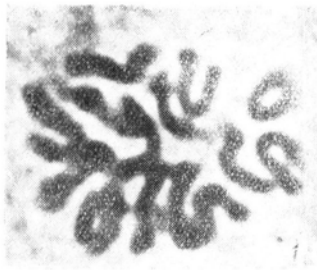

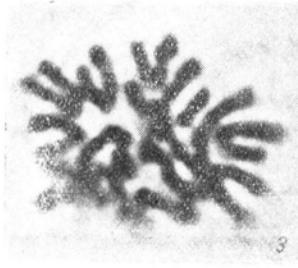

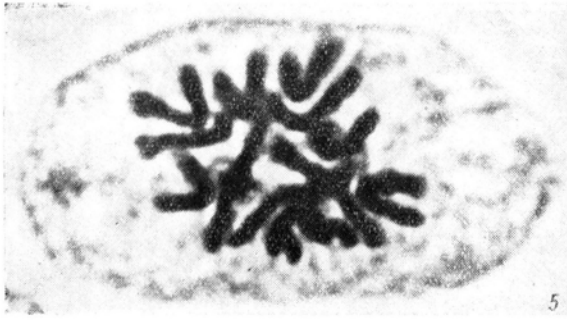

Explanation of the Plate

All figures represent root-tip metaphases of *Avena versicolor* V i l l.

Fig. 1, 2 — a plate without accessory chromosomes (Strain VII); dermatogen cell.

Fig. 3, 4 — a plate with one accessory chromosome (Plant V/1); plerome cell.

Fig. 5, 6 — a plate with two accessory chromosomes (Plant I); periblem cell. (Navashin-Gentian violet. Magnification of the drawings 3500 ×, of the microphotos 3000 ×). J. Rychlewski phot.