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The morphology of hairs in species of *Plantago* L. sectio *Coronopus* DC.

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Abstract

The hairs of 13 representatives of sectio *Coronopus* DC. genus *Plantago* were studied. The occurrence of 5 types of headless and 4 types of headed hairs was found. The investigations confirm the correctness of Rahn's (1978) and Dietrich's (1980) classification dividing the sectio *Coronopus* (subgenus) into two lower taxonomic units. Sectio *Coronopus* sensu Rahn is characterized by the presence of bottle-like hairs, while sectio *Maritima* Rahn by the occurrence of morel-like hairs.

Key words: genus Plantago L., sectio Coronopus DC., sectio Maritima Rahn, hairs, scanning electron microscopy

INTRODUCTION

Plantago L. is one of 3 genera of the *Plantaginaceae* family. It is usually divided into two subgenera: *Euplantago* Harms and *Psyllium* (Juss.) Barnéoud. Subgenus *Psyllium* is regarded as monotypic. Some investigators (Soják 1972, Holub 1973, Dietrich 1980) promote it to the rank of genus. Subgenus *Euplantago* (*Plantago*), on the other hand, is divided into several sections. Pilger (1937) distinguishes 18 sections on the basis of Decaisne's taxonomy. *Coronopus* DC. in one of them.

The important diagnostic feature of this section is the pubescence of the corolla tube.

Pilger (1898, 1930, 1937) ascibes 19 species to sectio *Coronopus* and distinguishes two groups: *Plantago coronopus* and allied species, and *P. maritima* and allied species.

The anatomical, genetic and chemotaxonomic investigations of other authors confirm the accuracy of such a division. Trapp (1932) pointed out the evident differences in the development of the endoderm in *P. coronopus* in comparison with *P. maritima* and *P. alpina*. According to Clarke and Jones (1977) there are two separate pollen types: the *P. coronopus* type and the *P. maritima* type. Rymkiewicz (1979) stresses the large differences in the structure of leaves and seeds between *P. coronopus* and *P. maritima*. On the basis of genetic investigations, Cartier (1973) came to the conclusion that sectio *Coronopus* is not homogeneous.

Gorenflot and Bourdu (1962) found that the species of sectio *Coronopus* can be divided into two groups differing from each other as far as the presence of ribose in seeds is concerned as well as in the basic number of chromosomes. The groups proposed by Gorenflot and Bourdu do not correspond precisely to Pilger's classification.

In 1978 Rahn suggested significant changes in the taxonomy of the genus *Plantago*. He promoted *Coronopus* DC, to the rank of subgenus, in which he distinguished two sections: *Coronopus* Lam. et DC. (corresponding to group A in Pilger's monography and *P. asphodeloides* — the species described later) and *Maritima* Rahn sect. nov. (the counterpart of group B in Pilger's monography).

The representatives of these newly formed sections differ from one another even in the basic number of chromosomes (sectio *Coronopus*: $x = 5$, sectio *Maritima*: $x = 6$).

A similar division, also corresponding to Pilger's taxonomy and based on the basic number of chromosomes, was introduced, independently of Rahn, by Dietrich (1980), who distinguished sectio *Coronopus* DC. and sectio *Maritima* Dietrich.

A previous paper (Andrzejewska-Golec and Świątek 1984) dealt with the chemotaxonomic investigations of tens of representatives of genus *Plantago*, among them — some from sectio *Coronopus*. The investigations show that the species *P. coronopus* is different not only from the taxa of the sectio *Coronopus* but also from the whole genus *Plantago* because of the absence of a glycoside from the group of iridoids — aucubin. The species is also characterized by the lack of aucubin and ribose in seeds (Gorenflot and Bourdu 1962, Rymkiewicz 1979).

The aim of the present paper is to supplement the mentioned chemotaxonomic investigations with studies on the morphology of hairs in sectio *Coronopus*; analogical morphological studies of other taxa will be presented in further papers.

Only short notes connected with hairs in the representatives of sectio

Table 1

Hair types occurring in sectio *Coronopus* sensu Rahn

Name of plant *	The investigated part of the plant ***	Headed hairs		Headless hairs				
		bottle-like	with two--cellular stalk and unicellular head	short thick-walled	consisting of several cells thin- or thick-walled	having bulgy cells	consisting of several overlapping cells	web-like
P. coronopus L. (Antwerp)	L	+	–	–	+	+	–	+
	S	+	–	–	–	–	+	+
	B	–	–	–	–	–	–	–
	C	+	+	–	–	–	–	–
	R	–	–	–	+	–	–	–
P. coronopus L. subsp. *coronopus* (Liége)	L	+	–	–	+	+	–	+
	S	+	–	–	+	–	+	+
	B	+	–	–	+	–	–	–
	C	–	–	–	+	–	–	–
	R	–	–	–	+	–	–	–
P. crassifolia Fors. (Coimbra)	L	+	–	+	–	–	–	+
	S	+	–	+	–	–	+	+
	B	–	–	–	+	–	–	–
	C	+	+	–	+	–	–	–
	R	–	–	–	+	–	–	–
P. subspathulata Pilger (Copenhagen)	L	+	–	–	+	+	–	+
	S	+	–	–	–	–	+	+
	B	+		–	+	–	–	–
	C	+	+	–	+	–	–	–
	R	–	–	–	+	–	–	–

* The name of the species according to the catalogue of the botanical garden (the seat of which is given in square brackets) from which the seeds were imported.

** L – leaf, S – scape, B – bract, C – calyx, R – corolla.

Table 2

Hair types occurring in sectio *Maritima* Rahn

The name of the plant *	The investigated part of the plant **	Headed hairs			Headless hairs				
		with unicellular stalk and two-celled head	morel-like	with two-cellular stalk and unicellular head	short thick-walled	consisting of several cells thin- or thick-walled	having bulgy cells	consisting of several overlapping cells	web-like
P. maritima L. (Wrocław)	L ****	–	+	–	–	+	–	–	+
P. maritima L. subsp. *maritima* (Munich)	L	–	+	–	–	+	–	–	+
	S	+	+	–	–	+	–	+	+
	B	+	+	–	–	+	–	–	–
	C	+	+	+	–	+	–	–	–
	R	–	–	–	–	+	–	–	–
P. maritima subsp. *serpentina* (All.) Arcang. (Oldenburg)	L	–	+	+	–	+	–	–	+
	S	–	+	–	–	+	–	+	+
	B	–	–	–	–	–	–	–	–
	C	+	–	–	+	–	–	–	–
	R	–	–	–	–	+	–	–	–
P. alpina L. (Koszyce)	L ****	–	+	–	+	–	–	–	+
P. holosteum Scop. (Marburg)	L	–	+	–	+	+	+	–	+
	S	–	+	–	+	+	–	+	+
	B	–	+	–	+	+	–	–	–
	C	+	+	+	+	+	–	–	–
	R	–	–	–	–	+	–	–	–
P. recurvata L. sec. Bory *** (Paris)	L	–	+	–	+	+	–	–	+
	S	+	+	–	+	+	+	+	+
	B	+	+	–	–	+	–	–	–
	C	+	+	+	–	+	–	–	–
	R	–	–	–	–	+	–	–	–
P. subulata subsp. *granadensis* Willk. (Marburg)	L	–	+	–	–	+	–	–	–
	S	–	+	–	–	–	–	+	+
	B	–	+	–	–	+	–	–	+
	C	–	+	–	–	+	–	–	–
	R	–	–	–	–	+	–	–	–
P. subulata subsp. *insularis* (Green and Godron) Nyman (Würzburg)	L *****	–	+	–	–	+	–	–	+
	B	–	–	–	–	+	–	–	+
	C	–	–	–	–	+	–	–	–
	R	–	–	–	–	+	–	–	–
P. juncoides Lam. var. *glauca* (Harnem) Fern. (Bayreuth)	L	–	+	–	–	+	–	–	+
	S ****	–	+	–	–	+	–	+	+

*, ** See notes to Table 1.

*** Syn. *P. holosteum* Scop.

**** The investigations of other parts of the plant have not been performed.

***** The investigations of the scape have not been performed.

Coronopus can be found in bibliography. Vesque (1885) observed web-like and headed hairs (with a unicellular stalk and two-celled head) in *P. subulata*, and Gravis (1936) observed headless hairs consisting of several cells in *P. coronopus*. The latter ascribed to them the double function of water absorption and reducing transpiration. Pilger (1898, 1937) described only simple, unicellular hairs with an enlarged basal cell, he regarded them as characteristic of sectio *Coronopus*.

MATERIALS AND METHODS

In the present work we have studied hairs of the leaf, scape bract, calyx and corolla of 13 representatives of section *Coronopus* DC. (Tables 1, 2). The plants were grown in the Garden of Medicinal Plants of the Department of Pharmacognosy from seeds imported from European botanical gardens.

The identity of the investigated taxa was checked according to Pilger (1937), Flora Europea (Moore 1976), and Flora Polska (Tacik 1967).

The material was collected during florescence and fructification (June--October 1984–1985). Raw material was used as well as conserved in 70% ethanol.

Light microscopic figures were drawn with the use of Abbe's apparatus.

The observations of the samples with the aid of a scanning electron microscope broadened the light microscopic observations thanks to the better resolving power and greater depth of sharpness of the scanning microscope. The technique made possible the investigations of the surface of the preparation. The samples for the investigations were initially fixed in 70% ethanol and after dehydration, critical point drying was applied. Samples prepared in this way were coated with gold and palladium alloy. Slight shrinking of the samples showed cell borders on the surface of the preparation.

RESULTS AND DISCUSSION

The occurrence of 5 types of headless hairs and 4 types of headed hairs in sectio *Coronopus* has been found (Tables 1, 2; Figs. 1–13; scanning microscope pictures: Figs. 14–16).

HEADLESS HAIRS

There were web-like or wooly hairs (Fig. 3B, C) at the base of the leaf and young scape of all of the studied taxa. In *P. crassifolia*, the

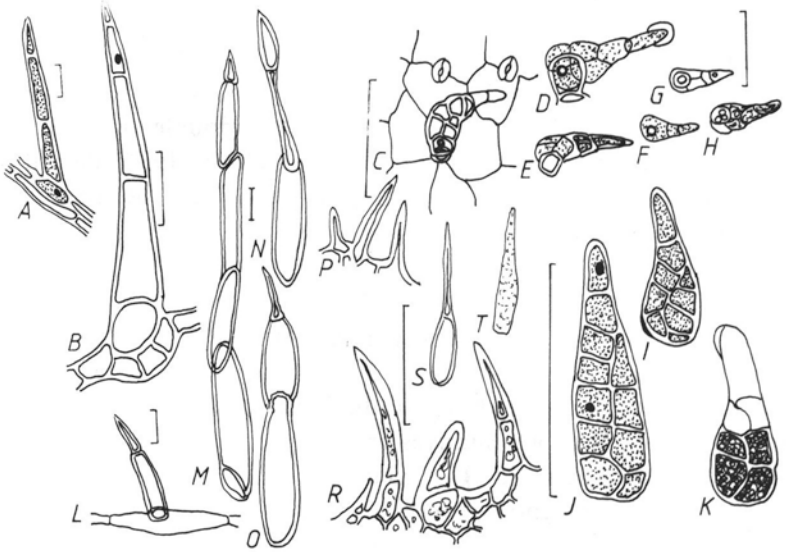


Fig. 1. *Plantago coronopus* L. hairs: A–K — from a leaf, L–O — from a scape, P — from a bract, R — from a calyx, S–T — from a corolla tube. Scale bar = 0.1 mm

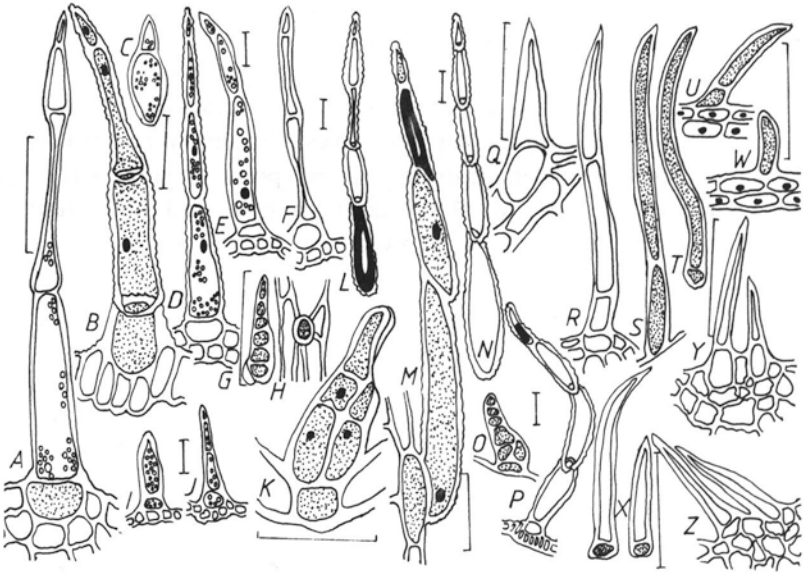


Fig. 2. *Plantago coronopus* L. subsp. *coronopus* hairs: A–K — from a leaf, H — "trace" of the bottle-like hair, L–P — from a scape, Q–R — from a bract, S–W — from a calyx, X — from a corolla tube, Y–Z — from a corolla lobe. Scale bar = 0.1 mm, only for K — 0.05 mm

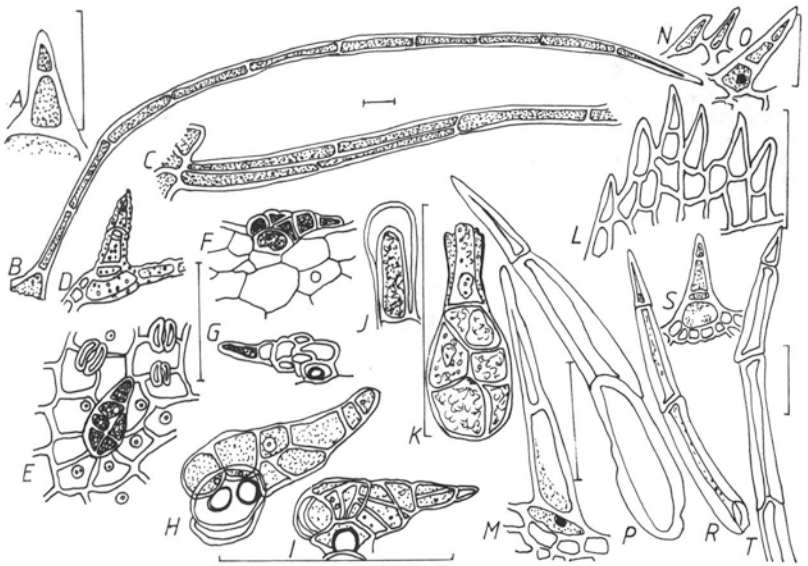


Fig. 3. *Plantago crassifolia* Fors. hairs. A–K — from a leaf, B — a web-like hair from the leaf base, C — fragment of a web-like hair base, J — the tip of a bottle-like hair, L — from a bract, M — from a calyx, N–O — from a corolla lobe, P–T — from a scape. Scale bar = 0.1 mm

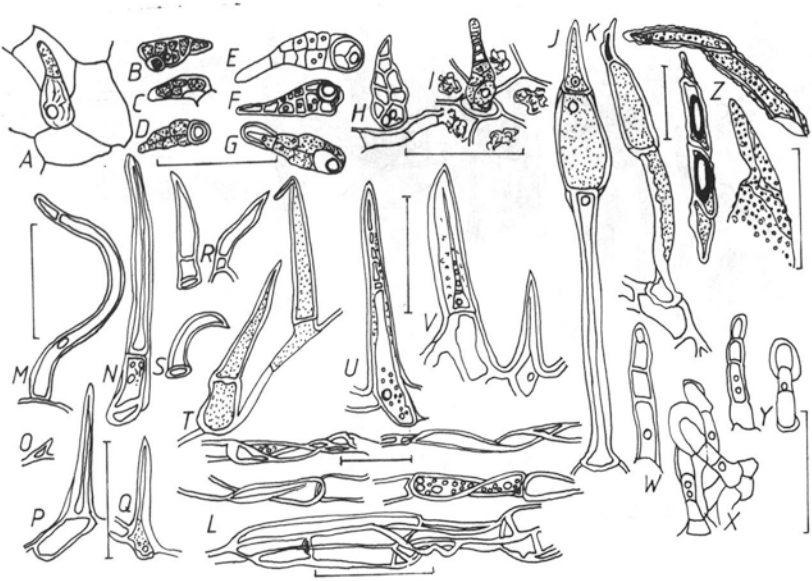


Fig. 4. *Plantago subspathulata* Pilger hairs. A–K — from a leaf, L — fragments of web-like hairs from the leaf base, M–Q — from a bract, R–T — from a corolla, U, Y — from a calyx, Z — from a scape. Scale bar 0.1 mm

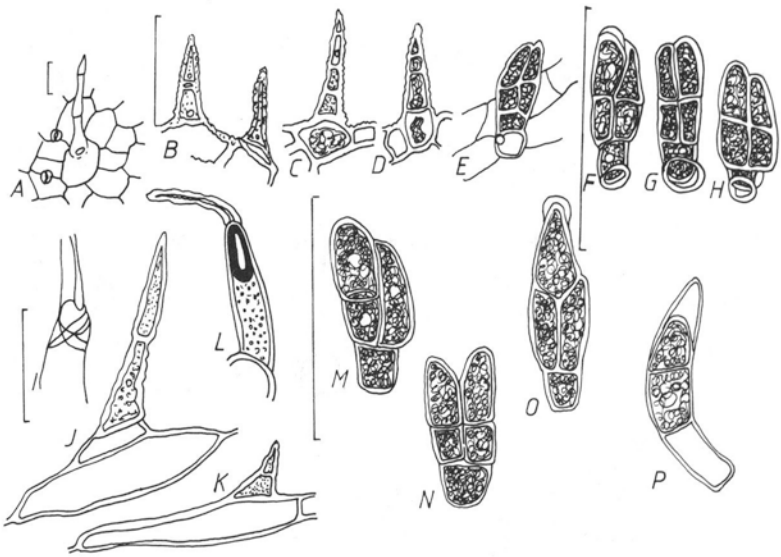


Fig. 5. *Plantago maritima* L. hairs from a leaf, I — fragment of a web-like hair from the leaf base. Scale bar 0.1 mm

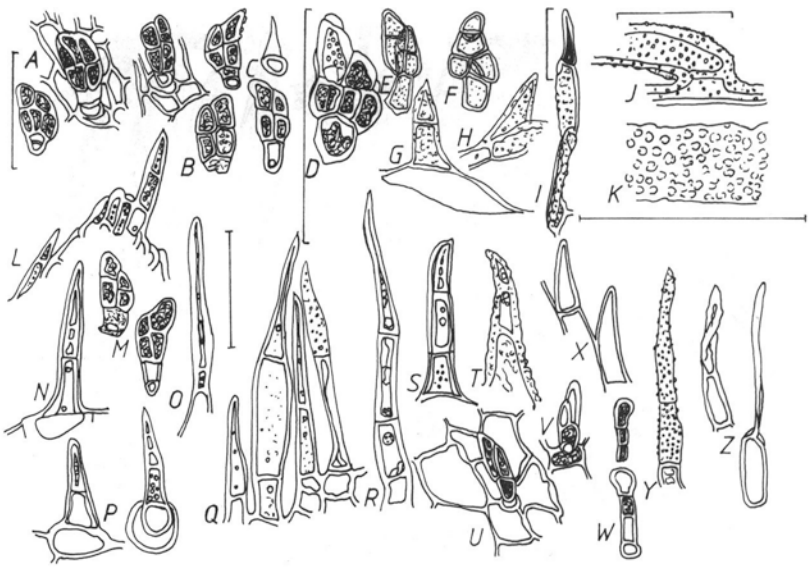


Fig. 6. *Plantago maritima* L. subsp. *maritima* hairs. A–H — from a leaf, I–K — from a scape, J — hair base, K — fragment of hair surface, L–P — from a bract, Q–W — from a calyx, X — from a corolla lobe, Y–Z — from a corolla tube. Scale bar 0.1 mm

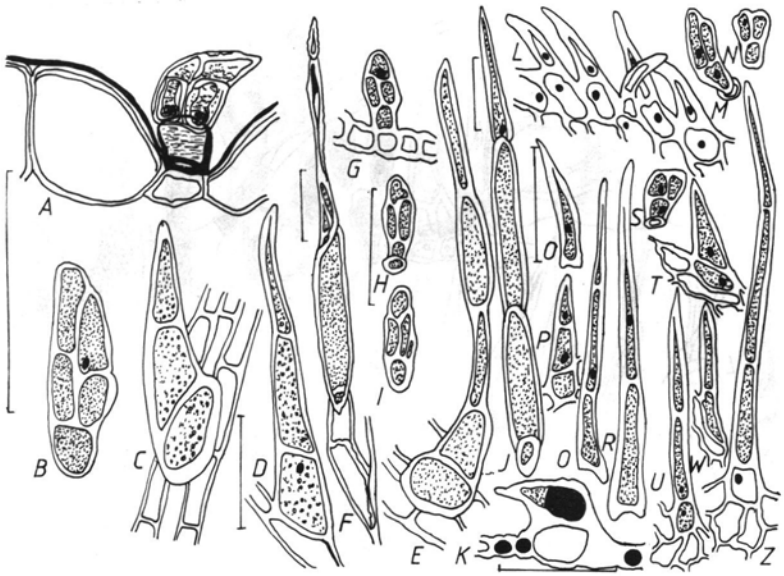


Fig. 7. *Plantago maritima* subsp. *serpentina* (All.) Arcangeli hairs. A–E — from a leaf, F–K — from a scape, L–N — from a bract, O–R — from a corolla, S–Z — from a calyx. Scale bar 0.1 mm

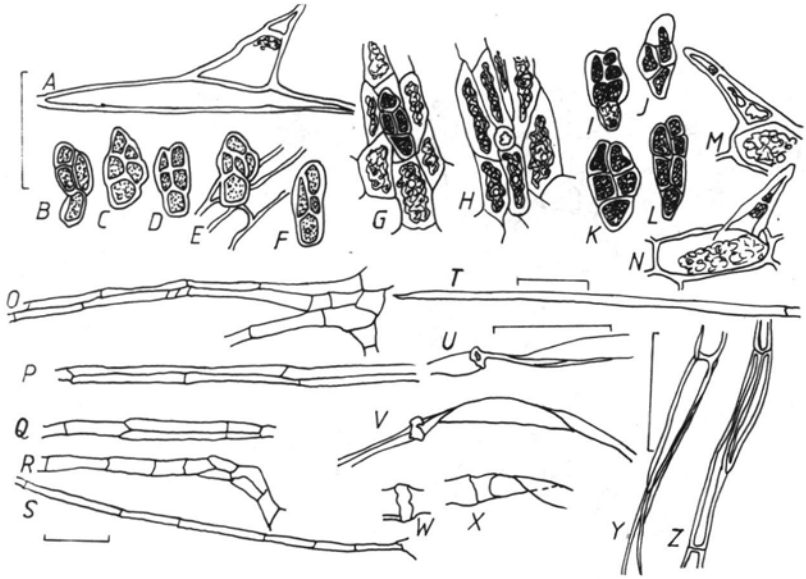


Fig. 8. *Plantago alpina* L. hairs. A–F — from the upper epidermis, G–N — from the lower epidermis, H — "trace" of a morel-like hair, O–Z — fragments of web-like hairs from the leaf base. Scale bar 0.1 mm

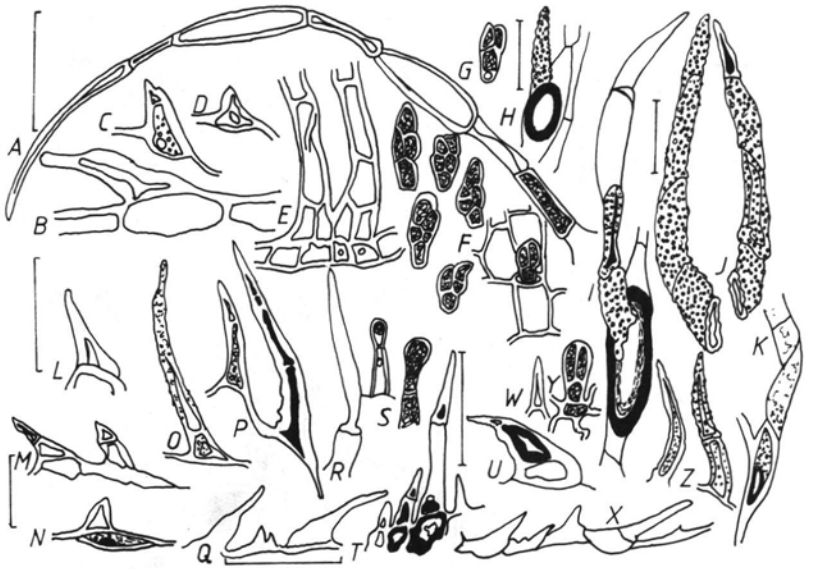


Fig. 9. *Plantago holosteum* Scop. hairs. A–F — from a leaf, E — fragment of web-like hairs the leaf base, G–K — from a scape, L–N — from a bract, O–Y — from a calyx, X — from a corolla lobe, Z — from a corolla tube. Scale bar 0.1 mm

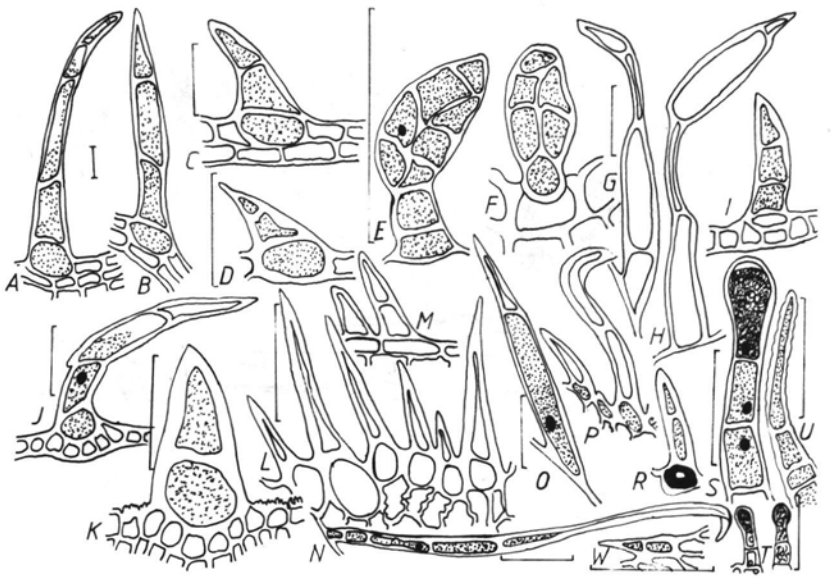


Fig. 10. *Plantago recurvata* L. sec. Bory (syn. *Plantago holosteum* Scop.) hairs. A–E — from a leaf, F–K — from a scape, L–O — from a bract, P–T — from a calyx, U — from a corolla tube, W — from a corolla lobe. Scale bar 0.1 mm, only the scale for S — 0.05 mm

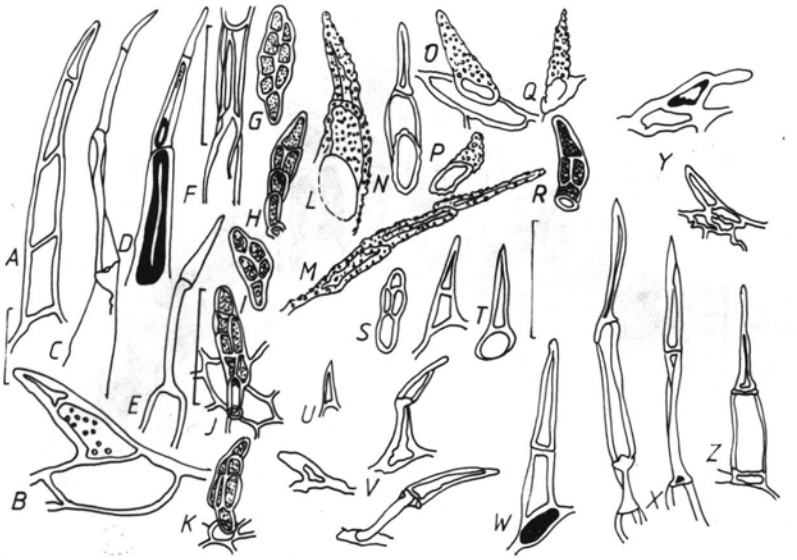


Fig. 11. *Plantago subulata* subsp. *granadensis* Willk. hairs. A–K — hairs from a leaf, F — fragment of a web-like hair from the leaf base, L–R — from a scape, S, T — from a bract, U–Z — from a calyx. Scale bar 0.1 mm

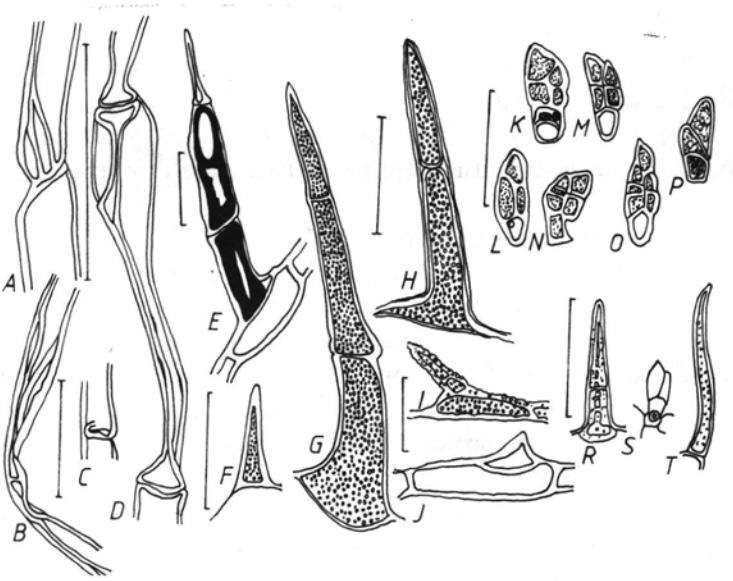


Fig. 12. *Plantago subulata* subsp. *insularis* (Gren. et Godron) hairs. A–P — from a leaf, A–D — fragments of web-like hairs from the leaf base, R — from a bract, S — from a calyx, T — from a corolla tube. Scale bar 0.1 mm

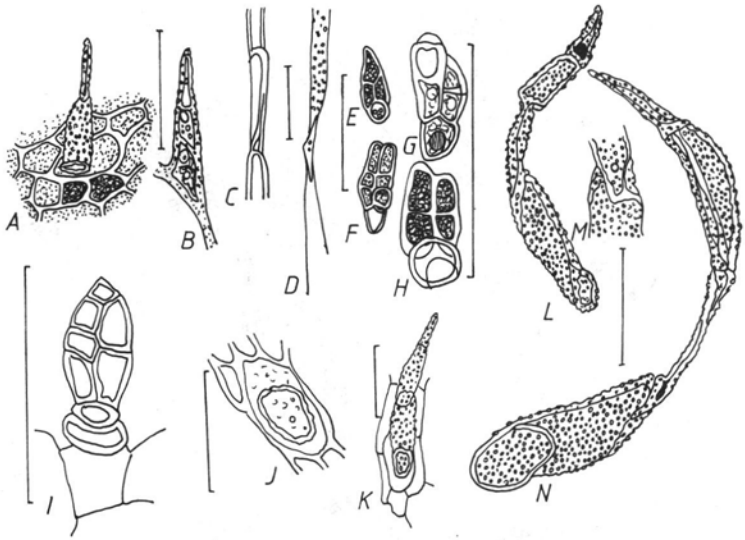


Fig. 13. *Plantago juncoides* Lam. var. *glauca* (Harnem) Fern. hairs. A–I — from a leaf, C, D — fragments of web-like hairs from the leaf base, J–N — from a scape, J — "trace" of a hair with overlapping cells — combination of two cells. Scale bar 0.1 mm

hairs could also be found at the base of older scapes. The hair length varied from 0.3 to 1.5 cm. They were arranged in a single row but often they had bases arranged in two rows (e.g. Fig. 8M). The hairs were composed of a dozen or so to several tens of cells. Some of the cells had additional reinforcements and collapsed walls, sometimes they were filled with air bubbles (e.g. Fig. 4L).

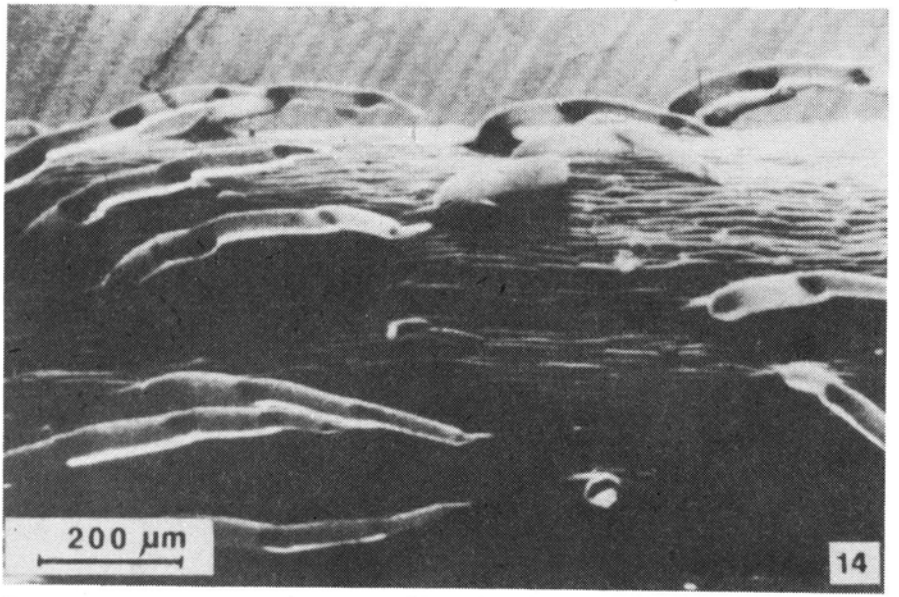
According to Pilger (1898) the web-like hairs can also be found at the base of the leaf in the representatives of all of the taxa of genus *Plantago*.

Another type of headless hairs includes 3–4 celled hairs, a few tenths of a milimeter long, with an enlarged basal cell (e.g. Fig. 1A, B). They were situated on the lamina of the leaf in all of the investigated taxa of sectio *Coronopus* except *P. crassifolia*. In the majority of the studied taxa they could also be found on the stalk, bract and elements of the flower.

The pubescence of the corolla tube, characteristic of sectio *Coronopus* DC. was formed by headless, single-row hairs 1–2 celled or multicellular, thin- or thick-walled, 0.1–0.3 mm long (e.g. Fig. 7O–R). Similar hairs could also be found on the bract and calyx.

Short headless hairs (about 0.1 mm long) cone-shaped, thick-walled, unicellular or 2–3 celled were present on the leaf and space of *P. crassifolia* (Fig. 3A, S) and sectio *Maritima* Rahn (e.g. Fig. 9B, C).

PLATE I



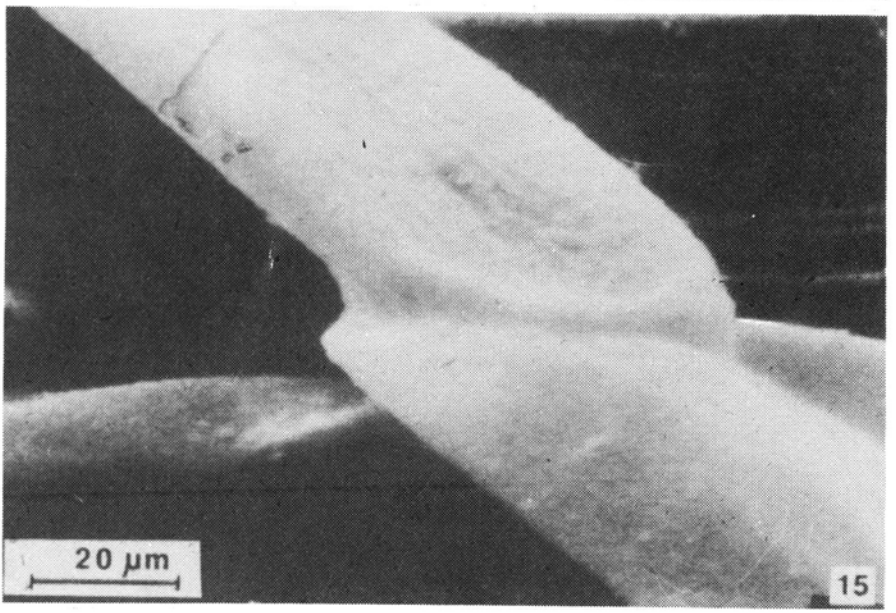


Fig. 14. Hairs with overlapping cells — the stalk of *Plantago subspathulata* Pilger, × 100.
Fig. 15. Fragment of a hair with overlapping cells — combination of two cells — the scape of *Plantago coronopus* L. subsp. *coronopus*, × 1000

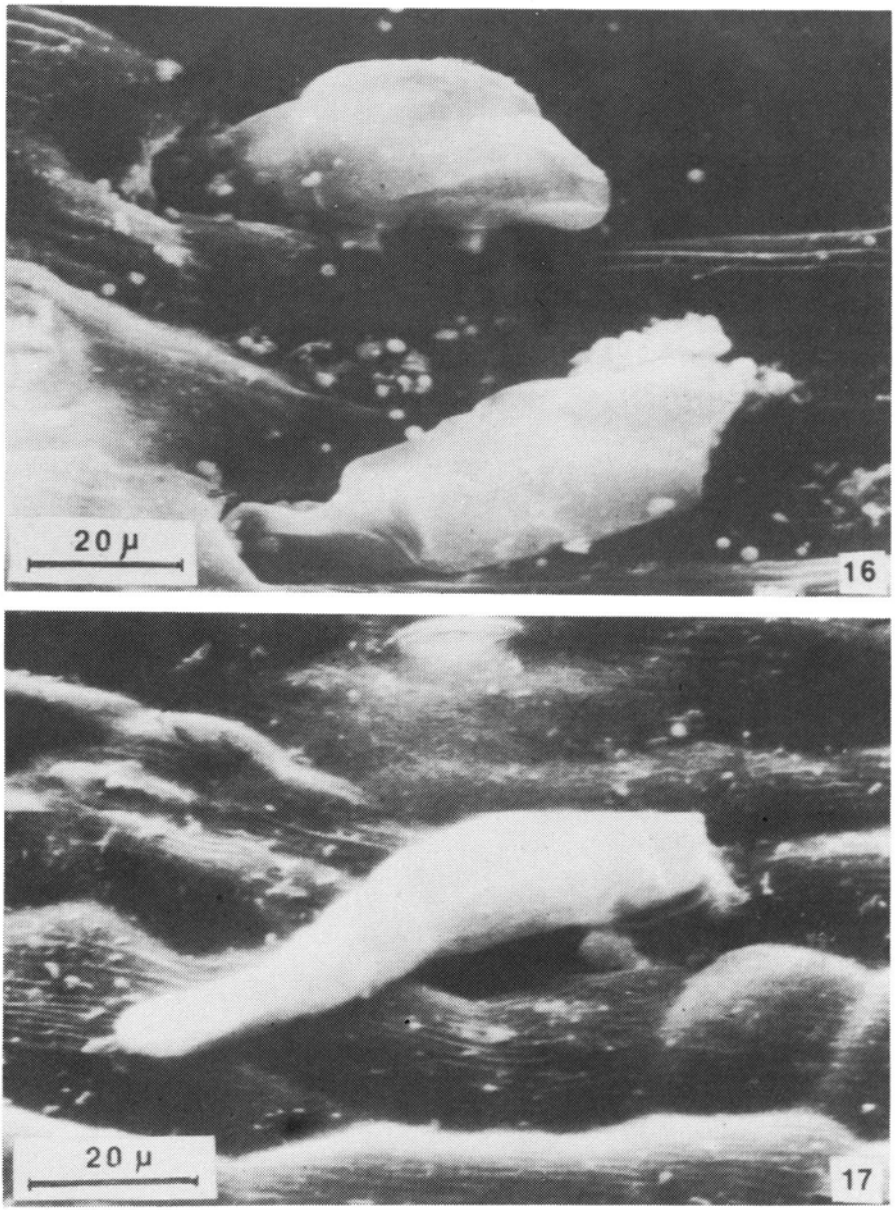
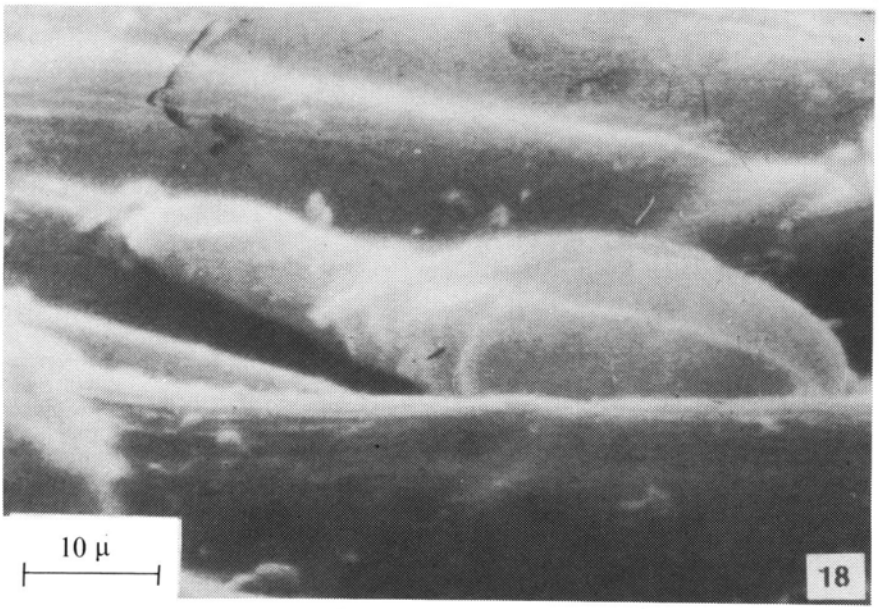


Fig. 16. Morel-like hairs on a leaf of *Plantago holosteum* Scop.. ×1000. Fig. 17. A bottle-like hair on a leaf of *Plantago coronopus* L. subsp. *coronopus*, ×1100



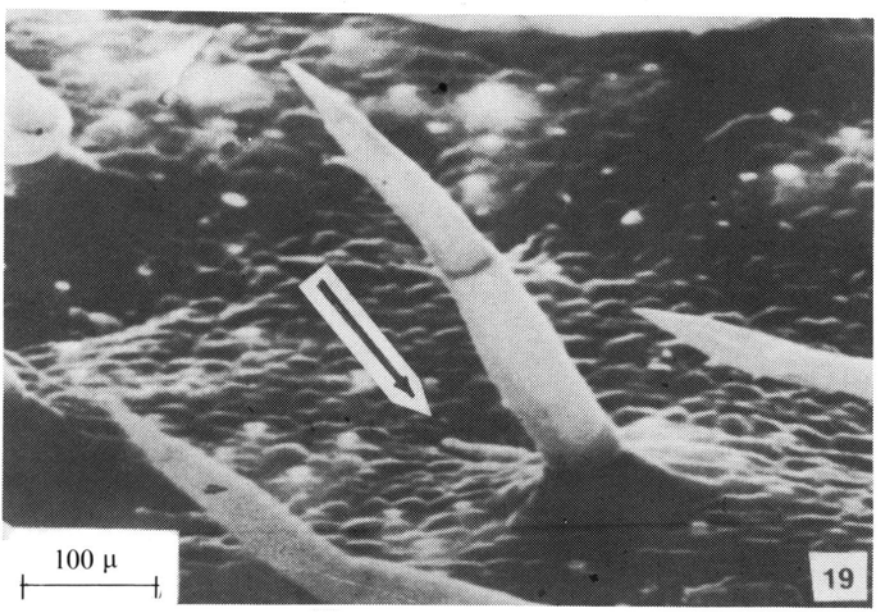


Fig. 18. A bottle-like hair in an epidermis hollow of *Plantago coronopus* L. subsp. *coronopus*, × 1800. Fig. 19. Simple headless hairs and bottle-like hairs (arrow) on a leaf of *Plantago coronopus* L. subsp. *coronopus*, × 180

Multicellular, thin-walled hairs with some bulgy cells were situated on the leaves of: *P. coronopus* ssp. *coronopus*, *P. coronopus*, *P. subspathulata* and *P. holosteum* and on the scape of *P. recurvata* (e.g. Figs. 9A, 10G, H). They were similar to those observed by Gravis (1936).

The scapes of the investigated taxa had simple hairs arranged on a single row, several tens of milimeters long, built of 3–6 overlapping cells (e.g. Fig. 2K, L, Ł). Unger (1926) described analogical hairs occurring on the scape of *P. lanceolata* (sectio *Arnoglossum*) and compared their appearance to a tress. The occurrence of this hair type has been also confirmed in *P. argentea* (sectio *Arnoglossum*) and *P. montana* (sectio *Oreades*) (Solereder 1908).

HEADED HAIRS

Hairs with a unicellular stalk stained with Sudan III, and along with unstained two-celled heads, could be found sporadically and in a small number in sectio *Coronopus* (e.g. Fig. 9Y). Vesque (1885) concluding from his own investigations of only 6 species, regarded those hairs as characteristic of the *Plantaginaceae* family.

In the majority of the investigated taxa there were 0.05–0.1 mm long hairs built of a 2-celled stalk and a unicellular head at the base of the calyx (e.g. Fig. 10S, T).

Two other types of headed hairs turned out to be the most interesting from the point of view the taxonomy of sectio *Coronopus*. Hairs belonging to one of them were 0.06–0.1 mm long and had a bottle-like head composed of a few to a dozen or so cells (e.g. Figs. 3E–K, 17). Their stalk, situated in epidermis cells, could be stained with Sudan III. The hairs were usually found in epidermis hollows (Fig. 18). As far as it is known, the occurrence of bottle-like hairs in the genus *Plantago* has not been described yet. We observed this hair type in sectio *Coronopus* sensu Rahn on the leaf and scape, and in some species on the bract and calyx; we did not find them, however, on the corolla (Table 1).

The representatives of sectio *Maritima* Rahn, on the other hand, had headed hairs 0.07 mm long with a unicellular stalk that could be stained with Sudan III and a 3–7 celled, cone-shaped head (e.g. Fig. 8B–L, 16). The basal cell was much smaller than the surrounding epidermis cells (Fig. 8H).

These hairs (called "morel-like" by us) were situated on the leaf and the scape, in the case of some of the species they could also be observed on the bract and the calyx, they were not found, however, on the corolla (Table 2). Similar hairs were observed by Unger (1926) on the leaves of *P. lanceolata* (sectio *Arnoglossum*).

Our observations have shown that there are no morel-like hairs in sectio *Coronopus* sensu Rahn, while in sectio *Maritima* sensu Rahn there are no bottle-like hairs.

Our data indicate that the hairs of the representatives of sectio *Coronopus* DC. are more varied than Pilger's description (see Introduction). It seems that hair differences among species of this section are not important.

It turned out that *Plantago coronopus* and allied species (sectio *Coronopus* sensu Rahn) do not possess the hairs described by Vesque as typical for *Plantaginaceae* family (unicellular stalk and two-celled head). They are also absent in two species of section *Maritima* Rahn.

Our studies show that morel-like, bottle-like hairs and headless, consisting of several cells, hairs appear on leaves, stalks, bracts and calyxes. Headless hairs with overlapping cells, on the other hand, were observed only on stalks; webb-like hairs only on the root of the leaf and stalk. Headed hairs with a two-celled stalk and unicellular head are situated only on the calyx. Headless hairs having bulgy cells were observed on the leaf and, in one case, on the stalk.

Our earlier taxonomical studies (Andrzejewska-Golec and Świątek 1984) did not provide the data allowing the division of the section according to Rahn's taxonomy to be made. The present studies confirm the accuracy of the division of sectio (subgenus) *Coronopus* into two separate taxonomic units (sections, subsections), since the representatives of sectio *Coronopus* sensu Rahn are characterized by the presence of bottle-like hairs while the representatives of sectio *Maritima* Rahn by the occurrence of morel-like hairs.

The species *P. coronopus*, differing from other representatives of sectio *Coronopus* in some features (see Introduction), has the same bottle-like hairs as the representatives of sectio *Coronopus* sensu Rahn. The above fact confirms the correctness of classifying this species into sectio *Coronopus* sensu Rahn.

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Morfologia włosków w gatunkach rodzaju Plantago L. sekcja Coronopus DC.

Streszczenie

Zbadano włoski u 13 roślin sekcji *Coronopus* rodzaju *Plantago* L. Stwierdzono występowanie pięciu typów włosków bezgłówkowych i cztery typy włosków główkowych. Badania potwierdzają słuszność podziału sekcji (podrodzaju) *Coronopus* na dwie niższe jednostki systematyczne, zgodnie z klasyfikacją proponowaną przez Rahna (1978) i Dietrich (1980). Sekcja *Coronopus* sensu Rahn charakteryzuje się obecnością włosków buteleczkowatych, natomiast sekcja *Maritima* Rahn — występowaniem włosków smardzowatych.