

## The morphology of hairs in species of *Plantago* L. Sections: *Leucopsyllium* Decne and *Hymenopsyllium* Pilger

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### Abstract

The hairs of the following representatives of the genus *Plantago* were studied: *Plantago ovata* Forsk., *P. hookeriana* Fisch. et Mey. (sectio *Leucopsyllium* Decne) and *P. bellardii* All. (sectio *Hymenopsyllium* Pilger). The occurrence of 3 types of headed hairs and 4 types of headless hairs was observed. *P. bellardii* is characterized by the presence of hairs with an unicellular, flask-shaped head and a four-celled stalk on a calyx and bract. Until now this type of hair has not been described in the representatives of the genus *Plantago*. The presence of appendices joining particular cells of the hair is the common feature of the studied taxa, which at present seems to distinguish the above-mentioned sections from other sections of the genus *Plantago*. The results of our study, similarly as the chemotaxonomic studies of Gorenflot and Bourdu (1962) confirm Pilger's accuracy in excluding *P. bellardii* from the sectio *Leucopsyllium* and formation of a distinct sectio *Hymenopsyllium* Pilger.

**Key words:** genus *Plantago* L., sectio *Leucopsyllium* Decne, sectio *Hymenopsyllium* Pilger, hairs, scanning electron microscopy

### INTRODUCTION

A previous paper (Andrzejewska-Golec and Świętosławski 1987) presented studies on the hairs of the representatives of genus *Plantago* L. subgenus *Euplantago* Harms (*Plantago*) sectio *Coronopus* DC. The present studies concern the hairs of the species of sectio *Leucopsyllium* Decne and *Hymenopsyllium* Pilger subgenus *Euplantago*.

Section *Leucopsyllium* includes over 60 species, the majority of which are plants of the American continent (Pilger 1937). Decaisne (1852) formed this section by joining two of Barneoud's (1844) sections: *Albicans* Barn. and *Gnaphaloides* Barn. Decaisne's approach was commonly accepted (Harms and Reiche 1897, Grigoriew 1958, Janchen 1958, Patzak 1964).

In 1978 Rahn (1978a) proposed substantial changes in the taxonomy of *Plantago*. Sections *Albicans* and *Gnaphaloides* (in this case returned to Barneoud's taxonomy) were transferred by him to subgenus *Psyllium*.

A medicinal species — *Plantago ovata* Forsk. is the most well-known representative of section *Leucopsyllium*. It is cultivated on a large scale in India. It grows wild in the Mediterranean, in South Asia, and also in the western parts of North America (Rahn 1979). According to Rahn (1979) *P. ovata* belongs to section *Albicans* ser. *Ovata* Rahn.

Another representative of section *Leucopsyllium* is *Plantago hookeriana* (Pilger 1937). This species grows wild on sandy areas of Texas and Mexico (Rahn 1978b). Rahn (1978b) includes it in section *Gnaphaloides* ser. *Gnaphaloides* Rahn.

In two representatives of section *Leucopsyllium*: *Plantago bismarckii* Niederl. and *P. nubigena* Kunth, Pilger (1898, 1937) describes headless hairs with an enlarged basal cell and a thin-walled first cell of the stalk and a whip-like tip cell. According to Pilger the observed hair type is common for 3 sections of subgenus *Euplantago*: *Leucopsyllium*, *Oreades* and *Arnoglossum*. Vesque (1885) observed the presence of similar hairs in another representative of section *Leucopsyllium* — *P. aristata* Michx. Volken (1887) described the hairs of *P. cylindrica* Forsk. which had four characteristic appendices joining the first cell of the stalk with the next cell.

Section *Hymenopsyllium* was formed by Pilger (1937) for three species: *P. bellardii* All., *P. cretica* L. and *P. cyrenaica* Durand et Barrtle. According to Barneoud (1844) they belong to section *Albicans*, according to Decaisne (1852) to section *Leucopsyllium*. Pilger (1937) included section *Hymenopsyllium* in subgenus *Euplantago*, but he regarded it as allied to subgenus *Psyllium*, whereas Rahn (1979) included *Hymenopsyllium* into subgenus *Psyllium*.

Gorenflot and Bourdu (1962) supported Pilger's decision of excluding *P. bellardii* from section *Leucopsyllium*. They showed that the species differed from the representatives of section *Leucopsyllium* by the presence of stachyose oligosaccharide in seeds.

Gorenflot's and Bourdu's (1962), as well as Andrzejewska-Golec and Świętek (1984) studies point to the presence of significant differences between *P. bellardii* and the taxa of subgenus *Psyllium*.

*P. bellardii* is an annual South European species (Moore 1976) brought to central Europe (Hegi 1906). It also appears in Iraq and Iran (Ka'bi 1961). It grows in sandy places.

We have not found any information about hairs in *P. bellardii* as well as in two other species of the sectio *Hymenopsyllium* in literature. Pilger (1937) states only that the presence of gland hairs is one of the common features of sectio *Hymenopsyllium* and the subgenus (sectio) *Psyllium*.

#### MATERIALS AND METHODS

We have studied hairs of the leaf, scape, bract, calyx and corolla of the following species: 1) *P. hookeriana* Fisch. et Mey., 2) *P. ovata* Forsk., 3) *P. bellardii* All.

The plants were grown in the Garden of Medicinal Plants of the Department of Pharmacognosy, Medical Academy of Łódź, from seeds imported from botanical gardens in Copenhagen, Berlin and Coimbra (Figs. 1-3).

The material was collected during florescence (August — September 1984-1985). Fresh material was used as well as conserved in 70% ethanol.

Light microscopic figures were drawn with the use of Abbe's apparatus. The samples were also observed with the aid of a scanning electron microscope, analogically as in a previous paper (Andrzejewska-Golec and Świątosławski 1987).

#### RESULTS

The corollas of the studied taxa were hairless.

##### HEADED HAIRS

The hair in all three species had unicellular stalks and heads divided vertically into two cells (Figs. 4 E, S; 5 L, M; 6 G; 7 G; 8 D, F; 9). Only sporadically was a two-celled stalk observed (Figs. 5 T, U; 7 H). The hair length varied from 20 to 100  $\mu\text{m}$ . The stalk cell stained intensively with Sudan III, while the head remained unstained. The basal cell was very small in comparison with surrounding epidermal cells. The surface of the head stalk was smooth, in contrast with the epidermis surface which was longitudinally corrugated.

Such hairs were observed in the representatives of some other sections of genus *Plantago*: *P. media* from *Lamprosantha* Decne, *P. cynops* L. from *Psyllium* (Juss.) Barn. (Vesque 1885) and *P. maritima* L., *P. recurvata* L. from *Coronopus* Decne (Andrzejewska-Golec and Świątosławski 1987). Unger (1926), studying the anatomy of plantain leaves used in medicine, claimed that they were typical not only for *P. media* but also for *P. major* L. (sectio *Polyneuron* Decne); they are absent, however, in *P. lanceolata* L. (sectio *Arnoglossum* Decne).

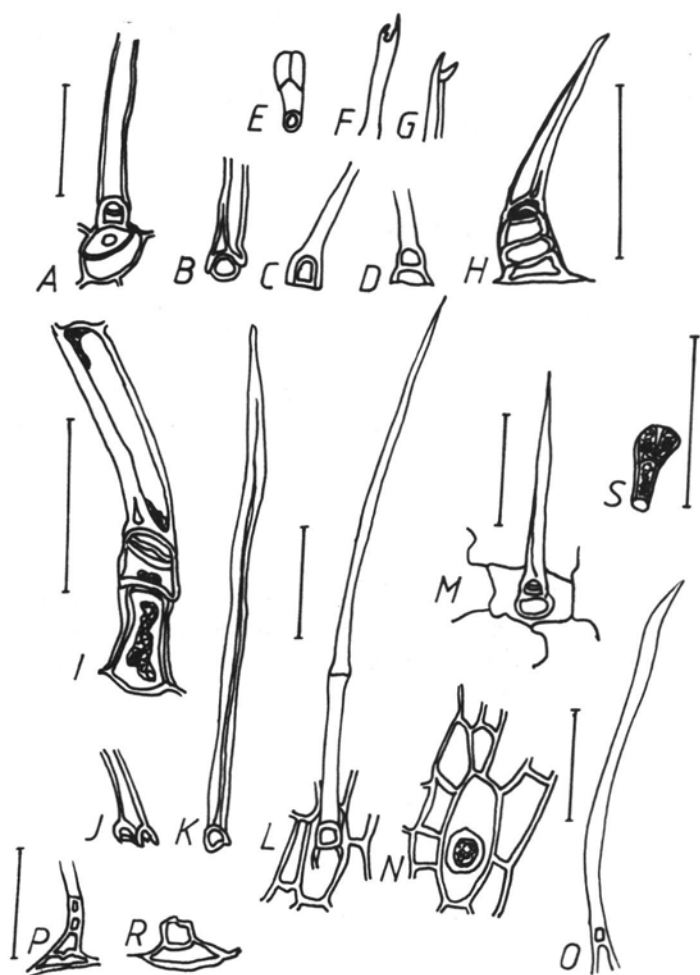


Fig. 4. *Plantago hookeriana* Fisch. et Mey. hairs: A-G — from a leaf; A-D — characteristic base of headless hairs; E — hair with a unicellular stalk and a two-celled head; F-G — fragments of headless hairs (appendices); H-N — from a scape; I — base of the headless hair; J — a characteristic ending of headless hair cell (appendices); K — torn tip cell of the headless hair; L — headless hair with a two-celled base and two long stalk cells; M — headless hair with a two-celled base and a "dagger-like" tip cell; N — a "trace" of the headless hair; P-R — fragments (base) of the hairs from the bract; S, O — hairs from the calyx. Scale bar — 0.1 mm

Brattsten (1945) described the occurrence of hairs with a unicellular stalk and two-celled head in *Plantago fernandezia* Bert. (sectio *Paleopsyllium*).

Such hairs were observed in all of the studied parts of the plants except the corolla. The hairs with a unicellular stalk and a unicellular head occurred only on the bract of *P. ovata* (Fig. 5 S).



Fig. 5. *Plantago ovata* Forsk. hairs: A-I — fragments of headless hairs from the leaf; J-O — from a scape; P-U — from a bract; W-Y — from a calyx; A-E — unicellular hair bases; F — a typical place from which headless hair was shed; G-K — stalk cell ending (appendices); R — headless hair base; S — hairs with an unicellular stalk and unicellular head; T-U — hairs with a two-celled head, typical with an unicellular stalk, non-typical with a two-celled stalk; W — headless hair fragment; X — hair from the tip of the calyx; Y — hair from the membrane part of a calyx. Scale bar — 0.1 mm

We observed headed 40  $\mu$ m long hairs on the bract and calyx of *P. bellardii*. They have not been described to date in the representatives of genus *Plantago* (Figs. 8 C, I; 10-13). Their basal cells were significantly larger than the surrounding epidermal cells and they protruded above those cells. The first cell of the stalk was much smaller than the three remaining stalk cells and, moreover, in contrast to them, it stained with Sudan III. The unicellular head had a flask-like shape (lageniform, gourd-shaped, flask-shaped hairs — Payne 1978), it was filled with a greenish content. The tips of some heads of these

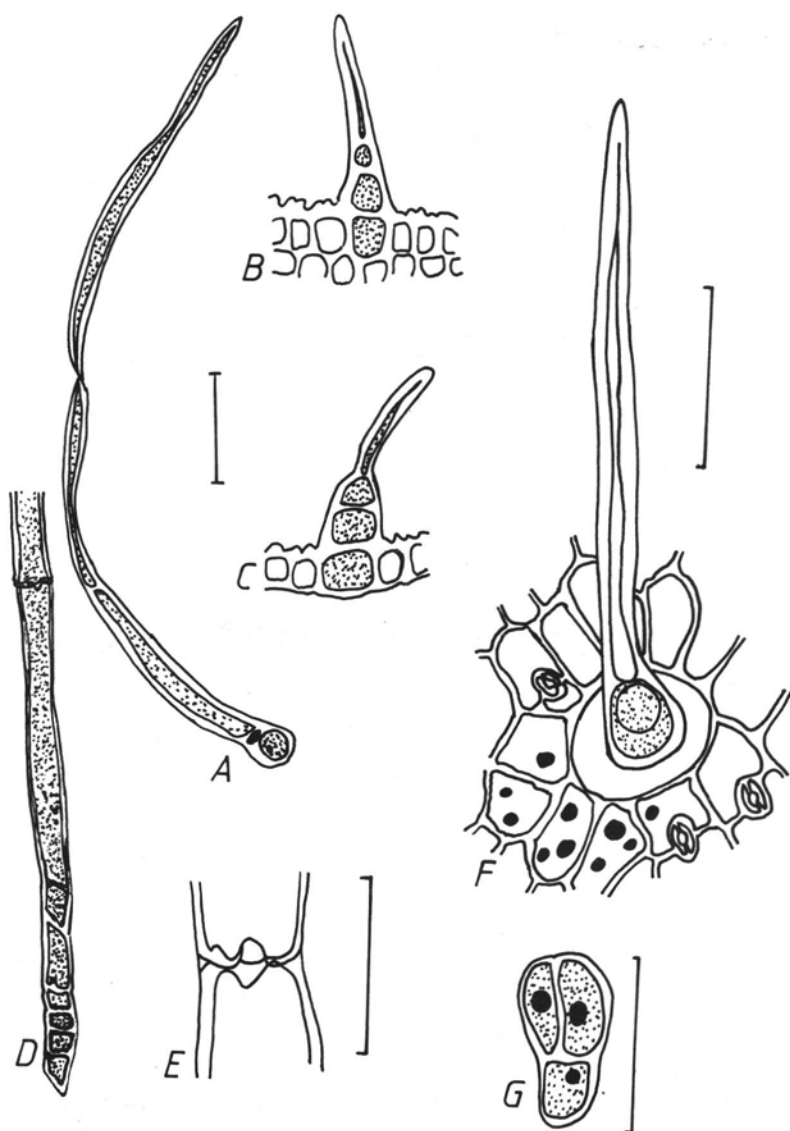


Fig. 6. *Plantago bellardii* All. hairs from a leaf: A — long headless hair with a small basal cell; B, C — short headless hairs with a two-celled base; D, E — fragments of a web-like hair from the leaf base; F — headless hair with an unicellular base; G — hair with an unicellular stalk and a two-celled head. Scale bar — 0.1 mm, only for E, G — 0.05 mm

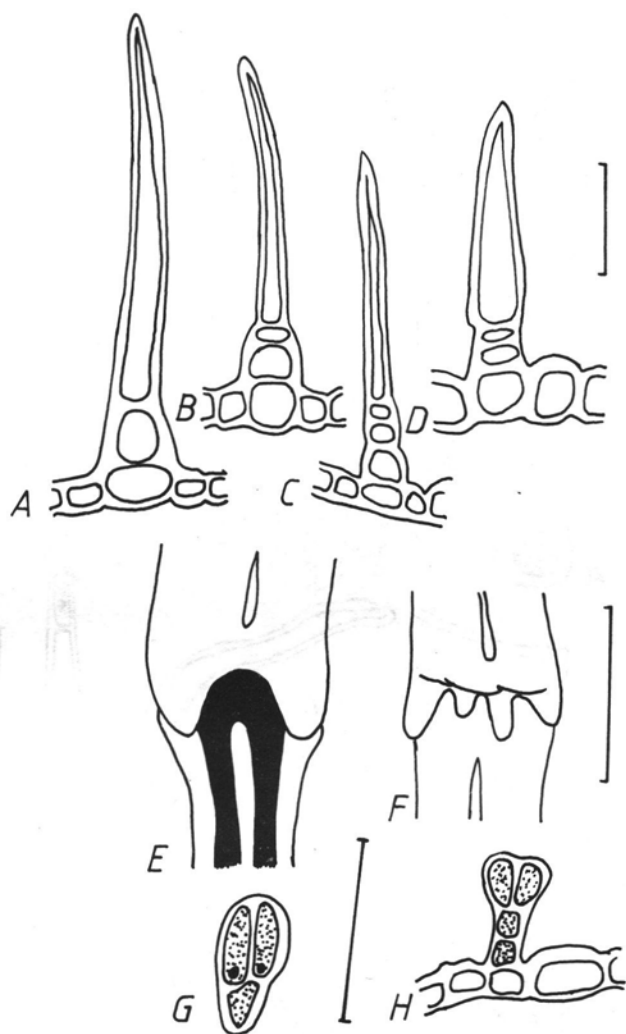


Fig. 7. *Plantago bellardii* All. hairs from a scape: A-D — “dagger-like” hairs with an unicellular 2- and 3-celled base; E, F — fragments of headless hairs with a multicellular stalk — the composition of two cells (appendices); G — typical hair with an unicellular stalk and a two-celled head; H — non-typical with two-celled stalk. Scale bar — 0.1 mm, only E, F — 0.05 mm

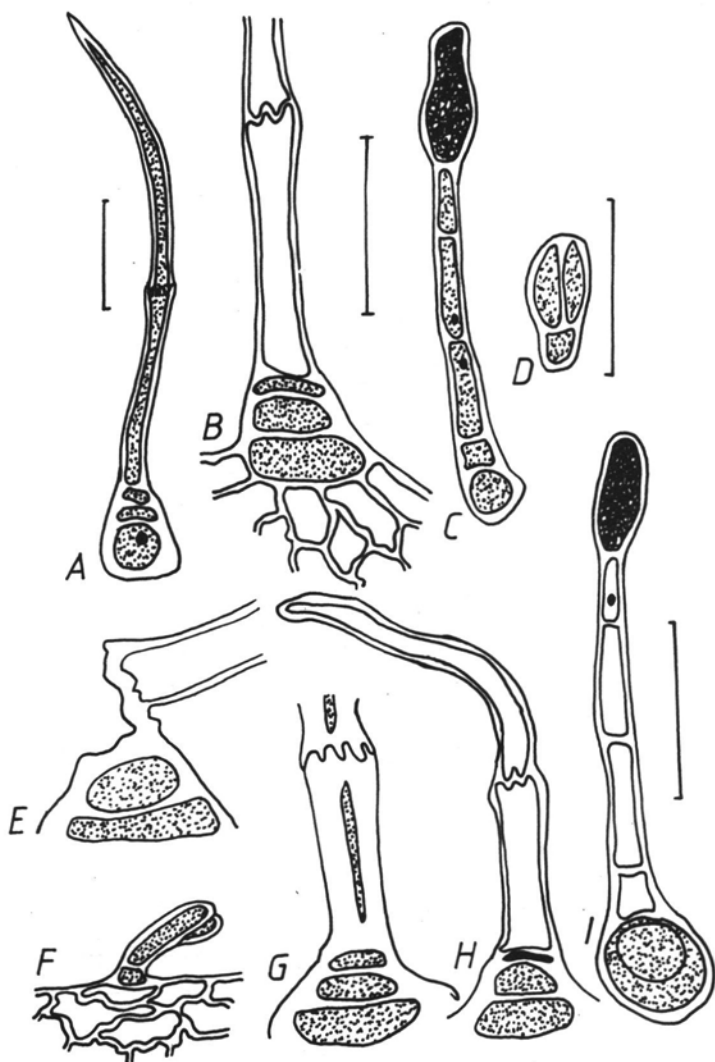
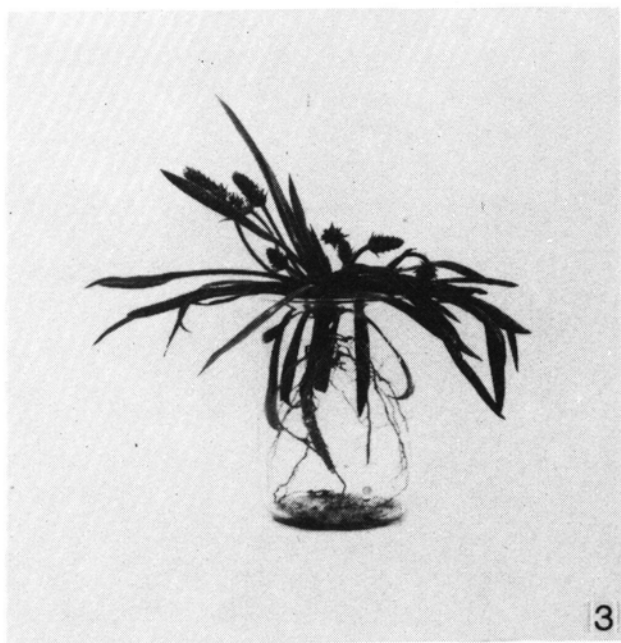
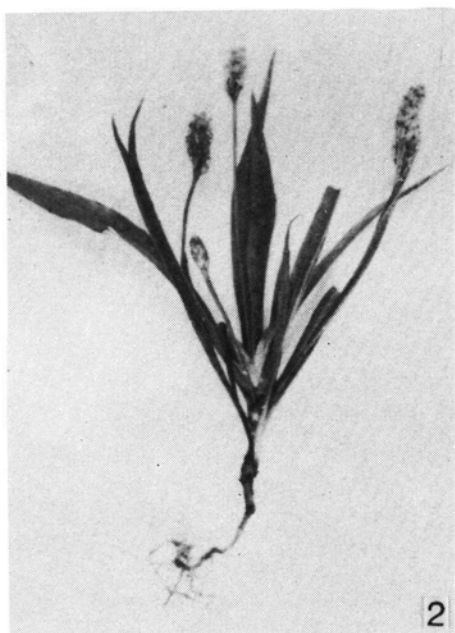


Fig. 8. *Plantago bellardii* All. hairs from flower elements: A-D — from a bract; E-I — from a calyx; A — headless hair with a three-celled base; B — fragment of a headless hair from a bract edge (a basal cell, a two-celled base and a characteristic combination of cells); C — hair with a flask-like head; D, F — hairs with unicellular stalk and two-celled head; E — typical shedding of a headless hair stalk; G — fragment of a headless hair with a typical base and a characteristic combination of thick-walled cells (appendices); H — headless hair with a typical base and a characteristic composition of thin-walled cells (appendices); I — hair with a flask-like head. Scale bar — 0.1 mm





Figs. 1-3. Plants cultivated by the authors: 1. *Plantago hookeriana* Fisch. et Mey,  $\times 0.3$ ; 2. *Plantago ovata* Forsk.,  $\times 0.5$ ; 3. *Plantago bellardii* All.,  $\times 0.5$

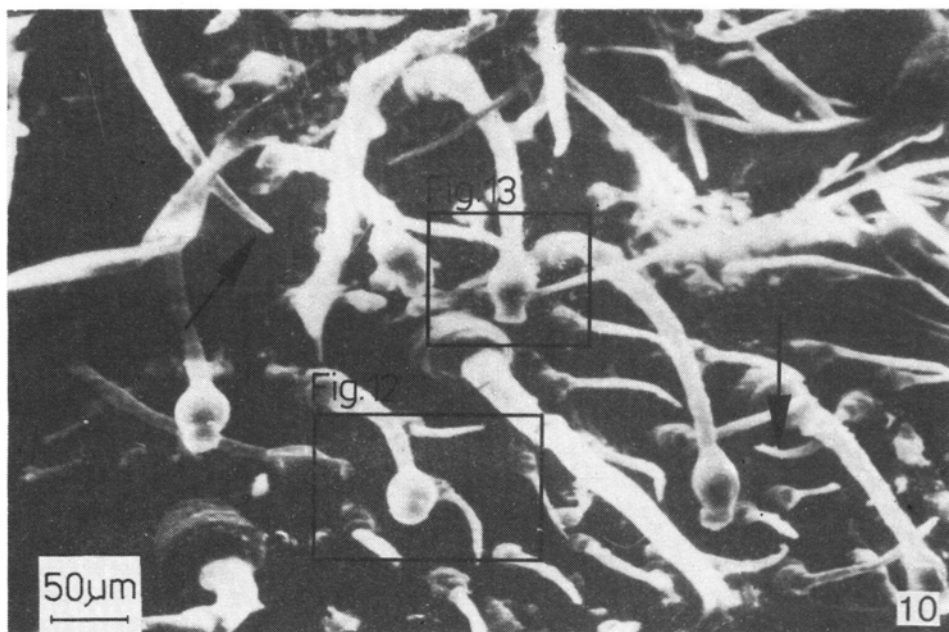
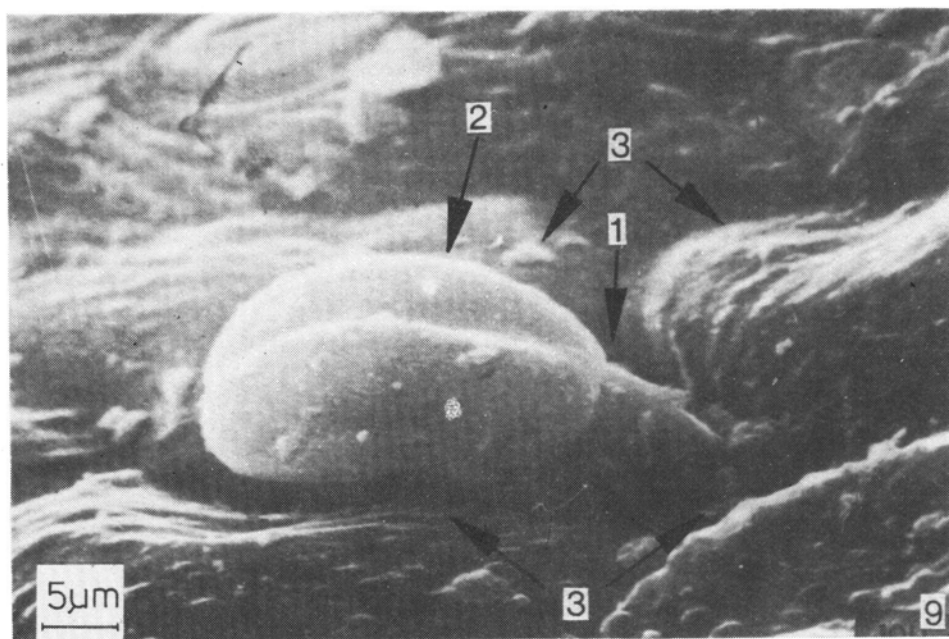


Fig. 9. Hair with an unicellular stalk (1) and a two-celled head (2) on a leaf of *Plantago bellardii* All., surrounding cells (3),  $\times 2000$

Fig. 10. Hairs with a flask-like head among headless hairs (arrows) on a bract of *Plantago bellardii* All. The marked parts of the picture are shown in enlargement: Figs. 12, 13,  $\times 200$

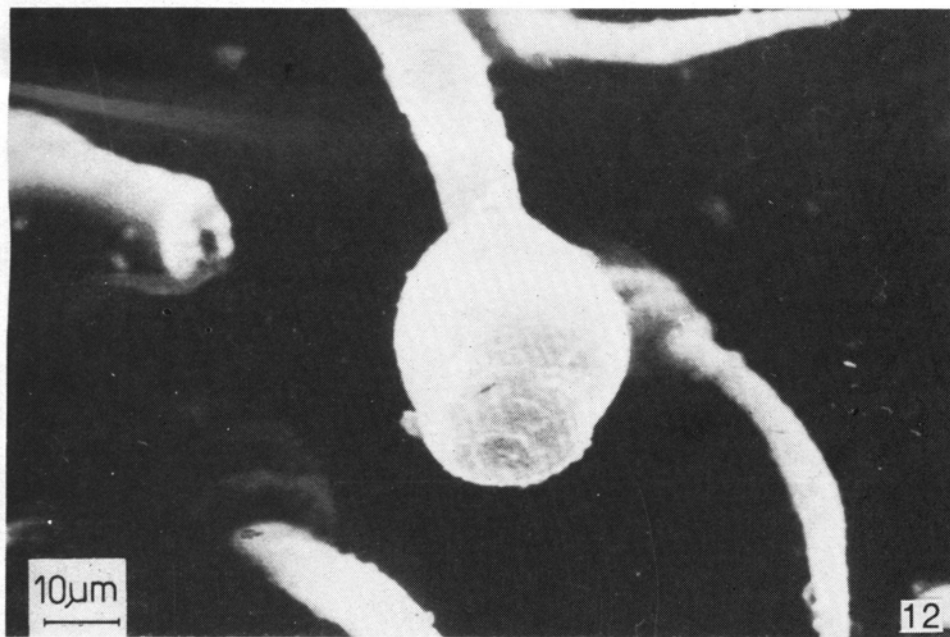
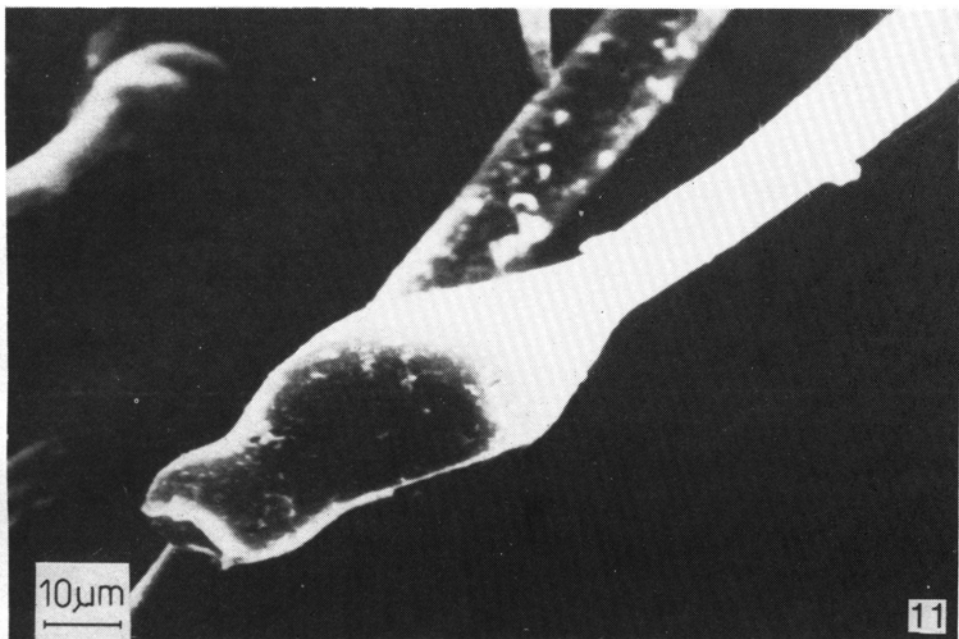


Fig. 11. Fragment of a hair with a flask-like head, from a bract of *Plantago bellardii* All.,  $\times 1000$

Fig. 12. Flask-like head of the hair from the bract of *Plantago bellardii* All.,  $\times 1000$

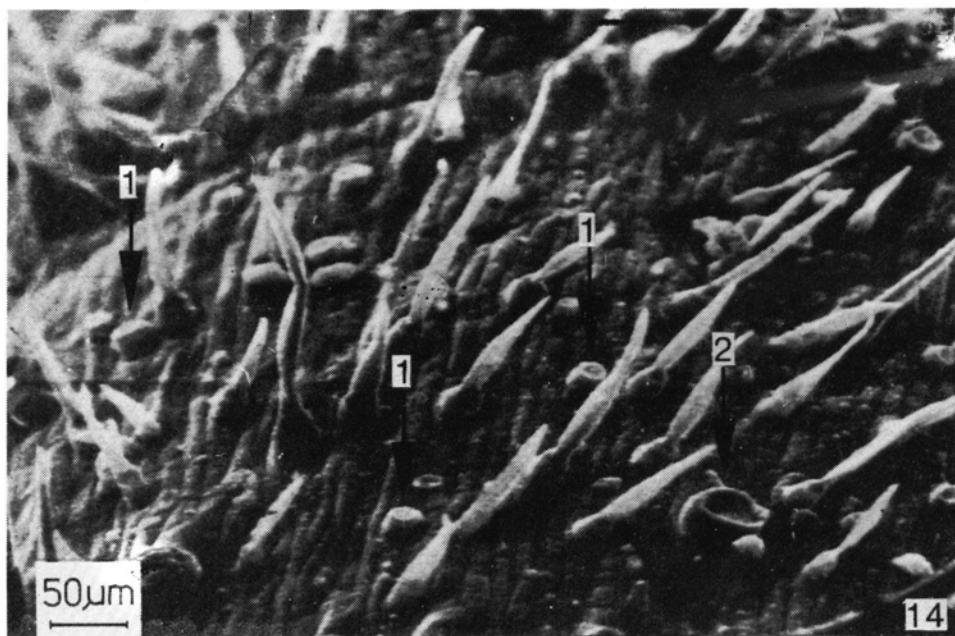
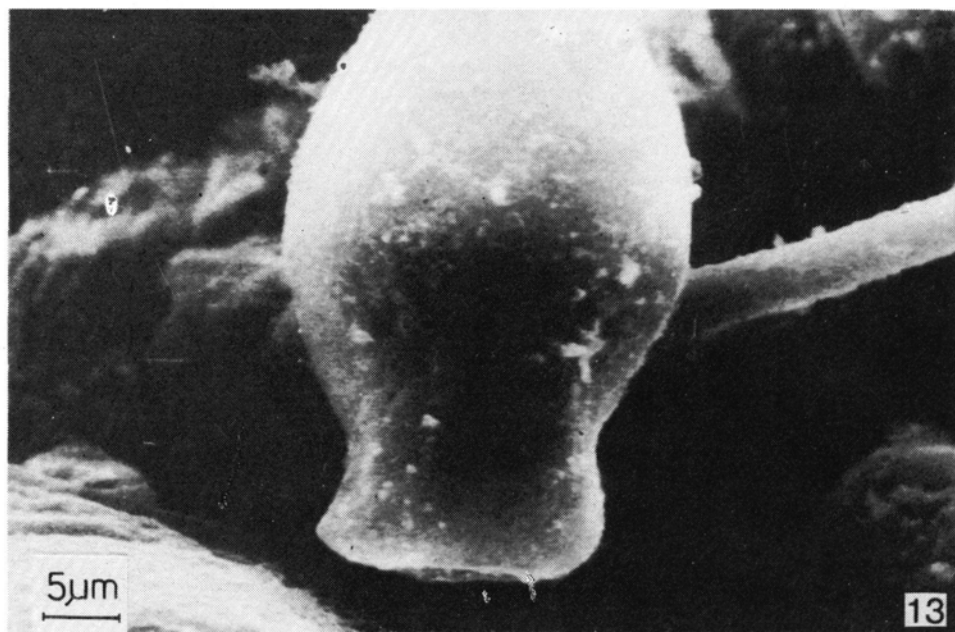


Fig. 13. The ending of another flask-like head,  $\times 2000$

Fig. 14. Headless "dagger-like" hairs on the scape of *Plantago bellardii* All., "traces" of headless hairs — arrows: 1 — dagger-like hairs, 2 — hairs with larger number of stalk cells,  $\times 100$

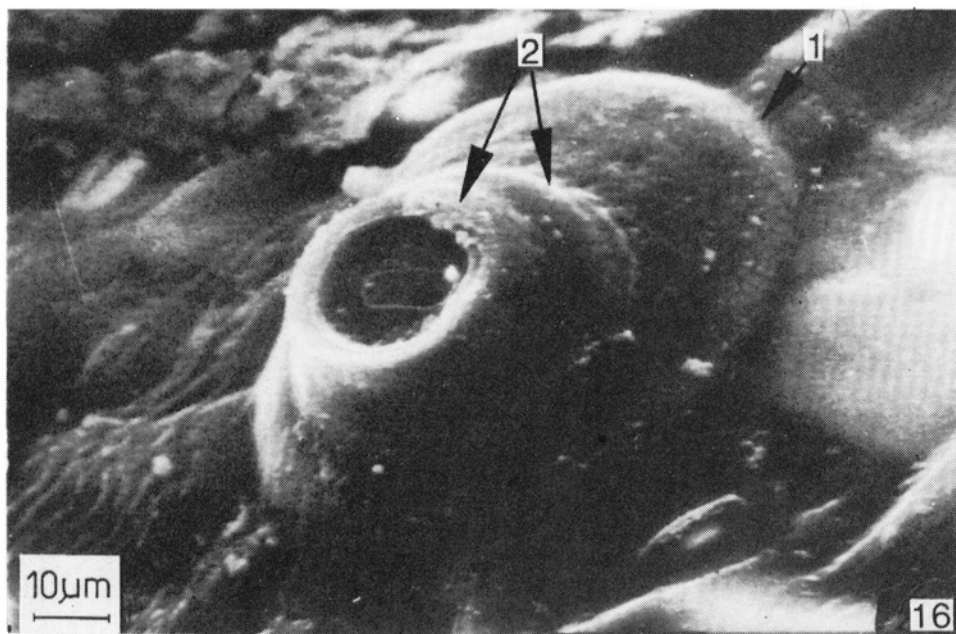
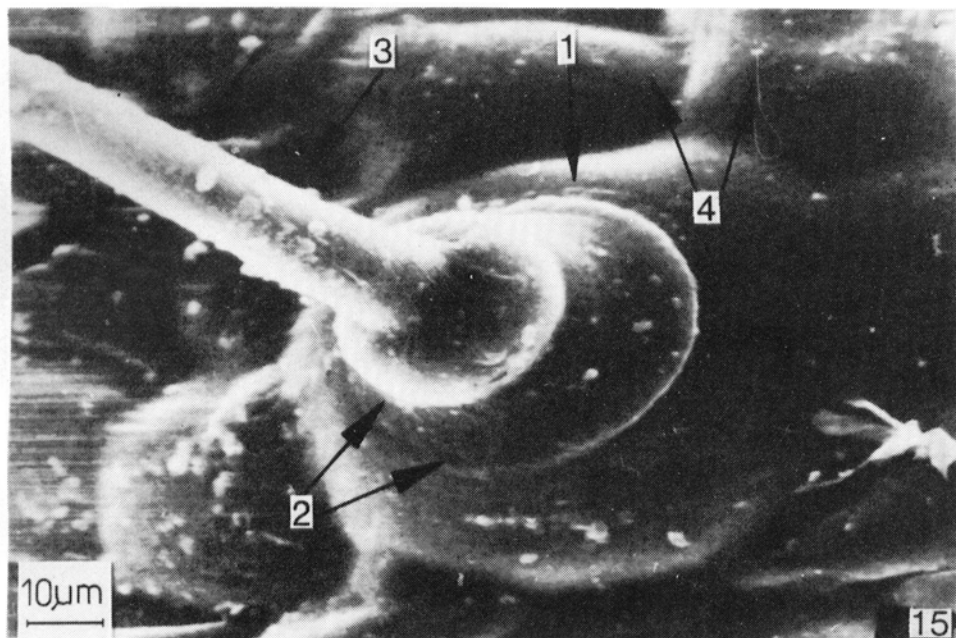


Fig. 15. *Plantago bellardii* All.: headless hair base, 1 — a basal cell, 2 — the first short cells of the stalk, 3 — an elongated cell of the stalk, 4 — surrounding epidermal cells,  $\times 1000$

Fig. 16. *Plantago bellardii* All.: "trace" of a headless hair, 1 — a basal cell, 2 — the first cells of the stalk,  $\times 1000$



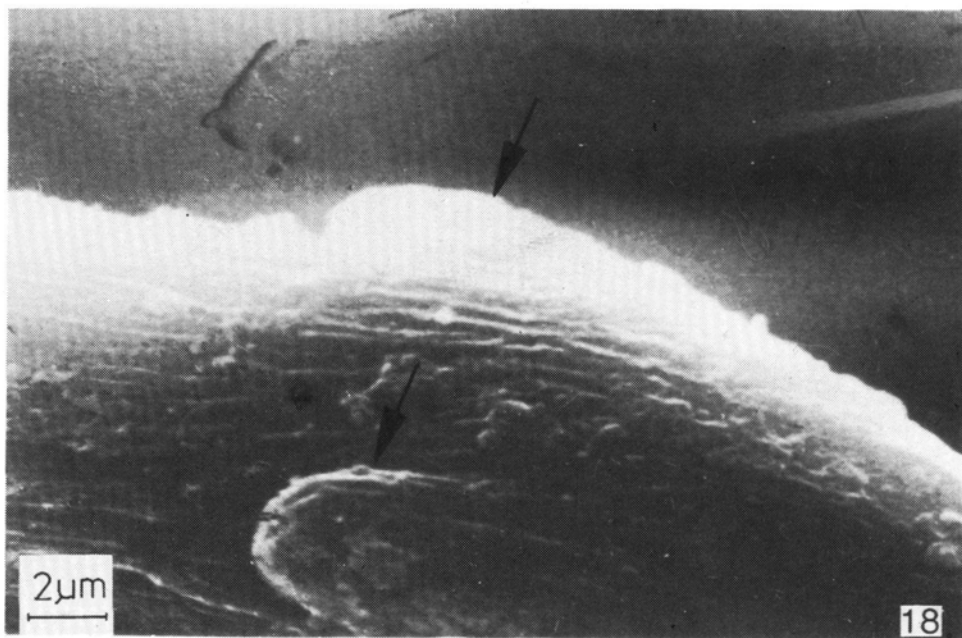
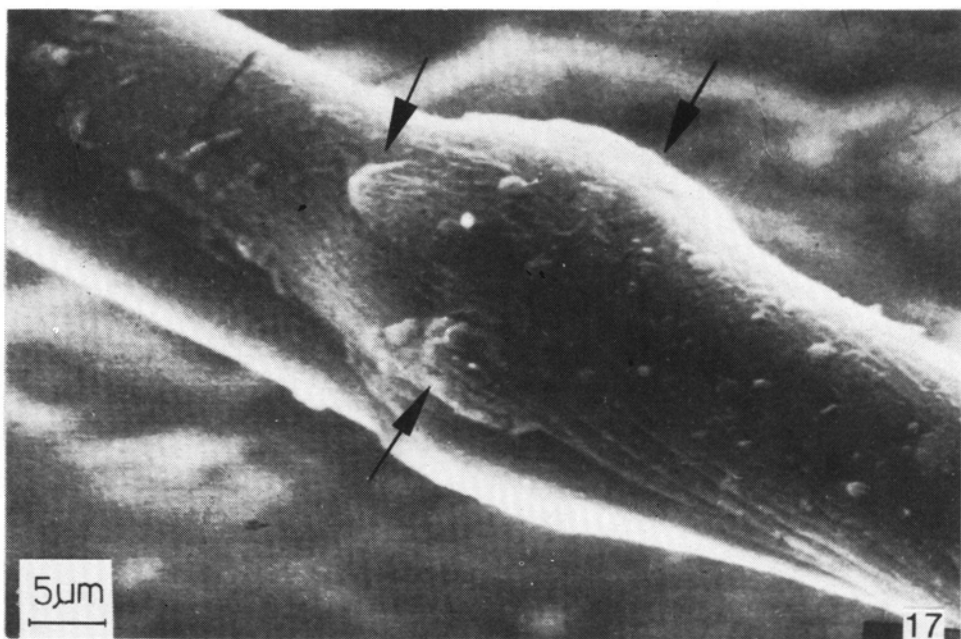


Fig. 17. Combination of two headless hair cells of *Plantago bellardii* All., (arrows — appendices),  
× 2000

Fig. 18. Appendices (arrows) of a headless hair *Plantago bellardii* All., × 5000

hairs were torn (Fig. 11). This may have been caused either by mechanical damage or by physiological phenomena connected with their secretory function.

#### HEADLESS HAIRS

The headless hairs were similar in the studied species. Four types of them could be distinguished. The first one (Figs. 4 D, H, M; 5 Y; 6 B, C, F; 7 A-D; 10 (arrows), 14) had a large basal cell protruding above other epidermal cells. The stalk base was composed of one (*Plantago hookeriana*, *Plantago ovata*), two or three (*Plantago hookeriana*, *Plantago bellardii*) short cells that stained with Sudan III. There was a tip "dagger-like" cell above the base. The length of the hairs varied from 100 to 300  $\mu\text{m}$ .

We could also observe traces of these hairs formed of a basal cell and one or two cells of the stalk (Figs. 4 R; 14 (arrows-1)). The shedding of the hairs may be the result of mechanical damage or physiological rejection of the hairs (Hummel and Staesche 1962).

Another type of the headless hairs (Figs. 4 L; 5 N, O, X; 8 A, B, G, H; 15) differed from the first by its larger number of stalk cells and the presence of characteristic appendices joining neighbouring cells (Figs. 4 J; 5 G-K; 7 E, F; 8 B, G, H; 17). The appendices were especially numerous and clearly seen in *P. bellardii* (Figs. 7 F; 8 A, G; 17; 18). We also observed traces of these hairs (Figs. 4 N; 14 (arrow-2); 16). The shedding of the hairs was similar to that described above (Figs. 5 F; 8 E).

The third type of the headless hair was characterized by the overlapping of the first cell of the stalk with the next cell (Figs. 4 B, C; 5 R).

There were web-like, 0.5-1.0 cm long hairs (Fig. 6 D) on the base of the leaves and scapes of the three studied taxa. They were composed of a dozen or so to several tens of cells and, according to Pilger (1937), are common in the *Plantaginaceae* family.

The web-like hair of the representatives of sectio *Leucopsyllium* and *Hymenopsyllium* studied by us had at their base, several cells (Fig. 6 D) that stained with Sudan III. Some cells of these hairs combined by means of the appendices (Fig. 6 E).

#### DISCUSSION

The results of our study, similarly as the chemotaxonomic studies of Gorenflot and Bourdu (1962), confirm the accuracy of exclusion of *P. bellardii* by Pilger from the sectio *Leucopsyllium* and the formation of a distinct sectio *Hymenopsyllium* Pilger. In *P. bellardii* there are hairs with a flask-like head distinguishing this species. The form of the head suggests their secretory function. Such hairs have not been described yet in the genus

*Plantago*. However, the majority of the hair types are the same in the representatives of sectio *Leucopsyllium* and *Hymenopsyllium*. The presence of the characteristic appendices joining neighbouring cells of the hairs is the common feature of the investigated taxa.

We plan to study the hairs of the representatives of sectio (subgenus) *Psyllium* and to compare them with the hairs of taxons of sections *Leucopsyllium* and *Hymenopsyllium*, because the latter are regarded as allied to the representatives of genus *Psyllium*. Rahn (1979) even includes the sections *Leucopsyllium* (*Albicans* and *Gnaphaloides*) and *Hymenopsyllium* into subgenus *Psyllium*.

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#### REFERENCES

- Andrzejewska-Golec E., Świątek L., 1984. Badania chemotaksonomiczne rodzaju *Plantago*. I. Analiza frakcji irydoidów. *Herba Polon.* 30: 9-16.
- Andrzejewska-Golec E., Świątosławski J., 1987. Morphology of hairs in species of *Plantago* L. sectio *Coronopus* DC. *Acta Soc. Bot. Pol.* 56: 367-379.
- Barnéoud, 1844. Recherches sur le développ., la struct. génér. et la classific. des Plantaginées et des Plumbaginées. Paris; ders., Monogr. génér. de la famille des Plantaginées, 52.
- Bråttsten J., 1945. Stames och bladets anatomiska byggand hos *Plantago fernandezia* Bert. och *P. pachyphylla* Gray. *Acta Hort. Göteborg* 16: 165-184.
- Dcaisne J., 1852. *Plantaginaceae*, in DC. *Prodr.* XIII. pp. 693-737.
- Gorenflot R., Bourdu R., 1962. Criteries biochimiques et taxonomie experimentale du genere *Plantago*. *Rev. Cytol. Biol. Veg.* 25: 349-360.
- Grigoriew J. S., 1958. Podorożnikowye — *Plantaginaceae* Lindl. In: *Flora SSSR*. Szyszkin B. K. (ed.), AN SSSR, Moskwa. Vol. 23., pp. 157-161.
- Harms H., Reiche C., 1897. *Plantaginaceae*. In: *Die natürlichen Pflanzenfamilien*. Engler A., Prantl K. (eds.), Leipzig. Vol. 4., pp. 363-373.
- Hegi G., 1906. *Illustrierte Flora von Mittel-Europa* T. VI/1. München. pp. 178-194.
- Hummel K., Staesche K., 1962. Die Verarbeitung der Haartypen in der natürlichen Verwandtschaftsgruppen. In: *Handbuch der Pflanzenanatomie* IV (5). Uphof J. C. T. (ed.), Gebrüder Borntraeger. Berlin-Nikolassee. pp. 207-292.
- Janchen E., 1958. Pteridophyten und Anthophyten. In: *Catalogus Florae Austriae*. Höfler K., Kudl T. (eds.), Springer Verlag. Vien. Vol. 1., pp. 549-552.
- Ka'bi Z. Ch., 1961. The genus *Plantago* in Iraq. *Bull. Iraq Natural History Museum* 1: 1-41.
- Moore D. M., 1976. *Plantaginaceae*. In: *Flora Europea*. Cambridge Univ. Press, Cambridge, Vol. 4., pp. 38-44.
- Patzak A., 1964. *Plantaginaceae*. In: *Flora Iranica*. Rechinger K. H. (ed.), Vien. pp. 1-23.
- Payne W. W., 1978. A glossary of plant hair terminology. *Brittonia*. 30: 239-285.
- Pilger R., 1898. Vergleichende Anatomie der Gattung *Plantago* mit Rücksicht auf die Existenzbedingungen. *Bot. J.* 25: 296-351.



- Pilger R., 1937. *Plantaginaceae*. In: Das Pflanzenreich. Engler A., Diels L. (eds.), Verlag von Wilhelm Engelmann. Leipzig. Vol. 4., pp. 1-466.
- Rahn K., 1978a. Nomenclatorial changes within the genus *Plantago* L., intraspecific taxa and subdivisions of the genus. Bot. Tidsskrift 73: 106-111.
- Rahn K., 1978b. *Plantago* ser. *Gnaphaloides* Rahn. A taxonomic revision. Bot. Tidsskrift 73: 137-154.
- Rahn K., 1979. *Plantago* ser. *Ovatae*. A taxonomic revision. Bot. Tidsskrift 74: 13-20.
- Unger W., 1926. Ein Beitrag zur anatomischen Kenntnis der Krauterd (*Folia Plantaginis*). Arch. Pharmazie 264: 754-762.
- Vesque J., 1885. Plantaginées. Ann. Sc. Nat. 7: 349-356.
- Volgens G., 1887. *Plantaginaceae*. Fl. Aegypt.-Arab. Wüste 15: 137-138.

### *Morfologia włosków u gatunków Plantago L. Sekcje: Leucopsyllium Decne i Hymenopsyllium Pilger*

#### Streszczenie

Zbadano włoski następujących przedstawicieli rodzaju *Plantago* z sekcji *Leucopsyllium* Decne: *Plantago ovata* Forsk. i *P. hookeriana* Fisch. et Mey. oraz z sekcji *Hymenopsyllium* Pilger: *P. bellardii* All. Stwierdzono występowanie trzech typów włosków główkowych i czterech typów włosków bezgłówkowych. *P. bellardii* charakteryzuje się obecnością na przysadce i kielichu włosków o czterekomórkowym trzonku i jednokomórkowej główce butelkowatego kształtu. Do tej pory nie opisano tego typu włosków u przedstawicieli *Plantago*. Wspólną cechą badanych taksonów jest obecność wypustek łączących poszczególne komórki włoska. Cecha ta wyróżnia sekcje *Leucopsyllium* i *Hymenopsyllium* spośród innych sekcji rodzaju *Plantago*. Wyniki naszej pracy, podobnie jak chemotaksonomiczne badania Gorenflota i Bourdu (1962), potwierdzają słuszność wyłączenia przez Pilgera *Plantago bellardii* z sekcji *Leucopsyllium* Decne i umieszczenia tego gatunku w odrębnej, nowo utworzonej przez niego, sekcji *Hymenopsyllium* Pilger.