The morphology of hairs in taxa of the genus *Plantago* L. Sections: *Polyneuron* Decne and *Lamprosantha* Decne

EMILIA ANDRZEJEWSKA-GOLEC*, JACEK ŚWIĘTOSŁAWSKI**

*Department of Biology and Pharmaceutical Botany, Institute of Environmental Research and Bioanalysis, Medical Academy, Muszyńskiego 1, 90-151 Łódź, Poland

**Laboratory of Electron Microscopy, Institute of Pathology, Medical Academy, Sterlinga 5, 91-425 Łódź, Poland

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Abstract

The hairs of above-ground parts (leaf, scape, bract, calyx) of 10 taxa from the section *Polyneuron* Decne and three from section *Lamprosantha* Decne are very similar. The presence of one type of headed hairs and three types of headless hairs was found in all of the studied taxa. The headed hairs are built analogically. The headless hairs in the taxa of section *Polyneuron* are composed of 3-4 cells, while in the taxa of section *Lamprosantha*, of 6-7 cells. *P. japonica* Franchet et Savat. f. *polystachya* Makino distinguishes itself among all the studied taxa because of the presence of a small basal cell in the headless hairs made up of several cells.

Key words: genus *Plantago* L., section *Polyneuron* Decne, section *Lamprosantha* Decne, hairs, scanning electron microscopy

INTRODUCTION

Sections: *Polyneuron* Decne (syn. *Plantago*) and *Lamprosantha* Decne are assigned to subgenus *Plantago* (syn. *Euplantago* Harms), genus *Plantago* L. (Pilger 1937, Grigoriev 1958, Rahn 1978). Pilger (1922, 1937) includes 14 species in section *Polyneuron*, among which only *Plantago major* L. is a European plant. Since this is a species of great variety, there is much diversity as far as its division into smaller systematic units is concerned (Pilger 1922, 1937, Jain 1978, Pěnková 1986). According to Pilger (1923, 1937) 3 species, among them one European — *Plantago media* L., belongs to section

Lamprosantha. *P. major* and *P. media* appear commonly in Poland (Tacik 1967, Szafer et al. 1986).

P. major was taken from Europe to various parts of the world and nowadays it is treated as a nearly cosmopolitan species (Pilger 1937, Tacik 1967). *P. media* occurs not only in Europe but also in Asia and North America (Pilger 1937, Bassett 1967, Tacik 1967). Recently a Canadian taxon — *P. rugelii* Decne has settled in Europe (Hawthorn 1974) and has become a successful worldwide weed (Meagher et al. 1978). Interesting forms *P. major* (*P. major* L. *purpurea*, *P. major* L. *rosularis*) and *P. media* are occasionally grown as ornamental plants (Wehrhahn 1931, Pilger 1937, Hawthorn 1974).

Since the leaves of *P. major* and *P. media* have been used as medicinal material since ancient times (Dobrowolski 1938, Piroznikow 1985, Czikow and Laptiew 1987) their structure, including hair morphology is well known.

Vesque (1885) found the presence of hairs with a unicellular stalk and a head vertically divided into two cells in *P. media*. He also observed such hairs in some other representatives of *Plantaginaceae* family and regarded them as characteristic for this family. The studies of a great number of species of genus *Plantago* confirmed his presumption (Andrzejewska-Golec and Świętosławski 1987, 1989, in press). Fuchs (1932) and Fisher (1937) described such hairs not only in *P. media* but also in *P. major*. According to the former author there is a slight difference between the appearance of hairs with a two-celled head in *P. major* and in *P. media* (longer head cells in *P. media*); the latter author claims that they are identical. According to Fuchs (1932) and Fisher (1937), the headless hairs in both taxa are also similar. However, both their length (*P. major* — 130-140 μm , *P. media* — 0.8-2 mm) as well as the number of stalk cells differ significantly. The stalk of headless hairs in *P. major* consists of only 3-4 cells while the stalk of *P. media* hairs usually has more cells. Fuchs (1932) reports 3-5 cells for *P. major* and 7-9 cells for *P. media*, while according to Fischer (1937), the number of cells in *P. media* hairs is from 4 to 8, usually 6. According to Fuchs (1932) there are no differences in the cuticle of headless hairs in *P. major* and *P. media* and it is slightly verrucose ("fein gewarzt"). Fischer (1937) claims that the cuticle of headless hairs in *P. media* is slightly verrucose ("fein gekörnt") while the cuticle of those hairs in *P. major* is thickly verrucose ("grob gekörnt"). The hair surface may be important from the taxonomical point of view. E. g. Dehgan (1980) pointed to its taxonomic significance in the genus *Jatropha* (*Solanaceae*). According to him it is possible to differentiate the representatives of two subgenera of this taxon on the basis of the hair surface. Edmonds (1982) found that the surface of glandular multicellular hairs in taxa of the genus *Solanum* are always verrucose, while glandular hairs may have a smooth or verrucose surface.

One of the differences between the closely related species *P. media* and *P. stepposa* Kuprian. (syn. *P. media* var. *urvilleana* Rapin) is, according to

Kazanfarova and Gasanov (1973), the presence of 3-celled hairs on the leaf of *P. media*, while in *P. stepposa* they are longer and consist of 5-7 cells (see above — the description of headless hairs *P. media* according to Fuchs and Fischer). According to Kazanfarova and Gasanov (1973) *P. media* is characterized by the presence of glandular hairs on the leaf and the hairless scape, in contrast to *P. media* where there are only nonglandular hairs on leaves and the scape is haired.

The present study is a continuation of the studies performed on the hairs of the representatives of various *Plantago* sections (Andrzejewska-Golec and Świątosławski 1987, 1988, 1989, in press) and also gives data for taxa which have not been investigated till now.

MATERIAL AND METHODS

The hairs of above-ground parts (leaf, scape, bract, calyx, corolla) of 10 taxa belonging to section *Polyneuron* and 3 belonging to section *Lamprosantha* were studied. The plants (Figs. 1-4) had been grown from seeds obtained from various botanical gardens by Andrzejewska-Golec (field culture). The identity of the taxa was confirmed with the use of appropriate keys and descriptions (Pilger 1937, Tacik 1967, Moore 1976). The following taxa were studied:

Section *Polyneuron* Decne:

1. *P. major* L. [Strzyżów],
2. *P. major* f. *cruenta* (Holuby) Pilger [Leipzig],
3. *P. major* subsp. *intermedia* (DC.) Arcangeli [Copenhagen],
4. *P. major* L. *rosularis* [London],
5. *P. major* L. *artropurpurea* [Cean],
6. *P. major* L. *rubra* [Bratislava],
7. *P. major* "Rubrifolia" [Copenhagen],
8. *P. major* L. *purpurea* [Poznań],
9. *P. rugelii* Decne [Antwerp],
10. *P. japonica* Franchet et Savat. f. *polystachya* Makino [Tokyo];

Section *Lamprosantha* Decne:

1. *P. media* L. [Gdańsk],
2. *P. media* L. var. *media* [Bonn],
3. *P. stepposa* Kuprian. [Leipzig].

The material was collected during florescence and fructification (August-October 1984-1987). Fresh material as well as that conserved in 70° ethanol was used. The leaf base, petiole and leaf lamina were studied. Hairs from three parts of the scape: its base, middle section, top section (below the spike) were examined. In the case of the bract and calyx, we examined the base, membranous part and nerve or green middle belt. The corolla, which is membranous in the representatives of genus *Plantago*, was studied as a whole.

The preparations were observed under a light microscope. The figures were drawn with the use of Abbe's apparatus. A scanning microscope was also used.

Table 1
Hair types occurring in sectio *Polyneuron* Decne

Plant	The investigated part of the plant*		Headed hairs	1-3-celled -conical	Headless hairs			Multicellular (web-like)
					consisting of several cells			
					perpendicular to the epidermal surface	parallel to the epidermal surface		
		with small discoid cell	without small discoid cell					
<i>Plantago major</i> L. (Strzyżów)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	—	—	—	—	—
<i>Plantago major</i> L. f. <i>cruenta</i> (Holuby) Pilger (Leipzig)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	—
		middle section	+	—	—	—	+	+
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—

<i>Plantago major</i> L. subsp. <i>intermedia</i> (DC.) Arcangeli (Copenhagen) syn. <i>Plantago intermedia</i> DC.	B	base	—	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
<i>Plantago major</i> L. <i>rosularis</i> " (London)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
<i>Plantago major</i> L. <i>artropurpurea</i> (Cean)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
<i>Plantago major</i> L. <i>rubra</i> (Bratislava)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	—	—
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	+	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	—	—	—	—	—

<i>Plantago major</i> L. "Rubrifolia" (Copenhagen)	L	base	—	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base		—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
	B	base	—	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
<i>Plantago major</i> L. <i>purpurea</i> (Poznań)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
<i>Plantago rugelii</i> Decne (Antwerp)	L	base	—	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
<i>Plantago japonica</i> Franch. et Sav. f. <i>polystachya</i> Makino (Tokyo)	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	—	—	—	—	—	+
		middle section	+	—	—	+	—	—
		upper section	+	—	—	+	—	—
	B	base	—	—	—	—	—	—
		nerve scarious margin	+	—	—	—	—	—
		edge	—	—	—	—	—	—
	C	green belt scarious margin	+	+	—	—	—	—
		edge	—	+	—	—	—	—

* L — leaf, S — scape, B — bract, C — calyx.

** Perhaps synonym *P. rosea* Decne, *bracteata* Moench, *P. major* L. var. *bracteata* Schlechtend, *P. major* f. *monstr. bracteata* Pilger (Pilger 1922, 1937), taxon known in garden as the Rose Plantain. The flower-spike replaced by a rose-like rosette of blunt green-bracts.

Table 2
Hair types occurring in sectio *Lamprosantha* Decne

Plant	The investigated part of the plant*		Headed hairs	Headless hairs			
				1-3-celled -conical	consisting of several cells		Multicellular (web-like)
					perpendicular to the epidermal surface	parallel to the epidermal surface	
					with small discoid cell	without small discoid cell	
<i>Plantago media</i> L. (Gdańsk)	L	base	+	—	—	—	+
		petiole, lamina	+	—	+	—	—
	S	base	+	—	—	—	+
		middle section	+	—	—	+	—
		upper section	+	—	—	+	—
	B	base	+	—	—	—	+
		nerve scarious margin	+	—	—	—	—
		edge	—	+	—	—	—
	C	green belt scarious margin	—	—	—	—	—
		edge	—	+	—	—	—
<i>Plantago media</i> L. var. <i>media</i> (Bonn)	L	base	—	—	—	—	+
		petiole, lamina	+	—	+	—	—
	S	base	—	—	—	—	+
		middle section	+	—	—	+	—
		upper section	+	—	—	+	—
	B	base	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—
		edge	—	+	—	—	—
	C	green belt scarious margin	+	—	—	—	—
		edge	—	+	—	—	—

<i>Plantago</i> <i>stepposa</i> Kuprian. (Leipzig) syn. <i>P. media</i> L. var. <i>urvilleana</i> Rapin <i>P. media</i> var. <i>longifolia</i> Meyer	L	base	+	—	—	—	—	+
		petiole, lamina	+	—	+	—	—	—
	S	base	+	—	—	—	—	+
		middle section	+	—	—	—	+	—
		upper section	+	—	—	—	+	—
	B	base	+	—	—	—	—	+
		nerve scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—
	C	green belt scarious margin	+	—	—	—	—	—
		edge	—	+	—	—	—	—

* — See notes to Table 1.

RESULTS

The hairs from the leaf, scape, bract, calyx and corolla of 13 taxa of subgenus *Plantago* (*Euplantago*) from two sections: *Polyneuron* Decne and *Lamprosantha* Decne were studied. The results are shown in Tables 1 and 2, Figures 5-42. The corolla of all the studied taxa turned out to be hairless. No differences in types of hairs on the petiole and leaf lamina as well as on the middle section (nerve or green belt) and the membranous part of the bract and calyx were found.

In the studied representatives of both sections there were two types of hairs: headed and headless.

HEADED HAIRS

Headed hairs were observed in all of the studied organs (except the corolla) of the representatives of sections *Polyneuron* and *Lamprosantha*. They were most numerous on the leaf. On the scape they were rare and often deformed (Fig. 40). Their appearance was analogous in all of the studied taxa (Figs. 5-8). They were built of a small basal cell, short unicellular stalk and a head divided vertically into two cells. The length of the hairs varied from 50-250 μm . The basic cell was situated among (2-) 4-5 (-7) surrounding cells much bigger than

4 cm

1

2 cm

2

Fig. 1. *Plantago japonica* Franchet et Savat. f. *polystachya* Makino, x 0.25. Fig. 2. *Plantago major* f. *cruenta* (Holuby), Pilger, x 0.5

PLATE II

3.3cm

3

3.3cm

4

Fig. 3. *Plantago major* L. subsp. *intermedia* (DC.) Arcangeli, x 0.3. Fig. 4. *Plantago major* L. *rosularis*, x 0.3

the basal cell itself (Figs. 5A, N; 7N, 26). Scanning studies showed that the cuticula covering the hairs was smooth (Figs. 26, 32). The stalk cell was cutinized (it could be stained intensively with Sudan III).

As can be concluded from bibliography and our earlier studies, headed hairs are common in the representatives of the majority of *Plantago* sections (Vesque 1885, Unger 1926, Fuchs 1932, Fischer 1937, Andrzejewska-Golec and Świętosławski 1987, 1988, 1989, in press). Their absence in *P. lanceolata* is the feature differentiating the leaves of *P. lanceolata* from the leaves of *P. media* and *P. major*, which may have a practical meaning in differentiating the material (Fuchs 1932). It has turned out that their absence is characteristic for section *Arnoglossum* Decne, one of the representatives of which is *P. lanceolata* (Andrzejewska-Golec and Świętosławski 1989a).

Untypical hairs could be sometimes noticed, but they cannot be regarded as characteristic for the taxa given. The typical shape of the head is oval but there were hairs with clearly elongate head cells. We did not observed,

Fig. 5. Headed hairs in the taxa of section *Polyneuron*; A-D — *P. major* L.: A — from a leaf lamina, B — from a superior part of a scape, C — from a bract, D — from a calyx. E-J — *P. major* f. *cruenta* (Holuby) Pilger: E, F — from a leaf petiole, G — from a leaf lamina, H, I — from the central part of a scape, J — from the superior part of the scape, K-N — *P. major* L. subsp. *intermedia* (DC.) Arcangeli: K — from a leaf petiole; L, M — from a leaf lamina; N — from a bract; O-S — *P. major* L. *rosularis*: O — from a leaf base; P, Q — from a leaf lamina, R, S — from a central part of the scape; T-Z — *P. major* L. *artropurpurea*: T — from a leaf base; U — from a leaf petiole; X — from a leaf lamina; X — from a scape base; Z — from the superior part of the scape. Scale bar 0.1 mm

Fig. 6. Headed hairs in the taxa of section *Polyneuron*. A-F — *P. major* L. *rubra*: A — from a leaf petiole; B — from the superior part of the scape; C — from a bract; D-H — *P. media* L. var. part of a scape; F — from a calyx; G-M — *P. major* L. "*Rubrifolia*": G, H — from a leaf base; I — from a leaf lamina; J-L — from the superior part of the scape; M — from a bract; N-Z — *P. major* L. *purpurea*: N-P — from a leaf petiole; R-Z — from a leaf lamina. Scale bar 0.1 mm

Fig. 7. Headed hairs in the taxa of section *Polyneuron*. A-F — *P. rugelii* Decne: A-D — from a leaf petiole; E — from a leaf lamina; F — from a scape; G-N — *P. japonica* Franchet et Savat. f. *polystachya* Makino: G, H — from a leaf base; I-K — from a leaf lamina; M, N — from a calyx. Scale bar 0.1 mm

however, a difference in the length of head cells in *P. media* (Figs. 8A-C, 32) and *P. major* (Figs. 5A-D, 26), as was observed by Fuchs (1932).

The head cells of typical hairs were more or less identical. Hairs with heads formed of cells varying significantly in size were rare (Figs. 6U, 7I). There were also hairs with untypical numbers of cells: with three head cells (Fig. 6R) or with two stalk cells (Fig. 6S, T).

Fig. 8. Headed hairs in the taxa of section *Lamprosanthia*. A-C — *P. media* L.: A — from a leaf petiole; B — from the superior part of the scape; C — from a bract; D-H — *P. media* L. var. *media*: D — from a leaf lamina; E — from the base of the scape; F — from the superior part of a scape, G — from a bract; H — from a calyx; I-T — *P. stepposa* Kuprian.: I-K — from a leaf petiole; L — from a lamina; M, N — from the central part of the scape; O — from the superior part of a scape; R, S — from a bract; T — from a calyx. Scale bar 0.1 mm

HEADLESS HAIRS

Three types of headless hairs: 1) 1-3 cellular conical (Figs. 9, 41, 42), 2) consisting of several cells (Figs. 11-19, 25, 31, 39) and 3) web-like (Figs. 20-23) occur commonly in the representatives of the studied sections.

Conical hairs 20-100 μm long are formed of a basal cell, not different from surrounding cells, and of one, sometimes two or three stalk cells. Such hairs occur on the edge of the bract and calyx in all of the studied taxa.

Simple hairs, 100-950 μm long consisting of several cells have a big, round basal cell different from surrounding cells and (3)4-6(7) stalk cells. The number of surrounding cells varies from 6 to 15 (Figs. 12C, 13D, 14C, 15K). The top cell is usually smaller than other stalk cells and it is often pointed (Figs. 36, 39). The first and the second cells of the stalk usually overlap. The hairs of the leaf are placed more or less perpendicularly to the epidermal surface, on the scape they are, on the other hand, parallel to this surface (Fig. 16A). This is related to the way in which the first stalk cell is joined with the basal cell. In the hairs from the bottom and middle section of the scape the junction between the basal and stalk cells occurs near the base (Fig. 11C), while in the hairs from the upper section, the junction can be found in the middle part of the first stalk cell (Fig. 11E-G). These hairs are similarly built in the studied taxa. The only exception is *P. japonica* Franchet et Savat f. *polystachya* Makino where a small

Fig. 9. Headless (conical) hairs in the taxa of section *Polyneuron* — A-N and *Lamprosanthia* — O-U: A — *P. major* L. — from a bract; B-D — *P. major* f. *cruenta* (Holuby) Pilger: B — from a calyx; C, D — from a bract; E, F — *P. major* L. subsp. *intermedia*, from a bract; G, H — *P. major* L. *artropurpurea*, G — from a bract, H — from a calyx. I-P — *P. major* L. *rubra* from a bract; J, K — *P. major* L. "Rubrifolia", from a bract. L-N — *P. japonica* Franchet et Savat. f. *polystachya* "Makino": L — from a bract; M, N — from a calyx; O, P — *P. media* L.: O — from a bract; P — from a calyx; R, S — *P. media* L. var. *media*, R — from a bract, S — from a calyx; T-U — *P. stepposa* Kuprian.: T — from a bract, U — from a calyx. Scale bar 0.1 mm, for E, F, K — 0.2 mm, for N, T — 0.05 mm

discoïd cell can be found between a basic cell and stalk cells (Fig. 16A-D). According to Unger (1926), Fuchs (1932) and Fischer (1937) headless hairs of *P. major* have a comparatively short 3-4-celled stalk while headless hairs of *P. media* have long stalk consisting of 6 (Unger 1926, Fisher 1937) or 3-5 (7-9) cells (Fuchs 1932).

On the basis of our studies it can be assumed that a 3-4-celled stalk is characteristic not only of *P. major* but also of all representatives of section *Polyneuron* (Figs. 10-16), the (5)6-7-celled stalk is characteristic not only of *P. media* but also of other representatives of section *Lamprosanthia* (Figs. 17-19). Hairs consisting of 5-6 cells could also be found in taxa of the section *Polyneuron* (Figs. 10G, O; 12K, M; 13F) but only sporadically. The headless hairs on the scape were often damaged. We observed "cratered" traces of these hairs made up of a basal cell (Fig. 24). Similar traces occurred (rarely) on the leaf (Fig. 27). The shedding of the hairs may be the result of mechanical damage or physiological rejection (Hummel and Staesche 1962). The surfaces of the headless hairs of *Plantago major* L. (Figs. 29) and *P. rugelii* Decne (Figs. 30) are very similar (section *Polyneuron* Decne). The surfaces of the headless hairs

Fig. 10. Headless hairs in the taxa of section *Polyneuron*. A-J — *P. major* L.: A, B — from a leaf petiole; C, D — from a leaf lamina; E — from the central part of the scape, F-J — from the superior part of the scape; K-S — *P. major* f. *cruenta* (Holuby) Pilger: K-M — from a leaf lamina; N, O — from the central part of the scape; P-S — from the superior part of a scape. Scale bar for A, B, D, E, I, K, M, N — 0.1 mm, for C, F; G, H, L, O, R, S — 0.2 mm, for J — 0.05 mm

Fig. 11. Headless hairs in *P. major* L. subsp. *intermedia* (section *Polyneuron*); A — from a leaf petiole, B — from a leaf lamina, C — from the central part of a scape; D-G — from the superior part of a scape. Scale bar 0.1 mm

of *Plantago media* L. (Figs. 33) and *P. stepposa* Kuprian. (Figs. 37) are also very similar (section *Lamprosantha* Decne).

Web-like hairs occur on the base of the leaf, scape and bract in all of the studied taxa of sections *Polyneuron* and *Lamprosantha*. These hairs consist of 10-45 cells. Their length varies from a few (on the bract base) to a dozen or so millimeters (on the base of the leaf and scape). The walls of the hairs are thin,

Fig. 12. Headless hairs in *P. major* L. *rosularis* (section *Polyneuron*): A-C — from a leaf petiole; D-I — from a leaf lamina; J, K — from the central part of a scape; L, M — from the superior part of a scape. Scale bar 0.1 mm

sometimes, sunken, covered with smooth cuticle. The web-like hairs have single (Figs. 20O, 21S, 22E, 23Z) double (Figs. 21Q, 23P) or triple-rowed bases (Fig. 23N, L). The first cells of the hair are small, nearly square, then increasingly elongated (Figs. 20O, 22E). The top cell is sharp (Figs. 20F, Y, 21O, R), sometimes hooked-ended (Figs. 20M, 21P). Some cells of the web-like hairs are characteristically joined. The web-like hairs are common in many representatives of genus *Plantago* (Pilger 1937, Andrzejewska-Golec and Świątosławski 1987, 1988, 1989, in press).

Fig. 13. Headless hairs in the taxa of section *Polyneuron*. A-H — *P. major* L. *artropurpurea*; A — from a leaf petiole; B-E — from a leaf lamina; F — from the central part of a leaf; G, H — from the superior part of a scape; I-L — *P. major* L. *rubra*: I — from a leaf petiole, J — from a leaf lamina; K, L — from the superior part of a scape. Scale bar A-C, H-J, L — 0.2 mm, D-G, K — 0.1 mm

DISCUSSION

The hairs of the representatives of sections *Polyneuron* and *Lamprosantha* are very similar. The only visible difference is the number of cells in headless hairs built of several cells: 3-4(5,6) celled are characteristic of section *Polyneuron*, (5)6-7 celled for the taxa of section *Lamprosantha*.

Fig. 14. Headless hairs in the taxa of section *Polyneuron*. A-J — *P. major* "Rubrifolia": A, B — from a leaf petiole; C, D — from a leaf lamina, E, F — from the central part of the scape, G-J — from the superior part of a scape; K-O — *P. major* L. *purpurea*: K — from a leaf petiole; L-O — from a leaf lamina. Scale bar — 0.1 mm, for O — 0.05 mm

There is a slight difference in the structure of headless hairs built of several cells on various heights of the scape (different places of joinings between a basal cell and a hair stalk).

On the leaf headless hairs consisting of several cells are perpendicular to the epidermal surface, while on the scape they are parallel to it; this is related to the site where the basal cell and the first cell of the stalk join.

P. japonica Franchet et Savat. f. *polystachya* Makino, distinguishing itself by its ramate spike from among the other studied representatives of sections

Fig. 15. Headless hairs in the taxa of section *Polyneuron*. A-G — *P. rugelii* Decne: A-D — from a leaf lamina; E-G — from a scape; H-K — *P. japonica* Franchet et Savat. f. *polystachya* Makino: H-J — from a leaf petiole; K — from a leaf lamina. Scale bar — C-E, H-J — 0.1 mm; for A, B, F, G — 0.2 mm

Polyneuron and *Lamprosantha*, is the only taxon characterized by the presence of a discoid cell in headless hairs made up of several cells.

According to our observations, in contrast with the studies of Kazanfarova and Gasanov (1973), it is impossible to differentiate taxa of *P. media* from those of *P. stepposa* on the basis of the occurrence and structure of the hairs (see Introduction). Our studies show that: 1) glandular hairs are present

Fig. 16. Headless hairs in the *P. japonica* Franchet et Savat. f. *polystachya* Makino (section *Lamprosantha*): A-B — from the central part of a scape; C, D — from the superior part of a scape. Scale bar 0.1 mm

on the leaf of *P. media* as well as on the leaf of *P. stepposa*, 2) the number of stalk cells of headless hairs in *P. media* is the same as in *P. stepposa*, 3) the scape of both species is haired.

In conclusion we can state that:

1. The presence of one morphological type of headed hairs (a unicellular stalk and head divided vertically into two cells) is characteristic for taxa of sections *Polyneuron* and *Lamprosantha*. These hairs are typical for the representatives of the majority of the genus *Plantago* sections.

2. One to three-celled hairs (conical) and multicellular hairs (web-like) are built analogically to the same hairs in other taxa of the genus *Plantago*.

3. In the same organs in sections *Polyneuron* and *Lamprosantha* headless hairs made up of several cells are analogical. In the taxa of section *Polyneuron* the hairs were composed of 3-4(5) cells, in the taxa of section *Lamprosantha*, of (3,4)6-7 cells.

Fig. 17. Headless hairs in the *P. media* L. (section *Lamprosantha*): A-B — from a leaf lamina; C-E — from a leaf petiole; F, G — from a superior part of a scape; H, I — from the central part of a scape. Scale bar — 0.1 mm; for C-E — 0.05 mm

Fig. 18. Headless hairs in *P. media* L. var. *media* (section *Lamprosantha*): A-C — from a leaf petiole; D, E — from a leaf lamina, F-H — from the central part of a leaf; I — from the superior part of a leaf. Scale bar 0.2 mm, for C — 0.05 mm

Fig. 19. Headless hairs in *P. stepposa* Kuprian. (section *Lamprosantha*): A, B — from a leaf petiole; C-D — from a leaf lamina; E, F — from the central part of a scape; G, H — from the superior part of a scape. Scale bar 0.1 mm, for C — 0.05 mm

Fig. 20. Web-like hairs in the taxa of section *Polyneuron*. A-F — *P. major* L.: A, B — from the base of a leaf; C-F — from the base of a scape; G-N — *P. major* f. *cruenta* (Holuby) Pilger: G-I — from the base of a leaf; J, K — from the base of a scape; L-N — from the base of a bract; O-R — *P. major* L. subsp. *intermedia* (DC.) Arcangeli: O, P — from the base of a leaf; Q, R — from the base of a bract; S-X — *P. major* L. *rosularis*: S — from the base of a leaf; T-Y — from the base of a scape. Scale bar 0.1 mm, for O-S, W — 0.05 mm

Fig. 21. Web-like hairs in the taxa of section *Polyneuron*. A-G — *P. major* L. *artropurpurea*: A-C — from the base of a leaf; D-E — from the base of a scape; F, G — from the base of a bract; H-M — *P. major* L. *rubra*: H, I — from the base of a leaf; J, K — from the base of a scape; L, M — from the base of a bract; N-S — *P. major* L. "Rubrifolia": N, O — from the base of a leaf; P-R — from the base of a scape; S — from the base of a bract; T-W — *P. major* L. *purpurea*, from the base of a leaf. Scale bar 0.1 mm; for D, E — 0.05 mm

Fig. 22. Web-like hairs in the taxa of section *Polyneuron*. A, B — *P. rugelii* Decne, from the base of a scape; C-J — *P. japonica* Franchet et Savat. f. *polystachya* Makino: C-F — from the base of a leaf; G-J — from the base of a scape. Scale bar A-F — 0.2 mm, G — 0.1 mm, H-J — 0.05 mm

Fig. 23. Web-like hairs in the taxa of section *Lamprosanthia*: A-I — *P. media* L.: A-C — from the base of a leaf; D-G — from the base of a scape; H, I — from the base of a bract; J-S — *P. media* L. var. *media*: J-M — from the base of a leaf; N-Q — from the base of a scape; R-S — from the base of a bract; T-Z — *P. stepposa* Kuprian.: T-W — from the base of a leaf; X — from the base of a scape; Z — from the base of a bract. Scale bar 0.1 mm, for I, U, W — 0.05 mm

PLATE III

Fig. 24. The surface of a scape of *Plantago major* L., "trace" of headless hair (arrow), x 1000.
 Fig. 25. The surface of a leaf of *Plantago major* L., 1 — headless hair, 2 — hairs with a unicellular stalk and two-celled head, x 200

PLATE IV

Fig. 26. Hair with a unicellular stalk (1) and two-celled head (2) on a leaf of *Plantago major* L., 3 — surrounding cells, 4 — stoma, x 1000. Fig. 27. "Trace" of a headless hair on a leaf of *Plantago major* L., 1 — surrounding cells, 2 — basal cell, 3 — fragment of first cell of the stalk, x 1000

PLATE V

Fig. 28. The surface of a headless hair of a leaf of *Plantago major* L., combination of two cells (arrow), x 1000. Fig. 29. The top cell of a headless hair of *Plantago major* L., x 2000

Fig. 30. The surface of a headless hair on a leaf of *Plantago rugelii* Decne, 1 — basal cell, 2 — the first cell of the stalk (fragment), x 2000

PLATE VII

Fig. 31. The surface of a leaf of *Plantago media* L., 1 — headless hair, 2 — hair with unicellular stalk and two-celled head, x 100. Fig. 32. Hair with a unicellular stalk (1) and two-celled head (2) on a leaf of *Plantago media* L., x 1000

PLATE VIII

Fig. 33. The surface of a headless hair of a leaf of *Plantago media* L., x 1000. Fig. 34. The surface of a headless hair of a leaf of *Plantago media* L., x 5000

PLATE IX

Fig. 35. The surface of a leaf of *Plantago stepposa* Kuprian., 1 — headless hairs, 2 — hairs with a unicellular stalk and two-celled head, x 50. Fig. 36. Headed hair of a leaf *Plantago stepposa* Kuprian., 1 — six-celled stalk, 2 — basal cell, 3 — top cell, 4 — hairs with a unicellular stalk and two-celled head, x 200

PLATE X

Fig. 37. The surface of a headless hair on a leaf of *Plantago stepposa* Kuprian., combination of two cells (arrow), x 2000. Fig. 38. The surface of a headless hair on a scape of *Plantago stepposa* Kuprian., combination of two cells (arrow), x 2000

PLATE XI

Fig. 39. The surface of a scape of *Plantago stepposa* Kuprian., 1 — headless hair, 2 — trace of headless hairs, x 200. Fig. 40. Characteristic "trace" of a headed hair on the scape of *Plantago stepposa* Kuprian., stalk cell (arrow), x 2000

Fig. 41. Bristle-shaped hairs of a calyx of *Plantago stepposa* Kuprian., (arrows), x 200. Fig. 42. Bristle-shaped hairs of a calyx of *Plantago stepposa* Kuprian., x 1000

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Morfologia włosków w gatunkach rodzaju Plantago L.
Sekcje: Polyneuron Decne i Lamprosantha Decne

Streszczenie

Zbadano włoski nadziemnych części (liść, szypuła kwiatostanowa, przysadka, kielich) 10 taksonów sekcji *Polyneuron* Decne i 3 taksonów sekcji *Lamprosantha* Decne. Okazało się, że włoski przedstawicieli obu tych sekcji są bardzo podobne. U wszystkich badanych taksonów stwierdzono obecność jednego typu włosków główkowych i trzech typów włosków bezgłówkowych. Włoski główkowe u wszystkich zbadanych taksonów są analogicznie zbudowane. Natomiast włoski bezgłówkowe kilkukomórkowe u taksonów sekcji *Polyneuron* składają się z 3-4 komórek, a u taksonów sekcji *Lamprosantha* z 6-7 komórek. Wśród badanych taksonów, *P. japonica* Franchet et Savat. f. *polystachya* Makino wyróżnia się obecnością małej komórki nasadowej we włoskach kilkukomórkowych.