The morphology of hairs in species *Plantago* L. Sections: *Novorbis* Decne and *Mesembrynia* Decne

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Abstract

This paper is a continuation of the investigation of hairs in representatives of various sections of the genus *Plantago* L. (Andrzejewska-Golec and Świątosławski 1987, 1988, 1989 a, b, 1991, in press 2). It deals with the species of the related sections: *Novorbis* Decne (3 species) and *Mesembrynia* Decne (5 species). The investigated taxa of both sections have one type of headed hair (typical of the representatives of the genus *Plantago*) as well as three types of headless hairs: 1) 1-3-celled-bristle-shaped, 2) consisting of several cells, and 3) multicellular-web-like. Only slight differences between the hairs of the investigated taxa of sections *Novorbis* and *Mesembrynia* were noticed. The hairs of the representatives of these sections are also similar to the hairs of representatives of another section, related to those mentioned above, viz. *Lamprosantha* Decne (Andrzejewska-Golec and Świątosławski 1991).

Key words: genus *Plantago* L., sectio *Novorbis* Decne, sectio *Mesembrynia* Decne, hairs, scanning electron microscopy

INTRODUCTION

The representatives of sectio *Novorbis* are South American species (Pilger 1929, 1937, Rahn 1974). The majority of taxa from section *Mesembrynia* grow in Australia and New Zealand (Pilger 1937). The only European species belonging to this section is *P. schwarzenbergiana* Schur (Chatter and Cartier 1976) which grows in Hungary and in Rumania. Another representative of sectio *Mesembrynia* is sometimes encountered in central Europe, viz brought from Siberia and Mongolia — *P. depressa* Willd. (Hegi 1906). The third non-Australian taxon of this section is *P. kamtschatica* Link, growing in Kamtschatka, Korea and Japan (Pilger 1937).

In the monography of Pilger (1937) sections *Novorbis* Decne (syn. *Virginica* Barn.), *Mesembrynia* Decne and *Lamprosantha* Decne are situated alongside each other (sections 9, 10, and 11), which may point to the relationship between them. Harms (1897) grouped the representatives of the first two sections into one section *Neoplantago* Harms (section *Novorbis* Decne — 1) *Cleiosantha* (Decne) Harms, section *Mesembrynia* Decne — 2) *Leptostachys* (Decne) Harms) together with section *Leucopsyllium* Decne (3) *Leucopsyllium* (Decne) Harms).

Tzelev (1979), however, included section *Mesembrynia* into section *Lamprosantha*. Rahn (1978), on the other hand, joins the section *Novorbis* and *Mesembrynia* and the monotypic section *Oreophytum* Decne with three species of section *Palaeopsyllium* Decne and *Leucopsyllium* Decne in one section, *Virginica* Barn. sensu Rahn.

There is no literature data on the hairs of the representatives of section *Mesembrynia*. Although Cugini (1877) gives a description of hairs in *P. arctica* (*nomina nuda*), the name of this taxon is ambiguous: *P. arctica* Decne is given both as the synonym of *P. kamtschatica* Link (section *Mesembrynia*) and the synonym of *P. canescens* Adams (section *Lamprosantha*). After Pilger (1937) *P. arctica* Schur and *P. arctica* Trev. are *formae dubiae* of *P. major* (section *Polyneuron*). In Pilger's monograph (1913) of the taxon *Novorbis*, only a description of one type of hairs (headless consisting of several cells, single-rowed, straight) can be found. However, the author does not mention the species in which the presence of such hairs was observed.

The present work is a continuation of investigations of hairs in the representatives of various sections of the genus *Plantago* (Andrzejewska-Golec and Świątosławski 1987-1989, in press 2). The results of our previous investigations show that it is possible to use the knowledge about hair morphology to differentiate the various sections of the genus *Plantago*. The taxonomic significance of hairs for distinguishing sections in other species of plants is known from literature (Emonds 1982, Seithe and Anderson 1982, Oosthuizen 1983, Mjakushko and Ilinskaja 1987).

MATERIAL AND METHODS

I have investigated the hairs of the leaves, scapes, bracts, calyxes, and corollas of three representatives of section *Novorbis* Decne:

1. *P. australis* Lam. (Leipzig),
2. *P. candollei* Rap. (Vacratot),
3. *P. myosuros* Lam. (Copenhagen),

and of five representatives of section *Mesembrynia* Decne:

4. *P. antarctica* Decne (Leipzig),
5. *P. kamtschatica* Link (Copenhagen),
6. *P. depressa* Willd. (Peking),

7. *P. raoulii* Decne (Leipzig),

8. *P. schwartzenbergiana* Schur (Iasi).

The plants were grown by author in field culture (Figs. 1-6) from seeds obtained from various botanical gardens whose names are given above in parentheses. The identity of the investigated taxa was checked with descriptions and keys in Pilger's (1937) and Rahn's monographs (1974) as well as in Flora Europea (Chater and Cartier 1976).

The material was collected during florescence (July-August 1984-1988). Both raw material as well as that conserved in 70% ethanol was used. The investigations were carried out by light and scanning microscopy, as described in previous papers (Andrzejewska-Golec and Świętosławski 1987-1989).

RESULTS AND DISCUSSION

It was found that the same kind of hair is present on both sides of the leaf blade. According to literature data (Strehl 1983, Jose and Inamdar 1988) marked differences in the morphology of the upper and lower cuticle occur in some plants.

One type of headed hairs was present in the investigated taxa along with three types of headless hairs: 1) 1-3 celled-bristle-shaped, 2) consisting of several cells, and 3) multicellular (web-like). The corolla was usually hairless.

Table 1

Hair types occurring in sectio *Novorbis* Decne

The name of the plant ¹	The investigated part of the plant ²	Headed hairs	Headless hairs		
			bristle-shaped	consisting of several cells	multicellular (web-like)
<i>P. australis</i> Lam. (Leipzig)	L	+	+	+ (2)3-6 ³	+
	S	+	-	+ (5-6)7	+
	B	+	+	+	-
	C	+	+	-	-
	R	-	-	-	-
<i>P. candollei</i> Rap. (Vacratot)	L	+	-	+ (4)5-6(7)	+
	S	+	-	+ (4)5-6(7)	+
	B	-	+	-	-
	C	+	+	-	-
	R	-	-	-	-
<i>P. myosuroides</i> Lam. (Copenhagen)	L	+	-	+ (3)4-6(7)	+
	S	+	-	+ (3)4-6(7)	+
	B	+	+	+	-
	C	+	+	-	-
	R	-	-	-	-

¹ The name of the species according to the catalogue of the botanical garden (the seat of which is given in parentheses) from which the seeds were imported. ² L — leaf, S — scape, B — bract, C — calyx, R — corolla. ³ The number of the cells of the stalk.

PLATE I

The representatives of sectio *Novorbis* Decne. Fig. 1. *Plantago myosuroides* Lam. x 0.35. Fig. 2. *Plantago candollei* Rap. x 0.35. Fig. 3. *Plantago australis* Lam. x 0.2

PLATE II

The representatives of sectio *Mesembrynia* Decne. Fig. 4. *Plantago raoulii* Decne. x 0.5. Fig. 5. *Plantago depressa* Willd. x 0.7. Fig. 6. *Plantago kamtschatica* Link x 0.4

Table 2

Hair types occurring in sectio *Mesembrynia* Decne

The name of the plant ¹	The investigated part of the plant ²	Headed hairs	Headless hairs			
			bristle-shaped	consisting of several cells		multicellular (web-like)
				perpendicular to the epidermis	parallel to the epidermis	
<i>P. antarctica</i> Decne (Leipzig)	L ⁴	+	-	+ (4)5-6(7) ³	-	+
<i>P. kamtschatica</i> Link ⁵ (Copenhagen)	L	+	-	+(2-4)5-7(8)	-	+
	S	+	-	+4-6	-	+
	B	+	+	+	-	-
	C	+	+	-	-	-
	R	-	-	-	-	-
<i>P. depressa</i> Willd. (Peking)	L	+	-	+(3-4)5-6(7)	-	+
	S	+	-	-	+3-5	+
	B	+	+	-	-	-
	C	+	-	-	-	-
	R	-	-	-	-	-
<i>P. raoulii</i> Decne (Leipzig)	L	+	-	+(3-4)5(6-7)	-	+
	S	+	-	-	+(3)4-5	+
	B	+	+	-	-	-
	C	-	-	-	-	-
	R	-	-	-	-	-
<i>P. schwarzenbergiana</i> Schur (Iasi)	L	+	-	+5-7(8)	-	+
	S	+	-	-	+5-6	+
	B	+	+	-	-	-
	C	-	+	-	-	-
	R	-	-	-	-	-

¹, ², ³ See notes to Table 1. ⁴ Other plant parts were not studied. ⁵ According to Pilger (1937): *P. kamtschatica* Link.

The results are presented in Tables 1 and 2, and on figures (Figs. 7-24) as well as on the photographs from scanning microscopy (Figs. 25-46).

HEADED HAIRS

Headed hairs are built of a small basall cell, unicellular stalk staining intensively with Sudan III and a head divided vertically into two cells (Figs. 17 K-O; 21 G-L; 30-32; 38). The hairs are surrounded with (3)4-5(6) hair-adjointing cells (Figs. 13 H, I; 20 H). The cuticle covering the hairs is usually smooth (Figs. 30, 31). However, the surface of headed hairs may be wrinkled (Figs. 32, 38). They are present on all of the investigated parts of the plant except for the corolla. They are also absent on the bract of *P. candollei* and the sepals of the calyx of *P. raoulii*.

Fig. 7. *Plantago australis* Lam. hairs from a leaf. Scale bar A-E — 0.2 mm; F-I — 0.1mm

Fig. 8. *Plantago australis* Lam. hairs: A-G — from a scape; D-G fragments of a headless hair; H-M — hairs from a bract. Scale bar A-G — 0.2 mm; H-M — 0.1mm

Fig. 9. *Plantago australis* Lam. hairs from a calyx: A, B — hairs from the tip of the calyx; C, D — from the edge of a calyx sepal; E, F — from the membranous part of a calyx. Scale bar 0.1mm

Fig. 10. *Plantago candollei* Rap. hairs from a leaf: A, B — the headless hairs from the leaf lamina; C — "trace" of the leaf base; D, E — a tip of a web-like hair from the leaf base; F, G — fragments of web-like hairs; H-K — a base of a web-like hair from the leaf base; L — a headed hair with surrounding cells; M, N, P, R — typical headed hairs; O — an atypical headed hair. Scale bar A-K — 0.1mm; L-R — 0.05mm

Fig. 11. *Plantago candollei* Rap. hairs from a scape. A, B — headless hairs; C-D — a base of a web-like hair from the base of a scape. E-K — headed hairs. Scale bar A, B — 0.2 mm; C, D — 0.1 mm; E-K — 0.05 mm

Fig. 12. *Plantago candollei* Rap. hairs: A-C — from a bract; D-I — from a calyx. Scale bar 0.05 mm

Fig. 13. *Plantago myosuroides* Lam. hairs from a leaf. Scale bar A-D — 0.2 mm; E-I — 0.05 mm

Fig. 14. *Plantago myosuuros* Lam. hairs: A-F — from a calyx; G-O — from a bract. Scale bar 0.05 mm

Fig. 15. *Plantago myosuroides* Lam. hairs: A-F — from a calyx; G-K — from a corolla. Scale bar 0.05 mm

Fig. 16. *Plantago antarctica* Decne hairs from the leaf lamina. Scale bar A-C — 0.1 mm; D-F — 0.05 mm

Fig. 17. *Plantago kamtschatica* Link hairs from a leaf: A-F — headless hairs from the leaf lamina; G-I — fragments of a web-like hairs from the leaf base; G, H — a base of a web-like hair; K-O — headed hairs. Scale bar A-F — 0.2 mm; G-I — 0.1 mm, K-O — 0.05 mm

Fig. 18. *Plantago kamtschatica* Link hairs from a scape. Scale bar A-E — 0.2 mm; F-H — 0.05 mm

Fig. 19. *Plantago kamtschatica* Link hairs: A-G — from a bract; H-K — from a calyx. Scale bar 0.05 mm; only A, B — 0.2 mm

Fig. 20. *Plantago depressa* Willd. hairs from a leaf. F, G — fragments of web-like hairs from the base.
Scale bar A-E — 0.2 mm; F-G — 0.1 mm; H, I, K — 0.05 mm

Fig. 21. *Plantago depressa* Willd. hairs: A-E, G from a scape; F, H, I — from a bract; K, L — from a calyx. Scale bar A-E — 0.01 mm; F-L — 0.05 mm

Fig. 22. *Plantago raoulii* Decne hairs from a leaf. A-C — the headless hairs; D, E — a base of a web-like hair from the leaf base, F-I — the headed hairs. Scale bar A-E — 0.2 mm; F-I — 0.05 mm

Fig. 23. *Plantago raoulii* Decne hairs: A-F — from a scape; G-I — from a bract. Scale bar A-E — 0.2 mm; F-I — 0.05 mm

Fig. 24. *Plantago schwarzenbergiana* Schur hairs: A-C, E — from a leaf lamina; F-G — from a scape; D, H, K — from a bract; I — from a calyx. Scale bar A-C, F G — 0.2 mm; D, E, H-K — 0.05 mm

PLATE III

Fig. 25. *Plantago candollei* Rap.: headless hairs from lower epidermis, x 20. Fig. 26. *Plantago candollei* Rap.: headless hairs and their traces on the leaf, 1 — a basal cell, 2 — a stalk cell, 3 — trace of the hairs, x 200

PLATE IV

Fig. 27. *Plantago candollei* Rap.: hairs from a leaf. 1 — trace of a headless hair, 2 — headed hairs, x 500. Fig. 28. *Plantago candollei* Rap.: a base of a headless hair from a leaf, 1 — a basal cell, 2 — the first cell of the hair stalk, x 1000

PLATE V

Fig. 29. *Plantago candollei* Rap.: headed hairs (arrows) on the lower surface of a leaf, x 100.
Fig. 30. *Plantago candollei* Rap.: a headed hair with characteristic head, x 1000

PLATE VI

Figs. 31, 32. *Plantago candollei* Rap.: a headed hair, x 1000

PLATE VII

Fig. 33. *Plantago candollei* Rap.: headless hairs on the scape, arrows — combination of cells, the marked part of the picture is shown in enlargement, see: Fig. 34, x 100. Fig. 34. *Plantago candollei* Rap.: surface of a headless hair, arrow — combination of cells, note small cavity, x 2000

PLATE VIII

Fig. 35. *Plantago myosuroides* Lam.: headless hairs on a leaf, arrow — combination of cells, x 200 (the marked part of the picture is shown in enlargement, see: Fig. 36). Fig. 36. *Plantago myosuroides* Lam.: fragment of a headless hair, arrow — combination of cells (see: Fig. 35), x 2000

PLATE IX

Fig. 37. *Plantago myosuros* Lam.: headless hair base, 1 — a basal cell, 2 — first cell of the hair stalk, 3 — surrounding cells, x 500. Fig. 38. *Plantago myosuros* Lam.: a headed hair with characteristic head, x 1000

PLATE X

Fig. 39. *Plantago kamtschatica* Link. Surface of the upper epidermis of a leaf: 1 — headed hair, 2 — headless hair, x 200. Fig. 40. *Plantago kamtschatica* Link hairs on a leaf: 1 — a headed hair, 2 — a headless hair base, x 1000

PLATE XI

Fig. 41. *Plantago kamtschatica* Link. Cratered trace of a headless hair: 1 — a basal cell, 2 — surrounding epidermal cells, x 1000. Fig. 42. *Plantago kamtschatica* Link headed hair from a scape: 1 — a stalk cell, 2 — a two-celled head, x 2000

PLATE XII

Fig. 43. *Plantago kamtschatica* Link. Surface of a scape: 1 — a headed hair, 2 — a headless hair, x 200 (the marked part of the picture is shown in enlargement, see: Fig. 44). Fig. 44. *Plantago kamtschatica* Link. Bases of the headless hairs: 1 — basal cell, 2 — first cell of hair stalk (see: Fig. 43), x 2000

PLATE XIII

Fig. 45. *Plantago depressa* Willd.: surface of a headless hair from a scape, x 1000. Fig. 46. *Plantago depressa* Willd.: a headed hair from a leaf, x 2000

This type of hairs was found previously in the majority of the investigated taxa of genus *Plantago* (Andrzejewska-Golec and Świątosławski 1987, 1989a,b, 1991, in press 2). They are absent only in the representatives of the sectio *Arnoglossum* Decne (Unger 1926, Fuchs 1932, Fisher 1937, Andrzejewska-Golec and Świątosławski 1989a), sectio *Coronopus* DC. sensu Rahn (Andrzejewska-Golec and Świątosławski 1987), as well as in annual species of the sectio *Psyllium* (Juss.) Barn. (Andrzejewska-Golec and Świątosławski in press 2).

As we have stated before (Andrzejewska-Golec and Świątosławski 1987, 1988, 1989a,b, 1991, in press 2), hairs with a bicellular head are very similar in the representatives of various sections. Also the headed hairs of the presently investigated taxa of sectio *Mesembrynia* do not differ from those described earlier (Figs. 16 D-F; 20 H-K). However, the head of these hairs in taxa of sectio *Novorbis* is typically elongated (Figs. 11 E-H, K; 12 D-F; 29, 30, 31, 38), and in *P. myosuroides* it has a very specific flame-like shape (Figs. 14 C-F, M-O; 38) distinguishing the hairs of this taxon not only from other investigated representatives of sectio *Novorbis* but also from hairs of the representatives of other sections of the genus *Plantago* as well.

HEADLESS HAIRS

1. 1-4 Celled (bristle-shaped) hairs are built of a basal cell and 1-3 celled stalk (Figs. 9 A-D; 23 H, I). They are present on the bract and the calyx of the investigated species and on the petals of the corolla in *P. myosuroides*.

2. Hairs consisting of several cells have an enlarged basal cell, protruding above the epidermis (Figs. 26, 28, 37) and a (3)4-6(7) celled stalk in taxa of sectio *Mesembrynia* (Figs. 16 A-C; 20 A-C; 24 A-C, F, G) and (3)4-6(7-9) celled stalk in taxa of sectio *Novorbis* (Figs. 11 A, B; 13 A-D; 26). The tip cell in these hairs is markedly smaller, "triangular" (Fig. 13 A-D).

Similarly built hairs are present on the leaf and scape, but on the scape they are parallel to the surface of the epidermis (Figs. 21 A-E; 24 F, G; 33), while on the leaf they are perpendicular (different way of joining the basal cell with the first cell of the stalk) (Figs. 10 A, B; 24 A-C).

The surface of headless hairs in *P. candollei* is verrucose, while in the case of *P. myosuroides* it is plicate.

Characteristic cratered traces of the headless hairs formed of a basal cell were observed (Figs. 26, 27). Shedding of hairs was also observed in representatives of other sections of the genus *Plantago* (Andrzejewska-Golec and Świątosławski 1988, 1989a,b, 1991, in press 2). This phenomena may be the result of mechanical damage or physiological rejection of the hairs (Hummel and Staesche 1962).

Headless hairs consisting of several cells of the taxa of sections *Mesembrynia* and *Novorbis* are very much like these hairs of the representatives of sectio

Lamprosantha (Unger 1926, Fuchs 1932, Fisher 1937, Andrzejewska-Golec and Świętosławski 1991). The similarity concerns the number of cells (in sectio *Lamprosantha* — 6) and their shape and mutual arrangement.

Similarities may also be observed when comparing headless hairs consisting of several cells of the representatives of sectio *Novorbis* and *Mesembrynia* with the hairs of the taxa of sectio *Polyneuron* (Andrzejewska-Golec and Świętosławski 1991), though the stalk of the hairs of the representatives of the latter sections is made up of only three cells.

3. Multicellular hairs (web-like, arachnoid hairs) can be found on the base of leaves and scapes of the investigated taxa. These hairs have a structure (Figs. 10 D-K; 11 C, D; 17 G-I) similar to that found in other representatives of genus *Plantago* (Andrzejewska-Golec and Świętosławski 1987, 1988, 1989a,b, 1991, in press 2).

It can be seen from our previous investigation (Andrzejewska-Golec and Świętosławski 1988) that the representatives of sectio *Leucopsyllium* have the same type of headed hairs as the representatives of sectio *Mesembrynia*, while the headless hairs of sectio *Leucopsyllium* have a more complicated structure (the stalk base is composed of one to three short cells that stain with Sudan III) than the headless hairs of the taxa of sections *Novorbis* and *Mesembrynia*, and are similar to the hairs of the representatives of sections *Oreades* (Pilger 1937, Andrzejewska-Golec and Świętosławski 1989b 1) and *Arnoglossum* (Fuchs 1932, Unger 1932, Fischer 1937, Andrzejewska-Golec and Świętosławski 1989a). This is in agreement with Pilger's (1937) and Rahn's (1978) views, according to which sectio *Leucopsyllium* is more distant from section *Novorbis* and *Mesembrynia*.

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Morfologia włosków w gatunkach rodzaju Plantago L.
Sekcje: Novorbis Decne i Mesembrynia Decne

Streszczenie

Praca jest kontynuacją badań włosków przedstawicieli różnych sekcji rodzaju *Plantago* L. (Andrzejewska-Golec i Świętosławski 1987-1989, w druku 1-2). Dotyczy ona gatunków spokrewnionych sekcji: *Novorbis* Decne (3 gatunki) i *Mesembrynia* Decne (5 gatunków). U wszystkich badanych taksonów obu sekcji występuje jeden typ włosków główkowych (charakterystyczny dla przedstawicieli rodzaju *Plantago*) oraz trzy typy włosków bezgłówkowych: 1) 1-3 komórkowe — szczecinkowate, 2) kilkukomórkowe i 3) wielokomórkowe — pajęczynowate. Stwierdzono występowanie tylko niewielkich różnic między budową włosków badanych taksonów sekcji *Novorbis* i *Mesembrynia*. Włoski przedstawicieli obu tych sekcji są ponadto podobne do włosków przedstawicieli innej, spokrewnionej z wyżej wymienionymi, sekcji *Lamprosantha* Decne (Andrzejewska-Golec i Świętosławski w druku 1).

Stwierdzono jedynie niewielkie różnice w budowie włosków badanych taksonów sekcji *Novorbis* w porównaniu z analogicznymi typami włosków sekcji *Mesembrynia*.