The morphology of hairs in *Verbascum* L. species

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Abstract

The hairs on the flowers and perfloral leaves of 25 representatives of the genus *Verbascum* L. were examined. Thirteen morphological types of hairs were identified. The calyx and perfloral leaves possess the most morphologically diversified hairs while the stamens usually have only one type of hairs. Clavate and headed hairs are typical of the studied species. It has been found that the structure of hairs can serve to distinguish taxa of various ranks among the genus *Verbascum*. The structure of the hairs of *V. roripifolium* and *V. capitis-viridis* suggests that both of these species be set apart from the genus *Verbascum*.

Key words: *Verbascum* L., flower hairs

INTRODUCTION

Current knowledge about the taxonomy of the genus *Verbascum* L. (mullein) is based mainly on the monography of this taxon by M u r b e c k (1933). The author divided the genus *Verbascum* into two sections: *Bothrosperma*, which contains 251 species, and *Aulacosperma* with 1 species. He distinguished subsections within *Bothrosperma*: 1) *Fasciculata*, containing the series *Heterandra* and *Isandra*; 2) *Singuliflora* with the series *Cladotricha*, *Adenotricha* and *Holotricha*. The division of subsection *Singuliflora* into series was based by the cited author on the occurrence of branched, unbranched and glandular hairs in these taxa.

The studies on the structure of hairs in the genus *Verbascum* that have been conducted to date have mainly dealt with the hairs found on the foliage leaves

(Boros 1924, Miroslovov 1970, Hare 1979, Stefanova-Gateva and Boeva 1979) and on stamens. The hairs occurring on stamens (the color and distribution of the hairs) are used in keys to identify mullein species.

Data in literature on the hairs of the perianth are fragmentary. The hairs of the corolla of *V. virgatum* Stokes were described by Datta and Deb (1975). Budantsev and Kuzmina (1986) found the presence of hairs on the calyx in several species of *Verbascum* but did not give a detailed description.

The objective of this study was to carry out a morphological analysis of the hairs of the flowers and perifloral leaves in the representatives of genus *Verbascum*. We undertook it with the intention of using this information for the fuller characterization of lower-ranked taxa of this genus.

MATERIAL AND METHODS

This study encompassed 25 species of *Verbascum*, of which 23 belong to section *Bothrosperma*, whereas the systematic position of two species (in terms of section, subsection, series), *V. roripifolium* (Hal.) I. K. Ferg. and *V. capitis-viridis* (Hub.-Mor.) has not been determined more precisely.

The following parts of the flower were studied: calyx, corolla, stamens, pistil, and, in addition, the perifloral leaves (bracts or bracteoles) of plants cultivated in the Medicinal Plant Garden of the Pharmacognosis Department of the Medical Academy in Łódź. Data on the provenance of the seeds from which the cultivated plants were obtained were presented in a paper on the phytochemistry of plants from the genus *Verbascum* (Grabias and Świątek 1987). The species *V. phlomoides* L., *V. densiflorum* Bertol. (*V. thapsiforme* Schrad.) and *V. lychnitis* L. were collected from natural stands in Poland. The identity of these species was determined using the following keys: Murbek (1933), Flora polska (Taciak 1963) and Flora Europaea (Ferguson 1972).

This study was done on material either fresh or fixed in 70% ethanol. The drawings from the light microscope (Studar) were made using an MNR-1 projection attachment. Scanning electron microscope (Stereoscan 600) photographs were taken of parts of flowers of selected mullein species. The material for this purpose was initially fixed in 70% ethanol, dehydrated and dried at its critical point, followed by deposition of a gold palladium alloy.

RESULTS AND DISCUSSION

We have found that hairs occur on all flower parts and perifloral leaves in the 23 studied representatives of section *Bothrosperma*. These hairs are morphologically highly diversified. We have divided them into 2 groups: headless and headed hairs. Next, in each of these groups we have identified several morphological types of hairs according to the following key:

I. Headless hairs

- A. 1-Celled (clavate hairs) type I (Fig. 1)
 B. 1-3(4)-Celled, fibrous hair cells over 15 mm in length (twin cells) type II (Fig. 2)
 C. 1-8-Celled, single rowed (unbranched hairs, straight) type III (Fig. 3)
 type III (Fig. 3)

Fig. 1. Type I hairs: A — from the corolla of *Verbascum thapsus* L., B-D — from the stamen of *Verbascum lagurus* Fisch. Mey. Scale: 0.05 mm. Fig. 2. Type II hairs from the calyx of: A — *Verbascum phoeniceum* L., B,C — *Verbascum spectabile* MB. Scale 0.05 mm. Fig. 3. Type III hairs from the calyx of: A — *Verbascum pulverulentum* Vill., B — *Verbascum pyramidalatum* MB., C — *Verbascum spectabile* MB., Scale 0.05 mm for hairs A, B; 0.1 mm — C. Fig. 4. Type IV hairs: A — from the calyx of *Verbascum oreophilum* C. Koch var. *oreophilum*, B — from the calyx of *Verbascum niveum* Ten. ssp. *garganicum* (Ten.) Murb., C — from the corolla of *Verbascum thapsus* L., D — from the calyx of *Verbascum Chaixii* Vill. Scale 0.05 mm

D. Multicelled, branched hairs

- a. Hairs branched only on the tip of the stalk type IV (Fig. 4)
- b. Hairs branching at the tip of the stalk and in nodes
 1. Hair stalk with 1-2 nodes type V (Fig. 5)
 2. Hair stalk with 3-5 (6-7) nodes type VI (Fig. 6)

Fig. 5. Type V hairs from the calyx of: A — *Verbascum olympicum* Boiss., B — *Verbascum bombyciferum* Boiss., C — *Verbascum lagurus* Fisch. Mey. Scale 0.05 mm. Fig. 6. Type VI hairs: A — from the calyx of *Verbascum phlomoides* L., B — from the corolla of *Verbascum thapsus* L., C, D — from the calyx of *Verbascum densiflorum* Bertol. Scale 0.05 mm

II. Headed hairs

A. 1-2 Celled hair head

a. 1-4 Celled hair stalk

1. Length of hair from 0.025 to 0.05 mm (short hair)

. type VII (Fig. 7)

2. Length of hair from 0.06 to 0.12 mm (medium length hair) type VIII (Fig. 8)
3. Length of hair from 0.13 to 0.2 m-m (long hair) type IX (Fig. 9)
- b. Hair stalk 2-10-celled; hair length from 0.1 to 0.7 mm type X (Fig. 10)

Fig. 7. Type VII hairs from the calyx of: A, B — *Verbascum gnaphalodes* MB., C — *Verbascum pyramidatum* MB., D, E — *Verbascum lychnitis* L., F — *Verbascum phlomoides* L. Scale 0.05 mm. Fig. 8. Type VIII hairs from the calyx of: A — *Verbascum Boerhaavii* L., B — *Verbascum phlomoides* L., C — *Verbascum mallophorum* Boiss. et Heldr. Scale 0.05 mm. Fig. 9. Type IX hairs from the calyx of: A — *Verbascum mallophorum* Boiss. et Heldr., B, C — *Verbascum bombyciferum* Boiss. Scale 0.05 mm. Fig. 10. Type X hairs from the calyx of: A, B — *Verbascum undulatum* Lam., C, D — *Verbascum niveum* Ten. ssp. *garganicum* (Ten.) Murb. Scale 0.05 mm

B. Hair head 4-10 (12)-celled

- a. Hair length from 0.03 to 0.05 mm type XI (Fig. 11)
- b. Hair length from 0.06 to 0.15 mm type XII (Fig. 12)

C. Hair made up of multiple (up to 30) cells; hair length from 0.05 to 0.45 mm type XIII (Fig. 13)

Fig. 11. Type XI hairs from the calyx of: A — *Verbascum densiflorum* Bertol., B — *Verbascum gnaphalodes* MB., C — *Verbascum bombyciferum* Boiss., D — *Verbascum Chaixii* Vill. Scale 0.05 mm. Fig. 12. Type XII hairs from the calyx of: A — *Verbascum densiflorum* Bertol., B — *Verbascum mallophorum* Boiss. et Heldr., C — *Verbascum pulverulentum* Vill. Scale 0.05 mm. Fig. 13. Type XIII hairs from the calyx of: A — *Verbascum pyramidatum* MB., B — *Verbascum oreophilum* C. Koch var. *oreophilum*, C — *Verbascum spectabile* MB., D — *Verbascum phoeniceum* L., E — *Verbascum blattaria* L. Scale 0.05 mm

The distribution of the types of hairs on the flower parts and perfloral leaves of the studied species is given in Table 1.

Scanning microscope observations showed that type I hairs (clavate) are covered with a papillate cuticle (Fig. 14a and 14b), type III usually with a smooth cuticle, that sometimes may be striated (Fig. 15). A fully striated cuticle covers the stalk of type XIII headed hairs (Fig. 16). The cuticle covering the remaining

hair types is smooth (e.g. in branched, Fig. 17 and headed type XII, Fig. 18). In *V. lagurus* all of the hairs on stamens (see Table 1) have a striated cuticle (Figs. 19 and 20) with the exception of clavate hairs, which are covered by a papillate cuticle.

The greatest morphological differentiation of hairs was observed on the calyx and perfloral leaves, whereas the hairs on stamens were little diversified. Clavate hairs (type I) were observed on the stamens of all of the studied *Verbascum* species; only in three species did other types of hairs occur along with the clavate type (Table 1).

On comparing the description given by Stefanova-Gateva and Boeva (1979) of the morphology of headed hairs occurring on foliage leaves with our observations of hairs on flower parts we can conclude that the hairs on the latter plant parts are characterized by greater morphological diversity. For example in *V. phlomoides*, *V. thapsiforme* and *V. niveum*, we observed headed hairs of various lengths (type VII-X) on the calyx. On the foliage leaves of the same three species, the cited authors reported the occurrence of short glandular cells only (the hair stalk either equal or double the length of the head).

When analysing our material in terms of taxonomy, we found that the clavate shape of hairs (type I) along with headed hairs (type VII) are a common feature of species belonging to section *Bothrosperma*. Our study confirms the validity of M u r b e c k ' s (1933) division of this section into two subsections (*Fasciculata* and *Singuliflora*), and these subsections further into series. Representatives of subsection *Fasciculata* are distinguished by abundant and more diversified hair in comparison with species from subsection *Singuliflora*. The latter are characterized by the presence of type XIII headed hairs, which do not occur in subsection *Fasciculata*.

Each of the species of subsection *Fasciculata* is characterized by the presence of numerous branched hairs. In series *Heterandra* belonging to this subsection, the branched hairs are often set on a multicellular base (Fig. 6A, C and D); in addition, hairs branching out from more than two nodes (type VI) are often found here. We did not find hairs of this type in species from series *Isandra* belonging to the same subsection.

Only hairs branching from the tip of the stalk (type IV) and at most from nodes (type V) are found in series *Isandra*. The former are, in some species, the only branched hairs. We observed hairs of both types in *V. undulatum* along with highly branched hairs (type VI) characteristic of representatives of the series *Heterandra*. This species may, however, carry traits characteristic of both series within the subsection *Fasciculata* since, in M u r b e c k ' s taxonomy (1933), it is placed at the beginning of the series of successive species of the series *Isandra*.

The series *Isandra* is characterized by the small degree of morphological differentiation of headed hairs in comparison with series *Heterandra*; there are often only two types of hairs occurring in a given species: VII and XI (short hairs).

Types of hairs of *Verbascum* L. section *Bothrosperma*

Species	Studied part of plant ¹	Types of hairs (see text)												
		headless						headed						
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Subsection <i>Fasciculata</i> Series <i>Heterandra</i> <i>V. bombyciferum</i> Boiss.	A	--	--	++	++	+-	+-	++	-+	-+	--	++	-+	--
	C	-+	--	+-	+-	+-	+-	--	--	--	--	+-	--	--
	S	++	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	-	-	-	-	-	-	-
<i>V. lagurus</i> Fisch. Mey.	B	--	--	++	++	+-	+-	-+	-+	-+	--	++	-+	--
	A	--	--	++	++	++	+-	++	++	--	--	++	--	--
	C	-+	--	+-	+-	+-	--	+-	+-	--	--	+-	+-	--
	S	++	--	+-	--	--	--	--	+-	+-	--	--	+-	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
<i>V. phlomoides</i> L.	P	-	-	+	+	+	+	-	-	-	-	-	-	-
	B	--	--	++	++	++	+-	++	--	-+	--	++	--	--
	A	--	--	--	+-	+-	+-	++	++	--	--	++	-+	--
	C	-+	--	+-	+-	+-	--	+-	+-	--	--	+-	--	--
	S	-+	--	--	--	--	--	--	--	--	--	--	--	--
<i>V. densiflorum</i> Bertol.	R	-	-	+	+	+	-	+	-	-	-	-	-	-
	P	-	-	+	+	+	-	+	-	-	-	+	-	-
	B	--	--	+-	++	+-	+-	++	-+	--	--	++	-+	--
	A	--	--	++	++	++	+-	++	-+	--	--	++	++	--
	C	-+	--	--	+-	+-	--	+-	--	--	--	+-	+-	--
<i>V. niveum</i> Ten. ssp. <i>garganicum</i> (Ten.) Murb.	S	++	--	--	--	--	--	+-	--	--	--	+-	--	--
	R	-	-	+	+	+	-	+	-	-	-	+	-	-
	P	-	-	+	+	-	-	+	-	-	-	-	-	-
	B	--	--	++	++	++	+-	++	-+	-+	--	++	++	--
	A	--	--	++	++	++	++	++	-+	-+	-+	-+	-+	--
	C	-+	--	++	++	+-	+-	-+	-+	--	--	-+	--	--
	S	++	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	+	-	-	-	-	+	-	-
	P	-	-	+	+	-	-	+	-	-	-	-	-	-
	B	--	--	++	++	++	++	++	++	-+	--	++	--	--

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>V. thapsus</i> L.	A	--	--	--	+ -	+ -	+ -	+ +	- +	--	--	+ +	- +	--
	C	- +	--	+ -	+ -	+ -	+ -	+ -	--	--	--	+ -	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	-	+	-	-	-	-	-	-
	P	-	-	-	+	+	-	+	-	-	-	+	-	-
<i>V. Boerhaavii</i> L.	B	--	--	+ -	+ -	+ -	+ -	+ -	--	--	--	+ -	--	--
	A	--	--	+ -	+ -	+ -	+ -	+ +	+ +	--	--	+ +	--	--
	C	- +	--	+ -	+ -	+ -	--	+ -	+ -	--	--	+ -	+ -	--
	S	+ +	--	--	--	--	--	+ -	--	--	--	+ -	--	--
	R	-	-	+	+	+	+	+	-	-	-	+	-	-
Series <i>Isandra</i> <i>V. undulatum</i> Lam.	P	-	-	+	+	+	+	+	+	-	-	+	-	-
	B	--	--	+ -	+ -	+ -	+ -	+ +	+ +	--	--	+ +	+ +	--
	A	--	--	+ +	+ +	+ +	+ +	+ +	- +	--	- +	- +	--	--
	C	--	--	+ -	+ -	+ -	--	- +	- +	--	--	- +	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
<i>V. soongaricum</i> Schrenk	R	-	-	+	+	+	-	+	-	-	-	-	-	-
	P	-	-	+	+	-	-	+	-	-	-	-	-	-
	B	--	--	+ +	+ +	+ +	+ +	+ +	- +	- +	- +	- +	--	--
	A	--	--	+ -	+ -	--	--	+ +	--	--	--	+ +	--	--
	C	--	--	+ -	+ -	--	--	+ -	--	--	--	+ -	--	--
<i>V. speciosum</i> Schrad.	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	-	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	+	-	-	-	-	-	-
	B	--	--	+ -	+ -	--	--	+ +	--	--	--	--	--	--
	A	--	--	+ -	+ -	+ -	--	+ +	--	--	--	+ -	--	--
	C	- +	--	--	+ -	--	--	+ -	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	-	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	+	-	-	-	-	-	-
	B	--	--	+ -	+ -	+ -	--	+ +	--	--	--	--	--	--

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>V. gnaphalodes</i> MB.	A	--	--	+ -	+ -	+ -	--	+ +	--	--	--	- +	--	--
	C	--	--	+ -	+ -	--	--	--	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	+	-	-	-	+	-	-
	B	--	--	+ -	+ -	+ -	--	+ +	--	--	--	- +	--	--
<i>V. olympicum</i> Boiss.	A	--	--	+ -	+ -	+ -	--	+ +	--	--	--	+ +	--	--
	C	--	--	+ -	+ -	+ -	--	+ -	--	--	--	+ -	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	+	-	-	-	-	-	-
	B	--	--	+ -	+ -	+ -	--	+ +	--	--	--	+ +	--	--
<i>V. pulverulentum</i> Vill.	A	--	--	+ -	+ -	+ -	--	+ +	- +	--	--	- +	- +	--
	C	- +	--	+ -	+ -	+ -	--	+ -	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	-	+	-	-	-	+	-	-
	P	-	-	+	+	+	-	+	-	-	-	+	-	-
	B	--	--	+ +	+ +	+ +	--	+ +	- +	--	--	+ +	- +	--
<i>V. lychnitis</i> L.	A	--	--	+ -	+ -	--	--	+ +	--	--	--	- +	--	--
	C	--	--	+ -	+ -	--	--	--	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	-	-	-	-	-	-	-	-	-
	B	--	--	+ -	+ -	--	--	+ +	--	--	--	+ +	--	--
<i>V. sinuatum</i> L.	A	--	--	+ -	+ -	+ -	--	+ +	--	--	--	+ +	--	--
	C	--	--	+ -	+ -	--	--	--	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	+	-	-	-	-	-	+	-	-
	B	--	--	+ -	+ -	+ -	--	+ +	--	--	--	+ +	--	--
<i>V. mallophorum</i> Boiss. et Heldr.	A	--	--	+ -	+ -	+ -	--	+ +	- +	- +	--	+ +	- +	--
	C	- +	--	+ -	+ -	+ -	--	+ -	--	--	--	+ -	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	+	-	-	-	-	-	-	-	-
	P	-	-	+	+	-	-	+	+	-	-	+	-	-
	B	--	--	+ -	+ +	+ -	--	+ +	- +	- +	--	+ -	- +	--
<i>V. Chaixii</i> Vill.	A	--	--	+ -	+ -	--	--	+ +	--	--	--	+ +	--	--
	C	--	--	+ -	+ -	--	--	--	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	-	-	+	-	-	-	+	-	-
	B	--	--	+ -	+ -	--	--	+ +	--	--	--	+ +	--	--

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>V. ni-grum</i> L.	A	--	--	+ -	+ -	+ -	--	+ +	+ -	--	--	+ -	+ -	--
	C	- +	--	+ -	+ -	--	--	+ -	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	-
	P	-	-	+	+	-	-	+	+	-	-	+	+	-
	B	--	--	+ -	+ -	+ -	--	+ +	+ -	--	--	+ -	+ -	--
Subsection <i>Singuliflora</i>														
Series <i>Cladotricha</i>														
<i>V. spectabile</i> MB.	A	--	+ +	+ -	+ -	--	--	- +	- +	--	--	+ +	+ +	+ +
	C	- +	--	+ -	+ -	--	--	--	--	--	--	--	+ -	+ -
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	+	+	-	-	+	+	-
	P	-	-	+	+	-	-	+	-	-	-	-	-	+
	B	--	+ +	+ -	+ -	--	--	- +	--	--	--	+ +	+ +	+ +
<i>V. pyramidatum</i> MB.	A	--	--	+ -	+ -	--	--	+ +	+ +	+ -	--	+ +	+ +	+ +
	C	--	--	+ -	+ -	--	--	+ -	+ -	+ -	--	--	+ -	+ -
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	+	+	-	-	-	-	-	-	-	-	+
	P	-	-	+	+	-	-	-	-	-	-	-	-	-
	B	--	--	+ -	+ -	--	--	+ +	--	--	--	--	--	+ -
<i>V. oreophilum</i> C. Koch var. <i>oreophilum</i>	A	--	--	+ -	+ -	--	--	+ +	--	--	--	--	--	+ -
	C	- +	--	+ -	+ -	--	--	+ -	+ -	--	--	+ +	+ +	+ +
	S	+ +	--	--	--	--	--	--	--	--	--	+ -	+ -	+ -
	R	-	-	+	+	-	-	+	-	-	-	+	-	+
	P	-	-	+	+	-	-	+	-	-	-	+	+	+
	B	--	--	+ -	+ -	--	--	+ +	--	--	--	+ -	+ -	+ -
Series <i>Adenotricha</i>														
<i>V. blattaria</i> L.	A	--	--	--	--	--	--	- +	--	--	--	--	--	+ +
	C	- +	--	--	--	--	--	--	--	--	--	--	--	+ -
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	-	-	-	-	-	-	-	-	-	-	+
	P	-	-	-	-	-	-	-	-	-	-	-	-	+
	B	--	--	--	--	--	--	+ +	--	--	--	--	--	+ +
Series <i>Holotricha</i>														
<i>V. phoeniceum</i> L.	A	--	+ +	--	--	--	--	- +	--	--	--	--	--	+ +
	C	- +	--	--	--	--	--	--	--	--	--	--	--	--
	S	+ +	--	--	--	--	--	--	--	--	--	--	--	--
	R	-	-	-	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-	-	-	+
	B	--	+ +	--	--	--	--	- +	--	--	--	--	--	+ +

* A — calyx, C — corolla, S — stamens, R — pistil (style), P — pedicel, B — perfloral leave (bract or bracteole).

+ The hair present on the organ, — no hair on the organ. Double marks for A, C, B designate occurrence of the hairs as follows: the former on the external surface, the latter on the internal surface of the organ; for S - the former mark designates the anterior stamens, the latter — posterior stamens.

PLATE I

Fig. 14. a — *Verbascum olympicum* Boiss., stamen: apical part of a clavate hair, x 2000.
b — *Verbascum oreophilum* C. Koch var. *oreophilum*, corolla: surface of a clavate hair, x 5000.
Fig. 15. *Verbascum spectabile* MB., calyx: joining of the two last cells of a straight hair, x 2000

PLATE II

Fig. 16. *Verbascum blattaria* L., a fragment of headed hair from the calyx, x 1000. Fig. 17. *Verbascum bombyciferum* Boiss., calyx: fragments of branched hairs, x 1000

PLATE III

Fig. 18. *Verbascum niveum* Ten. ssp. *garganicum* (Ten.) Murb., calyx: fragment of a headed hair, x 2000. Fig. 19. *Verbascum lagurus* Fisch. Mey., fragment of a straight hair from a stamen, x 2000

PLATE IV

Fig. 20. *Verbascum lagurus* Fisch. Mey., fragment of a headed hair from a stamen, x 5000. Fig. 21. *Verbascum capitis-viridis* Hub.-Mor., calyx: fragment of a straight hair, x 2000

We found type X hairs in only two species of subsection *Fasciculata*: *V. niveum* (series *Heterandra*) and *V. undulatum* (series *Isandra*); this hair type is probably a characteristic trait of both of these taxa.

m In the other subsection, *Singuliflora*, the first series — *Cladotricha*, differs from the remaining series by the presence of hairs branched at the tip (type IV) and unbranched hairs (type III).

The series *Adenotricha* and *Holotricha* of subsection *Singuliflora* were represented in our studies by species *V. blattaria* and *V. phoeniceum*, respectively. They differ in the morphological details of type XIII headed hairs: in *V. blattaria* these hairs reach a length of 0.07 to 0.45 mm, while the dimensions of the head range from 0.09 to 0.12 x 0.04 to 0.05 mm (Fig. 13E); in *V. phoeniceum*, however, the hairs are shorter, 0.1 to 0.25 mm and the head is smaller, 0.06–0.07 x 0.02–0.04 mm (Fig. 13D). In addition, type II hairs occur in this species, while they are not found in *V. blattaria*. Type II hairs, also occurring in *V. spectabile* (series *Cladotricha*) were not hitherto known to occur in the genus *Verbascum*.

A separate discussion is called for in the case of *V. roripifolium* (Hal.) I. K. Ferg. and *V. capitis-viridis* Hub.-Mor., taxa that are not included in M u r b e c k ' s monography (1933).

V. roripifolium exhibits great similarity to the studied representatives of series *Adenotricha* and *Holotricha* of subsection *Singuliflora*, due to the occurrence of only two types of headed hairs (type VII and XIII) (Fig. 22A-C). The headless hairs (with the exception of clavate hairs) have a different morphology as compared with the hairs observed in the species belonging to section *Bothrosperma*: they are long (over 15 mm), multicelled, 2-4-rowed with wedged overlapping cells (Fig. 22D-F); they occur only on the calyx and perfloral leaves.

The species *V. capitis-viridis* has hairs that are highly diversified morphologically (Fig. 23). Especially interesting here are headless, multicellular hairs due to their different, as compared with types IV-VI, kind of branching. The branch in this type of hair is formed by one or several (2-4) cells arranged in

Fig. 22. A-F — Hairs from the calyx of *Verbascum roripifolium* (Hal.) I.K. Ferg. Scale 0.05 mm

Fig. 23. A-P — Hairs from the calyx of *Verbascum capitis-viridis* Hub.-Mor. Scale 0.05 mm

a row, and these cells do not always branch out from nodes but do so directly from stalk cells (Fig. 23B-D). The headed hairs in this taxa are similar to hair types VII-IX and XI-XIII. Noteworthy here is the presence of a large nucleus in most of their cells. The cuticle covering the hairs of *V. capitis-viridis* is usually spotted (Fig. 21).

V. roripifolium (Hal.) I. K. Ferg. syn. *Celsia roripifolia* Hal. was described in Flora Europaea (Ferguson 1972) as one of three species in the group, *V. daenzeri*. Huber-Morath (1973) introduced the name *V. capitis-viridis* for the species *Celsia insularis* Murb. The species *V. roripifolium* Ferg. and *V. capitis-viridis* Hub.-Mor., were, according to the cited author, transferred from the genus *Celsia* L. to the genus *Verbascum* L. That author holds that both of these genera are closely related in terms of botanical traits and difficult to distinguish from each other. However, the results of our study show that, in terms of the morphology of flower hairs, *V. roripifolium* and *V. capitis-viridis* differ from the other species of *Verbascum*. The problem of the botanical similarity between the species *Verbascum* and *Celsia* requires further studies that will include the morphology of their hairs.

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Morfologia włosków u gatunków Verbascum L.

Streszczenie

Przebadano włoski kwiatu i liści przykwiatowych u 25 przedstawicieli rodzaju *Verbascum* L. Wśród włosków wyróżniono 13 typów morfologicznych. Najbardziej zróżnicowaną morfologicznie włoski występują na kielichu i liściach przykwiatowych, natomiast na pręcikach występuje z reguły jeden typ włosków. Charakterystyczne dla badanych gatunków są włoski maczugowate i główkowe krótkie. Stwierdzono, że budowa włosków stanowi cechę, którą można wykorzystać do odróżnienia taksonów różnej rangi w obrębie rodzaju *Verbascum*. Budowa włosków u *V. roripifolium* i *V. capitis-iridis* przemawia za wyodrębnieniem obu tych gatunków z rodzaju *Verbascum*.