

A STUDY ON ACHENE MACRO- AND MICROMORPHOLOGICAL CHARACTERS OF POLISH SPECIES OF THE *Senecio jacobaea* GROUP

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Abstract

A study on achene macro- and micromorphological characters of the following five Polish species of the *Senecio jacobaea* group was carried out by LM and SEM: *S. aquaticus* (var. *aquaticus* and var. *barbareifolius*), *S. erucifolius* (subsp. *erucifolius* and subsp. *tenuifolius*), *S. jacobaea*, *S. paludosus*, and *S. subalpinus*. The achenes differed in several characters, but the most distinctive differences concerned their indument, especially the length and morphology of hairs. The study clearly shows that two morphologically similar species, *S. jacobaea* and *S. erucifolius*, which are often confused can be easily distinguished based on the morphological characters of achenes. Additionally, we showed differences between the achenes of *S. erucifolius* subsp. *erucifolius* and subsp. *tenuifolius*, the two taxa which were not distinguished in floristic studies and herbarium collections from Poland. The key to determine Polish species of the *Senecio jacobaea* group, based on the morphological characters of achenes, is also given.

Key words: Asteraceae, *Senecio jacobaea* group, taxonomy, fruits, SEM, LM

INTRODUCTION

Senecio L. (Asteraceae; Senecioneae) is a large and taxonomically difficult genus comprising between 1000 and 3000 species (Jeffrey et al. 1977; Nordenstam, 1978; Bremer, 1994; Vincent, 1996). The genus is divided into approximately 150 sections which are not clearly distinguished from one another. According to different authors, the section *Jacobaea* comprises from 3 to 15 species (Pelser et al. 2002). Such different views of the species composition of the section resulted from a very general section description by different authors (e.g. Chater and Walters, 1976; Jeffrey, 1992; Shishkin, 1995) which could also be applicable to many species

from other sections of *Senecio*. Three species: *S. aquaticus*, *S. erucifolius* and *S. jacobaea*, are considered to form the core of sect. *Jacobaea* with *S. jacobaea* as a type species of the section. The delimitation of sect. *Jacobaea*, its phylogenetic position as well as the relationships within and among *Senecio* sections were recently examined by Pelser et al. (2002, 2003, 2004, 2007).

The descriptions of *Senecio* achenes based on macromorphological characters are available in many floras, although they are not always consistent. From the *Senecio jacobaea* group, only *S. jacobaea* achenes were investigated using SEM (McEvoy, 1984). The aim of the present study was to describe the macro and micro-morphological characters of achenes of Polish species of the *Senecio jacobaea* group. We were interested in finding additional taxonomic characters which could be useful in identification and distinguishing taxa within sect. *Jacobaea*.

MATERIALS AND METHODS

Achenes of the following five species of the *Senecio jacobaea* group were examined: *S. aquaticus* (var. *aquaticus* and var. *barbareifolius*), *S. erucifolius* (subsp. *erucifolius* and subsp. *tenuifolius*), *S. jacobaea*, *S. paludosus*, and *S. subalpinus*. Plant material, 1–5 specimens per taxon, was obtained from various sources, both from natural localities and herbarium collections (Table 1). All examinations were carried out on fully developed dry fruits. Achene size (length and width), shape, outline, and colour as well as pappus length were determined from 30 fruits of each taxon using a PZO type 131 stereoscope microscope. Some macrographs were obtained with a Zeiss Stereo Lumar V12 stereoscope microscope. Five achenes of

each taxon were mounted on aluminium stubs with “Leit-Tabs” and coated with gold in an Agar sputter coater. Electron micrographs were obtained with a Zeiss EVO 40 scanning electron microscope at an accelerating voltage of 12 kV. Micromorphological characters were determined on the basis of SEM images. The terminology describing fruit shape and surface followed Bojňanský and Fargašová (2007) as well as Barthlott (1981, 1984).

RESULTS

The main macro- and micromorphological characters of the examined achenes are summarized in Table 2, while the selected macrophotographs and SEM microphotographs of the fruit showing its general view, the achene surface and pappus details are presented in Plates I–III. In case of two species – *S. aquaticus* (var. *aquaticus* and var. *barbareifolius*) and *S. erucifolius* (subsp. *erucifolius* and subsp. *tenuifolius*), infraspecific taxa were investigated. In *S. aquaticus*, no significant differences were found at the species level, so further we present the results only for nominal taxa. In *S. erucifolius*, the differences between the achenes of subsp. *erucifolius* and subsp. *tenuifolius* were well visible, so achenes of both taxa are presented and compared. Among the studied species, only *Senecio jacobaea* had dimorphic achenes (Plate I 2A*, 2A), whereas the remaining ones had homomorphic fruits.

Macromorphological characters

The achenes of the investigated species were oblong-cylindrical, in *S. aquaticus* sometimes narrowly obovoid, or linear in *S. paludosus* (Table 2, Plates I–III). They were longitudinally ribbed, with the ribs more or less distinct and the furrows sometimes darker than the rest of achenes. The colour of achenes differed from whitish-yellow to pale-brown. The apex of achenes had usually the form of a distinct white (in *S. erucifolius* yellowish) crest. The basal scar of achenes was more or less distinct, white or yellowish. The achenes were equipped with non-deciduous (except external *S. jacobaea* achenes) white pappus, usually about twice as long as the achene (Table 2).

Micromorphological characters

The achene surface of all species showed the reticulate type of microsculpture with a net-like cell arrangement. The epidermal cells of the exocarp were elongated, prosenchymatic, running parallel to the achene axis. Usually they were shorter on the ribs, where the hairs occurred, and longer between the ribs. The most elongated cells occurred in *S. erucifolius* and the shortest ones in *S. paludosus* (Plate II 2E, Plate III 1E). The anticlinal walls of exocarp cells were channelled in *S. jacobaea* and raised in the remaining species.

The outer periclinal walls were usually concave, with a smooth surface or with delicate cuticular striations running usually lengthways. In *S. paludosus*, the stripes were the most distinctive (Plate III 1E). Considering different micromorphological characters, the most distinctive differences related to hairs occurring on the surface of achenes (Plates I–III, D and E). Only *S. subalpinus* and external *S. jacobaea* achenes were bare. The remaining ones were covered with simple hairs. In *S. aquaticus* and *S. jacobaea*, hairs were scattered, short (up to about 70 µm), finger-like and tapering, occurring only on the ribs (Plate I 1D, 2D). In *S. erucifolius* subsp. *erucifolius*, achenes were medium hirsute with hairs, occurring mainly on the ribs, of medium length (up to about 150 µm), slightly spirally twisted and flattened, with a sharp bifurcate or single tip. In *S. erucifolius* subsp. *tenuifolius*, achenes were dense hirsute, with long (up to about 250 µm) hairs, distinctly spirally twisted and flattened, most often with a sharp single tip (Plate II 2D, 2E). In *S. paludosus*, achenes were medium hirsute with hairs, occurring on the entire surface, of medium length (up to about 100 µm) and with a characteristic bifurcate tip (Plate III 1D, 1E). SEM analysis of pappus bristles did not show any significant differences between the examined species. They were all simple, usually with two (sometimes one) terminal cells, more or less divergent.

A **key** to the Polish species of the *Senecio jacobaea* group, based on the morphological characters of achenes:

1. Achenes dimorphic, pappus deciduous, external achenes bare, internal ones hairy – *S. jacobaea*
- 1* Achenes homomorphic, pappus non-deciduous – 2
2. Achenes bare – *S. subalpinus*
- 2* Achenes with hairs – 3
3. Hairs scattered, short (up to about 70 µm), finger-like and tapering, occurring only on ribs – *S. aquaticus*
- 3* Achenes medium or dense hirsute with longer hairs (>70 µm) – 4
4. Achenes linear, 2.3–4.2 mm long, medium hirsute, hairs on the entire surface, of medium length (up to about 100 µm), with a bifurcate tip – *S. paludosus*
- 4* Achenes oblong-cylindrical, 1.3–2.1 mm long, medium or dense hirsute, hairs longer (>100 µm) – *S. erucifolius*
- a. Achenes medium hirsute, hairs mainly on ribs, of medium length (up to about 150 µm), slightly spirally twisted and flattened, with a sharp bifurcate or single tip – subsp. *erucifolius*
- a* Achenes dense hirsute, hairs long (up to about 250 µm), distinctly spirally twisted and flattened, most often with a sharp single tip – subsp. *tenuifolius*

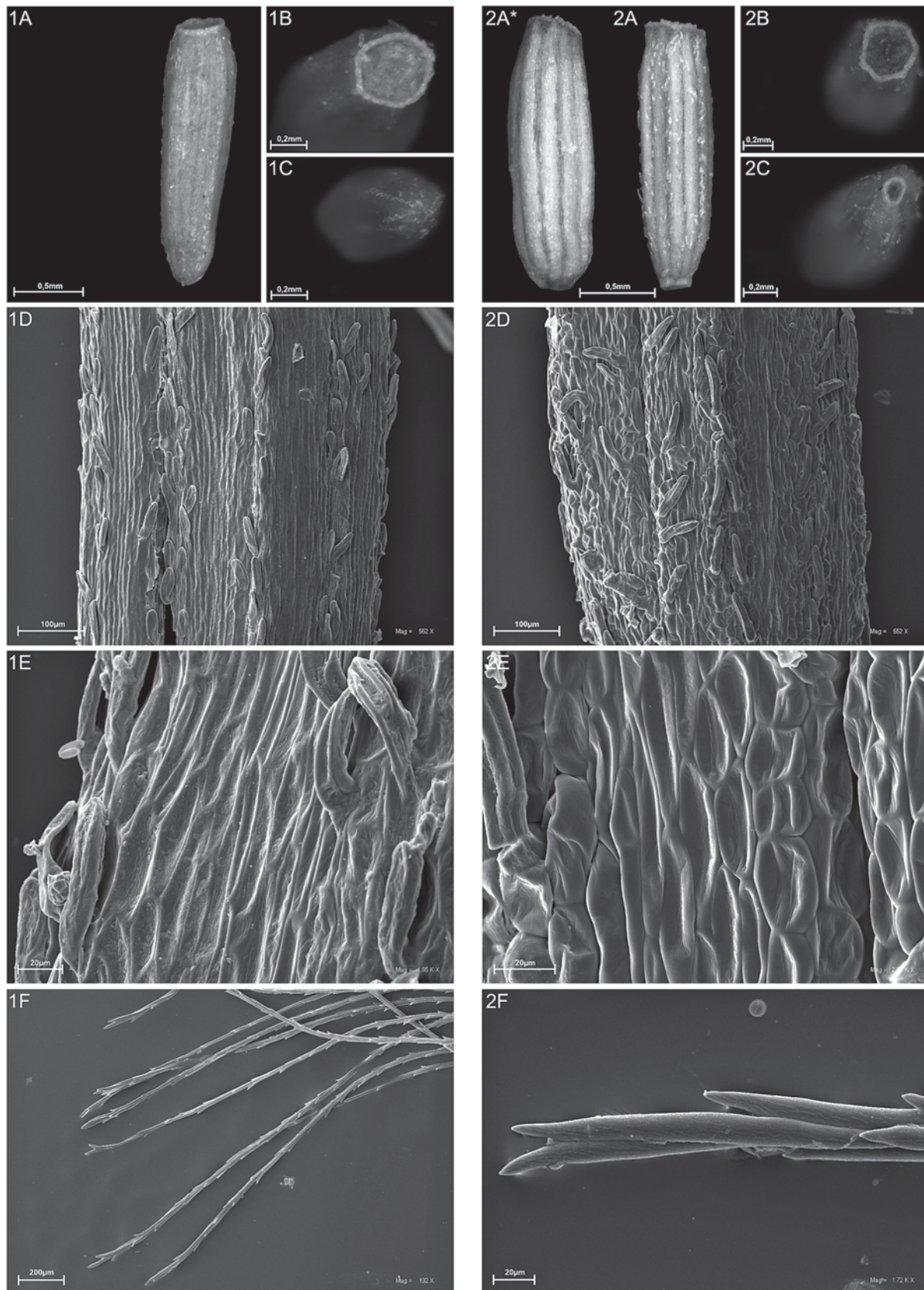


Plate I. Achene morphology of *Senecio aquaticus* (1) and *S. jacobaea* (2); A* – external achene in *S. jacobaea*, A – achene without pappus (LM), B – apex (LM), C – scar (LM), D – achene surface (SEM), E – details of achene surface (SEM), F – pappus bristles (SEM)

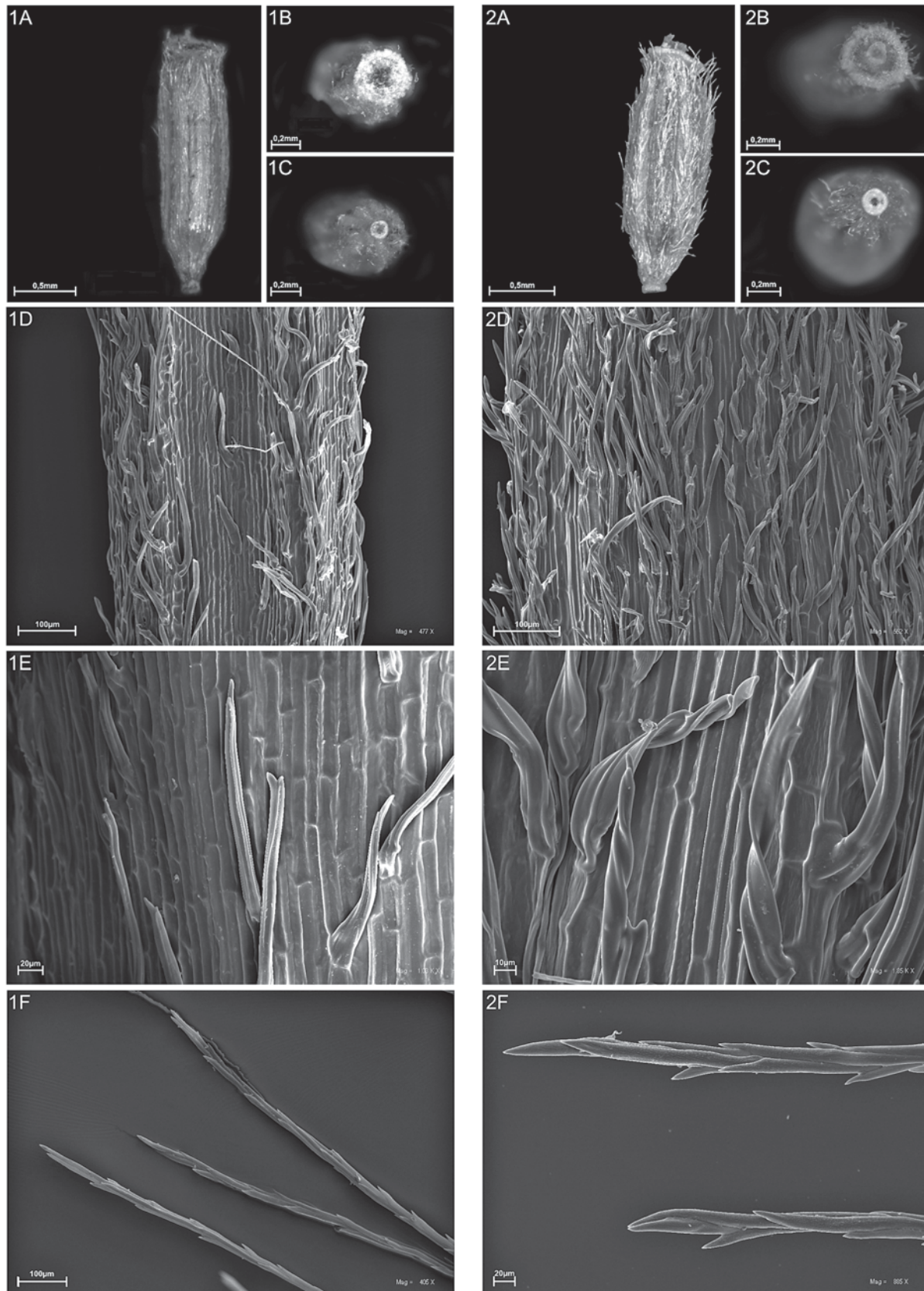


Plate II. Achene morphology of *Senecio erucifolius* subsp. *erucifolius* (1) and *S. erucifolius* subsp. *tenuifolius* (2); A – achene without pappus (LM), B – apex (LM), C – scar (LM), D – achene surface (SEM), E – details of achene surface (SEM), F – pappus bristles (SEM)

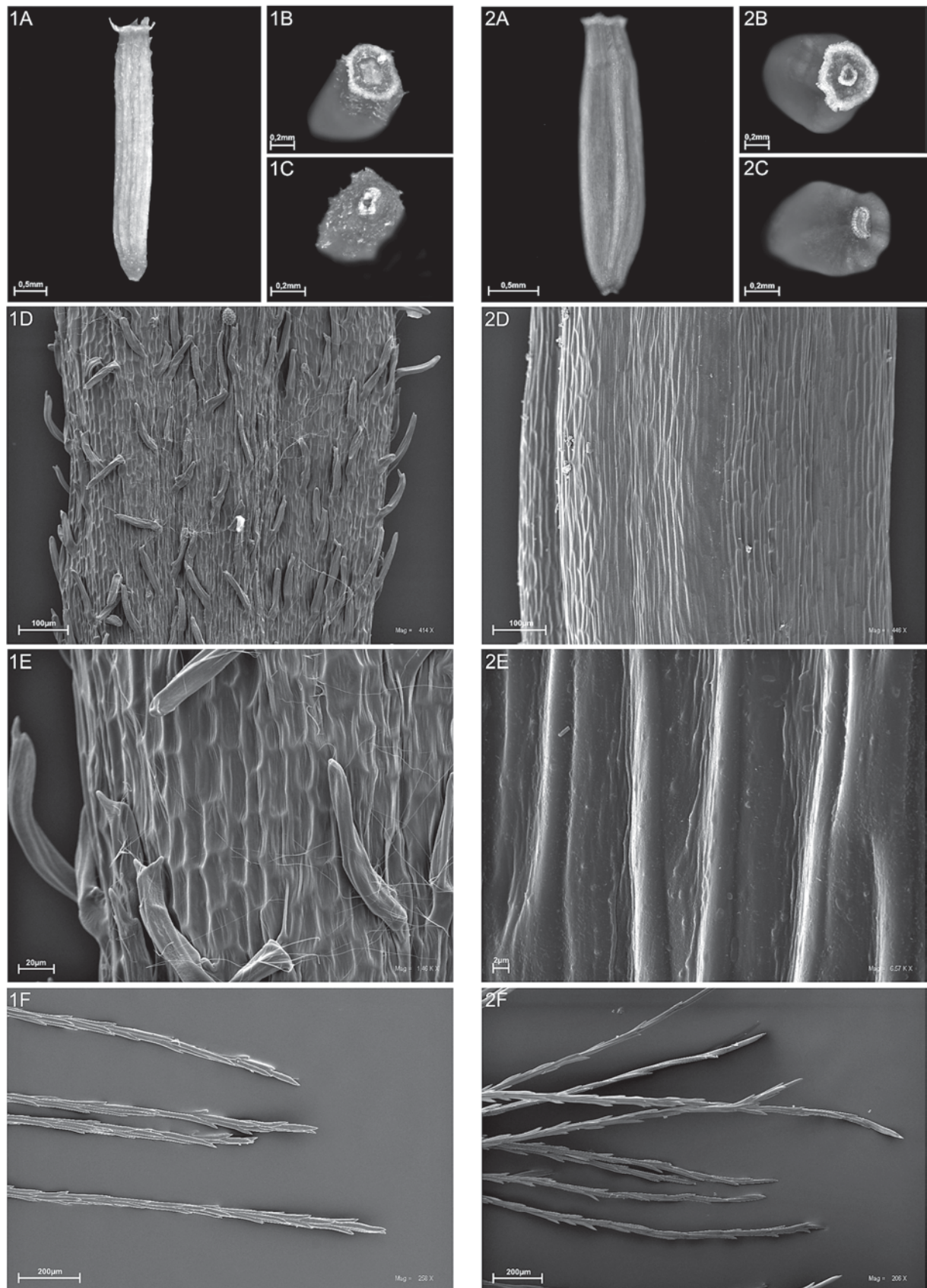


Plate III. Achene morphology of *Senecio paludosus* (1) and *S. subalpinus* (2); A – achene without pappus (LM), B – apex (LM), C – scar (LM), D – achene surface (SEM), E – details of achene surface (SEM), F – pappus bristles (SEM)

Table 1
Origin of plant material

Species	Localities and voucher specimens
<i>S. aquaticus</i> var. <i>aquaticus</i> Hill	Between Sława Wielkopolska and Skoki, Latowski K., Żukowski W., 24.07.1975 (POZ)
<i>S. aquaticus</i> var. <i>barbareifolius</i> (Krock.) Wimm. & Grab.	Budomierz near Tarnogród, Nowak L., 2.07.1988, (KRAM 366213)
<i>S. jacobaea</i> L.	Poznań-Naramowice, Bednorz L., 2.09.2011 Kielce-Podkarczówka, Podsiedlik M., 30.07.2011
<i>S. erucifolius</i> subsp. <i>erucifolius</i> L.	Szczecin-Skolwin, Podsiedlik M., 1.09.2012
<i>S. erucifolius</i> subsp. <i>tenuifolius</i> Schübl. & G. Martens	Męcierz, Bednorz L., Podsiedlik M., 23.08.2011
<i>S. paludosus</i> L.	Chrzanów-Kąty, Mazaraki I., 8.08.1967 (KRAM 35670)
<i>S. subalpinus</i> W.D.J Koch	Mount Grójec near Żywiec, Nowak K., 13.07.1985 (KRAM 529842)

KRAM – Polish Academy of Sciences Herbarium, POZ – Adam Mickiewicz University Herbarium

Table 2
Achene characters of the species studied

	<i>S. aquaticus</i>	<i>S. jacobaea</i> (disk)	<i>S. erucifolius</i> subsp. <i>erucifolius</i>	<i>S. erucifolius</i> subsp. <i>tenuifolius</i>	<i>S. paludosus</i>	<i>S. subalpinus</i>
Achene length (mm)	1.4-1.8 (mean 1.61±0.08)	1.6-2.0 (mean 1.79±0.14)	1.3-1.9 (mean 1.60±0.15)	1.6-2.1 (mean 1.77±0.19)	2.3-4.2 (mean 3.61±0.52)	2.2-2.9 (mean 2.47±0.23)
Achene width (mm)	0.4-0.06 (mean 0.51±0.06)	0.4-0.7 (mean 0.52±0.07)	0.4-0.7 (mean 0.58±0.06)	0.4-0.6 (mean 0.55±0.02)	0.4-0.7 (mean 0.58±0.07)	0.6-0.7 (mean 0.59±0.05)
Achene length/width	2.6-4.0 (mean 3.22±0.4)	2.5-4.25 (mean 3.49 ±0.51)	2.17-3.5 (mean 2.79±0.40)	2.8-3.8 (mean 3.18±0.33)	4.17-9.25 (mean 6.31±1.33)	3.5-4.6 (mean 4.24±0.39)
Achene shape	oblong-cylindrical, narrowly obovoid	oblong-cylindrical	oblong-cylindrical	oblong-cylindrical	linear	oblong-cylindrical
Achene outline	oblong to oblanceolate	oblong	oblong	oblong	linear	oblong
Achene colour	pale yellowish	whitish-yellow with darker furrows	yellowish-brown with brown furrows	yellowish-brown with brown furrows	pale yellowish-brown	pale-brown
Achene apex	distinct white crest	distinct white crest	distinct wide, yellowish crest	distinct wide, yellowish crest	distinct white crest	distinct white crest
Achene scar	indistinct	distinct white	distinct yellowish	distinct yellowish	distinct white	distinct yellowish
Pappus length (mm)	2.8-4.4 (mean 3.11±0.38)	3.4-5.1 (mean 4.5±0.49)	3.6-5.7 (mean 4.61±0.60)	3.9-6.9 (mean 4.8±0.86)	5.1-8.3 (mean 7.13±0.79)	5.0-6.8 (mean 6.11±0.48)
Pappus length/Achene length	1.67-2.67 (mean 1.93±0.26)	2.06-3.00 (mean 2.51±0.24)	2.38-3.50 (mean 2.88±0.36)	1.79-3.26 (mean 2.27±0.41)	1.62-3.0 (mean 2.01±0.3)	1.88-3.0 (mean 2.5±0.31)
Achene surface	glabrous with indistinct ribs, sparsely whitish hirsute	minute ribbed, fine hirsute	ribbed and furrowed, medium hirsute	distinct ribs and furrows; dense long hirsute	distinct ribs, medium hirsute	minute ribbed, glabrous
Hairs	on ribs, short, finger-like with a rounded top	on ribs, short but longer than <i>S. aquaticus</i> , finger-like, a bit sharp on top	on ribs, medium to long, slightly spirally twisted and flattened, often with a bifurcate tip	on ribs, long, spirally twisted and flattened	on entire surface, medium length, bifurcate tip	no hairs
Outline of cells	prosenchymatic polygonal	prosenchymatic polygonal	prosenchymatic polygonal	prosenchymatic polygonal	prosenchymatic polygonal	prosenchymatic polygonal
Size of cells (µm)	(8-15)-(40-70)	(5-17)-(20-80)	(10-18)-(40-105)	(8-15)-(35-110)	(10-20)-(20-50)	(10-20)-(40-80)
Anticlinical walls	raised, straight	channelled, straight	raised, straight	raised, straight	raised, straight	raised, straight
Curvature of periclinal walls	concave	concave	concave	concave	concave	concave
Fine relief of periclinal walls	smooth to striate	smooth to striate	smooth	smooth to striate	striate	smooth to striate

DISCUSSION

Both the macro- and micromorphological characters of achenes have rarely been taken into consideration in taxonomic studies at the infrageneric and infraspecific level in the genus *Senecio* (Pelser and Houchin, 2004; Pelsers et al. 2004; Hodálová et al. 2007, 2010; Xue-in and Guo-hail, 2007). Most often, the presence and length of achene hairs were compared, and scarcely also their internal structure and the tips of pappus bristles (Macloskie, 1883; Drury and Watson, 1965). Both cited authors described achene hairs of the species *Senecio* as superficially duplex, each having two tubes with a partition between. They also noticed that closer examination proved that there is always an additional small cell associated with the base of the hair. Macloskie (1883) described interesting duplex achenial hairs of *S. vulgaris* with a bifurcate tip and elaters protruding with excess of moisture. We observed a similar morphological type of hairs (but with no elaters) in *S. paludosus* and partially in *S. erucifolius* subsp. *erucifolius*. Drury and Watson (1965) distinguished two main morphological types of hairs: short, bent and blunt to more or less clavate, and more elongated, straight and tapering. The first type was not observed in the species observed by us, while the other one appeared on the achene surface of *S. aquaticus* and *S. jacobaea*. Drury and Watson (1965) also noticed that in a given species the hairs were always of the same type. The type of achenial hairs that we observed in *S. erucifolius* subsp. *tenuifolius* – very long, spirally twisted and flattened – had not been described before. The information about the length of achenial hairs is inconsistent. For example, Drury and Watson (1965) described these hairs as long in *S. jacobaea*, *S. erucifolius* and *S. paludosus*, whereas Bojňanský and Fargašová (2007) as short ones. In turn, in our study achenial hairs in these three species were distinctly different according to their length. Drury and Watson (1965) also examined pappus bristles in several European *Senecio* species. They noticed that in some species each pappus bristle had three terminal cells, while in others there were never more than two. In the latter case, the cells of the terminal pair were either divergent or appressed to their tips. According to their observations, in the *Senecio jacobaea* group they were divergent. Our study confirmed their observations, although we also noticed bristles with a single terminal cell.

In the introduction, we underlined that we were interested in finding additional taxonomic characters which could be useful in identification and distinguishing taxa within sect. *Jacobaea*. It is especially crucial for two morphologically similar species, *S. jacobaea* and *S. erucifolius*, which are often confused.

Our study clearly shows that by comparing the morphological characters of achenes these two species can be easily distinguished. Additionally, we showed differences between the achenes of *S. erucifolius* subsp. *erucifolius* and subsp. *tenuifolius*, the two taxa which were not distinguished in floristic studies and herbarium collections from Poland.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: concept of the study: LB; collecting plant material: MP, LB; fruit measurements: MP; data analyses: LB; writing the manuscript: LB.

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Badania nad makro- i mikromorfologicznymi cechami niełupek rodzimych gatunków rodzaju *Senecio* z sekcji *Jacobaea*

Streszczenie

Rodzaj *Senecio* L. (Asteraceae; Senecioneae) jest obszernym i taksonomicznie skomplikowanym taksonem, obejmującym od 1000 do 3000 gatunków, zgrupowanych w około 150 sekcjach. Sekcja *Jacobaea*, według różnych autorów, obejmuje od trzech do 15 gatunków. Badaniami objęto niełupki pięciu rodzimych dla Polski gatunków rodzaju *Senecio*, należących do sekcji *Jacobaea*: *S. aquaticus* (var. *aquaticus* i var. *barbareifolius*), *S. erucifolius* (subsp. *erucifolius* i subsp. *tenuifolius*), *S. jacobaea*, *S. paludosus*, *S. subalpinus*. Do obserwacji cech makro- i mikromorfologicznych niełupek wykorzystano mikroskop świetlny stereoskopowy (LM) oraz skaningowy mikroskop elektronowy (SEM). Obserwowane niełupki różnią się szeregiem cech, jednak najważniejsze różnice dotyczą stopnia owłosienia oraz długości i morfologii włosków. W pracy wskazano cechy pozwalające na odróżnienie dwóch często mylonych gatunków – *S. jacobaea* i *S. erucifolius* oraz taksonów wewnątrzgatunkowych w obrębie tego ostatniego. Artykuł zawiera również klucz do oznaczania rodzimych gatunków rodzaju *Senecio*, należących do sekcji *Jacobaea*, oparty na cechach niełupek.