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. barbarifolius), 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 jacobea 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 jacobea 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. barbarifolius), 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
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*
2. Achenes bare – *S. subalpinus*
3. Hairs scattered, short (up to about 70 μm), finger-like and tapering, occurring only on ribs – *S. aquaticus*
4. Achenes medium or dense hirsute with longer hairs (>70 μm) – 4

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.

Micromorphological characters

- 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*
- 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

<table>
<thead>
<tr>
<th>Species</th>
<th>Localities and voucher specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. aquaticus</em> var. aquaticus</td>
<td>Between Sława Wielkopolska and Skoki, Łatowski K., Żukowski W., 24.07.1975 (POZ)</td>
</tr>
<tr>
<td><em>S. aquaticus</em> var. barbarifolius</td>
<td>Budomierz near Tarnogród, Nowak L., 2.07.1988, (KRAM 366213)</td>
</tr>
<tr>
<td><em>S. jacobaea</em> L.</td>
<td>Poznań-Naramowice, Bednorz L., 2.09.2011</td>
</tr>
<tr>
<td><em>S. erucifolius</em> subsp. erucifolius</td>
<td>Kielce-Podkarczów, Podsiedlik M., 30.07.2011</td>
</tr>
<tr>
<td><em>S. jacobaea</em> L.</td>
<td>Chrzanów-Kąty, Mazaraki L., 8.08.1967 (KRAM 35670)</td>
</tr>
<tr>
<td><em>S. erucifolius</em> subsp. tenuifolius</td>
<td>Męczer, Bednorz L., Podsiedlik M., 23.08.2011</td>
</tr>
<tr>
<td><em>S. paludosus</em> L.</td>
<td>Mount Grójec near Żywiec, Nowak K., 13.07.1985 (KRAM 529842)</td>
</tr>
</tbody>
</table>

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

### Table 2
Achene characters of the species studied

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

Both the macro- and micromorphological characters of achenes have rarely been taken into consideration in taxonomic studies at the infragenic and infraspecific level in the genus Senecio (Pelser and Houchin, 2004; Pelser 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 (Macloksie, 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. Macloksie (1883) described interesting duplex achene 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 achene 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 achene 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 achene 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.

REFERENCES


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

S t r e s z c z e n i e