CHARACTERISTICS OF ACHENES
IN POTENTILLA COLLINA GROUP (ROSACEAE)

JEREMI KOŁODZIEJEK¹, BARBARA GABARA²

¹ Department of Geobotany and Plant Ecology
University of Łódź
e-mail: kolo@biol.uni.lodz.pl

² Department of Plant Cytology and Cytochemistry
University of Łódź
Banacha 12/16, 90-237 Łódź, Poland

(Received: April 10, 2006. Accepted: October 10, 2006)

ABSTRACT
Achene morphology in taxa from Potentilla collina s.l. i.e. P. collina Wibel s.s., P. leucopollitana P.J. Müller, P. thrysiflora Hüslen ex Zimmet. P. thrysiflora var. isosepala Th., W., P. silesiaca Uechtr. And P. wimanniana Günther & Schummel was examined with microscope and scanning electron microscopy. Achene of these taxa varied slightly in shape, size and colour, while marked differences among them appeared in the surface sculpture and in the dimensions of aril, dorsal ridge and ribs. SEM analyses allowed to distinguish two distinct morphological types of achenes. Type I – with rugulate sculpturing and aggregates of some material, various in shape and size, at the surface of partly covered epidermal cells covering fruit wall in P. leucopollitana, P. wimanniana and P. thrysiflora. Type II – with rugulate-reticulate sculpture due to well preserved epidermal cells in P. collina, P. silesiaca and P. thrysiflora var. isosepala. The obtained results have supported Blocki’s suggestion to treat P. thrysiflora var. isosepala as a separate species named P. isosepala. However, similarities in the surface sculpture of achenes in some taxa of P. collina group did not facilitate their classification, therefore this feature may be a valuable taxonomical criterion only in combination with others.

KEY WORDS: achenes, fruit wall sculpture, SEM, Potentilla collina group, taxonomy.

INTRODUCTION
The Potentilla collina group (Rosaceae), due to its changeability and related to it diversity of forms, belongs to the “critical” plant taxa. The causes of this changeability are the occurrence of polyploids, easiness of developing interspecies hybrids and ability to reproduce both sexually and apomictically, in the form of facultative apomixis (Müntzing 1928, 1931, 1958; Asker und Fröst 1970; Asker 1966, 1970, 1985, 1986; Eriksson et al 1998; Gregor et al. 2003). Hence, the division of this species aggregate in an intermediate one between taxa of the sections Argenteae (P. argentea group and P. inclinata) and Aureae (most propably P. tabernaemontani and P. incana), according to exclusively morphological criteria is complicated (Wolf 1908; Szafer and Pawłowski 1955; Gerstberger 2002; Kurtto et al. 2004). Differences between apomictic microspecies (agamic species) are most frequently slight, but usually stable. Because agamic taxa are more stable than microspecies of selffertilizing taxa, there is a temptation to ascribe the rank of taxonomic species to apomictic microspecies (Stace 1989).

In Poland between 5 and 8 species of the Potentilla collina group have been identified i.e. P. collina Wibel, P. isosepala Blocki, P. leucopollitana P.J. Müll., P. silesiaca Uechtr., P. sordida Zimmet., P. thrysiflora Zimmet., P. wimanniana Günth. et Schumm and P. wimannioides (Szafer and Pawłowski 1955; Zając and Zając 2001; Mirek et al. 2002). They were classified as microspecies, subspecies or rarely varieties (Ascherner and Graebner 1904-1905; Wolf 1908; Szafer and Pawłowski 1955; Gerstberger 2002; Kurtto et al. 2004).

Identification of most of the taxa from Potentilla collina group is based on the length ratio of sepals to corolla petals, the shape of carpel style, the number of leaflets on basal leaves, the pattern of pubescence of upper and lower surfaces of leaf blades (Wolf 1901, 1903, 1908; Juzepczuk 1941; Ball et al. 1968; Borhidi and Iszéta 1965; Soják 1995), as well as on the type of trichomes and the anatomy of leaves (Kołodziejek and Gabara 2003).
It is known that fruit and seeds are very useful in identification and classification of plant taxa (Karcz 1996; Liu and Lin 1999; Oczan 2004; Maciejewska-Rutkowska and Bednarz 2004; Fagúndez and Izco 2004). Description of achenes from taxa of *P. collina* group is limited to their length, shape and colour (Wolf 1908; Juzepczuk 1941; Kelley 1953; Szafer and Pawlowski 1955; Sojak 1995). These features, however, are not sufficient to identify the particular taxa.

Fruit in *Potentilla* named also achene is dry, not dehiscent and monomerospermous, small in size and brown in colour (Wolf 1908; Juzepczuk 1941; Kelley 1953; Szafer and Pawlowski 1955; Ball et al. 1968; Leht 1990; Andenberg 1994; Sojak 1995; Gerstberger 2002). This latter feature is a good criterion of its maturity, since an unripe fruit is more light brown than a mature one.

Therefore, the purpose of the present paper was the complex morphometric analysis of the achene from 6 taxa of *P. collina* group together with their shape, colour and surface sculpture.

**MATERIAL AND METHODS**

The following taxa from *P. collina* s.l. i.e. *P. collina* s.s., *P. leucopetoliana, P. thyrsiflora, P. thyrsiflora var. isosepala, P. wimanniana* and *P. silesiaca* were analysed. The nomenclature of taxa was used according to Wolf (1908) and Kurto et al. (2004). Plant material originated from natural habitat in Poland except *P. silesiaca* and *P. thyrsiflora* var. *isosepala* which came from herbaria (LE and BP).

Only mature, fully developed achenes, intensively brown in colour were used in the investigations while distinctly smaller and deformed ones were discarded.

Colour of the achenes was determined in daylight on the basis of colour scale recommended by Berggren (1969). Dimensions – length, width and thickness of the achenes, width of the aril, width and thickness of the ribs and width and height of dorsal ridge were measured according to the description presented in Figure 1. Morphometric analysis of the achenes except aril and rib dimensions, was made using a stereoscope microscope Nikon SMZ 800 with millimeter scale (exact to 0.05 mm). At least 30 individual achenes were analyzed for each taxon.

For scanning electron microscopy (SEM) samples were mounted on metal stubs, sputtered with technical gold (Pelco S.C.6 coating system), examined and photographed using a Tesla BS 340 scanning electron microscope. Shape of achenes, dimensions of aril and ribs as well as the pattern of surface sculpture of the fruit wall were analyzed on 5 photographs for each taxon.

The obtained data were statistically analyzed by means of the Student’s test. A difference was considered statistically significant when P<0.01.

**RESULTS**

The achenes in *Potentilla collina* group are bilateral, their shapes vary from almost oval in *P. leucopetoliana* and *P. thyrsiflora* var. *isosepala* (Fig. 2 and 7) to bean-like in *P. wimanniana*, *P. silesiaca*, *P. collina* and *P. thyrsiflora* (Figs 3-6).

Three types of achenes are distinguished: small, typical of *P. leucopetoliana* and *P. wimanniana*, large, present in *P. thyrsiflora* var. *isosepala* and medium in size observed in the remaining taxa (Table 1).

Achene colour varies slightly from light brown in *P. leucopetoliana* through nut-brown in *P. collina*, *P. silesiaca*, *P. thyrsiflora* and *P. wimanniana* to orange-brown in *P. thyrsiflora* var. *isosepala* (Table 1).

Scare attachment i.e. the point of achene attachment to the receptacle is surrounded by an aril slightly visible in *P. collina* and *P. silesiaca* or clearly – in *P. leucopetoliana, P. wimanniana, P. thyrsiflora* and *P. thyrsiflora var. isosepala* with their respective widths being 10 µm and 40 µm (Table 2).

A clear dorsal ridge about 80-40 µm wide and 20-40 µm thick was present in achenes of *P. leucopetoliana* (Fig. 2), *P. wimanniana* (Fig. 3), *P. collina* (Fig. 5) and *P. thyrsiflora* var. *isosepala* (Fig. 7) while an unclear one, about 40 µm wide and 20 µm thick was observed in *P. silesiaca* and *P. thyrsiflora* (Table 2).

Ribs seen at achene surfaces are brown in colour in *P. collina* and *P. silesiaca* or yellow in *P. leucopetoliana, P. thyrsiflora, P. thyrsiflora var. isosepala* and *P. wimanniana* (Table 1). Distinct ribs, very sharp in shape were seen in achenes of *P. silesiaca* (Fig. 4A, B), *P. collina* (Fig. 5A, B) and *P. thyrsiflora* var. *isosepala* (Fig. 7A, B) or oval in shape – in *P. leucopetoliana* (Fig. 2A, B), *P. thyrsiflora* (Fig. 6A, B) and *P. wimanniana* (Fig. 3A, B). Width of ribs varied from 10-20 µm in *P. silesiaca* through 40 µm in *P. collina* up to 80 µm in *P. leucopetoliana, P. thyrsiflora, P. thyrsiflora var. isosepala* and *P. wimanniana* (Table 2). Similarly rib height was the lowest (10 µm) in *P. silesiaca* while the largest (40-60 µm) in *P. leucopetoliana, P. thyrsiflora, P. thyrsiflora var. isosepala* and *P. wimanniana* (Table 2).

SEM analyses of the surface sculpture revealed two types of achenes:

I. With ruminate sculpture, characterized by oval ribs and epidermal cells partly destroyed and covered with numerous aggregates of some material (probably waxes etc.), various in shape and size. This type of achenes was typical for *P. leucopetoliana* (Fig. 2), *P. wimanniana* (Fig. 3) and *P. thyrsiflora* (Fig. 6).

II. With ruminate-reticulate sculpture; among distinct and sharp ribs well preserved epidermal cells, hexagonal in shape were visible. Achenes of this type were characteristic of *P. silesiaca* (Fig. 4), *P. collina* (Fig. 5) and *P. thrysiflora* var. *isodepala* (Fig. 7).

**DISCUSSION**

Taxonomy of *P. collina* group treated as a collective species is controversial because of lack of criteria to evaluate the systematic position of the particular taxa. Moreover, the problem of their taxonomic rank and phylogenetic relationships is also not defined. Therefore, in *P. collina* group an extensive and complicated synonymy appeared in consequence of various systematic classifications (Wolf 1908; Hegi 1923; Szafer and Pawłowski 1955; Ball et al. 1968; Szafer et al. 1976; Kurtto et al. 2004) and classification of many taxa to a lower order and then permanent changes in their rank. For example, Wolf (1908) divided the species aggregate of *P. collina* (as *Potentilla Subgrex Collinae*) into 16 microspecies (of witch 11 in Europe), later Juzepczuk (1941) (as *Potentilla subsect. Collinae*) distinguished 6 microspecies. A similarly narrow concept of species was presented by Kurtto et al. 2004, according to whom *P. collina* s.l. consists of 13 separate species in the area of Europe.

Therefore, besides difficulties in taxonomy, plants of *P. collina* group were improperly classified or simply unnoticed. For example, *P. thrysiflora* var. *isodepala* was described by Blockl (1896) as “*P. isodepala Bl*”. Later Wolf (1908) on the basis of features such as large flowers, significantly larger and longer stem, its dense foliage, seven leaflets on basal leaves, pattern of leaf blade crenation Wolf (1908) classified this taxon as variety of *P. thrysiflora*.

Our investigations of taxa from *P. collina* group revealed differences in colour and shape of achenes, as well as in their sizes. According to our measurements the lengths of achenes, 1.2-1.3 mm, were similar to those described by Sojak (1995), although significantly differed from the results obtained by Andenberg (1994), 1.4-1.9 mm.

Scanning electron microscopic analysis of achenes from *P. collina* group allowed to distinguish new additional features such as aril, dorsal ridge and aril dimensions, useful in taxonomy of this difficult collective species. These features of achenes in addition to the anatomy of leaves (Koledziejek and Gabara 2003) proved to be of high systematic importance in taxonomy of *Potentilla* species. On the other hand, contrary to our expectations the surface sculpture cannot be a good criterium in classification of taxa from *P. collina* group in achenes *P. collina*, *P. silesiaca* and *P. thrysiflora* var. *isodepala* it was almost identical although different from that of *P. leucopoliitana*, *P. wimaniniana* and *P. thrysiflora*.

---

Fig. 2-7. Surface sculpture of the achenes of *P. collina* group, at different magnifications [A] x500; [B] x1000; [C] x3000. Arrow indicates dorsal ridge. Fig. 2. *P. leucopoliitana* P.J. Müller; Fig. 3. *P. wimaniniana* Günther and Schumme; Fig. 4. *P. silesiaca* Uechtr; Fig. 5. *P. collina*; Fig. 6. *P. thrysiflora* Hülsen ex Zimmeter; Fig. 7. *P. thrysiflora* var. *isodepala* Th. W. Specimens used in the morphological treatment:

- Fig. 2. *P. leucopoliitana* – Kujawy-Pomorze pryz., Maksymilianowo near Bydgoszcz 55˚13'N/17˚58'E, pine coniferous forest, 12.08.2005, J. Kołodziejek.
Fig. 3. *P. wimanii*ana – Śląsk prov., Ogrodzieniec Podzamcze (region of Silesia-Cracow) 50°27’N/19°33’E, xerothermic grassland, 26.06.2004, J. Kołodziejek.

Fig. 4. *P. silesiaca* – Dolny Śląsk prov., Ostra Góra, between Miękinia and Mroźów (Breslau: Spitzberg, zwischen Nimkau und Nippern) loc. class., 28.06.1863, R. Unechiriz, (PRA).
Fig. 5. *P. collina* s.s. – Śląsk prov., Klobuck near Częstochowa 50°57ʹN/19°59ʹE, xerothermic grassland, 29.05.2004, J. Kołodziejek.

Fig. 6. *P. thymiflorae* – Śląsk prov., Cisowa near Pilica 50°28ʹN/19°43ʹE, xerothermic grassland, 3.06.2004, J. Kołodziejek.
The results of the present paper indicate significant differences between *P. thrysiflora* and *P. thrysiflora* var. *isosepala*. Differences in colour, surface sculpture of achenes and in dorsal ridge dimensions do not support Wolf’s (1908) classification of *P. thrysiflora* as a variety, on the contrary they indicate that this taxon should be identified as a species similar to Blocki’s (1896) idea and termed *P. isosepala*.

Key to the species of genus *Potentilla collina* s.l. based on morphological characteristics of fruits.

1. Surface of achenes between ribs with ruminate sculpture ............................ 2
1*. Surface of achenes with ruminate-reticulate sculpture .............................. 4
2. Colour light brown .............................. *P. leucopolitana*
2*. Colour nut-brown ........................................... 3
3. Dorsal ridge clear, c. 80 µm wide ...... *P. wimmeriana*
3*. Dorsal ridge unclear, c. 40 µm wide ...... *P. thrysiflora*
4. Colour orange-brown ...... *P. thrysiflora* var. *isosepala*
4*. Colour nut-brown ........................................... 5
5. Dorsal ridge clear, ribs c. 40 µm wide ...... *P. collina*
5*. Dorsal ridge unclear, ribs c. 10-20 µm wide .............................. *P. silesiaca*

ACKNOWLEDGEMENTS

We would like to thank the Curators of Herbaria for making available the material of *Potentilla*, and most of all Dr. Alexander Sennikov (V.L. Komarov Botanical Institute, Saint-Petersburg – LE), and Dr. Somlyay Lajos (Hungarian Natural History Museum in Budapest – BP) for lending the isotype *Potentilla silesiaca* Uechtr. and *P. thrysiflora* var. *isosepala* Th. W. Finally, We would like to thank Dr. Krzysztof Polański (Institute of Physics, University of Łódź) for taking the photographs.

We would like to thank Professor Janina Jakubowska-Gabara (Department of Geobotany and Plant Ecology, University of Łódź), who made the critics of the manuscript.

Part of this work was supported by grant No. 2 P04F 040 26 from the Ministry of Education and Science (KBN).

LITERATURE CITED


### TABLE 1. Dimensions (in mm) and colour of achenes from taxa of *Potentilla collina* group.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Lengh</th>
<th>Width</th>
<th>Thickness</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(µm)</td>
<td>(µm)</td>
<td>(µm)</td>
<td></td>
</tr>
<tr>
<td><em>P. leucopetala</em></td>
<td>1.16±0.02</td>
<td>0.85±0.02</td>
<td>0.64±0.01</td>
<td>Light brown</td>
</tr>
<tr>
<td><em>P. collina</em></td>
<td>1.25±0.01</td>
<td>0.96±0.01</td>
<td>0.69±0.01</td>
<td>Nut-brown</td>
</tr>
<tr>
<td><em>P. silesiaca</em></td>
<td>1.30±0.01</td>
<td>0.96±0.02</td>
<td>0.72±0.01</td>
<td>Nut-brown</td>
</tr>
<tr>
<td><em>P. thyrsiflora</em></td>
<td>1.28±0.01</td>
<td>0.96±0.02</td>
<td>0.70±0.01</td>
<td>Nut-brown</td>
</tr>
<tr>
<td><em>P. thyrsiflora var. isosepala</em></td>
<td>1.33±0.02</td>
<td>0.99±0.02</td>
<td>0.77±0.01</td>
<td>Orange-brown</td>
</tr>
<tr>
<td><em>P. wimanniana</em></td>
<td>1.23±0.01</td>
<td>0.89±0.01</td>
<td>0.62±0.01</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

### TABLE 2. Characteristic of achenes sculpture in taxa of *Potentilla collina* group.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Aril Width (µm)</th>
<th>Aril Dorsal ridge Width (µm)</th>
<th>Aril Dorsal ridge Thickness (µm)</th>
<th>Surface sculpture</th>
<th>Ribs (µm) Width</th>
<th>Ribs (µm) Height</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. leucopetala</em></td>
<td>Clear</td>
<td>40</td>
<td>20</td>
<td>20-40</td>
<td>80</td>
<td>40-60</td>
</tr>
<tr>
<td><em>P. collina</em></td>
<td>Unclear</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td><em>P. silesiaca</em></td>
<td>Unclear</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>10-20</td>
<td>10</td>
</tr>
<tr>
<td><em>P. thyrsiflora</em></td>
<td>Clear</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>80</td>
<td>40-60</td>
</tr>
<tr>
<td><em>P. thyrsiflora var. isosepala</em></td>
<td>Clear</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>80</td>
<td>40-60</td>
</tr>
<tr>
<td><em>P. wimanniana</em></td>
<td>Clear</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>80</td>
<td>40-60</td>
</tr>
</tbody>
</table>

KARCZ J. 1996. Skanioving mikroskop elektronowy w bana-
kacharopologicznym. Scanning electron microscope in car-
KELLEY W.R. 1953. Study of seeds identification and seed ger-

LIU J.Q., LIN S.J. 1999. Achene microstructure in *Pyreus, Gahnia* and *Schoenus* (Cyperaceae) from China and their taxono-
MIEREK Z., PIEKÓR-MIKÓRA H., ZAJAC A., ZAJAC M. 2002. Flowering plants and periplophyes of Poland. A check-
list. Krytyczna lista roślin nacyniowych Polski. Wyd. Instytu-
tut Botaniki im. W. Szafera Polskiej Akademii Nauk, Kra-
STACE C.A. 1989. Plant taxonomy and biosystematics. E. Ar-

nold Publ., Cambridge (Polish translation: Stace A. 1993. Ta-
SZAFA W., KULCZYŃSKI S., PAWŁOWSKI B. 1976. *Potentilla* L. In: “Rosliny polskie. Opisy i klucze do oznaczania wszystkich gatunków roślin nacyniowych rosnących w Pol-
sce bądź dzikie, bądź też dziedziczących lub częściej hodowa-
nych”. Szafer W. et al. (eds). PWN, Warszawa, pp. 312-320. (in Polish)