Roczniki Akademii Rolniczej w Poznaniu CCCXCI

Botanika – Steciana

16, 2012, 55-66

www.up.poznan.pl/steciana

ISSN 1896-1908

ALGOFLORA AND VASCULAR FLORA IN THE EUTROPHIC FENS OF THE PIENINY NATIONAL PARK (SOUTH POLAND)

Joanna Czerwik-Marcinkowska[1], Grzegorz Vončina[2]

J. Czerwik-Marcinkowska, Department of Botany, Institute of Biology, Jan Kochanowski University, Świętokrzyska 15, 25-406 Kielce, Poland, e-mail: marcinko@kielce.com.pl
G. Vončina, Pieniński Park Narodowy, Jagiellońska 107 B, 34-450 Krościenko n. Dunajcem, Poland, e-mail: gvoncina@poczta.onet.pl

(Received: March 3, 2012. Accepted: June 5, 2012)

ABSTRACT. Qualitative analysis of algoflora, including microhabitats and vascular vegetation in the eutrophic fens communities in the Pieniński National Park is presented. 54 taxa of algae and cyanobacteria and 162 taxa of plants were determined in fens, and the community types were defined. Numerous rare and endangered species of vascular plants and algae were observed. The most interesting algae are: *Amphipleura pellucida*, *Cymbella simonsenii*, *C. sinuata*, *Gongrosira calcifera*, *Oocardium stratum*, *Phormidium incrustatum*, *Phormidiochaete nordstedtii*, *Schizothrix pulvinata* and *Oedogonium decipiens*, *O. inversum* for. *subclusum*, *Bulbochaete pseudoareolata*, *B. mirabilis* and others. The most noteworthy vascular plants are: *Alchemilla glabra*, *Carex buxbaumii*, *C. davalliana*, *Epipactis palustris*, *Ophrys insectifera*, *Pedicularis palustris*, *Pinguicula vulgaris* and *Tofieldia calyculata*.

KEY WORDS: eutrophic fens, algae, cyanobacteria, vascular plants, Pieniński National Park

INTRODUCTION

The low-sedge mountain fens are a very peculiar plant communities in the Pieniński National Park. They are usually developed in the places with the slowly dripping water rich in the calcium carbonate. The fens, as a rule, appear in the places where the free flow of water is obstructed, that is in the sections of areas either flat or slightly inclined. Water, which cannot flow out, saturates soil layer close to the surface or the waste-mantle. This results in the area swamping, and allows the development of characteristic hydrophilic plants. Initially the water from the fens slowly flows out in the form of one or several rivulets (the outflowing fen is then created), but with time as the developing plants form a dense coating, the water flow out is blocked, and the transpirational fen is created (Tomaszewski 1970). Gąsiorek and Nicia (2010) considering the trophic status divided the mountain fens into oligotrophic, mesotrophic and eutrophic. Specific biotope conditions existing in the mountain fens are conducive to the occurrence of many plants and animals which are included into the rare, endangered or protected species in Poland (Piękoś-Mirkowa and Mirek 2003, Głowaciński and Nowacki 2004, Żarnowiec et al. 2004, Mirek et al. 2006).

Eutrophic mountain fens, belonging to the subassembly *Valeriano-Caricetum flavae caricetosum davallianae,* develop in the Pieniński National Park. These are distinguished from other syntaxa within the lowland bogs, by the presence of sedges *Carex davalliana* and *Carex flacca*, as well as by *Gymnadenia conopsea* (Vončina 2007). Furthermore characteristic components of this community are: *Valeriana simplicifolia*, *Carex flava*, *Eriophorum latifolium*, *Pinguicula vulgaris* and *Epipactis palustris* (Matuszkiewicz 2001). The layer at the ground level is built by the mosses with characteristic: *Limprichtia cossonii*, *Bryum pseudotriquetrum*, *Campylium stellatum*, *Calliergonella cuspidata* and relict *Tomentypnum nitens* (Stebel et al. 2010). Eutrophic fens occur at the base of the Pieniny Mts up to about 800 m a.s.l. mostly in flat places, both sufficiently sunny and shady (Kaźmierczakowa et al. 2004). These fens occupy only 0.4% of the Pieniński National Park area (Chećko 2004). In the Pieniny eutrophic fens occurs liverwort *Aneura maxima* rare in Poland (Mierzeńska and Vončina 2010).

Kulczyński (1928) initiated the investigations of local plant communities including the fens describing them as *Caricetum davallianae* community. Subsequent materials were collected by the investigators who compiled the plant communities map of the Pieniny National Park in 1965-1968 (Grodzińska et al. 1981). It constitutes an excellent source of information regarding both distribution and area occupied by the eutrophic fens in the Pieniny Mts. However, the authors have not published any phytosociological materials. Consecutive works contained only general information concerning the occurrence of the plant community described (Zarzycki 1982) or presented a fragmentary study of the Park's selected regions (Staszkiewicz 1993). Kaźmierczakowa et al. (2004) presented the eutrophic

fens *Valeriano-Caricetum flavae* against the Pieniny Mts meadow and humid communities. Interest in the Pieniny Mts fens resulted also in several publications in the scope of the nature protection (Wróbel 2000, Vončina 2001).

Algoflora of the region was investigated by Filarszky (1899, 1900), Wołoszyńska (1936), Chudyba (1965), Kawecka (1965), Tarnowska (1971), Wasylik (1971), Starmach (1975), Mrozińska-Webb (1976), Mrozińska (1982, 1990, 1992, 2000), Kawecka and Szczęsny (1984), Kawecka and Mrozińska (1989), Sanecki (1989, 1991), Sanecki and Bucka (1992), Mrozińska and Czerwik (1998), Sanecki et al. (1998), Kawecka and Sanecki (2003), Mrozińska and Czerwik-Marcinkowska (2003, 2004), Mrozińska et al. (2006, 2010), Czerwik-Marcinkowska and Mrozińska (2010).

STUDY AREA

The Pieniny Mts are a small mountain range constituting a part of long, broken up belt of limestone rocks on the border of the Central and External Western Carpathian Mts (Kondracki 2000). In Poland the Pieniny Mts form an arc 35 km long starting in the Stary Bystry up to the Rozdziele pass in the Small Pieniny Mts (Niemirowski 1982). Distinct diversity of the mountain range constitutes the base for its division into smaller units having separate geomorphological and floristic features (Pawłowski 1977, Kondracki 2000). The area of the investigations is located in the central part of the arc with its most characteristic relief with the steep cliffs from the south and elongated slopes from the north of the range (Niemirowski 1982). The Pieniny Mts borders are marked out by the Dunajec river from the west, south and east and the Krośnica river from the north. The soaring rocks made of limestones resistant to weathering dominate over the gorges and valleys and they originated from the washed out rocks susceptible to erosion (the marl, shale, sandstone, conglomerate). The soils of the Pieniny Mts are closely related to the geological substrate, and the area relief.

The mean annual temperature ranges from 6.3°C to 4.0°C in places of higher altitude. According to Kostrakiewicz (1982 a) the annual amount of rainfalls is lower than in the mountain ranges surrounding the Pieniny Mts and it oscillates in from 650 to 850 mm (extreme values 583-1050 mm).

The Pieniny Mts, like majority of the mountainous areas, are characterised by a large number of springs and presence of both concentrated (springs), and unconcentrated (the fens, leaks and water seepages) outflows. Majority of the springs are screened with the mantle rock or rock debris (Humnicki 2007). According to Kostrakiewicz (1982 b) the highest number of springs were found in the hypsometric zone 601-700 m a.s.l. The Pieniny streams have the precipitation-thaw water regime, and the highest flow values take place in July or August due to intensive rainfalls and large surface draining. The spring thaws period (March-April) is a successive intensive outflow of waters, but the registered values are decidedly lower than in the summer season (Humnicki 2007). The Pieniny Mts springs belong to the fresh slightly mineralised water, and are mainly characterised by neutral or slightly alkaline reaction. Among the anions in the Pieniny Mts spring waters hydrogen-carbonate (HCO^-_3), and sulphate (SO^{2-}) ions predominate, whereas the highest values of cations are reached by calcium Ca^{2+} and magnesium Mg^{2+} cations (Kostrakiewicz 1982 b).

MATERIAL AND METHODS

Samples for algological studies were collected from fens at a few weeks intervals from May until September in 2008 and 2010 (Fig. 1). The whole fragments of mosses and sedges with groups of algae and cyanobacteria occurring directly on the plants (as the epiphyte) or in the water layer were collected directly in the field. In order to obtain the groups of the epiphytic algae fragments of macrophytes were cut out, and small pebbles with distinct deposits or tufts of filamentous algae were collected. The algae and cyanobacteria species were identified using the light microscope JEMAMED 2. The quantity, and average size of each taxon, occurring in the sample, were studied. Due to lack of generative reproductive stages necessary to identify some Chlorophyta species such as Oedogonium genera or in the case when the diagnostic features were not sufficient for unambiguous species indentification in the light microscope, for example for some very small diatoms, only the names of the genera were given. The diatoms material was mounted in synthetic resin Naphrax. Algae and cyanobacteria were classified following Krammer and Lange-Bertalot (1986, 1991), Anagnostidis and Komárek (1988), Ettl and Gärtner (1988) and Hindák (2001) also Van Den Hoek et al. (1995). Whereas macroalgae according to Starmach (1977), and vascular plants according to Szafer et al. (1986), Rutkowski (2004) and Zarzycki et al. (2002).

RESULTS AND DISCUSSION

The studied eutrophic fens of the Pieniny Mts are characterised by interesting algoflora and vascular flora. 54 taxa of algae and cyanobacteria (belonging to 8 classes: Bacillariophyceae, Chrysophyceae, Chlorophyceae, Zygnematophyceae, Cladophorophyceae, Charophyceae, Rhodophyceae and Cyanophyceae) and 162 taxa of vascular plants were determined (Table 1 and 2).

Among the listed groups of algae and cyanobacteria the most numerously represented were the diatoms (Bacillariophyceae), the representatives of which usually preferred the environments rich in calcium carbonate. These are: *Amphipleura pellucida*, *Caloneis alpestris*, *Cymbella simonsenii*, *C. sinuata*, *C. helvetica*, *Surirella spiralis*, *Campylodiscus hibernicus* and others. According to throphic state, most taxa belong to meso and eutraphentic (Table 1). Second groups of organisms characteristic for this type of the environments were the cyanobacteria also occurring in the water environment rich in calcium carbonate. In the fens occur: *Phormidium incrustatum*, *Phormidiochaete nordstedtii*, *Leptolyngbya pseudovalderiana*, *Schizothrix fasciculata*, *S. pulvinata*, *S. tenuis*, *Lyngbya* cf. *martensiana*. The taxa for example:

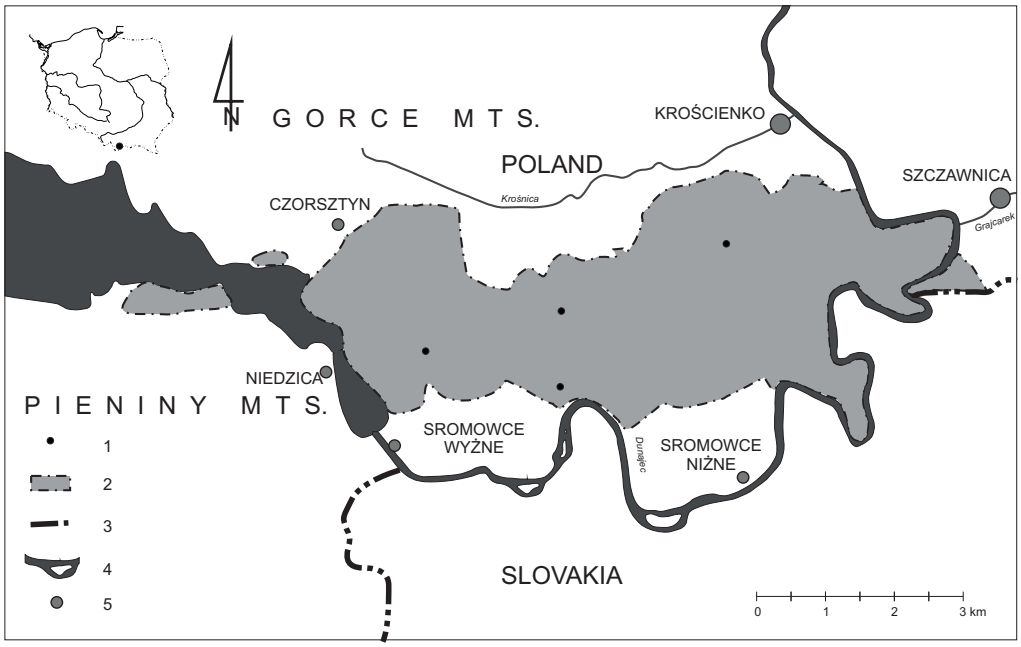

Fig. 1. General view of the studied eutrophic fens location in the Pieniński National Park
Explanations: 1 – eutrophic fens, 2 – boundary of Pieniński National Park, 3 – state boundary, 4 – Dunajec River, 5 – village and towns

Phormidium incrustatum or *Phormidiochaete nordstedtii*, thanks to their ability to precipitate calcium carbonate can form characteristic calcium incrustations which in the shape of crust strongly adhere to the substratum preventing the cyanobacteria from being washed away by water current. The species occur in this area are usually accompanied by *Oocardium stratum* (Starmach 1975, Mrozińska 1992). This alga can be mainly found in the spring part of the stream flowing in the Szopczańska Valley and in the Kotłowy Stream. Whereas the cyanobacteria: *Leptolyngbya pseudovalderiana*, *L. perelegans*, *Calothrix fusca*, *Hydrococcus cesatii* and *Schizothrix tenuis* can be encountered on the surface of the *Chaetophora* jellies or on the *Cladophora* thalluses (they can also occur only on the thalluses incrustated with calcium). Some Cyanobacteria can grow even inside the thalusses of such species as *Synechocystis pevaleckii*, its small cells were often encountered among the old and decomposing thalusses of *Chaetophora* (Starmach 1975, Mrozińska 1992), whereas *Hydrococcus cesatii* occurs permanently on the Cladophora thalluses forming on its surface small disc-like colonies. In *Schizothrix pulvinata*, pillow shape, strongly incrustated by calcium crusts, in which both live and dead layers arranged alternately were observed.

The phenomenon of calcium carbonate precipitation from water is characteristic not only for some cyanobacteria species, but it can be also observed in algae. *Oocardium stratum*, the species belonging the Desmidiaceae group is a typical representative for this area. Contrary to the Pieniny Mts where it occurs only sporadically (only in the parts of the Szopczański, Kotłowy streams close to their springs), the species is prevalent in the limestone Alps and in the Southern Europe karst areas, where it forms large tufaceous limestones used as building materials. Calcium carbonate precipitates on the tops of *Oocardium stratum* jelly-like small tubes, on rocks, sticks or mosses belonging to the genus C*ratoneuron*. In this manner the thick layers of the calcium incrustations are formed. This green alga permanently occurs accompanied by the cyanobacteria, and in particular by: *Phormidium incrustatum* and *Phormidiochaete nordstedtii* (the latter forms the small blue-green clusters). *Gongrosira calcifera* is growing in large number in the upper tributary of the Szopczański Stream where its incrustations firmly adhere to the stones, also belongs to this group of algae. Until recently this species was only reported from the Schilldow reserve in Germany, and from the mountainous areas in Spain (Krieger 1933, Aboal 1988). Short hair-like formations growing from top cells, and in general wider vegetative cells distinguish *Gongrosira calcifera* from *Gongrosira incrustans* and *Gongrosira de-baryana*, which are encountered on the stones in the Tatry mountains streams (Wasylik 1971). *Chrysonebula holmesii* is the other very rare species also belonging to this group of algae, which during the period of its intensive growth lasting from the autumn to the spring, cover the stones with visible from a distance thick jelly-like coating of grey-brown colour. Such a colour is probably due to calcium carbonate sedimentation inside the jelly-like coatings. This species is known from a few locations in Europe, e.g. the Gardle Beck stream in the karst area in England (Lund 1953, Starmach 1966, Hibberd 1977).

In the fens distributed in the northern side of the Pieniny Mts a very abundant species is *Chara vulgaris*, with time usually completely covered with calcium carbonate, which in consequence leads to its atrophy. This species plays an important role in forming local communities acting as a suitable substratum for the existence and development of other taxa. Among epiphytes the most interesting are: *Oedogonium decipiens*,

Table 1. List of algae and cyanophytes taxa found in eutrophic fens in the Pieniński National Park considering endangered categories and autecology (acc. van Dam et al. 1994 and Siemińska et al. 2006)

Species	Sampling site	Red list	Trophic state
1	2	3	4
Rhodophyta			
Rhodophyceae			
Audoinella pygmea Kützing	I, V		
Batrachospermum boryanum Sirodot	II	V	
Batrachospermum ectocarpum Sirodot	II, III	V	
Heterokonthophyta			
Bacillariophyceae			
Amphipleura pellucida (Kütz.) Kützing	I, II, III	R	2
Caloneis alpestris (Grun.) Cleve	III		3
Campylodiscus hibernicus Ehrenberg	I, II, V		5
Campylodiscus noricus Ehrenberg	II, III		3
Cymbella aspera (Ehrenb.) Cleve	II	V	7
Cymbella helvetica Kützing	III, IV	R	3
Cymbella silesiaca Bleisch			3
Cymbella simonsenii Krammer			5
Cymbella sinuata Gregory	II		3
Denticula tenuis Kützing	II		–
Diploneis ovalis (Hilse) Cleve	I, III	R	–
Ellerbeckia arenaria (Moore) Crawford	IV		1
Encyonema lange-bertalotii Krammer	II		–
Epithemia adnata (Kütz.) Brébisson	I, II, III		4
Epithemia argus (Ehrenb.) Kützing	IV, V		3
Epithemia argus var. *alpestris* (W. Sm.) Grunow	I		3
Eucocconeis flexella (Kütz.) Cleve			5
Mastogloia grevillei W. Smith	III, IV, V	V	5
Rhoicosphaenia abbreviata (Agardh) Lange-Bertalot	II, V		5
Stauroneis acuta W. Smith	II, III, V		–
Surirella angusta Kützing	II, III		–
Surirella spiralis Kützing	II, III, IV		1
Chrysophyceae			
Chrysonebula holmesii Lundl	I	V	
Chlorophyta			
Chlorophyceae			
Bulbochaete mirabilis Wittrock	II	V	
Bulbochaete pseudoareolata W. & O. Bock	II	R	
Coleochaete nitellarum Jost	I		
Oedogonium decipiens Wittrock	II, IV	V	

Table 1 – cont.

1	2	3	4
Oedogonium inversum Wittrock	IV, V	V	
Oedogonium inversum for. *subclusum* Wittrock	V	V	
Cladophorophyceae			
Cladophora glomerata (L.) Kützing	I, II, III		
Zygnematophyceae			
Actinotaenium cucurbita (Bréb.) Teilling	III, IV, V		
Cosmarium didymochondrium Nordstedt	IV		
Cosmarium obtusatum (Schmid.) Schmidle	IV		
Cosmarium tetraophtalmum Brébisson	II, III		
Gongrosira calcifera Krieger	I, V		
Oocardium stratum Nägeli	II, IV	E	
Staurastrum lapponicum (Schmid.) Grönblad	II		
Charophyta			
Charophyceae			
Chara vulgaris Lemmermann	I	V	
Cyanophyta			
Cyanophyceae			
Calothrix fusca (Kütz.) Bornet et Flahault	III		
Homoeothrix gloeophila Starmach	II, III, V		
Hydrococcus cesatii Rabenhorst	I, III, IV		
Leptolyngbya pseudovalderiana (Woron.) Anagn. & Komárek	I		
Lyngbya martensiana Meneghini ex Gomont	III, IV		
Lyngbya perelegans Lemmermann	V		
Phormidiochaete nordstedtii (Bornet & Flahault) Komárek	II		
Phormidium incrustatum (Nägeli) Gomont	III, IV		
Porphyrosiphon martensianus (Menegh. ex Gomont) Anagn. & Komárek	II		
Schizothrix fasciculata (Nägeli) Gomont	I, II		
Schizothrix pulvinata (Kütz.) Gomont	III, IV		
Schizothrix tenuis Woronichin	II		
Synechocystis pevaleckii Ercegović	II		

Explanations:
Categories of threat: E – extinct or probably extinct, V – vulnerable, R – rare.
Trophic state: 1 – oligotraphentic, 2 – oligo-mesotraphentic, 3 – mesotraphentic, 4 – meso-eutraphentic, 5 – eutraphentic, 7 – oligo- to eutraphentic (hypereutraphentic).

O. inversum for. *subclusum*, *Bulbochaete pseudoareolata* and *B. mirabilis*. In the fens, diatoms are also developing abundantly, and these are: *Cymbella aspera*, *C. silesiaca*, *Diploneis ovalis*, *Epithemia arcus*, *E. adnata*. *Campylodiscus noricus*, is common in the whole area of the Pieniny Mts, and it dominates in the fens, showing at the same time, a large morphological variability. Apart from the specimens with slightly bent cells, the typical saddle like cells were also encountered. The endophytic alga typical for the Pieniny fens is *Coleochaete nitellarum*, the species growing only in the tissues of *Chara vulgaris*.

Table 2. Vascular plants reported from eutrophic fens in the Pieniński National Park and their ecological characteristics (after Zarzycki et al. 2002)

Taxon	Life forms	Indicator values				Phytosociological unit	Categories of threat
		L	W	Tr	R		
1	2	3	4	5	6	7	8
Acer pseudoplatanus L.	M	3	3/4	4	3-5	Que-Fag	.
Achillea millefolium L.	G	4	2-3	3-4	3-4	Mol-Arr	.
Agrostis capillaris L.	H	4	2-3	3-4	3-4	Mol-Arr	.
Agrostis gigantea Roth.	H	4	3	3-4	3-4	Stel-med	.
Agrostis stolonifera L.	H	4	4	3-4	3-5	Mol-Arr	.
Ajuga reptans L.	H	3	3	3-4	3	Que-Fag	.
Alchemilla acutiloba Opiz	H	4-3	4-3	4	3-4	Mol-Arr	.
Alchemilla crinita Buser	H	4	3-4	4	3-4	Mol-Arr	.
Alchemilla glabra Neygenf.	H	4	4	4	4	Bident	V
Alchemilla gracilis Opiz	H	.	.	.	.	Mol-Arr	.
Alchemilla straminea Buser	H	.	.	.	.	Mol-Arr	.
Alchemilla xanthochlora Rothm.	H	3-4	3-4	.	.	Bident	.
Angelica sylvestris L.	H	4-3	4	4	4	Mol-Arr	.
Anthoxanthum odoratum L.	H	4	3	3	3	Mol-Arr	.
Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl	H	4	3	4	4-5	Mol-Arr	.
Astrantia major L.	H	3	4	4	3-4	Que-Fag	.
Bellis perennis L.	H	4	3-4	4	3-4	Mol-Arr	.
Blysmus compressus (L.) Panz. ex Link	G	4	4-5	3	4-5	Mol-Arr	.
Brachypodium sylvaticum (Huds.) P. Beauv.	H	3	3-4	3-4	4-5	Que-Fag	.
Briza media L.	H	4	3	3	2-4	Mol-Arr	.
Calamagrostis varia (Schrad.) Host	H	4	2-3	3	5	Seslerion	.
Caltha laeta Schott, Nyman & Kotschy	H	4	5	4	4	Que-Fag	.
Caltha palustris L.	H	4	5	4	4	Mol-Arr	.
Cardamine amara L.	H	3	5	4	4	Mol-Arr	.
Cardamine impatiens L.	H, T	3	4	4	3-5	Artemi	.
Cardamine pratensis L.	H	4	4	4	3-4	Mol-Arr	.
Carex buxbaumii Wahlenb.	G	4	5	3-4	5	Sch-Car	E
Carex davalliana Sm.	H	4	5	3	5	Sch-Car	V
Carex diandra Schrank	G, H	4	5	2-3	3	Sch-Car	.
Carex echinata Murray	H	4	5	3	3	Sch-Car	.
Carex flacca Schreb.	G	4	4	3	4-5	Fest-Brom	.
Carex flava L.	H	4	5	4	4-5	Sch-Car	.
Carex hirta L.	G	4	2-4	2-4	3-5	Mol-Arr	.
Carex nigra Reichard	G	4	4-5	2-4	2-4	Sch-Car	.
Carex ovalis Gooden.	H	4	3-4	3	2-3	Mol-Arr	.
Carex panicea L.	G, H	4	4	3	4	Sch-Car	.

Table 2 – cont.

1	2	3	4	5	6	7	8
Carex paniculata L.	H	4	5	4	4-5	Phragm	.
Carex rostrata Stokes	H	4	5	3-4	2-4	Phragm	.
Carex viridula Michx.	H	4	4	2	3-5	Sch-Car	.
Carex vulpina L.	G, H	4	5	4	4	Phragm	.
Carpinus betulus L.	M	2/3	3	3/4	3-5	Que-Fag	.
Carum carvi L.	H	4	3	4	4	Mol-Arr	.
Centaurea jacea L.	H	4	3	4	3-4	Mol-Arr	.
Cerastium holosteoides Fr. emend. Hyl.	C, H	4	3-4	3-4	3-5	Mol-Arr	.
Chaerophyllum hirsutum L.	H	3	4-5	4	4	Bident trip	.
Cirsium palustre (L.) Scop.	H	4	4	3	4	Mol-Arr	.
Cirsium rivulare (Jacq.) All.	H	5	4-5	4	4-5	Mol-Arr	.
Cornus sanguinea L.	N	3-4	2-4	4	4-5	Que-Fag	.
Corylus avellana L.	N	4	2-3	4-3	3-5	Que-Fag	.
Crepis mollis (Jacq.) Asch.	H	4	3	4	4	Mol-Arr	.
Crepis paludosa (L.) Moench	H	3	4-5	4	4-5	Mol-Arr	.
Cruciata glabra (L.) Ehrend.	H	4-3	3-4	4-3	3-5	Mol-Arr	.
Cynosurus cristatus L.	H	4	3	4	4	Mol-Arr	.
Dactylorhiza majalis (Rchb.) P.F. Hunt & Summerh.	G	4	4	3-4	3-5	Mol-Arr	.
Deschampsia caespitosa (L.) P. Beauv.	H	3-5	4	3-4	3-4	Mol-Arr	.
Eleocharis quinqueflora (Hartmann) O. Schwarz	H	4	5	3	5-4	Sch-Car	.
Eleocharis uniglumis (Link) Schult.	G	4	5	3	5-4		.
Epilobium hirsutum L.	H	4	5	4	5	Convol	.
Epilobium montanum L.	H	2	3	4	4	Que-Fag	.
Epilobium palustre L.	H	4	5	3	3	Mol-Arr	.
Epipactis palustris (L.) Crantz	G	4	5	4-3	5-4	Sch-Car	V
Equisetum arvense L.	G	4-5	3-4	3-4	3-4	Sisymbrion	.
Equisetum fluviatile L.	G	4	5	3-4	4-5	Phragm	.
Equisetum palustre L.	G	3-4	4	3-4	4	Mol-Arr	.
Equisetum sylvaticum L.	G	3	4	4-3	4-3	Que-Fag	.
Equisetum telmateia Ehrh.	G	4	4-5	4	4-5	Que-Fag	.
Equisetum variegatum Schleich.	C	4	4-5	3	5-4	Stel med.	.
Eriophorum latifolium Hoppe	H	4	5	4	4-5	Sch-Car	.
Eupatorium cannabinum L.	H	3-4	4	4-5	4-5	Artemi	.
Euphrasia rostkoviana Hayne	T	4	3	4	4	Mol-Arr	.
Euphrasia vernalis List	T	.	.	.	.	.	.
Festuca pratensis Huds.	H	4	3	4	4	Mol-Arr	.
Festuca rubra L.	H	4	2-4	3	4	Mol-Arr	.
Filipendula ulmaria (L.) Maxim.	H	3	4-5	4	4	Mol-Arr	.
Fraxinus excelsior L.	M	3	4-3	4	4	Que-Fag	.

Table 2 – cont.

1	2	3	4	5	6	7	8
Galeopsis speciosa Mill.	T	4	3-4	3-4	4	Sisymbrion	.
Galium boreale L.	H	4	4-2	3	4-5	Mol-Arr	.
Galium mollugo L.	H	4	3	4	4	Mol-Arr	.
Galium palustre L.	H	4	4-5	3	4	Phragm	.
Galium uliginosum L.	H	4	4	3	4	Mol-Arr	.
Geum rivale L.	H	3	4	4	4	Mol-Arr	.
Glyceria notata Chevall.	H	4	5	4	4	Phragm	.
Gymnadenia conopsea (L.) R. Br.	G	4	4-3	3	4-5	Mol-Arr	.
Heracleum sphondylium L.	H	4	4	4	4-5	Mol-Arr	.
Hieracium lactucella Wallr.	H	3-4	3	3	3-5	Mol-Arr	.
Holcus lanatus L.	H	4	4	3-4	4	Mol-Arr	.
Hypericum tetrapterum Fr.	H	4	4	3	2	Mol-Arr	.
Juncus articulatus L. emend. K. Richt.	H	5	4-5	3-4	5	Sch-Car	.
Juncus compressus Jacq.	G	4	4	4	4-5	Mol-Arr	.
Juncus conglomeratus L. emend. Leers	H	4	4-5	3	4-5	Mol-Arr	.
Juncus effusus L.	H	4	4-5	4-3	4	Mol-Arr	.
Juncus inflexus L.	H	4	4-5	3-4	4	Mol-Arr	.
Knautia arvensis (L.) J.M. Coult.	H	5	3	3-4	4-5	Mol-Arr	.
Lathyrus pratensis L.	H	4	3-4	4	4	Mol-Arr	.
Lathyrus vernus (L.) Bernh.	G	2-3	3	4	4-5	Que-Fag	.
Leontodon hispidus L. subsp. *hastilis* (L.) Rchb.	H	4	3-4	4	4	Mol-Arr	.
Leontodon hispidus L. subsp. *hispidus*	H	4	3-4	4	4	Mol-Arr	.
Leucanthemum vulgare Lam.	H	4	3	4	4	Mol-Arr	.
Linum catharticum L.	T	4	2-4	3	3-5	Mol-Arr	.
Listera ovata (L.) R. Br.	G	3-4	4-5	4	4-5	Coryneph	.
Lotus corniculatus L.	H	4	3-4	4-3	3-5	Mol-Arr	.
Lychnis flos-cuculi L.	H	4	4	4	4-5	Mol-Arr	.
Lycopus europaeus L.	H	3	5	4	4	Phragm	.
Lysimachia nummularia L.	C	3	4	4	4	Mol-Arr	.
Lysimachia vulgaris L.	H	4	4-5	4-3	4	Mol-Arr	.
Lythrum salicaria L.	H	4	4-5	4	4	Phragm	.
Maianthemum bifolium (L.) F.W. Schmidt	G	2	3	3	3	Que-Fag	.
Medicago lupulina L.	H	5	2-3	3-4	3-5	Sisymbrion	.
Melica nutans L.	H	2-3	3	3	4	Que-Fag	.
Mentha arvensis L.	G	5	3-4	3-4	3-5	Sisymbrion	.
Mentha longifolia (L.) L.	H	4	4-5	4	4-5	Mol-Arr	.
Myosotis palustris (L.) L. emend. Rchb.	H	4	4-5	4	4	Mol-Arr	.
Ononis arvensis L.	H, N	5	3	3-4	4-5	Fest-Brom	.
Ophrys insectifera L.	G	4	2-3	3	5	Fest-Brom	R

Table 2 – cont.

1	2	3	4	5	6	7	8
Parnassia palustris L.	H	4	4-5	4	5	Sch-Car	.
Pedicularis palustris L.	H	4	4-5	3	3	Sch-Car	V
Phleum pratense L.	H	4	2-3	3-4	4-5	Mol-Arr	.
Picea abies (L.) H. Karst.	M	3-4	3-4	2-3	1-3		.
Pimpinella major (L.) Huds.	H	4	3	4	4-5	Mol-Arr	.
Pinguicula vulgaris L.	H	4	4-5	3	5-3	Sch-Car	V
Plantago lanceolata L.	H	4	2-4	3-4	4	Mol-Arr	.
Plantago media L.	H	4	2-3	4-3	5-4	Fest-Brom	.
Poa trivialis L.	H	4	4	4	4	Mol-Arr	.
Polygala amarella Crantz	H	5	3-4	3	5	Sch-Car	.
Polygala comosa Schkuhr	H	5	2-3	3	5-4	Fest-Brom	.
Polygala vulgaris L.	H	4	3	3	3	Mol-Arr	.
Potentilla anserina L.	H	5	3-4	3-4	5-4	Mol-Arr	.
Potentilla erecta (L.) Raeusch.	H	4	3-4	2-3	2-4	Agr-Rumi	.
Potentilla reptans L.	H	5	3-4	3-4	5-4	Mol-Arr	.
Primula elatior (L.) Hill	H	3-4	3-4	4	4	Que-Fag	.
Prunella vulgaris L.	H	4	3-4	4	4	Mol-Arr	.
Ranunculus acris L.	H	4	3-4	4	4-5	Mol-Arr	.
Ranunculus repens L.	H	4-5	4-3	4	4-5	Mol-Arr	.
Rhinanthus minor L.	T	4	3-4	3	4	Mol-Arr	.
Rhinanthus serotinus (Schönh.) Oborný	T	4	3-4	4	4	Mol-Arr	.
Rumex acetosa L.	H	4	3-4	4	4	Mol-Arr	.
Salix cinerea L.	N	4	4-5	3-4	4	Agr-Rumi	.
Salix eleagnos Scop.	N	5	3-2	3	5	Sal purp	.
Salix pentandra L.	M, N	4	4-5	3-4	4	Agr-Rumi	.
Salix purpurea L.	N	4	4	4	4-5	Sal purp	.
Salix repens L. subsp. *rosmarinifolia* (L.) Hartm.	N, Ch	4	4-5	3	3-4	Agr-Rumi	.
Salix silesiaca Willd.	N	4	3-4	3	3-4	Sal purp	.
Scirpus sylvaticus L.	G	4	4-5	4	4-5	Mol-Arr	.
Scutellaria galericulata L.	H	4	4-6	4-3	.	Phragm	.
Senecio ovatus (P. Gaertn., B. Mey. & Scherb.) Willd.	H	3	3	4	4-3	Epilob	.
Stellaria graminea L.	H	4	3	4	4	Mol-Arr	.
Succisa pratensis Moench	H	4	4	3	4-3	Mol-Arr	.
Taraxacum paucilobum Hudziok	H	.	.	.	.	Mol-Arr	.
Thelypteris palustris Schott	G	2-3	4-5	4-3	4	Phragm	.
Tofieldia calyculata (L.) Wahlenb.	H	4	4	3	5	Sch-Car	V
Trifolium dubium Sibth.	T	4	3	4	4	Mol-Arr	.
Trifolium hybridum L.	H	4	4	4	4	Mol-Arr	.
Trifolium medium L.	H	4	3-2	3	4	Trif-Ger	.

Table 2 – cont.

1	2	3	4	5	6	7	8
Trifolium pratense L.	H	4	3	4	4	Mol-Arr	.
Trifolium repens L.	H	4	3-4	4	4	Mol-Arr	.
Triglochin palustre L.	H	4	4-5	3	4-5	Sch-Car	.
Tussilago farfara L.	G	5	3-4	3-4	4	.	.
Valeriana simplicifolia Kabath	H	4	5	3	5-4	Sch-Car	.
Veronica chamaedrys L.	H	4	3	4	4	Mol-Arr	.
Veronica scutellata L.	H	4	4-5	4	3-4	Sch-Car	.
Viburnum opulus L.	N	3	3-4	3-4	4	.	.
Vicia cracca L.	G	4	3	4	4-5	Mol-Arr	.

Explanations:
Life forms: C – non-woody chamaephytes, Ch – woody chamaephytes, G – geophytes, H – hemicryptophytes, M – megaphanerophytes, N – nanophanerophytes, T – therophytes.
Indicator values: Climate value (L) – light value, 1 – deep shade, 2 – moderate shade, 3 – half-shade, 4 – moderate light, 5 – full light; (W) – habitat moisture value, 1 – habitats very dry, 2 – habitats dry, 3 – habitats moderately moist, 4 – habitats very moist, 5 – habitats wet and water; Edaphic value (Tr) – basis trophy value, 1 – extremely poor, 2 – poor, 3 – moderately rich, 4 – rich, 5 – very rich; (R) – basis acidity value, 1 – highly acidic soils, pH < 4; 2 – acidic soils, 4 < pH < 5; 3 – moderately acidic, 5 < pH < 6; 4 – subneutral to neutral, 6 < pH < 7; 5 – alkaline, pH > 7.
Phytosociological unit: Agr-Rumi – *Agropyro-Rumicion crispi*, Artemi – *Artemisietea vulgaris*, Bident – *Bidentetea tripartiti*, Bident trip – *Bidention tripartiti*, Convol – *Convolvuletalia sepium*, Coryneph – *Corynephoretalia canescentis*, Epilob – *Epilobietea angustifolii*, Fest-Brom – *Festuco-Brometea*, Mol-Arr – *Molinio-Arrhenatheretea*, Phragm – *Phragmitetalia*, Que-Fag – *Querco-Fagetea*, Sal purp – *Salicetea purpureae*, Sch-Car – *Scheuchzerio-Caricetea nigrae*, Seslerion – *Seslerion*, Sisymbrion – *Sisymbrion*, Stel-med – *Stellarietea mediae*, Trif-Ger – *Trifolio-Geranietea sanguinei*.
Categories of threat: E – declining – critically endangered, V – vulnerable, R – rare, potentially endangered.

Analysing the degrees of threatened species (Table 2) it can be ascertained that 5% of species found in the Pieniny eutrophic fens is somehow threatened. Six species is at risk of being moved to the extinct category, if they remain under the influence negative factors. One species belongs to the rare category. However, 6 taxa are characteristic of the class *Scheuchzerio-Caricet*, which emphasizes the unique role of eutrophic fens.

The exceptionally rare communities of algae and cyanobacteria developing in the Pieniny National Park fens demand a particular care and protection. In these fens a special attention deserve the following taxa: *Oocardium stratum* accompanied by the cyanobacteria such as for example: *Phormidium incrustatum* and *Phormidiochaete nordstetii*. The advancing climatic, hydrological changes and also visible influence of anthropopression negatively affect the very sensitive Pieniny communities of eutrophic mountain fens and algae and cyanobacteria occurring there. The comprehensively acting factors, and in particular the irrational human behaviour can result in the complete destruction of the natural valuable micro-habitats of many very rare species of algae, cyanobacteria and vascular plants.

Acknowledgements

We are grateful to prof. dr hab. Teresa Mrozińska for encouragement, valuable comments and fruitful discussions on the manuscript.

REFERENCES

Aboal M. (1988): Aportación al conocimiento de las algas epicontinentales del S.E. de España. VII. Clorofíceas (Chlorophyceae Wille in Warming 1884). Candollea 43: 521-548.

Anagnostidis K., Komárek J. (1988): Modern approach to the classification system of Cyanophytes, 3-Oscillatoriales. Archiv. Hydrobiol. Suppl. Algol. Stud. 80, 1-4: 327-472.

Chećko E. (2004): Mapa roślinności Pienińskiego Parku Narodowego w liczbach. Studia Naturae 49: 327–348.

Chudyba D. (1965): Benthic algae in the River Dunajec. Probl. Zagosp. Ziem Gór. 11: 153-160.

Czerwik-Marcinkowska J., Mrozińska T. (2010): Kierunki i dynamika zmian składu gatunkowego glonów pro- i eukariotycznych w zbiornikach zaporowych Pienin i w Dunajcu w latach 1997-2008. In: Pieniny – Zapora – Zmiany. Eds R. Soja, S. Knutelski, J. Bodziarczyk. Monografie Pienińskie 2: 53-160.

van Dam H., Martens A., Sinkeldam J. (1994): A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Neth. J. Aquat. Ecol. 28, 1: 117-133.

Dąbrowski D., Jaguś A. (2003): Występowanie układów barycznych, mas powietrza i frontów atmosferycznych nad regionem pienińskim. Pieniny – Przyroda i Człowiek 8: 53-61.

Ettl H., Gärtner G. (1988): Chlorophyta II. Teil: Tetrasporales, Chlorococcales, Gloeodendrales. In: Süsswasserflora von Mitteleuropa. Band 10. Fischer, Jena.

Filarszky F. (1899): Adatok a Pieninek Moszatvegetatiójehoz. Magy. Természettud. Műz. 27: 1 (723)-8 (800).

Filarszky F. (1900): Beiträge zur Algenvegetation des Pieninen-Gebirges auf ungarischer Seite. Hedwigia 39: 133-148.

Gąsiorek M., Nicia P. (2010): Zawartość wybranych makroelementów w glebach młak o zróżnicowanym trofizmie. Woda Środ. Obsz. Wiej. 10, 29: 33-39.

Głowaciński Z., Nowacki J. (2004): Polska czerwona księga zwierząt – Bezkręgowce. Instytut Ochrony Przyrody PAN, Kraków, Poznań.

Grodzińska K., Jasiewicz A., Pancer-Kotejowa E., Zarzycki K. (1981): Mapa zbiorowisk roślinnych Pienińskiego Parku Narodowego 1965-1968. Skala 1:10 000. Zakład Ochrony Przyrody i Zasobów Naturalnych PAN, Instytut Botaniki PAN, Kraków (1 arkusz).

Hibberd D.J. (1977): The cytology and ultrastructure of *Chrysonebula holmesii* Lund (Chrysophyceae), with special reference to the flagellar apparatus. Br. Phycol. J. 12: 369-383.

Hindák F. (2001): Fotograficky atlas mikroskopickych sinic. Veda Publishing House of the Slovak Academy of Sciences, Bratislava.

van den Hoek C., Mann D.G., Jahns H.M. (1995): Algae. An introduction to phycology. University Press, Cambridge.

Humnicki W. (2007): Hydrogeologia Pienin. Wyd. Uniwersytetu Warszawskiego, Warszawa.

Kawecka B. (1965): Communities of benthic algae in the River Białka and its Tatra tributaries of the Rybi Potok and Roztoka. Komisja Zagospodarowania Ziem Górskich 11: 113-117.

Kawecka B., Mrozińska T. (1989): Wybrane zagadnienia hydrobiologiczne (algologiczne) w dorzeczu Górnego Dunajca. In: Dunajec wczoraj – dziś – jutro. Sympozjum naukowe, Niedzica, 15 czerwca 1989. Red. J. Starmach. Szkoła Główna Gospodarstwa Wiejskiego, Akademia Rolnicza, Warszawa: 82-94.

Kawecka B., Sanecki J. (2003): *Didymosphenia geminata* in running waters of southern Poland – symptoms of change in water quality? Hydrobiologia 495: 193-201.

Kawecka B., Szczęsny B. (1984): Dunajec. In: Ecology of European rivers. Ed. B.A. Whitton. Blackwell Sci. Publ., Oxford-Edinburgh-Boston Alto-Melbourne: 499-525.

Kaźmierczakowa R., Zarzycki J., Wróbel I., Vončina G. (2004): Łąki, pastwiska i zbiorowiska siedlisk wilgotnych Pienińskiego Parku Narodowego. Stud. Nat. 49: 195-251.

Kondracki J. (2000): Geografia regionalna Polski. Wyd. Nauk. PWN, Warszawa.

Kostrakiewicz L. (1982 a): Klimat. In: Przyroda Pienin w obliczu zmian. Ed. K. Zarzycki. Stud. Nat. Ser. B, 30: 53-69.

Kostrakiewicz L. (1982 b): Hydrografia. In: Przyroda Pienin w obliczu zmian. Ed. K. Zarzycki. Stud. Nat. Ser. B, 30: 70-93.

Krammer K., Lange-Bertalot H. (1986): Bacillariophyceae. 1. Teil: Naviculaceae. In: Süsswasserflora von Mitteleuropa. Band 2/2. Eds H. Ettl, J. Gerloff, H. Heying, D. Mollenhauer. Fischer, Jena.

Krammer K., Lange-Bertalot H. (1991): Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In: Süsswasserflora von Mitteleuropa. Band 2/3. Eds H. Ettl, J. Gerloff, H. Heying, D. Mollenhauer. Fischer, Jena.

Krieger W. (1933): Die Algen. In: Das Naturschutzgebiet Schildow. Ed. M. Hilzheimer. Teil 2: Kalktuffgelände am Tegeler Fließ. Neudamm, Berlin: 55-81.

Kulczyński S. (1928): Die Pflanzenassoziationen der Pieninen. Bull. Acad. Pol. Sci. Cl. 2, ser. B, 2, 1927: 57-203.

Lund J.W.G. (1953): New or rare British Chrysophyceae II. *Hyalobryon polymorphum* n. sp. and *Chrysonebula holmesii* n. gen. n. sp. New Phytol. 52: 114-123.

Matuszkiewicz W. (2001): Przewodnik do oznaczania zbiorowisk roślinnych Polski. Vademecum Geobotanicum 3. Wyd. Nauk. PWN, Warszawa: 8-537.

Mierzeńska M., Vončina G. (2010): New localities of the rare liverwort *Aneura maxima* (Schiffn.) Steph. (Metzgeriales, Marchantiophyta) in Poland (Pieniński National Park, Western Carpathians). Cryptogamie, Bryologie 31, 4: 305-312.

Mirek Z., Zarzycki K., Wojewoda W., Szeląg Z. (2006): Red list of plants and fungi in Poland. Czerwona lista roślin i grzybów Polski. Polish Academy of Sciences, W. Szafer Institute of Botany, Kraków.

Mrozińska T. (1982): Glony. In: Przyroda Pienin w obliczu zmian. Ed. K. Zarzycki. Stud. Nat. Ser. B, 30: 164-172.

Mrozińska T. (1990): Glony Pienin i ich znaczenie w ochronie wód. In: Materiały na seminarium „Środowisko przyrodnicze i Kultura Podhala. Stan obecny i możliwości rozwoju". Szczawnica Zdrój, 4-6 maja 1990. Rada Główna i Zarząd Główny, Polska Akademia Nauk, Centrum Podstawowych Problemów Gospodarki Surowcami Mineralnymi i Energią, Zakład Geosynoptyki Kopalin i Energii: 259-266.

Mrozińska T. (1992): Algae of the Pieniny National Park (South Poland). Veröffentlichungen des Geobotanischen Institutes dr ETH 107, Stiftung Rübel, Zürich: 218-237.

Mrozińska T. (2000): Sinice (Cyanophyta) i glony (Algae). In: Flora i fauna Pienin. Ed. J. Razowski. Monografie Pienińskie 1: 23-29.

Mrozińska-Webb T. (1976): A study on epiphytic algae of the order Oedogoniales on the basis of materials from Southern Poland. Fragm. Florist. Geobot. 22, 1-2: 147-227.

Mrozińska T., Czerwik J. (1998): Cyanophytes and algae in the period of construction at New built reservoirs. In: 9th Hungarian Algological Meeting, 12-15 May 1998. Ed. Keve T. Kiss. Gardony, Hungary. Book of abstract: 23.

Mrozińska T., Czerwik-Marcinkowska J. (2003): Eucaryotic algae and cyanophyceae in the River Dunajec between Nowy Targ and Krościenko and their use for monitoring. In: 5th International Symposium Use of Algae for Monitoring Rivers, 2-6 September 2003, Cracow. Book of abstract: 64.

Mrozińska T., Czerwik-Marcinkowska J. (2004): Eucaryotic algae and cyanobacteria in the River Dunajec upstream and downstream from the new dam reservoirs in Czorsztyn and Sromowce and their use for monitoring. Oceanol. Hydrobiol. Stud. 3: 83-97.

Mrozińska T., Czerwik-Marcinkowska J., Gradziński M. (2006): A new species of *Didymosphenia* (Bacillariophyceae) from the Western Carpathian Mountains of Poland and Slovakia. Nova Hedwigia 83, 3-4, 499-510.

Mrozińska T., Czerwik-Marcinkowska J., Gradziński M. (2010): Gatunki z rodzaju *Didymosphenia* (Bacillariophyceae), ich migracja i potencjalny wpływ na zbiorowiska glonów Pienin. Fragm. Florist. Geobot. Pol. 17, 1: 171-177.

Niemirowski M. (1982): Położenie i ukształtowanie. In: Przyroda Pienin w obliczu zmian. Ed. K. Zarzycki. Stud. Natur. Ser. B, 30: 17-31.

Pawłowski B. (1977): Szata roślinna gór polskich. In: Szata roślinna Polski. Eds W. Szafer, K. Zarzycki. Vol. 2. PWN, Warszawa: 189-252.

Piękoś-Mirkowa H., Mirek. Z. (2003): Flora Polski. Atlas roślin chronionych. Multico Oficyna Wydawnicza, Warszawa.

Rutkowski L. (2004): Klucz do oznaczania roślin Polski niżowej. Wyd. Nauk. PWN, Warszawa.

Sanecki J. (1989): Zbiorowiska glonów osiadłych w Dunajcu. In: Dunajec wczoraj – dziś – jutro. Sympozjum naukowe, Niedzica, 15 czerwca 1989. Szkoła Główna Gospodarstwa Wiejskiego, Akademia Rolnicza, Warszawa. Zeszyty CPBP 04.10 Ochrona i Kształtowanie Środowiska Przyrodniczego 11: 42-50.

Sanecki J. (1991): Zbiorowiska glonów osiadłych w Dunajcu w jego górnym biegu i w rejonie zbiorników zaporowych. Typescript. PhD thesis. Jagiellonian University in Kraków.

Sanecki J., Bucka H. (1992): Prognoses of changes in phytocoenosis of the River Dunajec (southern Poland) as a result of hydrotechnical constructions. Acta Hydrobiol. 34: 357-373.

Sanecki J., Dumnicka E., Starmach J. (1998): Charakterystyka podstawowych elementów biocenoz Dunajca i jego dopływów w rejonie nowo powstałych zbiorników zaporowych. Pieniny – Przyroda i Człowiek 6: 89-99.

Siemińska J., Bąk M., Dziedzic J., Gąbka M., Gregorowicz P., Mrozińska T., Pełechaty M., Owsianny P.M., Pliński M., Witkowski A. (2006): Red list of the algae in Poland. In: Red list of plants and fungi in Poland. Eds Z. Mirek, K. Zarzycki, W. Wojewoda, Z. Szeląg. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków: 35-52.

Skiba S., Drewnik M., Zaleski T. (2002): Mapa gleb Pienińskiego Parku Narodowego w jednostkach taksonomii międzynarodowej. Pieniny – Przyroda i Człowiek 7: 91-95.

Starmach K. (1966): Uber neue und seltene Chrysophyceae in der Algenflora Polens. Acta Hydrobiol. 8: 5-14.

Starmach K. (1975): Algae in the Szopczański Gorge in the Pieniny Mts. Fragm. Florist. Geobot. 21, 4: 537-549.

Starmach K. (1977): Phaeophyta – Brunatnice. Rhodophyta – Krasnorosty. In: Flora słodkowodna Polski. Eds K. Starmach, J. Sieminska. Warszawa, Kraków.

Staszkiewicz J. (1993): Zbiorowiska roślinne hali Majerz Pienińskiego Parku Narodowego. Busola sp. z o.o., Kraków.

Stebel A., Ochyra R., Vončina G. (2010): Mosses of the Pieniny Range (Polish Western Carpathians). Sorus, Poznań.

Szafer W., Kulczyński S., Pawłowski B. (1986): Rośliny polskie. PWN, Warszawa.

Tarnowska (1971): Wiosenna flora okrzemek potoku Kamionka w Małych Pieninach (Karpaty Zachodnie). Fragm. Florist. Geobot. 17, 4: 439-443.

Tomaszewski J.T. (1970): Młaki górskie. Czas. Geogr. 41, 4: 427-442.

Vončina G. (2001): Problemy ochrony młak eutroficznych Pienińskiego Parku Narodowego. Praca dyplomowa. Maszyn. SGGW, Warszawa.

Vončina G. (2007): Rozmieszczenie i syntaksonomia młak eutroficznych z rzędu *Caricetalia davallianae* w polskiej części Karpat. Praca doktorska. Maszyn. Zakład Taksonomii Roślin i Fitogeografii Uniwersytetu Jagiellońskiego, Kraków.

Wasylik K. (1971): Algal communities in the Czarny Dunajec River (Southern Poland) and in some of its affluents. Fragm. Florist. Geobot. 17, 2: 257-364.

Wołoszyńska J. (1936): Kilka nowych stanowisk krasnorostów słodkowodnych. Sprawozdania Komisji Fizjograficznej PAU 68, 9: 65-66.

Wróbel I. (2000): Ekosystemy nieleśne Pienińskiego Parku Narodowego – praktyczna realizacja planu ochrony na lata 1989-1998. Szczeliniec 4: 293-303.

Zarzycki K. (1982): Biotopy łąk i pastwisk. Roślinność łąk i pastwisk. In: Przyroda Pienin w obliczu zmian. Ed. K. Zarzycki. Stud. Nat. Ser. B, 30: 340-351.

Zarzycki K., Trzcińska-Tacik H., Różański W., Szeląg Z., Wołek J., Korzeniak U. (2002): Ekologiczne liczby wskaźnikowe roślin naczyniowych Polski. Vol. 2. Biodiversity of Poland. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Zarzycki K., Szeląg Z. (2006): Red list of the vascular plants in Poland. In: Red list of plants and fungi in Poland. Eds Z. Mirek, W. Zarzycki, W. Wojewoda, Z. Szeląg. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków: 9-20.

Żarnowiec J., Stebel A., Ochyra R. (2004): Threatened moss species in the Polish Carpathians in the light of a new Red-list of mosses in Poland. In: Bryological studies in the Western Carpathians. Eds A. Stebel, R. Ochyra. Sorus, Poznań: 9-28.

For citation: Czerwik-Marcinkowska J., Vončina G. (2012): Algoflora and vascular flora in the eutrophic fens of the Pieniny National Park (South Poland). Rocz. AR Pozn. 391, Bot. Stec. 16: 55-66.