OPOLE SCIENTIFIC SOCIETY
NATURE JOURNAL
No 47 – 2014: 9-21

FLAGSHIP SPECIES OF THE PIENINY NP. PROTECTED *EX SITU* AT PAS BG CBDC SEED BANK AT WARSAW-POWSIN

JERZY PUCHALSKI[1], ARKADIUSZ NOWAK[2], AGATA SMIEJA[1], ANNA RUCIŃSKA[1], ADAM KAPLER[1], MACIEJ NIEMCZYK[1], PIOTR WALEROWSKI[1], ANTONI KRZYŻEWSKI[1]

[1]Polish Academy of Sciences Botanical Garden – Center for Biological Diversity Conservation in Powsin, Warsaw, Prawdziwka 2 str., 02-973 Warsaw, bgpas@obpan.eu
[2]Opole University, Department of Biosystematics, 45-052 Opole, Oleska St. 22
anowak@opole.uni.pl

ABSTRACT: Pieniny Mts. are important biodiversity hotspot in Central Europe. According to Pieniny National Park Long Term Conservation Plan 2000-2020 small, isolated populations of some of Pieniny NP flagship species can become extinct till 2020. That is why their *ex situ* preservation at seed bank is justified and reasonable as supplement of active and passive *in situ* conservation measures carried out by National Park staff. PAS Botanical Garden – Center for Biological Diversity Conservation at Warsaw-Powsin has a long tradition of cooperation with Pieniny National Park (S Poland). This article focuses on the actions undertaken during EU funded conservation project: "*Ex situ* conservation of native, threatened and protected plant species in eastern Poland - FlorNaturOB". Seeds of *Dendranthema zawadzkii*, *Erysimum pieninicum* and *Minuartia setacea* collected by „FlorNaturOB" team at Pieniny NP: (1) showed orthodox behaviour (could be easily dried and frozen at ultra-low temperatures of liquid Nitrogen), (2) do not exhibit seed dormancy. Species' localization and collecting time influenced the seed samples quality.

KEY WORDS: Pieniny NP special interest plant species, *Dendranthema zawadzkii, Erysimum pieninicum, Minuartia setacea,* cryopreservation, seed dormancy, "FlorNaturOB" project

Introduction

Carpathians are northernmost centre of plant endemism in Europe. Polish-Slovakian Pieniny Mts. due to their limestone rocks, unique orography (steep-sided cliffs and gorges), climatic conditions and geological history are important biodiversity hotspot of Central Europe (Pawłowski 1970; Zarzycki 1976; Smólski 1982; Benčat'ová 2001; Mirek and Piękoś-Mirkowa 2009). During Pleistocene the Pieniny mountain range had been a refugium for xerothermophilous flora and fauna, including Ponto-Panonian, Irano-Turanian and Submediterranean elements. During Holocene this small mountain range become migration route for:

- alpine plant species descending from Tatra Mts. at Małopolska and Roztocze Uplands e.g.: *Dryas octopetala* L., *Aster alpinus* L.;
- steppe and thermophilous oakwood species recolonizing Central and Northern Europe e.g.: *Adenophora liliifolia* Bess., *Crepis praemorsa* Tausch, *Inula ensifolia* L., *Senecio integrifolius* (L.) Clairv. etc. (Bodziarczyk 2008; Kaźmierczakowa 2008; Piękoś-Mirkowa 2008; Zarzycki and Wróbel 2012).

Alkaline soils and range isolation are key factor enhancing speciation (Favarger 1972; Hendrych 1982; Tribsch and Schönswetter 2003; Piękoś-Mirkowa and Mirek 2009). That is why Pieniny flora has many neoendemic varieties and small species, with recognizable but disputable taxonomic rank e.g.: *Erysimum pieninicum* (Zapał.) Pawł., *Minuartia setacea* (Thuill.) Hayek var. *pienina* (Zap.) Pawł., *Centaurea triumfetti* All. var. *pieninica* Pawł. (Pawłowska 1953; Pawłowski 1970; Zarzycki 1976; Piękoś-Mirkowa and Mirek 2003, 2009; Fig. 1,2). The oldest Pieniny endemic is *Taraxacum pieninicum* Pawł., which evolved in Paleogene (Pawłowska 1953; Małecka 1962; Prochazka et al. 1999; Wróbel 2004, 2008). Extinction risk assessment of the flora of the Polish Pieniny was published by Szczocarz et al. (1992), Wróbel (2003), Wróbel and Zarzycki (2010), and Zarzycki and Wróbel (2012).

Wróbel (2003) claims that „*during the enforcement of National Park Conservation Plan some minute, isolated populations of flowering plant species such as: Androsace lactea, Taraxacum pieninicum, Lilium bulbiferum, as well as some orchid species and species associated with wet and humid habitats, can become extinct at Pieniny range.*"

Ex situ preservation of germplasm of the above mentioned seed bank seems reasonable and justified as supplement of active and passive *in situ* conservation measures carried out by National Park staff. PAS Botanical Garden – Centre for Biological Diversity Conservation at Warsaw-Powsin has a long tradition of cooperation with Pieniny National Park (S Poland)

(Galera et al. 2000; Puchalski 2000; Zarzycki and Lankosz-Mróz 2000; Gasek et al. 2004; Puchalski and Gawryś 2007; Puchalski et al. 2011, 2013; Trejgell et al. 2013).

Material and methods

Conservation measures had been carried out in the frameworks of EU program: „*Ex situ* conservation of native, protected and threatened species in Eastern Poland. Polish: Ochrona *ex-situ* dziko rosnących, zagrożonych i chronionych roślin w Polsce wschodniej – FlorNaturOB" in the years: 2010 – 2013".

Seeds were collected and prepared for long-term preservation at Seed Bank according to ENSCONET standards, described in international manuals (http://ensconet.maich.gr/Download.htm). Seeds viability has been tested using PAS BG CBDC Seed Bank own methods (Muranyi 2002 unpubl.; Muranyi and Wróbel 2006; Puchalski et al. 2013).

Seeds biology of three Pieniny National Park flagship (charismatic) species: *Erysimum pieninicum* (Zapał.) Pawł., *Minuartia setacea* (Thuill.) Hayek var. *pienina* (Zap.) Pawł. and *Dendranthema zawadskii* (Herb.) Tzvelev, had been studied in detail (tab.1).

After gathering and delivering to bank seeds of above mentioned species were cleaned (using mechanical seed separator) and dried to 20% moisture content (15°C, 20% RH). 30 days later, when seeds moisture reached 6-8% its viability, germination biology (germination tests in environmental chamber with controlled conditions of temperature, light and humidity) has been checked. Due to previously observed lack of dormancy their viability has been tested through germination on paper moistened with distilled water, at climatic chamber, applying conditions adopted in the past by Muranyi for Pieniny rare species germination: 25°C/15°C (16h/8h), 70% RH (Muranyi 2002 unpubl.). To avoid pathogenic microfungi seeds had been treated with Funaben T fungicide during the germination tests. Due to small number of gathered seeds only 25 seeds of each Pieniny flagship species were used to each germination test and the tests had been repeated twice a week.

After checking their germination ability, the second experiment were test for freezing tolerance in LN2. It has been applied by: direct immersion in LN2 or slow freezing (0,5°C/minute) according to control, non-frozen sample. After 30 days of storage in vapour of LN2 (ca. -160°C) the seed germinability was again tested. In case of no differences between frozen and control samples the particular seed sample was transferred for long-term storage in cryogenic vaults. *E. pieninicum* and *M. setacea* seeds were examined in two repeats of 25 seeds each, *D. zawadskii* generative diaspores has been examined in three repeats also 25

seeds each. Each freezing tolerance test for *E. pieninicum* and *D. zawadskii* seeds had three options:

- direct immersion of seeds at LN_2 vapours (circa -160^oC)
- gradually cooling of seeds at IceCube device (0,5°C/min.) to LN_2 temperature (circa -160^oC)
- unfrozen control (K).

In case of *M. setacea* seeds we had to resign from gradually cooling of seeds at IceCube device due to small number of available seed material.

After 30 days in cryogenic vault the germinability of frozen seeds has been examined again using previously described, standard Powsin Seed Bank methods. Above mentioned viability and freezing tolerance tests were necessary due to ensure that material gathered will remain viable after cryostorage.

Results

Three Pieniny NP. flagship species collected at four natural sites has been secured *ex situ* at PAS BG-CBDC Seed Bank (Tab. 1). Carried out standard viability and freezing tolerance tests confirmed *D. zawadskii, E. pieninicum* and *M. setacea* seeds excellent capacity to long-term cryostorage.

Above mentioned seed material had fully withstand drying to 6-8% RH. Seeds do not exhibit dormancy and its germinability were significant (Tab. 2). Only *E. pieninicum* seed sample gathered at 2010 had not germinated successfully and achieved only 8% of viability in our, standard germination test. We carried out additional tests using GA_3 (400 ppm) to coerce germination. After supplementation with gibberelic acid seeds from this sample germinated in 76%, but obtained seedlings were weak and they were dying out fast. Next we differentiated time of seeds exposition to GA_3 from one to seven days. In each options seeds germinated but the seedlings died soon after germination.

That is the reason why we decide to repeat the gathering of *E. pieninicum* seed material at Pieniny NP. Material collected at 2011 had been checked and proved itself to be viable, germinating up to 86%. The reason of negligible germinability of 2010 seed lot were probably too early time of collecting – July instead of August-early September. Although *Erysimum*' siliquae seemed mature at July 2010 there were too young for gathering to seed bank (Table 2).

In case of *D. zawadzkii* seed material germinability were very high (94% from Okrąglica, 76% from Wąwóz Sobczański population). *M. setacea* sample collected at 2010 germinated in 80%.

Carried out freezing tests proved that all Pieniny flagship species remain viable after long-term cryostorage (Tab. 2). In most cases no significant differences between control and deeply frozen samples has been observed. *D. zawadzkii* seed material from Wąwóz Sobczański germinability of the directly immersed at LN2 sample were even higher (68%) than control (52%). Only *M. setacea'* seeds germinability slightly decreased after freezing.

After standard tests all gathered Pieniny flagship seed samples (excluding *E. pieninicum* from 2010) have been safeguarded in Powsin Seed Bank deposit. Duplicates of above mentioned samples had been secured at Forest Gene Bank "Kostrzyca" near Karpacz to enforce total safety of the germplasm (Puchalski et al. 2013).

Discussion

According to Piękoś-Mirkowa and Mirek (2010) „*one of most important, current tasks of botanic gardens should be ex situ conservation of Polish endemics, especially endemics in the strict sense of the word. Modern botanic gardens' activity remains insufficient to conservation needs"*.

European funded program „*Ex situ* conservation of native, protected and threatened species in Eastern Poland – FlorNaturOB. Polish: Ochrona *ex situ* dziko rosnących, zagrożonych i chronionych roślin w Polsce wschodniej - FlorNaturOB" could has been a remedy to this negligence.

Effective, long-term preservation of Pieniny endemics and relics' germplasm by seed cryopreservation require a good knowledge on their germination biology and optimization of seeds drying, germinating, freezing and refreezing. According to Ellis and his collaborators (1985) drying is the most important procedure in seeds safeguarding. Fortunately all three Pieniny flagship species produce *orthodox* seeds. They can be easily dry to very low humidity and secured at liquid nitrogen. Only *Minuartia setacea'* generative diaspores revealed some loss of germinability after cryostorage. However unpublished Muranyi observations from 2002 proved that even *Minuartia setacea'* seeds remained viable in 80% after cryostorage. Obtained results also confirm that testing of each seed sample germinability is a necessary procedure (Table 2). Sample quality can be influenced by gathering locality (*D. zawadzkii*), date of collecting (*E. pieninicum*) as well as other factors contribute to total sample quality, and reaction on liquid Nitrogen (Tab. 2).

Even the best *in situ* protection at National Parks and nature reserves can be insufficient due to: abiotic factors (avalanches, wildfires, floods, droughts, windthrows), pathogen and herbivore activity, illegal plant gathering, genetic drift and shift etc. This the reason why *in situ* protection ought to be supported by *ex situ* conservation. Seed cryopreservation proved to be useful tool in long-term securing of the Pieniny flagships conservation outside their natural habitats.

Acknowledgements

Conservation project „ *Ex situ* conservation of native, protected and threatened species in Eastern Poland. Polish: Ochrona *ex situ* dziko rosnących, zagrożonych i chronionych roślin w Polsce wschodniej - FlorNaturOB" has been funded by the European Union at the framework of the The Operational Programme Infrastructure and Environment (OPI&E), Priority V, Action 5.1.2 „Species *ex situ* conservation, protection of genetic resources and establishment of the animal rehabilitation centres", and from the Polish government funds provided by the National Fund for Environmental Protection and Water Management.

Figure 2. Flowering *Erysimum pieninicum* at Czorsztyn Castle Hill, Pieniny NP (phot. A. Nowak).

Figure 3. *Minuartia setacea* at Okrąglica, Pieniny NP (phot. A. Nowak).

Tab. 1. Species protected in Seed Bank of PAS BG CBDC in 2010-2013 period.

Species name*	**Category of threat****	**Localization**	**Other information**
Minuartia setacea (Thuill.) Hayek	CR	Okrąglica	Steppe relic
Erysimum pieninicum (Zapał.) Pawł.	VU	Góra Zamkowa at Czorsztyn	Polish neoendemic (stenochoric) species
Dendranthema zawadzkii (Herbich) Tzvelev	LR	Okrąglica Wąwóz Szopczański	Pleistocene or even late Paleogene steppe relic, gene donor for ornamental chrysanthemums

*Species names after Mirek et al. (2002),
**Threat categories according to Mirek and Zarzycki (2006), Kaźmierczakowa and Zarzycki (2001) and. Mirek and Piękoś-Mirkowa (2008)

Tab. 2. Results of viability and freezing tolerance tests.

Species	**Locality/ year of collection**	**1000 seed weight (g)**	**Germinability test**				**Freezing test**			
			variant	**germina-bility (%)**	**number of germina-ted seeds**	**dura-tion (days)**	**variant**	**germina-bility (%)**	**number of germina-ted seeds**	**dura-tion (days)**
Dendranthema zawadzkii	Okrąglica/ 2011	0,400	H_2O	94	47	12	LN_2	97	73	
							st. LN_2	97	73	17
							K	99	74	
	Sobczański Valley/ 2011	0,310	H_2O	76	38	16	LN_2	68	34	
							st. LN_2	52	26	12
							K	52	26	
Erysimum pieninicum	Czorsztyn, Góra Zamkowa / 2010	0,362	H_2O	8	4	42	-	-	-	-
			GA_3	0	0	42	-	-	-	-
	Czorsztyn, Góra Zamkowa/ 2011	0,655	H_2O	86	43	7	LN_2	72	36	
							st. LN_2	78	39	8
							K	80	40	
Minuartia setacea	Okrąglica/ 2010	0,103	H_2O	80	40	23	LN_2	48	24	
							st. LN_2	28	14	28
							K	70	35	

Bibliography

Bencat'ova B. 2001. Cievnaté rastliny Pienin. Arbora Publishers, Zvolen. strony

Bodziarczyk J. 2008. Starzec polny *Senecio integrifolius* (L.) Clairv. – CR. 402-403 In: Mirek Z., Piękoś-Mirkowa H. (red.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W. Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Cyunel R.1959. Studia nad rozmieszczeniem gatunków kserotermicznych w polskich Karpatach Zachodnich. Fragmenta Floristica et Geobotanica 5(3): 409–441.

Dostal J. 1989. Nova květena ČSSR. 1. Academia, Praha. 656 pp.

Ellis R., Hong T., Roberts E.1985. Handbook of seed technology for genebanks. Volume II. Compendium of specific germination information and test recommendations. International Board for Plant Genetic Resources. Handbooks for Genebanks, No. 3, Rome. 429 pp.

Favarger C. 1972. Endemism in tohe montane floras of Europe. In: D.H. Valentine (ed.), Taxonomy, Phytogeography and Evolution. Academic Press, London and New York, pp. 191–204.

Galera H., Puchalski J., Gawryś W. 2000. Polskie kolekcje roślin chronionych i zagrożonych oraz endemitów i reliktów. Część 2. Taksony zagrożone oraz endemity i relikty. Biul. Ogr. Bot. 9: 19-43.

Gasek A., Kościelak A., Puchalski J. 2004. Endangered species in the collection of mountain plants of Polish flora in the botanical garden of the Polish Academy of Science. Biul. Ogr. Bot. 13: 31-38.

Halada L. 1994. *Ruscus hypoglossum* L. in Slovakia. Thaiszia, J. Bot. Koszice 4: 183-195.

Hendrych R. 1982. Material and notes about the geography of the highly stenochoric to monotopic endemic species of the European flora. - Acta Universitatis Carolinae, Biologia 3–4: 335–372.

Kaźmierczakowa R., Zarzycki K. (ed.) 2001. Polska Czerwona Księga Roślin, Paprotniki Rośliny Kwiatowe. Instytut Botaniki im. W.Szafera, Instytut Botaniki PAN, Kraków.

Kaźmierczakowa R. 2008. Pępawa różyczkolistna *Crepis praemorsa* (L.) Lausch – CR. 372-374. In: Mirek Z., Piękoś-Mirkowa H. (ed.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W.Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Kolanowska M., Naumowicz J., Naczk A., Święczkowska E. 2012. Dwulistnik muszy *Ophrys insectifera* (Orchidaceae) w Pienińskim Parku Narodowym – nowe stanowiska. Chrońmy Przyrodę Ojczystą 68(2): 143–145.

Kucharzyk S. 2009. System ochrony przyrody w Karpatach ze szczególnym uwzględnieniem parków narodowych. - Roczniki Bieszczadzkie 17:15–42.

Małecka J. 1962. Studies in the mode of reproduction of the diploid endemic species *Taraxacum pieninicum* Pawł. Acta Biologica Cracoviensis, Series Botanica 4(1): 25–42.

Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. 2002. Flowering plants and pteridophytes of Poland. A Checklist. vol. 1. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków. v

Mirek Z., Piękoś-Mirkowa H. (ed.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W. Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Mirek Z., Piękoś-Mirkowa H. 2009. Phytogeographic aspects of endemism in Poland. Wiadomości Botaniczne 53(3/4): 7–30.

Mitka J. 2003. The genus *Aconitum* (Ranunculaceae) in Poland and adjacent countries. A phenetic-geographic study. Institute of Botany, Jagiellonian University, Cracow. 165 pp.

Muranyi R. 2002. Sprawozdanie z prac prowadzonych w ramach działalności podstawowej. Temat badawczy nr 1: „Opracowanie metod kiełkowania i kriogenicznego przechowywania nasion roślin zagrożonych i chronionych". Warszawa-Powsin, (unpbl, mscr).

Muranyi R., Wróbel I. 2006. Rola Narodowego Banku Nasion w ochronie zagrożonych gatunków roślin Pienińskiego Parku Narodowego. Pieniny – Przyroda i Człowiek 9: 79-85.

Pawłowska S.1953. Rośliny endemiczne w Polsce i ich ochrona. Les especes endemiques en Pologne et leur protection. Odbitka z rocznika XXI Ochrony Przyrody. Kraków, ss. 34.

Pawłowski B. 1970. Remarques sur l'endemisme dans la flore des Alpes et des Carpates. Vegetatio 21(4-6): 181–242.

Piękoś-Mirkowa H., Mirek Z. 2003. Endemic taxa of vascular plants in the Polish Carpathians. Acta Societatis Botanicorum Poloniae 72(3): 235–242.

Piękoś-Mirkowa H. 2008. Dzwonecznik wonny *Adenophora liliifolia* (L.) Besser – EX. 336-337. In: Mirek Z., Piękoś-Mirkowa H. (ed.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W.Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Piękoś-Mirkowa H., Mirek Z. 2009. Distribution patterns and habitats of endemic vascular plants in the Polish Carpathians. Acta Societatis Botanicorum Poloniae 78(4): 321–326.

Piękoś-Mirkowa H., Mirek Z. 2010. Zagrożenie i ochrona endemicznych roślin naczyniowych występujących w Polsce. Chrońmy Przyrodę Ojczystą 66(1): 15–26.

Prochazka F., Stepanek J., Kirschner J. 1999. *Taraxacum erythrocarpum* Kirschner et Stepanek. In: Čerovsky J, Ferakova V., Holub J., Maglocky S., Prochazka F. (ed.) 1999. Červena kniha ohroženyh a vzacnýh druhu rostlin a živocichu CR a SR. Vol. 5. Vyssi rostliny. Příroda, Bratislava. 367 pp.

Puchalski J. 2000. Banki genów w zachowaniu roślin rzadkich i zagrożonych. Biul. Ogr. Bot. 9: 91-97.

Puchalski J. 2004. International programmes for seed preservation of European native plants. Biul. Ogr. Bot. 13: 11-18.

Puchalski J., Gawryś W. 2007. Kolekcje roślin chronionych i zagrożonych oraz gatunków objętych Konwencją Berneńską w polskich ogrodach botanicznych. Biul. Ogr. Bot. 16: 47-184.

Puchalski J., Kapler A., Niemczyk M. 2011. *Ex situ* conservation of Polish endangered plant species in botanical gardens. pp.: 94-122. In: Botanic Gardens and Biodiversity. 200th Anniversary of University Botanic Gardens Ljubljana, European Botanic Gardens Consortium Meeting, Ljubljana, 12-16.05.2010. 160 pp.

Puchalski J., Kapler A., Niemczyk M., Smieja A., Walerowski P., Krzyżewski A., Podyma W. 2013. Zachowanie *ex situ* w kriogenicznym banku nasion rzadkich, zagrożonych i chronionych gatunków flory polskiej jako efekt projektu „FlorNaturOB". 19-21. In: Kierunki i możliwości rozwoju ogrodów botanicznych i arboretów w Polsce XXI w. Materiały konferencyjne. XLII Zjazd Ogrodów Bot i Arboretów w Polsce, Kraków, 19-21 września 2013 r. p. 50.

Richards A., Sell P. 1976. *Taraxacum* Weber. Ss.: 332-343. In: Tutin T., Heywood V., Burges N., Moore D., Valentine D., Walters S., Webb D. (ed.). Flora Europaea. Vol. 4. Cambridge University Press, Cambridge. 584 pp.

Smólski S. 1982. Historia ochrony przyrody w Pieninach i jej zadania w obliczu nadchodzących zmian. In: K. Zarzycki Z. J. Witkowski – Dlaczego chronimy Pieniny? 9 (ed.), Przyroda Pienin w obliczu zmian. Stud. Naturae, Ser. B, 30: 475–485.

Synge H. (ed.) 1981. The biological aspects of rare plants conservation. J. Wiley & Sons, Chichester. 162 pp.

Synge H. 1991. Conserving the wild plants of Gran Canaria. WWF, IUCN, Gran Canaria. 188 pp.

Bencat'ova B. Szczocarz A. 1992. Wielka hydrotechnika w Pienińskim Parku Narodowym. Pieniny – Przyroda i Człowiek 1: 109–127.

Szeląg Z. 2008. Mokrzyca szczeciolistna *Minuartia setacea* (Thuill.) Hayek – CR. 126-127. In: Mirek Z., Piękoś-Mirkowa H. (ed.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W.Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Trejgell A., Chernetskyy M., Podlasiak J., Tretyn A. 2013. An Efficient System for Regenerating *Taraxacum pieninicum* Pawł. from Seedling Explants. Acta Biol. Cracov. Ser. Bot. 55, 1: 73–79.

Tribsch A., Schoenswetter P. 2003. Patterns of endemism and comparative phylogeography confirm palaeoenvironmental evidence for Pleistocene refugia in the eastern Alps. Taxon 52: 477-497.

Vončina G. 2010. Tajęża jednostronna *Goodyera repens* (L.) R.Br. – nowy przedstawiciel storczykowatych Orchidaceae w Pienińskim Parku Narodowym. Pieniny – Przyroda i Człowiek 11: 33–38.

Webster R., Holt S., Avis C. 2001. Stan Karpat. Raport opracowany w ramach Inicjatywy Ekoregionu Karpackiego. p. 66.

Wróbel I. 2003. Szata roślinna Pienińskiego Parku Narodowego. Podsumowanie Planu Ochrony na lata 2001–2020. Pieniny – Przyroda i Człowiek 8: 63–69

Wróbel I. 2004. Mniszek pieniński *Taraxacum pieninicum* Pawł. – gatunek specjalnej troski w Pienińskim Parku Narodowym. Chrońmy Przyrodę Ojczystą 60(2): 11–16.

Wróbel I. 2008. Mniszek pieniński *Taraxacum pieninicum* Pawł. – CR. 406-408 [in:] Mirek Z., Piękoś-Mirkowa H. (ed.) 2008. Czerwona Księga Karpat Polskich. Rośliny naczyniowe. Instytut Botaniki im. W.Szafera & Instytut Ochrony Przyrody PAN, Kraków. 615 pp.

Wróbel I., Zarzycki K. 2010. Oddziaływanie zespołu zbiorników wodnych Czorsztyn-Niedzica i Sromowce Wyżne na florę i roślinność Pienin. Pieniny–Zapora–Zmiany — Monografie Pienińskie 2: 131–152.

Zarzycki K. 1976. Małe populacje pienińskich roślin reliktowych i endemicznych, ich zagrożenie i problemy ochrony. Ochrona Przyrody 41: 7–75.

Zarzycki K. 1981. (ed.) Przyroda Pienin w obliczu zmian. Stud. Naturae, ser. B. 30: 1–578., Kraków.

Zarzycki K. 1982. Rośliny rodzime. [in:] K. Zarzycki (ed.), Przyroda Pienin w obliczu zmian. Studia Naturae, Ser. B, 30: 127–142.

Zarzycki K., Lankosz-Mróz M. 2000. Zadania polskich ogrodów botanicznych i arboretów w obronie różnorodności flory krajowej. Biul. Ogr. Bot. 9: 15-17.

Zarzycki K., Mirek Z. (ed.) 2006. Red list of plants and fungi in Poland. Czerwona lista roślin i grzybów Polski. Instytut Botaniki im. W. Szafera PAN, Kraków. 99 pp.

Zarzycki K., Wróbel I. 2012. Przemiany pienińskiej flory roślin naczyniowych w XX wieku. Pieniny – Przyroda i Człowiek 12: 43–56.

Zemanek B. 2009. Fitogeograficzne problemy Karpat. Roczniki Bieszczadzkie 17: 43-58.