

CAREX SECALINA (CYPERACEAE), A CRITICALLY ENDANGERED SPECIES OF EUROPE: HISTORIC AND NEW LOCALITIES IN POLAND

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ABSTRACT

Carex secalina, a species recognized as extinct in Poland for 40 years, was re-discovered in 2000 and its natural populations covered by monitoring. From among nine historic localities, only for two – Jacewo and Turzany, in the vicinity of Inowrocław – the occurrence of the species was confirmed. In the course of the field studies, six new localities, not previously recorded in literature, were discovered. The sedge occupies sub-halophytic habitats in which it occurs along with halophytic species (particularly, such as *Glaux maritima* and *Puccinellia distans*) and a group of ruderal taxons. One of the newly discovered localities of *C. secalina* comprises an anthropogenic habitat. On the whole, the population sizes ranged from 20 to 350 individuals. The studies revealed a positive correlation between the size of a population and cattle pasturing, i.e. *C. secalina* forms the largest populations in the habitats remaining under the intense pressure of grazing and treading. Moreover, it was found that the high generative reproduction rate compensates the damage caused by animal grazing. The results suggest that an active protection of the sedge populations through the agricultural use of its habitats is the only effective way of securing its further occurrence in Poland, while including the sub-halophytic pastures with *C. secalina* in the agricultural and environmental program should be a priority task in the nearest future.

KEY WORDS: *Carex secalina*, endangered species, halophyte, monitoring, population size, species composition, active protection.

INTRODUCTION

Carex secalina Willd. ex Wahlenb. 1803 (weeping alkali-grass) is one of three species representing the section Secalinae (O. Lang) Kuk. 1909 of the subgenus *Carex*, in the family Cyperaceae (Egorova 1999). It is a halophyte with the disjunctive Euro-Siberian – sub-Irano-Turanian distribution range (Meusel et al. 1965). Throughout the whole area of its occurrence, it is considered a rare species, growing in scattered and isolated localities of Europe and Asia. In the European part of its range it is more frequently found in South Germany, Austria, Hungary and in the southern part of Ukraine and Russia – at the mouth of the Dnieper river to the Black Sea and the Volga river to the Caspian Sea. Localities from the southern Ural Mts. relate to the South-Siberian part of the species' geographic range. Its Asian portion consists of isolated localities, scattered from the southern Ural Mts. in the west, through Kazakhstan and up to Lake Baikal in the east (Meusel et al. 1965; Egorova 1999).

In several countries of Europe, *Carex secalina* is ranked among critically endangered or endangered species (Ma-

glocký and Feraková 1993; Ludwig and Schnittler 1996; Holub and Procházka 2000; Chmiel et al. 2001). It is protected under the Convention on the Conservation of European Wildlife and Natural Habitats, adopted in Bern in 1979. In Poland, in the beginning of the 20th century, *C. secalina* occurred in nine localities, concentrated in the Kujawy region (Bock 1908). At the latest, it was observed in Rąbin, near Inowrocław (Wodziczko et al. 1938; Urbański 1930). The post WW2 studies by Wilkoń-Michalska (1963) on the halophytic flora and vegetation of Kujawy have not confirmed the presence of *C. secalina* in these localities. For over 40 years, it was considered an extinct taxon on the scale of the region (Wilkoń-Michalska 1963; Żukowski and Jackowiak 1995) and, at the same time, of the whole country (Zarzycki and Szelağ 1992; Zając and Zając 1993). In 2000, the presence of the sedge was once more confirmed in two historic localities and one new locality was found as well. In the last edition of the Polish Red Data Book of Plants, *C. secalina* is classified as a critically endangered species (Chmiel et al. 2001).

In 2000, the systematic monitoring of *C. secalina* populations in the field was started and, at the same time, its

garden cultivation established. In the studied *C. secalina* populations, a few years old individuals dominate. Their exact age is unknown, however, as the results of our garden experiment show, the individuals entering sexual reproduction are at least three year old. Each individual from the observed populations in the field and garden has started its sexual reproduction phase. The production of generative shoots with both unisexual (typical of the species) and bisexual spikes (not noted for the species before) was high (Żukowski et al. 2005; Lembicz et al. 2006). The obtained results allowed to formulate a hypothesis that the species' populations retain the ability to regenerate in the field and

their disappearance in Poland is not a permanent phenomenon. On the basis of high germination capability of seeds, the possibility of the natural seed bank presence and the manner of habitat use (which for halophytes is of significant importance), we assume that the populations of this sedge can be characterised by the temporary disappearance and revival capacity.

This work presents the outcomes of the field studies in which: (1) all historic localities of *C. secalina* were verified, (2) the search for the species' new localities in inland salt marshes was carried out, (3) the size of populations was estimated and (4) the assessment of the species' habitats,

TABLE 1. A list of localities, population sizes and forms of habitat use.

Localities	Location (GPS)	Maximal number of individuals observed after the year 2008	Forms of habitat use
<i>Historic localities (not confirmed for recent 100 years)</i>			
Kłopot	N 52° 48' 55.29'' E 18° 15' 56.19''	none	built-up area
Zajezerze	N 52° 55' 00.98'' E 18° 26' 03.37''	none	ceased grazing, sporadic pressure by fishermen
Rąbin	N 52° 47' 01.39'' E 18° 13' 53.18''	none	built-up area
Rąbinek	N 52° 46' 33.81'' E 18° 13' 59.01''	none	built-up area
Latkowo	N 52° 49' 48.93'' E 18° 18' 06.76''	none	built-up area
Kruśliwiec	N 52° 48' 19.22'' E 18° 14' 13.16''	none	built-up area
Gniewkowo	N 52° 53' 40.99'' E 18° 24' 27.25''	none	built-up area
<i>Historic localities confirmed after the year 2000</i>			
Jacewo 1	N 52° 48' 02.88'' E 18° 17' 50.78''	30	sporadic recreational pressure
Turzany	N 52° 47' 20.90'' E 18° 20' 16.58''	73	extensive grazing, fringes of watering place
<i>Localities discovered after the year 2000</i>			
Dulsk	N 52° 45' 19.72'' E 18° 20' 31.05''	20	extensive grazing (in the last year no pasturing)
Radojewice	N 52° 45' 01.29'' E 18° 24' 47.77''	300	surroundings of a village pond, sporadically used for extensive grazing
Bąbolin	N 52° 52' 37.84'' E 18° 23' 46.96''	350	a cattle pen, fringes of watering place, extensive grazing
Skotniki	N 52° 41' 29.83'' E 18° 28' 16.10''	60	extensive grazing
Szymborze	N 52° 45' 56.08'' E 18° 16' 18.55''	10	fire reservoir
Jacewo 2*	N 52° 48' 02.88'' E 18° 17' 50.78''	38	levelled pond edges

* New locality of the sedge in close proximity of the historical locality (Jacewo 1) – anthropogenic habitat.

based on the analysis of co-occurring species composition, was carried out. The results of these investigations allowed to bring the condition of the Polish populations of *C. secalina* and the ways of their protection up for discussion.

MATERIALS AND METHODS

Field study

Verification of localities and the search for new ones. In 2000, after 40 years, the re-discovery of the locality of *C. secalina* in the vicinity of Inowrocław was made by accident, in the course of population-based studies on the grass *Puccinellia distans* (L.) Parl. Since then, the systematic verification of the species' historic localities, scattered in the vicinity of Inowrocław, has been carried out. In those cases, when *C. secalina* was not found, the condition of its habitat and assumed reasons for population's extinction were determined. The field explorations embraced also the areas where this species may potentially occur. The surroundings of small water bodies localized in the vicinity of the villages in which, at least periodically, the cattle gra-

zing was conducted, have been investigated particularly thoroughly. In the confirmed old localities and in newly discovered ones, the estimation of population sizes was carried out, allowing for both the specimens in the reproductive phase of development and younger ones, which have not started their reproduction yet.

Estimation of population size, habitat and species composition. In the characteristics of habitats occupied by populations of *C. secalina*, the form and intensity of land use as well as the structure of species composition in the patches with the sedge participation were considered. The assessment of species composition was conducted on the basis of phytosociological relevés, according to the Braun-Blanquet method. It took into account the maximal area of a patch, which complied with the criterion of homogeneity. The analysis of population size, for newly discovered or confirmed historic localities, was made at the end of June and at the beginning of July. In some sites, the research plots embracing the whole area of the species' population were designated. Within them, in the basic plots of 1 m², all individuals of *C. secalina* were recorded.

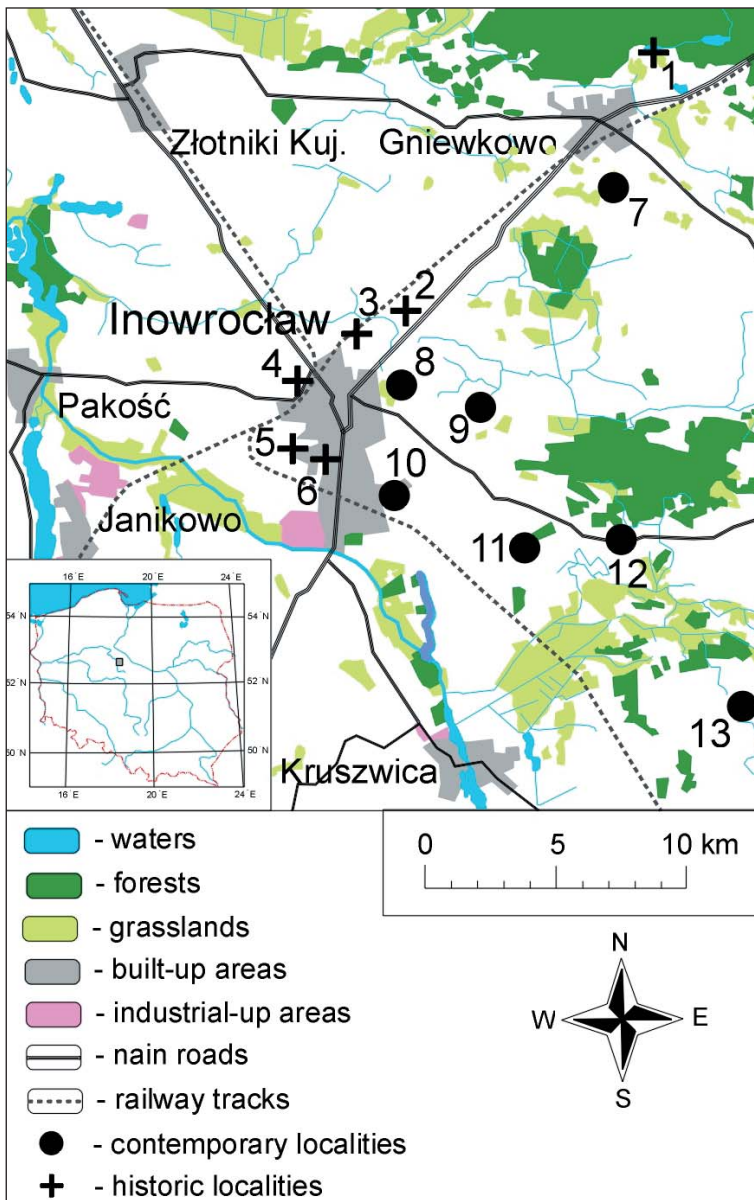


Fig. 1. Historic and contemporary localities of *Carex secalina* in Poland. All localities are situated in the vicinity of Kujawy region: 1 – Zajezerze; 2 – Latkowo; 3 – Kłopot; 4 – Kruśliwiec; 5 – Rąbinek; 6 – Rąbin; 7 – Bąbolin; 8 – Jacewo; 9 – Turzany; 10 – Szymborze; 11 – Dulsk; 12 – Radojewice; 13 – Skotniki.

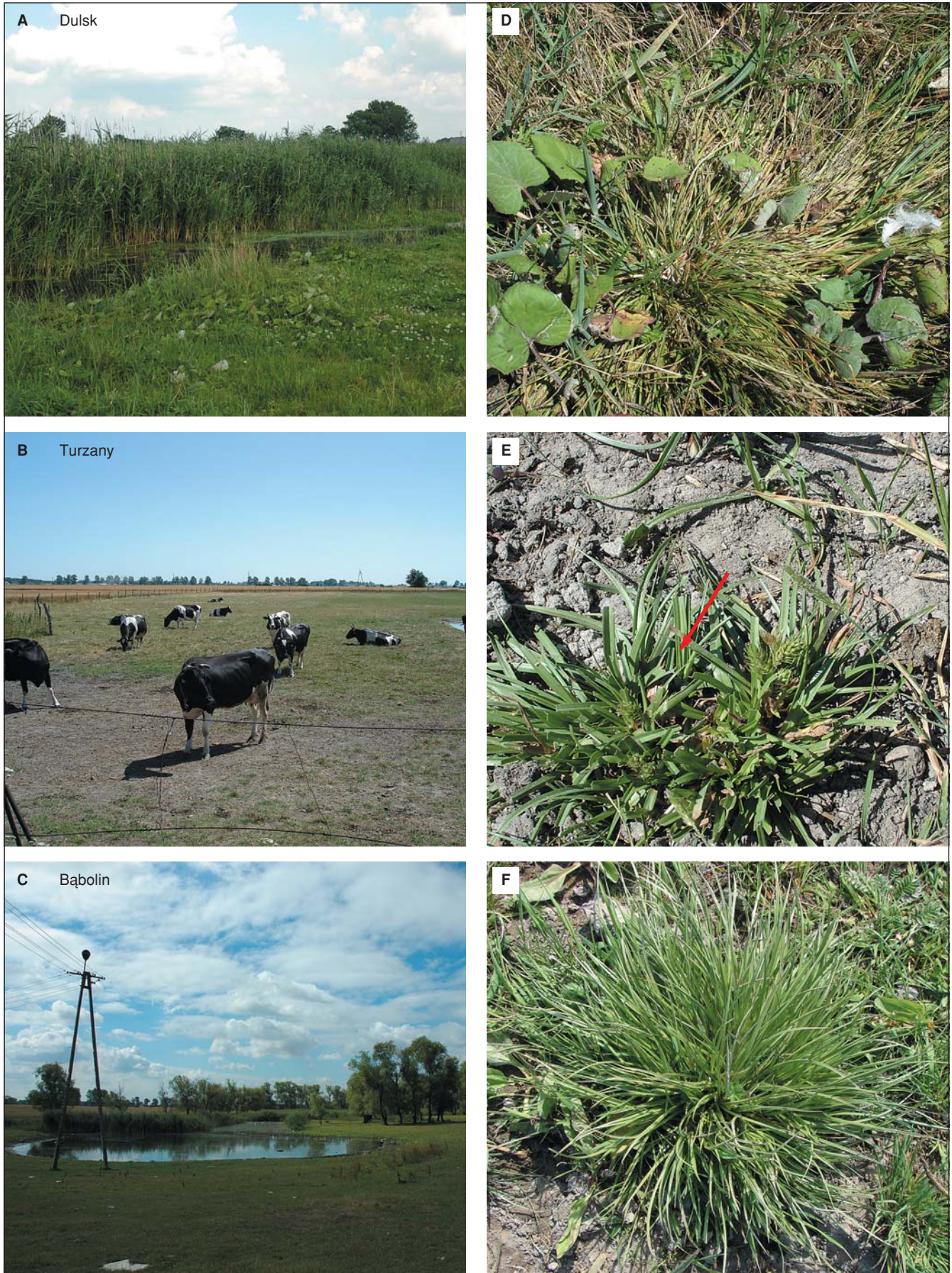


Fig. 2. Usage of pasture land – a type of habitat currently occupied by *Carex secalina*. Intense grazing is an essential factor enhancing the competitive ability of *Carex secalina* (A-C – pastures with the largest populations of the sedge); D-F – the tufts of grass growing in these pastures, with distinct marks of cow grazing (indicated by the arrow) (Photographs by A. Bogdanowicz and K. Jankowska).

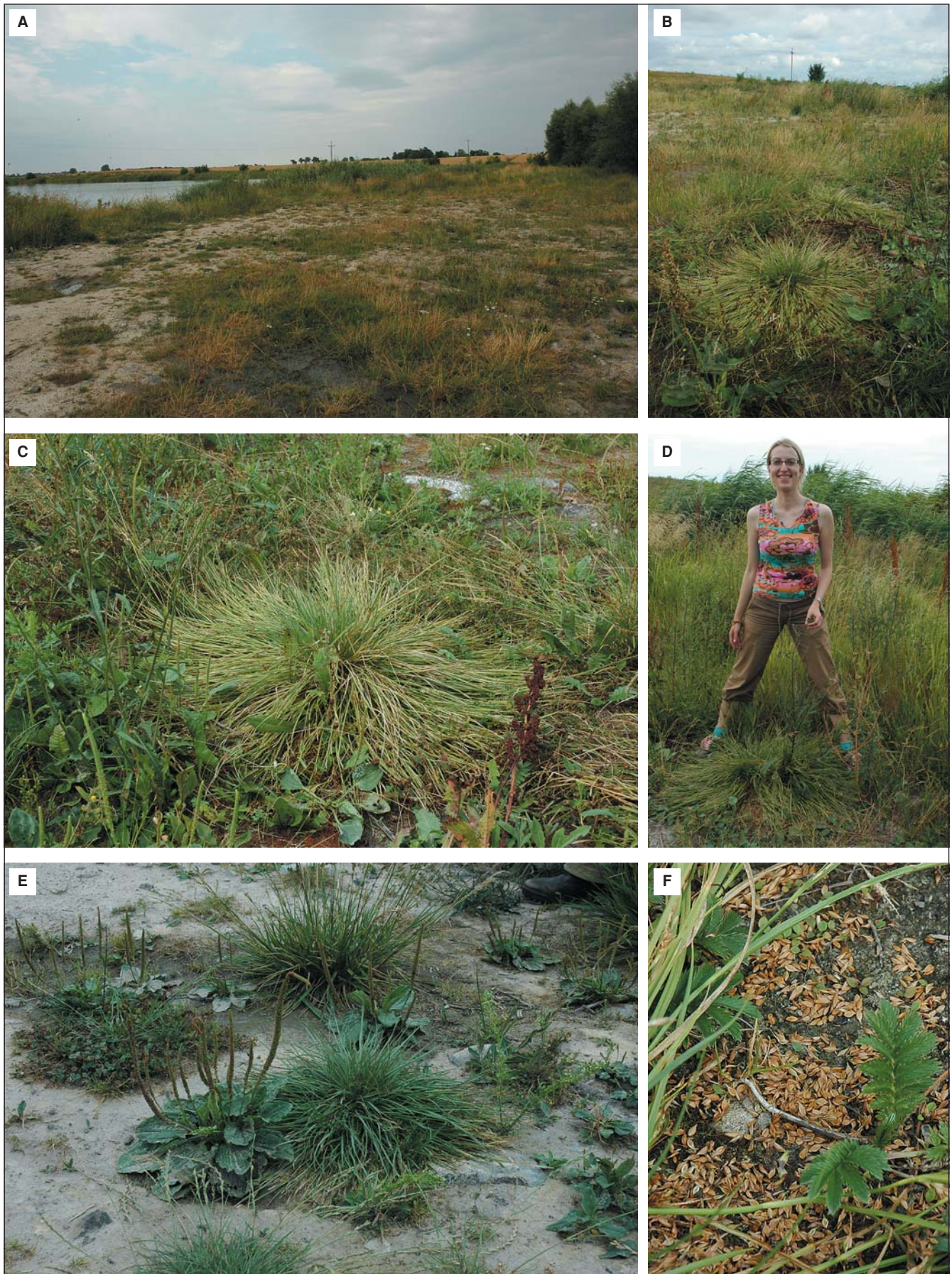


Fig. 3. New anthropogenic locality with *Carex secalina*. In this locality, the sedge co-exists with ruderal species. A – the water reservoir in Jacewo – the site of occurrence of *C. secalina*; B-D – the general habit of the tufts in this locality distinguished by the exceptionally large size; E – *Plantago major* – one of the species most often accompanying the sedge in this habitat; F – seeds profusely produced by the tufts of *C. secalina* (Photographs by A. Bogdanowicz and M. Lembicz).

RESULTS

Localities and population sizes

From among 8 historical localities, only for two – in Jacewo and Turzany – the occurrence of *Carex secalina* has been confirmed (Table 1). Additionally, six new localities for the species, not recorded in literature before, have been discovered (Fig. 1). The populations in these localities included from 20 individuals in Dulsk up to 350 in Bąbolin.

Habitats

The largest populations of the sedge were noted in the habitats extensively used as pastures (Fig. 2). Most often, *C. secalina* was observed in sub-halophytic and periodically flooded habitats, in the immediate surroundings of small water bodies, situated in the vicinity or just within the village boundary. Usually, these water bodies include natural ponds (Bąbolin, Turzany, Radojewice) and small lakes (Dulsk, Skotniki), used as watering places for grazing farm animals, or some artificial reservoirs utilized for other purposes (Jacewo, Szymborze).

Species composition

The number of species accompanying *C. secalina* in individual patches ranged from 8 to 29. The patches usually represent the alliance Agropyro-Rumicion *crispi* Nordhagen 1940 em. R.Tx. 1950 (syn. Lolio-Potentillion *anserinae* R.Tx. 1947, Agrostion *stoloniferae* Görs 1966) and are the impoverished forms of the following communities: Potentillo-Festucetum *arundinaceae* (R.Tx. 1937) Nordhagen 1940 nom. invers., Blysmo-Juncetum *compressi* (Br.-Bl. 1922 ex Libbert 1932) R.Tx. 1950 and Potentilletum *anserinae* Rapaics 1927 em. Pass. 1964 (Table 2). A special attention deserves the regular presence of sub-halophytic species from the class Juncetea *maritimi* Br.-Bl. 1931 ex R.Tx. et. Oberd. 1958.

Most frequent were *Puccinellia distans* and *Glaux maritima*, while much rarer – *Melilotus dentata* and *Lotus tenuis*. Because the patches with *C. secalina* are often situated in the immediate vicinity of small water bodies, they are characterised by a significant participation of species from the class Bidentetea *tripartitae* R.Tx., Lohmeyer et Preising in R.Tx. 1950 and Phragmitetea *australis* (Klika in Klika et Novák 1941) R.Tx. et. Preising 1942. In the patches with *C. secalina* located near animal watering places, such species as, among others, *Atriplex prostrata*, *Chenopodium glaucum* and *Ch. rubrum* were also noted. In turn, rush communities were most often represented in these patches by *Phragmites australis*, while the class Molinio-Arrhenatheretea R.Tx. 1937 em. 1970 by such high constancy species as: *Plantago major*, *Lolium perenne*, *Poa pratensis*, *Taraxacum officinale*, *Trifolium repens* and *Leontodon autumnalis*. Very rarely, within the patches in the localities of Bąbolin, Jacewo2 and Turzany, an admixture of some ruderal species originating from the nearby urbanized areas was found (Fig. 3). These included, among others: *Arctium tomentosum*, *Atriplex nitens*, *Capsella bursa-pastoris*, *Coryza canadensis*, *Lactuca serriola* and *Matricaria inodora*.

DISCUSSION

Currently, in Poland, *Carex secalina* occurs in eight localities. In as many as six historic localities quoted by Bock (1908) it has not been confirmed any longer. Nowadays, these habitats are taken up by the built-up areas with only small patches of greenery. The urban spread of the agglomeration of Inowrocław is the main cause of the sedge disappearance from these localities. In the localities where *C. secalina* was recorded by authors, we found a positive correlation between the size of population and grazing. This regularity has been described for many grassland species (Harper 1977; Falińska 2004), particularly, for many halophytes (Wilkoń Michalska 1963; Renzhong and Ripley 1997; Bouchard et al. 2003; Loucougaray et al. 2004; Bonis et al. 2005).

C. secalina forms the largest populations in habitats remaining under the influence of very intense pressure of grazing and/or treading by cattles, like, e.g., in Bąbolin and Turzany. Nevertheless, the population found in Dulsk in 2000 and estimated then as quite large, according to our data from 2008, has almost completely disappeared. We assume that the reason for this, and not only in this case, is the abandonment of grazing practices. We also think, that as a result of the pasturing reintroduction, the sedge population may regenerate, possibly, thanks to the soil seed bank presence. The seeds of *C. secalina* are characterized not only by high germination ability but also by their capacity to retain the germination power for several years (Żukowski et al. 2005, unpublished data).

Generally, the seeds of sedges are long-lived, as indicates the very small loss of seeds during germination in the burial experiments (Schütz and Rave 1999; Schütz 2000, 2002, Budlesky and Galatowitsch 2004; Brändel and Schütz 2005; Leck and Schütz 2005).

It was found that the viability of buried seeds of *C. flava* and *C. viridula* was not more than 6 years and below 5 years for: *C. scoparia*, *C. viridula*, *C. flava*, *C. elongata*, *C. curta*, *C. pseudocyperus* (Schütz 2000). Frequently, the seeds of sedges are present in the soil seed bank, even though, no mature plants are observed above the ground level. The long-lasting seed bank, often at large depths (>10 cm), enables the survival of a population, even through 2-7 decades, i.e. as long as viable seeds are available in the soil. Hence, in favorable conditions, often, after removing the surface layer of the soil, the revival of the potentially extinct species can be observed. Newly discovered populations of *C. secalina* may be just such populations recently developed from the soil seed bank (unpublished data). It seems that populations of this species are characterized by the periodic disappearance and regeneration, as a result of changes in habitat conditions. It is why it has not been recorded in Poland for 40 years. The issue of the regeneration of *C. secalina* population is currently the subject of our research.

An essential element helping the species to compete with other plants is grazing. High generative reproduction ability of individuals, completely compensates the damage resulting from pasturing (Żukowski et al. 2005). Trampling diaspores into the ground by animal hoofs, as the factor enhancing the sprouting efficiency, is also of significant importance.

Summing up, it can not be excluded that as a result of further search for *C. secalina* in inland salt marshes of Po-

TABLE 2. Diversity of vegetation layers with *Carex secalina*.

Number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
Date	12. 07. 08	12. 07. 08	12. 07. 08	24. 07. 06	12. 07. 08	23. 05. 06	23. 05. 06	24. 07. 06	11. 07. 01	23. 05. 06	25. 07. 01	5. 07. 01	12. 07. 08	12. 07. 08	12. 07. 08	24. 07. 06	12. 07. 08	24. 07. 06	23. 05. 06	16. 05. 00	25. 07. 01	24. 07. 06	12. 07. 08	24. 07. 06	12. 07. 08		
Locality	Turzany	Skomiki	Skomiki	Radziejewice	Radziejewice 2	Dulsk	Dulsk	Skomiki	Jacewo 1	Dulsk	Dulsk	Dulsk	Bąbolin	Turzany	Dulsk	Skomiki	Turzany	Jacewo 1	Dulsk	Dulsk	Dulsk	Radziejewice	Bąbolin	Radziejewice	Bąbolin		
Cover of herbaceous (%)	80	100	100	100	40	100	100	95	95	100	100	100	100	80	20	80	80	50	100	90	100	100	80	100	60		
Area of relevé (m ²)	5	25	9	4	20	4	4	6	4	4	4	4	100	4	2	6	5	4	4	14	4	4	20	9	8		
Number of species	8	14	15	15	30	9	11	15	19	12	11	14	14	16	9	14	11	8	9	10	8	18	15	13	16		
<i>Carex secalina</i>	1.1	+	1.2	1.1	1.1	r	+	3.3	1.1	r	1.1	1.1	2.2	1.1	r	1.1	1.2	1.1	+	2.2	+	3.3	1.1	r	+		
Ch. Potentillo-Festucetum arundinaceae (R.Tx. 1937) Nordhagen 1940 nom. invers.																											
<i>Festuca arundinacea</i>	1.1	+	r	r	r																						
Ch. Potentilletum anserinae Rapaics 1927 em. Pass. 1964																											
<i>Potentilla anserina</i>	4.4	3.3	3.3	+	4.4	4.4	4.4	4.4	3.3	3.3	2.2	2.2	2.2	1.1	1.1	1.1	3.3	+	3.3	2.2	4.4	+					
<i>Agrostis stolonifera</i>	2.2	2.2	4.4	2.2	1.1	4.4	4.4	2.2	4.4	3.3	3.3	4.4	1.1	3.3	2.2	+											
Ch. Blysmo-Juncetum compressi (Br.-Bl. 1922 ex Libbert 1932) R. Tx. 1950																											
<i>Trifolium fragiferum</i>	3.3		3.3	+	1.1			4.4	1.1	4.4	2.2	2.2	3.3	1.1		1.1	2.2	4.4	3.3	+	+	r	1.1				
<i>Juncus compressus</i>					+		3.3	+	1.1	3.3	2.2	+				+		r	3.3	1.1	1.1						
<i>Blysmus compressus</i>		2.2	+		+	2.2	r		1.1	+				r													
<i>Carex distans</i>									+																		
Ch. Agropyro-Rumicion crispus Nordhagen 1940 em. R.Tx. 1950																											
<i>Carex hirta</i>				1.1		1.1	1.1	r		1.1	1.1	2.2	1.1			+			+	2.2	r						
<i>Elymus repens</i>			r		1.1															r							
<i>Rumex crispus</i>				r	r																		r		r		
<i>Rorippa sylvestris</i>					r																				r		
<i>Odontites serotina</i>									r																r		
Ch. Polygono arenastri-Poetea annuae Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991																											
<i>Polygonum aviculare</i>					+																		r		+		
<i>Poa annua</i>					1.1																			1.1			
<i>Chamomilla suaveolens</i>																								1.1	+		

TABLE 2. Cont.

Number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25						
Date	12. 07. 08	12. 07. 08	12. 07. 08	24. 07. 06	12. 07. 08	23. 05. 06	23. 05. 06	24. 07. 06	11. 07. 01	23. 05. 06	25. 07. 01	5. 07. 01	12. 07. 08	12. 07. 08	12. 07. 08	24. 07. 06	12. 07. 08	24. 07. 06	23. 05. 06	16. 05. 00	25. 07. 01	24. 07. 06	12. 07. 08	24. 07. 06	12. 07. 08						
Locality	Turzany	Skomiki	Skomiki	Radziejewice	Jacewo 2	Dulsk	Dulsk	Skomiki	Jacewo 1	Dulsk	Dulsk	Dulsk	Bąbolin	Turzany	Dulsk	Skomiki	Turzany	Jacewo 1	Dulsk	Dulsk	Dulsk	Radziejewice	Bąbolin	Radziejewice	Bąbolin						
Ch. Isoëto durieui Juncetea bufonii (Br.-Bl. et R.Tx. 1943 ex Westhoff et al. 1946) Rivas-Martinez 1988																															
<i>Cyperus fuscus</i>																															
<i>Juncus bufonius</i>											+																				
<i>Centaurium pulchellum</i>																															
Ch. Bidentetea tripartitae R.Tx., Lohmeyer et Preisling in R.Tx. 1950																															
<i>Ranunculus sceleratus</i>								r																							
<i>Chenopodium rubrum</i>								r																							
<i>Alopecurus geniculatus</i>			r		+			r												r											
<i>Atriplex prostrata</i>			+					1.1																							
<i>Chenopodium glaucum</i>													r																		
<i>Rumex maritimus</i>								r																							
<i>Senecio congestus</i>																															
<i>Alopecurus aequalis</i>																															
<i>Polygonum persicaria</i>																															
<i>Bidens tripartita</i>																															
<i>Bidens frondosa</i>																															
Others																															
<i>Tussilago farfara</i>																															
<i>Lycopus europaeus</i>																															
<i>Medicago lupulina</i>																															
<i>Sonchus arvensis</i>																															
<i>Chenopodium album</i>																															
<i>Urtica dioica</i>																															
<i>Cirsium vulgare</i>																															
<i>Marricaria inodora</i>																															
<i>Juncus articulatus</i>																															

Sporadic: *Arctium tomentosum* 23(r), *Atriplex nitens* 5(r), *Capsella bursa-pastoris* 14(+), *Conyza canadensis* 5(+), *Epilobium adnatum* 5(r), *Juncus inflexus* 22(+), *Lactuca serriola* 5(+), *Chamomilla recutita* 5(r), *Medicago sativa* 5(r), *Pastinaca sativa* 12(r), *Pteris hieracioides* 5(r), *Polygonum amphibium* 15(+), *Rumex obtusifolius* 25(r), *Senecio jacobaea* 5(r), *Solanum nigrum* 25(r), *Stellaria media* 25(r), *Triglochin palustre* 9(r).

land, new localities of this taxon will be discovered. Undoubtedly, the main condition of *C. secalina* preservation is the continuation of grazing practices. The observations of conditions affecting the sedge occurrence in the Bałolin and Turzany localities, demonstrate that the intense pasturing and treading not only do not pose the risk to the species but rather enhance its competing power. The active protection of populations of *C. secalina* through agricultural use of its habitats is the only efficient way of ensuring its further occurrence in Poland. Moreover, including the sub-halophytic pastures with *C. secalina* in the agricultural and environmental program should be a priority task in the nearest future.

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LITERATURE CITED

- BOCK W. 1908. Taschenflora von Bromberg (Das Netzegebiet). Mittlerer'sche Buchhandlung, pp. 214.
- BONIS A., BOUZILLÉ J.-B., AMIAUD B., LOUCOUGARAY G. 2005. Plant community patterns in old embanked grasslands and the survival of halophytic flora. *Flora* 200: 74-87.
- BOUCHARD V., TESSIER M., DIGAIRE F., VIVIER J.-P., VALÉRY L., GLOAGUEN J.-C., LEFEUVRE J.-C. 2003. Sheep grazing as management tool in Western European salt-marshes. *C. R. Biologies* 362: 148-157.
- BRÄNDEL M., SCHÜTZ W. 2005. Temperature effects on dormancy levels and germination in temperate forest sedges (*Carex*). *Plant Ecol.* 176: 245-261.
- BUDLESKY R.A., GALATOWITSCH S.M. 2004. Establishment of *Carex stricta* Lam. seedlings in experimental wetlands with implications for restoration. *Plant Ecol.* 175: 91-105.
- CHMIEL J., LEMBICZ M., ŻUKOWSKI W. 2001. *Carex secalina* Willd. ex Wahlenb. – turzycza żytowata. In: Polska Czerwona Księga Roślin. Paprotniki i rośliny kwiatowe. Polish Red Data Book of Plants. Pteridophytes and flowering plants. pp. 508-510. Zarzycki K., Kaźmierczakowa R. (eds.). Instytut Botaniki im W. Szafera PAN, Instytut Ochrony Przyrody PAN, Kraków (In Polish with English Summary).
- EGOROVA T.V. 1999. The sedges (*Carex* L.) of Russia and adjacent States (within the limits of the former USSR), St. Petersburg State Chemical-Pharmaceutical Academy, St. Petersburg; St. Louis Missouri Botanical Garden Press, St. Louis.
- FALINSKA K. 2004. Ekologia roślin. PWN, Warszawa, pp. 134-140. (in Polish)
- HARPER J.L. 1977. Population Biology of Plants. Academic Press, London, New York, San Francisco, pp. 435-456.
- HOLUB J., PROCHÁZKA F. 2000. Red list of vascular plants of the Czech Republic. *Preslia* 72: 187-230.
- LECK M.A., SCHÜTZ W. 2005. Regeneration of Cyperaceae, with particular reference to seed ecology and seed banks. *Perspect. Plant Ecol. Evol. Syst.* 7, 95-133.
- LEMBICZ M., BOGDANOWICZ A., ŻUKOWSKI W. 2006. Production and structure of unisexual and bisexual inflorescences in populations of *Carex secalina* (Cyperaceae). *Polish Bot. Stud.* 22: 343-346.
- LOUCOUGARAY G., BONIS A., BOUZILLÉ J.-B. 2004. Effects of grazing by horses and/or cattle on the diversity of coastal grasslands in western France. *Biol. Conserv.* 116: 59-71.
- LUDWIG G., SCHNITTLER M. 1996. Rote liste gefährdeter Pflanzen Deutschlands. Schriftenreihe für Vegetationskunde H. 28. Bundesamt für Naturschutz, Bonn-Bad Godesberg.
- MAGLOCKÝ S., FERA KOVÁ V. 1993. Red list of ferns and flowering plants (Pteridophyta and Spermatophyta) of the flora of Slovakia (the second draft). *Biológia (Bratislava)* 48 (4): 361-385.
- MEUSEL H., JÄGER E., WEINERT E. 1965. Vergleichende Chorologie der Zentraleuropäischen Flora. Bd. I. G. Fischer Verlag, Jena.
- RENZHONG W., RIPLEY E.A. 1997. Effects of grazing on a *Leymus chinensis* grassland on the Songnen plain of north-eastern China. *J. Arid Environ.* 36: 307-318.
- SCHÜTZ W. 2000. Ecology of seed dormancy and germination in sedges (*Carex*). *Perspect. Plant Ecol. Evol. Syst.* 3: 67-89.
- SCHÜTZ W. 2002. Dormancy characteristics and germination timing in two alpine *Carex* species. *Basic Appl. Ecol.* 3: 125-134.
- SCHÜTZ W., RAVE G. 1999. The effect of cold stratification and light on the seed germination of temperate sedges (*Carex*) from various habitats and implications for regenerative strategies. *Plant Ecol.* 144: 215-230.
- URBAŃSKI J. 1930. Rezultaty wycieczek florystycznych po Wielkopolsce wraz z projektami ochrony stanowisk rzadkich roślin. *Wyd. Okr. Kom. Ochr. Przyr. na Wielkopolskę i Pomorze*, 1: 37-46. (in Polish)
- WILKOŃ-MICHALSKA J. 1963. Halofity Kujaw. *Stud. Soc. Sc. Tor.*, Sect D 7(1), Toruń, pp. 122. (in Polish)
- WODZICZKO A., KRAWIEC F., URBAŃSKI J. 1938. Pomniki i zabytki przyrody Wielkopolski. *Wyd. Okr. Kom. Ochr. Przyr. na Wielkopolskę i Pomorze*, 8: 313-360. (in Polish)
- ZAJĄC A., ZAJĄC M. 1993. *Carex secalina* Willd. ex Wahlenb. – turzycza żytowata. s. 250-251. In: Zarzycki K., Kaźmierczakowa R. (eds.), Polska Czerwona Księga Roślin. Paprotniki i rośliny kwiatowe. Polish Plant Red Data Book. Pteridophyta and Spermatophyta. Instytut Botaniki im. W. Szafera PAN, Instytut Ochrony Przyrody PAN, Polish Academy of Sciences W. Szafer Institute of Botany, Institute of Nature Conservation, Kraków. (in Polish with English summary)
- ZARZYCKI K., SZELAĞ Z. 1992. Czerwona lista roślin naczyniowych zagrożonych w Polsce. Red list threatened vascular plants in Poland. In: Zarzycki K., Wojewoda W., Heinrich Z. (eds), Lista roślin zagrożonych w Polsce. List of threatened plants in Poland. s. 87-98. Instytut Botaniki im. W. Szafera PAN, Kraków. (in Polish)
- ŻUKOWSKI W., JACKOWIAK B. 1995. Lista roślin naczyniowych ginących i zagrożonych na Pomorzu Zachodnim i w Wielkopolsce. List of endangered and threatened vascular plants in Western Pomerania and Wielkopolska (Great Poland). 11-96. In: Żukowski W., Jackowiak B. (ed.), *Ginące i zagrożone rośliny naczyniowe Pomorza Zachodniego i Wielkopolski. Endangered and threatened vascular plants of Western Pomerania and Wielkopolska. Prace Zakładu Taksonomii Roślin UAM w Poznaniu nr 3. Publications of the Department of Plant Taxonomy of the Adam Mickiewicz University in Poznań No 3*, Bogucki Wydawnictwo Naukowe. (in Polish)
- ŻUKOWSKI W., LEMBICZ M., OLEJNICZAK P., BOGDANOWICZ A., CHMIEL J., ROGOWSKI A. 2005. *Carex secalina* (Cyperaceae), a species critically endangered in Europe: from propagule germination to propagule production. *Acta Soc. Bot. Pol.* 74: 141-147.