Biodiv. Res. Conserv. 3-4: 329-332, 2006

BRC
www.brc.amu.edu.pl

Solidago graminifolia (L.) Elliott on anthropogenic sites of the Silesian Upland (Poland)

Agnieszka Kompała-Bąba[1] & Wojciech Bąba[2]

[1]University of Silesia, Department of Geobotany and Nature Protection, Faculty of Biology and Environmental Protection, Jagiellońska 28, 40-032 Katowice, Poland, e-mail: akompala@us.edu.pl
[2]Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, 31-120 Kraków, Poland, e-mail: wbaba@iop.krakow.pl

Abstract: The aim of this paper is to show the distribution of *Solidago graminifolia* (L.) Elliott in the Silesian Upland and to examine the floristic composition of phytocoenoses with its participation. This species was recorded on anthropogenic habitats such as: open-cast quarry, railway embankment and ditches. The floristic diversity of phytocoenoses can be explained by two environmental gradients: soil fertility (marked on I PCA axis) and moisture and soil reaction (marked on II PCA axis). Phytocoenoses which develop in the open-cast quarry are the richest in species and the most differentiated. In their floristic composition meadow species (particularly from the *Molinetalia* order) occurred with high frequency. Phytocoenoses which grow in wet places, with a high ground water level, are distinguished by species from the *Scheuchzerio-Caricetea fuscae* and *Phragmitetea* classes, whereas in those which are confined to drier places short-lived species from the *Stellarietea mediae* class can be found.

Key words: invasive species, *Solidago graminifolia,* ruderal habitats, clonal plant, PCA, Upper Silesian Upland

1. Introduction

Solidago graminifolia (L.) Elliott comes from the eastern part of Northern America. In natural habitats it is confined to damp and drier shores, thickets and meadow edges of marshes, calcareous seepages, borders of lakes, abandoned fields and ditches along railroads (Gleason 1963).

It was introduced into Europe in the 19th century mainly as an ornamental plant. Among the alien species of goldenrods, it has the lowest colonisation rate (128 km^2/year) (Weber 1998, 2001). Its range in Europe is small and limited to a few distinctive locations (Weber 1998). Such features as: a smaller stem, slower germination rate, poorer seed dispersal ability and lower frequency of cultivation in comparison to other species of goldenrods are probably responsible for the slower expansion rate of *Solidago graminifolia* (Price *et al*. 2004; Weber 1998). According to some authors, *Solidago graminifolia* may still be in the introductory phase of invasion (probably a time lag between initial introduction and subsequent population growth) (Weber 2001).

The first record of the spontaneous occurrence of grass-leaved goldenrod in Poland dates back to 1885. Nowadays, it is considered to be an alien species in Polish flora, permanently established in natural or seminatural communities – agriophyte (Zając *et al*. 1998; Tokarska-Guzik 2005). Its locations were recorded mainly in south-western Poland (Zając & Zając 2001). *Solidago graminifolia* prefers wet habitats such as: ditches, forest edges, borders of ponds, clay pits and roads (Guzikowa & Maycock 1986).

2. Material and methods

The field works on the synanthropic vegetation of the Silesian Upland were carried out during 1995-2005. The study area was divided into 10-kilometre squares and subsequently into smaller 2-kilometre squares according to the rules of the cartographic method adapted in the ATPOL (Zając 1978). Phytosociological relevés based on the Braun-Blanquet method (Braun-Blanquet 1964) were made in order to examine the floristic diversity of phytocoenoses with a participation of *Solidago graminifolia* which developed in different ruderal habitats such as: sand-pits, railway scarps, quarries and ditches. The relevés were subsequently ordinated along the first two Principal Component

Analysis (PCA) axes (Gauch 1986) with the use of CANOCO Package (Jongman *et al.* 1995). The Braun-Blanquet cover/abundance scale was transformed into a percentage scale: r=1%, +=2%, 1=3%, 2=13%; 3=38%, 4=68%, 5=88%. Prior to the analysis the data were log-transformed. Only those species which explain at least 5% of the total variance were taken to analysis. In order to identify the environmental gradients which are explained by PCA axes, the mean values of R, T, F, N, total number of species (S), Shannon-Wienner index (H'), evenness (E; Hill 1973) and number of species from the following classes: *Molinio-Arrhenatheretea*, *Artemisietea*, *Scheuchzerio-Caricetea fuscae*, *Phragmitetea*, *Stellarietea mediae*, *Koelerio-Corynephoretea* were correlated with the I and II axes scores.

Species were classified into phytosociological units according to Brzeg & Wojterska (2001). The names of vascular plants follow Mirek *et al.* (2002).

3. Results

In the Silesian Upland locations of *Solidago graminifolia* were recorded on anthropogenic sites in the Dąbrowska Basin (sand-pit scarps and the bottom embankments of a watercourse which flows into anthropogenic water reservoir Pogoria I – DF34), on the Tarnowicki Plateau (Bobrowniki quarry near the Tarnowskie Góry – DF21) and in the Wilkoszyńska Basin (the railway embankment near Chrzanów – DF55). The patches occupied an area from 4 to 180 m^2.

The PCA ordination of phytosociological relevés allowed two environmental gradients to be distinguished. The first I PCA axis arranges species and phytocoenoses along the nutrient gradient (Fig. 1, Table 1). Together with the increase of soil fertility, the total number of species in the relève decreases and in most phytocoenoses an increase in the dominance of a few species is recorded (*Solidago graminifolia* mostly reaches higher values of abundance). The highest number of species was recorded in phytocoenoses which develop at the bottom of the sand-pit 'Kuźnica Warężyńska' (from 24 to 42 species), whereas the lowest number of species (13 species) in the community occurred on the initial, skeletal soil at the bottom of a dolomite quarry.

The I PCA axis is negatively correlated with the number of species from the *Scheuchzerio-Caricetea fuscae, Koelerio-Corynephoretea* classes and weakly with the species from the *Molinio-Arrhenatheretea* class. Meadow species occurred with high frequency in the phytocoenoses which grow on the open-cast mine. The phytocoenoses which were recorded on the railway embankment near Chrzanów are distinguished by fresh meadow species and some species from the *Agropyro-Rumicion crispi* alliance. In communities that occur on embankments of watercourse and sand-pit scarps, meadow plants play a lesser part.

The II PCA axis arranges species in accordance with a gradient of moisture and soil reaction (Fig. 1, Table 1). It is also weakly positively correlated with the number of short-lived species from the *Stellarietea mediae* class. These species are confined mainly to initial sandy-roads which lead through the sand-pit. Moreover, the II PCA axis is negatively correlated with the number of species from the *Scheuchzerio-Caricetea fuscae* and *Phragmitetea* classes.

The fen species from the *Scheuchzerio-Caricetea fuscae* class and species of reed and sedge fen from the *Phragmitetea* class occurred in the floristic composition of phytocoenoses which developed at the bottom of the sand-pit, where the level of ground water was frequently high. Because of the reclamation works which are aimed at the formation of a water reservoir, some parts of this

Table 1. Kendall rank correlation between the eigenvalues of the first two PCA axes and chosen Ellenberg's indicator values and number of species from the selected phytosociological units

	Ax1	p	Ax2	p
Eigenvalue:	0.172		0.141	
total number of species (S)	**-0.54**	**0.0002**	-0.01	0.9598
Shannon-Wienner index (H')	**-0.35**	**0.0173**	0.18	0.2149
evenness (E)	**-0.31**	**0.0329**	0.19	0.1971
Number of species from the classes:				
Molinio-Arrhenatheretea	**-0.29**	**0.0447**	-0.15	0.2975
Koelerio-Corynephoretea	**-0.61**	**0.0000**	0.09	0.5275
Scheuchzerio-Caricetea fuscae	**-0.72**	**0.0000**	**-0.40**	**0.0063**
Phragmitetea	-0.18	0.2117	**-0.31**	**0.0356**
Stellarietea mediae	-0.18	0.2140	**0.29**	**0.0509**
Artemisietea	0.12	0.4268	0.09	0.5249
Mean numbers of Ellenberg's indicators:				
nutrients (N)	**0.59**	**0.0001**	-0.04	0.7846
soil's reaction (R)	0.14	0.3441	**-0.35**	**0.0169**
moisture (F)	0.04	0.7651	**-0.33**	**0.0220**
temperature (T)	0.11	0.4518	0.14	0.3406

sand-pit were rebuilt and started to fill with water. As a result of the disturbances *Solidago graminifolia* grows mainly on sandy scarps and on sites near former railway tracks.

There is a correlation with the number of ruderal species from the *Artemisietea* class. In some phytocoenoses which occupy open-cast sites, the ruderal species from the *Onopordion acanthii* alliance occur more frequently.

4. Discussion and conclusions

In the Silesian Upland *Solidago graminifolia* grows mainly on post-industrial wastelands and its patches occupy an area from 4 to 180 m^2. Dajdok & Nowak (2005) found *Solidago graminifolia* localities in southern Poland. The species mainly invaded abandoned fields, meadows and ruderal habitats (quarries) there, therefore, in the floristic composition of patches, meadow species from the *Molinio-Arrhenatheretea* class have a distinctive participation. *Solidago graminifolia* belongs to species which are definitely less invasive in comparison to other species from the *Solidago* genera. These species form large patches in the investigated area which can be classified into different syntaxonomical units of the Braun-Blanquet system.

Some disturbances, such as soil disintegration and transport caused by reclamation works, may have an influence on *Solidago graminifolia* spread by seed dispersal and/or fragmentation of rhizomes and their translocation to different places. Probably the low competition with neighbouring plants for resources on

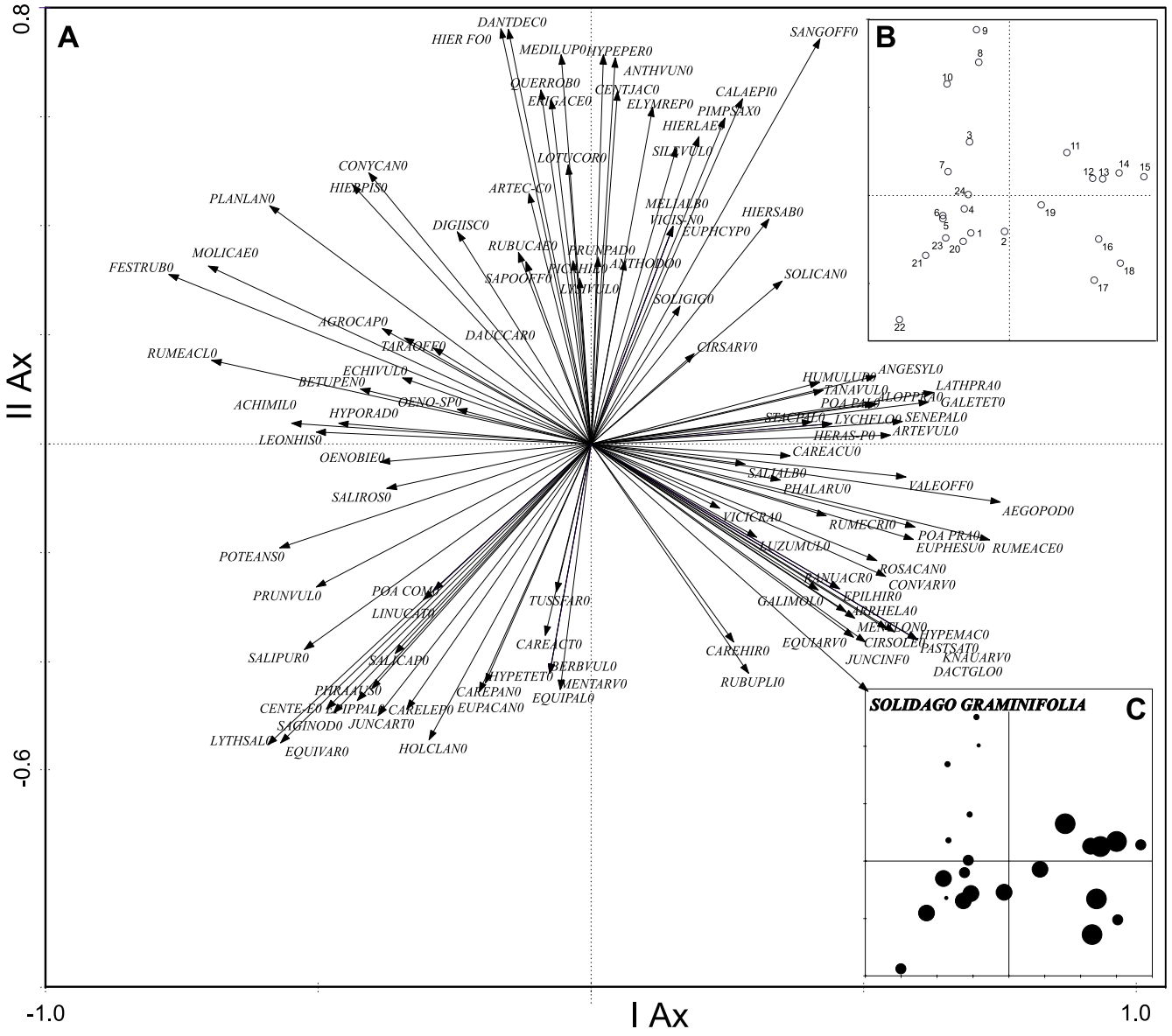

Fig. 1. PCA ordination of phytocoenoses with the participation of *Solidago graminifolia* which occur on anthropogenic sites of the Silesian Upland

Explanations: A – species, B – relevés, C – percentage cover of *Solidago graminifolia* in the relevés; species abbreviations (first 4 letters – name of genus; 3 – names of species)

the bare sands also plays an important part in its spread. Patches which occurred close to a small river and grew on the railway embankment were completely different. The individuals of *Solidago graminifolia* observed in the quarry were much lower than in other sites and patches had an impoverished floristic composition.

The phytocoenoses in which floristic composition *Solidago graminifolia* occurs are differentiated with reference to soil fertility, moisture and soil reaction. Phytocoenoses which develop in the open-cast site are the richest in species and the most differentiated. They approximate to wet meadow communities from the *Molinetalia* order. Phytocoenoses which grow in wet places with a high ground water level are distinguished by species from the *Scheuchzerio-Caricetea fuscae* and *Phragmitetea* classes. In patches that develop in drier places short-lived species from the *Stellarietea mediae* class have a higher participation. Some research on ecological preferences of co-occurring *Solidago* species reveals that *Solidago graminifolia* prefers a clay-rich substrate and the moist end of the soil moisture gradient, and more acidic soils (Abrahamson *et al*. 2005).

References

Abrahamson W. G., Dobley K. B., Houseknecht H. R. & Pecone A. 2005. Ecological divergence among five co-occurring species of old-field goldenrods. Plant Ecology 177: 43-56.

Braun-Blanquet J. 1964. Pflanzensoziologie. 3rd ed, 865 pp. Soringerverlag, Wien.

Brzeg A. & Wojterska M. 2001. Zespoły roślinne Wielkopolski, ich stan poznania i zagrożenie. In: M. Wojterska (ed.). Szata roślinna Wielkopolski i Pojezierza Południowopomorskiego. Przewodnik sesji terenowych 52. Zjazdu PTB, pp. 39-110. Bogucki Wyd. Nauk., Poznań.

Dajdok Z. & Nowak A. 2005. *Solidago graminifolia* in Poland: the status of spread. 8th International Conference on the Ecology and Management of Alien Plant Invasions 5-12 September 2005, Poland, p. 52.

Gauch A. G. 1986. Multivariate analysis in community ecology. 298 pp. Cambridge University Press, Cambridge.

Gleason H. A. 1963. The New Britton and Brown illustrated flora of the northeastern United States and adjacent Kanada. New York Botanical Garden, New York.

Guzikowa M. & Maycock P. F. 1986. The invasion and expansion of three North American species of goldenrods (*Solidago canadensis* L. sensu lato, *Solidago gigantea* Ait. and *Solidago graminifolia* (L.) Salisb.) in Poland. Acta Soc. Bot. Pol. 55(3): 367-384.

Hill M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54(2): 427-432.

Jongman R. H. G., Ter Braak C. J. F. & van Tongeren O. F. R. 1995. Data analysis in community and landscape ecology. 299 pp. Pudoc, Wageningen.

Mirek Z., Piękoś-Mirkowa H., Zając A. & Zając M. 2002. Flowering plants and pteridophytes of Poland. A checklist. In: Z. Mirek (ed.). Biodiversity of Poland 1, 442 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Price J. S., Bever J. D. & Clay K. 2004. Genotype, environment, and genotype by environment interactions determine quantitative resistance to leaf rust (*Coleosporium asterum*) in *Euthamia graminifolia* (Asteraceae). New Phytologist 162: 729-743.

Tokarska-Guzik B. 2005. The Establishment and Spread of Alien Plant Species (Kenophytes) in the Flora of Poland. Prace Naukowe Uniwersytetu Śląskiego, 2372, 192 pp. Wyd. Uniw. Śląskiego, Katowice.

Weber E. 1998. The dynamics of plant invasions: a case study of three exotic goldenrod species (*Solidago* L.) in Europe. Journal of Biogeography 25: 147-154.

Weber E. 2001. Current and potential ranges of three exotic goldenrods (*Solidago*) in Europe. Conservation Biology 15(1): 122-128.

Zając A. 1978. Założenia metodyczne 'Atlasu rozmieszczenia roślin naczyniowych w Polsce'. Wiad. Bot. 22(3): 145-154.

Zając A., Zając M. & Tokarska-Guzik B. 1998. Kenophytes in the flora of Poland: list, status and origin. In: J. B. Faliński, W. Adamowski & B. Jackowiak (eds.). Synantropization of plant cover in new Polish research. Phytocoenosis 10 (N.S.) Suppl. Cartogr. Geobot. 9: 107-116.

Zając A. & Zając M. (eds.). 2001. Distribution atlas of vascular plants in Poland. xii+715 pp. Edited by Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University, Cracow.