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Structure of *Asclepias syriaca* L. population against phytocenotic and habitat conditions in Widuchowa (West Pomerania)

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Abstract: *Asclepias syriaca* L. is on the invasive species list in Poland. Its sites are scattered, with the exception of cultivation sites; they are also not well identified in the country and that is why they have not been presented in the ATPOL (Distribution Atlas of Vascular Plants in Poland) yet. In this study, spatial structure of *A. syriaca* population against phytocenotic and soil conditions in Widuchowa (West Pomerania**)** were examined. Number of specimens, their density per 1 m^2, and mean crowding were determined. In addition, the population spatial structure type was identified through observations and by calculation of the dispersion coefficient. On the basis of the conducted research, it was found that the investigated population comprised 1 500 specimens and occupied the area of 38 m^2. It exhibited regular spatial distribution type (dispersion coefficient<1) and was characterized by high value of mean shoot density, which amounted to 29 spec./1 m^2 (max. 35 spec./1 m^2). On the basis of the conducted chemical analysis of the soil from the *A. syriaca* habitat, the substrate was classified as alkaline soil (pH=7.3-7.6), of low total nitrogen (0.07-0.15%), as well as low total carbon content (0.8-1.45%).

Key words: *Asclepias syriaca*, anthropophyte, invasive species, population

1. Introduction

The *Asclepias* genus includes over 100 species growing in North America (Woodson 1954). Four of them were recorded in Poland and included: *A. incarnata* L., *A. speciosa* Torr., *A. syriaca* L. and *A. tuberose* L. (Pogorzelec 2006). Because of their interesting flower structure and high honey production, they are grown as ornamental plants or in bee-gardens. Common milkweed (*A. syriaca*) has become the best-acclimatized species among them. However, its sites are not numerous, not all of them have been recorded yet and, therefore, they have not been shown in the ATPOL – Distribution Atlas of Vascular Plants in Poland yet (Zając & Zając 2001).

The interest in common milkweed is increasing because of possibilities of its use in biofuel production (Roşu *et al*. 2011). The described plant is also rubber-yielding; it contains up to 10% of rubber (Sudnik-Wójcikowska 2011).

Earlier world scientific reports regarding *A. syriaca* referred to seed germination process in different aspects (Baskin & Baskin 1977; Bhowmik 1978; Farmer *et al.* 1986) – nectar production, and honey production – that is nectar role in pollen germination process (Southwick 1983; Kevan *et al*. 1989; Farkas & Zajácz 2007). The issue of interdependence between insects and common milkweed was described in various publications (Morse & Fritz 1983; Malcolm *et al*. 1989; Hughes & Bazzaz 1997; Zalucki & Malcolm 1999; Fordyce & Malcolm 2000; Van Zandt & Agrawal 2004a, 2004b; Agrawal 2005; Delaney *et al*. 2008; Smith *et al*. 2008). Some studies concerned its ecology, pollination evolution, and propagation (Sparrow & Pearson 1948; Morse & Fritz 1983; Kahn & Morse 1991; Wyatt & Broyles 1994). Research was also conducted on *A. syriaca* defense systems against herbivores (Agrawal & Fishbein 2006; Bingham & Agrawal 2010; Rasmann *et al*. 2011). Furthermore, scientists were also interested in the species genetic structure (Kabat *et al*. 2010) and in

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chemical substances contained in different parts of the plant (Vaughan 1979).

Few examinations concerning common milkweed were carried out in Poland. The conducted studies concerned isolation, qualitative and quantitative evaluation of different chemical constituents contained in leaves, flowers, and seeds of *A. syriaca*. Those substances can be used for therapeutic purposes (Sikorska *et al*. 2000, 2001; Sikorska & Matławska 2000). Other investigations were performed on its flowering, nectar production, and flower attractiveness for insects, which is important in apiculture. Some records of common milkweed occurrence in anthropogenic habitats in Poland are found in geobotanical studies (e.g. Sowa & Warcholińska 1994; Kucharczyk 2001; Pacyna 2004; Urbisz & Urbisz 2006; Wrzesień 2006; Nobis 2007; Czarna 2009; Tokarska-Guzik *et al*. 2011); however, its biology (systematics, morphology, and distribution) was more precisely described by Bacieczko *et al*. (2013) and Puchałka *et al*. (2013).

According to the Regulation of the Minister of Environment of the 9th September 2011 (Regulation 2011), *A. syriaca* is on the invasive species list (Annex 1). That species comes from eastern part of North America and it was brought to Poland in the 18th century. According to geographic-historical classification accepted in Poland (Kornaś 1977a, 1977b, 1981; Sudnik-Wójcikowska & Koźniewska 1988; Sudnik-Wójcikowska 2011), that taxon is a kenophyte and is characterized by the status of established and potentially invasive plant.

The aim of the research project was to determine phytosociological and edaphic conditions of *A. syriaca* population occurrence in Widuchowa (West Pomerania) as well as to examine and define the type of its spatial structure and vitality of its specimens.

2. Material and methods

Asclepias syriaca population was recorded in Widuchowa commune, in Gryfino district (West Pomeranian Voivodeship). It occupies the area of about 1 650 square meters, near an asphalt road leading from Widuchowa in the direction of Lubiczyn. That species was introduced by farmers, who took up beekeeping and used common milkweed as a plant of high honey production.

The examined object is situated in AC 12 square according to ATPOL cartographic system (Zając & Zając 2001) and it is situated in the mesoregion of Myślibórz Lakeland according to Kondracki (2011). The evaluated common milkweed population is situated on uneven terrain with mild slope (to 10 degrees), slanting in north-western direction. The population area extends from a forest with dominating Scots pine (*Pinus sylvestris* L.) in the west to agricultural fields in the east, and from dry grasslands in the north to an asphalt road in the south.

Studies on common milkweed population were conducted in the growing season of 2013. They consisted of the research object recognition with regard to floristic and phytosociological considerations. Phytosociological relevés were made in selected plots according to the Braun-Blanquet method (1951). The modified cover-abundance scale of Barkman *et al*. (1964) was used to estimate species cover. The relevés are shown in Table 1. For each species, its constancy (S) and coverage index (Ic) was calculated according to the following formula (Pawłowski 1959):

$$I_c = \frac{S}{n} \times 100$$

where: S – total of means of coverage of each species in all relevés in the table, in which this species is present, n – number of relevés in the table.

Plant species nomenclature follows Mirek *et al*. (2002) and syntaxonomical nomenclature was adopted after Matuszkiewicz (2011). The type of population spatial structure was defined on the basis of shoot distribution in the examined area and on the basis of dispersion coefficient calculation according to Trojan (1975). This coefficient (Cd) reached the following values: Cd<1 – regular type of spatial distribution, Cd=1 – random type of spatial distribution, Cd>1 – clustered type of spatial distribution. Population size and shoot concentration per 1 square meter were also estimated and average overcrowding, expressed in Lloyd coefficient value (Collier *et al*. 1978) was determined. Lloyd coefficient indicates with how many – on average – other specimens each specimen shares its square. Precise geographic coordinates were given by means of manual GPS receiver for each research square and for five chosen plots where phytosociological relevés were made.

To determine edaphic conditions of the evaluated population, four soil samples were taken from the rhizosphere layer (where plant rhizome was growing) using the Egner's soil stick. Then dried soil material was delivered to the laboratory of the Regional Chemical and Agricultural Station in Szczecin to conduct physical and chemical analysis. Soil reaction (pH_{KCl}) was determined in the laboratory according to potentiometric method with potassium chloride (KCl) solution of concentration C (KCl) = 1 mol·dm^{-3}. Calcium carbonate content was determined according to the Scheibler method and carbon content was determined according to the Turin method. Total nitrogen content was determined according to the Kjeldahl method. Digestible potassium forms (K_2O) were determined by means of flame photometry method according to PN-R-04022:1996 standard, and digestible phosphorus (P_2O_5) was determined with the

Table 1. Phytosociological structure of the community with *Asclepias syriaca* L.

Number of relevé	1	2	3	4	5	S	Ic
Latitude [N]	53°07′42.3″	53°07′42.5″	53°07′42.6″	53°07′43.2″	53°07′43.0″		
Longitude[E]	14°24′28.3″	14°24′28.4″	14°24′28.4″	14°24′28.6″	14°24′27.5″		
Herbaceous layer cover [%]	100	100	100	100	100		
Shrub layer cover [%]	0	1	5%	1	0		
Moss layer cover [%]	3	5	3	0	3		
Number of species in the relevé	12	19	19	20	18		
Asclepias syriaca	4	3	3	3	4	V	4750
Trees and shrubs							
Acer pseudoplatanus b	.	.	1	.	.	I	100
Quercus robur c	.	+	.	+	.	I	4
Quercus robur b	.	.	+	.	.	I	2
Pyrus communis b	.	.	.	+	.	I	2
Quercus robur c	.	+	.	+	.	I	4
Acer pseudoplatanus c	.	+	.	.	.	I	2
Acer negundo c	.	.	.	.	+	I	2
Molinio-Arrhenatheretea							
Arrhenatherum elatius	2m	2m	1	2	2	V	1500
Dactylis glomerata	2m	.	1	2	1	IV	900
Calamagrostis epigejos	2m	.	.	1	1	III	550
Rumex acetosa	1	+	+	1	1	V	300
Phleum phleoides	.	1	1	.	1	III	300
Achillea millefolium	.	1	.	1	1	III	300
Achillea pannonica	.	.	+	+	.	II	4
Heracleum sibiricum	.	.	.	+	+	II	4
Koelerio glaucae-Corynephoretea canescentis							
Helichrysum arenarium	.	1	1	.	.	II	200
Trifolium arvense	.	+	+	.	.	II	4
Festuco-Brometea							
Artemisia campestris	.	1	.	.	+	II	102
Petrorhagia prolifera	.	.	+	+	.	II	4
Agropyretea							
Convolvulus arvensis	1	.	.	+	+	III	104
Equisetum arvense	+	+	+	1	+	V	108
Trifolio-Geranietea							
Galium verum	2m	.	1	.	2a	III	800
Astragalus glycyphyllos	.	.	.	.	2m	I	350
Others							
Festuca trachyphylla	.	4	2b	.	.	II	1600
Hypericum perforatum	.	+	.	1	1	III	202
Vicia hirsuta	.	.	.	1	.	I	100
Melandrium album	+	+	+	+	+	V	10
Senecio jacobea	.	.	+	+	+	III	6
Vicia tetrasperma	+	+	.	.	.	II	4
Myosotis sylvatica	+	.	.	.	.	I	2
Trifolium aureum	.	+	.	.	.	I	2
Hieracium umbelatum	.	.	+	.	.	I	2
Centaurea stoebe	.	.	+	.	.	I	2
Anchusa officinalis	.	.	.	+	.	I	2
Cynoglossum officinale	.	.	.	+	.	I	2
Moss layer							
Rhytidiadelphus squarrosus	.	+	.	.	+	II	4
Brachythecium salebrosum	+	.	.	.	.	I	2
Calliergonella cuspidata	.	+	.	.	.	I	2
Hypnum cupressiforme	.	.	+	.	.	I	2

Explanations: all phytosociological relevés were collected on 8th July 2013 in Widuchowa, on a slope of 10° inclination, area of relevés 25-30 m^2; S – constancy class, Ic – coverage index

assistance of spectrophotometric method on the basis of PN-R-04023:1996 standard. Digestible content of magnesium (Mg) was determined according to the spectrophotometric method with titanium yellow, according to PN-R-04020:1994 standard.

3. Results

3.1. Plant communities

On the basis of phytosociological relevés from the observation area with *A. syriaca*, it was found that the plant occurred in semi-natural turfy meadow communities of the *Molinio-Arrhenatheretea* class (Table 1). This species reached the V constancy degree and was characterized by the highest coefficient of coverage that attained 4750. *Arrhenatherum elatius* (L.) P. Beav. was a dominating species of outgoing *Arrhenatheretum elatioris* community. It was also characterized by V constancy degree (S) in plots; however, its coefficient of coverage Ic was much lower (1500). Among species typical for the *Arrhenatheretalia* order: *Dactylis glomerata* L., *Achillea millefolium* L., and *Heracleum sibiricum* L. were recorded. Species growing in sandy and xerothermic grasslands of the *Koelerio glaucae-Corynephoretea canescentis* and *Festuco-Brometea* classes were recorded in a smaller amount. These included: *Helichrysum arenarium* (L.) Moench., *Trifolium arvense* L., *Artemisia campestris* L. and *Petrorhagia prolifera* (L.) P. W. Ball & Heywood. Also high participation of accompanying species was observed within the floristic composition of plots. Among those species, *Festuca trachyphylla* (Hack.) Krajina was characterized by a high quantity attribute value, and its coefficient of coverage (Ic) achieved 1600 (Relevés 2 and 3 – Table 1).

3.2. Edaphic conditions

On the basis of the conducted chemical analyses of the examined soil from plots with *A. syriaca*, it was found that soil reaction ranged from 7.3 to 7.5 and the evaluated soil was classified as slightly alkaline. Such alkaline reaction affected both microorganism development in the soil, and the mineralization process, which was reflected in low accumulation of organic matter and humus in the evaluated samples (Table 2). Organic carbon content in soil is one of the most important indicators of its fertility. The C_{org} content of C_{org} in the evaluated soil varied from 0.61 to 1.45%. The content of total nitrogen in soil surface levels ranged from 0.07 to 0.15% indicating that the examined soil was poor in that element. C:N ratio ranged from 7.6 to 11.4%. Differences in that ratio values indicated various rates of mineralization of organic carbon and nitrogen compounds. The content of digestible potassium (K_2O), according to IUNG standards, was high and ranged from 16.1 to 21.4 mg • 100 g-1 soil, similarly to magnesium content which varied from 5.2 to 8.9 mg • 100 g-1 soil. The content of digestible phosphorus (P_2O_5) was determined as low, according to national standards. Its content ranged from 4.7 to 18.2 mg • 100 g-1 soil (Table 2).

3.3. Group traits

Population size in the examined area of about 1 650 square meters was estimated at 1 500 shoots. However, the average density was 29 plants per 1 square meter (35 specimens per 1 square meter at most). On the basis of observations and of the calculated value of dispersion coefficient , it was found that *A. syriaca* population was characterized by a regular type of spatial distribution (dispersion coefficient <1). Average overcrowding value, expressed as Lloyd's coefficient, amounted to 26.2. This value was only slightly lower than the average concentration.

4. Discussion

In Central European countries, e.g. Slovakia and Hungary, *Asclepias syriaca* covers ruderal and xerothermic sites of several hectares (Valachovič 1987; Csontos *et al*. 2009), whereas in Poland its populations grow in dozens of dispersed localities where they cover insignificant areas, like the investigated population in the vicinity of Widuchowa (Urbisz & Urbisz 2006; Wrzesień 2006; Nobis 2007; Czarna 2009; Tokarska-Guzik *et al*. 2012; Urban & Wójciak 2012). For the first time, the locality was recorded in 2011 (unpublished data); therefore, it is difficult to evaluate the exact date when the species appeared in the investigated area. Presumably, it was planted in the first half of the 20th century by the owners of a nearby farm, as a melliferous plant.

The investigated population was growing on an insolated slope along a road, in the vicinity of arable land. Hartzler & Buhler (2000), in their research, also stated that in the USA (Iowa), localities of *A. syriaca* were

Table 2. Chemical characteristics of rhizosphere of *Asclepias syriaca* L.

Samples	pH	Organic matter	Humus	C_{org}	Total – N	$CaCO_3$	C:N	P_2O_5	K_2O	Mg
	content [%]							content of digestible components [mg • 100 g^{-1} soil]		
1	7.5	2.47	1.38	0.8	0.07	6.9	11.4:1	4.7	16.1	5.7
2	7.3	3.41	2.13	1.24	0.15	1.7	8.3:1	15.6	17.8	5.2
3	7.4	3.61	2.5	1.45	0.14	2.9	10.4:1	9.9	17.0	8.9
4	7.6	1.79	1.04	0.61	0.08	0.2	7.6:1	18.2	21.4	6.5

found more frequently near roads, where they accounted for 71% of all 859 recorded localities. It proves that roads are artificial ecological corridors, which enable a long-range dispersion of diaspores of alien plant species (Tokarska-Guzik *et al*. 2012). In Poland, the existing populations of *A. syriaca* have island-like distribution which is mostly caused by the intentional introduction of the species to cultivation or accidental spread of its vegetative parts or seeds. The species also occurs in unused arable lands (Hungary), meadows (USA) or deserted vineyards (Hungary, Slovakia) (Hartzler & Buhler 2000; Csontos *et al*. 2009; Pauková *et al*. 2013).

The investigated population of *A. syriaca* covered the area of 1 650 m^2 and it reached 1 500 specimens, with mean density of 29 specimens per m^2. Pauková *et al*. (2013), in their study, claimed considerably lower density. Also Csantos *et al*. (2009) recorded lower mean density in deserted vineyards (7.4 specimens per m^2) and arable lands (18.1 specimens per m^2). Similar values (1.2-8.8 specimens per m^2) of specimen density were found in North America (Bhowmik & Bandeen 1976), whereas significantly higher density (45 specimens per m^2) was recorded by Valachovič (1987) in western Slovakia. Despite intensive growth of the investigated population, it did not reveal a long-distance spontaneous expansion trend, presumably because its spread was limited by the surrounding phytocoenoses. No other *A. syriaca* localities were found in the vicinity of the population even though, in general, on average, plants of this species produce up to 226 anemochorous seeds (Willson & Rathcke 1974).

The population was growing in slightly alkaline soil (pH 7.3-7.6). Also Groh (1943) claims that the species prefers alkaline soils in the east of Canada. According to Timmons (1946) and Spurway (1941), however, in North America *A. syriaca* grows in acidic soils of 4-5 pH. This proves that the species is able to adapt to soils of lower pH (Bhowmik & Bandeen 1976).

Floristic composition of communities in which *A. syriaca* was recorded was diverse (Valachovič 1987; Pauková *et al*. 2013; Puchałka *et al*. 2013). In the case of the investigated site, the species was found to grow in wasteland, in former meadow communities of the *Molinio-Arrhenatheretea* class, in which *Arrhenatherum elatius*, *Dactylis glomerata*, and *Calamagrostis epigejos* achieved high degree of coverage. The wasteland was not used for agricultural purposes, nor mowed for more than 20 years. In the study of Valachovič (1987), *Asclepias syriaca* was found predominately in ruderal communities. In Slovakia, depending on the habitat type, the species was accompanied by: *Centaurium erythraea*, *Rubus fruticosus*, *Sambucus ebulus*, and *Verbascum densiflorum* – in deserted vineyards, *Achillea millefolium*, *Centaurea jacea*, *Cichorium intybus*, *Cirsium arvense*, *Convolvulus arvensis*, and *Rubus fruticosus* – in meadows and roadsides. Such species composition was also confirmed by the study of Puchałka *et al*. (2013) conducted in Poland. In *A. syriaca* localities near Toruń, depending on habitat conditions, the species was accompanied by plants from *Artemisietea vulgaris*, *Festuco-Brometea*, *Koelerio-Corynephoretea*, *Epilobietea angustifolii*, *Molinio-Arrhenatheretea*, *Stellarietea mediae*, *Phragmitetea*, *Querco-Fagetea*, and *Salicetea purpureae* classes.

5. Conclusions

It is recommended to include the locality with the *A. syriaca* population near Widuchowa (West Pomerania) in monitoring system. Long-term observations would allow determining whether this invasive species requires introduction of any preventive measuresin order to limit its further spread. The population of *A. syriaca* in recent years has been an interesting object of scientific research; therefore, the study will be continued.

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