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New localities and habitat preferences of common milkweed *Asclepias syriaca* L. in Toruń (Central Poland)

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Abstract. The paper presents the location and general description of habitats and plant communities with common milkweed occurring within the city limits of Toruń. The data set comprised new localities of this species as well as those where *Asclepias syriaca* has been observed for several years but the sites have not been described in the ecological literature. Relevés made at these sites were compared with those described by Puchałka et al. (2013) from three sites of *Asclepias syriaca* in Toruń. A larger set of new sites included in the analysis allows for a more accurate description of the impact exerted by some ecological factors, e.g. afforestation, on the growth of the studied species. As evidenced by the new sites of *Asclepias syriaca* found recently in Toruń and the surrounding area, it is necessary to monitor the dynamics of the population and to undertake the research on the impact of common milkweed on plant communities.

Key words: Ellenberg indicators**,** invasive alien species, numerical classification, relevés, ruderal habitat, urban vegetation.

1. Introduction

During the last ten years, many new sites of common milkweed *Asclepias syriaca* L. have been found in Poland. New sites of this species have been reported from different regions of Poland by e.g. Bróż & Maciejczak (1991), Sowa and Warcholińska (1992), Korczyński (1996), Święs and Wrzesień (2003), Urbisz and Urbisz (2006), Tokarska-Guzik et al. (2010, 2012), Bloch-Orłowska and Żółkoś (2012), Bomanowska et al. (2012), Urban and Wójciak (2012) as well as Puchałka et al. (2013). Because the described species is on the list of 16 particularly undesirable alien species in Poland (Regulation …2011), the new sites of *A. syriaca* should be documented (Puchałka et al. 2013).

The previous reports on the species from areas located close to Toruń come from Abromait et al. (1903; unfortunately the site was not described precisely), and Hohnfeldt (1885) who found the species' site in the area of the present-day Kujawy-Pomerania Province where Toruń is one of the main cities. After nearly a hundred years, i.e. in 1989, the species was spotted near the city of Toruń, i.e. the village of Grębocin, by Ceynowa-Giełdon. In 1990, two sites of the described species were found in Toruń by Rutkowski. One of them was described in the recently published paper by Puchałka et al. (2013). This site was presented in the above-mentioned paper with two other sites of *Asclepias syriaca* located in Toruń and several sites located outside the city, but close to its southern boundary. In addition, the cited paper describes a few sites of the common milkweed from the vicinity of Ciechocinek. On the basis of the collected set of 30 relevés, Puchałka et al. (2013) completed a description of habitat conditions at the sites of common milkweed, using also information provided by ecological indicator values assigned to plant species by Ellenberg.

A year after the paper by Puchałka et al. (2013) was published, we found another sites of *Asclepias syriaca* in Toruń. Some of them were characterised by environmental conditions significantly different from those observed previously. Others were located in areas with restricted

access, used by military units. For this reason, those sites were most likely overlooked by botanists and ecologists for a long time. At these sites, we made relevés in 2014. In 2015, we also made relevés at some locations whose descriptions were provided in the form of relevés by Puchałka et al. (2013).

The objective of this study was to compare new relevés with *Ascelpias syriaca* made at new and old sites with sites and relevés described previously in the ecological literature. The comparison included known and unknown sites and relevés from the urban area of Toruń and was carried out with the assumption that it can provide new information on the impact of various ecological factors on the populations of this species. It may also provide more precise data on the effect of common milkweed on plant communities having the species in their floristic composition.

2. Study area

Toruń is the second largest city in the Kujawy-Pomerania Province. It is the seat of local and provincial authorities. It was founded in 1233 by the Teutonic Knights on the right bank of the Vistula River. In 1795-1918, it was a border city of Prussia and acted as a stronghold. In 1877-1893, a fortification system was built, including 15 forts and ca. 60 shelters around the city. At that time, ca. 4000 ha of forests were cut down around the city to clear the ground. Despite such major deforestations around the city, the Bydgoszcz-Toruń Forest has survived to this day. Pine forests dominate on extensive fields of inland dunes. Until 1938, part of modern Toruń located on the left bank of the Vistula River represented a separate city referred to as Podgórz. Present-day Toruń covers an area of 115.75 km^2 and is inhabited by approximately 200,000 residents. Twelve years ago, the oldest, central part of the city received UNESCO cultural heritage status. A considerable part of the city is covered with forests (ca. 24% of the total area). A large area in the north-eastern part of the city is covered by industrial and warehouse infrastructure. The largest plant in this part of the city, i.e. Zakład Włókien Sztucznych "Elana" (plant of synthetic fibres), was built in the late 1950s and early 1960s. The largest residential district is located south of the industrial zone and is referred to as Toruń − Rubinkowo. It was built in the 1960s and from the west it borders on the older Jakubskie district, which comes from the late 18th century. The industrial-warehouse district with the factory "Elana" and the residential Rubinkowo district were built on the lands used for agricultural purposes. After the construction of the factory, cultivation of plants was continued at the allotments leased mainly by the staff of "Elana". At present, agricultural lands in Toruń, including mostly meadows, are located mainly in the south-eastern part of the city, on the left bank of the Vistula River. There is also a residential area in this part of the city – referred to as Czerniewice, where single-family buildings dominate and intakes of mineral waters are located. At the southern limits of the city, military grounds are located, including an artillery range existing since the 17th century and fortifications of the fort stronghold from the late 19th and early 20th century.

The research covered all known sites of *Asclepias syriaca* within the urban area. The sites were distributed mainly in the north-eastern part of the city in the industrial and warehouse area near the "Elana" plant and along the peripheries of the residential district of Rubinkowo. The second group of sites was located in the south-eastern part of the city, including the district Czerniewice and the military grounds in Stawki.

3. Material and methods

The species composition of plant communities with *A. syriaca* at eight sites was reflected in 12 relevés made in 2013-2015 with the Braun-Blanquet method. The efforts were made to preserve the homogeneity of vegetation patches. Therefore, the area of relevés was small and ranged from 20 to 25 m^2. Four relevés were made in 2013. These relevés were published in the study by Puchałka et al. (2013) and they were marked with the letter A. Two relevés were repeated in 2015 at the sites already known and described in the literature. These relevés were denoted by the symbol B. Six relevés made in 2014 came from the new sites. They were not published yet and marked with the letter C.

Location of the species' sites and location of relevés were plotted on the ATPOL grid of squares (geographic coordinates in DMS, ATPOL). For a more accurate location, the length of a square side was set at 1 km, which means that the basic squares of the system, i.e. 10x10 km (Zając & Zając 2001), were divided into 100 smaller units (Fig. 1).

In addition to the abundance of species, also barren and flowering individuals of *Asclepias syriaca* were counted and noted while making the relevés. Particular attention was paid to the presence of woodlots or forests near the population of the studied species.

Sites and relevés made at these sites were marked using codes consisting of letters and numbers. In addition to symbols A, B, C defined above, the codes consisted of two capital letters referring to the name of a district and a street at which a given site was located and a small letter indicating the type of object located next to a site. A numeral symbol was used to mark the subsequent number of a relevé made at the same site, in the same year or in following years.

Twelve relevés were analysed so the symbols were defined as follows:

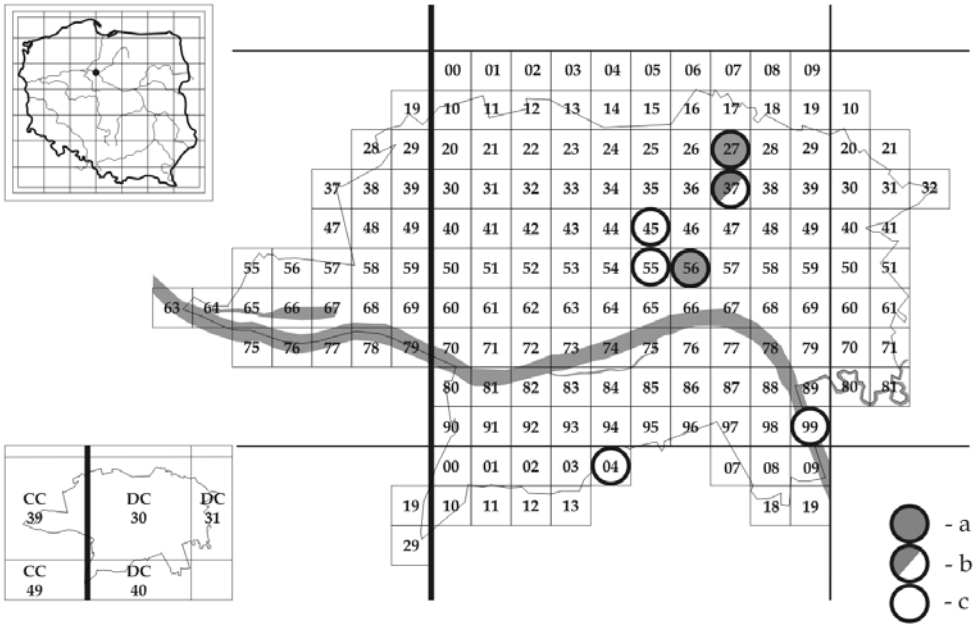

Figure 1. Distribution of *Asclepias syriaca* in Toruń in ATPOL squares (small letter symbols denote: a – squares with old sites, b – squares with old and new sites, c – squares with new sites only). Locality of Toruń is presented in the small map of Poland

A-HM-s – the north-eastern part of Toruń, the Hutowo district (north of the "Elana" plant), the Morwowa street. An initial population, consisting of several barren shoots, occurs on the embankment of the closed railway track. It was found in 2012. The relevé published by Puchałka et al. (2013) was made in 2013. The site has the following coordinates: N 53º2'55.8492", E 18°39'29.1126", ATPOL square DC3027.

A-RW-t-1 – in the Rubinkowo district at the Wschodnia street, a ruderal area at a tramway line. A few hundred shoots occur at the site, including flowering and fruiting specimens. The population was found already in 1981. The published relevé was made in 2012. Coordinates of the site: N 53°1'47.8698", E 18°38'33.8568", ATPOL square DC3056.

B-RW-t-2 – the relevé was made at the same site (i.e. as relevé A-RW-t-1) in 2015 on the roadside grassland by the authors of this study.

B-RW-t-3 – the relevé was made at the same site (i.e. as relevé A-RW-t-1) in 2015 by the authors of this study in the place where vegetation cover together with a humus layer was removed during reconstruction of a tramway line.

A-EP-i-1 – next to "Elana" plant, in industrial sandy areas near the Płaska street. The population of *Asclepias syriaca* was found at this site in 2010. The published relevé was made in 2013. The coordinates of the site: N 53°2'35.4156", E 18°39'35.478", ATPOL square DC3037.

A-EP-i-2 − the relevé was made at the same site in 2013 by Puchałka et al. (2013).

New sites discovered in 2014, so far not described in the literature

C-SF-e – Stawki district, Fort XIII Kniaziewicz at the Okólna street. A glade amidst trees growing on inner upper ridges of fort embankments. Coordinates of the site: N 52°48'57" E 18°36'57.13" in ATPOL square DC4004.

C-SF-b – Stawki district, Fort XIII, a sandy escarpment, an outer buttress with northern exposure. Coordinates N 52°59'2.77" E 18°36'59.47", ATPOL square DC4004.

C-C-g – Czerniewice district**,** grasslands in the floodplain of the Vistula River. Coordinates N 52°59'25.41", E 18°41'19.94", ATPOL square DC3099.

C-E-r – next to "Elana", in ruderal areas near a ditch running along the southern side of railway tracks, in the vicinity of a junction of Toruń-Olsztyn and Toruń-Lipno lines. Coordinates N 53°2'42", E 18°39'44", ATPOL square DC3037. The site of common milkweed is located near the Płaska street (dirt road) and a fragmentary site described in 2013 as A-EP-i.

C-MM-s – Mokre district, an area at the new Średnicowa Route running along the former Mazurska street with a soil surface. Coordinates of the site: N 53°1'51.42" E 18°37'32.32", ATPOL square DC3045.

C-JZ-r – Jakubskie district on the route of a railway siding located at the Żółkiewskiego street. Coordinates N 53°1'23'', E 18°38'28'', ATPOL square DC3055.

The nomenclature of vascular plants in the summary table of all relevés was accepted after Mirek et al. (2002), and that of mosses – after Ochyra et al. (2003). To compare the species composition of plant communities with *A. syriaca*, numerical classification of relevés was performed using the MVSP statistical package (Kovach 1993). The Squared Euclidean distance was used as a measure of distance between relevés, and clustering was performed using the minimum variance method. The species cover coefficients were converted from the Braun-Blanquet scale to the scale of van der Maarel (1979).

The heterogeneity of habitat conditions at individual sites of *A. syriaca* was assessed by comparing average indicator values of Ellenberg et al. (1992) assigned to species in each relevé. Mean values of Ellenberg's indicator values for every relevé was calculated using the software JUICE 7.0 (Tichý 2002). Furthermore, the comparison of the two subsets of relevés was performed, i.e. 6 relevés made at the old sites and 6 relevés made at the new sites, in respect of each of the seven indicators. The t test was used for the comparisons.

4. Results

It follows from the map presented in Fig. 1 that the sites of *Asclepias syriaca* are located in two parts of Toruń, i.e. in the northeastern and southeastern part. The populations occurring in the northeastern part of Toruń grow in sandy ruderal areas on former railway lands and lands adjoining to factories. This area is dominated by thermophilic species from the class *Agropyretea intermedio-repentis, Artemisietea vulgaris*, *Festuco-Brometea* and *Koelerio-Corynephoretea* (Table 1). Both old and new sites of *Asclepias syriaca* are found in this part of the city. In the southern part of Toruń, on the left bank side of the Vistula River, all sites are new, i.e. not found previously. In Czerniewice, located on the southeastern outskirts of Toruń, the population of *A. syriaca* occurs on river alluvial soils. In the area of Fort XIII, both populations occur on exposed grounds amidst trees overgrowing this military object.

The floristic composition of communities with common milkweed significantly varies (Table 1). A total of 122 plant taxa were identified in 12 relevés, including 118 species of vascular plants and four moss taxa. Most species, i.e. 102 taxa, occurred with a frequency of up to 25%. In addition to *Asclepias syriaca*, *Calamagrostis epigejos* from the class *Epilobietea angustifolii* occurred with the highest frequency, i.e. in 11 relevés. Also species from the class *Agropyretea intermedio-repentis*: *Elymus repens* and *Poa angustifolia* occurred with a high frequency.

Similarly to Puchałka et al. (2013), due to a different structure of phytocoenoses compared to that described in handbooks (cf. Matuszkiewicz 2007), relevés made in 2014-2015 were not classified as plant associations. Nitrophilous species from the class *Artemisietea vulgaris* dominated at most of the sites, but different combinations of species from this class dominated in subsets of relevés from the old and new sites. The following species occurred in the first subset: *Oenothera biennis*, *Anchusa officinalis*, *Berteroa incana*, *Melandrium album* and *Urtica dioica*. Whereas *Cirsium arvense*, *Galium aparine*, *Echinops sphaerocephalus* and *Melilotus alba* occurred at the new sites.

At the identified sites of *Asclepias syriaca*, depending on the habitat conditions and the local gene pool of plant species, xerothermic species occur (class *Koelerio-Corynephoretea*), such as *Chondrilla juncea*, *Sedum acre*, *Silene otites* and *Racomitrium canescens* and some species from the class *Festuco-Brometea* listed in Table 1: *Artemisia campestris*, *Centaurea stroebe*, *Medicago falcata* and *M. minima*, in addition to taxa from the class of *Artimiesietea*. In relevés from the new sites, meadow species from the class *Molinio-Arrhenatheretea*, e.g. *Arrhenatherum elatius*, *Taraxacum officinale*, *Galium album* and *Vicia cracca* occur in large numbers. This group of species in relevés from the old sites is frequently represented by single plants of *Rumex thyrsiflorus.* In some relevés from the new sites (in particular from the embankments of Fort XIII – site C-SF-e and from the closed railway tracks at the Żółkiewski street – site C-JZ-r), segetal species from the class *Stellarietea mediae* play an important role. This syngenetic group in relevés from the old sites is frequently represented by *Lepidium densiflorum*.

The presence of trees discriminates between the relevés from the old and new sites. Several-year-old seedlings of *Acer negundo*, *Populus tremula*, *P. alba*, *P. nigra*, *Acer pseudoplatanus*, *Quercus robur*, *Padus serotina* are frequent components of such phytocoenoses at the new sites. *Sambucus nigra* occurred in the layer b at the old site near the Wschodnia street in the Rubinkowo district.

The differences in the species composition between the old and new sites are best seen on the dendrogram produced using the minimum variance method. Relevés C-SF-e and C-SF-b from Fort XIII and the relevé C-C-g from Czerniewice made on grasslands growing on the Vistula alluvial soils appear different on the dendrogram (Fig. 2). Also the relevé C-JZ-r from the site at Jakubskie Przedmieście (suburb), defined as an unused railway track at the Żółkiewski street is significantly different. The difference of this relevé results from the fact that the following species are found only at this site: *Bromus inermis*, *Partenocissus inserta*, *Humulus lupulus*, *Melilotus officinalis*, *Verbascum phlomoides*, whereas *Echinops sphaerocephalus*, *Achillea pannonica* and *Conyza canadensis* oc-

Table 1. Plant communities with *Asclepias syriaca* in Toruń and mean values of their ecological numbers according to Ellenberg et al. (1992) (codes of relevés and sites are explained in part 3. Material and methods)

Relevé no. in table	1	2	3	4	5	6	7	8	9	10	11	12
Field no. of relevé	1	4	[1]	[2]	2	3	(1)	(3)	(4)	(2)	(5)	(6)
Locality: code of site	A-HM-s	A-RW-t-1	B-RW-t-2	B-RW-t-3	A-EP-i-1	A-EP-i-2	C-SF-e	C-SF-b	C-C-g	C-E-r	C-MM-s	C-JZ-r
Date: year month, day	2013.07.03	2012.09.20	2015.08.26	2015.08.26	2013.07.03	2013.07.03	2014.05.10	2014.09.17	2014.09.25	2014.08.11	2014.07.31	2014.06.21
Relevé area [m^2]	20	20	20	20	20	20	20	30	25	25	25	20
Cover of shrub layer [%]	0	5	5	5	0	0	0	<5	0	5	0	0
Cover of herb layer [%]	90	100	90	90	85	90	100	80	95	80	60	70
Cover of moss layer [%]	15	0	0	0	5	1	0	80	0	5	0	0
Number of species	24	22	26	21	21	22	28	24	21	20	15	47
Asclepias syriaca	+	4	4	4	1	2	2	4	1	4	3	1
Ch. *Agropyretea intermedio-repentis*												
Elymus repens	.	1	3	1	3	3	+	.	3	1	2	1
Poa angustifolia	3	.	1	+	2	2	2	2	.	2	.	+
Equisetum arvense	.	+	+	.	.	.	.	.	+	.	+	+
Convolvulus arvensis	.	+	1	+	.	.	+	.	.	.	1	+
Bromus inermis	.	.	.	.	.	.	.	.	.	.	.	2
Ch. *Epilobietea angustifolii*												
Calamagrostis epigeios	3	4	2	2	.	+	1	3	1	2	1	1
Sambucus nigra b	.	1	.	1	.	.	.	.	.	.	.	.
Populus tremula b	.	.	.	.	.	.	.	.	.	1	.	.
Ch., D. *Artemisietea vulgaris*												
Artemisia vulgaris	+	1	+	.	.	.	.	+	.	.	+	1
Oenothera cf. *biennis*	+	+	+	+	+	+	.	.	.	.	.	.
Anchusa officinalis	.	+	+	+	+	+	.	.	.	.	.	+
Berteroa incana	+	+	+	+	.	.	.	.	.	.	.	+
Medicago sativa	.	.	+	.	+	+	.	.	.	.	.	.
Medicago x*varia*	.	.	+	.	+	+	.	.	.	.	.	.
Melandrium album	+	.	+	+	.	.	.	.	.	.	.	.
Tragopogon dubius	+	.	.	.	.	+	.	.	.	.	.	.
Linaria vulgaris	.	+	.	.	.	.	.	.	.	.	.	.
Medicago lupulina	+	.	.	.	.	.	.	.	.	.	.	.
Urtica dioica	.	+	.	+	.	.	.	.	.	.	.	.
Verbascum densiflorum	.	.	.	.	.	+	.	.	.	.	.	.
Cirsium arvense	.	.	.	.	.	.	.	.	2	.	+	+
Galium aparine	.	.	.	.	.	.	1	+	.	.	+	+
Echinops sphaerocephalus	.	.	.	.	.	.	+	1	.	(+)	.	2
Chelidonium majus	.	.	.	.	.	.	1	.	.	.	.	+
Geum urbanum	.	.	.	.	.	.	1	+	.	.	.	.
Saponaria officinalis	.	.	.	+	.	.	1	+	.	.	.	.
Solidago gigantea	.	.	.	.	.	.	.	.	2	.	(2)	.
Tanacetum vulgare	.	.	.	.	.	.	.	.	2	.	(1)	.
Anthriscus sylvestris	.	.	.	.	.	.	+	.	.	.	.	.
Echium vulgare	.	.	+	+	.	.	.	.	.	.	.	+
Rubus caesius	.	.	.	.	.	.	.	+	.	.	.	.
Torilis japonica	.	.	.	.	.	.	.	1	.	.	.	.
Melilotus alba	.	.	.	.	.	.	.	.	.	+	.	1
Melilotus officinalis	.	.	.	.	.	.	.	.	.	.	.	1
Verbascum phlomoides	.	.	.	.	.	.	.	.	.	.	.	1
Ch., D. *Koelerio-Corynephoretea*												
Chondrilla juncea	+	.	.	.	+	+	.	.	.	.	.	.
Sedum acre	+	.	.	.	+	+	.	.	.	.	.	.
Silene otites	.	.	.	.	+	+	.	.	.	.	.	.
Hieracium pilosella	1	.	.	.	.	.	.	.	.	.	.	.
Carex ligerica	.	.	.	.	+	.	.	.	.	.	.	.
Helichrysum arenarium	.	.	.	.	+	.	.	.	.	.	.	.
Potentilla argentea	+	.	.	.	.	.	.	.	.	.	.	.

Trifolium arvense	.	.	.	.	.	+	.	.	.	+	.	+
Senecio vernalis	.	.	.	.	.	.	.	.	.	.	.	+
Racomitrium canescens d	1	.	.	.	1	1	.	.	.	.	.	.
Brachythecium albicans d	2	.	.	.	1	.	.	.	.	1	.	.
Ch., D. *Festuco-Brometea*												
Artemisia campestris	+	+	+	.	+	+	.	.	.	.	.	.
Medicago falcata	.	1	1	+	1	+	.	.	.	.	.	.
Centaurea stoebe	.	+	.	.	.	+	.	.	.	.	.	.
Hypericum perforatum	+	+	.	.	.	.	.	+	.	.	.	.
Medicago minima	.	.	.	.	+	+	.	.	.	.	.	.
Petrorhagia prolifera	+	.	.	.	.	.	.	.	.	.	.	.
Poa compressa	+	.	.	.	.	.	.	.	.	.	.	.
Achillea pannonica	.	.	+	+	.	.	.	.	.	.	.	1
Centaurea scabiosa	.	.	.	.	.	.	.	.	.	+	.	.
Euphorbia cyparissias	.	.	.	.	.	.	.	.	.	+	.	.
Ch., D. *Molinio-Arrhenatheretea*												
Festuca rubra	1	+	+	+	+	.	+	1	1	1	.	+
Arrhenatherum elatius	.	.	2	.	.	.	4	1	.	1	.	+
Galium album	+	.	.	.	.	.	1	1	.	.	.	+
Taraxacum officinale	.	.	.	.	.	.	.	.	4	.	+	+
Vicia cracca	.	.	.	.	.	.	+	1	1	.	.	.
Rumex thyrsiflorus	+	+	1	+	.	.	+	.	.	.	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	1	.	.	+
Dactylis glomerata	.	+	.	.	.	.	.	.	.	.	.	+
Poa pratensis	.	+	.	.	.	.	.	.	.	.	.	.
Achillea millefolium	.	.	.	.	+	.	.	.	.	.	.	.
Lathyrus pratensis	.	.	.	.	.	.	+	.	.	.	.	.
Agrostis stolonifera	.	.	.	.	.	.	.	.	+	.	.	.
Lysimachia vulgaris	.	.	.	.	.	.	.	.	+	.	.	.
Ch., D. *Stellarietea mediae*												
Conyza canadensis	.	+	.	+	.	.	.	.	2	.	+	3
Viola arvensis	.	.	.	.	.	.	+	.	.	.	.	+
Lepidium densiflorum	.	.	+	+	+	+	.	.	.	.	.	.
Stellaria media	.	.	.	.	.	.	+	.	.	.	.	+
Bilderdykia convolvulus	.	+	.	.	.	.	+	.	.	.	.	+
Lapsana communis	.	.	.	.	.	.	+	.	.	.	.	+
Setaria viridis	.	.	.	.	.	.	.	.	1	.	.	+
Vicia hirsuta	2	.	.	.	.	.	.	.	.	.	.	.
Vicia angustifolia	+	.	.	.	.	.	.	.	.	.	.	.
Polygonum aviculare	.	.	.	.	.	+	.	.	.	.	.	.
Sisymbrium altissimum	.	.	.	.	.	+	.	.	.	.	.	.
Lamium purpureum	.	.	.	.	.	.	+	.	.	.	.	.
Chenopodium album	.	.	.	3	.	.	.	.	.	.	.	1
Matricaria maritima ssp. *inodora*	.	.	.	.	.	.	.	.	.	.	.	+
Chenopodium strictum	.	.	.	+	.	.	.	.	.	.	.	+
Lactuca serriola	.	.	1	.	.	.	.	.	.	.	.	+
Papaver rhoeas	.	.	.	.	.	.	.	.	.	.	.	+
Vicia villosa	.	.	.	.	.	.	.	.	.	.	.	+
others												
Acer negundo c	.	.	.	.	.	.	.	+	+	+	+	+
Euphorbia eusula	.	.	.	.	.	.	+	+	.	.	.	+
Verbascum lychnitis	.	.	+	.	.	.	.	.	.	+	.	.
Festuca trachyphylla	.	.	+	.	.	.	.	.	.	+	.	.
Veronica chamaedrys	.	.	.	.	.	.	+	+	.	.	.	.
Chaenomeles japonica	.	.	5	.	.	.	.	.	.	.	.	.
Rumex confertus	.	.	.	.	.	.	3	.	.	.	.	.
Symphytum officinale	.	.	.	.	.	.	.	.	2	.	.	.
Parthenocissus inserta	.	.	.	.	.	.	.	.	.	.	.	2
Euonymus europaeus	.	.	.	.	.	.	1	.	.	.	.	.
Poa palustris	.	.	.	.	.	.	.	.	1	.	.	.
Humulus lupulus	.	.	.	.	.	.	.	.	.	.	.	1
Iris cf. *germanica*	.	.	.	.	+	.	.	.	.	.	.	.
Moehringia trinervia	.	.	.	.	.	.	+	.	.	.	.	.
Caragana arborescens c	.	.	.	.	.	.	.	+	.	.	.	.
Pimpinella saxifraga	.	.	.	.	.	.	.	+	.	.	.	.
Quercus robur juv.	.	.	.	.	.	.	.	+	.	.	.	.

Prunus spinosa b	.	.	.	.	.	.	.	+	.	.	.	.
Phalaris arundinacea	.	.	.	.	.	.	.	.	+	.	.	.
Peucedanum oreoselinum	.	.	.	.	.	.	.	.	.	+	.	.
Populus alba b	.	.	.	.	.	.	.	.	.	+	.	.
Potentilla recta	.	.	.	.	.	.	.	.	.	+	.	.
Acer pseudoplatanus juv.	.	.	.	.	.	.	.	.	.	.	.	+
Chenopodium hybridum	.	.	.	.	.	.	.	.	.	.	.	+
Oenothera hoelscheri	.	.	.	.	.	.	.	.	.	.	.	+
Oenothera royfraseri	.	.	.	.	.	.	.	.	.	.	.	+
Helianthus tuberosus	.	.	.	.	.	.	.	.	.	.	(2)	.
Morus alba juv.	.	.	.	.	.	.	.	.	(+)	.	.	.
Padus serotina juv.	.	.	.	.	.	.	.	.	.	.	(+)	.
Populus nigra juv.	.	.	.	.	.	.	.	.	(+)	.	.	.
Leymys arenarius	.	.	.	.	.	.	.	.	.	(+)	.	.
Datura stramonium	.	.	+	.	.	.	.	.	.	.	.	.
Plagiomnium sp. d	.	.	.	.	.	.	.	3	.	.	.	.
Brachythecium sp. d	.	.	.	.	.	.	.	3	.	.	.	.
Ellenberg's indicators												
Shannon-Wiener Diversity Index - H	2.38	1.86	2.14	1.99	2.32	2.37	2.35	2.26	2.32	2.03	2.08	3.32
Light – L	7.70	7.63	7.90	7.94	8.25	8.06	6.55	6.76	7.00	7.43	7.36	7.33
Temperature – T	6.18	6.08	6.20	6.25	6.53	6.33	5.63	5.64	5.55	6.00	5.89	6.03
Continentality – C	4.41	5.17	5.63	5.38	5.20	5.25	4.31	4.50	4.78	4.85	4.75	4.81
Moisture – M	3.67	4.19	3.72	4.06	3.19	3.25	4.93	4.83	6.38	4.08	5.14	4.32
Soil Reaction – R	6.33	6.70	7.00	7.00	6.62	6.92	6.83	7.00	7.20	6.45	7.00	6.73
Nutrients – N	3.76	5.19	4.53	5.24	2.93	3.56	6.44	5.92	6.31	4.15	6.50	5.68

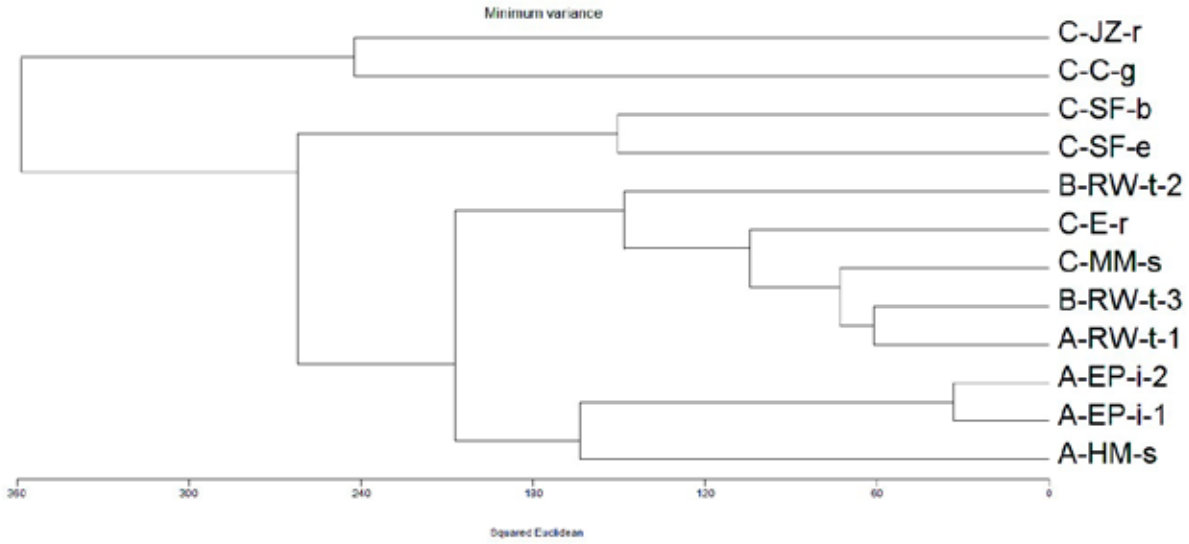

Figure 2. Hierarchical classification of 12 relevés with *Asclepias syriaca* by the minimum variance method using the squared Euclidean distance (letter symbols of relevés as in Table 1)

cur with higher abundance compared to the other relevés. The species composition at the new sites discovered in the industrial areas near "Elana" (C-E-r) and in the Mokre district at the former Mazurska street (C-MM-s) corresponds to the relevés from the previously described sites located in the northeastern part of the city.

Analysis of the *Asclepias syriaca* development at different sites reveals that the species does not bloom at the sites on Fort XIII and on grasslands in Czerniewice. In the former case, the likely cause is competition of trees through shading, in the latter case – shading by a neigh-

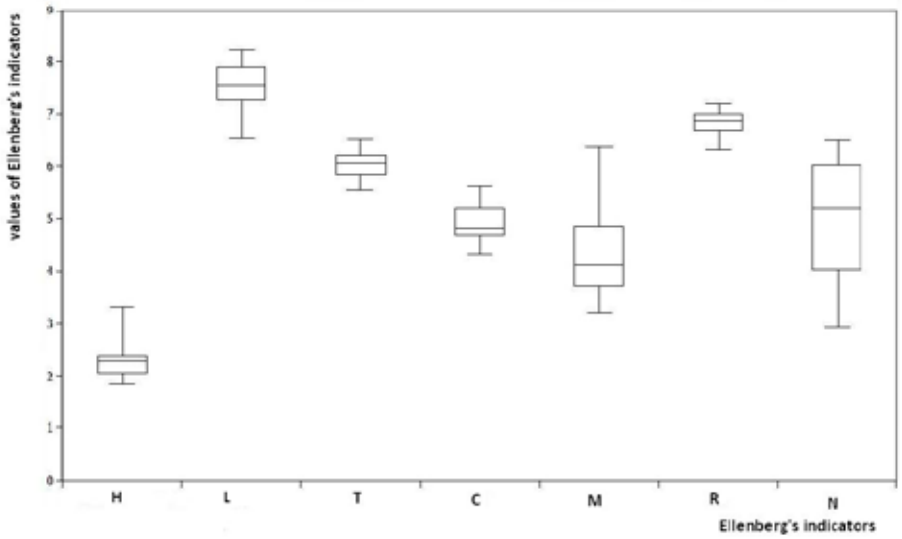

Figure 3. Mean values with standard deviation of seven Ellenberg's indicators for the set of 12 relevés made at the *Asclepias syriaca* sites in Toruń (letter symbols of Ellenberg's indicators: H – Shannon-Wiener Diversity Index, L – Light, T - Temperature, C – Continentality, M – Moisture, R – Soil reaction, N – Nutrients)

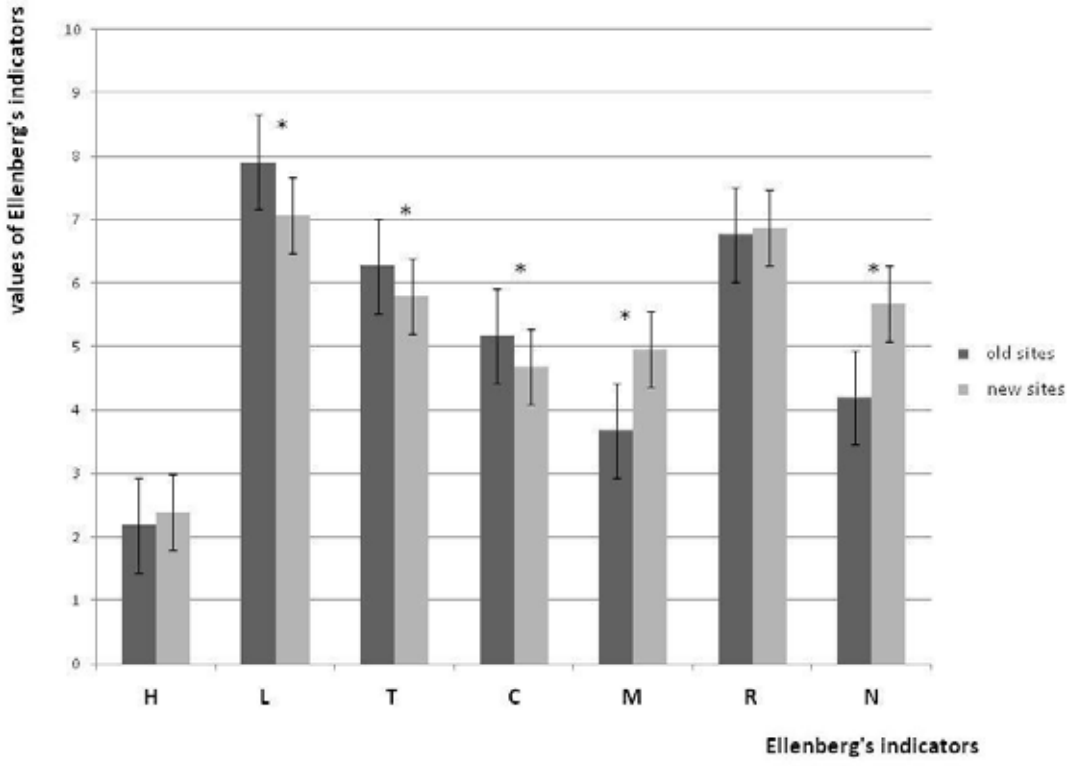

Figure 4. Mean values with standard deviation of Ellenberg's indicators for the two sets of relevés from old and new sites in Toruń. Asterisks denote statistically significant differences ($p < 0.05$) between the relevés from the new and old sites according to the t test results

bouring group of trees and mowing before blooming of plants.

Analysis of mean Ellenberg's indicator values performed on the set of 12 relevés showed that *Asclepias syriaca* occurs in Toruń in a wide range of moisture content and habitat fertility. The range of variation of these indicators ranges from 3.19 to 6.38 and from 2.93 to 6.50, respectively (Table 1, Fig. 3). The species diversity index also significantly varies. In the phytocoenosis growing at the site near the Wschodnia street (A-RW-t-1), strongly dominated by common milkweed, the value of the index was only 1.86. On the other hand, in the plant community near the Żółkiewskiego street (C-JZ-r), where the abundance of the species was reduced as a result of disturbances caused by engineering works, the index was 3.32.

Large differences in ecological conditions occur at both sites of Fort XIII, i.e. C-SF-e and C-SF- b. Relevés from these sites had the lowest values of the light indicator L, i.e. 6.55 and 6.76, respectively, with the highest value of 8.25 at the site A-EP-i-1 next to "Elana" plant, in industrial sandy areas near the Płaska street. At both sites from Fort XIII, the common milkweed does not produce flowers. On the other hand, several dozens of blooming plants occur at the site near the Płaska street. The sites in the fort area were also characterised by the lowest mean values of the continentality and temperature indicators. The content of nutrients in the substrate, i.e. the habitat fertility indicator was relatively high at these sites (although the values were not the highest compared to the other sites).

Site C-C-g on the grasslands in Czerniewice was also considerably different from the other sites. The relevé from this site was distinguished by the highest value of the humidity indicator – 6.38, with the lowest value of 3.19 determined for the relevé in the industrial areas of the former factory "Elana". The relevé was also characterised by the highest value of soil reaction – 7.20, in relation to the lowest value of 6.33 obtained for relevé A-HM-s from the site at the Morwowa street in the Hutowo district in the north-eastern part of Toruń.

It follows from the comparisons of relevés made at the old and new sites that the new relevés are characterised by smaller variability. Mean values of the light L, temperature and continentality indicators were smaller in the subset of six new relevés (Fig. 4). On the other hand, values of the species diversity, moisture content, soil reaction and fertility are higher compared to the subset of six old relevés. Differences between both subsets are statistically significant between the values of five out of seven indicators. Differences are insignificant for only two indicators, i.e. the species diversity index and soil reaction (Fig. 4).

5. Discussion

Significantly lower or higher values of the five indicators in the set of new relevés evidence that ecological conditions at the new sites were more extreme compared to ecological factors at the old sites. For some ecological factors, e.g. light, conditions at the new sites corresponded to conditions close to the ecological tolerance limits of *Asclepias syriaca*. This is evidenced by the lack of flowering specimens or the small number of shoots at some sites, especially those strongly shaded by trees.

As evidenced by the past observations of *Asclepias syriaca* distribution in Poland, the species occurs at few, scattered sites, mostly in the vicinity of its crops (Schwarz 1967; Sowa & Warcholińska 1992; Bomanowska et al. 2012; Tokarska-Guzik et al. 2012). It was recorded mostly on ruderal habitats – on railway embankments (Bróż & Maciejczak 1991; Święs & Wrzesień 2003; Wrzesień 2006), roadsides (Krzaczek 1961, 1963; Urban & Wójciak 2012), seldom on cultivated fields (Sowa & Warcholińska 1992). These observations suggested that the common milkweed spreads only in arid and sunny areas, i.e. in similar habitat conditions to those observed in Toruń and its suburbs. So far the site in Czerniewice is the only site in Poland where the species grows on habitats of river valleys. The occurrence of the studied species in similar conditions at the sites located south of Toruń was described only by Puchałka et al. (2013).

All the aforementioned habitat types, however, represent only a small part of the range of ecological conditions suitable for the development of *Asclepias syriaca*. In its natural range, the common milkweed occurs on prairies, roadsides of traffic routes, in cereal crops, meadows, grazing lands, forest areas, alluvia of rivers, and even swamps (Browmik & Bandeen 1976; Baskin & Baskin 1977; Hartzler & Buhler 2000). According to Browmik and Bandeen (1976), the species prefers soils with neutral and slightly alkaline reaction, but it occurs also on soils with low pH. Soil reaction in the analysed set of sites ranges from neutral to slightly alkaline.

As evidenced by the analysis of ecological indicator values and bibliographic data, the species can spread in a very wide range of habitats in open areas. In Slovakia (Valachovič 1987) and western Russia (Panasenko et al. 2011), *Asclepias syriaca* was observed in communities with similar floristic composition corresponding to phytocoenoses from the class *Epilobietea*, *Artemisietea* and *Agropyretea*. In Serbia, the common milkweed was recorded in the association of *Convolvulo arvensis-Agropyretum repensis* (Stanković-Kalezić et al. 2008). In central and southern Europe, the species is common in plant associations of ruderal habitats, in crops and xerothermic grasslands (Valachovič 1987; Kojić et al. 2004; Mar'yushkina & Gritsenko 2005; Pál 2007; Stanković-Kalezić et al. 2008,

2009; Csontos et al. 2009; Dolmagić 2010; Öllerer 2010; Volutsa 2010; Jarić et al. 2011; Panasenko et al. 2011). Due to a relatively large size and density of specimens, this species is often dominant in plant communities (Csontos et al. 2009; Panasenko et al. 2011). The occurrence of common milkweed was also observed in pine and *Robinia* forests, as well as on waterlogged habitats together with species of wet meadows and rush vegetation (Szollát & Schmotzer 2004; Csontos et al. 2009).

Bibliographic data (e.g. Browmik & Bandeen 1976) and analysis of indicator values (Table 1, Fig. 3) indicate that *A. syriaca* is a species of high light and thermal requirements. Probably those are the main factors limiting the spread of the species. High light requirements mean that the species may colonize open and moderately shaded areas. On the other hand, thermal conditions affect reproduction and dispersion. Success in the colonization of new habitats in warmer regions characterised by suitable conditions for the production of large quantities of anemochorous seeds (Csontos et al. 2009). In areas with cooler climate, seeds of the common milkweed do not ripen and the plants reproduce mainly vegetatively (Fomina & Tokhtar 2010). It appears that the populations near Toruń also rarely reproduce generatively. This is reflected in the species distribution in the form of small, spatially-limited clusters and the presence of only single seedlings.

Invasion of the common milkweed in central-northern and north-eastern Europe may be limited by suboptimal climate conditions. It is possible that low temperature may negatively affect the development of late-autumn ripening seeds (Fomina & Tokhar 2010; Puchałka et al. 2013). Nevertheless, studies of the viability of *A. syriaca* seeds from botanical gardens in different regions of Europe do not provide evidence of such correlations (Csontos 2005).

The origin of the common milkweed populations occurring near the city of Toruń is unknown. The location and the fate of the site reported by Abromeita et al. (1903) from Toruń have not been determined either. Considerable distances between the sites may prove that they developed independently (Fig. 1). Other species cultivated by beekeepers occur in the vicinity of many sites of common milkweed in Toruń, in particular *Echinops sphaerocephalus* and *Phacelia tanacetifolia* (Lipnicki 1976), thus it can be concluded that *A. syriaca* was introduced to support apiary crops.

On the basis of observations carried out within the framework of the present study and previous studies conducted by Puchałka et al. (2013), it is difficult to predict whether the common milkweed will become an invasive species near Toruń. The historical case of the species spreading in Hungary, where *A. syriaca* was introduced for cultivation in the 19th century, proves that there is a possibility of unexpectedly invasion. Until the 1970s, only incidental cases of the species' dispersal were reported, and from 1997 an invasion in a wide range of habitats has been observed. At present, *A. syriaca* is considered one of the most undesirable alien species in Hungary (Csontos et al. 2009). Hence the abundance and the distribution of this species at the sites in Poland should be monitored.

The observations carried out at individual sites should cover the impact of various natural processes and land-use treatments on the development of the studied species. Interesting information may be provided by the populations observed on the Fort in Toruń. Lack of flowering specimens after the lush population growth (due to increased land afforestation) does not exclude the possibility that the site may represent a potential source of invasion. The planned work on the arrangement of fort greenery, consisting in the removal of trees and shrubs, may improve the habitat conditions of the species, particularly light penetration, and help to improve the condition of individuals and production of seeds.

Phytochemical properties of *A. syriaca* are also important to the species dispersal. Tissues of this species contain highly toxic cardenolides, so only a few insect species (distributed in its natural range) can prey on common milkweed (Agrawal 2005). Therefore, the species does not have any natural enemies among herbivores on the old continent. Due to a relatively large size of the plant and often high density of shoots as well as allelopathic properties, the species can contribute to qualitative and quantitative changes in the local assemblages of organisms (Szitár & Török 2008; Kazinczi et al. 1999, 2013). On the other hand, toxic properties of *A. syriaca* may cause allergies and poisoning of livestock and man (Konstantinović et al. 2009; Anderson 1999). Consequently, the presence of the species in Poland should be monitored and studies of its impact on the structure of plant communities and other elements of ecosystems should be undertaken.

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