Biodiv. Res. Conserv. 40: 13-20, 2015

BRC
www.brc.amu.edu.pl

DOI 10.1515/biorc-2015-0026

Submitted 10.03.2015, Accepted 21.12.2015

Scandix pecten-veneris L. (Apiaceae) in the Małopolska Upland (S Poland) – regional changes in the distribution and population resources of declining weed species

Grzegorz Łazarski

Department of Plant Taxonomy, Phytogeography and Herbarium, Institute of Botany, Jagiellonian University, Kopernika 27, 31-501 Kraków, Poland, e-mail: grzegorz.lazarski@gmail.com

Abstract: The paper presents results of the inventory of localities of *Scandix pecten-veneris* L. in the Małopolska Upland conducted after 2000. The existing population resources were estimated and current distribution of the species in the Małopolska Upland and Poland was showed. Some threats to this species as well as conservation prospects were discussed.

Key words: *Scandix pecten-veneris*, endangered weed species, distribution, population resources, archaeophytes, the Małopolska Upland, Poland

1. Introduction

Scandix pecten-veneris L. has a status of an archaeophyte in Polish flora. It is a plant of Mediterranean-Irano-Turanian origin (Zając 1987) which, as a weed, spread its range, among others, to Central Europe. Meusel *et al.* (1965) classed it as a Mediterranean-Irano-Turanian-Central-European connecting element. Parts of the eastern and northern limit of its secondary range are placed in Poland (Hultén & Fries 1986; Zając *et al.* 2014).

The species was recorded mainly in southern part of Poland – in the Małopolska, Lublin and Silesian-Kraków Uplands. Solitary localities from north and north-west Poland are considered as historical (Zając *et al.* 2014). The largest numbers of the Polish localities of the species come from the Małopolska Upland. They are concentrated in center (limestone part of the Świętokrzyskie Mountains and the Przedbórz-Małogoszcz Range) and south (the Nida Basin) of the Upland. Most of known localities from the southern part of the Małopolska Upland were recorded in 1950s and 1960s. These data were the result of intensive studies conducted by botanists from the neighbouring Kraków research center. In 1970s and 1980s, several papers were published on synanthropic (principally segetal) flora of central part of the Małopolska Upland – in broadly understood Kielce region (Wnuk 1972, 1978; Fijałkowski & Cieśliński 1975; Dominiak & Moćko 1980; Głazek *et al.* 1986-1987; Maciejczak 1988). Fourteen localities of *S. pecten-veneris* were listed by Wnuk (1972, 1978) in the Przedbórz-Małogoszcz Range. Dominiak & Moćko (1980) reported its occurrence in the Świętokrzyskie Mountains. Głazek *et al.* (1986-1987) investigated distribution of selected species of segetal weeds in Kielce and Tarnobrzeg regions. According to them, *S. pecten-veneris* was a frequent (!) archeophyte with 97 localities in the area of study. These authors indicated Pińczów Hummock, Szydłów Foothill and south, limestone part of the Świętokrzyskie Mountains as areas with the highest density of its stations. More recent studies (Nobis *et al.* 2007) carried out in the southern part of the Małopolska Upland (Nida Basin) showed that a vast majority of those localities became extinct (only several were confirmed).

S. pecten-veneris, as other segetal species from the *Caucalido-Scandicetum* association, has been in decline recently. Populations observed after 1980s are small, usually consisting of several individuals. The species decreased as a result of modern agricultural methods

(mainly herbicide treatments and seed screening). For all these reasons, *S. pecten-veneris* was placed in the Polish "Red Book" and "Red List" of archaeophytes as a critically endangered – CR category (Zając *et al.* 2009, 2014) and "Red List" of all regions of Poland where it occurred. In the area of Western Pomerania and Wielkopolska (Żukowski & Jackowiak 1995; Jackowiak *et al.* 2007), Gdańsk Pomerania (Markowski & Buliński 2004), Lower Silesia (Anioł-Kwiatkowska & Popiel 2011), it was found to be extinct (EX category). In Lublin region (Kucharczyk & Wójciak 1995), the Małopolska Upland (Bróż & Przemyski 2009) and the territory of Silesian Voivodeship (Parusel & Urbisz 2012), the species was included in the category of endangered (EN) plants.

S. pecten-veneris occurs on alkaline soils (mainly rendzinas) formed on limestone or rarely gypsum. It grows in cereal cultivations (in a rare *Caucalido-Scandicetum* association, where it is a character species) and, sporadically, in root crop cultivations (in *Lamio-Veronicetum politae*) (Matuszkiewicz 2006).

This work shows the results of analyses of the existing population resources and current distribution of *S. pecten-veneris* in the Małopolska Upland. The previously known localities from the Małopolska Upland, both confirmed and not evidenced, as well as newly found during the field research are presented. These results are a contribution to the research that should be conducted also in other regions to gain a comprehensive knowledge of the distribution and population resources of *S. pecten-veneris* in Central Europe in times of widespread weed extinction.

2. Material and methods

The field inventory of *S. pecten-veneris* population was made during a general phytogeographical study which was conducted in the central part of the Małopolska Upland: in the Świętokrzyskie Mountains (in 2010-2014), in the SE edge of Przebórz-Małogoszcz Range (2008-2010). Floristic data were collected in plots – squares of 2.5 km side, which were determined on the basis of the ATPOL grid system (Zając 1978). Locations of the registered stations were set using a GPS receiver. Units of regionalization of Poland follow Kondracki (2002). At each locality, the population size was estimated by counting flowering or fruiting individuals.

Localities of *S. pecten-veneris* known from literature were selected and located in the ATPOL grid system units (squares of 2.5 km side), if possible. The herbarium collections of the species were also taken into account.

Table 1. Localities of *Scandix pecten-veneris* L. in the Małopolska Upland discovered or confirmed after 2000

No.	ATPOL square	Locality	Geographical coordinates	Literature	Pop. size	Habitat
			Świętokrzyskie Mts			
1!	EE7233	S of the central part of Gałęzice v. (near the Ostrówka quarry)	50°50'29.5"N 20°24'44.7"E	-	D	cult. of barley on d. rendzinas
2!	EE8201	NE of the NW edge of Milechowy v. (SW slope of Grzęby Bolmińskie range)	50°49'33.5"N 20°19'54.0" E	-	C	cult. of barley on j. rendzinas
3	EE8202	NE of the central part of Bolmin v. (SW slope of Grzęby Bolmińskie range)	50°48'59.4"N 20°21'05.9"E	registered also by Dominiak & Moćko 1980	A in 2012; B in 2014	cult. of wheat on j. rendzinas
			Nida Basin			
4 & 5	EF1302 & EF1303	b. Skowronno reserve and a closed dairy in Pińczów, at the foot of the S slopes of Pińczów Mts	-	Nobis *et al.* 2007	B	fields and fallows adjacent to grasslands, at the
6 & 7	EF1420 & EF1421	E of Pińczów (b. Pińczów and Bogucice v.), at the foot of S slopes of Pińczów Mts	-	Nobis *et al.* 2007	B	foot of S slopes of hills
8	EF2400	n. Krzyżanowice reserve, from the side of the road connecting the Gacki and Krzyżanowice v.	-	Nobis *et al.* 2007	A	fields at the foot of a steep hill
9 & 10	EF2401 & EF2412	n. Wola Zagojska Dolna	-	Nobis *et al.* 2007	D	fields at the foot of a gypseous hill

Explanations: classes of estimated population size, A – 1-10, B – 11-50, C – 51-100, D – >100; population of plants growing close to each other, but in the different units of 2,5 x 2,5 km cartogram, were considered as separate localities (according to the cartogram method); cult. – cultivation, v. – village, n. – near, b. – between, j. – Jurassic, d. – Devonian, ! – newly discovered localities, Pop. – Population

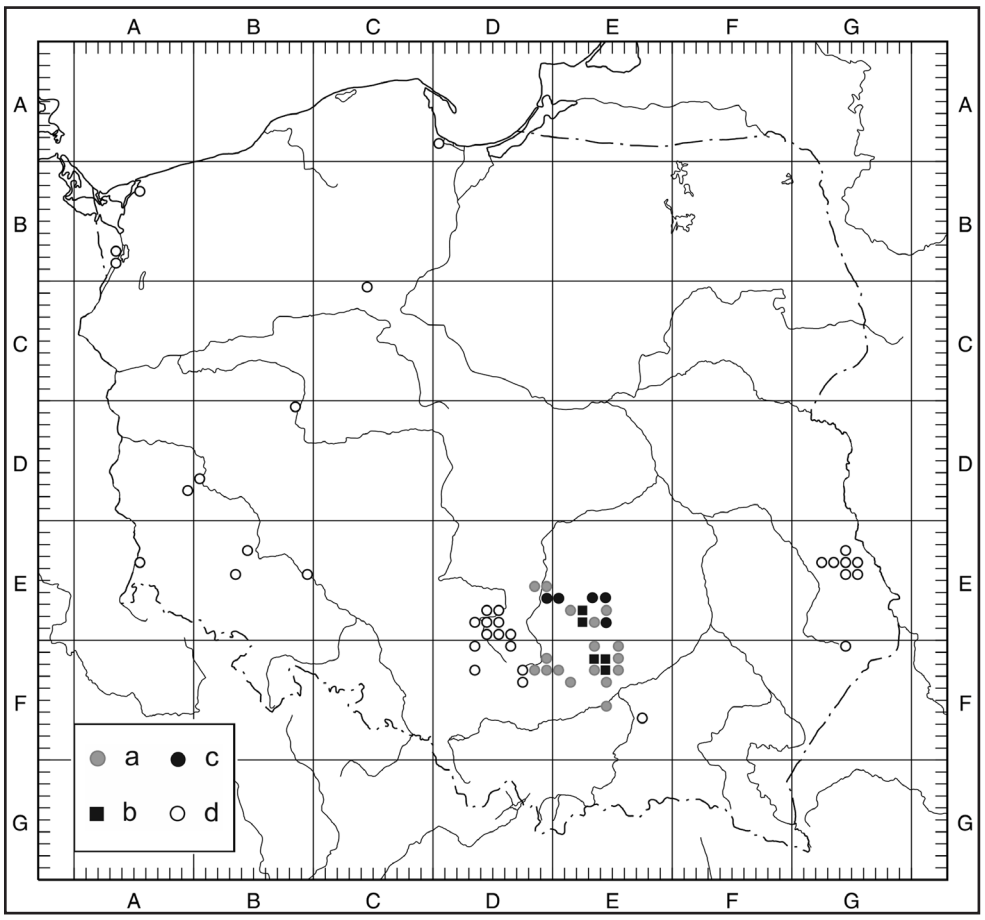

Fig. 1. Distribution of *Scandix pecten-veneris* L. in Poland (Zając & Zając 2001, modified)
Explanations: a – published and unpublished localities from the Małopolska Upland, b – localities confirmed after 2000, c – published localities from the Małopolska Upland, which weren't included in the ATPOL database, d – published and unpublished localities from other parts of Poland

Finally, a list of localities of *S. pecten-veneris* was created on the basis of: data collected by the author during field studies, published information, unpublished data gathered in ATPOL database and accessible herbarium collections. Imprecise data from the article of Głazek *et al.* (1986-1987), presented in the form of large-scale map with plotted localities of the species (without the list of localities), was left out of this list.

Distribution of the species in the Małopolska Upland was presented on the map with ATPOL grid in cartogram

Table 2. Localities of *Scandix pecten-veneris* L. in the Małopolska Upland, found in the literature but not included in the ATPOL database

No	ATPOL square	Locality	Literature	Habitat
1	DE6900	Kolonia Łapczyna Wola	Wnuk 1978	weedy cult. of wheat and barley on mixed j. and c. rendzinas
2	DE6901	Dobromierz		
3	DE6901	Kowale		
4	DE6903	Stara Wieś		
5	EE6032	Wola Świdzińska		
6	EE6032	Świdno	Wnuk 1972	arable cult.
7	EE6333	b. Laskowa and Kostomłoty Drugie	Bróż & Maciejczak 1991	arable cult. on d. rendzinas
8	EE6430	Kostomłoty	Dominiak & Moćko 1980	arable cult. on rendzinas
9	EE8400	N of Kowala Duża	Bróż & Maciejczak 1991	arable cult. on d. rendzinas
10	EE8410	S of Kowala Duża		

Explanations: cult. – cultivation, b. – between, j. – Jurassic, c. – Cretaceous, d. – Devonian

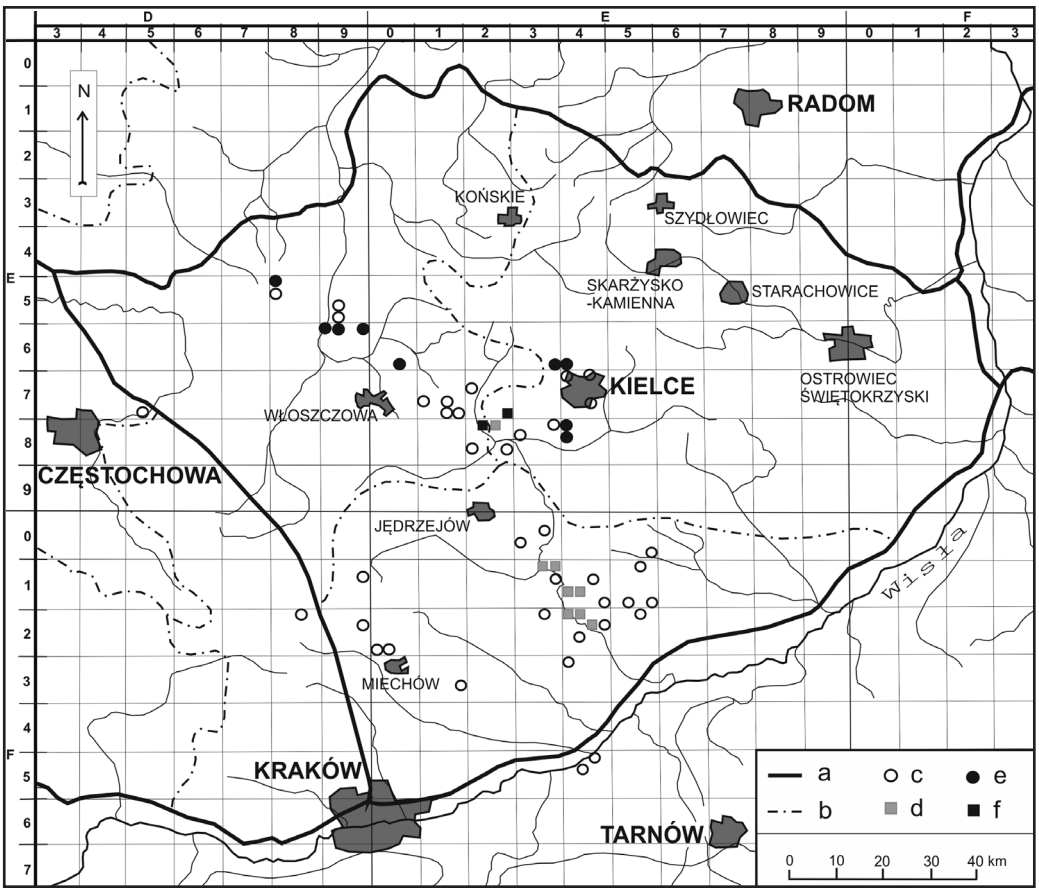

Fig. 2. Distribution of *Scandix pecten-veneris* L. in the Małopolska Upland
Explanations: a – border of the Małopolska Upland, b – border of the macroregions, c – localities published or unpublished, d – localities confirmed after 2000, e – published localities, which weren't included in the ATPOL database, f – a newly discovered locality

of 2.5 km side, and in Poland – of 10 km side. In the ATPOL grid system, capital letters designate 100-km squares and the first two digits indicate 10-km squares and two further ones –2.5-km squares (Zając 1978).

3. Results

On the basis of the collected data, a list of localities of *S. pecten-veneris* (Appendix 1) in the area of the Małopolska Upland was drawn up. As available literature indicates, the species was listed in over 60 stations located in 57 cartogram units of 2.5 km side in the Małopolska Upland. Only 10 of them were confirmed during field research conducted after 2000 (Table 1). Moreover, there were two new localities found in 2014.

Based on the available data, distribution maps of *S. pecten-veneris* in Poland (Fig. 1) and in the Małopolska Upland (Fig. 2) were prepared and distinction was made between historical and currently occurring localities. Updated maps also contain published data, which was not listed in the ATPOL database (Table 2).

The observed populations usually ranged from a few to several individuals. However, in localities near the villages of Wola Zagojska Dolna (Nida Basin) and Gałęzice (the Świętokrzyskie Mts.), the species grew abundantly (populations consisted of several hundred individuals).

4. Discussion

Results support earlier observations that Polish localities of *S. pecten-veneris* are concentrated in the Małopolska Upland. Considering that the published data on the species was not confirmed in Lublin region during research in 2005-2010 (Haliniarz & Kapeluszny 2014), in Gdańsk Pomerania (Markowski & Buliński 2004) and Western Pomerania and Greater Poland (Żukowski & Jackowiak 1995; Jackowiak *et al.* 2007), reports of new localities in the Małopolska Upland are all the more important. The Świętokrzyskie Mts. and Nida Basin are the only subregions in the Małopolska Upland, where *S. pecten-veneris* localities were confirmed after 2000. The species was not reported from the area of south-eastern part of the Przedbórz-Małogoszcz Range (Łazarski 2011). Localities based on literature data (Wnuk 1972, 1978) in the rest of this area need confirmation.

4.1. Reasons of decrease

Rare weed species are currently under pressure due to changes in arable management practices (Peters & Gerowitt 2014). Out of more than 165 of all archaeophytes in Poland, 74 are classifies as extinct or endangered (Zając *et al.* 2009**).** In modern times, first changes in the frequency of segetal species occurred with the introduction of mineral fertilizers and mechanized management (Holzner & Immonen 1982) followed by the adoption of widespread herbicide use (Baessler & Klotz 2006; Peters & Gerowitt 2014). Introduction to cultivation of new, more competitive, high-yielding varieties of cereals also became a serious threat to rare archaeophytes. High-yielding crops in conjunction with the use of mineral fertilizers caused greater crop densities which, afterwards, affected the increase of shadow in lower cultivation layers (Wilson 2006). This resulted in species of poor competitors for light, such as *S. pecten-veneris*, to disappear from habitat. In experimental studies, species richness and weed growth were significantly reduced in the fertilized cultivation, which was associated with restricted light penetration (Kleijn & van der Voort 1997). All these factors led to uniformity of land use hazardous for biodiversity.

Recently, attention is drawn to consequences of climate change for frequency of occurrence of rare arable weed species. Experimental research showed that negative effects of the use of modern agricultural practices on segetal weed species can be more intensive in conjunction with climate changes. Under warmer and dryer conditions, *S. pecten-veneris* flowered earlier and for shorter time and, finally, produced fewer shoots and seeds at harvesting time (lower generative production). These changes in climatic conditions are neutral or even advantageous for weeds species, but only under nutrient-poor soil (so not under current agricultures practices). Nowadays, agricultural management provides no limiting nutrient conditions in which *S. pecten-veneris* is low competitive (retained nutrients provide no advantage). Similar effects are caused by a high density of crops (which is a result of fertilization and sowing high-yielding varieties of cereals). Seed output of the *S. pecten-veneris* is lower in dense crops. Probably, it is the result of increased shading caused by high crop density (Peters & Gerowitt 2014); moreover, *S. pecten-veneris* requires large gaps in vegetation for seedling formation (Wilson 2006).

It is considered that most rare weed species exhibit specific trait syndromes. Among these traits, *S. pecten-veneris* has, for example, low height, poor competitive ability, large seeds, poor seed dispersal, easy seed cleaning, relatively short-lived seed-bank (Storkey 2006; Wilson 2006; Lososová *et al.* 2008). Most of these traits are disadvantageous under conditions created by modern agricultural practices. Earier-mentioned life history traits of *S. pecten-veneris* reflect its low phenotypic plasticity (Peters & Gerowitt 2014).

4.2. Conservation prospects

The best chance to save or regenerate weed fields with their "natural" combination of species is to establish areas (maybe, as agricultural reserves or within protected areas whose aim could be to take care of the preservation of landscape specificity) where traditional, extensive cultivation would be carried out. At the same time, in areas with endangered weed species, a system of subsidies to farmers for maintaining traditional methods of cultivation should be implemented (Nobis *et al.* 2007). Additionally, rare weeds should be grown, for example, in open-air museums, botanical gardens and other research institutions. They could be a resource of specimens for introduction into substitute habitats (Zając & Zając 2014). Diaspores of species, collected in different regions, should be deposited in seed banks.

Moreover, to assist protection of rare weed species, it is important to apply herbicides that are highly specific to aggressive weed species and to create unsprayed conservation headlands and field margins. Conservation of headlands and field margins could be a method of providing a refuge for endangered arable weeds (de Snoo 1994; Kleijn & van der Voort 1997).

5. Conclusions

S. pecten-veneris still remains in the Małopolska Upland mainly in small, declining populations. From among about 60 localities of this species published up to 2000, only about 15% were confirmed in this study. Only populations in Gałęzice and Wola Zagojska Dolna villages were numerous with more than one hundred individuals. Others contained a dozen or so specimens (in Milechowy village) and most of them with few individuals. While agriculture in Poland underwent a deep process of modernization, the risk of extinction of *S. pecten-veneris* is high and its gradual disappearance from arable fields is probably inescapable.

Because of high specialization, *S. pecten-veneris* is restricted to *Caucalido-Scandicetum* association. This weed species is competitive only under nutrient-poor, calcareous soils and in crops of low density. Due to its low phenotypic plasticity, the species is less buffered against changes which take place in agricultural practices (Fried *et al.* 2010; Peters & Gerowitt 2014). In order to save *S. pecten-veneris*, apart from promotion of traditional cultivation methods on calcareous soils in selected areas, it is also necessary to start *ex situ* cultivation and gather diaspores in seed banks. Conservation of headlands and field margins may provide a refuge for endangered segetal weeds.

Acknowledgements. I wish to thank Prof. Maria Zając for her helpful comments on the manuscript and providing me the localities of *Scandix pecten-veneris* from the ATPOL data base. I am also grateful to Agata Maćkowiak for her linguistic support during preparation of the manuscript.

References

Anioł-Kwiatkowska J. & Popiel A. 2011. *Scandix pecten-veneris* (Apiaceae) – historia występowania na Dolnym Śląsku. In: J. Anioł-Kwiatkowska & E. Szczęśniak (eds.). Zagrożone archeofity Dolnego Śląska. Acta Bot. Siles., Suppl. 1: 192-194.

Baessler C. & Klotz S. 2006. Effects of changes in agricultural land-use on landscape structure and arable weed vegetation over the last 50 years. Agric. Ecosyst. Environ. 115: 43-50.

Bróż E. & Maciejczak B. 1991. Some new, rare and endangered species of vascular plants of Kielce and its suburb. Fragm. Flor. Geobot. 36(1): 171-179.

Bróż E. & Przemyski A. 2009. The red list of vascular plants in the Wyżyna Małopolska upland (S Poland). In: Z. Mirek & A. Nikiel (eds.). Rare, relict and endangered plants and fungi in Poland, pp. 123-136. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Dominiak B. & Moćko E. 1980. Interesujące gatunki segetalne mezoregionu Góry Świętokrzyskie. Studia Kieleckie 3(27): 33-35.

Fijałkowski D. & Cieśliński S. 1975. Rzadsze rośliny synantropijne Kielecczyzny jako wskaźniki siedliskowe. Studia Kieleckie 4(8): 5-20.

Fried G., Petit S. & Reboud X. 2010. A specialist-generalist classification of the arable flora and its response to changes in agricultural practices. BioMed Cent. Ecol. 10(20): 1-11.

Głazek T. 1984. Rezerwat stepowy Góry Pińczowskie w województwie kieleckim. Chrońmy Przyr. Ojcz. 40(5-6): 5-13.

Głazek T., Kowalik E., Łuszczyńska B. & Łuszczyński J. 1986-1987. Distribution of selected species of segetal weeds belonging to the *Caucalidion daucoidis* R. Tx. 1950 alliance on the area of the Kielce province and the western part of the Tarnobrzeg province (the Central Little Poland Highland subprovince). Fragm. Flor. Geobot. 31-32(1-2): 121-140.

Haliniarz M. & Kapeluszny J. 2014. Rzadkie gatunki flory kalcyfilnej w zbiorowiskach segetalnych na terenie województwa lubelskiego. Annales Universitatis Mariae Curie-Skłodowska Lublin-Polonia. Sec. E. 69(1): 11-23.

Holzner W. & Immonen R. 1982. The agrestal weed flora and vegetation of the world. In: W. Holzner & M. Numata (eds.). Biology and ecology of weeds, pp. 203-226. The Hague, Boston.

Hultén E. & Fries M. 1986. Atlas of North European vascular plants. North of the Tropic of Cancer. I-III. xvi+1172 pp. Koeltz Scientific Books, Königstein.

Jackowiak B., Celka Z., Chmiel J., Latowski K. & Żukowski W. 2007. Red list of vascular flora of Wielkopolska (Poland). Biodiv. Res. Conserv. 5-8: 95-127.

Kleijn D. & van der Voort L. A. C. 1997. Conservation headlands for rare arable weeds: the effects of fertilizer application and light penetration on plant growth. Biological Conservation 81: 57-67.

Kondracki J. 2002. Geografia regionalna Polski. Wyd. 3. 441 pp. Wyd. Nauk. PWN, Warszawa.

Kostrowicki S. A. 1966. Stosunki biogeograficzne. In: J. Kondracki (red.). Studia geograficzne w powiecie pińczowskim. Przegl. Geogr. 47: 115-163.

Kucharczyk M. & Wójciak J. 1995. Ginące i zagrożone gatunki roślin naczyniowych Wyżyny Lubelskiej, Roztocza, Wołynia Zachodniego i Polesia Lubelskiego. Ochrona Przyrody 52: 33-46.

Lososová Z., Chytrý M. & Kühn I. 2008. Plant attributes determining the regional abundance of weeds on central European arable land. J. Biogeogr. 35: 177-187.

Łazarski G. 2011. Rare and endangered species of vascular plants in the valley of the Biała Nida river near Małogoszcz (the central part of Małopolska Upland). Fragm. Flor. Geobot. Polonica 18(2): 257-264.

Maciejczak B. 1988. Flora synantropijna Kielc, Skarżyska-Kamiennej i Starachowic. 162 pp. KTN, Kielce.

Markowski R. & Buliński M. 2004. Ginące i zagrożone rośliny naczyniowe Pomorza Gdańskiego. Acta Botanica Cassub. Monogr. 1: 1-75.

Matuszkiewicz W. 2006. Przewodnik do oznaczania zbiorowisk roślinnych Polski. In: J. B. Faliński (ed.). Vademecum Geobotanicum 3, 537 pp. Wyd. Nauk. PWN, Warszawa.

Meusel H., Jäger E. & Weinert E. 1965. Vergleichende Chorologie der zentraleuropäischen Flora. I. Text 583 pp., Karten 258 pp. Gustav Fischer Verlag, Jena.

Nobis M., Nobis A., Kozak M. & Przemyski A. 2007. Occurrence of *Conringia orientalis* (Brassicaceae) and *Scandix pecten-veneris* (Apiaceae) in the area of Nida Trough. Fragm. Flor. Geobot. Polonica 14(1): 49-59.

Parusel J. B. & Urbisz A. (eds.). 2012. Czerwona lista roślin naczyniowych województwa śląskiego. Raporty Opinie 6(1): 105-177.

Peters K. & Gerowitt B. 2014. Response of the two arable weed species *Lithospermum arvense* and *Scandix pecten-veneris* to climate change conditions. Plant Ecol. 215: 1013-1023.

de Snoo G. R. 1994. Cost-benefits of unsprayed crop edges in winter wheat, sugar beet and potatoes. In: N. Boatman (ed.). Field margins: integrating agriculture and conservation. BCPC Monogr. 58, pp. 197-202.

Sowa R. & Warcholińska A. U. 1979. Flora segetalna Wzgórz Radomszczańskich. Acta Univ. Lodz. Ser. 2. 27: 75-119.

Storkey J. 2006. A functional group approach to the management of UK arable weeds to support biological diversity. Weed. Res. 46: 513-522.

Szwagrzyk J. 1987. Flora naczyniowa Niecki Nidziańskiej. In: A. S. Kleczkowski (ed.). Wartości środowiska przyrodniczego Niecki Nidziańskiej i zagadnienia jego ochrony. Część 2. Studia Ośrodka Dokumentacji Fizjograficznej 15: 17-91.

Wilson P. 2006. UK Biodiversity Action Plan for *Scandix pecten-veneris*. Plantlife International, The Wild Plant Conservation Charity. http://www.plantlife.org.uk/uploads/documents/Scandix_pecten-veneris_dossier.pdf. Accessed 14 Jan 2015.

Wnuk Z. 1972. Rzadsze chwasty segetalne Pasma Przedborsko-Małogoskiego i przyległych obszarów. Zesz. Nauk. Uniw. Łódzkiego. Ser. 2. 51: 181-186.

Wnuk Z. 1978. Flora segetalna Pasma Przedborsko-Małogoskiego i przyległych terenów. Acta Univ. Lodz. Ser. II, 20: 183-255.

Wnuk Z. 1981. Niektóre nowe i rzadkie gatunki we florze segetalnej Wyżyny Częstochowskiej. Acta Univ. Lodz. Folia Bot. 1: 181-205.

Zając A. 1978. Założenia metodyczne "Atlasu rozmieszczenia roślin naczyniowych w Polsce". Wiad. Bot. 22(3): 145-155.

Zając A. 1987. Studies on the origin of archaeophytes in Poland. Part III. Taxa of Irano-Turanian, Euro-Siberian-Irano-Turanian and Mediterranean-Irano-Turanian origin. Zeszyty Nauk. Uniw. Jagiell. 834, Prace bot. 15: 93-129.

Zając A. & Zając M. (eds.). 2001. Distribution Atlas of Vascular Plants in Poland. xii+714 pp. Edited by Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University, Cracow.

Zając M., Urbisz A., Nobis M., Nobis A. 2014. CR *Scandix pecten-veneris* L. – czechrzyca (trybulka) grzebieniowa. In: R. Kaźmierczakowa, K. Zarzycki & Z. Mirek (red.). Polska czerwona księga roślin. Paprotniki i rośliny naczyniowe, wyd. 3, pp. 350-352. Instytut Ochrony Przyrody PAN, Kraków.

Zając M., Zając A. & Tokarska-Guzik 2009. Extinct and endangered archaeophytes and the dynamics of their diversity in Poland. Biodiv. Res. Conserv. 13: 17-24.

Zając M. & Zając A. 2014. Survival problems of archaeophytes in the Polish flora. Biodiv. Res. Conserv. 35: 47-56.

Żukowski W. & Jackowiak B. 1995. List of endangered and threatened vascular plants in Western Pomerania and Wielkopolska (Great Poland). In: W. Żukowski & B. Jackowiak (eds.). Endangered and threatened vascular plants of Western Pomerania and Wielkopolska. Publications of the Department of Plant Taxonomy of the Adam Mickiewicz University in Poznań 3: 9-96. Bogucki Wyd. Nauk., Poznań.

Appendix 1. List of localities of *Scandix pecten-veneris* in the Małopolska Upland

Explanations: *leg.* – collected by, n. – near, v. – village, not publ. – data not published in the ATPOL data base, GŚ – Góry Świętokrzyskie (Świętokrzyskie Mts.), NN – Niecka Nidziańska (Nida Basin), OB – on the border between Małopolska Upland and Częstochowa Upland, PPM – Pasmo Przedborsko-Małogoskie (Przedbórz-Małogoszcz Range), WR – Wzgórza Radomszczańskie (Radomsko Hills), ? – used by Nobis *et al.* (2007) – after the number of cartogram unit denotes an uncertain location of the species locality in the ATPOL grid system (2,5 x 2,5 km), but after the name of the village/town it is an uncertain location of a locality, resulting from an imprecise distribution map created by Głazek *et al.* (1986-1987), ?? – uncertain location of a species locality in the ATPOL grid system (2,5 x 2,5 km)

WR: 1. DE5800 – Granice (Sowa & Warcholińska 1979); **2.** DE5810 – Chełmo (Sowa & Warcholińska 1979; Wnuk 1978; Sowa & Warcholińska 1978 not publ.); **PPM: 3.** DE5921 – Wymysłów (Wnuk 1972); **4.** DE5931 – Rączki (Wnuk 1972); **5.** DE6900 – Kolonia Łapczyna Wola (Wnuk 1978); **6.** DE6901 – Dobromierz (Wnuk 1978); **7.** DE6901 – Kowale (Wnuk 1978); **8.** DE6903 – Stara Wieś (Wnuk 1978); **9.** EE6032 – Świdno (Wnuk 1972); **10.** EE6032 – Wola Świdzińska (Wnuk 1978); **11.** EE7120 – Gruszczyn (Wnuk 1972); **12.** EE7122 – Bukowa Mt. (Wnuk 1978); **13.** EE7132 – Cieśle (Wnuk 1978); **14.** EE7132 – Kościółek Mt. (Wnuk 1978); **15.** EE7133 – Leśnica (Wnuk 1978); **16.** EE8220 – Karsznice (Wnuk 1978); **GŚ: 17.** EE6333 – between Laskowa and Kostomłoty Drugie (Bróż & Maciejczak 1991); **18.** EE6430 – Kostomłoty (Dominiak & Moćko 1980); **19.** EE7210 – Ruda (=Ruda Zajączkowska), Piekutowska 1979 not publ. **20.** EE7233 – S of the central part of Gałęzice v. (n. the Ostrówka quarry), 50°50'29.5"N; 20°24'44.7"E; **21.** EE7400 – Kielce, Kruszelnickiego "Wilka" Str. (Maciejczak 1988); **22.** EE7400 – Niewachlów (Dominiak & Moćko 1980); **23.** EE7402?? – Szydłówek (Dominiak & Moćko 1980); **24.** EE7422?? – Zagórze (Dominiak & Moćko 1980); **25.** EE8201 – NE of the NW edge of Milechowy v. (SW slope of Grząby Bolmińskie range), 50°49'33.5"N; 20°19'54.0" E; **26.** EE8202 – NE of the central part of Bolmin v. (SW slope of Grząby Bolmińskie range), 50°48'59.4"N, 20°21'05.9"E; Bolmin (Dominiak & Moćko 1980); **27.** EE8223 – n. Choiny v. (Bróż & Przemyski 1992 not publ.); **28.** EE8303 – Nowiny (Bróż 1991 not publ.); **29.** EE8310 – Korzecko (Dominiak & Moćko 1980); **30.** EE8400 – N of Kowala Duża (Bróż & Maciejczak 1991); **31.** EE8410 – S of Kowala Duża (Bróż & Maciejczak 1991); Wzgórza Kowalskie – Kowala Duża, 5. 1988, leg. E. Bróż & A. Skrzypczak (KTC); **NN: 32.** DF1913 – Mstyczów? (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); **33.** DF2913 – at the foot of Biała Góra Mt. n. Tunel, 6.1969, leg. H. Błaszczyk (KRA 89667); Biała Góra Mt. above Uniejów-Rędziny v., 2.07.1947, leg. J. Kornaś (Herbarium of A. & J. Kornaś); Uniejów-Rędziny n. Tunel, 14.09.1948, leg. J. Kornaś (KRA 72777); Tunel n. Miechów, 8.06.1952, leg. H. Błaszczyk (KRA 054143) & 22.06.1952 leg. H. Błaszczyk (KRAM 185153, 490628) & leg. E. Pancer (KRAM 225982); Piaskowiec Mt. n. Tunel, W slope above Uniejów Księży v., 25.05.1947, leg. B. Pawłowski (KRAM 325035) & 25.05.1947, leg. J. Kornaś (Herbarium of A. & J. Kornaś); Uniejów Księży n. Tunel, 30.05.1952, leg. B. Gumińska (KRA 0272584); Uniejów n. railway station in Tunel, 22.06.1947, leg. K. Kostrakiewicz (KRAM 230052); **34.** EF0312? – Motkowice, 18.07.1980, leg. W. Więcławik (KRA 0225252); **35.** EF0320 – Imielno (Głazek *et al.* 1986-1987; Nobis *et al.* 2007; W. Więcławik 1982 not publ.); **36.** EF0533 – Zawada (Głazek *et al.* 1986-1987; Nobis *et al.* 2007; E. Kowalik 1980 not publ.); **37.** EF1302 – at the foot of S slopes of Pińczów Mts, between Skowronno reserve and closed dairy in Pińczów (Nobis et al. 2007); Skowronno (Kostrowicki 1966); Skowronno Dolne n. Pińczów, 24.05.1972, leg. R. Ochyra (KRAM 226748); Skowronno, 30.07.1980, leg. A. Zawłodzka (KRA 0228956); **38.** EF1303 – at the foot of S slopes of Pińczów Mts, between Skowronno reserve and closed dairy in Pińczów (Nobis *et al.* 2007); Pińczów Mts (Głazek 1984; Głazek *et al.* 1986-1987); **39.** EF1313? – Pińczów (Kostrowicki 1966; Głazek *et al.* 1986-1987); **40.** EF1412 – Galów (Głazek *et al.* 1986-1987; Nobis *et al.* 2007; A. Piekutowska 1979 not publ.); **41.** EF1420 – at the foot of S slopes of Pińczów Mts, E of Pińczów (between Pińczów and Bogucice v.) [Nobis *et al.* 2007]; **42.** EF1421 – at the foot of S slopes of Pińczów Mts, E of Pińczów (between Pińczów and Bogucice v.) [Nobis *et al.* 2007]; Bogucice, between Pińczów and Busko, 21.05.1920, leg. B. Pawłowski (KRA 118767; KRAM 325037); 6.07.1947, leg. B. Szafran (KRAM 008150); Bogucice (Kostrowicki 1966); **43.** EF1433 – Wełcz n. Pińczów, 2.06.1984, leg. M. Piotrowska (KRA 0232957); **44.** EF1502? – Młyny (Fijałkowski & Cieśliński 1975; Szwagrzyk 1987); **45.** EF1531 – Busko Zdrój (Fijałkowski & Cieśliński 1975; Szwagrzyk 1987); **46.** EF1533? – Żerniki, 7.06.1957, leg. K. Chronowska (KRAM 098512); Żerniki Górne (Głazek *et al.*1986-1987; Nobis *et al.*2007; T. Głazek 1983 not publ.); **47.** EF2030 – Pstroszyce Podbukowiec (Szwagrzyk 1987; K. Leszczak 1979 not publ.); **48.** EF2031 – Strzeżów (Szwagrzyk 1987); **49.** EF2302 – Młodzawy (Kostrowicki 1966); **50.** EF2400 – n. Krzyżanowice reserve, from the side of the road connecting the v. Gacki and Krzyżanowice (Nobis *et al.* 2007); Krzyżanowice (Kostrowicki 1966); **51.** EF2401 – n. Wola Zagojska Dolna, between narrow gauge railway and the foot of a gypsum hill extending from Skotniki Górne v. to the Dolina Nidy plant (Nobis *et al.* 2007); **52.** EF2412 – n. Wola Zagojska Dolna, between narrow gauge railway and the foot of a gypsum hill extending from Skotniki Górne v. to the Dolina Nidy plant (Nobis *et al.* 2007); Winiary n. Busko, 6.06.1953, leg. A. Jasiewicz (KRAM 421543); Skotniki Górne (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); **53.** EF2413 – Skorocice n. Busko Zdrój 6.06.1953, leg. A. Jasiewicz (KRAM 421542); 3.06.1966, leg. K. Szczepanek (KRA 111536); 19.05.1971, leg. R. Ochyra (KRAM 226747); 30.05.1984, leg. A. Mirosławska (KRA 0228353); Skorocice (Szwagrzyk 1987; A. Mirosławska 1985 not publ.); **54.** EF2421 – Zagość (Kostrowicki 1966); **55.** EF2502 – between Busko and Owczary, 26.05.1951, leg. A. & J. Kornaś (KRA 054145); **56.** EF3123? – Racławice? (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); **57.** EF3400 – Pełczyska-Złota (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); 8.1976, leg. ? (KRA 0228771); **58.** EF5402 – Przemyków (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); 7.07.1982, leg. E. Trela (KRA 0236374); **59.** EF5411 – Sokołowice-Siedliska? (Głazek *et al.* 1986-1987; Nobis *et al.* 2007); OB: **60.** DE7531 – Kłobukowice (Wnuk 1981); **61.** DF2802 – Kleszczowa (Wnuk 1981).