THE STUDY OF BLOOMING AND POLLEN EFFICIENCY OF *Adonis vernalis* L. IN XEROTHERMIC PLANT COMMUNITIES

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S u m m a r y

The study was conducted in the years 2004 – 2005 using two populations of *Adonis vernalis* L. occurring in the *Adonido-Brachypodietum pinnati* community at Pliszczyn near Lublin and in the *Brachypodio-Teucrietum* community at Stawska Góra near Chełm. The blooming of *A. vernalis* in the Lublin region occurs from the first days of April to the end of May. The species is characterized by an early, daytime pattern of flower opening limited to 4 hours during the day. The habitat conditions significantly modified the traits that influenced pollen efficiency. Depending on the community and study year blooming abundance was from 97 to 325 flowers · $1m^{-2}$. At the Pliszczyn site the plants bloomed more abundantly than at Stawska Góra and were characterized by a greater number of stamens, higher mass of pollen delivered and higher pollen viability. The average mass of pollen supplied by 100 anthers of *A. vernalis* was from 2.04 mg do 3.18 mg and it correlated positively with the size of anthers. In thermophilous communities *A. vernalis* supplies on average 3 – 10 g · 10 m^{-2} of pollen. Due to the early blooming period it is a valuable amount so that the preservation of natural *A.vernalis* sites should be promoted and its cultivation should be encouraged in gardens thereby enriching pollen supply mainly for bees living in the wild.

Keywords: *Adonis vernalis* L., blooming, pollen abundance, xerothermic swards.

INTRODUCTION

Because of controversial opinions that beekeepers hold on the usefulness of the plants of the buttercup family as forage sources for bees the observations have been conducted for a number of years on the species which occur in great numbers in the natural environment of deciduous forests and meadows (Szklanowska 1955) and on the *Ranunculaceae* commonly recommended to be grown in gardens (Żuraw, Denisow 2002; Denisow, Żuraw 2003). The majority of those species bloom in early spring when the demand of bee-like insects for both nectar and pollen rises rapidly. Pollen efficiency of the *Ranunculaceae* and their usefulness especially for wild insects is valued very highly. In the beekeeping literature the species cited as pollen-yielding are *Adonis amurensis*, *A. bistorta*, *A. pyrenaica*, *A. vernalis* (Gluchov 1950). In the steppe habitats of the Ukraine *Adonis vernalis* is an important pollen-yielding perennial (Bodnarczuk et al. 1993). It is cited as the forage plant for halictids (Ruszkowski et al. 1994). In Poland it has been on the protected list for many years. Over 90% of the recorded sites of that species in this country are on the Lublin Upland and Małopolska Upland (Fijałkowski 1961). The species makes part of xerothermic communities. Banaszak (1983) stresses

that those associations are particularly heavily settled by *Apoidea* the density of which in thermophilous habitats reaches 805 – 1555 individuals per ha. Of particular interest in terms of entomofauna diversity is the *Adonido-Brachypodietum pinnati* community in which *Adonis vernalis* is the dominant species.

The objective of the study was to compare *Adonis vernalis* growing in two xerothermic communities for certain aspects of blooming and for pollen abundance potential. The composition of the pollinating insects was also established.

MATERIAL AND METHODS

The records were taken in two growing seasons of 2004 and 2005 on two *Adonis vernalis* L. populations. The first site was at a mid-field elevation at Pliszczyn near Lublin and the other at the Stawska Góra nature preserve near the town of Chełm. Additionaly, for comparison sake, specimens of *A. vernalis* growing in the UMCS Botanical Garden were observed.

At Stawska Góra *A. vernalis* occurs at a low density on a slope covered with shallow chalk rendzina. At Pliszczyn it forms dense swards on a loess-covered slope of the Bystrzyca River valley. The plants from the Botanical Garden were part of the buttercup family collection set up on the loess-originated soil with a pH 6 – 7.

The phenological records of the date and duration of blooming were taken on both plant populations. Pollen efficiency was assayed using the method by Warakomska (1972) modified by Szklanowska (1984, 1995). Fresh and dry mass of anthers and pollen content thereof was determined. When estimating blooming abundance in natural populations plant counts were made by throwing a hoop 36.7 cm in diameter which corresponds to a surface area of 0.1 m^2. In addition, the average number of flowers on an individual plant was counted. When in full bloom the plants were observed for diurnal flower opening and pollen abundance rates (*inter alia* Jabłoński, Szklanowska 1997). The viability of pollen grains was examined by staining the protoplasts with acetocarmine and the size of pollen grains was measured in glycero--gelatin slides.

The results were subjected to ANOVA and examined for the significance of differences between the populations using Duncan's test at the confidence level of α=0.05.

RESULTS

Adonis vernalis at the Pliszczyn site is a component of the *Adonido-Brachypodietum pinnati* community, its population being estimated at ca. 1000 individuals. In early spring it is a dominant species of that association. The population at Stawska Góra which numbers ca. 100 individuals is part of the *Brachypodio-Teucrietum* community. In that association *A. vernalis* flowered together with other species e.g. *Anemone sylvestris*, *Chamaecytisus ratisbonensis*, *Potentilla arenaria* and *Primula veris*.

In both growing seasons *Adonis vernalis* in the Botanical Garden in Lublin flowered ca. two weeks earlier than its counterpart in natural populations. In 2004 the blooming of *A. vernalis* started in mid-April i.e. a week earlier that at Stawska Góra. In the subsequent year the specimens near Chełm were the first to flower. Generally, the blooming season of *A. vernalis* in the Lublin region occurs from the first days of April to the end of May and lasts 38 days on average. The species proved particularly sensitive to early spring drops in temperature. With daytime temperatures below 7°C new flower buds failed to develop and open flowers prematurely closed their corollas. The phenomenon was particularly conspicuous at Pliszczyn where plants grew on

Table 1

The abundance of *Adonis vernalis* blooming on different stations in 2004-2005.

Station	Year	Period of blooming	Flowers · plant^{-1}	Plants · m^{-2}	Flowers · m^{-2}
Pliszczyn	2004	14.04 - 28.05	17.1	19.0	324.9
	2005	20.04 - 25.05	21.2	11.5	243.8
	average		19.15b	15.25b	284.4b
Stawska Góra	2004	21.04 - 30.05	9.2	18.4	169.2
	2005	17.04 - 30.05	8.6	11.3	97.2
	average		8.90a	14.80a	133.20a
Lublin	2004	04.04 - 25.05	12.7	21.0	266.7
	2005	10.04 - 29.05	11.70	18.0	210.6
	average		12.20ab	19.50c	238.65b

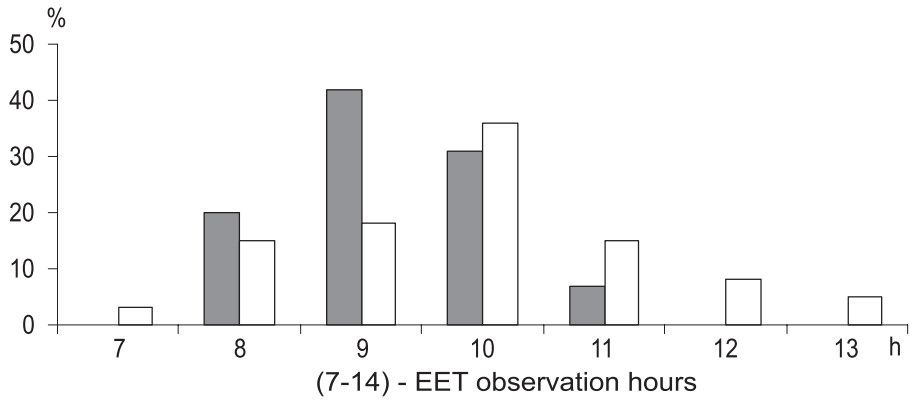

Fig. 1. The diurnal dynamic of blooming and anther bursting in *Adonis vernalis* flowers (on the basis of average from 2004-2005 in Lublin).

a SW-NE oriented slope. It appeared that *Adonis vernalis* was characterized by an early and brief pattern of flower opening that was limited to mere 4 hours during the day (Fig. 1). Pollen release in part of the stamen heads began already in closed buds and lasted for ca. 7 hrs with a peak at ca. 10:00 when pollen was released simultaneously from 40% of the anthers that released pollen on a given day. Starting from 11:00 the process markedly declined and from 14:00 onwards no new pollen-releasing anthers appeared. The duration of pollen release by one *A. vernalis* flower due to the high number of stamens was from 2 to 5 days. Pollen release started at a temperature of ca. 10°C and its rate was augmented with temperatures rising to ca. 15 – 18°C.

Among the bee-like insects, the re-

Table 2

The number of anthers in *Adonis vernalis* flowers, weight of fresh and dry anthers and mass of delivered pollen in 2004-2005.

Station	Year	Stamens · flower^{-1}		Weight of 100 anthers (mg)		Mass of pollen per 100 anthers	
		min - max	average	fresh	dry	mg	%
Pliszczyn	2004	87 - 148	119.4	43.65	8.8	2.67	30.3
	2005	80 - 161	123.6	42.13	7.7	3.70	48.0
	average		121.5b	42.89	8.25c	3.18c	39.1
Stawska Góra	2004	75 - 121	96.5	35.60	5.50	1.98	36.0
	2005	81 - 134	117.3	39.47	8.30	2.81	33.8
	average		106.5a	35.86	6.90b	2.39b	34.9
Lublin	2004	125 - 151	140.0	22.40	4.60	1.60	34.7
	2005	107 - 161	142.0	23.90	6.70	2.47	36.8
	average		141.0c	23.15	5.70a	2.04a	35.7

Fig. 2. The percentage participation of different *Apoidea* on *Adonis vernalis* from two lacations (average from 2004-2005).

corded pollinating agents of *A. vernalis* included mainly solitary bees (74.9% on the average), honeybees (21.3%) and bumblebees (3.8%) (Fig. 2). At the Stawska Góra site a much higher percentage of honeybees visiting *A. vernalis* flowers was recorded (31.2%) compared to the analogous percentage at Pliszczyn (11.3%). Dipters were also observed but only in 2004 and homopters were recorded at Pliszczyn. The density of entomofauna was always correlated with the daily pattern of pollen release.

It was found that it was the habitat conditions that primarily affected the pollen efficiency of *A. vernalis*. Weather conditions

Table 3

The pollen efficiency and features of pollen grains of *Adonis vernalis* on three stations in 2004-2005.

Station	Year	Mass of pollen			Viability (%)	The length of axis (µm)	
		flower (mg)	plant (mg)	m^{-2} (g)		polar (P)	equatorial (E)
Pliszczyn	2004	3.18	54.3	1.03	95.7	25.0	22.5
	2005	4.47	94.8	1.09	87.6	26.3	23.3
	average	3.82	74.6	1.06c	91.7	25.6	22.9
Stawska Góra	2004	1.91	17.6	0.32	51.3	22.5	18.8
	2005	3.29	28.3	0.30	43.1	21.2	18.2
	average	2.60	22.9	0.31a	47.2	21.8	18.5
Lublin	2004	2.24	28.4	0.59	93.6	24.0	22.5
	2005	3.50	40.9	0.74	98.5	25.0	23.5
	average	2.87	34.6	0.67b	96.1	24.5	23.0

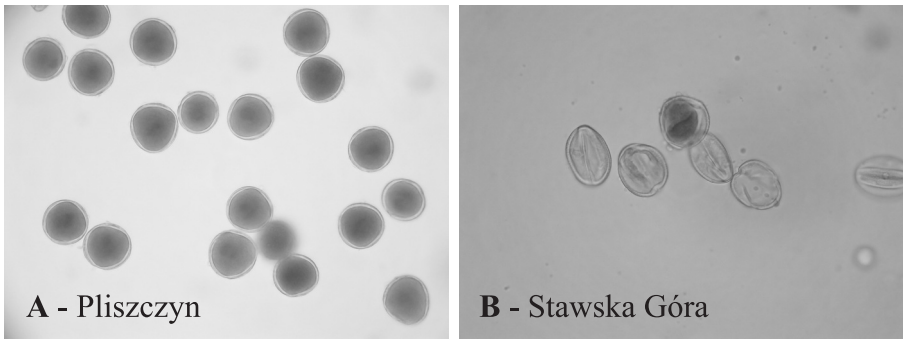

Photo 1. Viability of *Adonis vernalis* pollen grains from A – Pliszczyn and B – Stawska Góra.

also influenced blooming abundance and caused number of stamens and the mass of pollen delivered to vary from year to year. The *A. vernalis* plants growing at the Pliszczyn site were characterized by the greatest number of floral shoots averaging 19.1 per plant and by the highest number of flowers per 1 m^2 – 284.4 on average. Similar data were recorded for the Lublin site (Table 1). The blooming abundance of the Stawska Góra population was lower by half.

In both years the number of stamens per flower was the highest at the cultivated site (Table 2). Significant differences in the value of that trait were also recorded between populations growing at natural sites. Fresh mass of 100 anthers which reflects pollen size and hydration of pollen sacs wall tissues varied substantially among sites and averaged 23.15 mg for anthers from the Lublin site. Fresh mass of 100 anthers from *A. vernalis* flowers from Stawska Góra and Pliszczyn was 35.86 mg and 42.89 mg, respectively. Water content of the anthers studied varied from 75.7% to 81.8%. Fresh weight of 100 anthers including pollen was the highest for flowers from the Pliszczyn site. The trait was positively

correlated with the amount of pure pollen contained in pollen sacs. The best-developed anthers from the Pliszczyn site yielded on average 3.18 mg of pollen per 100 anthers (39.1% of the total anther weight) the less developed anthers from the sites at Stawska Góra and Lublin yielded 2.39 mg (34.9%) and 2.04 mg (35.7%), respectively.

In all study years pollen viability in flowers from Stawska Góra was the lowest (43% – 51%), it was higher in those from the Pliszczyna and Lublin sites (from 87 % to 99%) (Table 3, Phot.1).

The polar to equatorial axis length ratio (P/E) ranging from 1.06 to 1.12 points to prolato-spheroides shape of *A. vernalis* pollen grains. A lowest size was found in pollen grains from the Stawska Góra population (P=21.8 μm i E=18.5 μm), at the remaining sites pollen grains were of similar size.

DISCUSSION

The plant traits that influence pollen abundance are genetically determined as was repeatedly proved (*inter alia* Warakomska 1972, Szklanowska 1984, 1995, Denisow, Żuraw 2003). The comparison of two populations of *Adonis vernalis* which grew under natural conditions revealed a substantial effect of habitat-related conditions on the parameters that have a direct impact on pollen efficiency. *A. vernalis* at the Pliszczyn site bloomed more abundantly than that at Stawska Góra, developed more stamens with larger anthers which yielded more pollen per anther, per flower and per plant and, consequently, per unit area.

A positive correlation was found between anther size and mass of pollen delivered. At the same time, the percentage of pollen in total anther weight varied significantly from year to year indicating that microsporogenesis is to large extent, dependent not only on habitat conditions but is primarily influenced by weather parameters.

Pollen viability was likewise dependent on external factors. Pollen from the flowers of *A. vernalis* growing at the Pliszczyn site was characterized by high viability and probably that is the reason behind the population's growth. As compared to the data of Fijałkowski (1961) the number of individuals in the *Adonido-Brachypodietum pinnati* community increased manifold. A reverse tendency was observed at the Stawska Góra site where *A. vernalis* population declined at the same period which was undoubtedly related to poor reproduction capabilities of the ecotype present there due to small amount and low viability of pollen produced, among other things. The progressive succession in xerothermic communities at Stawska Góra and a rapid development of the *Rhamno-Prunetea* communities may also result in an increasingly poorer renewal of *A. vernalis*, a heliophilous species.

During the study the authors saw honeybee colonies being moved to the mid-field elevation area at Stawska Góra and hence probably the greater proportion of honeybees among the pollinators of *A. vernalis* at this site compared to that found at Pliszczyn.

The amounts of polen obtained 3 – 11 g · ·10 m^{-2} are similar to those yielded by anemones occurring in deciduous forests (Szklanowska 1995). Therefore it is worth advocating the preservation of natural sites of *A. vernalis* and its introduction to cultivation in order to improve the early spring pollen flow especially for wild-living insect pollinators for which every pollen-yielding plant may become an important additional source of forage.

CONCLUSIONS

Blooming of *Adonis vernalis* in xerothermic communities in the Lublin region occurred from the first days of April to the end of May and lasted for 35 – 48 (38) days.

The size of the population of *Adonis vernalis* in xerothermic swards was dependent on type of community. It was substantially larger in *Adonido-Brachypodietum pinnati* swards where the species is one of the dominant ones reaching high degrees of coverage and small in *Brachypodio-Teucrietum*.

Habitat-related factors and weather conditions significantly modified blooming abundance, number of stamens, and anthers size in *A. vernalis* flowers as well as the mass of the pollen delivered by anthers and pollen viability.

Small amounts of pollen with low viability (ca. 47%) yielded by *Adonis vernalis* flowers from Stawska Góra points to the declining tendencies of that population. The quantitative analysis of pollen production and qualitative parameters of pollen grains may be useful to determine and to compare population-related traits (e.g. population dynamics – regression, progression).

Bee-like hymenopters are the primary pollinating agents of *Adonis vernalis*, solitary bees being the most numerous accounting for 74.95% of total pollinators. However, due to low spread of xerothermic communities with *A. vernalis* its importance for apifauna is small.

In thermofilous communities *Adonis vernalis* plants may yield on average $3 – 10 \text{ g} \cdot 10 \text{ m}^{-2}$ of pollen which is of value because of the early blooming time. Therefore the preservation in nature and introduction to cultivation of that species should be advocated.

REFERENCES

Banaszak J. (1983)– Ecology of bees (*Apoidea*) of agricultural landscape. *Pol. Ecol. Stud.* 9 (4): 421 – 505.

Bodnarczuk Ł. I., Solomacha T. D., Iliasz A. M., Solomacha W. A. (1993)– Atlas medonosnich roslin Ukrainy. *Urożaj*. Kijev: 158 – 159.

Denisow B., Żuraw B. (2003)– Wydajność pyłkowa czterech gatunków pełnika (*Trollius* L.). *Annales UMCS.* Lublin sectio EEE, 13: 85 – 92.

Fijałkowski D. (1961)– Miłek wiosenny (*Adonis vernalis* L.) w województwie lubelskim. *Annales UMCS*, sec. C. 16: 49 – 73.

Gluchov M. (1950)– Važniejszije miedonosnyje rastienija i sposoby ich razviedenija. *Gosudarstviennoje Izdatielstvo Selskochozjastviennoj Literatury*. Moskva.

Jabłoński B., Szklanowska K. (1997)– Wpływ niektórych czynników pogody na kwitnienie, nektarowanie, pylenie i oblot przez owady zapylające entomofilnych roślin uprawnych. *LTN*, Lublin : 53 – 58.

Ruszkowski A., Biliński M., Kaczmarska K., Gosek J. (1994)– Rośliny pokarmowe smuklika koniczynowca *Halictus tumulorum* (L.) (*Apoidea*, *Halictidae*) oraz jego znaczenie gospodarcze. *Pszczeln. Zesz. Nauk.* 38: 183 – 193.

Szklanowska K., Pluta S. (1984)– Wydajność pyłkowa sadu wiśniowego odmian Kerezer, Nefris, Łutówka. *Pszczeln. Zesz. Nauk.*, 28: 63 – 90.

Szklanowska K. (1995)– Pollen flows of crowfoot family (*Ranunculaceae* L.) from some natural plant communities. In: Changes in fauna of wild bees in Europe. *Pedagogical Univ*. Bydgoszcz: 201 – 209.

Warakomska Z. (1972)– Badania nad wydajnością pyłkową roślin. *Pszczeln. Zesz. Nauk.* 16(1): 63 – 90.

Żuraw B., Denisow B. (2002)– Biologia kwitnienia i pylenie kwiatów z rodzaju *Helleborus* L. *Annales UMCS* s. EEE 10: 45 – 50.

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WSTĘPNE BADANIA KWITNIENIA I WYDAJNOŚCI PYŁKOWEJ MIŁKA WIOSENNEGO (*Adonis vernalis* L.) W ZBIOROWISKACH KSEROTERMICZNYCH

Denisow B., Wrzesień M.

S t r e s z c z e n i e

Badania prowadzono w latach 2004 – 2005, wykorzystując dwie populacje miłka wiosennego (*Adonis vernalis* L.) występującego w zespole *Adonido-Brachypodietum pinnati* w Pliszczynie k/Lublina oraz w zespole *Brachypodio-Teucrietum* na Stawskiej Górze k/Chełma. Kwitnienie miłka wiosennego na Lubelszczyźnie przypada w okresie od pierwszych dni kwietnia do końca maja. Gatunek ten charakteryzuje się wczesnym, dziennym rytmem rozkwitania, ograniczonym jedynie do 4 godzin w ciągu doby. Czynniki siedliskowe istotnie modyfikowały cechy wpływające na wydajność pyłkową. Zależnie od zespołu i roku badań obfitość kwitnienia wynosiła od 97 do 325 kwiatów · 1 m^{-2}. Na stanowisku w Pliszczynie rośliny kwitły obficiej niż na Stawskiej Górze, charakteryzowały się większą liczbą pręcików, masą dostarczanego pyłku oraz jego żywotnością. Średnia masa pyłku dostarczanego przez 100 pręcików miłka wiosennego wynosiła od 2,04 mg do 3,18 mg i dodatnio korelowała z wielkością główek pręcikowych. W zespołach ciepłolubnych miłek wiosenny przeciętnie dostarcza 3 – 10 g · 10m^{-2} pożytku pyłkowego. Ze względu na wczesny okres kwitnienia jest to ilość cenna, dlatego należy propagować zachowanie stanowisk naturalnych miłka oraz rozpowszechniać jego uprawę w ogrodach, wzbogacając w ten sposób pożytek pyłkowy głównie dla dzikich błonkówek.

Słowa kluczowe: *Adonis vernalis*, kwitnienie, obfitość pylenia, siedlisko kserotemiczne.