

NECTAR SECRETION OF *Sisymbrium loeselii* L. IN SOME RUDERAL PHYTOCENOSES IN THE CITY OF LUBLIN AREA

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Received 2 October 2005; accepted 28 October 2005

S u m m a r y

The observations were conducted in the years 2002 - 2005. Nectar secretion by Loesel's mustard was compared in the following antropogenic associations in the Lublin area: A - *Sisymbrietum loeselii*, B - *Sisymbrietum loeselii* with *Onopordon acanthium* and C - *Sisymbrietum loeselii* with *Papaver rhoeas*. The blooming abundance of *Sisymbrium loeselii* varied substantially among associations and was from 5,000 to 18,000 flowers per 1 m². The succession processes occurring in the phytocenooses under investigation caused a systematic decrease in the blooming abundance of a taxon over the successive years of the study. The mass of sugars secreted by the flowers was significantly dependent on the position of the flower in the raceme, weather conditions and habitat. On average one *Sisymbrium loeselii* flower can supply 0.5 mg of sugars. Sugar yield in the years of high blooming abundance may reach as much as 200 kg per 1 ha. In the associations involving *Onopordon acanthium* and in those involving *Papaver rhoeas* due to a lower density of individuals, *Sisymbrium loeselii* may yield, on average, 97 kg per ha and 23 kg per ha of sugars, respectively. The density of bee-like insects foraging on *Sisymbrium loeselii* flowers in the phytocenooses varied averaging from 2 per 1 m² in the association with *Papaver rhoeas*, 8 in that with *Onopordon acanthium* to 20 per 1 m² in the *Sisymbrietum loeselii* association.

Keywords: nectar production, sugars potential, *Sisymbrium loeselii*, ruderal vegetation.

INTRODUCTION

The species of the family *Brassicaceae* have entomogamous flowers and are characterized by generally good forage value (*inter alia* Jabłoński et al. 1985, 1999, Kołtowski 2001, Masierowska 2001). Species occurring at unplowed dividing ridges between fields, at roadsides and on idle lands are an important source of food for the honeybee and for wild *Apoidea* which is borne out by pollen analysis (Wróblewska 1995, Warakomska 1997, Teper 2002, 2003).

Sometimes growing over extensive areas and forming numerous variants *Sisymbrietum loeselii* association of Loesel's mustard is a frequently occurring

species of the ruderal flora in lowland Poland (Mirek et al. 1995). The preliminary observations indicate that the species is very willingly visited by different bee-like species which collect both nectar and pollen (Denisow 2003, 2004). Weed species of the genus *Sisymbrium* occurring in Ukraine in some periods provide important supporting flow (Bodnarczuk et al. 1993). The honey yield of *Sisymbrium polymorphum* Murr. under cultivations was estimated by Jabłoński and Kołtowski (1993) at 300-400 kg/ha.

The study was aimed at assessing the nectar secretion by *Sisymbrium loeselii* occurring in ruderal associations in the Lublin area.

MATERIAL AND METHODS

The records were taken in the years 2002-2005 in plant phytocenoses that developed in vacant lots in three districts of Lublin: Wrotków (site A), Czechów (site B), Sławin (site C). The sites were screened for the presence of Loesel's mustard (*Sisymbrium loeselii* L.). The taxonomy of the screened associations was determined using the Braun-Blanquet method (Pawłowski 1972). All the phytocenoses were developed on dry loamy soils of anthropogenic origin that contained substantial addition of breakstone and gravel.

In order to determine the blooming abundance of *Sisymbrium loeselii* in individual associations counts of flowers were made on shoots of plants picked at random and the number of plants occurring per 1 m² was calculated.

Nectar secretion studies were made using the pipette method (Jabłoński and Szklanowska 1979, Jabłoński 2002, 2003). Nectar secreted after 24 hours was

collected between 8:00 and 9:00, several times during the season. The percentage of sugars was determined by Abby refractometer. Relevant calculations allowed the determination of the amount of sugars secreted by 10 flowers and the sugar yield of Loesel's mustard in individual associations.

Weather conditions during the growing season and particularly during blooming were analyzed based on the data obtained from the Marie Curie University weather station in Lublin.

The data were subjected to double factor ANOVA and the differences were examined for significance using Duncan test at $\alpha=0.05$.

RESULTS

During the blooming period of the species air temperature, relative humidity and rainfall varied. In the year 2002 the diurnal temperatures and relative humidity were above the long-term averages. It was also warm in the next year but it was very

Table 1.

Time, length and abundance of blooming of *Sisymbrium loeselii* in Lublin in years 2002-2005

Association	Year	Blooming period	Number of flowers · plant ⁻¹		Number of plants · m ⁻²		Number of flowers · m ⁻² (thousands)
			min-max	average	min-max	average	
<i>Sisymbrium loeselii</i> (A)	2002	1.06-1.07	376-2894	2170.2	5-16	12.9	28.0
	2003	28.05-30.06	156-1970	1131.5	5-11	6.8	7.7
	average			1650.9 b		9.9 b	17.9
<i>Sisymbrium loeselii</i> with <i>Onopordon acanthium</i> (B)	2002	7.06-5.07	537-4926	2038.7	4-12	10.2	20.8
	2003	26.05-1.07	744-3588	1769.5	4-12	7.4	13.1
	2004	29.05-1.07	503-2317	1245.2	3-8	5.6	6.9
	average			1684.5 b		7.7 a	13.6
<i>Sisymbrium loeselii</i> with <i>Papaver rhoeas</i> (C)	2003	1.06-5.07	260-1670	806.0	2-9	5.3	4.3
	2004	30.05-1.07	374-2009	988.0	2-10	7.8	7.7
	2005	15.06-15.07	361-1721	779.0	3-7	4.9	3.8
	average			857.7 a		6.0 a	5.3

Table 2.
Nectar secretion of *Sisymbrium loeselii* flowers in different associations
in Lublin in years 2002-2005

Association	Year	Number of examined flowers	Concentration of sugars in nectar (%)			Amount of sugars per 10 flowers (mg)		
			min-max	average	±SD	min-max	average	±SD
<i>Sisymbrietum loeselii</i> (A)	2002	120	21-52	39.6	±11.9	3.0-14.0	6.9	±3.9
	2003	110	20-48	33.7	±10.2	1.6-5.5	3.0	±1.7
	average			36.7 a			5.0 a	
<i>Sisymbrietum loeselii</i> with <i>Onopordon acanthium</i> (B)	2002	130	26-46	34.5	±7.7	3.2-13.0	8.0	±3.5
	2003	80	38-62	49.3	±10.0	4.2-10.7	8.3	±2.9
	2004	80	30-42	34.0	±6.3	2.1-5.2	2.8	±1.2
	average			39.3 a			6.4 b	
<i>Sisymbrietum loeselii</i> with <i>Papaver rhoeas</i> (C)	2002	130	24-53	38.3	±10.5	3.0-8.2	5.0	±1.9
	2003	60	36-46	40.7	±5.0	3.6-6.4	4.7	±1.5
	2004	160	19-60	40.1	±13.1	1.0-9.1	3.4	±2.7
	average			39.7 a			4.4 a	
Average				38.6			5.3	

Table 3.
The average density of Apoidae per 1 m² of *Sisymbrium loeselii* plots in different associations in Lublin in years 2002-2005

Association	Year	<i>Apis mellifera</i> L.	<i>Bombus</i> sp.	Solitary bees	Total
<i>Sisymbrietum loeselii</i> (A)	2002	7.2	4.6	7.7	19.5
	2003	7.7	2.2	10.8	20.7
	average	7.4	3.4	9.3	20.1
<i>Sisymbrietum loeselii</i> with <i>Onopordon acanthium</i> (B)	2002	4.1	0.1	6.1	10.3
	2003	2.1	0.1	4.0	6.2
	2004	1.8	0	7.8	9.6
	average	2.7	0.07	5.9	8.7
<i>Sisymbrietum loeselii</i> with <i>Papaver rhoeas</i> (C)	2003	0.3	0	2.0	2.3
	2004	0.2	0	0.9	1.1
	2005	0.5	0	2.2	2.7
	average	0.3	0	1.7	2.0
Average		3.4	1.2	5.6	

dry with rainfall in the month of June 26.2 mm lower than the average. In the years 2004 - 2005 it was cooler than in the previous years and there were spells with no rainfall.

By using phytosociological classification following plant associations were distinguished: *Sisymbrietum loeselii* (site A), *Sisymbrietum loeselii* variant with *Onopordon acanthium* (site B) and

Sisymbrium loeselii variant with *Papaver rhoeas* (site C). The blooming of Loesel's mustard in the associations screened in the Lublin area started nearly simultaneously over the study years but there were year-to-year differences of one to two weeks in the onset of blooming (Table 1). In the year 2002 that was characterized by an early onset of spring Loesel's mustard flowered already at the end of May whereas in the year 2005 it started to bloom as late as mid-June. On average, the duration of blooming of Loesel's mustard was four weeks in the screened associations.

Entomogamous flowers of Loesel's mustard open only very early in the morning during the day between 4:00 and 6:00 Eastern European Time.

There were significant differences among the associations for the number of plants per 1 m². The highest density of individual plants occurred in *Sisymbrium loeselii*. The number of plants per 1 m² ranged from 5 to 16 averaging 9.9 plants per 1 m². A lower density was found in the remaining associations with an average of 6-7 plants per 1 m². Plant succession processes that occurred in the associations under consideration resulted in significant differences from year to year in the number of plants per screened area. A particularly heavy decline in the number of plants and in the number of flowers thereon over the consecutive study years occurred at site A in the *Sisymbrium loeselii* association. In the second study year (2003) the number of plants declined by half as compared to that in the previous year. In the year 2004 the plants of Loesel's mustard failed to reappear.

The plants in all the associations differed significantly for the number of lateral shoots and for the number of flowers. The individuals occurring at sites A and B had three times more flowers than did those growing at site C (the variant with *Papaver rhoeas*). The average

number of flowers per 1 m² ranged from 4,000 in the *Sisymbrium loeselii* association with *Papaver rhoeas* to 28,000 in *Sisymbrium loeselii* (site A). Likewise, at site B (variant with *Onopordon acanthium*) there was a gradual decline in blooming abundance of Loesel's mustard but the association persisted in the studied area over three consecutive years.

The nectary tissue in the flowers of Loesel's mustard is around all stamens. Nectar secretion commences immediately after corolla have opened. The concentration of sugars in nectar directly dependent on relative air humidity showed a large variation from 19% to 62% and averaged 36-40% (Table 2).

The highest amounts of sugars were found in Loesel's mustard flowers when the plants grew in association with a fairly large number of *Onopordon acanthium* plants, the average amount of sugars being 4-5 mg per 10 flowers.

The weight of sugars in nectar differed significantly over the study years, too. The largest amounts averaging 7.5 mg per 10 flowers were secreted in the first study year, the amount decreasing by ca. 30% in the following year. In the years 2004-2005 when blooming coincided with air temperatures lower than those in the previous years and with periods of water deficit the flowers of the species yielded ca. 3 mg of sugars per 10 flowers.

In all study years, irrespective of the site, the weight of secreted sugars was clearly dependent on the position of the flowers in the inflorescence (Fig. 1). The highest amount of sugars, 6.3 mg per 10 flowers, was secreted by flowers at lower inflorescence position, those at mid-raceme positions had an average secretion rate of 5.2 mg of sugars per 10 flowers whilst 3.5 mg of sugars per 10 flowers was secreted by flowers at upper inflorescence positions.

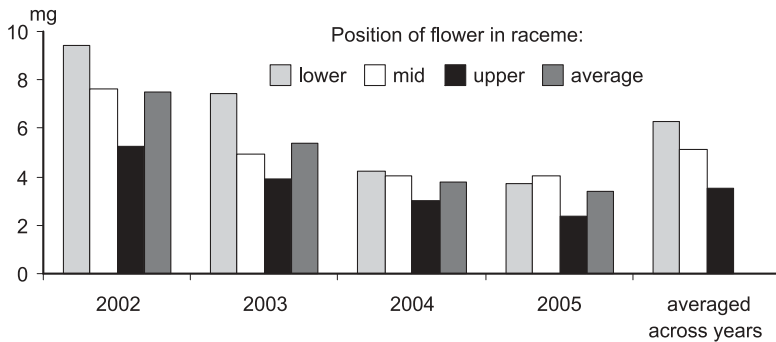


Fig. 1. The average amount of sugars secreted per 10 flowers of *Sisymbrium loeselii* in different blooming stages in years 2002-2005.

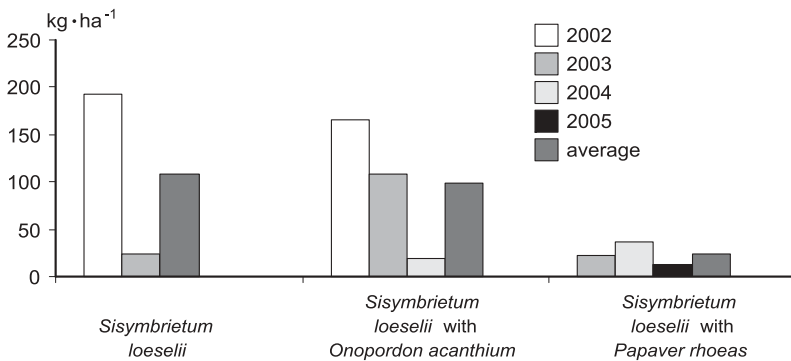


Fig. 2. Sugars productivity of *Sisymbrium loeselii* in ruderal vegetation of Lublin in the years 2002-2005.

The honey yield of the species forming part of the *Sisymbrietum loeselii* association in the abundant secretion year was nearly 200 kg but was lower by 80% in the following year (Fig. 2). A similar decrease in the amount of sugars in that plant association varied from 19 to 166 kg per 1 ha and averaged 97 kg per 1 ha. A substantially lower sugar yield, only 13-35 kg per 1 ha, was obtained from the *Sisymbrietum loeselii* association that involved *Papaver rhoeas*.

In all study years there was an intensive visitation of plants by bee-like insects, but was a considerable site-to-site variation in the insect densities observed (Table 3). The highest density was observed in the *Sisymbrietum loeselii* association, averaging 20 per 1 m². At site B the density was by ca. 60% lower, and an average

count of *Apoidea* representatives on 1 m² of the *Papaver rhoeas* variant was only 2. Generally, with favorable weather at full blooming an average of 6 small solitary bees and three honeybee foragers were recorded per 1 m² of the screened area. Bumblebees were observed but sporadically. They foraged only by afternoon hours and were more inclined to form pollen loads than to harvest nectar.

DISCUSSION

The mass of sugars in the nectar secreted by *Sisymbrium loeselii* flowers was subject to variation with weather factors, blooming stage, habitat conditions and plant succession processes. The effect of variable weather conditions during blooming on the weight of carbohydrates accumulated by flowers of different plant

species was demonstrated earlier by numerous investigators (*inter alia* Jabłoński and Szklanowska 1979, Jabłoński and Kołtowski 1993, Masierowska 2001). The highest nectar secretion rate by the flowers of *Sisymbrium loeselii* occurred during sunny and warm weather with the air temperature of 18-24°C and with relative humidity of 70-80%. Prolonged drought spells did not favor nectar secretion by the species under investigation.

Under the conditions prevailing in the Lublin area the weight of sugars in nectar secreted by 10 *Sisymbrium loeselii* flowers per day averaged 5 mg. The value is somewhat higher than that obtained for cultivated *Brassicaceae* species, among others for cultivars of oilseed rape and species of mustard (Jabłoński et al. 1999, Kołtowski 2001, Masierowska 2001). However, it is lower by 35% than that determined by Jabłoński and Kołtowski (1993) for *Sisymbrium polymorphum*.

The flowers of Loesel's mustard secreted the highest quantities of sugars when growing in association with *Onopordon acanthium*, averaging 6.4 mg per 10 flowers. A simultaneous influence of environmental and intra-population factors as well as the impact of allelopathic potential makes it difficult, at the present stage of investigations, to assess their actual effect on the nectar secretion rate of the species in different anthropogenic associations. The issue requires further study.

The demonstrated higher sugar content in flowers at lower raceme positions as compared to that in flowers positioned further up the inflorescence probably may stem from the dissimilar inflow of assimilates to those parts. With higher inflorescence positions flowers become smaller and, conceivably, they have a smaller nectary surface. Additionally, as pollination, fertilization, seed and fruit set

advances the majority of assimilates produced by the plant is used up for growth and development processes which may detract from the weight of sugars present in the nectar of the flowers further up the inflorescence.

The plant associations of which *Sisymbrium loeselii* is the principal component are subject to rapid succession. It stems from the environmental properties of the species, Loesel's mustard being essentially a terrophyte and but to a small extent a hemicryptophyte. The study furnished evidence that the persistence of *Sisymbrium loeselii* at the same site reaches three years. Blooming abundance decreases substantially as the phytocoenoses recover over consecutive years. In all investigated associations in the last year of their persistence there was a substantial decrease in the amount of sugars yielded by flowers. Individuals in declining phytocoenoses developed significantly fewer flowers which was proven statistically. Supposedly, they also developed fewer leaves and thus had a smaller assimilation area and thereby their nectar secretion rate could have been affected.

Blooming abundance is in close relationship to the amount of forage per unit area. In the years of abundant blooming one hectare of a dense stand of *Sisymbrium loeselii* is capable of supplying 200 kg of sugars. This figure is slightly lower than that reported by Jabłoński and Kołtowski (1993) for *Sisymbrium polymorphum* under cultivation. It thus can be expected that by undersowing Loesel's mustard in beekeeping gardens and thereby obtaining a larger density than that in anthropogenic associations the amounts of sugars yielded by a unit area will be higher by ca. 50-100% than those determined experimentally for wild-growing plants.

CONCLUSIONS

Under the conditions of south-eastern Poland the blooming of *Sisymbrium loeselii* in plant associations of which it is the prevalent species occurred from the end of May to mid-July and lasted on average from 30 to 37 days.

The highest number of flowers (ca.18,000) was formed by the plants of *Sisymbrium loeselii* that grew in *Sisymbrietum loeselii*, fewer flowers were counted in the association with *Onopordon acanthium* (ca. 13,600), and the fewest, when Loesel's mustard grew in association with *Papaver rhoeas* (ca. 5,300).

Phytocenoses of which *Sisymbrium loeselii* was the dominant species were characterized by a systematic decline. In the years when the phytocenosis is at its highest the number of flowers of Loesel's mustard developed per unit area may be 3 to 4 times higher than that in the years when the association is the declining stage.

The weight of sugars secreted by *Sisymbrium loeselii* flowers during 24 hr averaged 5.3 mg per 10 flowers, the variation being from 2.8 mg to 9.3 mg. It varied with weather factors, blooming stage and habitat conditions.

The sugar yield of *Sisymbrium loeselii* in anthropogenic associations was varied. In the *Sisymbrietum loeselii* association it reached 200 kg per 1 ha, in the association involving *Onopordon acanthium* it averaged 97 kg per 1 ha and in that with *Papaver rhoeas* it was 23 kg per 1 ha.

The density of bee-like insects foraging on *Sisymbrium loeselii* flowers varied substantially from association to association. It was highest in the *Sisymbrietum loeselii* association averaging 20 per 1 m², lower in the association that involved *Onopordon acanthium* (8 per 1 m² on average) and lowest in the association with *Papaver rhoeas* (2 per 1 m² on average).

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NEKTAROWANIE STULISZA LOESELA (*Sisymbrium loeselii* L.) W KILKU ZBIOROWISKACH RUDERALNYCH LUBLINA

D e n i s o w B .

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

Obserwacje prowadzono w latach 2002-2005. Porównywano nektarowanie stulisza Loesela w następujących zespołach antropogenicznych na terenie Lublina: A - *Sisymbrietum loeselii*, B - *Sisymbrietum loeselii* wariant z *Onopordon acanthium* oraz C - *Sisymbrietum loeselii* wariant z *Papaver rhoeas*. Obfitość kwitnienia stulisza Loesela różniła się znacznie pomiędzy zespołami i wynosiła 5-18 tys. kwiatów na 1 m². Procesy sukcesyjne zachodzące w badanych fitocenozach powodowały systematyczny spadek obfitości kwitnienia badanego taksonu w kolejnych latach badań. Masa wydzielanych w kwiatach cukrów istotnie zależała od położenia kwiatów w gronie, warunków pogody oraz siedliska. Przeciętnie jeden kwiat stulisza Loesela może dostarczyć 0,5 mg cukrów. Wydajność cukrowa w latach o dużej obfitości kwitnienia może sięgać 200 kg z 1 ha. W zespołach z udziałem *Onopordon acanthium* oraz z *Papaver rhoeas* ze względu na mniejsze zagęszczenie osobników stulisz Loesela może dostarczyć średnio z 1 ha odpowiednio 97 kg i 23 kg cukrów. Zagęszczenie owadów pszczołowych oblatujących kwiaty *Sisymbrium loeselii* w badanych fitocenozach było zróżnicowane i wynosiło około 2 na 1 m² w wariacie z *Papaver rhoeas*, 8 na 1m² z *Onopordon acanthium* i 20 na 1 m² w zespole *Sisymbrietum loeselii*.

Słowa kluczowe: nektarowanie, wydajność cukrowa, *Sisymbrium loeselii*, zespoły ruderalne.