

BLOOMING AND POLLEN PRODUCTION OF TWO *Lamium L. SPECIES*

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S u m m a r y

The studies of the period and abundance of flowering, and the seasonal and diurnal dynamics of *Lamium purpureum* and *L. album* blooming, were carried out from 1995-1997 in Puławy, Poland and from 2002-2005 in Lublin, Poland. Some morphological features of flowers were observed. The abundance of pollen produced in anthers and flowers was studied. Both species develop similar number of flowers per plant (38.3-46.8 - *L. purpureum*, 30.4-58.9 - *L. album*). Most flowers bloom in the morning hours. The diurnal dynamics of *L. album* blooming fluctuates slightly depending on the daylength of the season. The flowering of the studied species is weather dependent. Drought seems to be a strong limiting factor of flower development. The mass of pollen produced in anthers is positively correlated with anther size. Anthers of *Lamium album* produced from 3.5 mg to 7.15 mg of pollen per 100 anthers. Smaller sized *L. purpureum* produced only 0.45- 1.18 mg per 100 anthers. Pollen grains of the *Lamium* studied, are trizonocolpate, medium and prolatum (P/E = 1.17). The time and abundance of blooming as well as the amount of delivered pollen indicate that the studied species are attractive as a supplementary food source mainly for wild pollinators.

Keywords: *Lamium* sp., blooming, pollen production, bee forage.

INTRODUCTION

The Lamiaceae family consists mostly of herbs and undershrubs. Many are sold as kitchen herbs and ornamentals. Some examples are *Salvia*, *Mentha*, *Thymus* and *Lavandula*. One of the regions with the greatest concentration of the species is the Mediterranean basin. In this area a lot of Lamiaceae species are components of maquis and garrigue. A few genera (e. g. *Stachys*, *Lamium*) are cosmopolitan and grow in almost all types of habitat and at all altitudes (Heywood 1985).

In Poland there are over 75 species, among them there are 6 taxons of the genus *Lamium* (Rutkowski 2004). Two of them, *Lamium album* and *L. purpureum* grow commonly on ruderal sites. The perennial *Lamium album* is characteristic of the *Artemisietalia* order while *L. purpureum* is characteristic of the *Polygono-Chenopodion* alliance (Matuszkiewicz 2001).

The flowers of labiates are essentially bisexual, irregular with four or two epipetalous stamens. They have a superior ovary of two fused carpels. Various types of pollination mechanisms preferring cross-pollination occur and more over are usually linked with type of pollinators. The most advanced strategies are found in *Salvia* and *Ocimum* (Faegri and van der Pijl 1979, Bożek 2002, Chwil 2003). In Poland flowers of labiates are visited by a great number of insects (Bożek 2003). Nectar as the main attractant, is of a high sugar concentration (Jabłoński 1986, 1990). The pollen grains of the *Lamium* type were identified in the examined samples of honeys or pollen loads of *Apis mellifera* and *Bombus* sp. from different regions in Poland (Warakomska 1996, Wróblewska 2002, Teper 2005). This paper reports observation on floral biology and morphology, and the pollen productivity in two *Lamium* sp. common in Poland.

MATERIAL AND METHODS

For many years (1995-1997 and 2002-2005), observations were carried out in Puławy, Poland (site A) and Lublin, Poland (site B).

The studies examined the details of seasonal and diurnal dynamics of blooming, and the flower morphology of *Lamium album* L. and *L. purpureum* L. The phenological records of the date and duration of blooming were taken according to Jabłoński and Szkłanowska (1997). While determining the diurnal dynamics of blooming, hourly records were made of flowers opening and of pollinating insects. The observations of the daily pattern of *Lamium album* flowers opening were made in the spring. These observations were made during the full blooming period. They were made again during the later period of blooming at the end of the summer. The life span of the flowers was also recorded. The abundance of blooming was estimated by flower-counts per plant (n=30) for each species. The pollen production was estimated using Warakomska's method (1972), modified by Szkłanowska (1995). The size of the anthers was determined both, by direct measurements and by fresh and dry matter weight of anthers. The entirely closed but mature anthers with their filament removed were collected from flowers and placed in tarred vessels. Every vegetation season, 4 samples of 200 anthers were analyzed. The size and shape of pollen grains were determined in glycerin jelly slides.

The results were subjected to ANOVA. They were examined for differences between species and among species in the studied years. Duncan's test at $\alpha=0.05$ was used.

RESULTS

The time and period of blooming differed among species, and blooming also differed

in the years of the study. It was strongly dependent upon weather conditions mainly before the flowering. The average period of flowering lasted from early spring till autumn with a short break from the end of June to the end of July. In the successive years of observations the flowering season of *Lamium purpureum* began approx. 5-10 days earlier than *L. album*. The flowering date of both species was the earliest in 1995, the latest in 1996 and 2003. February and March 1996 and 2003 were colder than average. Generally, low temperatures combined with a drought more negatively affected the blooming than wet and rainy weather.

The detailed seasonal dynamics of blooming were observed in early spring 1997 for *Lamium purpureum*. This observance showed that the rate of flowers blooming on consecutive days was strongly influenced by weather conditions (Fig. 1).

The phases of the beginning and the end of blooming were rather short. These phases lasted four and five days, respectively. The most intensive blooming between 28th April and 7th May was during the warm weather. The temperatures were above 20°C, and the air humidity approx. 65%. Night ground frost occurring on 27th and 28th April and high day temperatures did not slow the process significantly. At the end of full blooming on 8th May, rain fell and the rate of flower bud development slowed down. This definitely ended the blooming of *Lamium purpureum* on 12th May.

For both examined species higher temperatures shorten the life span of the flower and lower temperatures lengthen it. The life span of *Lamium album* flowers lasted 4-5 days in early spring and autumn when the average temperature was below 18°C. The life span was shorter, lasting only 2 days when the temperature was higher (about 25-30°C). The life span of *L. purpureum* flowers was 3-4 days, on average.

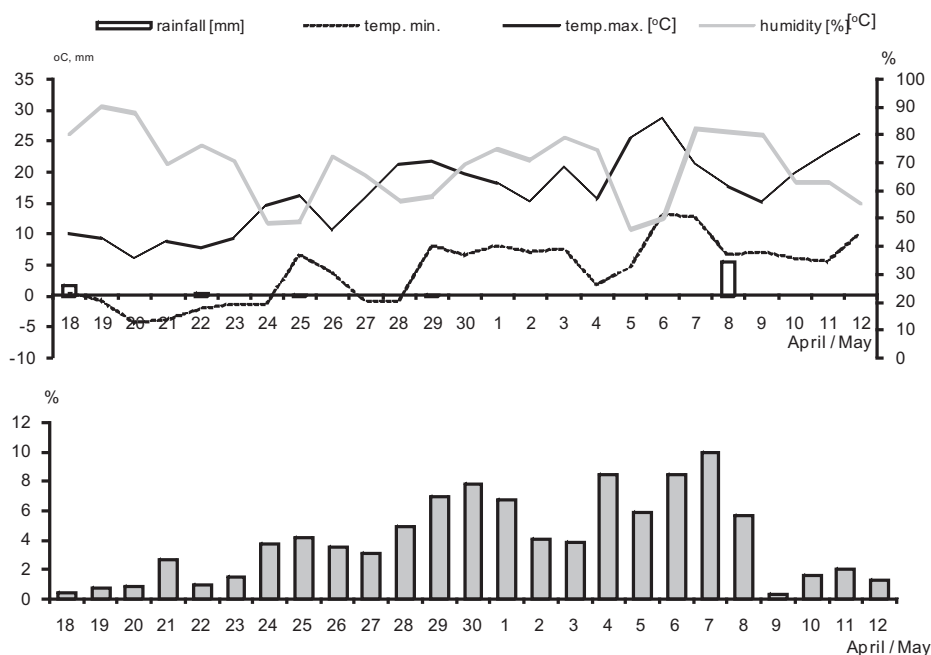


Fig. 1. Seasonal dynamics of *Lamium purpureum* blooming and some weather factors in 1997 in Lublin.

■ - number of flowers, shown in %.

The flowers are typically entomophilous. The corolla comprising five petals. Two of them are elongated and curved to form a hook-shaped structure. The remaining three petals compose a convenient landing platform for insect visitors. The average length of a flower from the base of the calyx to the corolla apex was 17.09 mm ($Sd \pm 1.217$) - (*L. purpureum*) and 20.12 mm ($Sd \pm 1.411$) - (*L. album*). The length of the corolla tube was 6.78 mm ($Sd \pm 0.667$) - (*L. purpureum*) and 8.45 mm ($Sd \pm 0.4211$) - (*L. album*). There are spectacular visual, signal guides present on the internal part of the corolla. These are dark violet, stripes located on the lower lip and in the entrance to the curved tube of *L. purpureum*. Yellowish, and slightly less visible marks are present only on the lower lip in *L. album*. The guides are associated with flower maturation. The guides also

facilitate finding and recognizing the kind, and presence or absence of flow for pollinators. Additionally, the colours of the *L. purpureum* corolla change during flower maturation from violet in the bud stage, to pink during pollen exposition. Then the flowers turn light pink towards the end of their life-span. Anthers and stigma are found under the hooded part of the upper lip. The flowers are chasmogamous with synchronic maturation of anthers and stigmas. The organs, however, are spatially separated making cross-pollination possible. The long style adheres to the back part of the corolla while the decurrent stigma reach a high part of the upper lip exactly in the space where the anthers are (Fig. 2 A,B). Though the style is placed among the anthers the insect first touches the receptive, bent back stigma. It then rubs the anthers. The pollen is then rubbed off onto the pollinator's back and is

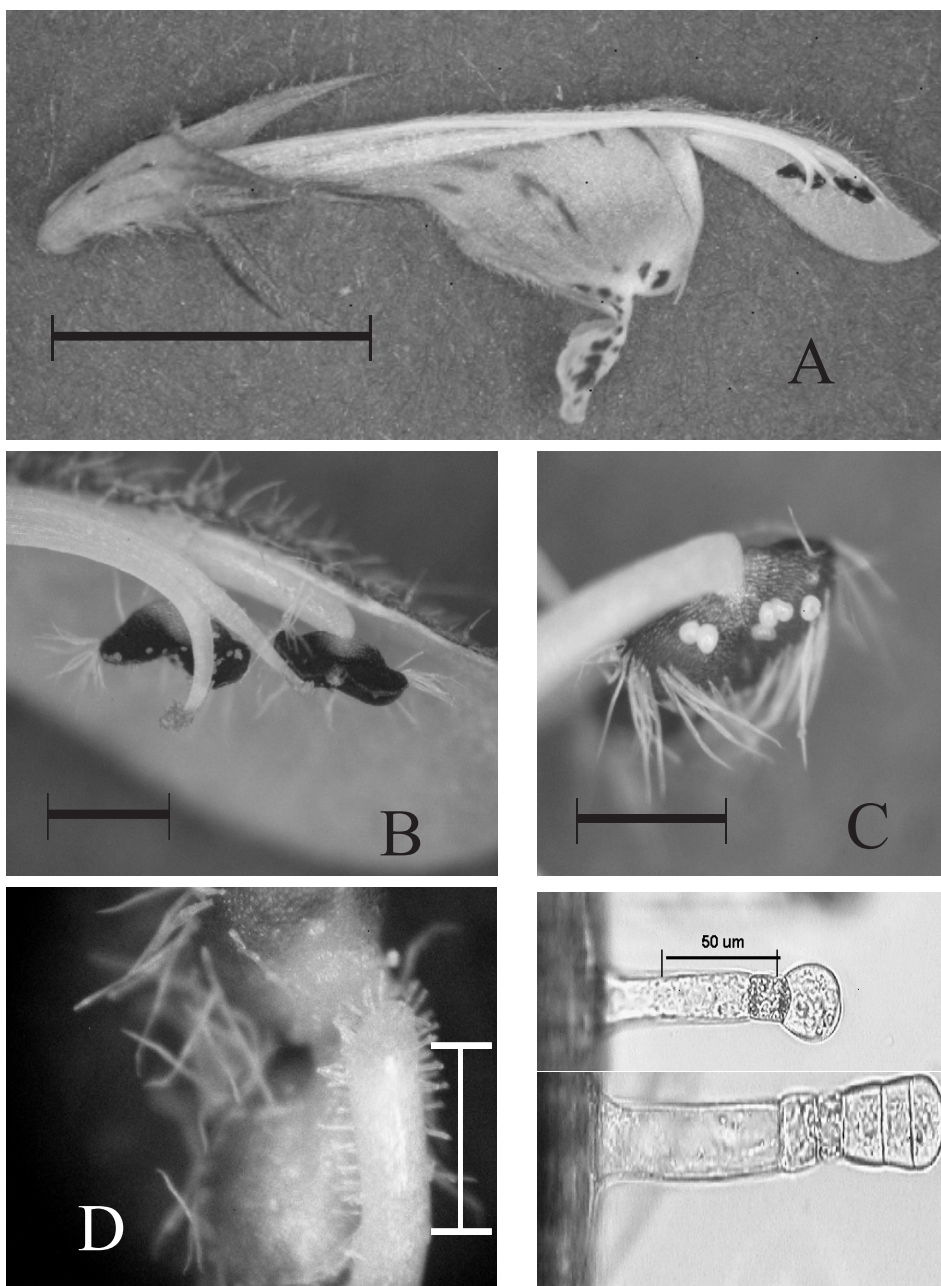


Fig. 2

A – The longitudinal section of *Lamium purpureum* flower (bar = 5mm)

B - Fragment of *L. purpureum* flower with anthers and stigma visible (bar = 1mm)

C – The anthers of *L. purpureum* with numerous non-glandular trichomes (bar = 1mm)

D - The fragment of *L. album* anther with glandular trichomes on the apex of filament (bar = 1mm)

E – The glandular trichomes from the epidermis of filament of *L. album* (bar = 50 µm)

carried to the style of the next flower. Flowers of studied taxons form functional anthers dehiscing almost simultaneously (Fig. 2 C).

Non glandular trichomes were present on the external part of anthers in both *Lamium* taxons. Numerous glandular trichomes were found on the filament of *Lamium album* anthers as well (Fig. 2. D, E).

The flowering of *Lamium* sp. is more abundant in spring aspect than in autumn. During summer only singular flowers were present on *L. album* while *L. purpureum* stopped blooming completely. The average number of flowers per plant varied slightly, but not statistically, between years and

species. Slightly less flowers were recorded on *L. purpureum* – 39.09 per plant, while on *L. album* - 45.4 flowers per plant (Table 1).

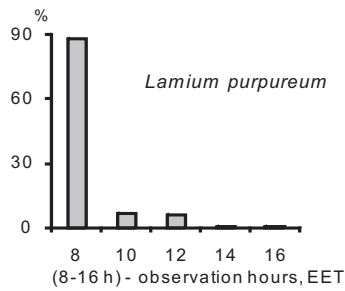
On average, over 80% of the flowers opened in the morning hours, by 8:00 for *L. purpureum* and by 9:00 for *L. album* (Fig. 3). As the day progressed the process significantly slowed down and in one hour intervals from 10 a.m till 4 p.m (6 p.m) the increase was only 0.7-6% of the total number of opened flowers. *L. album*, bloomed abundantly in spring and autumn. There was a shift of the peak intensity of diurnal flower opening in August and September towards later hours compared to the flower opening pattern observed in

Table 1

The abundance of flowering, features of anthers, and the mass of delivered pollen, depending on *Lamium* species and the year of study.

Species	Year	Number of flowers per plant	Fresh weight 100 anthers (mg)	Dry weight 100 anthers (mg)	Mass of pollen (mg) per	
					100 anthers	100 flowers
<i>Lamium purpureum</i>	1995	46.75	13.05	3.84	1.02 _b	4.08
	1996	40.60	10.25	2.65	0.55 _a	2.20
	1997	38.30	11.97	3.94	1.18 _b	4.72
	average	41.88	11.75_B	3.47_A	0.92_B	3.88
	2002	32.90	9.17	3.95	0.70 _b	2.80
	2003	34.87	5.15	2.28	0.45 _a	1.80
	2004	41.20	9.52	4.13	0.83 _b	3.32
	average	36.30	7.94_A	3.45_A	0.66_A	2.64
<i>Lamium album</i>	1995	54.00	83.00	21.00	3.50 _a	14.00
	1996	41.90	76.08	16.30	3.68 _b	14.72
	1997	30.40	76.05	20.65	7.15 _c	28.60
	average	42.10	78.38_A	19.32_A	4.78_A	19.11
	2002	48.50	74.05	20.50	4.15 _a	16.60
	2003	38.80	67.95	18.93	3.70 _a	14.80
	2004	58.90	82.57	25.00	5.45 _b	21.80
	average	48.73	74.85_A	21.48_A	4.43_A	17.73
<i>L. purpureum</i>	average for species	39.09	9.84 _A	3.46 _A	0.79 _A	3.26
<i>L. album</i>	average for species	45.42	76.61 _B	20.4 _B	4.61 _B	18.42

Means within columns followed by the same small letters do not differ significantly between years and followed by the same capital letters do not differ significantly between species at $\alpha=0.05$ according to Duncan's t-test.



Lamium album (18.5%, on average) dehiscid in the closed bud stage. The mass of pollen delivered by anthers has been species-related and a year-to-year variation was found. The average fresh weight of 100 anthers, over the years studied, was 76.6 mg (*L. album*) and 9.84 mg (*L. purpureum*)- (Table1).

The mass of pollen produced in anthers positively correlated with anther size.

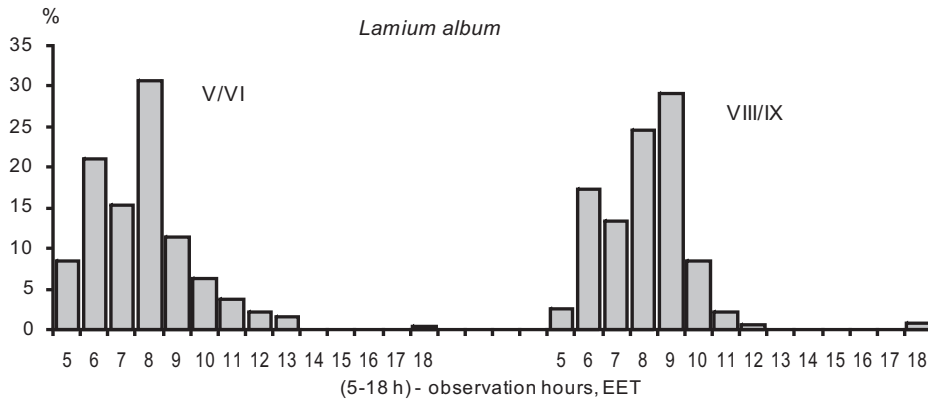


Fig. 3. Diurnal dynamics of blooming of two *Lamium* species.



- number of flowers shown in % of total number bloomed during whole day.

May.

Depending on the weather conditions and the flower daytime opening the pollen exposition lasts 1 to 2 days. The weather in 2002 was extremely sunny and dry. Rainfall was 50% lower than average, and in such conditions some anthers of

Larger anthers of *Lamium album*, produced from 3.5 mg to 7.15 mg of pollen per 100 anthers. Smaller anthers of *L. purpureum* produced only 0.45 - 1.18 mg per 100 anthers.

The pollen grains are trizonocolpate, medium and prolatum. The largest grains

Table 2

The size and shape of pollen grains of *Lamium* species.

Species	Length of axis (μm)				Coefficient
	polar (P)		equatorial (E)		
	min - max	average	min - max	average	
<i>Lamium purpureum</i>	31.25 – 38.75	35.08	26.25 – 35.00	30.08	1.17
Lamium	26.25 – 32.50	29.38	22.50 – 27.50	25.13	1.17

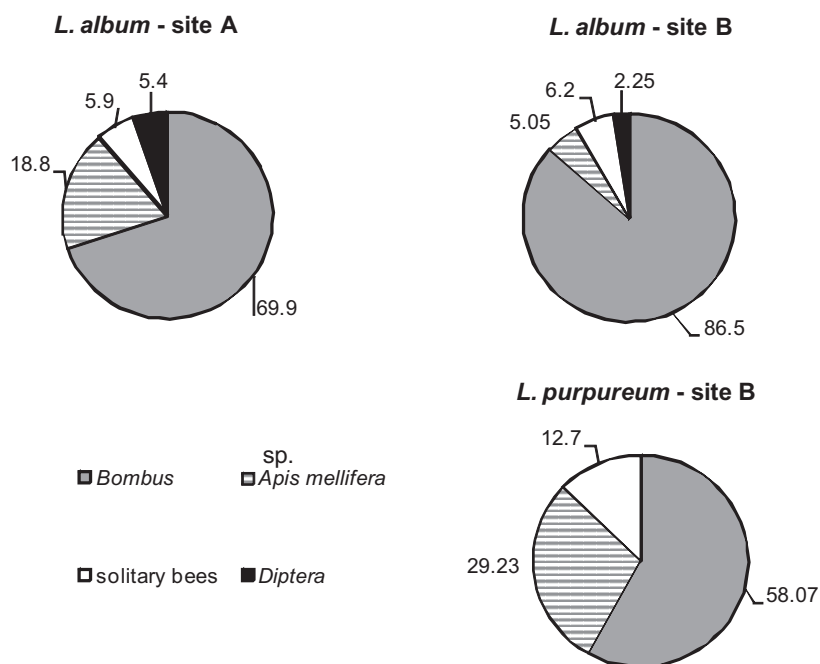


Fig. 4. The participation of different groups of pollinators foraging on two *Lamium* species (average from years of study).

with the average lengths of the polar and equatorial axes were found in *Lamium purpureum* flowers (35.08 μm : 30.08 μm) – (Table 2).

The flowers were visited mainly by *Apoidea*. Some *Diptera* were also observed on *L. album* flowers (Fig. 4).

Apis mellifera was more frequently observed on *L. purpureum* flowers, during morning hours and form amaranth pollen loads. The participation of honey bees was 28% - 42.1% (approx. 35.4%) on *L. purpureum* and only 1.0% - 18.8% (approx. 11.9%) on *L. album*. Most pollinators of *L. album* were bumble bees. A slightly different composition of insects were found on *L. album* in Puławy (site A) than in Lublin (site B). The increase in abundance of *Apis mellifera* was recorded in Puławy.

DISCUSSION

The studied *Lamium* species, flower in early spring in south-eastern Poland and bloom again towards the end of the summer. *L. album* bloomed more intensely than *L. purpureum*. The weather conditions influence the blooming of both examined species. The fact was described for many plants (e.g. Faegri and van der Pijl, 1979, Bożek 2002, Denisow 2004). In the case of the studied *Lamium* sp. high temperatures combined with drought affected the initial phase and length of blooming.

Lamium's flowers are bisexual. Bisexuality promote different mechanisms which opposes self-pollination. We found out that anthers and stigma in both studied species mature simultaneously. The arrangement of anthers and stigma, however, confirmed the adaptation to

cross-pollination or considerable increase of its proportion. The *Lamium* flowers were visited by different pollinators, as the flowers offered both nectar and pollen. The access to both *Lamium* flower's reward is signaled by visual stripes on the corolla. The signaling with pollen and stamens are present in studied taxons, also. Non-glandular trichomes are of a contrasting color. They are present on the abaxial part of anthers. Moreover, great amounts of pollen form yellow (*L. album*) or orange clumps (*L. purpureum*) and they are displayed during pollen presentation time. These colours are a good visual contrast to the dark anthers tissues. The comparable visual signaling function of the androecium was described in many plant species (Lunau, 2000). With no doubt the subtle colour changes of the *L. purpureum* corolla are associated with floral visual signaling. The colour changes also signal the cessation of nectar and pollen. The phenomena is widely known among species from various families (e.g. Proctor et al 1996).

Flowers of the studied *Lamium* species are chasmogamous. Exclusively when the weather is particularly sunny and dry, some *Lamium album* anthers release pollen in the bud stage. The morphology and biology of *Lamium* flowers indicate that self- and cross- pollination is possible. During suitable environmental conditions cross-pollination is presumably preferred. In all probability although autogamy makes gene flow impossible and restricts new features, it supports the breeding system in extreme conditions. Drought seems to be a strong limiting factor for *Lamium album* cross-pollination. In Italy Pacini (2000) reports cleistogamy in *Lamium* taxons.

The daily intensity of the opening of new flowers in *L. album* shifted from the early hours in spring to the later hours in September. This tendency is probably linked to the decreasing daylight and the day activity of pollinators. A similar

relationship was described by Denisow (2004) for *Berteroa incana*, which opened its flowers slightly earlier in spring than in autumn.

As expected the mass of pollen produced, as a genetically dependent feature, varied between studied species. It also positively correlated with anther size. The mass of pollen from *L. album* anthers was five to six times higher than from *L. purpureum*. That interdependence was described earlier for other species (e.g. Warakomska 1972, Szklanowska 1995). There were significant differences in the mass of pollen delivered between studied years within the taxons. This indicates a substantial impact of external factors for the efficiency of pollen production. There was an extreme lack of humidity in 2003. This caused a considerable decrease in the amount of pollen delivered by both studied *Lamium* species.

The amount of pollen delivered by *Lamium album* flowers is 3-6 times higher than other labiates (e.g. *Lavandula angustifolia*, *Hysopus officinalis*) reported by Božek (2003). Together with the average amount of pollen offered by *L. purpureum* flowers (3.26 mg per 100 flowers), the studied *Lamium* taxons are a good spring source of pollen in Poland.

The variety of pollinators of the studied species was found to be connected with the floral morphology; mainly the length of the corolla tube. Flowers of *L. album* with a longer corolla tube were more frequently visited by bumble bees. Morphology of flowers has been recognized as a main factor determining pollinators composition among different insect-pollinated plants (Faegri and van der Pijl 1978). The variation on the local scale was important in the case of pollinators on *Lamium album*. The most frequent were still bumble bees. The significant increase of honey bees in Puławy versus Lublin was presumably connected with the nearby

apiary. Vegetation cover may also influence the pollinators preferences causing competitiveness at flowers (Bożek 2000, Denisow 2004).

CONCLUSIONS

1. The average period of flowering of *Lamium album* and *L. purpureum* in the conditions of south-eastern Poland lasts from the early spring till the autumn with a short break from the end of June to the end of July. The flowering of the studied species is weather dependent; drought seems to be a strong limiting factor on flowers development.
2. *Lamium album* and *L. purpureum* flowers are entomophilous with visual signaling of the flow as stripes on the corolla or contrasting non glandular trichomes. The androecium is a part of the signaling system.
3. Most flowers of *L. purpureum* open by 8:00 and *L. album* by 9:00. The diurnal dynamics of *L. album* blooming fluctuate slightly depending on the daylength of the season.
4. The average amount of delivered pollen was 3.26 mg per 100 flowers of *Lamium purpureum* and 18.42 mg per 100 flowers of *L. album*.
5. The main pollinators of *Lamium purpureum* and *L. album* are wild *Apoidea* (bumblebees and solitary bees). Among foraging insects the participation of *Apis mellifera* is 35% for *Lamium purpureum* and 11.9 % for *L. album*.

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KWITNIENIE I OBFITOŚĆ PYLENIA DWÓCH GATUNKÓW Z RODZAJU *Lamium* L.

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Streszczenie

Badania pory, obfitości kwitnienia, dziennej i sezonowej dynamiki rozkwitania kwiatów *Lamium album* i *L. purpureum* prowadzono w latach 1994-1997 w Puławach oraz w latach 2002-2005 w Lublinie. Dodatkowo obserwowano niektóre cechy morfologiczne kwiatów i ustalano obfitość pylenia kwiatów. Obfitość kwitnienia obu badanych gatunków była zbliżona (38,3-46,8 kwiatów na roślinie - *L. purpureum*, oraz 30,4-58,9 - *L. album*). Gatunki charakteryzowały się wczesnym dziennym rytmem kwitnienia. Na ich kwitnienie duży wpływ wywierały czynniki pogody, a susza panująca podczas kwitnienia istotnie hamowała ten proces. Masa dostarczanego pyłku korelowała dodatnio z wielkością pylników. Pylniki *L. album* produkowały od 3,5 mg do 7,15 mg pyłku w 100 pylnikach. Pylniki *L. purpureum* dostarczały 0,45 – 1,18 mg pyłku ze 100. Ziarna pyłku badanych gatunków z rodzaju *Lamium* są trójbruzdowe, średniej wielkości, wydłużone (*prolatum* P/E = 1,17). Termin, obfitość kwitnienia oraz ilości dostarczanego pożytku pyłkowego sprawiają, że badane gatunki stanowią atrakcyjne uzupełnienie pożytku, zwłaszcza dla dzikich pszczołowych.

Słowa kluczowe: *Lamium* sp., kwitnienie, produkcja pyłku, oblot przez owady.