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Nutritive for insects attractants in *Asphodelus albus* Miller flowers

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Summary

The studies on *Asphodelus albus* Miller flowers were conducted in the Botanical Garden of the UMCS in Lublin in the years 2004–2005. The flower nectaries location was determined in a stereoscopic microscope. The nectaring abundance was studied with a pipette method described by Jabłoński and Szklanowska (1979), while pollen efficiency determined after Warakomska`s ether method (1972). Pollen viability was computed in a sample of 400 grains after acetocarmine staining. The following measurements of pollen grains were made: the length of polar axis (P), equatorial longitudinal axis (EL) and equatorial transverse axis (ET). In *Asphodelus albus* flowers, there are three nectary glands located in the ovary septa whose outlets are situated in the upper part of the ovary. The nectar secretion starts in a dehiscing bud and persists until the withering stage of perianth leaves. Considering the size of monocolpate pollen grains of *Asphodelus albus*, they are ranked among great, whereas their shape assumed flattened and circular at the polar view. In the Poland climatic conditions, a pollen showed high vitality (98%). The *Asphodelus albus* plants constitute a valuable source of nutrition for the pollinators as a single flower generated on average 4,22 mg sugars and 0,2 mg of pollen grains.

Key words: *Asphodelus albus*, flowers, nectary, nectar secretion, pollen grain morphology, pollen efficiency

INTRODUCTION

The white asphodel *(Asphodelus albus* Miller) is grown in Poland and other European countries as a border ornamental perennial plant. It belongs to the Asphodelaceae

family, which is separated of the Liliaceae family. It comes from southern Europe where it grows in dry situations, reaching the height of about 1 m (P o d b i e l k o w s k i , 2003). Flowers of the white asphodel form racemes attached to a leafless stem. In the middle part of white flowers of the perianth, a green vein is clearly noticeable. Long linear leaves form a thick cluster of leaves of the rosette type at the base of the stem (S z w e y k o w s k a and S z w e y k o w s k i , 1993).

Studies in pollination ecology demonstrated that *A. albus* produces entomophilous flowers. Among over a dozen of insects species which visit asphodel flowers, the most effective pollinators were bumblebees (*Bombus* spp.). A problem in the biology of reproduction of *Asphodelus albus* is the poor seed setting and fruit dying at the beginning of the fruiting phase (O b e s o , 1992; 1993). Pollen of different *Asphodelus* species was found in honeys (F l o r i s et al., 1996; P r o t a et al., 1997), what indicates the apicultural importance of these plants.

It was found that *A. albus* roots contain anthraquinones with medicinal properties, occurring at the time of flowering in small amounts, and their contents significantly increases after fruit formation (U t r i l l a et al., 1989).

The aim of the studies conducted was to determine the apicultural value of *A. albus* in the conditions of Poland. The weight of pollen and nectar produced was estimated, investigations on the location of the nectary and morphology of pollen grains were carried out.

MATERIALS AND METHODS

The studies of *Asphodelus albus* Miller flowers were conducted on the premises of the Botanical Garden of the Maria Curie-Skłodowska University in Lublin in the years 2004-2005. The abundance of nectar production was examined by the pipette method described by J a b ł o ń s k i and S z k l a n o w s k a (1979). Nectar was sampled twice in five samples in the phase of full flowering of plants. The weight of nectar from 6-8 flowers constituted a sample. The percentage sugar content was estimated by using the Abbe refractometer. In order to estimate pollen yield of flowers, the ether method of W a r a k o m s k a (1972) was used. In a stereoscope microscope the location of the flower nectaries was identified. Measurements of pollen grains were made: the length of the polar axis (P) in the equatorial transverse view and the length of the equatorial longitudinal axis (EL) and the equatorial transverse axis (ET) in the polar view for 200 pollen grains. Pollen viability (in %) was calculated in a sample of 400 grains after acetocarmine staining.

RESULTS

Relatively large flowers of the white asphodel (20–25 mm in diameter) develop in May and June. The most intensively coloured elements of flowers of the species studied are orange anthes (Fig. 1). The lower expanded parts of long filaments cover

the ovary of the pistil (Fig. 2). The outer surface of the expanded part of the filaments is covered with glistening hairs (Fig. 3, 4), which may indicate to insects the location of nectar in the flower head and protect it against drying. Fragments of the filaments adjoining the ovary probably also protect nectar against outflowing from the flower.

Figs 1, 2. Flowers of *Asphodelus albus;* 1, 2 – x 2.

Figs 3, 4. Glittering trichomes on abaxial surface of extended fragments of filaments surrounding ovary (arrow); 3 – x 5; 4 – x 20.

Septal nectary glands occur in the ovary walls of the pistil of *Asphodelus albus*. The nectary develop together with the pistil. They have the form of three sacs surrounded by the nectary tissue, with their outlets situated in the upper part of the

ovary, at a small distance from the style. In a closed bud, those outlets are small (Fig. 5, 8) and they grow in size together with the development of the nectary. In a bursting bud, before the opening of the perianth leaves, nectar secretion starts (Fig. 6, 9). In the phase of full development of the flower, the secretory openings have the largest dimensions (Fig. 10, 11). Quite large drops of nectar were observed in them (Fig. 7, 12), they were also present in the phase of perianth leaves withering.

Figs 5–12. Secretion outlets of nectaries *Asphodelus albus* on the ovary surface (arrow) in different phases of blooming. On figs; 7, 9, 12 visible effluent drops of nectar; 5, 6 – x 15; 7, 12 – x 20; 11 – x 25; 8, 9 – x 45.

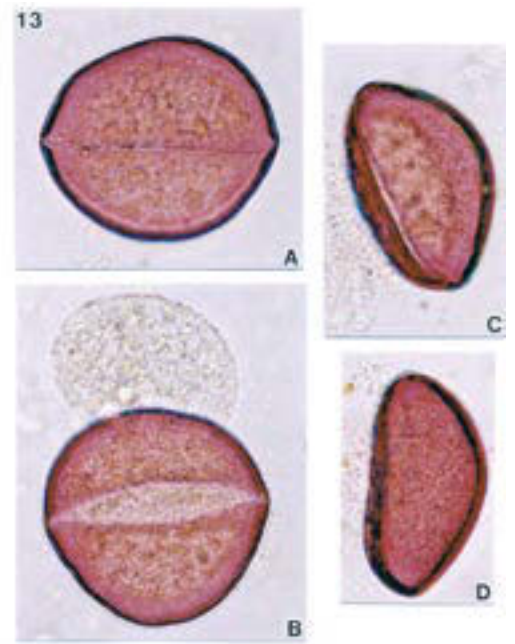

Fig 13. Pollen grains of *Asphodelus albus*; in polar view (A, B) and in equatorial longitudinal view (C, D); A, B – x 800; C, D – x 760.

The nectar secreted by the white asphodel flowers was characterised by a relatively high concentration of sugars in the range between 28.2% and 37.2%, with the average sugar content of 33.6%. *Asphodelus albus* plants nectared abundantly. The weight of nectar secreted by one flower ranged from 5.2 mg up to 12.8 mg, with the average value of 7.9 mg. It was calculated that there was 422 mg of sugars in the nectar from 100 flowers (Tab. 1).

Table 1

Value flow of *Asphodelus albus* flower.

Nectar secretion and weight of pollen grains					
Concentration of sugars in nectar			min. - max.	(%)	28.2 - 37.2
			$\bar{x}$		33.3
Weight of	nectar	min. - max.	from 10 flowers	(mg)	52 - 128
		$\bar{x}$			79.1
	sugars				42.2
	pollen grains		from 100 stamens		33.8
			from 10 flowers		2.0

Numerous insects, among other things bees visiting the white asphodel flowers, also collected pollen, in addition to nectar. The average weight of pollen obtained in the investigation of 100 stamens was 33.8 mg, and 2 mg of pollen was obtained from 10 flowers (Tab. 1). Results relating to the content of nutritive attractants in the white asphodel flowers suggest that it is a good source of food for bees and other pollinating insects in the climatic conditions of Poland.

Asphodelus albus pollen grains were yellow coloured. They were heteropolar, monocolpate (Fig. 13). The colpus extends on the distal pole and covers the whole length of the equatorial longitudinal axis (EL) of the grain. These grains were characterised by the *psilate-perforate* surface of the exine. On the distal pole, small surface folds were visible. In terms of the size of pollen grains, *Asphodelus albus* was classified among large ones. The average dimensions of grains were as follows: P = 42.4 µm, EL = 60.5 µm, ET = 58.8 µm. In most of the measurements, grains in which the length of the equatorial longitudinal axis (EL) was larger than the length the equatorial transverse axis (ET) were recorded. The ET/EL ratio was 1.03, what indicates their spherical shape in the polar view. In the equatorial longitudinal view, these grains had a plano-convex shape. Grains with the equatorial transverse axis longer or grains with the abovementioned axes equal (EL=ET) were also met. Based on the P/EL shape ratio, which was 0.7, *Asphodelus albus* pollen grains were determined to be oblate. Pollen grains of this species demonstrated high viability amounting to 98% (Tab. 2).

Table 2

Characteristics of *Asphodelus albus* pollen grains.

Feature of pollen grains				
Length of axis	equatorial longitudinal (EL)	min.- max.	(µm)	50.10 - 65.13
		$\bar{x}$		60.50
	equatorial transverse (ET)	min.- max.		50.10 - 65.13
		$\bar{x}$		58.81
	polar (P)	min. - max.		38.41 - 46.76
		$\bar{x}$		42.45
P/EL				0.70
EL/ET				1.03
Pollen grains		alive	%	98
		sterile		2

DISCUSSION

Septal nectaries of *Asphodelus albus* secret nectar through three openings situated in the upper part of the ovary. Earlier studies relating to *Asphodelus aestivus* showed that the outlets of the septal nectaries in this species were located in the middle of the height of the ovary. Spherical wax structures occurred on the surface of the epidermis lining the secretory openings of the nectaries, but no stomata were found to be present (Weryszko-Chmielewska and Sawidis, 2005).

The nectar secreted by the secretory cells of the white asphodel was characterised by a relatively high concentration of sugars (33.3%). Similar results of studies conducted in different years, relating to the content of sugars in *Asphodelus albus* (49.5%), were obtained by Żuraw (2005a). But the concentrations of sugars in the nectar secreted by flowers of several populations of *Asphodelus aestivus* in the conditions of Spain were in the range 38.13–91.86%, whereas their weight was on the average 2.25 mg/per flower (Lifante, 1996c).

When analysing the value of nutritive attractants of *Asphodelus albus*, it was found that the flower of this species produces on the average 4.2 mg of sugars and 0.2 mg of pollen. Thus, the weight of sugars from one *A. albus* flower was higher than for *A. aestivus* studied by Lifante (1996c). This fact allows *A. albus* to be included among valuable pollen- and nectar-producing plants. When comparing the weight of sugars contained in the nectar of the white asphodel flower with the secretion of flowers also producing septal nectaries in several taxa from this class of monocotyledonous plants, it can be stated that the sugar efficiency of the *Asphodelus albus* flower was higher than the yield of *Acidanthera bicolour* (Weryszko-Chmielewska et al., 2003) and smaller than that of *Asphodeline lutea* and *Allium ursinum* (Żuraw, 2005a, b). In southern Europe variety honey from *Asphodelus* nectar is known (Cherchi et al., 1995; Floris et al., 1996; Prota et al., 1997).

Somerville and Nicol (2002) studied the chemical composition of pollen and they found that *Asphodelus fistulosus* pollen collected by bees contained a high concentration of potassium (38000 mg kg^{-1}). This value exceeded sevenfold the average value of this element in pollen loads from pollen grains of other plants. The white asphodel flowers with a high nutritive value attract numerous pollinating insects, primarily bees and bumblebees (Obeso, 1992; Żuraw, 2005). According to Lifante (1996c), the percentage share of insects visiting *Asphodelus sativus* flowers varied depending on the population of this taxon and the period of observation. At three different dates of investigation, the highest percentage shares of the following insects were recorded: *Apis mellifera* (91%), *Apidae* (73%) and *Scolias* sp. (83%).

Based on the morphological analysis of monocolpate pollen grains of the white asphodel, they were classified as large (P = 42.4 µm, EL = 60.5 µm and ET = 58.8 µm) with an oblate shape. According to literature data, the dimensions of pollen grains of several populations of *Asphodelus albus* are in the following ranges: P (26–44 µm), EL (57–69 µm) and ET (58–71 µm), whereas their average values were as follows,

respectively: 35 µm, 58.3 µm and 61 µm (Lifante, 1996a, b). When describing the size of pollen grains of the white asphodel, Beug (2004) mentions two dimensions: minimum (52.6 µm) and maximum (73.1 µm). Comparing literature data with the results of the studies conducted, it can be stated that the dimensions of *A. albus* pollen grains obtained in the study are to some extent approximate to the size of pollen grains of this species mentioned by Lifante (1996a, b). The varied length of the EL and ET equatorial axes of pollen grains of the taxa studied and of those described in literature on other species from the *Asphodelus* genus explain the different shapes of grains in the polar view, which Campo (1959) and Lifante (1996a, b) define as spherical to elliptical and in terms of their size they classify them as large, rarely medium.

Beug (2004) classifies *Asphodelus albus* pollen grains in the *Asphodelus* group. Lifante (1996a), when investigating pollen of sixteen species from the *Asphodelus* genus, distinguished four types of grains in morphological terms. In the first type, he included *Asphodelus album* pollen, which was isobisymmetrical with the EL/ET proportion ranging 0.78–1.12. In the polar (p.v) and equatorial optical (e.o.s) views, grains had a spherical shape, biconvex in the equatorial transverse view (e.t.v) and from biconvex to plano-convex in the equatorial longitudinal view (e.l.v). Pollen grains in this group are shaped from very oblate to slightly oblate with the P/ET average ratio in the range of 0.36–0.85. In terms of the size, these are large grains with the following dimensions: P=21–51µm, EL= 45–79 µm, ET= 50–80 µm.

The exine surface observed in a light microscope was defined as *psilate-perforate*. Other authors who analysed the surface sculpture of *A. albus* pollen grains in an electron microscope state that it is *psilate-perforate* and *undulate* in the distal part, whereas the surface of the colpus is *psilate* (Erdtman, 1952; Lifante, 1996b; Kosenko et al., 1999; Beug, 2004).

REFERENCES

Beug H.J., 2004. Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete. *Verlag Dr. Friedrich Pfeil*, München.

Campo M., 1959. *Asphodelus tenuifolius* Cav. (Liliaceae). In: Polen et Spores. Muséum National d'Histoire Naturelle, 1: 49-52.

Cherchi A., Porcu M., Spanedda L., Tuberoso C.I.G., Cosentino S., Palmas F., 1995. Identification of parameters useful for the characterization and evaluation of typical Sardinian honeys: asphodel, thistle and strawberry tree. Rivista di Scienza dell'Alimentazione, 2(4): 523-534.

Erdtman G., 1952. Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist and Wiksell, Stockholm.

Lifante D.Z., 1996a. Inter- and intraspecific variation in pollen size in *Asphodelus* section *Asphodelus* (Asphodelaceae). Grana, 35: 97-103.

Lifante D.Z., 1996b. Pollen morphology of *Asphodelus albus* L. (Asphodelaceae): taxonomic and phylogenetic inferences at the infrageneric level. Grana, 35: 24-32.

Lifante D.Z., 1996c. Reproductive biology of *Asphodelus albus* (Asphodelaceae). Pl. Syst. Evol. 200: 177-191.

Floris I., Prota R., Fadda L., 1996. Quantitative pollen analysis of typical Sardinian honeys. Apicoltore Moderno, 87(4): 161-167.

Jabłoński B., Szklanowska K., 1979. Propozycje zmiany metody badań nektarowania roślin. Pszczeln. Zesz. Nauk. 23: 105-113.

Kosenko V.N., Sventorzhetskaya O.Y., 1999. Pollen morphology in the family Asphodelaceae (Asphodeleae, Kniphofieae). Grana, 38: 218-227.

Obeso J.R., 1992. Pollination ecology and seed set in *Asphodelus albus* (Liliaceae) in Northern Spain. Flora, 187(3-4): 219-226.

Obeso J.R., 1993. Selective fruit and seed maturation in *Asphodelus albus* Miller (Liliaceous). Oecologia, 93(4): 564-570.

Podbielkowski Z., 2003. Słownik roślin użytkowych. PWNiL, Warszawa.

Prota R., Floris I., Papoff C.M., 1997. Comparison of the chemical and physical characteristics of Sardinian and Corsican honeys. Apic. Mod. 88(2): 51-59.

Somerville D.C., Nicol H.I., 2002. Mineral content of honeybee-collected pollen from southern New South Wales. Aust. Jour. Exp. Agric. 42(8): 1131-1136.

Szweykowska A., Szweykowski J., 1993. Słownik botaniczny. Wiedza Powszechna, Warszawa.

Utrilla M.P., Cabo J., Jimenez J., Miro M., 1989. Antraquinones in *Asphodelus albus* Miller ssp. *albus*. Pharmazie, 44(5): 358-359.

Warakomska Z., 1972. Badania nad wydajnością pyłkową roślin. Pszczel. Zesz. Nauk. 16: 63-90.

Weryszko-Chmielewska E., Sawidis T., 2005. Morfologia i anatomia nektarników przegrodowych *Asphodelus aestivus* Brot. V Ogólnopolska Konferencja Naukowa. „Biologia kwitnienia roślin i alergie pyłkowe". Streszczenia, Lublin, 9-10 listopada: 37.

Weryszko-Chmielewska E., Masierowska M., Laskowska H., 2003. Budowa nektarnika acidantery dwubarwnej murielskiej (*Acidanthera bicolor* var. *murielae* Perry). Ann. Univ. Mariae Curie Skłodowska, sect. EEE, 13: Hortic 123-127.

Żuraw B., 2005a. Nektarowanie złotogłowu białego *Asphodelus albus* Mill. i złotnicy żółtej *Asphodeline lutea* L. (Asphodelaceae). V Ogólnopolska Konferencja Naukowa. „Biologia kwitnienia roślin i alergie pyłkowe". Streszczenia, Lublin, 9-10 listopada: 35.

Żuraw B., 2005b. Sekrecja i resorpcja nektaru w kwiatach czosnku niedźwiedziego (*Allium ursinum* L.). V Ogólnopolska Konferencja Naukowa. „Biologia kwitnienia roślin i alergie pyłkowe". Streszczenia, Lublin, 9-10 listopada: 40.

Atraktanty pokarmowe dla owadów w kwiatach *Asphodelus albus* Miller

Streszczenie

Badania kwiatów *Asphodelus albus* Miller przeprowadzono na terenie Ogrodu Botanicznego UMCS w Lublinie w latach 2004–2005. W mikroskopie stereoskopowym określono położenie nektarników kwiatowych. Obfitość nektarowania badano metodą pipetową opisaną przez Jabłońskiego i Szklanowską (1979). Do oznaczeń

wydajności pyłkowej kwiatów zastosowano metodę eterową Warakomskiej (1972). Żywotność pyłku obliczono w próbie 400 ziaren po zabarwieniu acetokarminem. Wykonano pomiary ziaren pyłku: określono długość osi biegunowej (P) oraz osi równikowej podłużnej (EL) i poprzecznej (ET). W kwiatach *Asphodelus albus* występują trzy gruczoły nektarnikowe położone w przegrodach zalążni, które mają ujścia usytuowane w górnej części zalążni. Sekrecja nektaru rozpoczyna się w pękającym pąku i trwa do fazy więdnięcia listków okwiatu. Jednobruzdowe ziarna pyłku *Asphodelus albus* pod względem wielkości zaliczono do dużych, zaś ich kształt określono jako spłaszczony, a w położeniu biegunowym kolisty. Pyłek w warunkach klimatycznych Polski wykazał wysoką żywotność (98%). Rośliny *Asphodelus albus* są wartościowym źródłem pokarmu dla owadów zapylających, gdyż jeden kwiat wytwarzał średnio 4,22 mg cukrów i 0,2 mg pyłku.