

Original Article

BOTANICAL CHARACTERISTICS OF POLISH HONEYS FROM NATURA 2000 HABITATS

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Abstract

Eighteen samples of honeys which were harvested over several beekeeping seasons from apiaries located in the area of the "Kózuki" Nature Reserve (central-eastern Poland) were the subject of the present study. The "Kózuki" Nature Reserve is included in the European Ecological Network Natura 2000 program. A microscopic analysis of the pollen sediment in the honeys showed the presence of 61 pollen types from 32 botanical families in the investigated material. There were represented by nectariferous (72.1%) and non-nectariferous plants (27.9%) and both entomophilous and anemophilous ones. The total number of pollen taxa in individual samples ranged from 13 to 37. The main sources of nectar from trees and shrubs were: *Frangula alnus*, *Prunus*, *Robinia pseudacacia*, *Rubus*, *Salix*, *Tilia*. The main sources of nectar from herbaceous plants were: *Anthriscus*, *Brassicaceae*, *Caryophyllaceae*, *Centaurea cyanus*, *Taraxacum*, and *Trifolium repens*. Four unifloral honeys (three fruit tree honeys and one lime honey) and fourteen multifloral honeys, with a significant percentage of pollen from several nectariferous plant taxa, were distinguished in the studied material.

Keywords: botanical origin, honeys, Network Nature, Poland, pollen analysis.

INTRODUCTION

Microscopic pollen analysis is one of the methods that enable the botanical and geographical origin of bee products to be identified. The presence of pollen grains of various taxa in the sediment is also an important source of information concerning food resources for honey bees and other Apidae in the vicinity of an apiary. In Polish research articles on pollen analysis of bee products, honeys are the most frequent object of interest. The microscopic analysis of bee honeys in Poland was started in the second half of the last century by Demianowicz and Demianowicz (1955) as well as by Demianowicz (1961) who developed a method for harvesting unifloral honeys. The existing research on the pollen content in bee honeys was conducted in several regions of Poland by, *inter alia*, Lecewicz (1984) Warakomska (1996) Wróblewska et al. (2006) Wróblewska and Warakomska (2009) and Stawiarz and Wróblewska (2010, 2012).

The aims of the present study were to determine the taxonomic composition of pollen and based on pollen spectrum, to establish the nectar flora important

for honey bees as well as to distinguish specific and multifloral honeys obtained in the area of the "Kózuki" Nature Reserve covered by the Natura 2000 program. The reserve is located within the boundaries of the "Podlasie Bug Gorge" Landscape Park. The Bug River Valley is considered to be an ecological corridor of European importance. The protection of its ecological structure and biological diversity is of special significance for the entire European Union (Faliński et al., 2000; Landsberg, 2002). The study area is located in Masovia province which belongs to a group of regions which does not have a very high honeybee-colony density. The number of bee colonies per 1 km² is 2.7 here, whereas the average all over is 4.2, and for all EU countries it is 3.2 (Semkiw, 2012). In 2012 and 2013, honey production in Masovia reached 1786.0 and 1672.9 tons, respectively, and was higher than the national average (Semkiw, 2012, 2013). The studied region is one of the least industrialised regions in Poland and therefore the flora in this area can offer nectar rewards of high ecological quality to insects. Honeys harvested from this area could obtain the so-called health food certificate. Among all the bee products

honey is often used in biomonitoring of environmental contamination. Honey is often used to evaluate the biological characteristics of the area (Porrini et al., 2003; Bogdanov, 2006). It was Borowska (2011) who drew attention to the favorable environmental conditions for keeping ecological apiaries in Natura 2000 sites in Poland. Among 38 honeys registered in the national list of traditional products by the Ministry of Agriculture and Rural Development, 5 honeys are protected in the EU as a traditional regional product. In Europe, microscopic analysis of bee products from protected natural areas has been carried out in Spain (Terrab et al., 2003; Andrés et al., 2004; 2006), Portugal (Morais et al., 2011), and Lithuania (Čeksterytė et al., 2013).

MATERIAL AND METHODS

Collection of honey samples

Eighteen honey samples were collected for analysis over the period from 2008 to 2013. They

came from individual apiaries located in the area of the "Kózki" Nature Reserve (52°21'42.54"N-22°51'39.61"E), which is a protected area included in the European Ecological Network Natura 2000 (Fig. 1). This nature reserve, located in the Municipality of Sarnaki (Masovia province), occupies an area of 82.1 ha. Geographically, this reserve is situated in the province of the Central Polish Lowlands (Niziny Środkowopolskie), South Podlasie Lowland (Nizina Południowopodlaska) macroregion, and Siedlce Upland (Wysoczyzna Siedlecka) mezoregion (Kondracki, 2009). Various plant communities with many plant species, both herbaceous and woody, are found in the area of the reserve (Marciniuk, 2009; Warda et al., 2011; Wróblewska et al., 2012; Kulik et al., 2013). The characteristic landscape features include sandy grassland patches which occur frequently in the immediate vicinity of meadows and pastures as well as forest and thicket communities (Dombrowski and Wereszczyńska, 1991; Warda et al., 2011).

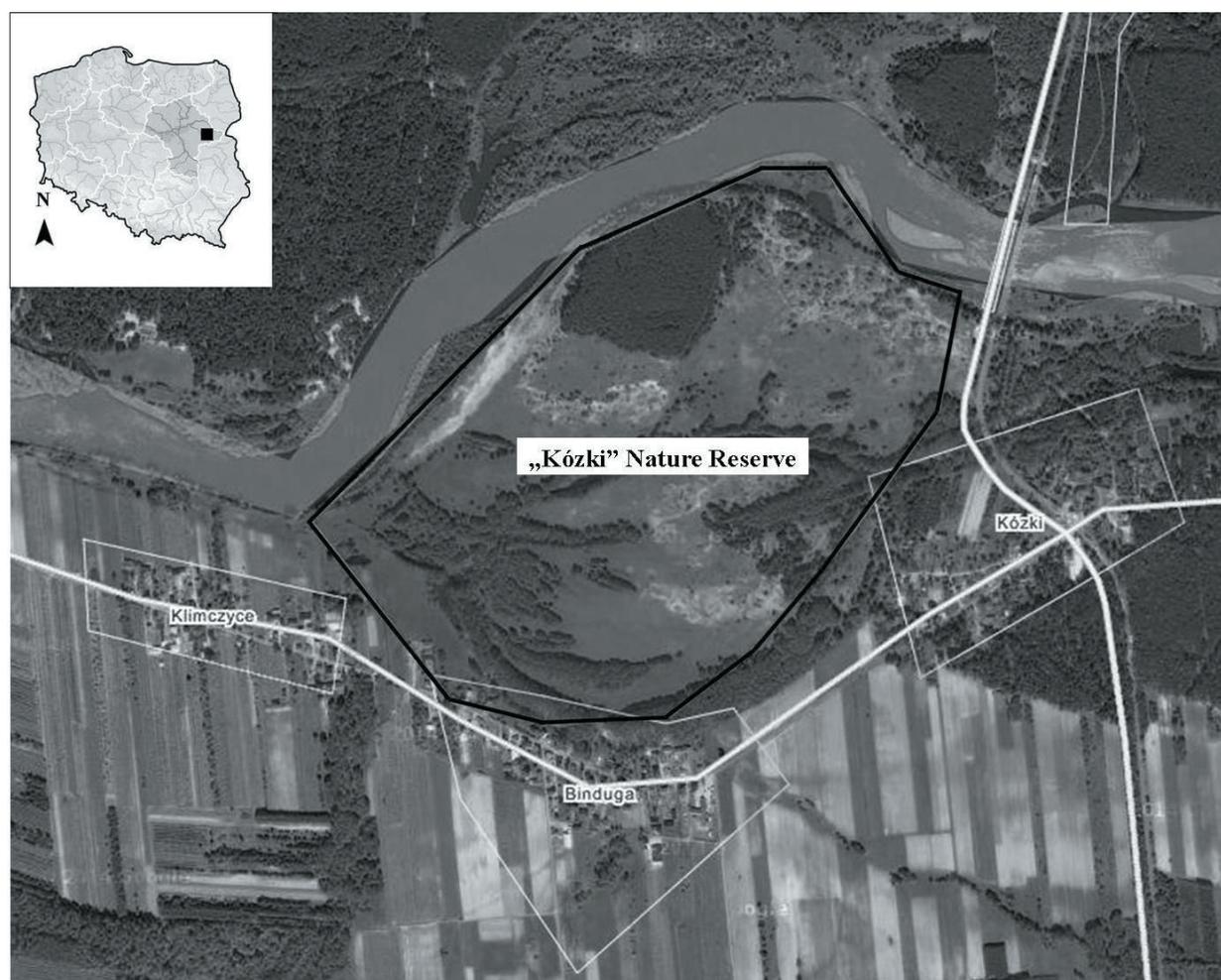


Fig. 1. Map of the study area.

Melissopalynological study

The microscopic analysis of the honeys was performed following the recommendations of the International Commission for Bee Botany of IUSB (Louveaux et al., 1978), in accordance with the requirements of the International Honey Commission (IHC) (von der Ohe et al., 2004) and the guidelines of the Polish Standard "Bee Honey" (PN-88/A-77626, 1988). In each slide, at least 300 pollen grains were counted (Moar, 1985). Pollen grains were identified, if possible, to the level of species (e.g. *Frangula alnus*), type of structure (*Prunus* type), genus (*Tilia*), or family (Caryophyllaceae). In relation to the representatives of Brassicaceae and Poaceae, the term "other" (other Brassicaceae, other Poaceae) was additionally used. This term includes other pollen taxa from these families present in the honey sediment which were not identified to the genus or species level. During the identification process, pollen keys (Zander, 1935, 1937; Sawyer, 1988; Faegri and Iversen, 1993; Ricciardelli d'Albore, 1998) and reference slides were used. In the group of nectariferous pollen, the following classification of pollen percentages was used for each sample analysed: dominant pollen >45%; secondary pollen 16 - 45%; important minor pollen 3 - 16%; minor pollen <3%. The nomenclature of pollen taxa followed the guidelines of Zander (1935, 1937). The pollen of particular taxa was assigned to specific botanical families. In individual microscopic slides, the percentage of pollen from nectariferous and non-nectariferous plants was determined. Based on the pollen analysis results, unifloral and multifloral honeys were distinguished in the investigated material. The honeys were classified on the basis of the pollen percentages of particular taxa in the group of nectariferous plants. As far as the unifloral honeys are concerned, in the case of most of them, the pollen of a nectariferous dominant taxon must reach a percentage of at least 45% (Zander, 1935, 1937; Warakomska, 1987; Polish Standard PN-88/A-77626, 1988; Wróblewska, 2002). Due to the low contamination of lime nectar with its own pollen, unifloral lime honey should contain at least 20% of *Tilia* pollen. In the fruit tree honeys, the percentage of pollen grains of *Prunus* and *Malus* types was calculated together.

RESULTS

Pollen spectrum

Pollen grains of 61 taxa were found to be present in the sediments of the honey samples, among

which nectariferous plants accounted for 73.8%, while non-nectariferous plants, represented by the entomophilous and anemophilous species, made up 26.2 % (Fig. 2 - 3). The presence of 13 - 37 pollen taxa in total, was found in individual samples. The pollen of 9 - 24 taxa originated from nectariferous plants, while the pollen of 2 - 13 taxa originated from non-nectariferous plants. The identified pollen grains belonged to 32 botanical families (Fig. 4). The following were represented in the greatest numbers: Asteraceae, Fabaceae and Rosaceae, and seven different pollen types were recorded within each of them (Fig. 4).

From among the 45 nectar-producing taxa from 23 botanical families, *Frangula alnus*, *Prunus* type, and *Salix* reached the highest frequency in the studied material; their pollen grains were present in all the honeys investigated. In this group, the following also showed a high frequency (more than 50%): Brassicaceae (including *Brassica napus*), *Centaurea cyanus*, *Rubus* type, *Trifolium repens*, *Anthriscus* type, *Robinia pseudacacia*, *Tilia*, *Taraxacum* type, and Caryophyllaceae (Fig. 2). Non-nectar-producing plants were represented by 12 botanical families which included 16 pollen types, among which *Filipendula* and Poaceae showed a frequency of more than 50% (Fig. 3). The percentage of nectariferous pollen in the investigated honeys and the percentage of non-nectariferous taxa in individual samples are shown in Table 1 and in Figure 2.

Nectariferous flora

The microscopic analysis results revealed that the honey samples were characterised by rich and varied floral pollen assemblages. Most of the plant taxa (73.8%) present in the honeys are a source of nectar food for bees. In the group of eleven recorded nectar-producing tree and shrub taxa, *Prunus* and *Salix* can be considered to be spring nectar sources in the study area. *Frangula alnus*, *Robinia pseudacacia*, *Rubus*, and *Tilia*, which bloom in late spring and early summer, provide similarly abundant nectar rewards.

Among the trees and shrubs, *Prunus* and *Salix*, which provide nectar and pollen during the early spring period when the food requirement of a bee colony is highest, can be considered to be the main sources of this raw material for honey. *Frangula alnus*, *Robinia pseudacacia*, and *Tilia*, which provide food to insects at the turn of spring and early summer, are also an abundant source of nectar. *Rubus*, commonly found in different regions of Poland, also offers good nectar rewards. Among the nectariferous taxa representing

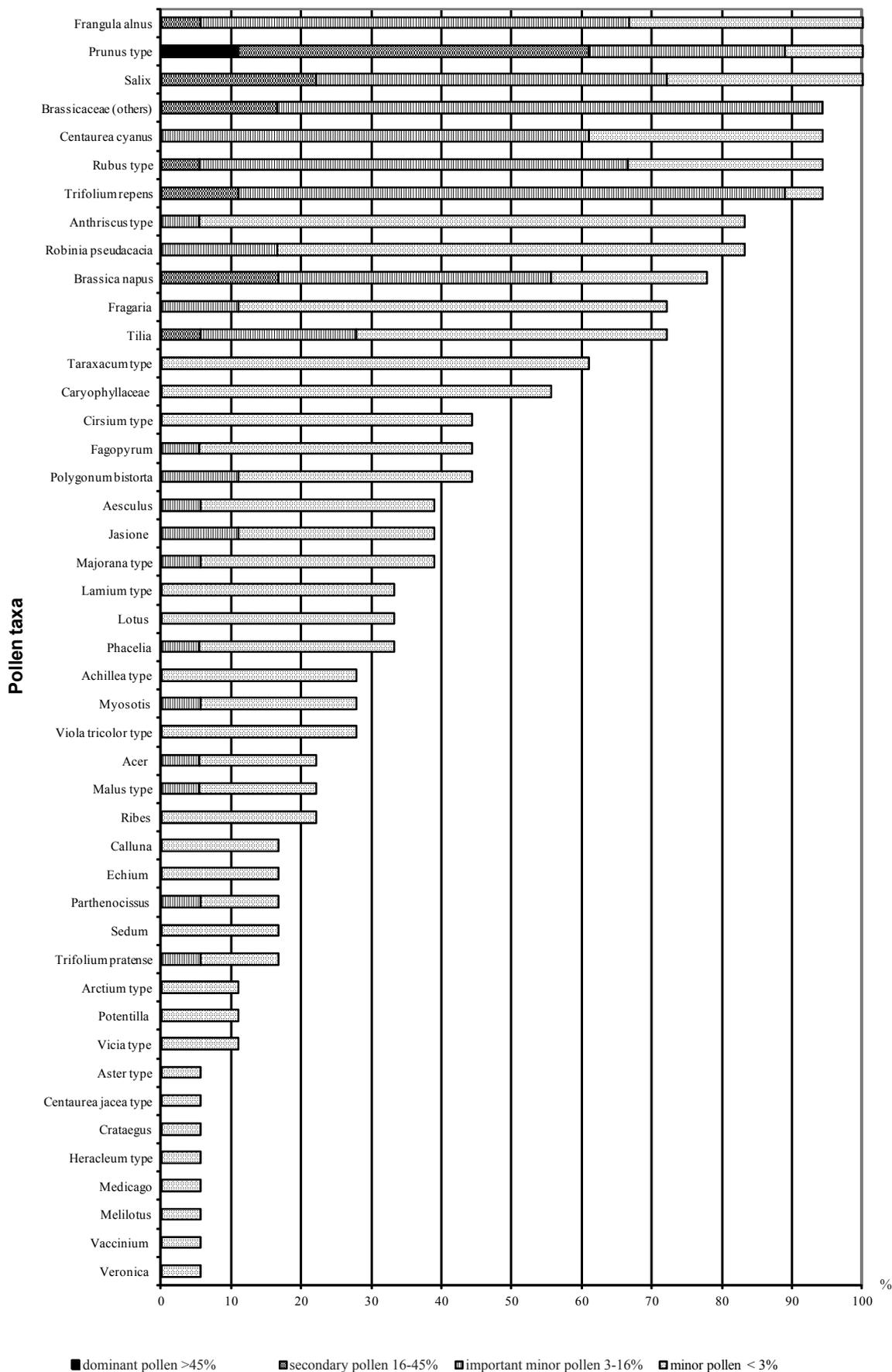


Fig. 2. Pollen frequency of nectariferous plants and its contribution in the microscopic image of the examined honeys (%).

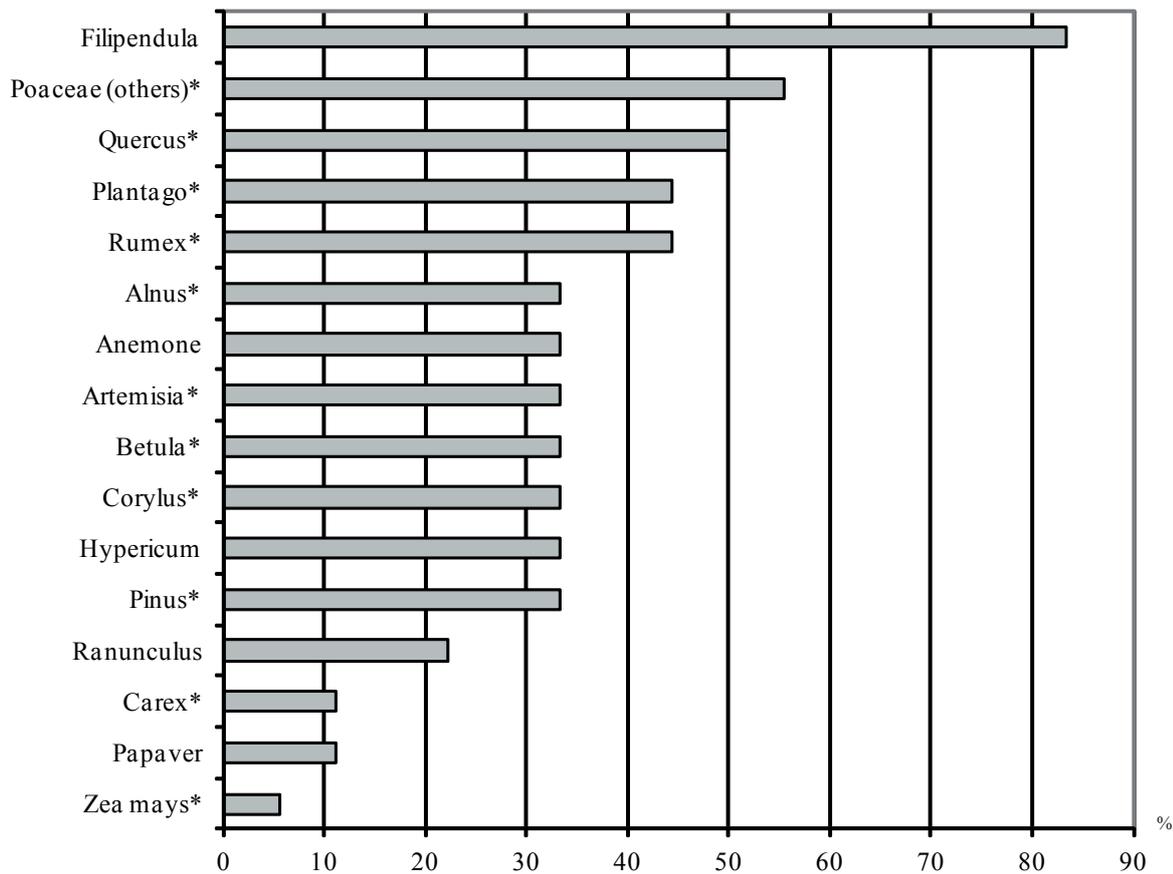


Fig. 3. Pollen frequency of non-nectariferous plants in the examined honeys (%).
* - anemophilous taxa

herbaceous plants, Brassicaceae (including *Brassica napus*), *Trifolium repens*, and *Anthriscus*, *Centaurea cyanus*, Caryophyllaceae, and *Taraxacum*, whose pollen reached a frequency ranging 55 - 95%, belong to the most important taxa within the study area. Flowers of the above-mentioned plant taxa provide food to insects in spring and summer during the full flowering period. Among the other pollen grains recorded in the honeys, herbaceous taxa were by far the most predominant, but they reached a much lower frequency and lower pollen percentages in the investigated material (Fig. 2). Nevertheless, they supplement food sources for insects during various periods of the beekeeping season.

Botanical classification of honeys

Four unifloral honeys and fourteen multifloral honeys were distinguished. The group of unifloral honeys included three fruit tree honeys and one lime honey. Two fruit tree honeys were determined to be *Prunus* honeys. The percentage of *Prunus* type pollen reached in the two fruit tree honeys was 49.76% and 52.35%, respectively. The third fruit tree honey was a mixed honey and the combined percentage of *Prunus* type and *Malus* type pollen

was 53.44%. In the lime honey, the percentage of *Tilia* pollen grains was 28.41% (Tab. 1). In the pollen spectrum of the other fourteen honeys identified as multifloral, from 20 to 37 pollen types were found to be present in individual samples. Nectariferous taxa accounted for 81.56 - 97.07%. A significant proportion (25 - 45%) of pollen from several taxa was found in this group of honeys. The pollen types were: *Prunus* type (in seven samples), *Salix* and *Brassica napus* (three), *Trifolium repens* (two), and *Rubus* type (one) (Tab. 1). The pollen percentages for more important nectariferous taxa and a fragment of the microscopic image of some of the honeys are included in the Table 1 and in Figure 5.

DISCUSSION

The microscopic analysis results showed a varying composition of floral pollen in the sediment of the honeys. Among the 61 pollen types recorded, nectariferous plants, which provide bees with the raw material for honey, accounted for 72.1%. *Frangula alnus*, *Prunus* type, and *Salix* showed the highest frequency (100%) in the group of nectariferous taxa. In Poland and other European countries, these taxa

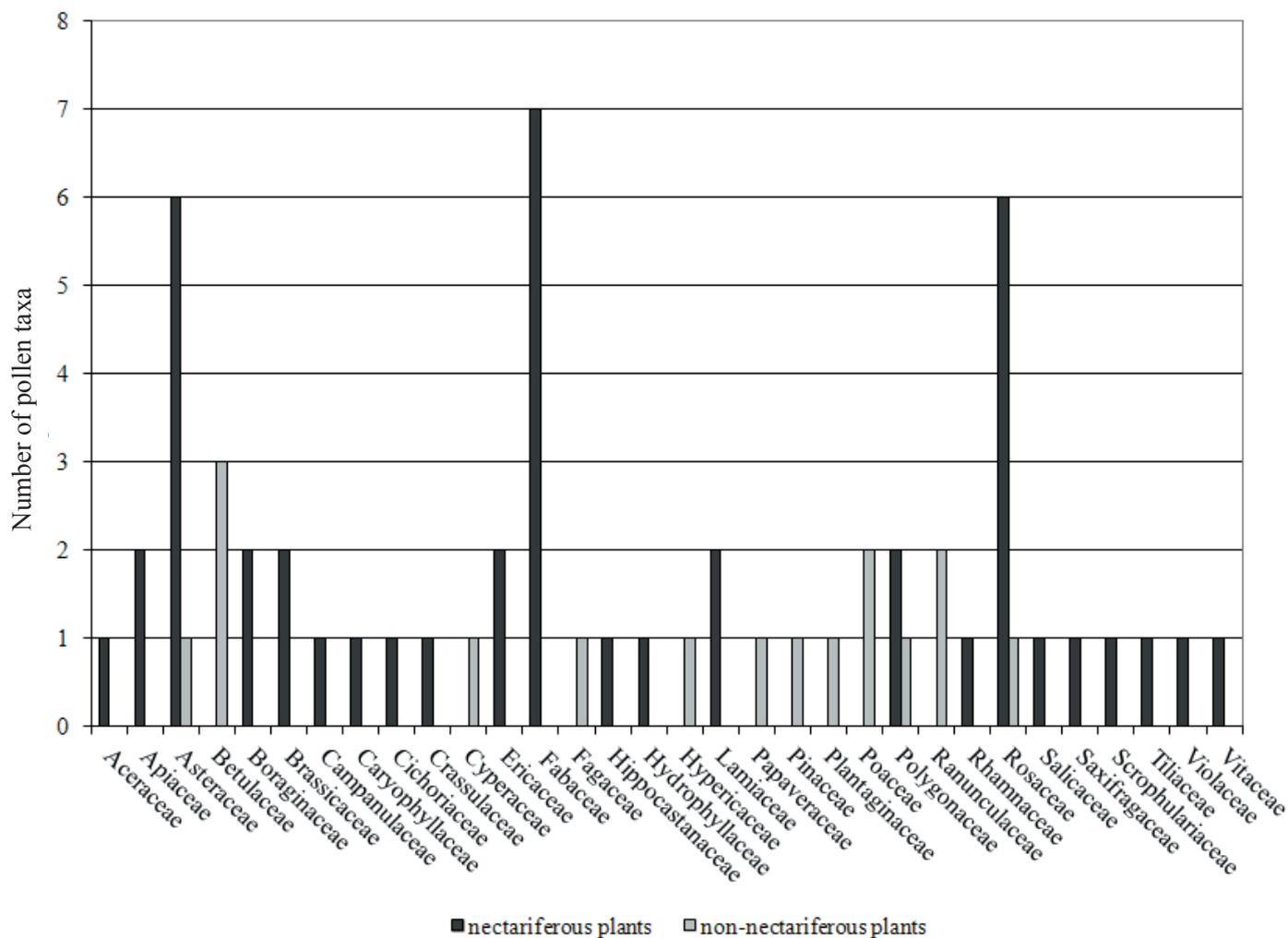


Fig. 4. Number of pollen taxa within the botanical families.

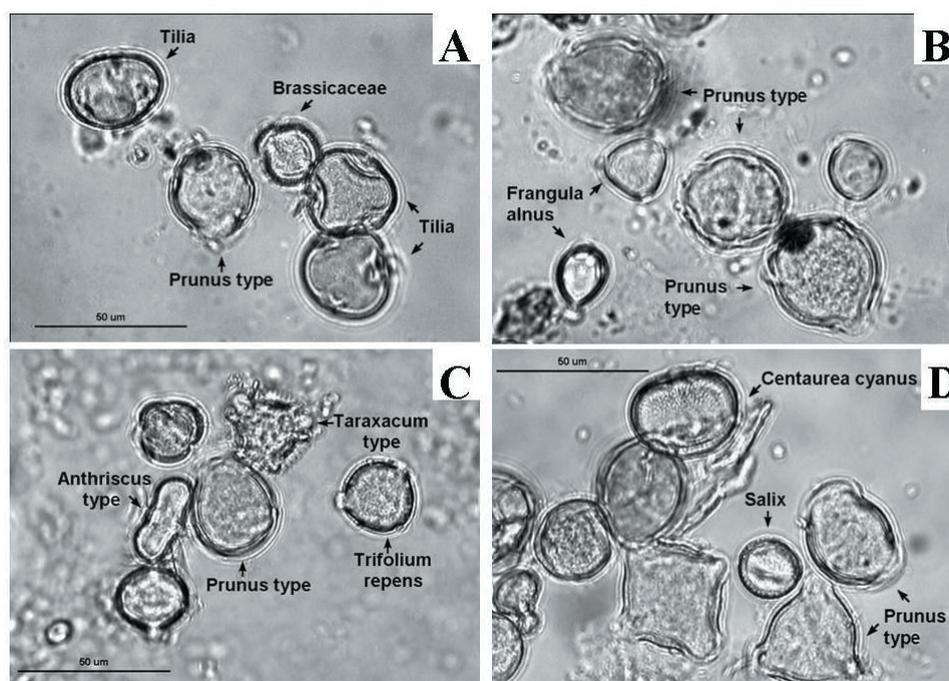


Fig. 5. A part of the microscopic image of selected honeys: A - lime (2/2011), B - fruit tree (4/2012), C - multifloral (1/2010), D - multifloral (1/2013).

produce abundant nectar when weather conditions were favorable and the high frequency and percentage of their pollen in honeys are confirmed in research articles (Warakomska, 1987; Persano Oddo et al., 2004; Stawiarz, 2006; Wróblewska et al., 2006; Salonen et al., 2009; Wróblewska and Warakomska, 2009; Sabo et al., 2011; Čeksterytė et al., 2013; Dobre et al., 2013). Brassicaceae, *Centaurea cyanus*, *Rubus* type, *Trifolium repens*, *Anthriscus* type, *Robinia pseudacacia*, *Tilia*, *Taraxacum* type, and Caryophyllaceae, with a pollen frequency of more than 50%, are also attractive sources of pollen to insects. The other taxa recorded in the honeys are

supplementary food resources for Apidae. Among the 32 botanical families, Asteraceae, Fabaceae, and Rosaceae were represented in the greatest numbers in the pollen spectrum. The abundance of the representatives of these families in the study area was confirmed by the observations of Marciniuk (2009). From ten botanical families, Marciniuk (2009) noted that the three above mentioned ones occur most abundantly in marginal habitats of the Podlasie Bug River Gorge (Podlaski Przełom Bugu). Flowers of many representatives of these families are readily visited by insects taking advantage of the nectar as reported by many authors in numerous publica-

Table 1.

Pollen contribution in honeys

Sample No. (harvest season)	Major nectariferous taxa	Non-nectariferous taxa in total (%)	
fruit tree honeys			
4/2008 (May)	<i>Prunus</i> type	38.0	6.4
	<i>Malus</i> type*	15.4	
	<i>Salix</i>	34.6	
2/2012 (June)	<i>Prunus</i> type	49.8	5.3
4/2012 (June)	<i>Prunus</i> type	52.3	1.9
lime honey			
2/2011 (July)	<i>Tilia</i>	28.4	24.7
	Brassicaceae (others)	22.3	
multifloral honeys			
1/2008 (July)	<i>Brassica napus</i>	18.1	4.1
2/2008 (July)	<i>Frangula alnus</i>	18.6	8.1
3/2008 (July)	<i>Salix</i>	25.1	2.9
1/2010 (June)	<i>Trifolium repens</i>	36.3	3.4
	<i>Brassica napus</i>	34.4	
1/2011 (July)	<i>Prunus</i> type	27.3	29.0
3/2011 (August)	<i>Rubus</i> type	43.0	18.4
1/2012 (July)	<i>Prunus</i> type	41.0	3.5
3/2012 (June)	<i>Brassica napus</i>	33.8	3.8
	<i>Prunus</i> type	17.5	
5/2012 (August)	<i>Prunus</i> type	36.0	10.8
1/2013 (July)	<i>Salix</i>	40.8	8.2
	<i>Prunus</i> type	37.2	
2/2013 (July)	<i>Salix</i>	33.4	7.2
	<i>Prunus</i> type	33.2	
	Brassicaceae (others)	16.6	
3/2013 (August)	Brassicaceae (others)	19.5	16.1
	<i>Prunus</i> type	18.1	
4/2013 (June)	<i>Prunus</i> type	28.2	8.6
5/2013 (August)	<i>Trifolium repens</i>	21.2	29.7

dominant pollen >45%, secondary pollen 16 - 45%;* important minor pollen

tions evaluating the apicultural value of various plant species. The many authors include: Crane et al. (1984), Wróblewska et al. (1993), and Farkas and Zajáč (2007).

In the group of non-nectariferous plants, pollen grains of the entomophilous taxon *Filipendula* as well as of the anemophilous taxa Poaceae and *Quercus* were most frequently found. The presence of these pollen grains is often recorded in the pollen spectrum of the honeybee honeys as an effect of secondary contamination (Warakomska, 1985; 1996; Wróblewska, 2002; Andrés et al., 2004; Stawiarz, 2006; 2009; Jerković et al., 2011; Dobre et al., 2013).

From among the eighteen samples, in the three fruit tree honeys, the *Prunus* type pollen grains were largely predominant, and reached a dominant proportion (>45%) in two samples, while in one sample this pollen type was secondary (16 - 45%). One sample of mixed honey from the *Prunus* and *Malus* source, was characterised by a total percentage of 53.44% for the pollen of both these taxa. In the studied material, *Prunus* type pollen grains reached a 100% frequency which was attributable to the abundant occurrence of trees and shrubs of the genus *Prunus* in the study area (Wróblewska et al., 2012). In the species composition of the dendroflora in the Kózki reserve, the family Rosaceae was represented in the greatest numbers. Within the Rosaceae family *Prunus spinosa* and *Prunus avium* were by far predominant. Single apple trees growing in the wild in this reserve can offer small *Malus* nectar rewards. In some European countries, under favorable weather conditions, bee keepers obtain honeys from fruit trees when the trees flower abundantly. Such honeys are harvested, among others, in Spain (Pérez-Arquillué et al., 1995; Persano Oddo et al., 2004), Croatia (Jerković et al., 2011), Lithuania (Čeksterytė et al., 2013), and Romania (Dobre et al., 2013) where various species of the genus *Prunus* are found in great numbers in the wild. In Poland, varietal honeys from fruit trees can only be obtained in some regions of the country, and only under favorable weather conditions for flowering and nectar production (Wróblewska, 2002; Wróblewska and Warakomska, 2009; Stawiarz and Wróblewska, 2012). Pollen from *Prunus* and *Malus* flowers is particularly valuable during the spring period when abundant food is necessary for the proper development of bee colonies.

The only lime honey in the investigated material contained 28.41% of *Tilia* pollen. From the genus *Tilia*, *Tilia cordata* was primarily recorded in the study area (Marciniuk, 2009). Due to the low contamination of lime nectar with its own pollen, in lime

honeys the percentage of *Tilia* pollen in the group of nectariferous taxa should reach at least 20% (Polish Standard PN-88/A-77626, 1988). The genus *Tilia* is represented by numerous species which in many European countries belong to major nectar-producing plants. These plants provide the raw material for the production of lime honeys (Persano Oddo and Piro, 2004; Persano Oddo et al., 2004). In Poland, lime honeys are harvested in different regions of the country (Warakomska, 1996; Wróblewska, 2002; Stawiarz, 2009; Wróblewska and Warakomska, 2009; Waś et al., 2011).

Microscopic analysis showed a much higher variation in the pollen assemblage in the multifloral honeys compared to the unifloral honeys. The number of pollen taxa in individual samples of the multifloral honeys ranged from 20 to 37, while in the unifloral honeys this range was from 9 to 18. In the multifloral honeys, 7 taxa were found in the secondary pollen group (16 - 45%). The *Prunus* type was found to be present in eight samples of these honeys, and this type was represented in the greatest numbers. Among the herbaceous plants, Brassicaceae and *Trifolium repens*, were present in the great numbers in the study area, and these plants provided large pollen rewards. The Brassicaceae and *Trifolium repens* pollen grains were secondary pollen in several honeys. *Brassica napus* nectar rewards probably originated from oilseed rape crops adjacent to the nature reserve.

Multifloral honeys are some of the most frequently harvested honeys in many European countries. In Poland, multifloral honeys have been the subject of research by among others, Warakomska (1996), Wróblewska et al., (2006), Wróblewska and Warakomska (2009), Stawiarz and Wróblewska (2010).

CONCLUSIONS

The results of the melissopalynological analysis of honeys showed that the area of "Kózki" Nature Reserve included in the European Ecological Network Natura 2000 was characterised by a diversity of flora which provides ecological food sources for honey bees for several months of the growing season. The most important nectariferous plant among the trees and shrubs were: *Frangula alnus*, *Prunus*, *Robinia pseudacacia*, *Rubus*, *Salix* and *Tilia*. The most important nectariferous plants among herbaceous taxa were: *Anthriscus*, Brassicaceae, Caryophyllaceae, *Centaurea cyanus*, *Taraxacum* and *Trifolium repens*.

In the study region, multifloral honeys were the most frequently harvested. In the examined material among the unifloral honeys there were: three fruit trees honeys from *Prunus* and *Malus*, and one lime honey from *Tilia*.

Environmental conditions on the Natura 2000 area are favorable for obtaining ecological honeys. The presence of honey bees as plant pollinators may contribute to the conservation of biodiversity in the Natura 2000 area.

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