

FOOD PLANTS OF *Bombus terrestris* L. DETERMINED BY PALYNOLOGICAL ANALYSIS OF POLLEN LOADS

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Received 22 November 2004; accepted 10 December 2005

S u m m a r y

In July of 2000 and 2001 pollen loads were collected from returning to the nest workers of *Bombus terrestris* and then insects were released. A total of 61 pollen load pairs were collected. Microscope preparations were made and subjected to palynological analysis. The analysis showed the occurrence of 29 pollen types. The species considered as principal forage plants were those which formed one-species pollen loads. They were: *Brassicaceae*, *Centaurea cyanus*, *Echium vulgare*, *Filipendula ulmaria*, *Lotus corniculatus*, *Hypericum*, *Plantago*, *Trifolium pratense* and *Trifolium repens*.

Keywords: *Bombus terrestris*, food plants, pollen loads, pollen analysis.

INTRODUCTION

The bumblebee (*Bombus* Latr.), alongside with the honeybee, belongs to principal pollinators. The importance of bumblebees in pollinating fodder pulses such as *Trifolium*, *Vicia*, *Medicago*, *Lotus* was confirmed by research of many investigators (among others Ruszkowski, Biliński 1969; Ruszkowski, Żak 1974). Palynological studies of pollen collected from bumblebee nests conducted by Brian (1951) as well as the analysis of pollen loads of bumblebees caught on flowers of many plant species (Anasiewicz, Warakomska 1977; Warakomska, Anasiewicz 1991) substantially enlarged the list of known forage species of those insects. The interest in bumblebees has received an additional boost since the time they were introduced to pollinate greenhouse crops, tomatoes in particular. *Bombus terrestris* proved to be especially valuable due to the relative ease with which it can be reared. The research into the artificial rearing of that species was started more than 30 years ago by Biliński (1973, 1976) and it has been

continued till the present day (Biliński 2002).

Ruszkowski and Żak (1974) in a pollen food list for *B. terrestris* and *B. lucorum* in Puławy, compiled based on records taken in the years 1961 - 1970 name 35 plant species visited by bumblebees throughout the season. Of those, 13 species make up the so-called major pollen food list and the remaining 22 species are on the minor food list. In an approximate pollen food list of *B. terrestris* and *B. lucorum* for the Lubelskie voivodeship (without Puławy) the investigators name 24 species of which 17 are taxons not recorded in the Puławy area. Ruszkowski and Żak list a total of 52 species visited by *B. terrestris* and *B. lucorum* in the Lubelskie voivodeship area.

Palynological analysis of pollen loads of bumblebees caught on *Vicia villosa* and *Vicia sativa* (Warakomska, Anasiewicz 1991) furnished evidence that part of the insects foraging on the flowers of that plant did not harvest pollen since no pollen was found in the pollen loads. During a two-year study among 277 bumblebees trapped on *Vicia villosa* there were 123

workers of *Bombus terrestris* of which 33 gathered pollen, including 14 foragers on *Vicia*. Likewise, on *Vicia sativa* among 187 bumblebee specimens belonging to 9 species there were 112 workers of *B. terrestris* of which 29 had pollen loads but only 5 of them contained *Vicia* pollen. Pollen analysis of the pollen loads formed by workers of *B. terrestris* trapped on two species of *Vicia* allowed the identification of 23 plant species from which bumblebees gathered pollen. Most frequently, the pollen loads were not homogeneous and contained pollen of several plant species.

In another study aimed at identifying food plants of bumblebees (*Bombus* Latr.) in the Lubelskie voivodeship (Anasiewicz, Warakomska 1977) a total of nearly 1.5 thousand insects were caught. Among them there were 189 pollen gatherers of which 48 belonged to *B. terrestris*. In pollen loads of the workers of that species 37 types of pollen were found from plants belonging to 18 families. The principal pollen source was *Trifolium pratense*. Pollen of *Lotus corniculatus*, *Trifolium repens*, *Hypericum*, *Papaver* and *Sinapis arvensis* was also found frequently.

Similar results were obtained by Brian (1951) when she analyzed palynologically pollen stores gathered in the nests of *B. lucorum*, *B. agrorum* (*B. pascuorum*) and *B. hortorum*. The investigator reported *Ericaceae*, *Trifolium repens*, *T. pratense*, *Lotus* and *Vicia* as the principal pollen plants of bumblebees.

MATERIAL AND METHODS

In the study of food plants of *Bombus terrestris* based on the palynological analysis of pollen loads conducted in the years 2000 and 2001 two colonies of *Bombus terrestris* were used. The colonies were raised in all-year-round rearing run for many years by the Apiculture Division of Research Institute of Pomology and

Floriculture in Puławy. In both years the colonies were set up in a house garden at the village of Skoki near the town of Dęblin. In July, returning to the nest workers with pollen loads were caught with an insect net. Pollen loads were carefully removed with a preparation needle and the insects were released. The pollen loads were put in labeled bottles. Twenty-nine pollen load pairs were collected on five sampling dates in the first year, 32 on seven dates in the second. Microscope preparations were made from 61 pollen loads collected over two years. The preparations were palynologically analyzed.

RESULTS AND DISCUSSION

Pollen analysis of the 29 pollen loads collected in the first year showed the presence of 22 pollen types (Table 3). In 10 pollen loads the pollen was homogeneous. Pollen of *Brassicaceae* accounted for half of the homogeneous (one-species) pollen loads. Two homogeneous pollen loads contained pollen of *Echium vulgare* and 1 pair of pollen load contained pollen of *Lotus corniculatus*, *Centaurea cyanus* and *Filipendula ulmaria* each. Each of the remaining 19 pollen loads contained pollen from 2 to 7 plant species. Based on the pollen analysis results a food list for *B. terrestris* was compiled (Table 1).

Pollen loads sampled on the first date (July 4) contained pollen from 7 plant species: *Symphytum officinale*, *Solanum tuberosum*, *Vicia*, *Brassicaceae*, *Echium vulgare*, *Filipendula ulmaria* and *Trifolium repens*. A week later pollen loads no longer contained *Symphytum*, *Solanum* and *Vicia*, but pollen of *Rubus*-type, *Centaurea cyanus* and *Lotus corniculatus* as well as pollen of *Rosaceae*, *Potentilla* and *Clematis* made their appearance only to disappear on later dates. Likewise, on later dates no pollen was found of *Echium vulgare* and *Filipendula ulmaria*, but on July 18 pollen

of *Hypericum*, *Phlox* and *Plantago* was found. The latter two types did not reappear on later dates.

Microscope preparations from pollen loads collected on July 25 no longer contained pollen of *Brassicaceae* and pollen of *Rubus*-type but contained pollen of *Veronica*, *Cichorium* and *Melilotus*, pollen types present only on that sampling date. Pollen loads sampled on the last sampling date contained pollen of *Hypericum*, *Lamium*, *Ranunculus* and *Verbascum*.

In pollen loads collected in the second year 16 pollen types were found (Table 3). Homogeneous pollen loads were formed from pollen of *Brassicaceae* (2 pairs), *Hypericum* (1 pair), *Plantago* (2 pairs), *Trifolium pratense* (1 pair), *Trifolium repens* (1 pair). The remaining pollen loads contained mixed pollen involving 2 to 6 types. Based on the results obtained in July a succession of food plants for *Bombus terrestris* was compiled (Table 2).

At the beginning of 2001 the workers of

Table 1

Succession of food plants of *Bombus terrestris* compiled based on the results of pollen loads collected in July of 2000

Pollen	Pollen load sampling dates				
	04.07	11.07	18.07	25.07	30.07
<i>Symphytum officinale</i>					
<i>Solanum tuberosum</i>					
<i>Vicia</i>					
<i>Brassicaceae</i>					
<i>Echium vulgare</i>					
<i>Filipendula ulmaria</i>					
<i>Trifolium repens</i>		→			
<i>Rosaceae</i>					
<i>Potentilla</i>					
<i>Clematis</i>					
<i>Rubus</i> -type					
<i>Centaurea cyanus</i>			→		
<i>Lotus corniculatus</i>			→		
<i>Phlox</i>					
<i>Plantago</i>					
<i>Hypericum</i>				→	
<i>Veronica</i>					
<i>Cichorium</i>					
<i>Melilotus</i>					
<i>Lamium</i>					
<i>Ranunculus</i>					
<i>Verbascum</i>					

→ - conjectural continuity of pollen harvest

Table 2

Succession of food plants of *Bombus terrestris* compiled based on the results of pollen loads collected in July of 2001

Pollen	Pollen load sampling dates						
	10.07	12.07	14.07	16.07	20.07	25.07	30.07
<i>Filipendula ulmaria</i>							
<i>Tilia</i>							
<i>Plantago</i>							
<i>Rubus</i> -type							
<i>Hypericum</i>							
<i>Helianthus</i> -type		→	→				
<i>Brassicaceae</i>	→						
<i>Trifolium repens</i>				→			
<i>Cichorium</i>				→			
<i>Cirsium</i> -type							
<i>Geranium</i>				→	→	→	
<i>Anthriscus</i> -type							
<i>Gramineae</i>					→		
<i>Lamium</i>							
<i>Lotus</i>							
<i>Trifolium pratense</i>							

→ - conjectural continuity of pollen harvest

Bombus terrestris formed pollen loads of pollen of *Filipendula ulmaria*, *Tilia*, *Plantago*, *Rubus*-type, *Hypericum*, *Helianthus*-type, *Brassicaceae* and *Trifolium repens*. After July 12 pollen of *Filipendula* and *Tilia* and on July 14 also that of *Plantago* and *Rubus*-type was missing from the pollen loads. Instead, pollen of *Cichorium*, *Cirsium*-type and *Geranium*, not recorded before, appeared. On July 16 pollen of *Anthriscus*-type and of *Gramineae* was found. Starting with July 20 the foragers no longer brought pollen of *Hypericum*, *Helianthus*-type, *Brassicaceae*, as well as that of *Cirsium*-type and *Anthriscus*-type. In the pollen loads of 20th July there was no pollen of *Geranium* and *Gramineae*. However, bumblebees were likely to continue

to forage on those plants since in the pollen loads sampled on later dates the pollen reappeared. Not recorded earlier, pollen of *Lamium*, *Lotus*, and *Trifolium pratense* was also found there.

During the two-year study a total of 29 pollen types were identified, nine of which occurred in both years (Table 3). Workers used 9 types of pollen to form homogeneous pollen loads. In both years such pollen loads were formed only of *Brassicaceae* pollen. Of the pollen of *Centaurea cyanus*, *Echium vulgare*, *Filipendula ulmaria* and *Lotus corniculatus* homogeneous pollen loads were formed only in 2000 whilst only in 2001 homogeneous pollen loads made up of pollen of *Hypericum*, *Plantago*, *Trifolium pratense* and *T. repens* were

Table 3
The list of pollen types
in the examined pollen loads

Pollen	Study year	
	2000	2001
<i>Anthriscus</i> -type	–	+
<i>Brassicaceae</i>	++	++
<i>Centaurea cyanus</i>	++	–
<i>Cichorium</i>	+	+
<i>Cirsium</i> -type	–	+
<i>Clematis</i>	+	–
<i>Echium vulgare</i>	++	–
<i>Filipendula ulmaria</i>	++	+
<i>Geranium</i>	–	+
<i>Gramineae</i>	–	+
<i>Helianthus</i> -type	–	+
<i>Hypericum</i>	+	++
<i>Lamium</i>	+	+
<i>Lotus corniculatus</i>	++	+
<i>Melilotus</i>	+	–
<i>Phlox</i>	+	–
<i>Plantago</i>	+	++
<i>Potentilla</i>	+	–
<i>Ranunculus</i>	+	–
<i>Rosaceae</i>	+	–
<i>Rubus</i> -type	+	+
<i>Solanum tuberosum</i>	+	–
<i>Symphytum officinale</i>	+	–
<i>Tilia</i>	–	+
<i>Trifolium pratense</i>	–	++
<i>Trifolium repens</i>	+	++
<i>Verbascum</i>	+	–
<i>Veronica</i>	+	–
<i>Vicia</i>	+	–

++ - pollen from which homogeneous pollen loads were formed

found. The differences were probably due to different flowering dates of the same species in the two years as well as to a relatively small number of sampled pollen loads. However, the idea of sampling a greater number of pollen loads was discarded as it might have had an adverse impact on the bumblebee colony. Nine species, pollen of which was found in homogeneous pollen loads, can be recognized as the principal food source for *B. terrestris* (in Table 3 marked with “++”).

Anasiewicz and Warakomska (1977) and Warakomska and Anasiewicz (1991) also list *Brassicaceae* (*Sinapis*), *Centaurea cyanus*, *Hypericum*, *Lotus corniculatus*, *Trifolium pratense* and *T. repens* as the principal pollen plants for bumblebees. However, they do not report *Filipendula*, *Echium*, or anemophilous *Plantago*, indicated in this study. Presumably, those species did not occur in the area covered by that study. Similar results were reported by Brian (1951) who listed *Trifolium pratense*, *T. repens*, *Lotus corniculatus*, *Vicia* as the principal pollen plants of bumblebees as well as pollen of *Ericaceae*, not found in this study, probably belonging to *Calluna vulgaris*. That species is the principal food plant in Scotland in August and September when the investigator sampled bumblebee nests for pollen analysis.

Ruszkowski and Żak (1974) list 52 plant species as visited by *B. terrestris* and *B. lucorum* throughout the season, of which 23 species bloom in July. In the major food plant succession for bumblebees in the Puławy area in July they include: *Medicago media*, *Salvia verticillata*, *Gaillardia aristata*, *Dahlia pinnata*, *Echinops sphaerocephalus*. As the minor forage succession they list: *Hypericum perforatum*, *Nepeta grandiflora*, *Tilia euchlora*, *Teucrium scorodonia*, *Tilia tomentosa*, *Helianthus annuus*, *Trifolium*

pratense, *Centaurea scabiosa*, *Borago officinalis* and *Lavandula officinalis*. The list should be supplemented with 5 additional species that bloom in July which the investigators mention separately as the "approximate food plant list" for *B. terrestris* and *B. lucorum* in the Lubelskie voivodeship. The list includes *Alectorolophus glaber*, *Phaseolus vulgaris*, *Vicia angustifolia*, *Melandrium album* and *Origanum vulgare*. When assessing the forage value of those plants the investigators took into account flowers' visiting intensity only. Taking that approach they indicated *Medicago media*, *Dahlia pinnata* and additionally *Trifolium pratense* and *Helianthus annuus* as the most valuable for bumblebees in Puławy area.

Considerable discrepancies between the species content the food plant lists reported by the mentioned investigators and the results of the palynological analysis of pollen loads in this study stem from the fact that in the 60's no distinction was made between pollen and nectar foragers. Probably the majority of observed bumblebees were nectar foragers. The palynological analysis of pollen loads allows the identification of plant species that were visited for pollen. Furthermore, the differences in reported plant lists were doubtlessly also caused by varied and changing vegetation of the investigated areas due, among other things, to the fact that *Trifolium pratense* is becoming increasingly rare and *Medicago media* has almost totally disappeared from the landscape.

Pollen analysis of 61 pollen load pairs collected from bumblebees in 2000 and 2001 allowed the identification of nearly 30 food plants species of *B. terrestris*. Ruszkowski and Żak (1974) after 9 years of observations in Puławy area list 23 species as visited in July by *B. terrestris* and *B. lucorum*. Thus the results furnish evidence that even a small number of pollen loads subjected to palynological

analysis allows the identification of many plants visited by bumblebees because the foragers oftentimes form loads of pollen of belonging to several species.

CONCLUSIONS

1. Palynological analysis of 61 pairs of pollen loads collected from workers of *Bombus terrestris* allowed the identification of 29 pollen plants for bumblebees.
2. *Brassicaceae*, *Centaurea cyanus*, *Echium vulgare*, *Filipendula ulmaria*, *Lotus corniculatus*, *Hypericum*, *Plantago*, *Trifolium pratense* and *Trifolium repens* from the pollen of which workers formed homogeneous pollen loads were recognized as the principal food plants species of *Bombus terrestris*.
3. Pollen analysis of pollen loads seems to be more efficient than observation based methods in the identification of food plants of insects because it allows the identification of a greater number of visited plant species with lower labour inputs involved.

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ROŚLINY POKARMOWE TRZMIELA ZIEMNEGO (*Bombus terrestris* L.) OKREŚLANE NA PODSTAWIE ANALIZY PALINOLOGICZNEJ OBNOŻY PYŁKOWYCH

T e p e r D .

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

Trzmielce (*Bombus* Latr.), poza pszczołą miodną, należą do najważniejszych zapylaczy. Ich szczególne znaczenie w zapylaniu zwłaszcza motylkowych roślin pastewnych takich jak: *Trifolium*, *Vicia*, *Medicago*, *Lotus* zostało potwierdzone w wielu obserwacjach, a badania palinologiczne pyłku pobranego z gniazd oraz obnoży pyłkowych trzmieli odławianych na kwiatach różnych gatunków znacznie poszerzyły listę znanych roślin pożytkowych tych owadów. Zainteresowanie trzmielami dodatkowo wzrosło, od kiedy wprowadzono je do zapylania upraw szklarniowych, zwłaszcza pomidorów. Trzmiel ziemny (*Bombus terrestris*) okazał się szczególnie cenny ze względu na stosunkowo łatwą hodowlę.

W lipcu 2000 i 2001 roku od powracających do gniazd robotnic trzmiela ziemnego (*Bombus terrestris*) odbierano obnoża pyłkowe, a owady wypuszczano. Zebrano łącznie 61 par obnoży, z których wykonano glicerożelatynowe preparaty mikroskopowe i przeprowadzono ich analizę palinologiczną. Analiza wykazała występowanie 29 typów pyłku, z których obecność 9 stwierdzono w obnożach w obydwu latach badań, a pozostałe 20 typów notowano w 2000 albo 2001 roku. Za główne rośliny pokarmowe trzmieli uznano te taksony, z których owady formowały jednorodne obnoża. Były to: *Brassicaceae*, *Centaurea cyanus*, *Echium vulgare*, *Filipendula ulmaria*, *Lotus corniculatus*, *Hypericum*, *Plantago*, *Trifolium pratense* i *T. repens*. Analiza pyłkowa obnoży wydaje się być również bardziej skuteczna w oznaczaniu roślin pokarmowych owadów, niż metody obserwacyjne stosowane przez Ruszkowskiego i innych (1969, 1974), ponieważ umożliwia poznanie większej liczby odwiedzanych gatunków roślin przy znacznie mniejszych nakładach pracy.

Słowa kluczowe: trzmiel ziemny, *Bombus terrestris*, rośliny pokarmowe, obnoża pyłkowe, analiza pyłkowa.