

Journal of the Hellenic Veterinary Medical Society

Vol 73, No 1 (2022)



Comparing protein content of pollen and his impact on the lenght of life of honeybees

Zheko Radev

doi: [10.12681/jhvms.25905](https://doi.org/10.12681/jhvms.25905)

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To cite this article:

Radev, Z. (2022). Comparing protein content of pollen and his impact on the lenght of life of honeybees. *Journal of the Hellenic Veterinary Medical Society*, 73(1), 3835–3840. <https://doi.org/10.12681/jhvms.25905>

Impact of the protein content in pollen on honey bees (*Apis mellifera* L.) lifespan

Zh. Radev 

Tobacco and Tobacco products institute, Agricultural Academy, Bulgaria

ABSTRACT: The objective of the research work was to determine the protein content in identified pollen grains and the lifespan of worker honey bees fed with pollen with different protein content. In this study the number of the identified floral species was nine. The percentage of the total protein content in the bee-collected pollen pellets ranged from 11.5% for *Chondrilla juncea* to 25.1% for that of *Brassica napus*, and the average value was 18.5%. The average protein content of entomophilous plants was 18.5%, whereas it was 18.4% in anemophilous plants. Protein is one of the main components in pollen, and vary among different floral species source. The lifespan of worker bees ranged from 25 days when they consumed pollen from *Brassica napus* (25.1% protein content) to 14.3 days when they consumed pollen from *Zea mays* (17% protein content). The present study was performed to draw a comparison between the lifespan of worker bees fed with pollen with different protein content and significant differences were found. The worker honey bees lived longer when they consumed pollen with higher protein content. There is prolonged lifespan of bees fed with pollen from *Cirsium* sp., *Helianthus annuus* and *Chondrilla juncea*, as compared to bees fed with pollen from *Zea mays*, despite the higher protein content in the latter's pollen.

Keywords: pollen nutrition; protein needs; honey bees

Corresponding Author:
Zh. Radev, Tobacco and Tobacco products institute, 4108 Markovo, Bulgaria
E-mail address: zhekoradev@abv.bg

Date of initial submission: 25-01-2021
Date of revised submission: 15-03-2021
Date of acceptance: 21-07-2021

INTRODUCTION

Pollen satisfies the dietary needs of bees for protein (Herbert, 1992). Pollen differs in its nutritional value to bees (Vivino and Palmer, 1944; Standifer, 1967; Haydak, 1970; Crailsheim, 1990). Protein content in pollen ranges from 3.8% to 40.8% (Stanley and Linskens, 1974; Herbert and Shimanuki, 1978; Loper and Berdel, 1980). According to Kleinschmidt and Kondos (1977) protein content in pollen ranges from 7% to 37%, and for Roulston et al. (2000) ranged from 2.5% for *Cupressus arizonica* to 61.7% for *Dodeca-theon clevalandii*. Liolios et al. (2015) showed that the protein content of pollen ranged from 12.8% for pollen from *Smilax* sp. to 30.1% for that of *Fallopia* sp., with an average of 20.8%. According to Kleinschmidt and Kondos (1976) protein content in pollen less than 20% cannot satisfy colony requirements for optimum brood rearing.

According to Avetisyan (1983) are 20 amino acids in pollen, but for honey bee's body 10 amino acids-threonine, valine, methionine, isoleucine, leucine, phenylalanine, histidine, lysine, arginine and tryptophan are essential of their diet (De Groot, 1953).

High protein content in pollen contains necessary amino acids in high concentrations (Wille et al., 1985). On turn most pollen types contain all necessary amino acids (Herbert, 1992). Individual amino acids are important in bee development (Herbert et al., 1970). There is a close relation between the nutritional value of pollen and the development, reproduction, and productivity of the bee colonies (Radev et al., 2014).

The honey bee (*Apis mellifera* L.) is using for aging research (Rueppell et al., 2004a). The lifespan of honey bees is influenced of different factors (Maurizio, 1961; Brucner, 1980; Winston and Katz, 1982; Milne, 1982, 1985). High level of protein content in pollen gives a long-lived bees, while low protein content minimises the longevity of bees (Kleinschmidt and Kondos, 1978; Schmidt et al., 1987). According to Levchenko (Stashenko, 1988), the level of protein content in pollen significantly affects the bee biology. Low protein content in pollen reduces the resistance of honey bees to diseases (Matilla and Ottis, 2006). Deficiency of quality protein in the diet of the bee colony can be one of the reasons for the emergence of invasion and infectious diseases (Bilash, 1990). One of the best ways to fight against dangerous diseases is by feeding the bees with pollen (Lavrehin and Pankova, 1983).

The purpose of this study was to determine the lifespan of worker honey bees according to consuming identified pollen with different protein content. In the literature there is not much information about pollen protein content of identified floral species and lifespan of honey bees.

MATERIALS AND METHODS

Pollen collecting

Pollen bottom traps (Figure 1) were placed at five bee hives and the pollen pellets harvested every second day from April until September in area of Belozem (Bulgaria) (N 42.201860/E 25.049330). The pollen loads from each hive were analyzed carefully. Four hundred and ten samples of bee-collected pollen pellets were separated over white paper according to their colour, shape, and texture (Figure 2).



Figure 1. Inside pollen trap



Figure 2. Separated pollen for identifying

Sampling

The labeled pollen samples were stored in separate vials in a freezer at -18 °C. The plant species represented by each pollen sample was identified through a microscopic examination of pollen grains (Figure 3). Palynological analysis was carried out using a similar methodology as Louveaux et al. (1978). To identify the pollen, is referred to the database of the laboratory of Apiculture-Sericulture of the Agricultural school of Aristotle University in Thessaloniki, Greece.

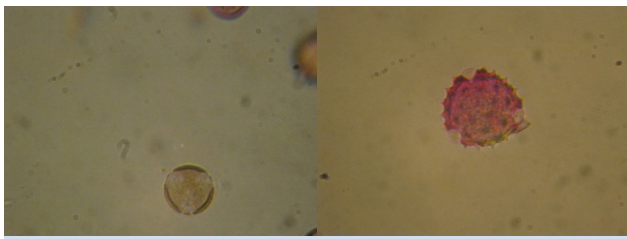


Figure 3. Microscopic pollen grains

Kjeldahl method

For nitrogen content determination, pollen was analyzed using the Kjeldahl method. The crude protein content was estimated using the factor 5.60 (Rabie et al., 1983) times the volume of HCL added to the pollen. In this case, the following formula applied: $\text{protein (\%)} = 0.791 \cdot V/m$, where: V = the volume (mL) of HCl used for titration and m = the amount of pollen (g). Two replicates from each sample were analyzed, and the results were averaged.

Lifespan of worker honey bees

Nine groups with three cages 10*10*10 cm each were created (Figure 4). One hundred newly emerged worker honey bees were placed in each cage and fed with 50% sugar syrup (1:1 sugar/water). By pipet (Figure 5), a quantity of 20 ml sugar syrup containing two grams pollen from each identified floral species for each cage group were added. The mixed syrup was replaced every day with new one. All cages were placed under the same conditions, covered for darkness in a room at temperature 28 °C. In pre study fed only with sugar syrup, honey bees lived longer than 10 days at this temperature. The alive worker honey bees were checked every day and the last remaining found dead in each cage was reported for lifespan.



Figure 4. Cage with wax comb and honey bees



Figure 5. Pipet with sugar syrup and pollen

Statistical analysis

The results were statistically processed by used a Student's T-test and "Anova".

RESULTS

In the present study, identified pollen grains from nine floral species were used. They represent plants which are favored by honey bees. The largest number of taxa come from Asteraceae - 5, and 4 families by one representative (Figure 6). The results underline the fact that pollen from different plant species has a greatly varying protein content. The percentage of the total protein content in bee-collected pollen grains ranged from: 11.5% for *Chondrilla juncea* to 25.1% for *Brassica napus*, and the average value was 18.5%.

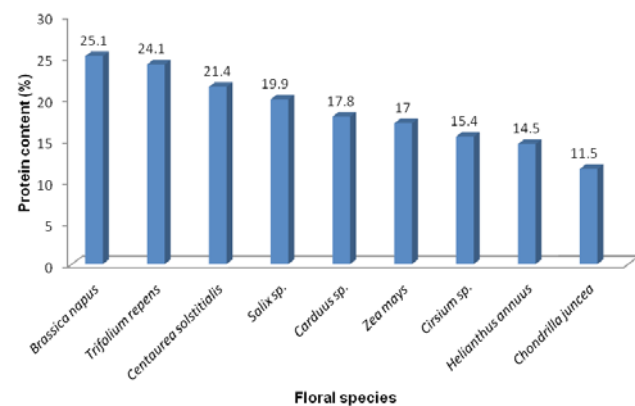


Figure 6. Protein content (dry matter %) of 9 different pollen species

Significant difference in the protein content in pollen of entomophilous plants - 18.5% compared to protein content in pollen of anemophilous plants - 18.4% was not found ($P < 0.05$, Student's t-test). *Salix sp.* was presented as an anemophilous plant in this study. The protein content values of *Salix sp.* and the other anemophilous plant *Zea mays* were pretty high. The result obtained for *Zea mays* could be attributed to hybrid variety.

Table 1. Average lifespan (in days) of worker bees fed with sugar syrup and pollen of different plant species from Bulgaria

	Lifespan of bees I cage	Lifespan of bees II cage	Lifespan of bees III cage	Average lifespan of bees
Worker bees fed with sugar syrup and pollen from <i>Brassica napus</i>	26	24	25	25 a
Worker bees fed with sugar syrup and pollen from <i>Trifolium repens</i>	24	23	25	24 a
Worker bees fed with sugar syrup and pollen from <i>Centaurea solstitialis</i>	23	23	24	23.3 a
Worker bees fed with sugar syrup and pollen from <i>Salix</i> sp.	23	24	23	23.3 a
Worker bees fed with sugar syrup and pollen from <i>Carduus</i> sp.	23	24	22	23 a
Worker bees fed with sugar syrup and pollen from <i>Zea mays</i>	15	14	14	14.3 b
Worker bees fed with sugar syrup and pollen from <i>Cirsium</i> sp.	18	20	22	20 ac
Worker bees fed with sugar syrup and pollen from <i>Helianthus annuus</i>	17	19	16	17.3 c
Worker bees fed with sugar syrup and pollen from <i>Chondrilla juncea</i>	17	16	18	17 c

The data in Table 1 shows a slight reduction of the lifespan of worker bees when they consumed pollen with lower protein content. The longest lifespan was observed in the bees which consumed pollen from *Brassica napus* (25 days), while the shortest - in bees which consumed pollen from anemophilous plant species *Zea mays* (14.3 days). The present study was performed to make a comparison between the lifespan of worker bees fed with pollen from: *Brassica napus* (25.1% protein content), *Trifolium repens* (24.1% protein content), *Centaurea solstitialis* (21.4% protein content), *Salix* sp. (19.9% protein content), *Carduus* sp. (17.8% protein content), *Zea mays* (17% protein content), *Cirsium* sp. (15.4% protein content), *Helianthus annuus* (14.5% protein content) and *Chondrilla juncea* (11.5% protein content).

When comparing the results (Anova: Single factor), significant differences were found between the lifespan of worker bees fed with pollen from *Brassica napus* (25 days), *Trifolium repens* (24 days), *Centaurea solstitialis* (23.3 days), *Salix* sp. (23.3 days) and *Carduus* sp. (23 days), as compared to bees fed with pollen from *Zea mays* (14.3 days), *Helianthus annuus* (17.3 days) and *Chondrilla juncea* (17 days) ($F > F$ crit). Significant differences were also found between the lifespan of worker bees fed with pollen from *Brassica napus* (25 days) and *Trifolium repens* (24 days), compared to bees fed with pollen from *Cirsium* sp. (20 days) ($F > F$ crit).

The statistical analysis showed no significant differences ($F \leq F$ crit) in the lifespan of bees fed with pollen from *Cirsium* sp. (20 days) compared to bees fed with pollen of: 1) *Centaurea solstitialis* (23.3 days), *Salix* sp. (23.3 days) and *Carduus* sp. (23 days); 2) *Helianthus annuus* (17.3 days) and *Chondrilla juncea* (17 days).

It is noted, there was a prolonged lifespan for bees fed with pollen from *Cirsium* sp., *Helianthus annuus* and *Chondrilla juncea*, in comparison to bees fed with pollen from *Zea mays*, despite the higher protein content in the latter's pollen.

DISCUSSION

In this study, the results for pollen protein content come from some of worker bees' favorite plant species. Protein content in pollen depends on the plant visited by bees. The knowledge of pollen protein content of floral species in the area of beekeeping is the main aspect of utmost importance related to honey bees vitality and development.

The results presented in this study provided additional insight into the impact of protein content in pollen to honey bees lifespan. This would be useful information for beekeepers and would help them in bee colonies development. There are not many studies about the lifespan of bees fed with identified pollen with known protein content. The lifespan studies are

for bees which are a part of honey bee colonies.

According to: Taranov (Azimov, 1969), Tyunin (Azimov, 1969) and Azimov (1969) the lifespan of bees is about 30 days; El-Dib (Azimov, 1969) the lifespan from the Caucasian breed of bees is 27-29 days; Omholt and Amdam (2004) the life of bees varies from 3 to 4 weeks in the summer to over 6 months in the winter. According to Radev (2013) in a period of intensive rearing of brood the lifespan of honey bees is over 47 days on average.

It was found that the protein content in pollen of *Zea mays* is higher in comparison to that of *Cirsium* sp., *Helianthus annuus* and *Chondrilla juncea*, but the lifespan of the worker bees fed with that pollen is shorter than that of the bees fed with pollen from the other three floral species. This difference could be attributed to hybrid variety of the cultivated plant or other components in the pollen and needs further research. *Zea mays* is a cultivated plant and could be contaminated by a pesticide. Further research must be provided for components in pollen from *Zea mays* to establish why honey bees which consume pollen from it have the shortest lifespan.

According to Höcherl et al. (2012), extensive cultivation of *Zea mays* could force bees to collect mainly of it pollen instead of other kinds, and these

honey bees fed maize pollen had shorter lifespan.

This research was a prerequisite for studying the impact of protein content in pollen on honey bees' lifespan. Analysis provided us with exclusive information about the nutrition of honey bees and could be used for further research. Every pollen type contains components such as: vitamins, minerals, enzymes, lipids, sugars and etc. in different amounts and bees are better off consuming mixed pollen rather than only one pollen type.

CONCLUSIONS

Protein is a main component of pollen and its content vary among different floral species. The lifespan of worker honey bees was longer when they consumed pollen with higher protein content.

ACKNOWLEDGEMENTS

The author is grateful to the members of Laboratory of Apiculture-Sericulture, Department of Agriculture, Aristotle University of Thessaloniki, Greece: Andreas Thrasyvoulou, Chrysoula Tananaki, Vasilis Liolios, Dimitris Kanelis, Maria Dimou, Georios Goras, Emmanuel Karazafiris.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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