LEAD CONTENT OF BEES, BROOD AND BEE PRODUCTS FROM DIFFERENT REGIONS OF POLAND

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Received 15 June 2003; accepted 27 November 2003

Summary

The aim of the study was to determine the lead content of bees, brood and of bee products originating from different regions of Poland.

Samples of worker bees, brood (pupae), honey (from comb cells), beeswax (from comb), bee bread (from comb) and propolis (between the frames) were used in the study. The samples were collected across Poland from 24 apiaries/72 honeybee colonies - a total of 432 samples. Lead contents of the samples were assayed using the Graphite Furnace Atomic Adsorption Spectrometry (GF-AAS) method.

All samples were found to be contaminated with lead to a lesser or greater extent. Lead content was dependent, to a large degree, on the kind of the material sampled and on the sampling site. The greatest average lead content was determined for propolis, followed by bee body, beeswax, bee bread, and brood. It was also found that the penetration of lead into bee bodies, beeswax, and propolis poses a certain threat both to the bees and to the consumers.

A low lead content of honey, the main product consumed by man, was a positive finding.

Keywords: honeybee, brood, bee products, lead, bio-indicator.

INTRODUCTION

Chemical, heavy and food industries as well as the dynamic growth of automobile traffic have resulted in an increase of lead contamination of the environment. The contamination makes its way to bees from the pollen, nectar, honeydew and water they feed on. At a high concentration it may be harmful both to bees and to humans. Lead in particular has strong toxic properties for living organisms, especially for animals and for humans. Many methods have been developed to determine contamination status of the environment. Of these, those making use of biological material have been increasingly more popular.

Many investigators commented upon the possibility to use bees to monitor the purity of the environment (Crane 1984, Gilbert and Lisk 1979, Jędruszczuk 1987, Migula 1990, Muszyńska 1995, Roman 1997,1998, 2000, Szcześniak et al. 1999, Żarski et al. 1996). In many parts of the world attempts were made to use bees and bee products to assay the degree of environmental pollution. Harmful compounds penetrate into the bodies of adult insects as well as into pollen, beeswax, honey and propolis (Loper et al. 1980, Pratt and Sikorski 1985, Roman 2000, Żarski et al. 1996). Bees and bee products are good bio-indicators of environment pollution as the way of life of those insects exposes them directly and indirectly to the impact of pollution and the material is easily available. The honeybee has, at the same time, another advantage over animals living in the wild in that its foraging area and the kind of pastures it forages on at a given time can be easily determined. Thus the contamination in the form of heavy metals building up in the bee’s body may reflect
Table 1

Lead content in the tested samples broken down across the four regions of Poland (mg/kg)

<table>
<thead>
<tr>
<th>Region</th>
<th>Bee body</th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>minimum</td>
<td>maximum</td>
<td>median</td>
<td>mean</td>
<td>standard deviation</td>
<td>variance coefficient</td>
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<tr>
<td>northwestern</td>
<td>0.114</td>
<td>1.69</td>
<td>0.491</td>
<td>0.652 a*, A**</td>
<td>0.521</td>
<td>79.896</td>
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<td>0.123</td>
<td>1.3</td>
<td>0.369</td>
<td>0.546 a, A</td>
<td>0.392</td>
<td>71.751</td>
</tr>
<tr>
<td>southeastern</td>
<td>0.138</td>
<td>2.96</td>
<td>0.292</td>
<td>0.550 a, A</td>
<td>0.727</td>
<td>132.213</td>
</tr>
<tr>
<td>southwestern</td>
<td>0.204</td>
<td>4.76</td>
<td>0.341</td>
<td>1.761 b, B</td>
<td>1.929</td>
<td>109.546</td>
</tr>
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<td>0.114</td>
<td>4.76</td>
<td>0.354</td>
<td>0.827</td>
<td>1.104</td>
<td>133.528</td>
</tr>
<tr>
<td>Brood</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>northwestern</td>
<td>0.01</td>
<td>0.031</td>
<td>0.01</td>
<td>0.013 a, A</td>
<td>0.007</td>
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<td>0.08</td>
<td>0.058</td>
<td>0.017</td>
<td>0.022 ab, AB</td>
<td>0.015</td>
<td>66.484</td>
</tr>
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<td>0.043</td>
<td>0.026</td>
<td>0.022 b, AB</td>
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<td>Poland</td>
<td>0.01</td>
<td>0.069</td>
<td>0.019</td>
<td>0.022</td>
<td>0.015</td>
<td>69.052</td>
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<td>Honey</td>
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<td></td>
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</tr>
<tr>
<td>northwestern</td>
<td>0.016</td>
<td>0.102</td>
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<td>0.062 a, A</td>
<td>0.046</td>
<td>73.482</td>
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<td>0.105</td>
<td>0.028</td>
<td>0.043 a, A</td>
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<tr>
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<td>0.005</td>
<td>0.147</td>
<td>0.026</td>
<td>0.038 a, A</td>
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<td>southwestern</td>
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<td>Poland</td>
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<td>0.147</td>
<td>0.034</td>
<td>0.048</td>
<td>0.043</td>
<td>87.988</td>
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<td>Bee bread</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>northwestern</td>
<td>0.062</td>
<td>0.447</td>
<td>0.326</td>
<td>0.416 b, B</td>
<td>0.345</td>
<td>83.057</td>
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<td>northeastern</td>
<td>0.065</td>
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<td>0.423</td>
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<td>0.255 a, AB</td>
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<td>0.245</td>
<td>0.288</td>
<td>0.211</td>
<td>73.258</td>
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<td>Beeswax</td>
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<tr>
<td>northwestern</td>
<td>0.077</td>
<td>1.60</td>
<td>0.1733</td>
<td>0.460 a, A</td>
<td>0.528</td>
<td>117.692</td>
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<td>northeastern</td>
<td>0.129</td>
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<td>1.935</td>
<td>1.726 b, B</td>
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<tr>
<td>southeastern</td>
<td>0.152</td>
<td>1.71</td>
<td>0.438</td>
<td>0.626 a, A</td>
<td>0.461</td>
<td>73.610</td>
</tr>
<tr>
<td>southwestern</td>
<td>0.054</td>
<td>0.56</td>
<td>0.219</td>
<td>0.249 a, A</td>
<td>0.158</td>
<td>63.683</td>
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<tr>
<td>Poland</td>
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<td>3.18</td>
<td>0.367</td>
<td>0.781</td>
<td>0.901</td>
<td>15.272</td>
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<td>Propolis</td>
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<td></td>
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</tr>
<tr>
<td>northwestern</td>
<td>1.2</td>
<td>28.47</td>
<td>14.895</td>
<td>15.064 b, B</td>
<td>10.009</td>
<td>66.448</td>
</tr>
<tr>
<td>northeastern</td>
<td>2.3</td>
<td>17.0</td>
<td>3.78</td>
<td>5.762 a, A</td>
<td>5.111</td>
<td>88.711</td>
</tr>
<tr>
<td>southeastern</td>
<td>1.8</td>
<td>20.4</td>
<td>4.82</td>
<td>6.938 a, A</td>
<td>5.611</td>
<td>80.875</td>
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<tr>
<td>southwestern</td>
<td>1.52</td>
<td>26.9</td>
<td>10.02</td>
<td>9.944 a, AB</td>
<td>7.514</td>
<td>75.568</td>
</tr>
<tr>
<td>Poland</td>
<td>1.2</td>
<td>28.47</td>
<td>4.97</td>
<td>9.302</td>
<td>7.973</td>
<td>85.724</td>
</tr>
</tbody>
</table>

* means followed by different small characters are significantly different at 0.05
** means followed by different capital characters are significantly different at 0.01
the contamination of plants, soil, air and water in that area. According to many investigators (Guderska 1978, Jędruszczyk 1987, Muszyńska 1995) bees are good indicators of pollution in a given area, and the range of their visitation is 12.5 km² (Muszyńska 1995).

The aim of the study was to determine the lead content of bee bodies, brood and bee products originating from different regions of Poland.

**MATERIAL AND METHODS**

The investigations were performed at the Laboratory of Economic Insects Improvement, Faculty of Animal Science, Agricultural University of Warsaw. The study material was collected in the spring of 2002 from private and state-run apiaries from across Poland (Fig. 2). All-in-all, the material originated from 24 apiaries or from 72 honeybee colonies, a total of 432 samples. The samples were stored until the tests were conducted in the refrigerator at -12°C.

The samples were tested for lead content at the Department of Physical and Chemical Analyses, Agricultural University in Warsaw. The biological samples were made uniform by carefully breaking up and mixing each of them, 1 gram portions were weighed and mineralized in the mixture of nitric acid and hydrogen peroxide. Mineralization was done using the microwave method in a closed system. Due to that the mineralization proceeded without losses of the elements to be studied.

Graphite Furnace Atomic Absorption Spectrometry (Gf-AAS) was used to measure lead concentration of the samples. AA Scan atomic absorption spectrometer manufactured by Thermo Jawell Ash Corp. with the Visimax II cathode lamp was used for the assays.

The data were subjected to comprehensive statistical tests. Multifactorial ANOVA and multiple range test were used. The significance of differences was tested at 0.05 and 0.01 confidence levels. Bar graphs were used to visualize the results.

In order to compare lead contents of bee bodies, brood and of bee products over different regions as well as nationwide the following presentations were made:

Lead contents of the samples over the four regions of the country (Table 1), graphic representation of the average lead contents of different kinds of samples from 24 apiaries across Poland (Fig. 1). The degree of lead contamination of Poland based on the lead content of propolis - the most heavily contaminated material - was shown in Fig. 2.

![Fig. 1. Average lead contents of different samples collected from 24 apiaries across Poland](image-url)
Legend:
List of aparies sampled for propolis:
1. apiary in Jtwencin near Koszalin
2. apiary in Gdansk
3. apiary in Szczecin - Agricultural University
4. apiary in Gorzow
5. apiary in Torun
6. apiary in Poznan - Agricultural University
7. apiary in Olsztyn - University of Warmia and Mazury
8. Polish Academy of Sciences experimental apiary at Wielki Las
9. apiary in Bialystok
10. apiary in Gostawa near Sklerniewice
11. apiary in Warsaw - Agricultural University of Warsaw
12. apiary in Siedlce
13. apiary in Skapec near Zielona Gora
14. apiary in Wroclaw - Agricultural University
15. apiary in Maciejow near Kluczbork
16. Breeding apiary in Rochus near Nysa
17. apiary in Orzeszko near Katowice
18. apiary in Lalezin - Agricultural University
19. apiary in Puszcza Wola - complex of agricultural secondary schools
20. apiary in Sitnno near Zamosc
21. apiary in Zbysnów
22. apiary in Krakow
23. apiary in Nowy Sacz
24. apiary in Monasterzec near Sanok

Fig. 2. Lead contamination of Poland based on lead content of propolis - the most heavily contaminated material of the study
RESULTS AND DISCUSSION

Lead content of bee bodies

The lead content of bee bodies was found to range from 0.114 (northeastern Poland) to 4.76 mg/kg (southwestern Poland) (Table 1). The nationwide average was 0.827 mg/kg. When comparing the results with those obtained by other investigators one has to state that they are comparable but in a small part. To wit, in an industrial area lead concentrations were 29.59 mg/kg and a non-industrial area it was 15.12 (Muller and Aghte 1988). Pratt and Sikorski (1985) found a high lead content of bee bodies in colonies situated close to a heavy traffic road, the content being 28.1 mg/kg. In the control group, though, the lead content was much lower averaging 1.4 mg/kg. In the bodies of bees from colonies located in the vicinity of a zinc and lead mill Nikodemska and Patryn (1972) found lead content to range from 12.0 to 185.5 mg/kg. Jędrusczuk (1987) obtained similar results. Roman (1997) demonstrated a large variation in lead content among different bee samples (0.010 to 20.130 mg/kg). The investigator reported the following values of lead content of bee bodies in the two years, respectively: Opole area 1.060 and 3.116 mg/kg, Głogów area 0.932 and 7.160 mg/kg, Ruda area 1.900 and 3.800 mg/kg. Generally, the concentration of that element in bee bodies was high and much in excess of the average content obtained in this study. A record concentration of lead in bees was reported by Bornus (1975) for samples from the vicinity of lead and zinc processing plants (271 - 607 mg/kg).

Lead content of honey

The minimum lead content of honey found in the study was 0.005 mg/kg (southeastern Poland), the maximum content was 0.147 mg/kg (southeastern Poland). The nationwide average was 0.048 mg/kg. The data in the domestic literature on the subject were found to be similar and just as low. According to Lipińska and Zalewski (1989) the lead content of honey varied from 0.057 to 0.370 mg/kg. Gajewska et al. (1984) found lead content of domestic honeys to be 0.05 mg/kg and that of imported honeys was 0.30 mg/kg. To compare it with the data reported in foreign literature, Accorti et al. (1990) found 0.21 mg of lead in 1 kg of honey. Rowarth (1990) found a lead content of 0.133 mg/kg.

The lower level of lead content of domestic nectar honeys as determined in this study is similar to those found by other investigators both domestic and foreign (Bogdanov et al. 1986, Goloskov 1983, Zalewski et al. 1989). A slightly higher lead content of honey was found by Jabłoński et al. (1995), Celli et al. (1987), Rostkowski et al. (1992) and Stein and Umland (1986) whereas Höffel (1985) in West Berlin and Altmann (1985) in the vicinity of Stolberg found lead content of honeys to be much higher, averaging 0.18 mg/kg and 0.277 mg/kg, respectively. Likewise in Poland, Dobrzański et al. (1994) found the lead content of honey from a mixed farmland and industrial area to be 1.762 mg/kg whereas that from a farmland/woodland area was 0.369 and 1.025 mg/kg. Roman (1997) found a maximum lead content of honey of 3.535 mg/kg in the vicinity of Głogów.

Lead content of propolis

Lead content of propolis was very high in all regions surveyed by Roman (1997). According to that investigator the maximum level of lead concentration was recorded in Rudna (97.330 mg/kg). In the Głogów area the average concentration was 24.020 and 11.480 mg/kg (the 1st and the 2nd year). The respective values for Opole and Ruda were 17.830 and 6.732 mg/kg. The lead content of propolis from the Głogów area averaged 18.39 mg/kg.
(Roman 2000). Confronted with the results reported by Roman (1997, 2000) the level of lead contamination of propolis found in this study was lower and averaged 9.302 for the whole country. Generally, lead content of propolis across Poland ranged from 1.2 (northwestern Poland) to 28.47 mg/kg (northwestern Poland). This notwithstanding, the values should be regarded as high, if only compared with those obtained by Szcześni et al. (1999) (2.25-4.85 mg/kg).

Lead content of bee bread

The average nationwide lead content of bee bread was 0.288 mg/kg and came within range of 0.041 (southeastern Poland) to 0.447 mg/kg (southwestern Poland). Somewhat higher results are reported by Szcześni et al. (1993) for pollen loads (0.45-0.98 mg/kg). Lead contents of pollen that are positively higher than those found in this study were reported by Konopectka et al. (1993). According to that investigator the highest lead contents were observed in spring pollen from colonies located at Końskowola (average of 1.195 mg/kg) and at Las Stocki (average of 1.189 mg/kg). However, Poland’s record high concentration of that metal in pollen loads and in bee bread was found by Lipińska and Zalewski (1989) who estimated the lead content at 10.87 mg Pb/kg. Even higher lead contents were found by Loper et al. (1980). Their estimates of lead content of pollen and bee bread from the locations close to a highway in California were from as much as 6 to 15 mg/kg.

Lead content of brood and beeswax

In this study, lead content of brood was found to vary from 0.01 (northwestern Poland) to 0.069 mg/kg (southwestern Poland). The nationwide average was 0.022 mg/kg. In beeswax, lead contents were found to vary from 0.054 (southwestern Poland) to 3.18 mg/kg (northeastern Poland), the nationwide average being 0.781 mg/kg. In both domestic and foreign literature there are no mentions whatever about the lead content of brood, and surrogate data are concerned with the lead content of beeswax. To wit, Roman (2000) reports an average lead content of beeswax to be 5.40 mg/kg for the Walbrzych area and 2.56 mg/kg for the Głogów area. In view of that, the investigations of lead content of brood and beeswax reported in this study are novel.

The high level of average lead contents of the samples indicates a certain environmental hazard related to the contamination of the studied area with that pollutant (Fig. 1). Fortunately, there is a viable chance that the situation will improve in the nearest future because an increasing number of vehicles is fuelled with lead-free petroleum or with LPG gas.

The lead content of the samples was also dependent on the site of the apiary (Fig. 2). Generally, it can be said that the lead content of bee, brood, and bee product samples collected across Poland was substantial. A particularly high lead content was found in samples from apiaries located over an extensive area of northwestern and southeastern Poland, extending as a broad belt from Koszalin across central Poland down to Kielce and Lublin.

In accordance with the new commercial standards developed in line with the EU directives and the documents of the FAO/WHO Food Codex Committee (1972) the admissible lead content of foodstuffs should not exceed 0.5 mg/kg. On the other hand, according to the latest regulation by the Minister of Health (2003) the admissible lead content of honey must not exceed 0.3 mg/kg. It is evident from the graph that the average lead contents of honey, bee bread and brood do not exceed those norms (Fig. 1). However, the average lead contents of bee bodies and beeswax are much in excess of the current norms. The average lead content of propolis is several times higher than the above mentioned norm. It
indicates that in some bee products (propolis, beeswax) lead may be a real hazard to man. Fortunately, much less of that contaminant makes its way to honey - the main bee product.

It can be seen from the data discussed above that the highest lead content was found in propolis. It was followed by that in bee bodies, beeswax, bee bread and honey. The lowest lead content was found in brood. It means that brood under natural conditions is little exposed to pollution with lead. Propolis, on the other hand, is the most highly exposed to that kind of contamination.

CONCLUSIONS
1. The lead content of samples varied with the kind of sample and sampling site.
2. The highest lead content was found in propolis and the lowest in bee brood.
3. The lead content of propolis over the majority of regions in Poland exceeded the current norms. The lead concentration in honey was well below the current limits.

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Rozporządzenie Ministra Zdrowia z dnia 13 stycznia 2003 w sprawie wykazu dopuszczalnych ilości substancji dodatkowych i innych substancji obcych dodawanych do środków lub użyczk, a także zanieczyszczen, które mogą znajdować się w środkach lub użyczkach. Dz.U. 2003, nr 37, poz. 326.


ZAWARTOŚĆ OŁOWIU W CIELE PSZCZÓŁ, W CZERWIU ORAZ W PRODUKTACH PSZCZELICH Z RÓŻNYCH REJONÓW POLSKI

Madras-Majewska B., Jasiński Z.

Streszczenie

Przemysł chemiczny, ciężki i spożywczy, a także dynamiczny wzrost ruchu samochodowego powoduje wzrost zanieczyszczenia środowiska naturalnego ołowiem. Zanieczyszczenia przenoszą się także na pszczoły ze zbieranego przez nie pyłku, nektaru, spadzi i wody. Przy dużej ich koncentracji mogą być szkodliwe zarówno dla pszczół, jak i dla człowieka. Szczególnie ołów posiada silne właściwości toksyczne dla organizmów żywych, zwłaszcza dla ludzi i zwierząt. Opracowano wiele metod do określania staniu skażenia środowiska naturalnego, w których coraz popularniejsze są te, które wykorzystują materiał biologiczny.

Celem pracy było określenie zawartości ołowiu w ciele pszczół, w czerwiu i w produktach pszczelich pochodzących z różnych rejonów Polski.

Badanie wykonano w Pracowni Hodowli Owadów Użytkowych przy Wydziale Nauk o Zwierzętach SGGW w Warszawie. Materiał do badań zebrano wiosną 2002 r. z pasiek prywatnych i państwowych położonych na terenie całej Polski. Próby pozyskano z 24 pasiek, z 72 rodzin pszczelich, co dało ich łącznie 432. Materiał do badań stanowiły próbki pszczół (robotnice), czerwiu (poczwariki), miodu (z komórek plastra), vosku (z plastra), pierzgi (z plastra) oraz propolisu (ze szczelin międzyramkowych).


Stwierdzono, że wszystkie badane próbki były zanieczyszczone ołowiem w mniejszym lub większym stopniu. Zawartość ołowiu uzależniona była w znacznym stopniu od rodzaju pobranego materiału, czyli rodzaju próbki, a także od miejsca jej pobrania. Największą średnią zawartość ołowiu w Polsce oznaczono w propolisie, następnie kolejno w ciele pszczół, vosku, pierdze, miodzie oraz czerwiu. Stwierdzono także, że przenikanie ołowiu do ciała pszczół, vosku i propolisu stanowi pewne zagrożenie zarówno dla pszczół jak i konsumentów. Pozytywnym zjawiskiem jest wykazana niska zawartość ołowiu w mildzie, głównym produkcie pszczelin spożywanym przez człowieka.

Słowa kluczowe: pszczoła miodna, czerw, produkty pszczele, ołów, biowskaźnik.