PSZCZELNICZE ZESZYTY NAUKOWE
Rok XLIV 2000

AN ATTEMPT AT DETERMINATION OF HONEYBEE COLONIES REQUIRED FOR POLLINATION OF NATURAL PLANT COMMUNITIES IN POLAND

Józef Banaszak, Tomasz Cierzniak

Institute of Biology and Environmental Protection, Bydgoszcz University of Kazimierz Wielki, ul. Chodkiewicza 30, 85-064 Bydgoszcz, Poland, e-mail: lednica@wsp.bydgoszcz.pl

Data nadesłania - 28 kwiecień 2000

Summary

On the basis of flower density and effectiveness of the honeybee potential number of colonies required for pollination of natural and seminatural plant communities was estimated. It was calculated that coniferous forests, deciduous forests and open areas with swards during full bloom require visits and pollination by about 6 million honeybee colonies. This number is divided respectively into 1.1 million for coniferous forests, 0.09 million for deciduous forests and 4.7 million for meadows and pastures, and 0.06 million for xerothermic swards. Polish agriculture requires visits of at least 1.5 million honeybee colonies.

Keywords: honeybee, bee colonies, *Apis mellifera*, flower density, effectiveness of bees, pollination, coniferous forests, deciduous forests, swards.

INTRODUCTION

One of the leading concerns in Polish apiculture literature of the 1990s is the severe drop in the number of honeybee colonies and concern for plant pollination (Pidek 1991,1992,1996, Sęczyk 1998, 1999, Winiarski 1998, Woyke 1998, Nogal 1999, Wacławek 2000, Wilde 2000). In the decade between 1985 and 1995 the number of bee colonies in Poland decreased from 2.6 million to 1 million. At the end of 1998 the number of registered colonies was only 790,000, and the number of apiarists had dropped to 48,000 (in 1987 there were 227,000 apiarists). Earlier, such a drastic drop in the number of honeybees occurred only during World War II. Such a situation poses the problem of crop plant pollination, particularly in orchards and vegetable gardens. It is commonly believed that pollinating insects, and particularly honey bees, give a twenty times higher income in seeds and fruit than in apiary products and honey. Research proves that the optimum number

of bee colonies in Poland which should not be exceeded without damage to agriculture is about 1.7 million colonies (Bornus, after Albigowski 1995). However, there is no problem with honey and other products. In the present free market economy, our country is being flooded with cheaper honey from Asia, although of not very high quality.

The needs of agriculture for bee colonies in Poland highly exceed the number of apiaries, particularly during full bloom of fruit trees and rape. According to statistics there are about 800,000 ha of orchards and rape fields in Poland. Assuming that for pollination of 1ha of each crop plant two bee colonies are required, the potential needs exceed 1.5 honeybee colonies.

So far the evaluation of the role of pollinating bees has referred only to cropland, orchards and vegetable gardens. The literature concerning this problem is quite extensive, but in the case of the specific value of honeybee activity, or of other representatives of *Apoidea*, one may face difficulties.

However, one may raise the issue of the role of honeybees in the pollination of natural and seminatural plant communities, and the difficulty of evaluating the possible ecological consequences of the highly limited pollinating activity of this species in recent years. It seems that a certain attempt in that respect is an evaluation of the flow resources of the natural environment and the need of entomogamous plants for the pollinating activity of the honeybee. This problem is discussed in this article. The phrase 'need of plants' is understood when we talk about crop plants, whereas we understand that when used in reference to natural and seminatural communities, we anthropomorphise the issue. However, this convenient shortcut refers both to potential flow resources of bees, and the number of bee colonies which can sustain these resources.

We would like to express our gratitude to Professor Bolesław Jabłoński of Institute of Pomology and Floriculture, Bee Department, Pulawy for detailed reading of the manuscript and exceptionally valuable remarks and additions to this article, due to which we managed to escape many mistakes.

METHODOLOGY

In Poland, the basic types of natural and seminatural plant communities are coniferous and deciduous forests, as well as sward communities, so-called marginal communities, such as roadsides, balks and other barrens. The forests, which are dominant, at present cover about 28% of Poland's territory. The main forest-forming species are anemophilous (which do not require pollinating insects), such as: pine, spruce, fir, larch, alder, ash, elm, birch, aspen, oak, hornbeam and beech. The anemophilous brushes are hazel, juniper and yew. Plants requiring pollination in forests are limited to undergrowth and underwood.

However, open environments, overgrown with different types of herbage, are difficult to evaluate. Year-books list areas of varied degrees of land use, also including areas covered with herbage. The given acreage comprise different plant communities in the type of swards, meadows, etc. together with some elements of industrial areas. Owing to this, the evaluation of entomogamous plant resources must be of an approximate character.

Taking into account the number of flowers developed in a given area of the basic types of ecosystems in Poland, as well as the honeybee effectiveness, the needs of different ecosystems for honeybee pollination to guarantee plant reproduction and seed yielding were estimated. Due to the fact that the problem of pollination of wild growing plants is not widely recognised, we can estimate such needs of these ecosystems for honeybee pollination only approximately.

To conduct these estimates, the following parameters were used: number of flowers, working time of bees and their effectiveness, the number of worker bees on flowers and the number of days of pollination („flights days").

For **number of flowers** in the given area in main types of forest habitats, meadow and sward ecosystems the main sources of information were the works of K. Szklanowska (1973, 1979), who described the nectar flows of different types of forests in Poland, and the work of E. Bartyś (1999), who determined the flow base for xerothermic meadows and swards. The extrapolation of the data for 8 basic types of forest habitats comprised, in our estimate, 80% of Polish forests (data for oak-hornbeam forest and thermophilous oak forest were averaged because the available data refers only to the area of these two forest types together). The estimate did not comprise mountain forests and some small areas of habitat types, such as floodplain forest and alder swamp. The data referring nectar supply of meadows and swards were modified. The numbers of flowers developed in 1 m^2 of meadows and swards given by Bartyś (1999) refer to very prolific and/or rich in flora communities and these data cannot be representative for the majority of meadows and pastures, as well as poor swards in e.g. residential districts, roadsides, etc.. Due to this, the density of flowers for 1 m^2 given by Bartyś (1999) was diminished ten times. The flower density obtained this way are, according to the authors, closer to the average values observed in the researched environments. The data modified this was used to estimate the needs for honeybee pollination with reference to meadows, pastures, roads, residential areas and barren land. The data of meadow blooming intensity were also extrapolated for pastures, whereas in the case of barrens, roads and residential areas, it was assumed that they are overgrown with plants similar to xerothermic swards.

Working time of bees is the number of hours during the day when bees visit flowers. In Poland bees' working time during the day changes with the

seasons of the year. According to literature and oral information (Wójtowski, Młyniec 1964, Dylewska et al. 1970, Anasiewicz 1972, Ziółkowski 1979, Jabłoński 1975, Biliński 1977, Bornus et al. 1976, personal communication of Professor Jabłoński) (Tables 1, 2, 3) we accepted the following number of flight hours during the day: April –4 hours, May – 7 hours, June – 10 hours, July – 10 hours August – 8 hours, September – 10 hours (Tables 1, 2, 3).

Effectiveness of bees is the number of flowers visited and pollinated by a worker honeybee in a definite time (e.g. 1 minute). As an initial value for calculation, an average number of different family plants visited within a minute was accepted (Tables 1, 2, 3) (Ziółkowski 1979, Wójtowski, Młyniec 1964, Jabłoński 1975, Dylewska et al. 1970, Anasiewicz 1972, Biliński 1977, Bornus et al. 1976).

The number of worker bees on flowers is the number of worker bees coming from one colony working at a given moment on flowers. It does not include worker bees on the way to collect the nectar flow and returning to the beehive or bringing the flow to the beehive. The size of bee family is changing gradually during the season, reaching its maximum in the second part of July, and then the number of worker bees is gradually getting smaller (Gromisz 1998). Due to thus, different numbers of worker bees working on flowers in consecutive months were accepted. In the theses on appletree crop yield it is estimated that in the spring an average bee colony placed in the vicinity of an orchard provides 3,000 worker bees working simultaneously on flowers (Bornus et al. 1976). Due to the fact that flight over wild plants in forests and swards usually involves a much longer distance to the yield and additional time to search scattered plants, in these calculations it was assumed that in spring (April) one colony provides 500 worker bees working at a given moment on flowers. In the following months, taking into consideration the increase in development, we accepted the following numbers of bees working on flowers: May – 1500, June – 2500, July – 3500, August – 3000, September – 2000.

The number of days of pollination („flights days") - these are days when weather conditions make it possible for bees to visit flowers. The main obstacles to flight are cold and rainy days. In the vegetation period in lowland Poland there are usually 8.8 days per month with precipitation above 1mm (an average between 1951 and 1990 provided orally by Professor J. Tamulewicz, UAM, Poznań). The remaining days in the month were the number of days when flight was possible.

These parameters served to estimate the number of bee colonies required for the pollination of undergrowth and underwood of main forest habitat types in Poland in the consecutive months of the vegetation period (Tables 1, 2).

Tabela 1a.

The number of bee colonies sustainable in Poland, estimated on the basis of potential nectar flow in coniferous forests - Liczba rodzin pszczelich możliwych do utrzymania w Polsce, oszacowana na podstawie potencjalnych zasobów pożytkowych borów

Parameters Uwzględnione parametry	Type of forest habitat - Typ siedliskowy lasu											
	Swamp forest - Bór bagienny						Mixed forest - Bór mieszany					
Month - Miesiąc	IV	V	VI	VII	VIII	IX	IV	V	VI	VII	VIII	IX
Number of flower (million, ind./ha) Liczba kwiatów (mln szt./ha)	0.00	56.41	55.25	3.81	3.30	2.80	0.19	36.83	20.66	1.83	0.00	0.00
Time work of bees h/day Czas pracy pszczół (godz./dzień)	4	7	10	10	8	7	4	7	10	10	8	7
Effectiveness of bees (flowers/minute) Wydajność pracy pszczół (kwiatów/min)	8.3						8.3					
Number of working bees/colony Liczba pracujących zbieraczek/rodzinę	500	1500	2500	3500	3000	2000	500	1500	2500	3500	3000	2000
Number of flowers pollinated by one colony during the day (millions) Liczba kwiatów zapylonych przez rodzinę w ciągu dnia (mln)	1.00	5.23	12.45	17.43	11.95	6.97	1.00	5.23	12.45	17.43	11.95	6.97
Days of pollination Liczba dni zapylania	21.2	22.8	21.2	22.8	22.8	21.2	21.2	22.8	21.2	22.8	22.8	21.2
Number of colonies required for pollination of 1ha Liczba rodzin potrzebna do zapylenia 1 ha	0.000	0.473	0.209	0.010	0.012	0.019	0.009	0.309	0.078	0.005	0.000	0.000
Acreage in Poland (ha) Powierzchnia w Polsce	35 503						1 863 965					
Required number of bee colonies (in thousands) - Wymagana liczba rodzin pszczelich (w tys.)	0.00	16.80	7.43	0.34	0.43	0.67	16.46	575.82	145.89	8.57	0.00	0.00

Tabela 1b.

Parameters Uwzględnione parametry	Type of forest habitat - Typ siedliskowy lasu											
	Fresh forest - Bór świeży						Dry forest - Bór suchy					
Month - Miesiąc	IV	V	VI	VII	VIII	IX	IV	V	VI	VII	VIII	IX
Number of flower (million, ind./ha) Liczba kwiatów (mln szt./ha)	0.00	24.30	2.49	1.39	0.69	0.00	0.57	10.40	9.04	0.36	38.89	12.96
Time work of bees h/day Czas pracy pszczół (godz./dzień)	4	7	10	10	8	7	4	7	10	10	8	7
Effectiveness of bees (flowers/minute) Wydajność pracy pszczół (kwiatów/min)	8.3						8.3					
Number of working bees/colony Liczba pracujących zbieraczek/rodzinę	500	1500	2500	3500	3000	2000	500	1500	2500	3500	3000	2000
Number of flowers pollinated by one colony during the day (millions) Liczba kwiatów zapylonych przez rodzinę w ciągu dnia (mln)	1.00	5.23	12.45	17.43	11.95	6.97	1.00	5.23	12.45	17.43	11.95	6.97
Days of pollination Liczba dni zapylania	21.2	22.8	21.2	22.8	22.8	21.2	21.2	22.8	21.2	22.8	22.8	21.2
Number of colonies required for pollination of 1ha Liczba rodzin potrzebna do zapylenia 1 ha	0.000	0.204	0.009	0.003	0.003	0.000	0.027	0.087	0.034	0.001	0.143	0.088
Acreage in Poland (ha) Powierzchnia w Polsce	2 608 394						109 200					
Required number of bee colonies (in thousands) - Wymagana liczba rodzin pszczelich (w tys.)	0.00	531.56	24.65	9.11	6.65	0.00	2.96	9.53	3.74	0.10	15.59	9.58

Tabela 1c.

Parameters Uwzględnione parametry	Type of forest habitat - Typ siedliskowy lasu Fir forest - Bór jodłowy					
Month - Miesiąc	IV	V	VI	VII	VIII	IX
Number of flower (million, ind./ha) Liczba kwiatów (mln szt./ha)	0.00	20.13	3.95	0.00	0.00	0.00
Time work of bees h/day Czas pracy pszczół (godz./dzień)	4	7	10	10	8	7
Effectiveness of bees (flowers/minute) Wydajność pracy pszczół (kwiatów/min)	8.3					
Number of working bees/colony Liczba pracujących zbieraczek/rodzinę	500	1500	2500	3500	3000	2000
Number of flowers pollinated by one colony during the day (millions) Liczba kwiatów zapylonych przez rodzinę w ciągu dnia (mln)	1.00	5.23	12.45	17.43	11.95	6.97
Days of pollination Liczba dni zapylania	21.2	22.8	21.2	22.8	22.8	21.2
Number of colonies required for pollination of 1ha Liczba rodzin potrzebna do zapylenia 1 ha	0.000	0.169	0.015	0.000	0.000	0.000
Acreage in Poland (ha) Powierzchnia w Polsce	9 504					
Required number of bee colonies (in thousands) Wymagana liczba rodzin pszczelich (w tys.)	0.00	1.60	0.14	0.00	0.00	0.00

Tabela 2.

The number of bee colonies sustainable in Poland, estimated on the basis of potential nectar flow in deciduous forests - Liczba rodzin pszczelich możliwych do utrzymania w Polsce, oszacowana na podstawie potencjalnych zasobów pożytkowych borów

Parameters Uwzględnione parametry	Type of forest habitat - Typ siedliskowy lasu Hornbeam and beech forest Grąd bukowo-grabowy						Oak and hornbeam forest + thermophilous oak forest Grąd dębowo-grabowy + świetlista dąbrowa					
Month - miesiąc	IV	V	VI	VII	VIII	IX	IV	V	VI	VII	VIII	IX
Number of flower (million, ind./ha) Liczba kwiatów (mln szt./ha)	1.99	7.25	0.86	0.00	0.00	0.00	0.27	4.92	1.02	0.00	0.00	0.00
Time work of bees h/day Czas pracy pszczół (godz./dzień)	4	7	10	10	8	7	4	7	10	10	8	7
Effectiveness of bees (flowers/minute) Wydajność pracy pszczół (kwiatów/min.)	8.3						8.3					
Number of working bees/colony Liczba pracujących zbieraczek/rodzinę	500	1500	2500	3500	3000	2000	500	1500	2500	3500	3000	2000
Number of flowers pollinated by one colony during the day (millions) - Liczba kwiatów zapylonych przez rodzinę w ciągu dnia (mln)	1.00	5.23	12.45	17.43	11.95	6.97	1.00	5.23	12.45	17.43	11.95	6.97
Days of pollination Liczba dni zapylania	21.2	22.8	21.2	22.8	22.8	21.2	21.2	22.8	21.2	22.8	22.8	21.2
Number of colonies required for pollination of 1ha Liczba rodzin potrzebna do zapylenia 1 ha	0.094	0.061	0.003	0.000	0.000	0.000	0.013	0.041	0.004	0.000	0.000	0.000
Acreage in Poland (ha) Powierzchnia w Polsce	237 281						1 834 148					
Required number of bee colonies (in thousands) Wymagana liczba rodzin pszczelich (w tys.)	22.33	14.42	0.77	0.00	0.00	0.00	23.67	75.65	7.09	0.00	0.00	0.00

Tabela 3.

The number of bee colonies sustainable in Poland, estimated on the basis of potential nectar flow in the main types of swards ecosystems - Liczba rodzin pszczelich możliwych do utrzymania w Polsce, oszacowana na podstawie potencjalnych zasobów pożytkowych borów

Parameters Uwzględnione parametry	Type of forest habitat - Typ zbiorowiska roślinnego											
	Meadows and pastures - Łąki i pastwiska						Xerothermic swards - Murawy kserotermiczne					
Month - Miesiąc	IV	V	VI	VII	VIII	IX	IV	V	VI	VII	VIII	IX
Number of flower (million, ind./ha) Liczba kwiatów (mln szt./ha)	13.20	134.77	182.69	119.04	79.61	3.09	0.00	5.18	21.80	20.16	0.10	0.03
Time work of bees h/day Czas pracy pszczół (godz./dzień)	4	7	10	10	8	7	4	7	10	10	8	7
Effectiveness of bees (flowers/minute) Wydajność pracy pszczół (kwiatów/min.)	8.3						8.3					
Number of working bees/colony Liczba pracujących zbieraczek/rodzinę	500	1500	2500	3500	3000	2000	500	1500	2500	3500	3000	2000
Number of flowers pollinated by one colony during the day (millions) Liczba kwiatów zapylonych przez rodzinę w ciągu dnia (mln)	1.00	5.23	12.45	17.43	11.95	6.97	1.00	5.23	12.45	17.43	11.95	6.97
Days of pollination Liczba dni zapylania	21.2	22.8	21.2	22.8	22.8	21.2	21.2	22.8	21.2	22.8	22.8	21.2
Number of colonies required for pollination of 1ha Liczba rodzin potrzebna do zapylenia 1 ha	0.625	1.113	0.692	0.300	0.292	0.021	0.000	0.043	0.083	0.051	0.000	0.000
Acreage in Poland (ha) Powierzchnia w Polsce	4 118 229						1 558 671					
Required number of bee colonies (in thousands) Wymagana liczba rodzin pszczelich (w tys.)	2574.48	4655.47	2850.45	1233.59	1203.04	86.12	0.00	67.75	128.76	79.09	0.57	0.35

Tabela 4.

Overall number of bee colonies sustainable in Poland estimated on the basis of potential natural nectar flow resources - Łączna liczba rodzin pszczelich, możliwych do utrzymania w Polsce, oszacowana na podstawie potencjalnych naturalnych zasobów pożytkowych

Month - Miesiąc	IV	V	VI	VII	VIII	IX
Required number of bee colonies (in thousand) Wymagana liczba rodzin pszczelich (w tys.)	Coniferous forests - Bory					
	19.43	1135.31	181.86	18.12	22.66	10.25
	Deciduous forests - Lasy					
	46.00	90.07	7.86	0.00	0.00	0.00
	Xerothermic swards in roadsides, residential areas and barrens Murawy kserotermiczne na terenach komunikacyjnych, osiedlowych i nieużytkach					
	0.00	67.75	128.76	79.09	0.57	0.35
	Meadows and pastures - Łąki i pastwiska					
	2 574.48	4 723.21	2 979.21	1 312.68	1 203.61	86.47
Total - Suma	**2 639.91**	**6 016.35**	**3 297.69**	**1 409.89**	**1 226.84**	**97.07**

Table 5.

Examples of beecolonies (bee trees) in beekeepers' forests in Poland between the16th and the 18th centuries (according to Wróblewski 1998)
Przykłady liczby rodzin pszczelich (barci) w borach bartnych na terenie Polski w XVI-XVIII wieku (wg Wróblewskiego, 1998)

Beekeepers' forests - Bory bartne	Periods - Okresy	Number of bee trees Liczba barci (rodzin pszczelich)
Kamieniecka Forest (present day neighbourhood of Kamieńczyk) Puszcza Kamieniecka (dzisiaj okolice Kamieńczyka)	mid-19th century Połowa XVI w.	950
Tucholski Forest - Bory Tucholskie	till 1772 Do roku 1772	20,000
Człuchowski Forest - Bory Człuchowskie	before 1772 Przed rokiem 1772	4,000
The river basins of Narew, Bug and San Dorzecze Narwi, Bugu, Sanu	16th - 18th	several thousands in a beekepers' forest Po kilka tysięcy na las bartny
The former province of Warsaw (Kamieniec County) Dawne województwo warszawski (starostwo kamienieckie)	1565	900
Parczewo County - Starostwo parczewskie	1564	700 busy - 1000 empty 700 zajętych - 1000 opuszczonych

Similarly, that is, using the above parameters, the need for honeybees in open habitats was estimated, while the first indicator (the number of flowers in the given area) was established with the help of Bartyś' thesis (1999), which referred to meadows and swards. Extrapolation of these data onto various plant communities found in open areas is an obvious approximation. We need to explain the general area of open spaces which we had chosen, which included the following habitats listed in geodetic surveys and year-books as types of land use: meadows, pastures, roads, residential areas, barrens, and

other areas. In the case of meadows, pastures and barrens, the whole area was accepted as covered by herbage. In the case of roads, we accepted that roadsides constitute $^1/_3$ of their area. However, residential areas are covered to $^1/_2$ by different types of sward vegetation (Table 2). This area, covered with herbage, covers about 4.4% of Poland's territory, namely 5.8 million ha.

RESULTS

Coniferous forest habitats. According to the data concerning the nectar flow stock of coniferous forests, the need for pollinating bees in the five habitat types of these forests, that is: humid (*Vaccinio uliginosi-Pinetum*), mixed (*Pino-Quercetum*), fresh (*Peucedano-Pinetum typicum*), dry (*Peucedano-Pinetum cladonietosum*) and fir (*Abietetum polonicum*) coniferous forest, was estimated. These forest types cover an area of 4,626,566 ha, accounting for 87.2% of coniferous forest area in Poland. One needs to remember that blooming intensity in forest ecosystems is not stable in the season, with the blooming peak in May and June in all types of coniferous forests (Table 1). Owing to this, the need for pollinating insects is highest at that time and in the case of *Apis mellifera* it equals 1.1 million colonies in May and about 181,000 in June. As is shown in Table 1, the most attractive for bees are the mixed and fresh coniferous forests, with each of them requiring flights of over 500,000 bee colonies at the peak of the blooming season.

Deciduous forest habitats. In the case of deciduous forests, three habitat types were considered: hornbeam and beech forest, oak and beech forest and thermophilous oak forest, accounting for 2,071,429 ha in Poland, which is 67.1% of deciduous forests. The oak-hornbeam forest herbage blooms earlier, yielding the first honey flow in April, although the blooming peak takes place in May. Then, the most attractive for bees are oak and hornbeam forests and thermophilous oak forests (Table 2). As early as May, wet-ground forests potentially require the flight of 90,000 bee colonies (Table 4).

All together, about 6.7 million ha of forests in Poland can be pollinated by 65,000 (April) to 1.2 million colonies (May).

Extrapolating the results onto the remaining, not estimated, 20% of forest area, the number of bee colonies required for pollinating forest communities in Poland should be expanded by 245,000 (May). The overall number of bee colonies necessary for pollination of wild growing plants in forest ecosystems amounts to 1.4 million in May.

One needs to emphasize that the conducted estimates referred only to the lower forest layer, and out of stern necessity the tree crown layer was omitted, where bees also find pollen and nectar.

Open areas, overgrown with swards blooming intensively throughout most of the vegetation period, require, in contrast to forests, many more bee visits.

Xerothermic swards in roadsides, residential areas and barrens require pollination by about 130,000 bee colonies in June and respectively fewer in other months, as illustrated in Table 4.

The habitats of hay-growing meadows and pastures are specific areas. On the one hand we find multitudes of blossoming plants, rare elsewhere, which can be compared only to entomogamous plantations; on the other hand, however, bees have access to these plants only during a very short time due to hay cutting or grazing of animals. Successful pollination of meadow and pasture plants in the blooming peak (May and June) would require visits from 4.7 (May) to 3.0 million bee colonies.

DISCUSSION

One should remember that the presented data referring to the nectar flow of forests and open areas in Poland are only approximations. The evaluation is not simple and it is difficult to present by means of one average of the whole vegetation period, due to the changeability in blooming of successive plants. This results in enormous changes in the state of nectar flow and consequently in the needs for bee pollination. Estimates prove that in the blooming peaks (May) natural and seminatural communities may require as many as 6 million bee colonies for pollination, with equally high demands in April and June (Table 4). These imprecise results also give a certain view of the food resources of pollinating insects. Suffice it to say that pollination of only the main crop plants requires 1.5 million bee colonies. W. Rawski (1947), estimating the requirements for pollinating bees, proved that the whole of the natural environment in Poland may sustain from 12 to 13 million honeybee colonies. Rawski took into account annual nectar flow of cropland, field weeds, trees, shrubs, forest herbage, riverbanks and others.

The real economic value of pollination is illustrated by the research of Banaszak and Cierzniak (1995), who evaluated the economic effect of pollination of several crop plants by honeybee and wild bees. They proved that the overall economic effect of pollination of 5 plants (lucerne, red clover, winter rape, buckwheat, apple-tree) equals from 60 to 340 million dollars (1995 prices). The worth of crops, gained due to honeybee activity, gives from 40 to 300 million dollars, whereas wild bees contribute to 18-30 million dollars' worth of crops.

There appears a question of ecological consequences resulting from the honeybee scarcity as a pollinating factor with reference to the problem of reproductive success of wild plants, the decrease in yielding and consequently

a decrease in food supply for numerous wild herbivores. This issue requires detailed research.

History proves that the honeybee has been systematically taken out of forest habitats for at least the last 300 years in Poland. Consequently, a new situation resulted: forests were deprived of their natural and prime element, whereas the honeybee was artificially introduced to open arable land by beekeepers. In the 16th century Poland was still considered to be one great apiary. In Mazovia, Małopolska and Pomerania there were many beekeeping forests with even up to several thousand bee trees (Table 5). In the old-Polish lands bee-keeping thrived especially in the basins of the River Bug and the River Narew, being most popular in the region of Kurpie. In the mid-16th century the process of the removal of beekeepers by farmers and shepherds and pushing them into forest enclaves began. One such enclave was Pomerania, where beekeepers grouped in great numbers, mainly in the Tucholski Forest and Kaszubia. Prussian authorities, having surveyed the conquered land of the Tucholski Forest after 1772, decided that the main occupation of the people was beekeeping. The number of bee trees in the Tucholski Forest was estimated to be about 20,000, and in Człuchowski Forest, 4,000! With the onset of Prussian administration, beekeeping in the region faltered, because apiculture did not go well with forestry. However, in the mid-19th century there were still dense beekeepers' forests, holding 200 or more inhabited bee trees (Wróblewski 1991, 1998). Even these summarised facts prove that the honeybee was a constant and prolific element of forest fauna in Poland, at least till the 17th century. The decline of forest beekeeping and the development of homestead apiculture have significantly changed the structure of pollinating insects inhabiting forests. At that time there must have been a change, difficult to describe today, in the entomogamous plant communities of the area. Since the 19th century bees have been only a temporary and locally limited element of forest community fauna. The consequences might have moved in two directions, namely: 1) a decrease in the plant diversity, especially herbage; 2) an increase in the number of solitary bees and bumblebees, due to a drop in the honeybee population and its competition.

A considerable decrease in honeybee numbers in Poland has become evident in the last decade, due to a possible drop in plant diversity or competition with wild insects. However, it must be said that the problem of food competition between honeybees and wild bees has not been definitely explained. Most research into the food supply division (sharing food), based on the observation of visits to flowers and nectar collecting, as well as on pollen analysis, do not exclude or presume the factor of competition.

The honeybee has always been the main pollinator of many naturally growing plants. This is supported by modern number evaluation of *Apoidea* in

ecosystems of a natural character. The share of *Apis mellifera* in comparison to other *Apoidea* in open sward environments, i.e. roadsides, balks and xerothermic swards, is up to 50%, whereas in meadows, it reaches even 90% (Banaszak 1983). In forests, depending on their age, the share of honeybees varies considerably: from 30% in plantation forests to 3% in mature forests (Banaszak 1983, Pawlikowski 1985, Banaszak, Cierzniak 1994, Krzysztofiak 1995). The listed research does not refer to forests as the honeydew source. The comparison of the numbers of *Apis* worker bees caught in traps set up in the herbage layer and in the deciduous tree crowns in the Wielkopolski National Park indicates an advantage of tree-tops to the undergrowth in these communities. The presence of honeydew or oak pollen is of prime importance to *Apis* in the oak forest. In this period bees rarely happen to stray to the bottom layer of the forest. However, in the pine forest the undergrowth with its abundance of heather blossoms in pads is of crucial value for bees (Banaszak 1998). Since the honeybee exile, or removal, from the forests, there has been an exceptional situation, and the above estimations of potential need for pollination of nectar flow resources prove that forests remain a neglected source of food. A re-introduction of this species could increase the diversity of forests. Thus this seems to be an important issue, awaiting a scientific explanation.

CONCLUSION

1. It was estimated that flower vegetation of natural and seminatural plant communities in Poland (forests, meadows, pastures, swards in residential districts, nearby roads and waste land) demands honeybee pollination at 2.3 million bee families in April, 6 million bee families in May, 3.3 million in June, 1.4 million in July, 1.2 million in August and 0.1 million in September.
2. Honey bee has been a constant and numerous element of forest fauna in Poland at least since the 18th century. For the recent 250-300 years honey bee has been being constantly removed from forest communities. Instead, honey bee has been introduced into agricultural areas by developing beekeeping (apiary). Today drastic fall in the number of bee families in Poland, diminishing the possibility of crop pollination, may lead to hard consequences for natural and seminatural vegetation and groups of wild pollinating insects.
3. There is the need for estimation of a) the influence of the fall in the number of Apis mellifera as the main pollinator in Poland on the diversity of natural entomogamous plant communities and b) changes in the content and number of wild plant pollinators under the influence of diminishing competition on the part of honey bee.

REFERENCES

Albigowski A. (1995)- Całe życie wśród pszczół. Rozmowa z prof. dr. hab. Leonem Bornusem. *Pszczelarz Polski*, 4: 14-25.

Anasiewicz A. (1972)- Oblot niektórych gatunków drzew owocowych i porzeczki czarnej przez błonkówki pszczołowate (*Hymenoptera, Apoidea*). *Pol. Pismo Entomol.*, 52: 491-506.

Banaszak J. (1983)- Ecology of bees (*Apoidea*) of agricultural landscape. Pol. Ecol. Stud., 9: 421-505.

Banaszak J. (1998)- Rola pszczoły miodnej w środowisku naturalnym. Polski Związek Pszczelarski, Warszawa, 59 pp.

Banaszak J., Cierzniak T. (1984)- Spatial and temporal differentiation of bees (*Apoidea*) in the forest of Wielkopolski National Park, Western Poland. *Ucta. Univ. Lodz., Folia zool.*, 2: 3-28.

Banaszak J., Cierzniak T. (1995)- Ekonomiczne efekty zapylania roślin uprawnych przez pszczołę miodna i dziko żyjące pszczołowate (*Apoidea*). Kosmos, 44, (1): 47-61.

Bartyś E. (1999)- Cechy ekologiczne kwiatów i morfologia ziaren pyłku niektórych gatunków roślin łąkowych oraz muraw kserotermicznych. Rozprawa doktorska. Akademia Rolnicza w Lublinie, Katedra Botaniki.

Biliński M. (1977)- Oblot koniczyny czerwonej przez owady zapylające. *Pol. Pismo Entomol.*, 47: 487-505.

Bornus L., Jabłoński B., Król S. (1976)- Próba określenia optymalnej ilości pszczół do dobrego zapylenia sadu jabłoniowego. *Pszczeln. Zesz. Nauk.*, 20: 1-20.

Dylewska M., Jabłoński B., Sowa S., Biliński M., Wrona S. (1970)- Próba określenia liczby pszczół (*Hym., Apoidea*) potrzebnych do należytego zapylenia lucerny. *Pol. Pismo Entomol.*, 40, 2; 371-398.

Gromisz M. (1998)- Pożytki i gotowość rodzin pszczelich do ich wykorzystania. Instytut Sadownictwa i Kwiaciarstwa w Puławach, 62 pp.

Jabłoński B. (1975)- Zagęszczenie owadów pszczołowatych na koniczynie czerwonej potrzebne do dobrego jej zapylenia. *Pszczeln. Zesz. Nauk.*, 19:13-29.

Kołtowski Z. (1996)- Oblot kilku odmian bobiku (*Vicia faba* L. ssp. *minor* Harz) przez owady zapylające. *Pszczeln. Zesz. Nauk.*, 40, 1:77-91.

Krzysztofiak A. (1995)- Struktura zgrupowań pszczół (*Apoidea, Hymenoptera*) w różnowiekowych drzewostanach świerkowo-sosnowych Wigierskiego Parku Narodowego. Praca doktorska, maszynopis. Wigierski Park Narodowy, 66 pp + 22 tab. + 23 ryc.

Nogal W. (1999)- Stan pszczelarstwa w Polsce. *Pszczelarz Polski*, 2: 2-3.

Pawlikowski T. (1992)- Zgrupowania dzikich pszczołowatych (*Hymenoptera, Apoidea*) na kserotermicznych siedliskach wydmowych Kotliny Toruńskiej. *Studia Soc. Sci. Torunensis*, 10 (4), E (Zoologia): 1-57 + 14 tab.

Pidek A. (1991)- Trendy w ekonomice pasiek w latach 1970-88 na podstawie estymacji funkcji. *Pszczeln. Zesz. Nauk.*, Puławy, 35: 83-90.

Pidek A. (1992)- Wykorzystanie pszczół do zapylania roślin sadowniczych w Polsce 1987-1990. *Pszczeln. Zesz. Nauk.*, 36: 15-19.

Pidek A. (1996)- Trends in the Polish bee-keeping on the background of the European Union. *Pszczeln. Zesz. Nauk.*, 40 (2): 235-236.

Pidek A. (1997)- Potencjał produkcyjny pszczelarstwa w Polsce. [w:] *„Postępy apidologii w Polsce"*, red. T. Cierzniak, Wyd. WSP w Bydgoszczy, 37-46.

Pidek A. (1998)- Organizacja i ekonomika pasiek. [w:] *„Pszczelnictwo"*, red. J. Prabucki, Wyd. Promoc. Albatros, Szczecin, 612-634.

Rawski W. (1947)- Pszczelarstwo a planowanie przestrzenne kraju. Skrypt na prawach rękopisu. Wydawnictwo „Ex Libris", Warszawa, 99 pp.

Sęczyk L. (1998)- Wie premier, zna minister. *Pszczelarstwo*, 5:3-4.

Sęczyk L. (1999)- Znaczenie pszczół dla rolniczych upraw. *Pszczelarz Polski*, 6: 22-25.

Szklanowska K. (1973)- Bory jako baza pożytkowa pszczół. *Pszczeln. Zesz. Nauk.*, 17: 51-85.

Szklanowska K. (1979)- Nektarowanie i wydajność miodowa ważniejszych roślin runa lasu liściastego. *Pszczeln. Zesz. Nauk.*, 23: 123-130.

Wacławek A. (2000)- Zanikające pszczelarstwo na Dolnym Śląsku. *Pszczelarz Polski*, 2: 5.

Woyke H. (1998)- Rola zapylania w pszczelarstwie i rolnictwie. *Pszczelarz Polski*, 6: 24-25.

Wilde J. (2000)- Polskie pszczelarstwo poprawić - zuchwałe rzemiosło. *Pszczelarstwo*, 1: 5.

Winiarski M. (1998)- Chrońmy pszczelarstwo amatorskie. *Pszczelarstwo*, 10: 12-13.

Wójtowski F., Młyniec W. (1964)- Zachowanie się błonkówek pszczołowatych na kwiatach wyki kosmatej. *Roczniki WSR* w Poznaniu, 19: 197-207.

Wróblewski R. (1991)- Polskie pszczelarstwo. Zakład Narodowy im. Ossolińskich, Wrocław, 376 pp.

Wróblewski R. (1998)- Barcie, kłody, koszki i ule polskie. Biblioteka Sądeckiego Bartnika. Seria Historyczna, *„Sądecki Bartnik"* A. J. Kasztelewicz, Nowy Sącz, 173 pp.

Ziółkowski H. (1979)- Owady pszczołowate (*Apoidea*) zapylające kapustę pastewną (*Brassica oleracea* L. *var. acephala* Hort.) o rzodkiewkę (*Raphanus sativus* L. *var. radicula* D.C.) na obszarze kujawsko-pomorskim. *Zesz. Nauk.* ATR w Bydgoszczy, Zootechnika, 71:149-182.

PRÓBA OCENY LICZBY RODZIN PSZCZOŁY MIODNEJ POTRZEBNYCH DO ZAPYLENIA ROŚLIN ZESPOŁÓW NATURALNYCH W POLSCE

J. Banaszak, T. Cierzniak

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

Na podstawie zagęszczenia kwiatów i wydajności zapylania pszczoły miodnej oszacowano potencjalną liczbę rodzin potrzebnych do zapylania roślin zespołów naturalnych i zbliżonych do nich w Polsce. Wyliczono, że bory, lasy i obszary otwarte z roślinnością murawową w okresie optimum kwitnienia roślin (maj) wymagają odwiedzin i zapylenia przez około 6 mln rodzin pszczoły miodnej, w innych okresach odpowiednio mniej: w kwietniu - 2,3 mln, w czerwcu - 3,3 mln, w lipcu - 1,4 mln, w sierpniu 1,2 mln, we wrześniu 0,1 mln. Z liczby 6 mln rodzin pszczelich na bory przypada około 1,1 mln, lasy - 0,09 mln i na łąki i pastwiska około 4,7 mln, murawy kserotermiczne na przydrożach i nieużytkach około 0,06 mln. Zapotrzebowanie polskiego rolnictwa dodatkowo wymaga obecności przynajmniej 1,5 mln rodzin pszczelich.

Słowa kluczowe: pszczoła miodna, rodziny pszczele, *Apis mellifera*, zagęszczenie kwiatów, wydajność zapylania, bory, lasy, roślinność murawowa.