DOI: 10.2478/JAS-2014-0003 J. APIC. SCI. VOL. 58 NO. 1 2014

DE GRUYTER OPEN

Original Article

BEES (HYMENOPTERA, APOIDEA, APIFORMES) IN THE AGRICULTURAL LANDSCAPE OF BULGARIA: SPECIES DIVERSITY

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Received 27 December 2012; accepted 15 January 2014

A b s t r a c t

Wild bees (Apiformes) were studied in 4 crop fields and 8 refuge habitats for 2 - 5 years in agricultural landscapes in the Pleven and Plovdiv regions of Bulgaria. In total, 233 bee species were recorded. Bee forage plants visited by the honey bee and wild Apiformes are listed for each refuge habitat. Species composition is given for individual habitats, including fields of alfalfa (*Medicago sativa*), oilseed rape (*Brassica napus*), sunflower (*Helianthus annuus*), and radish (*Raphanus sativus*). Species richness and dominance structure of bee communities in the 2 regions are compared, and species responsible for significant differences are identified.

Keywords: Bulgaria, dominance structure, Hymenoptera: Apoidea: Apiformes, Pleven region, Plovdiv region, species diversity.

INTRODUCTION

Although Bulgaria lies at the borders of several zoogeographic regions, the Bulgarian fauna of Hymenoptera, including wild bees (Apiformes), is poorly studied. Among the Apiformes, bumblebees are relatively well known, mostly thanks to Pittioni's (1938, 1939) research on Bulgaria and the whole Balkan Peninsula, supplemented by Atanassov (1939, 1974). Other wild bees have been investigated mostly by the latter author, e.g., Halictidae (Atanassov, 1960) and *Xylocopa* (Atanassov, 1962a), who also published faunistic lists for the Balkan Mountains (Stara Planina) and the Petrič region (Atanassov, 1962b), and from the island of Tasos (Atanassov, 1965). In the 1970s and '80s, more attention was paid to pollinators of crop plants, especially alfalfa, and to yields of this valuable forage plant as well as human management of *Megachile rotundata* F. (= *M. pacifica* Panz.) for pollination of alfalfa seed production fields. Most information on this subject can be found in numerous publications by Dochkova and colleagues concerning the Pleven region (e.g., Dochkova, 1981a, b, 1982a, b, 1984; Dochkova et al., 1981a, b, c, d, 1984, 1987). Alfalfa pollination and pollinators from north-eastern Bulgaria (Ruse) were also investigated by Dimitrov (1984, 1987, 1990, 1992a, b), Dimitrov et al. (1987), and Dimitrov and Dimitrova (1991a, b). Dimitrov et al. (1992) additionally studied pollinators of sunflower in the Ruse region. In the available literature, there is no information on the total number of bee species in Bulgaria, but the number is certainly high. Thus, the published literature currently includes only scanty reports on the bee fauna of this country.

Here we present data on wild bees collected in 2 types of agricultural landscapes: in the Danubian Plain (Pleven region in northern Bulgaria) and in the Upper Thracian Plain (Plovdiv region in central Bulgaria). Material was collected in 1986 - 1991, mostly along field margins and within fields of selected crop plants.

The study aims were (1) to assess the diversity and abundance of Apiformes in these 2 types of agricultural landscapes and (2) to investigate the dominance structure of pollinating insects and their phenology in these regions.

MATERIAL AND METHODS

Field research was conducted from April/May to September/October in 1986 - 1991, but the number of years varied between regions and individual study sites, as explained in the list of study sites below. In the first year, research was initiated in late July.
The insects were caught with an aerial insect net by searching on flowers and in favorite bee nesting sites. Bee abundance was assessed once or twice a month using the transect method (Banaszak, 1980), which consists of walking along a linear transect (200 m long, 1 m wide) and counting or, if necessary, catching observed insects. The investigations were conducted in conditions favorable for bee activity, i.e., when air temperature was ≥20°C and the wind was not strong. Obviously, we did not catch the species that could be readily identified, such as the honey bee and some of the larger wild bees. Each sample was composed of insects noted or caught in an area of 200 m^2. Bee abundance was next calculated and expressed as number of individuals per hectare. On every sampling occasion, 2 such samples were collected at each site. In further analysis, those coupled transects are considered as one sample. While counting the insects, we also recorded species of visited bee forage plants. As a result, a list of bee forage plants was compiled for individual sites.
To identify differences in the structure of wild bee communities between the study sites located in two agro-ecological landscapes (Pleven and Plovdiv), we used non-metric multidimensional scaling (NMDS). Similarity between samples was assessed on the basis of Bray-Curtis distances because of their close association with changes in community composition (Faith et al., 1987). Ordination was used for the samples where at least 5 individuals were observed, and the variables were the species represented by at least 5 individuals. The results reflected major patterns in the communities. Statistical significance of differences between communities (groups of samples) was assessed using a multi-response permutation procedure (MRPP). This method tests a hypothesis that there are no differences in species composition between study sites (Zimmerman et al., 1985; Bonner et al., 2009) and is based on the matrix of Bray-Curtis distances to compare mean dissimilarity within groups to dissimilarity between groups. The method estimates not only statistical significance but also the A statistic and is a measure of within-group homogeneity compared to random homogeneity. Its value varies from 0 (random) to 1 (all elements identical in the group). MRPP (similar to ANOSIM and ADONIS) may be used to indicate differences between groups of objects in multidimensional space (Dufrêne and Legendre, 1997; Hannon and Sisk, 2009).
To identify which species in the community are responsible for the lack of homogeneity between groups of samples, we calculated indicator values (IndVal) of bee species recorded in those areas (Dufrěne and Legendre, 1997). The IndVal is based on within-species abundance and occurrence comparisons in specified group. In addition, the IndVal method makes it possible to evaluate the strength of association between a given species and a given habitat. For this reason, IndVals were calculated for the whole collected material. If an IndVal was higher than 0.24, then the species was classified as strongly associated with the given habitat. The significance of IndVals was confirmed by a randomization procedure with 1000 replications. The above analyses were performed in the R software environment (R Development Core Team, 2008) with the use of vegan (Oksanen et al., 2011) and labdsv libraries (Roberts, 2010).
To compare species diversity between the landscapes and between individual sites, we used species accumulation curves, which are analytical estimates (using the MaoTau estimator) of the expected number of species for the given number of samples (Gotelli and Colwell, 2001). As Gotelli and Colwell (2010) observed, lack of independence between samples can be neglected if rarefaction curves are functions of the number of samples. Comparison of species richness with unequal sampling effort, which incorporates sample-based rarefaction curves, is often used (Calvillo et al., 2010; Banaszak-Cibicka and Żmihorski, 2012; Żmihorski et al., 2013).
To estimate the true species number, we applied 2 estimators: Chao2 (Chao, 1984) and Jackknife2 (Burnham and Overton, 1979). Chao2 is a simple estimator of the true species number (S^*_{chao2}) in the community, based on the number of observed species (S_{obs}) and rare species in the collected material, i.e., those present in a single sample (a) or in 2 samples (b):

$$S^*_{chao2} = S_{obs} + \left(\frac{a^2}{2b} \right)$$

The estimator is the lower limit of the estimation and serves well for data sets where most information is concentrated in low-frequency classes, i.e., where a majority of species are rare. First- and second-order jackknife estimators are methods for reducing estimation error. Second-order jackknife estimates the true species number on the basis of the number of species present in a single sample (uniques, L) and in 2 samples (duplicates, M):

$$S_{jack} = S_{obs} + \left[\frac{L(2n-3)}{n} - \frac{M(n-2)^2}{n(n-1)} \right]$$

Individual-based rarefaction curves and expected species richness were calculated using Estimate S software (Colwell, 2006).

To compare bee dominance structure between crop fields and semi-natural habitats, we used the evenness index (E_Q), which is not correlated with species number (S) (Smith and Wilson, 1996), as well as the slope angle of rank-abundance curves for most frequent species (top 40%) in the community. The latter measure was used to describe the initial dominance structure. To obtain dominance structure, we used pooled samples for a given study site. Ranks (x) of species were scaled (x/S) so that the species with the highest contribution to the dominance structure had a value close to 0 while the rarest one had a value equal to 1. E_Q was calculated according to the formula:

$E_Q = -2/\pi \arctan(b')$,

where b' is the slope of the inverse relationship between rank number and species abundance (species rank as a function of the logarithm of the number of individuals). E_Q values vary from 0 to 1, where 1 denotes complete evenness of species in the community.

To obtain statistical differences between mean E_Q values of fields and semi-natural habitats, we used simple Student's t tests, which test the null hypothesis of no group difference. The F test was conducted to check equality of variances between compared groups.

Study area

Field research was conducted in 2 lowland regions separated by the Balkan Mountains (Stara Planina): the Danubian Plain and the Upper Thracian Plain. In 1986 - 1991, wild bees were studied in northern Bulgaria, in the central part of the Danubian Plain, about 15 km west of Pleven, mostly at several sites in the village of Krushovitsa. Both Pleven and Krushovitsa lie along the river Vit, a tributary of the Danube. The climate of the Pleven region is temperate continental, with a mean annual temperature of 11.5°C. The coldest month is January (mean temperature -2.4°C), and the warmest is July (mean temperature 23.6°C). Maximum temperature in summer is 42 - 43°C whereas minimum in winter is -24°C. Westerly winds prevail in summer, and north-westerly in winter. In summer, dry days prevail (about 40 days). Mean annual precipitation is 580 - 600 mm, and monthly precipitation is highest in May - June. Snow cover lasts about 48 days. Autumn frost starts on October 17 - 21, and late spring frost is recorded until April 6 - 10. In the northern part of the region, carbonate chernozems are most common, while in the south, typical chernozems and grey forest soils prevail. Alluvial soils are found in river valleys. Land relief is varied. Most of the area is covered by arable fields (79.3%) and managed meadows (9.9%), and the crop plants cultivated there include wheat, barley, maize, sugar beet, tobacco, sunflower, alfalfa, grape vines, and fruit trees.

In 1990 - 1992, field research was conducted in southern Bulgaria, in the Upper Thracian Plain, 10 - 12 km north of Plovdiv. The climate of the Plovdiv region is transitional continental with a mean annual temperature of about 12°C. The coldest month is January (mean temperature 0.5°C), and the warmest is July (mean temperature 22.7°C). Maximum temperature in summer is 45°C while in winter the minimum is -31.2°C. Winds are mostly westerly or easterly, but about 50% of days are windless. Humidity is insufficient in summer, so it is a dry region and very dry in the south. Mean annual precipitation is 550 - 600 mm, with the most abundant rainfall in May - June. Snow cover lasts only about 20 days, most often in January and February. The first autumn frost in the Upper Thracian Plain is usually recorded in late October or early November, and the late spring frost lasts until April. In the Plovdiv region, soils include alluvial (meadows), chernozems, and leached brown soils. Farmland accounts for 44.5% of the area, and the major crop plants are wheat, maize, tobacco, rice, peanut, grape vine, alfalfa, and fruit trees.

List of study sites:

I. Danubian Plain, Pleven region (mostly Krushovitsa village)

Field research was conducted at 9 sites. Some were marginal habitats: field roadside, ditch edge, covering small areas, usually belts 1 - 3 m wide, dominated by ruderal plants with some species characteristic of xerothermic grasslands and meadows. Larger areas were covered by verges of the Vit river valley, with mostly thermophilous vegetation, neighboring with fields. Fields of 4 selected crops also were investigated.

1. Valley and slope of the Vit river (Krushovitsa village). Samples (64 + 11) collected April - October for 4 years (1986 - 1989).

2. Roadside. Samples (92) collected April - October for 4 years (1986 - 1989).

3. Irrigation ditch near maize (*Zea mays*). Samples (53) collected April - September for 4 years (1986 - 1989).
4. Ditch edge. Samples (61) collected April - October for 5 years (1986 - 1990).
5. Alfalfa (*Medicago sativa*). Samples (51) collected from flowering seed production fields from June to early August for 5 years (1987 - 1991).
6. Sunflower (*Helianthus annuus*). Samples (9) collected June - July for 2 years (1988 - 1989).
7. Oilseed rape (*Brassica napus* 'Elena', 'Tobin', and a Canadian cultivar). Samples (24) collected from April to mid-June for 2 years (1990 - 1991).
8. Radish (*Raphanus sativus* 'Omega'). Samples (11) collected from mid-May until mid-June for 2 years (1990 - 1991).

II. Upper Thracian Plain, Plovdiv region

As in the first region, the agricultural landscape was studied at 3 sites dominated by ruderal vegetation with some species typical of xerothermic grasslands. Trees and shrubs were very infrequent there.
1. Railway embankment, covered with grass and shrub communities. Samples (18) collected May - September for 2 years (1990 - 1991).
2. Roadside. Samples (19) collected May - September for 2 years (1990 - 1991).
3. Ditch edge. Samples (22) collected May - September for 2 years (1990 - 1991).

III Others (near Sofia)

Occasionally, bees were caught also at 2 other sites:
1. In the mountain massif of Vitosha near Sofia: edge of oak-hornbeam forest, roadside with rich herbaceous vegetation (*Cichorium intybus*, *Vicia* sp., *Carduus nutans*, *Hypericum* sp., *Rubus* sp.). Material collected in July 1986.
2. At the verges of Pancharevo, the southern suburbs of Sofia: pasture, meadow. Material collected in July 1986.

RESULTS

Overall species diversity

In total, 7046 wild bees of 232 species were collected and are now part of the personal collection of Prof. J. Banaszak in Bydgoszcz (Tab. 1). In the Pleven region, 206 species were found, whereas in the Plovdiv region, only 112 species were identified. Nonetheless, this disparity does not mean that the bee fauna of the Plovdiv region is poorer; material was collected there for only 2 years (total: 963 bees). In the Pleven region, it was collected for 6 years (total: 6007 bees). The expected cumulative number of wild bee species for these 2 regions indicates that species richness and diversity were similar in both. Thus, the smaller number of species reported from Plovdiv results from the shorter study period. Interpolation of results for the same number of samples suggests that species richness may be even greater for the agricultural landscape near Plovdiv. Species numbers estimated for Pleven and Plovdiv for similar numbers of samples do not differ significantly (overlapping 95% confidence limits) (Fig. 1).

Good estimators of the true species number for a small number of samples are Jackknife2 and Chao2 (Collwell and Coddington, 1994). However, the applied estimators indicate much higher numbers of species for the landscape of Pleven (Chao2: 297.7, lower bound 95% CI 252.65, upper bound 95% CI 383.62; Jackknife2: 311.39) than for Plovdiv (Chao2: 165.35, lower bound 95% CI 137.62, upper bound 95% CI 221.98; Jackknife2: 185.45). Based on the results of these estimators, species richness seems higher in the Pleven region.

Contribution of *Apis mellifera* and wild bees

Before discussing the dominance structure of wild bees, we should mention the contribution of honey bees to the studied ecosystems of the agricultural landscape. However, we discuss this question in detail in a separate publication (Banaszak et al., "unpubl. data"), for methodological reasons (it is difficult to match the number of wild bees observed during field research to species identified later), but also because the honey bee depends on location of apiaries and their size.

Honey bees were present at all the study sites, both in refuge habitats (e.g., roadsides, ditch edges, or river valleys) and in fields. However, the contribution of honey bees was highly variable, depending mostly on food resources. Thus, its abundance was variable in refuge habitats, where, e.g., large numbers of honey bees visited in spring the abundantly flowering *Lepidium draba* but in summer visited *Knautia arvensis*, *Lamium purpureum*, *Echium vulgare*, and others. The proportion of honey bees to wild bees varied between habitats and sampling sessions, as is well illustrated by Figure 2, where *Apis mellifera* was sometimes infrequent, whereas on another day and in a different place it accounted for 90% of the total. Its abundance varied from single individuals to 3 - 5 × 10^3/ha, respectively. As a rule, in crop fields, *Apis mellifera* was overwhelmingly dominant, accounting for 80/90 - 100% of the total catch, while wild bees contributed up to 20%, as in the winter rape field. The density of *Apis mellifera* reached up to 50 × 10^3/ha there compared to up to 1 × 10^3/ha for wild bees (Fig. 2).

Table 1.

List of species and number of individuals of Apiformes found at study sites

No.	Species	Pleven region									Plovdiv region			
		Vit river valley	Valley slope	Roadside	Ditch near maize	Ditch edge	Radish field	Sunflower field	Alfalfa field	Rape field	Railway embankment	Ditch edge	Roadside	Others (near Sofia)
1		2	3	4	5	6	7	8	9	10	11	12	13	14
1	*Colletes cunicularius* (LINNEUS 1761)			1										
2	*Colletes daviesanus* SMITH 1846	1												
3	*Colletes fodiens* (GEOFFROY 1765)										1			
4	*Colletes nasutus* SMITH 1853	8		1										
5	*Colletes punctatus* MOCSARY 1877					19								
6	*Hylaeus annularis* (KIRBY 1802)	2		1	1	2								
7	*Hylaeus bisinuatus* FÖRSTER 1871			2	1							1		
8	*Hylaeus communis* NYLANDER 1852			1										
9	*Hylaeus confusus* NYLANDER 1852	1		2										
10	*Hylaeus gibbus* SAUNDERS 1850	2			2									
11	*Hylaeus gredleri* FÖRSTER 1871												1	
12	*Hylaeus kahri* FÖRSTER 1871										2		1	
13	*Hylaeus moricei* (FRIESE 1898)		2	1								1		
14	*Hylaeus pictipes* NYLANDER 1852						1							
15	*Hylaeus variegatus* (FABRICIUS 1798)	2									1	2	1	
16	*Andrena aeneiventris* MORAWITZ 1872					5				1				
17	*Andrena alfkenella* Perkins, 1914						2							
18	*Andrena atrata* FRIESE 1887		2		1			1	1					
19	*Andrena bicolor* FABRICIUS 1775						1							
20	*Andrena bulgariensis* WARNCKE 1965										1	4	3	
21	*Andrena carbonaria* Linnaeus, 1767												1	
22	*Andrena chrysopus* PÉREZ 1903	1							1					
23	*Andrena chrysosceles* (KIRBY 1802)												1	
24	*Andrena cordialis* MORAWITZ 1878			8	6	2				1				

Table 1 Continued.
List of species and number of individuals of Apiformes found at study sites

1		2	3	4	5	6	7	8	9	10	11	12	13	14
25	*Andrena decipiens* SCHENCK 1859		1			9			6				3	
26	*Andrena dorsata* (KIRBY 1802)	1		6	1	3			1	1	1		1	
27	*Andrena enslinella* STOECKHERT 1924				1									
28	*Andrena falsifica* PERKINS 1915			2		2								
29	*Andrena figurata* MORAWITZ 1866						1							
30	*Andrena flavipes* PANZER 1799	13	4	75	46	46	52	2	36	72	2	1	4	1
31	*Andrena floricola* EVERSMANN 1852						2				2			
32	*Andrena fulvata* (STOECKHERT 1930)								1					
33	*Andrena gelriae* v. d. VECHT 1927					4			3					
34	*Andrena gravida* IMHOFF 1832			1					1					
35	*Andrena haemorrhoa* (FABRICIUS 1781)					1								1
36	*Andrena hattorfiana* (FABRICIUS 1775)	1	4											
37	*Andrena impunctata* PÉREZ 1895									1				
38	*Andrena jacobi* Perkins, 1921		1											1
39	*Andrena labialis* (KIRBY 1802)					3								
40	*Andrena minutula* (KIRBY 1802)				1					4		1	2	
41	*Andrena minutuloides* PERKINS 1914	1		5	3	2	1			3	2	11	3	
42	*Andrena nana* (KIRBY 1802)						1							
43	*Andrena nasuta* GIRAUD 1863	5		1									1	
44	*Andrena nitidiuscula* SCHENCK 1853				1									
45	*Andrena niveata* FRIESE 1887			1		1				1				
46	*Andrena obsoleta* PÉREZ 1895			1	1	3	2			5				
47	*Andrena ovatula* (KIRBY 1802)	2		8		5	2		17				2	
48	*Andrena pusilla* PÉREZ 1903						1			1				
49	*Andrena saxonica* STOECKHERT 1935			1										
50	*Andrena scita* EVERSMANN 1852						1							
51	*Andrena sericata* IMHOFF 1868			1		1								
52	*Andrena semilaevis* PÉREZ 1903						1							
53	*Andrena simontornyella* NOSKIEWICZ 1939	1												
54	*Andrena* sp.									4				
55	*Andrena spreta pusilla* PÉREZ 1902	1												
56	*Andrena subopaca* NYLANDER 1848	2		1		1					7		1	
57	*Andrena tibialis* (KIRBY 1802)									1				
58	*Andrena tringa* WARNCKE 1973					1	58			55			2	

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
59	*Andrena truncatilabris* MORAWITZ 1877	1		14	9	17	41		3	11		1		
60	*Andrena tsukubana* HIRASHIMA 1957			3	7	1				2				
61	*Andrena variabilis* SMITH 1853								1					
62	*Andrena viridescens* VIERECK 1916	1		1										
63	*Andrena wilkella* (KIRBY 1802)	4			5	3		1	8	1				
64	*Melitturga clavicornis* (LATREILLE 1806)								8					
65	*Panurginus labiatus* (EVERSMANN 1852)	1												
66	*Rhophitoides canus* (EVERSMANN 1852)			2		4			315		1			
67	*Rophites hartmanni* FRIESE 1902	5		1								7	2	
68	*Rophites quinquespinosus* SPINOLA 1808	2		4		1								
69	*Systropha curvicornis* (SCOPOLI 1770)	3	3	6		7			1		59	36	26	
70	*Systropha planidens* GIRAUD 1861	1	10	7	11	72			6		1			1
71	*Nomiapis diversipes* (LATREILLE 1806)	3		10	4	6			13					
72	*Nomioides minutissimus* (ROSSI 1790)			1								1		
73	*Halictus cochlearitarsis* DOURS 1872	3	1	3							1		2	
74	*Halictus compressus* WALCKENAER 1802	2		2		2								
75	*Halictus maculatus* SMITH 1848	11	1	99	122	91		1	7	7	10	7	15	1
76	*Halictus patellatus* MORAWITZ 1873				1				2	1	1			
77	*Halictus pollinosus cariniventris* MORAWITZ 1876	1												
78	*Halictus ponticus* BLÜTHGEN 1934			2		2								
79	*Halictus quadricinctus* (FABRICIUS 1776)	38	7	67	5	19		42		1				
80	*Halictus resurgens* NURSE 1903	58		38	6	17	1	7	21	1	2	68	45	
81	*Halictus scabiosae* (ROSSI 1790)	9	2	14	2	2		5					3	
82	*Halictus sexcinctus* (FABRICIUS, 1775)	23	3	9	1			1					5	
83	Halictus simplex/compressus	29	7	127	91	133	3	2	133	7	6	4	16	
84	*Halictus tectus* RADOSZKOWSKI 1875												1	
85	*Seladonia kessleri* (BRAMSON 1879)		8	9	2	12	1			3				
86	*Seladonia pollinosa* (SICHEL 1860)	1				1		1		1	1		3	

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
87	*Seladonia semitecta* (MORAWITZ 1874)					1			1					
88	*Seladonia smaragdula* (VACHAL 1895)		1		8	2			5				1	
89	*Seladonia subaurata* (ROSSI 1792)	6		10	17	5			3	1				
90	*Seladonia tataricus* (BLÜTHGEN 1933)			3										
91	*Seladonia tumulorum* (LINNAEUS 1758)	1		2	1	1								
92	*Lasioglossum aegyptiellum* (STRAND 1909)			1										
93	*Lasioglossum cristula donatum* (WARNCKE 1975)	1			1						5	7	4	
94	*Lasioglossum discum* (SMITH 1853)	3		2									2	
95	*Lasioglossum lativentre* (SCHENCK 1853)				1									
96	*Lasioglossum leucozonium* (SCHRANK 1781)	6	6	15	22	13	4			1	3			
97	*Lasioglossum morbillosum* (KRIECHBAUMER 1873)	18		38	14	20	2	1	1	2	3	7	10	
98	*Lasioglossum nitidum* (PANZER 1798)			1										
99	*Lasioglossum pseudomorbillosum* (EBMER 1970)	13	3	29	2	21	1		3	3		1	3	
100	*Lasioglossum aegyptiellum* (STRAND 1909)			1										
101	*Lasioglossum quadrinotatum* (KIRBY 1802)			3	1									
102	*Lasioglossum sexnotatum* (KIRBY 1802)			2			2							
103	*Lasioglossum xanthopus* (KIRBY 1802)		1											
104	*Lasioglossum zonulum* (SMITH 1848)				6	1								
105	*Evylaeus albipes* (FABRICIUS 1781)	2				2								3
106	*Evylaeus calceatus* (SCOPOLI 1763)	9	2	14	6	3				2				2
107	*Evylaeus clypearis* (SCHENCK 1853)	1		2		3					3		4	
108	*Evylaeus corvinum* (MORAWITZ 1878)	18	33	70	32	107	4	1		30	2	1		
109	*Evylaeus crassepunctatum* (BLÜTHGEN 1923)			2	1	2				2		1		
110	*Evylaeus fulvicornis* (KIRBY 1802)	1	1		3	2								
111	*Evylaeus glabriusculus* (MORAWITZ 1872)		4	14	61	5	14		11	51				

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
112	*Evylaeus griseolum* (MORAWITZ 1872)	4	4		1	1			1	3	1	2	4	
113	*Evylaeus interruptus* (PANZER 1798)										6	6	1	
114	*Evylaeus laticeps* (SCHENCK 1868)	3	2	1			2			3				
115	*Evylaeus leucopus* (KIRBY 1802)											3		
116	*Evylaeus lineare* (SCHENCK 1868)	13		7	5	10	1	2	1	1	3	3	1	
117	*Evylaeus linearis* (SCHENCK 1868)	3	1	3		5						1		
118	*Evylaeus lucidulus* (SCHENCK 1861)			3	19		1			12	22	27	16	
119	*Evylaeus malachurus* (KIRBY 1802)	143	34	166	111	85	26	60	5	58	10	2	1	1
120	*Evylaeus marginatus* (BRULLÉ 1832)	1	1	1	1					7				
121	*Evylaeus morio* (FABRICIUS 1793)	1												
122	*Evylaeus nigripes* (LEPELETIER 1841)	2		8							1		1	
123	*Evylaeus pauxillus* (SCHENCK 1853)	4	2	31	46	21	4	1	5	44			1	
124	*Evylaeus politus* (SCHENCK 1853)	1		1						2	8	11	1	
125	*Evylaeus pressi thorax* (EBMER 1974)						1							
126	*Evylaeus puncticolle* (MORAWITZ 1872)												1	
127	*Evylaeus sexstriqatus* (SCHENCK 1868)	1												
128	*Evylaeus truncaticolle* (MORAWITZ 1878)	16	12	23	10	12		2			2	21	62	
129	*Evylaeus truncaticollis* (MORAWITZ 1877)		1									2	1	
130	*Evylaeus villosulus* (KIRBY 1802)	2	1	4	1	2	3				1		1	
131	*Sphecodes crassus* THOMSON 1870									1				
132	*Sphecodes gibbus* (LINNAEUS 1758)			2	5							1		
133	*Sphecodes longulus* HAGENS 1882											3		
134	*Sphecodes monilicornis* (KIRBY 1802)											2		
135	*Sphecodes pellucidus* SMITH 1845											1		
136	*Sphecodes rufiventris* (PANZER 1798)											1		
137	*Sphecodes* sp.	1												
138	*Melitta leporina* (PANZER 1799)	2	2	2	1	7			134					

Table 1 Continued.
List of species and number of individuals of Apiformes found at study sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
139	*Melitta nigricans* ALFKEN 1905		21											
140	*Melitta tricincta* KIRBY 1802	1												
141	*Macropis fulvipes* (FABRICIUS 1804)													2
142	*Dasypoda hirtipes* (HARRIS 1780)	29	14	27	2				1		2	15		
143	*Lithurgus chrysurus* FONSCO-LOMBE 1834	3		3								7	2	
144	*Paranthidiellum lituratum* (PANZER 1801)	6	3	3	1	5						5	9	
145	*Paraanthidiellum tenellum* (MOCSÁRY 1881)	1	1	5		1					1	2	2	
146	*Anthidium florentinum* (FABRICIUS 1775)								1		2	6		
147	*Anthidium manicatum* (LINNAEUS 1758)	1		6							1	2		
148	*Anthidium punctatum* LATREILLE 1809	1												
149	*Anthidiellum strigatum* (PANZER 1805)	1											1	
150	*Heriades crenulatus* NYLANDER 1856											26	15	
151	*Chelostoma grande* (NYLANDER 1852)	1									1			
152	*Anthocopa andrenoides* (SPINOLA 1808)										1			
153	*Anthocopa bidentata* (MORAWITZ 1876)			2								6	3	
154	*Anthocopa spinulosa* (KIRBY 1802)	1		1							1	2	1	
155	*Hoplitis adunca* (PANZER 1798)		1								1			
156	*Hoplitis leucomelana* (KIRBY 1802)			1									1	
157	*Hoplitis manicata* (MORICE 1901)												1	
158	*Hoplitis rufohirta* LATREILLE 1811	1		17	1	3			1				4	
159	*Hoplitis tridentata* (DUFOUR and PERRIS 1840)												3	
160	*Osmia aurulenta* (PANZER 1799)	11		14		5			6		2	1	7	
161	*Osmia brevicornis* (FABRICIUS 1798)	2												
162	*Osmia caerulescens* (LINNAEUS 1758)	5	1	3			1		4		6	5		
163	*Osmia cornuta* (LATREILLE 1805)													6
164	*Osmia fulviventris* (PANZER 1798)										1		1	
165	*Megachile apicalis* SPINOLA 1808			2		2						4	1	
166	*Megachile centuncularis* (LINNAEUS 1758)	7	4	1	3							1		

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

1		2	3	4	5	6	7	8	9	10	11	12	13	14
167	*Megachile deceptoria* PÉREZ 1890		1	1		1			1				1	
168	*Megachile leucomalla* GERSTÄCKER 1869								1					
169	*Megachile pilidens* ALFKEN 1923	21	7	25	6	20			4		6	2	3	
170	*Megachile rotundata* (FABRICIUS 1784)								5					
171	*Megachile versicolor* SMITH 1844	5		4		1								
172	*Coelioxys afra* LEPELETIER 1841	1		1					2		1		1	
173	*Paradioxys pannonica* MOCSÁRY 1877			2										
174	*Anthophora crinipes* SMITH 1854										16			
175	*Anthophora plumipes* (PALLAS 1772)									1	2			
176	*Amegilla magnilabris* (FEDT-SCHENKO 1875)	3		1										
177	*Amegilla quadrifasciata* (VILLERS 1789)	1	2											
178	*Amegilla salviae* (MORAWITZ 1876)					1								
179	*Eucera chrysopyga* PÉREZ 1879	23		52	10	17	1		30	24	1			
180	*Eucera clypeata* ERICHSON 1835	3		2	1	4	1	1	107	3				
181	*Eucera dalmatica* LEPELETIER 1841			1										
182	*Eucera longicornis* (LINNAEUS 1758)	7	3	13	7	3			2					
183	*Eucera nigrilabris* LEPELETIER 1841				2									
184	*Eucera nitidiventris* MOCSÁRY 1879	4		28	7	5	1		32	4	1			1
185	*Eucera parvicornis* MOCSÁRY 1878			1										
186	*Eucera seminuda* BRULLË1832				1	1								1
187	*Eucera taurica* MORAWITZ 1871		1	11										
188	*Eucera tuberculata* (FABRICIUS 1793)	3		8	7	2			5	2				
189	*Tetralonia alternans* BRULLË1832											1		
190	*Tetralonia dentata* (KLUG 1835)	1											1	
191	*Tetralonia macroglossa* ILLIGER 1806	9	5	1							1		2	
192	*Tetralonia nana* MORAWITZ 1874	20	4	1		1								
193	*Tetralonia pollinosa* (LEPELETIER 1841)	7		7	1									
194	*Tetralonia ruficornis* (FABRICIUS 1804)	2		1								1	3	

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
195	*Tetralonia salicariae* (LEPELETIER 1841)	5	3											
196	*Tetralonia scabiosae* (MOCSÁRY 1881)		1			7					3			
197	*Tetralonia* sp.	3				1								
198	*Xylocopa valga* GERSTAECKER, 1872									1	1			
199	*Ceratina acuta* FRIESE 1896					1								
200	*Ceratina callosa* (FABRICIUS 1794)	7	3	1	1						1		1	
201	*Ceratina chalcites* GERMAR 1839		5								1	1	2	
202	*Ceratina cucurbitina* (ROSSI 1792)		1								15	1	3	
203	*Ceratina cyanea* (KIRBY 1802)	29	1	12	8	7	1			2	4	6	2	
204	*Ceratina dallotorreana* FRIESE, 1896	2		1	3	2					3	1		
205	*Ceratina parvula* SMITH 1854										1	2	1	
206	*Nomada basalis* HERRICH-SCHÄFFER 1839						4		1	1				
207	*Nomada emarginata* MORAWITZ 1877		3											
208	*Nomada fabriciana* (LINNAEUS 1767)				1									
209	*Nomada flavopicta* (KIRBY 1802)	1												
210	*Nomada fucata* PANZER 1798	2		1	2	1					1			
211	*Nomada kohli* SCHMIEDEKNECHT 1882	1		1	1	1				1		1		
212	*Nomada lathburiana* (KIRBY 1802)	1												
213	*Nomada nobilis* HERRICH-SCHÄFFER 1839						7		1	9				
214	*Nomada pleurosticta* HERRICH-SCHÄFFER 1839			1					1					
215	*Nomada sexfasciata* PANZER 1799								1					
216	*Nomada stigma* FABRICIUS 1804								1					
217	*Biastes brevicornis* (PANZER 1798)					3						1		
218	*Bombus argillaceus* (SCOPOLI 1763)	1		4	1									2
219	*Bombus cryptarum* (FABRICIUS 1775)				1			2			1	1		
220	*Bombus hortorum* (LINNAEUS 1761)	14		74		6		5			1	1		8
221	*Bombus humilis* ILLIGER 1806	1												
222	*Bombus hypnorum* (LINNAEUS 1758)													2
223	*Bombus lapidarius* (LINNAEUS 1758)													6

Table 1 Continued.

List of species and number of individuals of Apiformes found at study sites

1		2	3	4	5	6	7	8	9	10	11	12	13	14
224	*Bombus lucorum* (LINNAEUS 1761)	3			1							3		4
225	*Bombus muscorum* (LINNAEUS 1758)													1
226	*Bombus pascuorum* (SCOPOLI 1763)	1		1										17
227	*Bombus pratorum* (LINNAEUS 1761)	1		1						1				1
228	*Bombus ruderarius* (MÜLLER 1776)	2		2				1						
229	*Bombus subterraneus* (LINNAEUS 1758)													1
230	*Bombus sylvarum* (LINNAEUS 1761)	17		28	1	7		1	10					
231	*Bombus terrestris* (LINNAEUS 1758)	5		18	3	5		23	2		19	7	4	13
232	*Bombus veteranus* (FABRICIUS 1793)	2												
233	*Apis mellifera* LINNAEUS, 1758	+	+	+	+	+	+	+	+	+	+	+	+	+
Number of individuals in different habitats		795	252	1390	779	944	253	163	974	457	269	359	335	76
Total number of individuals		7046												
Number of species in different habitats		112	55	115	75	86	39	23	55	52	63	62	70	23
Number of species in different landscapes		206									112			

Dominance structure of wild bees

In the agricultural landscape of the Pleven region, mostly halictid bees were caught, representing *Evylaeus*, *Halictus*, and *Lasioglossum* species. The dominant taxon was *E. malachurus*, which accounted for 12% of the total number of bees at that site. It was eudominant at most study sites (12 - 18% of the total) and ranked second after the honey bee as a major flower visitor of sunflower (over 35%). It is a eusocial species, with remarkable morphological variation among castes: worker bees (*F. longulus*) are smaller and have more delicate mandibles than queens. Males emerge at the height of summer. The species prefers open, dry habitats, which also are present in the study area. It is regarded as a major pollinator of alfalfa while in the studied alfalfa seed production field it accounted for 10% of wild bees.

Halictus compressus/simplex (= *eurygnathus/simplex*) are subdominants. These 2 species of the subgenus *Monilapis* Ckll. – *H. simplex* (Blüthgen, 1923) and *H. compressus* (Walckenaer, 1802) (= *eurygnathus* Blüthgen, 1931) – have identical females. Here they jointly constituted almost 9% of wild bees in that landscape, but only single males were caught. These species were found mostly on herbaceous vegetation along the ditch in the Pleven region (over 13%), between the ditch and the maize field (nearly 12%), and in the alfalfa field (nearly 15%). Both eusocial species nest in dry and open habitats, as this study confirmed.

Relatively frequent (46% of the total catch) were also *Andrena flavipes*, *Halictus maculatus*, *Rhophitoides canus*, and *Evylaeus corvinum*. Each of them at some study sites reached a high proportion of wild bees. *Andrena flavipes* was eudominant in the rape field (almost 16%) and radish field (20%), and its contribution was considerable (4 - 6%) on the roadside, at the ditch edge, and along the ditch near a maize field. *Halictus maculatus* dominated (over 8%) in herbaceous vegetation along the ditch near maize (14%), at the ditch edge (about 9%), and on roadsides (about 5%). *Rhophitoides canus* was an overwhelmingly dominant flower visitor of alfalfa (over 32%, 315 individuals) in the alfalfa seed plantation, indicating that the habitat was probably a nesting site for this species.

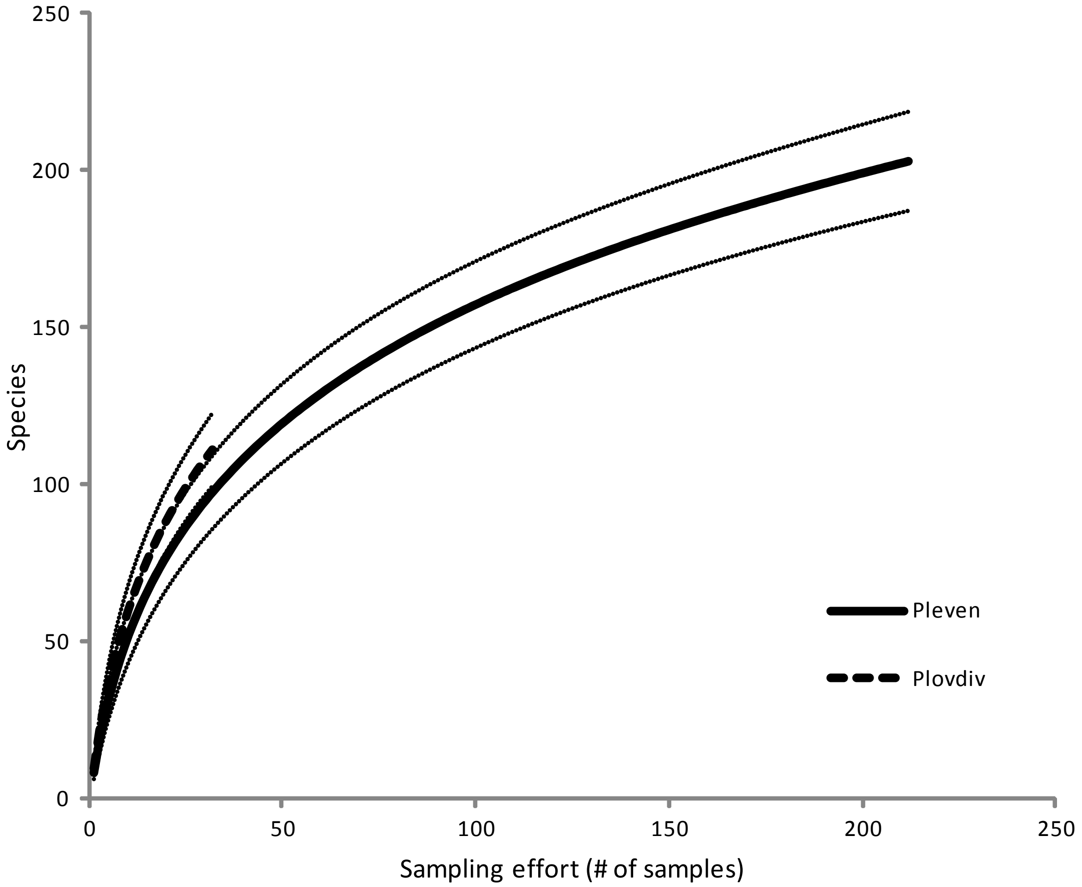

Fig. 1. Expected cumulative number of species (MaoTau estimator) as a function of number of samples for 2 Bulgarian agricultural landscapes. Dotted lines indicate 95% confidence intervals.

Evylaeus corvinum was a subdominant (about 11%) in herbaceous vegetation along the ditch and on slopes of the Vit valley near Pleven (over 13%, beside *Evylaeus malachurus*) whereas aboutand had a frequency of about 5 - 6% as a flower visitor of sunflower and oilseed rape. Another noteworthy species was *Andrena tringa*, which was represented in our material almost exclusively by 55 and 58 individuals caught in fields of rape and radish, respectively. Thus, it must nest within the fields or in the immediate neighborhood because in the other refuge habitats, it was represented by only a single individual on herbaceous vegetation along the ditch.
Two years of research at 3 study sites in the agricultural landscape of the Plovdiv region detected a very high contribution of Halictidae, very much like in the lowland near Pleven. The major species was *Heriades crenulatus* (about 4.2%) whereas the contribution of *Andrena* spp. was low. *Systropha curvicornis* was eudominant (about 22%) in the grass and shrub communities along railway tracks and dominant (10%) at the ditch edge and on the roadside (about 8%). This species is common in southern and central Europe to western and central Asia and is oligolectic, associated mostly with *Convolvulus*. It is recorded in summer, nesting in large aggregations, in nests up to 12 - 18 cm deep. Eudominants included also *Halictus resurgens* (about 12%), which was most numerous at the edge of the ditch (about 19%) and on the roadside (over 13%). Another frequent species was *Evylaeus truncaticollis* (about 9%), which was eudominant on the roadside (over 18%).

In comparisons of dominance structure (rank-abundance) (Fig. 3), the Student's t test showed a significant difference (p = 0.02) between E_Q values for crop fields (mean 0.2684) and refuge habitats (mean 0.3159). Lower values for fields were associated mostly with low species number and their high dominance in the community, as was confirmed by higher negative values of slope angle for most frequent species in fields compared to semi-natural habitats (means -4.57883 and -3.12336, respectively; Student's t test: p<0.001). Higher E_Q values for bee communities of refuge habitats resulted from more even division of environmental resources

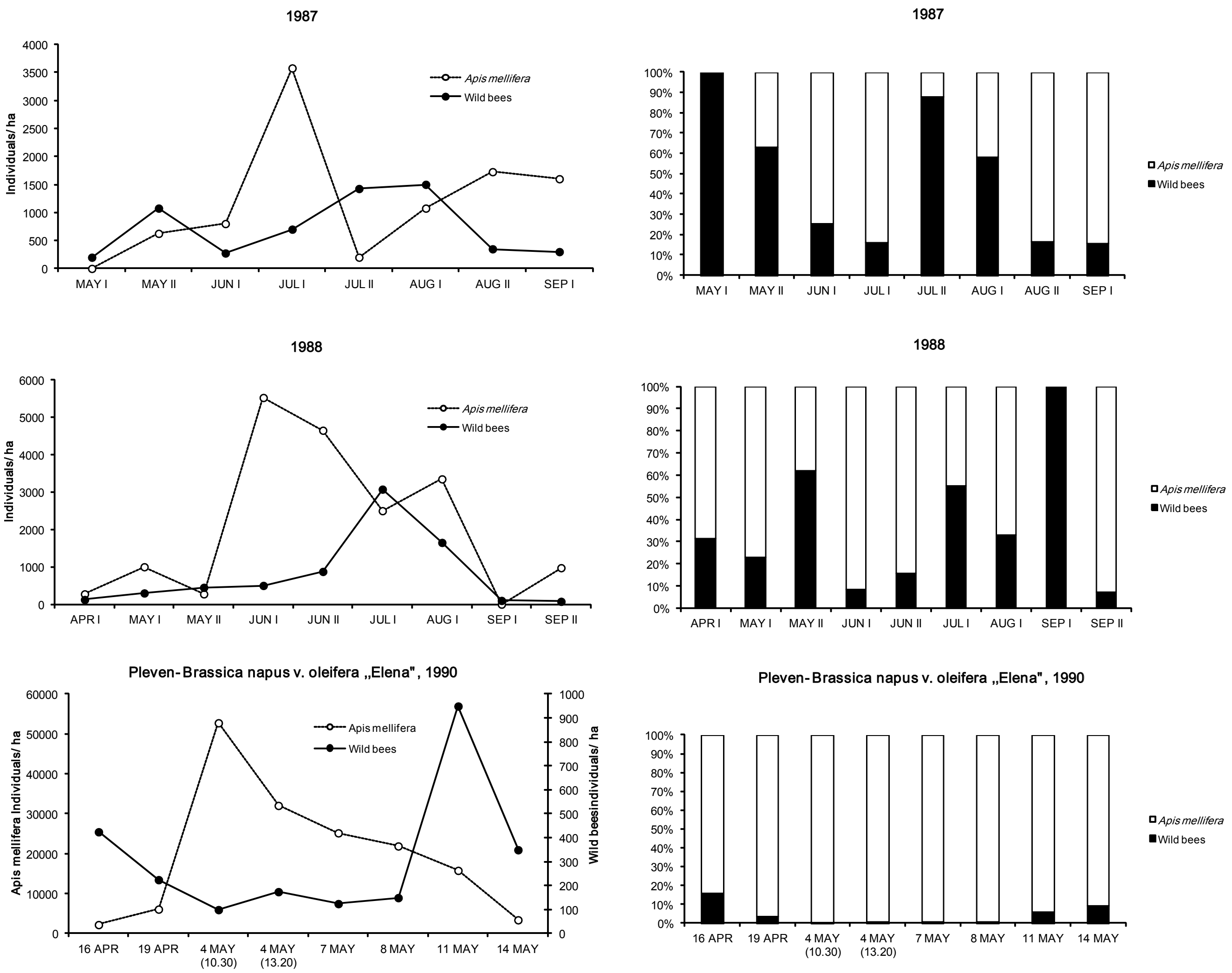

Fig. 2. Examples of changes in abundance and relative contributions of *Apis mellifera* and wild bees in a refuge habitat (ditch edge) in 1987 and 1988, and in an oilseed rape field

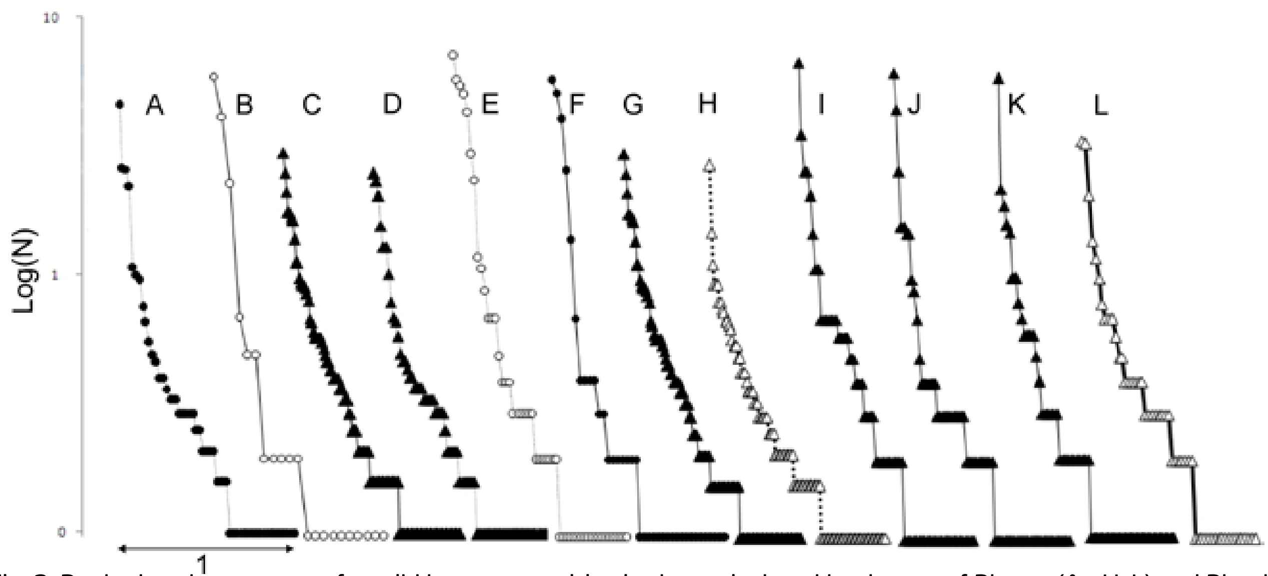

Fig. 3. Rank-abundance curves for wild bee communities in the agricultural landscape of Pleven (A - H, L) and Plovdiv (I - K). For comparison, the ranks were scaled to range from 0 to 1. The curves are in ascending order of EQ values. A - Alfalfa field, B - Sunflower field, C - Roadside, D - Ditch near maize, E - Rape field, F - Radish field, G - Ditch edge, H - Vit river valley, I - Ditch edge (Plovdiv), J - Roadside (Plovdiv), K - Railway embankment, L - Slope of Vit valley.

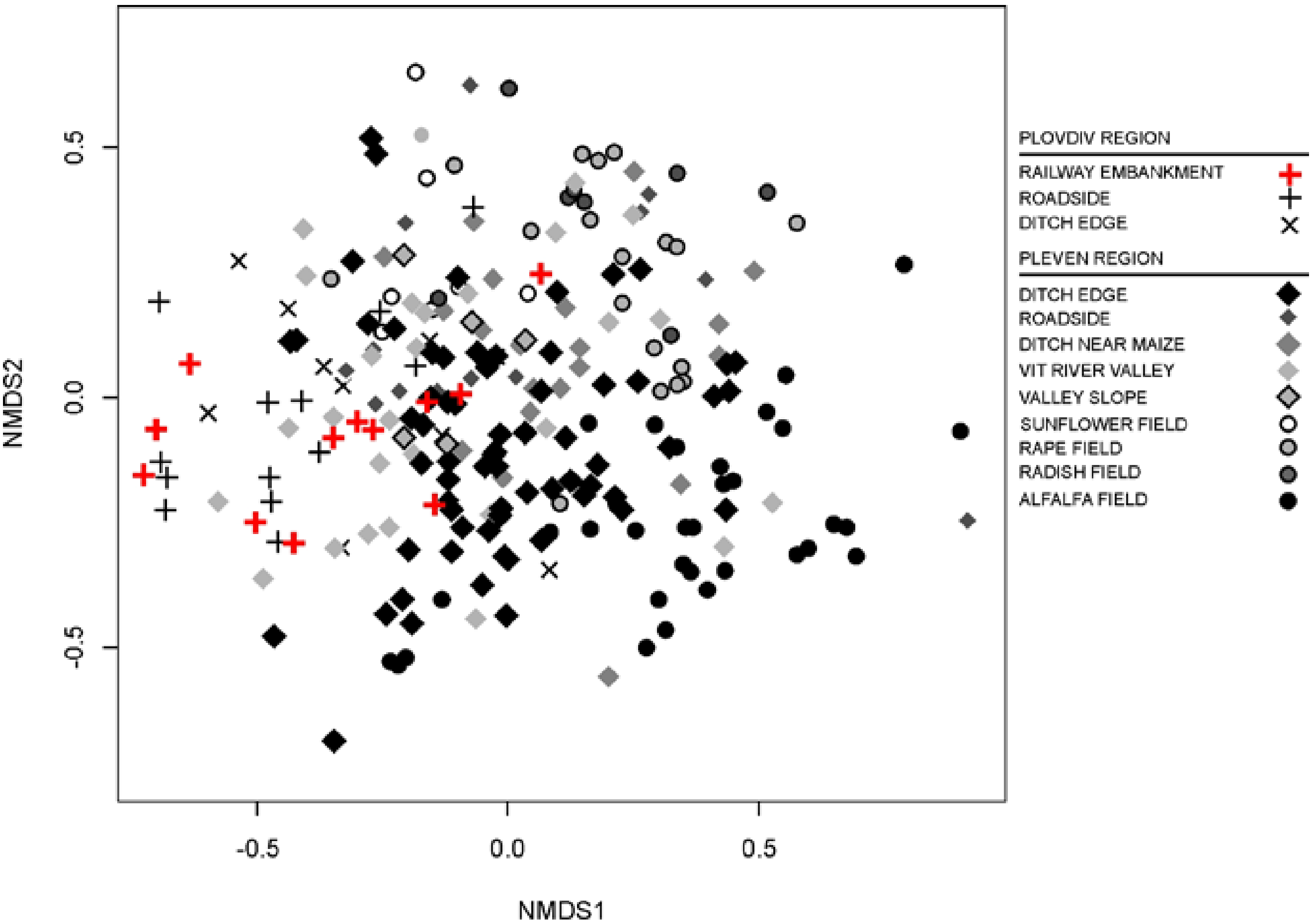

Fig. 4. NMDS ordination diagram of bee communities in habitats of the Pleven and Plovdiv regions based on the whole material. Each point on the diagram represents a single sample (231 for both crop fields (71) and semi-natural habitats (160) from the Pleven region; 38 from the Plovdiv region). Distances between them reflect similarity between bee communities in both abundance and diversity based on the Bray-Curtis dissimilarity index.

among bee species. These values were also reflected in the greater slope angle for the most frequent species in the community, i.e., smaller contributions of most frequent species.

Substantial differences in bee community structure and composition between semi-natural habitats of the 2 landscapes were confirmed by the results of NMDS (Fig. 4). Samples collected from semi-natural habitats of the agricultural landscape of Pleven are located mostly in the central part of the NMDS ordination diagram while samples collected from 3 sites in the Plovdiv region are in the left part. The multi-response permutation procedure confirmed significant differences between wild bee communities of the 2 regions ($p<0.001$, $A = 0.0217$), but at the same time confirmed a relatively low homogeneity of samples within the 2 groups of sites.

The analyzed field habitats clearly differed in bee community structure. The calculated statistically significant IndVals for species (Tab. 2) made it possible to identify which of them are responsible for the observed differences. The analysis showed that different species were characteristic for the compared types of agricultural landscapes. The Pleven region was characterised by the presence of *Evylaeus malachurus* and *Halictus simplex/eurygnathus*. Species with lower IndVals were *Andrena flavipes* and *Halictus quadricinctus*. The bee community of the Plovdiv region was distinguished primarily by the presence of *Evylaeus lucidulus*, *Systropha curvicornis*, and *Halictus resurgens*. Additionally, *E. truncaticolle* showed a lower fidelity and constancy in samples.

DISCUSSION

Bulgaria lies along the borders of several zoogeographic regions, near the Mediterranean basin, Black Sea, and Central Europe. Its location undoubtedly is one reason for its great diversity of animals, including bees, although the latter remain poorly studied. There is little published information on the diversity of Apiformes in this country, with no documented list of bee species and not even any estimates.

Table 2.

Calculated significant indicator values for species in the 2 analyzed landscapes

Landscape	Bee species	Indicator value	Probability
Pleven region	*Evylaeus malachurus* (Kirby, 1802)	0.47	0.004
	Halictus simplex/compressus	0.43	0.011
	Andrena flavipes Panzer, 1799	0.28	0.032
	Halictus quadricinctus (Fabricius, 1776)	0.25	0.001
	Evylaeus corvinum (Morawitz, 1878)	0.24	0.015
Plovdiv region	*Evylaeus lucidulus* (Schenck, 1861)	0.47	0.001
	Systropha curvicornis (Scopoli, 1770)	0.46	0.001
	Halictus resurgens Nurse, 1903	0.38	0.003
	Evylaeus truncaticolle Morawitz, 1887	0.29	0.007
	Evylaeus interruptum (Panzer, 1798)	0.24	0.001
	Heriades crenulatus Nylander, 1856	0.24	0.001

Atanassov (1972a, b) in the Balkan Mountains (Stara Planina) found 189 species of Apiformes. From the Petrič region, he reported 119 species (Atanassov, 1965), and from the island of Tasos, 27 species (Atanasov, 1965). Dimitrov (1987) and Dimitrov et al. (1987) near the city of Ruse (also known as Russe or Rousse) listed 40 – 51 bee species from an alfalfa field. Atanassov's (1960) study on the Halictidae brought information about 60 species, which certainly does not reflect the true number of species of this family. Dochkova et al. (1987) in an earlier study of the Pleven region, listed 85 species collected in fields of *Medicago sativa*, *Trifolium pratense*, *Lotus corniculatus*, and *Onobrychis sativa*. In the present work, data from the Pleven region have provided information about the occurrence of 204 species but did not confirm 44 species reported earlier by the cited authors. Overall, with the current investigation, the total number of bee species recorded in the Pleven region has increased to 248 species.

This short review of available data shows that the current knowledge of the bee fauna of Bulgaria concerns only a few local fauna with respect to natural habitats, as in the case of Atanasov's work. So far, the typically poorer agricultural landscape has been studied more extensively, although still at an initial stage. Predictions about true species richness concerning Pleven and Plovdiv indicate that up to 300 bee species can be expected.

It is also interesting to compare percentage contributions of individual bee families to the apifauna of various agricultural landscapes in 3 countries: Bulgaria, Romania, and Poland. Contributions of major families are similar, especially of the Andrenidae, Halictidae, Megachilidae, and Anthophoridae (Fig. 5). By contrast, there are large differences in contributions of the Colletidae and Apidae to the fauna of the compared landscapes.

Some comments about bumblebees must be added. Their species diversity was very low; they were represented in this study by only 11 species in both lowlands (the other 4 were found during occasional sampling near Sofia), and their abundance was also extremely low. So far, a total of 29 species of *Bombus* have been found in Bulgaria (Pittioni, 1938; Atanassov, 1939). In both lowlands, we caught only 337 specimens of bumblebees, which accounts for only 4.8% of the total. However, they were even less numerous in the agricultural landscape of Romania, where only 8 species were recorded (Banaszak and Manole, 1987). This information indicates that bumblebees play a minor role in the farmland of the lowland part of the country, as confirmed by the negligible density of these insects in the investigated fields, especially in the sunflower field. Research on pollinators of this plant, conducted by Dimitrov et al. (1992) in north-eastern Bulgaria, showed that bumblebees accounted for 20% while honey bees accounted for 62%. In Romania in sunflower fields, honey bees pollinated almost 100% of flower heads (Banaszak and Manole, 1987) whereas in Poland, bumblebees accounted for 30% (Banaszak, 1984). The low number of species of bumblebees and their low abundance in South European lowlands can be explained by the association of these insects with cooler climates, which has been reported previously

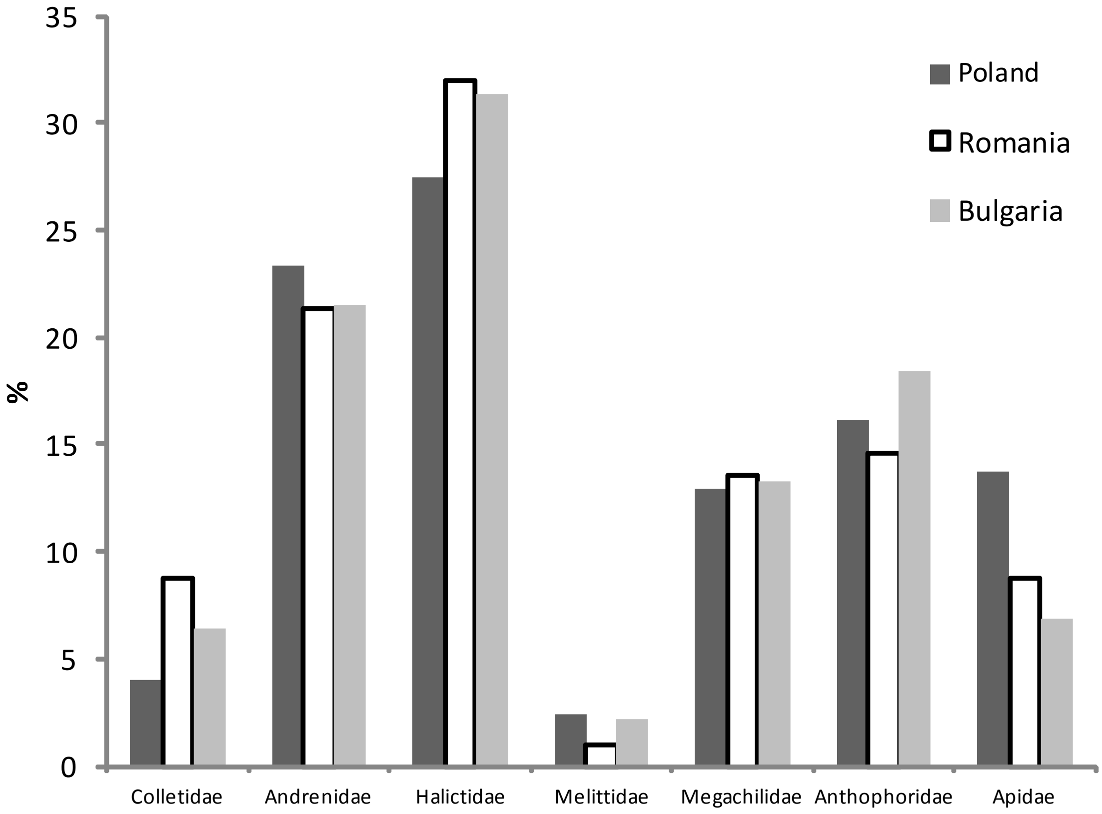

Fig. 5. Comparison of relative contributions of families of Apiformes in agricultural landscapes of Poland (Banaszak, 1983, 1984; Banaszak and Cierzniak, 1998), Romania (Banaszak and Manole, 1987), and Bulgaria.

(Banaszak, 1996). Most bumblebee species reported from Bulgaria live in submontane areas and in mountains (Atanassov, 1939).

Of note, in both investigated agricultural landscapes, the collected bees included very few or no parasitic species. In the study area, we found no *Psithyrus* spp., although at least 8 species exist in Bulgaria (Atanassov, 1939, 1974). We recorded only 7 species of *Sphecodes* and 11 of *Nomada*. These findings confirm that parasitic species are found mostly in permanent ecosystems whereas agroecosystems and the associated field margins are temporary ecosystems. It is assumed that in permanent communities, the contribution of parasites is higher (Archer, 1995; Calabuig, 2000). A lack or low contribution of parasites to the bee community indicates that the population of the host species is unstable—i.e., that the host species has recently colonized the given site—or that its population size varies greatly between years, or that occurrence of the species is ephemeral and does not result from nesting at the site. This finding is consistent with reports of Banaszak (1983), Cierzniak (2003), and Banaszak-Cibicka and Żmihorski (2012).

Among the investigated crop plant species, alfalfa pollinators are best studied. Research carried out by Dochkova et al. (1981a) in the Pleven region supplied information on the occurrence of 65 wild bee species; research by Dimitrov et al. (1987) near the city of Ruse detected 51 species. A comparable number (54 species) is reported in the present study. All the cited authors and the present study show that the major pollinators of alfalfa are *Melitta leporina*, *Eucera clypeata*, and *Rhophitoides canus*. According to Dochkova et al. (1981a), *R. canus* was infrequent in 1978 - 1979. In the Pleven region, they observed a high abundance of *Melitturga clavicornis*, *Megachile pilidens*, *Eucera longicornis*, and *E. interrupta*. Dimitrov et al. (1987) in the Ruse region also recorded a high contribution of *Bombus sylvarum*. These differences probably result mostly from the time of insect collection, i.e., the flowering period (there are 3 possible flowering periods of alfalfa).

CONCLUSIONS

The present studies of bees (Apiformes) in the agricultural landscape of Bulgaria showed the presence of 206 species in the Danubian Plain (the Pleven region) and 112 species in the Upper Thracian Plain (the Plovdiv region) (Tab. 1). The total of 7046 specimens of 232 wild bees species were collected. Regardless to the differences in the found numbers of species resulting from the different collection periods, the rarefaction curves calculated for both landscapes indicated similar diversity and species richness.
The Pleven region was characterised by the presence of *Evylaeus malachurus* and Halictus simplex/eurygnathus. Eusocial *Evylaeus malachurus* turned out to be the main, after the honey bee, pollinator of sunflower. The following species were weaker indicators: *Andrena flavipes* and *Halictus quadricinctus*. The communities of the Plovdiv region bees were strongly characterised by *Systropha curvicornis*, *Evylaeus lucidulus* and *Halictus resurgens*.
In both studied lowlands, low species diversity and especially low abundance of bumblebees can be noticed. This can be explained by the fact that these species prefer cooler and more humid climate.
Among the studied crops the composition of pollinators of alfalfa is examined to the broadest extent. 54 visiting species were found on this plant species with *Rhophitoides canus*, *Melitta leporina* and *Eucera clypeata* being the most abundant.
Both plains were characterised by low number or lack of parasitic species.
Apis mellifera was overwhelmingly dominant (80 - 100%) pollinator of the studied plantations, with relatively small (at most 20% on rapeseed) share of wild bees.

ACKNOWLEDGEMENTS

We are grateful to P. Andreas Werner Ebmer (Pfarer von Puchenau near Linz, Austria) for identification or verification of several dozen difficult species of the family Halictidae. Moreover, we owe our gratitude to Prof. Halina Ratyńska (Kazimierz Wielki University of Bydgoszcz, Poland) for botanical consultations. Sincere thanks are also due to assistants of the first author, Piotr Szefer, MSc, and Olga Sondej, MSc, for help in statistical and technical processing of the data. We are also grateful to Sylwia Ufnalska, MSc, MA, who translated this paper into English.

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