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Assessing the threatened status of bumble bee species (Hymenoptera: Apidae) in Hungary, Central Europe

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Abstract. Decline in the populations of bumble bees and other pollinators stress the need for more knowledge about their conservation status. Only one of the 25 bumble bee species present in Hungary is included in the Hungarian Red List. We estimated the endangerment of the Hungarian bumble bee (*Bombus* Latr.) species using the available occurrence data from the last 50 years of the 20th century. Four of the 25 species were data deficient or extinct from Hungary. About 60% of species were considered rare or moderately rare. Changes in distribution and occurrence frequency indicated that 10 of the 21 native species showed a declining trend, while only three species increased in frequency of occurrence. According to the IUCN Red List categories, seven species (33% of the native fauna) should be labelled as critically endangered (CR) and 3 (14%) as endangered (EN). Our results stress an urgent need of protection plans for bumble bees in Hungary, and further underlines the validity of concern over bumble bees all over Europe.

Introduction

Insects are often overlooked in the management for endangered species (Collins and Thomas 1991; Black et al. 2001). The often-mentioned reason of this discrepancy is the enormously high species diversity and the relatively low level of knowledge of insects (Moore 1991). Further, existing faunistic data are often fragmented and/or not widely available. Collating insect distribution data from private and public collections and from sporadic faunistical publications is complicated and not without problems of representativity and interpretation. However, such information can be very useful to help conservation decisions.

Pollinators are often considered keystone species in ecosystems (Kearns and Inouye 1997; Black et al. 2001), and bees are the most specialised insect pollinators (O'Toole and Raw 1991). Bumble bees are one of the best known wild bee groups (Kearns and Inouye 1997). They are important pollinators in both agricultural and natural habitats (Bohart 1972; Heinrich 1979; Corbet et al. 1991; Kwak et al. 1996; Corbet 1996; Williams 1996; Carvell 2002).

In recent years the disruption of pollination system was reported from many parts of the world (Allen-Wardell et al. 1998; Kearns et al. 1998; Kremen and

Ricketts 2000; Roubik 2000). Both the number and the diversity of bees (including bumble bees) are in decline all over the World (Buchmann and Nabham 1996 ; Kwak et al. 1996; Westrich 1996; Williams 1996; Kearns et al. 1998; Pekkarinen 1998; Kearns and Thomson 2001; Kells and Goulson 2003; Goulson 2003). Consequently, the importance of bee conservation is increasing (Matheson et al. 1996).

Except UK in most of Europe, detailed information on the abundance and distribution of the bumble bee species is not available (Williams 1998; Goulson 2003). The current status of pollinators in Central Europe, especially in the Carpathian Basin, is not well known (Kosior, personal communication). The last synthesis on the distribution of bumble bees in Hungary was published 50 years ago (Móczár 1953). Even this publication was restricted to data from the collection of the Hungarian Natural History Museum, Budapest.

To bring the outdated knowledge on the distribution of bumble bees in Hungary up to date, we collected the available data from the last 50 years, using data from the published literature as well as museum collections (Sárospataki et al. 2003). Using this database, in this paper we evaluate changes in species distribution and frequency and estimate the endangerment of bumble bees in Hungary.

Methods

In order to estimate the threatened status of the species we used our database of Hungarian bumble bee species records (Sárospataki et al. 2003). Bumble bee distributional data were collected from private and public collections and from the available (mostly Hungarian) scientific literature. The list of resources of the database information sources and UTM distribution maps of the species can be found in Sárospataki et al. (2003). One record of the database consists of the species name, information on collecting site, collecting date (if available) and the location identified by the code of the 10× 10 km UTM square of the collecting site. The total database contains about 5200 distributional records of 25 *Bombus* species. Our summarised data covered the 42% of the UTM squares in Hungary. About 4000 records were suitable to assess changes in distribution and occurrence frequency. The remaining records do not have a precise collection date.

We applied two approaches for estimating species endangerment suggested by the IUCN Red List criteria (IUCN 2001). The first one is the 'rarity approach'. This requires the calculation of the size of the area where the species can be found. Alternatively, the number of individuals or population size should be measured. Our data were suitable to calculate only relative frequencies.

Our data contained a total of 1976 recording events, but with large variation among decades (between 226 and 557). Consequently, standardising would be desirable. Standardising the occurrence of species simply by the number of

records would bias the evaluation because species-rich, productive collecting events would dominate. Therefore, we standardised the material on the basis of collecting effort, considering the number of collecting occasions. We considered records originating from the same collecting occasion if they had the same collecting date and place. In case when they did not have an exact collecting date, data from the same location and reported in the same publication were considered originating from the same collecting occasion.

Subsequently, we expressed the frequency of occurrence of individual species by dividing the number of occurrence records with the total number of collecting occasions. Multiplying this by 100, the frequency of occurrence was expressed in percentages:

Frequency of occurrence of species X = 100 * (number of occurrence records for species X/total no. of collecting occasions during the evaluation period).

The relative distribution frequency of the species was calculated as follows:

Relative distribution frequency of species X = 100 * (number of UTM squares with a record of species X/no. of UTM squares where any bumble bee species was found during the evaluation period).

The 'rarity' of the species was measured by the relative distribution frequencies over the whole time period including all our data (about 100 years, 1900–1999). The following categories were used: 'data deficient' ($< 1\%$), 'rare' (1–10 %), 'moderately rare' (11–20%), 'frequent' (21–40%), 'abundant' ($> 41\%$).

The second approach for estimating species endangerment is the 'trend approach'. This describes the change in abundance (measured either as density or as relative abundance) of the species over time. To obtain abundance trends, we arranged our species records according to their decade of collection. The cut-off for the first period was 'before 1953' the publication date of the last catalogue of the Hungarian bumble bees (Móczár 1953) because the exact dating of these data were not possible. The other category limits were fitted to decades. The 80s and 90s were combined because of the relatively low collecting effort in this period. We measured the changes in the frequency of occurrence and classified the species into endangerment categories according to the definition of the IUCN Red List categories (IUCN 2001):

Extinct from Hungary (EX): not detected since 1953.

Critically endangered (CR): species showing more than 80% loss in frequency of occurrence during the last 50 years.

Endangered (EN): species showing more than 50% loss in frequency of occurrence during the last 50 years.

Vulnerable (VU): the declining trend in frequency is ambiguous, but it is a rare species and is present on other European red lists.

Lower risk (LR): cannot be classified into any of the above groups.

Several European national Red Lists were consulted to estimate the European endangerment level of the species. The Red Lists of the following countries, accessible mostly on the Internet, were used: Estonia (Lilleleht 2001),

Finland (Anonymus 2000a), Germany (Anonymus 1998), Latvia (Red Data Book Council 1992), Moldova (Biodiversity Office, Republic of Moldova 2002), Poland (Banaszak 1992), Russia (Anonymus 1997), Ukraine (Anonymus 2000b), United Kingdom (Stokes 2001).

Results

Table 1 shows the relative distribution frequencies of the 25 Bombus species in Hungary. Three species were data deficient. Nine species (36% of the fauna) were rare and other 6 (24%) were classified as moderately rare. Only 4 (16%) and 3 (12%) species could be classified as frequent or abundant, respectively. The analysis using the occurrence frequencies showed a few changes in the species rank, but species shifts between categories did not occur.

The temporal changes in the occurrence frequency of the species are shown on Table 2. This table includes only 24 species, because the single record of *B. consobrinus* had no precise collecting date. Two species (*B. consobrinus* and *B. distinguendus*) were data deficient. Another two species (*B. elegans* and *B. serriquama*) had to be classified as extinct from Hungary, because only data

Table 1. The relative distribution frequency of the Hungarian bumble bee species.

Species name	Number of UTM squares with an occurrence record	Distribution frequency (%)	Frequency category
Bombus consobrinus Mor.	1	0.23	Data deficient
Bombus distinguendus Mor.	1	0.23	Data deficient
Bombus serrisquama Mor.	2	0.46	Data deficient
Bombus. soroeensis F.	6	1.37	Rare
Bombus elegans Seidl	7	1.59	Rare
Bombus fragrans Pall.	16	3.64	Rare
Bombus haematurus Kriechb.	17	3.87	Rare
Bombus paradoxus D.T.	17	3.87	Rare
Bombus hypnorum L.	28	6.38	Rare
Bombus argillaceus Scop.	31	7.06	Rare
Bombus laesus Mor.	38	8.66	Rare
Bombus subterraneus L.	40	9.11	Rare
Bombus pomorum Pz.	46	10.48	Moderately rare
Bombus lucorum L.	55	12.53	Moderately rare
Bombus confusus Schck.	57	12.98	Moderately rare
Bombus pratorum L.	62	14.12	Moderately rare
Bombus ruderatus F.	77	17.54	Moderately rare
Bombus muscorum F.	86	19.59	Moderately rare
Bombus humilis Ill.	162	36.90	Frequent
Bombus ruderarius Müll.	163	37.13	Frequent
Bombus hortorum L.	163	37.13	Frequent
Bombus silvarum L.	179	40.77	Frequent
Bombus pascuorum Scop.	208	47.38	Abundant
Bombus lapidarius L.	253	57.63	Abundant
Bombus terrestris L.	300	68.34	Abundant

Table 2. The temporal changes in the frequency of occurrence of Hungarian bumble bee species.

Time period	*argillaceus*	*confusus*	*distinguendus*	*elegans*	*fragrans*	*haematurus*	*hortorum*	*humilis*
Before 1953	5.38	7.69	0.38	2.69	6.92	0.00	13.46	26.92
1953–1960	0.96	2.88	0.00	0.00	0.32	0.00	14.74	14.10
1961–1970	0.60	5.22	0.00	0.00	0.00	0.00	17.27	17.27
1971–1980	0.54	3.23	0.00	0.00	0.18	0.00	10.05	9.52
1981–2000	0.00	0.87	0.00	0.00	0.00	2.60	12.43	8.67
No. of records	31	76	1	7	20	9	266	283
	hypnorum	*laesus*	*lapidarius*	*lucorum*	*muscorum*	*paradoxus*	*pascuorum*	*pomorum*
Before1953	0.38	13.46	25.38	5.00	15.77	3.46	31.54	9.62
1953–1960	0.32	0.32	17.63	10.26	4.81	0.00	37.82	1.28
1961–1970	0.00	0.20	19.68	9.24	3.82	0.20	28.51	1.81
1971–1980	0.00	0.72	38.24	3.95	2.87	0.00	16.88	0.72
1981–2000	3.18	0.29	26.59	5.20	1.73	0.57	34.68	1.73
No. of records	13	42	524	131	97	12	556	48
	pratorum	*ruderarius*	*ruderatus*	*serrisquama*	*silvarum*	*soroeensis*	*subterraneus*	*terrestris*
Before1953	5.00	11.15	17.69	0.77	24.23	0.38	4.23	26.54
1953–1960	4.81	12.50	8.97	0.00	8.33	0.00	0.96	17.95
1961–1970	4.82	13.86	3.01	0.00	17.47	0.00	1.41	34.14
1971–1980	2.87	12.21	2.15	0.00	9.34	0.00	4.13	48.11
1981–2000	5.20	11.56	6.36	0.00	6.94	1.45	0.87	28.90
No. of records	86	245	123	2	252	6	47	663

The values of the relative frequency of occurrence are given in percentage.

from before 1953 were found. Ten further species showed decreasing trends, while eight species had fluctuations in their frequencies of occurrence without an obvious trend. The remaining three species showed an increase in frequency. The changes of relative distribution frequencies showed very similar trends.

Discussion

More than half of the Hungarian bumble bee species seemed to be rare or moderately rare (36 and 24%, respectively). The situation is very similar in the Moscow region, Russia, where the 54% of the bumble bee species are rare (Berezin et al. 1995). The Red List of Bavaria reports not only the frequent but even the abundant Hungarian species as rare (e.g. *B. lapidarius* and *B. pascuorum*, Day 1991). The validity of these claims, however, could not be ascertained.

Almost half of all species (47.6%) had decreasing, while 14% showed an increasing frequency trend. This suggests a diversity loss in the bumble bee fauna during the last 50 years in Hungary. A similar diversity loss also occurs in other European countries (Kosior 1995; Kells and Goulson 2003). In the Moscow region, exactly half of the species show a decreasing, while only 9% show an increasing trend (Berezin et al. 1995). The situation in Belgium is even worse than in Hungary: 60–75% of the fauna is in decrease while only 10–15% show an increasing trend (Rasmont et al. 1992). From the 15 species found in both Hungary and Belgium, 11 showed similar trends. For species found in both Britain and Hungary, the species that appear to be declining in Hungary show a similar trend in UK as well (Williams 2004). The most probable reason of bumble bee decline both in Belgium and UK seems to be the degradation of open habitats with a consequent loss of food plants (Rasmont et al. 1992; Goulson 2003; Williams 2004). The same factors can be at work in Hungary, too, but this is not ascertained.

The three increasing species in Hungary had very few data. For *B. soroeensis*, there were only six available records, five of them from the 80's. These data originated from the detailed faunistical research of the Bükk and the Aggtelek National Parks. This suggests that the increase is only an artefact of collecting, i.e. that this 'hylophil' species was found only in detailed faunistical survey of northern, cool mountain regions of Hungary. However, the rarity and the presence of this species on other European Red Lists give reason to categorise *B. soroensis* as vulnerable (Table 3). For *B. hypnorum*, almost all available data (11) were from the 80's or the beginning of 90's. There has been no occurrence record during the last 10 years (Józan, personal communication). Thus direct evidence on the increase of this species is lacking.

On the other hand, *B. haematurus* seemed to be truly increasing. The species was not found in Hungary before 1980, but more and more records were found from the beginning of 80's. This trend is continuing, with several new collection

Table 3. Summary of the endangerment data of the Hungarian bumble bee species.

Species	Frequency	Trend of the frequency change	No. of European Red lists containing the sp.	IUCN category
B. consobrinus	– (0.23)	–	–	DD
B. distinguendus	– (0.23)	–	5	DD
B. elegans	r(1.59)	†*ger*	1	EX
B. serrisquama	– (0.46)	†*ger*	1	EX
B. argillaceus	r(7.06)	d	4	CR
B. confusus	mr(12.98)	d	5	CR
B. fragrans	r(3.64)	d	6	CR
B. laesus	r(8.66)	d	2	CR
B. muscorum	mr(19.59)	d	4	CR
B. paradoxus	r(3.87)	d	4	CR
B. pomorum	mr(10.48)	d	4	CR
B. humilis	f (36.90)	d	3	EN
B. ruderatus	mr(17.54)	d	4	EN
B. silvarum	f (40.77)	d	2	EN
B. soroeensis	r(1.37)	i	3	VU
B. subterraneus	r(9.11)	u	5	VU
B. haematurus	r(3.87)	i		LR
B. hortorum	f(37.13)	u		LR
B. hypnorum	r(6.38)	i		LR
B. lapidarius	a(57.63)	u		LR
B. lucorum	mr(12.53)	u		LR
B. pascuorum	a(47.38)	u		LR
B. pratorum	mr(14.12)	u		LR
B. ruderarius	f(37.13)	u	1	LR
B. terrestris	a(68.34)	u		LR

The numbers in parentheses are the relative distribution frequencies (%). The numbers in the fourth column indicate how many national red lists include the given species (total of 10 consulted). CR: critically endangered; DD: data deficient; EN: endangered; EX: extinct; LR: lower risk; VU: vulnerable; †*ger*: extinct from Hungary; a: abundant; d: decreasing; f: frequent; i: increasing; mr: moderately rare; r: rare; u: unchanged).

sites during the very recent years (2002–2003; Józan, personal communication). These suggest an intensive expansion of *B. haematurus* in Hungary.

It must be born in mind that such data are inherently noisy. The rare species are probably overrepresented in museum collections, while faunistic papers have no such difference in representation of species. Our older data (before 1960) consisted much higher proportions of museum collection data, than the newer ones, so the decline of rare species would seem to be an artefact of methodology. However, several factors indicated that this artefact effect cannot be serious:

We found strong declining trends not only for rare, but also for frequent species (e.g. *B. humilis* and *B. silvarum*).

A strong artefact effect would also generate an increasing trend for abundant species, which we did not find.

We classified the species into endangerment categories (Table 3) according to the IUCN Red List criteria (IUCN 2001). Seven species (33% of the native

fauna) were labelled 'critically endangered' (CR), three (14%) were 'endangered' (EN) and two (9.5%) species were 'vulnerable' (VU). One vulnerable species (*B. soroeensis*) had an increasing, the other one (*B. subterraneus*) a static frequency trend, but their rarity and presence in other European red lists (in three and five other countries, respectively) suggest their vulnerability.

The rarity of a species is a very problematic point in both ecology and conservation biology (Dobson et al. 1995; Standovár and Primack 2001). For example, *B. muscorum*, classified by rarity categories is almost 'frequent' (19.59%). However, this species should be categorised as CR, because of the serious decline in both the occurrence and distribution frequencies. The situation was very similar in the case of *B. humilis* and *B. silvarum*. Thus, according to our results, it is easier to estimate the endangerment of the species by measuring the temporal changes in frequencies than from their rarity.

The Hungarian *Bombus* fauna needs much more protection and a higher conservation effort than they can benefit from today. There is only one protected species (*B. argillaceus*), while our results showed that at least 10–12 species need protection. All of the species classified by us as 'threatened' in Hungary are endangered in other parts of Europe (Table 3). This highlights an urgent need to develop specific protection plans for bumble bees not only in Hungary, but in the whole of Europe.

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