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CHANGES IN THE COMPOSITION OF THE BEE POPULATIONS OF THE MOHELNO SERPENTINE STEPPE AFTER 70 YEARS (HYMENOPTERA: APIFORMES)

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Abstract

PŘIDAL, A., VESELÝ, P.: *Changes in the composition of the bee populations of the Mohelno Serpentine Steppe after 70 years (Hymenoptera: Apiformes).* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 6, pp. 291–312

Mohelno serpentine steppe (Mohelenská hadcová step) is a unique natural habitat of European importance. Since its last apidologic proper survey passed about 70 years. The objective of this work was to summarize the results of the apidological survey performed in the national nature reserve Mohelno Serpentine Steppe in a period of 2010–2011, characterize current changes in the composition of bee populations and propose recommendations for the management of this nature reserve.
The survey was performed within 20 days and includes a total of 91 hours of observations in the field with exact records of survey localization and weather. A total of 2705 bee individuals were caught using an insect net and examined. 71 to 276 bee individuals were identified on individual days of monitoring. The bee density varied in a range of 18.4–87.1 bees per hour of the pure time of sampling. A total of 176 bee species were identified. 115 bee species from the original list of 232 bee species were confirmed by this survey (50 %). Species that were not confirmed could disappear as a result of changes which have occurred in the Steppe biotope over the past 40 years or their disappearance is generally associated with changes in the population of a particular species in Moravia. The disappearance of 17 % of unconfirmed species (20 species) from the Steppe is very likely to occur but it is not associated with general changes in the population of these species in southern Moravia. 61 out of 176 bee species were recorded in the Steppe for the first time. *Pyrobombus lapidarius* was eudominant. The highest dominance was observed for *Halictus simplex* as a representative of the solitary species and for *Nomada succincta* as a representative of cleptoparasites. However, the major part of cleptoparasites (66 %) was not confirmed. The Shannon's index (H' = 3.97), Equitability (e = 0.77) and the Simpson's index (c = 0.04) were determined for bee populations. The following species occurred on the Steppe: a) ubiquitous species with an abnormally small population (49 species) and b) steppe specialists (xerothermophile) with abnormally abundant populations and strongly competitive to ubiquitous species (9 species). The survey revealed a significant decrease in the diversity of apidofauna on the Steppe, showing that the degradation change took place only partially and that some rare xerothermophile species on the Steppe were preserved. The composition of apidofauna still maintains its predominant xerothermophile character. The results of the survey were used to propose recommendations for managing the maintenance of the national nature reserve Mohelno Serpentine Steppe.

secondary succession, Mohelno serpentine steppe, xerotermophile bee species, Apoidea, Apiformes, apidofauna

The Mohelno Serpentine Steppe (Mohelenská hadcová step, thereinafter referred to as "Steppe") is a unique national nature reserve of European significance. First known records of its botanical significance date back to 1855 (Roemer, 1855). Systematic investigations of this site started in the early 1900s (Veselý, 2010). The first written report about apidological research conducted on the Steppe was submitted in 1944 (Šnoflák, 1944) and included a total of 227 species according to current taxonomic classification (Přidal & Veselý, 2010a). Other species later found on the Steppe (Tkalců, 1964; Straka *et al.*, 2007) originated from occasional and non-systematic sampling. Literature sources describe a total of 232 bee species found on the territory of the Mohelno Serpentine Steppe ("Steppe"). Some names reported by Šnoflák (1944) are likely to represent one or two species according to the current taxonomy (Přidal & Veselý, 2010a). In principle, the spectrum of bee species was gradually completed using the results of the apidological survey performed in 2010 (Přidal & Veselý, 2010b). This survey provided interesting records such as the findings of additional 50 bee species that had not been found on the investigated site before. However, many more species remained unconfirmed on the Steppe by this survey. Such differences could be caused by major changes in biotopes of the Steppe that have occurred over the past decades, being particularly manifested by a sharp increase in the degree of steppe's coverage with woody species and by related microclimatic changes (Veselý, 2002, 2010). This problem has not been addressed for many years. After 1988, the plant stand in the nature reserve consisting of pine (*Pinus*) and locus trees (*Robinia pseudacacia*) was reduced and one part of the plateau was mown irregularly. It was not until May 1997 that sheep grazing was re-introduced on the Steppe. This kind of management is still applied in this nature reserve, according to the Plan of Management for this national nature reserve (Veselý, 2010).

Přidal and Veselý (2010c) analysed the description of the site's condition before 1944 reported by Šnoflák (1944), comparing it with the current state and emphasizing specific features in the Steppe associated with the forage sources for bees and interconnections between individual biotopes.

The main objective of this work is to summarize the results of the apidological survey performed in a period from 20 April 2010 to 10 May 2011, analyze the differences between the current state and the findings made in previous surveys (Šnoflák, 1944; Tkalců, 1964; Straka *et al.*, 2007), and focus on xerothermophile bee species with narrow ecological valence (steppe species). The analysis of the results obtained in the apidological survey will be used to propose recommendations for managing the Mohelno Serpentine Steppe in order to preserve and create favourable conditions for valuable xerothermophile communities.

MATERIAL AND METHODS

Description of the site

The specific character of biotopes in the Mohelno Serpentine Steppe is due to specific subsoil consisting of Serpentine (basic rock with a high content of magnesium) and a typical relief formed by erosion on the subsoil in the distinct meander of the river Jihlava (Fig. 1). The basin of the river Jihlava is cut deeply into the terrain so that the altitude difference between the plateau and the river's water surface may reach 150 m (Fig. 2). Soils formed on the subsoil are shallow with a low content of nutrients, and contain a high portion of fragments from mother rock, which increases the content of air in soil, contributing to soil desiccation (Veselý, 2010). Such soil properties and specific microclimatic conditions derived from these properties enable xerothermophile communities to occur on this site. They often include very rare species that have their northern boundary of occurrence in the Steppe in spite of the fact that the Steppe is located at the foothills of the Bohemian-Moravian Highlands (Českomoravská vysočina). Veselý (2002, 2010) worked up a detailed description of the site, including the description of changes that have occurred on the Steppe over the past 70 years.

Methodology of the survey

The apidological survey was based on the catching of bees using an insect net with a frame sized 40 cm in diameter and a 70 cm rod. Bees were caught at the sites of their typical occurrence such as flowers of the bee forage, bare sites on the surface of soil including roads and rock ledges, margins and the surface of low and sporadic growth of grass, in the vicinity of dead wood, on stones exposed to sun, in the close vicinity of lower margins of the top of pine trees or bush plants where males performed hill-topping.

The bee caught was immediately identificated and its gender was recorded. It was then released (particularly bumble bees, Bombini, and easily identifiable species) and/or placed in an exhaustor containing wood shavings, and subsequently identified after preparation in a laboratory using a binocular magnifier at 10–50 fold magnification. The prepared species are currently deposited in the collection of the first author whereas duplicate specimens are deposited in collections of the Entomological Department of the Moravian Museum (Moravské zemské muzeum) in Brno. Honey bee (*Apis mellifera* Linnaeus, 1758) as a common species was excluded from monitoring and measurement; a total of 200 honey bee colonies are reared in Mohelno. This species was an eudominant species on the Steppe for the whole period of monitoring.

Samplings were performed at recorded time intervals whose total length (the interval of observation) and the length of the pure time of

1: *Mohehelno Serpentine Steppe – view of the plateau, a part of the amphiteatre with downy surface and at the bottom valley the river Jihlava (Date: 20. 8. 2006, P. Veselý)*

2: *Mohehelno Serpentine Steppe – view of the plateau and the south and southwest parts of amphiteatre above the river Jihlava (Date: 20. 8. 2006, P. Veselý)*

I: *Time and place of observations*

Date	Interval of observation (summer time)	Lenght of interval [h]	Pure time of sampling [h]	Explored parts of territory - map squares (Veselý, 2010)
20. 4. 2010	10:15–16:15	6.00	5.70	B18, C13-18, D14,D17-18, E14, F14-15, G14-15, H15-16, I16-19, J15, J19-20, K16, K20, L16, L20, M16, M19, M20, N16, O16, F23-24, G23-24, H23-24, I23-24
28. 4. 2010	10:00–16:40	6.67	6.30	B18-19, C18-19, D19-21, E19-23, F21-24, G22, G23, G25, H22-24
21. 5. 2010	10:30–14:45	4.25	4.30	B19, C10-13, C16, C19, D10, D12-19, E9-11, D13-15, F10-13, G11-12
28. 5. 2010	10:05–15:55	5.83	5.60	B19-20, C10-17, C19-21, D4-6, D8-9, D11-12, D17-20, E5-7, E11, E20-22, F6, F11, F22-24, G6, G11-12, G23-24, H7, H9-11, I8-9
4. 6. 2010	10:15–13:55	3.67	×	B4, C4-5, E5-6
5. 6. 2010	10:20–15:30	5.17	4.80	B4, B18-20, C4, C12-13, C20, D4-5, D11-12, D20-21, E5, E11, E20-22, F6, F11, G6, G11, H7, H10, I8-9
10. 6. 2010	10:25–14:45	4.00	4.20	A18, B17-19, C13, C19-20, D4-5, D12, D20-21, E2-3, E5, E9, E11, E21-23, F9-11, F21-24, G9-11, G23-24, H23-24
25. 6. 2010	10:20–14:30	4.17	3.90	B18-19, C4, C13, C19, D4, D12, D19, E5, E11, E12, E19, E20-21, F6, F11, F21, G6, G11, H7, H10-11, I8-9
28. 6. 2010	10:40–16:10	5.50	5.30	A18, B4, B17-18, C4, C13, D4, D12, D18-22, E5, E11-12, E18-23, F4-6, F11, F23, G7, G11, G23, H7-11
14. 7. 2010	10:00–14:02 15:00–16:16	5.30	4.55	A17-18, C13, C15-19, D12, D18, D19-20, E11, E20-22, F11, F23-24, G11, G23-24, H24, I-K26
23. 7. 2010	10:15–13:15	3.00	2.40	A18-21, B18, B21, C18, C21, D18-21, E20-23, F23, G23, H23, H-J24
4. 8. 2010	10:30–15:40	5.17	4.62	A18, B4,B17-18, C4, C13, D4, D12, D18-22, E5, E11-12, E18-23, F4-6, F11, F23, G7, G11, G23, H7-11
20. 8. 2010	10:40–15:25	4.75	4.30	B18-19, C4, C13, C19, D4, D12, D19, E5, E11-12, E19-21, F6, F11, F21, G6, G11, H7, H10-11, I8-9
26. 8. 2010	13:00–17:45	4.75	×	A18, B17-19, C13, C19-20, D4-5, D12, D20-21, E2-3, E5, E9, E11, E21-23, F9-11, F21-24, G9-11, G23-24, H23-24
25. 3. 2011	10:40–14:35 winter time	3.92	3.35	B18-19, C18-19, D17-18, D20, E18-23, F18-19, F23-24, G18, G24, H17-18, H24, I17-19, I25, J17, J20, J25-28, K17, K21, K27-29, L17, L21, L29, M17, M21, M29, N17, N30, O20, + locality named as Výhon
7. 4. 2011	13:30–15:20	1.83	×	E20-23, E24, N17
18. 4. 2011	10:20–14:52	4.53	3.83	B4, C3-4, C13-18, D4, D12, D18-19, E5-6, E20-21, F6, F22-24, G7, G24, H8, H24, I8-11, I17-19, I24-25, J17, J20-21, J24-25, K17, K21, K23, L17, L21-22, M17, M20, N20, O19-20
22. 4. 2011	11:25–16:58	5.55	4.45	C4-7, C12-18, D4-5, D8-13, D18-20, E5, E11-12, E20-22, F5, F11-12, F23-24, G5, G11-12, G24, H5-11, H24, I6-7, I9-10, I24, J24-26, K27-28, L29, M29-30, N28-30, O28-30
10. 5. 2011	10:12–16:30	6.30	5.87	B17-19, C9-17, C19, D3-4, C8-9, C12-13, C20, E3-5, E7-8, E11-12, E20-23, F4-7, F11, F23-26, G7-8, G11, G24-26, H8-11, H24-26, I24-26, J25-27, K25, K27-29, L29, M-N/28-30, O28.
13. 5. 2011	15:50–16:20	0.50	×	B18
20 days	**11:00–15:37**	**90.85**	**73.47**	–

sampling (i.e. time for searching for bees and collecting bees excluding breaks or transfers between individual sites) were defined (Tab. I).

Furthermore, weather including maximum, minimum and average temperatures in the interval of observation was recorded together with map squares according to Veselý (2010) where sampling was performed (Tab. II). Transects often applied in practice were not used in this survey since bee mapping in the heterogenous site of the Steppe was not suitable. Transects can be used in monocultures without major problems (for example, in fodder-crop monocultures Háslbachová & Veselý, 1981; Kubišová *et al.*, 1984). Transect sweeping does not provide complete solution (Banaszak, 1980). The method applied in this apidological survey is suitable according to our experiences and can be adapted to current and local conditions. It can also be repeated any time when the conditions of sampling such as the date and time of sampling, II: *Weather and fenology conditions of observations*

Date	Weather					Fenology(dominant flowering species)
	Placing of station	**T max. [°C]**	**T min. [°C]**	**T averg. [°C]**	**Course of weather**	
20. 4. 2010	P	21.0	15.5	18.9	Nearly cloudless, warm, light wind, afternoon in the vicinity of the storm, just a few drops without the rain;	*Allysum montanum, Potentilla arenaria, Ribes* sp.;
28. 4. 2010	P	23.0	15.5	19.4	morning cloudy, afternoon nearly cloudless, colder wind only on upland plateau (grasland);	fully blooming *Prunus mahaleb, Veronica prostrata, Genista pilosa*;
21. 5. 2010	P	23.5	18.0	20.3	morning cloudy, afternoon nearly cloudless, cold strong wind namely on upland plateau, cold day;	*Allysum montanum* and *Veronica prostrata* still blooming!, fully blooming *Lychnis viscaria, Salvia pratensis* and *Cerastium* sp.; fade blooming *Potentilla arenaria*
28. 5. 2010	P	25.5	17.5	21.6	cloudy to overcast, weak wind; after intensive raining in all May;	fully blooming *Campanula* spp., *Ranunculus* sp., *Knautia* sp., *Salvia* sp.; *Allysum montanum* and *Veronica prostrata* still blooming!;
4. 6. 2010	×	×	×	×	overcast, weak and warm wind, low bee activity;	-
5. 6. 2010	P	27.5	24.0	26.2	cloudless, weak warm wind, very low bee activity;	initiation of flowering (=first flowers): *Sedum* sp. and *Lotus corniculatus*; fully blooming *Frangula alnus*;
10. 6. 2010	P	31.0	26.5	29.3	cloudless, occasional weak to middle warm wind (namely on 13. hour); afternoon low bee activity;	fadeaway *Allysum montanum*; full blooming *Coronilla varia* and *Dorycnium germanicum*;
25. 6. 2010	P	28.0	21.0	23.8	strong wind namely on upland plateau, colder weather;	fully blooming *Echium* sp., *Carduus nutans, Convolvulus arvensis*;
28. 6. 2010	P	34.0	27.0	30.2	cloudless to nearly cloudless, calm to weak very warm wind, optimal conditions;	fully blooming *Echium* sp., *Carduus nutans, Convolvulus arvensis*;
14. 7. 2010	D19	38.0	31.0	34.7	cloudless to nearly cloudless, afternoon cloudy, calm to weak very warm wind, optimal conditions;	fadeaway *Coronilla varia*, last flower on *Lotus cornicultus*; fully blooming *Carduus nutans*;
23. 7. 2010	D19	30.5	25.0	27.7	nearly overcast and stronger warm wind with gusts, the weather like before the arrival a front;	dominant flowers of *Carduus* spp. and *Medicago falcata*; initiation of flowering *Allium flavum*;
4. 8. 2010	D19	28.0	20.5	24.4	cloudy, calm to weak wind;	dominant blooming *Pseudolysimachion spicatum, Allium flavum* and *Eryngium* sp.; first flowers of *Carlina vulgaris*; re-flowering *Lotus corniculatus* (on pasture); individual flowers of *Allysum montanum* - 2nd blooming?;
20. 8. 2010	D19	28.0	24.5	26.3	cloudless, very weak wind to calm;	initiation of flowering *Armeria vulgaris* subsp. *serpentini, Aster linosyris*; still several flowers of *Allysum montanum*; full blooming *Pseudolysimachion spicata*; re-flowering *Coronilla varia*; fadeaway *Allium flavum* and *Eryngium* sp.; continuing blooming of *Carlina vulgaris*;
26. 8. 2010	×	×	×	×	cloudless to nearly cloudless, afternoon up to cloudy, weak to moderate wind; only qualitative recognition;	dominant flowers *Carlina vulgaris, Lysimachion spicata* and *Aster lynosyris*; last flowers of *Allium flavum*;

Date	**Weather**					**Fenology(dominant flowering species)**
	Placing of station	**T max. [°C]**	**T min. [°C]**	**T averg. [°C]**	**Course of weather**	
25. 3. 2011	D19	19.0	16.5	18.0	cloudless to nearly cloudless, weak to moderate breeze somewhat colder = lower bee activity on plateau, on banks windless;	initiation of flowering *Allysum montanum* and *Potentilla arenaria*
7. 4. 2011	D19	28.5	26.0	27.3	nearly cloudless, very strong but not very cold wind restricted bee activity on the plateau;	*Allysum montanum*, *Potentilla arenaria*
18. 4. 2011	D4	17.0	23.0	20.1	cloudless and nearly calm in morning, calm in ravines, afternoon stronger wind and nearly cloudy with a decrease in temperature;	initiation of flowering *Prunus mahaleb* and *Genista pilosa*; fully booming of *Potentilla arenaria*, *Prunus spinosa*, *Lamium purpureum*; fadeaway willows (*Salix* spp.); past blossom *Corydalis* sp., *Pulmonaria* sp.;
22. 4. 2011	O28	30.5	25.5	29.2	cloudless and moderate wind with stronger gusts, occasionaly calm;	initiation of flowering *Veronica prostrata* and *Chamaecytisus ratisbonensis*; fully blooming *Prunus mahaleb;*
10. 5. 2011	O28	34.0	25.5	30.3	cloudless and weak breeze to calm;	fully blooming *Veronica prostrata* and *Crataegus* sp., blooming *Fragaria* sp., *Nonea pulla*, *Ranunculus* sp.; start of blooming *Salvia pratensis* and *Lychnis viscaria;*
13. 5. 2011	×	×	×	×	cloudless with weak wind.	*Ranunculus* sp.

main flowering bee forage sources, the interval of sampling, the pure time of sampling, average, minimum and maximum temperatures in a period of sampling and weather, are exactly specified (Tab. I, II).

Temperature was measured in the portable weather station at a height of ca 2.5 m above the ground using an automatic datalogger sensor recording temperature every 10 seconds during sampling. Respective values were used to determine the average temperature (arithmetic mean) and minimum and maximum temperatures in the degrees Celsius. The weather station was attached to a branch at a height of ca. 2–2.5 m above the ground, facing the South, preventing a shadow to be cast on it. All temperatures measured before and on 28 June 2010 were determined on the site located 12 km northeast from Mohelno (Příbram na Moravě, the station was placed at the height of 2 m on a separate stand, measurement was performed in a 5-minute interval); from 14 July 2010, temperature was measured at several sites described as map squares according to Veselý (2010), (Tab. II).

The recorded bee species were ranked by their dominance, indicating whether the respective finding confirmed the occurrence of a particular species (already published, confirmed species) or whether it was the first record not yet reported in the literature (firstly recorded species).

Observations were evaluated using the following diversity indices: the Shannon index (H´) (Shannon & Weaver, 1949), equitability (e) (Pielou, 1966), index of dominance = Simpson's diversity index (c) (Simpson, 1949) and dominance (D, %) (Tischler, 1965). Group dominance (D_x %) was also calculated where the total number of individuals in the denominator (N_x) represented the sum of all individuals identified in a particular genus and/or in several very closely related genera – groups of species: Anthidiini (= *Anthidium*, *Pseudoanthidium*), Bombinii (= *Bombus*, *Megabombus*, *Psithyrus*, *Pyrobombus*), Halictini A (= *Evylaeus* and *Lasioglossum*), Halictini B (= *Halictus* and *Seladonia*), Megachilini (= *Chalicodoma*, *Megachile* and *Coelioxys*), Osmiini (= *Allosmia*, *Heriades*, *Hoplitis*, *Chelostoma*, *Osmia*, *Tergosmia*), Rophitini (= *Rophites* and *Rhophitoides*). The remaining genera were then evaluated separately. Group dominance is important for comparing the density of closely related species with a significant bioindication potential.

$$D_x = n_i / N_x \ (\%),$$

n_i ... the number of individuals of a particular species

N_x.. the number of individuals of a particular genus or the group of genera.

Species that are known to occur on the Steppe according to literature data but that were not confirmed by this survey were highlighted (Tab. VI) to see whether the population of a particular species in Moravia is decreasing and whether it is likely (lower or higher) that a particular species will disappear (or extinction) in the Steppe. In the case of a lower probability, we assume that a particular species is likely to be found in the future survey which will take into account species bionomy and/or employ different sampling methods (e.g. traps). The above-mentioned division provided four groups of unconfirmed bee species:

x) species with a decreasing population in Moravia and on the Steppe are:
  x1) disappeared with a higher probability;
  x2) disappeared with a lower probability;
y) species in Moravia without a major decrease in their populations and on the Steppe are:
  y1) disappeared with a higher probability;
  y2) disappeared with a lower probability.

A total of 95 species were selected from confirmed species (i. e. 54%) and divided into the following indication groups (Tab. VII):

a) The species without any specific demand on the environment abundant everywhere (ubiquitous species):
  a1) on the Steppe with an abnormally low rate of occurrence;
  a2) on the Steppe very abundant (it applies to the first records that Šnoflák (1944) did not find this species on the Steppe).
b) Steppe (xerothermophile) species with a typical low to very low rate of occurrence and:
  b1) occurrence on the Steppe is very high, a medium rate of occurrence is rare (specialists with larger populations);
  b2) very low occurrence on the Steppe (potentially endangered species).
c) The species has also spreading in Central Europe over the past few years;
  c1) confirmed at multiple sites in Central Europe according to literature data;
  c2) only according to our observations and within the Czech Republic, a species with an unclear ecological valence.

The bees were identified accoding to following literature: Amiet *et al.* (1996, 1999, 2001, 2004, 2007); Dathe (1980), Dylewska (1987), Gusenleitner & Schwarz (2002), Pesenko *et al.* (2000) and Přidal (2001).

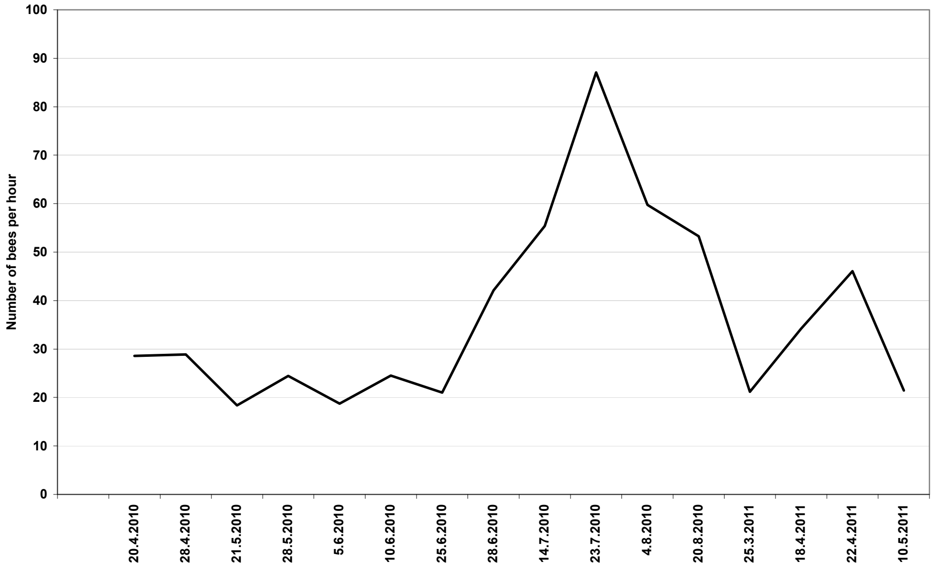
RESULTS

A total of 2,705 bee species were observed at the above-mentioned conditions (Tab. I and Tab. II). 71–276 bee individuals were identified on individual days (Tab. III), thus 18.4–87.1 bees per hour, as recalculated per time unit (the pure time of sampling) (Fig. 3). High values were due to bumble bee workers (Bombini) whereas low values were associated with a period of a low number of the bee forage plants in a period between phenological phases.

A total of 176 bee species including *Apis mellifera* were found in the apidological survey conducted on the Steppe. Sixty-one of these species were newly identified on the Steppe. The list of found bee species is provided in Tab. IV – according to their dominance (D %) and with indication the first record. *Pyrobombus lapidarius* was the only eudominant species (D = 14.74 %) due to a large number of bee workers in the summer season. The highest dominance was found for *Halictus simplex* as one of the solitary species, reaching a value of D = 7.99 % (dominant). *Nomada succincta* was the most dominant cleptoparasite (D = 1.42 %), followed by *N. bifasciata* (D = 0.56 %). *Nomada lathburiana* has the same value of dominance as *N. succincta* but the respective high value was due to the monitoring of this species directly at its nest place. Both species represented 2/3 of identified species of this genus ($D_x > 60$ %) A total of 45 species (25 %) was recorded in one individual (D = 0.04 %). Approximately one half of species was found in a maximum of 5 individuals (D < 0.2 %). A total of 157 species (89 %) belonged to a group of subrecedent species (D < 1 %). Group dominance shows that a maximum of one species was distinctly dominant in the genus or defined group in the overwhelming majority of cases, according to methodology (for example Bombini, Halictini B, *Hylaeus* or Osmiini), or rarely two (for example *Andrena*) and/or three species (for example Megachilini). The remaining species were subrecedent or recedent species. These findings are also reflected in the values of diversity indices (Tab. V).

III: *Number of bee individuals observed in each day*

Date	Number of observed individuals
20. 4. 2010	163
28. 4. 2010	182
21. 5. 2010	79
28. 5. 2010	137
4. 6. 2010	6
5. 6. 2010	90
10. 6. 2010	103
25. 6. 2010	82
28. 6. 2010	223
14. 7. 2010	252
23. 7. 2010	209
4. 8. 2010	276
20. 8. 2010	229
26. 8. 2010	103
25. 3. 2011	71
7. 4. 2011	32
18. 4. 2011	131
22. 4. 2011	205
10. 5. 2011	126
13. 5. 2011	6
Total	2 705



3: *Number of bee individuals observed per hour of pure time of sampling on each day*

IV: *List of the confirmed and the first recorded species according their dominance and with other notes*

Species	First record	Dominance D (%)	Group dominance D_x (%)	Indicator group
Apis mellifera (Linnaeus, 1758)		-	-	
Pyrobombus lapidarius (Linnaeus, 1758)		14.74	54.18	a2
Halictus simplex Blüthgen, 1923		7.99	76.98	a2
Andrena nigroaenea (Kirby, 1802)		6.46	22.21	a2
Megabombus pascuorum (Scopoli, 1763)		4.33	15.91	a2
Andrena flavipes Panzer, 1799	+	4.26	14.63	a2
Hylaeus lineolatus (Schenck, 1861)		3.47	67.39	b1
Bombus terrestris (Linnaeus, 1758)		3.25	11.93	
Andrena tscheki Morawitz, 1872		2.87	9.88	b1
Andrena vaga Panzer, 1799	+	2.35	8.09	
Bombus lucorum (Linnaeus, 1761)	+	2.24	8.23	
Andrena ovatula (Kirby, 1802)		2.02	6.93	
Evylaeus morio (Fabricius, 1793)		2.02	23.89	
Heriades crenulatus Nylander, 1852		1.83	42.98	b1
Ceratina cyanea (Kirby, 1802)		1.42	66.67	
Nomada lathburiana (Kirby, 1802)		1.42	30.16	
Nomada succincta Panzer, 1798	+	1.42	30.16	a2
Andrena cineraria (Linnaeus, 1758)		1.12	3.85	
Andrena gravida Imhoff, 1832		1.08	3.72	a1
Evylaeus calceatus (Scopoli, 1763)		1.01	11.95	a1
Andrena rugulosa Stoeckhert, 1935		0.97	3.34	b1
Andrena saxonica Stoeckhert, 1935	+	0.86	2.95	
Andrena labiata Fabricius, 1781		0.75	2.57	
Evylaeus tricinctus (Schenck, 1874)		0.75	8.85	b1
Rhophitoides canus (Eversmann, 1852)		0.75	90.91	
Andrena wilkella (Kirby, 1802)		0.71	2.44	
Evylaeus laticeps (Schenck, 1868)		0.71	8.41	
Halictus sexcinctus (Fabricius, 1775)		0.71	6.83	
Megachile pilidens Alfken, 1924		0.71	25.00	b1

Species	First record	Dominance D (%)	Group dominance D_x (%)	Indicator group
Andrena haemorrhoa (Fabricius, 1781)	+	0.67	2.31	
Seladonia tumulorum (Linnaeus, 1758)		0.67	6.47	a1
Sphecodes ephippius (Linné, 1767)		0.67	52.94	
Evylaeus minutulus (Schenck, 1853)	+	0.63	7.52	b1
Evylaeus politus (Schenck, 1853)		0.63	7.52	a1
Megabombus hortorum (Linnaeus, 1761)	+	0.63	2.33	
Andrena taraxaci Giraud, 1861		0.60	2.05	
Andrena bicolor Fabricius, 1775		0.56	1.93	a1
Nomada bifasciata Olivier, 1811	+	0.56	11.90	a2
Megachile circumcincta (Kirby, 1802)		0.52	18.42	
Melitta leporina (Panzer, 1799)		0.52	93.33	
Colletes similis Schenck, 1853		0.49	46.43	
Nomada goodeniana (Kirby, 1802)	+	0.49	10.32	a2
Andrena florivaga Eversmann, 1852	+	0.45	1.54	b2
Andrena potentillae Panzer, 1809	+	0.45	1.54	b2
Megachile pilicrus Morawitz, 1878	+	0.45	15.79	c1
Osmia rufa (Linnaeus, 1758)		0.45	10.53	a1
Psithyrus rupestris (Fabricius, 1793)		0.45	1.65	a1
Pyrobombus pratorum (Linnaeus, 1761)	+	0.45	1.65	a1
Anthidium manicatum (Linnaeus, 1758)		0.41	44.00	
Anthophora plumipes (Pallas, 1772)	+	0.41	61.11	
Seladonia kessleri (Bramson, 1879)	+	0.37	3.60	b1
Evylaeus interruptus (Panzer, 1798)		0.34	3.98	
Lasioglossum xanthopus (Kirby, 1802)		0.34	3.98	
Megabombus ruderarius (Müller, 1776)	+	0.34	1.23	
Ceratina cucurbitina (Rossius, 1792)	+	0.30	14.04	
Evylaeus villosulus (Kirby, 1802)		0.30	3.54	a1
Hoplitis adunca (Panzer, 1798)		0.30	7.02	
Lasioglossum leucozonium (Schrank, 1781)		0.30	3.54	a1
Megabombus sylvarum (Linnaeus, 1761)		0.30	1.10	b2
Andrena curvungula Thomson, 1870	+	0.26	0.90	
Anthophora aestivalis (Panzer, 1801)		0.26	38.89	
Colletes daviesanus Smith, 1846		0.26	25.00	a1
Evylaeus parvulus (Schenck, 1853)		0.26	3.10	a1
Hylaeus gibbus Saunders, 1850	+	0.26	5.07	a1
Hylaeus hyalinatus Smith, 1842		0.26	5.07	a1
Hylaeus nigritus (Fabricius, 1798)		0.26	5.07	
Chalicodoma ericetorum (Lepeletier, 1841)		0.26	9.21	a1
Chelostoma emarginatum (Nylander, 1856)	+	0.26	6.14	c2
Pyrobombus soroeensis (Fabricius, 1776)	+	0.26	0.96	
Andrena combinata (Christ, 1971)		0.22	0.77	b2
Andrena fulva (Müller, 1766)	+	0.22	0.77	c1
Andrena nitida (Müller, 1776)	+	0.22	0.77	a1
Andrena semilaevis Pérez, 1903	+	0.22	0.77	
Anthidium punctatum Latreille, 1809		0.22	24.00	
Ceratina nigrolabiata Friese, 1896	+	0.22	10.53	c1
Coelioxys quadridentata (Linnaeus, 1758)		0.22	7.89	
Evylaeus pauxillus (Schenck, 1853)		0.22	2.65	a1
Halictus quadricinctus (Fabricius, 1776)		0.22	2.16	

Species	First record	Dominance D (%)	Group dominance D_x (%)	Indicator group
Megachile lagopoda (Linnaeus, 1761)		0.22	7.89	
Nomada flavoguttata (Kirby, 1802)		0.22	4.76	
Osmia mustelina Gerstaecker, 1869	+	0.22	5.26	
Xylocopa violacea (Linnaeus, 1758)	+	0.22	85.71	
Andrena aberrans Eversmann, 1852	+	0.19	0.64	b2
Andrena susterai Alfken, 1914	+	0.19	0.64	b2
Ceratina chalybea Chevrier, 1872		0.19	8.77	
Evylaeus convexiusculus (Schenck, 1853)		0.19	2.21	b2
Hylaeus angustatus (Schenck, 1861)		0.19	3.62	
Megachile willughbiella (Kirby, 1802)	+	0.19	6.58	a1
Osmia niveata (Fabricius, 1804)		0.19	4.39	a1
Pseudoanthidium lituratum (Panzer, 1801)		0.19	20.00	
Tergosmia tergestensis (Ducke, 1897)	+	0.19	4.39	b2
Andrena dorsata (Kirby, 1802)	+	0.15	0.51	a1
Andrena falsifica Perkins, 1915	+	0.15	0.51	
Andrena helvola (Linnaeus, 1758)	+	0.15	0.51	a1
Andrena minutula (Kirby, 1802)		0.15	0.51	a1
Andrena strohmella Stoeckhert, 1928	+	0.15	0.51	
Colletes cunicularius (Linnaeus, 1761)	+	0.15	14.29	
Colletes graeffei Alfken, 1900	+	0.15	14.29	b2
Eucera longicornis (Linnaeus, 1758)		0.15	100.00	
Evylaeus marginatus (Brullé, 1832)		0.15	1.77	b2
Evylaeus pygmaeus (Schenck, 1853)		0.15	1.77	
Halictus maculatus Smith, 1848		0.15	1.44	a1
Hoplitis leucomelana (Kirby, 1802)		0.15	3.51	
Hylaeus brevicornis Nylander, 1852		0.15	2.90	
Hylaeus communis Nylander, 1852		0.15	2.90	a1
Hylaeus gredleri Förster, 1871	+	0.15	2.90	a1
Chelostoma distinctum (Stoeckhert, 1929)		0.15	3.51	
Nomada trispinosa Schmiedeknecht, 1882		0.15	3.17	
Osmia aurulenta (Panzer, 1799)		0.15	3.51	a1
Sphecodes gibbus (Linnaeus, 1758)		0.15	11.76	
Sphecodes rufiventris (Panzer, 1798)		0.15	11.76	
Andrena chrysopyga Schenck, 1853		0.11	0.39	b2
Andrena varians (Kirby, 1802)	+	0.11	0.39	a1
Anthidium oblongatum (Illiger, 1806)		0.11	12.00	
Evylaeus leucopus (Kirby, 1802)		0.11	1.33	
Evylaeus malachurus (Kirby, 1802)	+	0.11	1.33	
Chelostoma rapunculi (Lepeletier, 1841)		0.11	2.63	
Lasioglossum laevigatum (Kirby, 1802)		0.11	1.33	
Megachile melanopyga Costa, 1863		0.11	3.95	b2
Nomada signata Jurine, 1807	+	0.11	2.38	
Seladonia leucahenea (Ebmer, 1972)		0.11	1.08	b1
Andrena similis Smith, 1849	+	0.07	0.26	b2
Halictus compressus (Walckenaer, 1802)		0.07	0.72	b2
Hylaeus difformis (Eversmann, 1852)		0.07	1.45	
Nomada fulvicornis Fabricius, 1793		0.07	1.59	
Psithyrus bohemicus (Seidl, 1837)	+	0.07	0.27	a1
Psithyrus vestalis (Geoffroy, 1785)	+	0.07	0.27	a1

Species	First record	Dominance D (%)	Group dominance D_x (%)	Indicator group
Pyrobombus hypnorum (Linnaeus, 1758)	+	0.07	0.27	
Rophites quinquespinosus Spinola, 1808		0.07	90.91	
Sphecodes albilabris (Fabricius, 1793)		0.07	5.88	
Sphecodes crassus Thomson, 1870		0.07	5.88	a1
Allosmia rufohirta (Latreille, 1811)		0.04	0.88	
Andrena carantonica Pérez, 1902	+	0.04	0.13	a1
Andrena floricola Eversmann, 1852		0.04	0.13	b2
Andrena gelriae van der Vecht, 1927	+	0.04	0.13	b2
Andrena labialis (Kirby, 1802)		0.04	0.13	
Andrena nitidiuscula Schenck, 1853		0.04	0.13	a1
Andrena pilipes Fabricius, 1781	+	0.04	0.13	b2
Andrena polita Smith, 1847		0.04	0.13	b2
Andrena praecox (Scopoli, 1763)		0.04	0.13	
Andrena tibialis (Kirby, 1802)		0.04	0.13	
Dioxys tridentata (Nylander, 1848)	+	0.04	100.00	
Evylaeus fulvicornis (Kirby, 1802)		0.04	0.44	a1
Evylaeus nigripes (Lepeletier, 1841)		0.04	0.44	a1
Heriades truncorum (Linnaeus, 1758)		0.04	0.88	a1
Hoplitis claviventris (Thomson, 1872)		0.04	0.88	a1
Hoplitis mitis (Nylander, 1852)		0.04	0.88	b2
Hylaeus annularis (Kirby, 1802)		0.04	0.72	a1
Hylaeus confusus Nylander, 1852		0.04	0.72	a1
Hylaeus punctatus (Brullé, 1832)		0.04	0.72	a1
Hylaeus sinuatus (Schenck, 1853)		0.04	0.72	a1
Hylaeus styriacus Förster, 1871		0.04	0.72	b2
Chelostoma campanularum (Kirby, 1802)		0.04	0.88	a1
Chelostoma florisomne (Linnaeus, 1758)		0.04	0.88	a1
Lasioglossum quadrinotatum (Kirby, 1802)		0.04	0.44	
Megachile alpicola Alfken, 1924	+	0.04	1.32	a1
Megachile centuncularis (Linnaeus, 1758)		0.04	1.32	a1
Megachile nigriventris Schenck, 1868	+	0.04	1.32	c2
Megachile pacifica Panzer, 1798	+	0.04	1.32	b2
Melitta haemorhoidalis (Fabricius, 1775)	+	0.04	6.67	a1
Nomada flavopicta (Kirby, 1802)	+	0.04	0.79	
Nomada fucata Panzer, 1798	+	0.04	0.79	
Nomada melanopyga Schmiedeknecht, 1882		0.04	0.79	
Nomada noskiewiczi Schwarz, 1966	+	0.04	0.79	
Nomada picciolana Magretti, 1883	+	0.04	0.79	
Nomada ruficornis (Linnaeus, 1758)		0.04	0.79	
Nomada stigma Fabricius, 1804		0.04	0.79	
Osmia caerulescens (Linnaeus, 1758)		0.04	0.88	a1
Seladonia confusa (Smith, 1853)		0.04	0.36	b2
Seladonia subaurata (Rossius, 1792)		0.04	0.36	b2
Sphecodes miniatus Hagens, 1882	+	0.04	2.94	a1
Sphecodes monilicornis (Kirby, 1802)		0.04	2.94	a1
Sphecodes niger Hagens, 1874		0.04	2.94	
Sphecodes reticulatus Thomson, 1870	+	0.04	2.94	b2
Stelis breviuscula (Nylander, 1848)		0.04	100.00	b2
Xylocopa valga Gerstaecker, 1872	+	0.04	14.29	a1

V: *Indices of species composition of apidofauna in the Mohelno Serpentine Steppe*

Indice	Value
Shannon's index (H')	3.97
Equitability (e)	0.77
Simpson's index (c)	0.04

The apidological survey only confirmed 115 species (ca 50 %) out of 232 species reported in the literature before 2009. However, the remaining 117 species (nearly the same portion of species) was not confirmed in the recent survey (Tab. VI).

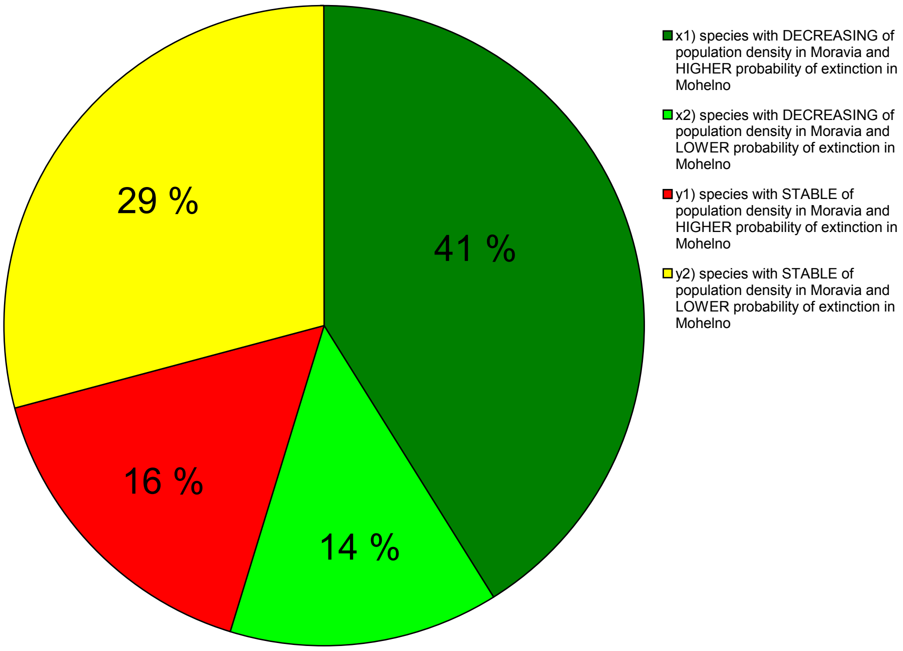
The graph (Fig. 4) illustrates the portions of unconfirmed species according to their division

VI: *List of unconfirmed species*

Species	Probability of species extinction in the Steppe	Decreasing populations also elsewhere in Moravia	Species	Probability of species extinction in the Steppe	Decreasing populations also elsewhere in Moravia
***Macropis* Panzer, 1809**			***Evylaeus* Robertson, 1902**		
fulvipes (Fabricius, 1804)	lower	not	*aeratus* (Kirby, 1802)	higher	not
***Hylaeus* Fabricius, 1793**			*albipes* (Fabricius, 1781)	lower	not
gracilicornis (Morawitz, 1867)	lower	not	*buccalis* (Pérez, 1903)	higher	not
leptocephalus (Morawitz, 1870)	higher	not	*clypearis* (Schenck, 1853)	higher	yes
pictipes Nylander, 1852	higher	yes	*euboeensis* (Strand, 1909)	higher	yes
signatus (Panzer, 1798)	higher	not	*fratellus* (Pérez, 1903)	lower	not
variegatus (Fabricius, 1798)	higher	not	*glabriusculus* (Morawitz, 1872)	higher	yes
***Colletes* Latreille, 1802**			*laevis* (Kirby, 1802)	lower	yes
inexpectatus Noskiewicz, 1936	lower	not	*linearis* (Schenck, 1868)	lower	yes
marginatus Smith, 1846	higher	not	*lucidulus* (Schenck, 1861)	higher	yes
***Chelostoma* Latreille, 1809**			*marginellus* (Schenck, 1853)	higher	yes
ventrale Schletterer, 1889	higher	not	*minutissimus* (Kirby, 1802)	higher	yes
***Osmia* Panzer, 1806**			*nitidiusculus* (Kirby, 1802)	lower	yes
cerinthidis Morawitz, 1876	lower	yes	*nitidulus* (Fabricius, 1804)	lower	yes
cornuta (Latreille, 1805)	lower	not	*punctatissimus* (Schenck, 1853)	lower	not
melanogaster Spinola, 1808	higher	not	*quadrisignatus* (Schenck, 1853)	higher	yes
***Neosmia* Tkalců, 1974**			*semilucens* (Alfken, 1914)	higher	yes
bicolor (Schrank, 1781)	lower	not	*setulosus* (Strand, 1909)	higher	not
***Hoplitis* Klug, 1807**			***Sphecodes* Latreille, 1805**		
anthocopoides (Schenck, 1853)	lower	yes	*croaticus* Meyer, 1922	higher	not
ravouxi Pérez, 1902	lower	yes	*geoffrellus* (Kirby, 1802)	lower	not
***Anthocopa* Lepeletier, 1825**			*longulus* Hagens, 1882	lower	not
papaveris (Latreille, 1799)	higher	yes	*marginatus* Hagens, 1882	lower	not
***Chalicodoma* Lepeletier, 1841**			*pellucidus* Smith, 1845	lower	yes
parietina (Geoffroy, 1785)	higher	yes	*puncticeps* Thomson, 1870	lower	not
***Megachile* Latreille, 1802**			***Rophites* Spinola, 1808**		
analis Nylander, 1852	higher	yes	*algirus* Pérez, 1903	higher	yes
lapponica Thomson, 1872	higher	yes	***Systropha* Illiger, 1806**		
ligniseca (Kirby, 1802)	lower	not	*curvicornis* (Scopolli, 1770)	higher	yes
maritima (Kirby, 1802)	lower	not	*planidens* Giraud, 1861	higher	yes
octosignata Nylander, 1852	higher	yes	***Dufourea* Lepeletier, 1841**		
versicolor Smith, 1844	lower	not	*dentiventris* (Nylander, 1848)	higher	yes
***Coelioxys* Latreille, 1809**			*halictula* (Nylander, 1852)	higher	yes
aurolimbata Förster, 1853	lower	yes	*minuta* Lepeletier, 1841	higher	yes
conoidea (Illiger, 1806)	lower	not	***Nomada* Scopoli, 1770**		
inermis (Kirby, 1802)	lower	not	*braunsiana* Schmiedeknecht, 1882	lower	yes
***Trachusa* Panzer, 1804**			*conjugens* Herrich-Schäffer, 1839	higher	yes
byssina (Panzer, 1798)	lower	not	*emarginata* Morawitz, 1878	lower	yes

Species	Probability of species extinction in the Steppe	Decreasing populations also elsewhere in Moravia
***Anthidiellum* Cockerell, 1904**		
strigatum (Panzer, 1805)	lower	not
***Stelis* Panzer, 1806**		
minuta Lepeletier et Serville, 1825	higher	yes
nasuta (Latreille, 1809)	higher	yes
phaeoptera (Kirby, 1802)	higher	yes
punctulatissima (Kirby, 1802)	lower	not
signata (Latreille, 1809)	higher	yes
***Dioxys* Lepeletier et Serville, 1825**		
cincta (Jurine, 1807)	higher	yes
***Andrena* Fabricius, 1775**		
alfkenella Perkins, 1914	higher	yes
barbilabris (Kirby, 1802)	lower	not
congruens Schmiedeknecht, 1884	lower	not
florea Fabricius, 1793	higher	yes
fulvago (Christ, 1791)	higher	yes
fulvida Schenck, 1853	higher	yes
hattorfiana (Fabricius, 1775)	higher	yes
humilis Imhoff, 1832	higher	yes
marginata Fabricius, 1776	higher	yes
minutuloides Perkins, 1914	lower	not
pandellei Pérez, 1895	lower	not
propingua Schenck, 1853	lower	not
proxima (Kirby, 1802)	higher	yes
rosae Panzer, 1801	higher	yes
schencki Morawitz, 1896	higher	yes
viridescens Vierdeck, 1916	higher	yes
***Panurgus* Panzer, 1806**		
calcaratus (Scopoli, 1763)	higher	not
***Panurginus* Nylander, 1848**		
labiatus (Eversmann, 1852)	higher	not
***Halictus* Latreille, 1804**		
rubicundus (Christ, 1791)	higher	yes
***Seladonia* Robertson, 1918**		
smaragdula (Vachal, 1895)	higher	not
***Lasioglossum* Curtis, 1833**		
breviventre (Schenck, 1853)	higher	not
costulatum (Kriechbaumer, 1873)	higher	not
lativentre (Schenck, 1853)	lower	not
sexnotatum (Kirby, 1802)	lower	yes
furvoides Stoeckhert, 1944	higher	yes
fusciocornis Nylander, 1848	higher	yes
guttulata Schneck, 1861	lower	not
mutabilis Morawitz, 1870	lower	yes
opaca Alfken, 1913	higher	yes
pleurosticta Herrich-Schäffer, 1839	higher	yes
rhenana Morawitz, 1872	higher	yes
roberjeotiana Panzer, 1799	higher	yes
rufipes Fabricius, 1793	lower	yes
zonata Panzer, 1798	lower	not
***Epeolus* Latreille, 1802**		
cruciger (Panzer, 1799)	higher	not
***Eucera* Scopoli, 1770**		
interrupta Baer, 1850	lower	not
nigrescens Pérez, 1879	lower	not
seminuda Brullé, 1832	higher	not
***Anthophora* Latreille, 1803**		
quadrimaculata (Panzer, 1798)	lower	not
***Clisodon* Patton, 1879**		
furcatus (Panzer, 1798)	lower	not
***Heliophila* Klug, 1807**		
bimaculata (Panzer, 1798)	higher	yes
***Melecta* Latreille, 1802**		
albifrons (Forster, 1771)	higher	not
***Thyreus* Panzer, 1806**		
orbatus (Lepeletier, 1841)	higher	not
***Psithyrus* Lepeletier, 1832**		
barbutellus (Kirby, 1802)	higher	yes
campestris (Panzer, 1801)	lower	not
***Confusibombus* Ball, 1914**		
confusus (Schenck, 1861)	lower	yes
***Megabombus* Dalla Torre, 1880**		
humilis (Illiger, 1806)	lower	not
muscorum (Linnaeus, 1758)	higher	yes
pomorum (Panzer, 1805)	higher	yes
subterraneus (Linnaeus, 1758)	lower	yes

into the four groups (x1, x2, y1, y2) according to methodology. More than one half (x1 = 41 %, x2 = 14 %, a total of 64 species) consists of species whose disappearance from the Steppe may be associated with factors that also operate in other sites in Moravia. It is highly probable in Group x2) (16 species) that they will be found in the next recognition in the Steppe. Although Group "y" (y1 = 16 %, y2 = 29 %) includes 53 species that have a more or less stable population in Moravia, they were not found on the Steppe. Similar to Group x2), one can expect that 34 species will be found from Group y2) in the next recognition but in Group y1)



4: *Unconfirmed species according to their probability of extinction in the Mohelno serpentine steppe*

VII: *Number of species in the indication groups of the confirmed species*

Indication group	Number of species
a1 – ubiquit with low density in Mohelno	49
a2 – ubiquit with high density in Mohelno	8
b1 – xerotermophillous species with high density in Mohelno	9
b2 – xerotermophillous species with low density in Mohelno	25
c1 – currently spreading species in the Central Europe	3
c2 – probably currently spreading species in the Central Europe	2

there is a very low probability that 19 species (16 %) will be found.

The division of selected species into the four indication groups according to methodology provided 6 groups of species (a1, a2, b1, b2, c1, c2). Group (a1) is the most abundant group consisting of ubiquitous species with abnormally small-sized populations on the Steppe (Tab. VII).

In contrast, some xerothermophile (steppe) species occurred at an abnormally high density on the Steppe whereas their closely related ubiquitous species are very rare (Tab. VIII).

The number of cleptoparasitic and host bee species are listed in Tab. IX: a) the original (initiative) number of species according to literature data, b) firstly recorded species and c) species confirmed or unconfirmed by this survey. Changes in incidence rates (expressed as a percentage related to the original number of species, 2nd column in Tab. IX) were compared. It follows from the comparison that an increase in the number of newly identified cleptoparasites (the first record) in percent is identical with an increase in the number of host species in percent (i. e. 26 %), (Fig. 5). However, in comparison with unconfirmed host species (46 %), the larger part of cleptoparasites remained unconfirmed (66 %), (Fig. 5), although the number of identified cleptoparasitic species (30 cleptoparasites = the sum of confirmed and newly recorded species) is almost the same as the number of unconfirmed species (33 cleptoparasites). This ratio in host species is much broader, being in favour of the species recorded on the Steppe (146:84).

DISCUSSION

The survey performed on the Steppe in a period of 2010–2011 covered the entire period of bee activity. This was useful for the apidological survey at this site since spring and late summer seasons were not sufficiently investigated in the past, as pointed out by Přidal and Veselý (2010c). This was also confirmed by this survey in both spring seasons 2010 and 2011 where species such as *Andrena aberrans, A. florivaga, A. helvola, A. pilipes, A. vaga, Seladonia kessleri*, etc. were found for the first time although it is likely that they have been present on the Steppe for a long time but were not recorded by Šnoflák (1944).

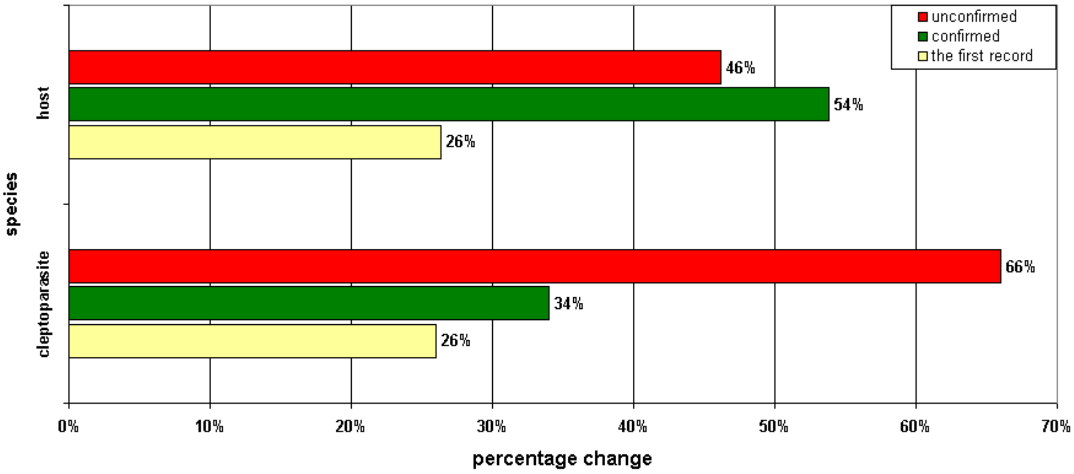
VIII: *Examples of steppe and ubiquitous related species with inverse dominance in Mohelno Serpentine Steppe*

Steppe species unusually highly dominant in the Steppe	Usually ubiquitous species with low density of its populations in the Steppe
Andrena tscheki *Andrena rugulosa* *Andrena florivaga*	*Andrena bicolor* *Andrena carantonica* *Andrena dorsata* *Andrena helvola* *Andrena minutula* *Andrena nitidiuscula* *Andrena varians* *Andrena wilkella*
Evylaeus tricinctus *Evylaeus minutulus*	*Evylaeus fulvicornis* *Evylaeus parvulus* *Evylaeus pauxillus* *Evylaeus villosulus*
Hylaeus lineolatus	*Hylaeus communis* *Hylaeus confusus* *Hylaeus gredleri* *Hylaeus sinuatus*
Megachile pilidens	*Megachile willughbiella* *Megachile centuncularis* *Megachile alpicola*
Heriades crenulatus	*Heriades truncorum*
Tergosmia tergestensis	*Hoplitis claviventris* *Hoplitis leucomelana* *Chelostoma florisomne* *Osmia aurulenta*

The total number of individuals investigated within the survey exceeded that of Šnoflák (1944) by 62 individuals; the investigated set of bees was therefore comparable as far as its size was concerned. Bee density determined by time-dependent sampling has not yet been reported. Since the newly determined density is the first measured particular at this site, it is not possible to compare it adequately. Šnoflák (1944) reported a total of 1824 individuals being observed within 18 days, i.e. he observed 101 bees every day on average. If he did sampling for only 5 hours of pure time, this would mean 20 pieces per hour. This is a very low number for the full summer season when he visited the Steppe, compared to our measured values of bee individuals per hour that varied in a range of 50–87 bees per hour in a comparable period of time. However, one has to take into account that Šnoflák (1944) worked selectively. On one hand, he excluded bumble bees from his monitoring and collected not only bees but also other Aculeata species. Nevertheless, the total number of bees in the Steppe is relatively very low. For example, *Dorycnium germanicum* is visited very rarely on the Steppe although on other steppe sites in southern Moravia it is visited much more. This fact already reported by Šnoflák (1944) was also confirmed by our observations. This phenomena typical of the Steppe was explained by Šnoflák (1944) with the fact that *D. germanicum* occurs on windy parts of the Steppe (on the plateau), therefore, a nectar could be dried. We can not confirm this explanation of the phenomena. The honey bees (*Apis mellifera*) were highly abundant on the clover *D. germanicum*, therefore, its atractivity was not affected probably due to low content or high concentrantion of nectar

IX: *Number of species cleptoparasitic and host bee species*

Species	The initial number of species	The first records	Confirmed	Uncorfirmed
Cleptoparasitic	50	13	17	33
Host	182	48	98	84



5: *Percentage of confirmed and unconfirmed of species cleptoparasitic and host bee species* collected by the honey bees. We propose following explanation: the xerothermophile communities on the Steppe are at the north-westernmost corner of their distribution before and under Českomoravská vrchovina Mts. and morevover, the Steppe is very small isolated area, therefore, the bee populations in the Steppe are much poorer than in southeastern habitats on south Moravia (Pádr, 1995) or Slovakia (Smetana *et al*., 2010) closer to the Pannonian territory. The same phenomena goes for *Sedum acre* on the Steppe.

In contrast to Šnoflák (1944) observations, we failed to confirm the originally high incidence of Aculeata in the inundation zone (particularly around the "paper-mill"). The current incidence of bees in this part of the investigated site is negligible, which is probably associated with a high degree of coverage with wood species and low exposure to sun.

Only 115 of the original bee species on the Steppe were confirmed (50 %). This is a relatively low portion which could indicate a negative effect of some factors which have operated on the Steppe over the past 40 years. The construction of a storage reservoir of water for nuclear power in Dukovany (i. s. near Mohelno) is one of the key factors (Veselý, 2002). The absence of previously recorded species is remarkable and cannot be compensated with firstly recorded species (61 first records + 115 confirmed species). In this connection, one also has to consider the fluctuation of populations (Begon *et al*., 1996). Currently, 55 % of unconfirmed species shows reduced populations at other sites of southern Moravia (for example *Hylaeus pictipes, Systropha planidens* or *Megabombus subterraneus*) and 45 % of species remains from unconfirmed species. This consideration has to take into account the fact that approximately 14 % of unconfirmed species can be found in future surveys, for example when other sampling methods are used (for example traps). For respective 45 % of species, the stability of populations remains unchanged according to our observation, even in other biotopes located in southern Moravia and their disappearance from the Steppe may be associated with the above-mentioned changes. However, their absence on the Steppe has not the same significance. It is expected in 28 % of species that their disappearance is not permanent and/or they will be found in future surveys by differents methods. However, it is assumed for 17 % of species that their reduction is irreversible. This group of 20 bee species (for example *Megachile, octosignata, Panurginus labiatus, Eucera seminuda* etc.) has been displaced from the Steppe probably due to an increasing degree of coverage with woody plants over the past 40 years.

The number of unconfirmed bee species is partially compensated by the presence of some species that are very sensitive to the site's conditions and that survived unfavourable conditions for bees on the Steppe. Such species particularly include *Andrena combinata* (the species sensitive to the site's overgrowing habitats; Westrich, 1990; Ember, 1996), *Evylaeus interruptus, Hoplitis mitis, Halictus compressus, H. quadricinctus, Seladonia leucahenea*, etc. Similarly, the first records of a number of species, some of them being very rare steppe specialists, confirm that specific conditions on the Steppe did not completely disappear in spite of irreversible changes. This particularly applies to *Andrena aberrans, Ceratina cucurbitina, Colletes graeffei, Dioxys tridentata, Seladonia kessleri, Tergosmia tergestensis*, etc. Some of the first records were realized due to the previous lower frequency of research in the spring season (Přidal & Veselý, 2010c). It should also be pointed out that some of the first records resulted from changes in taxonomy proceeding since 1944 (Přidal & Veselý, 2010a) and that former taxonomy did not distinguish some species, considering them as synonyms (for example *Hylaeus gredleri* was not distinguished from *Hylaeus brevicornis*).

The first records of some species can be considered as the indication of starting ruderalization of habitats on the territory of the Steppe. Species that belong to Group a2) according to their density and that represent a first recorded species in the Steppe (see Tab. VII in 2nd column with sign "+"), can be considered species newly colonizing habitats in the Steppe. Šnoflák (1944) did not certainly record these species although they are ubiquitous. For example, they include *Andrena flavipes* and its cleptoparasite *Nomada succincta* with high dominance and group dominance. However, *Andrena gravida* that is active in the same season was recorded by Šnoflák (1944). In addition, *A. flavipes* as a bivoltine species could have been recorded in summer observations by Šnoflák (1944), but it did not happen. Other representatives include *Bombus lucorum* or *Megabombus hortorum* etc.

In contrast, it is seen that some steppe specialists keep a strong degree of dominance on the Steppe whereas their closely related ubiquitous species show relatively very low populations (for example *Hylaeus lineolatus* versus *Hylaeus annularis* or *H. confusus*). Some nearly ubiquitous species were not found on the Steppe at all, for example by Šnoflák (1944) for the following species: *Osmia cornuta, Neosmia bicolor, Megachile versicolor, Andrena minutuloides, Panurgus calcaratus, Eucera nigrescens, Psithyrus campestris,* and from the species that have not been found on the Steppe, for example: *Nomada fabriciana*. Both these phenomena confirm the exceptionality of habitat conditions on the Steppe where ubiquitous species are not able to adapt to very specific habitat conditions of the Steppe and their populations show a low density. This is also why we think that an increase in formerly absent ubiquitous species indicates the beginning of ruderalization of the Steppe, reducing its natural value.

Šnoflák (1944) reported *Hylaeus gredleri* D = 9.21 % (= *Prosopis brevicornis*, see Přidal & Veselý, 2010a) as the most abundant species in the Steppe in the summer season. However, we failed to confirm his finding since this relatively common species occurred in the Steppe subrecedently (D = 0.15 %). In our observations, *Pyrobombus lapidarius* was the most abundant species, which is in conflict with findings made by Šnoflák (1944) who reported this species in recedent dominance (D = 1.10 %). This can be due to the fact that Šnoflák (1944) in his research did not pay enough attention to bumble bees, as he mentioned in the conclusion of his paper. Group dominance was partially confirmed for *Evylaeus morio*, as reported by Banaszak *et al.* (2006) in xerothermophile habitats in the valley downstream the river Vistula in Poland. The authors reported a relatively low abundance of bumble bees (Bombini) whereas *Pyrobombus lapidarius* was the most abundant species according to group dominance which is in a good agreement with our observations. In their view, the riverine habitats are natural migration pathways for spreading all xerothermophile insect species since biotopes suitable for nesting formed along them in the past due to river activities. This hypothesis is also supported by Klemm (1996) on the basis of his results from the downstream region of the river Rhine. The Steppe is characterized by the distinct altitude and the presence of specific habitats in its surroundings that resemble hilly regions. In spite of this, the Steppe presents species typical of lowland regions and specialized xerothermophile communities.

Přidal and Veselý (2010c) used quantitative data obtained by Šnoflák (1944) to calculate the Shannon index of diversity (H’ = 4.39) and equitability (E = 0.81). We completed this set of data by calculating the Simpson’s index of dominance, c = 0.025, for comparison. It follows from the data in Tab. V that the values reported by Šnoflák (1944) show a very high degree of diversity of the biotope of the Steppe until 1943, with a remarkable balance of apidofauna communities. However, it should be pointed out that the findings reported by Šnoflák (1944) come from non-systematic sampling without any details about methodology and from the periods of time when the inundation zone was very rich in bee forage (unlike the current state) and most steppe insect species (up to 80 %) were concentrated there (Šnoflák, 1944). This remark is important because random sampling of distinct species may artificially increase the Shannon index. The comparison of values of ecological indices from our surveys with those reported by other authors shows that in spite of their relative decrease their value still remains high. For example, Banaszak (1983) has reported the following data for xerothermic grass communities in Poland: H´ = 2.69, E = 0.64 and S = 65 (the number of species). Similar values were found for the xerothermic site Zahrady pod Hájem (National Nature Reserve) in the region of the Bílé Karpaty, Mts., Nature Reserve (Přidal, 1999 – unpublished results) H´ = 2.89, E = 0.77 and S = 45. Banaszak *et al.* (2006) have reported ecological indices for selected sites downstream the river Vistula, varying in the following ranges: H’ 2.16–3.34, E = 0.58–0.78 and S = 20–78. These values are lower than those found in the Steppe, however, these habitats are in downstream the river Vistula in Poland approximately 500 km more northward from the Steppe. Therefore, in comparison with similar habitats in Poland, these values are high.

In comparison with the published data, the list of species recorded in the Steppe now includes a 27 % increase in the bee population (Šnoflák, 1944; Tkalců, 1964; Straka *et al.*, 2007). Generally, a total of 293 bee species are currently reported to occur in the Steppe, which constitutes 52 % of species reported in Moravia (Straka *et al.*, 2007). For two of these species (*Andrena rugulosa* and *Nomada melanopyga*), the Steppe is the only one known site of their occurrence in the Czech Republic. One species (*Megachile nigriventris*) has the second known site in the Steppe in Moravia. Similarly, the Steppe is the only known place of occurrence in the Czech Republic for some species of flies (Diptera: Brachycera) (Rozkošný & Vaňhara, 1997). The exceptionality of this site and very specific ecological conditions of the Steppe are also documented by the occurrence of a larger population of ubiquitous species (49) that showed a subrecedent or rare occurrence in the Steppe (Tab. VII). In some cases, reversed dominance was found in 9 rare steppe species that formed abnormally large communities. Although the number of species from the Steppe has declined significantly, it is obvious that specific ecological conditions in the Steppe have partially persisted.

This is also confirmed by Buchar (1997) who reported that the species abundance of arachnofauna (Araneae) in a period of 1993–1993 is still high and includes a large number of first-order relicts for preserved sites. He claims that although these relict species have decreased over the past 40 years, they still persist and new species have occurred. The portion of unconfirmed species of spiders is very similar to that of unconfirmed bee species, i.e. 52 %. However, the number of the newly found species of spiders was significantly lower (only 9 % as compared to 26 % of bee species). Our findings are in a good agreement with his conclusion that without the detailed knowledge of the dynamics in the development of the microclimate in the Steppe one cannot explain the reasons of a significant decline in the populations of spiders (in our case bees). On the basis of the analysis of obtained data, Buchar (1997) has found that the arachnofauna of the Steppe has less species of the Pannonian region which have the northern boundary of occurrence in the Steppe, which – in case of apidofauna – applies only to a very few species (*Chelostoma ventrale, Osmia melanogaster, Dioxys cincta, Seladonia smaragdula, Evyleus setulosus, Nomada furvoides* a *Eucera seminuda*). The myrmecofauna of the Steppe has also changed over the past 60 years. Bezděčka (1993) pointed out that variation in the composition of ant species (not only a decline in the most sensitive species) clearly indicate adverse changes in the environment that occurred in the Steppe in the past.

Some species which we have recorded in the Steppe for the first time are among those that are currently spreading in Central Europe and have already colonized the Steppe. For example, this concerns *Ceratina nigrolabiata* whose prevalence was reported in 1999 (Schwarz *et al.*, 1999) and subsequently confirmed by Zettel *et al.* (2002). In the Czech Republic, its prevalence was first documented by Straka *et al.* (2007). Another representative in this group – *Megachile pilicrus* – was found in Moravia in 2002 (Straka *et al.*, 2004) and we also confirmed its occurrence in the Steppe which has been the northernmost record of this species in Moravia so far. Its prevalence in Austria is mentioned by Zettel *et al.* (2002) and Pachinger (2003). *Andrena fulva* was firstly reported by Kocourek (1966) in the Czech Republic as an Atlantic species that spread in Bohemia. The first findings in Moravia were reported by Pádr (1995) and Přidal (1998). Obviously, *A. fulva* is expanding in Europe as reported by Banaszak *et al.* (2006). Gradual recent findings of *Chelostoma emarginatum* and *Megachile nigriventris* on sites where they did not occur in the past (Přidal, 1998; Dvořák *et al.*, 2007; Straka *et al.*, 2007) may indicate an expanding character of spreading similar to that reported for the three previous species, although this has not yet been confirmed by literature data and the prevalence has not yet been completely elucidated, as reported by Ebmer (1997) for other Megachilidae species. Such species that spread generally cannot be investigated as potentially indicating species because they spread in southern Moravia and in some other sites. This is why they cannot be compared with the first record, for example *Ceratina cucurbitina*, that only occurs at the warmest sites in the Czech Republic (Moravia) and its finding in the Steppe is therefore very important from an indication point of view.

However, this group does not include a very significant finding of *Colletes graeffei* that was not detected by previous researchers in their sampling although it was very likely to occur here since the occurrence of its nutrient plant *Allium flavum* in the Steppe has long been known. *C. graeffei* has its north-westernmost boundary of occurrence in the Steppe (Schmid-Egger & Kuhlmann, 2008) and its finding is therefore significant not only in terms of the indication of site conditions in the Steppe but also for gaining deeper insight into the distribution of this species. The same applies to *Andrena aberrans,* monolectic to *Chamaecytisus ratisbonensis* in the Steppe. The first records of species such as *Andrena pilipes*¸ *A. potentillae, A. susterai, Evylaeus minutulus, Sphecodes reticulatus* (this cleptoparasite indirectly confirms the occurrence of the unconfirmed host *Andrena barbilabris*), *Nomada noskiewiczi, Pyrobombus soroeensis,* etc. remain rather uncertain, without any possibility of finding wider connections with the occurrence of this species.

A major reduction in cleptoparasites (Tab. IX, Fig. 5) may indicate the lower stability of host populations, even if one takes into account the fact that these species are difficult to monitor and that the numbers of respective monitored individuals are rather random, except for some cases and only in a very few individuals. However, this still indicates changes in site conditions which have occurred over the last few decades in the Steppe and – to some extent – resembles changes in the composition of arachnofauna in the Steppe that occurred in the same period of time (Buchar, 1997). On the other hand, some steppe species (specialists) had abnormally high densities whereas ubiquitous species showed low densities with typically very abundant populations. This indicates that specific conditions at the Steppe did not disappear completely and still persist for some species.

Former extreme xerothermophile conditions on the Steppe can be documented by the finding of a female of *Andrena tscheki* in September, as reported by Šnoflák (1944). This univoltine species is active in April to May (Kocourek, 1966; Westrich, 1990). Some species of the genus *Andrena* spp. are known to have two generations per year in the Mediterranean whereas in Central Europe they have only one generation. Since individual flowers of *Allysum montanum* were found on the slopes and rocky parts of the Steppe (particularly at the transition between the pasture land and amphitheatre, Tab. II) in late summer, it is assumed on the basis of this finding and its connection with the finding made by Šnoflák (1944) that there were extreme temperatures on the Steppe, enabling some part of the *A. tscheki* population to raise the second (summer) generation in late summer.

In order to maintain the high diversity of xerothermophile communities, we recommend a systematic reduction in the coverage with woody plants not only on the slopes of the amphitheatre but also on the adjacent marginal parts ("Výhon" and "Askalafův vrch") in the Steppe. Major reduction in coverage with woody plants is a key factor to ensure adequate nutrition not only for bees but also for other species, followed by applying pasture in the entire inundation zone ("Čertův ocas") (detailed recommendations for the management is provided in a paper by Přidal and Veselý, 2010d). This is the only way to revitalize the site conditions that were in the Steppe in a period of 1930–1940 (Veselý, 2002). A pine tree is a climax on the Steppe (Fig. 2). Xerothermophile bee species, including their forage plants were completely displaced from areas where it was formed.

CONCLUSIONS

The diversity of apidofauna in the Mohelno Serpentine Steppe (Mohelenská hadcová step) has significantly decreased over the past 70 years. A group of unconfirmed species particularly consisted of cleptoparasites and rare xerothermophile species. Recorded bee species also included rare xerothermophile species.

The density of the bee populations in the Mohelno Serpentine Steppe has been estimated at the same level approximately over the past 70 years, being comparatively lower than that in other xerothermophile habitats located in more southern Moravia.

It is very likely that the diversity of bees decreased due to changes in site conditions in the Mohelno Serpentine Steppe. Major changes have taken place here over the past 40 years, being manifested by a significant increase in a degree of coverage with woody plants and being associated with other changes in site conditions of the Steppe.

In order to maintain favourable site conditions for precious xerothermophile communities, it is essential to affect the composition of species in the grass cover by grazing in the inundation zone of the river Jihlava and reduce radically the plant stand of woody species on both rock slopes of the amphitheatre and adjacent parts on the "Askalafův vrch" and "Výhon".

SUMMARY

The main objective of this work was to summarize the results of the apidological survey performed in the national nature reserve Mohelno Serpentine Steppe (Mohelenská hadcová step) in a period of 2010–2011, characterize current changes in the composition of bee populations and propose recommendations for the management of this nature reserve.

The survey was performed within 20 days and includes a total of 91 hours of observations in the field with exact records of survey localization and weather. A total of 2,705 bee individuals were caught using an insect net and examined. 71 to 276 bee individuals were identified on individual days of monitoring. The bee density varied in a range of 18.4–87.1 bees per hour of the pure time of sampling. A total of 176 bee species were identified. 115 bee species from the original list of 232 bee species were confirmed by this survey (50 %). Species that were not confirmed could disappear as a result of changes which have occurred in the Steppe biotope over the past 40 years or their disappearance is generally associated with changes in the population of a particular species in Moravia. The disappearance of 17 % of unconfirmed species (20 species) from the Steppe is very likely to occur but it is not associated with general changes in the population of these species in southern Moravia. 61 out of 176 bee species were recorded in the Steppe for the first time. *Pyrobombus lapidarius* was eudominant. The highest dominance was observed for *Halictus simplex* as a representative of the solitary species and for *Nomada succincta* as a representative of cleptoparasites. However, the major part of cleptoparasites (66 %) was not confirmed. The Shannon's index (H' = 3.97), Equitability (e = 0.77) and the Simpson's index (c = 0.04) were determined for bee populations. The following species occurred on the Steppe: a) ubiquitous species with an abnormally small population (49 species) and b) steppe specialists (xerothermophile) with abnormally abundant populations and strongly competitive to ubiquitous species (9 species). The survey revealed a significant decrease in the diversity of apidofauna on the Steppe, showing that the degradation change took place only partially and that some rare xerothermophile species on the Steppe were preserved. The composition of apidofauna still maintains its predominant xerothermophile character. The results of the survey were used to propose recommendations for managing the maintenance of the national nature reserve Mohelno Serpentine Steppe (NPR Mohelenská hadcová step).

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