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ORIGINAL ARTICLE

Coprophagous beetle community (Coleoptera: Scarabaeidae, Geotrupidae, Hydrophilidae) in two cattle pastures in South Bohemia

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Abstract
Simultaneous monitoring of coprophagous beetles was carried out using baited pitfall traps in mountain pastures at Jenín and Pasečná in the southern part of the Czech Republic. In total, 5,787 specimens of 31 species were collected in six one-week sampling trials carried out during 2011–2013. Little difference was found between the pastures in the total abundance of the collected material (8%) and in the diversity (Shannon's index of diversity, Z = 1.78, P = 0.07). Considerable differences were found in the abundance of several species: *Aphodius sphacelatus* (Panzer 1798) and *Aphodius erraticus* (Linnaeus 1758) were more abundant at Jenín (by 85 and 98%, respectively), while *Onthophagus fracticornis* (Preyssler 1790), Anoplotrupes stercorosus (Hartmann in L. G. Scriba 1791), *Geotrupes stercorarius* (Linnaeus, 1758), and *Aphodius depressus* (Kugelann 1792) were more abundant at Pasečná (by 89%, 95% 100% and 100%, respectively). Due to their tunnelling breeding activity in soil beneath animal droppings, *O. fracticornis* and *G. stercorarius* may provide valuable ecosystem services in Pasečná pasture, mainly bioturbation and soil fertilisation.

Key words: dung decomposition; bioturbation; dung beetle; *Aphodius*; *Onthophagus*; *Geotrupes*

INTRODUCTION

The coprophagous beetles contribute to dung decomposition, nutrient cycling and bioturbation in pastures (Hanski and Cambefort 1991, Gittings et al. 1994). This reflects in ecosystem services: waste removal, pasture sward renovation, soil fertilisation, and plant productivity (Bang et al. 2005, Nichols et al. 2008). The role of the coprophagous beetle community in the functioning of the pasture ecosystem depends on its functional structure and population density, although most of the relevant information derives from experiments under laboratory conditions and more research *in situ* is needed (Nichols et al. 2008).

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In the Czech Republic, the composition and the functional meaning of coprophagous beetles has little been studied. Three studies based on dung-baited pitfall trapping (Křivan 2000, Šlachta et al. 2009) or artificially dropped dung pats (Sladecek et al. 2013) were carried out in South Bohemia. During the last two decades, the grazing of beef cattle has become more frequent there, as well as in other sub-mountain areas of the country, and a substantial area of arable land has been transformed to pastures. This process has been supported by the government and by the financial assistance of the EU aimed at sustainable agricultural practices, preferentially on permanent grasslands. However, intensive grazing leading to soil compaction may also lead to a deterioration in the ecological functions of grasslands (Pietola et al. 2005, Marshall et al. 2009). Tunnelling dung beetles are generally assumed to increase soil aeration and porosity in the upper soil layers (Nichols et al. 2008), but only a single study has assessed these effects empirically (Bang et al. 2005).

The aim of this study was to examine the composition and structure of the coprophagous beetle community in two cattle pastures so as to infer its potential consequences in ecosystem functioning. The study was focused on members of the Scarabaeidae, Geotrupidae and Hydrophilidae families, which comprise the majority of coprophagous beetles in temperate pastures (Hanski and Cambefort 1991).

MATERIALS AND METHODS

Study sites

Two pastures in South Bohemia 20 km apart were examined. One of these pastures – near the village of Jenín – was established in 2001 by the sowing of arable land utilised for decades for field production (silage maize, flax). Although grazing of sheep was common in the area until the 1950's, the only place where pasture persisted without break was close to the village of Rybník (3 km from Jenín), where about 70 dairy cows were bred and seasonally grazed. Recently, about 370 cows and 200 calves of beef cattle were grazed at Jenín in a total pasture area of 249 ha. The herd is divided into four sub-herds and grazed continuously from April to October, when it is transported for wintering away from the locality.

The second pasture examined was located near the village of Pasečná. The pasture was established in 1993 by the sowing of former arable land. No grazing has been carried out there since the 1950's. During the experimental period, about 140 cows and 40 calves of beef cattle were grazed at Pasečná in a total pasture area of 201 ha. The grazing runs from May to October; the wintering sites are in Pasečná near the pastures. The site examined was grazed by approx. 46 cows and 16 calves. More information on the localities is given in Table 1.

Table 1. Scheme of sampling trials, dates of traps exposition, sampling sites, and the number of traps (in parentheses). GPS data and altitudes refer to J1 and P1 sampling sites.

Sampling trial	Date of traps exposition	Site (number of traps)	
		Jenín	*Pasečná*
VI 2011	2 June 2011	J1 (3)	P1 (3)
VIII 2011	3 August 2011	J1 (2)	P1 (3)
IV 2012	11 April 2012	J1 (3)	P1 (3)
V 2012	8 May 2012	J1 (3)	P1 (3)
V 2013	17 May 2013	J1 (3), J2 (1), J3 (1)	P1 (3)
VII 2013	24 July 2013	J1 (3), J3 (1)	P1 (3), P2 (1)
GPS		48°38´31.579´´ N 14°24´3.200´´ E	48°35´58.118´´N 14°7´15.644´´ E
Altitude (m a. s. l.)		675	785
Mean annual temperature (°C)		6.5	5.5
Mean annual rainfall (mm)		650–800	900–950

Sampling and analysis

At each locality, one sampling site was selected (designated J1 and P1) with six sampling trials carried out from 2011 to 2013 (Table 1). In 2013, other sites were also monitored to get more information on the spatial variability of the beetle community within the pasture area. These sites are designated J2 (50 m from J1), J3 (500 m from J1), and P2 (1,400 m from P1). Dung-baited traps exposed for a one-week period were used according to the methodology of Šlachta et al. (2009). The traps were placed in both the localities in the morning hours of the same day (with a one-hour delay at Pasečná as compared to Jenín). The fresh dung of dairy cattle was used as the bait. It was collected in the barns in Rychnov (7 km from Jenín) on the day of the trap exposition and homogenised before its application. A triplet of traps was used in each of the sampling trials J1 and P1, while a single trap was used in J2, J3 and P2 sites (Table 1). In August 2011, cows destroyed one trap at J1. Formaldehyde (5% solution) was used as a preserving fluid in traps and the material collected was floated by hand. The material from three traps in a single sampling trial was pooled together. The species of the material was identified by the author according to Tesař (1957), Hansen (1987) and Vorst (2009). The higher classification and nomenclature follows Löbl and Smetana (2004, 2006), Boukal et al. (2007) and Juřena and Týr (2008).

The composition and structure of the communities were analysed for each locality separately and included also J2, J3 and P2 samples. Data from J1 and P1 were relevant for abundance and diversity comparisons between the localities, but mean abundances per trap in each sampling trial were also used in order to include J2, J3 and P2 data in comparisons. The sum of species abundances (or sum of mean abundances per trap) from all six sampling trials were used for abundance comparisons. Shannon's index of diversity (H') was calculated for each sampling trial at J1 and P1 sites (Magurran 1988). A statistical evaluation of differences in diversity at J1 and P1 sites was carried out by non-parametric Wilcoxon pair test using the software STATISTICA CZ (StatSoft, Inc. 2011). Potential consequences in the functioning of particular species were inferred from their abundances in samples and on the basis of literature data on their bionomy and functional meaning in pastures.

RESULTS

In total, 5,787 specimens of 31 species were collected (Table 2). Sixteen species appertained to Hydrophilidae, 12 species to Scarabaeidae, and 3 species to Geotrupidae. Twenty-seven species were recorded at Jenín and 29 species at Pasečná. The majority of species (25) was found at both the localities. The diversity did not differ significantly between J1 and P1 sites ($Z = 1.78$, $P = 0.07$), but there was a tendency to higher values of the diversity index at Pasečná in May 2013, June 2011 and July 2013 (Fig. 1). *Sphaeridium lunatum* Fabricius, 1792 was the most dominant species at both localities forming 32.1% and 33% (981 and 903 specimens) of total numbers in samples at Jenín and Pasečná, respectively (Tables 3, 4). The other dominant species was *Aphodius sphacelatus* (Panzer 1798) with 27.9 % at Jenín, and *Cercyon impressus* (Sturm 1807) with 12.2% at Pasečná. Other species were abundant in samples from both the localities: *Aphodius prodromus* (Brahm 1790) with 5.8% and 6.8%, *Cercyon lateralis* (Marsham 1802) with 5.3% and 7.6%, *Cercyon castaneipennis* (Vorst 2009) with 5% and 4.4%, or *Aphodius rufipes* (Linnaeus 1758) with 4.7% and 8.4% (of total numbers, at Jenín and Pasečná, respectively). While the dominant hydrophilid species of *Sphaeridium* sp. and *Cercyon* sp. occurred frequently in all sampling trials, except for April 2012, the other species were more restricted to a certain seasonal period, e.g. *Aphodius prodromus* (Brahm 1790) and *A. sphacelatus* to the spring period, whereas *A. rufipes* and *Aphodius rufus* (Moll 1782) to the summer period.

Table 2. List of collected species, their affiliation to families and numbers of collected specimens (N) at Jenín (J) and Pasečná (P)

Species	Family	J + P		J	P
		N	%	*N*	*N*
S. lunatum (Fabricius 1792)	H	1,884	32.6	981	903
A. sphacelatus (Panzer 1798)	S	913	15.8	851	62
C. impressus (Sturm 1807)	H	439	7.6	105	334
A. rufipes (Linnaeus 1758)	S	372	6.4	143	229
C. lateralis (Marsham 1802)	H	369	6.4	162	207
A. prodromus (Brahm 1790)	S	363	6.3	178	185
C. castaneipennis (Vorst 2009)	H	273	4.7	153	120
S. scarabaeoides (Linnaeus 1758)	H	197	3.4	95	102
A. ater (De Geer 1774)	S	123	2.1	60	63
A. erraticus (Linnaeus 1758)	S	118	2.0	117	1
Cr. minutum (Fabricius 1775)	H	118	2.0	41	77
A. fimetarius (Linnaeus 1758)	S	116	2.0	29	87
O. fracticornis (Preyssler 1790)	S	94	1.6	5	89
An. stercorosus (Hartmann in L. G. Scriba 1791)	G	81	1.4	1	80
A. fossor (Linnaeus 1758)	S	58	1.0	34	24
A. rufus (Moll 1782)	S	43	0.7	11	32
A. depressus (Kugelann 1792)	H	40	0.7	0	40
C. melanocephalus (Linnaeus 1758)	H	39	0.7	24	15
A. haemorrhoidalis (Linnaeus 1758)	S	35	0.6	15	20
S. bipustulatum (Fabricius 1781)	H	31	0.5	14	17
G. stercorarius (Linnaeus 1758)	G	24	0.4	0	24
C. pygmaeus (Illiger 1801)	H	15	0.3	9	6
A. pusillus (Herbst 1789)	S	9	0.2	7	2
A. luridus (Fabricius 1775)	S	8	0.1	7	1
C. haemorrhoidalis (Fabricius 1775)	H	8	0.1	2	6
S. marginatum (Fabricius 1787)	H	7	0.1	3	4
Cr. crenatum (Panzer 1794)	H	4	0.1	4	0
C. unipunctatus (Linnaeus 1758)	H	2	>0.1	1	1
M. concinnum (Marsham 1802)	H	2	>0.1	0	2
C. quisquilius (Linnaeus 1761)	H	1	>0.1	1	0
T. vernalis (Linnaeus 1758)	G	1	>0.1	0	1
Total N		5,787	100	3,053	2,734
Number of species		31		27	29

Abbreviations of genera: A – *Aphodius*; S – *Sphaeridium*; O – *Onthophagus*; C – *Cercyon*; Cr – *Cryptopleurum*; G – *Geotrupes*; An – *Anoplotrupes*; T – *Trypocopris*; M – *Megasternum*; abbreviations of families: S – Scarabaeidae; H – Hydrophilidae; G – Geotrupidae

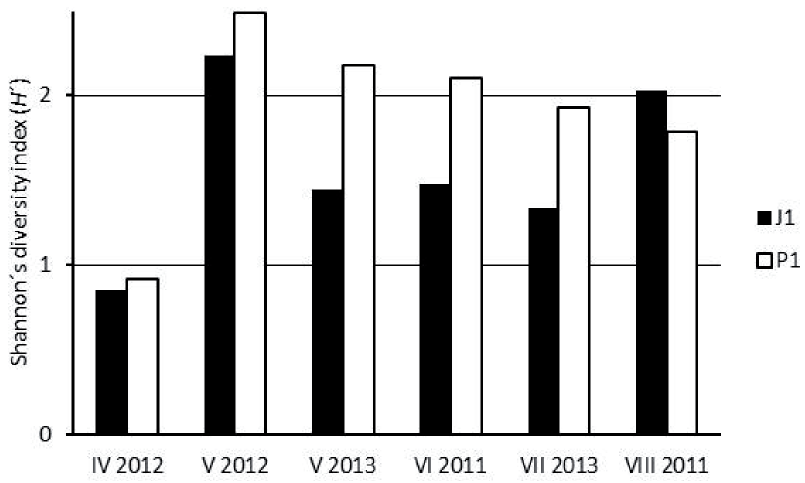

Fig. 1. Value of Shannon's diversity index in sampling trials (ordered according to calendar months) at Jenín (J1 site) and Pasečná (P1 site)

Similar total abundances were found in samples from both the localities: 2,698 and 2,314 specimens at J1 and P1, respectively (Table 5). The sum of mean abundances per trap, including the J2, J3 and P2 samples, was 860 and 801 specimens, at Jenín and Pasečná, respectively. However, substantial differences were found in the abundance of several species. Among the most dominant species, mainly *A. sphacelatus*, which was by 85%, resp. 86% more abundant at Jenín, and *C. impressus*, which was by 53%, resp. 34% more abundant at Pasečná. Among the less dominant species, the highest differences were found in *Aphodius erraticus* (Linnaeus 1758) (by 98% more abundant at Jenín), *Onthophagus fracticornis* (Preyssler 1790) (by 89% more at Pasečná), *Aphodius fimetarius* (Linnaeus 1758) (by 50%, resp. 49% more at Pasečná), or *A. rufus* (by 48% resp. 42% more at Pasečná). *Aphodius depressus* (Kugelann 1792) and *Geotrupes stercorarius* (Linnaeus 1758) were not recorded at Jenín at all, while at Pasečná they were collected in 40 and 24 specimens, respectively (Tables 2, 4). *Anoplotrupes stercorosus* (Hartmann in L. G. Scriba 1791) was recorded in a single specimen at Jenín (at J2), compared to 80 specimens at Pasečná (mostly at P1; Tables 3, 4).

DISCUSSION

Although well suited for comparisons between the two beetle communities at the time of examination, the experimental design allowed neither the spatial (inside-pasture) nor the long-term temporal variability evaluation of populations. The results should thus be treated with caution. Still, 31 species recorded by 6 sampling trials corresponded well to 39 species recorded by much more sampling effort (24 trials) in a former study at Rychnov (Šlachta et al. 2009), suggesting that satisfactory overview of local communities was obtained at Jenín and Pasečná.

Relatively small differences in the species composition, diversity and total abundances in samples were found between the localities. Substantial differences were revealed in the abundance of several species, however. In the dung dwellers' functional group, it referred mainly to *A. sphacelatus* and *A. erraticus*, which were by 85% and 98% more abundant at Jenín, respectively. Adults of *A. sphacelatus* attack cattle dung in high numbers early in spring, but their phytophagous larvae develop outside the dung (Gitting and Gilller 1997). *Aphodius erraticus* larvae are coprophagous and can feed on dung fragments transported by parents several centimetres deep in the soil, which is unusual behaviour in Aphodiinae (Vitner 1998). The impact of Aphodiinae on the dung decomposition depends on their size and their density in droppings. It varies from generally low (Rosenlew and Roslin 2008) to relatively high, when an accumulation of large species takes place in the droppings, as in the case of *A. rufipes* (Holter 1979a, b). Among the hydrophilid dung dwellers, the greatest contribution in dung decomposition may be expected by the largest species *S. lunatum*, which was dominant in both the localities. The larvae are predatory (Sowig 1997), but the adults dig tunnels in dung and thus leave openings in the upper crust of dung pats which facilitates access to other decompositors and to the weathering processes.

Table 3. Distribution of species records in sampling trials at Jenín (ordered according to calendar months) and species relative contribution to total abundance in samples

Sampling trial	**IV 2012**	**V 2012**		**V 2013**		**VI 2011**	**VII 2013**		**VIII 2011**	**% of total**
Site at Jenín	***J1***	***J1***	***J1***	***J2***	***J3***	***J1***	***J1***	***J3***	***J1***	
Number of traps	***3***	***3***	***3***	***1***	***1***	***3***	***3***	***1***	***2***	
S. lunatum	1	0	131	58	20	34	646	59	32	32.1
A. sphacelatus	717	13	56	59	6	0	0	0	0	27.9
A. prodromus	160	2	8	7	1	0	0	0	0	5.8
C. lateralis	0	37	6	43	1	3	40	7	25	5.3
C. castaneipennis	0	23	27	25	3	16	52	3	4	5.0
A. rufipes	0	0	0	0	0	0	80	15	48	4.7
A. erraticus	0	29	3	0	0	67	10	4	4	3.8
C. impressus	1	48	3	9	0	3	13	1	27	3.4
S. scarabaeoides	5	3	8	1	1	4	57	4	12	3.1
A. ater	49	1	6	2	1	0	1	0	0	2.0
Cr. minutum	0	4	0	5	0	1	15	1	15	1.3
A. fossor	0	28	0	2	0	0	0	4	0	1.1
A. fimetarius	10	9	1	1	0	0	7	0	1	0.9
C. melanocephalus	14	0	0	1	0	2	1	1	5	0.8
A. haemorrhoidalis	0	0	0	0	0	0	9	4	2	0.5
S. bipustulatum	0	6	0	0	0	0	8	0	0	0.5
A. rufus	0	0	0	0	0	0	11	0	0	0.4
C. pygmaeus	0	6	0	2	0	0	0	0	1	0.3
A. luridus	5	0	0	1	0	1	0	0	0	0.2
A. pusillus	0	6	0	0	0	0	1	0	0	0.2
O. fracticornis	1	1	0	0	0	3	0	0	0	0.2
Cr. crenatum	0	0	0	0	0	0	3	1	0	0.1
S. marginatum	0	0	0	0	0	0	2	0	1	0.1
C. haemorrhoidalis	0	0	0	0	1	1	0	0	0	0.1
C. quisquilius	0	0	0	0	0	0	1	0	0	>0.1
C. unipunctatus	0	0	0	0	0	0	1	0	0	>0.1
An. stercorosus	0	0	0	1	0	0	0	0	0	>0.1
Total N	963	216	249	217	34	135	958	104	177	100

Table 4. Distribution of species records in sampling trials at Pasečná (ordered according to calendar months) and species relative contribution to total abundance in samples

Sampling date	IV 2012	V 2012	V 2013	VI 2011	VII 2013		VIII 2011	% of total
Site at Pasečná	*P1*	*P1*	*P1*	*P1*	*P1*	*P2*	*P1*	
Number of traps	*3*	*3*	*3*	*3*	*3*	*1*	*3*	
S. lunatum	0	117	82	29	438	225	12	33.0
C. impressus	0	35	17	2	226	25	29	12.2
A. rufipes	0	0	0	2	136	31	60	8.4
C. lateralis	0	29	42	15	65	38	18	7.6
A. prodromus	157	17	9	2	0	0	0	6.8
C. castaneipennis	0	13	15	16	33	42	1	4.4
S. scarabaeoides	0	9	2	2	70	15	4	3.7
O. fracticornis	0	48	26	12	0	0	3	3.3
A. fimetarius	6	53	14	3	7	4	0	3.2
An. stercorosus	0	11	31	2	34	2	0	2.9
Cr. minutum	0	11	3	3	24	30	6	2.8
A. ater	4	21	3	0	34	1	0	2.3
A. sphacelatus	58	1	3	0	0	0	0	2.3
A. depressus	0	30	8	0	2	0	0	1.5
A. rufus	0	0	0	2	11	1	18	1.2
A. fossor	0	21	1	0	2	0	0	0.9
G. stercorarius	0	21	2	0	0	0	1	0.9
A. haemorrhoidalis	0	0	1	0	19	0	0	0.7
S. bipustulatum	0	16	0	0	1	0	0	0.6
C. melanocephalus	6	1	0	0	2	5	1	0.5
C. haemorrhoidalis	1	1	0	4	0	0	0	0.2
C. pygmaeus	0	3	0	0	2	1	0	0.2
S. marginatum	0	0	0	0	4	0	0	0.1
A. pusillus	0	0	1	0	1	0	0	0.1
M. concinnum	0	1	0	0	1	0	0	0.1
A. erraticus	0	0	1	0	0	0	0	>0.1
A. luridus	1	0	0	0	0	0	0	>0.1
C. unipunctatus	0	0	0	1	0	0	0	>0.1
T. vernalis	0	0	0	0	1	0	0	>0.1
Total N	233	459	261	95	1,113	420	153	100

More impacts on ecosystem functioning may however be assumed by the tunnellers (Hanski and Cambefort 1991, Nichols et al. 2008). This functional group comprises species of Scarabaeinae and Geotrupidae, adults of which construct their underground nests, to which they transport fragments of dung as a food supply for larvae. All four species of tunnellers recorded at Pasečná were less abundant or missing in samples from Jenín. Concerning the larger, geotrupid tunnellers, *G. stercorarius* and *T. vernalis*, were not recorded at Jenín at all, and *A. stercorosus* was recorded in a single specimen, compared to 80 specimens at Pasečná. *Anoplotrupes stercorosus* is a forest species (Kühne 1995) and its low abundance in Jenín samples probably resulted from longer distance from forest habitats, i.e. about 800 meters at Jenín (J1) vs. 60 meters at Pasečná (P1). Contrary to *A. stercorosus* (and *T. vernalis*), *G. stercorarius* is the pasture specialist (Kühne 1995). In May 2012, when 21 specimens of this species were recorded at Pasečná, warm and sunny weather was favourable to the flight of beetles in both localities. Immediately after their exposition, the baits attracted more *Aphodius* species and flies, but also three specimens of *G. stercorarius* at Pasečná. The grazing had not started yet in any of the examined sites, which made the sampling very effective due to leakage of other food sources in the surroundings. Still no *G. stercorarius* was attracted to traps at Jenín.

Table 5. Relative (%) differences (Diff.) in species abundance between Jenín and Pasečná localities (J1, 2, 3 – sampling sites at Jenín, P1, 2 – sampling sites at Pasečná, N – number of collected specimens)

	J1 + P1		J1	P1	Diff.	J1, 2, 3	P1, 2	Diff.
	N	*%*	*N*	*N*	*%*	*Sum of mean N / trap / trial*		*%*
S. lunatum	1,522	30.4	844	678	11	205.4	265.5	13
A. sphacelatus	848	16.9	786	62	85	271.2	20.7	86
C. impressus	404	8.1	95	309	53	38.5	77.8	34
A. prodromus	355	7.1	170	185	4	57.6	61.7	3
A. rufipes	326	6.5	128	198	21	44.8	58.8	14
C. lateralis	280	5.6	111	169	21	51.3	64.5	11
C. castaneipennis	200	4.0	122	78	22	37.5	41.5	5
S. scarabaeoides	176	3.5	89	87	1	23.1	24.8	4
A. ater	119	2.4	57	62	4	18.7	15.5	9
A. erraticus	114	2.3	113	1	98	38.7	0.3	98
A. fimetarius	111	2.2	28	83	50	9.8	28.5	49
O. fracticornis	94	1.9	5	89	89	1.7	29.7	89
Cr. minutum	82	1.6	35	47	15	14.7	26.7	29
An. stercorosus	78	1.6	0	78	100	0.5	21.3	95
A. fossor	52	1.0	28	24	8	12.3	8.0	21
A. rufus	42	0.8	11	31	48	3.7	9.0	42
A. depressus	40	0.8	0	40	100	0	13.3	100
C. melanocephalus	32	0.6	22	10	38	9.0	5.5	24
A. haemorrhoidalis	31	0.6	11	20	29	4.5	6.7	19
S. bipustulatum	31	0.6	14	17	10	4.7	5.7	10
G. stercorarius	24	0.5	0	24	100	0	8.0	100
C. pygmaeus	12	0.2	7	5	17	3.5	1.8	31
A. pusillus	9	0.2	7	2	56	2.3	0.7	56
A. luridus	7	0.1	6	1	71	2.5	0.3	76
C. haemorrhoidalis	7	0.1	1	6	71	0.8	2.0	41
S. marginatum	7	0.1	3	4	14	1.2	1.3	7
Cr. crenatum	3	0.1	3	0	100	1.0	0	100
C. unipunctatus	2	>0.1	1	1	0	0.3	0.3	0
M. concinnum	2	>0.1	0	2	100	0	0.7	100
C. quisquilius	1	>0.1	1	0	100	0,3	0.0	100
T. vernalis	1	>0.1	0	1	100	0	0.3	100
Total	5,012	100	2,698	2,314	8	859.6	801	4

Also the smaller tunneller species, *O. fracticornis*, was more abundant in samples at Pasečná (by 89%). In total, 89 specimens were recorded at Pasečná, compared to only 5 specimens at Jenín. *Onthophagus fracticornis* was one of the most abundant species at Pasečná, contributing up to 13% to total numbers in the samples. In the mentioned sampling trial in May 2012, a single specimen was captured at Jenín compared to 48 specimens at Pasečná. In May 2013, when the dung of grazing cattle was already accessible in both the pastures, two specimens of *G. stercorarius* and 26 of *O. fracticornis* were captured at Pasečná but none at Jenín. In June 2011, three specimens of *O. fracticornis* were captured at Jenín compared to 12 specimens at Pasečná. These results suggest that the tunnellers were less abundant at Jenín.

In a former study carried out in 2006–2010, *G. stercorarius* and *O. fracticornis* were recorded in cattle pastures at Rybník, 3 km from Jenín, as well as at Rychnov, 7 km from Jenín (Šlachta et al. 2009, Šlachta unpubl.). Moreover, another pasture specialist, *G. spiniger*, was present in both these pastures. Contrary to the former two species, which are the spring breeders, *G. spiniger* is the autumn breeder and the adults appear in pastures first in the middle of July (Kühne 1995). At Rybník and at Rychnov, this species has been recorded in traps since late July, already in higher numbers (up to 24 specimens). At Jenín, two sampling trials were performed in relevant seasonal periods (August 2011, July 2013), but no *G. spiniger* was recorded. On a regional scale, i.e. up to approx. 150 km of direct distance from Jenín, nine other cattle pastures were monitored by pitfall trapping in 2007–2010 (Šlachta et al. 2009, Šlachta unpubl.) All three mentioned species were recorded in six of them, and two species in three of them (*G. stercorarius* was not found in pastures with the lowest altitude, i.e. 450–500 m a. s. l., while *G. spiniger* in pasture with the highest altitude, 800 m a. s. l.). Křivan (2000) collected *O. fracticornis* and *G. stercorarius* by pitfall traps in pasture near Senotín (south-eastern Bohemia, 70 km from Jenín). According to these results, the absence of *O. fracticornis* and the *Geotrupes* species at the same time seems rather exceptional for cattle pastures of this region.

Soil and microclimatic conditions play a role in the habitat choice of the tunnellers (Sowig 1995, Roslin et al. 2009). The preliminary results of soil parameters at sampling sites J1 and P1 revealed reduced aeration and augmented compaction of the uppermost soil profile at Jenín in comparison to Pasečná (Fučík, personal communication). Also the quality of soil organic matter was lower at Jenín (evaluated as C/N and humic acids/fulvic acids ratios). A relatively shallow soil profile was found in the Jenín pasture. In some places, the weathered parent rock rich on mica (biotite) appeared already 30 cm below the surface. Biotite weathering, together with clay particles and elevated soil water content, may lead to the formation of almost impermeable layers of the upper part of the soil (Buol and Weed 1991). More intensive grazing applied at Jenín (about 1.5 livestock units per ha, contrary to about 0.5 livestock units per ha at Pasečná) could also contribute to the soil degradation at Jenín, as documented in other studies (Pietola et al. 2005, Marshall et al. 2009). These factors may deter the tunnellers from the pasture at Jenín. *G. stercorarius* digs its nests up to 50 cm deep in soil, with majority of food chambers being in 20–30 cm depth (Teichert 1955). *Geotrupes spiniger* constructs its nests up to 30 cm deep (Kühne 1995). *Geotrupes stercorarius* may have a substantial impact on the dung decomposition rate. Three specimens of this species doubled the dung weight loss in dung pats in comparison to the controls without this species (Rosenlew and Roslin 2008). In the same experiment, 45 specimens of more *Aphodius* species were responsible for only about 15% loss of dung weight. Teichert (1955) estimates that during its life, the female of *G. stercorarius* transports 0.2–0.5 kg of dung into the soil during nest construction, and the female of *G. spiniger* even 2.3–2.8 kg (Teichert 1957). The absence of this tunneller, as well as other tunnellers, at Jenín may thus have negative consequences as regards the nutrient cycling and bioturbation in the pasture.

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