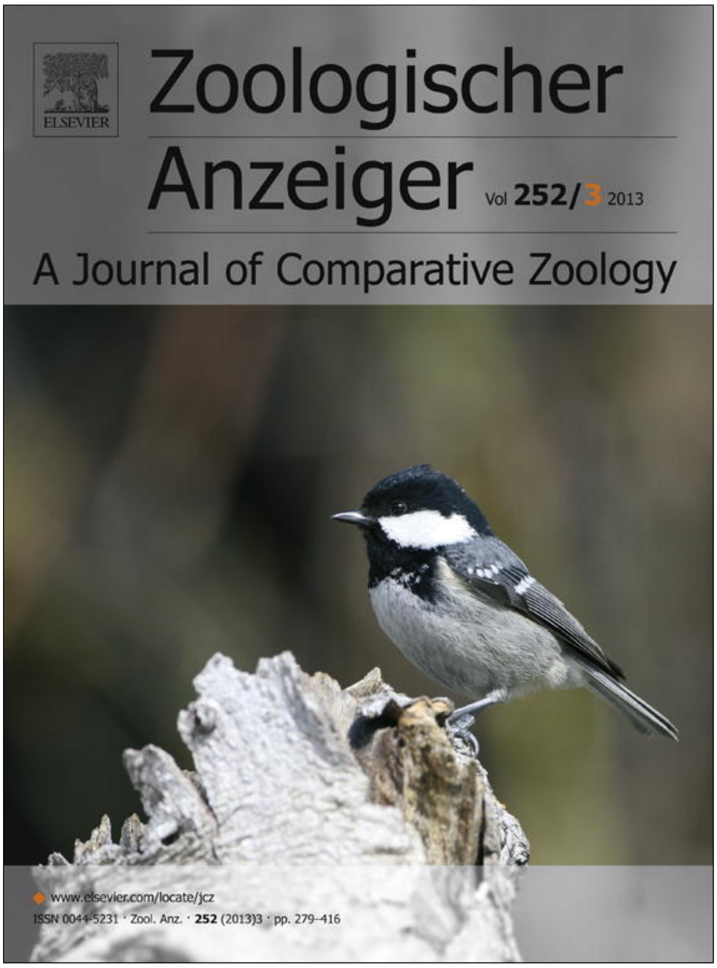
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How many mite species dwell in subterranean habitats? A survey of Acari in Belgium

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In memoriam Jean-Marie Hubart (1939–2009).

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ABSTRACT

Underground compartments are one of the least known environments in the world. In our study we collected 137 samples, using different techniques, in 30 caves and other cavities (mine galleries, underground chalk quarries, superficial underground compartments – SUC and resurgences). In total 814 individuals of mites were collected, representing 99 taxa from 43 families. Eighty-three species were added to the list of mite speleofauna in Belgium; the highest number of new species for underground environments was noted for Mesostigmata. Four mite species were classified as obligate cave dwellers. We also made an extrapolated estimate of the number of species in subterranean habitats in Belgium. The fauna of the superficial underground compartments was distinct with 60% of species typical of underground compartments. In most cavities accessible for tourists and artificial cavities high number of mites was observed. Additionally, the importance of using different sampling methods to recognize biodiversity in a subterranean biome were discussed.

1. Introduction

Cave ecosystems are poorly known and understood. Only a small fraction of caves in any region of the world has been explored and assessed (Culver et al., 2004). The description of the faunas found living in caves remains highly imperfect (Moseley, 2009a). Even in the few well-sampled caves throughout in the world, description of species richness is incomplete (Culver, 2008). Additionally, much less is known about the diversity and ecological relationships between cave animals and those of adjacent subterranean and surface habitats (Moseley, 2009a). Moseley (2009a) underlined that ironically our imperfect knowledge of cave-associated fauna is sometimes far better than that of the nearby epigean (surface) communities. Troglobite (obligate cave dwellers) richness and diversity remain poorly described. Culver and Holsinger (1992) estimate the global troglobite diversity at 50,000–100,000 species.

Recently Moseley (2009b) suggested that all caves might constitute ecotones between the surface on the one hand and the host rock fissure system on the other. The author visualized the “real” subterranean world as the enormous interconnected network of smaller spaces – mesocaverns and microcaverns, whereas the larger voids are caves. Caves can be seen as transitional marginal habitats between the hypogean biome and the outside epigean world (Moseley, 2009a). This view, the ecotonal nature of caves, developed and discussed further by Moseley (2009a), remains debatable, but adoption of the ecotone concept as a conceptual framework for studying and understanding underground habitats offers a radical new perspective with potential relevance to many of the unresolved questions about the ecology, biogeography and evolution of the subterranean fauna.

So far, the biological study of the underground realm was almost entirely restricted to accessible caves and it is only in recent decades that its vast extent and ecological heterogeneity have become more fully appreciated and understood (Moseley, 2009c). The superficial underground compartment (SUC, in French ‘milieu souterrain superficiel’ or MSS) was only recognised about thirty years ago (Juberthie et al., 1980). The SUC is situated below the soil and

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around caves. It is notably constituted by cracks in rock. Furthermore, Meštrov (1962) described a shallow subsurface subterranean habitats with a stygobiotic fauna which is called the hypotelminorheic habitats. Culver et al. (2006) emphasized that they may play an important role as a pathway of invasion into other, deeper subterranean habitats. According to Moseley (2009a) caves, the SUC and other underground habitats (e.g. talus slopes, Kaltlöcher) represent various zones of transition. Sampling methods used in caves are imperfect, but sampling the enormous network of smaller voids in the subterranean realm is much more difficult. And consequently our knowledge of the inhabitants of mesocaverns is much less than that of cave dwellers (Moseley, 2009a).

In Belgium, natural caves occur only in the southern part of the country (Wallonia), for upper soils of the northern part (Flanders) mainly consist of Tertiary and Quaternary loose deposits (sands, silts and clays). In Wallonia, caves are essentially formed in Paleozoic limestones, mainly Carboniferous and Devonian. The karstic zone is concentrated along the Meuse, Sambre, Ourthe and Amblève rivers. In Ardenna, where the Paleozoic underground is constituted of schists (shales) and quartzo-schists, natural caves are missing.

We know about 1000 natural caves in Belgium, at least 10 of them are highly (sometimes partly) touristic. Belgian caves have been studied for more a century and the reader will find a lot of information in Van den Broeck et al. (1910), Ek (1976, 1979) and in the publications of the AKWA (Atlas du Karst Wallon), published by the CWEPSS (Commission Wallonne pour l'Etude et la Protection des Sites Souterrains) under the direction of Claude De Broyer (De Broyer et al., 1999). But Belgium was also, during centuries, a mining country and mine galleries, dug in shale and coal, or underground quarries, in chalk or limestone, are very numerous. Most of them are now abandoned but are often of great interest for the study of the underground fauna. Subterranean acarology in Belgium began just before the Second World War and Leruth (1939) was the first to initiate a systematic exploration and to compile a list of Belgian aquatic and terrestrial cave species. Since then intensive studies were continued until now.

The goal of this research was to improve our knowledge of the species composition of the mite fauna from the major types of accessible terrestrial subterranean environment (natural caves, abandoned mines and superficial underground compartment SUC) and resurgences (aquatic) in the karst region of Belgium. In particular, the aims of the present study were as follows:

1. to outline the present and estimated mite diversity in caves and other underground habitats based on extensive collecting in the past and documented in the present study,
2. to analyse the presence of troglobites and troglophilous species in caves,
3. to assess possible human impact on mite diversity in subterranean compartments,
4. to discuss the importance of different sampling techniques in speleobiology.

2. Material and methods

2.1. Underground habitats sampled

During this study 30 caves and other subterranean cavities were sampled. Table 1 gathers the main characteristics of the stations. Most of them are natural caves, formed in Carboniferous or Devonian limestones and are still active (at least the under level). The environmental conditions at site collections are almost or completely stable. The temperature in studied caves was always about 9 °C and air moisture about 100% (besides five collection sites situated close to an entrance). All studied caves represent oligotrophic environments. Sometimes, in some places, organic material accumulates (dead leaves, rotten wood, bat guano) and then the site becomes at least mesotrophic. We have collected soil samples mainly in such mesotrophic places. Three sites were located in underground chalk quarries and the mine gallery, and additional four sites in so called resurgence. Some mites were also collected in the superficial underground compartment (SUC) above the caves of Ramioul and Lyell. All studied habitats are located in the karstic zone of Wallonia (Fig. 1).

2.2. Sampling design

In order to sample all the compartments or 'niches' of the subterranean environment, mites have been collected with the help of different techniques:

- *Method I.* At sight, hand picking, with a very fine brush or a tiny entomological exhauster, on concretions, under stones, etc. Regularly, the fauna was concentrated thanks to baits ('blue' cheese, fish, etc.) put under stones for two or three weeks. Ninety-eight samples were collected by this technique.
- *Method II.* With pitfall traps (Barber traps) of 5–6 cm in diameter, filled with beer or salt water and put everywhere in the cave where it is possible (clay or soft deposits thick enough) for a period of 4–5 days. Barber traps were used three times (code: "Bar", see Appendix A).
- *Method III.* Extraction of cave sediments, from samples of about 150–200 cm^3. The sample consists of light clay or soil (cave deposits), sometimes with more or less organic matter (dead leaves, rotten wood, and probably some bats dungs), especially on the shore of underground brooks. Bat guano was not collected separately as Belgian caves are now poor in bats and important guano deposits were not seen in studied caves. Mites were extracted in the Laboratoire de Biologie Souterraine de Ramioul (LBSR) using Berlese-Tullgren funnels. This technique was used for 13 samples (code: "Ber", see Appendix A).

In the superficial underground compartments mites were collected with the help of a modified trap (Hubart, 2001). To investigate this milieu, holes of about 80 cm deep were dug above the cave in the forest soil, samples for Berlese were taken and a kind of pitfall trap was placed for three weeks or so. Twenty-three samples were collected in the SUC.

In total, 137 samples have been collected between 1998 and 2005. The sampling was qualitative, mainly planned to analyse biodiversity in studied subterranean habitats. Each cave was visited at least twice, most of them four to five times, some of them more than twelve times. Mites were collected mainly in the deepest parts of caves. The distance of an entrance depends on the morphology of a cave and ranges from several to some tens of metres. Only in five cases samples were collected close to an entrance of a cave (code: "entrance", see Appendix A). Samples were not taken regularly, e.g. seasonally. In eight caves only one sample with mites was collected, mainly in order to avoid depleting the populations. A sample in our studies is mainly a "sample event".

2.3. Mite identification and data analyses

Mites were first preserved in alcohol (60–70%) and later mounted in lactic acid (Oribatida) or in Faure's fluid (other Acari) for identification purposes. Most developmental stages were identified, in most cases to the species level, representing 21.8% of the total number of collected mites. Some species could not be identified accurately, because of the poor condition of some individuals. Species identified in the study were related to four groups of mites, namely order Mesostigmata, suborder Oribatida, suborder

Table 1
List and descriptive parameters of sampled caves and cavities in Belgium.

Cavity name	Code	Type[a]	Status[b]	Province	Commune	UTM[c]	Geol.[d]	Hydrol.[e]	*D*[f]	*d*[g]	Samp.[h]	Other[i]
Arvilles	AR	Nat.	–	Namur	Gesves	FR48	D	R	423	18	1	–
Avignon (pont d')	AP	Nat.	CSIS	Namur	Nismes	FR14	D	S	120	0	1	–
Bernard (trou)	BT	Nat.	–	Namur	Assesse	FR48	D	S–(R)	1200	153	2	–
Brialmont	BR	Nat.	CSIS	Liège	Esneux (Tilff)	FS80	D	–	172	37	4	–
Chartreuse	CH	Art.	CSIS	Liège	Liège	FS81	Ca	S–R	1600	0	6	1
Comblain (abîme)	CA	Nat.	CSIS/T	Liège	Comblain-au-Pont	FR89	Ca	S–R	684	52	6	–
Comblain 1	CO	Res.	–	Liège	Comblain-au-Pont	FR89	Ca	R	0	0	2	–
Fayt	FA	Nat.	–	Namur	Jemelle	FS65	D	(S–R)	1335	62	1	–
Fontaine de Rivîre	FR	Nat.	CSIS	Liège	Hamoir (Sy)	FR88	D	S	900	30	4	–
Fouron-Saint-Pierre	FS	Res.	–	Limbourg	Fourons	FS92	–	R	0	0	2	–
Hotton	HO	Nat.	T (p.p.)	Luxembourg	Hotton-Hampteau	FR77	D	S–R	6000	67	3	–
Laminoir	LAM	Nat.	–	Liège	Flémalle	FS70	Ca	–	41	10	2	–
Lanaye inférieur	LI	Art.	–	Liège	Visé	FS83	Cr	–	15,000	0	8	2
Lanaye supérieur	LS	Art.	–	Liège	Visé	FS83	Cr	–	5000	0	3	2
Lesve (abîme de)	LA	Nat.	–	Namur	Profondeville	FR28	D	R	751	68	2	–
Lyell	LY	Nat.	CW	Liège	Engis	FS60	Ca	–	0	0	12	3
Lyell (grotte)	LG	Nat.	CW	Liège	Engis	FS60	Ca	S	335	15	12	–
Monceau (grotte)	MG	Nat.	–	Liège	Esneux (Tilff)	FS80	D	S–R	435	45	15	–
Monceau 2	MO	Res.	–	Liège	Esneux (Tilff)	FS80	D	R	0	0	1	–
Neptune	NE	Nat.	T (p.p.)	Namur	Couvin	FR04	D	R	1627	25	3	–
Noû Maulin	NM	Nat.	CSIS	Namur	Rochefort	FR55	D	(R)	1606	37	1	–
Ramioul	RA	Nat	–	Liège	Flémalle	FS70	Ca	–	0	0	11	3
Ramioul (grotte)	RG	Nat.	CSIS/T	Liège	Flémalle	FS70	Ca	(R)	1200	55	13	–
Remouchamps	RE	Nat.	CSIS/T	Liège	Aywaille	FR99	D	S–R	3883	110	2	–
Rosée	RO	Nat.	CW	Liège	Engis	FR60	Ca	–	485	11	3	–
Rosière (grotte)	RoG	Nat.	–	Liège	Neupré	FS80	D	R	60	15	1	–
Steinlein	ST	Nat.	–	Liège	Comblain-au-Pont	FR89	Ca	–	561	20	1	–
Tahaut (fontaine de)	TF	Res.	–	Namur	Hastière	FR26	Ca	R	0	0	1	–
Trotti-aux-Fosses	TR	Nat.	CSIS	Luxembourg	Marche-en-Famenne	FR66	D	R	200	26	2	–
Végétations	VE	Nat.	CSIS	Liège	Flémalle	FS70	Ca	–	70	15	12	–

[a] Type: nat. = natural; art. = artificial; res. = resurgence.
[b] Status: CSIS (cavité souterraine d'intérêt scientifique) = underground cavity of scientific interest; T = touristic (p.p. – pro parte); CW = private property of the Chercheurs de la Wallonie.
[c] UTM – Universal Transverse Mercator.
[d] Geol. (Geology): D = Devonian; Ca = Carboniferous; Cr = Cretaceous.
[e] Hydrol. (Hydrology): R = running water; S = stagnant water; ( ) = if temporary; – = only percolation and condensation waters.
[f] *D* – length (in m).
[g] *d* – denivelation (in m).
[h] Samp. = number of samples.
[i] Other: 1 = mine gallery; 2 = underground chalk quarries; 3 = SUC (superficial underground compartment).

Prostigmata and cohort Astigmata. Identification of species was based on the following determination keys: Giljarov and Krivolutskij (1975), Hughes (1976), Giljarov and Bregetova (1977), Zacharda (1980), Karg (1987, 1993), Bugrov (1995), Baker (1999), Klimov (2000), Weigmann (2006), Fan and Zhang (2007), Wohltmann et al. (2007), Niedbała (2008), Okabe et al. (2008), Colloff (2009), Krantz and Walter (2009) and Zacharda et al. (2010). The authorship of specific names as well as family affiliation of species is provided in Appendix A. Voucher specimens are permanently deposited in the Department of Ecology, University of Silesia, Katowice, Poland.

The four mite groups were characterized by the number of specimens collected in caves and other cavities and the total number of species. The cluster analysis of qualitative data (species presence) for each underground locality under study was made using the binary index – simple matching coefficient. The data were log(n + 1) transformed. The resemblance matrices were analysed in a hierarchical cluster analysis, employing the farthest neighbour method. The analysis was done in MVSP 3.2 software.

3. Results

The fauna records are collated and summarized in Table 2 and Appendix A. In total, 814 representatives of mites (Acari) were found in studied underground compartments. The highest number of mites was collected in the natural caves – Végétations (135) and Monceau (105). In five natural caves only 1–2 individuals of mites were found. In caves open to the public, the number of collected mites varied from 3 (Remouchamps) to 50 (Ramioul grotte). The number of mites collected in the mine gallery (Chartreuse) and the underground chalk quarries (Lanaye inférieur) was quite high (84 and 61, respectively). Only in the underground chalk quarries in the Lanaye supérieur, four individuals were collected. In two superficial underground compartments 114 specimens, representing mainly Mesostigmata, were collected. Low numbers of mites (1–4) were found in four studied resurgences (Table 2).

Mesostigmata made up the majority of the mite fauna collected in caves and other cavities (485 specimens, ~60%) (Table 2). The number of collected individuals in a cavity varied from one to even 87 (Lyell). Only in five underground cavities no individuals of this group were found. The second most numerous group of mites was Oribatida (228). In 11 cavities no oribatid mites were present. The highest number of Oribatida was recorded in natural caves (Monceau grotte – 54 and Végétations – 50). However, in some artificial underground compartments (Lanaye inférieur, Chartreuse) they were also recorded in high numbers. Sixty-three specimens of Astigmata were found in only eight cavities during the sampling period. Prostigmata were usually rare in caves, from one to seven individuals (38 individuals in total) (Table 2).

In our study we found ninety-nine mite taxa, representing forty-three families in 30 caves and other cavities. The total number of mite species per cavity ranged from 1 to 31 species. Only one species was found in five caves, whereas ten and more species were recorded in 11 caves. However, due to uneven sampling design, we should remember that overall mite diversity gained for a particular cave principally reflected the number of samples taken. Ten

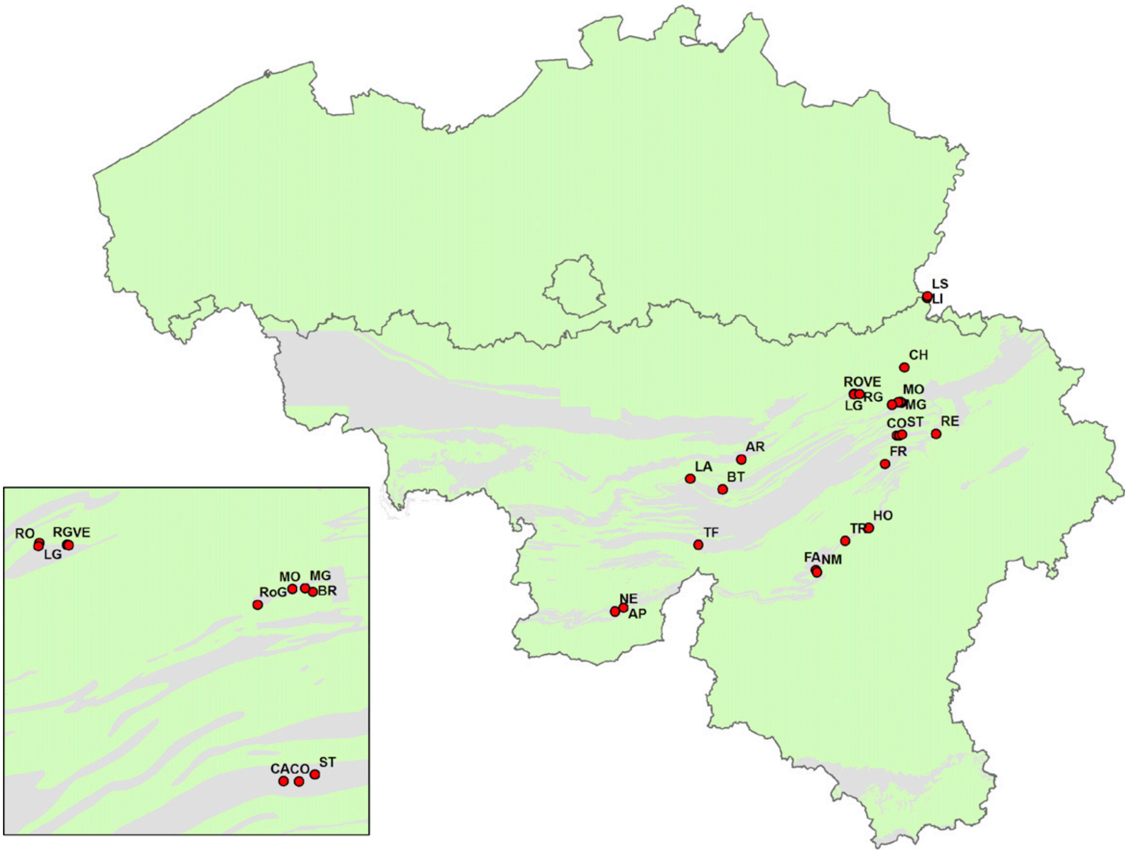

Fig. 1. Karstic zone of Belgium (in grey) and localisation of the most important sampled sites (map drawn by Claude Dopagne). Codes are defined in Table 1.

Table 2
Number of specimens (n) and number of mite species (s) in sampled cavities.

Cavities	Mesostigmata		Oribatida		Prostigmata		Astigmata		Acari	
	n	s	n	s	n	s	n	s	n	s
Arvilles	3	1	–	–	1	1	–	–	4	2
Avignon (pont d')	1	1	–	–	–	–	–	–	1	1
Bernard (trou)	2	2	–	–	–	–	–	–	2	2
Brialmont	13	6	3	3	1	1	–	–	17	10
Chartreuse	57	11	22	1	3	1	2	2	84	15
Comblain (abîme)	14	10	7	4	–	–	–	–	21	14
Comblain 1	3	3	1	1	–	–	–	–	4	4
Fayt	25	10	1	1	1	1	–	–	27	12
Fontaine de Rivîre	18	6	7	3	–	–	6	1	31	10
Fouron-Saint-Pierre	–	–	–	–	2	1	–	–	2	1
Hotton	22	6	1	1	–	–	15	2	38	9
Laminoir	3	3	2	1	–	–	–	–	5	4
Lanaye inférieur	20	8	39	8	2	2	–	–	61	18
Lanaye supérieur	3	3	–	–	1	1	–	–	4	4
Lesve (abîme de)	4	2	1	1	–	–	–	–	5	3
Lyell	87	4	1	1	–	–	–	–	88	5
Lyell (grotte)	36	9	14	2	3	2	–	–	53	13
Monceau (grotte)	45	15	54	9	5	2	1	1	105	26
Monceau 2	–	–	1	–	–	–	–	–	1	1
Neptune	4	3	–	–	–	–	27	1	31	4
Noû Maulin	1	1	–	–	1	1	–	–	2	2
Ramioul	19	8	5	3	2	1	–	–	26	12
Ramioul (grotte)	27	10	16	9	7	3	–	–	50	22
Remouchamps	–	–	1	1	2	2	–	–	3	3
Rosée	2	2	–	–	1	1	2	1	5	4
Rosière (grotte)	3	2	–	–	–	–	1	1	4	3
Steinlein	–	–	–	–	1	1	–	–	1	1
Tahaut (fontaine de)	–	–	2	1	–	–	–	–	2	1
Trotti-aux-Fosses	1	1	–	–	1	1	–	–	2	2
Végétations	72	17	50	10	4	3	9	1	135	31
Total	485	51	228	29	38	12	63	7	814	99

cavities studied in the project have gained the status of "cavité souterraine d'intérêt scientifique" (underground cavity of scientific interest) (Table 1). In these habitats we collected 68 mite species, whereas in another 20 cavities only 65 mite species were described (Appendix A). In cavities accessible for tourists, many mite species were recorded, ranging from 3 to 33. As regards artificial cavities, the number of species was comparatively high, ranging from 4 (Lanaye supérieur) to 18 (Lanaye inférieur). In our study the mite fauna of the two caves (Lyell and Ramioul) and two superficial underground compartments (SUC) above these caves was studied. The number of species in the SUC above the Lyell and Ramioul caves (5 and 12) was lower than those in caves (13 and 22). The fauna of the SUC was distinct (60% of species were typical of the SUC) and more similar than those of caves. *Porrhostaspis lunulata* was one of the most numerous species in the SUC, absent in both caves. Few species (one to four) were found in resurgences (Table 2).

The simple cluster analysis was carried out to find a pattern of distribution of cavities (Fig. 2). The dendrogram clearly showed the separation of four cavities – Ramioul (grotte), Monceau (grotte), Végétations and Lanaye inférieur (upper part of the dendrogram). Three (VE, LI) or at least two different sampling methods (RG, MG) were used in these cavities. Furthermore, the Ramioul grotte is accessible for tourists. In the lower part of the dendrogram a distinct group of five underground localities, for which the mite fauna is very similar, is identified. Three of these localities represent resurgences [Tahaut (fontaine de), Monceau 2 and Fouron-Saint-Pierre] and the other two are natural caves (Steinlein and Arvilles) in which only the single sample was collected. As regards other cavities, only small differences among mite faunas were observed. It is worthwhile to underline that the mites found in the SUC above the Lyell and Ramioul caves (LY, RA) and the caves itself (LG, RG) were located in different clusters of cavities in the dendrogram (Fig. 2).

The most speciose group was Mesostigmata with 51 species (Table 2). Over half of the recorded species belong to the Mesostigmata (51 species representing 14 families). The number of species of Mesostigmata in a cave varied from 1 to 17. The highest number was found in natural caves (Végétations and Monceau grotte). Nine species of Mesostigmata dominate (over 5% of the total number of specimens) in the mite fauna in studied cavities. They made up 65.2% of the total number of Mesostigmata. They were the following species: *Eugamasus magnus* (19.0% of the total number of mites), *Geolaelaps aculeifer* (7.0%), *Lysigamasus lapponicus* (6.6%), *Parasitus loricatus* (6.2%), *Alliphis halleri* (5.2%), *Geholaspis* (*Longicheles*) *mandibularis* (5.2%), *P. lunulata* (5.2%), *Parasitus* sp. (5.4%) and *Veigaia* sp. (5.4%).

Oribatid mites were represented by 29 species from 16 families, ranging from 1 to 10 species per cavity. The highest number was recorded in some natural (Végétations, Ramioul grotte or Monceau grotte) or artificial cavities (Lanaye inférieur) (Table 2). Seven dominant species of Oribatida constituted 73.8% of the total number of oribatids. They were following species: *Euzetes globulus* (16.7%), *Damaeus (Adamaeus) onustus* (14.3%), *Hermannia (H.) gibba* (9.8%), *Phthiracarus (Archiphthiracarus) anonymus* (9.8%), *Steganacarus (S.) magnus* (8.9%), *Xenillus (X.) tegeocranus* (8.4%) and *Phthiracarus (P.) ferrugineus* (5.9%).

Species richness of prostigmatid and astigmatid mites observed in the underground compartments in Belgium was much lower. It is noteworthy that 12 species of Prostigmata represent 11 families (Table 2). The number of species per cavity was very low, ranging from one to three species. Five prostigmatid mites were observed with the dominance index higher than 5%: *Traegaardhia* cf. *dalmatina* (44.4%), *Calyptostoma velutinum* (19.4%), *Campylothrombium clavatum* (5.6%), *Ereynetes* sp. (5.6%) and *Linopodes* sp. (5.6%). Seven species of Astigmata were recorded in studied cavities. One or two species were found in some of the studied cavities. *Tyrophagus longior* was the most numerous astigmatid species representing almost 47% of the total number of astigmatids (Table 2).

Eighty-three taxa were recorded for the first time from underground environments in Belgium (see Appendix A). The highest number of new species for underground environments in Belgium was noted for Mesostigmata (42). Twenty-two of those belong to Oribatida, 12 to Prostigmata and 7 to Astigmata. Twenty-two species appeared to be new species for the Belgium acarofauna. Among the suborder Oribatida 21 species were recorded for the first time from the territory of Belgium (Lebrun et al., 1989) and one species belongs to the Parasitengona (*Allothrombium adustum*) (Appendix A).

Different methods were used to collect mites. Most species (93) were taken by hand picking (method I). By method II and III, four and 40 species (with five unique species) were collected, respectively. Sixteen species (one unique species) were found in the SUC (Appendix A). Twenty-six species were found in samples taken close to the entrance of a cave (Appendix A).

4. Discussion

4.1. Described and estimated mite species richness in subterranean habitats

The total number of mite species per cave (from 1 to 31) was similar to estimates of mite species richness reported from a single cave. It ranged from 0 (e.g. Ducarme et al., 2003) to 43 (Perez-Iñigo, 1969). It is noteworthy that the decisive percentage (84) of the recorded species were observed for the first time from subterranean habitats in Belgium.

Our study in caves and other underground habitats in a small European country (comparatively well studied) proves that we still probably know only a small part of the mite biodiversity in subterranean habitats. To date, the total number of mite species recorded from underground environments in Belgium was 225 (Willmann, 1935; Leruth, 1939; Lebrun, 1967; Hubart, 1982; Dethier, 1998; Delhez et al., 1999; Hubart and Dethier, 1999; Dethier and Hubart, 2000a, 2003; Ducarme, 2003; Ducarme et al., 2003; Wauthy and Ducarme, 2006; Martin et al., 2009). The present work covers 99 mite species, with only 16 species in common. These figures tell a lot with respect to estimating the total species diversity of subterranean mites in Belgium. There are about 1000 natural caves in Belgium and many other underground compartments and samples for mites were collected only in about 90 (see above-mentioned references). In our project we found on average 1.9 species of mites as unique for a cave. So we can assume that over 1700 species are still waiting to be discovered in underground habitats in Belgium. Do we really know only 15% of the mite speleofauna in Belgium? A similar percentage of known species on our globe was suggested by Ehrlich and Wilson (1991). They suggested that the true number of species is closer to 10^8 than 10^7, whereas at present only 1.4 million species of plants, animals and microorganisms have been given scientific names.

In spite of the considerable interest in caves as ecological, evolutionary, and microbiological laboratories, the heart of speleobiology remains the description and explanation of species diversity (Culver, 2008). Over the decade, there has been a growing awareness and concern with biodiversity studies (Culver and Sket, 2000). Nevertheless, our knowledge of biodiversity in the world is still poor. There are not enough taxonomists to describe still undiscovered species in natural habitats or 'waiting' in museums. The cave fauna of Belgium seems to be the most extensively and comprehensively sampled and documented of any region in Europe.

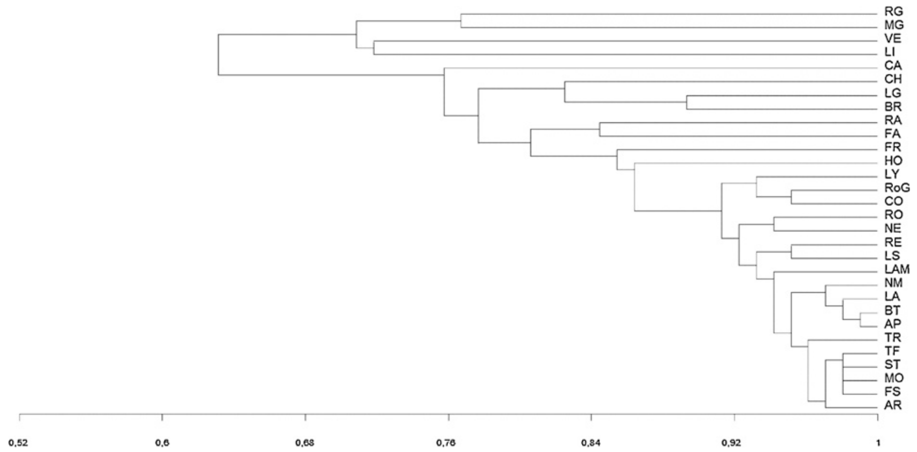

Fig. 2. The dendrogram for the studied underground compartments in Belgium, simple matching coefficient, farthest neighbour algorithm. Codes, see Table 1.

Nevertheless, it is not. It is apparent that the number of species observed is highly dependent on the number of caves sampled (Culver et al., 2003).

4.2. Species composition of mite fauna in underground compartments

Among species recorded in Belgian underground habitats, we recorded species well known from cavities in other countries, some considered as cavernicolous or even troglobite. Some representatives of Mesostigmata, e.g. *E. magnus*, *P. loricatus* and *P. lunulata* were previously considered as troglophiles (Leruth, 1939; Schmölzer, 1995). *E. magnus* (the most numerous mesostigmatid species) was previously recorded in many caves (Leruth, 1939; Micherdziński, 1969; Hyatt, 1980; Schmölzer, 1995; Fend'a and Košel, 2000). The typical habitat of occurrence of the species is humus and moss (Karg, 1993). *P. loricatus* – widespread European species, occurred in compost, dung heaps, rotting vegetation, mushroom beds, small mammal nests, birds' nests in burrows, holes in trees, mixed forests and caves (Hyatt, 1980). The species is broadly distributed in European (Schmölzer, 1995; Fend'a and Košel, 2000; Lundqvist et al., 2000; Papáč et al., 2006), Belgian (Leruth, 1939) and Polish caves (Micherdziński, 1969). *P. lunulata* – widespread European species, was found in a wide range of habitats. It was also recorded from caves (Leruth, 1939; Micherdziński, 1969; Hyatt, 1980).

Among other (comparatively) numerous mesostigmatid mites occurring in underground compartments, most were recorded in caves. *G. aculeifer* is a cosmopolitan species, known from a variety of habitats (Giljarov and Bregetova, 1977; Karg, 1993). It was recorded in Austrian and Slovak caves (Schmölzer, 1995; Papáč et al., 2006). Furthermore, it was recorded in active coal mines in Upper Silesia (Solarz et al., 2002) and in old mine galleries in Upper Silesia (Skubała et al., 2005). *L. lapponicus* is widely distributed in a wide range of habitats. It is known from caves (Micherdziński, 1969). *Geholaspis* (*Longicheles*) *mandibularis* is widespread in Europe in a wide variety of litter habitats (Hyatt and Emberson, 1988). It occurs also in Slovak caves (Papáč et al., 2006). This species, probably, had been introduced from Europe into Jenolan Caves (Australia) by the actions of Europeans humans (Halliday, 2001). *A. halleri* – was not observed in caves, so far. These mites are common in agricultural soils and phoretic on dung beetles (*Geotrupes* sp.), especially in Europe. It is a rare species in forests (Karg, 1993).

Most mesostigmatid species are known as predators. In studied underground compartments among Mesostigmata four species represent cohort Uropodina. According to Koehler (1999) Uropodina prey mainly on nematodes, insect larvae, but some genera are mycophagous. One representative of the Mesostigmata (*Spinthurnix* sp.) is a parasite (Krantz and Walter, 2009).

Oribatid mites were the second most abundant and diverse group of mite speleofauna. It was characteristic that most oribatids were animals of comparatively large dimensions, typical inhabitants of the upper layer of soil which also occur on the surface. The representatives of small oribatids, characteristic of lower parts of the soil (e.g. Oppiidae) were rarely found. Three species [*E. globulus*, *Damaeus (Adamaeus) onustus* and *Damaeus (D.) gracilipes*] were previously recognized as cavernicolous (Lebrun, 1967; Dethier and Hubart, 2000a; Mock et al., 2005). They are recorded mainly in forest habitats (Weigmann, 2006). *E. globulus* (the most numerous oribatid, recorded in five cavities) is of palaearctic distribution (Subias, 2004). It was recorded in Belgian caves in the past (Lebrun, 1967; Dethier and Hubart, 2003). *Damaeus (Adamaeus) onustus* is distributed in Palaearctic and Ethiopian regions (Subias, 2004). The species was recorded from many caves (Hippa et al., 1988; Morell and Subias, 1991; Dethier and Hubart, 2000a). *Damaeus (D.) gracilipes* is known from holarctic region (Subias, 2004) and was recorded in caves in Europe (Ľuptáčik and Miko, 2003; Mock et al., 2005).

Hermannia (H.) gibba and *Xenillus (X.) tegeocranus* (other numerously recorded species) are also large-sized, well sclerotized mites. They are typical of forest habitats or eurytopic and of holarctic and palaearctic distribution, respectively. *X. tegeocranus* was recorded in caves (Dethier and Hubart, 2003). The remaining dominant species belong to the Pthiracaridae [*Phthiracarus (Archiphthiracarus) anonymus*, *Phthiracarus (P.) ferrugineus*] and Steganacaridae [*Steganacarus (S.) magnus*] families. They are typical xylophagous soil mites, playing a significant role in the process of mechanical fragmentation of organic matter, particularly in forest ecosystems (Niedbała, 2008). *Phthiracarus anonymus* was found in caves in the presence of minimal amounts of organic matter (Lebrun, 1967; Morell and Subias, 1991; Ducarme et al., 2003).

Traegaardhia cf. *dalmatina* comprised about 45% of the total number of prostigmatids. *Traegaardhia dalmatina* was described by Willmann (1939) under the generic name *Rhagidia*. Later, Zacharda (1980) was created the new genus (*Traegaardhia*) on the base of specimens deposited in Willmann's collection. Thus, *T. dalmatina* remains a type-species for the genus. Recently, genus *Traegaardhia* contains 11 species, all connected with caves. The species is a representative of the Rhagidiidae family, which are predatory soil mites. They prey mainly on the collembolans, hunting them under stones and in detritus; rhagidiids seem to prefer moist, dark and cool niches. It was also suggested that some cave-dwelling species may have adapted to using the troglobiotic crustaceans as prey (Krantz and Walter, 2009). For example, the eleven species of *Traegaardhia* known up to the present were found in caves in Europe and North America, having morphological adaptations (troglomorphisms) to live in this type of habitat (Zacharda, 1979, 1980; Zacharda et al., 2010). The representatives of terrestrial Parasitengona mites, i.e. *C. velutinum* and *C. clavatum* also dominated among Prostigmata. Several species regarded as true troglobionts or at least troglophiles can be recognized within this group of mites (Mąkol and Gabryś, 2008). *C. clavatum* was not recorded from caves so far, whereas the finding of the larva of *C. velutinum* at the entrance to the Rift cave in Devon, Great Britain was reported by Turk (1972). *C. velutinum* is the species widely distributed in the Palaearctic, associated with humid and temporarily flooded areas, e.g. forests, meadows, marshes (Wohltmann, 2000; Gabryś et al., 2008). *C. clavatum* is a European species, associated with forests, including temporarily flooded areas (Wohltmann et al., 2007; Mąkol and Gabryś, 2008). Both species, similar to the majority of other Parasitengona, have parasitic larvae, thus the association of both taxa with cave habitats can result from habitat preferences of the host. Other members of the Prostigmata were represented by *Ereynetes* sp. (small predators, or more often saprophagous or mycophagous) and *Linopodes* sp. (usually live in soil microhabitats, distinguished by the extremely long first pair of legs) (Krantz and Walter, 2009). Both taxa were observed in caves in the past (Leruth, 1939; Hippa et al., 1988; Lundqvist et al., 2000; Ducarme, 2003; Ducarme et al., 2003; Moseley, 2007).

With regard to Astigmata, *T. longior* constituted almost half of the total number of astigmatids in underground habitats. Most individuals of the species were recorded in the Neptune cave. Due to the presence of this species the species composition of the cave was totally different from other caves. It is worthwhile to underline that the Neptune cave is a natural cave accessible for tourists with one characteristic species. *T. longior* is a common mite species, occurring mainly in byres, hay, straw and grain stacks on a field, in stored products in storages (hay, straw, grain), in dry grass, in honey, in bird nests, poultry houses and beehives, in dust samples from the working environments of farms (Hughes, 1976; Rosický et al., 1979; Terho et al., 1982; Hallas and Solberg, 1989; Hallas et al., 1991; Chmielewski, 1995; Franz et al., 1997; Solarz et al., 2004). This genus was observed in caves (Elliott, 2007). *Glycyphagus domesticus* was previously described as troglophilous by Moseley (2007). In our study we found only 1 specimen.

As regards, the mite fauna of the two SUC, it was less diverse but more similar and distinct than those of adjacent caves. This phenomenon was previously observed by Tercafs (2001). Mesostigmatid species *P. lunulata*, the most numerous species in the SUC, absent in both caves was previously recorded in other cavities in Belgium (Leruth, 1939). Moseley (2007) brought to mind that most so-called "cave" fauna is not restricted to caves as such but is widely distributed throughout mesocavernous voids and the SUC. Later Moseley (2009a) emphasized that caves have long been used by biologists as a proxy for other subterranean habitats and underlined that, with increasing knowledge of the subterranean milieu, it can no longer be sustained. It is also seen from our observations. They indicate that caves are differentiated physically and environmentally from the superficial underground compartments. And in general conditions are more identical within mesocavernous fissures than in caves. Comparatively high proportion of species (26%) was found in five samples collected close to an entrance. It confirms that the diversity of cave microarthropods is the function of the distance from the entrance and the accessibility of organic material as food basis.

4.3. Troglobiotic mite species in Belgium

As a result of this study we considered four species to be obligate cave dwellers (troglobites).

- *Veigaia hubarti* Mašán & Madej 2011 was described as the new species for science as a result of this study (Mašán and Madej, 2011). It was recorded only in the Hotton cave.
- We also proposed *Veigaia leruthi* Willmann 1935 as a troglobite (observed in two caves). Leruth (1939) described the species as a troglophile, but it has not been observed outside caves so far. Veigaiids exhibit some of the morphological adaptations characteristic of deep-cave arthropods, such as pale colour, elongate appendages, reduced sclerotization and slender body form (Howarth, 1983).
- *Traegaardhia* cf. *dalmatina* (Willmann 1939) constituted almost half of the collected prostigmatid mites and was observed in 11 caves. Hitherto, the localities of *T. dalmatina*, or even the morphospecies *dalmatina* are as follow: caves of Krivosije (Croatia), caves in central Dalmatia and east Bosnia (former Jugoslavia) and caves in the southwestern France (Pyrenees, Ariège, Cassis) (Willmann, 1939; Thor and Willmann, 1941; Zacharda et al., 2010).

The fourth troglobiotic mite was *Damaeus (Kunstidamaeus)* cf. *lengersdorfi* (Willmann 1932) (noted in the Brialmont cave). The species was mentioned by several authors as troglobiotic species (Lebrun, 1967; Palacios-Vargas et al., 1998; Kováč et al., 2005). It was noted in Belgian caves by Leruth (1939). Several troglobites were recorded from Belgian caves so far. Eight aquatic species (*Soldanellonyx chappuisi*, *Parasoldanellonyx typhlops belgicus*, *Schwiebea cavernicola*, *Feltria subterranea*, *Lobohalacarus weberi*, *Soldanellonyx visurgis*, *Stygomonomia latipes*, *Neoacarus hibernicus*) collected by Leruth (1939) and Martin et al. (2009) and four terrestrial species: *Gemnazetes cavatica*, *Belba lengersdorfi*, *Hypogeoppia belgicae* and *Pachyseius angustiventris* recorded by Willmann (1935), Leruth (1939) and Lebrun (1967) and Wauthy and Ducarme, 2006). We propose to raise to this status two additional mite species.

Caves have become a focus of conservation efforts because they represent a unique ecosystem with high levels of endemism (Elliott, 2000). Three main categories can be recognized for cave dwellers (Jefferson, 1983): troglobites (animals restricted to the cave environment), troglophiles (species that can live permanently underground, but which also occur on the surface) and trogloxenes (facultative dwellers of caves). For mites it is practically impossible to recognize troglophiles from trogloxenes. This depends on detailed comparison of the cave fauna with the mite fauna on the surface in soil and litter surrounding a cave. This information is almost never available. Furthermore, almost all representatives of edaphic fauna (excluding epigeic forms) may be considered as troglophiles. So, we decided not to discuss about mites as troglophilous species. Troglomorphism (elongation and attenuation of chelicerae, pedipalps, legs, and chaetotaxy, including slender dechitinization) is almost unknown in mites. It occur in the Rhagidiidae family (Zacharda, 1979). Bernini (1980) and Bruckner (1995) proposed an explanation for the lack of troglomorphism in Oribatida. According to the authors for these tiny animals, the subterranean environment may spatially resemble soils, so that further adaptations did not evolve.

4.4. Human impact and mite diversity in caves

Some cavities in Belgium are under the protection of an official committee authorised to take conservation measures. In 10 such cavities, we observed higher diversity than in 20 others. It may suggest that this form of protection of vulnerable subterranean habitats works quite well. It is noteworthy to mention that *V. hubarti*, *V. leruthi* and *D. lengersdorfi* (troglobites) were found in low numbers in Brialmont, Fayt, Hotton and Rosée caves. Most of these caves did not gain the status of underground cavity of scientific interest (CSIS). Furthermore, the Hotton cave is partly accessible for tourists.

Five studied caves are open to the public and this enabled us to discuss the problem of human impact upon the cave mite community. In these habitats comparatively high number of individuals and species were recorded. And it was characteristic that the highest number of Astigmata was found in Neptune and Hotton caves, which are accessible for tourists. Similarly, in three artificial cavities, many individuals and species were collected. It may suggest that passive transport of mites on footwear and on the clothes of visitors plays an important role in establishing mite fauna in caves. The strong influence of tourists on mite fauna in subterranean habitats is well proved by some authors (Skubała and Kłys, 2002; Skubała et al., 2005). However, the species composition of the mite communities in caves accessible for tourists did not differ much from other natural or artificial cavities. Only the mite fauna in the Ramioul grotte (open to public) belongs to a group of cavities clearly distinct from other studied underground localities (see Fig. 2).

4.5. Different sampling techniques and their efficiency

We used different sampling techniques to collect mite species in cavities (explained in Section 2). As a result we collected 99 mite species from 137 samples from 30 caves and other cavities. Similar studies on mite speleofauna in Belgian caves were done by Ducarme et al. (2003). The authors collected a lower number of mite species (77) from a higher number of samples (195) in 25 caves. Piles of earthy material (50 cm^3 and only some 150–200 cm^3) were chosen for sampling by them. Why were we able to find 22 more species while collecting fewer samples than the above-mentioned authors? We explored only five caves more, so the difference might be the result of using different sampling methods. It is noteworthy that simple cluster analysis identified the separated group of cavities in which two or three different sampling methods were implied. This phenomenon – the importance of using different sampling methods to recognize biodiversity of fauna in a subterranean biome – is well-known in speleology (Hippa et al., 1988; Ľuptáčik and Miko, 2003; Culver et al., 2004; Zagmajster et al., 2008). The authors also emphasised the desirability of multiple sampling over time. As regards collecting material, the volume of a sample is also important. In our studies earthy samples amounted to 150–200 cm^3 (higher than in Ducarme et al., 2003), which seems to be optimal.

Furthermore, the same three caves (Monceau, Noû Maulin and Remouchamps) were explored in our and Ducarme's studies (Ducarme et al., 2003). The authors collected 94 samples, whereas only 18 samples were collected in our studies in these caves. Twenty-six species were collected by Ducarme et al. (2003), whereas three more mite species were found in our collecting material. These data point out again that it is very important to combine several collecting methods in subterranean habitats to record the majority of mite species.

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Appendix A. Check-list of Acari species (Mesostigmata, Oribatida, Prostigmata, Astigmata) in cavities of Belgium. In brackets numbers of specimens found at each site.

Taxa	Distribution
Mesostigmata	
Cohort: UROPODINA	
Trachytidae	
Trachytes aegrota (C.L. Koch, 1841)[a]	FR 17.08.2000 (1dtn); MG 04.06.2001 [Ber] (1♀)
Trachytes lambda Berlese, 1903[a]	MG 04.06.2001 [Ber] (1♀)
Uropodidae	
Cilliba cassidea (Hermann, 1804)[a]	FA 07.07.2001 (1♀, 1dtn); MG 04.06.2001 [Ber] (2♀, 1dtn); VE 22.02.2001 [Ber] (5♀, 2♂); VE 29.03.2001 [entrance] (1♀)
Cilliba erlangensis Hirschmann & Zirngiebl-Nicol, 1969[a]	VE 22.02.2001 [Ber] (1♀)
Cohort: UROPODINA	
Zerconidae	
Zercon sp.	FR 17.08.2000 (1♀, 1♂)
Zerconidae	FR 17.08.2000 (2juv)
Parasitidae	
Eugamasus magnus (Kramer, 1876)	AP 23.06.2002 (1♀); BT 22.07.2000 (1♂); BR 24.07.2000 (1♀); CA 08.10.1998 (1♀); LA 05.04.2004 (1♀); LY 06-22.06.1999 (26♀, 15♂); LY 22.06-12.07.1999 (18♀, 13♂, 1dtn); LY 12-24.09.1998 (1♀); LG 21.07.2003 [Ber] [entrance] (1♀); MG 06.05.1999 [entrance] (1♀); MG 22.05.1999 [entrance](1♀); MG 28.04.2001 (1♂); NM 01.06.2002 (1♂); RA 03.04.1982 (6♀); RG 06.06.1999 (1♀); VE 28.07.2005 [Ber] (1♂)
Eugamasus sp.	CA 08.10.1998 (2dtn); LY 06-22.06.1999 (3dtn); LY 22.06-12.07.1999 (1prt, 2dtn); LG 21.07.2003 [Ber] [entrance] (3dtn)
Gamasodes spiniger (Trägårdh, 1910)[a]	LY 22.06-12.07.1999 (3dtn); RA02-23.09.1999 (1dtn)
Parasitus loricatus (Wankel, 1861)[a]	AR 11.11.2000 (2♀, 1♂); BR 10.05.2000 (1♀, 1♂); BR 10-15.05.2000 [Ber] (2♀); BR 24.07.2000 (1♀, 1♂); CA 08.10.1998 (1♀); CA 22.10.1998 (1♀); LAM 23.08.2001 [Ber] (1♂); LI 21.05.2004 (1♀); LI 21.10.2004 (2♀, 1♂); LS 03-04.05.2005 (1♀); MG 06.05.1999 [entrance] (1♂); MG 22.05.1999 [entrance] (3♀, 2♂); MG 04.06.2001 [Ber] (2♀, 2♂); VE 22-26.12.2000 [Ber] (3♂)
Parasitus sp.[a]	BT 08.09.2001 (1♀); BR 24.07.2000 (1dtn); CH 18.10.2003 (1prt); CA 08.10.1998 (1dtn); FA 07.07.2001 (2lrv, 1dtn); HO 30.10.2002 (1dtn); LAM 23.08.2001 [Berl] (1dtn); LA 03.01.2004 (3dtn); LG 21.07.2003 [Ber] [entrance] (1dtn); MG 04.06.2001 [Ber] (1lrv, 7dtn); RG 17.08.2002 (4dtn); VE 20.03.2005 (1lrv)
Poecilochirus austroasiaticus Vitzthum, 1930[a]	LI 21.05-03.06.2004 (1dtn)

Taxa	Distribution
Porrhostaspis lunulata Müller, 1859[a]	CO 06-12.06.2002 (1♀); FA 07.07.2001 (4♀, 3♂); LI 21.05.2004 (1♀); LI 21.05-03.06.2004 (2♀, 3♂); LI 13.07.2005 (1♀, 1♂); LY 12-24.09.1998 (1♀); LY 22.06-12.07.1999 (2♀, 1♂); RA 09-23.09.1999 (3♀); RoG 09-30.03.2000 (1♀); VE 29.03.2001 [entrance] (1♀)
Porrhostaspis sp.[a]	FA 07.07.2001 (1dtn)
Paragamasus (*Aclerogamasus*) *alpestris* (Berlese, 1904)[a]	FA 07.07.2001 (1♀); LAM 23.08.2001 [Ber] (1♀); MG 16.02.2003 (1♀); RA 29.04.1999 (1♂); RG 08.04.1999 (1♀, 1♂); RG 14.09.2001 (1♀); RG 17.08.2002 (1♀); VE 22-26.12.2000 [Ber] (1♀); VE 22.02.2001 [Ber] (1♀, 2♂); VE 29.03.2001 [entrance] (2♀, 3♂)
Lysigamasus lapponicus (Trägårdh, 1910)[a]	FR 17.08.2000 (6♀, 5♂); RG 17.08.2002 (2♂); VE 22.02.2001 [Ber] (8♀, 1♂); VE 29.03.2001 [entrance] (6♀, 3♂); VE 20.03.2005 (1♀)
Lysigamasus sp.	FR 17.08.2000 (1dtn)
Pergamasus (*Pergamasus*) *crassipes* (Linné, 1758)[a]	CO 06-12.06.2002 (1♂); LI 21.05-03.06.2004 [Bar] [entrance] (1♀); LI 21.10.2004 (2♀); MG 06.05.1999 [entrance] (1♀); RA 02-23.09.1999 (1♀); RA 09-23.09.1999 (2♀); VE 22.02.2001 [Ber] (2♀, 1♂); VE 29.03.2001 [entrance] (1♂)
Pergamasus (*Thenargamasus*) *norvegicus* (Berlese, 1905)[a]	MG 06.06.2005 (1♀); RG 17.08.2002 (1♀); VE 29.03.2001 [entrance] (12♀)
Pergamasus sp.	CH 03.05.2001 (1dtn); FA 07.07.2001 (1dtn); RG 17.08.2002 (1dtn); RoG 09-30.03.2000 (1♀); VE 29.03.2001 [entrance] (1dtn)
Veigaiidae	
Veigaia cervus (Kramer, 1876)[a]	VE 22.02.2001 [Ber] (1♀); VE 20.03.2005 (1♀)
Veigaia exigua (Berlese, 1916)	CH 16.02.2001 (3♀); LG 10.02.2001 (1♀)
Veigaia leruthi Willmann, 1935	FA 02.12.2000 (1♀); RO 28.08.2002 (1♂)
Veigaia nemorensis (C.L. Koch, 1839)[a]	CH 03.05.2001 (3♀, 1dtn); FR 17.08.2000 (1♀); HO 30.10.2002 (8♀)
Veigaia cf. *nemorensis* (C.L. Koch, 1839)[a]	FA 02.12.2000 (1♀)
Veigaia planicola (Berlese, 1892)	LS 03-04.05.2005 (1♀); VE 24.11.2000 (1lrv); VE 22-26.12.2000 [Ber] (1lrv, 2dtn); VE 22.02.2001 [Ber] (1♀)
Veigaia transisale (Oudemans, 1902)[a]	CH 16.02.2001 (1♀, 1dtn); CA 28.021999 (1♀)
Veigaia hubarti Masan & Madej 2010[c]	HO 30.10.2002 (2♀, 4dtn)
Veigaia sp.	BR 10.05.2000 (1dtn); CH 16.02.2001 (1dtn); CH 05.04.2001 (1♀); CH 03.05.2001 (1prt); FA 07.07.2001 (1dtn); HO 30.10.2002 (1lrv, 1dtn); LG 10.02.2001 (1dtn); MG 04.06.2001 [Ber] (1prt); NE 08.09.2003 (2dtn); RA 16.01.2002 (1dtn); RA 18-22.04.2002 (2dtn); RG 01.2000 (1lrv, 8dtn); RoG 22.02.2001 (2dtn); VE 12.10.2000 (1dtn)
Rhodacaridae	
Cyrtolaelaps mucronatus (G. & R. Canestrini, 1881)	CA 08.10.1998 (1♀, 1♂)
Rhodacarus section *calcarulatus*[a] Shcherbak (1980)	NE 08.09.2003 (1♂)
Rhodacarus sp.	VE 12.10.2000 (1♂)
Digamasellidae	
Dendrolaelaps (*Punctodendrolaelaps*) *fallax* (Leitner, 1949)[a]	CH 03.05.2001 (1♀)
Dendrolaelaps (*Punctodendrolaelaps*) cf. *fallax* (Leitner, 1949)[a]	CH 03.05.2001 (1♀)
Eviphididae	
Alliphis halleri (G. & R. Canestrini, 1881)[a]	LG 10.02.2001 (15♀, 8♂, 2dtn)
Eviphis ostrinus (C.L. Koch, 1836)	RG 01.2000 [Ber] (1♂)
Macrochelidae	
Geholaspis (*Geholaspis*) *longispinosus* (Kramer, 1876)	CO 06-12.06.2002 (1♀); FA 19.05.2000 (3♀); FA 07.07.2001 (3♀, 1dtn)
Geholaspis (*Longicheles*) *mandibularis* (Berlese, 1904)	BR 10.05.2000 (2♀); CH 16.02.2001 (2♀, 7dtn); CH 03.05.2001 (1♀); LG 03.06.1999 (1dtn); LG 21.07.2003 [Ber] [entrance] (1♀); MG 04.06.2001 [Ber] (4♀, 4dtn); NE 08.09.2003 (1♀); RG 17.08.2002 (1♀); TR 29.07-01.08.1999 (1♀)
Macrocheles carinatus (C.L. Koch, 1839)[a]	CA 08.10.1998 (1♀)
Macrocheles montanus (Willmann, 1951)[a]	LI 21.05-03.06.2004 [Bar] [entrance] (1♀); MG 04.06.2001 [Ber] (4♀); VE 22.02.2001 [Ber] (2♀)
Macrocheles sp.[a]	CA 08.10.1998 (2dtn); LI 13.07.2005 (1♀); LG 21.07.2003 [Ber] [entrance] (1dtn); MG 04.06.2001 [Ber] (1dtn); VE 29.03.2001 [entrance] (1♀)
Pachylaelapidae	
Pachylaelaps longisetis Halbert, 1915[a]	CH 16.02.2001 (1♀); RG 08.04.1999 (1♀); RG 12.10.2000 (1♂)
Pachylaelaps sp.	CA 04.08.1999 (1♀); LG 21.07.2003 [Ber] [entrance] (1♀); RA 12.07.2005 (1dtn); RO 28.08.2002 (1dtn)
Ascidae	
Zerconopsis remiger (Kramer, 1876)	BR 10.05.2000 (2♀)
Phytoseiidae	
Phytoseiidae[a]	CO 17.06.2001 (1♀)
Laelapidae	
Hypoaspis (*Alloparasitus*) *sardoa* (Berlese, 1911)[a]	LI 24.01.2004 [Ber] (1♀)
Hypoaspis (*Cosmolaelaps*) *vacua* (Michael, 1891)[a]	MG 06.06.2005 (1♀)
Geolaelaps aculeifer (Canestrini, 1883)[a]	CH 16.02.2001 (4♀, 1♂, 1lrv, 10dtn); CH 05.04.2001 (10♀, 2♂, 2dtn); HO 29.09.2002 [Ber] (1♀); HO 30.10.2002 (1♀, 1♂); RA 18-22.04.2002 (1♀)
Hypoaspis (*Geolaelaps*) cf. *praesternalis* Willmann, 1949[a]	LI 24.01.2004 [Ber] (1♀)
Hypoaspis sp.	HO 29.09.2002 [Ber] (2dtn); LS 30.08.2005 (1dtn)
Spinturnicidae	
Spinturnix sp.	MG 04.06.2001 [Ber] (1♀)
Oribatida	
Supercohort: ENARTHRONOTIDES	
Hypochthoniidae	
Hypochthonius rufulus C.L. Koch, 1835	LY 12-24.09.1998 (1); VE 29.03.2001 [entrance] (1)
Supercohort: MIXONOMATIDES	
Phthiracaridae	
Phthiracarus (*P.*) *crinitus* (C.L. Koch, 1841)[b]	RG 17.08.2002 (3); VE 29.03.2001 [entrance] (1)
Phthiracarus (*P.*) *ferrugineus* (C.L. Koch, 1841)[b]	RG 17.08.2002 (1); VE 22.02.2001 [Ber] (11)
Phthiracarus (*P.*) *laevigatus* (C.L. Koch, 1841)[a]	MG 04.06.2001 [Ber] (2); MG 06.06.2005 (3); RA 19.08.1999 (1); RA 09-23.09.1999 (1); RG 17.08.2002 (1 + 2)
Phthiracarus (*Archiphthiracarus*) *anonymus* Grandjean, 1933[a]	CH 16.02.2001 (16); CH 17.12.2002 (1); HO 29.09.2002 [Ber] (1); LAM 30.08.2001 (2)
Steganacarus (*S.*) *magnus* (Nicole, 1855)	LI 06.01.2005 (1); LG 21.07.2003 [Ber] [entrance] (4); MG 04.06.2001 [Ber] (8); RG 17.08.2002 (2); VE 22.02.2001 [Ber] (3)

Taxa	Distribution
Steganacarus (*S.*) *spinosus* (Sellnick, 1920)[a]	RG 17.08.2002 (1)
Supercohort: DESMONOMATIDES	
Cohort: NOTHRINA	
Crotoniidae	
Heminothrus (*Platynothrus*) *peltifer* (C.L. Koch, 1839)	FA 07.07.2001 (1); FR 17.08.2000 (1); LG 10.02.2001 (8juv); VE 22.02.2001 [Ber] (1)
Cohort: BRACHYPYLINA	
Hermanniidae	
Hermannia (*H.*) *gibba* (C.L. Koch, 1839)[a]	MG 04.06.2001 [Ber] (19); MG 17.08.2002 (1)
Hermanniellidae	
Hermanniella punctulata Berlese, 1908[b]	MG 04.06.2001 [Ber] (1)
Neoliodidae	
Platyliodes longisetosus Sitnikova, 1975[b]	RG 14.09.2001 (1)
Damaeidae	
Damaeus (*D.*) *gracilipes* (Kulczyński, 1902)[b]	LI 13.07.2005 (2); VE 24.11.2000 (1); VE 29.03.2001 [entrance] (2)
Damaeus (*Adamaeus*) *onustus* C.L. Koch, 1841	BR 24.07.2000 (1); LI 21.10.2004 (1); LI 13.07.2005 (20); LG 21.07.2003 [Ber] [entrance] (1); MG 04.06.2001 [Ber] (1); MG 06.06.2005 (2); RG 23.10.2004 (1); TF 12.11.2000 (2)
Damaeus (*Kunstidamaeus*) cf. *lengersdorfi* (Willmann, 1932)[b]	BR 10-15.05.2000 [Ber] (1)
Metabelba (*M.*) *pulverulenta* (C.L. Koch, 1839)[b]	CA 08.10.1998 (1)
Porobelba spinosa (Sellnick, 1920)[a]	CA 08.10.1998 (1)
Damaeidae (juv)	CA 08.10.1998 (2); LI 13.07.2005 (2); RA 09-23.09.1999 (1)
Liacaridae	
Liacarus (*L.*) *coracinus* (C.L. Koch, 1841)[a]	MO 06.09.2005 (1)
Xenillus (*X.*) *tegeocranus* (Hermann, 1804)	FR 17.08.2000 (1 + 1); LI 13.07.2005 (2); MG 04.06.2001 [Ber] (9); MG 17.08.2002 (1); RA 09-23.09.1999 (1); VE 22.02.2001 [Ber] (2)
Eremaeidae	
Eueremaeus oblongus (C.L. Koch, 1835)[a]	CA 08.10.1998 (1)
Oppiidae	
Oppia denticulata (G. & R. Canestrini, 1882)[b]	LI 21.10.2004 (2)
Berniniella sp.	MG 04.06.2001 [Ber] (1); RG 21.10.1999 (1); RG 01.2000 (1)
Oppiella (*O.*) *nova* (Oudemans, 1902)	VE 29.03.2001 [entrance] (1)
Cymbaeremaeidae	
Cymbaeremaeus cymba (Nicolet, 1855)[a]	LI 20.02.2004 [Ber] (1)
Oribatellidae	
Oribatella (O.) calcarata (C.L. Koch, 1835)[a]	FR 17.08.2000 (1); RA 12.07.2005 (1); VE 29.03.2001 [entrance] (8)
Ceratozetidae	
Ceratozetes (*C.*) *peritus* Grandjean, 1951[a]	BR 10-15.05.2000 [Ber] (1)
Euzetes globulus (Nicolet, 1855)	CA 08.10.1998 (2); LI 13.07.2005 (7); MG 04.06.2001 [Ber] (2); MG 17.08.2002 (1); MG 06.06.2005 (1); RG 17.08.2002 (2); VE 10-12.01.2001 [Bar] (1); VE 22.02.2001 [Ber] (1); VE 29.03.2001 [entrance] (17)
Humerobatidae	
Humerobates rostrolamellatus Grandjean, 1936[a]	RE 24.03-10.04.2000 (1)
Hemileiidae	
Dometorina plantivaga (Berlese, 1895)[a]	LI 13.07.2005 (1)
Galumnidae	
Galumna (*G.*) *lanceata* (Oudemans, 1900)[a]	CO 06-12.06.2002 (1)
Juveniles	CH 16.02.2001 (2 + 3); FR 17.08.2000 (2 + 1); LG 10.02.2001 (1); MG 16.02.2003 (1); MG 17.08.2002 (1)
Prostigmata	
Supercohort: EUPODIDES	
Bdellidae	
Neomolgus sp.[a]	MG 22.05.1999 [entrance] (1)
Eupodidae	
Linopodes sp.	FS13.07.2002 (1♀, 1dtn)
Protereunetes sp.[a]	AR 11.11.2000 (1♀ with 1 egg)
Rhagidiidae	
Traegaardhia cf. *dalmatina* (Willmann, 1939)[a]	BR 24.07.2000 (1♀ with 6 eggs); CH 05.02.2001 (1♀ with 4 eggs); CH 18.10.2003 (2♀); FA (07.07.2001 (1♀ with 7 eggs); LI 21.05-03.06.2004 (1trn); LS 03-04.05.2005 (1♀); LG 21.07.2003 [Ber] [entrance] (1♀); MG 06.05.1999 [entrance] (1♀ with 2 eggs + 1♀); MG 28.04.2001 (1♀ with 3 eggs); MG 17.08.2002 (1♀); RA 29.04.1999 (1♀ with egg); RA 30.11.2000-10.01.2001 (1♀); RG 01.2000 (1♀ with 2 eggs); RG 20.03.2005 (1♀); RE 24.03.2000 (1trn?); VE 10-12.01.2001 [Bar] (1trn?)
Ereynetidae	
Ereynetes sp.	LG 02.11.1999 (2♀)
Supercohort: ANYSTIDES	
Cohort: PARASITENGONA	
Calyptostomatidae	
Calyptostoma velutinum (Mueller, 1776)[a]	RG 18.02.1999 (1dtn); RG 01.2000 (1dtn); RG 13.01.2000 (1lrv); RG 02.03.2000 (1dtn); TR 29.07.1999 (1dtn); VE 22.02.2001 [Ber] (1ad); VE 29.03.2001 [entrance] (1dtn)
Trombidiidae	
Allothrombium adustum Oudemans, 1905[b]	RE 24.03.2000 (1ad)
Microtrombidiidae	
Campylothrombium clavatum (George, 1909)[a]	LI 13.07.2005 (1ad); RG 08.09.1998 (1ad)
Hydrachnidae	
Unidentified species	RO 28.08.2002 (1)
Supercohort: ELEUTHERENGONIDES	
Cohort: RAPHIGNATHINA	
Stigmaeidae	
Unidentified species[a]	VE 29.03.2001 [entrance] (1)
Tetranychidae	
Bryobia sp.[a]	ST 22.04.1999 (1♀)
Cohort: HETEROSTIGMATINA	

Taxa	Distribution
Scutacaridae	
Scutacarus sp.	NM 01.06.2002 (1♀)
Astigmata	
Glycyphagidae	
Glycyphagus domesticus (De Geer, 1778)[a]	RoG 22.02.2001 (1♀)
Acaridae	
Tyrophagus longior (Gervais, 1844)[a]	NE 21.08.2002 (11♀, 11♂, 5trn); RO 28.08.2002 (1♀, 1trn)
Tyrophagus putrescentiae (Schrank, 1781)[a]	VE 22-26.12.2000 [Ber] (9♀)
Tyrophagus similis Volgin, 1949[a]	FR 17.08.2000 (5♀, 1trn); HO 30.10.2002 (3♀, 1trn); MG 17.08.2002 (1♀)
Schwiebea lebruni Fain, 1977[a]	CH 16.02.2001 (1♂)
Schwiebea meerdeaelensis Fain, 1977 [a]	HO 30.10.2002 (10♀, 1prt)
Schwiebea sp.	CH 16.02.2001 (1♂)

Codes of cavities – see Table 1; ad – adult, juv – juvenile; lrv – larva; prt – protonymph; dtn – deutonymph; trn – tritonymph. Bar – method II (with Barber traps); Ber – method III (using Berlese funnels); entrance – samples collected close to an entrance of a cave.

[a] New species for the subterranean environments in Belgium.

[b] New species for the fauna of Belgium.

[c] New species to the science.

References

Baker, A.S., 1999. Mites and Ticks of Domestic Animals. An Identification Guide and Information Source. The Stationery Office, London.

Bernini, F., 1980. Notulae Oribatologicae. XXIV. Gli Acari Oribatei di alcune piccole grotte del Senese. Redia 63, 359–405.

Bruckner, A., 1995. Cave-dwelling oribatid mites (Acarina, Cryptostigmata) from East Austria. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich 132, 81–107.

Bugrov, A., 1995. New species of the genus *Schwiebea* (Astigmata, Acaridae) from Russia and adjacent countries. Zoologicheskij Zhurnal 74 (6), 61–75 (in Russian).

Chmielewski, W., 1995. Results of acarological analyses of honey. In: Proc. Symp. "Advances of Acarology in Poland", Siedlce, September 26–27, 1995. Drukarnia ISK, Siedlce, p. 204.

Colloff, M.J., 2009. Dust Mites. Springer. CSIRO Publishing, Collingwood, Australia.

Culver, D.C., 2008. The struggle to measure subterranean biodiversity. In: Martin, J.B., White, W.B. (Eds.), Frontiers of Karst Research. Special Publication 13. Karst Waters Institute, Charlottesville, Virginia, pp. 54–59.

Culver, D.C., Christman, M.C., Elliott, W.R., Hobbs, H.H., Redell, J.R., 2003. The North American obligate cave fauna: regional patterns. Biodiversity and Conservation 12, 441–468.

Culver, D.C., Christman, M.C., Sket, B., Trontelj, P., 2004. Sampling adequacy in an extreme environment: species richness patterns in Slovenian caves. Biodiversity and Conservation 13, 1209–1229.

Culver, D.C., Holsinger, J.R., 1992. How many species of troglobites are there? NSS Bulletin 54, 79–80.

Culver, D.C., Pipan, T., Gottstein, S., 2006. Hypotelminorheic – a unique freshwater habitat. Subterranean Biology 4, 1–8.

Culver, D.C., Sket, B., 2000. Hotspots of subterranean biodiversity in caves and wells. Journal of Cave and Karst Studies 62, 11–17.

De Broyer, Cl., Thys, G., Fairon, J., Michel, G., 1999. Atlas du Karst Wallon. Commission wallonne d'étude et de protection des sites souterrains (CWEPSS). 150 cartes.

Delhez, F., Dethier, M., Hubart, J.-M., 1999. Contribution à la connaissance de la faune des grottes de Wallonie. Bulletin des Chercheurs de la Wallonie 39, 27–54.

Dethier, M., 1998. La collection Delhez. 1. Catalogue provisoire. Bulletin des Chercheurs de la Wallonie 38, 33–76.

Dethier, M., Hubart, J.-M., 2000a. La collection Delhez. 2. Corrigenda et addenda. Bulletin des Chercheurs de la Wallonie 40, 17–35.

Dethier, M., Hubart, J.-M., 2003. Nouvelles récoltes et observations concernant la faune souterraine de Wallonie. Bulletin des Chercheurs de la Wallonie 42, 45–56.

Ducarme, X., 2003. Convergences et divergences microadaptatives chez les acariens endogés et cavernicoles. Thèse de doctorat. Université catholique de Louvain, p. 173.

Ducarme, X., Michel, G., Lebrun, Ph., 2003. Mites from Belgian caves: an extensive study. Subterranean Biology 1, 13–23.

Ehrlich, P.R., Wilson, E.O., 1991. Biodiversity studies: science and policy. Science 253, 758–762.

Ek, C., 1976. Les phénomènes karstiques. In: Pissart, A. (Ed.), Géomorphologie de la Belgique. Liège, pp. 137–157.

Ek, C., 1979. Les phénomènes karstiques dans les calcaires paléozoïques de la Belgique. Processus actuels, problèmes actuels. Annales de la Société Géologique de Belgique 102, 13–26.

Elliott, W.R., 2000. Conservation of the North American cave and karst biota. In: Wilkens, H., Culver, D.C., Humphreys, W.F. (Eds.), Subterranean Ecosystems. Elsevier, Amsterdam, pp. 665–689.

Elliott, W.R., 2007. Zoogeography and biodiversity of Missouri caves and karst. Journal of Cave and Karst Studies 69, 135–162.

Fan, Q.H., Zhang, Z.Q., 2007. Revision of *Tyrophagus* Oudemans (Acari: Acaridae) of New Zealand and Australia. Fauna of New Zealand, no. 56. Manaaki Whenua Press, Lincoln, Cantenbury, New Zealand.

Fenďa, P., Košel, V., 2000. The mites (Acarina: Mesostigmata) from caves of the Slovak Paradise. In: Mock, A., Kováč, Ľ., Fulin, M. (Eds.), Fauna jaskýň (Cave Fauna). Košice, pp. 21–30.

Franz, J.T., Masuch, G., Musken, H., Bergmann, K.C., 1997. Mite fauna in German farms. Allergy 52, 1233–1237.

Gabryś, G., Mąkol, J., Łaydanowicz, J., 2008. Calyptostomatoidea. In: Bogdanowicz, W., Chudzicka, E., Pilipiuk, I., Skibińska, E. (Eds.), Fauna of Poland. Characteristics and Checklist of Species, vol. 3. Muzeum i Instytut Zoologii PAN, Warszawa, pp. 140–142, 209.

Giljarov, M.S., Bregetova, N.G. (Eds.), 1977. Key to the Soil-Inhabiting Mites. Mesostigmata. Nauka, Leningrad (in Russian).

Giljarov, M.S., Krivolutskij, A.D., 1975. Key for the Identification of Soil Mites Sarcoptiformes. Izd. Nauka, Moskva (in Russian).

Hallas, T.E., Iversen, M., Korsgaard, J., Dahl, R., 1991. Number of mites in stored grain, straw and hay related to the age of the substrate (Acari). Entomologiske Meddelelser 59, 57–60.

Hallas, T.E., Solberg, H., 1989. Mites of stored hay on the Faroe Islands (Acari). Entomologiske Meddelelser 57, 151–156.

Halliday, R.B., 2001. Mesostigmatid mite fauna of Jenolan Caves, New South Wales (Acari: Mesostigmata). Australian Journal of Entomology 40, 299–311.

Hippa, H., Koponen, S., Mannila, R., Niemi, R., Uusitalo, M., 1988. Invertebrates of Scandinavian caves. VII. Acari. Notulae Entomologicae 68, 141–146.

Howarth, F.G., 1983. Ecology of cave arthropods. Annual Review of Entomology 28, 365–389.

Hubart, J.-M., 1982. Complements a l'inventaire faunistique de la grotte de Ramioul. Les chercheurs de la Wallonie. Bulletin de la Société Royale Belge d'Etudes Geologiques et Archeologiques 25, 341–345.

Hubart, J.-M., 2001. Le milieu souterrain superficiel. Geological Survey of Belgium Professional Papers 295, 107–109.

Hubart, J.-M., Dethier, M., 1999. La faune troglobie de Belgique: état actuel des connaissances et perspectives. Bulletin de la Société Royale Belge d'Entomologie 135, 164–178.

Hughes, A.M., 1976. The Mites of Stored Food and Houses, 2nd ed. Tech. Bull. Minist. Agric., Fish and Food, No. 9. Her Majesty's Stationery Office, London.

Hyatt, K.H., 1980. Mites of the subfamily Parasitinae (Mesostigmata: Parasitidae) in the British Isles. Bulletin of the British Museum (Natural History) Zoology 38, 237–378.

Hyatt, K.H., Emberson, R.M., 1988. A review of the Macrochelidae (Acari: Mesostigmata) of the British Isles. Bulletin of the British Museum (Natural History) Zoology 54, 63–125.

Jefferson, G.T., 1983. The threshold fauna. A neglected area of British cave biology. Studies in Speleology 4, 53–58.

Juberthie, C., Delay, B., Bouillon, M., 1980. Sur l'existence d'un milieu souterrain superficiel en zone non calcaire. Comptes rendus de l'Académie des Sciences de France 290, 49–52.

Karg, W., 1987. Zur Kenntnis der Gattung *Schwiebea* Oudemans, 1916 (Acarina, Sarcoptiformes). Deutsche Entomologische Zeitschrift 34, 141–148.

Karg, W., 1993. Acari (Acarina), Milben. Parasitiformes (Anactinochaeta), Cohorts Gamasina. Leach Raubmilben. Die Tierwelt Deutschlands, Teil 59. Gustav Fischer, Jena.

Klimov, P.B., 2000. A review of acarid mites of the tribe Caloglyphini (Acaridae, Acariformes) with description of a new genus and species from Siberia and Russian Far East. Vestnik Zoologii 34 (4–5), 27–35.

Koehler, H.H., 1999. Predatory mites (Gamasina, Mesostigmata). Agriculture, Ecosystems & Environment 74, 395–410.

Kováč, Ľ., Mock, A., Ľuptáčik, P., Košel, V., Fenďa, P., Svatoň, J., Mašán, P., 2005. Terrestrial arthropods of the Domica Cave system and the Ardovská Cave (Slovak Karst) – principal microhabitats and diversity. In: Tajovský, K., Schlaghamerský, J., Pižl, V. (Eds.), Contributions to Soil Zoology in Central Europe I. Institute of Soil Biology AS CR, České Budějovice, pp. 61–70.

Krantz, G.W., Walter, D.E. (Eds.), 2009. A Manual of Acarology. , third edition. Texas Tech University Press, Lubbock, TX.

Lebrun, Ph., 1967. Note sur quelques Oribates (Acarina: Oribatei) de la faune cavernicole de Belgique. Ann. Soc. royale entomol. Belgique 103, 183–188.

Lebrun, Ph., Wauthy, G., Dufrêne, M.,1989. Soil mites in Belgium: a review. In: Comptes rendus du Symposium "Invertébrés de Belgique". Institut Royal des Sciences Naturelles de Belgique, Bruxelles, pp. 203–210.

Leruth, R., 1939. La biologie du domaine souterrain et la faun cavernicole de Belgique. Mernoires du Muste royal d'Histoire naturelle de Belgique 87, 1–507.

Lundqvist, L., Hippa, H., Koponen, S., 2000. Invertebrates of Scandinavian caves. IX. Acari: Mesostigmata (Gamasina), with a complete list of mites. Acarologia 40, 357–365.

Ľuptáčik, P., Miko, L., 2003. Oribatid mites (Acarina, Oribatida) of Slovak caves. Subterranean Biology 1, 25–29.

Mąkol, J., Gabryś, G., 2008. Trombidioidea. In: Bogdanowicz, W., Chudzicka, E., Pilipiuk, I., Skibińska, E. (Eds.), Fauna of Poland, Characteristics and Checklist of Species, vol. 3. Muzeum i Instytut Zoologii PAN, Warszawa, pp. 145–148, 210–212.

Martin, P., De Broyer, Cl., Fiers, F., Michel, G., Sablon, R., Wouters, K., 2009. Biodiversity of Belgian groundwater fauna in relation to environmental conditions. Freshwater Biology 54, 814–829.

Mašán, P., Madej, G., 2011. Description of two cave-dwelling mites of the genus Veigaia (Acari: Mesostigmata: Veigaiidae) from Belgium: *V. hubarti* sp. n. and *V. leruthi* Willmann, 1935. Journal of Natural History 45, 751–765.

Meštrov, M., 1962. Un nouveau milieu aquatique souterrain: le biotope hypotelminorhéique. Comptes Rendus de l'Académie des Sciences Paris 254, 2677–2679.

Micherdziński, W., 1969. Die Familie Parasitidae Oudemans, 1901 (Acarina, Mesostigmata). Zakład Zoologii Systematycznej, PAN, Kraków (in German).

Mock, A., Ľuptáčik, P., Fenďa, P., Svatoň, J., Horszagh, I., Krumpal, M., 2005. Terrestrial arthropods inhabiting caves near Vel'ky Folkmar (Cierna Hora Mts.; Slovakia). In: Tajovsky, K., Schlaghamersky, J., Pizl, V. (Eds.), Contributions to Soil Zoology in Central Europe I. Institute of Soil Biology ASCR, Ceske Budejovice, pp. 95–101.

Morell, M.J., Subias, L.S., 1991. Oribatid mites from the Azores Islands (Acari, Oribatida). Boletim do Museu Municipal do Funchal (Funchal, Portugal) 43, 73–105.

Moseley, M., 2007. Acadian biospeleology: composition and ecology of cave fauna of Nova Scotia and southern New Brunswick, Canada. International Journal of Speleology 36, 1–21.

Moseley, M., 2009a. Are all caves ecotones? Caves and Karst Science 36, 53–58.

Moseley, M., 2009b. Estimating diversity and ecological status of cave invertebrates: some lessons and recommendations from Dark Cave (Batu Caves, Malaysia). Caves and Karst Science 35, 47–52.

Moseley, M., 2009c. Size matters: scalar phenomena and a proposal for an ecological definition of 'cave'. Caves and Karst Science 35, 89–94.

Niedbała, W., 2008. Ptyctimous mites (Acari, Oribatida) of Poland. Fauna Poloniae, Natura optima dux Foundation 3.

Okabe, K., Hinomoto, N., OConnor, B.M., 2008. Ecological and morphological attributes of parthenogenetic Japanese *Schwiebea* species (Acari: Acaridae). Experimental and Applied Acarology 44, 77–88.

Palacios-Vargas, J.G., Decu, V., Iavorski, V., Hutzu, M., Juberthie, C., 1998. Acari terrestria. In: Juberthie, C., Decu, V. (Eds.), Encyclopaedia Biospeologica, vol. 3. Societe de Biospeologie, Moulis-Bucarest, pp. 929–952.

Papáč, V., Kováč, Ľ., Mock, A., Košel, V., Fenďa, P., 2006. Terrestrial arthropods of selected caves in the Silica Plateau. In: Bella, P. (Ed.), Výskum, využívanie a ochrana jaskýň. 5. Vedecká konferencia s medzinárodnou účast'ou pri príležitosti životného jubilea RNDr. Antona Droppu, CSc., Zborník referátov. Správa slov. jaskýň, Liptovský Mikuláš, pp. 187–199.

Perez-Iñigo, C., 1969. Bioespeleología de la cueva de Ojo Guareña. Acaros Oribátidos. Boletín de la RSEHN (Sección Biológica) 67, 143–160.

Rosický, B., Černý, V., Daniel, M., Dusbábek, F., Palička, P., Samšiňák, K., 1979. Roztoči a klíšťata škodíci zdraví člověka. Academia, Praha (in Czech).

Schmölzer, K., 1995. Catalogus Faunae Austriae. Teil IX f: U. Ordn.: Anactinochaeta (Parasitiformes). Verlag der Österreichischen Akademie der Wissenschaften, Wien (in German).

Skubała, P., Madej, G., Solarz, K., Kłys, G., 2005. Old mine underground galleries as the habitat for mites (Acari). In: Tajovsky, K., Schlaghamersky, J., Pizl, V. (Eds.), Contributions to Soil Zoology in Central Europe I. ISB AS CR, České Budějovice, pp. 141–148.

Skubała, P., Kłys, G., 2002. Oribatid fauna (Acari: Oribatida) in the mine underground workings. In: Ignatowicz, S. (Ed.), Postępy polskiej akarologii. Wyd. SGGW, Warszawa, pp. 203–212.

Solarz, K., Madej, G., Żbikowska-Zdun, K., Dudziak, G., 2002. Mites of orders Acaridida, Gamasida and Oribatida in coal mines of Upper Silesian Region (Poland). In: Ignatowicz, S. (Ed.), Postępy polskiej akarologii. SGGW, Warszawa, pp. 179–193.

Solarz, K., Szilman, P., Szilman, E., Krzak, M., Jagła, A., 2004. Some allergenic species of astigmatid mites (Acari, Acaridida) from different synanthropic environments in southern Poland. Acta Zoologica Cracoviensia 47, 125–145.

Subias, L.S., 2004. Listado sistemático, sinonímico y biogeográfico de los Ácaros Oribátidos (Acariformes, Oribatida) del mundo (1758–2002). Graellsia 60 (in Spanish with English summary). Actualizado en febrero de 2011: http://www.ucm.es/info/zoo/Artropodos/Catalogo.pdf, Cited 20 May 2011.

Tercafs, R., 2001. The Protection of the Subterranean Environment: Conservation Principles and Management Tools. P.S. Publishers, Luxembourg.

Terho, E.O., Leskinen, L., Husman, K., Kärenlampi, L., 1982. Occurrence of storage mites in Finnish farming environments. Allergy 37, 15–19.

Thor, S., Willmann, C., 1941. Acarina 71a. Eupodidae Penthalodidae, Penthaleidae, Rhagidiidae, Pachygnathidae, Cunaxidae. Das Tierreich. Walter de Gruyter & Co.

Turk, F.A., 1972. Biological notes on Acari recently recorded from British caves and mines with descriptions of three new species. Transactions of the Cave Research Group of Great Britain 14, 187–194.

Van den Broeck, E., Martel, E.A., Rahir, E.D. (Eds.), 1910. Les cavernes et les rivières souterraines de la Belgique. Bruxelles, 2.

Wauthy, G., Ducarme, X., 2006. Description of *Hypogeoppia belgicae*, a new species of cave mite (Acari, Oribatida), and comments on some characters. Belgian Journal of Zoology 136, 203–218.

Weigmann, G., 2006. Hornmilben (Oribatida). In: Dahl, F. (Ed.), Die Tierwelt Deutschland und der angrenzenden Meeresteile. 76. Teil. Goecke & Evers, Keltern.

Willmann, C., 1935. Exploration biologique des cavernes de la Belgique et du Limbourg hollandais. XXV contribution: Acari. Bulletin du Musée royal d'Histoire naturelle de Belgique 11, 1–41.

Willmann, C., 1939. Drei neue terricole Acari. Zoologische Anzeiger 125, 244–248.

Wohltmann, A., 2000. The evolution of life histories in Parasitengona (Acari: Prostigmata). Acarologia 41, 145–204.

Wohltmann, A., Gabryś, G., Mąkol, J., 2007. Acari: terrestrial Parasitengona inhabiting transient biotopes. In: Gerecke, R. (Ed.), Süßwasserfauna von Mitteleuropa 7/2-1, Chelicerata, Araneae, Acari I. Spektrum Elsevier, München, pp. 158–240.

Zacharda, M., 1979. The evaluation of the morphological characters. In: Rodriguez, J.G. (Ed.), Rhagidiidae. Recent Advances in Acarology, vol. II. Academic Press, New York, San Francisco, London, pp. 509–514.

Zacharda, M., 1980. Soil mites of the family Rhagidiidae (Actinedida: Eupodoidea). Morphology, systematics, ecology. Acta Universitatis Carolinae-Biologia (1978) 5–6, 489–785.

Zacharda, M., Fong, D., Hobbs III, H.H., Piva, E., Slay, M.E., Taylor, S.J., 2010. A review of the genus Traegaardhia (Acari, Prostigmata, Rhagidiidae) with descriptions of new species and a key to species. Zootaxa 2474, 1–64.

Zagmajster, M., Culver, D.C., Sket, B., 2008. Species richness patterns of obligate subterranean beetles (Insecta: Coleoptera) in a global biodiversity hotspot-effect of scale and sampling intensity. Diversity and Distributions 14, 95–105.