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## The rove beetles (Coleoptera: Staphylinidae) form caves in the Częstochowa Upland

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**Abstract:** The paper refers rove beetles (Staphylinidae) from caves of the Częstochowa Upland (Poland). Currently, altogether 44 species are known from this area, three of them are eutroglophiles and nine subtroglophiles, others are considered as trogloxenes. The most common species is *Quedius mesomelinus mesomelinus*.

**Key words:** Staphylinidae, caves, Kraków-Częstochowa Upland, troglophiles, trogloxenes, ecology.

### INTRODUCTION

The beetles are the most numerous order among all arthropods, with more than 400 thousand described species. The largest family are rove beetles (Staphylinidae) which represent various species that have an aptitude for inhabiting many types of environment, thus many of them have colonised undergrounds. These beetles represent ca 1 % of all known beetles from caves, which is less than ground beetles (Carabidae) or round fungus beetles (Leiodidae) (MOLDOVAN 2012), however, they are still important components of underground ecosystems. Plenty of cave-dwelling species of this family were described from Mediterranean region like Balkans (ABSOLON 1915), Morocco, Algeria, Italy, Spain (MOLDOVAN 2012), but also from caves in the temperate zone (ØSTBYE & LAURITZEN 2013, RŮŽIČKA *et al.* 2016, WEBER 2013, ZAENKER *et al.* 2020). In ecological classification they are usually troglophiles, just a few are troglobites (MOLDOVAN 2012).

Some information about rove beetles from Polish caves was published in various articles concerning general information about underground fauna, starting from the first work about cave fauna in Poland (DEMEL 1918). The most frequently mentioned species is *Quedius mesomelinus mesomelinus* (MARSHAM, 1802), which was listed by DEMEL 1918, PAX & MASCHKE 1935, KOWALSKI 1955, SKALSKI & WÓJCIK 1968, SKALSKI 1973 and 1981, GUBAŁA 1996, OCHMAN 2004. According to KOCOT-ZALEWSKA & DOMAGAŁA (2020), altogether 12 species from caves of Poland were known. Until today no article was devoted only to Staphylinidae inhabiting Polish caves. The purpose of this paper is a presentation a list of rove beetles inhabiting caves in the Częstochowa Upland with their ecological classification.

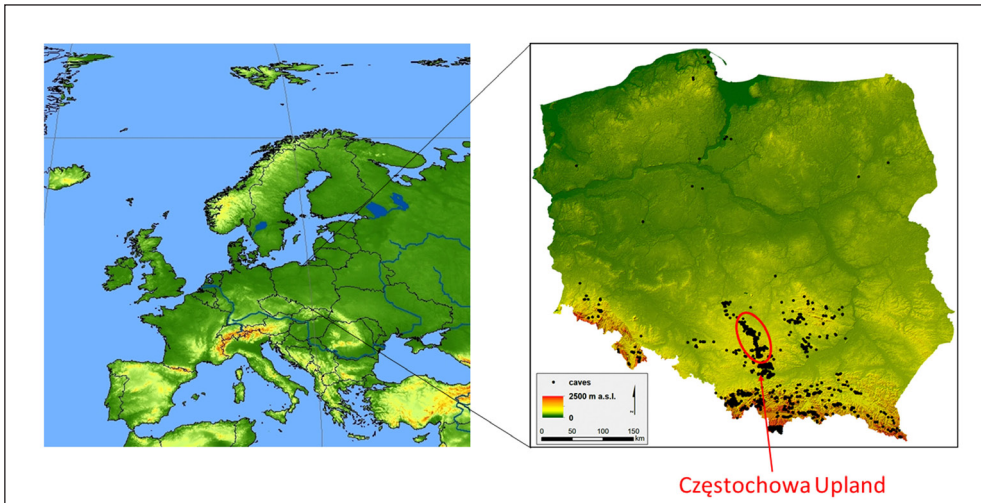


Fig. 1. Study area.

## MATERIAL AND METHODS

Study on rove beetles was performed as a part of a larger project concerning invertebrates cave fauna in the Częstochowa Upland (KOCOT-ZALEWSKA *et al.* 2021, KOCOT-ZALEWSKA & WOŹNICA 2021). Study area (Fig. 1) and collecting methods were precisely described in KOCOT-ZALEWSKA & WOŹNICA (2021). The rove beetles were found in: W Zielonej Górze Cave, Towarna Cave, Pod Sokolą Cave, Kroczycka Cave, Psia Cave, and Zegarowa Cave.

All collected specimens were determined using various identification keys for Staphylinidae. Further, basing on available literature, habitat and food preferences were analysed (BURAKOWSKI *et al.* 1979, 1980, 1981, 2000, KOCH 1989a, 1989b, 1992, MAJKA *et al.* 2009, SMOLEŃSKI 2000, SZUJECKI 2008, 2017). Additionally, constant, seasonal or occasional inhabiting in caves was evaluated by frequency in different time of year, which was the first factor taken to the ecological classification.

The concept of ecological classification is based on SKET (2008), who divided organisms into four groups with different degree of association with undergrounds:

1. Troglobionts (= troglobites) – species very closely associated to caves, that live and reproduce in cave (SKET 2008), with many morphological, physiological and behavioural adaptations to undergrounds, like depigmentation, vestigial eyes, long chemosensors, elongated life cycle (WHITE & CULVER 2012).

2. Eutroglophiles – organisms generally live on surface, but also able to create stable populations in caves, with possibility to evolve into troglobites (SKET 2008).

3. Subtroglophiles – species which prefer temporary or continuously inhabiting caves but in their biology are associated with surface environment, for example feeding or reproducing outside the cave (SKET 2008).

4. Troglonexenes – including all species that accidentally occupy caves, without capability to create stable underground population (SKET 2008).

## RESULTS

Altogether 264 specimens belong to 44 species were collected from caves in the Cześćochowa Upland (Table 1). The most frequently collected species were: *Quedius mesomelinus mesomelinus* (MARSHAM, 1802), *Omalium caesum* GRAVENHORST, 1806, and *Atheta sodalis* (ERICHSON, 1837).

Habitat preferences have been ascertained for all collected species. Results are in Figure 2. Half of studied species prefer forests. Many species live under decaying matter, litter or in burrows and tree hollows.

Constant, seasonal or occasional inhabiting in caves was evaluated by frequency in different time of year. Below are presented species that occurred in caves during the whole year (or almost) in different parts of studied caves:

– entrance zone: *Anthobium atrocephalum* (GYLLENHAL, 1810), *Atheta sodalis*, *Omalium rivulare* (PAYKULL, 1789), *Othius punctulatus* (GOEZE, 1777), *O. subuliformis* STEPHENS, 1833, *Lesteva longoetytrata* (GOEZE, 1777), *Omalium excavatum* STEPHENS, 1834, *Syntomium aeneum* (MÜLLER, 1821);

– twilight zone: *Quedius mesomelinus mesomelinus*;

– deep zone: *Quedius mesomelinus mesomelinus*, *Omalium validum* KRAATZ, 1857, *Tachinus subterraneus* (LINNAEUS, 1758).

The other species were collected only once or in two seasons. The frequency for each species was analysed, the results are in the Table 1.

Just for 38% it was possible to ascertain food preferences. An equal number of species were carnivorous and detritivorous, and one was fungivorous (mycophagus).

Based on abovementioned information, the ecological classification was performed. Three species have been recognized as eutroglophiles, nine species as subtroglophiles, and other 32 species as trogloxenes (Table 1).

Table 1. The list of species with marked seasonality, cave' number in which species was detected, and ecological classification. **1** – W Zielonej Górze, **2** – Towarna, **3** – Pod Sokolą, **4** – Kroczycka, **5** – Psia, **6** – Zegarowa.

N°	Species	Seasonality				Cave number	Ecological classification
		Spring	Summer	Autumn	Winter		
1.	<i>Acidota cruentata</i> MANNERHEIM, 1830					2,3	trogloxene
2.	<i>Anotylus inustus</i> (Gravenhorst, 1806)					6	trogloxene
3.	<i>Anotylus sculpturatus</i> (GRAVENHORST, 1806)					6	trogloxene
4.	<i>Anthobium atrocephalum</i> (GYLLENHAL, 1810)					1,3,4,6	subtroglophile
5.	<i>Atheta crassicornis</i> (FABRICIUS, 1793)					1,6	trogloxene
6.	<i>Atheta fungi</i> (GRAVENHORST, 1806)					1	trogloxene

N°	Species	Seasonality				Cave number	Ecological classification
		Spring	Summer	Autumn	Winter		
7.	<i>Atheta gyllenhalii</i> (THOMSON, 1856)					3	trogloxene
8.	<i>Atheta ravilla</i> (ERICHSON, 1839)					1,3	trogloxene
9.	<i>Atheta sodalis</i> (ERICHSON, 1837)					1,3,4,5,6	<b>subtroglophile</b>
10.	<i>Autalia longicornis</i> SCHEERPELTZ, 1947					1,3	trogloxene
11.	<i>Bryaxis puncticollis</i> (DENNY, 1825)					5	trogloxene
12.	<i>Bryophacis crassicornis</i> (MÄKLIN, 1847)					3	trogloxene
13.	<i>Bythinus macropalpus</i> AUBÉ, 1833					6	trogloxene
14.	<i>Dinaraea angustula</i> (GYLLENHAL, 1810)					3	trogloxene
15.	<i>Dinothenarus fossor</i> (SCOPOLI, 1771)					3	trogloxene
16.	<i>Domene scabricollis</i> (ERICHSON, 1840)					6	trogloxene
17.	<i>Gabrius breviventer</i> (SPERK, 1835)					3	trogloxene
18.	<i>Ischnosoma longicorne</i> (MÄKLIN, 1847)					4	trogloxene
19.	<i>Lesteva longoelytrata</i> (GOEZE, 1777)					3,6	<b>subtroglophile</b>
20.	<i>Liogluta alpestris</i> (HEER, 1839)					1,4	trogloxene
21.	<i>Mycetoporus clavicornis</i> (STEPHENS, 1832)					1	trogloxene
22.	<i>Ocalea picata</i> (STEPHENS, 1832)					3	trogloxene
23.	<i>Ocypus macrocephalus</i> (GRAVENHORST, 1802)					6	trogloxene
24.	<i>Omalium caesum</i> GRAVENHORST, 1806					1,3,5,6	<b>subtroglophile</b>
25.	<i>Omalium excavatum</i> STEPHENS, 1834					1,6	<b>subtroglophile</b>
26.	<i>Omalium rivulare</i> (PAYKULL, 1789)					1,6	<b>subtroglophile</b>
27.	<i>Omalium validum</i> KRAATZ, 1857					5,6	<b>eutroglophile</b>
28.	<i>Othius punctulatus</i> (GOEZE, 1777)					3,4,5	<b>subtroglophile</b>
29.	<i>Othius subuliformis</i> STEPHENS, 1833					1,4	<b>subtroglophile</b>
30.	<i>Oxypoda acuminata</i> (STEPHENS, 1832)					4	trogloxene
31.	<i>Oxypoda annularis</i> (MANNERHEIM, 1830)					1,3	trogloxene

N°	Species	Seasonality				Cave number	Ecological classification
		Spring	Summer	Autumn	Winter		
32.	<i>Oxyptoda praecox</i> ERICHSON, 1839					2	trogloxene
33.	<i>Philonthus decorus</i> (GRAVENHORST, 1802)					3	trogloxene
34.	<i>Phloeonomus punctipennis</i> THOMSON, 1867					3	trogloxene
35.	<i>Proteinus brachypterus</i> (FABRICIUS, 1792)					3,4	trogloxene
36.	<i>Quedius limbatus</i> (HEER, 1839)					3	trogloxene
37.	<i>Quedius mesomelinus mesomelinus</i> (MARSHAM, 1802)					1,2,3,4,5,6	eutroglophile
38.	<i>Sepedophilus marshami</i> (STEPHENS, 1832)					2	trogloxene
39.	<i>Staphylinus erythropterus</i> LINNAEUS, 1758					1	trogloxene
40.	<i>Syntomium aeneum</i> (MÜLLER, 1821)					6	subtroglophile
41.	<i>Tachinus subterraneus</i> (LINNAEUS, 1758)					1,6	eutroglophile
42.	<i>Xantholinus laevigatus</i> JACOBSEN, 1849					4	trogloxene
43.	<i>Xantholinus linearis</i> (OLIVIER, 1795)					2	trogloxene
44.	<i>Xantholinus longiventris</i> HEER, 1839					1	trogloxene

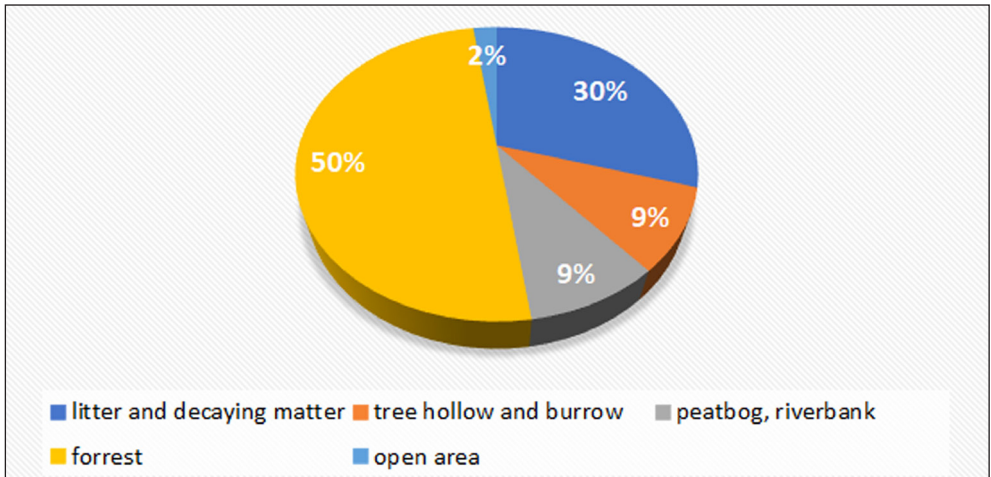


Fig. 2. Habitat preferences of the examined rove beetles.

## DISCUSSION

Results obtained in this study increase our knowledge about rove beetles inhabiting caves in Poland. Only 12 species were known from this environment so far (KOCOT-ZALEWSKA & DOMAGAŁA 2020), while nowadays it is 44. It's a significant result in view of the fact that previous data concerned a few cave regions in Poland like whole Kraków-Częstochowa Upland, Sudety Mts., Tatra Mts. and Świętokrzyski Region, whereas our results concern only one, quite small region.

The most frequently collected species was *Quedius mesomelinus mesomelinus*. It is a typical eutroglophile occurring in many caves in Europe, and widely in the Palearctic region (SALNITSKA & SOLODOVNIKOV 2019). This species was introduced to Greenland, the Australian region, North and South America (LÖBL & LÖBL 2015, SALNITSKA & SOLODOVNIKOV 2019). It was known also from previous study in Polish caves (DEMEL 1918, PAX & MASCHKE 1935, KOWALSKI 1955, SKALSKI & WÓJCIK 1968, SKALSKI 1973, GUBAŁA 1996). As an eutroglophile are also considered *Tachinus subterraneus* and *Omalium validum*, because specimens of both species occurred in the studied caves during the whole year and inhabited the deep part of them, which proves existing undergrounds populations. Both species prefer living in burrows (BURAKOWSKI *et al.* 1979, 1980). Additionally, *T. subterraneus* and *O. validum* have been previously known from caves. The first one from Tatra Mts. (KOWALSKI 1955), Czech Republic (MLEJNEK *et al.* 2015) and Germany (ZAENKER *et al.* 2020), and the second one from Luxemburg (in the collection of the Luxemburg National Museum of Natural History), Czech Republic (MLEJNEK *et al.* 2015) and Germany (ZAENKER *et al.* 2020).

As many as nine species were considered as subtroglaphiles (Table 1). Every species in this class has been caught in the entrance zone of studied caves. It was found also in a pitfall in front of caves. Some species, like *Atheta sodalis*, *Lesteva longoelytrata*, *Omalium caesum*, *O. rivulare*, *Syntomium aeneum* are known from Luxemburgish caves. Others, like *Anthobium atrocephalum*, *O. rivulare*, *Othius punctulatus* are known from the Mesovoid Shallow Substratum environment in Slovakia (RENDOŠ *et al.* 2012). The organisms, that live in MSS (JUBERTHIE *et al.* 1980, WHITE & CULVER 2012), prefer lack of light and high value of air humidity but tolerate considerable amplitude of air temperature. These organisms have often similar morphological adaptations as cave obligatory dwellers (PIPAN & CULVER 2012). All subtroglaphiles are also known from caves and MSS in Czech Republic (MLEJNEK *et al.* 2015). The analyses of accessible information about food and habitat preferences (BURAKOWSKI *et al.* 1979, 1980, 1981, 2000, Koch 1989a, 1989b, 1992, MAJKA *et al.* 2009, SMOLEŃSKI 2000, SZUJECKI 2008, 2017) shows that these species prefer shadow areas – under stones, in a litter and fallen leaves, and they feed decaying matter or are predators. Thus, we can assume, that these species do not penetrate caves accidentally, but actively.

## SUMMARY

The list of the Staphylinidae species known from Polish caves increased more than twice. Previously only 12 species were known, while currently 44 species are recognized. Nowadays three eutroglophiles and nine subtroglaphiles are identified in caves of Poland. The most common species is *Quedius mesomelinus mesomelinus*.

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