

TERRESTRIAL CAVERNICOLOUS

THE SUBTERRANEAN DOMAIN consists of four main terrestrial habitats (*i.e.*, soil, networks of microspaces between rock fragments, networks of small fissures, and caves). Of these, it is the cavernicolous habitat which has been the subject of most faunistic studies in Romania. Recent studies have also been concerned with both the edaphic (soil) fauna and with the fauna inhabiting the network of microspaces existing between rock fragments within the layer developed between the edaphic habitat and calcareous or noncalcareous bedrock.

An endemic (native) edaphobitic fauna was discovered in the soil layer containing roots of plants by washing the soil (using the Normand method). This fauna consists primarily of Coleoptera, Isopoda, Diplopoda, Collembola, and Acarina.

Investigations with Barber traps buried in the network of microspaces resulted in the discovery of new endemic taxa, most of which belonged to the Coleoptera (Juberthie, *et al.*, 1981). It is significant that almost all of the strictly subterranean taxa discovered so far in the network of microspaces are restricted to this habitat and have not also been found in caves, as happens in the Pyrenees. In the Carpathian Mountains, the mode of colonization of microspaces appears to be specific to the entire region and is determined by paleoclimatic, hydrologic, and tectonic factors.

According to the new classification of the subterranean domain, the caves and the fissure network, both developed within the bedrock, belong to the deep subterranean, while the soil and the microspace network are classified as the shallow subterranean. The caves, the fissure network, the microspace network, and the soil (particularly the first three) are connected through multiple interrelationships within a unique func-

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SUMMARY

Romania is divided into 5 biospeleological provinces based upon the present distribution of the endemic troglobitic and edaphobitic fauna. Ancestors of this fauna migrated into Romania primarily from the north Aegean region probably at various times during the Tertiary Age. Four paleogeographic barriers—the couloirs of the Danube, Timis-Cerna, Olt, and Mures Rivers—acted to constrain the migration routes and settlement areas, thus producing distinct patterns in the distribution of the cave fauna in the Carpathians. The present day terrestrial troglobitic fauna of Romania consists of 208 known species and subspecies, including 126 Coleoptera, 23 Araneae, 20 Diplopoda, 12 Collembola, 8 Pseudoscorpiones, and 6 Isopoda. More than 97 percent of these troglobitic taxa are endemic, and more than 80 percent are paleotroglobitic.

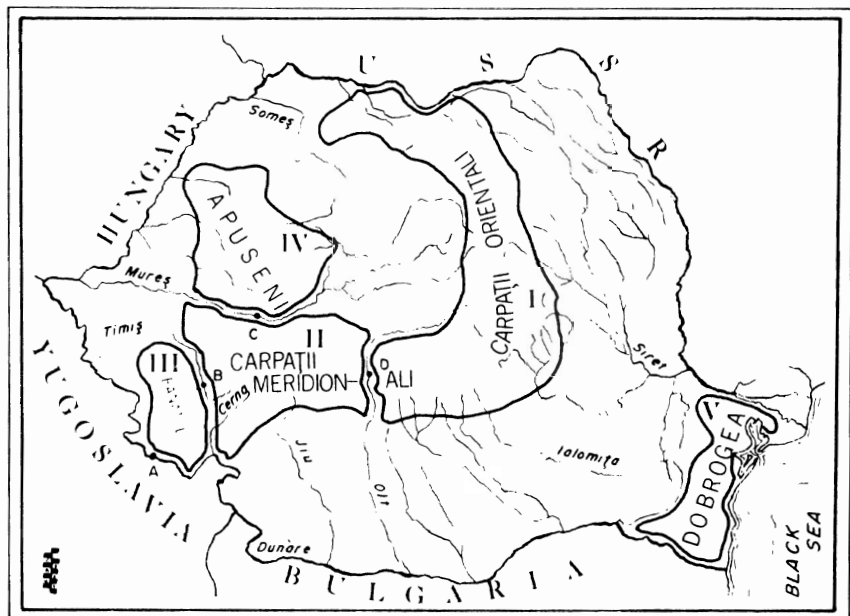


Figure 1. Biospeleological provinces I to V and the main paleogeographical Miocene barriers (interrupted line). Province I: eastern and southern Carpathians up to the Olt River; province II: southern Carpathians between the Olt River and the Timiș-Cerna Couloir; province III: western Carpathians south of the Mureș River (Banat Mountains); province IV: western Carpathians north of the Mureș River (Apuseni Mountains); province V: Dobrogea. (a) Dunăre Couloir; (b) Timiș-Cerna Couloir; (c) Mureș Couloir; (d) Olt Couloir.

tional system. Each of these habitats is characterized by a specific fauna (detectable through abundance criteria) as well as by a fauna also common to the other media.

In this paper, we briefly discuss the distribution of the terrestrial cavernicolous fauna in Romanian caves, with special emphasis on troglobitic species. As for the other ecological categories of cave-dwelling fauna, only a few references will be made to some of the main troglophile, guanophile, or subtroglophile (animals that use caves seasonally for aestivation or hibernation) elements in the Carpathians and in Dobrogea.

THE ORIGIN AND DISTRIBUTION OF THE TROGLOBITIC FAUNA

Figure 1, a map of Romania's biospeleological provinces, defines the province of the eastern and southern Carpathians up to the Olt River (I), the province of the southern Carpathians between the Olt River and the Timiș-Cerna Couloir (II), the province of the western Carpathians south of the Mureș River (Banat Mountains) (III), the province of the western Carpathians north of the Mureș River (Apuseni Mountains) (IV), and the province of Dobrogea (V). These

FAUNA OF ROMANIA

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faunistic regions were first defined and published by Decu in 1967. The five biogeographical provinces were delimited according to the distribution of presumed old endemic troglotic species, 61% of which are coleopterans (provinces II to V) and according to edaphobitic endemisms (province I). These five provinces presumably correspond to paleogeographical provinces of Tertiary isolation. Consequently, studies of

these areas into Romanian territory at various periods during the Tertiary Age. Romania, including the Apuseni Mountains region, is situated at the northern limit of the range of the cavernicolous fauna in general.

The migration of the ancestors of the troglotic and edaphobitic fauna from the south or from the north was dependent on the presence of wooded hills or low mountains (*i.e.*, areas ranging between 200 and

edaphobitic endemisms (Decu, 1967; Decu and Negrea, 1969).

In the eastern and southern Carpathians up to the Olt River (Province I), five troglotic species from the genera *Nesticus* and *Lepthyphantes* (Araneae), and *Romanosoma* (Diplopoda) have been found to date. The ancestors of the troglitic populations of edaphobitic beetles, probably belonging to *Trechus*, *Duvalius* (*Duvalidius*) *procerus* group, and *Duvaliopsis*, migrated from the Bohemian Massif and spread along the Carpathians up to the Olt River at the beginning of the Tertiary Age (probably in the Tortonian). An exception to this is *Duvalius* (*Duvalidius*) *delamarei* Decu, a neotroglitic species that crossed the Olt River and populated caves in the Comarnic Gorges (Stogu Massif).

From the caves of the southern Carpathians between the Olt River and the Timiș-Cerna Couloir (Province II), the only troglitic species of Bohemian origin are the *Duvalius* (*Duvalidius*) *merkli* group, which probably spread into the Carpathians towards the end of the Oligocene and the beginning of the Miocene, through the Tisia calcareous massif (Jeannel, 1931; Decu, 1967). All other cavernicolous forms are probably of Dinarian or east Balkan origin: *Duvalius* (*Duvaliotes*) *budai* group (Coleoptera-Trechinae), and *Sophrrochaeta*, *Tismanella*, and *Closania* (Coleoptera-Bathysciinae); *Trachysphaera*, *Trichopolydesmus*, *Dacosoma*, *Typhloiulus*, and *Anthroleucosoma* (Diplopoda); *Neobisium* (Pseudoscorpiones); *Centromerus* and *Troglohyphantes* (Araneae); and *Trichoniscus* and *Haplophthalmus* (Isopoda-Trichoniscidae).

The north-Aegean origin of these taxa, as well as of other taxa from the other remaining biospeological provinces, is indicated by their affinities and distribution in the Balkan region, particularly in Yugoslavia and Bulgaria. A number of taxa from Balkanian caves, *e.g.* *Duvalius* (*Duvaliotes*) *pilifer* group, and *Rhodopiola* (Coleoptera); *Trachysphaera orghidani* n. ssp. (Tabacaru, in press, a), *Bulgarosoma bureschi* Verhoeff, *B. crucis* Strasser, and *Verhoeffodesmus* (Myriopoda-Diplopoda); *Trichoniscus tenebrarum* Verhoeff, *T. bureschi* Verhoeff, and *Troglocyphoniscus* (Isopoda) are phylogenetically very near to cavernicolous species from Romania, *e.g.* *Duvalius*

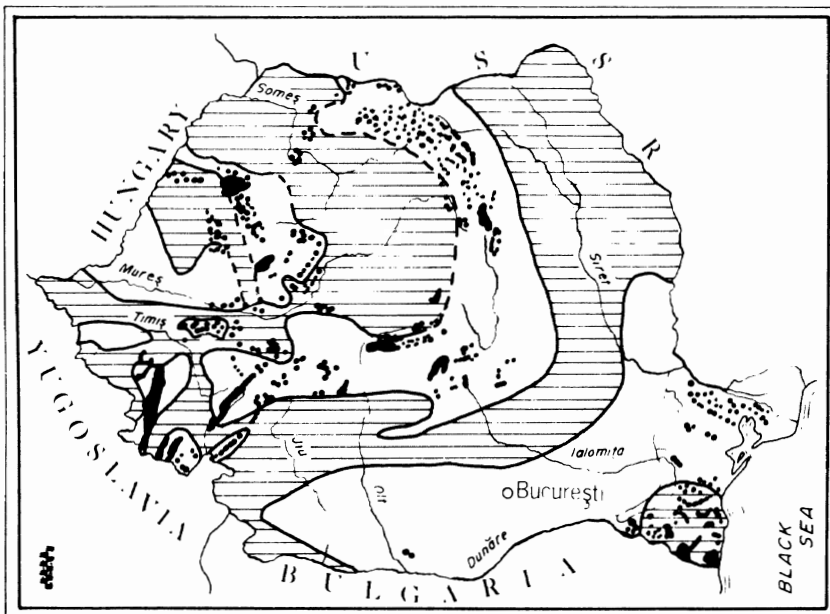


Figure 2. Paleogeographical map of Romania in the upper Tortonian (Miocene). The dark areas represent the present karstic zones, the hatched areas represent the Tortonian Sea.

the troglitic (and edaphobitic) elements have proven to be remarkably important for interpreting Romania's paleogeography. These elements provide evidence for the existence of the main Miocene geographical barriers and (implicitly) for the constraining effects on faunal distribution of many of the antecedent transverse valleys. Moreover, owing to the long time span that has elapsed since their arrival, these troglitic elements represent real biogeographical indicators (Decu and Negrea, 1969).

The ancestors of the Romanian troglitic and edaphobitic fauna were probably derived from faunistic elements established in the northern Aegean region (more precisely, in the Dinarian zone) and on the Bohemian Massif at the beginning of the Paleogene. The ancestors migrated from

1000 m elevation). This migration was not a continuous process; it took place during various geological periods, depending on the paleogeographical situation of the country and on the evolutionary potential of the species.

During the advance of this fauna into the southern and western Carpathians, four paleogeographical barriers played very important roles. These barriers were marine channels which, at that time, filled the couloirs of the (a) Dunăre, (b) Timiș-Cerna, (c) Mureș and (d) Olt where these rivers cut through the Carpathians (Fig. 1). These barrier-basins (some of them beginning with the Eocene, others in the Miocene) isolated four biogeographical provinces (I to IV) evidenced today by the distribution of the fauna showing characteristic troglitic and

(*Duvaliotes budai* and *redtenbacheri* groups, and *Banatiola* (Coleoptera); *Trachysphaera orghidani orghidani* (Tabacaru), *Bulgarosoma ocellatum* Tabacaru, and *Trichopolydesmus* (Diplopoda); *Trichoniscus inferus* Verhoeff and *Haplophthalmus tismanicus* Tabacaru (Isopoda).

The faunistic elements of north-Aegean origin (beetles, spiders, millipedes, centipedes, and isopods) probably colonized the southern Carpathians (Province II) by successive migrations beginning in the Miocene. During these migrations, Romania possessed a tropical-to-subtropical climate that allowed an easy and relatively homogeneous distribution of these elements up to the Olt River. Most of the troglobitic elements found in the area between the Olt River and the Timis-Cerna Couloir are distributed between the Cerna and Jiu rivers (Fig. 1) Beyond the Jiu Valley (which was another important paleogeographical barrier), they occur in smaller numbers—the most eastern troglobitic species being found in caves of the Stogu Vinturarija Massif. The present distribution and composition of the troglobitic elements in this part of the Carpathians parallels the variations registered from the west to the east in epigeal fauna and flora.

In the Banat Mountains (Province III), the troglobitic elements [*Trichopolydesmus* (*Banatodesmus*) *jeanneli* Tabacaru, *Bulgarosoma ocellatum*, and *Lithobius dacicus* Matic (Myriopoda), *Banatiola vandeli* Decu and *Duvalius milleri* (Frivaldszky) (Coleoptera)], are also of probable north-Aegean origin. Their ancestors apparently entered this region in the Miocene, but probably migrated independently of the troglobitic elements from the southern Carpathians. The Miocene (Tortonian) Sea (Fig. 2) that transformed the western and southern Carpathians into an archipelago isolated, through its various barriers, the areas colonized by the ancestors of the troglobitic (and edaphobitic) forms that presumably had recently immigrated from the south.

The Apuseni Mountains (Province IV) are populated by troglobitic elements: *Neobisium* (Pseudoscorpiones); *Nesticus* (Araneae); *Biharoniscus* (Isopoda); *Trachysphaera* and *Typhloiulus* (Diplopoda); *Pholeuon*, *Drimeotus*, and *Duvalius* (*Duvaliotes*) *redtenbacheri* group (Coleoptera); all of north-Aegean origin. However, the ancestors of at least the Coleoptera in the Apuseni Mountains did not migrate through Banat or through the western and southern Carpathians, but through the Tisia region (a massif of Triassic limestone whose sinking, beginning with the Miocene, gave birth to the Panonian Plain). Paleogeographic barriers deflected the migrating fauna away from the Banat region. Similarly,

paleogeographic barriers also kept the Bohemian (northern) elements away from the Apuseni Mountains when they immigrated into the southern Carpathians (Jeannel, 1931; Decu, 1967; Decu and Negrea, 1969). The spread of the ancestors of the troglobitic fauna into the Apuseni Mountains appears to have taken place towards the end of the Oligocene, because at the beginning of the Miocene, terrestrial communication between these mountains and the south terminated with the formation of the Panonian Sea and of the Mureş Couloir.

Troglobitic elements in Dobrogea (Province V) probably also immigrated from the south. From the upper Eocene to the upper Tortonian, Aegean faunistic elements migrated towards the northeast up to the Crimea and the Caucasus. These may also have spread over the entire Dobrogean region during the upper Tortonian. Later, in the Sarmatian, when the southern part of Dobrogea was submerged, the fauna which had probably migrated there, disappeared or migrated again towards the north. Beginning with the Pliocene, some faunistic elements with edaphobitic or cavernicolous representatives possibly began immigrating into Dobrogea from the south. We are inclined to believe that it was then that the ancestors of the cavernicolous forms of Diplopoda (*Trachysphaera* and *Apfelbeckiella*), of Coleoptera (*Trechus*), of Pseudoscorpiones (*Acanthocreagris*) and of Araneae (*Lessertiella*) among others, entered Dobrogea.

The present zoogeographical configuration of the troglobitic fauna, in the four Carpathian provinces as well as in Dobrogea, is due to (1) the evolution of Romania's geography, (2) its glacial and postglacial climate, (3) the karstification of the calcareous massifs (which deprives them of surface water, vegetation, and soil), (4) reduction in dispersal ability among earlier immigrants, as they became more cave adapted and (5) biotic interactions (such as competitive exclusion, prey and host species abundance, and food resources). A steppe climate became dominant in Dobrogea about 3,000 years ago which had important repercussions on the zoogeography of the hygrophilous fauna there.

THE PRINCIPAL CAVERNICOLOUS AQUATIC TAXA

Aquatic species are poorly represented in the caves of Romania and as such are here only briefly mentioned. Among the more interesting troglobitic species recorded so far, we would mention: *Dendrocoelum botosaneanui* del Papa and *D. tismanae* Codreanu and Balcesco (Tricladida); *Haploutaxis bur-*

eschi (Michaelsen) (Oligochaeta); *Troglochaetus beranecki* Delachaux (Polychaeta); *Paladilhia transsylvanica* (Rotarides) and *P. leruthi* Boettger (Gastropoda); *Kovalevskiiella phreatica* (Danielopol) (Ostracoda); *Megacyclops reductus propinquus* Pleşa, *Speocyclops troglodytes* Chappuis, *Elaphoidella phreatica* Chappuis, and *Spelaocamptus spelaus* Chappuis (Copepoda); *Parabathynella motasi* Dancău and Şerban and *Bathynella paranatans* Şerban (Bathynellacea); *Microcerberus plesai* Chappuis and Delamare (Isopoda); *Niphargus carpathicus variabilis* Dobreaanu, Manolache, and Puscariu, *N. andropus* Schellenberg, and *N. longicaudatus maximus* Karaman (Amphipoda).

THE PRINCIPAL CAVERNICOLOUS TERRESTRIAL TAXA

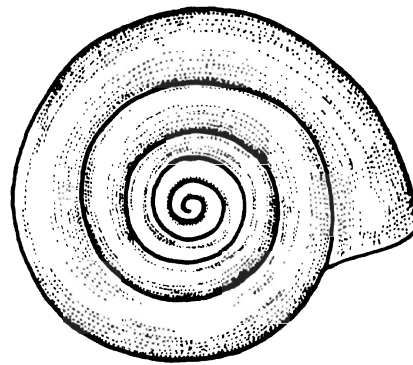
OLIGOCHAETA: Earthworms

The terricolous oligochaetes are typical endogeous forms. The cavernicolous populations generally live in clayey silt, but can sometimes occur in other media such as guano or various vegetal remains. Most of the cavernicolous oligochaetes are geophagous forms and do not show troglobitic adaptations.

In Romania, troglobitic terricolous oligochaetes have not yet been identified. Among the approximately 12 troglophile species commonly found in caves from the whole of the country, we cite the following: *Fridericia striata* (Levinsen) and *Enchytraeus bucholzi* Vejdovski (Enchytraeidae), as well as *Allobophora rosea* (Savigny) and *Dendrobaena rubida* (Savigny) (Lumbricidae). (See also Botea, 1970 and in press.)

GASTROPODA: Gastropods

No terrestrial troglobitic gastropods have been found in Romanian caves. Among the 24 troglophilic species, 4 are more frequent cave inhabitants: *Oxychilus glaber* (Rossmässler) (Fig. 3), *O. depressus* (Sterki), *Spelaodiscus triaria* Rossmässler, and *Troglovitrea argintarui* Negrea and Riedel.



The *Oxychilus* species are widely distributed in central and southeastern Europe, being the most frequently encountered species of gastropods from the caves of Romania, particularly in provinces II and III (Oltenia and Banat). They possess flattened, transparent, reddish-brown shells. *S. triaria* is much smaller (4 to 5.5 mm), with a yellow-brown shell and a horny appearance. It is endemic to Romania and has been found only in the caves of Banat, the northwest of Oltenia, and Transylvania. *T. argintarui*, endemic to northwestern Oltenia, has a thin, whitish or yellowish shell.

In caves, the gastropods live on moist walls, clay, guano, and various other organic remains. (See also Negrea, A., 1966 and in press.)

ISOPODA: Isopods

Terrestrial species of this group of crustaceans are well represented in caves. The troglobitic and troglomorphic species belong to the family Trichoniscidae (see figs. 4 and 5). All troglobitic species are endemic, blind, and depigmented. Among the most significant are: *Caucasonethes* n. sp. (Tabacaru, in press, b), endemic to Liliecilor Cave (Bat Cave) in Gura Dobrogei; *Trichoniscus* aff. *inferus* Verhoeff, inhabiting many caves in Oltenia; *Haplophthalmus tismanicus* Tabacaru (Fig. 4), found in the cave at the Tismana Monastery; and *Biharoniscus racovitzae* Tabacaru, discovered in the Cîmpeasca Cave (Apuseni Mountains). A troglomorphic species, *Mesoniscus graniger* (Frivaldsky) (Fig. 5), is distributed in many

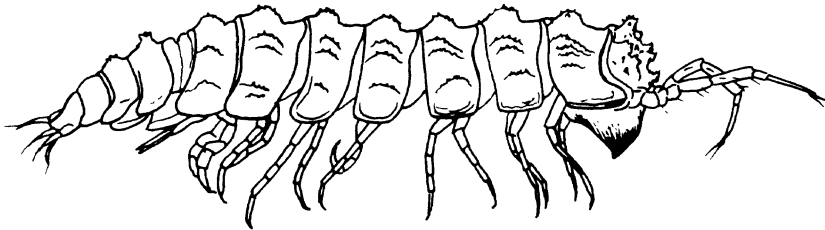


Figure 4. (above) *Haplophthalmus tismanicus* Tbc. (about 2.5 to 3 mm in length), a troglobitic species of haplophthalmid isopods, endemic in the cave at Tismana Monastery.

Figure 5. (below) *Mesoniscus graniger* (Frv.) (about 1 cm in length), a troglomorphic species of mesoniscid isopods, widely distributed in the caves of the Carpathian chain, but most frequently found in the Banat and Apuseni mountains.

caves of the Carpathians, particularly in those from the Apuseni Mountains and Banat. It is an endogamic species known from the southeastern Alps, from the Dinaric Alps, and from the Tatra Carpathians. (See also Tabacaru, in press, b.)

PSEUDOSCORPIONES: Pseudoscorpions

This group of arachnids is well represented in caves. Troglobitic forms are small, blind, depigmented and, together with opilionids, are the most important

predators in the caves of Romania.

In Europe, most of the troglobitic species belong to the genera *Neobisium*, *Chthonius*, and *Rhoncus*. In Romania, most belong to the genus *Neobisium*, e.g. *N. (Blothrus) closanicus* Dumitrescu and Orghidan, inhabiting several caves from the Motru Basin; *N. (Blothrus) brevipes* Frivaldszky, from Soroniște Cave and several caves in the Apuseni Mountains; and *N. (Blothrus) leruthi* Beier (Fig. 6), known also from several caves from the Apuseni Mountains. These three species, together with an additional five species, are considered paleotroglobitic. *Acanthocreagriss callaticola* Dumitrescu and Orghidan, populating Limanu Cave and *Chthonius vandeli* Dumitrescu and Orghidan, from Liliecilor Cave of Gura Dobrogei, are endemic neotroglobites in Dobrogea. Among the troglomorphic species, we mention *N. blothroides* (Tömösvary), endemic to several caves in the Apuseni Mountains. (See also Dumitrescu, et al., in press.)

OPILIONES: Harvestmen or Daddy-Longlegs

There are no troglobitic species of opilionids known from Romania. From among those having troglomorphic populations, we cite *Holoscotolemon granulatus* (Röwer) (Fig. 7) and *Paranemastoma sillii* (Herman). The former belongs to the suborder Laniatores and inhabits only caves of the Carpathians, particularly those in northwestern Oltenia. It prefers wet caves, is depigmented, but possesses eyes. *P. sillii* belongs to another suborder, Palpatores, but, unlike *H. granulatus*, it has thin pedipalps and long legs, and the integument is pigmented. It can be found in caves, especially in winter, as it is a main component of the parietal (wall-dwelling) community. It has been reported from the caves of provinces II, III and IV, being more frequently recorded in provinces

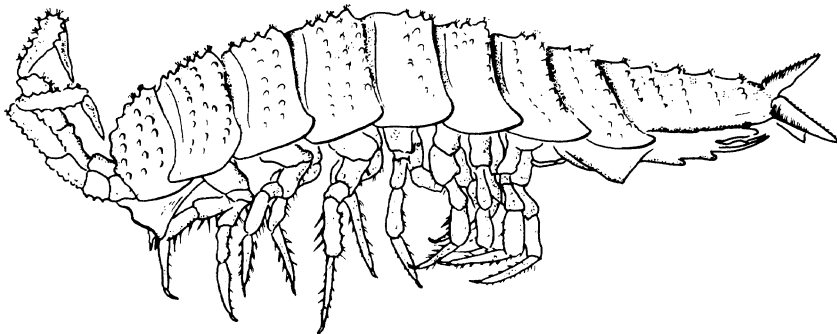
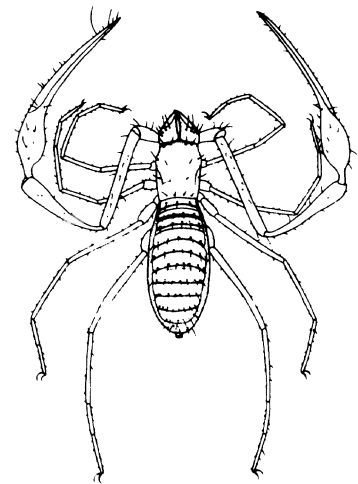


Figure 3. (left) *Oxychilus glaber* (Rossm.), a troglomorphic species of zonitid snails (shell about 14 mm in diameter), commonly found in the caves of Oltenia and Banat (provinces II and III).

Figure 6. *Neobisium leruthi* Beier (about 3.5 to 4.5 mm), a troglobitic species of neobisiid pseudoscorpions, endemic in several caves from the Apuseni Mountains.



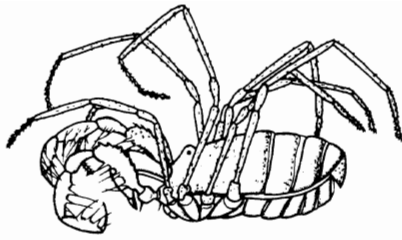
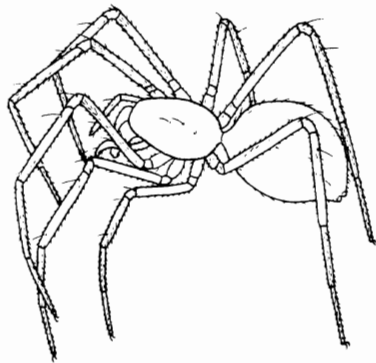


Figure 7. (above) *Holoscotolemon granulatus* (Roewer) (about 4.5 mm in length), a trogliphilic species of erobomastrid opilionids, found in caves throughout the Carpathians, particularly in Province II.

Figure 9. (below) *Centromerus dacicus* Dumitrescu and Georgescu (about 1 mm in length), a troglitic species of linyphiid spiders, endemic in caves of northwestern Oltenia (Province II). It is the most interesting species of troglitic spiders in Romania. Its cocoon contains 1 or 2 (rarely 3) eggs.

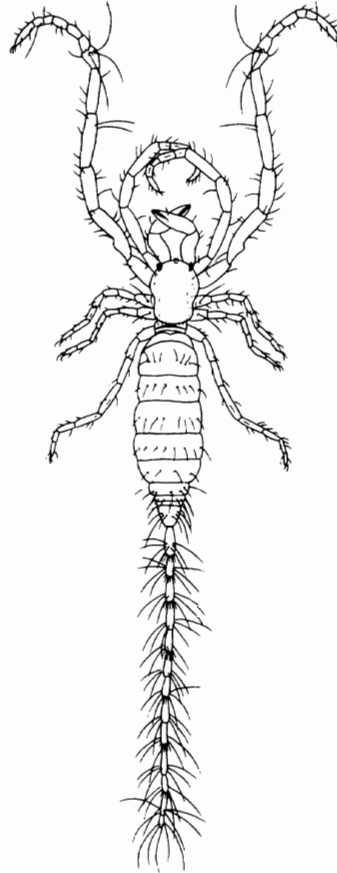


II and III (Oltenia and Banat). Outside of caves, it is found in various biotopes in the forests of mountainous and submountainous regions. (See also Avram and Dumitrescu, 1969; Avram, in press.)

PALPIGRADI: Micro-Whip-Scorpions

Members of this order of arachnids are small, depigmented, blind and have fragile bodies. They occupy the shallow subterranean habitat and represent the remnants of a warm climate fauna. In the Mediterranean area, there are also cavernicolous troglitic forms. Several species of *Eukoenenia* are known from the caves of Romania, e.g., *E. margaretae* Orghidan, Georgescu, and Sârbu (Fig. 8) that inhabits the Cloşani and Bulba caves and the network of fissures connected to these caves. (See also Orghidan, *et al.*, 1982; Georgescu, in press.)

Figure 8. (below) *Eukoenenia margaretae* Orghidan, Georgescu, and Sârbu (about 2.5 mm in length), a strictly subterranean species of Koeneniidae, characteristic of the fissures network, found so far only in Cloşani and Bulba caves (Province II), especially at the water surface.



ARANEAE: Spiders

As with other groups of arthropods, the troglitic spiders belong to lines adapted to obscure, moist biotopes in which took place the physiological preadaptation of the forms now living in caves. The paleotroglitic forms are blind and depigmented. In numbers of troglitic species (23), the Araneae are second only to the Coleoptera. Troglitic species from the families Linyphiidae, Nesticidae, Micryphantidae, and Argiopidae are known from Romania.

The first family includes *Centromerus dacicus* Dumitrescu and Georgescu (Fig. 9), a small, endemic species (about 1 mm) that inhabits caves of northwestern Oltenia (e.g., Cloşani Cave), *Troglohyphantes herculanus* (Kulczynski), a species endemic in caves of provinces II and III, and *Porrhomma pygmaeum convexum* Westring, inhabiting caves in Oltenia, Hunedora, Banat, and the Apuseni Mountains.

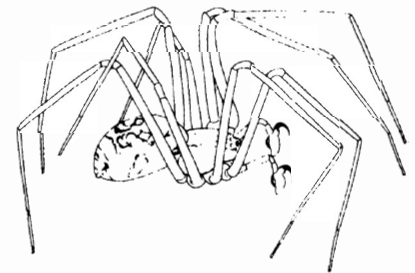
Among the Nesticidae are several species of *Nesticus*, most of which (13) are neotroglitic—for example: *N. ionescui* Dumitrescu (Fig. 10), present in many caves from Oltenia; *N. biroi* Kulczynski; endemic in several caves of the Apuseni Mountains; and *N. puteorum* Kulczynski, a species endemic in caves of Province II.

The micryphantid *Lessertiella dobrogica* Dumitrescu and Miller is a neotroglitic species endemic in Liliicilor Cave from Gura Dobrogei, which possibly became isolated in the subterranean habitat once the steppe climate became dominant.

The single representative of Argiopidae is *Meta bourneti* Simon, a neotroglitic species known only from the caves of Dobrogea.

Besides these troglitic species, there also are trogliphilic species found only very rarely outside of caves: e.g., *Leptyphantes pallidus* (Cambridge), another linyphiid, inhabiting caves in provinces I-IV; *Nesticus cellulanus* (Clerck), a species frequent in the

Figure 10. (below) *Nesticus ionescui* Dumitrescu (about 6 mm in length), an endemic neotroglitic spider (Nesticidae) which inhabits many caves in the western portion of the southern Carpathians (Province II).



caves of Oltenia and Banat; and *Meta menardi* (Latreille), an argiopid common in the first four of Romania's biospeleological provinces. (See also Motas, *et al.*, 1967; Dumitrescu, 1979, 1980; Dumitrescu and Georgescu, 1970, 1980, 1981, and in press.)

ACARINA: Mites

In addition to the troglitoxenic species of mites inhabiting the caves of Romania, trogliphilic, guanophagic, and parasitic taxa are also known. Two species probably are troglitic, i.e., *Rhagidia gigas longipes* Trägårdh and *Poecilophysis spelaea* (Wankel) (Fig. 11), found in a few caves in the Carpathian chain (particularly from the Apuseni Mountains). They are depigmented, blind, and have long appendages. *P. spelaea* occurs only in European caves and under rocks in northern Siberia. The caver-

niculous populations are probably glacial relicts (Zacharda, 1978).

The trogliphilic-guanophilic species most frequently found are: *Euryparasitus emarginatus* (Koch), *Parasitus niveus* (Wankel), and *Hypoaspis miles* Berlese, belonging to the guano community; a uropodid, *Uroactinia* sp., probably representing a tropical relict and extremely abundant in Adam's Cave in Baile Herculane; *Trichouropoda orbicularis* Koch, also an uropodid and well represented in Adam's Cave and in Gura Ponicovei Cave.

A species common in the caves of all bi-speleological provinces is *Ixodes vespertilionis* Koch, an ixodid whose females are parasitic only on bats. (See also Georgescu, 1968; Iavorschi, *et al.*, in press.)

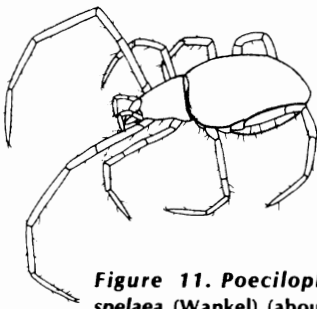
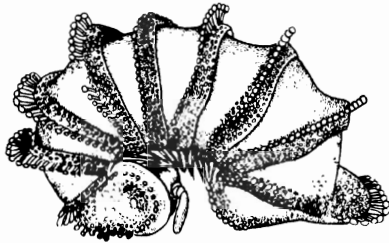


Figure 11. *Poecilophysis spelaea* (Wankel) (about 0.8 to 1.1 mm), a probably trogliphilic species of rhagidiid mite, found in several caves in the Carpathians.

to 1.1 mm), a probably trogliphilic species of rhagidiid mite, found in several caves in the Carpathians.

Figure 12. *Trachysphaera orchidani* (Tbc.) (about 4.7 mm in length), a trogliphilic trachysphaerid millipede, endemic in caves in the western portion of the southern Carpathians (Province II).



DIPLOPODA: Millipedes

After Coleoptera and Araneae, the Diplopoda have the next largest number of trogliphilic forms in the caves of Romania. All the trogliphilic species are blind, depigmented, and belong to the following families: Trachysphaeridae, Polydesmidae, Trichopolydesmidae, Orobainosomidae, Anthroleucosomidae and Iulidae. These are saprophagous hygrophilous forms, living in caves on areas with clayey moist substratum, on rotten wood, on patches of old guano, and under stones. All the trogliphilic species found so far are endemic to individual bi-speleological provinces of Romania.

Among the Trachysphaeridae, we mention the genus *Trachysphaera* with many

Figure 13. (below, center) *Polydesmus oltenicus* Negr. and Tabc. (about 8.5 mm in length), an endemic trogliphilic species of polydesmid millipede, found in caves in the western portion of the southern Carpathians (Province II).

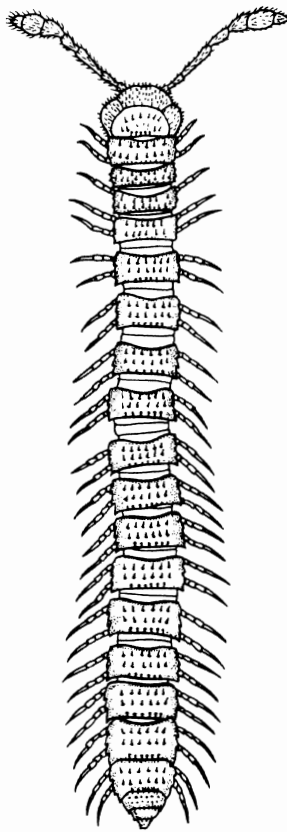
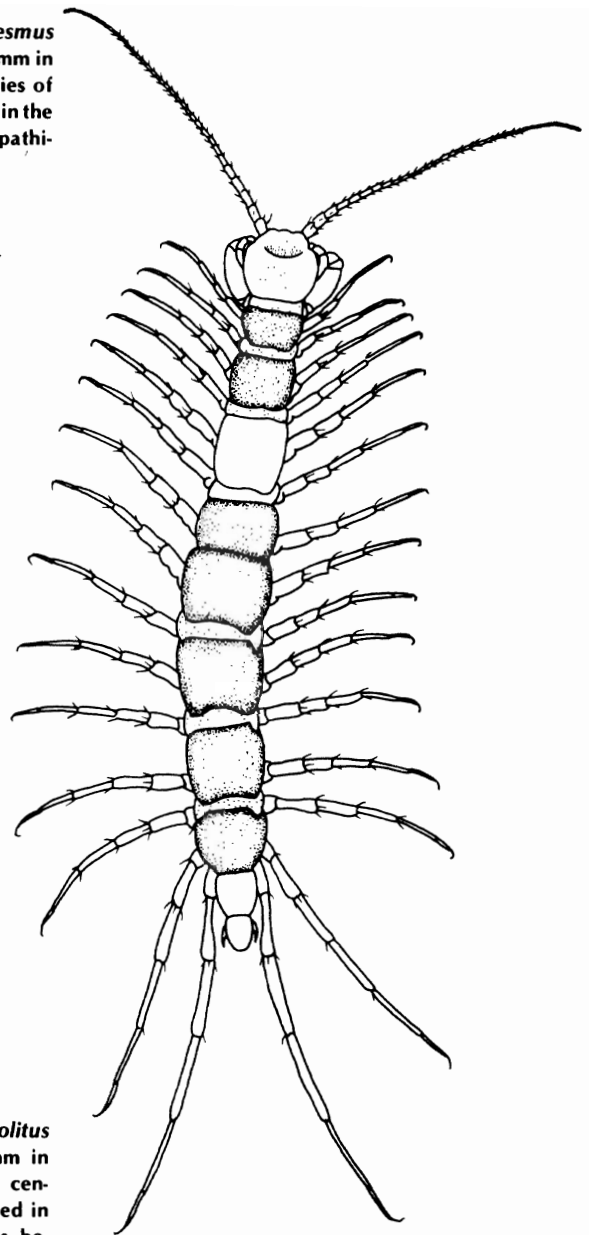


Figure 14. (right) *Lithobius decapolitus* Mat., Negr., and Prun. (12 to 19 mm in length), an endemic neotrogliphilic centipede (Lithobiidae), widely distributed in the caves of the southern Carpathians, between the Olt Valley and the Timiș-Cerna Couloir.



species, some of which are trogliphilic: *T. orchidani* (Tabacaru) (Fig. 12), *T. jonescui* (Brölemann), *T. dobrogica* Tabacaru, and *T. biharica* Ceuca (distributed in provinces II to V). *T. costata* (Waga), a trogliphilic form, lives in provinces I to IV.

Among the Polydesmidae, noteworthy are *Brachydesmus* and *Polydesmus*. The first genus is represented in caves by trogliphilic populations of *B. trogliphilus* Daday and *B. dadayi frondicola* Verhoeff. *Polydesmus* also includes a neotrogliphilic species with depigmented integument, *P. oltenicus* Negr. and Tabacaru (Fig. 13), distributed in caves in Province II.

The Trichopolydesmidae, a group widely

distributed in America, is represented in Romania by two paleotrogliphilic species: *Trichopolydesmus eremitis* Verhoeff, an endemic species frequently found in the caves of northwestern Oltenia and southeastern Banat, and *T. jeanneli*, also found in Banat.

The Orobainosomidae are represented by a probable trogliphilic, *Orobainosoma hungaricum orientale* Tabacaru, found so far only in provinces II and III.

The Anthroleucosomidae are well represented in the caves of Romania by the following endemic trogliphilic species: *Anthroleucosoma banaticum* Verhoeff, *A. spelaea* Ceuca, and *Dacosoma motasi* Tabacaru, all inhabiting caves from province II; and *Bulgarosoma ocellatum*, in Province III.

Among Iulidae, significant troglobitic species include: *Apfelbeckiella trnowensis dobrogica* Tabacaru from central Dobrogea; *Typhloiulus serbani* (Ceuca), present in several caves of Province IV; and *T. mehedintzensis* Tabacaru, from Oltenia. (See also Tabacaru, 1970, 1979 and in press, a.)

CHILOPODA: Centipedes

Among the families of this class, only two have subterranean representatives: Lithobiidae and Cryptopidae.

The lithobiids live in soil, in leaf litter and other vegetal remains, and under stones, that is, in environments resembling those of the caves. They are hygrophilous and lucifugous animals, and, unlike the diplopods, they are represented in the subterranean environment by three troglobitic species: *Lithobius dacicus*, endemic in Banat, *Harpolithobius oltenicus* Negrea, and *Lithobius decapolitus* Matic, Negrea, and Prunescu (Fig. 14), endemic in the caves of province II (Oltenia). The first and second species are blind and depigmented; the third species has ocelli, and segments 5 and 6 and their appendages as well as segment 16 are yellow.

The Cryptopidae have no troglobitic representatives. Frequently encountered troglomorphic species are *Cryptops hortensis* Leach, a western and central European species and *C. parisi* Brölemann, a central-southern European species. They are blind and depigmented, hygrophilous, and lucifugous. (See also Negrea, S. 1966 and in press.)

COLLEMBOLA: Springtails

This is the most widespread order of primitive, subterranean, apterous (wingless) insects. Most of the cavernicolous species are hygrophilous and polyphagous; according to their affinities within the caves, most of these 64 species of Collembola are troglomorphic and guanophagous. Only 12 troglobitic species have been discovered so far, most of which belong to the family Onychiuridae, more precisely to the genus *Onychiurus* (*O. closanicus* Gruia [Fig. 15], *O. ancaea* Gruia, *O. boldorii* Denis, *O. romanicus* Gruia, etc.).

The families Entomobryidae and Tomoceridae include troglobitic elements of the genera *Pseudosinella*, *Heteromurus*, and *Tomocerus*. All are blind, depigmented, and, according to the specialists, are neotroglobitic forms.

Among the guanobitic forms (possibly troglobitic-guanobitic) of note are *Acherontides spelaea* (Ionescu) and *Mesogastrura ojcoviensis* (Stach), commonly found in caves containing guano in Oltenia and Banat. They are both depigmented, the latter also being blind. (See also Gruia, 1969 and in press.)



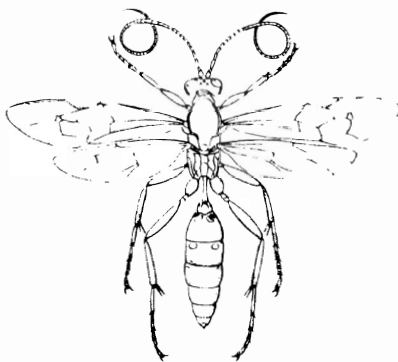
Figure 15. (left) *Onychiurus closanicus* Gruia (about 1.2 to 1.8 mm), an endemic troglobitic species of onychiurid Collembola, found in caves between the Jiu and Cerna valleys.

Figure 17. *Triphosa sabaudiata* (Dup.) (about 4 cm), a subtroglobitic species of geometrid moths, common in the caves of Romania, both in winter and summer.

DIPLURA: Diplurians

These depigmented, blind, hygrophilous, and apterygotous forms are frequently recorded in caves, although their favorite habitat is the soil and its direct annexes (sensu Cassagnau, 1961). In caves, they live on clayey areas or moist humus, under stones, on vegetal remains, and on guano. Among the subterranean species, we mention *Paurocampa spelaea* Ionescu and *Plusiocampa elongata* Ionescu, inhabiting, respectively, the Glod Cave and Dracului Cave from Paroşeni. (See also Ionescu, 1955; Decu, in press.)

Figure 16. *Amblyteles quadripunctorius* (Müll.) (16 to 20 mm in length), a subtroglobitic hymenopteran (Ichneumonidae), only females of which enter caves, both in summer and in winter, for diapause. They have been found in all five biospeleological provinces.



THYSANURA: Bristletails

This is another group of apterygotous insects uncommon in caves and found only at the entrances. Most often encountered are two species of Machilidae, i.e.: *Trigoniophthalmus banaticus* Verhoeff and *T. alternatus* Silvestri, two subtroglobitic forms which go underground and hibernate in October or November, leaving the caves in March. (See also Motaş, et al., 1967; Hollinger, in press.)

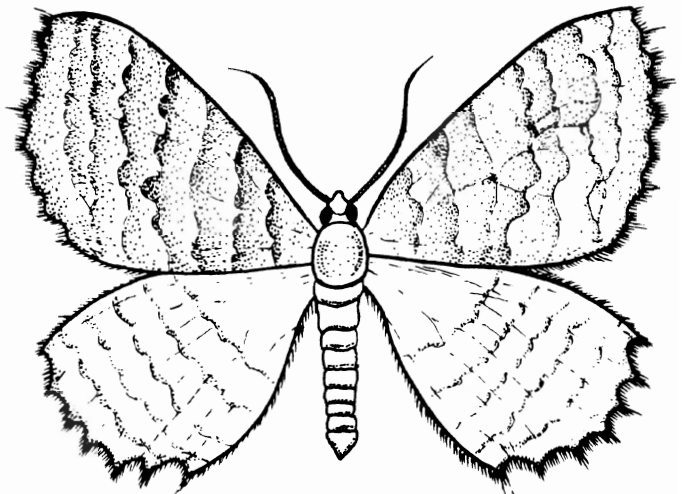
HYMENOPTERA: Sawflies, Ichneumons, Chalcids, Ants, Wasps, and Bees

Like the Thysanura, these are represented in the subterranean media solely by subtroglobitic forms (populations that enter caves

to aestivate or hibernate). Among these, two species are known from all the five biospeleological provinces, i.e.: *Amblyteles quadripunctorius* (Müller) (Fig. 16) and *Exallonyx longicornis* (Nees). It is only the females that enter caves for diapause. These species are widely distributed in European caves. (See also Decu and Decu, 1961.)

TRICHOPTERA: Caddisflies

Three species of caddisflies, *Stenophylax permistus* McLachlan, *Micropterna nycterobia* McLachlan, and *M. testacea* (Gmelin),



distributed in the Palearctic Zone, enter moist and cold caves (in summer) for diapause, where they remain from May until September. The individuals entering caves are subtrogliphiles which aestivate. *S. permistus* and *M. nycterobia* occur in caves in provinces I to IV, particularly in caves from provinces II and III; *M. testacea* has been found only in caves from Province IV. No subtrogliphile caddisfly (nor any dipteran or mycetophilid) has been found in Dobrogea, because of the semi-arid steppe climate which began in that region at the end of the lower Quaternary. (See also Botoșăneanu, 1966.)

LEPIDOPTERA: Moths and Butterflies

The moths, too, have several cavernicolous representatives which, together with Trichoptera, Diptera, and Hymenoptera, form the principal components of the parietal community. Most subtrogliphilic species enter caves to aestivate or hibernate. Like other subtrogliphilic cavernicolous organisms, they do not show troglomorphic adaptations.

Among the most frequently encountered species of subtrogliphilic Lepidoptera, we mention *Scoliopteryx libatrix* (L.), a holarctic species distributed in caves throughout Romania and more abundant in winter. *Triphosa dubitata* (L.) (palearctic species) and *T. sabaudiata* (Duponchel) (Fig. 17), distributed in Europe and Asia Minor, are two species of Lepidoptera also found very frequently in the caves of Romania. *Acrolepia pulicariae* Klimesch, also found in Yugoslavia, is another moth present in Romanian caves (Oltenia), which aestivates from April to May and begins its hibernation in September or October. (See also Căpușe and Georgescu, 1963; Motaș *et al.*, 1967.)

DIPTERA: Flies

Cave-dwelling species of flies belong to the parietal, to the vegetal remains, and to the guano communities. Although they have been inhabiting caves for a very long time, they do not show adaptations to cave life, and none of them may be considered troglitic. A few are trogliphiles, but most of them are subtrogliphiles. Among the more frequently found trogliphilic forms in the caves of Romania is *Speolepta leptogaster* Winnertz (Bolithophilidae), a species widely distributed in caves in Europe and North America. The larvae weave webs on moist and sheltered areas of the walls, on which they move in pursuit of food. According to some authors, they seem to be carnivorous.

The number of subtrogliphilic dipterous species is large. We shall cite below only the most frequently found and most abundant species. *Tarnania fenestralis* (Meigen) (Fig. 18), a mycetophilid, commonly aestivates in the caves of Romania, as well as in those of central, southern, and western Europe. *Limonia nubeculosa* Meigen, a limoniid, is also common in Romania's caves, as well as in those from southern, eastern, and western Europe. More important

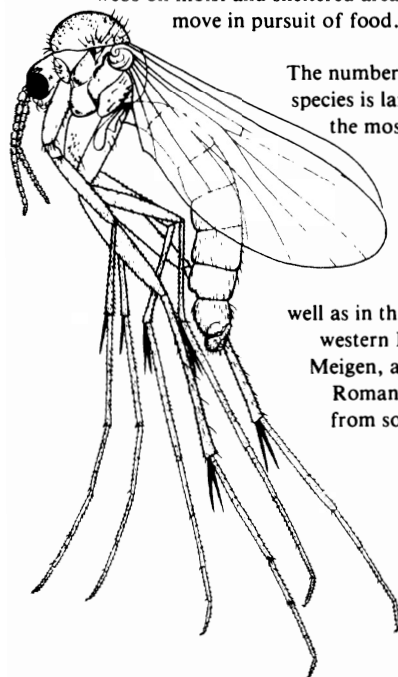
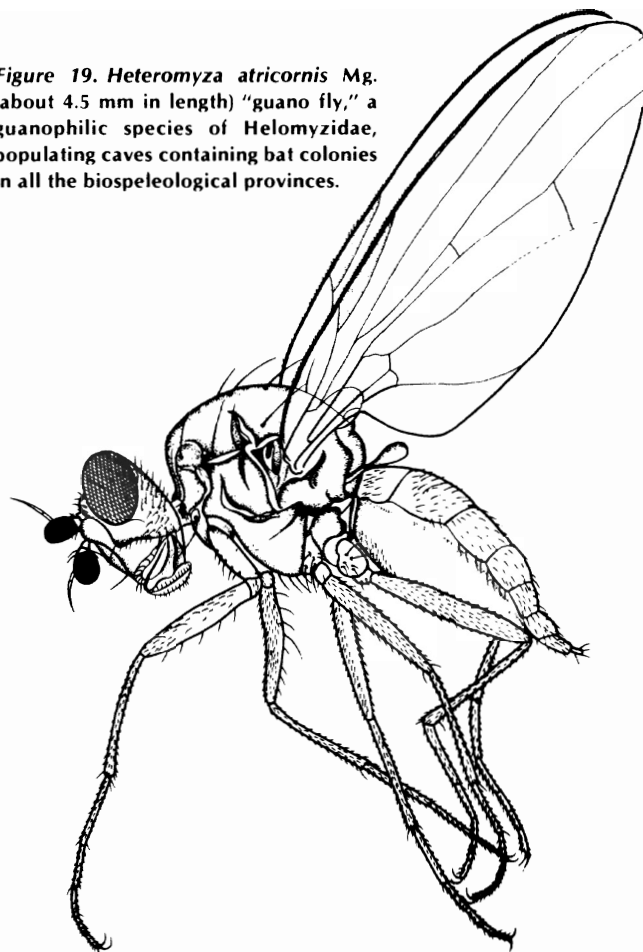


Figure 18. *Tarnania fenestralis* (Mg.) (about 6.5 mm in length), a subtrogliphilic species of mycetophilid fly, inhabiting cold and wet caves in all five biospeleological provinces.

Figure 19. *Heteromyza atricornis* Mg. (about 4.5 mm in length) "guano fly," a guanophilic species of Helomyzidae, populating caves containing bat colonies in all the biospeleological provinces.



hibernating subtrogliphilic species are: *Exechiopsis magnicauda* (Lundström) (Mycetophilidae) identified so far only from caves of Virghiș Schlucht and the southern Carpathians, west of the Olt River; *Culex pipiens pipiens* L. (Culicidae) widely distributed all over Romania, in Europe, and in North America; *Helomyza captiosa* Gorodkov, the most frequent species of Helomyzidae in Romania's caves (except in Dobrogea). *H. captiosa* is, likewise, common in the caves of other European countries. Unlike the other two hibernating subtrogliphilic species, it prefers colder caves.

Caves with bat guano contain *Heteromyza atricornis* Meigen (Fig. 19), the "guano fly," whose larvae feed on fresh guano. *H. atricornis* also occurs in caves in other areas of Europe and in Algeria. In caves inhabited by bats, some Diptera (Nycteribiidae) parasitic on them are also found. These show a high degree of host specificity. Among them, we cite *Nycteribia biarticulata* Hermann, a parasite especially on some species of *Rhinolophus*; *N. schmidlii* Schiner, a parasite on *Miniopterus schreibersi* Kühl; and *Penicillidia dufouri* (Westwood), parasitic on *Myotis myotis* Borkhausen.

Except for *Culex pipiens pipiens*, *Heteromyza atricornis*, and the Nycteribiidae, which are present in all five biospeleological provinces, Diptera have not been found in the caves of Dobrogea. The reason for their absence is the same as for the caddisflies, *i.e.*, the presence of a semi-arid steppe climate in that region. (See also Decu-Burghel, 1963; Burghel-Bălăcescu, 1965 and 1966; Motaș, *et al.*, 1967.)

COLEOPTERA: Beetles

Beetles are the order of insects possessing the largest number of troglitic taxa in the world (more than 1500). In Romania, about 60% of the now known troglitic species (126) are beetles of the subfamilies Bathysciinae (Catopidae) and Trechinae (Trechidae). The

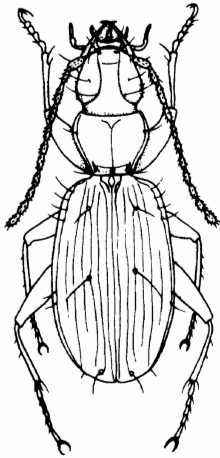
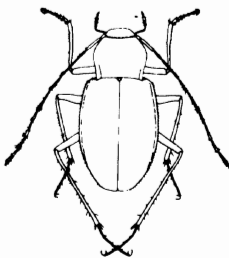


Figure 20. (above) *Duvalius budai* Kend. (about 4.7 mm in length), an endemic troglobitic species of trechine beetles, found in caves in the western portion of the southern Carpathians (Province II).

Figure 22. (below) *Closania winkleri* Jeann. (about 5.2 mm in length), an endemic troglobitic species of bathysciine beetles, found in several caves from the western portion in the southern Carpathians (Province II).



specialization index (Sbordoni, *et al.*, 1977) attains 0.90 for Bathysciinae and 0.74 for Trechinae.

The occurrence of paleotroglobitic Coleoptera in only three of the five biospeleological provinces is interesting. There are species, genera, or groups of species characteristic of each province. In Province I, there are no troglobitic Coleoptera; in Province II, the caves are inhabited by species of the *Duvalius* (*Duvaliotes*) *budai* group (Fig. 20) (family Trechidae), of *Sophrrochaeta* (Fig. 21), of *Tismanella*, and of *Closania* (Fig. 22) (family Catopidae); in Province III (Banat Mountains), there are only two troglobitic species: *Duvalius* (*Duvaliotes*) *milleri* (Trechidae) and *Banatiola vandeli* (Catopidae); in Province IV (Apuseni Mountains), live most of the troglobitic beetles, belonging to the following genera: *Duvalius* (*Duvaliotes*) *redtenbacheri* group (Trechidae), *Drimeotus*, *Pholeuon* (Fig. 23), and *Protophroleuon* (Catopidae); in Province V (Dobrogea), there occurs a single species of *Trechus* (*T. dumitrescui* Decu), which could be considered a neotroglobitic element. It inhabits the Liliecilor Cave in Gura Dobrogei, where it seems to have sheltered itself, as did *Lessertiella dobrogica* (Araneae), from the steppe climate.

Except *T. dumitrescui*, all the other troglobitic species of beetles are old forms that entered the subterranean media a long time ago. They are blind, depigmented, and apterous. The caves are inhabited not only by troglobitic species, but also by troglomorphic, subtroglobitic or guanophilic Coleoptera belonging to other families. The genera *Quedius*, *Atheta*, and *Aleochara* (Staphylinidae) and *Choleva* and *Catops* (Catopidae) are common in European caves. They show only physiological adaptations to the subterranean habitat. (See also Decu, 1963, 1967, 1980; Decu and Negrea, 1969.)

SIPHONAPTERA: Fleas

One family of fleas (Ischnopsyllidae) is parasitic only on bats. Species be-

longing to the genera *Ischnopsyllus*, *Rhynolophopsylla*, and *Nycteridopsylla*, like the Nycteribiidae (Diptera), are host-specific forms.

Fleas, like many other parasites, are not here considered true cavernicolous forms, as their presence in caves is more dependent upon the host than upon the subterranean environment.

CHIROPTERA: Bats

Bats are the only group of vertebrates inhabiting Romania's caves. They live in isolated colonies, and only six species (out of the 21 now known to exist in Romania) are troglomorphic; *Rhinolophus ferrumequinum* (Schreber), *Rh. hipposideros* (Bechstein), *Rh. mehelyi* Matschie, *Rh. euryale* Blasius,

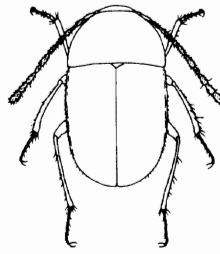
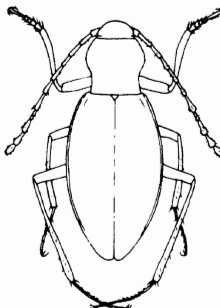


Figure 21. (above) *Sophrrochaeta oltenica* Jeann. and Mall. (about 3.5 mm in length), an endemic troglobitic species of bathysciine beetles, found in several caves in the western portion of the southern Carpathians (Province II).

Figure 23. (below) *Pholeuon angusticolle* Hpe. (about 4.7 mm in length), a troglobitic species of bathysciine beetles, endemic to the caves of the Apuseni Mountains.



Myotis myotis, and *Miniopterus schreibersi*.

Rh. ferrumequinum has a wide palearctic distribution. It is the most characteristic species found in Romania's caves and is recorded throughout the country. It is gregarious and forms colonies when giving birth and when hibernating. In some caves (such as Liliecilor Cave from Bistrița Monastery), this species forms permanent colonies. *Rh. hipposideros* (distributed in Europe, southwestern and central Asia, and north Africa) occurs throughout Romania, but does not form colonies. *Myotis myotis* (inhabiting Europe and the southern part of palearctic Asia) and *Miniopterus schreibersi* (found in southern Europe, southern Asia, the Philippines, New Guinea, northern Australia, and northwestern Africa) are present in all the five provinces and form large colonies when hibernating or producing young.

There are some subtroglobitic species of Chiroptera which show preferred distributional patterns. *Rh. mehelyi* has been recorded only in Dobrogea, and *Rh. euryale*, which, although found in small numbers and only in a few caves (most of them in Banat), forms a large summer colony in Adam's Cave (Băile Herculane).

All species of Chiroptera from Romania are insectivorous. (See also Dumitrescu, *et al.*, 1963.)

GENERAL CHARACTERIZATION OF THE TROGLOBITIC FAUNA DISTRIBUTION

The terrestrial troglobitic fauna, with the exception of that inhabiting province I, is almost entirely of north-Aegean origin. Its ancestors probably entered Romania at the end of the Oligocene or the beginning of the Miocene. Successive individual migrations from the northern Aegean region probably took place into biospeleological provinces II to V.

The Carpathian troglobitic fauna occurs almost exclusively in caves of the western and southern provinces, west of the Olt River (about 170 caves). Here dwell about 195 taxa (189 troglobitic and 6 edaphobitic) out of the nearly 227 (208 troglobitic and 19 edaphobitic) discovered so far in Romania (Fig. 24). The most intensely karsted zones are the Bihor, Pădurea Craiului (Province IV), Vilcanului and Mehedinți Mountains (Province II). These areas, which possess favorable environmental conditions and a diversity of habitats, are refugia containing large numbers of troglobitic species. The degree of diversification of the troglobitic fauna in the Apuseni Mountains is much higher than that seen in the southern Carpathians and in the Banat Mountains.

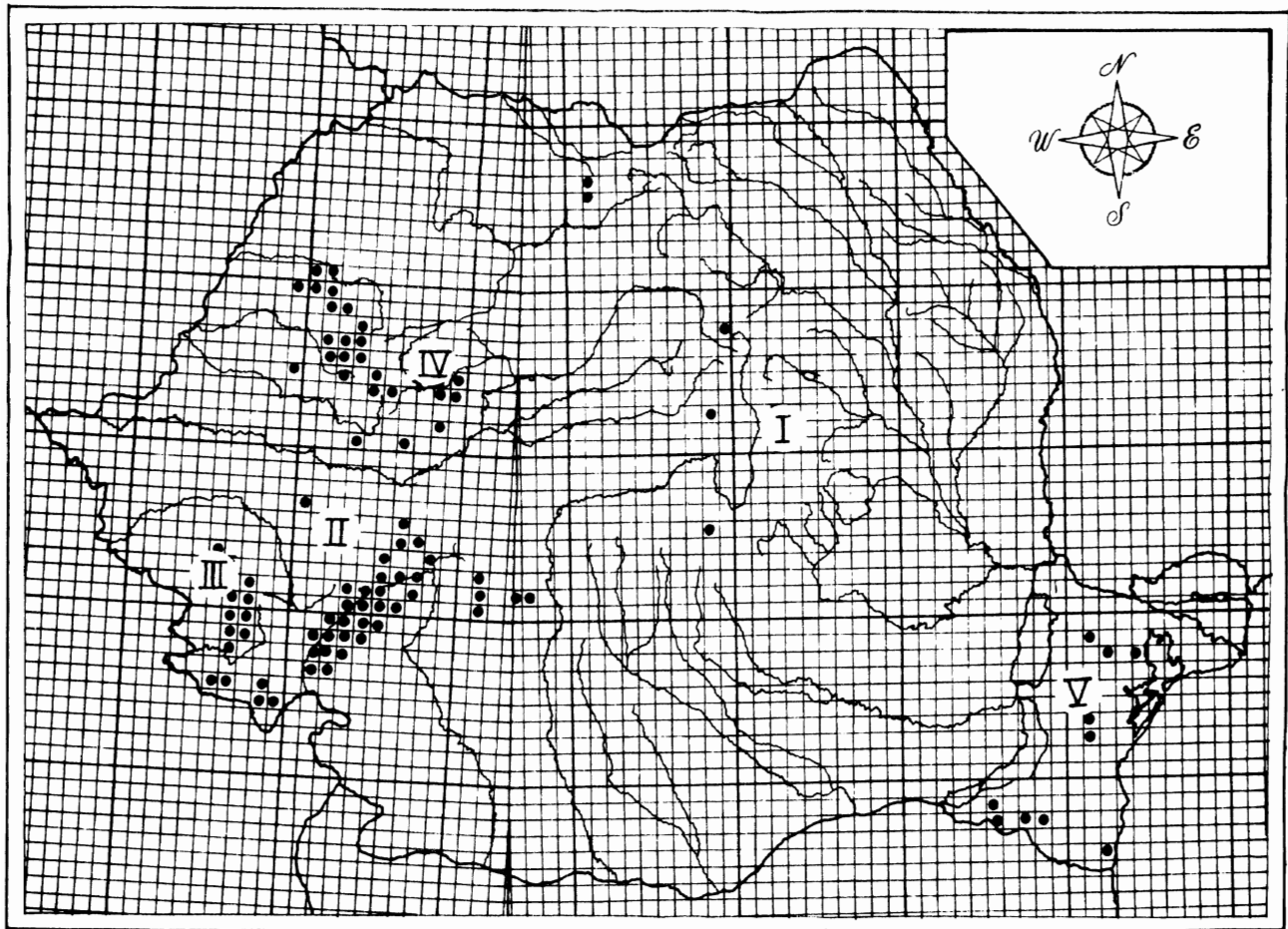


Figure 24. Distribution of terrestrial troglobitic fauna in Romania, on a map in Universal Transverse Mercator Grid. Biospeleological provinces marked I through V.

Only five troglobitic elements have so far been discovered in the first biospeleological province. But, in this province there are many edaphobitic elements with cavernicolous populations. In general, the northern elements have provided a cavernicolous subterranean fauna formed entirely of troglophiles. The largest part of the cavernicolous fauna of this biospeleological province is of central-European origin.

In Dobrogea, six troglobitic elements have been discovered so far. Four of them are neotroglobitic: *Lessertiella dobrogica*, *Meta bourneti*, *Acanthocreagris callaticola*, and *Trechus dumitrescui*. They probably entered the subterranean habitat when the developing steppe climate in Dobrogea caused the disappearance of the forests. In southern Dobrogea, where forest remnants still exist, species which in central Dobrogea are limited to shallow and deep subterranean habitats may be found in the surface litter and soil.

The number of terrestrial troglobitic taxa cited so far is not large. There are about 208, including 126 Coleoptera, 23 Araneae, 20 Diplopoda, 12 Collembola, 8 Pseudoscor-

piones, and 6 Isopoda. Most troglobitic populations are small, and cases are known where only a few specimens belonging to a species could be collected at one time. More than 97 percent of the troglobitic forms are endemic, and more than 80 percent are paleotroglobitic.

As compared to other animal species, the old troglobitic forms occupy the smallest territories and are the most isolated. Out of the total number of taxa inhabiting Romania's caves, 84 percent have been found in only 1 to 3 caves (57 percent in one cave, 10 percent in two, and 17 percent in three caves) and only 16 percent in more than three caves. This latter category generally includes the neotroglobitic taxa; a species occupying a large discontinuous area is, for instance, *Lithobius decapolitus*, a neotroglobitic element found in more than 75 caves (Decu, 1983). Many troglobitic species and races consist of single populations (such as those inhabiting only one cave).

Caves, even more than islands and mountain peaks, are the most discontinuous of terrestrial habitats. The connections be-

tween populations of terrestrial troglobites are severely restricted. The territories of the troglobitic taxa inhabiting one cave are continuous; the territories of the populations of some taxa inhabiting a group of caves also may be continuous (via less than human-sized subterranean cavities communicating through the karst), although the uninterrupted processes of mechanical and chemical deposition in the networks of fissures and cavities generally prevents that.

The number of closely related but geographically isolated troglobitic taxa (*i.e.*, vicariants), specific and infraspecific, is large. Most of them belong to the beetle genera *Duvalius*, *Pholeuon*, *Drimeotus*, and *Sophrochaeta*. The marked vicariance is due to erosion and sedimentation within the limestone massifs as well as to the troglolitization of the troglophilic fauna *in situ*. Isolated in caves, the taxa that became vicariant troglobites may not be able to enlarge their territories (excepting those that inhabit interconnected cavities).

There are no instances known of two troglobitic races (or one troglobitic race and one troglophilic race) of the same species which

inhabit parts, no matter how isolated, of the same cave system. At present, only a few cases of coexistence (in the same cave) of two troglitic species belonging to the same genus (*Neobisium* or *Duvalius*, for example) are known. Somewhat more frequent are the cases of such coexistence when one taxa is troglitic and the other trogliphilic, or when both are trogliphilic.

In the southern Carpathians, west of the Olt River (Province II) and in the Banat Mountains (Province III), the number of trogliphilic taxa and edaphobitic taxa belonging to genera and species with cavernicolous populations is much smaller than in the Apuseni Mountains (Province IV). In the Coleoptera, for instance, the number of these taxa is 15 in provinces II and III and 28 in Province IV. The specialization index of cavernicolous Coleoptera from the southern Carpathians and the Banat Mountains is 0.87, while for those from the Apuseni Mountains, it is 0.83 (Decu, 1980).

Caves inhabited by troglitobites are found at moderate elevations (300 to 1300 m ASL,

most of them under 1000 m) where the limestone, by its physical and chemical characteristics (particularly temperature conditions), offers the biogeographical optimum of a stable environment, most favorable to endemism. As compared to the total number of cavernicolous trogliphilic, troglitobitic-guanobitic, and troglitobitic taxa (about 500), the number of endemic taxa is large, attaining about 50 percent.

In most cases, the troglitobitic fauna of the southern Carpathians and of the Banat Mountains inhabit caves lying from 300 to 750 m ASL, unlike the cave fauna of the Apuseni Mountains, which inhabit caves situated from 300 to 1300 m ASL.

As far as the zoogeographical affinities of the elements characteristic of the five provinces are concerned, most of the common elements belong to provinces II and IV. The lack of marked affinities between the various biospeleological provinces reflects past differences between the provinces during the periods when the ancestors of the

troglitobitic (and edaphobitic) fauna migrated into the Carpathians as well as into Dobrogea.

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