Hypogeal fauna of the military subterranean fortification Forte di Vernante Opera 11 "Tetto Ruinas" (Piedmont, Italy)

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Abstract

The military subterranean fortification Forte di Vernante Opera 11 "Tetto Ruinas" is not mentioned in the extensive specific literature about the NW Alps underground works. Only the project in the Military Engineers Corps archives is known, however, the survey recently detected by our research association Biologia Sotterranea Piemonte – Gruppo di Ricerca highlights differences from the original map. On the contrary, pubblications about the hypogeal fauna in this artificial cavity are numerous. Two new species of spiders with remarkable adaptations to the underground environment were discovered by Angelo Morisi (1943-2016): the Linyphiidae *Troglohyphantes konradi* Brignoli, 1975 and the Nesticidae *Typhlonesticus morisii* (Brignoli, 1975). Subsequently, other adapted to this particular environment spiders were observed, such as *Kryptonesticus eremita* (Simon, 1880) and *Leptoneta crypticola* Simon, 1907. Spiders with less evident adaptations were reported for this cavity, such as *Tegenaria silvestris* L. Koch, 1872, *Pimoa rupicola* (Simon, 1884), *Meta menardi* (Latreille, 1804), *Metellina merianae* (Scopoli, 1763). Terrestrial Crustacean adapted to underground environment are present in this fort: *Buddelundiella zimmeri* Verhoeff, 1930 and *Trichoniscus voltai* Arcangeli, 1948. Among the Miriapods were observed the Chilopoda *Eupolybothrus longicornis* (Risso, 1826) and *Lithobius microps* Meinert, 1868, and the Diplopoda *Plectogona vignai draco* (Strasser, 1975), a very specialized organism, and the larger and less adapted *Callipus foetidissimus* (Savi, 1819). The troglophile grasshopper *Dolichopoda azami* Saulcy, 1893 is very common in the cavity. Of considerable interest are the anophthalmous beetle *Duvalius carantii* (Sella, 1874), and the very rare Staphylinidae *Blepharhymenus mirandus* Fauvel, 1899. Moreover, it is possible to observe the cave salamander *Speleomantes strinatii* (Aellen, 1958) and different Chiroptera species. The association Biologia Sotterranea Piemonte - Gruppo di Ricerca deals mainly the study of subterranean species and environments and their conservation. Our last twenty years research in this subterranean military cavity have allowed to observe and monitor the presence of all the mentioned in the bibliography organisms, and to document the presence of other 20 species. Our studies in this and other artificial cavities of Piedmont highlight the presence of different extremely adapted to the hypogeal environment species, reiterating the importance of the subterranean fauna monitoring in the artificial cavities too, and the presence of these organisms due to some biotic and abiotic environmental factors, regardless of the natural or artificial origin of the cavity.

Keywords: subterranean biology, artificial cavities, war works.

Introduction

Subterranean environments include natural and artificial voids suitable for the occurrence of life. In the last decades, different research on subterranean fauna were done, highlighting the presence of these organisms in large distribution areas, however, due to a misconception of the "cave" fauna, artificial cavities are much less studied than caves. Apart from darkness, different environmental parameters and climatic conditions have a direct effect on subterranean ecosystems and induced a number of physiological, metabolic, morphological and behavioral adaptations in hypogeal fauna (Culver e Pipan, 2010; Howarth et al., 2018), making it extremely interesting for researchers (Mammola *et al.*, 2020).

Hypogeal animals live in the rock cracks, in which they move on in search of trophic resources, included subterranean environments suitable for human exploration (Juberthie, *et al.*, 1981; Giachino e Vailati, 2010): it is not important the origin (natural or artificial) of the cavity, instead, the rock typology, biotic and abiotic factors, and the geographical position in which cavities develop are fundamental. Even in the case of artificial cavities, evident connections occur through the artificial structures and the fissures of the bedrock, favoring subterranean fauna displacement, especially when internal surfaces are not covered with plaster or concrete. In underground works with covered and/or intact walls, a less subterranean environment adapted fauna was observed (Lana *et al.,* 2021).

The research association Biologia Sotterranea Piemonte – Gruppo di Ricerca (BSPGR) deals mainly the study of subterranean species and environments and

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Fig. 1 – The military subterranean fortification Forte di Vernante Opera 11 “Tetto Ruinas” (photo E. Lana)

their conservation, monitoring and detecting caves and artificial cavities. The military subterranean fortification Forte di Vernante Opera 11 “Tetto Ruinas” (FOP11) has different publications about its hypogeal fauna. The aim of this study is to monitor over time the presence of all previously mentioned in bibliography organisms, and to document the presence of other species, due to biotic and abiotic environmental factors in the artificial cavity, highlighting the most subterranean life adapted species.

Study area

In 1931, in Italy officially started the construction of the “Alpine Wall”, a defensive arrangement to secure the protection of the Italian Alpine borders. However, in 1924-1925 a series of antecedent fortifications were realized in the Maritime Alps, Piedmont (Corino, 1997). The Alpine Wall maps and projects were kept in the Military Engineers Corps of Cuneo archives; after its closure, about twenty years ago, the material was transferred to the Military Engineers Corps of Turin archives, today called “Archivio 1° Reparto Infrastrutture di Torino”. For the northernmost valleys of Piedmont, specific publications dealing with the fortifications of the Alpine Wall are present (Corino, 1997; Ruzzi e Comello, 2017), instead, no written work related to the Vermenagna Valley was found.

The FOP11 is located at about half a km to Vernante, Piedmont, on the left orographic bank of the Vermenagna stream, at 800 m a.s.l. Most structures are hypogeal, however, some buildings such as the observatory are visible on the surface. The subterranean areas, carved into limestone rock, are mostly incomplete: the floors are not covered, on which abundant debris from the excavation work were accumulated, as well as in the central hall (fig. 1). Some lateral branches are sketchy, reduced to windows or short galleries ending on a rock wall or on a slide of large rocky debris.

The schematic survey recently detected by our research association BSPGR (fig. 2) highlights differences from the original map. The observatory, which should have been significantly higher and accessible from the central hall with a stairway, was merged and superimposed on the first left batch (South), the only one completed; this batch was reinforced with a side workstation not foreseen in the original design. Two side corridors had to be detached from the long central hall for the building of two stations, however, only one was done. Finally, another station had to be built next to the entrance but it was not made.

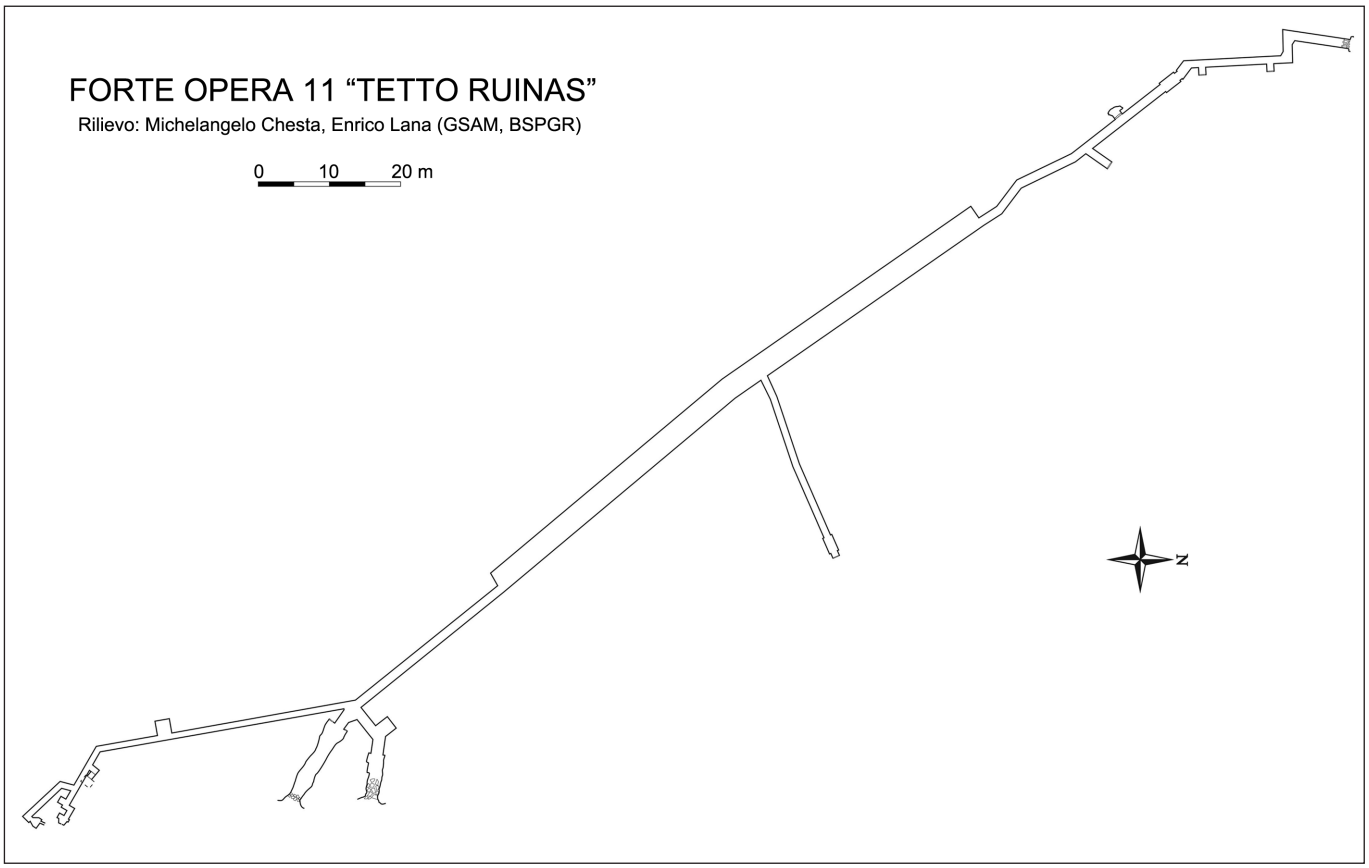

Fig. 2 – The recent survey of the military subterranean fortification Forte di Vernante Opera 11 “Tetto Ruinas” (survey by M. Chesta and E. Lana).

Materials and method

Visual encountered surveys, supported by the acquisition of macrophotographs of the observed species were performed from 2000 to 2023. Samples of the taxa were collected manually for the determination of the species and were placed directly in 96% ethanol in sampling tubes. Species were determined by reference experts.

Photographs of the specimens were taken using a Canon EOS 550D and 760D reflex cameras equipped with MP-E 65 mm Macro lenses and MT-24EX Macro flash and Canon EOS 70D reflex camera equipped with EF 100 mm Macro lens 1:2.8 USM and integrated flash.

The survey was performed using Suunto Tandem/360PC/360R DG Clino/Compass and Leica Disto D510 Laser distance meter.

Fig. 3 – *Troglohyphantes konradi* (photo V. Balestra)

Biological research

Angelo Morisi (AM) (1943-2016) and Augusto Vigna Taglianti (1943-2019) carried out the first study on the subterranean fauna of the FOP11 in the 70s, published in some speleological bulletins (Morisi, 1972; Morisi 1973). Other citations of the fortification are reported in different lists (e.g. Strasser, 1975; Brignoli, 1975; Lana, 2001; Arnò e Lana, 2005; Isaia *et al.*, 2011). An updated subterranean species list of the FOP11 was reported in Lana *et al.*, 2021, with full citation of the related bibliographical research.

The FOP11 is the *locus typicus* of two spider species and one diplopod subspecies with notable underground life adaptations. *Troglohyphantes konradi* Brignoli, 1975 (fig. 3) was discovered in 1972 by AM and dedicated to the arachnologist Konrad Thaler. This spider is one of the most adapted to the hypogeal environ-

Fig. 4 – *Typhlonesticus morisii* (photo E. Lana)

Fig. 5 – *Plectogona vignai draco and Trichoniscus voltai* (photo E. Lana)

ment in the Western Alps: it has a 3.5 mm long depigmented body and atrophic eyes reduced to diaphanous scars. It weaves its thick webs in horizontal drape, in wall recesses or between big stones on the ground, and catches dipterans and small insects. New stations of this arachnid were found in different Gesso and Vermenagna Valleys caves (Arnò e Lana, 2005; Isaia *et al.*, 2011; Lana *et al.*, 2021). *Typhlonesticus morisii* (Brignoli, 1975) (fig. 4) was discovered by AM in 1972 and dedicated to him. This spider weaves sparse webs formed by single threads, creating a three-dimensional network with which it mainly catches especially flying insects. It is one of the most underground life adapted spiders in the Western Alps: it has about 5 mm long totally depigmented body, with atrophied eyes. For over thirty years it was considered an exclusive endemic of the FOP11, however, in the last decade new stations in Ellero and Vermenagna Valleys were found (Lana *et al.*, 2017; Isaia *et al.*, 2017). *Plectogona vignai draco* (Strasser, 1975) (fig. 5) was discovered by AM in 1972; this diplopod is a distinct subspecies of *Plectogona vignai* (Strasser, 1970), discovered in Camoscere cave (PI105), and observed in Bandito cave (PI1002), near the FOP11. The *Plectogona* genus counts different diplopods with marked hypogeal life adaptations, such as depigmentation and reduced visual organs. *P. vignai draco* has a body size of about 18 mm and feeds on decaying organic matter. Numerous stations of *P. vignai* and its subspecies are known in the Cuneo area and other still indeterminate specimens were found in different Vermenagna Valley caves (Lana *et al.*, 2021). Other specialised spiders were observed too, such as *Kryptonesticus eremita* (Simon, 1880) and *Leptoneta crypticola* Simon, 1907. *K. eremita* is a spider having reduced vision organs and a 5mm long body with characteristic dark drawings on the exoskeleton. It weaves webs similar to the *T. morisii* ones, useful to catch dipterans and small arthropods. It has spread in central-southern Europe natural or artificial cavities (Arnò e Lana, 2005); in the Western Alps it was reported in hundreds of underground stations (Lana *et al.*, 2021). *L. crypticola* is a depigmented spider of small size (2-3 mm), with reduced eyes and characteristic iridescent reflections of the exoskeleton. It builds very fine texture webs, usually between the stones on the ground, undermining Collembola and other small arthropods. The distribution area of *L. crypticola franciscoloi* subspecies Caporiacco, 1950, present in the FOP11, is from the Ligurian to the Cottian Alps (Isaia *et al.*, 2011; Lana *et al.*, 2021).

Different spiders with less evident adaptations were observed in this cavity: *Tegenaria silvestris* L. Koch, 1872, *Pimoa rupicola* (Simon, 1884), *Meta menardi* (Latreille, 1804), and *Metellina merianae* (Scopoli, 1763) (Arnò e Lana, 2005: Lana *et al.*, 2021). These spiders have a body of considerable size (10-15 mm) and little evident adaptations to the underground environment; generally, they can be observed in the cavity entrances, where they weave their ample webs to catch flying or jumping insects even of big size.

Terrestrial Crustacean adapted to underground environment are present in the FOP11: *Buddelundiella zimmeri* Verhoeff, 1930 and *Trichoniscus voltai* Arcangeli, 1948. *T. voltai* (fig. 5) was discovered in 1947 in Bossea cave. Today it is reported in other cavities of the Cuneo area, from Tanaro to Vermenagna Valleys (Lana *et al.*, 2021). This animal feeds on rotting plant residues; it is depigmented and anophthalmic, with a body of about 3 mm long. *B. zimmeri* was discovered in 1929 among the ruins of the Ceva Castle; today, it is reported in dozens of underground cavities, from Tanaro Valley to the Maritime Alps (Lana *et al.*, 2021). It has dimensions similar to *T. voltai*, but is less adapted to underground life.

Among the Myriapoda were observed also *Eupolybothrus longicornis* (Risso, 1826), *Lithobius microps* Meinert, 1868 and *Callipus foetidissimus* (Savi, 1819). *E. longicornis* is an arthropods' predator up to 25 mm long, instead, *L. microps* has similar biology but dimensions < 20 mm. *C. foetidissimus* is a less spe-

Fig. 6 – *Duvalius carantii* (photo V. Balestra)

cialized diplopod widespread in most of Italy; in the Western Alps it is present in the Cottian, Maritime and Ligurian Alps and in Piedmont it was reported in about 50 underground stations (Lana *et al.*, 2021). It secretes a whitish repellent substance of nauseating smell which is at the origin of its name; it is pigmented, has small eyes and can exceed 50 mm of length.

The troglophile grasshopper *Dolichopoda azami* Saulcy, 1893 is very common in the FOP11, recently attributed to the *D. azami ligustica* subspecies Baccetti & Capra, 1959 (Allegrucci *et al.*, 2014). It is present in the Western Alps and it was observed in about 300 subterranean cavities of Piedmont (Lana *et al.*, 2021). This orthoptera is a predator. It usually spends the winter in underground environments, forming numerous gatherings, instead, in summer it gets out during the night to hunt. It has a body of about 15 mm, little eyes and very long antennae.

Of considerable interest are the anophthalmous Trechini beetle *Duvalius carantii* (Sella, 1874), and the very rare Staphylinidae *Blepharhymenus mirandus* Fauvel, 1899. *D. carantii* (fig. 6) is a predatory beetle belonging to the Carabidae family with remarkable adaptations to the underground life: it is depigmented and anophthalmos, and an average body size of about 4.5 mm. It was the first hypogeal insect belonging to the genus *Duvalius* described in the Western Alps, discovered in the Certosa di Pesio crypt. It is currently the most widespread *Duvalius* in Southern Piedmont (Lana *et al.*, 2021). *B. mirandus* (fig. 7) is a beetle described on specimens found in the Maritimes Alps. About ten subterranean stations were found in Piedmont (Lana *et al.*, 2021). Little depigmented, it has medium size eyes, long antennae and legs, and a 5 mm body length.

At the entrances, it was possible to observe the cave salamander *Speleomantes strinatii* (Aellen, 1958) (fig. 8), a protected amphibian whose biology is closely linked to hypogeal environment.

Fig. 7 – *Blepharhymenus mirandus* (photo V. Balestra)

Fig. 8 – *Speleomantes strinatii* (photo E. Lana)

Inside the FOP11, different Chiroptera colonies were observed over the years, belonging to *Rhinolophus ferrumequinum (*Schreber, 1774), *Rhinolophus hipposideros* (Bechstein, 1800) and *Barbastella barbastellus* (Schreber, 1774) species; a significant data, since all bat species are protected in Italy.

Faunal list

To date, 55 organisms were found in the FOP11, of which over 20 not previously observed. The following list was drawn up on the basis of the latest observations reported in Lana *et al.*, 2021, with new additions.

Mollusca, Gastropoda

Phenacolimax blanci (Pollonera, 1884) (Stylommatophora, Vitrinidae)
Morlina glabra (Rossmässler, 1835) (Stylommatophora, Oxychilidae)

Annelida, Clitellata

Dendrodrilus sp. Omodeo, 1956 (Haplotaxida, Lumbricidae)

Arthropoda, Arachnida

Euscorpius sp. Thorell, 1876 (Scorpiones, Euscorpiidae)
Holoscotolemon oreophilum Martens, 1978 (Opiliones, Cladonychiidae)
Leiobunum religiosum Simon, 1879 (Opiliones, Sclerosomatidae)
Amilenus aurantiacus (Simon, 1881) (Opiliones, Phalangiidae)
Chthonius sp. C.L. Koch, 1843 (Pseudoscorpiones, Chthoniidae)
Tegenaria silvestris L. Koch, 1872 (Araneae, Agelenidae)
Amaurobius sp. C.L. Koch, 1837 (Araneae, Amaurobiidae)
Cicurina cicur (Fabricius, 1793) (Araneae, Hahniidae)
Leptoneta crypticola Simon, 1907 *franciscoloi* Caporiacco, 1950 (Araneae, Leptonetidae)
Labulla thoracica (Wider, 1834) (Araneae, Linyphiidae)
Troglohyphantes konradi Brignoli, 1975 (Araneae, Linyphiidae) (fig. 3)
Kryptonesticus eremita (Simon, 1880) (Araneae, Nesticidae)
Typhlonesticus morisii (Brignoli, 1975) (Araneae, Nesticidae) (fig. 4)
Pimoa rupicola (Simon, 1884) (Araneae, Pimoidae)
Meta menardi (Latreille, 1804) (Araneae, Tetragnathidae)
Metellina merianae (Scopoli, 1763) (Araneae, Tetragnathidae)
Sottoclasse ACARINA, Trombidiformes, Rhagidiidae indet.

Arthropoda, *Subphylum* Crustacea, Malacostraca

Trichoniscus voltai Arcangeli, 1948 (Isopoda, Trichoniscidae) (fig. 5)
Buddelundiella zimmeri Verhoeff, 1930 (Isopoda, Buddelundiellidae)

Arthropoda, Superclasse Myriapoda, Chilopoda

Eupolybothrus longicornis (Risso, 1826) (Lithobiomorpha, Lithobiidae)
Lithobius microps Meinert, 1868 (Lithobiomorpha, Lithobiidae)
Lithobius sp. Leach, 1814 (Lithobiomorpha, Lithobiidae)

Arthropoda, Superclasse Myriapoda, Diplopoda

Callipus foetidissimus (Savi, 1819) (Callipodida, Callipodidae)
Plectogona vignai draco (Strasser, 1975) (Chordeumatida, Craspedosomatidae) (fig. 5)
Polydesmus cf. *testaceus* C.L. Koch, 1847 (Polydesmida, Polydesmidae)
Polydesmus troglobius Latzel, 1889 (Polydesmida, Polydesmidae)

Arthropoda, Superclasse Hexapoda, Entognatha

Collembola, Onychiuridae indet.

Arthropoda, Superclasse Hexapoda, Insecta

Machilis sp. Latreille, 1804 (Archaeognatha, Machilidae)
Dolichopoda azami ligustica Baccetti & Capra, 1959 (Orthoptera, Rhaphidophoridae)
Duvalius carantii (Sella, 1874) (Coleoptera, Carabidae, Trechini) (fig. 6)
Sphodropsis ghilianii ghilianii (Schaum, 1858) (Coleoptera, Carabidae)
Laemostenus obtusus (Chaudoir, 1861) (Coleoptera, Carabidae)
Platynus sp. Bonelli, 1810 (Coleoptera, Carabidae)
Coleoptera, Scydmaenidae indet.
Dasycerus sulcatus Brongniart, 1800 (Coleoptera, Dasyceridae)
Bryaxis tendensis Besuchet, 2002 (Coleoptera, Staphylinidae, Pselaphinae)

Vulda sp. Jacquelin Du Val, 1853 (Coleoptera, Staphylinidae)
Quedius bicolor Mulsant & Rey, 1876 (Coleoptera, Staphylinidae)
Quedius mesomelinus (Marsham, 1802) (Coleoptera, Staphylinidae)
Blepharhymenus mirandus Fauvel, 1899 (Coleoptera, Staphylinidae, Aleocharinae) (fig. 7)
Limonia nubeculosa Meigen, 1804 (Diptera, Limoniidae)
Culex sp. Linnaeus, 1758 (Diptera, Culicidae)
Diptera indet.
Triphosa tauteli Leraut, 2008 (Lepidoptera, Geometridae)
Hypena obsitalis (Hübner, 1813) (Lepidoptera, Erebidae)
Scoliopteryx libatrix (Linnaeus, 1758) (Lepidoptera, Erebidae)

Chordata, *Subphylum* Vertebrata, Amphibia

Speleomantes strinatii (Aellen, 1958) (Urodela, Plethodontidae) (fig. 8)
Rana temporaria Linnaeus, 1758 (Anura, Ranidae)

Chordata, *Subphylum* Vertebrata, Mammalia

Rhinolophus ferrumequinum (Schreber, 1774) (Chiroptera, Rhinolophidae)
Rhinolophus hipposideros (Bechstein, 1800) (Chiroptera, Rhinolophidae)
Barbastella barbastellus (Schreber, 1774) (Chiroptera, Vespertilionidae)
Glis glis (Linnaeus, 1766) (Rodentia, Gliridae)
Vulpes vulpes (Linnaeus, 1758) (Carnivora, Canidae)

Conclusions

In the last decades, different research on the Western Alps subterranean fauna were done, highlighting the presence of these organisms in natural and artificial cavities. These animals live in the rock cracks, in which they move on in search of trophic resources. In the FOP11 tunnels there are large internal surfaces not covered with plaster or concrete, therefore, there is a direct contact between the fortification structures and the rock cracks, populated by the subterranean fauna. For this reason and thanks to favorable environmental factors it was possible to observe in the FOP11 55 different species.
The BSPGR last twenty years research in this subterranean fortification have allowed to observe and monitor all previously mentioned in bibliography organisms and to document the presence of other 20 species. Our observations in this fortification and in different artificial cavities of Piedmont show the presence of different extremely adapted to the subterranean environment species, regardless of the natural or artificial origin of the cavity; the presence of these animals is linked to biotic and abiotic environmental factors in the cavity, underlining the importance of the hypogeal fauna monitoring in the artificial cavities too.

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