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Tychobythinus inopinatus, a new troglobitic species from Sicily (Coleoptera, Staphylinidae, Pselaphinae)

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Abstract

A new troglobitic species of the subfamily Pselaphinae (Coleoptera: Staphylinidae), *Tychobythinus inopinatus* **sp**. **nov**., is described from Monello Cave (Syracuse, Syracuse Province, Sicily). Major diagnostic features are illustrated based on both male and female specimens. The new species shows some adaptations to cave life, i.e., pale brown colour; setation consisting of long and flattened setae and suberect shorter setae; absence of wings; and anophthalmy and elongate legs and antennae. It can be easily separated from the related taxa by the different shapes of the head, palpi, gular carina of the male, and aedeagus. *Tychobythinus inopinatus* **sp**. **nov**. is known only from Monello Cave, a limestone cave in the south-eastern Sicily.

Key words: Goniaceritae, Bythinini, *Tychobythinus inopinatus* **sp. nov**., limestone cave, biospeleology, nature reserve

Introduction

Extensive field work over the last year allowed the discovery of a new troglobitic species of Pselaphinae, which is described here. The new species belongs to the genus *Tychobythinus* Ganglbauer, 1896, a large Holarctic genus of the tribe Bythinini, with 91 taxa (87 species and 4 subspecies) known from the Palaearctic region (Schülke & Smetana 2015; Sabella *et al*. 2019), and five species from the Nearctic region (Chandler 1997; Newton *et al*. 2001).

Five species of *Tychobythinus* are known from Sicily. They include, in addition to the present new species: 1) *T. glabratus* (Rye, 1870), widely distributed in Western Europe, and reported in Sicily only from the Peloritani Mountains (Sabella 1998); 2) *T. effeminatus* Sabella, 1999, strictly endogean and endemic to Sicily, known only from Mount San Giuliano (Erice, Trapani); 3) *T. molarensis* Sabella, Grasso & Spena, 2012, a troglobitic species from Molara Cave (Palermo province); and 4) *T. villasmundi* Sabella, Amore & Nicolosi, 2019, a troglobitic species endemic from Villasmundo Cave (Melilli, Syracuse province).

Materials and methods

Notes on the sampling environment. Monello Cave (cadastral number SiSr7007, Latitude 37°01'40.00''N; Longitude 15°09'57''E) is located in the eastern part of Sicily in Syracuse (Italy), within the Strict Nature Reserve "Grotta Monello" (Fig. 1). The Reserve is managed by CUTGANA (Centro Universitario per la Tutela e la Gestione degli Ambienti Naturali e degli Agroecosistemi) of Catania University, and was established in 1998, with the aim of protecting a cave with speleothems of extraordinary beauty (Fig. 3) and its specialized subterranean fauna. It is part of the Special Area of Conservation (SAC) ITA090011 "Grotta Monello", and also a Geosite of regional interest.

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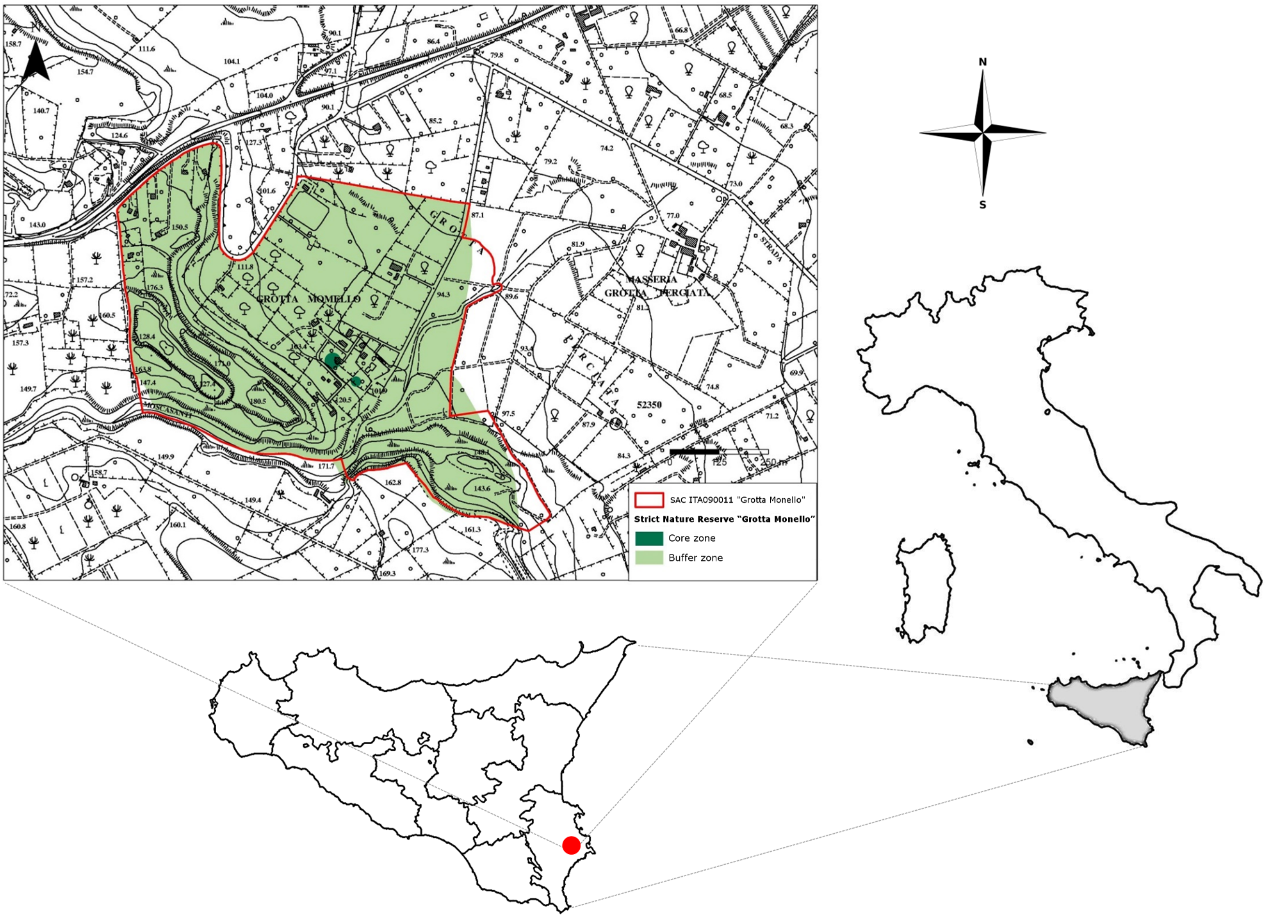
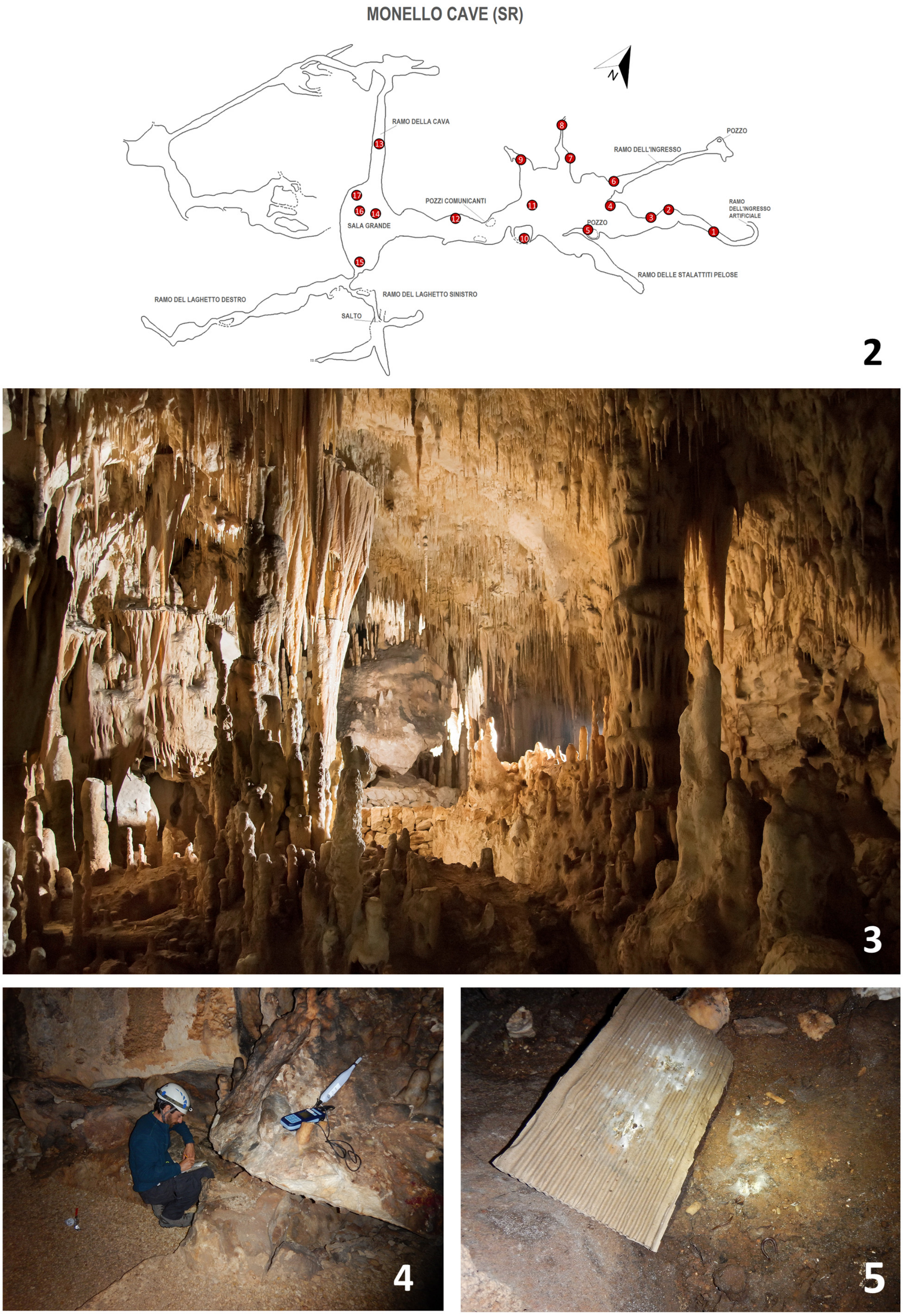


FIGURE 1. Location map of Strict Nature Reserve "Grotta Monello".

The studied area is part of the eastern sector of the Hyblean Plateau in southeastern Sicily. The nature reserve of "Grotta Monello" is located within the NW-SE trending Late Quaternary Floridia Basin (Ghisetti & Vezzani 1980), a 12 km wide, 20 km long tectonic depression affecting the northeastern sector of the Hyblean Plateau. The Monello cave developed inside the Early-Middle Miocene calcarenites and calcirudites with fragments of bryozoa, echinoderm, algae and bivalves that constitute the upper member or Siracusa Member of the Climiti Mounts Formation. Its genesis is due to the various stages of karst dissolution process by meteoric waters infiltrating into the ground and by airflow rich in CO_2. With a total lenght of about 540 m, the cave consists of several levels where remarkable concretions (stalactites, stalagmites, columns, veils, etc.) can be observed, and especially in the upper level (Fig. 2).

The cave was discovered in 1948 and in the 1980s a successive series of works aimed at tourist fruition carried out by the "Provincia di Siracusa" have profoundly modified it, altering its naturalness. The same group has commissioned the University of Catania to perform a faunistic study before the official opening, highlighting an invertebrate fauna of considerable interest (Caruso 1995). By using a combination of monitoring techniques including collection by sight and the use of pit-fall traps, the monitoring activities carried out by the University of Catania had in fact established the importance of this ecosystem thanks to the discovery of some specialized species of this cave environment, some endemic to the Monello cave, including the pseudoscorpion *Chthonius multidentatus* Beier, 1963 and the isopod *Armadillidium lagrecai* Vandel, 1969. The presence of the latter, currently known only from the Monello cave, and of other species of considerable scientific interest, favored the establishment of the Strict Reserve, avoiding an uncontrolled tourist use of this reserve. Despite the intense monitoring activities previously conducted, the presence of *T. inopinatus* **sp. nov.** was never detected.

Currently, the entrance into the cave is limited to strictly scientific purposes only, but starting in 2018 a limited number of visitors have been allowed as part of a research project aimed at evaluating the presence of human impacts on the hypogean environment. As part of the same project a faunistic study of the invertebrate fauna was performed



FIGURES 2–5. 2. Topography of the Monello Cave (by Ruggieri & Amore 2000, modified). The red dots indicate the sampling points where the cardboard pieces were placed. 3. Speleothems in Monello Cave (Ph. S. Costanzo). 4. One of the spots where *T. inopinatus* **sp. nov.** was collected (Ph. S. Costanzo). 5. Cardboard used for the sampling activity (Ph. S. Costanzo).

starting in December of 2018. In order to minimize the impact on the fauna, the monitoring was performed avoiding the use of trapping, but rather through use of a series of cardboard pieces of 15 cm x 30 cm (Fig. 5) that were positioned along the main galleries of the cave. The position of the cardboard pieces are illustrated in Figure 2.

The invertebrate fauna attracted by cardboard, which is presumed to act as a refuge, were counted every two weeks, and a small number of specimens were collected and preserved in alcohol in case of the need for further identification. The methodology used allowed the confirmation of species already known from the cave, but also the detection of species previously unknown for the cave, including the Dipluran *Plusiocampa* (*Plusiocampa*) *tinoamorei* Sendra & Nicolosi, 2019 (see also Nicolosi *et al.* 2019), recently described for the Villasmundo Cave, and the new *Tychobythinus inopinatus* **sp. nov**., which is here described. Specimens of *T. inopinatus* **sp. nov.** were collected by using soft forceps and were directly transferred into 70% ethanol.

During collection environmental parameters (temperature, humidity, and CO_2) were measured using the mobile instrument Indoor Air Quality Monitor Delta Ohm (Fig. 4). The cave produced values for temperature and relative humidity that were constant in the deeper parts of the cave, reaching and exceeding the values of 18°C for the temperature and 100% for the relative humidity. CO_2 was quite variable depending on the season, varying from 400 to over 6.000 ppm.

The specimens were collected throughout the cave but mostly from the inner branches, where environmental parameters (temperature and relative humidity) are stable year round.

The body length is measured from the anterior clypeal margin to the posterior margin of the last visible abdominal tergite. The length and width of the body parts were measured between points of maximum extension, e.g. the head length is measured between the anterior clypeal margin and the posterior margin of the neck; the head width includes the eyes, the elytral length along the suture line, and the elytral width is the total width of the two elytra taken together at the middle. The abdominal tergites are numbered based on order of visibility. Morphological terminology follows Chandler (2001), except that the abdominal sternites are termed ventrites.

The aedeagus of the holotype and the telisternite of a female paratype were mounted in Canada balsam. A camera lucida mounted on a Leica DMLB stereomicroscope was used for drawings, while photos were made using a Leica digital camera mounted on Leica DMLB stereomicroscope, using the software CombineZ.

The holotype and the paratypes are deposited in the Sabella Collection, University of Catania (acronym DBUC).

Taxonomy

Tychobythinus inopinatus Sabella, Costanzo and Nicolosi, sp. nov.

(Figs. 6–16)

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Type material. **Holotype**: **ITALY**: Sicily Region: Syracuse, Monello Cave, 22.X.2019, trap 17, 1 ♂, G. Nicolosi leg. (DBUC). **Paratypes** (all 17 specimens in DBUC): **ITALY**: Sicily Region: 1 ♀, same data of holotype; 1 ♀, same data of holotype, but trap 8; 1 ♀, same data of holotype, but trap 10; 1 ♂, same data of holotype, but trap 12; 1 ♀, same data of holotype, but trap 16; 1 ♀, same locality, 31.VII.2019, trap 10, G. Nicolosi leg.; 2 ♀♀, same data, but trap 12; 1 ♀, same locality, 22.VIII.2019, trap 12, G. Nicolosi leg.; 1 ♀, same locality, 05.IX.2019, trap 12, G. Nicolosi leg.; 1 ♀, same locality, 19.IX.2019, trap 17, G. Nicolosi leg.; 1 ♀, same locality, 07.X.2019, trap 10, G. Nicolosi leg.; 1 ♀, same data, but trap 17; 1 ♀, same locality, 07.XI.2019, trap 10, G. Nicolosi leg.; 3 ♀♀, same locality, 05.XII.2019, trap 10, G. Nicolosi leg.

Description. *Male* (Fig. 6): Length 1.30–1.35 mm, apterous and anophthalmous. Pale brown or brown with lighter antennae, palpi, and legs. Pubescence consists of long and flattened setae (length: 0.07–0.08 mm) on head, pronotum, elytra, and abdomen, other suberect shorter setae (length: 0.03–0.04 mm) on antennae, and legs, and thin fluff on apical segment of maxillary palpi.

Head (Fig 8) wider (0.30 mm) than long (0.24 mm) narrower than pronotum. Frontal lobe wider (0.175 mm) than long (0.08 mm) with subparallel, protruding and sharp sides; antennal tubercle protruding. Frons between antennal tubercles with large median sulcus reaching anterior edge of vertexal foveae. Median clypeal carina well-defined, equally visible in dorsal as well as lateral view, extending to ocular region. Tempora rounded, convex occipital region traversed by median longitudinal sulcus, extending to posterior edge of vertexal foveae, these last wide and well-impressed. Gular region (Figs 10–11) behind labium with deep and broad impression margined posteriorly by transverse ridge projecting and laterally recurved backwards on each side of head. This ridge with long and acute median process, process projecting ventrally and ending with a bifid tuft of setae on the tips. Base of median process enlarged posteriorly in an oval impression, at base with two long and sturdy median bristles. Antennae 0.65–0.66 mm long, scape more than 4 times longer (0.19–0.20 mm) than wide (0.045 mm), narrowed and flattened with sharp medial margin on basal third, wider at middle. Pedicel ovoid, slightly asymmetric, about 1.5 times longer than wide, about as wide as scape, and wider than funicular segments. Antennomere III distinctly longer than wide and narrowed at base; antennomeres IV and V about as long as wide, antennomeres VI–VII wider than long, antennomeres VI shorter and closer than VII; antennomeres VIII wider than long, and wider than VII. Antennal club consisting of last three antennomeres which are widening progressively from IX to XI. Antennomeres IX and X distinctly wider than long, antennomere XI distinctly longer than wide and twice as long as combined length of antennomeres IX and X. Maxillary palpi (Fig. 13) with palpomere IIs elongate and gradually expanded from base to apex, their surface covered by 8-10 tubercles. Palpomeres III slightly longer than wide, surface with 4–6 tubercles; last palpomere about 5 times as long (0.29 mm) as wide (0.055 mm), widest at basal third, lateral margin distinctly curved and sinuate at middle.

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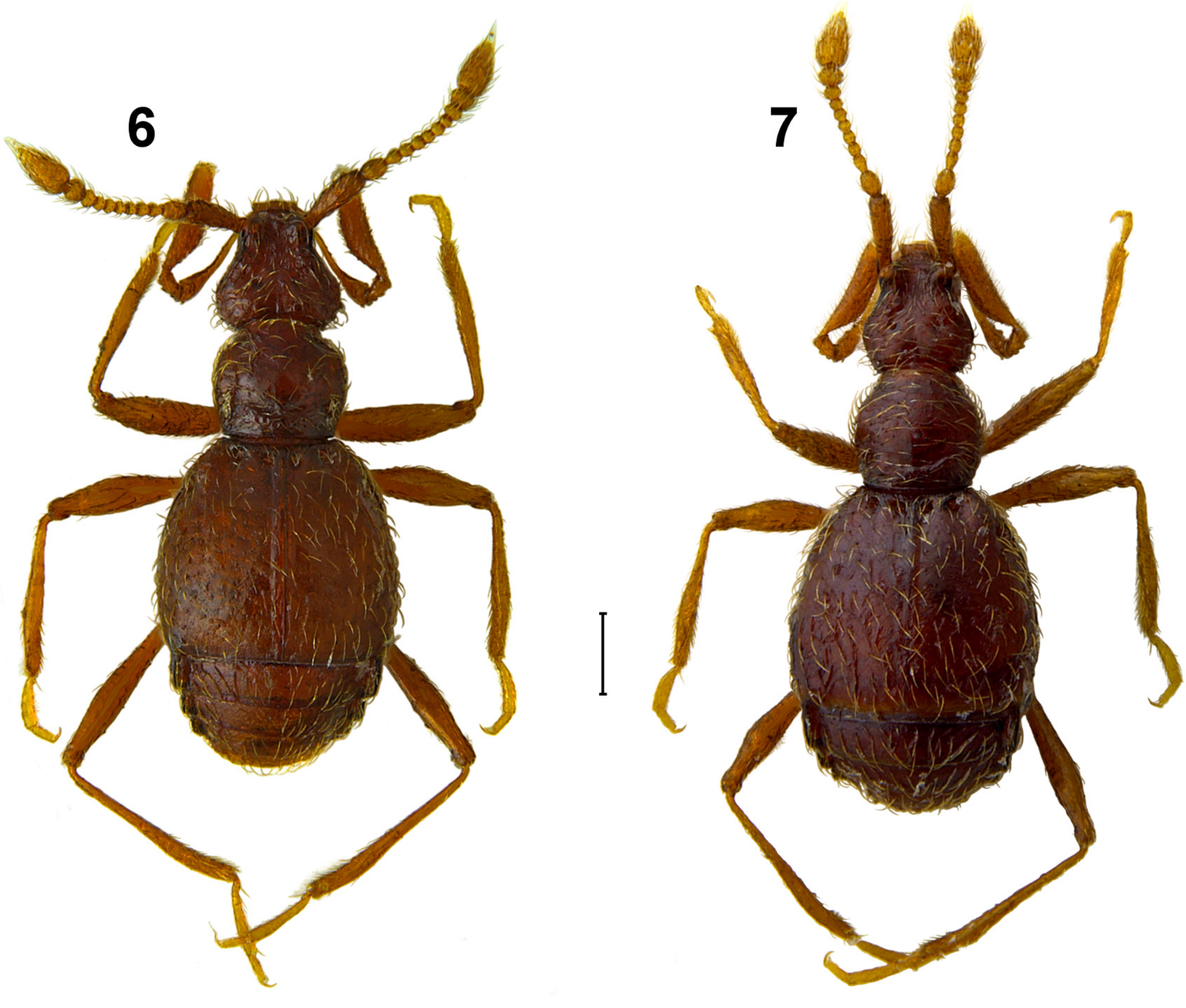


FIGURES 6–7. *Tychobythinus inopinatus* **sp. nov.** habitus, dorsal view. 6. Holotype, male. 7. Paratype, female (Ph. G. Nicolosi). Scale: 0.1 mm.

Pronotum wider (0.31 mm) than long (0.295 mm), widest near middle, anteriorly narrowed with convergent sides, posteriorly very slightly narrowed with rounded and subparallel sides very flattened laterally. Dorsal surface shiny with some sparse and faint punctures. Two well-impressed antebasal lateral foveae linked by wide antebasal sulcus. Tegument between pronotal posterior margin and antebasal sulcus rough, makeing it difficult to see small median antebasal fovea. Metaventrite distinctly raised at middle, its surface with dense and large punctures, with median sulcus beginning from its posterior margin and extending to just posterior to mesocoxal cavities. Base of mesocoxal cavities with pubescent lateral mesosternal fovea on each side.

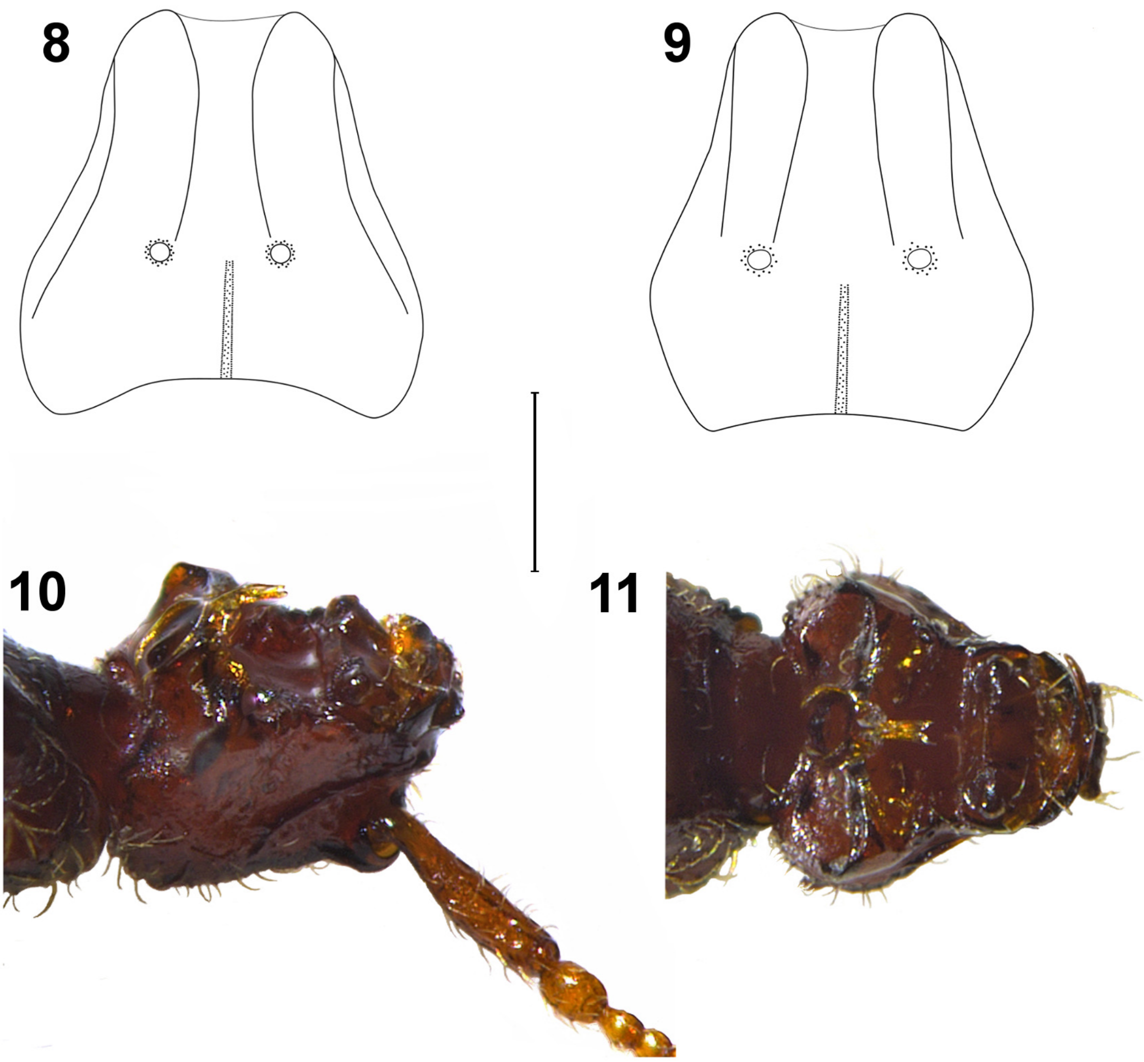
Elytra distinctly wider (0.57 mm) than long (0.52 mm), convex, sides slightly rounded from base to the apex, widest near middle. Humeral calli strongly reduced. Dorsal surface shiny with only some superficial punctures. Each elytron with two basal foveae, subhumeral fovea well-defined. Both marginal and sutural striae reaching to about elytral apices, discal striae lacking.

Abdomen normally shaped without species-specific characters.

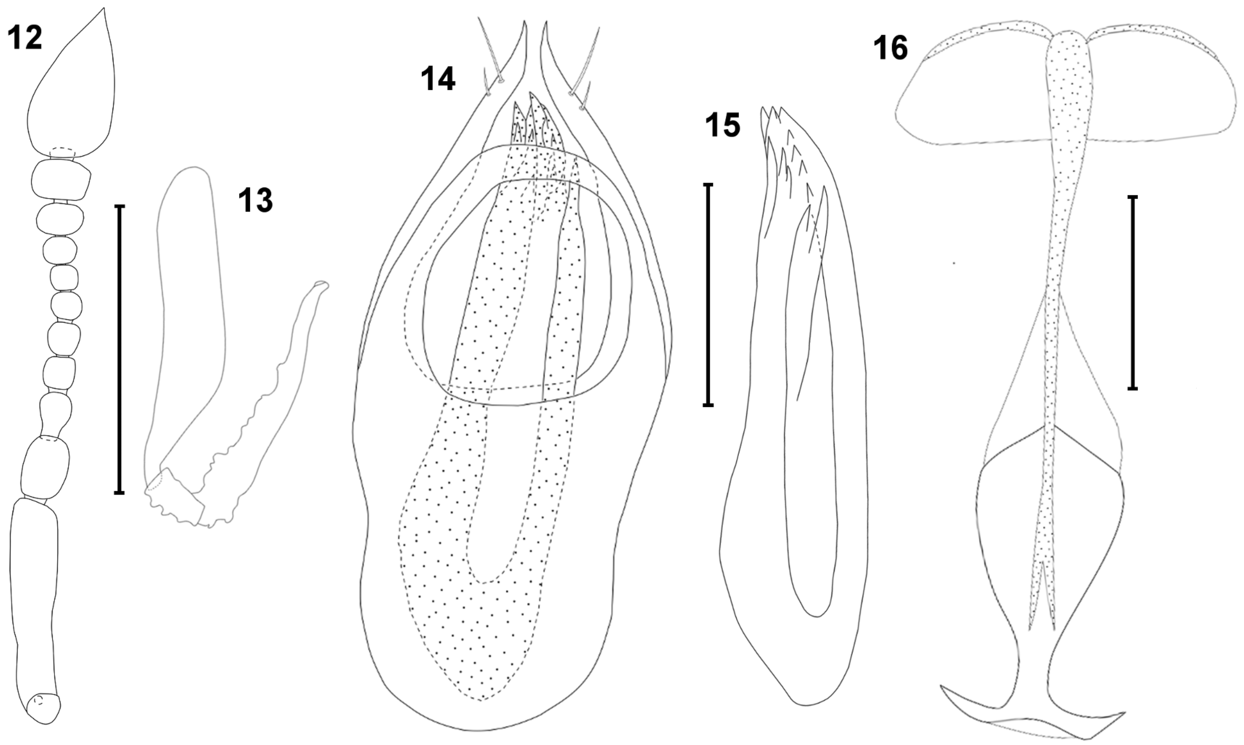
Legs relatively long and thin. Protrochanters with 1–2 tubercles on ventral surface, protibiae slightly flattened and sinuate at distal third, protarsomere II slightly dilated. Meso- and metatrochanters simple; femora simple, mesotibiae slightly enlarged and sinuate for distal third, length of metatibiae: 0.45–0.46 mm, slightly enlarged and sinuate for distal third.

Aedeagus (Fig. 14) 0.325–0.33 mm long, ovoid with relatively short parameres, parameres convergent and with narrow apex, each bearing two subapical setae. Internal sac (Figs 14–15) with two long apophyses converging to apices with numerous spines.

Female (Fig. 7): Similar to male, length 1.30–1.35 mm, head (Fig. 9) slightly wider (0.25–0.26 mm) than long (0.23–0.24 mm), gular region unmodified, slightly convex. Antennae (Fig. 12) a little shorter (length: 0.63-0.64 mm) and with sligthly thinner antennomeres than in male; surface of palpomere II covered by 10–14 tubercles, anterior sides of pronotum narrower than in male. Metaventrite lacking median impression; legs with protibiae, tarsomere II of protarsi, and metatibiae unmodified. Telisternite as in Fig. 16.



FIGURES 8–11. *Tychobythinus inopinatus* **sp. nov.** 8. Male head in dorsal view, schematic drawning. 9. Female head in dorsal view, schematic drawning. 10. Paratype male, head, lateral view (Ph. G. Nicolosi). 11. Paratype male, head, ventral view (Ph. G. Nicolosi). Scale: 0.1 mm.



FIGURES 12–16. *Tychobythinus inopinatus* **sp. nov.** 12. Paratype female, left antenna. 13. Paratype female, right maxillary palpus. 14. Holotype male, aedeagus, dorsal view. 15. Paratype male, internal sac of aedeagus, dorsal view. 16. Paratype female, telisternite, dorsal view. Scale: 0.1 mm.

Discussion. *Tychobythinus inopinatus* **sp. nov**. differs from all other congeneric species by its aedeagal and exoskeletal features. It shares affinities with *Tychobythinus villasmundi* Sabella, Amore, Nicolosi, 2019, however it differs from the latter in numerous characters: antennal scape more than 4 times longer than wide (less than 4 times longer than wide for *T. villasmundi*); last palpomere about 5 times longer than wide, with lateral margin distinctly curved and sinuate at middle (about 4 times longer than wide with lateral margin slightly curved and sinuate at middle for *T. villasmundi*), different shape of gular ridge of male (cfr. Figs 10–11 with Figs 8–9 in Sabella *et al.* 2019), aedeagus with different apical morphology of the parameres, which are not narrowed in *T. inopinatus* **sp. nov**., and are distinctly narrowed in *T. villasmundi* (cfr. Fig. 14 with Fig. 12 in Sabella *et al*. 2019), and differences of the internal sac (cfr. Figs 14–15 with Fig. 12 in Sabella *et al*. 2019).

Like *T. villasmundi, T. inopinatus* **sp. nov**. shares affinities to the congeneric species from North Africa which belong to two distinct groups (Sabella *et al.* 2014). However, they do not represent, with certainty, two homogeneous phyletic lineages because their external morphology is closely related to their different levels of adaptation to endogean life.

The aedeagus of *T. inopinatus* **sp. nov**. is comparable to the species belonging to the *Tychobythinus algiricus* group (Sabella *et al.* 2014; *Chiasmatobythus sensu* Jeannel 1956), due to their troglobitic adaptations. *T. inopinatus* **sp. nov**. is externally close to the species belonging to the *Tychobythinus theryi* group (Sabella *et al*. 2013; *Anopsibythus sensu* Jeannel 1956).

Among the material examined we also found a female collected in Monello Cave, 06.VI.2019, trap 13, G. Nicolosi leg. (DBUC), with only 10 antennomeres, and with antennomere VI distinctly longer than wide, which is probably derived from the fusion of antennomers VI and VII. This specimen has been excluded from the type series.

Finally, it seems interesting to underline that the previous research conducted inside Monello Cave in 1991 (Caruso 1995), which used the same collection techniques, did not produce any specimens of the new species. On the contrary, our investigation that began on 11 January 2019 and is still in progress allowed us to collect, in addition to the species relieved in the previous study, 18 specimens (2 males and 16 females) of the new species of *Tychobythinus* in various areas of the cave, but only during the period from August to December 2019.

This fact could be explained considering that the ecological conditions inside the cave have improved significantly in the last thirty years, probably in relation to the implemented strict conservation measures, but the factors driving this change certainly deserve further study (with a careful comparison of the environmental data emerged from the study conducted in 1991 and in 2019), which however goes beyond the purpose of this article.

A simpler explanation can be provided by the different sampling periods for the two research programs: research in 1991 covered the period January–July, while our research program, still in progress, covered the entire year of 2019, with collection of the new species happening between August and December, a period not covered by the previous research program.

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