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New staphyliniform beetles (Histeridae and Staphylinidae) from Iron Formation cave environments in Brazil

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Abstract

Beetles are recognized for their ability to inhabit a wide range of environments, including subterranean habitats, where they have achieved notable ecological success. In Brazil, research on beetle fauna has increased substantially, however this trend does not extend to cave-dwelling species. Staphyliniform beetles are no exception, and current knowledge of their subterranean representatives remains limited. To address this gap, the present study describes two new taxa from the same Brazilian cave. One of these is a new species of *Plagiogramma* Tarsia in Curia, 1935 (Histeridae, Tribalinae), while the second taxon is the second species of the genus *Tavakilianidia* Orousset, 1985 (Staphylinidae, Osoriinae). For both taxa, this study represents the first record of these genera in cave environments and, for *Tavakilianidia*, the first record in Brazil. *Plagiogramma unicum* Leivas, **sp. nov.**, resembles *P. amplistria* Kovarik & Dégallier, 2021, but differs in its smaller size, light brown coloration, body dorsally and ventrally finely and sparsely punctate, reduced eyes, fronto-clypeal region strongly concave, a carinal striae of the prosternal keel that divergent anteriorly and subparallel posteriorly, and an indistinct median metaventral suture. *Tavakilianidia flava* Caron, **sp. nov.** differs from *T. anophtalma* Orousset, 1985 in having a lighter body, antennomeres 4–6 not pedicellate, and a perfectly globose spermatheca. These findings increase the known diversity of these previously neglected beetle groups in Brazil and provide new insights into the biology of their genera.

Key Words

Biodiversity, cave-dwelling species, neotropical, new species, troglophilic species

Introduction

Beetles comprise the most successful lineage on Earth. This success is largely attributed to their morphology, particularly the presence of a heavily sclerotized pair of forewings that protect most of the body. This protective adaptation enables beetles to move through narrow and confined spaces and to occupy a wide range of habitats, including subterranean environments (Grimaldi and Engel 2005). Among these environments, caves impose strong ecological constraints, including permanent darkness, high humidity, climatic stability, and limited trophic resources. These conditions act as selective filters, favoring the evolution of specialized traits (Culver and Pipan 2019).

Cave-dwelling beetles may exhibit a suite of morphological traits that facilitate life in subterranean environments, such as reduced body size, loss of pigmentation, increased pubescence, and reduction or absence of eyes (Chen et al. 2021). As in other hypogean organisms, these beetles can be classified as troglobites (species restricted to subterranean environments), troglophiles (species frequently occurring in the subterranean domain but not restricted to them), or trogloxenes (species occasionally found in such habitats). However, this classification remains challenging for most species recorded from caves or other subterranean environments (Culver et al. 2023; Duarte et al. 2025), particularly in the case of beetles based on isolated records.

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A recent synthesis of the Brazilian coleopteran fauna confirms the country as megadiverse, accounting for approximately 9% of the world's described species (Caron et al. 2024). However, several families, including Staphyliniforms, remain insufficiently studied, particularly in subterranean habitats. Duarte et al. (2025) provided a list of the troglophilic fauna of Brazil, while Asenjo et al. (2025) compiled the list of Brazilian beetle species described as troglobites. For Staphyliniform beetles, only a few studies have documented their occurrence in caves, of which just two include identified species (Asenjo et al. 2018, 2024).

The material studied herein was collected during speleological assessments associated with the Pau Branco Mine Project, operated by Vallourec Tubos do Brasil Ltda. in southeastern Brazil. These assessments were conducted within the framework of Brazilian environmental legislation (Normative Instruction No. 02/2009), which prohibits irreversible impacts on subterranean cavities harboring undescribed taxa prior to their formal taxonomic description. In support of the environmental licensing process for mine expansion, two previously unknown taxa, belonging to the families Histeridae and Staphylinidae and recorded from caves PBR-0004/0005 and PBR-0021, respectively, were identified and are formally described herein.

Both taxa represent the first records of their respective genera from cave environments, and the staphylinid also constitutes the first record of its genus in Brazil. These findings increase the known diversity of these poorly known beetle groups in the country, provide new insights into the biology and distribution of the genera involved, and further highlight the hidden biodiversity of subterranean ecosystems. Moreover, mining activities have already removed approximately 50% of the iron formation outcrops in the Iron Quadrangle (Salles et al. 2018), posing a significant threat to this still poorly understood environment.

Material and methods

The material studied is deposited in the Museu de Zoologia da Universidade de São Paulo (MZ-USP) and comes from speleological studies carried out in the Iron Quadrangle region (municipalities of Brumadinho and Nova Lima, state of Minas Gerais, Brazil) from 44 different caves (Fig. 1) totaling a study of 530 specimens. In these caves, collections were carried out considering climate seasonality; dry season (04–05/viii/2009, 28/ix/2009–04/x/2009, 02–17/ix/2014, 03–04/vi/2015, 04/vii/2017) and rainy season (15–20/iii/2009, 14–15/iv/2009, 04–06/ii/2015, 08/ii/2017). Specimens were collected through active-search sampling, consisting of systematic manual surveys throughout the entire extent of each cave and across all available microhabitats, including rocky substrates, clastic deposits, and accumulations of organic matter. Sampling effort was designed to maximize taxonomic representation by thoroughly inspecting the broadest possible range of subterranean habitats. Specimens were visually detected, recorded, and collected manually using fine brushes and forceps, and subsequently preserved in 70% ethanol. Sampling duration was adjusted according to habitat heterogeneity, with a maximum search effort standardized at 30 minutes per 10 m^2 per collector.

Among this set of cavities, the cave PBR-0021 was the only one that recorded the new taxa of Histeridae and Staphylinidae herein described. An additional specimen from cave PBR-0004/0005, initially identified as Leptotyphlinae, was later recognized during preparation as belonging to Osoriinae and possibly conspecific with the material from PBR-0021. However, because the specimen consisted only of a highly degraded abdominal fragment, it was lost during overnight clearing in 10% KOH, precluding examination of diagnostic characters and species-level confirmation. Following standard curatorial protocol, the specimen is herein reported as lost during preparation for study, in order to document its collection history and tentative taxonomic placement.

The PBR-0021 cave is one among thousands of Iron Formation caves recently recorded in Brazil (Auler et al. 2022). It develops both in detrital canga (an iron-rich conglomerated cemented by a ferruginous matrix) and BIF (Banded Iron Formation) (-20.164088°S, -43.976838°W, 1534 m), has a total area of 59 m^2, volume of 69 m^3, a length of 25.8 m, and a 5.3 m upward slope from the cave opening (Fig. 2). It contains hypogean environment with entrance, penumbra, and aphotic zones, and a maximum light intensity of 5 lux. The cave is located amidst grassland and shrubby vegetation (Fig. 2), with a minimum Modified Photochemical Reflectance Index (MPRI) of 0.088 and a maximum of 0.018. Among the photosynthetic organisms recorded inside the cave are vegetable sprouts, seedlings, bryophytes, and pteridophytes (Fig. 3). The height of the leaf litter measured at the waterline varied between 1.3–5 cm. The trophic resources recorded in the cave include plant material (leaves, branches, seeds, surface networks, and roots throughout the floor (Fig. 4), walls, and ceiling), animal and plant debris, and non-flying vertebrate feces. The following traces were recorded inside the cave: shells, rodent nest (Fig. 5), termite trail, moth cocoons, invertebrate exoskeleton, feather, and anthill. Unfortunately, this cave collapsed and no longer exists because its location has already been explored for mining. The Histeridae and Staphylinidae species described in this work were collected in this cave.

The rove beetle specimen was received in approximately 70% alcohol, and habitus photographs were taken from the dried specimen. Afterward, the entire specimen was placed in 10% potassium hydroxide for approximately 10 hours. It was then immersed in acetic acid to neutralize the hydroxide and subsequently washed with water. Dissections were performed using a stereoscopic microscope, and the dissected parts were illustrated using a light microscope. Finally, a permanent slide was prepared.

The terminology for Histeridae followed: Beutel and Komarek (2004), Caterino and Tishechkin (2013) and Degallier et al. (2021). The terminology used for Staphylinidae study follows Orousset (1985). The labels of type ma-

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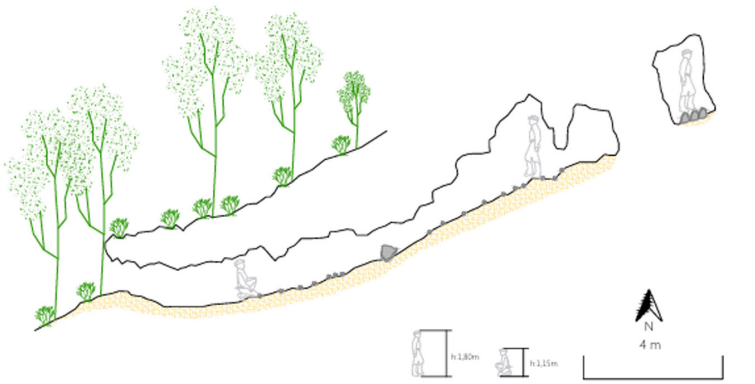

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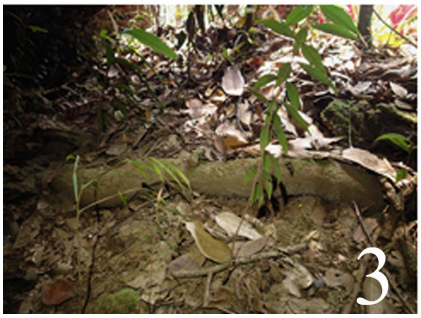

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Figures 1–5. Modified from Rodrigues and Nobre (2020). **1.** Iron Quadrangle region (municipalities of Brumadinho and Nova Lima, state of Minas Gerais, Brazil (red square); **2.** Cave PBR-0021 (-20164088°S, -43.976838°W, 1534 m, 1534 red arrow); **3–5.** Photos inside the cave: **3.** Photosynthetic organisms; **4.** Roots throughout the floor; **5.** Rodent nest.

terial are organized and enumerated in sequence from top to bottom. The data from each label are enclosed within double quotes (“ ”), and a backslash (\) separates lines. Additional information, label details, and comments are enclosed in square brackets ([]). All information from the labels is listed as found.

Results

Here we describe two cave-dwelling species classified in Staphyliniformia (Coleoptera). The environment in which these species were collected is a cave developed both in canga and BIF with entrance, penumbra, and aphotic zones (Fig. 2). However, there is no specific record of which substrate the specimens were collected from or in which zone inside the cave the species were found. The specimens were collected manually inside the cave during the dry season.

Due to the satisfactory sampling effort carried out throughout the 44 studied caves, there is a strong possibility that these species have a limited geographic distribution, but at present we do not have enough information to state for sure that these species are exclusively restricted to internal cave environments (Fig. 1).

One of the new species belongs to the genus *Plagiogramma* Tarsia in Curia, 1935 representing the first record of the genus for cave environments. The genus *Plagiogramma* is poorly studied, more easily collected associated with decaying logs, under bark tree and fungus (Degallier et al. 2021).

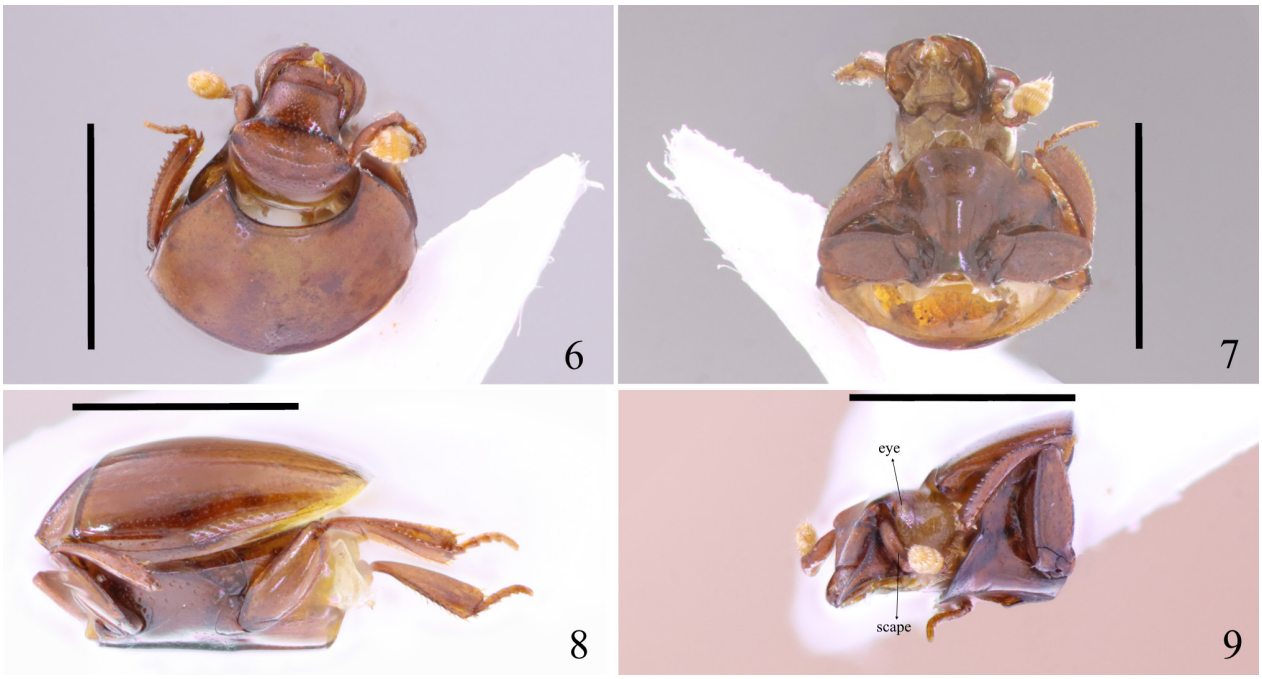
The other new species described here represents the second species of *Tavakilianidia* Orousset, 1985 (Staphylinidae, Osoriinae). Until now, the genus was known only from French Guiana, where the type species had been regarded as an edaphic (soil-dwelling) species.

Plagiogramma unicum Leivas, sp. nov.

https://zoobank.org/FA033738-E186-4495-810B-8C7F305C4A4A

Figs 6–11

Type material. Holotype, sex undetermined: • “Brasil, Minas Gerais, Brumadinho\ (Gruta PBR21), \ -20.164088, -43.976838, \ 28.ix-3.x.2009. Bessi et al. leg, \ Carste (Coleo) 0853-95” [white label, printed in black]; • (2) “MZSP 93544” [white label, printed in black]; • (3) “Holotype\ *Plagiogramma unicum* Leivas \ desig. Leivas, 2026” [red label, printed in black].



Figures 6–9. *Plagiogramma unicum* sp. nov., holotype. **6.** Head in dorsal view and pronotum; **7.** Head in ventral view and prosternum; **8.** Mesoventrite, metaventrite and elytron in lateral view; **9.** Head and prosternum in lateral view. Scale bars: 1 mm

Figures 10–11. *Plagiogramma unicum* sp. nov., holotype. **10.** Elytra in dorsal view; **11.** Mesoventrite, metaventrite and 1st first visible abdominal ventrite (morphologically the 3rd ventrite). Scale bars: 1 mm

Diagnosis. *Plagiogramma unicum* and *Plagiogramma amplistria* Kovarik & Dégallier, 2021 are the only species known to exhibit a mesoventral supramarginal stria; however, *Plagiogramma unicum* differs by having a smaller size, light brown coloration, body dorsally and ventrally finely and sparsely punctate, reduced eyes, fronto-clypeal region strongly concave, carinal striae of the prosternal keel divergent anteriorly and subparallel posteriorly, and an indistinct median metaventral suture.

Description. Length (pronotum + elytra) 1.9 mm and width (humeral region) 1.6 mm. Body light brown and shiny; legs and antennae light brown, except for the antennal club which is yellow (Figs 6, 7); dorsally and ventrally finely and sparsely punctate (Figs 6–11). Frons and clypeus finely punctate with slightly denser punctation on the clypeus (Fig. 6); thin frontal stria marked only over the region of insertion of the antennae and eyes. Eyes reduced, with a width subequal to the scape (Fig. 9). Fronto-clypeal region strongly concave (Fig. 9); front-clypeal division well delim-

ited by a dark line (Fig. 6). Mandibles with one prominent apical tooth and one inconspicuous subapical tooth (Fig. 6).

Pronotum sparsely and finely punctate; anterior margin of the pronotum almost straight; anterior angles acute; lateral margins slightly projected outwards. Marginal pronotal stria thin, complete and weakly crenulated on the anterior margin (Fig. 6). Prosternal lobe broad, approximately 1/3 of the prosternal length with coarser and denser punctation than the prosternal keel; anterior margin almost straight; marginal stria of the prosternal lobe thin and complete; presternal suture thin and complete (Fig. 7). Prosternal keel sparsely and finely punctate; posterior margin of the prosternal keel almost straight, slightly emarginated; carinal striae of the prosternal keel divergent anteriorly and subparallel posteriorly; the area between the carinal striae convex anteriorly and flattened posteriorly (Fig. 7).

Elytra sparsely and finely punctuated, equally in the epipleural region (Figs 8, 10). Elytral striae weakly crenulated; epipleura with two striae (Fig. 8); external subhumeral stria present in the anterior half of the elytra and marked by a small rudiment at the beginning of the posterior third (Fig. 10); oblique humeral stria weak, short and almost subparallel to the first dorsal stria; internal subhumeral stria absent; elytral dorsal striae 1–4 complete; 1st and 2nd dorsal striae subparallel, the 3rd and 4th striae recurved inwards in their basal third of the elytra; 5th dorsal stria present in the posterior half of the elytra; sutural stria absent in the anterior region, but longer than the 5th dorsal stria (Fig. 10). Mesoventrite sparsely and finely punctate; mesoventral supramarginal stria thin and marked only in the anterior lateral angles; mesoventral marginal stria slightly crenulated, complete and laterally contiguous to the lateral metaventral stria; mesometaventral stria crenulated, not reaching the median line of the mesoventrite, laterally connecting with the mesoventral marginal stria; mesometaventral suture weak, almost imperceptible (Fig. 11). Metaventral disc with slightly thicker and denser punctation than mesosternal disc (Fig. 11), except in region external to lateral metaventral stria which presents thick and shallow punctures (Figs 8, 11); median metaventral suture indistinct; postmesocoxal stria short and almost transverse; lateral metaventral stria almost reaching metepimeron; metanepisternum narrow and with fine and sparse punctures; metepimeron with thick and shallow punctures (Fig. 11).

Anterior tibiae with an arched outer margin, with spines little longer towards apical region (Figs 6, 7); outer submarginal region with a series of setae that gradually extend towards central region towards the apex of the tibia; apical margin with two robust spines of different sizes; inner margin of tibia with setae that are slightly denser towards apex of the tibia (Fig. 7); inner submarginal region without setae. Middle tibiae with subparallel sides, widening towards apical region; outer margin with setae and presenting spines close to the apical region; apical margin with robust spines; outer submarginal region with a series of setae that gradually extend towards central region towards apex of the tibia; inner margin with progressively longer and spaced setae towards apex of the tibia; inner submarginal region without setae. Posterior tibiae with subparallel sides, widening towards the apical region; outer margin with setae, without spines (Fig. 10); outer submarginal region with a series of setae that gradually extend towards the central region towards apex of the tibia; apical margin with some robust spines; inner margin with progressively longer and spaced setae towards apex of the tibia (Fig. 10); inner submarginal region with a series of setae.

First abdominal ventrite visible finely and sparsely punctate on the disc; inner stria of the 1st abdominal ventrite complete; outer stria of the 1st abdominal ventrite shorter, absent posteriorly; lateral areas outside the striae with coarse and shallow punctation (Fig. 10). Other abdominal segments are absent in the specimen, including propygidium, pygidium and genitalia.

Distribution. Known only from the type locality.

Etymology. The specific epithet *unicum* is derived from the Latin adjective *unicus*, *-a*, *-um*, meaning "unique" or "singular." It is treated as a neuter adjective in agreement with the generic name *Plagiogramma*. The name refers to the fact that the species is known from a single specimen at the time of description.

Remarks. Although 44 caves were sampled and all Histeridae material was studied by us, this species is known only from a single specimen. The specimen has a prothorax disarticulated with the meso- and metaventrite, and with the exception of the first visible external abdominal segment, all other abdominal segments, including the genitalia, have been lost. Even so, the species possesses very distinct characteristics from other specimens of the genus, enough to determine it as a still undescribed species.

In Brazil, 16 species of *Plagiogramma* were known until now (Leivas et a. 2024); *Plagiogramma unicum* represents the seventeenth. *Plagiogramma amplistria* Kovarik & Dégallier, 2021 and *Plagiogramma unicum* are the only described species of the genus that present three striae on the mesoventrite: mesoventral supramarginal stria, mesoventral marginal stria, and mesometaventral stria. However, they can be easily distinguished by the characters presented in the diagnosis.

Regarding the other species known for Brazil, *Plagiogramma unicum* can be distinguished by not presenting an anterscutellar pronotal impression [present in *Plagiogramma arciger* (Marseul), *P. angularis* (Schmidt), *P. brasiliensis* Tarsia, *P. epulo* (Marseul), *P. inscriptus* (Schmidt), *P. paradoxa* Mazur, and *P. nitescens* (Marseul)], by presenting a tristriate mesoventrite [mesoventrite bistriate, just with mesoventral marginal stria and mesometaventral stria in *Plagiogramma erwini* Kovarik and Dégallier, *P. fissus* (Marseul), *P. glabra* (Bickhardt), *P. mundus* (Erichson), *P. parvoperuana* Kovarik and Dégallier and *P. peruana* (Schmidt)], by the 1st and 2nd dorsal striae of the elytra being complete [1st dorsal stria is absent and the 2nd dorsal stria is rudimentary at the apex in *Plagiogramma tersus* (Erichson)] and by the 5th dorsal stria and sutural stria absent in the anterior region [5th dorsal stria and sutural stria complete in *Plagiogramma fornicata* (Marseul)].

Diagnosis of *Plagiogramma* known from Brazil

Plagiogramma can be distinguished from all other histerid genera in Brazil by having a prosternal lobe, a setose labrum, antennal cavities concealed by prosternal alae, and a mesometaventral stria. Of the 17 known Brazilian species for the genus, 10 of them can be identified using the key by Degallier et al. (2021). This genus is undergoing taxonomic revision and more information for species identification will be published soon (P. Kovarik personal communication).

Tavakilianidia flava Caron, sp. nov.

https://zoobank.org/09400668-A298-4C43-9881-01A1378DC9CF

Figs 12–23

Type locality. Brazil, Minas Gerais, Brumadinho (Gruta PBR21), -20.164088°S, -43.976838°W.

Type material. Holotype, female (dissected, mounted on slide), deposited in MZUSP, labels: • (1) "Brasil, Minas Gerais, Brumadinho,\(Gruta PBR21),\-20.164088, -43.976835\28.ix.-3.x.2009, Bessi et al. Leg.,\Carste(-Coleo) 0852-95" [white label, printed in black]; • (2) "MZSP 93544" [white label, printed in black]; • (3) "Holotype*Tavakilianidia flava* Caron\desig. Caron, 2026" [red label, printed in black].

Diagnosis. *Tavakilianidia flava* differs from *T. anophtalma* in having a lighter body; antennomeres 4–6 not pedicellate (antennomeres 4–6 pedicellate in *T. anophtalma*); and spermatheca perfectly globose (formed by two unequal hemispheres in *T. anophtalma*).

Description. Female. Maximum body length 2.00 mm; maximum elytral width 0.30 mm. Body elongate and parallel-sided (Figs 12–14), yellowish, with lighter appendages. Body overall shiny, with sparse white pubescence (setigerous punctation); integument with somewhat hexagonal microsculpture, more conspicuous on the elytra and mesoventrite (Figs 19, 20). Head longer than wide; anterior margin of front truncate; supra-antennal area non-prominent; eyes absent (Fig. 14); neck absent; gular sutures fused. Antennae short, reaching the middle of the pronotum; scape longest, subequal in length to pedicel and antennomere 3 combined; pedicel twice as long as antennomere 3, both longer than wide and of similar width; antennomere 4 shortest, slightly wider than antennomere 3; antennomeres 4–10 gradually increasing in length and width toward the apex; antennomere 11 1.5 times as long as antennomere 10, symmetrically pointed. Labrum wider than long, with sparse setae directed anteriorly**;** epipharynx dorsally short, with long fringes on the anterior margin. Mandibles slightly asymmetrical, each bearing blunt teeth on the apical third: one tooth on the left mandible and two on the right; prostheca weakly developed, with a maximum of three fringes; mola well developed, occupying the entire basal third and presenting a roughened grinding surface. Maxillary galea equal in length to the lacinia; lacinia with 7–8 sparse long setae on the inner margin; galea with few short setae at the apex; maxillary palpus with palpomere 4 longest and widest, pyriform. Mentum twice as long as wide, trapezoidal; labial palpomere 2 longest and widest (Fig. 15); apical and lateral margins of the glossa each with few long fringes. Pronotum convex, as wide as long; apical half with subparallel sides and basal half gradually narrowing toward the base; prosternum with anterior margin curved and projected medially on the apical third; prosternal process sharp; postcoxal hypomeral projection long and acute. Scutellum visible, triangular.

Elytra as long as wide, gradually widening toward the apex; apical margin slightly emarginate. Hind wings undeveloped. Mesoventrite with anterior margin broadly emarginate (Fig. 8); mesoventral process long and acute, twice as long as metaventrite process; metaventrite process sharp; posterior margin of mesocoxal cavity with well-developed carina. Procoxa with deep groove and carina on mesal surface; protibia mucronate, inner edge concave and bearing a ctenidium, outer edge slightly convex and with four robust spines (Fig. 16); mesotibia and metatibia mucronate (mucro shorter than that of protibia), outer edge slightly convex and bearing four and three robust spines, respectively (Figs 17, 18). Tarsal formula 3–3–3; tarsomere 3 longer than tarsomeres 1–2 combined; claws very long, subequal in length to tarsomere 3.

Abdominal segments III–VII each bearing a complete ring; segment VII longest, subequal in length to segments IV–V combined (Fig. 13). Tergite 8 trapezoidal, basal margin somewhat curved, apical margin truncate (Fig. 21). Sternite 8 with basal margin truncate and apical margin curved and projected medially (Fig. 22). Hemitergites 9 without ventral struts, separated by tergite 10; tergite 10 with posterior margin truncate, anterior margin slightly curved, and sparse long setae. Spermathecal duct short, distal portion more sclerotized; capsule perfectly globose (Fig. 23). Male. Unknown.

Distribution. South America: Brazil. This species is known only from the type locality, Brumadinho (state of Minas Gerais), where it was found inside a cave.

Etymology. The specific name is a Latin adjective referring to the yellow color of the holotype, and it agrees in gender with the generic name (feminine).

Remarks. *Tavakilianidia flava* is the second species of the genus. The species is very similar to *T. anophtalma* (the type species of the genus), and the differences are only those mentioned in the diagnosis (Orousset 1985). The genus has been recorded only from South America. This is the first record of the genus in Brazil, and the country now includes all five tribes, with 28 of the nearly 120 known genera (Moreno et al. 2025; Newton 2026; Newton and Caron 2026).

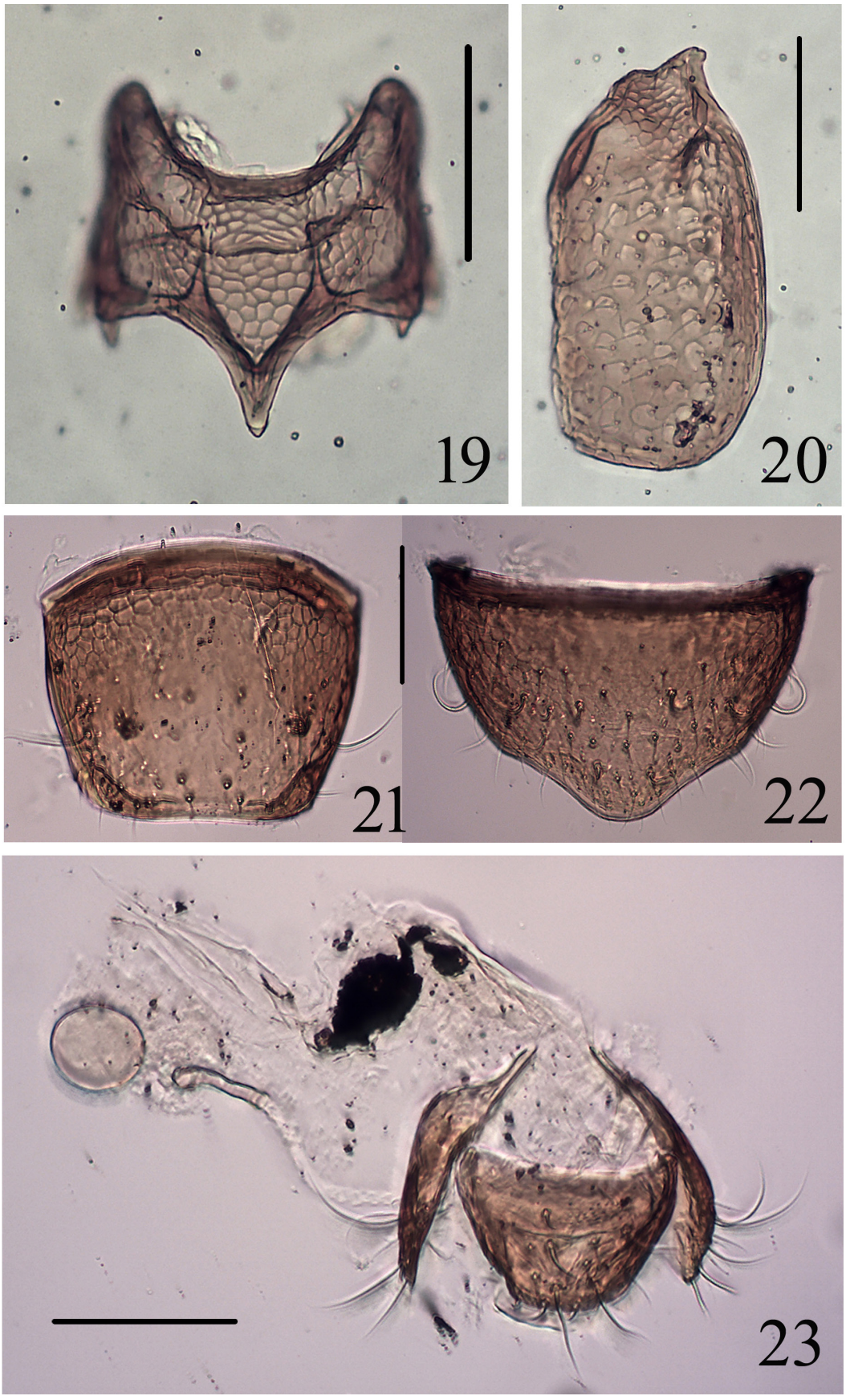
Discussion

The discovery of the two new beetle species, representing the first records of their respective genera from cave environments in Brazil, highlights the still poorly known subterranean biodiversity associated with Iron Forma-

Figures 12–14. Habitus of *Tavakilianidia flava* sp. nov., holotype, female. **12.** Head and thorax, dorsal view; **13.** Abdomen, lateral view; **14.** Head and thorax, lateral view. Scale bars: 1.0 mm.

tion caves and reinforces the relevance of taxonomic surveys in these highly threatened habitats (Gomes et al. 2019). Beyond expanding current knowledge of subterranean beetle diversity, these findings provide further evidence that Iron Formation caves harbor unique and potentially endemic lineages with restricted distributions,

Figures 15–18. *Tavakilianidia flava* sp. nov., holotype, female. **15.** Labium, ventral view; **16.** Protibia and tarsus, dorsal view; **17.** Mesotibia and tarsus, dorsal view; **18.** Metatibia and tarsus, dorsal view. Scale bars: 0.07 mm.



Figures 19–23. *Tavakilianidia flava* sp. nov., holotype, female. **19.** Mesoventrite, ventral view; **20.** Elytron, dorsal view; **21.** Tergite 8, dorsal view; **22.** Sternite 8, ventral view; **23.** Tergites 9–10 and spermatheca, dorsal view. Scale bars: 0.15 mm.

as has been documented for other biological groups (e.g., Zeppelini et al. 2022; Torres and Bichuette 2024). Our study emphasizes that integrative taxonomic efforts are essential not only to advance understanding of subterranean biodiversity, but also to support conservation strategies for Iron Formation landscapes under increasing anthropogenic pressure.

Acknowledgments

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Artificial Intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.
Regarding the use of AI in the preparation of this manuscript, the authors declare the following: GPT.
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LMSMD, PGS, and ASA contributed to the conceptualization and methodology of specimen collection and cave environment research. EC and FWTL contributed to the conceptualization, methodology of morphological studies, systematic research, taxonomic descriptions, and preparation of the original draft. All authors contributed to the review and editing of the final version, supervision, and project administration. All authors have read and agreed to the published version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.