Dtsch. Entomol. Z. 59 (2) 2012, 201–206 / DOI 10.1002/mmnd.201200015

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Ferricixius davidi gen. n., sp. n. – the first cavernicolous planthopper from Brazil (Hemiptera, Fulgoromorpha, Cixiidae)

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Received 10 July 2012
Accepted 12 July 2012
Published 11 December 2012

Key Words

Taxonomy
Troglobite
Troglomorphy
Caves
Neotropics

Abstract

A new troglobitic (obligate cavernicolous) species of the cixiid tribe Cixiini is described from Brazil. It could not be placed in any of the described genera, thus a new genus is established. Information on its distribution and ecology are given. This is the first record of a troglobitic planthopper from Brazil, and only the fifth troglobitic cixiid species from the Neotropics.

Introduction

A systematic survey of iron ore caves in the "Quadrilátero ferrifero" region (Iron quadrangle) located in the central part of Minas Gerais State in south-eastern Brazil by a team from the Federal University of Lavras revealed the existence of a hitherto unknown planthopper species belonging to the family Cixiidae (Fig. 1).

This is the first record of a troglobitic (obligate cavernicolous) planthopper species in Brazil, and only the fifth troglobitic cixiid species from the Neotropics. Two species are known from Mexico: *Cixius orcus* Fennah (Fennah 1973), *Cixius actunus* Hoch (Hoch 1988), one from Argentina: *Notolathrus sensitivus* Remes Lenicov (Remes Lenicov 1992), not assigned to any subfamily, and one from Galápagos: *Oliarus hernandezi* Hoch & Izquierdo (Hoch & Izquierdo 1996), subfamily Cixiinae, tribe Pentastirini Emeljanov, 1971. For none of them could closely related epigean relatives be recognized among the surface fauna. This new cavernicolous species from Brazil belongs to the tribe Cixiini. According to Holzinger et al. (2002) four genera in this tribe have hitherto been recognized in the Neotropics: *Cixius* Latreille, 1804, *Cixiosoma* Berg, 1879, *Microlelodrida* Fowler, 1904 and *Pachyntheisa* Fowler 1904. Despite the work of Ceotto & Bourgoin (2008) and Ceotto et al. (2008), the phylogenetic relationships within Cixiidae are not sufficiently resolved, and only a few genera can be regarded as well-founded monophyletic units. Especially *Cixius* – distributed worldwide with more than 260 species (Holzinger et al. 2002) – acts as a "bucket" genus, characterized by plesiomorphic characters: mesonotum tricarinate, hind-tibiae with 1–3 lateral spines, apical margin of forewing without tubercles between apical veins (Holzinger et al. 2002). The new species from Brazil clearly represents a distinct lineage, which cannot be assigned to any of the existing genera. A new genus, *Ferricixius* gen. n., is thus established to accommodate it.

The discovery of this new cavernicolous species from Brazil hopefully comes in time to protect its specialized habitat, which is currently threatened by large-scale iron ore extraction (see below: ecology).

Materials and methods

Collecting, preservation, permanent storage. Specimens were detected by visual searching, collected by hand, and transferred immediately into vials containing 70 % ethanol. For permanent storage, after dis-

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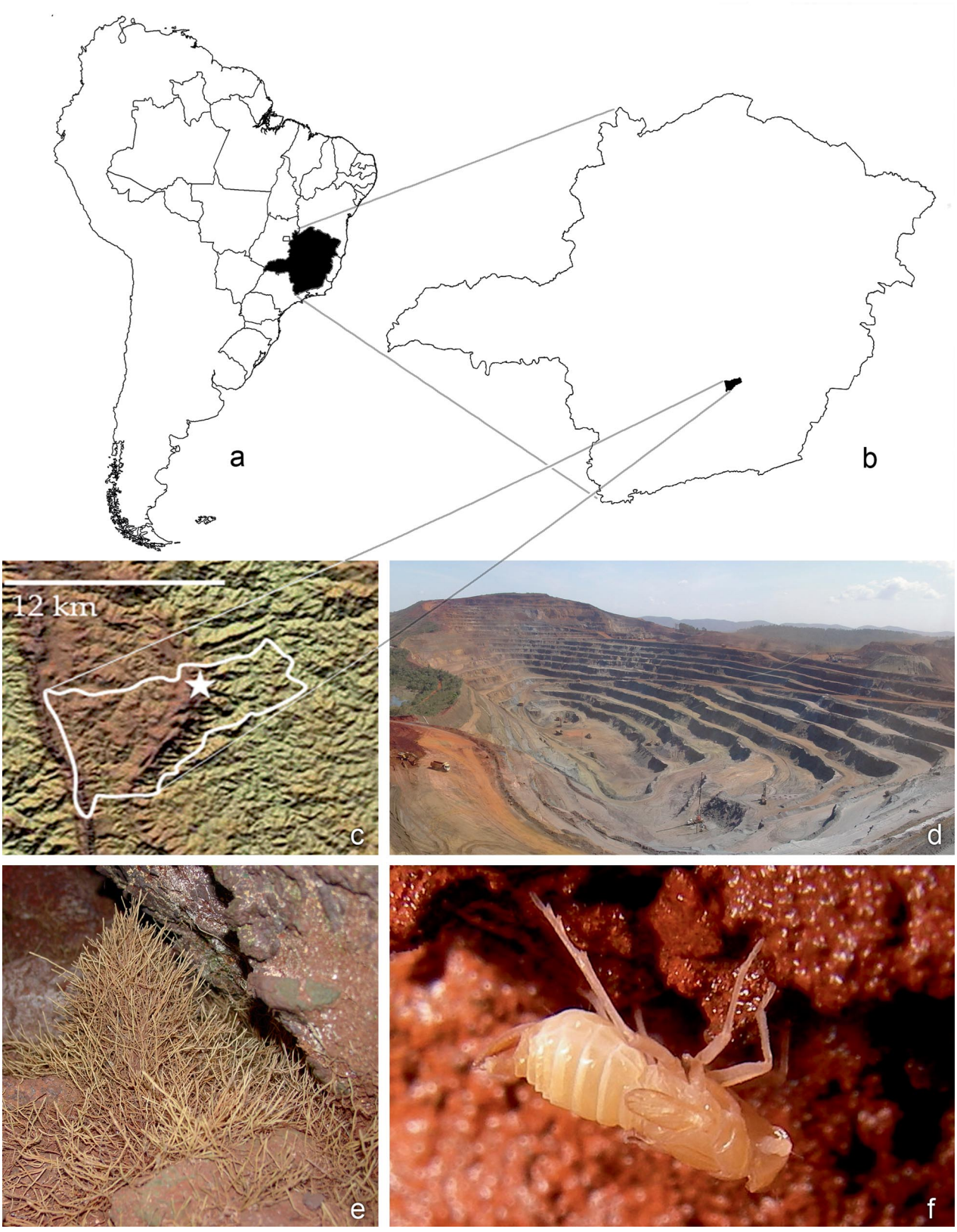


Figure 1. a. South America; **b.** Minas Gerais State, Brazil; **c.** Iron quadrangle; **d.** Mine; **e.** Root carpet in the MP8 cave; **f.** *Ferricixius davidi*, adult female, crawling on rock.

section and examination, the genitalia and abdomen were transferred to polyethylene vials, and individually associated with the specimen vial.

Morphological examination techniques, visualization. Measurements and examinations of external body features were made from specimens in alcohol, without further manipulation.

To prepare male genitalia for dissection, the genital capsule was removed from the specimen, macerated in 10 % KOH (24 h) at room temperature, washed in water, and transferred to glycerine for storage or to glycerine-jelly for drawings. Examinations and drawings were made using a Leitz stereomicroscope with a *camera lucida* attachment.

Depository. ES: Laboratório de Ecologia Subterrânea/ISLA: Coleção de Invertebrados Subterrâneos da UFLA – Universidade Federal de Lavras, Brazil; MFN: Museum für Naturkunde, Berlin, Germany.

Results

Ferricixius Hoch & Ferreira gen. n.

Type-species. Ferricixius davidi sp. n., Brazil, MP8 cave (20°12′39,32″ S; 43°51′14,43″ W), Itabirito, Minas Gerais State, Brazil.

Description. Habitus strongly troglomorphic: compound eyes and ocelli absent, tegmina very short, barely attaining base of abdomen, wings vestigial, bodily pigmentation reduced (Fig. 2).

Head (Fig. 2). Vertex short, ca. 3.6× wider than medially long, smoothly rounded onto frons. Frons slightly shorter than maximally wide, ca. 2/3 as long as post- and anteclypeus together; frons with a very faint median carina vanishing towards vertex; lateral margins of frons strongly ridged; frontoclypeal suture almost straight, only very slightly arched towards frons; post- and anteclypeus with a distinct median carina. Rostrum not surpassing posterior margin of hind coxae. Compound eyes and ocelli absent. First antennal joint short, ring-like, 2nd antennal segment ovoid, subglobular.

Thorax (Fig. 2). Pronotum tricarinate, ca. 2.5× wider than vertex posteriorly, medially short, widening laterad, posterior margin medially deeply incised; median and lateral carinae obsolete; mesonotum tricarinate, with lateral carinae attaining posterior margin, median carina vanishing towards posterior tip. Tegulae well developed. Hind tibiae laterally with numerous minute rigid spines (hardly distinguishable from the base of regular setae), 3 of which are slightly more pronounced, hind tibiae distally with 6 teeth, arranged as follows: 2 (lateral) + 4 (median: 1st of 4 slightly larger than remaining 3) in a row. First and 2nd metatarsal joints distally with 4 teeth. Pretarsal claws distinct, arolia small. Tegmina reduced to small flaps, in dorsal aspect barely attaining base of abdomen, venation obsolete; hind wings vestigial.

Male genitalia. Genital segment bilaterally symmetrical, in lateral aspect ± trapezoidal, posterior margin straight; medioventral process in ventral aspect triangular. Anal segment bilaterally symmetrical, hood-shaped, ventrally concave. Parameres spoon-shaped. Shaft of aedeagus narrow, tubular, ventrally with compressed process arising at ca. midlength of shaft, with ventral margin irregularly dentate; shaft with 3 subapical spinose processes. Flagellum bent dorsad and left laterad, in repose nearly attaining base of shaft; membranous portion of flagellum narrow, bilobate; phallotreme exposed left lateroventrally.

Female genitalia. Tergite IX in lateral aspect short, caudally truncate, concave, wax plate distinctly defined. Anal segment in dorsal aspect rectangular, ca. 2× longer than wide, lateral margins parallel, ventrocaudal margin truncate; anal segment ventrally slightly concave. Ovipositor complete, well-developed, curved dorsocaudad, at rest not surpassing tip of anal segment.

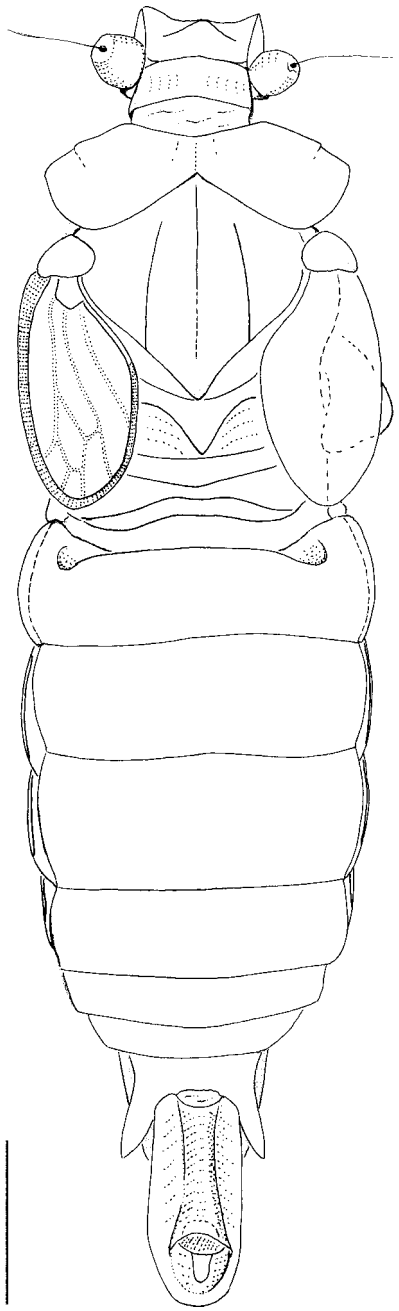


Figure 2. Habitus (holotype male). Body length 3.7 mm.

Etymology. The genus name refers to the distribution of the type-species in an area rich in iron (*ferrum*, Latin for iron).

Ferricixius davidi Hoch and Ferreira sp. n.

Figures 1f, 2–6

Description. Habitus (Figs 1, 2). Small, strongly troglomorphic cixiid (3.2–4.1 mm), with strongly reduced tegmina and hind wings, colouration pale yellowish-white throughout.

Body length. Male (anterior margin of head to posterior margin of anal segment) 3.2–3.88 mm ($n = 5$). Females. 3.52–4.1 mm ($n = 2$).

Colouration. Vertex, frons and clypeus pale yellow, head laterally incl. antennae whitish; pronotum anteriorly of lateral carinae yellowish, posterior margin whitish; mesonotum, legs, tergites, sternites, and genital capsule yellowish, otherwise whitish.

Configuration, shape and proportions of head and thorax as described for the genus.

Male genitalia (Figs 3–6). Genital segment with triangular medioventral process in ventral aspect slender, gradually tapering in proximal three quarters, rapidly tapering distally.

Anal segment in dorsal aspect ca. twice as long as wide, lateral margins parallel, ventrally straight, caudal margin evenly rounded, smooth.

Parameres with distal dilated part ventrally slightly and medially distinctly concave, ventral margin finely rippled.

Aedeagus shaft narrow at base, slightly widening toward apex, in proximal half more strongly sclerotized than in distal half, ventrally with a large, compressed process arising from a wide base at ca. midlength of shaft, with ventral margin irregularly dentate; shaft with 3 subapical spinose processes, one arising left laterally, in repose slightly curved ventrally, not reaching midlength of shaft, two arising right laterally: one curved nearly parallel to left lateral shaft spine and nearly as long, the other ca. twice as long, straight, in repose directed ventrobasad. Flagellum near base with a sturdy, hook-like process directed left laterad; visible part of ejaculatory duct distinctly rugose.

Female genitalia. As described for the genus.

Distribution. Brazil. Endemic to Iron quadrangle formation; so far found only in MP-8 Cave.

Ecology. The cave where the specimens were collected (the MP8 cave) is located in a complex iron ore outcrop regionally known as the ”Quadrilátero Ferrífero” (Iron quadrangle). There are distinct litho-types in the area, with caves associated with the superficial ferruginous breccia (canga formation), and to the iron ore formations (Hematite and Itabirite). More than 300 caves are known in the entire area and at least a third of them were investigated in biospeleological surveys. However, this species was found in only a single cave, which demonstrates its extreme rarity.

The MP8 cave (UTM 7764761N, 619795E, 23K) is quite large (120 meters long) when compared with most of the caves in the area, which are usually less than 50 meters long. Furthermore, the cave is connected to a huge net of small channels (canaliculi), typically found in the canga formation, which considerably enhances the availability of habitats for the subterranean fauna (Souza-Silva et al. 2011). The adjacent area – locally known as “Minas do Pico” – is rich

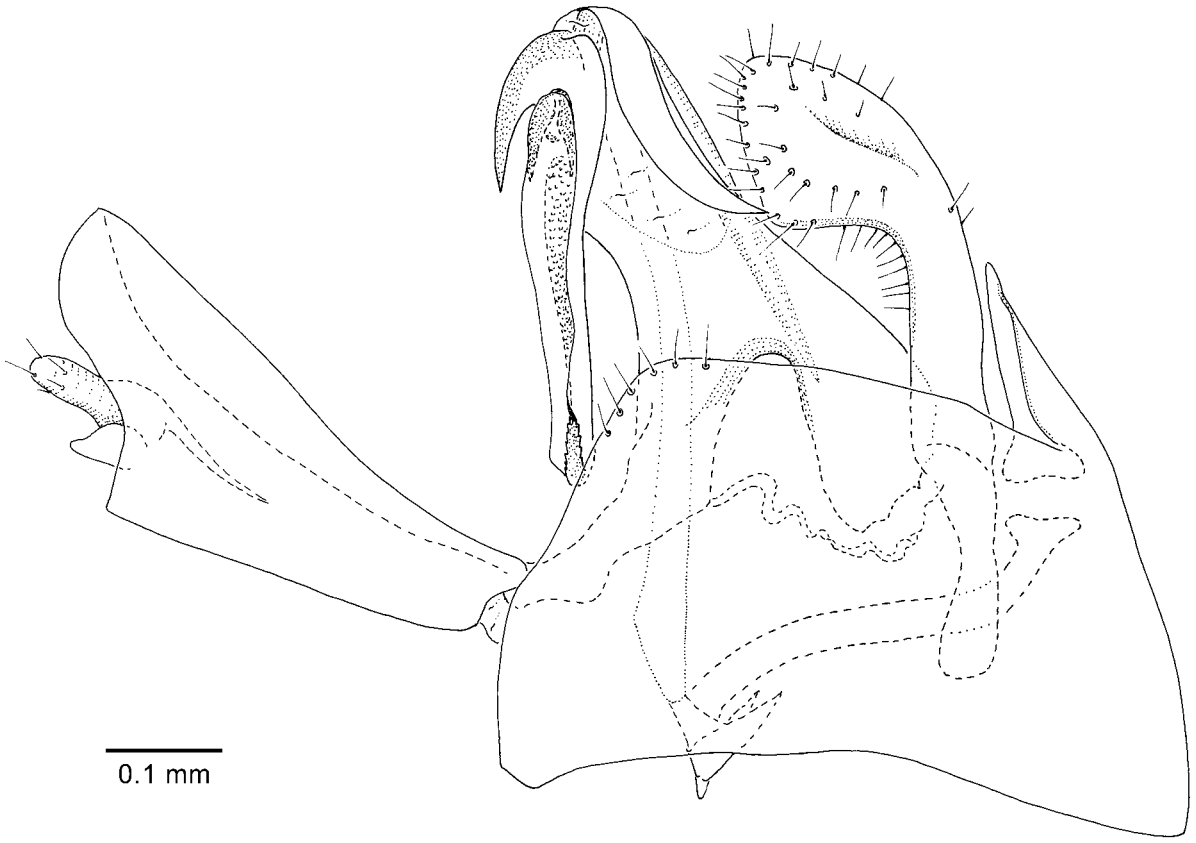
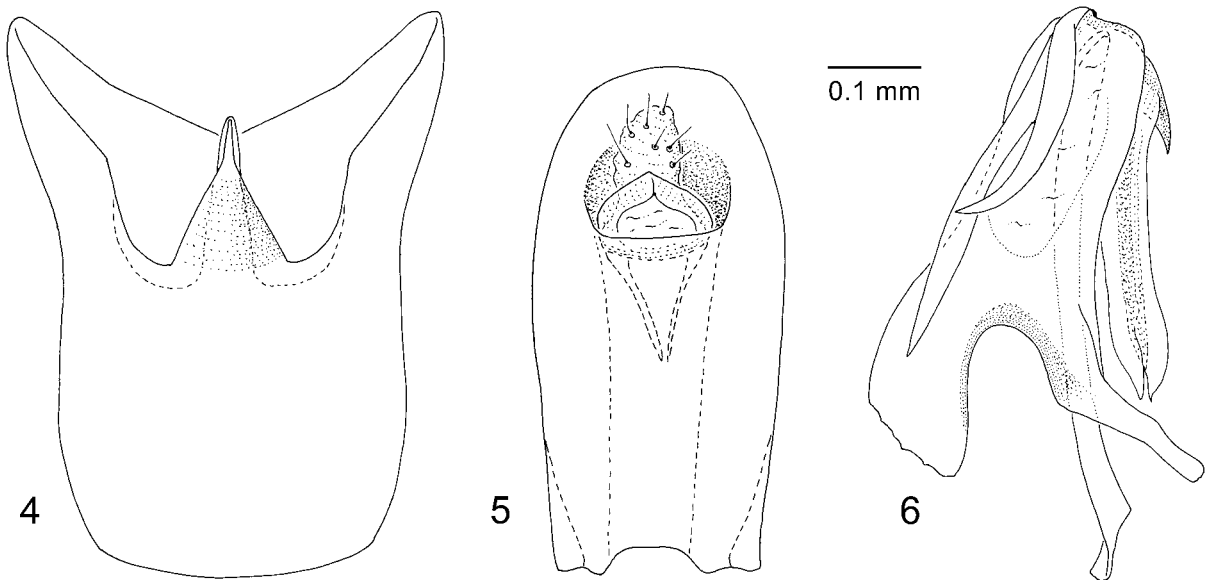


Figure 3. *Ferricixius davidi* sp. n., male genitalia, *in situ*, left lateral aspect (holotype).



Figures 4–6. *Ferricixius davidi* sp. n., male genitalia. **4.** Genital segment, ventral aspect; **5.** Anal segment, dorsal aspect; **6.** Aedeagus, right lateral aspect.

in caves (at least 15 of which are known). Each of these has been surveyed at least three times; however cixiids were only found in the MP8 cave. This result provides at least some evidence for a high habitat specificity of *Ferricixius davidi*.

A total of nine *Ferricixius* specimens were observed and collected in the cave between the years 2005 and 2012, both at the end of the dry period (Sept. 2005: a single female; Oct. 2011: one adult male, one nymph) and at the end of the rainy season (March 2012: 4 males, 2 females). Although the specimens were collected during only three visits to the cave, these observations suggest that specimens are more abundant in the macrocavern during the rainy periods. Whether or not this observation reflects population dynamics or is an artifact of collecting cannot be decided at the present moment.

The MP8 cave is located at an altitude of 1,550 m a.s.l. which is considerably higher than the altitude at which most iron ore caves in the Iron quadrangle are located. The importance of altitude in determining the evolution of some troglobitic taxa (Picker & Samways 1996, Ferreira 2005, Souza-Silva et al. 2011) deserves attention. On the surface above these caves conditions may be extreme, due to higher (daily and annual) temperature oscillations and more intense winds (causing faster desiccation) than at lower altitudes (Ferreira 2005).

Adaptation to such extreme conditions may explain the evolution of highly troglomorphic traits as observed in *Ferricixius*, but also its (apparent) restriction to a single cave.

Inside the cave, *Ferricixius* specimens were found mainly in deeper zones, although one specimen was found in the twilight zone not far from one entrance. The cave possesses many roots, which constitute most likely the food resource for *Ferricixius.* However, the diverse surface vegetation in the area did not allow us to clearly associate the roots to one or more plant species; thus at present there is no information for *Ferricixius* on host specialization.

The MP8 cave harbours a diverse invertebrate community, including many troglophilic and some troglobitic species, including predators, such as Ochiroceratideae and Tetrablemmidae spiders (yet undescribed, Ferreira unpublished data) which may prey upon nymphs, but – due to their small size – most likely not on adults of *Ferricixius*.

Etymology. The species epithet refers to David, king-to-be of Israel (1 Sam 17, Hebrew Bible and Christian Old Testament) who managed to defeat Goliath, a physically far superior Philistine warrior. The epithet was chosen in the face of the immanent threat of extinction for this species by extensive iron mining activities, which might eventually destroy this specialized subterranean habitat.

Material examined. Holotype ♂. BRAZIL, Minas Gerais State, Itabirito Municipality, MP-08 Cave, 20.X.2011, leg. Oliveira, M.P., ES/ISLA 1768.

Paratypes. 4 ♂♂, 3 ♀♀, same data as holotype, except 8.IX.2005, Ferreira R.L. leg. (1♀), and 29.III.2012, Oliveira, M.P. (4 ♂♂, 2 ♀♀), ES/ISLA, MFN.

Additional material. 1 nymph (V. instar), same data as holotype.

Discussion and perspectives

As is the case for the other cavernicolous Neotropical Cixiidae, for *Ferricixius davidi* there is no closely related epigean relative which has been recognized in the surface fauna. Consequently, *Ferricixius davidi* must currently be regarded as a relict species. Whether initial adaptation to the subterranean environment took place in allopatry – by extinction of closely related epigean

populations, as is postulated by the *climatic relict hypothesis*: e.g., Vandel 1964, Barr 1968 – or occured in parapatry by an *adaptive shift* of troglophilic populations to the cave environment in order to exploit novel food resources (as suggested by Howarth 1981) cannot be decided on the basis of the information currently available. The epigean cixiid fauna of the Neotropics, especially in a country as rich in insect biodiversity as Brazil, must be considered very insufficiently investigated, and it cannot be excluded that close epigean relatives of *Ferricixius davidi* may still be extant.

In regard to their cavernicolous planthopper fauna, the Neotropics must also be considered largely unexplored: so far only five obligate cavernicolous Cixiidae (see above) and four species of the family Kinnaridae have been recognized (*Oeclidius hades* Fennah from Mexico: Fennah 1973, *Oeclidius antricola* Fennah and *Oeclidius persephone* Fennah from Jamaica: Fennah 1980, one from Brazil: yet undescribed, Hoch & Ferreira unpublished data). Given the overall size of the continent, the apparent richness of the surface planthopper fauna and the availability of potential habitats in many countries – see contributions on the occurrence of caves in Central and South America and the history of their exploration in Juberthie & Decu 1994) – it is likely that many more cavernicolous taxa still await discovery.

In Brazil, exploration of its cave fauna has, until recently, been strongly neglected. Only in the last few years have systematic surveys been conducted. New species are now continuously being discovered, many of them obligate cavernicoles: more than 300 troglobitic invertebrate species were discovered in different areas of Brazil during in the past five years (Ferreira, unpublished data). These discoveries clearly demonstrate that the inventory of the Brazilian cave fauna is far from complete and that there is only a very small body of knowledge existing on the biology and ecology of each of these species. However, there is serious concern regarding the protection of this fauna. A variety of anthropogenic activities threaten these habitats. Especially the extension of mining (iron ore extraction), as facilitated by a fateful change in Brazilian law in 2008, heavily impacts the specialized habitat of many of these life forms which are highly adapted to the subterranean biome.

The existence of a rich and diverse, but still poorly studied subterranean fauna is one of Braziĺs valuable and unique biological resources. Legal measures for its conservation and their consequent reinforcement are urgently required if the loss of an entire fauna is to be prevented.

Acknowledgements

We would like to express our sincere thanks to our colleagues Marcus Paulo de Oliveira for assistance in the field, for collecting some specimens and for taking photos of live specimens inside the cave, and to Marconi Souza Silva (Centro Universitário de Lavras) for helping with collections, as well as to Marita Steinhöfel and Nils Hoff, for image processing, to Jason Dunlop and Eva Patzschke, for language editing and editorial support, respectively, and to Manfred Asche, for taxonomic advise, helpful comments on the manuscript and his everlasting enthusiasm for biospeleology (all Museum für Naturkunde, Berlin). Funding was provided by CNPq to R.L.F. (grant nr. 301061/2011-4).

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