

Two new species of cave dwelling *Trechus* Clairville, 1806 of the *fulvus*-group (Coleoptera, Carabidae, Trechinae) from Portugal

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Abstract

Received 28 April 2008
Accepted 5 November 2008
Published 25 May 2009

Key Words

Estremenho Karstic Massif
Caves
Troglobitic
Ecology
Biogeography

Two new cave-dwelling ground beetle species, *Trechus gamae* sp. n. and *Trechus lunai* sp. n., from Portugal, are described. The new species are included in the *Trechus fulvus*-group by their morphological characters. The work provides diagnostic characters in particular those of the structure of male genitalia, and the distribution of the hypogean species of the *fulvus*-group at the Estremenho Karstic Massif is mapped. Some comments on the seasonal activity of *T. gamae* sp. n. are also given. An identification key to the males of the *T. fulvus*-group species from the Estremenho Karstic Massif is presented, and biogeographical comments are also included.

Introduction

The genus *Trechus* Clairville, 1806 (Coleoptera: Carabidae: Trechinae) includes more than 500 species (Casale et al. 1998), distributed in the Holarctic Region and East Africa. As a consequence of geophilic, lucifugous and hygrophilous affinities, this genus exhibits a large geographic range and is very successful in hypogean life. According to Jiménez-Valverde & Ortuño (2007) there are 49 known species in the Iberian Peninsula, 13 of them being exclusive to caves.

Only one species of cave dwelling beetles was known for Continental Portugal: *Trechus machadoi* Jeannel, 1941. It was described on the basis of two specimens from Alcobertas Cave, collected by António de Barros Machado (Jeannel 1941). In 1975, Eduard Vives gave a new location for this species (Contenda cave), but this work did not provide any morphological detail on male genitalia. Vives (1975) also refers that this is a rare beetle, close to *Trechus fulvus* Dejean, 1831, living in very humid caves.

The largest Portuguese limestone unit is the Estremenho Karstic Massif. Located in the centre of the country, it is composed by three major geological sub-

units of middle Jurassic (Dogger) limestone, separated by two main depressions (Fig. 11), one of them an active polje with periodical inundations (Martins 1949).

The aim of this work is to describe two new species of the genus *Trechus* from Portugal, both of the *fulvus*-group. The species belonging to this group are recognized by a combination of characters given in Jeannel (1927, p. 198). We also discuss relationships between these species and their closest forms. Furthermore we give a key to the males of all known species of the *T. fulvus*-group found in the Estremenho Karstic Massif.

Representatives of this group are distributed throughout North Africa, the Iberian Peninsula and the Atlantic coast of North Europe (Jeannel 1927). There are six recognizable subspecies within *T. fulvus* in the Iberian Peninsula (Serrano 2003), but there are also some debates about the status of some of them (e.g., Ortuño & Marcos 2003).

Material and methods

Field work was conducted in 10 caves (Tab. 1) within the three subunits of Estremenho Karstic Massif: Serra dos Candeeiros, Planalto de

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Santo António and Serra de Aire/Planalto de São Mamede (Fig. 11). Each cave was monitored in three different zones: (i) near the entrance, (ii) in the central zone and, (iii) in the deeper/terminal part of the cave. Monitoring was conducted at a maximum depth of ~120 m. Sets of five pitfall traps (each trap: 5 cm radius, 6 cm depth, and 1 cm diameter tube fixed inside at the centre) were used in each selected zone of the caves during a period of six months. Traps were partly filled with 1.2-propanodiol, and pig liver was used as attractive lure. Traps were covered with small stones to avoid water overflow and the disturbance by small vertebrates. The traps were checked and material collected monthly, from November 2006 to May 2007, except for Gralhas VII and Pena caves, where the traps were checked once more in August 2007. Some sound seasonal activity was obtained only in 5 caves located at the Planalto de Santo António (Tab. 2). Active search was also performed during the periodical visits to the caves.

The morphological study of adult specimens, including measurements and drawings of the new species, was performed with a Wild M5 stereoscopic microscope equipped with a dissecting microscope ocular micrometer and a drawing tube. The measurements done were body length (apex of labrum to apex of longer elytron), head length (apex of labrum to the middle region between the posterior area of tempora), head width (measured across the head and between the eyes), eye length (measured from anterior to posterior margin along middle region), eye width (measured from basal margin to upper margin along middle region), pronotum length (measured from anterior to basal margin along midline), pronotum width (between the widest region of the lateral margins), elytron length (basal margin near scutellum to apex of the longer elytron) and elytra width (measured across the widest point of the two elytra).

The *Trechus machadoi* lectotype was studied. However the specimen had not its genitalia and the legal depository of this lectotype (Muséum National d'Histoire Naturelle, Paris) gave us the information that the microscopic preparation with genitalia had been lost. Therefore our study was mainly based on the description and drawings of *T. machadoi* given by Jeannel (1941, p. 10, Fig. 1). A male specimen of *Trechus*

fulvus fulvus Dejean from Santa Margarida da Serra (Serra de Grândola, Portugal) was also analysed in what concerns its aedeagus. More seven specimens of this species from some localities of Portugal were measured concerning the length and width of its eyes.

Alcobertas Cave, the type locality of *T. machadoi* was monitored during six months, but no specimens of this species was sampled or observed. This unsuccessfulness is probably a consequence of the strong anthropogenic intervention in this cave since the 1970's, for tourism concerns. The aim of these actions had not been finished until nowadays and deep changes were introduced in the cave, like the opening of a second entrance almost at the end of the main gallery which drastically changed cave environment.

The specimens collected have been deposited in the following entomological collections:

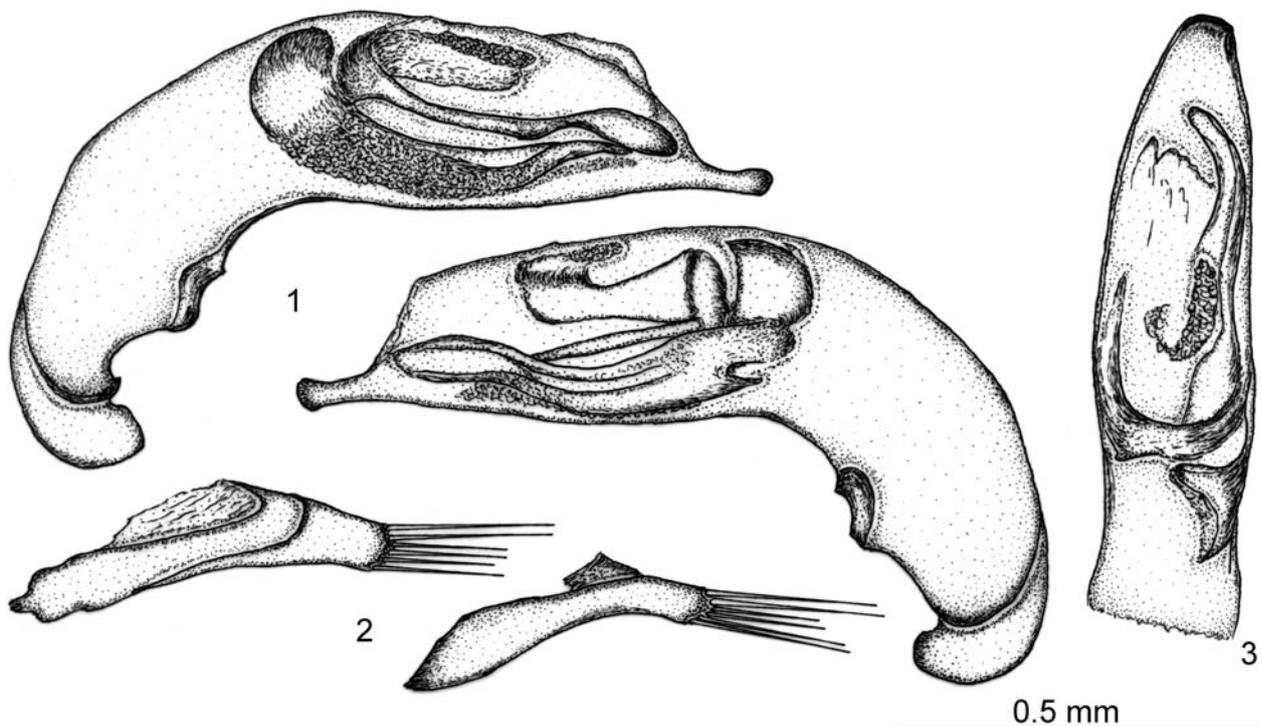
AS	Artur Serrano, Faculdade de Ciências da Universidade de Lisboa, Portugal
MNHN	Muséum National d'Histoire Naturelle, Paris
PO	Pedro Oromí, Tenerife, Canary Islands, Spain
SR	Sofia Reboleira, Caldas da Rainha, Portugal

Results

Trechus gamae Reboleira & Serrano sp. n.

Figures 1–3, 11

Diagnosis. Microphthalmous, apterous, body sub-parallel, convex and light brown. Pronotum transverse and slightly cordate. Elytra convex, eight well defined striae, protruding shoulder, with a small tooth. Both sexes show similar external morphology, except for the first two protarsomeres, which are dilated in males. Shape of aedeagus as in figures 1–3; median lobe of the aedeagus with apex strongly acuminate (Figs 1–2).



Figures 1–3. Aedeagus. *Trechus gamae* sp. n.: 1. Median lobe in left and right lateral view, respectively; 2. Left and right parameres (lateral view); 3. Median lobe (dorsal view).

Description. Length of holotype: 4.83 mm; width of holotype: 1.86 mm. Length of paratypes: 4.83–5.38 (males), 3.94–5.44 mm (females); width of paratypes: 1.82–2.05 mm (males), 1.47–2.11 mm (females). Head about 1.1 times wider than long [length: 0.77–1.06 mm (males), 0.67–1.12 mm (females), width: 0.96–1.06 mm (males), 0.80–1.09 mm (females)]. Eyes reduced, about 1.3 times wider than long [length: 0.11–0.14 mm (males), 0.10–0.16 mm (females); width: 0.16–0.19 mm (males), 0.11–0.22 mm (females)]. Mouthparts and antennae as in *T. fulvus fulvus*. Pronotum slightly cordiform, convex and transverse, about 1.2 times wider than long [length: 0.99–1.09 mm (males), 0.83–1.12 mm (females) width: 1.25–1.41 mm (males), 1.02–1.41 mm (females)]. Chaetotaxy as in *T. fulvus fulvus*. Elytra oblong, sub-parallel and convex, 1.5–1.7 times longer than wide [length: 3.04–3.23 mm (males), 2.43–3.23 mm (females), width: 1.47–2.11 mm (males), 1.82–2.05 mm (females)]. Apterous. Humeral angle with a small tooth. Chaetotaxy: Elytral setae as in *Trechus fulvus fulvus*; umbilical series normal (4 + 2 + 2). Legs as in *Trechus fulvus fulvus*. Male genitalia (Figs 1–3) in lateral view (Figs 1–2) with apex of median lobe strongly acuminate, slightly bent to right in dorsal view (Fig. 3); sclerites of the internal sac and the dorsal scale plate well developed; parameres (Fig. 2) with six setae apically.

Type Series. Holotype ♂: Portugal, Algar de Marradinhas II (U.T.M. coordinate: 29SND24627144), 18.V.2007, (S. Reboleira leg.), (AS). Paratypes, 1 ♀, Portugal, Algar das Gralhas VII (U.T.M. coordinate: 29SND13596782), 16.XII.2006, 1 ♀, same locality, 13.I.2007, 2 ♂ and

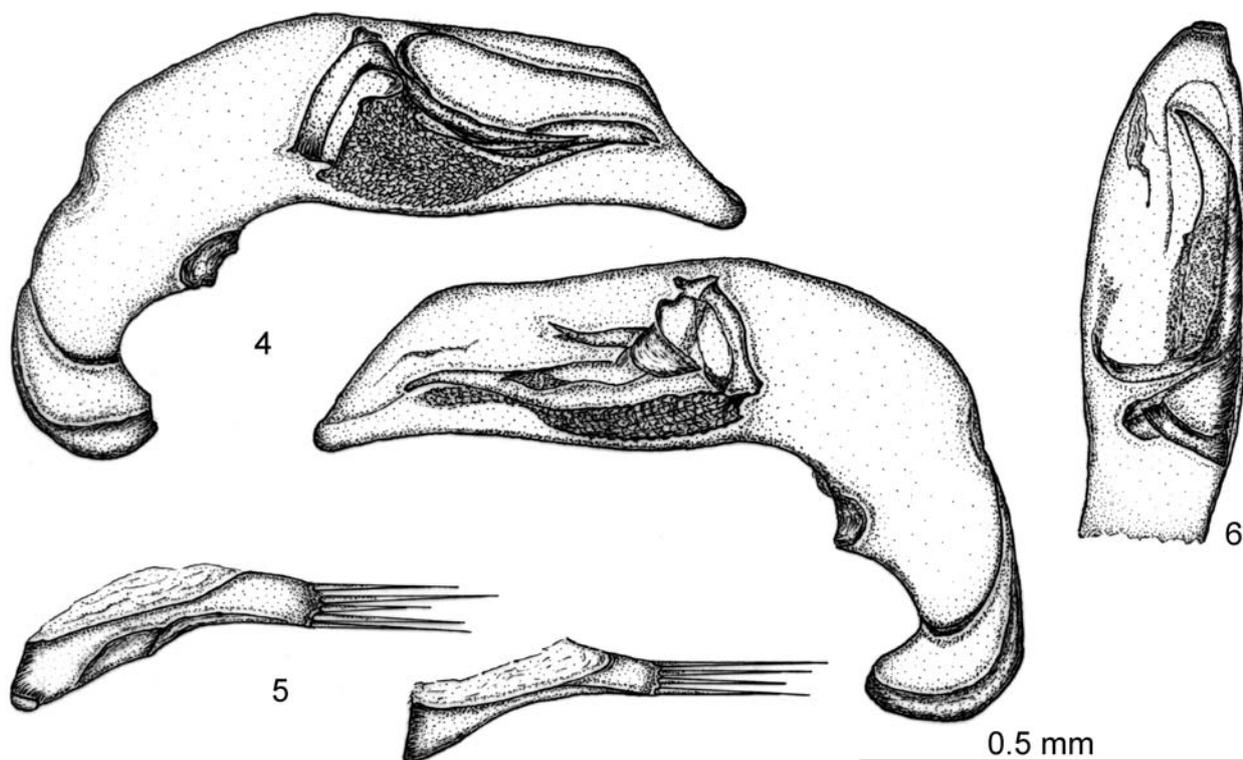
1 ♀, same locality, 10.II.2007, 2 ♂ and 5 ♀, same locality, 24.III.2007 (S. Reboleira leg.) (AS, SR), 1 ♂ and 5 ♀, Portugal, Algar do Pena (U.T.M. coordinate: 29SND16596841), 11.IV.2007, 1 ♂ and 2 ♀, same locality, 9.V.2007, 4 ♂ and 2 ♀, same locality, 18.VIII.2007 (S. Reboleira leg.) (AS, MNHN, PO, SR), 1 ♀, Portugal, Algar de Marradinhas II (U.T.M. coordinate: 29SND24627144), 04.II.2007, 1 ♀, same locality, 10.IV.2007, (S. Reboleira leg.) (AS), 3 ♀, Portugal, Algar da Arroiteia (U.T.M. coordinate: 29SND15617902), 18.III.2007, (S. Reboleira leg.) (AS, SR), 1 ♀, Portugal, Algar do Ladoeiro (U.T.M. coordinate: 29SND21127515), 3.II.2007, 1 ♀, same locality, 17.III.2007, (S. Reboleira leg.), (AS, SR). The holotype and fifteen paratypes (4 ♂, 11 ♀) are deposited at the Faculdade de Ciências da Universidade de Lisboa, two paratypes (1 ♂, 1 ♀) at Muséum National d'Histoire Naturelle collection, two paratypes (1 ♂, 1 ♀) at Pedro Oromí collection and fifteen paratypes (4 ♂, 11 ♀) at Sofia Reboleira collection.

Etymology. The specific epithet, *gamae*, is used as a noun in apposition based on the name of Maria Manuela da Gama, a world eminent expert on Collembola, who had greatly contributed to the taxonomic and faunistic knowledge of the Portugal cave fauna.

Trechus lunai Reboleira & Serrano sp. n.

Figures 4–6, 10, 11

Diagnosis. Microphthalmous, apterous, body sub-parallel, convex and light brown. Integument microreticulate on the head. Pronotum transverse and slightly cordate. Elytra convex, with eight well defined striae, protruding shoulders with a small tooth. Both sexes show similar external morphology, except for the first two protarsomeres, which are dilated in males. Shape of aedeagus



Figures 4–6. Aedeagus. *Trechus lunai* sp. n.: 4. Median lobe in left and right lateral view, respectively; 5. Left and right parameres (lateral view); 6. Median lobe (dorsal view).

as in figures 4–6; median lobe of the aedeagus with basal margin strongly arcuate outwards (Figs 4–5); inner sac without the dorsal plate of scales (Figs 4–5).

Description. Length of holotype: 4.2 mm; width of holotype: 1.73 mm. Length of paratypes: 3.55–4.73 mm; width of paratypes: 1.76–1.92 mm (males and female).

Head 1.1–1.2 times wider than long [length: 0.74–0.80 mm (males), 0.88 mm (female); width: 0.86–0.90 mm (males), 0.96 mm (female)]. Eyes reduced, about 1.2–1.4 times wider than long [length: 0.08–0.13 mm (males), 0.19 mm (female); width: 0.10–0.19 mm (males), 0.22 mm (female)]. Mouthparts and antennae as in *T. fulvus fulvus*. Pronotum transverse about 1.2–1.4 times wider than long [length: 0.83–0.93 mm (males), 0.97 mm (female), width: 1.18–1.22 mm (males), 1.15 mm (female)]. Elytra oblong, convex and sub-parallel, 1.5–1.6 times longer than wide [length: 2.72–2.78 mm (males), 2.88 mm (female), width: 1.73–1.86 mm (males), 1.92 mm (female)]. Apterous. Humeral angle with a small tooth.

Chaetotaxy: Elytral setae as in *Trechus fulvus fulvus*; umbilical series normal (4 + 2 + 2). Legs as in *Trechus fulvus fulvus*. Male genitalia (Figs 4–6) in lateral view (Figs 4–5) with basal margin strongly arcuate outwards, slightly bent to right in dorsal view (Fig. 6); absence of the dorsal plate of scales of the inner sac; left and right parameres (Fig. 5) with five and four apical setae, respectively.

Type Series. Holotype ♂: Portugal, Gruta da Nascente do Almonda (U.T.M. coordinate: 29SND33087287), 01.I.1991, F. Regala & R. Mergulho leg. (AS). Paratypes: same locality, 01.I.1991, 1 ♂, F. Regala & R. Mergulho leg., 30.IV.2007, 1 ♀, S. Reboleira leg., Gruta da Contenda (U.T.M. coordinate: 29SND25847594), 27.I.2007, 1 ♂, S. Reboleira leg. (in 1,2-Propanodiol) (AS). Holotype and paratypes are deposited at Faculdade de Ciências da Universidade de Lisboa.

Etymology. In a modest homage to his memory, the specific epithet, *lunai*, is used as a noun in apposition based on the name of Eduardo Luna de Carvalho, a Portuguese entomologist which was a world eminent expert on Coleoptera Paussinae and Strepsiptera.

Key to the males of the *T. fulvus*-group species of the Estremenho Karstic Massif

1. Eyes well developed (length: 0.22–0.27 mm; width: 0.27–0.32 mm); aedeagus as in figures 7–9 *T. fulvus*
– Eyes reduced (length: 0.08–0.14 mm; width: 0.10–0.19 mm); aedeagus different from above 2
2. Plate of dorsal scales in internal sac of median lobe of aedeagus absent; aedeagus as in figures 4–6 *T. lunai* sp. n.
– Plate of dorsal scales in internal sac of median lobe of aedeagus present; aedeagus different from above 3
3. Median lobe of aedeagus (lateral view) strongly enlarged in the middle region; apical region of the median lobe (lateral view) with dorsal margin slightly downing toward apex (Jeannel 1941, fig. 1) *T. machadoi*
– Median lobe of aedeagus (lateral view) not enlarged in the middle region; apical region of the median lobe (lateral view) with dorsal margin abruptly downing before apex (Figs 1–3, this work) *T. gamae* sp. n.

Affinities and biogeographical and ecological remarks

Taking into account the morphological features proposed by Jeannel (1927), *T. gamae* sp. n., *T. lunai* sp. n. as well as *T. machadoi* are included in *T. fulvus*-group. The external morphology of all these three species is very similar. The best features to differentiate one from the others are the shape of the median lobe of aedeagus and the development of sclerites of the internal sac. The eye size is also a useful feature to differentiate *T. fulvus fulvus* from the three above mentioned remaining species. While the nominal *T. fulvus* exhibits well developed eyes, the three latter species present reduced eyes.

Trechus gamae sp. n. is very close to *T. machadoi* taking into account the sclerites and the dorsal plate of scales development of the internal sac. Nevertheless, conformation of their median lobes in lateral view are quite different (*cf.* fig. 1 in Jeannel 1941 and in this work). On the other hand, *T. lunai* sp. n. can be easily discriminated from *T. gamae* sp. n. and *T. machadoi* by the shape of the median lobe of aedeagus, and also by

the minor development of the sclerites of the internal sac and the absence of the dorsal plate of scales in the same structure (*cf.* Figs 1, 4). Moreover this last feature and the general conformation of median lobe of aedeagus segregate also well *T. lunai* sp. n. from *T. fulvus fulvus* (see Figs 4–6 and 7–9).

Trechus gamae sp. n. was found in the deep parts (from – 50 m to – 95 m) of the caves within the Planalto de Santo António, the central subunit of Estremenho karstic massif (Fig. 10). In these sites air humidity levels are very high (above 98%) and mean temperature ranges from 13.5 °C (Algar do Pena) to 17 °C (Algar de Marradinhas II) (Tab. 1). This new species was the only hypogean beetle sampled in that caves during the monitored period. Sometimes, it was found in sympatry the ground beetle *Laemostenus (Pristonychus) terricola* (Herbst, 1783), which is in accordance with the troglophile tendency of this species in many world geographic areas where it occurs (Casale 1988; Serrano 2003). Some other groups of arthropods (not studied) like Araneae, Chilopoda, Symphyla, Isopoda, Collembola, Diplura and Psocoptera were sampled together with the above mentioned ground beetle species. The seasonal activity

Table 1. Caves studied with indication of type (horizontal* or vertical**), coordinates (UTM, 10 × 10 m), entrance level (meters), maximum depth sampled (meters), substrate type with or without guano, and mean temperature in depth zone (°C). (Abbreviations: Cl – Clay, G – Guano, Li – Limestone).

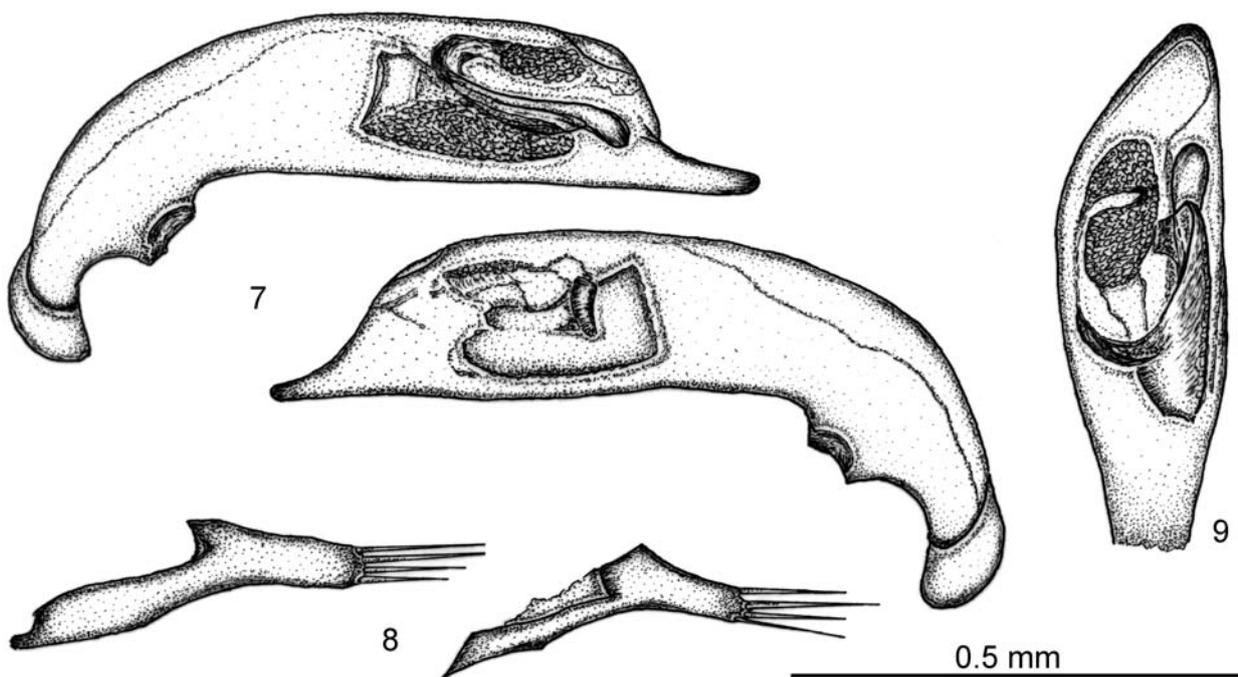
Cave name (Mountain or Plateau)	Type of cave	Coordinates (UTM)	Entrance level (m)	Sampled depth	Type of substrate	Mean Temperature
Alcobertas (Sra. Candeeiros)	Horizontal	29SND07146444	385	H	Cl, Li	13.5
Pena (PN) (P. Sto. António)	Vertical	29SND16596841	340	–95	Cl, Li	13.5
Gralhas VII (GVII) (P. Sto. António)	Vertical	29SND13596782	350	–75	Cl, Li	15
Cheira (P. Sto. António)	Vertical	29SND21617027	265	–15	Cl, Li, G	16
Marradinhas II (MARII) (P. Sto. António)	Vertical	29SND24627144	250	–50	Cl, Li	17
Ladoeiro (LDR) (P. Sto. António)	Vertical	29SND21127515	485	–80	Cl, Li, G	15.5
Arroteia (ART) (P. Sto. António)	Vertical	29SND15617902	450	–60	Cl, Li	16
Moinhos Velhos (MV)/Contenda (CTD) Cave System (Sra. Aire/Sra. Mamede)	Horizontal	(MV) 29SND25407679 (CTD) 29SND25847594	307 210	–50	Cl, Li	18
Lomba (Sra. Aire)	Vertical	29SND28027481	385	–120	Cl, Li	17
Almonda (Sra. Aire)	Horizontal	29SND33087287	95	–80	Cl, Li, G	18

* Cave without evident difference in level between entrance and deep zone.

** This type of cave is named "Algar" in Portuguese.

of *T. gamae* n. sp. during the studied period was quite different when we compare the pitfall results obtained in Planalto de Santo António caves, the subunit where this species occurs (Tab. 2). At Algar das Gralhas the activity began in December and had a peak in Mars, dropping abruptly after this month. Surprisingly, the activity of this species just began in April in the other caves (Tab. 2). The periodical monitoring ended in May for most of the caves, so with these data we cannot anticipate the real period of activity for *T. gamae* n. sp. in these caves.

On the other hand, *T. lunai* sp. n. is known from two caves (Gruta do Almonda Velho and Gruta da Contenda) within Serra de Aire/Planalto de São Mamede, the eastern subunit of Estremenho Karstic Massif (Fig. 10). As a consequence of the seasonal flooding of these caves, overlapping 2–3 months with the sampling period, the monitoring was mainly performed by direct observation instead of pitfall trapping. The species seems rare and occurs also in the deep parts of caves (–50 m), with high humidity (above to 98%) and mean temperature near 18 °C. It was also the only hy-



Figures 7–9. Aedeagus. *Trechus fulvus*: 7. Median lobe in left and right lateral view, respectively; 8. Left and right parameres (lateral view); 9. Median lobe (dorsal view).

Table 2. Number of *Trechus gamae* sp. n. specimens (imagoes) sampled by pitfall traps during the sampling period (see text). (Abbreviations: ART – Algar da Arroteia; GVII – Algar de Gralhas VII; LDR – Algar do Ladoeiro; MARII – Algar das Marradinhas II; PN – Algar do Pena).

Month year/Cave*	GVII	PN	MARII	ART	LDR
December 2006	1	0	0	0	0
January 2007	1	0	0	0	0
February 2007	3	0	1	0	0
March 2007	7	0	0	0	0
April 2007	0	6	1	3	1
May 2007	0	3	1	0	1
August 2007	0	6	–**	–**	–**

* All specimens were sampled in the deeper zone of caves.

** Not monitored in this month.

pogean beetle recorded in these caves. Once again *L. terricola* was found in sympatry with the new species. It was impossible to assess the seasonal activity evolution of *T. lunai* sp. n. during the studied period, as a consequence of the very low number of specimens sampled.



Figure 10. Facies of the male (holotype) of *Trechus lunai* sp. n. (Scale: 1 mm). This figure is available in colour online at museum-dez.wiley-vch.de

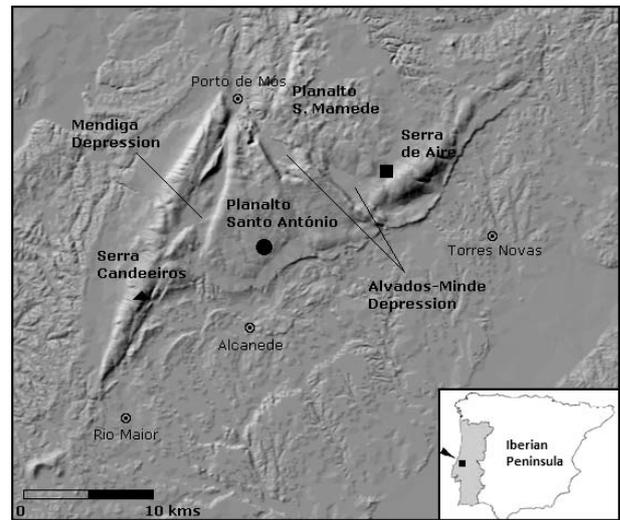


Figure 11. Geographic distribution of the hypogean species of the *Trechus fulvus* group at the Estremenho Karstic Massif (Portugal): *Trechus machadoi* (triangle), *Trechus gamae* sp. n. (circle) and *Trechus lunai* sp. n. (square). (Map modified from Martins, 1949.)

The status of new species for these two assemblages of specimens is reinforced by their apparently geographic isolation (*T. gamae* sp. n. was exclusively found in Planalto de Santo António, and *T. lunai* sp. n. was only found in Serra de Aire/Planalto de S. Mamede). On the other hand, each assemblage of these subunits presents stable morphological features concerning the aedeagus and the size of the eyes. Vives (1975) recorded *T. machadoi* for Contenda cave in the subunit Serra de Aire/Planalto de S. Mamede. However, after our results we think that Vives (1975) specimens probably belong to *T. lunai* sp. n. Taking into account Jeanel's (1941) work and our own results, *T. machadoi* is probably confined to Serra dos Candeeiros subunit. These data suggests that *Trechus machadoi* and the new species probably originated by radiation and allopatric speciation from the epigeal *T. fulvus*. As a consequence of this we are facing a group of sibling species isolated in different hypogean subunit blocks within the same massif, functioning like islands. There are many examples of this speciation pattern in other hypogean *Trechus* of the Iberian Peninsula (Ortuño & Arillo 2005). In a near future, molecular studies could give more insights in the phylogeography of this *Trechus* species group.

As final remarks, we would like to point out that these two new species were never found near cave entrances, as well in areas with accumulated organic material like bat guano. Furthermore, their microphthalmic characters lead us to believe that they are true troglolites.

Acknowledgements

We express our gratitude to Azadeh Taghavian from Muséum National d'Histoire Naturelle de Paris for sending *T. machadoi* lectotype

for studying purposes. We are indebted to Pedro Oromi for reading this manuscript and providing helpful criticism to improve it and to two anonymous reviewers for their helpful comments and suggestions. We also thank all the Portuguese caving groups for their support in the field work (CEAE-LPN, NEUA, GPS, NEL, AES and ECLER) and to Parque Natural das Serras de Aire e Candeeiros (PNSAC) for all the logistic support in the field work.

References

- Casale, A. 1988. Revisione degli Sphodrina (Coleoptera, Carabidae, Sphodrini). – Monografie 5, Museo Regionale di Scienze Naturali, Torino.
- Casale, A., Vigna-Taglianti, A. & Juberthie, Ch. 1998. Coleoptera Carabidae. In Juberthie, C. & Decu, V. (eds). Encyclopaedia biospéologica. Vol. 2. Société de Biospéologie, Moulis, France: pp. 1047–1081.
- Jeannel, R. 1927. Monographie des Trechinae 2. Morphologie comparée et distribution géographique d'un groupe de Coléoptères. – L'Abeille 33: 1–592.
- Jeannel, R. 1941. Premières explorations des grottes du Portugal par M. A. de B. Machado. Coléoptères. – Anais da Faculdade de Ciências do Pôrto 26 (2): 5–15.
- Jiménez-Valverde, A. & Ortuño, V.M. 2007. The history of endemic Iberian ground beetle description (Insecta, Coleoptera, Carabidae): which species were described first? – Acta Oecologica 31: 13–31.
- Martins, A. F. 1949. Maciço Calcário Estremenho. Contribuição para um estudo de geografia física. Oficinas da impressão de Coimbra, Coimbra.
- Ortuño, V.M. & Arillo, A. 2005. Description of a new hypogean species of the genus *Trechus* Clairville, 1806 from eastern Spain and comments on the *Trechus martinezi*-lineage (Coleoptera: Adephaga: Carabidae). – Journal of Natural History 39 (40): 3483–3500.
- Ortuño, V.M. & Marcos, J.M. 2003. Los Caraboidea (Insecta: Coleoptera) de la Comunidad Autónoma del País Vasco. Tomo I. Introducción; morfología; sistemática: Cicindelidae, y Carabidae: Carabinae, Nebriinae, Notiophilinae, Omophroninae, Elaphrinae, Loricarinae, Clivininae, Trechinae y Patrobinae. Biodiversidad 2. Servicio Central de Publicaciones del Gobierno Vasco, Vitoria-Gasteiz, 573 pp.
- Serrano J. 2003. Catálogo de los Carabidae (Coleoptera) de la Península Ibérica. Monografías S.E.A., 9, Sociedad Entomológica Aragonesa, Zaragoza, 130 pp.
- Vives, E. 1975. Coleópteros cavernícolas nuevos o interesantes de la Península Ibérica y Baleares. – Speleon 22: 159–169.