On some Collembola from a Sicily cave, with the description of a new species of *Serroderus* Delamare, 1948 (Collembola, Cyphoderidae)

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Abstract
This paper deals with some cave collembola from Sicily. The analysis has revealed the presence of the species *Acherontiella carusoi* Dallai, 1978, *Heteromurus nitidus* (Templeton, 1835), *Disparrhopalites patrizii* (Cassagnau and Delamare, 1953), and *Serroderus trinacriae* n. sp., new to science. This is the first record of the genus *Serroderus* for Sicily and Italy. The new species is characterized by the multidentate shape of the mucron, the presence of three to four spines, and by the number of scales on the inner (five) and outer (eight) rows of the dens. The biogeographical distribution of the genus and the taxonomic relationships of *S. trinacriae* n. sp. are discussed.

Keywords: Cave collembola, Collembola, Cyphoderidae, Serroderus trinacriae n. sp

Introduction
The cave collembola from Italy need to be further studied because many karstic areas along the peninsula are still not well known. A list of cave collembola from Italy, including a total of 91 species, was made (Dallai and Malatesta 1982); 48 species were considered as troglophilic or trogloxenic, being found both in caves and soil samples, while the remaining 43 species were considered as troglobitic. The morphological specializations leading some of these species to be well adapted to cave life were discussed (Dallai and Malatesta 1982). Later on, these characters were further discussed considering their adaptation from a biological and ecological point of view (Thibaud 1994). Some other notes have also been published concerning the cave colembola from Italy, and four new species have been added to the previous list (Dallai and Sabatini 1981; Nosek and Paoletti, 1981a, 1981b, 1981c). Since these findings, no new cave species from Italy have been described even though some colembolan species, among the general fauna of caves, were reported (Pascutto and Ghielmetti 1996; Pascutto 2003). More recently, however, two new species...
have been found (Fanciulli 1999; Fanciulli et al. 2005), while for another one, Troglopedetes ruffoi Delamare Deboutteville, 1951, a redescription was made (Fanciulli et al. 2003).

In this paper, we describe the collembolan fauna from a cave near Siracusa. The analysis has revealed the presence of four species belonging to four different families. One of them was a cyphoderid species of the genus Serroderus, whose features have not yet been found in other species. Thus, the taxon is new to science and it will be described here.

The systematic relationships within the family Cyphoderidae were re-examined many years ago (Delamare-Debouteville 1948), and some genera and species from western Africa were described, especially among termitophilous and mirmecophilous taxa. The most important diagnostic characters used for identifying the species were the shape of mouthparts and head, the number of the scales in the inner and outer rows of the dens, the shape of the foot complex, and the shape and number of teeth and spines on the mucron.

On the basis of these characters, 10 valid genera in the family Cyphoderidae were recognized (Delamare-Debouteville 1948). Later on, some species were described from the Near East (Lebanon and Syria) (Christiansen 1957) whereas the two genera Cyphoda and Serroderus were considered as subgenera of Cyphoderus. More recently, some taxa were revised and some new ones were described (Yoshii 1980, 1987, 1992). New morphological characters were suggested (Yoshii 1992) with the aim of establishing a better taxonomic system for the family. Cyphoderus and Serroderus are considered very closely related genera, distinguishable one from the other by the presence (Cyphoderus) or absence (Serroderus) of a dorsal row of setae between the inner and the outer rows of scales on the dens.

Materials and methods

Individuals were collected in the Monello cave near Siracusa (Sicily, Italy) (cave number SR7007, 100 m asl, IGM maps 274 III SE Floridia) in two different periods, August 1992 and June 2002. Individuals of both Serroderus trinacriae n. sp and Acherontiella carusoi were processed for scanning electron microscopy observations following the standard procedure. Material preserved in 80% ethanol was dehydrated in absolute ethanol, critical-point dried in a Balzer CPD 030 apparatus, and coated with gold in a Balzers MED 010 sputter coater. Observations were performed with a Philips XL20 scanning electron microscope.

Results

Family HYPOGASTRURIDAE Börner, 1906
Genus Acherontiella Absolon, 1913
Acherontiella carusoi Dallai, 1978

Material. Four specimens collected in the largest room of the Monello cave over a guano deposit, they were prepared for scanning electron microscopy.

The genus Acherontiella includes about 21 species all over the world. It has a cosmopolitan distribution with nine palearctic species, three nearctic, one neotropic, four African, one pantropic, two Oriental, and one from New Caledonia (Thibaud et al. 2004). The Italian fauna includes three species: A. bougisi Cassagnau and Delamare, 1955, A. cavernicola (Tarsia in Curia, 1941), and A. carusoi Dallai, 1978. Acherontiella bougisi is widespread in the Mediterranean Basin (Dallai 1978), in Italy it has been found both in caves and soil samples from Sicily. Acherontiella cavernicola and A. carusoi are indeed cave
species so far reported only from Italy: the first from a cave near Iseo (Brescia, northern Italy), while *A. carusoii* was described by Dallai (1978) from two caves in the same area of the Monello cave (Caruso and Costa 1978). The new finding of *A. carusoii* confirms its presence in the area of the original description, and allows the examination of some characters by means of scanning electron microscopy, such as the shape of the tibiotarsus with two knobbed tenent hairs, and claw with subapical tooth (Figure 1A), and the presence of a terminal vesicle and four oval sensilla on antennomere IV (Figure 1B, C).

**Family ENTOMOBRYIDAE** Schött, 1891

**Genus Heteromurus** Wankel, 1860

**Heteromurus nitidus** (Templeton, 1835)

**Material.** Numerous individuals found in different sites of the cave. 

*Heteromurus nitidus* is a troglophilic species with holarctic distribution. It has been reported from numerous localities along the Italian peninsula (Dallai et al. 1995) both from soil samples and caves (Dallai and Malatesta 1982) where it usually occurs as a typical element.

**Family SMINTHURIDAE** Lubbock, 1862

**Genus Disparrhopalites** Stach, 1956

**Disparrhopalites patrizii** (Cassagnau and Delamare, 1953)

**Material.** Numerous individuals found in different sites of the cave.

*Disparrhopalites patrizii* is a troglophilic species with a southwestern European distribution (Bretfeld 1999). It has been collected both in open (Dallai 1973; Schleuter 1985) and cave habitats (Dallai and Malatesta 1982; Christian 1998; Bretfeld 1999). For many years the genus was believed to be monospecific with only one species (*D. patrizii*) (Dallai 1970); however, a new species, *D. tergestinus* was recently described by Fanciulli et al. (2005), from a cave near Trieste (NE Italy). The two species can be easily separated from each other by means of some characters such as: the eye patch, that is absent in *D. tergestinus*, and is present with eight ocelli in *D. patrizii*; the number of the subarticles of antennomere IV, that consists of 14 in *D. tergestinus* but only 12 in *D. patrizii*; the shape of the hindfoot complex provided with an untoothed claw in *D. tergestinus* and a toothed claw in *D. patrizii*.

**Family CYPHODERIDAE** Börner, 1913

**Genus Serroderus** Delamare, 1948

**Serroderus trinacriae** n. sp.

Holotype: **3♂** and 10 paratypes mounted on slides are conserved in the collection of R. Dallai at the Department of Evolutionary Biology University of Siena.

The species is named according to the ancient name of Sicily: Trinacria.

**Description**

Body length up to 1.7 mm, white in alcohol. Without eye patch. Ratio ant./head diagonal 86:50. Antennal segment ratios I:II:III:IV as 11:21:22:32. Antennae have numerous slender sensillate elements (Figure 2A–D), which are about 60, 70, 50, and 6, respectively, on antennomeres IV, III, II, and I. Other shorter sensilla are also present at the tip of
Figure 1. Scanning electron micrographs of *Acherontiella carusoi*. (A) Tibiotarsus III with knobbled tenent hairs and claw with subapical tooth (arrow); (B) apical part of antennomere IV showing the terminal vesicle (asterisk); (C) antennomere IV with four oval sensilla (arrows).
Figure 2. *Serroderus trinacriae* n. sp. (A) Antennomere IV, arrows indicate two apical shorter sensilla; (B) antennomere III; (C) antennomere II; (D) antennomere I; (E) mandible; (F) maxilla; (G) foot complex III.
antennomeres II–IV (arrows in Figure 2A–C), and three sensilla are on antennomere I (arrows in Figure 2D). Scales present on antennomere II. Mandible and maxilla (Figure 2E, F) show typical morphology; outer maxillary lobe as in Figure 4G. Labrum with 4/5–5–4 smooth setae disposed as in Figure 3C. No labral margin structures were observed. Labial area with six setae (Figure 3B). Prefrontal setae plus 1+1 lateral setae all smooth (Figure 3D). Frontal area with barbed setae (Figure 3D): f-0 is a pair of minute sensilla, f-4 is shorter than others while f-5 is the longest one. Dorsal and ventral chaetotaxy of the head as in Figure 3A, B. Anterior part of ventral tube with 2+2 barbed and 4+4 smooth setae on the lateral flaps (Figure 4H). Posterior part of ventral tube with 2+2 distal and 4+4 basal setae plus one unpaired seta, in addition to 2+2 small pegs (Figure 4I). All these setae are smooth. Furca well developed, ratio manubrium: dens: mucro 37:30:12. Dens (Figure 4A) with two rows of scales without setae between them; there are five scales in the inner and eight in the outer row. Two barbed setae are in the distal part of dens, while a row of these seta is parallel to the outer row of scales; about 10 barbed setae are in the proximal part of the dens. Three (Figure 4A), sometimes four (Figure 4B), spines follow the scales of the inner row toward the basis of dens. Mucro of the multidentate type, apical tooth not curved, followed by two strong teeth and a series of smaller spines; the formula is aAA7-8 (Delamare-Debouteville 1948) (Figures 4E, 5A). Two ventral slender scales are present behind the mucro. Clasping organ as in Figure 4C. Retinaculum with four teeth and one smooth seta on the basal body (Figure 4D). Unguis has one inner tooth and a pair of basal teeth, the outer is larger than the inner one (Figures 2G, 5B, C). Basal unguis and pretarsus both with small spines (Figure 2G); unguiculus with a broad outer tooth. Tenent hair pointed. Trochanteral organ (Figure 4F) composed of nine smooth setae arranged in a v-form. Anterior margin of Th.II with numerous long blunt ciliated setae as in Figure 3E. Two, three, and three trichobotria for each emitergites, respectively, on II, III, and IV abdominal segments arranged as in Figure 4K.

**Taxonomic relationships and biogeographic considerations**

Serroderus trinacriae n. sp. is the first record of the genus for Sicily and Italy and the second finding in the Mediterranean region after *S. spinatus* (Christiansen 1957). Serroderus trinacriae n. sp. is easily distinguishable from the other congeneric species by a combination of characters, the most important of which are the presence of spines and the number of scales in the inner row on the dens, and the shape of mucron. Dental spines are also present in *S. spinatus* but the number is quite different in the two species, being three to four in *S. trinacriae* n. sp. and only two in *S. spinatus*. The two species also differ in the number of scales in the inner row of dens, which are five in *S. trinacriae* n. sp. and two in *S. spinatus*.

A character frequently observed in some species of the genus *Serroderus* is the multidentate shape of the mucro. This character is shared by several species besides *S. trinacriae* n. sp. (*S. acanthotermiensis* Delamare, 1948, *S. bilobatus* Delamare, 1948, *S. interpositus* (Denis, 1942), *S. multidentatus* (Delamare, 1948), *S. protermiensis* Delamare, 1948, *S. socialis* Delamare, 1948, and *S. termophilus* Delamare, 1948). However, all of them differ from the new species by the different formulae of teeth and spines on the mucro (Delamare-Debouteville 1948), the absence of spines on the dens, and the different number of scales on the inner row of dens. Only *S. multidentatus* has the number of scales higher than that of *S. trinacriae* n. sp.

The genus *Serroderus* at present includes 26 species, most of which are distributed in the African subequatorial region. Eight species are from the Oriental region, while *S. delamarei*
Cassagnau, 1963 is from South America (Figure 6). Rapoport (1971) considered the genus as a holotropical taxon and outlined several factors that could have been responsible for such wide distribution. The finding of *S. trinacriae* n. sp. in a Sicily cave could be explained.

Figure 3. *Serroderus trinacriae* n. sp. (A) Dorsal chaetotaxy of the head; (B) ventral chaetotaxy of the head; (C) labrum chaetotaxy; (D) chaetotaxy of the prefrontal area.
Figure 4. *Serroderus trinacriae* n. sp. (A) Chaetotaxy of the dens; (B) spines on the basal inner side of the dens; (C) clasping organ of the furca; (D) retinacule showing four teeth; (E) shape of the mucro; (F) trochanteral organ; (G) outer maxillary lobe; (H) ventral tube anterior part; (I) ventral tube posterior part; (K) schematic distribution of the dorsal trichobotria.
in the light of the past geological and climatic events which occurred in the Mediterranean Basin from the Tertiary age. During the early Tertiary the boreal region was dominated by tropical or subtropical conditions. However, at the end of the Tertiary (Pliocene), the climate progressively changed toward cold temperatures and many tropical plants and animals were eliminated and substituted by new taxa. Some elements of the ancient fauna, however, survived in quite isolated refuges. Caves represented one of these suitable ecosystems for many tropical organisms. According to this scenario, the new species of Serroderus can be considered as a relict taxon which has survived as a troglobitic element.

Figure 5. Serroderus trinacriae n. sp., scanning electron micrographs. (A) Mucro; (B) foot complex II; (C) foot complex III.
since the end of the Tertiary age. The cave environment, with constant temperatures and high rates of humidity (Caruso 1994), provided suitable conditions for its survival. On the other hand, *S. trinacriae* n. sp. is not the only troglobitic species found inside the Monello cave. Some other endemic species were found (Caruso 1994) and among them the finding of the isopod *Armadillidium lagrecai* Vandel is relevant. This species, and the closely related *A. ghardalamensis* Caruso and Hili, 1991 from Malta (Caruso and Hili 1991), are considered to be relict species of tropical Tertiary origin (Rapoport 1971) which, as with *S. trinacriae*, remained inside the cave when the climate changed towards colder conditions.

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