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Insular species swarm goes underground: two new troglobiont *Cylindroiulus* millipedes from Madeira (Diplopoda: Julidae)

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Abstract

Two new species of the genus *Cylindroiulus* Verhoeff, 1894, *C. julesvernei* and *C. oromii,* are described from the subterranean ecosystem of Madeira Island, Portugal. Species are illustrated with photographs and diagrammatic drawings. The new species belong to the *Cylindroiulus madeirae*-group, an insular species swarm distributed in the archipelagos of Madeira and the Canary Islands. We discuss the differences between the new species and their relatives and present information on the subterranean environment of Madeira. An updated overview of the subterranean biodiversity of millipedes in Macaronesia is also provided.

Key words: taxonomy, lava tube, troglobiont, Portugal, Macaronesia

Resumo

Duas novas species de *Cylindroiulus* Verhoeff, 1894, *C. julesvernei* and *C. oromii* são descritas de tubos de lava da ilha da Madeira, Portugal. As novas espécies pertencem ao complexo insular de espécies do grupo *Cylindroiulus madeirae* e são ilustradas com fotografias e desenhos esquemáticos. As diferenças com os seus parentes mais próximos e informações acerca do seu habitat são discutidas. Apresentamos também uma visão global da biodiversidade de mil-pés cavernícolas na Macaronésia.

Introduction

Analysis of subterranean millipede biodiversity in Portugal began only very recently (Reboleira & Enghoff in press). Recent studies in subterranean ecosystems in Portugal have contributed to elucidate new patterns of distribution for Iberian subterranean millipedes, and several new species have been described (Enghoff & Reboleira 2013a, 2013b, Reboleira & Enghoff 2013, in press), but so far, no subterranean-adapted millipedes have been recorded from the Portuguese Macaronesian islands, i.e., the Azores, Madeira and Selvagens archipelagos (Reboleira *et al.* 2011).

The Madeira archipelago has its origin in a volcanic hotspot and it is estimated to have emerged from the sea about 4.7 Ma ago (Geldmacher *et al.* 2000). It is composed of the main island Madeira (728 km^2), Porto Santo Island (69 km^2) and the three Desertas islands (15 km^2). Together with the Selvagens, Canaries and Azores, the Madeira archipelago constitutes the biogeographic region of Macaronesia (Fernández-Palacios *et al.* 2011). The nearest continental area is at 650 km on the west coast of Morocco and it is about 850 km distant from the southern coast of the Iberian Peninsula.

Madeira harbours seven troglobiont species and although it is far from being considered a hotspot for subterranean biodiversity, as the case of the Canary Islands, it holds a considerable promise for future research in

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The unique hook-like shape of the mesomerite and the lack of rugose internal margins in the pro- and mesomerite in *C. julesverni*, whose female remains unknown, would be expected to be accompanied by modifications in the female vulvae shape, since pro- and mesomerite are used during copulation as a pair of forceps that seize the vulvar operculum of the female (Haacker & Fuchs 1970; Tadler 1996). Considering the deviating gonopods and the lack of female specimens, the inclusion of *C. julesvernei* in the *C. madeirae*-group rests on quite meagre evidence: *C. julesvernei* has a (sub)complete whorl of setae on the preanal ring, a character shared by the *C. madeirae*-group and just a few non-Madeiran species.

The vulvae of *Cylindroiulus oromii* **n. sp.** and *Cylindroiulus* sp. are typical of the *C. madeirae*-group, with the operculum lacking setae and the receptaculum seminis consisting in a subsphaerical vesicle, provided with a small terminal appendix (Enghoff 1982). However, these vulva characters also occur in the Iberian *C. perforatus*-group, presumed sister-group of the *C. madeira*-group (Read 1989a,b)

The exceptionally short accessory claw in both species is paralleled among the epigean species only by *C. obscurior* and *C. zarcoi*. Enghoff (1983) suggested that short accessory claw may facilitate climbing, and in fact *C. obscurior* seems to favour the microhabitat "moss on stones", while the only known specimen of *C. zarcoi* was collected from moss and lichens on a tree trunk (Enghoff 1983; Read 1989a). Being able to climb is obviously more necessary for a cave-dwelling species than for a litter- or soil-dwelling one, and the short accessory claws of *C. oromii* and *C. julesverni* should probably be understood in this light.

Millipedes in the subterranean ecosystems of Macaronesia

Within the biogeographic region of Macaronesia, 11 species of troglobiont millipedes are now known (Oromí 2008; Enghoff 2012).

The highest diversity is located within the Canarian archipelago, which harbours 9 species belonging to the families Glomeridae and Julidae. Four species are present on the island of Tenerife: *Glomeris speobia* Golovatch & Enghoff, 2003; *Dolichoiulus ypsilon* Enghoff, 1992; *D. labradae* Enghoff, 1992 and *D. chioensis* Enghoff, 1992, all from lava tubes (Enghoff 1992; Golovatch & Enghoff 2003). Three species on Gran Canaria: *D. typhlocanaria* Enghoff, 2012; *D. oromii* Enghoff, 2012 and *D. longunguis* Enghoff, 2012 (Enghoff 2012), mainly from the superficial subterranean habitat (mss), but also found in caves and artificial mines (Enghoff 2012). One species on El Hierro, *D. troglohierro* Enghoff, 1992, from caves in the southern part of the island, and one on La Gomera, *Thalassiobates emesesensis* Enghoff, 2013, exclusively from the mss and probably a result of a speciation by adaptative shift from marine littoral to the subterranean habitat (Enghoff 1992, 2013). The blind, introduced *D. typhlops* Ceuca, 1973, is common in the subterranean environment of the Canary Islands of La Palma and El Hierro (Enghoff 1992, 2002). This high subterranean millipede diversity in the Canary Islands, matches with the high biodiversity for other groups of troglobiont arthropods there (Oromí 2008).

Subterranean millipedes are so far unknown in the Azores (Reboleira *et al.* 2011; Borges *et al.* 2012), which can be explained by the probable lack of indigenous epigean species of millipedes in that archipelago (Enghoff 2011).

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