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CASES OF TRUNK SEGMENTAL ANOMALIES IN THE GEOPHILOMORPH CENTIPEDES *CLINOPODES FLAVIDUS* C. L. KOCH AND *CLINOPODES TREBEVICENSIS* (VERHOEFF) (CHILOPODA: GEOPHILOMORPHA)

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Abstract. — We describe and analyze two examples of naturally occurring morphological anomalies in the geophilomorph centipedes. Recorded abnormalities include a supernumerary hemisclerite in an adult female specimen of *Clinopodes flavidus* C. L. Koch, and an even number of leg-bearing segments in a subadult male specimen of *Clinopodes trebevicensis* (Verhoeff). The morphological complexity of these defects makes them hard to explain as the result of healing or regeneration. They are most probably congenital and are interpreted as the effects of perturbation of different morphogenetic processes occurring at different phases of development of the segments in a given trunk region.

Key words: Chilopoda, morphological defects, supernumerary hemisclerite, even number of leg-bearing segments, developmental instability, naturally occurring experiments.

UDC 595

INTRODUCTION

The typical centipede body plan includes six head segments followed by a pair of maxillipedes, a series of trunk leg-bearing segments with one pair of legs per segment, and the terminal segments (Lewis, 1981; Edgecombe and Giribet, 2007). In geophilomorphs, the number of leg-bearing trunk segments (= pairs of walking legs) varies between 27 and 191 (Minelli et al., 2000). Interestingly, this is always an odd number, so the number of trunk segments (including the maxillipede segment) is always even (Minelli and Bortoleto, 1988). Each leg-bearing segment consists of two dorsal tergites, including a short anterior pretergite and a longer posterior metatergite, a ventral sternite accompanied by several less conspicuous intercalary sternites, and a few lateral pleurites (Leśniewska et al., 2009b).

According to the evidence available to date (Brölemann, 1894, 1904, 1920; Léger and Duboscq, 1903; Selbie, 1913; Balazuc and Schubart, 1962; Demange and Pereira, 1980; Minelli and Pasqual, 1986; Pereira and Minelli, 1995; Kettle et al., 2000; Simaiakis et al., 2007; Leśniewska et al., 2009a,b), besides minor trunk anomalies and defects confined to the appendages, the occasional occurrence of specimens with trunk segmental anomalies has been documented in natural populations of nine geophilomorph species: *Himantarium gabrielis* (Linnaeus), *Schendyla vizzavonae* Léger and Duboscq, *Stigmatogaster subterranea* (Shaw), *S. dimidiata* (Meinert), *Geophilus procerus* Koch, *Schendylops pallidus* (Kraus), *S. titicacaensis* (Kraus), *S. attemsi* (Verhoeff), and *Strigamia maritima* (Leach). The most commonly reported types of trunk segmental defects include the so-called "spiral segmenta-

tion" (helicomery) and partially reduced trunk segments.

In this paper, we focus on two cases of naturally occurring trunk segmental anomalies in the geophilomorph centipedes *Clinopodes flavidus* C. L. Koch and *Clinopodes trebevicensis* (Verhoeff). *C. flavidus* is distributed from the Mediterranean region, across central and eastern Europe, to western Asia (Matic, 1972; Zapparoli, 2002; Bonato and Minelli, 2009; Mitić et al., 2010; Minelli and Foddai, 2011), while *C. trebevicensis* occurs in northeastern Italy and the Balkan peninsula (Matic, 1972; Zapparoli, 2002; Minelli and Foddai, 2011).

MATERIAL AND METHODS

The centipede material used in this study includes 353 specimens of *C. flavidus* and 255 specimens of *C. trebevicensis*, collected by hand in leaf litter, under stones or bark of decayed logs and fallen trees, during the period from 2002 to 2011. The collected samples are from eight sites in Serbia, the first of which was near an embankment in Kotež (Belgrade). The other sites were "Jevremovac" Botanical Garden (Belgrade), Košutnjak (Belgrade), Mt. Avala, Mt. Debela Gora (Ovčar Banja), Dubočica (village of Milićе, Mt. Radočelo), Golijska Reka (Mt. Golija), and the village of Sesalac (Soko Banja). Additionally, we checked for morphological anomalies in 159 specimens of *C. flavidus* and 107 specimens of *C. trebevicensis* from the collections of the Natural History Museum of Vienna, Natural History Museum of Denmark, and "Emil Racovita" Institute of Speleology of Romanian Academy.

All these specimens were examined using light microscopy and standard methods for clearing, temporary mounting and dissection of the mouth parts of the geophilomorph centipedes (Foddai et al. 2002). The identification was based on the diagnostic characteristics reported by Matic (1972), Stoev (2002), and Bonato and Minelli (2008). Images were taken with a digital camera mounted on a Carl Zeiss Stemi 2000-C stereomicroscope, after standardizing the position of the specimen and the photographic conditions. Special attention was paid to size, shape and relative position of all sclerites along the trunk. Our analysis focuses on the segmental architecture of the trunk, thus disregarding anomalous features of the appendages, since the scarce information on modes of appendage healing and uncertainty regarding the possibility of appendage regeneration in geophilomorphs do not allow for discrimination between congenital defects and defects resulting from accidents during post-embryonic life (Maruzzo et al., 2005).

RESULTS AND DISCUSSION

Morphological anomalies on the body trunk were found in one adult *C. flavidus* female out of 512 specimens examined (0.002%), and one subadult *C. trebevicensis* male out of 362 specimens examined (0.003%); these records do not include defects recognizable as scars resulting from post-embryonic life accidents (found in a vast number of specimens). Here we present a closer analysis of the two individual abnormalities recorded:

Supernumerary hemisclerite

The unusual structure of the posterior part of the trunk (Fig. 1) of one of the *C. flavidus* specimens was apparent. On the ventral surface, a small triangular hemisclerite appears in the region between S. (= sternite) 69 and S. 70 (Fig. 1a), while on the dorsal surface, it starts up between the pretergite and the metatergite of T. (= tergite) 69 (Fig. 1b). As a consequence of the abnormality, one body side has one walking leg more than the other (72 *vs*. 71). This form of the anomaly is not exactly like any teratological geophilomorph specimen described in the literature (mentioned in the introduction), and we suppose that it is the result of a perturbation of the morphogenetic processes occurring at different phases of the development of the segments in a given trunk region.

Even number of leg-bearing segments

One of the *C. trebevicensis* specimens from Mt. Debela Gora (Ovčar Banja) with a regularly patterned

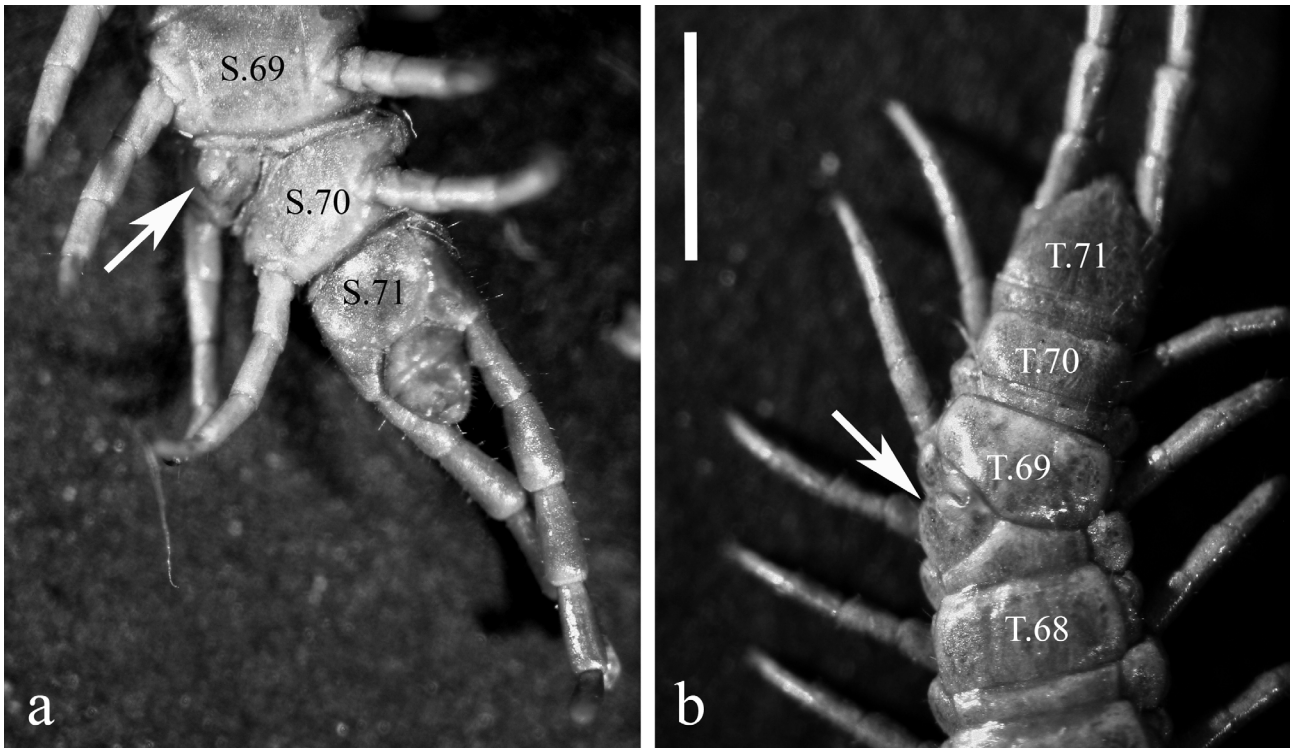

Fig. 1. Supernumerary hemisclerite in an adult female specimen of *C. flavidus* from Kotež (Belgrade) — ventral view (a), and dorsal view (b).

trunk has an anomalous even number (48) of unambiguously recognizable leg-bearing segments. It was not possible to identify the position of the defect responsible for the anomalous segment number. For the whole *C. trebevicensis* sample, the number of leg-bearing segments varied in the range of 49 to 57 for males, and 51 to 59 for females. This case of trunk segmental anomaly could be the result of developmental disturbances at an early embryonic phase of the segmentation process. The perfectly patterned *C. trebevicensis* specimen with an even number of leg-bearing segments is the second ever reliably recorded in epimorphic centipedes; the first one was a specimen of *Stigmatogaster subterranea* from the Citadel Park in Poznań (Leśniewska et al., 2009 a,b).

We could mention here that Kettle et al. (2000) also discovered a male specimen of the coastal geophilomorph *Strigamia maritima* that exhibited a complete transformation of the "intercalary segment" into a repeat of the final trunk segment. This transformation gave the affected individual two pairs of specialized back legs and, in total, an even number of pairs of legs (as in our case). The transformation was reasonably symmetrical, and produced by the homeotic mutation.

The two cases of trunk segmental anomalies analyzed in the present study are almost certainly of developmental origin. The morphological complexity of these defects makes them hard to explain as the result of healing or regeneration. From our observations on *C. flavidus* and *C. trebevicensis*, complemented by the cases of developmental anomalies reported in literature, it is evident that studies of morphological anomalies (i.e. Ćurčić et al., 1983; Ćurčić et al., 1991; Mitić and Makarov, 2007) can provide useful insight into hitherto only vaguely described morphogenetic processes in normal development. These "naturally occurring experiments" are particularly valuable for taxa which, likely geophilomorphs, are not easily amenable to direct experimental manipulation.

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