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Validation of three sympatric *Thoracophelia* species (Annelida: Opheliidae) from Dillon Beach, California using mitochondrial and nuclear DNA sequence data

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Abstract

Thoracophelia (Annelida, Opheliidae) are burrowing deposit feeders generally found in the mid- to upper intertidal areas of sandy beaches. *Thoracophelia mucronata* (Treadwell, 1914) is found along the west coast of North America, including at Dillon Beach, CA. Two additional species, *Thoracophelia dillonensis* (Hartman, 1938) and *T. williamsi* (Hartman, 1938) were also described from this beach. These three sympatric species have been primarily distinguished by branchial morphology, and efforts to determine the validity of the species have been based on morphological, reproductive and ecological studies. Here we demonstrate using mitochondrial and nuclear DNA sequence data that these three species are valid. Mitochondrial Cytochrome c subunit 1 (COI) sequences show uncorrected interspecific distances of ~9–13%. We found no inter-specific differences in body color or in hemoglobin concentration, but found that reproductive males were pinkish-red in color and had lower hemoglobin concentrations than purplish—red reproductive females.

Key words: hemoglobin, COI, ITS1, sympatric, polychaete

Introduction

Thoracophelia is a genus of Opheliidae that was erected by Ehlers (1897) for *Thoracophelia furcifera* Ehlers, 1897 from the Magellan region of southern Chile. *Thoracophelia* was subsequently made a subgenus within *Euzonus* Grube, 1866 by Hartman (1956). This arrangement was either generally accepted, or *Thoracophelia* was not used as a subgenus at all, until it was shown by Brewer *et al.* (2011) that *Euzonus* was a junior homonym of *Euzonus* Menge, 1854, which was erected for a millipede species. Brewer *et al.* (2011) suggested that the 15 currently accepted *Euzonus* species be placed within *Pectinophelia* Hartman, 1938, but Blake (2011), however, reviewed the taxonomic history of these taxa and demonstrated that *Thoracophelia* Ehlers, 1897 was the valid genus and listed 17 known species. *Thoracophelia* species are characterized by having the body divided into three distinct body regions: (1) an anterior cephalic region consisting of the prostomium and first two chaetigers; (2) a swollen thoracic region; and (3) a long narrow posterior region characterized by a ventral groove and branchiae. A transverse groove/lateral notopodial ridge separates the thoracic and posterior region (Santos *et al.* 2004). *Thoracophelia* species have been described from the high latitudes of each hemisphere, including the US, Australia, Brazil, Japan and New Zealand and are generally intertidal sand-dwelling species, though deep-sea taxa have been described (Blake 2011; Santos *et al.* 2004).

Three species of *Thoracophelia* are accepted as valid from the west coast of North America (Blake 2011). *Thoracophelia mucronata* (Treadwell, 1914) was described (as *Ophelina mucronata*) by Treadwell (1914) from ‘in sand’ at La Jolla in southern California, where they can reach very high densities of over 40,000 worms m⁻² (McConnaughey & Fox 1949). *Thoracophelia mucronata* has been recorded as far north as Vancouver Island in Canada (Berkeley & Berkeley 1932; Dafoe *et al.* 2008a, 2008b), with other records from Oregon (e.g., Kemp 1986, 1988). Hartman (1938) described two new species in a new opheliid genus *Pectinophelia* from Dillon Beach in central California. These are now referred to as *Thoracophelia dillonensis* (Hartman, 1938) and *T. williamsi* (Hartman, 1938). Hartman (1944) also recorded *T. mucronata* from the same beach.