INSTITUTIONEN FÖR BIOLOGI OCH MILJÖVETENSKAP

Exploring the species boundaries in terrestrial clitellates (Annelida: Clitellata)

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Akademisk avhandling för filosofie doktorsexamen i Naturvetenskap inriktning Biologi, som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras fredag den 18 november 2016 kl. 10:00 i Föreläsningssalen, Zoologihuset, institutionen för biologi och miljövetenskap, Medicinaregatan 18 A, Göteborg

ISBN: 978-91-628-9987-5, tryckt version
ISBN: 978-91-628-9988-2 elektronisk version
Tillgänglig via http://handle.net/2077/46702

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Abstract

The biological diversity in the soil is much higher than most people can imagine, and a very important group of animals living there are earthworms and other clitellate worms. It has been found that several clitellate morphospecies are in fact complexes of so called cryptic species, and the number of species in this group may be much higher than previously believed. In this thesis, I explore the species boundaries of terrestrial clitellates by combining various data sources and methods as a basis for taxonomical decisions. A widely used approach for studying cryptic species is DNA-barcoding, where a single standardised marker is used for the identification of organisms and discovering new species. For animals, the marker generally used is the mitochondrial COI gene.

In the thesis, I present four different cases, from three different clitellate families: 1) A variety of *Rhyacodrilus falciformis* was shown to be a distinct species, whereas other COI clusters were found to be part of the same species. 2) Extensive cryptic diversity was found in the genus previously known as *Cognettia*, a group that includes *C. sphagnetorum*, a well-studied model in soil biology. This taxon and *C. glandulosus* were both found to be complexes of cryptic species. The generic taxonomy of *Cognettia* was revised and the genus split into its two senior synonyms, *Euenchytraeus* and *Chamaedrilus*, and the species in the *C. sphagnetorum* complex were revised and described. 3) In the earthworm *Aporrectodea longa,* two well separated COI lineages were found to be part of the same species. 4) In the earthworm genus *Lumbricus*, the previously noted split between *L. terrestris* and *L. herculeus* was verified using nuclear data, and in the morphospecies *L. rubellus* seven cryptic species were found. The first evidence of limited hybridisation within the genus was also found, between *L. terrestris* and *L. herculeus*, as well as and between species within *L. rubellus s.lat*.

To conclude, I have shown that the species diversity among terrestrial clitellates is larger than previously known based on morphology, and that species can be robustly delimited using a combination of mitochondrial and nuclear markers, supported with morphology. I have also found that using DNA-barcoding alone will often overestimate the number of clitellate species, and caution is required when using it.

Keywords: Annelida, Clitellata, cryptic species, DNA-barcoding, Enchytraeidae, Lumbricidae, Naididae, Oligochaeta, species delimitation