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Phylogenetic relationships and taxonomic revision of *Paranoplocephala* Lühe, 1910 sensu lato (Cestoda, Cyclophyllidea, Anoplocephalidae)

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Abstract

An extensive phylogenetic analysis and genus-level taxonomic revision of *Paranoplocephala* Lühe, 1910-like cestodes (Cyclophyllidea, Anoplocephalidae) are presented. The phylogenetic analysis is based on DNA sequences of two partial mitochondrial genes, i.e. cytochrome c oxidase subunit 1 (*cox1*) and NADH dehydrogenase subunit 1 (*nad1*), and includes 51 cestode isolates. The revision concerns all 34 *Paranoplocephala*-like species considered valid, of which 21 species could be included in the molecular phylogenetic analysis. Based on the phylogenetic relationships and main morphological features, with emphasis on the structure of the scolex, suckers and neck, length of the vagina (relative to the cirrus sac) and distribution of testes, 12 new genera are proposed for cestodes traditionally assigned to *Paranoplocephala* s. l. This results in 23 new combinations. The new genera are: *Gulyaevia* **n. g.**, *Chionocestus* **n. g.**, *Microticola* **n. g.**, *Beringitaenia* **n. g.**, *Arctocestus* **n. g.**, *Rauschoides* **n. g.**, *Eurotaenia* **n. g.**, *Douthittia* **n. g.**, *Lemminia* **n. g.**, *Tenoraia* **n. g.**, *Rodentocestus* **n. g.** and *Cookiella* **n. g.** In addition, *Paranoplocephala* (s. s.) and *Parandrya* Gulyaev & Chechulin, 1996 are redescribed; the latter genus is considered valid, although it has been earlier synonymized with *Paranoplocephala*. A new species (*Beringitaenia nanushukensis* **n. sp.**) from *Microtus miurus* is described. Based on the DNA sequence data, several additional lineages probably representing independent species are identified, but not described as new taxa because of lack of good-quality specimens or absence of reliable morphological differences. The study also presents the first evidence for the phylogenetic position of the monotypic genus *Gallegoides* Tenora & Mas-Coma, 1978 based on DNA sequence data. A key for the *Paranoplocephala*-like genera is presented. The patterns of diversity and zoogeography of cestodes representing the "arvicoline clade" (72 species) are complex, involving mechanisms of dispersal, geographic colonization and host switching linking faunas across Eurasia and North America.

Key words: *Gulyaevia* **n. g.**, *Chionocestus* **n. g.**, *Microticola* **n. g.**, *Beringitaenia nanushukensis* **n. g.**, **n. sp.**, *Arctocestus* **n. g.**, *Rauschoides* **n. g.**, *Eurotaenia* **n. g.**, *Douthittia* **n. g.**, *Lemminia* **n. g.**, *Tenoraia* **n. g.**, *Rodentocestus* **n. g.,** *Cookiella* **n. g.,** *Parandrya*, *Gallegoides,* cytochrome c oxidase subunit 1 (*cox1*), NADH dehydrogenase subunit 1 (*nad1*), rodents, Arvicolinae

Introduction

In terms of species diversity, the anoplocephalid cestodes, particularly the genus *Paranoplocephala* Lühe, 1910 s. l., comprise the dominant helminth group of rodents at higher latitudes in the northern hemisphere. Phylogenetic analyses (Wickström *et al.* 2005, Haukisalmi *et al.* 2008, 2009a) based on nuclear (28S rDNA, ITS1) and mitochondrial (*cox1*) sequences show that *Paranoplocephala* spp. belong to the diverse "arvicoline clade" of cestodes along with *Anoplocephaloides* Baer, 1923 s. s., *Microcephaloides* Haukisalmi, Hardman, Hardman, Rausch & Henttonen, 2008 and *Diandrya composita* Darrah, 1930, most of them from arvicoline rodents (voles and lemmings). *Paranoplocephala* s. s. [i.e. *Paranoplocephala omphalodes* (Hermann, 1783) and related species] forms an exclusive monophyletic group, but otherwise the phylogenetic structure within *Paranoplocephala* s. l.

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