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Amphilinidea

Amphilinidea Poche, 1922 (Order)

Klaus Rohde

Phylum Platyhelminthes

Class Cestoda

Subclass Cestodaria

Order Amphilinidea

doi:10.32873/unl.dc.ciap031
2024. *In* S. L. Gardner and S. A. Gardner, eds. Concepts in Animal Parasitology. Zea Books, Lincoln, Nebraska, United States.

Chapter 31

Amphilinidea Poche, 1922 (Order)

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Introduction

The cestodes (tapeworms) are a large group of endoparasitic worms infecting various vertebrates. Most species are included in the Eucestoda (true tapeworms), characterized (with few exceptions) by a number of segments (proglottids). Examples are *Taenia* (the pig and cattle tapeworms, of which the adults live in humans) and *Diphyllobothrium* (the broad fish tapeworm) infecting humans. Two groups of cestodes, the Gyrocotylidea and Amphilinidea, do not possess proglottids. The Amphilinidea are discussed here. Only 8 species included in 3 genera are known. They have little economic significance, although 1 species was shown to adversely affect sturgeon, the producers of caviar. Amphilinids are of considerable interest to biologists because they may cast light on the phylogeny of tapeworms and of related forms.

They are large (several cm-long), dorsoventrally flattened worms infecting the body cavity of freshwater and marine teleost (bony) fishes and freshwater turtles. Larvae are **ciliated** and possess 10 posterior **hooks**, which are retained in the adult. A well-known species is *Austramphilina* (= *Gigantolina*) *elongata* from Australia, with freshwater crustaceans as intermediate hosts and freshwater turtles as final (definitive) hosts.

A considerable number of studies deal with its morphology, electron microscopy, and life cycle (Rohde and Georgi, 1983; Rohde and Garlick, 1985a; 1985b; 1985c; 1985d; Rohde, 1986; 1987; 1994; Rohde et al., 1986; Rohde and Watson, 1986; 1987; 1988; 1989; 1990a; 1990b). Brief overviews of the Amphilinidea are by Rohde (2005) and Read (2007). The Tree of Life webpage by Rohde (1998) (available at http://tolweb.org/Amphilinidea) contains an account of all aspects of Amphilinidea and an extensive bibliography. Older references can be found in Dubinina (1982). Important papers on some aspects of *Amphilina foliacea* are by Bisserova et al. (2000) and Dudicheva and Bisserova (2000). *Austramphilina elongata* is also discussed in greater detail.

Structure of the Adult *Austramphilina elongata*

The adult worm reaches a length of about 150 or more mm, with a width of about 14 or more mm (Figure 1). As in all amphilinids, the **uterus** forms 3 loops in the body; it extends from the posteriorly located **ovary** to the anterior end, turns back and forward again, opening through a **uterine pore** at the anterior end. The **vagina** opens at the posterior

Figure 1. *Austramphilina elongata*. Several worms in the body cavity of the freshwater turtle *Chelodina longicollis*. Source: K. Rohde. License: CC BY-NC-SA 4.0.

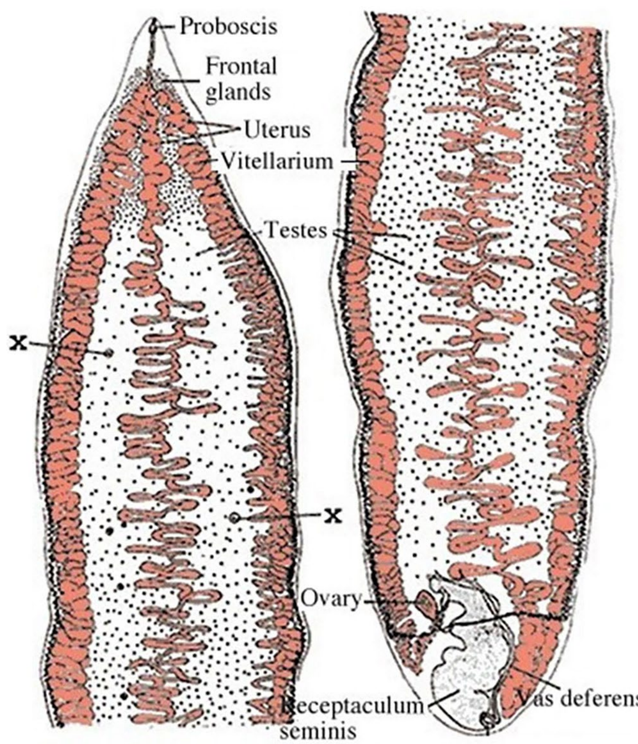

Figure 2. *Austramphilina elongata*, whole mount. X = bodies of unknown function. Source: K. Rohde. License: CC BY-NC-SA 4.0.

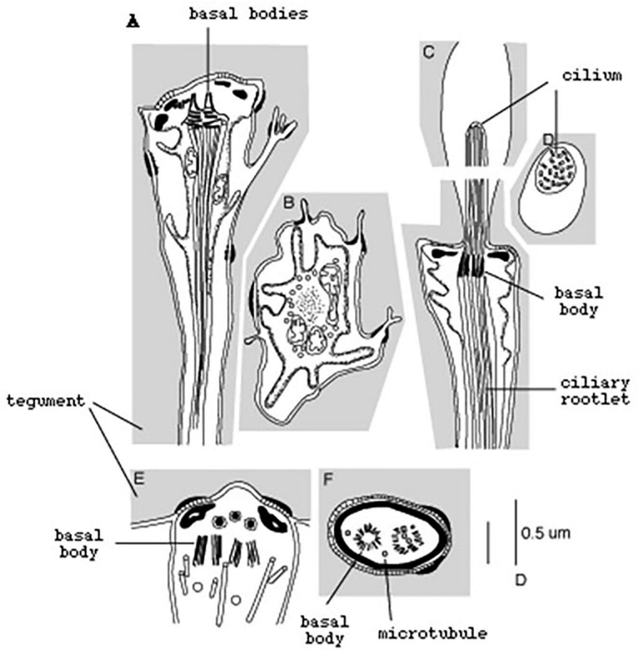

Figure 3. *Austramphilina elongata*, receptors of adult. Source: Adapted from Rohde and Watson, 1990b. License: CC BY-NC-SA 4.0.

end. **Vitellaria** extend in the lateral parts of the body from the anterior to the posterior ends of the body. **Testes** are scattered throughout the body and the male **gonopore** is located near the female one at the posterior end (Figure 2). Electron microscope studies have shown several types of **sensory receptors** (Figure 3).

Structure of Larval *Austramphilina elongata*

The larvae are **ciliated** and possess 10 posterior **hooks** of 3 different kinds. Two pairs are serrate, the others are sickle-shaped (Figures 4 and 5). Ducts of clusters of **gland cells** open near the anterior end. The **protonephridial** (excretory/osmoregulatory) system consists of 3 **flame cells** or **bulbs** on each side of the body, with paired **excretory pores** located near the posterior end (Figure 4). A large number of transverse **muscle bands** extend below the **tegument** (surface layer) of the larva. There are several clusters of **sensilla** (**sensory receptors**) (Figures 5 and 6).

The larvae possess a ciliated **epidermis** located on an underlying tegument which becomes the surface layer (**neodermis**) once the epidermis is shed by the invading larva (Figure 7).

The larva possesses a considerable number of sensory receptor types differing with respect to the presence or absence of cilia, the number and shape of the cilia, and the shape of the basal bodies/ciliary **rootles** (Figure 8).

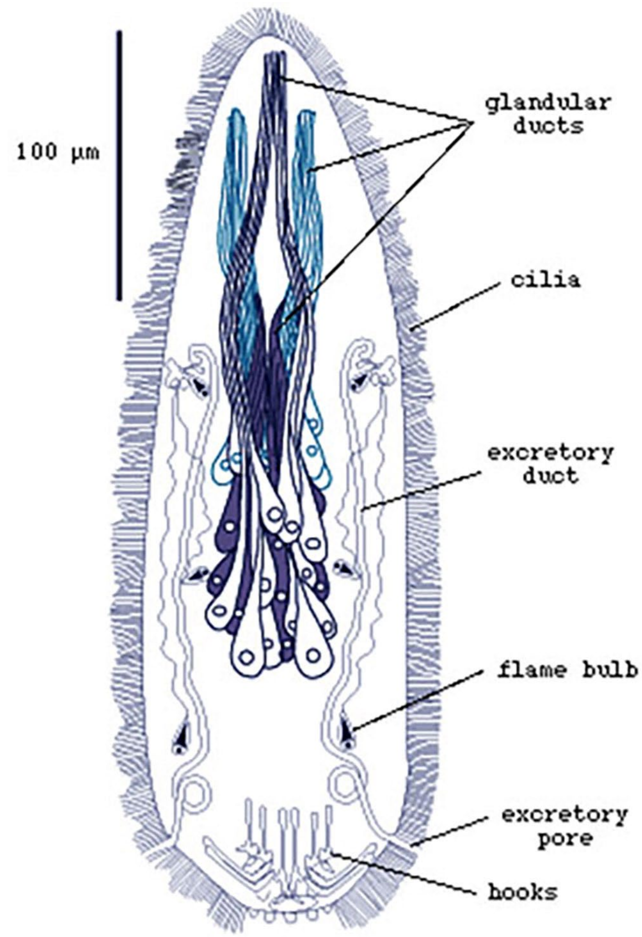

Figure 4. *Austramphilina elongata* larva. Note the bundles of secretory glands opening near the anterior end, the protonephridial system with 3 flame bulbs on each side opening near the posterior end, and the 10 posterior hooks. Source: Adapted from K. Rohde, 1986. License: CC BY-NC-SA 4.0.

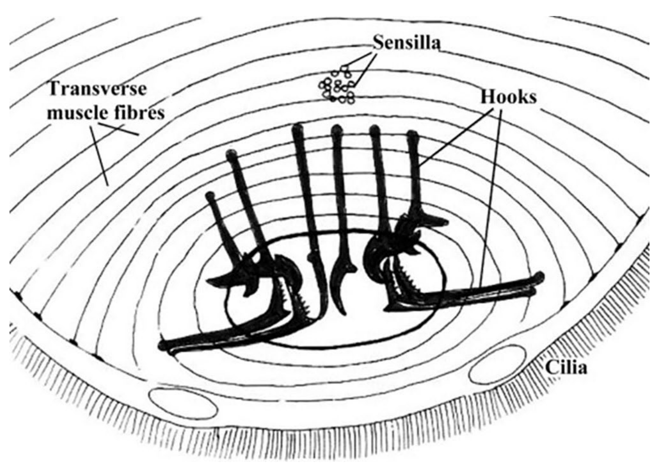

Figure 5. Posterior end of a larval *Austramphilina elongata*. Note the cluster of sensilla, transverse muscle bands, ciliated epidermis, and 5 pairs of hooks of 3 types. Source: K. Rohde. License: CC BY-NC-SA 4.0.

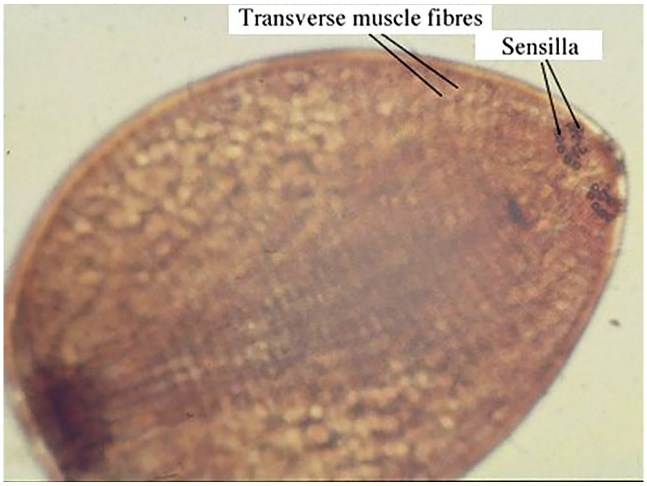

Figure 6. Larva of *Austramphilina elongata* impregnated with silver. Note the transverse muscle bands and receptors (sensilla). Source: K. Rohde. License: CC BY-NC-SA 4.0.

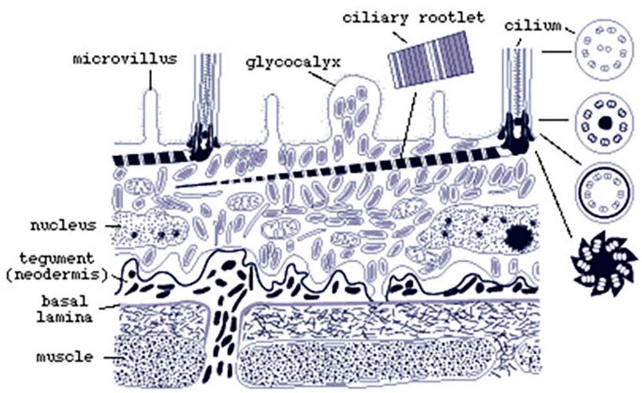

Figure 7. Larval *Austramphilina elongata*, diagram of electron-microscopic structure of surface layers. Note larval syncytial and ciliated epidermis at the surface, based on the tegument (neodermis) that has insunk (below the surface) nuclei (only the process leading to 1 nucleus is illustrated). Source: K. Rohde. License: CC BY-NC-SA 4.0.

Life Cycle of *Austramphilina elongata*

The eggs of *Austramphilina elongata* have to get into freshwater for further development (Figure 9). The escape route from the host is unknown. Larvae hatch in freshwater. They swim around in water until they get into contact with a crayfish (phylum Arthropoda: class Crustacea: order Decapoda). On the crayfish, the larva bends in such a way that both the anterior and posterior ends are located close together on the cuticle of the host. The sickle-shaped hooks pierce into the cuticle, the serrate ones perform sawing movements, cutting through the cuticle. The 3 types of anterior

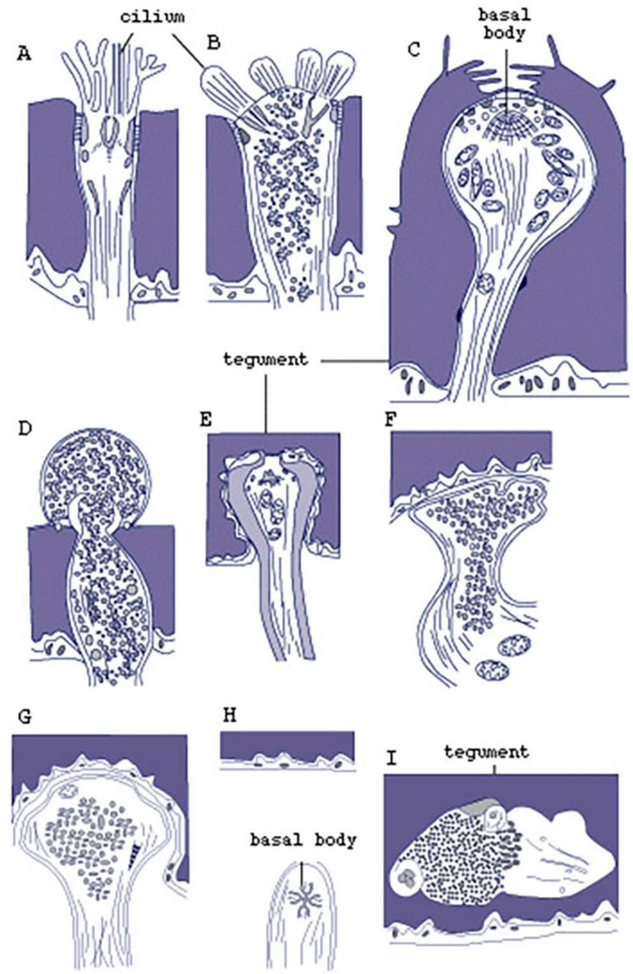

Figure 8. *Austramphilina elongata,* diagrams of larval receptors as seen under the transmission electron microscope. Source: Adapted from Rohde et al., 1986a. License: CC BY-NC-SA 4.0.

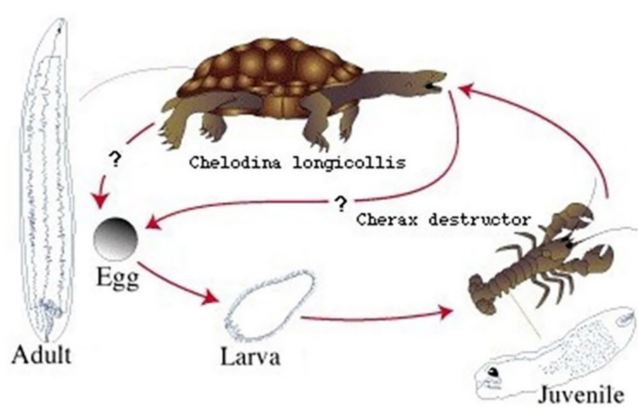

Figure 9. Life cycle of *Austramphilina elongata*. Note: Escape route of egg from turtle is unknown. Source: K. Rohde. License: CC BY-NC-SA 4.0.

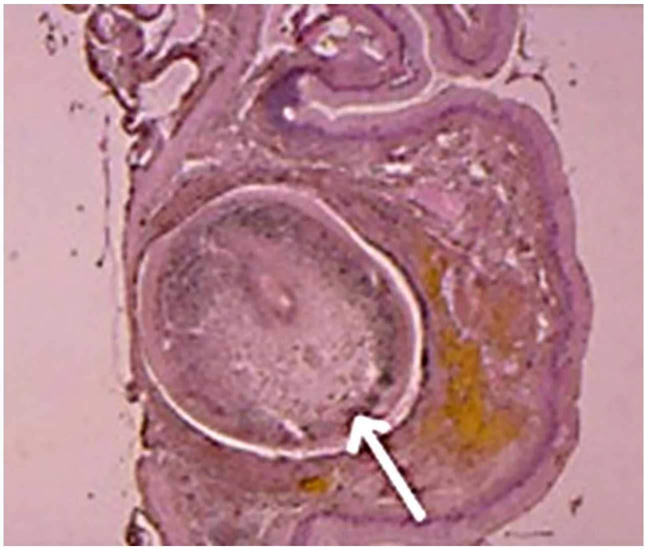

Figure 10. Section though the esophageal wall of a turtle, *Chelodina longicollis,* showing a penetrating *Austramphilina* juvenile (arrow). Source: K. Rohde. License: CC BY-NC-SA 4.0.

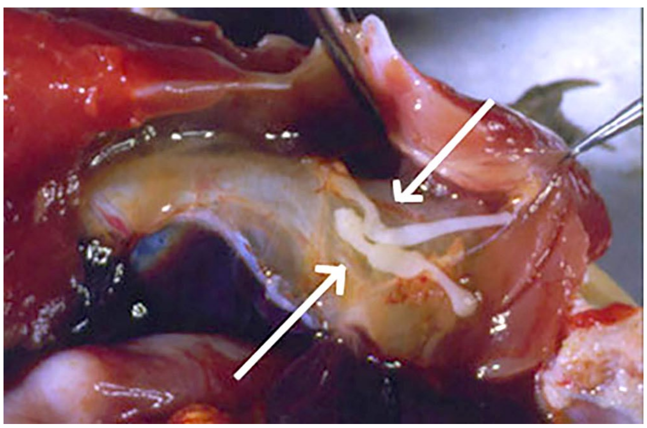

Figure 11. Two juvenile *Austramphilina* specimens (arrows) migrating along the trachea towards the body cavity of a turtle. Source: K. Rohde. License: CC BY-NC-SA 4.0.

glands apparently produce a secretion (which, however, has not been identified) dissolving the surface layer. The larva penetrates into the host's tissue, shedding the ciliated epidermis in the process. Penetration is observed to occur through the gills, and through the thin junctions between the crayfish's segments within 30 minutes after first contact. Larvae infective to turtles are several mm long and may be observed in the abdomen of crayfish. Turtles become infected by eating crayfish. Juvenile worms penetrate through the wall of the esophagus (Figure 10), migrate along the trachea (Figure 11), and through the septum into the body cavity where they mature. Adult worms are seen mainly in the body cavity, but occasionally also in the lungs. This suggests that eggs may

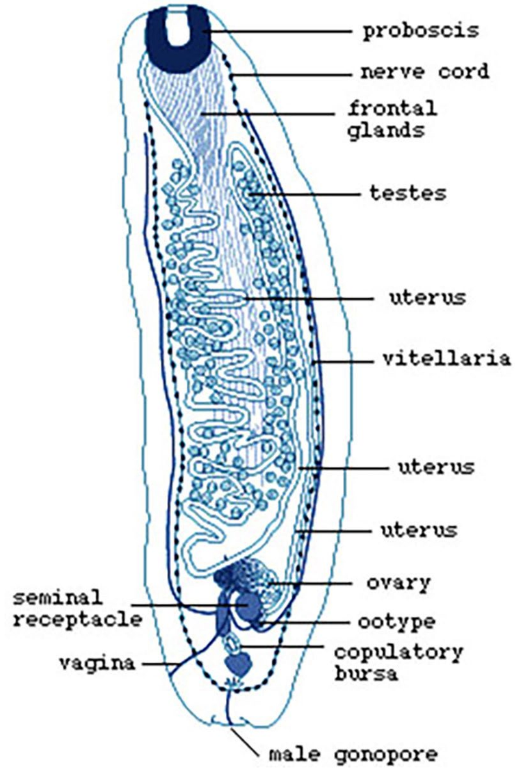

Figure 12. *Amphilina foliacea,* adult. Source: Adapted from Dubinina, 1982. License: CC BY-NC-SA 4.0.

leave the host via the trachea and mouth cavity from where they are spit out into water. Once, an adult was also seen in the urinary bladder, and once in the oviduct of a turtle, suggesting that eggs may be shed through the cloaca. Freshwater shrimps could also be infected experimentally, but larvae did not reach a size infective to turtles in them.

Other Species

Only 1 other species has been studied in detail, namely, *Amphilina foliacea*. It differs from *Austramphilina* in a number of morphological features (Figure 12). Its protonephridial system forms a network of canals, differing from that of other species, for example, *Gephyrolina paragonopora* (Figure 13).

Amphilina foliacea uses freshwater amphipods (class Crustacea: order Amphipoda) as intermediate hosts and *Accipenser* (sturgeon) as final hosts. It inhabits the body cavity of the final host and eggs escape through the coelomic pore which connects the body cavity to the outside (it is not present in turtles!). Eggs containing infective larvae are ingested by the amphipods, whose mouthparts break the eggshell allowing the larva to escape and penetrate into the host.

Adult *Nesolecithus africanus* infect African freshwater fish. Juveniles have been recovered from freshwater prawns (class Crustacea: order Decapoda).

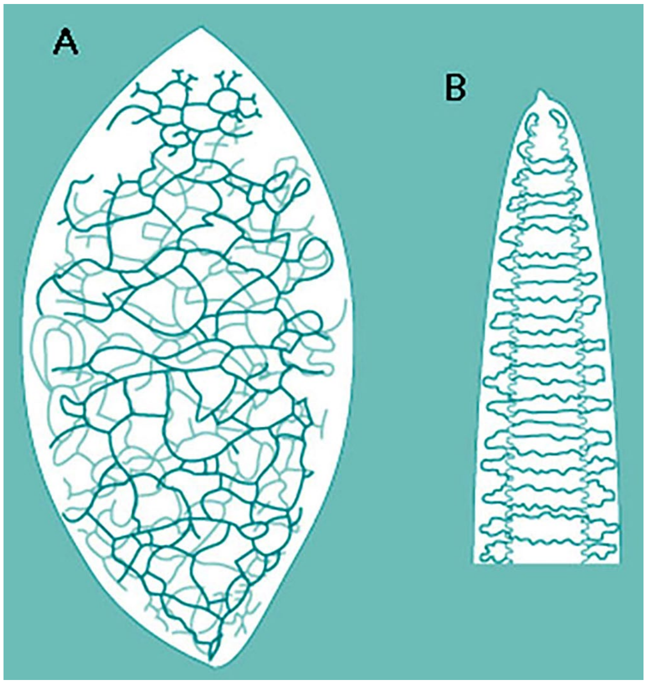

Figure 13. Protonephridial canal system of *Amphilina foliacea* (A) and of *Gephyrolina paragonopora* (B). Adapted from Dubinina, 1982. License: CC BY-NC-SA 4.0.

Taxonomy and Phylogeny

Gibson (1994) has provided a key to the species (see also Schmidt, 1986) and Dubinina (1982), in a detailed monograph of the Amphilinidea, has discussed the position of the group in the phylum Platyhelminthes (see also Galkin, 1999). Eight species have been described:

1) *Amphilina foliacea*
   synonyms *Monostomum foliaceum*, *A. neritina*
2) *Am. japonica*
   synonyms *Am. bipunctata*, *A. foliacea*
3) *Gephyrolina paragonopora*
   synonyms *Am. paragonopora*, *Hunteroides mystel*, *Schizochoerus paragonopora*
4) *Schizochoerus liguloideus*
   synonyms *M. liguloideum*, *Am. liguloidea*
5) *Nesolecithus janickii*
   synonyms *Am. liguloidea*, *M. liguloideum*, *S. janickii*
6) *N. africanus*
   synonym *S. africanus*
7) *Austramphilina elongata*
   synonyms *Kosterina Kuiperi*, *Gigantolina elongata*
8) *Gigantolina magna*
   synonyms *Am. magna*, *Gyrometra albotaenia*, *Gy. kunduchi*

The Gyrocotylidea have often been considered to be the sister group of the amphilinids, both comprising the Cestodaria (non-segmented tapeworms) (Bandoni and Brooks, 1987). However, later studies do not support a monophyletic group, Cestodaria. Instead, gyrocotylids appear to be the earliest divergent lineage within the cestodes followed by the amphilinids and then the eucestodes (true cestodes) (Waeschenbach et al., 2012; Littlewood et al., 2015; Waeschenbach and Littlewood, 2017). The Cestoda must be considered to be the sister group of the Trematoda (see, for example, Park et al., 2007) and all the large groups of parasitic flatworms Polyopisthocotylea and Monopisthocotylea (= "Monogenea"), Trematoda, and Cestoda (including the Eucestoda, Amphilinidea, and Gyrocotylidea) are monophyletic comprising the Neodermata, as first proposed by Ehlers (1985) and later confirmed by numerous electron microscope and DNA studies (for example, Egger et al., 2015). Various hypotheses of these relationships are currently being tested using deep sequencing of DNA at the genome level.

Acknowledgement

Based on the author Rohde's online articles available at https://krohde.wordpress.com/2009/08/03/the-amphilinidea-a-small-group-of-xk923bc3gp4-21/ and https://krohde.wordpress.com/2009/08/03/die-amphilinidea-eine-kleine-gruppe-xk923bc3gp4-22/

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