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Introductory Chapter: Helminthes Diversity - Focus on Nematodes

Omolade Olayinka Okwa

1. Introduction

Parasitic helminthes are worms of great medical and veterinary importance. They include the Nematodes (Roundworms) and the Platyhelminthes (Flatworms) which consist of the Trematodes (Flukes) and Cestodes (Tapeworms). These invertebrates are agents of debilitating, deforming and fatal diseases of humans and their agricultural animals and so responsible for great morbidity and mortality. Domestic and wild animals affected by a barrage of helminthes infections may also transmit these infections to humans by zoonoses [1, 2].

Helminthes infections may be vectored, food or water borne. Infections due to parasitic helminthes are no doubt widespread in tropical as well as temperate regions with both regions having their own share of peculiar and distinctive infections. In fact, in Tropical Africa, helminthiasis is regarded as part of the “Neglected tropical diseases” [1].

The platyhelminthes (flatworms) are acoelomates that possess the beginning of some advanced features of the animal kingdom such as cephalization, bilateral symmetry and triploblastic body organization. The trematodes or flukes are endoparasitic platyhelminthes with complex life cycles. The Digeneans are a peculiar group of trematodes in having mollusca (snails) as their intermediate hosts in a life cycle involving one or two hosts; for example: *Schistosoma haematobium* and *Schistosoma mansoni* (blood flukes of man), *Fasciola hepatica* and *Fasciola gigantica* (sheep and cattle liver flukes) and *Paragonimus westermani* (human lung fluke).

Cestodes differ in a number of ways from other flatworms. Their bodies are elongated, ribbon-like and flattened, made up of many segments called proglottids. Most cestodes require at least two hosts of which vertebrates are usually the intermediate host [2]. All these features are adaptations to their exclusively parasitic mode of existence; for example, *Taenia solium* and *Taenia saginata* (pork and beef tapeworms of man), *Echinococcus granulosus* and *Echinococcus multilocularis* (dog tapeworms) and *Diphyllobothrium latum* (broad fish tapeworm of man).

2. Nematodes (the roundworms)

2.1 The ubiquity of nematodes

Nematodes are cosmopolitan and ubiquitous. They are one of the most numerous metazoans in the animal kingdom with broad ranges of environment having successfully adapted to every ecosystem both aquatic and terrestrial. They are a large group of bilaterally symmetrical, elongated, pseudocoelomate helminthes in the animal kingdom. They are elongated, non-metamerically segmented, and cylindrical or round so referred to as the round worms. *Nema* from the word Nematode

means thread because they are threadlike, vermiform and slender worms [1]. They are the largest and the most successful pseudocoelomate phylum and very remarkable organisms. It has been estimated that the total number of nematode species might be approximately 1,000,000 in about 20 orders within two classes [3]. It is believed that 90% of animals on the ocean floor and 80% of animals on earth may be nematodes. It is believed that a handful of soil contains hundreds of nematodes and that soil habitats may contain undescribed free-living nematodes [4].

2.2 Parasitic nematodes

Most nematodes are free-living but over 16,000 are parasitic and cause infections leading to great morbidity and mortality to humans, animals and plants [2].

For example, some nematodes are directly transmitted through the soil which harbors their eggs and larvae stages and hence called the soil transmitted helminthes. Such nematodes are *Ascaris lumbricoides* (common roundworm of man), *Trichuris trichiura* (whipworm), *Necator americanus* and *Ancylostoma duodenalis* (hookworms of man) and *Strongyloides stercoralis* (thread worm of man) [5, 6].

Some nematodes are indirectly transmitted as they require vectors usually arthropods for them to be transmitted from one host to another as in the filarial worms such as *Loa loa* (African eye worm), *Onchocerca volvulus*, *Wuchereria bancrofti* and *Brugia* species.

Some nematodes are parasitic in animals, for example, *Ascaris suum* (pig), *Ascaridia galli* (chicken), *Toxocara canis*, *Trichuris vulpis* and *Strongyloides canis* (dogs), *Ancylostoma tubaeforme* and *A. brasilense* (cat hookworms) [7].

2.3 Types of parasitic nematodes

Nematode parasites can reside in every tissue in their vertebrate host. Therefore, they can be categorized according to their residence in their host [8, 9]:

- **Intestinal nematodes:** they are usually large nematodes transmitted directly to the host and dwelling in the gastrointestinal tract, e.g., *Ascaris lumbricoides*, *Trichuris trichiura*, *Hookworms*, *Strongyloides stercoralis*, and *Enterobius vermicularis*. Polyparasitism of enteric nematodes has been documented [1].
- **Soil-transmitted nematodes** (geohelminths): these are nematodes whose eggs embryonate in the soil and larvae stages also undergo ecdysis in the soil and are transmitted directly to the host, e.g., *Ascaris lumbricoides*, *Trichuris trichiura*, *Necator americanus* and *Ancylostoma duodenale* (hookworms).
- **Filarial nematodes:** these are thread like nematodes that have a pre-larval stage call microfilaria and are transmitted indirectly via an insect vector to the host which are usually mammals, e.g., *Onchocerca volvulus*, *Loa loa*, *Wuchereria bancrofti*, *Brugia malayi*, *Brugia timori* and *Dipetalonema streptocerca*.
- **Tissue dwelling nematodes:** these are nematodes living in the tissues of the host such as in the lymphatics, e.g., *Wuchereria bancrofti*, *Brugia malayi* and *Dracunculus medinensis* (serous tissue).
- **Subcutaneous nematodes:** these consist of nematode dwelling in the subcutaneous tissue of their host, e.g., *Onchocerca volvulus*, *Loa loa*, *Mansonella perstans*.

3. General transmission and reproduction patterns of nematodes

Nematodes have diverse modes of transmission strategies and great variation in life cycles which are complex. Nematodes are gonochoristic with distinct separate sexes. They have larger females than males, which possess copulatory spicules for internal fertilization. They have tubular gonads and amoeboid sperm cells. Only very few nematodes are monoecious [5, 6].

Some nematodes are parthenogenetic such as threadworms. Most are oviparous such as *Ascaris lumbricoides* (common roundworm), *Trichuris trichiura* (whipworm) and *Enterobius vermicularis* (pinworm). Ovoviviparous nematodes include threadworms and hookworms because they lay eggs with larvae. Viviparous nematodes are *Trichinella spiralis*, filarial worms and *Dracunculus medinensis* (Guinea worm) because they give rise directly to larvae [5–7].

Nematodes are long lived worms with highly resistant eggs and great fecundity (large egg outputs) which is adaptive to juvenile survival. Their eggs exhibit remarkable uniformity in size ranging from 50 to 90 μm long. However, the egg shells are highly variable but basically have three to five layers and are highly resistant to environmental conditions. Nematodes have life cycles with larval stages that resemble the adults. The larval stages have four molts and one adult basically (egg-L₁-L₂-L₃-adult) [1, 2].

3.1 Adaptations of parasitic nematodes

These are features that make their parasitic existence a success and they include the:

- **Body wall and pseudocoel:** this protects the worm in the host environment which is the small intestine. The epidermis is a syncytium consisting of a single layer of cells, covered by a thick collagenous cuticle. The complex and metabolically active cuticle often have two or three distinct layers. Underneath the epidermis, lies a layer of longitudinal muscle cells. The pseudocoel acts as hydrostatic skeleton [6, 7].
- **Digestive system:** the digestive systems are highly efficient for parasitic mode of life. The oral cavity opens into a muscular sucking pharynx, also lined with cuticle. They have complete digestive system, referring to the alimentary canal which extends from the anterior mouth to the anus located near the tail. The mouth has lips in some cases.
- **Reproductive system:** this is adaptive to the survival of the parasites. Sexes in nematodes are separate and they have complex life cycles. They have prodigious fecundity and eggs are often highly resistant to desiccation. The eggs are protected by an outer shell, secreted by the uterus. The larval stages resemble the adults and undergo 4 molts (first to third stage larvae). The third stage larva is usually infective and can respond to a wide range of stimuli before it molts to adult in the host [1, 2].

4. Conclusion

Helminthiasis, no doubt consists of a group of diseases of important public health and socio-economic significance so it is a paradox to be described as “Neglected tropical diseases.” The cosmopolitan, ubiquitous and adaptive nature of nematodes and other helminthes are far more than we often think. This gives reasons to suggest that helminthiasis should not be underestimated as a serious cause of morbidity and mortality.

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Author details

Omolade Olayinka Okwa
Department of Zoology, Lagos State University, Lagos, Nigeria

*Address all correspondence to: okwaomolade@hotmail.com

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