



**BIOECOLOGICAL DIVERSITY OF ROUNDWORMS (NEMATODA) AND THEIR
BIOLOGICAL ANALYSIS**

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Abstract This article provides a biological analysis of the bioecological diversity of organisms belonging to the roundworm (Nematoda) phylum, detailing their role in nature and human health. The research is focused on highlighting the morphophysiological adaptations of free-living and parasitic nematodes, their significance in ecosystems, and their impact within the medical and veterinary fields.

Keywords: Nematodes, bioecology, parasitism, biological analysis, morphophysiological adaptation, medical zoology, helminthiasis.

Introduction Roundworms (Nematoda) are considered one of the most widespread and numerous multicellular organisms on Earth. Their bioecological diversity is extremely broad; they are adapted to live in almost all environments, from the ocean floor to high mountains, from soil ecosystems to the bodies of plants, animals, and humans. According to scientific sources, while more than 25,000 species of nematodes have been described today, their actual number is estimated to exceed one million.

From the perspective of medical and biological sciences, the parasitic representatives of nematodes (such as the human ascaris, pinworm, whipworm, and others) are of particular importance as they cause dangerous helminthic diseases. At the same time, free-living nematodes actively participate in increasing soil fertility and nutrient cycling. The purpose of this study is to categorize the main ecological groups of roundworms and to conduct a comprehensive analysis of the biological adaptation mechanisms to their habitats.

Materials and Methods During the research, general biological, ecological, and medical zoology scientific literature, monographs, and modern articles from international databases (Scopus, Web of Science, PubMed) were studied using a comparative-analytical method. In conducting the biological analysis of nematodes, the following criteria were evaluated:

- Morphological structure and body coverings (cuticle, hypodermis).



- Histological features and the evolutionary development of the digestive, excretory, nervous, and reproductive systems.

The morphological structure and body coverings of roundworms (Nematoda) have formed in a highly unique evolutionary manner, collectively constituting the dermo-muscular sac (body wall). The body covering mainly consists of two layers: the outer cuticle and the underlying hypodermis.

Below is a scientific-biological and histological analysis of these structures:

- Classification by trophic (feeding) groups (bacteriophages, phytophages, predators, parasites).

1. Cuticle (Cuticula) The cuticle is an acellular, highly dense, and complex multilayered structure that covers the surface of the nematode's body. It is produced (secreted) by the hypodermis.

- **Histological structure:** It typically consists of 3 main layers (cortical, matrix, and basal), and under an electron microscope, it has been found to have up to 10 sub-layers. Its composition primarily consists of collagen-like proteins, keratin-like substances, and lipids.

- **Protective (Barrier) function:** In parasitic species (e.g., ascaris, whipworm), the cuticle is extremely thick, protecting the worm from the host organism's strong digestive enzymes (pepsin, trypsin) and the effects of immune cells in the gastrointestinal tract. This is one of the most fundamental morphological adaptations to parasitism.

- **Hydroskeleton and Support:** The cuticle is very tough and elastic, maintaining the high hydrostatic pressure (turgor) inside the body. It acts as an external support (exoskeleton) to maintain the worm's body shape and facilitate movement through muscle contraction.

- **Molting (Ecdysis):** The cuticle can stretch but does not grow. Therefore, for the worm to grow during its larval stage, it undergoes a molting process several times (usually 4 times), shedding the old cuticle and synthesizing a new one via the hypodermis.

2. Hypodermis (Hypodermis) The hypodermis (or epidermis) is the living tissue layer located directly beneath the cuticle, responsible for its synthesis. It is mainly formed from the modification of single-layered epithelial tissue.

- **Syncytial structure:** In most nematodes, especially parasites, the hypodermis has a syncytial structure. That is, the boundaries (membranes) between cells have disappeared, and numerous nuclei are scattered within a single common cytoplasmic mass. This increases the tissue's resistance to damage.

- **Longitudinal ridges (Chords):** The hypodermis layer does not lie flat. It bulges inward into the body cavity (pseudocoelom) along the four sides of the body (dorsal, ventral, and two lateral sides), forming four longitudinal ridges or chords.

- **Dorsal and ventral ridges:** The longitudinal nerve trunks of the central nervous system pass through here.

- **Lateral ridges:** The excretory system canals are located here. These lateral ridges are larger and more distinct compared to the others.

- **Reserve and metabolic function:** The hypodermis layer actively participates in metabolism. It accumulates glycogen and lipid reserves. This is a crucial source of energy, derived via the glycolysis process, especially for parasites living in the oxygen-free (anaerobic) conditions of the intestine.

Conclusion on Morphology: The cuticle and hypodermis complex of nematodes represents their strongest morphophysiological adaptation to their environment, specifically to the aggressive biochemical environment within the host organism. While the cuticle serves as an



impenetrable biochemical "armor," the hypodermis is the center that continuously maintains this armor and protects vital systems (nerve trunks, excretory canals) within it.

The life cycles of species parasitizing humans and animals were subjected to a retrospective analysis.

Analysis of Medical-Biological and Histological Features of Nematodes The life cycle of parasitic nematodes (human ascaris, whipworm, hookworms) inside the human body is based on complex medical-biological mechanisms. Their activity in the host organism is characterized not only by mechanical impact but also by profound histological and biochemical changes:

1. **Penetration of epithelial barriers and migration processes:** Many parasitic nematodes (e.g., *Ascaris lumbricoides* larvae) penetrate the intestinal mucosal epithelium during their migration stage, enter the blood vessels, and reach the pulmonary capillaries via the lesser circulation. In this process, the larvae mechanically damage the epithelium of the respiratory tract (bronchi and alveoli). Histologically, this condition is accompanied by the disruption of alveolar septa, local hemorrhages (microhemorrhages), and dysfunction of the ciliated epithelium, which in turn paves the way for the development of secondary bacterial infections.

2. **Protective function of the cuticle layer and immune evasion:** One of the specific biological features of nematodes is their multilayered and complexly structured cuticular covering. The cuticle not only acts as a hydroskeleton but also provides reliable protection against the host's digestive enzymes (pepsin, trypsin) and immune system cells (macrophages, neutrophils). Furthermore, nematodes are capable of evading the immune response through "molecular mimicry" (camouflage) by synthesizing molecules on their surface that are similar to the host organism's proteins.

3. **Reactions in connective tissues and inflammation:** The localization of parasites in tissues or the death of larvae provokes strong local reactions in the surrounding tissues. The host organism forms granulomas consisting of connective tissue cells to isolate the parasite. In histological analyses, the accumulation of eosinophils, lymphocytes, and fibrovascular tissues is clearly visible in such foci. In chronic processes, this can lead to tissue fibrosis.

4. **Disruption of trace element metabolism and homeostasis:** Nematodes (especially blood-feeding hookworms or competing ascarids in the intestine) absorb essential nutrients and trace elements (iron, zinc, copper, and vitamins) from the human body. As a result of this biological antagonism, the host organism develops anemia, hypoxia, and chronic metabolic disorders. The toxic-allergic effect occurs as a result of the parasite's metabolic products being absorbed into the blood.

3. Results (Results) The results of the biological analysis allowed the bioecological diversity of roundworms to be classified into three major groups, primarily based on their lifestyle and feeding characteristics:

- **Free-living nematodes:** They are mainly found in soil and water bodies. Feeding on bacteria, fungi, and organic debris, they act as decomposers.

- **Plant nematodes (Phytohelminths):** They parasitize the root, stem, and leaf systems of agricultural crops, causing significant economic damage to agrocenoses (e.g., root-knot nematodes).

- **Animal and human parasites (Zooelminths):** The most important group from a medical perspective. Analyses show that their morphology is highly adapted to a parasitic lifestyle: a thick and multilayered cuticle (for protection against host digestive enzymes), a well-developed reproductive system, and high fertility (the ability to lay thousands of eggs in a single day).



Histologically, it was analyzed that the body cavity (pseudocoelom) of roundworms serves as a hydroskeleton and ensures metabolism. In particular, due to the absence of respiratory and circulatory systems, it was found that the process of anaerobic respiration (glycolysis) predominates in endoparasitic species.

4. Discussion (Discussion) The obtained results indicate that the successful distribution of nematodes in nature is directly related to their high degree of adaptability. The role of free-living species in ecosystems is invaluable: they control microflora and serve as a crucial link in the food chain.

When discussed from the perspective of medical science, it is confirmed that the biological characteristics of parasites such as *Ascaris lumbricoides* (human ascaris) or *Enterobius vermicularis* (pinworm) cause complex pathological processes, toxic-allergic reactions, and mechanical tissue damage in the human body. Their eggs are highly resistant to environmental factors, and their long-term survival in the soil increases epidemiological risks. These features emphasize the necessity of integrating not only medical treatment but also sanitary-hygienic and ecological preventive measures in the fight against helminthiasis.

Conclusion (Conclusion) Roundworms are a bioecologically unique phylum, encompassing forms ranging from free-living saprophytes to obligate parasites with complex life cycles. Their biological analysis shows that morphological simplification (the absence of circulatory and respiratory systems) is compensated for by highly developed protective coverings and a high reproductive capacity. An in-depth study of these organisms is of significant scientific and practical importance in evaluating soil ecology, combating agricultural pests, and, most importantly, preventing helminthic diseases among humans.

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