

VETERINARY HELMINTHOLOGY

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Keywords: parasitology, helminths, nematodes, cestodes, trematodes, livestock, horses, pets, zoonoses, overview

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Summary

Helminth parasites (nematodes, cestodes and trematodes) are ubiquitous among domestic animals and wildlife in ecosystems around the world. Their life cycles depend on close linkages with their hosts and the environment, and transmission for many species depends on amazing behaviors and resilience. Helminths can reduce production (of meat, milk, and wool), can cause clinical disease and death, and many have more subtle effects. The significance of helminths depends primarily on parasite and host

species, levels of infection, and the host's overall health status. The detection and identification of many helminths is moving from morphology to molecular biology, but traditional methods remain important. There are four major approaches to the control of helminths: ecological – which depend on shifting the local ecosystem to favor the hosts; chemical – in which drugs are used to treat, and in some cases prevent, helminth infections; genetic – where the aim is to breed livestock with enhanced resistance to important helminths; and immunological – where the goal is safe and effective vaccines. Many helminths are zoonoses – they can transmit between animals and people. Some zoonoses are endemic in animal and human populations, others occur only sporadically in one or both groups. Ecosystem disruptions, including climate change, have the potential to alter patterns of helminth infection and disease, including for some zoonoses. Considerable information is available on helminths of wildlife, but significant knowledge gaps remain for many host species and geographic regions, and for health significance. Critical targets for the future include enhanced control for helminths of domestic animals and for zoonotic species, and increased awareness and understanding of the potential effects of ecosystem disruptions on the occurrence and significance of helminths in all hosts.

1. Introduction

Veterinary helminthology is the study of helminth (worm) parasites of domestic and free-ranging mammals and birds. Some parasitologists would include all vertebrate wildlife. Most attention is focused on species with significant impacts on domestic animal, wildlife or human health, and on the well-being of individuals and communities. While many helminths infect only animals or birds, several species are zoonotic – they are transmissible between animals and people.

Helminths important in veterinary medicine are in four distinct taxonomic groups: nematodes (commonly known as roundworms); cestodes (commonly known as tapeworms); trematodes (commonly known as flukes); and acanthocephalans (commonly known as thorny-headed worms). Globally, acanthocephalans are of relatively little significance. Species of parasite within each of these four groups share structural, functional and ecological characteristics. Particularly important are: the typical life cycle for each group, involving the production of offspring and their development from immature to adult stages; the locations of immature and adult stages within the organs and tissues of the hosts; the adverse effects these stages have on the hosts; and the ease with which hosts can be treated to remove the parasites and re-infection can be prevented.

While some helminth parasites occur in many parts of the world, others have more restricted distributions. The distributions depend primarily on: 1) history (especially the movement of infected animals, sometimes centuries ago); 2) the current availability of suitable hosts; and 3) a climate supportive of any free-living stages of the parasite, and of other animals (including arthropods and other invertebrates) critical for completion of the parasite's life cycle.

Virtually all domestic animals and wildlife have helminth parasites at some point during their lives, usually as mixed-species infections. In general, the prevalence and

abundance of these parasites are higher in young animals than in adults because of variations in inherent resistance, specific immunity, and/or exposure to the parasites. Also, several helminths have evolved life cycle strategies that enhance the infection of young offspring. For example, egg counts of gastro-intestinal nematodes in ewes increase significantly around the time of lambing. This results in large numbers of infective larvae on pastures when the lambs begin to graze.

2. Helminths - Life Cycles

The life cycle of a helminth is the process by which adult parasites produce offspring, and these develop successfully to infect new and suitable hosts and complete maturation to the adult stage.

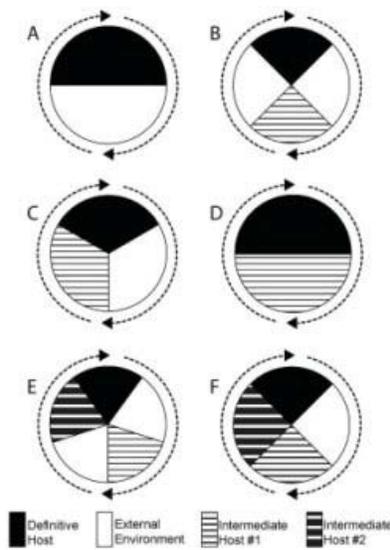


Figure 1. Life cycle patterns of helminth parasites showing species-dependent progress through definitive and intermediate hosts and the external environment. The arrows indicate the direction of parasite progress from adult through immature stages to adult. A – direct life cycle; B-F – indirect life cycles with one (B-D) or two (E-F) intermediate hosts. (See Tables for examples.)

The life cycles of parasitic helminths are either direct or indirect. With direct life cycles – characteristic of many nematodes important in veterinary medicine – the adult parasites live and develop only in a mammalian or avian definitive host, in which they undergo sexual reproduction, and the parasite is transmitted among these hosts by free-living stages in the environment. Indirect life cycles – characteristic of other nematodes and of all cestodes, trematodes and acanthocephalans – involve a definitive host, and often the environment, but also require one or more (sequential) intermediate hosts in which immature parasites undergo essential development and may reproduce asexually, but not sexually. Intermediate hosts important in veterinary helminthology include mammals, amphibians, mollusks and arthropods. Completion of the life cycles of several helminth species can also be facilitated by non-essential paratenic hosts – in which there is infection by immature stages but no development, or by transport hosts –

which simply move immature parasites from place to place on their feet, hair coat or plumage, or in their gastro-intestinal tracts.

3. Helminths and Host Ecology – Linkages and Shifts

Anywhere in the world, hosts, parasites and the local environment are intimately linked. Parasites are totally dependent on these linkages for transmission and for persistence in host populations. For example, for helminths with direct life cycles, transmission depends on environmental conditions that support the survival and development of the free-living life cycle stages and host access to these stages. There are the same requirements for helminths with indirect life cycles, but for these the environment must also support the intermediate hosts. For helminths with indirect life cycles transmitted through predator-prey links, relevant food webs must also be maintained.

In many situations, there is balance between the needs of the hosts and of the parasites, but circumstances can shift to favor either the hosts, with a possibility of parasite loss or extinction, or the parasites, with the risk of host morbidity and/or mortality. For many animal populations, both free-ranging and domestic, these effects on hosts and parasite illustrate the potentially critical role for parasites in the structure and function of local ecosystems, be they savannah, swamp, forest, mountain, or pasture.

Climate change, altered land use, and the search for resources are among the impacts of human activity on ecosystems around the world. A possible result of these impacts is altered patterns of infectious diseases in domestic and free-ranging animals, and in people. For example, for helminth parasites and their hosts the possible effects include shifts in: 1) spatial distributions; 2) host-parasite assemblages and other ecological associations; 3) demographic rates; 4) the seasonal timing of life cycle events for hosts (e.g. mating and birthing) and parasites (e.g. peaks in the availability of infective life cycle stages), and of linkages between these and food supply for the hosts; and 5) patterns of both infection and disease in the hosts. On occasion, and despite the resilience inherent in many ecosystems, these disturbances lead to the emergence of new parasitic diseases, or to the re-emergence of diseases that were common in the past.

4. Nematodes – Basics

Typical adult male and female nematodes are thread-like, have distinct anterior and posterior ends, and vary with species from a few mm to > 50 cm in length. Each nematode is essentially a sheath enclosing a bundle of tubular organs for digestion, absorption, reproduction and excretion.

Most nematodes have some degree of ecological specificity: each species is found in only one or a few host species; the life cycle stages of each species in the host are almost always in the same organ(s) and tissue(s); and the life cycle of individuals within a species follow the same basic pattern. Worldwide, probably the most important nematodes of domestic animals and wildlife are those with adults infecting the gastrointestinal system. Considering nematodes as a group, however, adult and immature parasites can live successfully in almost any organ or tissue in any mammalian or avian host. Other parasitic nematodes are found in amphibians, reptiles,

fish, and arthropods. There are also nematode species that parasitize plants, and many are free-living in terrestrial, freshwater and marine environments.

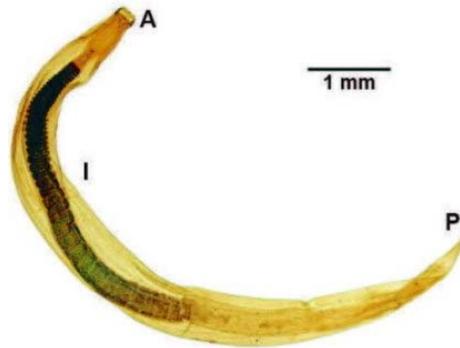


Figure 2. A parasitic nematode – immature female cyathostome from a horse. A – anterior end with mouth; P – posterior end; I – intestine (longitudinal tubular structure with pharynx anteriorly).

The life cycles of all nematodes include adults and four larval stages. Females of most species produce eggs, but some produce first-stage larvae. The larval (immature) stages are miniature, sexually immature versions of the adults and proceed from one larval stage to the next by molting (growing a new sheath beneath the existing sheath, which is then shed). Each nematode species has a larval stage that is infective for its definitive hosts. These infective stages include first- and third-stage larvae free in the environment, first and second stage larvae within eggs, and larval stages in intermediate and paratenic hosts. For almost all nematodes important in veterinary medicine, one egg or larva becomes only a single adult of the next generation.

5. Cestodes – Basics

Adult cestodes are hermaphrodite, have the appearance of a segmented ribbon, and vary with species from a few mm to a meter or more in length. All adult cestodes are parasitic, and the adults of most species live only in the intestinal tract of their definitive hosts. Adults have a distinct anterior holdfast organ (the scolex) which anchors the parasite to intestinal mucosa. The body of a tapeworm consists of a ribbon of connected segments that are produced behind the scolex. Each segment contains one or two sets of reproductive organs, depending on species.

Cestodes lack an anatomical gut, and nutrients are absorbed through the body covering. Cestodes have ecological specificities similar to those of nematodes. All cestodes important in veterinary helminthology have indirect life cycles with a single intermediate host. Depending on parasite species, suitable intermediate hosts include arthropods, gastropods and mammals. Many cestodes can utilize several similar species of these hosts. Infection of intermediate hosts is by ingestion of tapeworm eggs in the feces of the definitive host. Each cestode species has a specific larval stage that is infective for the definitive host, and among cestodes as a group these stages show considerable morphological diversity. For many cestode species, one egg produced by an adult can become only a single adult of the next generation, but with some species

there is asexual reproduction by the larvae in the intermediate hosts, and for these one egg can become several adults of the next generation.

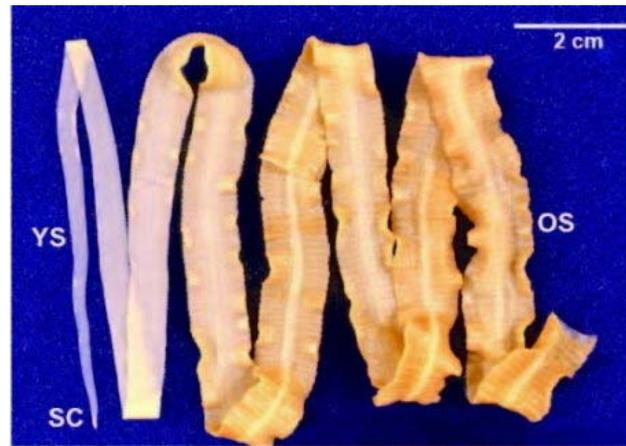


Figure 3. An adult cestode – *Diphyllobothrium* species from a dog. SC – scolex; YS – younger segments (close to the scolex); OS – older segments (distant from the scolex).

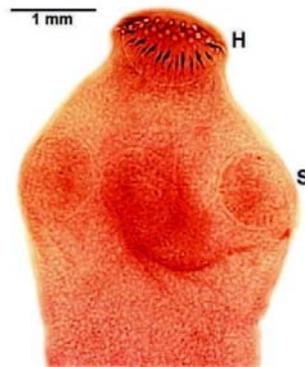


Figure 4. A cestode scolex – *Taenia* species from a cat. H – hooks on the rostellum (retractable and helps to keep the parasite attached to the host); S – muscular suckers on the scolex (helps to keep the parasite attached to the host).

6. Trematodes – Basics

All adult trematodes are parasitic and the adults of species important in veterinary helminthology are hermaphrodite, leaf-shaped, and vary with species from a few mm to a few cm in length. All have a prominent muscular sucker surrounding the apical mouth, and another on their ventral surface. Trematodes have an anatomical gut.

Adults of most trematodes live in the gastro-intestinal system, including the liver, gall bladder and bile ducts. Other species parasitize the lungs, the vascular system or the urinary tract. All trematodes have an indirect life cycle. Depending on species, there may be one or more intermediate hosts, and sometimes paratenic hosts. The first intermediate host is always a snail. Subsequent intermediate and paratenic hosts depend

on the trematode species, and include amphibians, fish and mammals. For the larval stages of trematodes in snails there is a consistent sequence of development through the various larval stages to the infective stage, and each stage is morphologically distinct. Asexual reproduction in the snail intermediate hosts is a feature of all trematodes, and thus one egg can become several adults of the next generation.

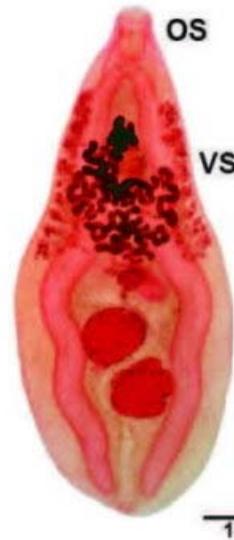


Figure 5. An adult trematode – *Metorchis conjunctus* from a dog. OS – oral sucker (surround mouth); VS – ventral sucker (partly obscured by the dark, coiled uterus).

7. Helminths and Disease – Mechanisms

Many domestic animals and wildlife infected with helminths rarely if ever show obvious evidence of the parasites. In many of these situations the parasites are probably having adverse effects, but these are subtle and not detected by current clinical and laboratory-based evaluations. Obvious morbidity and mortality among hosts can result, however, when the balance within the ecosystem favors the parasites. Among the many factors precipitating disease and death in such situations are: 1) parasite species that are particularly pathogenic; 2) large numbers of parasites; 3) hosts that are unable to resist, mitigate and/or curtail the infections; and 4) absence of adequate preventative, anti-parasite and host-supportive interventions. Another key factor in the host-parasite balance is the ubiquity of simultaneous infections with several species of parasite (polyparasitism), as well as with other pathogens such as fungi, bacteria and viruses. Acting together, these multiple pathogens might have additive or synergistic effects on the hosts.

The various life cycle stages of helminth parasites within their hosts can cause damage by several means including: 1) physical and functional disruption of the organs and tissues through which they migrate and in which they establish as adults; 2) interference with appetite and with the digestion, absorption and utilization of key nutrients, potentially causing loss of body mass or reduced growth, reduced wool growth or milk production, and a reduced capability to resist parasites and other pathogens; 3)

stimulation of immune responses that are harmful to the host; and 4) alteration in the condition and behavior of hosts that might affect their reproductive success. Some helminth species (e.g. *Haemonchus contortus* in sheep, *Fasciola hepatica* in cattle, *Oxyuris equi* in horses, and *Ancylostoma caninum* in dogs) are capable of producing distinct disease syndromes in their hosts. These and/or other species can also act together to suppress host health and productivity. In these situations it can be difficult to precisely identify the relative significance of the various parasite species.

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Biographical Sketch

Lydden Polley is Professor of Parasitology at the Western College of Veterinary Medicine, University of Saskatchewan, Canada. His current research interests relate to parasites of keystone wildlife in the Canadian Arctic, the effects of climate change on parasitic infections in domestic animals and wildlife, and parasite zoonoses. Dr Polley received his veterinary degree and PhD in Parasitology at the University of Bristol in England.