

Aspiculuris

(helminth: nematode)

Overview

Nematodes are triploblastic pseudocoelomate unsegmented worms that undergo protostomial embryonic cleavage and grow by cuticular moulting (ecdysis). Two groups identified by the presence/absence of sensory phasmids have partly been ratified by molecular studies recognising three subclasses: Enoplia and Dorylaimia (both without phasmids) and Chromadoria (most with phasmids). Many phasmodian parasites of vertebrates are grouped in the chromadorian order Rhabditida; including tylenchinids, rhabditinids and spirurinids. The latter contains the infraorder Oxyuridomorpha which includes the oxyuroids (pinworms) characterised by their small tapering shape, pointed tails, oesophagus with a terminal bulb, and the males are non-bursate with a single spicule. They have simple direct life-cycles involving faecal-oral transmission of eggs containing infective larvae. The eggs may be passed in faeces or oviposited around the anus (perineum) where they are subsequently dislodged. Pinworms are common in the large intestines of many mammals, birds, reptiles, amphibians and some insects. While *Aspiculuris tetraptera* usually causes subclinical infections in mice, the parasites may still pose problems for the production of 'germ-free' laboratory animals.

Classification:

Domain: Eukaryota (membrane-bound nucleus)
Supergroup: Amorphea (unikonts with single flagellum, or nonflagellated amoebae)
Kingdom: Metazoa (multicellular eukaryotes, heterotrophs, notably animals)
Group: Protostomia (triploblastic, spiral cleavage)
Subgroup: Ecdysozoa (cuticle moulted = ecdysis)
Phylum: Nematoda (unsegmented, pseudocoelomate roundworms, tubular digestive tract, dioecious)
Class: Chromadorea (spiral amphids, three oesophageal glands, usually annulated bodies, free-living and parasitic)
Order: Rhabditida (Secernentea, Phasmodia) (secretors, with phasmids, bipartite oesophagus, single testis)
Suborder: Spirurina (mostly parasitic in vertebrate hosts)
Infraorder: Oxyuridomorpha (small pinworms, pointed tails, oesophagus with terminal bulb, males with single spicule)
Superfamily: Oxyuroidea (common in mammals, birds, reptiles, amphibians)
Family: Heteroxyematidae (direct cycle, females deposit eggs in faeces, infection by ingestion of egg/larva)
Genus: *Aspiculuris* (parasitic in large intestines of rodents)
Species: *A. tetraptera* (causes subclinical infections in mice)

Parasite biodiversity and host range: Most Metazoa are multicellular triploblastic animals with differentiated tissues, many being bilaterally symmetrical with a body cavity. Most invertebrate animals are protostomes as their embryonic development involves spiral determinate cleavage. Those that moult their external cuticles during their life-cycles (process known as ecdysis) are grouped together in the unique clade Ecdysozoa, including the nematodes (roundworms), onychophorans (velvet worms), tardigrades (water bears) and arthropods (myriapods, chelicerates, crustaceans and hexapods, all with jointed limbs). Nematodes (roundworms) are unsegmented tubular worms with a fluid-filled body cavity (pseudocoelom) that acts as a hydrostatic skeleton. They have longitudinal muscles and typically exhibit a sideways thrashing motion. They have well developed digestive tracts with various partitions: the foregut comprising the mouth (often with lips and papillae), buccal capsule (sometimes with ridges, rods, plates, spines, stylets or teeth) and oesophagus (glandular, muscular or both); the midgut (nonmuscular absorptive section); and hindgut (rectum) emptying through a subterminal anus (cloaca in males). Most nematodes are dioecious and form separate sexes. Male worms have a single testis (sometimes 2), an elongate vas deferens often equipped with a seminal vesicle and ejaculatory duct (glandular and/or muscular), 1-2 copulatory spicules (sometimes with an accessory gubernaculum), and bursate species with elaborate posterior claspers. Female worms are usually didelphic (some monodelphic or polydelphic) with 2 ovaries, 2 oviducts usually with spermatheca, 2 uteri opening into a common vagina and a vulva often equipped with a muscular ovejector. Female worms are oviparous or viviparous and produce numerous eggs or larvae, respectively. Larval stages undergo several moults (L1-L4) before maturing into adult worms. Some nematodes have direct life-cycles where eggs or larvae infect definitive hosts (per os or per cutaneous), but many have indirect cycles where larvae first develop in invertebrate intermediate hosts before infecting definitive hosts (by ingestion, injection or deposition). Many nematode species are free-living in terrestrial and aquatic habitats, while some species from diverse groups have become plant or animal parasites. Two nematode groups identified by the presence/absence of sensory phasmids have partly been ratified by molecular studies recognising three subclasses: Enoplia and Dorylaimia (both without phasmids) and Chromadoria (most with phasmids). Most Enoplia are free-living marine organisms but some are found in freshwater, and on land as plant parasites. The Dorylaimia comprise numerous freshwater and terrestrial species, including major groups of plant and animal parasites. The Chromadoria is represented by many marine groups as well as a terrestrial group of plant and animal parasites. The taxonomic ranks of many nematode assemblages vary considerably depending on which classification system has been followed. Molecular phylogenetic studies, however, have supported the separate

classification of most groups, particularly at the level of superfamily. Collectively, species from at least 16 superfamilies are considered to pose serious threats to human and animal health as infectious diseases.

CLASSIFICATION* OF SUPERFAMILIES OF PARASITIC NEMATODES
Class: Enoplea (Aphasmidea, Adenophorea) (gland-bearers, cylindrical oesophagus, no phasmids, setae, two testes)
Subclass: Dorylaimia (five or more oesophageal glands, buccal stylet (odontostyle), free-living or parasitic)[clade I(2)]
Order: Trichinellida (Trichocephalida, Trichurida) (single spicule, stichosome oesophagus, L1 with buccal stylet)
Superfamily: Trichinelloidea (oesophagus with short anterior muscular and long posterior glandular portions)
Class: Chromadorea (spiral amphids, 3 oesophageal glands, usually annulated bodies, free-living and parasitic)
Order: Rhabditida (Secernentea, Phasmidea) (secretors, phasmids present, amphids anterior, bulbous oesophagus)
Suborder: Rhabditina (free-living or parasitic in invertebrates/lower vertebrates)[clade V(9)]
Infraorder: Rhabditomorpha ('rod-shaped' buccal cavity)
Superfamily: Rhabditoidea (open tube stoma, excretory system with lateral canals)
Superfamily: Strongyloidea (bursate males, prominent buccal capsules, parasites of mammals, birds, reptiles)
Suborder: Spirurina (animal parasites, many use invertebrate intermediate hosts (IH))[clade III(8)]
<i>Incertae sedis</i> Superfamily: Dracunculoidea (elongate parasites of vertebrate tissues, freshwater crustacean IH)
Infraorder: Ascaridomorpha (large roundworms, three large lips, numerous caudal papillae)
Superfamily: Ascaridoidea (ascarids, eggs thick-shelled, larvae may undertake hepato-pulmonary migration)
Superfamily: Heterakoidea (preanal sucker anterior to cloaca in males, direct cycle, infection by egg ingestion)
Infraorder: Gnathostomatomorpha ('jaw-mouthed' due to unique bulbous armed heads)
Superfamily: Gnathostomatoidea (first IH copepod, often use paratenic hosts)
Infraorder: Oxyuridomorpha (pinworms, pointed tails, oesophagus with terminal bulb, males with single spicule)
Superfamily: Oxyuroidea (common in mammals, birds, reptiles, amphibians)
Infraorder: Spiruromorpha (enigmatic clade linked by molecular characters, indirect cycles with IHs)
Superfamily: Acuarioidea (small parasites mostly of birds, with cephalic cordons, ptilina or serrated shields)
Superfamily: Camallanoidea (conspicuous phasmids, L1 with dorsal tooth, ovoviviparous, L1-L3 in copepod)
Superfamily: Filarioidea (tissue-dwelling filarial parasites, lack lips, infect tissues/vessels, arthropod IH)
Superfamily: Habronematoidea (unique head structures with small pseudolabia and median lips)
Superfamily: Physalopteroidea (stomach worms in mammals, insect IH)
Superfamily: Spiruroidea (pseudolabia, bipartite oesophagus, infect birds (crop/gizzard), arthropod IHs)
Superfamily: Thelazioidea (eye-worms of birds and mammals, transmitted by insects)
Suborder: Tylenchina (fungal, plant and animal parasites)[clade IV(10,11,12)]
Infraorder: Panagrolaimomorpha (free-living or parasitic (insects, reptiles, amphibians, mammals))
Superfamily: Strongyloidoidea (dauer stages, lip region without processes, striated cuticle)

*Contemporary genotypic classification schemes recognize strong monophyletic clades at the level of superfamily and infraorder, while previous phenotypic classification schemes had ranked many as separate orders.

The infraorder Oxyuridomorpha comprises the pinworms, unique microphagous nematodes with pointed tails, an oesophagus with a terminal bulb and the males having only a single spicule. Pinworms are conventionally classified in the order Oxyurida, the only major nematode group with adult representatives in either vertebrates or invertebrates. Two superfamilies are recognised: Oxyuroidea (parasites of the posterior gut of vertebrates (including mammals, birds and some reptiles) and Thelastomatoidea (parasites of invertebrates, especially herbivorous arthropods with a fermentation chamber (such as cockroaches, diplopods, orthopterans)). Members of the superfamily Oxyuroidea are distinguished by small nonbursate males with reduced numbers of caudal papillae and females with complex ovejectors producing thin-shelled eggs flattened on one side. The parasites have monoxenous transmission cycles whereby unembryonated eggs are passed into the environment with host faeces or gravid females migrate to the anus and deposit eggs in the perianal region. Three families are recognised: Oxyuridae (amphids non-pedunculate, genital cone without sclerotized supporting structure, male tail irregular, often bluntly truncate with or without dorsal point, sometimes with large digitiform papillae extending into caudal alae, parasitic in mammals and rarely birds); Pharyngodonidae (amphids pedunculate, genital cone supported by V-shaped sclerotized structure, parasitic in lower cold-blooded vertebrates, and a few in archaic mammals); and Heteroxynematidae (amphids non-pedunculate, genital cone without sclerotized supporting structure, male tail regular, conical or flattened dorsoventrally, parasitic in mammals and birds).

The family Heteroxynematidae contains 2 subfamilies: Labiostominae (anal papillae grouped around anus, ovejector with glandular ring, thick-shelled egg with operculum, complex pharyngeal and buccal structures with lamellar extensions, parasites of lagomorphs); and Heteroxynematinae (last pair of male post-anal papillae near caudal extremity, glandular part of ovejector not ring-like, egg without operculum, simple pharyngeal and buccal structures, parasites of birds and rodents). The subfamily Heteroxynematinae contains 9 genera: *Aspicularis* (*Aspicularis*), *Dentostomella*, *Dermatopallarya*, *Eudromoxyura*, *Fastigiuris*, *Heteroxynema*, *Rauschoxyuris*, and *Syphaciella*. Pinworm genera of medical and veterinary significance are tabulated below:

Genus	No. spp.	Definitive Hosts	Location	Adult worms	Eggs	Transmission
Family: Heteroxyematidae						
Subfamily: Heteroxyematinae						
<i>Aspiculuris</i>	23	rodents	large intestines	2-5 mm long, prominent cervical alae, oesophagus with terminal oval bulb, eggs passed in faeces	70-98 x 29-50 µm, spindle-shaped, thin-shelled	ingestion of larvated eggs
Family: Oxyuridae						
Subfamily: Oxyurinae						
<i>Oxyuris</i> (pinworm)	21	mammals, birds, reptiles	caecum, large intestines	1-16 cm long, oesophagus with terminal globular bulb, pin-tailed, eggs oviposited around anus	85-95 x 40-45 µm, D-shaped, thin-shelled	ingestion of larvated eggs
Subfamily: Syphaciinae						
<i>Passalurus</i> (pinworm)	3	lagomorphs, rodents	large intestines	3-11 mm long, circular cuticular striations, oesophagus with terminal bulb, eggs passed in faeces	93-105 x 43-45 µm, D-shaped, thin-shelled	ingestion of larvated eggs
<i>Syphacia</i>	86	rodents	large intestines	1-6 mm long, small cervical alae, oesophagus with terminal globular bulb, eggs oviposited around anus	72-153 x 25-55 µm, reniform, thin-shelled	ingestion of larvated eggs
Subfamily: Enterobiinae						
<i>Enterobius</i> pinworms	27	primates, rodents	large intestines	1-15 mm long, lateral alae, oesophagus with terminal bulb, slender pointed tails, eggs oviposited around anus	50-60 x 20-30 µm, D-shaped, thin-shelled	ingestion of larvated eggs

The genus *Aspiculuris* contains over 20 species reported from the large intestines of cricetid and murid rodents. Male worms are characterised by having 3 pairs of alae along their tails (preloacal, postloacal and caudal). While earlier studies allocated some 9 species to 5 different subgenera: *A. (Aspiculuris)* (with cephalic bulb, cervical alae with sickle-shaped margins and not continuous with lateral alae), *A. (Paraspiculuris)* (with cephalic bulb, cervical alae with sickle-shaped margins and continuous with lateral alae), *A. (Pseudaspiculuris)* (with cephalic bulb, cervical alae without sickle-shaped margins and continuous with lateral alae), *A. (Anaspiculuris)* (with cephalic bulb, cervical alae with sickle-shaped margins, without lateral alae), *A. (Subaspiculuris)* (without cephalic bulb, cervical alae with sickle-shaped margins, without lateral alae), most workers now recognize 2 species groups: one group of 14 species with arrow-headed cervical alae; and another group of 6 species with spear-headed cervical alae. All species have direct monoxenous life-cycles involving the faecal-oral transmission of larvated eggs. The species *A. tetraptera* (commonly known as the mouse pinworm) has a worldwide distribution but rarely causes disease, although persistent infections can become a nuisance in pet stores and laboratory animal colonies.

<i>Aspiculuris</i> species	Definitive hosts	Location [Clinical signs]	Distribution
<i>A. ackerti</i> (now <i>Lamotheoxyuris</i>)	Rodentia: cricetid (bushy-tailed woodrat, white-throated woodrat)	caecum, intestines	North America
<i>A. africana</i>	Rodentia: murid (Cairo spiny mouse)	intestines	Africa
<i>A. (Anaspiculuris) americana</i>	Rodentia: cricetid (cotton mouse, Florida mouse, white-footed mouse, deer mouse, rock mouse)	intestines	North America
<i>A. arianica</i> sp. inq.	Rodentia: sciurid (long-tailed marmot)	intestines	Asia
<i>A. artigasi</i>	Rodentia: murid (house mouse)	intestines	South America
<i>A. aserbaidjanica</i>	Rodentia: murid (wood mouse), cricetid (common vole, European snow vole)	intestines	Europe, Africa
<i>A. (Pseudaspiculuris) asiatica</i>	Rodentia: cricetid (social vole), murid (great gerbil, jird)	intestines	Asia
<i>A. (Paraspiculuris) bengalensis</i>	Rodentia: murid (house mouse)	intestines	India
<i>A. (Subaspiculuris) caviellae</i>	Rodentia: caviid (guinea pig)	intestines	India
<i>A. (Aspiculuris) dinnicki</i>	Rodentia: cricetid (bank vole, grey red-backed vole, northern red-backed vole, social vole, European water vole, European snow vole, Caucasian snow vole, Robert's snow vole), sciurid (red squirrel)	intestines	Eurasia

<i>A. huascaensis</i>	Rodentia: murid (house mouse)	caecum	North America
<i>A. indicus</i>	Rodentia: murid (house mouse, black rat)	intestines	Asia
<i>A. (Aspiculuris) kazakstanica</i>	Rodentia: murid (wood mouse), cricetid (social vole)	intestines	Europe, Africa
<i>A. (Aspiculuris) lahorica</i>	Rodentia: murid (house mouse)	large intestines	Pakistan
<i>A. mexicana</i>	Rodentia: cricetid (tarabundi vole, Mexican harvest mice)	colon	North America
<i>A. (Paraspiculurus) pakistanica</i>	Rodentia: murid (black rat)	caecum, large intestines	Pakistan
<i>A. (Paraspiculurus) ratti</i>	Rodentia: murid (black rat)	intestines	India
<i>A. rysavyi</i>	Rodentia: cricetid (silver mountain vole)	intestines	Eurasia
<i>A. (Aspiculuris) schulzi</i>	Rodentia: murid (wood mouse), cricetid (northern red-backed vole, social vole)	intestines	Europe
<i>A. shikoloveta</i>	Rodentia: murid (Namaqua rock rat)	intestines	Africa
<i>A. tianjinensis</i>	Rodentia: cricetid (gray-sided vole)	intestines	China
<i>A. (Aspiculuris) tetraptera</i> (syn. <i>Aspicularis</i>) (mouse pinworm)	Rodentia: murid (house mouse, Algerian mouse, white mouse, wood mouse, yellow-necked mouse, eastern broad-toothed field mouse, Natal multimammate mouse, brown rat, black rat, white rat, Mongolian gerbil, great gerbil, Libyan jird), cricetid (common vole, bank vole, social vole, European bank vole, European water vole, European snow vole, Robert's snow vole, northern red-backed vole, Mediterranean pine vole, European hamster, Turkish hamster, Chinese striped hamster, grey dwarf hamster), nesomyid (Gambian pouched rat); sciurid (red squirrel)	caecum, colon	worldwide
<i>A. tschertkovi</i>	Rodentia: murid (Korean field mouse), cricetid (European hamster, northern red-backed vole, Chinese striped hamster, grey dwarf hamster)	intestines	Eurasia
<i>A. versterae</i>	Rodentia: murid (Natal multimammate mouse)	caecum	Africa
<i>A. witenbergi</i>	Rodentia: murid (North African gerbil, bushy-tailed jird)		North Africa

Parasite morphology: *Aspiculuris* spp. form 3 different types of morphological stages: eggs; larvae (4 successive stages encoded L1-L4); and adult worms. The eggs are spindle-shaped and slightly asymmetric longitudinally measuring 70-98 x 29-50 μm (although a few species form smaller eggs, e.g. *A. huascaensis* 54-69 x 18-30 μm). The eggs are not operculated and are bound by smooth thin shells containing a central morula or first-stage larvae (L1) when excreted in faeces. Little is known about larval morphology as development to L3 occurs within the eggs and L4 are transient parasitic stages. Adults are small white cylindrical worms measuring 2.6-4.7 mm long and bound by a tough cuticle with poorly-marked but elaborately-wrinkled cuticular annulations. The head is bulb-like being inflated to form cephalic vesicles and both sexes possess well-developed cervical alae. Indeed, 2 species groups are recognised on the basis of their morphology: group 1 having arrow-headed alae (*A. americana*, *A. arianica*, *A. aserbaidjanica*, *A. dinnicki*, *A. huascaensis*, *A. kazakstanica*, *A. lahorica*, *A. mexicana*, *A. pakistanica*, *A. rysavyi*, *A. schulzi*, *A. tetraptera*, *A. tianjinensis*, *A. tschertkovi*, *A. versterae*); and group 2 having spear-headed (lanceolate) alae (*A. ackerti*, *A. africana*, *A. asiatica*, *A. ratti*, *A. shikoloveta*, *A. witenbergi*). Both sexes also have smooth lateral alae running the length of the body, but not continuous with the cervical alae. The mouth is anterior and contains a cuticularized cephalic plate or cap (usually round but sometimes oval, square or laterally elongated) with 3 poorly-developed lips (each with 2 indistinct labial papillae), 4 cephalic papillae (arranged in a square) and 2 lateral amphids. The oesophagus is bipartite and club-shaped with a long cylindrical anterior muscular part and a stout oval-clavate glandular posterior bulb with serrated ridges (but not valved). Adult worms are sexually dimorphic, with females being slightly larger than males (2.6-4.7 x 0.2-0.3 mm cf. 2.0-4.0 x 0.1-0.2 mm). Mature females are didelphic with 2 ovaries and uteri arranged in a prodelphic configuration (parallel) and connected to muscular ovejector opening into an anterior vulva with a single anterior lip. Females have tapering conical tails 400-600 μm long with transverse striations. Mature males are monorchid having a single testis connected to the posterior intestines to open at a common cloaca. They are readily identified as they possess 3 pairs of alae (precloacal, postcloacal, caudal) around their short conical tails (100-170 μm) but lack mamelons, a gubernaculum and a spicule.

Site of infection: Adult worms live in the lumen of the large intestines (mainly the colon, sometimes the caecum) of their rodent hosts, occasionally extending into the small intestines. Earlier larval stages undergo transient development in intestinal crypts before returning to the lumen to mature.

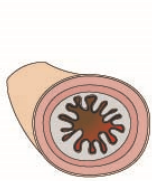
Pathogenesis: Most infections are asymptomatic and even heavy worm burdens rarely cause mild clinical signs of enteritis. Adult worms reside in the lumen and feed on intestinal contents, and while larvae may enter the crypts for brief periods, they are not considered to be invasive and cause little damage. Mice are most susceptible to infection at 5-6 weeks of age and they subsequently develop an age-related resistance with immune expulsion of parasites and protection against re-infection. Female mice become resistant during their first oestrous, while males gradually developed resistance as they aged. Most parasite species were relatively specific for particular hosts, although a few species apparently had broader host specificity but infections did not thrive in all hosts (e.g. only a few under-developed worms of *A. tetraoptera* established experimentally in gerbils and rats).

Developmental cycle and mode of transmission: *Aspiculuris* spp. have simple direct monoxenous life-cycles involving the faecal-oral transmission of infective eggs. Gravid female worms move to lower colon to lay eggs which are excreted in the mucus layer covering faecal pellets. Egg production was often discontinuous or intermittent, and did not show any distinct diurnal rhythm although reports suggested more eggs were deposited at night. In the external environment, larvae developed inside the eggs to form infective L3 in 5-8 days at 24-27°C. The eggs are quite resistant to desiccation and may survive for several weeks, but they are sensitive to high temperatures. Rodents become infected by ingesting eggs contaminating food or by coprophagy. Ingested eggs hatch in the large intestines releasing L3 which moult to L4 and enter colonic crypts where they remain for 4-5 days (larvae do not undertake any somatic or extra-intestinal migration). The larvae return to the lumen and migrate anteriorly to the proximal colon over 1-3 weeks where they moult to subadults (sometimes called L5) which subsequently mature. The prepatent period (time from infection to first egg excretion) ranges from 21-35 days and adult worms have been found to live for 45-50 days.

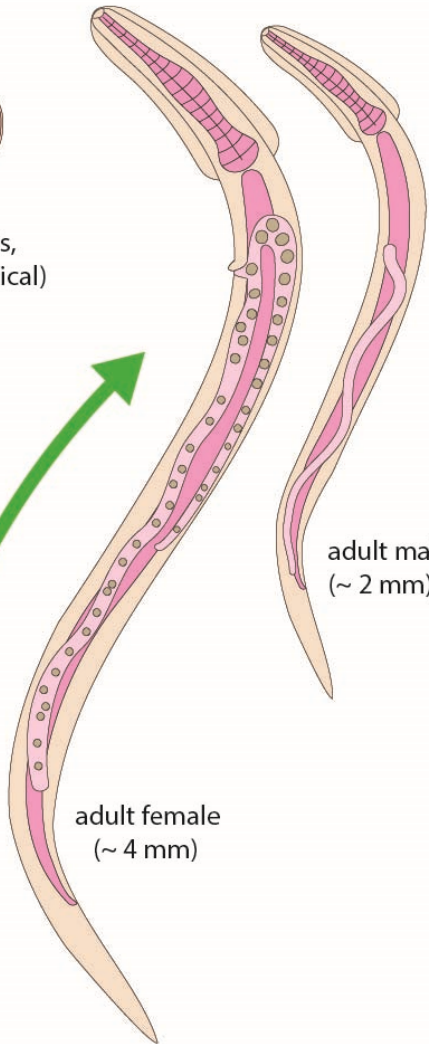
Differential diagnosis: Infections are conventionally diagnosed by the microscopic detection of worm eggs in faecal samples following their concentration by floatation (sticky-tape impression smears are ineffective as these pinworms do not attach eggs to perianal regions). The worm eggs are characteristic in size and shape, being spindle-shaped rather than D-shaped like *Syphacia* eggs. Infections may also be diagnosed at post-mortem by the detection of adult worms in the colon. Molecular biological techniques have been used to characterize parasite species following the polymerase chain reaction (PCR) amplification of nuclear genes (18S ribosomal RNA) and mitochondrial genes (cytochrome oxidase subunit I).

Treatment and control: A wide range of drug treatments have been tested against pinworm infections in laboratory mice, mostly as oral medications administered via food or water. Conventional anthelmintics, such as benzimidazoles (thiabendazole, fenbendazole), diethylenediamines (piperazine), organophosphonates (dichlorvos, trichlorfon, haloxon) and heterocyclic thiazines (phenothiazine), were effective against adult worms and larval stages but not eggs. Earlier studies reported some anthelmintic effects using cyanine dyes (pyrvinium), triarylmethane dyes (gentian violet, crystal violet), fluorides (sodium fluoride), iodides (stilbazium iodide), substituted dihydroxybenzene (hexylresorcinol) and halogenated hydrocarbons (carbon tetrachloride, tetrachloroethylene). Recent studies also found that several antibiotics (terramycin, aureomycin, bacitracin, puromycin) apparently reduced worm burdens. It should be noted that repeated or sustained treatments were required to prevent re-infection in addition to thorough cleaning of holding facilities. Worm eggs have been found on cages, equipment, ventilation ducts and even dust in laboratory animal colonies, and the eggs are highly resistant to cold, dessication and many disinfectants, but are susceptible to heat. Preventive strategies should therefore not only include the removal and disposal of host faeces and soiled bedding, but also the sterilization of cages and rooms preferably using steam-cleaning devices. Routine surveillance, quarantine and isolation procedures should also be implemented to detect and manage infections in rodent colonies, as they can be difficult to eradicate once established.

Aspicularis

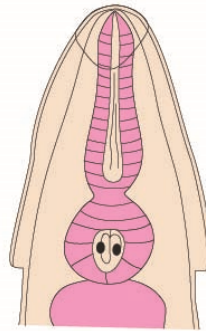


intestines
(mild enteritis,
mostly subclinical)

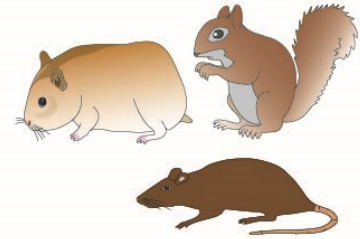


adult male
(~ 2 mm)

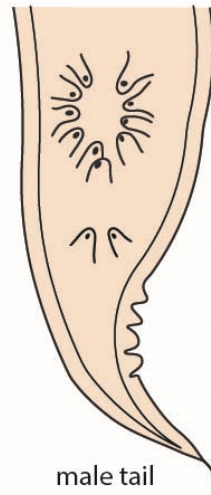
adult female
(~ 4 mm)



head



Definitive Hosts
(rodents)



male tail



eggs
excreted
in mucus
covering
faeces



eggs ingested
with food/water
or via grooming
or coprophagy

L3 develop
within eggs



eggs
(~ 90 μ m)

eggs contaminate
environment

contaminative transmission



Aspiculuris adult worm, head



Aspiculuris worm egg