Aelurostrongylus
(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 phasmidian parasites of vertebrates are grouped in the chromadorian order Rhabditida; including spirurinids, tylenchinids and rhabditinids. The latter contains the infraorder Rhabditomorpha which includes strongyloid nematodes characterised by an expansion of the tail of the male known as the copulatory bursa (clasper with one dorsal and two lateral lobes with muscular rays). Many families are recognised: including lungworms with small buccal capsules and reduced male bursae. Adult worms are found mostly in the lungs of their hosts, although some inhabit the pulmonary artery, meninges or connective tissues. Five main groups occur: dictyocaulids in ruminants and horses; metastrongyles in pigs; protostrongyles in ruminants; angiostrongyles in carnivores and rodents; and filaroids in dogs. Angiostrongyles have indirect life-cycles involving the development of L3 in invertebrate intermediate hosts, and their carriage in paratenic (transport) hosts. Adult *Aelurostrongylus* in the lungs produce eggs which release L1 that are swallowed and passed in faeces. L1 then penetrate the foot of a snail or slug and develop to L3. These larvae may persist in the tissues of small mollusc-eating animals, such as rodents, birds and lizards. When cats eat intermediate or paratenic hosts, L3 migrate via the lymphatics to the lungs and develop into adult worms. Infections by *A. abstrusus* may cause respiratory signs in cats worldwide.

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, Phasmidea) (secretors, with phasmids, bipartite oesophagus, single testis)
Suborder:	Rhabditina (free-living or parasitic in invertebrates/lower vertebrates)
Infraorder:	Rhabditomorpha (‘rod-shaped’ buccal cavity)
Superfamily:	Strongyloidea (bursate males, prominent buccal capsules, parasites of mammals, birds, reptiles)
Family:	Angiostrongylidae (no buccal cavity, infection of vertebrates by ingestion of earthworm/molluscan IH)
Genus:	*Aelurostrongylus* (parasitic in lungs of cats)
Species:	*A. abstrusus* (causes respiratory signs in cats)

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, spears, 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 in bursate species, elaborate posterior claspers. Female worms are usually didelphic with 2 ovaries (some monodelphic or polydelphic), 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)]
Incertae sedis 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 superfamily Strongyloidea comprises a range of worms often with prominent buccal capsules and specialised oral structures well-suited to their feeding habits on host tissues and/or fluids. Adults of most species are parasitic in the gastrointestinal tracts of mammals and some birds, while larval stages feed on bacteria in the external environment, although some larvae may infect invertebrates as intermediate or paratenic hosts. The adult worms are sexually dimorphic, the smaller males characterised by an expansion of the tail (bursa) which is used as a copulatory clasping organ. Many classification schemes group these 'bursate' nematodes into one or more superfamilies in the order Strongylida (with suborders containing the strongyles, trichostrongyles, hookworms and lungworms), although the families essentially remain the same. Many families are recognised on the basis of parasite morphology, biology, life-cycle, host specificity and tissue tropism; including the following which contain many notorious parasites of vertebrates.

Representative Strongyloidea (cf. Strongylida) [with bursate males]				
Family	**Characters**	**Definitive Hosts**	**Transmission***	**No. genera**
Metastrongylina (lungworms)				
Angiostrongylidae (lungworms)	no or reduced buccal cavity, short club-shaped oesophagus	carnivores, rodents	ingestion of IH or PH carrying L3	28
Metastrongylidae (lungworms)	small buccal capsule, 2 trilobed lips, bursa with reduced dorsal lobe	Suids	ingestion of IH carrying L3	1
Protostrongylidae (lungworms)	small buccal capsule, bursa with large lobes, gubernaculum	artiodactyls	ingestion of IH carrying L3	17
Dictylocaulidae (lungworms)	small buccal capsule, bursa with large lobes, short stout spicules	ungulates, reptiles	ingestion of L3	5
Filaroididae (lungworms)	small buccal capsule, reduced male bursa, infective L1	carnivores	ingestion of L1	4
Trichostrongylina (trichostrongyles)				
Trichostrongylidae (trichostrongyles)	reduced buccal capsule, ridged synlophe, oesophagus lacking bulb, thin-shelled eggs	artiodactyls, birds	ingestion of L3	50
Molineidae (stomach/intestinal worms)	reduced buccal capsule, cephalic vesicle, female tail with spine or cusps, oviparous/viviparous	mammals, birds, reptiles	ingestion of L3	61
Heligmonellidae (hookworm-like)	body coiled, cephalic vesicle, ridged synlophe, bursa asymmetrical	mammals, birds	transdermal penetration of L3	56
Strongylina (strongyles)				
Strongylidae (strongyles)	large buccal capsule often armed with teeth, leaf crown around mouth	mammals, reptiles, birds	ingestion of L3	32
Chabertiidae (nodule worms)	large buccal capsules, leaf crown of labial collar, L3 sheathed	artiodactyls, primates	ingestion of L3	22
Syngamidae (gapeworm)	cup-shaped buccal capsule, armed with teeth, male attached to female	birds, mammals	ingestion of L3 or invertebrate PH	7
Stephanurinae (kidneyworm)	buccal capsule armed with teeth, leaf crowns and external epaulettes	Suids	transdermal penetration or ingestion of L3 or PH	1
Ancylostomatina (hookworms)				
Ancylostomatidae (hookworms)	large buccal capsule bent dorsally, armed with teeth/cutting plates	primates, carnivores, artiodactyls	transdermal penetration of L3 (sometimes *per os*)	20

*IH = intermediate host, PH = paratenic (transport) host, L1 = first-stage larva, L3 = third-stage larva

Lungworms are characterised mostly by their unique location within the respiratory systems of their mammalian hosts, although some species also infect cardiovascular, nervous or intermuscular connective tissues. Adult worms have a small buccal capsule, often reduced to an annulus, and sometimes possessing lips. Male worms have a caudal bursa that is variable in structure (often with reduced lobes and/or rays), spicules and a gubernaculum and telamon that are often not highly developed. Female worms have a median or posterior vulva, sometimes with a sphincter, and they are oviparous (releasing eggs) or ovoviviparous (releasing larvae). Many species have direct cycles involving the ingestion of infective larvae, while others have indirect cycles involving the ingestion of larvae in invertebrate intermediate hosts, and sometimes paratenic hosts. Eight metastrongyline families are recognised: Metastrongylidae (mouth with 2 large lateral trilobed lips, bursa with large lateral lobes and reduced dorsal lobe, oviparous, indirect cycle, earthworms used as intermediate hosts, 1 genus in lungs of suids); Angiostrongylidae (mouth with or without lips, bursa well-developed, oviparous, ovoviviparous, indirect cycle, gastropods used as intermediate hosts, 28 genera in respiratory and vascular systems of marsupials, rodents, insectivores, lemurs, mustelids, viverrids, felids and canids); Dictyocaulidae (mouth small, bursa with large lateral lobes and large dorsal lobe (divided to base), ovoviviparous, direct cycle, 2 genera in airways of ruminants and horses); Filaroididae (mouth small, bursa absent or reduced (rays reduced to papillae), ovoviviparous, direct cycle, 4 genera in respiratory system of canids, mustelids, pinnipeds, primates, and marsupials); Protostrongylidae (mouth small, bursa with large lateral lobes and prominent dorsal lobe, highly developed gubernaculum and telamon, oviparous, indirect cycle, molluscs used as intermediate hosts, 17 genera in lungs of ruminants, felids, canids, leporids, and skeletal muscles and central nervous system of cervids); Pseudaliidae (mouth small, bursa reduced (rays fused but not reduced to papillae), ovoviviparous, direct cycle, 7 genera in respiratory, auditory, circulatory systems of delphinids, phocoenids, monodontids and mongoose); Skrjabingylidae (mouth small, bursa modified to form lateral fleshy lobes, ovoviviparous, direct cycle, 1 genus in nasal cavities of mustelids); and Crenosomatidae (mouth small, bursa with large lateral lobes and large dorsal lobe (not divided to base), ovoviviparous, direct cycle, 5 genera in respiratory system of canids, felids, pinnipeds, soricids and marsupials). Genera covered in this resource are tabulated below:

Genus	No. spp.	Definitive Hosts	Location	Adult worms	Worm larvae
Angiostrongylidae					
Aelurostrongylus (lungworm)	5	carnivores	lungs	4-10 mm long, small buccal capsule, short club-shaped oesophagus, indirect cycle, eggs laid in lungs, swallowed, L1 voided, L3 develop in snail IH, then in small mollusc-eating PH	300-400 µm, dorsal spine
Angiostrongylus (lungworm)	15	carnivores, rodents	lungs, blood vessels	14-34 mm long, small buccal capsule dorsally hooked, indirect cycle, eggs laid in tissues travel to lungs, swallowed, L1 voided, L3 develop in snail IH, then small mollusc-eating PH	310-400 µm, long narrow buccal chamber
Parastrongylus (lungworm)	12	rodents, primates	pulmonary arteries	10-42 mm long, vestigial buccal capsule, indirect cycle, eggs laid in vessels enter lungs, swallowed, L1 voided, L3 develop in snail IH, then small mollusc-eating PH	250-300 µm, sheathed

The family Angiostrongylidae contains 28 genera (*Aelurostrongylus, Andersonstrongylus, Angiocaulus, Angiostrongylus, Antechinostrongylus, Cercogylus, Chabaudistrongylus, Cosmostrongylus, Didelpostrongylus, Filostrongylus, Gallegostrongylus, Glirovyngylus, Gurltia, Heterostrongylus, Madafilaroides, Madangiostrongylus, Malayometastrongylus, Marsupostrongylus, Parastrongylus, Procyonostrongylus, Pulmostrongylus, Rauschivyngylus, Rodentocaulus, Sobolevingylus, Stefanskostrongylus, Thaistrongylus, Trilobostrongylus, Viverrostrongylus*) parasitic in the respiratory and vascular systems of Australian and South American marsupials, insectivores, rodents, felids, mustelids, viverrids, canids and lemurs. The genus *Aelurostrongylus* contains worms whose males have a reduced bursa and an undivided dorsal ray, no gubernaculum, stout arcuate spicules, and females with subterminal vulva and anus. Five species have been described from the lungs of felids, mustelids and rodents; and assigned to 2 subgenera on the basis of egg development: *A.* (*Aelurostrongylus*) (oviparous), and *A.* (*Perostrongylus*) (ovoviviparous). The species *A. abstrusus* is cosmopolitan in distribution and primarily infects cats where it may cause chronic cough and weight loss, particularly in cats that hunt (stray, feral and wild cats). Infective larval stages develop in invertebrate intermediate hosts (snails and slugs) and they may also be carried various small vertebrates (birds, reptiles, amphibians and rodents) which act as paratenic (transport) hosts.

***Aelurostrongylus* species**	**Definitive hosts**	**Location [Clinical signs]**	**Intermediate hosts [plus Paratenic hosts (PH)]**	**Distribution**
A. abstrusus (syn. *Sytheocaulus, Strongylus pusillus, nanus*) (cat lungworm)	Carnivora: felid (cat, wild cat, jaguarundi, Eurasian lynx, snow leopard), canid (dog)	lungs [chronic cough]	Gastropoda: achatinid (*Achatina* (*Lissachatina*) *fulica*), agriolimacid (*Agriolimax* (*Deroceras*) *laevis, agrestis, columbianus, obstrusus*), arionid (*Arion circumscriptus*, *lusitanicus*), enid (*Chondrula septemdentata*), helicid (*Cepaea hortensis, Helix aspersa, cavata, Levantina cesareana, hierosolyma, Theba pisana*), helminthoglyptid (*Helminthoglypta* (*Epiphragmophora*) *arrosa*, *californiensis*, *nickliniana tzickliuliniza*), hygromiid (*Cernuella virgata*, *Helicella barbesiana*, *vestalis joppensis, Monacha syriaca*), limacid (*Limax flavus*), planorbid	worldwide

			(*Biomphalaria glabtrata*), pleurodontid (*Thelidomus aspera*), subulinid (*Rumina decollata*), zonitid (*Betinella nitellina*) [plus PH: Rodentia: murid (mouse, striped field mouse); Anseriformes: anatid (duck); Galliformes: phasianid (chicken); Passeriformes: passerid (sparrow); Insecta: blattid (American cockroach); Anura (frog?, toad?); Serpentes (snake?); Sauria (lizard?)]	
A. dubosti (syn. *Stefanskostrongylus*)	Afrosoricida: potamogalid (giant otter shrew)			Africa
A. falciformis	Carnivora: mustelid (European badger)			Europe
A. pridhami	Carnivora: mustelid (European mink, American mink, European badger, stoat), canid (red fox)			Europe, North America
A. pottoi	Afrosoricida: tenrecid (web-footed tenrec)			Madagascar

Parasite morphology: *Aelurostrongylus* spp. form 3 different types of developmental stages: eggs; larvae (4 consecutive stages encoded L1-L4); and adult worms. The eggs are ovoid-ellipsoid in shape measuring from 63-84 x 54-70 µm and contain a central developing embryo surrounded by a thin delicate eggshell. L1 are active cylindrical forms measuring 300-400 x 18-20 µm enclosed by a cuticle covered with fine transverse striations. They have a rounded head, a simple mouth opening surrounded by 6 papillae, a rhabditiform (bulbed) oesophagus extending 33-50% the length of the body, and an undulating S-shaped (kinked) tail with distinct notches and a subterminal dorsal spine. Subsequent larval stages are similar in appearance but are larger (L2 measuring 380-480 x 28-36 µm, L3 450-530 x 26-30 µm, L4 700-880 x 35-45 µm) and their tails have lost their caudal notches and spines. L2 and L3 sometimes appear ensheathed within the cuticles of the preceding stages, but the sheaths are shed during the infection process. Adults are thin elongate brown worms measuring 4-10 mm in length and they have cuticles with longitudinal ridges (synlophe present), rounded heads with small buccal capsules, short club-shaped oesophagi, and tapering tails. Mature worms are sexually dimorphic, with male worms being smaller than females (4-7 x 0.07 mm cf. 9-10 x 0.05-0.08 mm). Males have a significantly reduced caudal bursa without distinct lobes but with visible supporting rays, a gubernaculum with a raised central section and lateral channel, and short stout spicules appearing as curved striated rods 100-130 µm long. Females are didelphic with 2 ovaries and uteri in a prodelphic configuration (parallel and anteriorly directed) connected to a common posterior vulva, sometimes with a prominent sphincter. Mature females are oviparous and produce eggs at various stages of embryonation depending on species.

Site of infection: Adult worms infect pulmonary alveoli, alveolar ducts and the terminal respiratory bronchioles in the lungs of their vertebrate definitive hosts (mainly carnivores). Infective larvae (L3) form in the tissues of invertebrate intermediate hosts (gastropods) and they may also encyst in the viscera of small vertebrate paratenic (transport) hosts (rodents, birds, frogs, lizards, snakes).

Pathogenesis: While infections are relatively common, particularly in cats, they often remain asymptomatic or subclinical although prolonged exposure may cause a chronic respiratory syndrome, especially in stray cats. The severity of disease depends primarily on parasite virulence, host susceptibility and the intensity of infection. Infective larvae migrate into the lungs, adult worms develop in the small airways and produce eggs which lodge in tissues releasing larvae which migrate out of the lungs. Parasites therefore cause traumatic damage and airway occlusion, exacerbated by strong host inflammatory responses with lesion formation in alveoli, bronchioles and local arteries. Pulmonary arteries may show disrupted endothelia as early as 10 days after infection and severe pulmonary disease may develop over 5-15 weeks with many vessels becoming occluded by 24 weeks due to hypertrophy and hyperplasia of intimal and medial layers. Obstructions and lesions in the alveoli and bronchioles may result in nodular pneumonia, bronchiolitis, peribronchiolitis and compensatory emphysema. Nodules appear as grey raised subpleural lesions 1-10 mm in diameter, which may coalesce producing large foci and confluent areas of consolidation, and even calcify in chronic infections. Clinical signs include coughing and sneezing with a mucopurulent nasal discharge, progressive dyspnoea with production of reddish

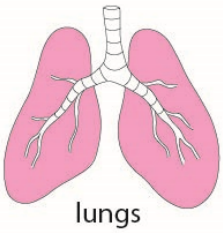
mucoid sputum, tachypnoea with rapid open-mouth abdominal breathing, bronchial crackles and heart murmur (on auscultation), loss of appetite, anorexia, weight loss, adynamia (lack of strength/vigour) and death.

Developmental cycle and mode of transmission: *Aelurostrongylus* spp. have indirect heteroxenous life-cycles involving the formation of adult worms in vertebrate definitive hosts (carnivores) and the development of infective larvae in invertebrate intermediate hosts (gastropods) and sometimes their carriage in small vertebrate paratenic hosts (rodents, birds, reptiles, amphibians). Female worms lay eggs in the lungs where they embryonate and hatch releasing L1 (eggs deeply embedded in the parenchyma form ducts for larval release). The L1 than move up the mucociliary escalator to the trachea where they are swallowed and excreted in host faeces. Larval production and excretion is often sporadic, but they may remain viable in moist soils for up to 4 weeks. Terrestrial snails and slugs become infected when L1 penetrate foot tissues where they moult twice and form infective L3 which may survive for up to 2 years. The gastropods thus act as obligate intermediate hosts as they are required for larval development. If infected gastropods are eaten by some small vertebrates (birds, rodents, frogs, lizards, snakes), the L3 may invade their viscera and encyst surviving for up to 3 months. These hosts thus act as opportunistic or facultative paratenic (transport) hosts as the parasites are simply carried without undergoing further development. Definitive hosts become infected when they ingest infective L3 contained in the tissues of prey animals, usually paratenic hosts and sometimes intermediate hosts. Ingested L3 penetrate the intestinal mucosa and migrate to the lungs via the bloodstream or lymphatics where they moult twice and grow to adults in alveoli and bronchioles in 8-9 days. Following maturation and mating, female worms begin to lay eggs as early as 25 days after infection. The prepatent period (time from infection to first larval excretion) ranges from 28-42 days, peaking around 3 months but persisting for 6-9 months.

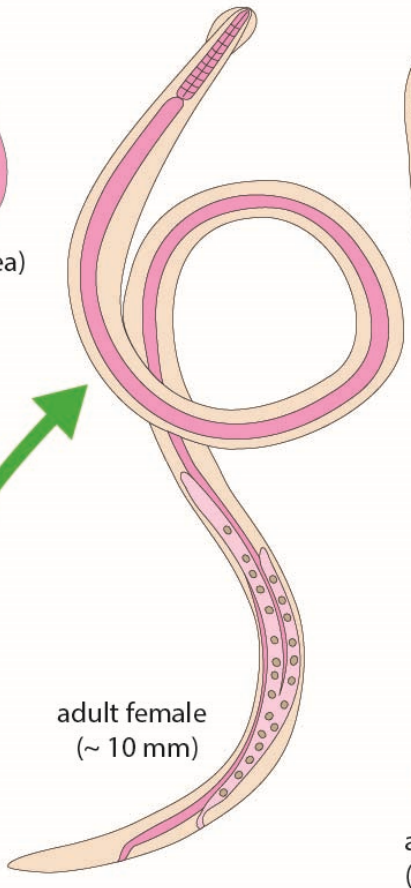
Differential diagnosis: While pulmonary signs may be suggestive of infection, particularly in animals deemed to be most susceptible (e.g. wild or stray felids), most clinical signs are non-specific and may be related to other respiratory conditions. Medical imaging techniques (X-rays and computed tomography (CT) scans) may reveal diffuse broncho-interstitial and patchy alveolar pulmonary patterns due to cellular infiltrations and nodule formation around parasites, sometimes with pleural effusions and thickening. Infections are generally confirmed by the microscopic detection of characteristic L1 (S-shaped tail with subterminal spine) either in faecal samples (smears, floats, or Baermann filtrates) or airway cytology samples (pharyngeal swabs, tracheal washings, bronchoalveolar lavages). Infections may also be diagnosed at necropsy by the detection of nodular pneumonia with multiple small grey foci or larger consolidated granulomas, but recovering the tightly coiled worms from lesions is difficult. Immunoserological tests (enzyme immunoassays) have been developed to detect specific host antibodies against worm antigens, but some cross-reactivity was found with other nematode infections. Molecular biological techniques have been used to examine phylogenetic relationships between various lungworm species following the polymerase chain reaction (PCR) amplification and sequencing of nuclear genes (internal transcribed spacer regions of ribosomal RNA).

Treatment and control: Clinical infections have been treated with variable success with several anthelmintics: including benzimidazoles (fenbendazole), macrocyclic lactones (ivermectin, moxidectin, selamectin), isoquinolines (praziquantel) and depsipeptides (emodepside); with some reports claiming complete eradication while others noted the cessation of larval excretion for 2 weeks but its resumption thereafter. Supportive therapy with bronchodilators and corticosteroids was also necessary in many instances to aid respiration and ameliorate host inflammatory reactions to dying and dead parasites. Efforts made to curb transmission by restricting contact between predatory definitive hosts and their smaller prey (particularly paratenic hosts but also including intermediate hosts) may be suitable in domestic urban situations, but are difficult to implement in peri-urban, rural or wild populations. Nevertheless, molluscicides and gravel barriers may be used to reduce gastropod populations in small communal areas, baiting and trapping may be used to control rodent populations, vertebrate pest agencies may be employed to gather feral or stray animals, and free-ranging hosts should be confined or prevented from hunting.

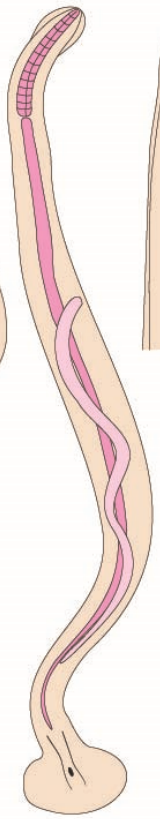
Aelurostrongylus



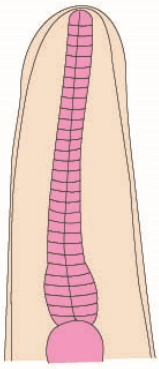
lungs
(nodules, dyspnoea)



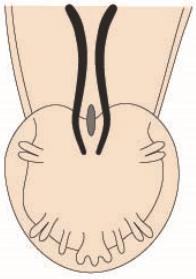
adult female
(~ 10 mm)



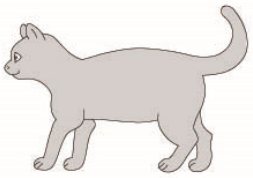
adult male
(~ 6 mm)



head



male tail



Definitive Hosts
(carnivores)

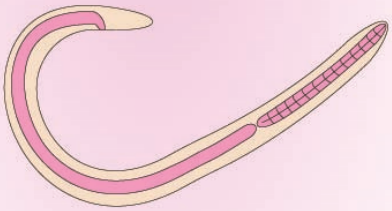
PH/IH
ingested

L1
excreted
in faeces

eggs hatch in host

IH

external
environment



third-stage larvae (L3)
(~ 600 µm)

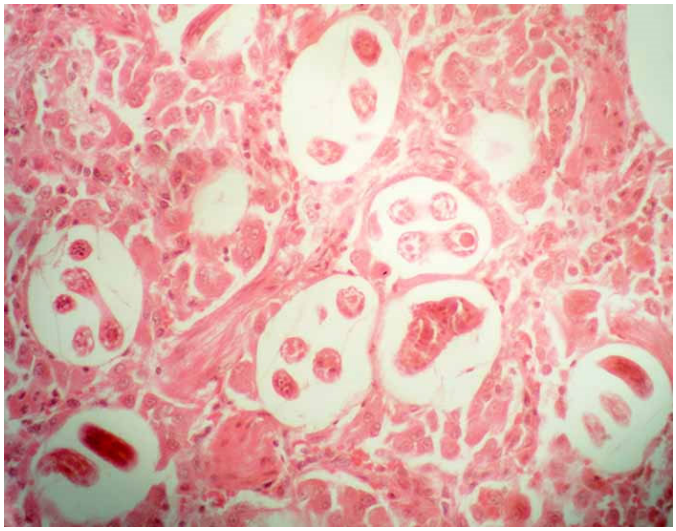
first-stage larvae (L1)
(~ 400 µm)

Paratenic Hosts (PH)
(birds, rodents, reptiles)
(viscera)

L1 ingested
or penetrate
gastropod

Intermediate Hosts (IH)
(pulmonate snails/slugs)
(internal tissues/sinuses)

Aelurostrongylus larva



Aelurostrongylus lung lesion