

## *Amoebotaenia*

(platyhelminth: cestode)

### Overview

Platyhelminths have triploblastic acoelomate soft bodies which are markedly flattened in profile (hence their common name as flatworms). They undergo protostomial embryonic development but do not moult during growth. On the basis of molecular evidence, they are classified within the Lophotrochozoa despite the absence of lophophore mouthparts and trochophore larvae. Three classes are composed entirely of parasitic flatworms (Cestoda, Trematoda and Monogenea), which have prominent attachment organs (suckers or bothria), syncytial teguments, shell glands and vitellaria involved in ectolecithal egg development, and life-cycles involving a variety of larval stages. Cestodes (tapeworms) have elongate ribbon-like bodies ranging from a few millimetres to several metres in length. Cyclophyllidean tapeworms are usually intestinal parasites of terrestrial vertebrates and have an anterior scolex (hold-fast organ with suckers and sometimes hooks) and a posterior tape (strobila) made up of segments (proglottids). Adult worms lack a gut (they absorb nutrients) and they are hermaphroditic (segments containing both male and female reproductive organs). Eucestodes have indirect life-cycles involving oncospheres (hexacanth embryos) released from ingested eggs to form encysted larval stages (metacestodes) in the tissues of intermediate hosts and their transmission to definitive hosts by predation. Adult dilepidids usually have an armed rostellum and are parasitic in poultry but are rarely pathogenic. The encysted larval stages (cysticercoids) of *Amoebotaenia* spp. occur in earthworms which are consumed during foraging.

### 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: Lophotrochozoa (lophophore feeding structure or trochophore larva or neither)

Phylum: Platyhelminthes (flatworms, acoelomate, most hermaphroditic, prominent attachment organs)

Clade: Neodermata (syncytial tegument = neodermis)

Class: Cestoda (tapeworms, gut absent, anterior scolex, proglottid segments, heteroxenous, predator-prey cycles)

Subclass: Eucestoda (larvae hexacanth (with six hooks))

Order: Cyclophyllidea (terrestrial species, scolex with four suckers, often bearing hooks, eggs release oncospheres)

Family: Dilepididae (tapeworms of dog/cat and fowl, scolex usually armed, genital pores alternate, some with paired genitalia, cysticercoid larva)

Genus: *Amoebotaenia* (parasitic in small intestines of birds)

Species: various species cause infections in chickens

**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 do not moult during their life-cycles are grouped together in the enigmatic clade Lophotrochozoa, including the platyhelminths, rotifers, lophophorates, annelids and molluscs. Platyhelminths (flatworms) have soft acoelomate flat bodies with three-dimensional arrays of muscles that generate a typical writhing motion (cf. longitudinal muscles in nematodes producing a thrashing motion). Flatworms do not have a single unifying characteristic (synapomorphy) but comprise diverse free-living (most Turbellaria) and parasitic (Neodermata) assemblages. Neodermata have non-ciliated syncytial (multinucleate) teguments and 3 classes are recognized, all with prominent attachment organs, namely, Cestoda with anterior bothridia/bothria (true/false suckers), Trematoda with oral and ventral suckers (acetabula), and Monogenea with posterior haptors (opisthaptors). All have shell glands surrounding the ootype, and most exhibit ectolecithal egg development (yolk not present in egg but secreted by accessory glands called vitellaria or yolk glands). Most have indirect life-cycles involving the development of adult worms in vertebrates and larval stages in intermediate hosts (usually invertebrates).

The cestodes (or tapeworms) lack digestive tracts and have elongate ribbon-like bodies (strobila); most being polyzoic (segmented) divided internally and/or externally into proglottids, although some are monozoic (unsegmented). Serial proglottids may be craspedote (overlapping) or acraspedote. Proglottids are generally hermaphroditic, possessing both male and female reproductive organs (those in which the male system matures first are protandrous, those in which the female system matures first are progynous). Terminal proglottids may detach from the strobila when they are immature (hyperapolytic), mature (euapolytic) or gravid (apolytic), or remain attached until they degenerate (anapolytic). Cestodes possess remarkable anterior attachment organs on the head (scolex): many divided into 4 membrane-bound muscular acetabula evident as suckers or bothridia (stalked, fused or bearing loculi); others bearing two weakly muscular bothria; some possessing a simple apical funnel (monobothriate); and some with a complex apical organ or rostellum that may be retractable, armed with hooks or bearing tentacles. Fertile tapeworms produce

eggs in which larval stages develop as non-ciliated oncospheres or ciliated coracidia or lycophores. These stages possess 6 or 10 hooks which they use to invade the tissues of intermediate hosts where they form encysted metacestode stages: either alacunate forms (proceroid with tail-like cercomer, plerocercus with retracted scolex, plerocercoid with an everted scolex, or merocercoid with an invaginated scolex) or lacunate forms (cysticercoid with cercomer and a retracted scolex, or cysticercus with an invaginated scolex). Two main cestode subclasses are recognized: Cestodaria with decacanth larvae (with 10 hooks) and Eucestoda with hexacanth larvae (with 6 hooks). The Eucestoda are divided into 17 orders on the basis of many morphological and biological differences, many groups being well supported by contemporary molecular characterization studies. Acetabulate orders (with bothridia) include Lecaniccephalidea, Tetrphyllidea, Proteocephalidea, Cyclophyllidea, Tetrabothriidea, Phyllobothriidea and Rhinebothriidea; those bearing bothria include Bothriocephalidea, Caryophyllidea, Diphyllidea, Diphyllbothriidea, Haplobothriidea, Spathebothriidea and Trypanorhyncha; while others with apical pads/suckers include Cathetocephalidea, Litobothriidea and Nippotaeniidea.

Order (+ no. families)	No. spp.	DH <sup>a</sup>	Scolex	IH1 <sup>b</sup>	Stage <sup>d</sup>	IH2 <sup>c</sup>	Stage <sup>d</sup>
Class: <b>Cestoda</b> (tapeworms, without gut, monoecious, endoparasites, heteroxenous, predator-prey cycles)							
monozoic (unsegmented)							
Subclass: Cestodaria (adult lacking scolex, larvae decacanth (with 10 hooks))							
Gyrocotylidea (1)	10	F,S,L	muscular sucker-like organ	-	-	-	-
Amphilinidea (1)	8	F,P	muscular proboscis, or absent	C	pro	-	-
Subclass: Eucestoda ('true' tapeworms, adult with variable scolex; larvae hexacanth (with six hooks))							
Caryophyllidea (4)	122	F	acetabula, loculi, bothria, apical disc or polymorphic	W	pro		
polyzoic (segmented)							
Cathetocephalidea (1)	6	S	apical pad, papillary band				
Diphyllidea (2)	59	S,R	2 bothria; armed rostellum	C,L	ple		
Trypanorhyncha (16)	315	S,R	2 or 4 bothria, 4 tentacles	C	pro	F,C,L	ple, plc
Litobothriidea (1)	9	S	apical sucker, 3-5 segments				
Lecaniccephalidea (3)	90	S,R	4 suckers or bothridia, and apical structure or tentacles	C,L,F	pro		
Rhinebothriidea (4)	136	R	4 stalked loculate bothridia	C	pro	F	ple
"Tetrphyllidea" relics (6)	104	S,R,M	4 stalked bothridia	C	pro	F,L,C, M	ple, mer
Spathebothriidea (4)	6	F	undifferentiated or 1-2 bothria	C	ple		
Haplobothriidea (1)	2	F	club-shaped, tentacles, bothria	C	pro	F	ple
Bothriocephalidea (7)	132	F,A	2 bothria	C	pro	F	ple
Nippotaeniidea (1)	6	F	single sucker	C			
Tetrabothriidea (1)	70	B,M	4 muscular bothridia	C,F			
Phyllobothriidea (1)	69	S,R	unarmed bothridia, apical suckers	C,F	ple		
Oncoproteocephalidea (2)	562	F,A,P,S,R	4 loculate bothridia, rostellum	C	pro	F	ple
Diphyllbothriidea (6) (= Pseudophyllidea)	70	M,B,P,A	2 shallow bothria, unarmed	C	pro	F,A,P, M	ple
Cyclophyllidea (16) (incl. Mesocestoididae)	3,034	M,B,P	4 suckers, rostellum, often armed	M,A,B, L,T,I	ccc, ccs	-	-
LEGEND							
<sup>a</sup> DH = definitive host; <sup>b</sup> IH1 = first intermediate host; <sup>c</sup> IH2 = second intermediate host;							
[A = amphibian; B = bird; C = crustacean; F = teleost; I = insect; L = mollusc; M = mammal, P = reptile; R = ray; S = shark; T = acarine; W = annelid];							
<sup>d</sup> Metacestode: pro = proceroid, plc = plerocercus; ple = plerocercoid, mer = merocercoid; ccc = cysticercoid; ccs = cysticercus, coenurus, strobilocercus or hydatid cyst							

Cyclophyllidean cestodes are polyzoic containing from 2 to > 1,000 proglottids demarcated by external segmentation. They possess an anterior scolex with 4 suckers, many with a rostellum (often armed), and they have compact post-ovarian vitellaria. Adult worms are found in terrestrial vertebrate definitive hosts (mammals, birds, reptiles, amphibians) while larval metacestodes occur in vertebrate (mammal, amphibian, bird) or invertebrate (mollusc, acari, insect) intermediate hosts. Over 3,000 species have been described in 400 genera in 16 families: Acoleidae, Amabiliidae, Anoplocephalidae, Catenotaeniidae, Davaineidae, Dioecocestidae, Dilepididae, Dipylidiidae, Gyrporhynchidae, Hymenolepididae, Mesocestoididae, Metadileptidae, Nematotaeniidae, Paruterinidae, Progynotaeniidae, and Taeniidae (all with lateral genital pores, except the Mesocestoididae).

Over 120 dilepidid genera have been described as intestinal parasites of birds and some carnivores. Adult tapeworms usually possess an armed scolex and the genital pores alternate in their lateral location on consecutive proglottids. Larval stages (cysticercoids) are formed in invertebrate intermediate hosts which are ingested when the definitive hosts feed. The genus

*Amoebotaenia* contains over 20 species mostly parasitizing wild and domestic birds throughout the world, including chickens, turkeys, pheasant and quail. Cysticeroid stages have been recorded in a diverse range of insects (flies, locusts, ants, termites) and annelids (earthworms).

<i>Amoebotaenia</i> species	Definitive host (DH) [adults in small intestines]	Intermediate hosts (IH) [cysticeroids in tissues]	Distribution
<i>A. aveeki</i>	Passeriformes: leiothrichid (white-crested laughingthrush)		India
<i>A. awogera</i>	Piciformes: picid (Japanese green woodpecker)		Japan
<i>A. bhonslei</i>	Galliformes: phasianid (chicken)		India
<i>A. bhujangi</i>	Charadriiformes: charadriid (yellow-wattled lapwing)		India
<i>A. brevis</i> (syn. <i>Nototaenia</i> )	Charadriiformes: charadriid (European golden plover, black-bellied plover, common ringed plover)		Europe, North America
<i>A. cohni</i>	Galliformes: phasianid (chicken)		India
<i>A. cuneata</i> (syn. <i>A. sphenoides</i> )	Columbiformes: columbid (pigeon); Galliformes: phasianid (chicken); Charadriiformes: charadriid (lapwing)	Oligochaeta: lumbricid ( <i>Allolobophora (Eisenia) foetida</i> , <i>Lumbericus</i> , <i>Allotophora?</i> ), megascolecid ( <i>Pheretima peguana</i> ), ocnodrilid ( <i>Ocnodrilus (Ilyogenia) africana</i> )	worldwide
<i>A. domesticus</i>	Galliformes: phasianid (chicken)		India
<i>A. fragida</i>	Galliformes: phasianid (chicken)		Egypt
<i>A. fuhrmanni</i>	Charadriiformes: scolopacid (snipe)		China
<i>A. gallusae</i>	Galliformes: phasianid (chicken)		India
<i>A. indiana</i>	Galliformes: phasianid (chicken, grey francolin)		India
<i>A. jadhavae</i>	Galliformes: phasianid (chicken)		India
<i>A. kharati</i>	Galliformes: phasianid (chicken)		India
<i>A. lini</i>	Charadriiformes: scolopacid (Eurasian woodcock)		Asia
<i>A. longisacculus</i>	Galliformes: phasianid (chicken)		Indonesia
<i>A. madrasiensis</i>	Passeriformes: passerid (house sparrow)		India
<i>A. maharashtrii</i>	Galliformes: phasianid (chicken, grey francolin)		India
<i>A. megascolesis</i>	Galliformes: phasianid (chicken, grey francolin)		India
<i>A. minuta</i>	Charadriiformes: charadriid (yellow-wattled lapwing)		India
<i>A. mohekarae</i>	Galliformes: phasianid (chicken)		India
<i>A. oligorchis</i>	Galliformes: phasianid (chicken)		Japan
<i>A. pekinensis</i>	Charadriiformes: charadriid (oriental plover)		China
<i>A. prabhuravii</i>	Galliformes: phasianid (chicken)		India
<i>A. scolopax</i>	Charadriiformes: scolopacid (Eurasian woodcock)		Asia
<i>A. soyagaonensis</i>	Galliformes: phasianid (chicken)		India
<i>A. spinosa</i>	Galliformes: phasianid (chicken)		Indonesia
<i>A. urotrichi</i>	Eulipotyphla: talpid (Japanese shrew mole)		Japan
<b>Reassigned species</b>			
<i>A. lumbrici</i> (now <i>Paricterotaenia</i> )	Eulipotyphla: talpid (European mole), soricid (common shrew)		Eurasia

**Parasite morphology:** *Amoebotaenia* spp. form 3 different stages in their developmental cycles: eggs, larval metacestodes (cysticeroids) and adult tapeworms. Eggs are almost spherical measuring from 35-45 µm in diameter and they contain a nonciliated hexacanth (6 hooked) embryo (oncosphere) surrounded by a non-striated shell (embryophore) and a delicate membrane. Cysticeroids are lacunate (with internal cavity) and possess a retracted (not invaginated) scolex and a tail-like cercomer. Adult tapeworms are small and triangular measuring only 1-4 mm long and usually containing 20-30 proglottids, which are wider than long. They have an anterior scolex with 4 unarmed suckers surmounted by a small retractable rostellum armed with 12-14 hooks in a single row. Adult worms are hermaphroditic and each segment possesses one set of male and female reproductive organs with a common genital pore located laterally at the anterior end of the proglottid margin. Those of consecutive segments alternate sides irregularly. Each proglottid contains 12-20 testes and a sac-like slightly-lobed uterus. Reproductive organs become more mature in

posterior segments which become larger in size (thus contributing to the triangular shape of the worm). Gravid segments are shed from the posterior end of the worm and passed in host faeces.

**Site of infection:** Adult *Amoebotaenia* tapeworms are found in the small intestines of a range of birds, particularly in galliform birds. Larval stages (cysticercoids) develop in the body cavities and tissues of invertebrate intermediate hosts, notably earthworms.

**Pathogenesis:** Most infections by *Amoebotaenia* are asymptomatic or subclinical as the tapeworms do not feed on host tissues but absorb nutrients from the gut lumen. Nonetheless, this competition for food may result in low feed conversion efficiency and reduced production parameters, including retarded growth, reduced weight gain and decreased egg production. Heavy infections may cause clinical signs, including enteritis (sometimes haemorrhagic), anorexia, weight loss, apathy and depression. Histopathological changes include vacuolation of epithelial cells, catarrhal enteritis, congestion of submucosal glands, granuloma formation, desquamation of villi and villous atrophy. Heavy infections also appear to lower host resistance to other infectious agents.

**Developmental cycle and mode of transmission:** These dilepidid tapeworms have indirect heteroxenous life-cycles involving cyclic transmission between avian definitive hosts (harbouring adult tapeworms) and annelid intermediate hosts (infected with larval stages). Gravid proglottids containing eggs are shed with bird faeces into the external environment. The proglottids are motile and move into the surrounding vegetation and soil. Earthworms ingest the gravid segments which are digested in the gut thereby releasing the eggs. The eggs then hatch releasing the contained oncospheres which actively migrate through host tissues into the body cavity of the earthworms. Here they develop into infective cysticercoids within 14 days. Birds ingest infected earthworms which become digested releasing the cysticercoids which attach to the gut wall and develop into adult tapeworms. The prepatent period (time between infection and shedding of first eggs) is around 4 weeks, and adult tapeworms live for around a year. Infections in domestic poultry are common in tropical regions, especially where housing and husbandry practices are poor and climatic conditions are favorable for parasite survival. Frequently, poultry become infected after moderate-heavy rainfall which draws earthworms towards the soil surface and facilitates their easier predation by birds. Various seasonal patterns of infection have been reported around the world.

**Differential diagnosis:** Infections are usually diagnosed by the direct detection of gravid segments in bird faeces, but the dropping must be fresh as the proglottids rapidly migrate out into the surrounding environment. Faecal concentration techniques (sedimentation and/or floatation) rarely detect free *Amoebotaenia* eggs as they remain inside gravid segments. Adult tapeworms may be detected at post-mortem after dissecting the gut and examining the mucosa for attached worms.

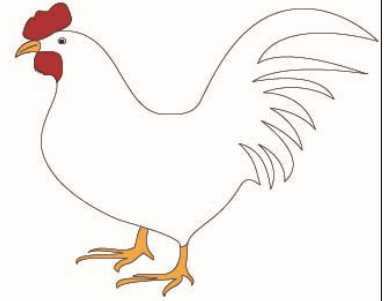
**Treatment and control:** Individual birds or flocks at risk may be treated for infections using broad spectrum anthelmintics effective against cestodes (including benzimidazoles (albendazole, febantel, fenbendazole, mebendazole, oxfendazole), halogenated phenols (hexachlorophene) or halogenated hydrocarbons (butynorate)) or specific cestodicides (niclosamide, praziquantel). Most drugs are available as additives for drinking water or feed, but careful attention should be given to any contra-indications (e.g. niclosamide is toxic for geese, praziquantel plus pyrantel tartrate is toxic for chickens). Some measure of parasite control may also be afforded in domestic flocks or aviaries by improving bird housing conditions (especially by eliminating earthen floors), frequently changing litter and bedding materials, sanitary disposal of faecal material, and restricting bird foraging behaviours for earthworms (particularly after rainfall). Few of these options are available for managing infections in wild bird populations, and any efforts to reduce earthworm populations should be discouraged for ecological reasons.

# Amoebotaenia



intestines  
(rarely enteritis,  
anorexia, depression)

hermaphroditic  
adults  
(~ 1-4 mm)



Definitive Hosts  
(birds, esp.  
galliforms)

mature  
proglottid

gravid  
proglottid

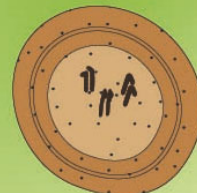
transmission  
through  
ingestion  
of infected  
worms

excretion  
of eggs in  
faeces

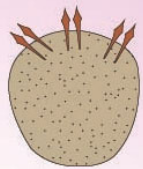


cysticercoid  
(~ 150  $\mu$ m)

external  
environment



egg  
(~ 40  $\mu$ m)



oncosphere  
(~ 40  $\mu$ m)



Intermediate Hosts  
(earthworms)  
(body cavity)



*Amoebotaenia* adult worm