

Cochlosoma

(protist: flagellate)

Overview

Protists are single-celled organisms with membrane-bound nuclei (eukaryotes). Flagellates are protists that swim using one or more flagella (undulipodia); each arising from a small centriole (basal body, kinetosome) and having a microtubular axoneme core (2+9 configuration). Rather than forming a monophyletic group, flagellates are divided into several disparate groups: metamonads (amitochondriate flagellates), heteroloboseans (amoebflagellates), euglenozoans (euglenids and kinetoplastids), stramenopiles (heterokonts), alveolates (dinoflagellates) and cercozoans (biflagellates). The metamonads comprise fornicates (diplomonads), parabasalians (trichomonads, hypermastigids, retortamonads) and preaxostylans (oxymonads). Parabasalid flagellates have conspicuous parabasal bodies which have been shown to be dictyosomes (Golgi bodies) connected by striated fibres to the flagellar basal body. Hypermastigids (cristamonads) have multiple flagella arranged in tufts, plates or rows, including the trichomonads which have a tuft of anterior flagella plus a recurrent flagellum free or associated with the cell body forming an undulating membrane. Most *Cochlosoma* species are parasitic in the intestines of birds and the trophozoites have an anterior adhesive disc, lateral grooves and the mastigont system comprises six flagella, an axostyle and a parabasal body.

Classification:

- Domain: Eukaryota (membrane-bound nucleus)
- Supergroup: Excavata (with conspicuous ventral feeding groove)
- Group: Metamonad (amitochondriate flagellates with karyomastigonts)
- Phylum: Parabasalia (anaerobic flagellates with parabasal body supporting Golgi cisternae or dictyosome, trichomonads, hypermastigids, retortamonads)
- Class: Trichomonadea (single mastigont, comb-like structure absent, infrakinetosomal body absent)
- Order: Trichomonadida (lamelliform undulating membrane, B-type costa)
- Family: Trichomonadidae (5-6 flagella, cone-like axostyle)
- Genus: *Cochlosoma* (parasitic in intestines of birds)
- Species: various species cause enteritis in birds

Parasite biodiversity and host range: Protists are unicellular eukaryotes that move using undulipodia (flagella or cilia), pseudopodia (false-feet) or a unique gliding motion. Flagellated species have one or more flagella with an internal microtubular core (in a characteristic 2+9 configuration comprising 2 single central microtubules and 9 peripheral doublets) anchored to a submembranous protein structure (known variously as a centriole, basal body, kinetosome or blepharoplast). Many types of flagellated cells have been described and recent phylogenetic studies have classified them into several disparate groups: including the metamonads (amitochondriate flagellates), heteroloboseans (amoebflagellates), euglenozoans (euglenids and kinetoplastids), stramenopiles (heterokonts), alveolates (dinoflagellates) and cercozoans (biflagellates). While most flagellated protists are free-living organisms swimming and feeding in aquatic environments, representatives of several groups have developed symbiotic relationships with various hosts; some being endoparasitic in vertebrates (notably anaerobic metamonads in tubular organs, and heterotrophic euglenozoans occurring in blood or tissues), and some being parasitic in invertebrates (alveolates in crustacean tissues) (representatives tabulated below).

Higher taxonomy	Class or order	Family	Genera	Hosts (tissues)	Transmission*
Supergroup: Excavata (with conspicuous ventral feeding groove)					
Group: Metamonad (amitochondriate flagellates with karyomastigonts)					
Phylum: Fornicata (diplomonads)	Order: Diplomonadida (1-2 karyomastigonts)	Hexamitidae (2 karyomastigonts with binary axial symmetry)	<i>Giardia</i>	vertebrates (gut)	direct (f-o)
			<i>Hexamita</i> <i>Spironucleus</i>	vertebrates (tissues)	direct (f-o, w)
Phylum: Parabasalia (with parabasal body)	Order: Trichomonadida (3-5 anterior flagella plus recurrent flagellum)	Monocercomonadidae (costa absent, most without undulating membrane)	<i>Histomonas</i>	birds (gut, liver)	direct (f-o)
			<i>Dientamoeba</i>	vertebrates (gut)	direct (f-o)
		Trichomonadidae (stout axostyle, costa, undulating membrane)	<i>Trichomonas</i>	vertebrates (urogenital tract, gut)	direct (f-o, v)
		Cochlosomatidae (anterior adhesive disc)	<i>Cochlosoma</i>	birds (gut)	direct (f-o)

Group: Discoba (diverse group supported robustly by molecular studies)					
Phylum: Euglenozoa (flagella inserted in anterior pocket, heterotrophs, autotrophs)	Class: Kinetoplastea (heterotrophs, with extranuclear DNA (= kinetoplast) associated with mitochondrion)	Ichthyobodonidae (flagellar pocket continues as groove)	<i>Ichthyobodo</i> (= <i>Costia</i>)	fish (gills, skin)	direct (w)
		Parabodonidae (epizoic or endozoic)	<i>Cryptobia</i>	fish (gills, skin)	direct (w)
			<i>Trypanoplasma</i>	fish (blood)	indirect (v-b)
		Trypanosomatidae (monogenetic forms in insects/plants, digenetic forms in vertebrates & arthropods)	<i>Trypanosoma</i>	vertebrates (blood, tissues)	indirect (v-b)
<i>Leishmania</i>	vertebrates (blood, tissues)		indirect (v-b)		
Supergroup: SAR (Stramenopiles + Alveolata + Rhizaria) (3 groups unified by molecular studies)					
Group: Alveolata (with cortical alveoli)					
Phylum: Dinoflagellata (with unique mesokaryotic nuclei)	Order: Blastodiales (uninucleate trophonts with chloroplasts)	Oodiniaceae (trophont with rhizoid-like invasive organelle)	<i>Amyloodinium</i> <i>Crepidodinium</i> <i>Piscinoodinium</i>	fish (skin)	direct (w)
	Order: Syndiniales (multinucleate plasmodial trophonts)	Syndiniaceae (without chloroplasts)	<i>Haematodinium</i> <i>Ichthyodinium</i>	crustaceans, fish (tissues)	direct (w)
Phylum: Perkinsozoa (parasitic)	Order: Perkinsorida (released trophonts form biflagellated zoospores)	Perkinsidae (incomplete conoid)	<i>Perkinsus</i>	gastropods, bivalves (tissues)	direct (w)

*f-o = faecal-oral transmission; v-b = vector-borne transmission; w = water-borne transmission; v = venereal transmission

Metamonads are a group of excavates (with ventral feeding groove) that have several subcellular elements associated with their flagella forming a unique mastigont (an ultrastructural complex of organelles and cytoskeletal fibrils (incl. dictyosomes (Golgi bodies), centrioles (basal bodies) and a microtubular axostyle)). The metamonads comprise fornicates (diplomonads), parabasalians (trichomonads, hypermastigids, retortamonads) and preaxostylans (oxymonads). Most metamonads are amitochondriate but have retained reduced organelles of mitochondrial origin (fornicates containing mitosomes while parabasalians possess hydrogenosomes). Members of the phylum Parabasalia typically possess parabasal bodies adjacent to Golgi bodies (dictyosomes), and have microtubular arrays forming a conspicuous pelta-axostyle complex (cap-like pelta and a cone- or tube-like longitudinal axostyle). Six parabasalid classes are currently recognized on the basis of morphological, biological and molecular phylogenetic studies. Cells in three classes (Trichomonadea, Tritrichomonadea, Hypotrichomonadea) bear single mastigonts (set of kinetosomes (basal bodies) and associated appendages – ancestral unit comprising 4 kinetosomes) with flagella arranged in an anterior tuft, but many have one recurrent flagellum forming an undulating membrane (lamelliform or rail-type) supported by a costa (A- or B-type) and sometimes a basal comb-like structure and/or infrakinetosomal body. Many species are symbiotic (mutualists, commensals or parasites) in animals, although some are free-living in moist habitats. Most species have simple life cycles with longitudinal binary fission of motile-flagellated or rounded tissue-phase cells (only a few species form cysts). Cells in another three classes (Cristamonadea, Trichonymphea, Spirotrichonymphea) have more complex structures, often with multiple mastigonts bearing hundreds to thousands of flagella. Most were previously assigned to the now-defunct group Hypermastigida, and they are primarily found as symbionts (mutualists) in insects (mostly termites).

Family	Key characters to 'trichomonad' families in vertebrates*						Representative genera
	Number of flagella	Undulating membrane	Costa	Axostyle	Comb-like structure	Infra-kinetosomal body	
Class Trichomonadea (single karyomastigont)							
Order Trichomonadida (with costa) (endobiotic in vertebrates (mammals, birds, reptiles, amphibia) and invertebrates)							
Trichomonadidae	5-6	lamelliform	B-type	cone-like	absent	absent	<i>Cochlosoma</i> , <i>Trichomonas</i> , <i>Trichomitopsis</i> , <i>Tetratrichomonas</i> , <i>Pentatrichomonas</i>
Order Honigbergiellida (without costa) (endobiotic in vertebrates (mammals, reptiles, amphibia))							
Hexamastigidae	5-6	absent	absent	cone-like	absent	absent	<i>Hexamastix</i>

Class Trichomonadea (uninucleate to binucleate)							
Order Trichomonadida (endobiotic in vertebrates (mammals, birds, reptiles, amphibia, fish))							
Trichomonadidae	4-5	rail-type	A-type	tube-like	present	present	<i>Trichomonas</i>
Simplicimonidae	4	absent	absent	tube-like	present	present	<i>Simplicimonas</i>
Monocercomonidae	4	absent	absent	cone-like	present	present	<i>Monocercomonas</i>
Dientamoebidae	0-4	absent	absent	cone-like	absent	absent	<i>Dientamoeba, Histomonas</i>
Class Hypotrichomonadea (single karyomastigont)							
Order Hypotrichomonadida (endobiotic in vertebrates (reptiles, amphibia, mammals) and invertebrates)							
Hypotrichomonidae	4	lamelliform	A-type	cone-like	present	absent	<i>Trichomitus, Hypotrichomonas</i>

*Taxa found only in invertebrate hosts (such as termites and cockroaches) are not listed

The class Trichomonadea contains a diverse range of cells with single karyomastigonts giving rise to 2-6 flagella, with one being recurrent but lacking a comb-like structure and infrakinetosomal body. Two orders are recognized: Honigbergiella (undulating membrane absent or lamelliform without supporting costa); and Trichomonadida (most with lamelliform undulating membrane supported by B-type costa and stout cone-like axostyles). The family Trichomonadida contains some 10 genera (*Cochlosoma*, *Lacustera*, *Pentatrachomonas*, *Pentatrachomonoides*, *Pseudotrachomonas*, *Pseudotrypanosoma*, *Tetratrachomonas*, *Trichomitopsis*, *Trichomonas* and *Trichomonoides*) which vary in their cellular, organellar and flagellar configurations, zoogeography (host ranges), and biological characteristics (heterotrophs ranging from mutualists to commensals to parasites). The genus *Cochlosoma* contains robust conical-ovoid cells with 6 flagella, an anterior adhesive disc and lateral groove and prominent protruding axostyle. Some 5 species have been described as endoparasites in the intestines of birds and shrews, with at least one species causing enteritis in domestic poultry and waterfowl, particularly in North America.

Parasite species†	Size (µm)	Vertebrate Hosts	Location	Clinical signs	Distribution
Class: Trichomonadea (single karyomastigont) [4-6F-CLS-IKB(+CA in most genera, TA or reduced in others)]					
Order: Trichomonadida [5-6F+LUM+BC]					
Family: Trichomonadidae [+CA]					
<i>Cochlosoma</i> (anterior adhesive disc, lateral groove) [6F-UM-C+CA]					
<i>Cochlosoma anatis</i> (syn. <i>C. rostratum</i>)	6-12 x 4-7	Anseriformes: anatis (mallard, muscovy, pintail, shoveler, lesser scaup), Galliformes: phasianid (turkey, chicken)	caecum, large intestines, cloaca	enteritis, runting	worldwide
<i>Cochlosoma picae</i>	5-8 x 3-5	Passeriformes: corvid (American magpie)	cloaca		North America
<i>Cochlosoma soricis</i>	9-12 x 4-7	Eulipotyphla: soricid (vagrant shrew, American water shrew)	intestines		North America
<i>Cochlosoma striatum</i>		Galliformes: phasianid (ruffed grouse)			North America
<i>Cochlosoma turdi</i>	4-8 x 2-5	Passeriformes: turdid (American robin, incl. eastern robin)	cloaca		North America
<i>Cochlosoma</i> sp.		Galliformes: phasianid (quail), Passeriformes: fringillid (finches), estrildid (parrot-finches); Chiroptera (bats)			mostly North America

†Coding: + = present; - = absent; #F = total number of flagella; UM = undulating membrane; LUM = lamelliform undulating membrane; C = costa; BC = B-type costa; CA = cone-like axostyle (*Trichomonas*-type); TA = tube-like axostyle (*Trichomonas*-type); CLS = comb-like structure; IKB = infrakinetosomal body.

Parasite morphology: *Cochlosoma* spp. only form one developmental stage: trophic forms known as trophozoites. These small flagellated stages have asymmetrical ovoid-pyriform bodies that are broader anteriorly and narrower posteriorly. Trophozoites usually measure from 5-10 µm in length but those of some species range up to 18 µm long. The anterior end is obliquely truncated by a prominent cup-like adhesive disc from which a lateral groove extends along one side. Trophozoites are uninucleate with a single subspherical nucleus situated near the centre of the body. The anterior nucleus adjoins a prominent parabasal apparatus, consisting of a Golgi complex and a solitary parabasal fiber extending posteriad. Trophozoites possess 6 flagella which arise from the anterior end of the cell and vary in length. One flagellum is recurrent and is attached along the length of the cell body by an undulating membrane but extends free at the posterior end. The undulating membrane runs along the lateral groove and is supported by a conspicuous costa with type B periodicity. Four flagella are free and emerge anterolaterally from the lateral groove. The sixth flagellum emerges from a basal body on the dorsal side of the body, independent of the basal body complex of the other flagella. A thin axostyle originates near the anterior basal bodies and passes longitudinally through the cell protruding posteriorly. Most

Cochlosoma spp. also possess variable numbers of double membrane-bound organelles (similar to hydrogenosomes) throughout the cytoplasm (differences in type and number sometimes used to differentiate species). Several studies have noted the rare occurrence of non-flagellated ovoid stages, and while it has been suggested that they may be 'pseudocyst' stages, further confirmatory studies are required.

Site of infection: Infections by *Cochlosoma* spp. have been recorded mainly in birds and occasionally in mammals. Some 5 parasite species have been detected in over 20 species of birds belonging to 4 passerine families (corvids, estrildids, fringillids, turdids) and 2 non-passerine families (anatids, phasianids), and at least 2 species have been found in mammals (shrews and bats). Flagellates are found extracellularly within the digestive tract, particularly the large intestines, caeca and cloaca, and sometimes the small intestines. Most infections have been detected in North America, but one species (*C. anatis*) has been found worldwide.

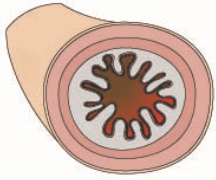
Pathogenesis: Most infections are asymptomatic, but some have been associated with outbreaks of diarrhoea in turkeys and ducks and mortalities in finches. Trophozoites may occur free in the lumen of the intestines, but they can attach themselves by suction to surface epithelia using their adhesive discs. Attachment leaves distinctive marks on host cells resulting in microscopic inflammatory lesions. This may cause catarrhal enteritis in wild and domestic turkey poults and ducklings that is characterized by the excretion of yellow-stained or moist bulky droppings with progressive dehydration, lethargy, ruffled feathers, runting and some mortalities amongst nestlings. While most infections in adult finches are subclinical, young birds are highly susceptible to severe diarrhoeal disease with high mortalities. It should also be noted that many clinical cases involve concomitant infections with other intestinal pathogens, notably coccidia, *Hexamita* and *Salmonella*, which often confounds the aetiology of disease.

Developmental cycle and mode of transmission: Observations on *Cochlosoma anatis* have revealed a simple monoxenous (one-host) life-cycle whereby trophozoites reproduce asexually by longitudinal binary fission within the host intestines. Despite the occasional reported of nonflagellated pseudocyst stages in some hosts, little is known about how parasites are transmitted from host-to-host. Studies on faecal-oral transmission have been unequivocal, but there have been reports of oral transmission by experimental inoculation suggesting young animals may become infected when fed by infected parents. Indeed, adult animals appear to be resistant to clinical infections but can act as long-term carriers. Further studies are required to demonstrate transmission cycles.

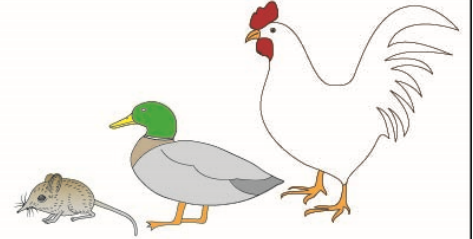
Differential diagnosis: The diagnosis of infections on clinical grounds is confounded by the nonspecificity of any signs observed as they may be caused by numerous other enteric infections and conditions. Infections are diagnosed by the direct microscopic detection and identification of motile trophozoites in fresh samples of faeces or intestinal scrapings taken soon after host death. Trophozoites may be observed swimming in a characteristic rotary (corkscrew) pattern, and are best observed using microscopic illumination systems that introduce diffraction (winding down the condenser or closing the diaphragm) or contrast (phase-contrast or interference-contrast) into fresh wet smear samples. Attempts to counter-stain or fix trophozoites in samples do not work well as the cells rapidly lose motility, die, lyse or simply do not take up stains. Recourse may be made to examining histological sections of infected tissues, but parasites can be hard to detect in mucosal epithelia. Transmission and scanning electron microscopy have been used to examine internal and topographical ultrastructural features of harvested trophozoites preserved in suitable fixatives. More recently, molecular biological techniques have been used to detect parasites in clinical samples, and even in house flies (*Musca domestica*), by the polymerase chain reaction (PCR) amplification of mitochondrial (16S ribosomal RNA) gene sequences.

Treatment and control: Infections in birds have been treated effectively by the application of nitroimidazole (metronidazole, ronidazole) or organoarsenic compounds (nitarsone) administered in their drinking water, but these drugs are not registered for in commercial poultry due to concerns about bioaccumulation and harmful residues. Infections may be controlled by instituting good husbandry practices to reduce flock contamination and maintain host health (such as regular monitoring, quarantining sick or new birds, providing good nutrition and clean water, prompt waste removal, and decontaminating fomites and equipment).

Cochlosoma



intestines
(catarrhal enteritis,
diarrhoea, poor
condition)



Vertebrate Hosts
(birds, esp. poultry,
waterfowl), some
mammals (shrews)

unique anterior
adhesive disc

6 flagella
(4 anterior,
2 recurrent)

parabasal body

nucleus

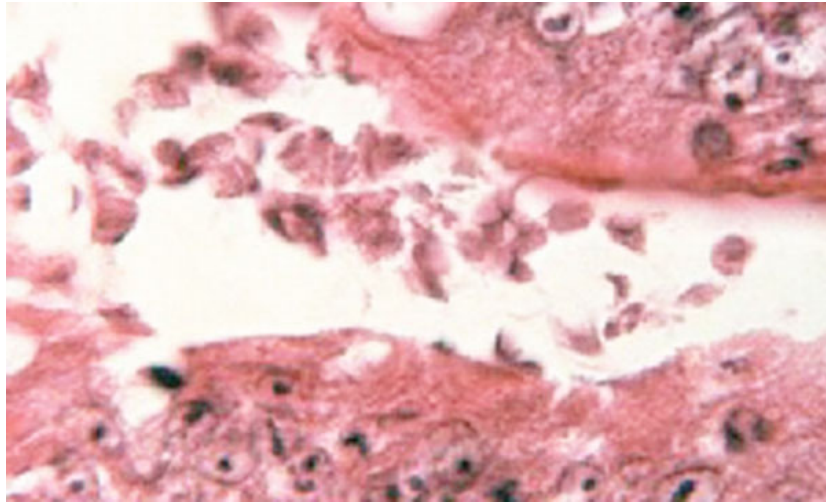
lateral groove

trophozoites
(5-18 μ m)

axostyle

no cyst formation

direct transmission presumably by transfer of trophozoites
via close contact (flocking, grooming, nesting, allo-feeding)



Cochlosoma trophozoites