

Dipylidium

(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 carnivorous definitive hosts. Adult dipylidiids have an armed rostellum, elongate gravid segments with two lateral pores and are parasitic in various carnivores (esp. dogs and cats) but are rarely pathogenic. The encysted larval stages (cysticercoids) occur in fleas and lice which are ingested during grooming.

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: Dipylidiidae (armed scolex, proglottids with paired reproductive organs and two lateral genital pores)
Genus: *Dipylidium* (parasitic in small intestines of dogs/cats)
Species: various species cause anal discomfort in dogs/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 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 Lecanicephalidea, 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 ^a	Scolex	IH1 ^b	Stage ^d	IH2 ^c	Stage ^d
Class: Cestoda (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				
Lecanicephalidea (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 ^a DH = definitive host; ^b IH1 = first intermediate host; ^c 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]; ^d 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).

Dipylidiid tapeworms have proglottids with paired reproductive organs and two lateral genital pores (*di* = two, *pylidium* = entrance), and the scolex has 4 suckers and a protrusible rostellum armed with hooks. The tapeworms shed terminal gravid proglottids containing numerous eggs within uterine capsules (egg balls). Three genera are recognized: *Dipylidium*, *Diplopylidium*, and *Joyeuxiella* (formerly *Joyeuxia*) which all parasitize the small intestines of mammals. Species in all 3 genera utilize arthropods (usually fleas) as intermediate hosts for larval stages (cysticercoid metacestodes), but the latter 2 genera also form encysted cysticercoid stages (monocercus and polycercus, respectively) in second intermediate hosts (usually reptiles, but occasionally amphibians or small mammals). The genus *Dipylidium* is characterized by the possession of a rostellum with rosethorn-shaped hooks, the vagina is situated posterior to the cirrus sac, the genital pore occurs in the middle of the lateral border of the segment, and the ‘egg balls’ contain up to 30 eggs. The species *D. caninum* commonly infects dogs and cats (and their fleas) around the world, and humans in close contact with pets (especially children) can also be infected. Molecular studies on nuclear and mitochondrial gene sequences have suggested the occurrence of at least two ‘host-adapted’ genotypes of *D. caninum*: a ‘canine’ genotype found predominantly in dogs, dog fleas and human fleas; and a ‘feline’ genotype found mostly in cats, cat fleas and cat lice. However, this apparent host specificity is not absolute as instances of cross-infections have been recorded.

Dipylidiid species	Definitive hosts [adults in intestines]	Intermediate hosts (IH) [cysticercoids in body cavity/tissues]	Distribution
<i>Dipylidium</i> (rosethorn-shaped hooks, egg capsules contain up to 30 eggs)			
<i>D. buencaminoi</i>	Carnivora: canid (dog)		Philippines
<i>D. caninum</i> (flea tapeworm, double-pored tapeworm, cucumber seed tapeworm) (syn. <i>D. ascalabotidis</i> , <i>canicum</i> , <i>canium</i> , <i>caracidoi</i> , <i>cati</i> , <i>compactum</i> , <i>crassum</i> , <i>cucumerinum</i> , <i>diffusum</i> , <i>gracile</i> , <i>halli</i> , <i>longulum</i> , <i>manthaensis</i> , <i>oerleyi</i> , <i>porimamillanum</i> , <i>sexcoronatum</i> , <i>terensis</i> , <i>walkeri</i>)	Carnivora: canid (dog, dingo, golden jackal, black-backed jackal, red fox, bat-eared fox, crab-eating fox), hyaenid (striped hyena, aardwolf), felid (cat, African wildcat, Egyptian hunting cat, Charteux cat, fallow cat, jungle cat, fishing cat), viverrid (palm civet, common genet); occasionally Primates: hominid (human)	Siphonaptera: pulicid fleas (<i>Ctenocephalides canis</i> , <i>C. felis</i> , <i>Pulex irritans</i>); Phthiraptera: trichodectid lice (<i>Trichodectes canis</i> , <i>Felicola subrostratus</i>)	Eurasia, Africa, Americas, Australasia
<i>D. otocyonis</i>	Carnivora: canid (bat-eared fox)		Africa
Reassigned species			
<i>D. latissimum</i> (now <i>Cittotaenia denticulata</i>)	Lagomorpha: leporid (rabbit)		Europe
<i>D. leuckarti</i> (now <i>Neoctenotaenia ctenoides</i>)	Lagomorpha: leporid (rabbit)		Europe
<i>D. pectinatum</i> (now <i>Mosgovoyia</i>)	Lagomorpha: leporid (mountain hare)		Europe
<i>Diplopylidium</i> (clawhammer-shaped (‘taenioid’) hooks, egg capsules contain single egg, prey animals may act as second IH)			
<i>D. acanthotetra</i> (syn. <i>D. fabulosum</i> , <i>D. quinquecoronatum</i> , <i>D. trichesii</i> , <i>D. triseriale</i>)	Carnivora: felid (cat), viverrid (African civet, common genet), canid (dog)	first IH unknown; second IHs include Serpentes: colubrid (green whip snake, horseshoe whip snake, spotted whip snake, viperine water snake, northern green bush snake), psammophiid (eastern Montpellier snake); Sauria: agamid (rougtail rock agama), scincid (cylindrical skink, ocellated skink), lacertid (sand lizard, common wall lizard), phyllodactylid (common wall gecko), gekkonid (Mediterranean house gecko, northern house gecko); Anura: bufonid (Berber toad)	Europe, Middle East, Africa
<i>D. aurangabadensis</i>	Carnivora: felid (cat)		India

<i>D. avicola</i>	Accipitriformes: accipitrid (Cape griffon)		South Africa
<i>D. genettae</i> (syn. <i>Dipylidium genettae</i> , <i>Dipylidium dongolense</i>)	Carnivora: viverrid (common genet, small-spotted genet)		Africa
<i>D. monoophorum</i>	Carnivora: felid (cat), viverrid (Malabar civet, common genet)	first IH unknown; second IHs include Serpentes: colubrid (northern green bush snake)	Africa
<i>D. nolleri</i> (syn <i>D. monoophoroides</i>)	Carnivora: felid (cat), canid (dog, sand fox)	first IH unknown; second IHs include Sauria: phyllodactylid (common wall gecko), lacertid (Lebanon lizard), gekkonid (Mediterranean house gecko); Serpentes: colubrid (spotted whip snake), psammophiid (eastern Montpellier snake), viperid (horned desert viper)	Europe, Middle East
<i>D. paurodex</i>	Carnivora: viverrid (rusty-spotted genet)		Africa
<i>D. skrjabini</i>	Carnivora: felid (cat)	first IH unknown; second IHs include Sauria: phyllodactylid (naked-toed gecko)	Europe
<i>D. udgirensis</i>	Carnivora: felid (cat)		India
<i>D. zschokkei</i>	Carnivora: herpestid (yellow mongoose)	first IH unknown; second IHs possibly includes Serpentes: viperid (horned desert viper)	South Africa
<i>Joyeuxiella</i> (rosethorn-shaped hooks, egg capsules contain single egg, prey animals may act as second IH)			
<i>J. echinorhyncoides</i> (syn. <i>Taenia</i> , <i>Dipylidium</i>)	Carnivora: canid (dog, fox, bat-eared fox, fennec fox, golden jackal), felid (cat); Rodentia: murid (Indian gerbil)	first IH unknown; second IHs include Sauria: agamid (rougtail rock agama), scincid (cylindrical skink, common skink), phyllodactylid (fan-footed gecko); Serpentes: colubrid (green whip snake, Dahl's whip snake, spotted whip snake, European cat snake); psammophiid (eastern Montpellier snake, hissing sand snake)	Middle East, India
<i>J. fuhrmanni</i> (syn. <i>Dipylidium fuhrmanni</i> , <i>Joyeuxiella paucitestis</i>)	Carnivora: felid (cat, serval, African wildcat), viverrid (common genet, rusty-spotted genet)		Africa
<i>J. pasqualei</i> (syn. <i>Dipylidium chyzeri</i> , <i>D. rossicum</i> , <i>Diplopylidium fortunatum</i> , <i>Joyeuxia aegyptica</i> , <i>J. pasqualeiformis</i> , <i>Joyeuxiella guilhoni</i> , <i>J. domestica</i>)	Carnivora: felid (cat, serval, European wildcat, African wildcat, South African wildcat), canid (dog, gray wolf, fox, golden jackal), mustelid (common weasel)	first IH unknown; second IHs include Sauria: agamid (rougtail rock agama), lacertid (common wall lizard, European green lizard, Schreiber's fringe-fingered lizard), phyllodactylid (common wall gecko), gekkonid (Mediterranean house gecko, common house gecko); varanid (desert monitor), scincid (snake-eyed skink); Serpentes: colubrid (green whip snake, Dahl's whip snake, European cat snake); Eulipotyphla: soricid (lesser white-toothed shrew)	Europe, Middle East, Africa, India, Asia

Parasite morphology: *Dipylidium* spp. form three distinct developmental stages: eggs (containing oncospheres), larvae (cysticercoids) and adult tapeworms. Definitive hosts excrete gravid proglottids containing uterine packets of 8-30 eggs. The eggs are yellow to brown in colour, oval to spherical in shape and range from 20-60 μm in diameter. Each egg contains a nonciliated hexacanth (6-hooked) embryo (oncosphere) covered by a thin eggshell and a non-striated embryophore (outer cellular covering of embryo). Oncospheres are ovoid measuring around 25 μm in diameter, lacunate (with internal channels) and possess anterior penetration glands. Metacestodes (cysticercoids) develop in intermediate hosts; firstly in insects (fleas, lice), then secondly in reptiles (lizards, snakes). Cysticercoids have oval-elongate contractile bodies (0.1-2.0 mm in length) with a tail-like cercomer and a retracted (not invaginated) scolex with a fully developed rostellum. Adult tapeworms have elongated ribbon-like bodies measuring from 15-80 cm (most 20-40 cm) in length and ranging in colour from white (ivory) to yellowish-pink. The posterior strobila (tape) is composed of numerous (60-175) elliptical segments (proglottids) measuring 0.5-1.0 cm long by 0.1-0.2 cm wide. The anterior scolex is small, muscular, rhomboidal in shape (0.35-0.50 mm in diameter), bearing 4 cup-shaped acetabula (suckers) and surmounted by an apical retractable club-shaped protuberance (rostellum) armed with 30-150 rosethorn-shaped hooks arranged in 1-8 (usually 4-6) rows. *Joyeuxiella* spp. have similar rosethorn-shaped hooks, while *Diplopylidium* spp. have clawhammer-shaped ('taenoid'-like) hooks. Adult dipylidiid worms are hermaphroditic and each segment contains not one but 2 sets of male and female reproductive organs (one set per side) with bilateral genital pores used for reproduction and not egg release (one of the common names for *D. caninum* is the 'double-pored' tapeworm). Female reproductive organs comprise an ovary, oviduct, ootype, seminal receptacle, vitelline gland, vagina and a reticulated net-like uterus. Male reproductive organs consist of numerous testes (up to 200) in the intervascular space, a sperm duct, coiled vas deferens, and cirrus. Fertilized oocytes enter the uterus and develop to preoncospheres. As proglottids mature, the uteri disappear and are replaced by hyaline egg capsules (also known as egg packets, clusters or balls). Mature *Dipylidium* proglottids may contain up to 150 egg capsules (120-200 μm), each containing 15-30 oncospheres with distinctive inner and outer envelopes. In contrast, the egg capsules of *Diplopylidium* and *Joyeuxiella* spp. contain single eggs. Gravid proglottids drop off and are passed in host faeces where they crawl about, expanding and contracting to release egg packets. They resemble cucumber or pumpkin seeds and eventually desiccate and shrivel to resemble rice grains.

Site of infection: Adult *Dipylidium* tapeworms infect the small intestines of their mammalian definitive hosts. Metacestodes (cysticercoids) develop in the body cavities (haemocoel) of their first intermediate hosts (insects) or become encysted within connective tissues of their second intermediate hosts (reptiles).

Pathogenesis: Tapeworms do not have digestive tracts and do not feed off host tissues but rather absorb nutrients from the gut lumen. *Dipylidium* spp. generally do not cause clinical disease in their definitive hosts, except in heavily-infected or malnourished individuals which may experience indigestion, abdominal pain, constipation or diarrhoea, and weight loss. Such animals may appear pot-bellied and unthrifty, but rarely do they develop life-threatening intestinal obstructions. Heavy infections in cats and dogs have occasionally been associated with convulsions, epileptiform seizures and haemorrhagic enteritis. More often, infections in companion animals cause anal pruritus when gravid proglottids migrate out onto perianal regions or attach to hairs where they may dry out. Pruritus may be accompanied by fever and eosinophilia due to host inflammatory responses and afflicted animals may itch and scratch by scooting their perineum along the ground. Infections in humans are usually low in intensity, being related to the small number of intermediate hosts and cysticercoids ingested. Most *D. caninum* infections are asymptomatic, but some patients (typically infants or small children in contact with domestic pets) may exhibit indigestion, abdominal pain, nocturnal irritability, anorexia, poor weight gain or weight loss and dysphoria (depression), sometimes with diarrhoea, dizziness, nausea and allergic (hypersensitivity) manifestations such as urticaria, pruritus ani and eosinophilia. Parents and pet owners frequently express psychological 'disgust' when encountering proglottids writhing in nappies or underwear or crawling over perianal hair or faeces.

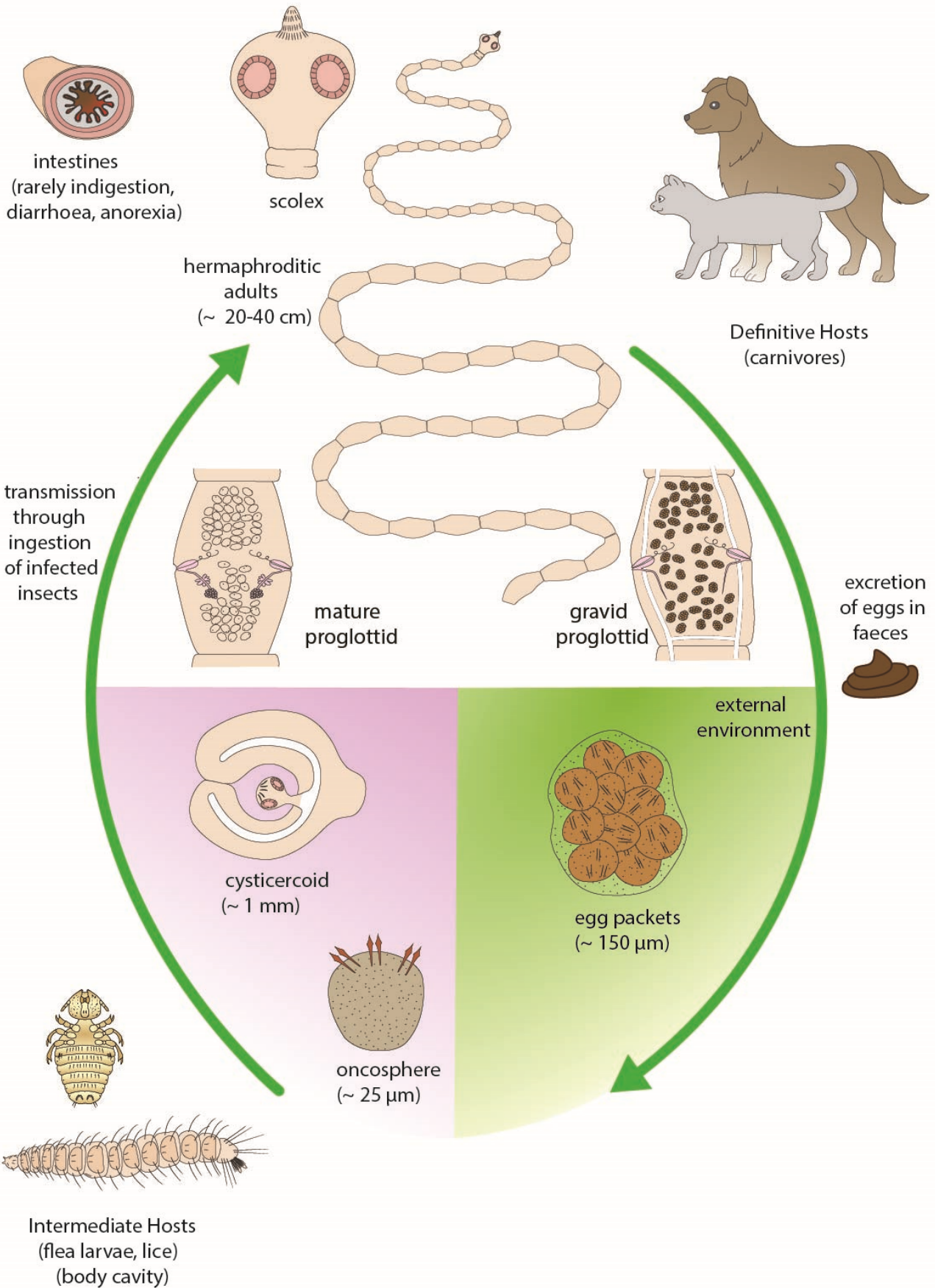
Developmental cycle and mode of transmission: Tapeworms have indirect heteroxenous (2 host) life-cycles involving faecal-oral transmission of eggs from definitive hosts to invertebrate intermediate hosts and then predator-prey transmission of larval stages from intermediate hosts back to definitive hosts. Gravid proglottids filled with egg packets are released from posterior end of the adult tapeworm body through a process known as apolysis. The proglottids are motile and emerge from the host's anus or are excreted with faeces where they contract and expand releasing egg capsules. Eggs have been found to survive for several months in desiccated proglottids. Egg capsules are ingested by first intermediate hosts, mainly flea larvae which have mandibulate (chewing) mouthparts (adult fleas have siphon-like (sucking) mouthparts and cannot ingest egg capsules). *D. caninum* develops more effectively in larvae of the cat flea *Ctenocephalides felis* rather than those of the dog flea *C. canis*. Occasionally, chewing lice (*Trichodectes canis*, *Felicola subrostratus*) have been implicated as additional intermediate hosts. Eggs ingested by flea larvae and lice release their contained oncospheres which then enter the body cavity (haemocoel) using their hooks and penetration glands secreting lytic enzymes. The oncospheres lie dormant until the insect larvae form pupae, at which time they begin transformation into cysticercoids. Pupation generally lasts from 5-24 days before adult fleas or lice hatch and take bloodmeals which stimulates the growth and encystment of tailed cysticercoids in the epithelium of the insect midgut. Metacestode growth rates have been found to vary according to temperature (ambient temperature for stages in insect pupae then host body temperature for stages in feeding adult insects), but development to infective cysticercoids is completed within 3 weeks (usually 13-18 days). Infected fleas may contain 2-82 cysticercoids (average of 10), although some have been found with over 160. Many dipylidiid tapeworms have also been found to utilize second intermediate hosts in the form of reptiles (lizards and snakes) which have ingested infected insects (presumably)

and developed encysted cysticercoid stages mainly within connective tissues. Definitive hosts become infected by ingesting cysticercoids in fleas and lice during grooming (or accidentally when children play with pets) or, in the case of most *Diplopylidium* and *Joyeuxiella* spp., by ingesting cysticercoids in reptile prey animals. The ingested cysticercoids attach to the mucosa of the small intestine of the definitive host and develop into mature adult tapeworms in around a month (prepatent period of 2-4 weeks). Adult tapeworms are not long-lived and generally die within a year. The dynamics (quantity) and kinetics (timing) of transmission and infection intensity depends largely on the population density of intermediate hosts (first and second intermediate hosts, as applicable), the abundance and gregarious nature of definitive hosts and prevailing climatic conditions (all demonstrating different seasonal patterns in different countries).

Differential diagnosis: Infections are usually diagnosed by the direct detection of ivory-coloured barrel-shaped gravid proglottids (either crawling or dried) in faeces, bedding or around the anus. Specimens may deteriorate quickly so fresh samples are required or they may be preserved in 70% alcohol. Dried proglottids resemble uncooked rice grains but upon rehydration they often return to their characteristic cucumber or pumpkin seed appearance. Visual examination may reveal the presence of bilateral genital pores located just behind the middle of each segment which can be confirmed by light microscopy after clearing segments with carboxylene. Squashing gravid proglottids may also reveal the presence of numerous egg capsules containing nonoperculated eggs with nonstriated walls (most other tapeworms do not form egg capsules and their eggs have striated walls or may be operculate). Infections in insect intermediate hosts are diagnosed by the demonstration of cysticercoid stages in haemolymph smears or histological sections, while infections in reptilian intermediate hosts are usually made by the detection of cysticercoid stages in host tissues during dissection or upon histological examination. Serological techniques (enzyme immunoassays) have recently been developed to detect host antibodies in dogs against *D. caninum* antigens derived from mature and gravid proglottids. Molecular biological techniques have also used polymerase chain reactions (PCR) to characterize restriction fragment length polymorphisms (RFLP) or partial sequences for nuclear (28S ribosomal RNA, repeat units D1-3) and mitochondrial genes (cytochrome c oxidase subunit 1).

Treatment and control: Infections by dipylidiid tapeworms may be successfully treated with a range of anthelmintic (deworming) drugs, especially the isoquinolines (praziquantel and epsiprantel), salicylanilides (niclosamide) and substituted isothiocyanate (nitroscanate). The current treatment of choice is praziquantel which is well tolerated in animals and humans, although some people develop skin rashes. It is effective against immature and mature tapeworms and can be administered orally, subcutaneously, transcutaneously or intramuscularly. In comparison, epsiprantel is less effective as it is poorly absorbed in the gut, niclosamide may cause abdominal pain and pruritus, and nitroscanate may have adverse side effects such as lethargy, vomiting, diarrhoea and anorexia. Parasite control options should also include interventions to reduce transmission between intermediate and definitive hosts, such as the hygienic disposal of contaminated faecal material, monitoring the hygiene habits of infants playing with pets, eliminating intermediate host populations (fleas and lice) using regular insecticidal treatments, instituting environmental control by cleaning fomites (bedding, furniture, carpets/rugs, household surfaces, utensils) potentially contaminated with insect larvae/pupae, curbing the hunting behaviour of carnivores for reptilian second intermediate hosts, and above all, educating pet owners and the general public.

Dipylidium





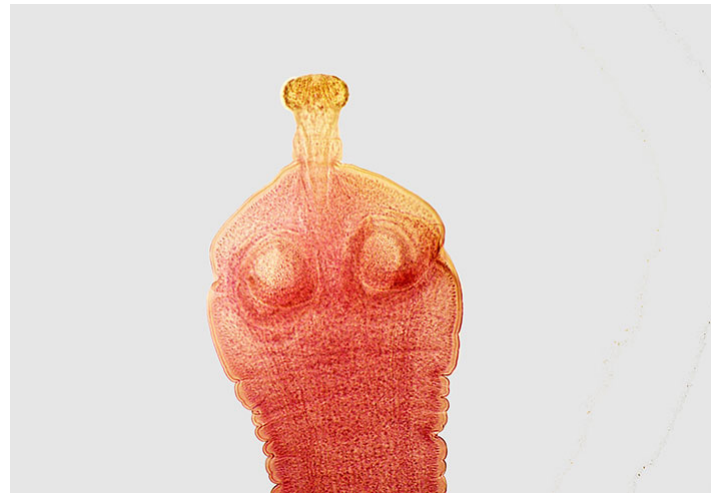
Dipylidium adult worms



Dipylidium adult worms



Dipylidium scolex



Dipylidium scolex extended



Dipylidium egg packet