

Ergasilus

(crustacean: copepod)

Introduction

Arthropods are coelomate metameric invertebrate animals with a chitinous exoskeleton and jointed limbs. They undergo protostomial embryonic development and most grow by cuticular moulting (ecdysis). Three main subphyla are recognized: Chelicerata, Crustacea and Hexapoda. Crustaceans have a very strong cuticle strengthened by calcium salts; thus their growth must proceed through repeated moults. Most species are aquatic with internal or external gills, two pairs of antennae, mouthparts comprising one pair of mandibles and two pairs of maxillae, and each heteronomous body segment usually bears a pair of ventral biramous extremities (podia). Maxillopods lack appendages on abdominal segments and the nauplius larval stage has a unique maxillopodan eye. Copepods have an elongate segmented body (first few thoracic segments fused with head to form cephalothorax) and they undergo gradual metamorphosis with a series of copepodid instars succeeding naupliar instars. Many species are free-living, although some are ectoparasitic on fish. Poecilostomatoid copepods range from simple parasitic forms of fishes to bizarre symbiotic forms of invertebrates. Adult segmentation is often lost, the antennules are small in size and the buccal cavity is slit-like. Ergasilids have antennae highly modified to attach to freshwater and marine fishes. Infestations by *Ergasilus* spp. on the gills cause respiratory problems and mortalities, particularly in aquaculture facilities.

Classification:

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: Arthropoda (chitinous exoskeleton, segmented body, jointed limbs, haemocoel)
Subphylum: Crustacea (mandibular mouthparts, gills, two pairs antennae, biramous podia, larval nauplius/zoea)
Class: Maxillipoda (nauplius with maxillipodan eye)
Subclass: Copepoda (elongate body, series of copepodid instars succeeding naupliar instars, several ectoparasites)
Order: Cyclopoida (formerly Poecilostomatoida, now 'poecilostome' lineage comprising simple parasitic forms of fishes to bizarre symbiotic forms of invertebrates)
Family: Ergasilidae (antennae modified into powerful attachment organs, parasitic in freshwater and marine fishes)
Genus: *Ergasilus* (parasitic on gills of fish)
Species: various species cause respiratory problems in fishes

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). Arthropods have small segmented bodies encased in chitinous exoskeletons with articulated limbs. Most species are free-living in terrestrial and aquatic habitats, although a small range are ectoparasitic on other animals, some feeding on the blood or skin of vertebrates. Five subphyla are recognized: Chelicerata, Crustacea, Hexapoda, Myriapoda and Trilobita. Crustaceans have very strong cuticles strengthened by calcium salts, so they moult periodically as they grow and metamorphose through different types of larval stages before forming adults. Most species are aquatic and have internal or external gills, while terrestrial species have internal gills which are kept moist. Crustaceans have mouthparts with two pairs of maxillae (to handle food) and paired mandibles (with opposing biting and grinding surfaces). They have two sets of antennae and each body segment usually gives rise to a pair of ventral biramous appendages (podia). Six crustacean classes are recognized: Brachiopoda, Cephalocarida, Malacostraca, Maxillipoda, Ostracoda and Remipedia. Maxillopods usually have a body plan comprising 5 cephalic, 6 thoracic and 4 abdominal segments followed by a telson. The thoracic segments bear biramous (sometimes uniramous) limbs, but the abdominal segments lack appendages. The carapace is present or reduced, most feed using maxillae, and the nauplius larval stages have unique eyes with three cups, each with tapetal cells (= maxillopodan eye). Six maxillopodan subclasses are recognized: Branchiura, Cirripedia, Copepoda, Mystacocarida, Pentastomatida and Tantulocarida.

Major parasitic crustacean families	Biodiversity	Hosts	Parasitic stages	Pathogenesis	Disease transmission
Class: Maxillipoda					
Subclass: Copepoda (copepods)					
Order: Cyclopoida (open buccal cavity)					
Family: Lernaecidae (anchor worms)	19 genera, 114 spp.	freshwater fishes	copepodids and adults	skin lesions	direct (water)
Former order: Poecilostomatoida (slit-like buccal cavity)[now a "poecilostome" lineage within the Cyclopoida]					
Family: Ergasilidae (gill lice)	27 genera 61 spp.	freshwater and marine fish	adult ♀	gill/skin lesions	direct (water)
Subclass: Branchiura (head with flattened bilobed cephalic fold, carapace expands laterally)					
Order: Argulidea (discoid bodies, attach using hooks, suckers and barbs)					
Family: Argulidae (fish lice)	4 genera 150 spp.	marine and freshwater fish	juveniles, adults	skin lesions	direct (water)
Subclass: Pentastomatida (tongue worms, elongate annulated bodies, 2 pairs tiny anterior claws near mouth)					
Order: Porocephalida (mouth between/below anterior hooks)					
Family: Porocephalidae	5 genera, 10 spp.	snakes (rodent IH)	adults	lung lesions	indirect (via IH*)
Family: Linguatulidae	1 genus, 4 spp.	carnivorous mammals (mammal IH)	adults	naso-pharyngeal lesions	indirect (via IH*)

*IH = intermediate host

Copepods are small aquatic crustaceans that are one of the most speciose metazoan groups in aquatic communities (over 13,000 morpho-species known). They inhabit a wide range of water sources, ranging from oceans and marine sediments, freshwater streams, rivers, lakes, subterranean cave pools, and even damp leaf litter and puddles in bromeliad leaves. Most species are free-living (important as both predators and prey in planktonic food chains) and some are symbiotic or internal/external parasites of other metazoa, including commercial fish species. Copepods lack a carapace and have elongate segmented bodies (first few thoracic segments fused with head to form cephalothorax) with a single pair of uniramous maxillipods and four pairs of biramous thoracic swimming appendages. They undergo gradual metamorphosis with a series of copepodid instars succeeding naupliar instars. Copepods have been classified within 2 superorders: Gymnoplea (prosome-urosome division posterior to fifth leg-bearing somite) with 2 orders (Calanoida and Platycopioidea) and Podoplea (prosome-urosome division anterior to fifth leg-bearing somite) with 9 orders (Canuelloidea, Cyclopoida (incl. Poecilostomatoida which is no longer recognised as a valid order as all its cognate families form a well-defined "poecilostome" lineage within the Cyclopoida), Gelyelloidea, Harpacticoida, Misophrioida, Monstrilloidea, Mormonilloidea, Platycopioidea and Siphonostomatoida). Members of the former order Poecilostomatida (now the 'poecilostome' lineage in the order Cyclopoida s.s.) form adults with slit-like buccal cavities as simple parasitic forms on fish or as bizarre symbiotic forms on invertebrates. A total of 64 'poecilostome' families are recognized, including the family Ergasilidae. This family is unusual in that only adult females are parasitic (typically on fishes) while all developmental stages and males are free-living. Females have modified claw-like antennae which act as powerful organs of prehension used to attach to the gills (and sometimes skin) mostly of freshwater and some marine fishes, although some occur on bivalve molluscs. A total of 30 genera have been described (*Abergasilus*, *Acusicola*, *Amplexibranchius*, *Anklobranchius*, *Brasergasilus*, *Dermoergasilus*, *Duoergasilus*, *Ergasilus*, *Gamidactylus*, *Gamispatulus*, *Gamispinus*, *Gauchergasilus*, *Majalincola*, *Miracetyma*, *Mugilicola*, *Neoergasilus*, *Nipergasilus*, *Paeonodes*, *Paraergasilus*, *Pindapixara*, *Prehendorastrus*, *Pseudovaigamus*, *Rhinergasilus*, *Sinergasilus*, *Teredophilus*, *Therodamas*, *Thersitina*, *Tiddergasilus*, *Urogasilus* and *Vaigamus*) from hosts found near the coasts of all continents except Antarctica. The genus *Ergasilus* contains 158 species of gill lice recorded from a wide range of fish species, sometimes in association with lesions and respiratory diseases, particularly in aquaculture facilities, aquaria or overstocked fisheries.

<i>Ergasilus</i> species	Hosts	Distribution
<i>E. acusicestraeus</i>	Mugiliformes: mugilid (Goldie River mullet)	Papua New Guinea
<i>E. anchoratus</i>	Siluriformes: silurid (Amur catfish); Tetraodontiformes: balistid (yellowmargin triggerfish)	Asia
<i>E. argulus</i>	Beloniformes: belonid (freshwater needlefish, shoulderspot needlefish)	Americas
<i>E. arthrosis</i>	Acanthuriformes: sciaenid (freshwater drum); Atheriniformes: atherinopsid (brook silverside); Beloniformes: belonid (Atlantic needlefish); Carangiformes: carangid (crevalle jack); Clupeiformes: clupeid (skipjack shad); Perciformes: centrarchid (warmouth, bluegill, dollar sunfish, longear sunfish, redear sunfish, spotted sunfish, spotted bass, largemouth bass, white crappie, black crappie), moronid (striped bass, white perch, yellow bass), percid (common logperch,	North America

	yellow perch); Percopsiformes: aphredoderid (pirate perch); Pleuronectiformes: achirid (lined sole); Siluriformes: ictalurid (flathead catfish, blue catfish, black bullhead, yellow bullhead, brown bullhead, channel catfish)	
<i>E. atafonensis</i>	Mugiliformes: mugilid (fantail mullet, redeye mullet, white mullet, Lebranche mullet)	North America
<i>E. auritus</i>	Gasterosteiformes: gasterosteid (ninespine stickleback, three-spined stickleback); Gobiiformes: oxudercid (longjaw mudsucker); Osmeriformes: osmerid (rainbow smelt); Salmoniformes: salmonid (lake trout, brook trout, sockeye salmon, coho salmon, lake whitefish, cisco); Scorpaeniformes: cottid (Amur sculpin)	North America
<i>E. australiensis</i>	Mugiliformes: mugilid (yellow-eye mullet); Perciformes: sparid (goldsilk seabream, black bream, yellowfin bream), toxotid (largescale archerfish)	Australia
<i>E. bagarii</i>	Siluriformes: sisorid (devil catfish)	China
<i>E. bahiensis</i>	Mugiliformes: mugilid (white mullet)	Americas
<i>E. bani</i>	free-swimming	Japan
<i>E. barbi</i>	Cypriniformes: cyprinid (shabout)	Asia
<i>E. batai</i>	Cypriniformes: cyprinid (bata)	India
<i>E. bengalensis</i>	Siluriformes: silurid (wallago catfish)	Asia
<i>E. boettgeri</i>	Cyprinodontiformes: poecilid short-finned molly)	North America
<i>E. boleophthalmi</i>	Gobiiformes: gobiid (brown frillfin), oxudercid (mudskipper)	Middle-East, Africa
<i>E. borneoensis</i>	Perciformes: serranid (Malabar grouper); Labriformes: labrid (rainbow wrasse)	Indonesia
<i>E. brari</i>	Siluriformes: silurid (wallago catfish)	Asia
<i>E. brevimanus</i>	free-swimming	Africa
<i>E. briani</i> (syn. <i>E. minor</i>)	Cypriniformes: cyprinid (bitterling, redfin, yellowfin, Amur ide, white Amur bream, stone moroko, sunbleak, silver carp, spotted steed, yellowcheek, goldfish, common bleak, Chinese bleak, common bream, zope, Khanka gudgeon, threelips, Mossul bleak, Eurasian carp, gudgeon, sharpbelly, tench, common roach), cobitid (pond loach), gobionid (Soldatov's gudgeon), xenocypridid (grass carp); Gobiiformes: odontobutid (sleeper); Osmeriformes: osmerid (European smelt); Perciformes: sparid (blackhead seabream), percid (redfin perch); Salmoniformes: salmonid (pink salmon, rainbow trout); Siluriformes: bagrid (yellowhead catfish)	Eurasia, Africa
<i>E. bryconis</i>	Characiformes: characid (red-tailed brycon); Siluriformes: doradid (granulated catfish)	Americas
<i>E. caeruleus</i>	Acanthuriformes: sciaenid (freshwater drum); Anguilliformes: anguillid (American eel); Cypriniformes: catostomid (silver redhorse, lake chubsucker, white sucker, longnose sucker, quillback, golden redhorse, shorthead redhorse), cyprinid (fallfish, creek chub, redfin shiner, common shiner, Eurasian carp), leuciscid (chiselmouth, longnose dace); Cyprinodontiformes: fundulid (golden topminnow); Esociformes: esocid (muskellunge); Gadiformes: lotid (burbot); Lepisosteiformes: lepisosteid (alligator gar, shortnose gar, longnose gar); Perciformes: centrarchid (black crappie, redbreast sunfish, dollar sunfish, red-ear sunfish, spotted sunfish, bluespotted sunfish, flier, rock bass, green sunfish, pumpkinseed, warmouth, orange-spotted sunfish, bluegill, longear sunfish, smallmouth bass, spotted bass, largemouth bass, white crappie, black crappie), moronid (white bass), percid (blue walleye, black-banded darter, yellow perch, sauger, walleye, cisco, lake whitefish, brook trout, lake trout); Percopsiformes: aphredoderid (pitate perch), percopsid (trout-perch); Petromyzontiformes: petromyzontid (sea lamprey); Salmoniformes: salmonid (sockeye salmon, round whitefish); Siluriformes: ictalurid (stonecat, tadpole madtom)	cosmopolitan
<i>E. callophysus</i>	Siluriformes: pimelodid (vulture catfish)	South America
<i>E. caraguatatubensis</i>	Mugiliformes: mugilid (white mullet, redeye mullet, liza)	Atlantic
<i>E. celestis</i> (syn. <i>E. osburni</i>)	Anguilliformes: anguillid (American eel); Gadiformes: lotid (burbot); Perciformes: percid (walleye)	North America
<i>E. centrarchidarum</i> (syn. <i>E. nigrilus</i>)	Cypriniformes: catostomid (longnose sucker, lake chubsucker), cyprinid (creek chub); Gadiformes: gadid (frostfish); Osmeriformes: osmerid (European smelt, rainbow smelt); Perciformes: centrarchid (smallmouth bass, bluegill, pumpkinseed, rock bass, mud sunfish, redbreast sunfish, redear sunfish, flier, green sunfish, white crappie, black crappie, warmouth, bluegill, spotted bass, largemouth bass), moronid (white bass), percid (yellow perch, redfin perch, sauger, walleye)	North America
<i>E. cerastes</i>	Siluriformes: ictalurid (channel catfish, brown bullhead, yellow bullhead, white bullhead, blue catfish)	North America
<i>E. ceylonensis</i>	Cichliformes: cichlid (green chromide); Cypriniformes: cyprinid (olive barb)	India

<i>E. chautauquaensis</i>	free-swimming	North America
<i>E. chelangulatus</i>	Siluriformes: pimelodid (catfish)	South America
<i>E. clupeidarum</i>	Clupeiformes: clupeid (American gizzard shad, threadfin shad, blueback herring, skipjack shad)	North America
<i>E. coatiarus</i>	Perciformes: sparid (Australasian snapper)	Australasia
<i>E. cochlearius</i>	Siluriformes: sisorid (sucker catfish)	Asia
<i>E. colomesus</i>	Tetraodontiformes: tetraodontid (Amazon puffer)	South America
<i>E. coniformis</i>	Cypriniformes: cyprinid (pale bleak)	Asia
<i>E. cotti</i>	Perciformes: percid (rainbow darter); Scorpaeniformes: cottid (mottled sculpin)	North America
<i>E. cunningtoni</i>	Characiformes: alestid (African tigerfish, elongate tigerfish, nurse tetra, kawara), distichodontid (grass-eater, African pike-characin, harmaahertta tetra); Cichliformes: cichlid (microdon, lohe, Congo cichlid); Clupeiformes: clupeid (pellonula, small-toothed pellonula); Cypriniformes: cyprinid (Senegal trout-barb, blackstripe barb); Osteoglossiformes: mormyrid (Cornish jack, elephant fish, elephant-nosed fish, rypoun obrooky, lundembe, mbamzogh, Niger mormyrid, Greshoff's mormyrid); Siluriformes: mochokid (blotched upside-down catfish), schilbeid (schilbid catfish)	Africa
<i>E. curticus</i>	Characiformes: characid (black fin)	South America
<i>E. cyanopictus</i>	Mugiliformes: mugilid (flathead grey mullet)	Asia
<i>E. cyprinaceus</i>	Cypriniformes: cyprinid (creek chub, silver chub, bluehead chub, golden shiner, bandfin shiner, bluntnose minnow), leuciscid (weed shiner, blacktail shiner, rough shiner, greenhead shiner, highscale shiner, longnose shiner, cherryfin shiner, central stoneroller, clear chub); Cyprinodontiformes: fundulid (black-spotted top minnow); Gasterosteiformes: gasterosteid (brook stickleback); Perciformes: centrarchid (black crappie); Siluriformes: ictalurid (freckled madtom, yellow bullhead, brown bullhead)	North America
<i>E. danjiangensis</i>	Cypriniformes: cyprinid (pale bleak), xenocypridid (ahmattibarbi)	China
<i>E. davidi</i>	Perciformes: centropomid (common snook), lutjanid (yellow snapper)	Americas
<i>E. divergens</i>	free-swimming	Europe
<i>E. ecuadorensis</i>	Mugiliformes: mugilid (white mullet, hospe mullet)	Atlantic
<i>E. egyptiacus</i>	Cichliformes: cichlid (redbelly tilapia)	Africa
<i>E. enshiensis</i>	Cypriniformes: cyprinid (sichuani sirgsuu)	China
<i>E. extensus</i>	Mugiliformes: mugilid (pinkeye mullet)	Australia
<i>E. felichthys</i> (syn. <i>E. elongatus</i> , <i>thomsoni</i>)	Acipenseriformes: polyodontid (American paddlefish); Siluriformes: ariid (hardhead catfish, gafftopsail catfish)	North America
<i>E. fidiformis</i>	Cypriniformes: leuciscid (big-scaled redbfin)	Asia
<i>E. flaccidus</i>	Cichliformes: cichlid (Tanganyika tilapia)	Africa
<i>E. foresti</i>	free-swimming	South America
<i>E. fryeri</i>	Cichliformes: cichlid (redbelly tilapia); Mugiliformes: mugilid (golden grey mullet, thinlip mullet, flathead grey mullet)	Africa
<i>E. funduli</i>	Atheriniformes: atherinopsid (inland silverside); Cyprinodontiformes: cyprinodontid (American flagfish, sheepshead minnow), fundulid (mummichog, longnose killifish, Gulf killifish, diamond killifish, Bayou killifish, marsh killifish, rainwater killifish), poecilid (western mosquitofish, sailfin molly); Gasterosteiformes: gasterosteid (three-spined stickleback, black-spotted stickleback); Osmeriformes: osmerid (rainbow smelt)	North America
<i>E. genuinus</i> (syn. <i>Limnoncaea</i>)	free-swimming	Japan
<i>E. gibbus</i>	Anguilliformes: anguillid (European eel); Gobiiformes: gobiid (round goby)	Europe
<i>E. glyptothoracis</i>	Siluriformes: sisorid (kani tengra)	Asia
<i>E. gobiorum</i>	Gobiiformes: gobiid (racer goby, monkey goby, bighead goby)	Eurasia
<i>E. hamiltoni</i>	Anabantiformes: anabantid (climbing perch)	Asia
<i>E. hemibagri</i>	Siluriformes: bagrid (largefin longbarbel catfish)	China
<i>E. holobryconis</i>	Characiformes: bryconid (mourning tetra)	South America
<i>E. hydrolycus</i>	Characiformes: cynodontid (payara)	South America
<i>E. hypomesi</i>	Cypriniformes: cyprinid (bronze gudgeon); Osmeriformes: osmerid (pond smelt)	Eurasia
<i>E. hypophthalmi</i>	Siluriformes: pimelodid (highwaterman catfish)	South America
<i>E. ilani</i>	Mugiliformes: mugilid (flathead grey mullet, South African mullet)	Africa
<i>E. inflatipes</i>	Beloniformes: belonid (Senegal needlefish)	Africa
<i>E. intermedius</i>	Clupeiformes: clupeid (bony bream); Perciformes: percichthyid (golden perch, trout cod); Siluriformes: plotosid (eel-tailed catfish)	Australia

<i>E. iraquensis</i>	Mugiliformes: mugilid (greenback mullet)	Indo-Pacific
<i>E. jaraquensis</i>	Characiformes: prochilodontid (kissing prochilodus)	South America
<i>E. jiangxiensis</i>	Cypriniformes: cyprinid (sharpbelly)	North America
<i>E. kabatai</i>	free-swimming	India
<i>E. kandti</i>	Characiformes: citharinid (moonfish); Cichliformes: cichlid (latticed cichlid, Tanganyika tilapia, Congo cichlid, hump-back bream, Mweru hump-backed bream, tanga, petokotiloahven, juovasuomunsoyoja, juhmurisuomunsoyoja); Perciformes: latid (Nile perch); Siluriformes: bagrid (bayad); mochokid (moustache catfish), schilbeid (silver butter catfish)	Africa
<i>E. kimi</i>	Myliobatiformes: dasyatid (marbled whipray)	Indonesia
<i>E. labracis</i>	Atheriniformes: atherinopsid (golden silverside); Gadiformes: gadid (Atlantic tomcod); Gasterosteiformes: gasterosteid (three-spined stickleback); Osmeriformes: osmerid (rainbow smelt); Perciformes: moronid (white perch, striped bass); Salmoniformes: salmonid (Atlantic salmon, brook trout)	North America
<i>E. lacusauratus</i>	Characiformes: characid (golden dorado)	South America
<i>E. lagunaris</i>	free-swimming	Europe
<i>E. lamellifer</i>	Cichliformes: cichlid (Alluaud's haplo, bicolor haplo, degen haplo, guiarti haplo, longirostris haplo, obesus haplo, nuchisquamulatus, obliquidens); Siluriformes: schilbeid (glass schilbid)	Africa
<i>E. lanceolatus</i>	Clupeiformes: clupeid (American gizzard shad); Hiodontiformes: hiodontid (mooneye)	North America
<i>E. latus</i>	Cichliformes: cichlid (redbelly tilapia, Nile tilapia, Guinean tilapia, mango tilapia, blackchin tilapia, ekouni); Siluriformes: claroteid (giraffe catfish, bagrid catfish), schilbeid (African butter catfish)	Africa
<i>E. leiocassi</i>	free-swimming	China
<i>E. leporinidis</i>	Characiformes: anostomid (black-banded leporinus)	South America
<i>E. lizae</i> (syn. <i>E. nanus</i>)	Acanthuriformes: sciaenid (Atlantic croaker, spot croaker); Anguilliformes: anguillid (European eel); Carangiformes: carangid (Florida pompano); Cichliformes: cichlid (blue tilapia, redbelly tilapia, mango tilapia); Clupeiformes: clupeid (twait shad); Cypriniformes: cyprinid (common barbel, white bream, gudgeon, common chub, common minnow); Cyprinodontiformes: cyprinodontid (sheepshead minnow, gold-spotted killifish), fundulid (Gulf killifish, banded killifish, longnose killifish); Gobiiformes: gobiid (round goby); Mugiliformes: mugilid (thinlip mullet, thicklip grey mullet, flathead grey mullet, leaping mullet, longarm mullet, fantail mullet, pinkeye mullet, golden grey mullet, goldspot mullet, white mullet, so-iuy mullet); Ovalentaria: embiotocid (shiner perch); Perciformes: centrarchid (largemouth bass, redear sunfish, bluegill), ephippid (Atlantic spadefish), moronid (striped bass), sparid (pinfish, yellowfin bream, goldsilk seabream, black bream); Pleuronectiformes: soleid (common sole); Siluriformes: clariid (mudfish)	Americas, Eurasia, Australia
<i>E. lobus</i>	Perciformes: serranid (Malabar grouper)	Asia
<i>E. longicaudatus</i>	free-swimming	Europe
<i>E. longimanus</i>	Mugiliformes: mugilid (flathead grey mullet)	Asia
<i>E. longipalpus</i>	Tetraodontiformes: diodontid (bridled burrfish)	Americas
<i>E. luciopercarum</i> (syn. <i>E. confusus</i> , <i>skrabjini</i>)	Anguilliformes: anguillid (American eel); Clupeiformes: clupeid (alewife); Cypriniformes: catostomid (white sucker), cyprinid (fathead minnow); Esociformes: esocid (northern pike); Gadiformes: lotid (burbot); Perciformes: centrarchid (rock bass, smallmouth bass, largemouth bass), moronid (white perch, white bass), percid (yellow perch, redfin perch, sauger, walleye), percopsid (trout-perch); Salmoniformes: salmonid (Atlantic salmon, rainbow trout, cisco, lake whitefish, round whitefish, chinook salmon, brown trout, brook trout, lake trout)	North America
<i>E. ludhianata</i>	Cypriniformes: cyprinid (Eurasian carp)	Eurasia
<i>E. macrodactylus</i>	Characiformes: alestid (imberi); Cichliformes: cichlid (haplo, tilapia, sandeater, mbuna)	Africa
<i>E. magnicornis</i>	Cypriniformes: cyprinid (goldfish, crucian carp); Mugiliformes: mugilid (greenback mullet)	Australasia
<i>E. malnadensis</i>	Siluriformes: silurid (wallago catfish)	Asia
<i>E. manicatus</i>	Atheriniformes: atherinopsid (inland silverside, tidewater silverside, Atlantic silverside); Cypriniformes: catostomid (lake chubsucker); Cyprinodontiformes: fundulid (mummichog, striped killifish, rainwater killifish, sheepshead minnow); Gasterosteiformes: gasterosteid (three-spined stickleback, blackspotted	North America

	stickleback); Osmeriformes: osmerid (rainbow smelt)	
<i>E. megaceros</i> (syn. <i>E. fragilis</i>)	Clupeiformes: clupeid (American gizzard shad); Cypriniformes: catostomid (lake chubsucker, creek chubsucker, blacktail redhorse, white sucker), cyprinid (fallfish, golden shiner, silver chub, blacktail shiner, pretty shiner, cherryfin shiner, pugnose minnow, fathead minnow, bullhead minnow), leuciscid (Mississippi silvery minnow, silver chub, weed shiner, fluvial shiner, silverband shiner); Esociformes: esocid (chain pickerel, redfin pickerel); Perciformes: centrarchid (rock bass, largemouth bass); Petromyzontiformes: petromyzontid (sea lamprey); Siluriformes: ictalurid (channel catfish, black bullhead, yellow bullhead)	North America
<i>E. megacheir</i>	Cichliformes: cichlid (Congo cichlid, humphead cichlid, scale-eater, raitapetoahven, pikkupetoahven, petosuuhautoja, kalterilevahautoja, keltavatsahautoja, juhmurisuusomunsoyoja); Siluriformes: mochokid (upside-down catfish, cuckoo catfish)	Africa
<i>E. mendisi</i>	Siluriformes: silurid (butter catfish)	Asia
<i>E. mirabilis</i>	Characiformes: alestid (African tigerfish, spot-tail), hepsetid (African pike characin); Cichliformes: cichlid (banded jewel cichlid); Cypriniformes: cyprinid (rednose labeo, Hamilton's barb); Gobiiformes: gobiid (tank goby); Osteoglossiformes: mormyrid (Zambesi parrotfish, bulldog, churchill); Siluriformes: clariid (African sharptooth catfish, blunt-toothed African catfish), mochokid (leopard squeaker, largespot squeaker, blackspotted squeaker, brown squeaker), schilbeid (silver catfish, African butter catfish)	Africa
<i>E. monodi</i>	Perciformes: lobotid (Atlantic tripletail); Siluriformes: ariid (hardhead catfish)	Americas
<i>E. mosulensis</i>	Cypriniformes: cyprinid (Mesopotamian himri, kangal fish); Mugiliformes: mugilid (Abu mullet, largescale mullet, rock mullet, bluespot mullet)	Africa
<i>E. mugilis</i>	Acanthuriformes: sciaenid (spot croaker, Atlantic croaker); Elopiformes: elopid (ladyfish); Mugiliformes: mugilid (thinlip mullet, flathead grey mullet, white mullet)	North America
<i>E. myctarotes</i>	Carcharhiniformes: sphyrnid (smooth hammerhead shark)	Jamacia
<i>E. nerkae</i>	Cypriniformes: catostomid (longnose sucker, white sucker, largescale sucker, Utah sucker, shorthead redhorse), cyprinid (peamouth), leuciscid (lake chub, Utah chub, spottail shiner, redbase shiner, northern squawfish); Gasterosteiformes: gasterosteid (three-spined stickleback, ninespine stickleback); Hiodontiformes: hiodontid (goldeneye); Perciformes: centrarchid (largemouth bass), percopsid (trout-perch); Salmoniformes: salmonid (sockeye salmon, coho salmon, lake trout, rainbow trout, lake whitefish, round whitefish, mountain whitefish, cisco, Arctic grayling); Scorpaeniformes: cottid (slimy sculpin)	North America
<i>E. nodosus</i>	Characiformes: alestid (nurse tetra, kawara), distichodontid (harmaahertta tetra, African pike-characin); Cichliformes: cichlid (Congo cichlid, lohe, microdon); Clupeiformes: clupeid (small-toothed pella); Osteoglossiformes: mormyrid (elephant-nosed fish, stonebasher, rypoun-obrooky); Siluriformes: bagrid (bayad), mochokid (blotched upside-down catfish)	Africa
<i>E. ogawai</i>	Carangiformes: latid (barramundi); Rhinoprismiformes: pristid (largetooth sawfish)	Australia
<i>E. orientalis</i>	Beloniformes: belonid (reef needlefish, nanaifichi); Gobiiformes: oxudercid (yellowfin goby); Mugiliformes: mugilid (squaretail mullet, kanda)	Asia
<i>E. osmeri</i>	Osmeriformes: osmerid (smelt)	Eurasia
<i>E. ovatus</i>	Cypriniformes: cyprinid (goldfish)	Europe
<i>E. pakistanicus</i>	Synbranchiformes: mastacembelid (zig-zag eel)	Asia
<i>E. parabahiensis</i>	Mugiliformes: mugilid (mountain mullet)	South America
<i>E. pararostralis</i>	Mugiliformes: mugilid (greenback mullet)	Middle-East
<i>E. parasiluri</i>	Siluriformes: silurid (Amur catfish)	Asia
<i>E. parvitergum</i>	Acanthuriformes: leiognathid (splendid ponyfish), siganid (golden-lined spinefoot); Anabantiformes: anabantid (climbing perch); Beloniformes: hemiramphid (halfbeak); Carangiformes: carangid (Malabar trevally); Centrarchiformes: terapontid (Jarbua terapon); Cichliformes: cichlid (green chromide, orange chromide, Mozambique tilapia); Clupeiformes: clupeid (Bloch's gizzard shad); Gonorynchiformes: chanid (milkfish); Mugiliformes: mugilid (flathead gray mullet); Ovalentaria: ambassid (bald glassy); Perciformes: lutjanid (snapper); Siluriformes: bagrid (catfish); Tetraodontiformes: triacanthid (short-nosed tripodfish)	Sri Lanka
<i>E. peregrinus</i>	Ababantiformes: channid (northern snakehead); Anguilliformes: anguillid (Japanese eel); Cypriniformes: cyprinid (grass carp, Eurasian carp, yellowcheek,	Eurasia

	chub, Amur ide), cobitid (pond loach); Gobiiformes: odontobutid (dark sleeper); Perciformes: siniperid (mandarin fish, golden mandarin fish)	
<i>E. philippinensis</i>	Gobiiformes: gobiid (tank goby)	Asia
<i>E. piriformis</i>	Mugiliformes: mugilid (yellowtail mullet)	India
<i>E. pitalicus</i>	Cichliformes: cichlid (cichlid)	Americas
<i>E. plecoglossi</i>	Osmeriformes: plecoglossid (ayu)	Asia
<i>E. polynemi</i>	Perciformes: polynemid (fourfingered threadfin)	Indo-Pacific
<i>E. ponticus</i>	Syngnathiformes: syngnathid (black-stiped pipefish)	Europe
<i>E. rhinos</i>	Perciformes: centrarchid (flier, redbreast sunfish, pumpkinseed)	North America
<i>E. rostralis</i>	Mugiliformes: mugilid (Abu mullet, largescale mullet, goldspot mullet, bluespot mullet, greenback mullet, Tade gray mullet, longarm mullet)	India
<i>E. rotundicarpus</i>	Perciformes: siganid (orange-spotted spinefoot)	Asia
<i>E. salmini</i>	Characiformes: characid (golden dorado)	South America
<i>E. sarsi</i>	Characiformes: alestid (spot-tail); Cichliformes: cichlid (microdon, hump-back bream, Mweru hump-backed bream, paratilapia, mbuna cichlid); Cyprinodontiformes: poecilid (Tanganyika killifish); Osteoglossiformes: mormyrid (bulldog); Siluriformes: clariid (mudfish, blunt-toothed African catfish, African sharptooth catfish, eel-like fattyfin catfish), mormyrid (elephantnose fish), mochokid (blackspotted squeaker)	Africa
<i>E. scalaris</i>	Cypriniformes: cyprinid (yellowcheek); Siluriformes: silurid (Soldatov's catfish)	Eurasia
<i>E. scotti</i>	Siluriformes: silurid (wallago catfish)	Asia
<i>E. sergipensis</i>	free-swimming	South America
<i>E. sheyangensis</i>	Mugiliformes: mugilid (mullet)	Asia
<i>E. sieboldi</i> (syn. <i>E. baicalensis</i> , <i>depressus</i> , <i>esocis</i> , <i>hoferi</i> , <i>surbecki</i> , <i>trisetaceus</i>)	Acanthuriformes: leiognathid (splendid ponyfish); Anabantiformes: anabantid (climbing gourami); Anguilliformes: anguillid (European eel); Beloniformes: hemiramphid (halfbeak), Cichliformes: cichlid (green chromide, orange chromide, Mozambique tilapia); Clupeiformes: clupeid (Bloch's gizzard shad, Pontic shad, Atlantic herring); Cypriniformes: cyprinid (ziege, chub, gudgeon, longspine scraper, seven khramulya, Orontes bleak, Mossul bleak, sunbleak, zope, common bream, white bream, shabout, Mesopotamian himri, binni, crucian carp, broad-snout, asp, Tigris asp, silver carp, ide, Amur ide, common roach, tench, common bleak, grass carp, Eurasian carp, common rudd), gobionid (Soldatov's gudgeon), leuciscid (asp); Esociformes: esocid (northern pike); Gadiformes: lotid (burbot); Gasterosteiformes: gasterosteid (three-spined stickleback); Gobiiformes: gobiid (round goby); Gonorynchiformes: chanid (milkfish); Mugiliformes: mugilid (flathead gray mullet, thinlip mullet, Abu mullet, golden grey mullet, leaping mullet); Osmeriformes: osmerid (European smelt); Ovalentaria: ambassid (bald glassy); Perciformes: centrarchid (warmouth, pumpkinseed), lutjanid (snapper), percid (zander, Volga pikeperch, Eurasian ruffe, redfin perch), siganid (golden-lined spinefoot), terapontid (jarbua terapon); Pleuronectiformes: pleuronectid (European flounder, European plaice), scophthalmid (turbot); Salmoniformes: salmonid (rainbow trout, brown trout, cisco, common whitefish, peled, blaufelchen, grayling); Siluriformes: bagrid (catfish), ictalurid (brown bullhead), silurid (wels catfish)	cosmopolitan
<i>E. sinefalcatius</i>	Characiformes: bryconid (golden dorado)	South America
<i>E. sittangensis</i>	Mugiliformes: mugilid (Burmese mullet)	Asia
<i>E. spatulus</i>	Beloniformes: belonid (Atlantic needlefish, timucu needlefish)	Americas
<i>E. spinilaminatus</i>	Perciformes: percichthyid (golden perch), terapontid (leathery grunter)	Australia
<i>E. spinipes</i>	Perciformes: sparid (goldsilk seabream)	Africa
<i>E. suboculatus</i>	Mugiliformes: mugilid (thinlip mullet)	Asia
<i>E. synanceiensis</i>	Perciformes: synanceiid (blackfin stonefish)	India
<i>E. thailandensis</i>	free-swimming	Asia
<i>E. thatcheri</i>	Siluriformes: heptapterid (South American catfish)	South America
<i>E. tipurus</i>	Characiformes: cynodontid (biara); Siluriformes: pimelodid (vulture catfish, duckbill catfish)	South America
<i>E. tissensis</i>	Cypriniformes: cyprinid (common barbel)	Europe
<i>E. triangularis</i>	Characiformes: anostomid (striped headstander)	Asia
<i>E. trygonophilus</i>	Myliobatiformes: pomatotrygonid (freshwater stingray, long-tailed river stingray)	South America
<i>E. tumidus</i>	Cypriniformes: cyprinid (bitterling, common minnow, lake minnow); Perciformes: sparid (blackhead seabream)	North America
<i>E. turgidus</i>	Gasterosteiformes: gasterosteid (three-spined stickleback); Ovalentaria:	North America

	embiotocid (shiner perch); Salmoniformes: salmonid (sockeye salmon); Scorpaeniformes: cottid (roughback sculpin)	
<i>E. turkayi</i>	Characiformes: serrasalmid (redhook piranha)	South America
<i>E. turucuyus</i>	Characiformes: acestrorhynchid (pirapuco), characid (pikili)	Africa
<i>E. uniseriatus</i>	Gobiiformes: gobiid (tank goby)	Australasia
<i>E. urupaensis</i>	Characiformes: prochilodontid (black prochilodus)	South America
<i>E. vembanadensis</i>	Siluriformes: silurid (wallago catfish)	Asia
<i>E. ventriosus</i>	Cypriniformes: acheilognathid (uyeki bitterling), cyprinid (pale bleak, giant Chinese bitterling)	Asia
<i>E. versicolor</i> (syn. <i>E. elegans</i>)	Anguilliformes: anguillid (American eel); Clupeiformes: clupeid (skipjack shad); Cypriniformes: catostomid (shorthead redhorse, blacktail redhorse, white sucker, spotted sucker, smallmouth buffalo, bigmouth buffalo, lake chubsucker, creek chubsucker, sharpfin chubsucker); Eupercaria: sciaenid (black drum); Gasterosteiformes: gasterosteid (brook stickleback); Lepisosteiformes: lepisosteid (longnose gar, short-nosed gar, alligator gar, Cuban gar); Mugiliformes: mugilid (flathead grey mullet, striped mullet, white mullet); Perciformes: centrarchid (green sunfish, warmouth, bluegill, longear sunfish, largemouth bass, rock bass, spotted bass), moronid (white bass, yellow bass); Siluriformes: ictalurid (black bullhead, brown bullhead, blue catfish, black bullhead, yellow bullhead, brown bullhead, mud cat, Fulton cat, channel catfish, stonecat, flathead catfish, tadpole madtom)	North America
<i>E. wareaglei</i>	Cypriniformes: catostomid (white sucker, northern hog sucker, Alabama hog sucker)	North America
<i>E. wilsoni</i>	Cypriniformes: cyprinid (Zeravshan dace); Gasterosteiformes: gasterosteid (three-spined stickleback); Gobiiformes: gobiid (dusky tripletooth goby, biringo, ukigori); Osmeriformes: osmerid (pond smelt); Salmoniformes: salmonid (pink salmon)	Eurasia
<i>E. xenomelanirisi</i>	Atheriniformes: atherinopsid (Brazilian silverside)	South America
<i>E. xinguensis</i>	Cichliformes: cichlid (Xingu blue streak eartheater, freshwater eartheater)	South America, Asia
<i>E. xinjiangensis</i>	Cypriniformes: cyprinid (balkhash marinka)	China
<i>E. yaluzangbus</i>	Cypriniformes: cyprinid (naked schizothoracin)	Asia
<i>E. yandemontei</i>	Atheriniformes: atherinopsid (pejerrey); Perciformes: percichthyid (perch)	South America
<i>E. youngi</i>	Siluriformes: ariid (cangata)	South America
<i>E. yumaricus</i>	Characiformes: serrasalmid (red-bellied piranha, Eigenmann's piranha, redeye piranha)	South America
<i>E. zacconis</i>	Cypriniformes: cyprinid (pale bleak); Osmeriformes: plecoglossid (ayu)	Asia

Several species have also been reclassified to other genera: including *E. amplexans* = *Dermoergasilus*; *E. biuncinatus* = *Thersitina gasterostei*; *E. coleus* = *Dermoergasilus*; *E. effcatus* = *Bomolochus*; *E. euripedesi* = *Gauchergasilus*; *E. gasterostei* = *Thersitina*; *E. iheringi* = *Tiddergasilus*; *E. intermedius* = *Dermoergasilus*; *E. japonicus* = *Neoergasilus*; *E. semicoleus* = *Dermoergasilus*; and *E. tenax* = *Acusicola*.

Parasite morphology: *Ergasilus* spp. form 4 different morphological stages during their developmental cycles: eggs; nauplii (3-6 free-swimming instars), copepodids (5 free-swimming instars); and adults (free-swimming males and females, but fertilized females become parasitic on fish gills). The eggs are small (around 0.05 mm), ovoid, white to light brown and located in eggs sacs in multiseriate arrangements until dispersed into the water column. They hatch to release small free-swimming naupliar stages, with different studies reporting 3 or 6 instars (most parasitic taxa have 3 instars, while most free-living taxa have 6). The nauplii grow in size from 0.08-0.25 mm with their small unsegmented bodies possessing only 3 pairs of functional appendages (antennules, antennae, mandibles) and a single unique maxillopodan eye. The antennae do possess feeding processes on the coxae (common to free-living taxa) which supports the view that ergasilid copepodids are planktotrophic and feed on other planktonic organisms (esp. unicellular algae), whereas parasitic copepods have lecithotrophic nauplii relying on yolk stores for nutrients. The final naupliar stage moults to form a copepodid stage which is also free-swimming. Copepodids develop through 5 instars (common to most free-living taxa) and their segmented bodies grow from 0.3-0.8 mm long, adding a body somite at each moult (thus growing from 6-10 segments). They have a cyclopid body plan similar to adult stages, with a full set of cephalic appendages but the antennae are not modified into claspers and they only have 2 pairs of swimming legs. The final copepodid stages moult into male and female copepods which are free-swimming as they become sexually mature. After mating, the males die while the fertilized females become parasitic on the gills of fish. The most conspicuous change exhibited by parasitic females is the modification of the antennae into large prehensile claws used to clasp gill filaments. The antennae consist of 4 slender segments, the first short, the second long, the third directed inwards, and the fourth ending in a sharp hooked claw. The third and fourth segments are opposable with the second (subchelate) and may pierce gill filaments or completely encircle them. The body lies parallel to the gill filament with the

head facing towards the base. Adults have cyclopid bodies which are pyriform (tapering posteriorly) and range in size from 0.5-2.0 mm in length. The carapace may be transparent to opaque white, sometimes lightly pigmented brown with traces of purple. The elongate body contains 11 segments in males and 10 in females. Segmentation conforms to a podoplean body plan with 4 pairs of legs and the division of the anterior prosome and the posterior urosome occurring after the fourth leg-bearing somite (in contrast to the gymnoplean plan exhibited by many free-living copepods with 5 pairs of legs and the division occurring after the fifth leg-bearing somite). The body is divided into 4 regions: the cephalothorax (with antennules, antennae, mandibles, maxillules, maxillae, and maxillipeds (present only on males)), free thorax (with swimming legs), genital segment (with egg sacs), and abdomen (with caudal structures). The cephalothorax consists of the head fused with the first few thoracic segments. It is dorsoventrally flattened, longer than wide, and rounded anteriorly with a single eye with pigmented inner margins located close to the anterior midline. The small antennules have 5-6-segments and are sensory with setae on their anterior borders. The mouthparts are small and located ventrally near the centre of the cephalothorax. They are used for scraping or rasping delicate gill tissues (not for biting and chewing) and have been described as poecilostome (slit-like mouths with sickle-shaped mandibles) rather than gnathostome (open mouths with short broad mandibles) or siphonostome (tubular mouth with stylet-like mandibles). A plate-like labrum fused to the ventral surface of the carapace acts like an upper lip, and the mouth contains saw-like mandibles with 3 serrated blades that oppose the elongate maxillae. The maxillules are reduced and appear as lobate papillae bearing setae. The maxillae also have spiny tips that are thought to help grasp gill filaments. The maxillipeds are absent in parasitic females and only develop on males midway through their copepodid developmental stages. Parasitic females are able to move between gill filaments using 4 pairs of swimming legs (their setae are lost soon after attachment). The first legs are attached to the cephalothorax and are often rigid with blade-like spines thought to be used to assist feeding. All legs are biramous with broad coxae and bases, the first endopod contains 2 or 3 segments, the fourth exopod contains 3 segments (except for the fourth pair of legs which have 2 segments), and all other rami have 3 segments. There are conflicting reports about the presence of a fifth pair of legs, but in those instances where they are considered to be present, they are highly reduced to stumpy papillae, sometimes with 1-2 setae. Patterns of leg segmentation and setation have been used to differentiate many ergasilid species. The mouth feeds into the digestive tract consisting of lobulate stomach (with median, diagonal and lateral lobes), tubular intestines (with excretory tubules) and posterior rectum. The free thorax has 4 segments, the fourth one often being reduced and adjoining a robust genital segment (wider than long) bearing oviductal openings. The abdomen narrows posteriorly and lacks appendages (like all maxillopods). The female urosome has 4 well-defined segments (5 in males) and the terminal telson consisting of simple furcal (forked) rami (arms) with long setae (the inner setae being the longest). Fertile females bear paired egg sacs that hang posteriorly from either side of the genital segment (similar to other podoplean copepods). The sacs are initially white ovoid structures but become long cylindrical trailing 'tails' that often darken with age to brown. Mature females produce clutches of up to 200-220 multiseriate eggs which are ultimately dispersed to hatch. Males are entirely free-living and do not become parasitic. They are smaller and slenderer than females, their antennae are smaller (but still prehensile), their mouthparts are similar, they possess maxillipeds with long curved terminal segments, their swimming legs have rami with 3 segments, and their abdomens have one more segment than females.

Site of infection: The larval stages (nauplii and copepodids) and young adults are all free-swimming stages living in aquatic environments. However, females become parasitic after mating and seek out fish hosts on which to attach. They typically invade the gill chambers and cling onto gill filaments, but some have been found in the nasal fossae and a few occasionally on the skin and fins. They are typically found on fish around coastal regions, mostly in freshwater but also euryhaline (estuarine and marine) environments. They have a broad host specificity and have been recorded on fish from 33 different orders, as well as on a few sharks and rays. They are most abundant on Cypriniformes, Perciformes, Siluriformes and Mugiliformes.

Pathogenesis: Ergasilid copepods are notorious in aquaculture for causing morbidity (respiratory distress and hypoxia) and mortality. They are often called gill lice, and sometimes gill maggots (due to the appearance of their mature egg sacs). Fertilized females attach to the gills by piercing or encircling gill filaments with their large claws. They use their rasping mouthparts, and possibly enzyme secretions, to feed on epithelial tissues, mucus and blood. Both attachment and feeding cause a range of pathological alterations to the gills, with loss of normal structure and disruption of blood flow leading to respiratory problems. The parasites cause traumatic lesions on the gill filaments with erosion of the surface epithelium, cell necrosis, tissue loss and sometimes small haemorrhages. The host reacts by mounting inflammatory responses with hyperplasia (proliferation) of epithelial cells, rodlet cells, and mucous cells. This leads to compression of the tissues which constricts and occludes blood vessels, further exacerbated by parasites constricting gill filaments with their claw-like antennae. Heavily-infested fish exhibit respiratory distress with hypoxia due to disrupted gas exchange and lamellar fusion, as well as reduced osmoregulatory function, loss of condition, retarded growth and sluggish behaviour sometimes culminating in death. Infested fish are less tolerant of environmental changes associated with local weather patterns (fluctuating temperatures and oxygen levels) and are less able to survive seasonal variations (particularly over-winter). Lesions caused by the parasites are also highly susceptible to secondary infections with bacteria, fungi and viruses. There are anecdotal reports that ergasilids may be able to act as mechanical or even biological vectors for other fish diseases, but further studies (particularly molecular screening) need to confirm these suspicions.

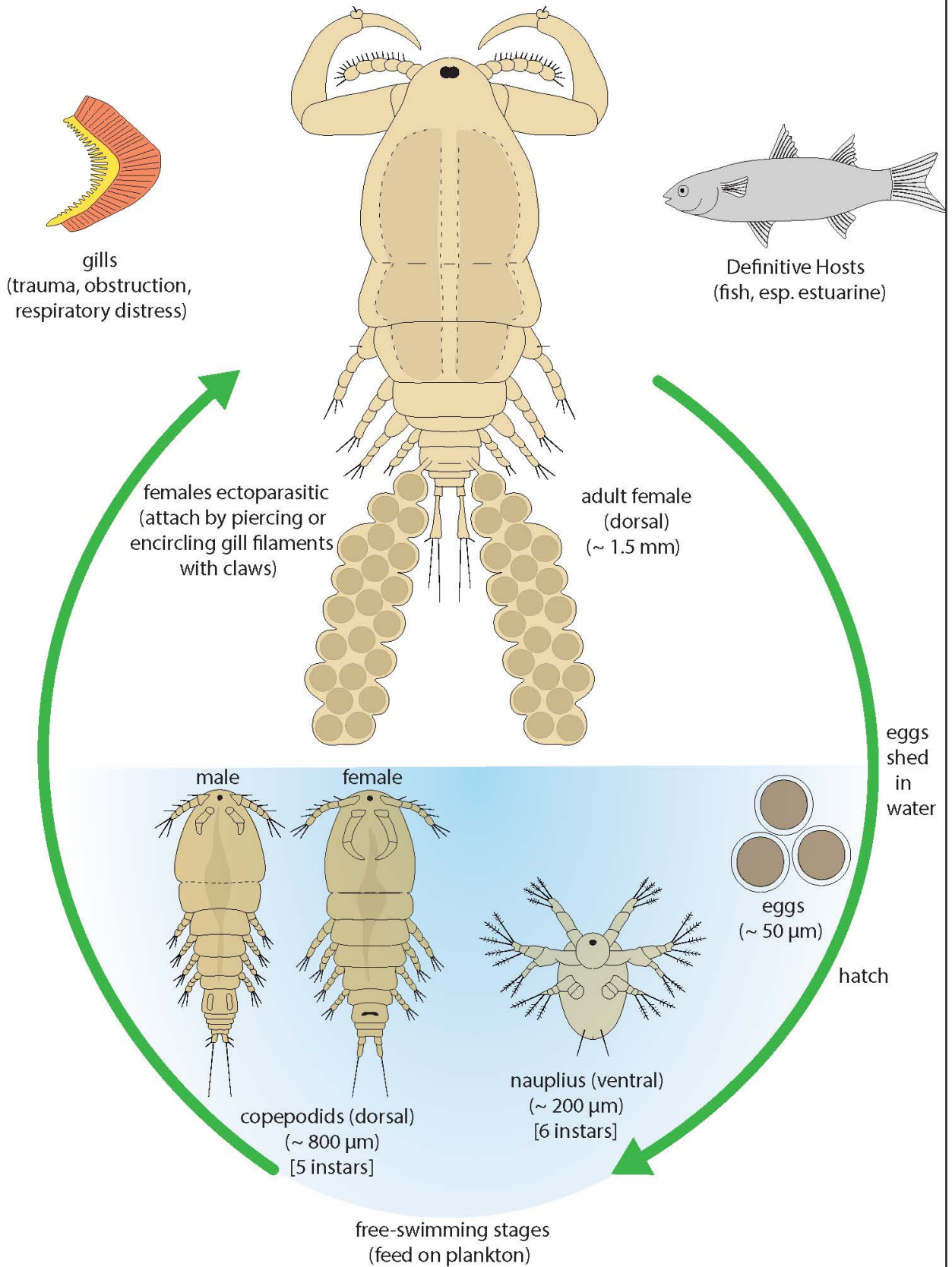
Developmental cycle and mode of transmission: These copepods undergo gradual metamorphosis whereby a succession of free-living planktonic larval stages slowly transform into adults. Only fertilized females then go on to parasitize fish hosts culminating in the production of numerous eggs which embryonate in attached egg sacs. The eggs hatch after 3-6 days releasing small unsegmented

nauplii (singular, nauplius) into the water column. Current studies indicate that there are 6 naupliar instars that feed on other planktonic organisms (especially algae) over several weeks. The parasites then form more complex segmented copepodid stages that also swim about feeding on planktonic organisms. There are 5 copepodid instars which become progressively more like adults by the additional of an extra body somite at each moult. Both male and female adult copepods are formed after several weeks and they mate as free-swimming stages. The males do not parasitize fish but die after mating, whereas the fertilized females seek out freshwater, estuarine or marine fishes and become parasitic on their gills by developing specialized claw-like antennae for attachment. Parasitic females may live for up to 1 year and they usually produce 2-5 clutches of 200-200 eggs in that time. The whole life-cycle may be completed in 30-70 days depending on environmental conditions (longer at lower temperatures) and females can over-winter on their fish hosts.

Differential diagnosis: Infestations may be suspected when fish exhibit respiratory distress despite good oxygen levels in the water. Diagnoses are made ante-mortem or post-mortem by direct observation of ergasilids (gill lice or gill maggots) on gill filaments. Gravid female copepods are readily seen as their white-tan egg sacs dangle freely from the tips of gill filaments. The parasites cannot be easily removed intact so biopsy samples of the gill filaments are collected should microscopy be required. Molecular biological techniques have been used to identify and characterize species by polymerase chain reaction (PCR) amplification of nuclear genes sequences (28S ribosomal RNA and internal transcribed spacers 1 and 2).

Treatment and control: The treatment of infestations is difficult for a range of reasons, including the lack of suitable and effective chemotherapeutic agents, the resistance of all developmental stages to a wide range of environmental conditions (salinity, temperature), the persistence of free-living planktonic stages in the water column, the long life-spans and high fecundity of parasitic females, the cryptic nature of many infestations (remaining subclinical for long periods) and the sporadic appearance of outbreaks (often triggered by unknown factors). Nevertheless, because the parasites affect the gills, infested fish are generally more sensitive to changes in water quality and low dissolved oxygen levels. Maintaining good water quality and high oxygen levels will help fish respire and lessen the impact of infestations. Various attempts have been made to treat infections with chemical baths (potassium permanganate, formalin, quicklime, copper solutions, and even organophosphate and pyrethroid insecticides), but none were proven to be very effective. The only way to eradicate parasites and their free-living stages would be to de-stock, drain and lime the entire fishery, which is simply impractical in most situations. Implementing some sensible management procedures may help in controlling infestations in culture facilities; such as carefully managing fish stocks (regular health surveillance, quarantine new stock, avoid over-crowding, culling sick individuals, increasing water flow) and maintaining hygiene (periodically disinfect holding tanks and equipment).

Ergasilus





Ergasilus adults on fish gills



Ergasilus nauplius