Chapter12

Parasites and Parasitic Diseases in Fish Culture System

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Introduction

The fish production system in India has two main sources viz. culture fisheries- the fish grown in captivity and capture fisheries- the fish caught from the wild stock. There are also some intermediate forms of production such as culture-based fisheries, enhanced capture fisheries and capture based aquaculture. In culture based fisheries, fishes are stocked in reservoirs and lakes and caught back after they grow by utilizing natural food. Enhanced capture fishery means augmenting the fish stock in capture fisheries by stocking support. Under capture-based aquaculture fish seed collected from wild are grown in captivity. The major sources of fish production in India are: freshwater aquaculture, mariculture and coastal aquaculture with intermediate culture system based on culture based fisheries and enhanced capture fisheries of reservoirs/wet lands, marine capture fisheries of open sea, and inland capture fisheries of rivers estuaries and lakes. Of these, the first three hold huge potential to achieve a significant increase in fish productivity and production to meet the growing demand of fish as a protein source at affordable price besides providing livelihood for over 400 million people. At present, the three Indian major carps viz. catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) constitute the main contributor (90%) for freshwater aquaculture production with about half of the total fish production in the country followed by silver carp, grass carp and common carp.

Culture system with different combination of carps have been standardized to meet local requirements. Apart from culture of Indian major carps, opportunities exist for developing culture of magur (*Clarius batrachus*), many coldwater fishes like trouts and mahseers in hill states like Jammu and Kashmir, Himachal Pradesh, Uttrakhand, Sikkim and Arunachal Pradesh. Mariculture is also a fast growing enterprise with seabass (*Lates calcarifer*), grouper (*Epinephelus tauvina*, *E. malabaricus*), mullet (*Mugil cephalus*), red snapper (*Lutjanus argentimaculatus*) and many other marine fish species. Cobia (*Rachycentron canadum*) is also gaining importance as a promising marine fish species for sea farming in offshore grow-out cages. Coastal aquaculture, though dominated by shrimp species is also having potential for fish production with brackishwater species like seabass (*Lates calcarifer*), mullet (*Mugil cephalus*) and milk fish (*Chanos chanos*) either in pond, cage or pen culture (Figs 1-5). Fish production system which was practiced earlier as a traditional activity has grown into a commercial enterprise in late 1980's due to the thrust given to aquaculture. The growth of this sector has been phenomenal, contributing significantly to food security export earnings and employment generation. At present the country produces 4.6 million tons of fish and is the second largest producer of inland fish in the world and third in terms of total fish production contributing more than 1% to the country's GDP and 4.7% to the agricultural GDP. Apart from food sector, ornamental fish farming and trade is also developing rapidly in India. Recently brackishwater and marine aquarium is also drawing the attention of fish hobbyists in India.

Fig.1: A fish culture pond in West Bengal

Fig .2: Cage farming of Asian seabass in Kerala

Fig. 3: A polyculture farm in West Bengal

Fig .4: Cultured Tilapia fish in West Bengal

Aquaculture in the country holds tremendous potential to contribute towards the food security and for augmenting export earnings. The intensification of culture practices though helped to increase production levels, also led to the outbreaks of viral, bacterial and parasitic diseases. Many diseases result from intensification of culture practices without basic perception of the intricate balance between host, pathogen and environment challenging the sustainable development of aquaculture. Aquaculture environment that are suitable for growth and reproduction of cultured animals are also hospitable to potential pathogens. Like any other culture species, fish culture also has to deal with various pathogens like virus, bacteria, fungi and parasites. In wild, parasitism is a ubiquitous phenomenon in the marine environment. The effect of parasites on the condition and dynamics of wild populations are still poorly understood. A large volume of information on parasitic infections in wild fish is available in India, but the significance of these as a disease entity is vague. Readers are referred to recent compilation and checklist published by Abidi (2002). Parasitic diseases in fishes range from extremely pathogenic ones to those that are practically harmless and are broadly categorized into two major groups, protozoan and metazoan parasites. The present chapter deals with fish parasites and parasitic infections in wild and culture system that are of economic concern for production system and the emerging parasitic diseases in India and neighboring countries.

Fig .5: A cage design used for sea farming in India (CMFRI, 2010)

Fig.6: Mortality of cultured fish due to diseases, Andhra Pradesh

Fig.7: Seabass broodstock floating upside down with disease symptoms, Tamil Nadu

Diseases in aquaculture system

Disease is now a primary constraint to aquaculture production globally impeding both economic and social development in many countries. This is attributed to many factors such as intensification and diversification of aquaculture practices through translocation of broodstock, post larvae, fry and fingerlings, etc.; globalization of live fish trade including ornamentals and their products; the enhancement of marine and coastal areas through stocking aquatic animals raised in hatcheries; unanticipated negative interactions between cultured and wild fish populations; poor or lack of effective biosecurity measures; slow awareness on emerging diseases and above all global change in climate and human mediated movements of aquaculture commodities. Control of disease is complex and relies heavily on a combination of the following pathogen detection, disease diagnosis, treatment, prevention and general health management.

Parasitic diseases in fin fishes

Parasitic diseases are one of the most serious problems in fishes, though not of much concern among the wild fish stock because in most instances, no significant harm appears to be caused to them. However, parasites often cause serious disease outbreaks of among farmed fish. With the exception of cases of mass mortalities caused by outbreaks of parasites, assessment of the effects of parasite infection in natural fish populations is particularly difficult because of the presence of predators or scavengers which rapidly remove moribund or dead fish. Majority of the fish parasites belong to three major groups, protozoan, helminths and arthropods bring dominated by crustaceans.

Protozoan parasites

Protozoan parasites are either external or internal parasites, present in large numbers on the surface of the skin, gills or in the internal organs of fishes. They have direct life cycle and hence build up to very high numbers in a short time especially when fish are overcrowded. The most common protozoan parasite observed in fish culture system are ciliates although some obligate amoebic, flagellate and microsporidians (sporozoa) are also noticed.

Ciliate infections : Ciliates are external parasites with a direct life cycle and many are common inhabitants of pond reared fish (Figs 8-11). Most species get noticed once they become a problem due to excessive numbers on the host. Infection occurs in fishes when there is high level of organic matter in the water or poor water exchange and the stocking density is high.

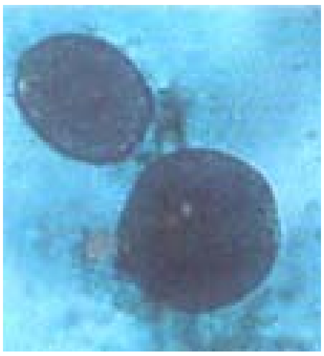


Fig.8: Amyloodinium spp

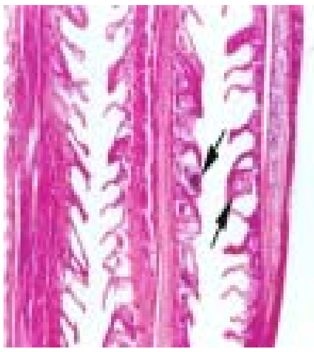


Fig.9: *Cryptocaryon* spp. on gills

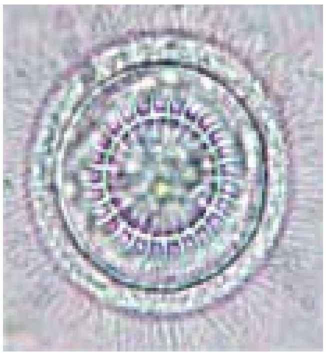


Fig.10: *Trichodina* spp. (fresh)

Fig.11: *Cryptocaryon* spp.

Ichthyophthirius spp. in freshwater and *Cryptocaryon* spp. in marine and brackishwater are the most common ciliates. Others are *Chilodonella*, *Tetrahymena*, *Trichodina*, *Ambiphyra*, *Apiosoma*, *Epistylis*, etc. *Chilodenella* is a large, heart shaped ciliate 60-80m with bands of cilia along the long axis of the organism. *Ambiphyra* and *Apiosoma* are sedentary ciliates commonly found on the skin, fins or gills of pond reared fish. *Epistylis* is a stalked ciliate that attaches to the skin or fins of the host in colonies.

Icthyophthirius multifilis : It **c**auses icthyophthiriasis, also known as 'Itch' or 'white spot' and is probably the most significant protozoan disease which affects the early stages of all freshwater food fishes. They are up to 1 mm in size characterised by its large horse-shoe shaped nucleus. Incidences of large scale mortality are common in nursery and rearing ponds with numerous pin-head shaped white spots on skin, fins, and gills. In advanced cases the entire body surface of the fish becomes covered with such nodules resulting in severe mortality. The parasite feeds on the epithelial tissues and fluids of the fish causing simple hyperplasia of the epidermal cells around the site of infection. Stages of *I. multifilis* within the dermal tissues of the host fish are almost impossible to remove using chemotherapy. Hence control is targeted against the life cycle stages outside the dermal tissue of the host.

Cryptocaryon irritans : It is a pear shaped (0.3-0.5 mm in size) ciliate found often on the surface of the fish. Infection sets in when there is high stocking density and decreased water temperature.

Species affected : The pathogen, *I. multifilis* accounts for significant economic losses to the aquaculture of catfish, carp, tilapia, seabass, grouper, snapper, etc. and ornamental fishes, and epizootics in wild fish population can result in mass kill.

Gross signs: Symptoms typical of ciliate infection include skin, and gill irritation displayed by flashing, rubbing and rapid breathing. Infected fish show tiny white spots on the fins and skin when infection has reached the mature stage, increased mucus production; fish often rub against submerged objects.

Effects on host: The disease causes massive mortality within a short time. The parasite may destroy the skin and gills causing respiratory problems, secondary bacterial infection and mass mortality. Occurrence of this parasite is often linked with a drop in ambient temperature.

Diagnosis: Encysted organism appears as visible white spots on the surface of the fish. Microscopic examination of the mucous from skin and gills may reveal round or oval parasites with cilia and horse shoe shaped macronucleus typical of ciliates.

Prevention and control*: For 'itch'*

- An elevation of water temperature to 30°C for 6 hr. daily for 3-5 days.
- 0.05% salinity shock.
- 100 ppm formalin for 1 hr for 2-3 days.
- 25 ppm formalin and 0.1 ppm malachite green.
- Transfer of infected stock in previously dry parasite free tanks for 2-3 times at 3 day interval.

For Cryptocaryon

- Copper sulphate bath (0.5 ppm) for 5-7 days with good aeration and daily replenishment of water. Long bath treatment with 25-ppm formalin, for 5-7 days with good aeration and replacement of treated water daily.
- Preferred treatment for *Epistylis* is salt (0.2%) as an indefinite bath or a 3% salt dip.

Trichodina spp. : One of the most common ciliates found on the skin and gills of pond reared fish. Serious pathogens affecting the fry at low saline water with body shaped like hockey puck with its characteristic movement, which makes them fly through the water like a flying saucer. They mainly live on gills, skin with rings of chitinous teeth and spiral cilia around cytostome. *Trichodina* has a circular body 100 (microns)/*u* diameter with cilia around the perimeter. The infection sets in when there is high level of organic matter in the water or poor water exchange.

Species affected : Catfish, carp, tilapia, mullet, milk fish, seabass, grouper, snapper, etc.

Gross signs : It infects mainly gills, body surface and fins and causes excessive mucus production on gills and body surface with frayed fins.

Effects on host : Low numbers are not harmful, but overcrowding or deterioration of water quality facilitates rapid multiplication and serious damage besides susceptibility to opportunistic bacterial infections. Clinically fish has pale gills with irritation of body and hence they rub body against objects. Fish becomes weak during heavy infection and there can be high mortality among young fish.

Diagnosis : Microscopic examination of wet mounts of gill filaments and mucous from skin reveals saucer shaped parasite with cilia. Characteristic darting movements and presence of a toothed, circular disc within the body makes the identification easy.

Prevention and control : Easy to treat but the correction of the environmental problem is of prime importance.

- Salinity shock using 2-3% salt solution for 2-5 min. for 3-4 days
- Freshwater bath for 1 hour for 3 days
- Short bath with 200-ppm formalin for 30-60 min. for 3 days.

Amoebic infections : Amoebae are considered as serious pathogens of cyprinid fish. Most of the amoebic parasites are opportunistic pathogens, which leads a free life normally.

Causative agents : Some species of the genera *Entamoeba* cause kidney inflammation in trouts, while those of *Acanthamoeba* infect tilapia fish.

Life cycle : Direct and multiply very fast in numbers on debilitated fish.

Species affected : Cyprinids

Gross signs: Infected fish show respiratory distress, dropsy and anaemia.

Effects on host : Cause nodules in visceral organs, and enlargement of kidneys and spleen. Lamellar hyperplasia and hypertrophy, cellular infiltration and necrosis have been reported.

Diagnosis : Amoebae are readily detectable in wet mounts of infected tissues; however species identification is a matter of specialized job.

Prevention and Control : Good hygiene and husbandry besides treatment with saltwater or formalin baths are suggested.

Flagellate infections : Flagellate protozoans infect fish externally and internally. They infect both freshwater and marine fish and are characterized by one or more flagella to aid in a whip like or jerky motion. Majority of the flagellates are considered harmless; however some of them are well known parasites in fishes.

Causative agents : Dinoflagellates are external microscopic parasites with flagella for movement (eg. *Amyloodinium*). It is usually attached to the gill filaments or body surface of affected fish. Infection occurs in low saline water with high level of organic matter and high stocking density of fish. *Amyloodinium ocellatum*, a dinoflagellate causes 'velvet disease' in marine fishes. Primarily a parasite of the gills, later on spreads throughout the body imparting a velvety appearance to the fish and may even invade tissues. Lack of specificity and direct life cycle makes the infection to reach the level of fatal epizootics. *Piscinoodinium* sp. and *Crepidoodinium* spp. are similar to *Amyloodinium* spp. in all aspects and are found to infect freshwater fishes. *Hexamita* is small intestinal parasite commonly found in the intestinal tract of freshwater fish. Trypanosomes are flagellate parasites found infecting the blood of both freshwater and marine fishes with leeches as intermediate hosts. Most of the species are considered less pathogenic but sometimes heavy infection can lead to mortality with clinical signs of sluggishness, pale gills and anaemia. *Trypanoplasma* are biflagellate blood parasites similar to trypanosomes, infecting freshwater fishes. *Cryptobia* spp. causing cryptobiasis is also a biflagellate affecting fresh and marine fishes. Ichthyobodosis caused by *Ichthyobodo* spp. is also a dangerous infection, attacking the entire body surface and gills causing high mortality in freshwater fishes. Non-specific nature and direct life cycle coupled with high stocking densities usually result in fatal epizootics in culture conditions.

Life cycle : The life cycle is direct. The trophont detaches from the host fish, encysts and undergoes a series of divisions to produce free swimming infective stages to infect fresh hosts.

Species affected : Serious disease conditions affecting cat fish, carp, tilapia, seabass, grouper, snapper, etc. among food fishes and occasional mortality in marine ornamental fishes (*Abudefduf bengalensis*) kept under captive conditions.

Gross signs : Fish often come to the water surface or gather near the zone of aeration. Pale gills and darkening of the body surface are also noticed.

Effects on host : Destroy gills and skin, high or mass mortality, if not treated. Sick fishes are dark in colour and extremely thin.

Diagnosis : Diagnosis is by the squash preparation of mucous from gills, skin and fins in case of external parasites and intestinal contents in case of internal parasites.

Prevention and control : Most of the infections are easy to control. Copper sulphate bath (0.5 ppm) for 3-5 days with good aeration and a daily replenishment of water. Short bath treatment with 200 ppm formalin for 1 hr with good aeration is also recommended.

Sporozoan infections : Sporozoans, as a group are spore forming endoparasites, accommodates the largest number of fish parasites. Generally their life cycle consist of three stages, merogony, gamogony and sporogony and in many forms an intermediate host is also involved. Major groups infecting fishes are microsporidians and coccidians.

Microsporidians: Microsporidians which are also obligate intracellular parasites forming oval spores with an average size of 6 *u*m in a wide range of fishes. The infection manifests itself when there is poor water quality and poor nutrition.

Life cycle: The life cycle is direct and infections occur on ingestion of spores either as free spores or via a vector or predation. After ingestion, the infective sporoplasms are released and they enter the target host cell where the parasite undergoes vegetative development to produce characteristic cyst like structure of host origin (xenoma). Large numbers of spores are released from xenoma on host cell rupture.

Causative agents: Many species exist but most important fish microsporidians are *Pleistophora* spp. and *Glugea* spp. (Figs 12-15).

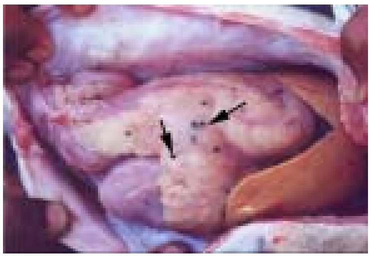


Fig.12: Microsporidian(*Glugea* spp.) nodules (xenoma) in the visceral organs of grouper (*Epinephelus tauvina*)

Fig.13: Fresh spores of microsporidian (*Glugea* spp.) from grouper, *E.tauvina* (1000x).

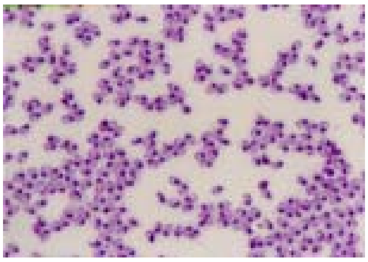


Fig.14: Giemsa stained micro-sporidian (*Glugea* spp.) spore from grouper, *E. tauvina* (1000x)

Fig.15: Histological section showing the *Glugea* spp. xenoma in the adipose tissues of grouper, *E. tauvina* (40x).

Species affected : Ranges of wild and cultured fish are susceptible.

Gross signs: No visible signs of infection except the finding of cysts like xenomas during necrosis of fish.

Effects on host : Infect various internal organs like intestinal wall, ovary, fat tissue, etc. The growth and proliferation of the microsporidian within the host cell results in complete destruction of the cells. The development stages and mature spores gradually replace the cell contents until the host cell becomes a mere envelope containing the parasites. Host tissue is damaged by pressure atrophy, which elicits proliferation of the connective tissue around the parasite mass forming a brown or blackish cyst-like structure of various size and shape, called as xenoma.

Diagnosis : The main diagnostic stage of the parasite, the minute unicellular spore measures 3-10 m with a single coiled polar filament.

Often they form small pea sized nodules of different sizes and colours on the affected tissues and are filled with pear shaped transparent spores.

Prevention and control : Good water exchange and management interventions. No treatment is available.

Coccidians: Most of the coccidian species have low pathogenicity and do not cause significant disease, but there is increasing evidence that they are potential pathogens. The most common infection in fish are intestinal. Other infection sites include reproductive organs, liver, spleen and swim bladder.

Causative agents : Main species belong to the genera are *Eimeria* and *Goussia*.

Life cycle : The typical life cycle may be direct by the ingestion infective oocysts which release sporozoites and invade host cells in the gastrointestinal tract. After several stages of development within host cells typical to each species, oocysts with sporocysts are released through host faeces to continue the life cycle.

Species affected : Catfish, tilapia, seabass, grouper, mullet, snapper, ornamental fish, etc.

Gross signs : Lethargy, poor feeding, emaciation and mucous strands protruding through anus

Effects on host : Typical coccidian pathology affecting the intestinal epithelial lining.

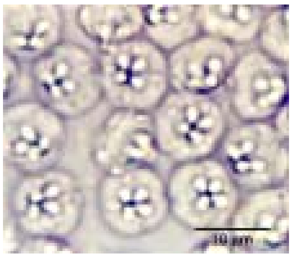
Diagnosis : Suspected fish shows mucous strands in the faeces and intestinal haemorrhages. Confirmation requires microscopic examination of intestinal contents for the presence of characteristic coccidian oocysts.

Prevention and control : No recommended treatment is available except the removal of affected fish from husbandry system and good and hygienic management practices.

Metazoan parasites

Compared to protozoan, metazoan parasitic diseases are less pathogenic. They have a multicellular organization but largely do not have the ability to multiply within host's body. Hence intensity of infection depends on the number of initial infective stages. Diseases caused by myxozoans, parasitic helminths, crustaceans and leeches are grouped under this category.

Myxozoans : Myxozoan comprises more than 2180 spp., most of which are fish parasites, and infect any tissue and group organ and cause disease in a wide variety of fishes (Figs 16-28). Myxozoans earlier classified under protozoans are internal microscopic parasites composed of unique morphology and several shell valves. The average size of the spore is 10 um. They are obligate parasites of tissues of various organs (histozoic) or live freely in cavities like gall bladder, abdominal cavity (coelozoic), having an indirect life cycle involving a vertebrate (fish) and an invertebrate (annelid) intermediate host. Severe infections can result in death of the fish. The myxozoan infections in fishes occur when there is poor water quality, high stocking density, feeding with infected trash fish and lack of quarantine measures. Many species of myxozoans were also recorded from marine ornamental fishes, such as Sergeant major, *Abudefduf bengalensis* and Blue damsels, *Pomacentrus caeruleus* (CMFRI, 2009).



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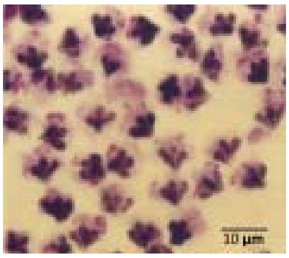

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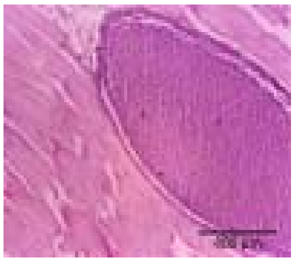

Fig.18:

Fig.19:

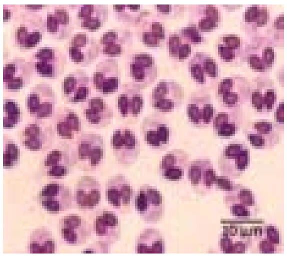

Fig.20:

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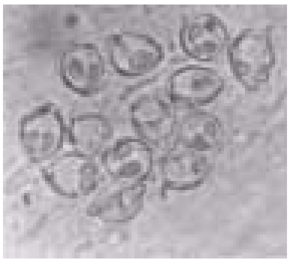

Fig.22:

Fig.23:

Fig.24:

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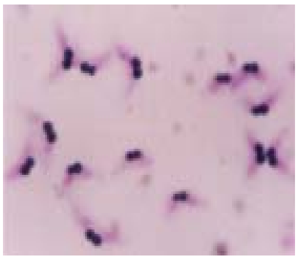

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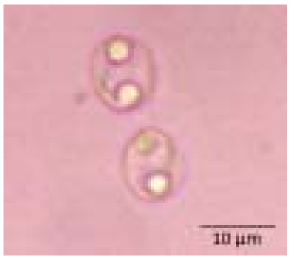

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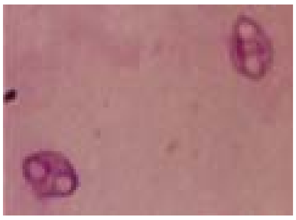


Fig.28:

Fig.16: Squash preparation of cysts recovered from skeletal muscle of *M. cephalus* showing freshspores of *Kudoa* spp. (x1000).

Fig.17: *Kudoa* spores stained with Giemsa (x1000, note the deeply stained polar capsules and less dense sporoplasm).

Fig 18: Histological section of infected muscle showing *Kudoa* cyst (x100)

Fig 19: Squash preparation of cysts recovered from intestine of *M. cephalus* showing fresh spores of *Myxobolus* spp. (x1000)

Fig 20: Spores of *Myxobolus* spp. stained with Giemsa (x1000)

Fig 21: Histological section of intestine showing *Myxobolus* spp. cysts filling the intestinal lumen (x100)

Fig 22: Fresh spores *Myxobolus etropli* infecting bulbus arteriosus of *Etroplus suratensis* (x1000)

Fig 23: Spores of *M. etropli* stained with Giemsa (x1000)

Fig 24: Histological section of the bulbus arteriosus showing cysts of *M. etropli* (x100)

Fig 25: Fresh spores of *Ceratomyxa etroplusi* infecting gall bladder of *Etroplus suratensis* (x1000)

Fig 26: Spores of *Ceratomyxa etroplusi* stained with Giemsa (x1000)

Fig 27: Fresh smears of gall bladder fluid showing *Myxidium* spp. in *Epinephelus tauvina* (x1000)

Fig 28: Spores of *Myxidium* spp. from *Epinephelus tauvina* stained with Giemsa (x1000)

Causative agents : Some of the common genera of myxozoans are *Hennegua*, *Myxobolus*, *Myxidium*, *Ceratomyxa*, *Kudoa*, *Sphaerospora*, *Zschokkella*, etc.

Life cycle : Involve a complex life cycle with an invertebrate intermediate host (oligochaetes, polychaetes, etc.).

Species affected : Almost all fish species; wild, cultured, and ornamental fishes with some degree of host and site specificity.

Gross signs : No apparent visible clinical symptoms. But visible white or blackish cysts can be seen on body surface, gills, fins and internal organs in affected fish.

Effects on host : The parasites invade all major organs and form cysts or freely floating mass called pansporoblast. They destroy gills and all major target organs according to the species. Severe infestations by these parasites can result in disease and/or death of the host fish. Each parasite is somewhat species specific as well as organ specific.

Diagnosis : By observing the characteristic spores with or without stains (Giemsa, Methylene Blue) within the cysts in various organs or as developmental stages. Histology also allows visualisation of the distinctive spores.

Prevention and control : No effective treatment, but prevention is possible by efficient water exchange, avoid feeding of trash fish and quarantine measures.

Trematodes or flat worms

These are relatively large external or internal parasites with adhesive structures for attachment to the host. Monogeneans are external parasites with specialized posterior attachment organs characteristic to each species and require a single host, while the digeneans are internal parasites occurring mostly in the intestinal tract and need more than one host species for completion of their life cycle.

Monogeneans comprise 'skin' and 'gill' flukes infecting skin, gill and fins of fishes (Figs 29-35). Monogeneans are capable of multiplying in large numbers in short time due to their simple life cycle involving a single host. They are often found threatening to young fish with massive mortality. Gill flukes are again ectoparasites, 0.5-1 mm long and the infection is a sign of high stocking density and poor sanitation. Skin flukes are 2-6 mm long. The most common skin flukes encountered are *Benedenia* spp., *Dactylogyrus* spp., etc. These infections are common when there is high stocking density, poor water exchange and overlapping generations of cultured fish.

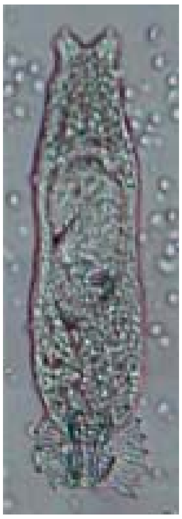


Fig.29: Various species of monogeneans in fish *Gyrodactylus* spp from mullet;

Fig.30: *Dactylogyrus* spp.from mullet;

Fig.31: *Diplectanum* spp. from seabass;

Fig 34: A monogenean parasite on seabass gills

Fig.32: *Benedinea* spp. from grouper;

Fig.33: *Dactylogyrus* spp. from mullet)

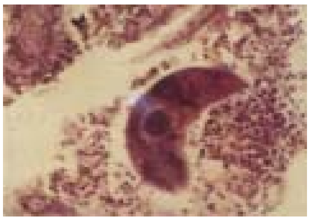


Fig 35: An unidentified fluke in gill section(Courtesy: Dr. P.K. Sahoo)

Causative agents : The most common monogenean parasites in fishes are *Dactylogyrus, Gyrodactylus*, *Diplectanum, Benedenia*, etc. among predominantly among marine and brackishwater fishes and *Diplozoon, Bifurcohaptor* among many freshwater edible fishes.

Life cycle : Monogeneans are either oviparous or viviparous with a single host and hence transmission is direct. Life cycle is simple involving hermaphroditic adults, eggs and larva. The eggs of many viviparous monogeneans possess long filaments to aid in attachment to substrates and other fish which hatch to free swimming stage to seek fresh hosts. Species of *Gyrodactylus* are viviparous in which the larva is retained in the uterus until it develops in to a functional preadult, inside which a second larva is already formed with a third larva inside that and a fourth inside the third like Chinese boxes, a condition called 'polyembryony'. When fish are living closely together, as in a cage or pond environment, it is easy for the adult worms and larval stages to move from one fish to another thus spreading the infection at an exponential rate.

Species affected : Catfish, carp, tilapia, seabass, grouper, mullet, pearl spot, etc.

Gross signs : Mainly affect body surface, gills, fins and rarely eyes as well. Fish shows lethargy, excessive mucus production on gills and body surface accompanied with opaque eyes, skin lesions, etc. The fish rub its body against submerged objects during heavy infection. High or mass mortality due to the rapid multiplication of the parasite in culture system have been recorded.

Effects on host : Gill flukes mainly affect gills and hence show pale gills and poor appetite, erratic swimming behaviour due to irritation and heavy mucus production on gills. In *Dactylogyrus* infection, the colour of gills becomes pale and produces excessive secretion of mucus. Damage is usually done by the attachment organs as well as by feeding activities. Small and weak fishes are easily infected although massive infections of adult fishes are also reported. The parasite damage the host's tissues leading to secondary bacterial infections. Often high or mass mortality due to the rapid multiplication of the parasite is reported in captive condition. Eye infection leads to blindness.

Diagnosis : Gross and microscopic examination of mucous from skin and gills for the worms with posterior adhesive organs armed with hooks and spines. The presence of eggs with long coiled filament is also diagnostic feature in the genus *Diplozoon, Diplectanum*, etc.

Prevention and control: Short bath treatment with freshwater for 10-30 min. or short bath treatment with 200 ppm hydrogen peroxide for 60 min. or 100-200 ppm formalin, with strong aeration.

Digeneans are mainly intestinal parasites and vary in size according to the spp. A large number of digenea have been recorded parasitizing various fish species (Figs 36-39). However, only a few have been found to cause concern in fish culture systems. Adult trematode may infect the intestine or gall bladder of fishes and are generally harmless as the pathology is restricted to irritation and inflammation at the site of attachments. However, larval trematode, the metacercaria, which invades and encysts in various organs, causes lot of damage. *Diplostomulum* or eye fluke is a larval digenean that develops in the eye of may warm water fish species. The visible signs are opaque, white lens. In India, metacercarial stages of *Diplostomum* spp. have been reported to cause black spot disease in carp nursery and rearing ponds.

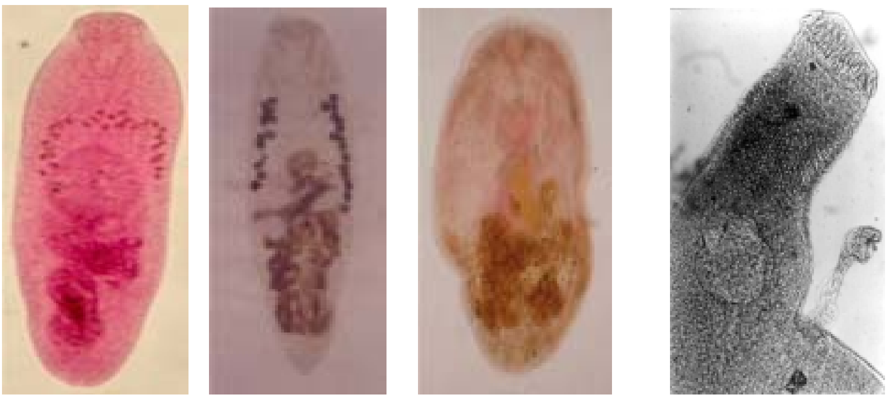


Fig.36-39: Digenean Parasites of Intestine (Unidentified)

Causative agents: Many species which are of non-significant nature are observed among wild fish. *Lecithochirium* spp., *Pseudometadena* spp. and *Bucephalus* spp. were found in many species of fishes. *Diplostomum* is known to be pathogenic in fishes.

Life cycle : As the digeneans complete its life cycle involving at least a molluscan host and one or more fish host where it is found as adults. The life cycle involves fishes either as the primary host or an intermediate host (by harbouring the larval forms, metacercaria) of several digenean spp. of other animals and man.

Species affected : Catfish, carp, tilapia, seabass, grouper, snapper, etc.

Gross signs : *Diplostomum* spp. in case of heavy infection may cause blindness. Yellow grub disease, black spot diseases, etc. are also caused by metacercaria in fishes which encyst in tissues.

Effects on host : Affected fishes have black ovoid patches on the body surface. These pigmented patches are cysts of metacercaria and is the diagnostic feature of the disease.

Diagnosis : Metacercariae are visible in various tissues and adults in intestine.

Prevention and control : No treatment method is effective although anthelminthic drugs are of use. As the digeneans complete its life cycle involving at least a molluscan host, controlling of molluscan host in the culture facility would reduce the transmission cycle (larval stages) of the parasites.

Cestodes or tapeworms

Though cestodes are found inhabiting the digestive tract of wild fishes they do not pose serious problems in cultured fish. Fish also act as intermediate hosts for other tapeworms of higher vertebrates.

Causative agents : *Ligula intestinalis* is a large visceral tapeworm found in pond cultured and some wild populations of many fishes. *Caryophyllaeus* and *Khawia* spp. are encountered in carps. Tapeworm larva (plerocercoid) burrows through the stomach wall into the body cavity and grows. Plerocercoid of *Diphyllobothrium latum* is capable of human infection and is of zoonotic importance.

Life cycle : Aquatic cestodes require at least two hosts. Fish may act as either a second intermediate/parataenic or as final host depending upon the species. The first intermediate host is usually a copepod, where in larval stages released from ingested tapeworm eggs develops as infective form of the tapeworm.

Species affected : Catfish, carp, tilapia, seabass, grouper, snapper, etc.

Gross signs : Clinical signs include emaciation, anemia, discolouration of the skin and susceptibility to secondary infections. Fishes are found to harbour pleurocercoides (larval form of tape worms) in brain, heart, spleen, kidney and gonads, which are harmful to the hosts.

Effects on host : The adult parasites live in the intestinal tract of vertebrates and are usually not considered as serious pathogen. In heavy infection, visible sign is greatly swollen belly due to the blocking of intestine. Intermediate stages live in a variety of body locations in both vertebrate and invertebrate hosts causing tissue reactions.

Diagnosis: Diagnosis of cestodiasis is dependent upon demonstration of the parasite within the intestinal tract/body cavity of the fish.

Prevention and control : There are no known treatments for larval cestodes. Praziquantel is being used in aquarium industries.

Nematodes or round worms

Nematodes are mainly the inhabitants of intestine and body cavities of fish and are large enough to be seen by the naked eye ranging from a few millimeter to several centimeters (Figs 40-45). Fish act as definitive as well as intermediate hosts. Adults seldom cause pathogenicity, but larval stages cause serious tissue damage and even death. Anisakiasis caused by the larvae is a serious problem in marine fishes. Larvae of *Philometra* spp. by its feeding and migration causes inflammation and haemorrhage of swim bladder. Very large nematodes like *Philometroides marinus* recorded from *Rachycentron canadum* reach up to 80 cm may affect the health status and thereby the reproductive performance in broodstock fish.





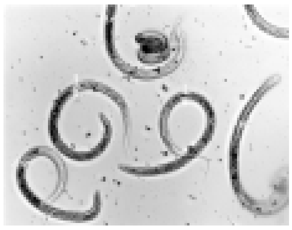


Fig.40: *Philometra* spp. in sub-cutaneous nodules on caudal fins.

Fig.41: Adults of *Philometra* spp. infected sub-cutaneous portion of caudual fins of *Otolithes ruber.*

Fig.42 & 43: Anterior and posterior end of adult nematode, *Philometra* spp. collected from *Otolithes ruber.*

Fig.44 & 45: Larvae of *Philometra* spp. specimen from *Otolithes rubber* (Courtesy: Dr. S.N. Sethi).

Causative agents: *Cucullanus, Camellanus, Spirocamellanus, Anisakis*, *Philometra*, *Philometroides*

Life cycle: Dioecious; most nematodes in fishes have complex lifecycle involving at least two hosts,

Species affected: Siganids, Sciaenids, catfish, seabass, grouper, snapper, etc.

Gross signs: In case of parasites in the stomach and intestine, the affected fish is emaciated and have discoloured body which is some time swollen depending on the degree and species of infection.

Effects on host: May impair feeding, resulting in emaciation and mild mortality,

Diagnosis: Gross examination and dissection of the viscera or intestine with liquefied contents and worms.

Prevention and control: Elimination of intermediate hosts, drying and disinfection of culture facilities. Prevention is possible by maintaining hygiene in the fish tank.

Acanthocephalans

Comprises worms with an anterior proboscis covered with many hooks and hence referred as are 'thorny' or 'spiny headed' worms with aquatic life cycles; fish as final or parataenic hosts and crustaceans as intermediate hosts. Adults feed on the intestinal walls of vertebrates, especially freshwater and marine fishes. They are often encountered in culture system as majority of the broodstock fishes are sourced from wild. Some of the species like *Serrasentis nadakali* reported from captive cobia (*Rachycentron canadum*) are large measuring more than 10 cm and resemble a tapeworm due to pseudo segmentation of the body. Very heavy infection of acanthocephalan parasite *Tenuisproboscis* spp. in red snapper, *Lutjanus argentimaculatus* are detrimental to the broodstock health (Sanil *et al.*, 2011) and may affect the reproductive performance of captive cobia broodstock (CMFRI, 2010).

Causative agents : Medium to large sized parasite, most common species are *Acanthocephalus, Neoacanthorhynchus, Tenuiproboscis.*

Life cycle : Worms are dioecious endoparasites; males usually smaller than females. Eggs are released by female worms directly in water via the host faeces, the ciliated larvae called acanther infects first intermediate host (usually a crustacean and develops into a cystacanth which in turn finds it way on ingestion by a fish to act as a primary host or even as parataenic host before reaching its final predator host fish.

Species affected : Catfish, carp, tilapia, mullet, seabass, grouper, milk fish, snapper, etc.

Gross signs : The parasite is attached to the intestinal mucosa, emaciated body but no visible external symptoms.

Effects on host : The parasite causes necrotic hemorrhagic ulcers in the intestine of the host. Pathogenicity is mainly due to the mechanical injury caused by the attachment of spiny proboscis on the intestinal wall leading to inflammation and tissue necrosis.

Diagnosis : Identifiable only during necropsy examination with characteristic sac like worms with retractile and thorny proboscis.

Prevention and control : Control of intermediate hosts and quarantine of new stocks for prevention.

Fig.46: Neoechinorhynchus agilis in mullet gut

Crustaceans

Parasitic crustaceans (Phylum: Arthropoda) resemble in their general morphology with other crustaceans in having segmented body, covered with exoskeleton and jointed appendages. There are three parasitic groups comprising mainly external parasites in cultivable finfish in the class Crustacea; the Branchiura, Copepoda and Isopoda (Table 1). Members of the Branchiura and Isopoda are relatively large and both sexes are parasitic, while Copepods (the most common crustacean parasites) are generally small even microscopic with both free living and parasitic stages in their life cycle. Infestation by these parasites in the wild do not manifest in serious disease outbreaks. Males of parasitic copepods die after copulation in the pre-adult stages, that is usually seen attached to the fish is the mature female with distinctive paired egg sacs at the posterior end.

Parasitic copepods have a complex life cycle with different larval stages; between each of which is a moult. Eggs hatch to release free-swimming nauplius larvae. After a succession of naupliar stages they moult to form copepodid stages. In primitive groups of parasitic copepods such as ergasilids, the copepodids are free swimming. Copulation occurs during the free-swimming stages, after which the males die. The female is left to seek, attach and mature on a marine or freshwater fish host with the help of the prominent claw like second antennae. In more evolved copepods such as the caligids some or all of the copepodid stages may be parasitic including adult male. Caligid copepods generally have direct life cycle, consisting of a free-living planktonic nauplius stage, free swimming infective copepodid stages, attached chalimus, pre-adults and adult stages. In case of *Lernaea* spp., the eggs released by the female hatch in 1-3 days with subsequent nauplii larvae. The nauplius metamorphoses into first or second copepodid stage in 4-16 days. No further development occurs unless it attaches to a host. Larvae pass through five successive copepodid stages before attachment. Copulation occurs during the fourth copepodid stage and the male dies similar to the *Ergasilus* spp. Although *Argulus* spp. cannot survive without a host for long period, they may swim freely looking for new host. Unlike other crustaceans, there is no sexual dimorphism; eggs are not carried by the females in egg sacs, but leaves its host to deposit its eggs to submerged objects. Larvae do not hatch as nauplii but as copepodid stage with thoracic appendages to follow a series of subsequent larval stages by progressive development of the dorsal shield and abdomen, the maxillary suckers

Table 1: Common crustacean parasitic infection in brackishwater finfish in coastal and estuarine zones.

Subclass/ family	Genus	Characteristics
Branchiura		
Argulidae	*Argulus* sp.	Body broad and flat covered anteriorly with dorsal shield with a pair of compound eyes,hooks and barbs,which it uses to attach to the fins, gills and skin of its host, second maxillae usually form prehensile suckers.
Copepoda		
Caligidae	*Caligus* sp. *Lepeophtheirus* sp. *Anuretes* sp	Transparent, cephalothorax covered dorsally by a sub circular shield, with a pair of suckers on the frontal edge of the body and four pair of legs, vestigial abdomen in some species, found in large numbers on gills and body surface with different stages of life cycle in the same host
Ergasilidae	*Ergasilus* sp.	Cephalothorax constituting half or more of body length, the second antennae are modified for clinging to the host, moderate to large numbers on gills with rigorous feeding action and movements
Lernanthropidae	*Lernanthropus* sp.	Few in number but large in size, feed on gill tissues and blood, seriously damage the tissues
Lernaeidae	*Lernaea* sp.	Body unsegmented, with its anterior part deeply embedded in host tissue with the help of a hold fast organ,infect nostril, skin, fin, gills, buccal cavity
Isopoda		
Cymothoidae	*Cymothoa* sp.	Entire dorsal surface of body divided into many narrow segments, eyes are sessile, parasite immovably attached to surface, buc cal or branchial cavity of fish.

and reproductive organs. Thus, transmission of parasites within the system is by physical contact with infected animals or by the free living infective stages after reproduction. Many species simply glide from one fish to other. Many parasites are transferred to culture system by way of water, live feed, wild fish, contaminated farm implements, etc. Hence control methods may vary greatly depending upon the farm conditions, the type of parasites and its life cycle stages.

Branchiurans **:** Members of the family Argulidae represented by genus *Argulus* commonly called as 'fish lice' is an important parasites of fish (Fig 47). It has a broad, flat oval body with hooks and barbs, which it uses to attach to the fins, gills and skin of its host. They are one of the most widespread and dangerous ectoparasites in fresh water fish ponds causing large scale fish mortality. Argulosis is a major problem in many areas of Orissa and Andhra Pradesh where freshwater aquaculture is concentrated and the infection has emerged as a significant problem in composite fish culture ponds in India (Mishra, 1991) and considered as lethal pathogen in semi-intensive and intensive aquaculture (Saurabh *et al.*, 2010).

Fig.47: *Argulus siamensis* on body surface of Carp fish, *Labeo rohita* (Courtesy: Dr. P.K. Sahoo

Causative agents : Argulus siamensis, A. indicus, A. foliaceus

Life cycle : Branchiuran parasites on fishes are usually found in the walls of the branchial cavity and not permanently attached to their hosts, but can crawl on their surfaces and can slowly swim leaving one fish to another. Sexual dimorphism is not marked. Both sexes are parasites and lead a direct lifecycle. After mating the female deposits the eggs on a suitable substrate, such as aquatic plants. The eggs hatch, develop and infect fresh hosts and metamorphose to adults.

Species affected : Catfish, carp, etc.

Gross signs : Fish suffering from argulosis exhibit behavioural abnormalities including lethargy, irritation and loss of appetite. Infected fish may show increased flashing, agitation and excess mucous production.

Effects on host : They damage the fish directly by extracting blood and vital tissue fluids from the host with their modified mouthparts.

The mode of feeding of *Argulus* involves secretion and injection of relatively large quantities of digestive fluids, which are toxic to the fish. The sting of one fish lice can kill a small fish. Feeding sites become hemorrhagic and ulcerated and provide access to secondary infections by other pathogens. Mucous is secreted when skin, fin and gills become infected.

Diagnosis : *Argulus* spp. can be diagnosed by naked eye with characteristic two spots on the body.

Prevention and control : The only way to prevent *Argulus* infection is to deny parasite's access to the cultivable fish. Since both adults and larval stages are active swimmers, it is difficult to prevent them from entering the pond. Appropriate filter designs might prove more efficacious to check the degree of infestation. Treatment with organophosphates, formalin or potassium permanganate will eradicate adults. Juveniles can be treated with 2% salt bath. Draining and drying is good option for larger system.

Copepods

The most important copepods affecting fish are *Caligus* (sea lice), *Ergasilus* (gill maggots) and *Lernaea* (anchor worm). They are ectoparasites infecting skin, fins and gills (Figs 48-51). The intensity of copepod infestation generally increases in rainfall and late spring and decline in winter and summer due to the lack of recruitment and parasite death. This is a major problem in cage cultured brackishwater fishes but the economic impact of this disease is not known.

Fig.48: *Caligus epidemicus* on the gill in Pearl-spot, *Etroplus suratensis*

Fig.49: *Lernanthropus shishidoi* on the gills in Mullet, *Mugil cephalus*

Fig.51: Cymothoid parasite attached to the gill chamber in wild marine fish (Courtesy: Dr. S.N. Sethi)

Caligus spp. or 'sea lice' is a common copepod parasite under Caligidae infesting a wide range of fish species in the coastal and estuarine zones although other lesser known species viz. *Lepeophtheirus* and *Anuretes* spp. are reported from marine fishes in Indian subcontinent. Three species of *Caligus*, *C. epidemicus*, *C. orientalis* and *C. punctatus* are the potential major pathogens in the development of cage culture. *C. orientalis* seriously affects wild population as well. When they first infect a farmed fish population they cause extensive irritation and nervous activity.

Ergasilus spp. also known as 'gill maggot' are found on the body surface, gills and branchial and nasal cavities of many fish species including seabass, grouper, mullet, pearl spot, tilapia, etc. where it feeds on blood and epithelium. Heavy infestations can result in mechanical damage, patechial hemorrhage, impaired respiration, epithelial hyperplasia, and anemia with growth retardation. Severe gill damage is caused by the feeding activity of the copepod and this often leads to fish death. Proliferation of this parasite is observed in summer.

Lernanthropus spp. is relatively large, reddish in colour, firmly attached to the gills, inflicts serous damage to the gills by way of erosion, desquamation and necrosis of the secondary lamellae near the site of attachment. The grasping action of the mandibles and the maxillae results in the exposure of blood vessels and hemorrhages. This serious pathogen is frequently encountered in many species of wild fish and cultured sea bass, mullet, etc. and is relatively difficult to control.

Lernaea spp., better known as the 'anchor worm', this species affects a large number of warm water fishes. Adults are visible to the naked eye. Although *Lernaea* (eg. *L. cyprinacea* in carps and a number of freshwater fishes including ornamental fishes) is typically a freshwater copepod; it has been reported from brackishwater fish also. Different fish species were reported to have varying levels of susceptibility to *Lernaea* infection under natural environment and culture conditions. The parasite seems to have an affinity for the heart region of small fish and kills them by piercing the heart or other vital organs. The female lernaeidid copepod has long filamentous body with trailing attached egg sacs. Morphological modifications include the head, which is a rounded knob inserted into the musculature of its fish host; one or two pairs of anchors to hold it in position. Damage to the fish host includes haemorrhagic and ulcerated lesions with potential for secondary infections, anemia, retarded growth, loss of weight and loss of equilibrium.

The destructive activity of *Lernaea* spp. is due to its relatively large size and its mode of attachment and feeding. As the maximum damage to the fish is caused by the adult parasite which remain attached to the host tissue with an anterior holdfast organ and also by the developmental stages that remain attached to the host, any reliable and effective prophylactic measure should aim to kill the free living stages of the parasites at nauplii and copepodid stages before it gets attached to the fish host. *Lernaea* is extremely difficult to control because only the free-living larvae are susceptible to treatment. The adult female produces three sets of eggs; these eggs produce larvae over a four week period. Since the larvae remain free living for about one week, it is necessary to treat it once a week for four weeks to eliminate this parasite.

Life cycle : Copepods have direct life cycle, consisting of a free-living planktonic nauplius stage, free swimming infective copepodid stage, attached chalimus, pre-adult and adult stages. In most cases, it is the attached chalimus stage that causes significant pathological lesions leading to mortality when present in large numbers. The pre-adult and adult stages are not very invasive and cause minor tissue damages.

Species affected : Tilapia, seabass, mullet, grouper, pearl-spot, snapper, etc.

Gross signs : Excessive mucus production and signs of irritation including frequent flashing.

Effects on host : Feeding on the fish skin, mucous and blood, these lice can cause small hemorrhages and sores, erode the skin and expose the underlying tissue to secondary infection. In disease situations, death is caused by the development of secondary infections exacerbated by stress, osmoregulatory failure and in the case of the gills, respiratory impairment. It is well recognized that parasites act as mechanical vectors of the pathogens though they are not an obligatory host.

Diagnosis : Parasites can be seen on skin or gill scrapings. Anchor worms are clearly visible to the naked hanging from the body and *Ergasilus* spp. seen attached to the gills.

Prevention and control : Parasitic copepods with relatively narrow host ranges such as *Ergasilus* are easier to control, especially where there are few wild hosts present. The species with broad host ranges and/or abundant wild hosts (e.g. *Caligus* spp.) in the vicinity of aquaculture sites are generally difficult to control because of recurrent infestations from carrier hosts. In pond culture, overcrowding and poor water quality had been cited as factors responsible for the development of parasitic copepod diseases. The important management techniques to be followed are rearing different batches in separate tanks, pond drying, removal of all probable hosts from the stocking sites prior to stocking so that all infectious stages die due to lack of hosts, quarantine prior to stocking and introduction to the rearing system and frequent cleaning of holding tank/nets. The parasites can be controlled by fresh water bath for 10-15 min or by chemical treatment using 1000 ppm hydrogen peroxide or 100-200 ppm formalin for 30-60 min. Some of the treatments commonly applied in marine/brackishwater fishes are shown in Table 2. Strong aeration must be provided during treatment. Drying of unused tanks also helps to destroy the developing stages. Treated fish should be transferred to clean parasite free facility. In all cases, infected fish should be quarantined to avoid cross-infection. Complete draining and disinfection of the system may be the option to break the life cycle. Generally copepod infections are treated with organophosphates. Dichlorvos has been found to be effective against the *Caligus* and *Ergasilus* at a concentration of 1 ppm. *Lernaea* spp. is very difficult to control due to different stages of life cycle showing different susceptibility to chemicals. Further, the concentration of these chemicals required to kill the developmental stages are toxic to fish. Successful control in freshwater ornamental fishes using gradual shift to salinity of about 10 ppt has been reported. Temperature dependant development of larval stages and the lethal effects of even low salinity on larval stages etc. can be utilized for the control of fresh infections in the system. Eradication of copepods using freshwater bath is also suggested.

Table 2: Common treatment against copepods in marine/ brackishwater finfish

Drugs / chemicals	Dose	Type of treatment, duration
Formalin	100-200 ppm	Short bath; 30-60 min
H_2O_2	1000 ppm	Short bath; 30-60 min
Dichlorvos	0.75 - 1 ppm	Short bath; 60 min
Caprylic acid	I mM	Short bath; 5-10 min

Isopods : Isopods are large parasites (6-50 mm in size) with its body divided into many narrow segments, with a pair of large eyes. They are protandric hermaphrodites, living on the skin in the gill chambers or in the mouth of the host fish. *Cymothoa* spp. has been reported as a serious problem in fishes kept in captivity or cages besides wild tropical marine fishes.

Causative agents : *Cymothoa indica* is a common parasite under this class found commonly in the gill chamber, buccal cavity or body surface of many fishes. *Nerocila* spp., *Aegas* spp., *Gnathia* spp. and *Cirolana* spp. have been found to cause mortality in cage cultured seabass. Others commonly observed in wild fishes are *Joryma* spp., *Glossobius* spp. and *Agarna* spp.

Life cycle : Parasites are generally found in male female pairs. Female were found to have thousands of young larval forms, which could spread to other fishes under high stocking density. They have a short free-living planktonic phase; juveniles and adults are exclusively parasitic living on the skin, buccal cavity and gill chamber of the fish.

Isopods absorb their nourishment directly from the host's body and depend upon their hosts for feeding.

Species affected : Tilapia, seabass, grouper, mullet, pearl spot, snapper and many species of marine fishes.

Gross signs : The affected fish rub its body against objects and inflict injury. If buccal cavity of small fish is occupied by large number of parasites, there is difficult in feeding and thereby emaciation is often found.

Effects on host : No much mortality has been reported, the damages caused by them resemble that of other copepods but the most serious effect of isopod infection is destruction of host tissue resulting from the pressure of the parasite's body. Fishes with *C. indica* infection in the branchial chamber showed loss of weight, loss of fat content, changes in the water content of various tissues and significant reduction of respiratory surface area of the host fish.

Diagnosis : Diagnosis is usually done by gross and microscopic examination of scrapings from skin, gills, fins, etc. from affected fishes and by observing general clinical symptoms. Pre-disposing factor for transmission of crustacean parasites is poor water exchange and thus sufficient water exchange can prevent their proliferation.

Prevention and control: No specific control or therapeutic measures against isopods have been in practice except the manual removal of the parasite; by implementing optimum management practices during culture as infection in the planktonic phase is the common feature. Formalin bath 200 ppm for 30-60 min. can reduce the gravity of infection. Manual removal and destruction of the parasites were also found to be effective in larger fishes.

Leeches

Leeches are large annelid parasites with pseudo-segmented body, 8-15 mm long and with anterior and posterior suckers used for feeding and movement (Fig 52). Found on body surface, fins, mouth, gill chamber, eyes, etc. Leech infestation is associated with poor maintenance facilities and poor water quality in pond.

Causative agents : Many species in freshwater and marine fish including *Pontobdella* spp., *Zeylanicobdlla* spp.

Species affected : Catfish, carp, tilapia, mullet, seabass, grouper, snapper, etc.

Life cycle : They have a direct life cycle with immature and mature stages being parasitic on hosts.

Gross signs : Mainly affect body surface, fins, eyes and rarely gills. Brownish-black parasites attached in patches in the affected area. The fish rubs its body against objects during heavy infection.

Effects on host : Pathogenic effect is related to the number and size of leeches leading to chronic anemia. The feeding and attachment sites of the parasite damage the host's tissues leading to hemorrhagic lesions and possibly secondary bacterial infections.

Diagnosis : Visible to naked eye as being attached to fins, gills, and skin

Prevention and control: Manual removal of the parasite from the affected fish after segregation or short bath treatment with 50-100 ppm formalin for 1 h with strong aeration and subsequent transfer of treated fish to a clean, parasite free tank. Ponds with heavy leech infestation require drainage, treatment with chlorinated lime followed by drying to destroy the adults and eggs.

Fig.52: An unidentified leech from Grouper fish

Parasitic zoonoses of fish origin

Fish borne zoonotic parasites or ichthyozoonoses transmitted by fish and shell fish products pose major public health problems in many countries. Though the transmission of these parasites through fish caught in the wild has been well documented, the association between cultured fish and human infection has gained the attention only recently. There is a complete lack of priority for parasites of zoonotic significance and this remains an unexplored area even though some parts of the country face these problems. Major fish borne parasitic zoonoses in India are listed in Table 2. Food safety issue is a growing concern especially in the export sector as majority of the fish products are being exported as frozen items. The zoonotic parasites of fish origin also vary from freshwater, brackishwater and marine ecosystem. Many zoonotic parasites enter human by way of consumption of raw aquatic vegetation/tubers, etc. In India, food borne zoonosis in general and the fish borne in particular are comparatively very less prevalent than in South East and Far East countries mainly because of the traditional culture of cooking and serving. However, eating raw or undercooked fish, crustacean, snail, etc. is a delicacy in certain ethnic communities, and people. A single factor responsible for fish born zoonoses could be lack of hygiene (poverty, lack of personal hygiene, scarcity of potable water, consumption of raw or undercooked food) and/or favorable climatic conditions for parasite growth and transmission. So the incidence of helminthozoonosis can be minimized substantially, if people are provided with clean drinking water and hygienic living conditions. Besides, people need to be made aware and educated of risks of infection by way of consumption undercooked fish/crab. The future impact of these fish-borne zoonotic parasites may be linked closely to the expected growth of aquaculture in Asia. However, there is disagreement on the relative importance of pond cultured fish versus wild caught fish in the epidemiology of human infection.

Fish borne parasites come from three main groups: digenetic trematodes (species under families Opisthorchiidae, Heterophyidae), cestodes (species under family Diphyllobothriidae) and nematodes (species under family Anisakidae, Gnathostomatidae). Generally, human infection takes place through the consumption of raw, undercooked or otherwise under-processed fish containing the infective stages of the parasites. Dermal exposure by introduction of infectious agents into open wounds or abrasions through handling of infected fish or infected water is also possible.

A large number of freshwater fish species can transmit the infective trematode metacercariae, the fish belonging to cyprinidae (carps) being the most common. *Chlonorchis*, *Opisthorchis, Paragonimus, Heterophyes, Haplorchis*, *Metagonimus*, etc. are examples. Aquaculture being the world's most important food sector dominated by Asian countries, fish-borne trematodiasis is also most prevalent in Asian region.

Cestode, *Diphyllobothrium latum* causes a mild disease in about 20 million individuals per year with recent increase in cultivated fish as well, due to consumption of raw fish in ethnic dishes such as sushi, sashimi, ceviche, and other similar products (Figs 53-55). The parasite has a complex life cycle with piscivorous animals and man, as primary host and copepods as the first intermediate host, and a predatory freshwater or salt water fish as the second intermediate host.

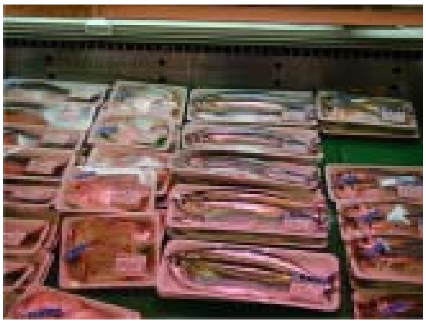
Table 2: Fish-borne parasitic zoonoses

Sl. No.	Name of the parasite (Host)	Name of the parasitic stage infective to man	Source of infection to man	Mode of infection	Remarks
			Trematodes		
1.	*Heterophyes heterophyes* (dog, cat, man)	Metacercaria	Freshwater fish, *Mugil cephalus* and others	Ingestion of raw or undercooked fish	Human cases have not been diagnosed in India
2.	*Opisthorchis tennuicollis* (dog, cat, man)	Metacercaria	Cyprinid fish	Ingestion of raw or undercooked fish	Human cases have not been diagnosed in India
3.	*Clonorchis sinensis* (dog, cat, pig, man)	Metacercaria	Cyprinid fish	Ingestion of raw or undercooked fish	Human cases have not been diagnosed in India
4.	*Paragonimus westermani* (dog, cat, pig, cattle, goat, tiger, man)	Metacercaria	Crabs (*Potamon* sp. In India) or Cray fish	Ingestion of raw or undercooked crustaceans, Contamination of food through utensils and hands	'Lung fluke' infection, a public health problem existed in Madras, West Bengal, Assam and Manipur; recent reports from NEH only.

5.	*Pseudamphistomum truncatum* (pig, man)	Metacercaria	Freshwater fish, *Leuciscus rutilus*	Ingestion of raw or undercooked fish	No reports of human infection in India
6.	*Echinochasmous perfoliotus* (dog, cat, fox, man)	Metacercaria	Fish	Ingestion of raw or undercooked fish	No reports of human infection in India
			Cestodes		
7.	*Diphyllobothrium latum* (dog, man)	Plerocercoid	Freshwater fish, particularly large predator fish and others (barbel, parch, trout etc.)	Ingestion of raw or undercooked fish harboring plerocercoids	'Broad fish tape worm' of man and other animals, No reports of human infection in India in recent years
8.	*Spirometra* spp. (dog, cat, man)	Procercoid & Plerocercoid stages	Cyclops, containing procercoids and fish, tadpoles, frogs containing plerocercoids	Accidental ingestion of intermediate host (s)	'Sparganum' a disease caused by the larval stage of the species *Spirometra* have been reported recently from Rajasthan

			Nematodes		
9.	*Gnathostoma spinigerum* (dog, cat, man)	L_3 encysted in viscera and muscles of freshwater fish (*Ophiocephalus* spp. *Clarius* spp., eels), frog etc.	Inadequately processed fish, frog, or other second intermediate hosts and paratenic hosts	Ingestion of infected fish, frog; rarely direct penetration of the skin by the infective larvae	Reported from animals; Infective larvae of the nematode may be found in freshwater fish (*Ophiocephalus punctatus)* in viscera and muscles, Reports of human case dates back too 1945.
10.	*Anisakis* spp. (Marine animals, man)	Infective larvae in a variety of marine fish and also in anadromous and freshwater fish.	Raw or semi cooked fish	Ingestion of infected fish containing infective larvae	Cause 'herring worm disease' in human, mainly a common problem in many European, American and Asian countries; but there is no incidence of this disease in India.
11.	*Angiostrongylus contonensis* (rat, man)	Infective larvae	Intermediate hosts (slugs, snail) and many paratenic hosts like prawn, crab, frog etc.	Ingestion of food containing raw or undercooked infected intermediate and paratenic hosts.	'Lung worm' of rats; Only accidental human parasites through aquatic animals. Human cases with eosinophic meningitis reported in India.

12.	*Dioctophyma ranale* (dog, man)	Infective larvae	Paratenic hosts like frog, fish harbouring encysted infective larvae	Ingestion of frog or fish carrying infective larvae	No reported cases in India.
			Protozoa		
13.	*Entamoeba histolytica* (man and animals as reservoir hosts)	Mature cysts	Food (fish) and water contaminated with faeces of infected man, animals	Ingestion of food (fish) and water contaminated with mature cysts.	Mechanical contamination only
14.	*Giardia lamblia* (man and animals as reservoir hosts)	Mature cysts	Food (fish) and water contaminated with faeces of infected man, animals	Ingestion of food (fish) and water contaminated with mature cysts.	Mechanical contamination only
15.	*Balantidium coli* (pig, man)	Mature cysts	Food (fish) and water contaminated with faeces of infected man, animals	Ingestion of food (fish) and water contaminated with mature cysts.	Mechanical contamination only
16.	*Cryptosporidium* spp. (Domestic, wild animals, aquatic animals (?), man)	Sporulated oocysts	Food (fish?) and drinks contaminated with sporulated oocysts	Ingestion of food (fish) and water contaminated with oocysts.	Mechanical contamination only



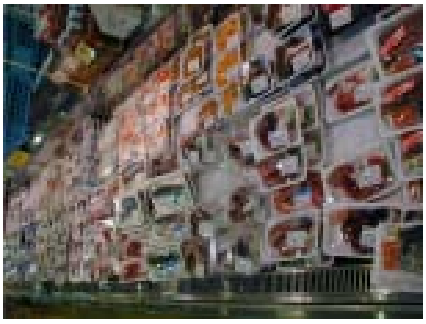


Fig.54: Ready to cook fish and other aquatic animal products in Asian market

Fig.55: Largely raw or semi-cooked/ processed delicacies like 'sushi' on dining table.

Nematodiasis dominated by Anisakiasis refers to infection with larval stages of fish nematodes of the genera *Anisakis*, *Contracaecum*, etc. Anisakiasis is a serious zoonotic disease caused by the consumption of raw or undercooked fish dishes containing the larvae of parasite with clinical entity of acute or chronic infection. Gnathostomiasis caused by *Gnathostoma* spp. in man is considered as an accidental hosts where the condition 'larva migrans' is one of the known symptoms. The life cycle is complex involving intermediate, parataenic and finals hosts.

Prevention and Control : About 18 million people are affected by fish borne trematodes alone and are geographically confined to population living in low and middle income countries called as 'hot spots' of fish borne zoonoses including parts of India. No much information on fish borne zoonotic metacercariae from brackishwater and marine fish though these parasites are common in country's freshwater fish.

Fish borne parasites are derived from the consumption of raw fish, or fish dishes or products that have not been cooked or have not been processed sufficiently to kill the parasites in farm. Apparently, the control is easy with consumer education campaigns, mass education, besides the consumption of well cooked/processed fish products. Application of HACCP principles in the production system where each stage is evaluated for the existence of hazards and risks for public health is a tool that has the potential to assumes safety of cultivated fish at risk of infection with zoonotic fish borne parasites.

Emerging parasitic infections in cultured fishes

There are parasitic infections which assume clinical significance and cause pathological condition in farmed fish. A couple of examples worth mentioning include apicomplexan parasitic diseases such as coccidiosis and cryptosporidiosis. Piscine apicomplexan parasites of significance belong to the genera *Cryptosporidium*, *Eimeria*, *Goussia*, etc. These parasites have been known to infect many fish species and cause chronic disease with gradual mortality. The pathogenesis of piscine coccidiosis has been reported in many fish species such as carps, gold fish and cat fishes. However, not much clinical significance was attached to these infections in culture conditions till recently. Among production animals, cryptosporidiosis causes significant economic losses and remains a potential zoonotic condition. In contrast, there is scanty literature regarding piscine cryptosporidiosis, despite infection being increasingly reported in dozens of species of marine and freshwater fish during the last decade (Baragahara *et al*., 2011; Gabor *et al*., 2011). However, recently, some reports of severe outbreaks of diseases in *Lates calcarifer* juveniles with high prevalence of *Cryptosporidium* and *Eimeria* were reported from Vietnam (Gabor *et al*., 2011; Gibson-Kueh *et al*., 2011). The origin of these infections remains unknown though using trash fish as feed is suspected to be the cause. Same is true with the taxonomy and zoonotic potential of *Cryptosporidium* of fish origin. In India, the sector is largely unaware of these infections due to inadequate capacity building in diagnosing these infections in culture facilities.

Another area requiring attention is the parasites in aquarium fishes as most of the trade is by breeding the exotic fishes in India. Live fish trade by import and export may increase the possibility of transboundary movement of parasites across geographical regions. Though this sector is dominated by freshwater ornamentals, originated from backyard/cottage units from rural India, some species of hatchery produced marine (*Amphiprion*, *Premans*) and brackishwater (*Scatophagus*) ornamental fish seeds are now available. There is need for health management studies during culture operations in non-native environment and the potential transfer from wild to cultured animals and *vice versa*.

Issues in fish parasitology research in India

Fish diseases are major constraints in the sustainability of aquaculture industry in coastal states of India. Diseases of aquatic animals and biosecurity measures for managing risks of aquatic animal disease outbreaks have received less attention than livestock diseases. Intensification of aquaculture production systems continues to create new paradigms for disease expression, and new knowledge of disease pathogenesis is fueling and refining our surveillance needs. Further increasing globalization and trade volume of the aquaculture sector has created new mechanisms by which pathogens and diseases may be introduced or spread to new areas. Trans-boundary movement of aquatic animals contributes to faster spread of various diseases. Considering the importance of Parasitology research in India in cultured fish species it is a fact that there is lack of detailed studies on epidemiology, host-pathogen relations and paucity of such studies with regard to parasites. The researchable issues related to the discipline and also short-term and long-term priorities are listed below. There is a need for the networking of Fish Parasitologists, need to identify research priorities in the area of fish parasitology with a blend of biotechnology application for the diagnosis and control of important fish parasites. Further, fish parasitologists should strengthen their affiliation to the discipline, considering the limited manpower in this specialized area, either independently through an identified research project at the institute level or on a collaborative mode with other fisheries research institutes or with other institutions engaged in fish parasitology research.

Voluminous research work on fish parasitology has been undertaken by many general universities; however most of this information has never been compiled. Food safety issue is a growing concern; especially in export sector as majority of the fish products are being exported as frozen items. Further, there is also a need for the establishment of a national network of fish parasitologists and a national surveillance system for parasite diseases in the country. Host-parasite interactions, taxonomy, diagnosis, prophylaxis, epidemiology and economic losses associated with these parasites should be considered as priority areas for future research. Establishment of national surveillance system for parasitic diseases in fishes could alsobe considered for augmenting the research programme. The following is the list of the thematic areas in the field of fish parasitology for prioritization.

Area I: Taxonomy

- Parasite profile of commercially important finfish-a least investigated area
- Exploration of fish parasites diversity and digital documentation

Area II: Epidemiology

- Establishment of national surveillance system for aquatic parasitic diseases.

Area III: Host-parasite interactions

- Application of molecular tools in the control of important parasites affecting fish
- Host-parasite relations using molecular tools

Area IV: Diagnostics

- Development of molecular detection tools for OIE listed fish parasites.

Area V: Therapeutics and Prophylaxis

- Development of novel therapeutics and prophylactics against parasitic diseases.

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