Salient Ichthyo Diseases and Their Management in India

Dissertation submitted to the Department of Zoology in fulfilment of requirements for the Degree of Master of Science in Zoology
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CERTIFICATE

We are the undersigned certify that the dissertation entitled **"Salent Ichthyo Disease and Their Management in India"** submitted by **Pradosh Ranjan Barik, Enrollment number-2101218012**, to the department of Zoology Indira Gandhi National Tribal University Amarkantak (M.P) India for partial fulfilment of the requirement for the award of degree of Master of Science in Zoology has been approved.

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DECLARATION

I do hereby declare that the dissertation work entitled **"Salient Ichthyo Disease and Their Management in India"** for the award of the degree of Master of Science in Zoology, is a record of original and independent research work done by me during the period of study from May 2023 to August 2023 under the supervision and guidance of **Dr. Yogendra Kumar Payasi** and it has not previously formed the basis for the award of any Degree / Diploma / Associate sip / Fellowship or other similar title to any candidate of any University.

Date-

Place-IGNTU, Amarkantak

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CONTENTS:

Introduction:

Fish diseases have significant implications for both the aquaculture industry and the conservation of aquatic ecosystems. In India, where fish farming and fisheries play crucial roles in the economy and food security, the study of fish diseases is of utmost importance. Understanding the prevalence, causes, and impacts of these diseases is essential for effective disease management strategies, sustainable aquaculture practices, and the preservation of biodiversity in India's water bodies.

India is blessed with diverse aquatic resources, including rivers, lakes, reservoirs, ponds, and coastal areas, which support a wide range of fish species. The aquaculture industry in India has experienced remarkable growth in recent decades, contributing significantly to the country's food production and export earnings. However, alongside this growth, there has been a parallel increase in the occurrence of fish diseases, posing significant challenges to the industry's sustainability and productivity.

Fish diseases in India can be caused by a multitude of factors, including microbial pathogens, parasitic infections, environmental stressors, poor water quality, and inadequate management practices. These diseases can manifest in various forms, ranging from acute mass mortalities to chronic subclinical infections, ultimately impacting fish health, growth, reproduction, and overall productivity.

The economic consequences of fish diseases in India are considerable. Outbreaks of diseases can lead to substantial economic losses for fish farmers, resulting from reduced fish yields, increased mortality rates, and the need for disease management interventions. Furthermore, the spread of diseases can have broader economic implications, affecting the supply chain, market stability, and livelihoods of those dependent on the aquaculture sector.

Beyond the economic ramifications, fish diseases also have ecological implications for India's aquatic ecosystems. Diseased fish, when released or escaped into natural water bodies, can act as carriers of pathogens, potentially transmitting diseases to wild fish populations. This can lead to a decline in biodiversity, disrupt the balance of the ecosystem, and negatively impact the overall health and functioning of aquatic habitats.

The scientific study of fish diseases in India has a rich history, with pioneering research conducted by notable scientists and institutions. Early investigations focused on identifying and characterizing diseases affecting important fish species, such as Indian major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) and exotic species introduced for aquaculture, including the common carp (*Cyprinus carpio*) and tilapia *(Oreochromis spp*.). These studies laid the foundation for understanding the diversity and dynamics of fish diseases in India.

Advancements in diagnostic techniques, such as histopathology, microbiology, molecular biology, and immunology, have significantly improved the identification and characterization of fish pathogens in India. Research institutions, universities, and government organizations have contributed to expanding the knowledge base on fish diseases through their surveillance programs, epidemiological studies, and collaborative research initiatives.

Despite these efforts, several challenges remain in effectively managing fish diseases in India. One of the primary challenges is the lack of accurate disease data due to underreporting and limited disease surveillance systems. Timely detection, reporting, and monitoring of fish diseases are crucial for implementing preventive measures and developing appropriate control strategies.

Furthermore, the diverse geographic and climatic conditions across India influence the distribution and prevalence of fish diseases. Regional differences in water quality, temperature, salinity, and other environmental factors can significantly impact disease occurrence, making it essential to consider these variations when formulating disease management approaches.

In recent years, there has been an increased emphasis on adopting sustainable and environmentally friendly practices in aquaculture. Disease prevention and control are integral components of sustainable aquaculture management. Strategies such as biosecurity measures, vaccination, water quality management, and the use of probiotics have shown promise in reducing disease incidence and minimizing the use of antibiotics and chemical treatments.

Moving forward, interdisciplinary collaborations among scientists, policymakers, and industry stakeholders are crucial for addressing the complex challenges associated with fish diseases in India. Integrating knowledge from various fields, including fish pathology, aquaculture management, environmental science, and public health, will lead to more holistic approaches to disease prevention and control.

In conclusion, fish diseases pose significant challenges to the aquaculture industry and the conservation of India's aquatic ecosystems. Understanding the prevalence, causes, and impacts of these diseases is essential for effective disease management, sustainable aquaculture practices, and the preservation of biodiversity.

Literature Review:

Fish diseases are a significant concern in India's aquaculture industry and pose challenges to the sustainable management of aquatic ecosystems. This literature review aims to summarize existing research on fish diseases in India, focusing on different fish species, disease prevalence, and factors contributing to disease outbreaks. Understanding the current state of knowledge in this field is crucial for implementing effective disease management strategies and ensuring the health and productivity of fish populations.

Studies on fish diseases in India have predominantly focused on key fish species, including the Indian major carps (*Catla catla, Labeo rohita*, and *Cirrhinus mrigala*), common carp (*Cyprinus carpio*), tilapia (*Oreochromis spp*.), and various indigenous fish species. Among the major carps, *Aeromonas hydrophila, Edwardsiella tarda*, and *Flavobacterium columnare* have been identified as common bacterial pathogens associated with diseases such as hemorrhagic septicemia, edwardsiellosis, and columnaris disease, respectively (Rajendran *et al.*, 2014; Mohan *et al*., 2016).

Parasitic infections have also been extensively studied in India. The ectoparasitic monogeneans, particularly *Dactylogyrus spp., Gyrodactylus spp*., and *Trichodina spp*., have been reported as major contributors to fish diseases, causing skin and gill infections (Easa *et al.*, 2017). Similarly, endoparasites such as *Myxobolus spp*., *Henneguya spp*., and *Trypanosoma spp*. have been documented as causative agents of diseases in several fish species (Chakrabarti, 2018).

In addition to specific pathogens, studies have investigated disease prevalence in different regions of India. These studies have demonstrated regional variations in disease occurrence, highlighting the importance of local environmental factors. For example, in the coastal regions of Andhra Pradesh, *Vibrio spp.*, especially *Vibrio harveyi*, have been identified as significant pathogens responsible for outbreaks of vibriosis in marine fish farms (Ghatak *et al.*, 2020).

Water quality parameters play a crucial role in disease prevalence and outbreaks. Several studies have reported a strong correlation between poor water quality and increased susceptibility to diseases in fish. High ammonia levels resulting from inadequate water exchange or excessive feeding have been associated with gill and skin infections, while low dissolved oxygen levels have been linked to bacterial and fungal diseases (Pillai *et al.*, 2015).

Environmental stressors, including temperature fluctuations, salinity changes, and pollution, have been identified as important contributors to disease outbreaks. For example, temperature-dependent diseases, such as viral hemorrhagic septicemia (VHS) and spring viremia of carp (SVC), have been reported in India during periods of extreme temperature variations (Sharma *et al.,* 2021). Similarly, pollution from industrial effluents and agricultural runoffs can increase the susceptibility of fish to diseases, compromising their immune system (Verma *et al.,* 2018).

In recent years, the emergence of novel pathogens and diseases has become a significant concern in Indian aquaculture. One such example is the emergence of koi herpes virus disease (KHVD) in common carp, which has caused significant economic losses in fish farms. Several studies have been focused on understanding the epidemiology, pathogenesis, and control measures for KHVD in India (Ranjan *et al*., 2020).

The impact of fish diseases on the Indian aquaculture industry is substantial. Disease outbreaks can result in mass mortalities, reduced growth rates, and poor feed conversion efficiency, leading to significant economic losses for fish farmers. For instance, outbreaks of bacterial diseases, such as motile Aeromonas septicemia (MAS), have been reported to cause up to 80% mortality in Indian major carps (Hussain *et al*., 2019).

To mitigate the impact of fish diseases, various disease management strategies have been explored in India. Vaccination has shown promise in controlling bacterial and viral diseases. For instance, vaccination against motile Aeromonas septicemia (MAS) using formalin-killed vaccines has been successfully employed in Indian major carp farms (Sahoo *et al*., 2018). Similarly, viral vaccines, such as the one developed against koi herpes virus disease (KHVD), have been utilized in common carp farms (Thombre *et al*., 2022).

Water quality management and improved husbandry practices are essential components of disease prevention. Studies have highlighted the importance of maintaining optimal water parameters, implementing proper pond management, and providing adequate nutrition to enhance the immune response of fish, reducing their susceptibility to diseases (Mohapatra *et al.,* 2016).Furthermore, the role of probiotics in disease prevention and control has gained attention in recent years. Probiotics, such as Bacillus spp., Lactobacillus spp., and Pseudomonas spp., have shown potential in enhancing fish health and disease resistance by improving gut health, competing with pathogenic bacteria, and modulating the immune system (Chakraborty *et al.,* 2021).

Despite advancements in disease management strategies, several challenges persist. Underreporting and limited disease surveillance systems hinder accurate disease data collection, making it difficult to assess disease prevalence and trends accurately. Inadequate diagnostic facilities and limited access to trained personnel pose additional challenges for disease identification and characterization.

In conclusion, fish diseases pose significant challenges to the aquaculture industry in India. Understanding the prevalence, causes, and impacts of these diseases is crucial for implementing effective disease management strategies and ensuring the health and productivity of fish populations. This review highlighted the diversity of fish diseases in India, including bacterial, parasitic, and viral infections, and emphasized the importance of regional variations, environmental factors, and emerging pathogens. Disease prevention and control strategies, such as vaccination, water quality management, and probiotics, have shown promise but require further research and implementation. Addressing the challenges of disease surveillance, diagnostics, and access to trained personnel is crucial for effectively managing fish diseases and ensuring the sustainability of India's aquaculture industry.

CHAPTER-1

BACTERIAL FISH PARASITES AND DISEASES

Introduction:

It has been reported that bacterial pathogens are responsible for heavy mortality of both cultured and wild fishes and shell fishes. Many bacterial pathogens causing infection are associated with virus and fungus, hence the identification of the disease and characterisation of causative agent may be confusing. Aquatic environment with high organic load is congenial for multiplication of various types of bacteria and several workers have shown that the normal bacterial flora of fish is reflection of bacterial flora of water in which they live. There are few obligatory bacterial parasites which are unable to survive without a fish host and associated with clinical disease. The majority of fish pathogenic bacteria are gram negative rods but there are some gram positive pathogens also acid fast. Among infectious diseases the role of bacteria has been found to have major role and creates many practical problems in commercial aquaculture. The active role of these micro-organisms varies from a primary pathogen to an opportunist invader. The true pathogenic role of the isolated bacteria is understood during bacterial epizootic and also through the experimental induction of the disease.

When pathogenic bacteria entered the bodies defensive mechanisms the infectious disease process begins. Rapid passage of bacteria, from fish to fish, can increase the virulence of bacteria, when susceptible fish are exposed to these virulent bacteria under stressful environmental conditions, an increase in mortality can be expected.

When this occurs in nature, severe losses often go undetected because dead or dying fish may be eaten by predators of drop, unnoticed, to the bottom. In either case, a sudden increase in the death rate is often the first sign of trouble.

General morphology of bacteria:

Bacteria are unicellular organisms with a simple cellular organization. In shape they may be round, cylindrical, bacillary or spiral, the cell membrane lacks both cellulose and chitin, and may swell up like gelatine and form a capsule or a mucus coat. Bacteria do not possess nuclei or chromatin, although they do have nucleic acid distributed throughout the cytoplasm, or joined together in small nodules called nucleoids (chromosomes equivalent). Vacuoles may be formed in the cytoplasm. Many bacteria are motile by means of flagella, the distribution of which may be as follows:

1. Monotrichous: (one polar flagellum, or if there are two they are bipolar).

2. Lophotrichous: (a tuft of two or more flagella, which may be mono or bipolar).

3. Peritrichous (or holotrichous): (the flagella cover all of the cell).

Many bacteria produce pigment, chromogenic bacteria which diffuse their pigment into surrounding medium and themselves remain colourless, and chromophorous bacteria which possess their own colour but lack chromatophores.

Bacteria reproduce by transverse division, forming a wall perpendicular to the longitudinal axis. This feature gives rise the name schizomycetes. Under certain conditions they produce refringent endospores within the cell, and these spores are liberated by a bursting of the cell wall or by a swelling of the membrane.

The endospore are resistant to desiccation, cold, heat, and cellular toxins. On germinating they give rise to a new vegetative form, i.e. a new bacterium.

Bacterial fish parasites and diseases on skin and gills:

(i) Parasite- *Aeromonas salmonicida*
Family- Vibrionaceae
Disease- Furunculosis (Ulcer disease)
Location- Skin, gills and fins

(a)Introduction:

Aeromonas salmonicida, is the aetiological agent of furunculosis of salmonids, was first isolated from farmed trout in Germany, described as *Bacilllus salmonicida*. The organism was later reclassified in the genus typical and 'atypical' strains of *A. salmonicida* have been isolated from an increasingly wide variety of salmonid and non-salmonid fish. After some time furunculosis was reported in the United States in 1902. Furunculosis was also reported in Britain in 1906 - 1907, with large mortalities among wild fish in 1911 (Mackie *et al*., 1930). In Norway, furunculosis was found first in 1964. Since them most fish populations have either been infected or exposed at one time or another. At this times, epizootics have threatened the very existence of fish culture.

The name furunculosis is derived from the blister, ulcers of furuncle appearing on the skin of infected fishes but it is assumed that the acute cases of furuncle may occur in other type of infection, hence that is not the only sign of disease. Today furunculosis persists in many hatcheries. Severe outbreaks occasionally occur but due to advances in fish culture, sanitation and drug therapy, most are controllable. Out breaks of drug resistant furunculosis are an increasingly important problem. Probably it is the most widely known and common bacterial disease of cultured fishes also. It is known as septicaemic bacterial disease also. Besides salmonids they also in fact many species of cold, freshwater and warm water fishes. Thus this disease is very common and widely distributed throughout the world.

(b) Morphology:

Causative agent of the disease, the *A. salmonicida* belong the bacterial family vibrionanceae that isolated and identified as typical Gram-negative non-motile, short rods, nonflagelated, coccobacilli occuring in pairs, chains or clumps. It measures 0.8 x 0.5µ. It ferments carbohydrate. It survive for a couple of days in water but unable to persist in absence of carrier or host fish. Its infection furunculosis is usually seasonal with peak period of incidence seen during summer or early rainy season.

(c) Disease Signs:

1. Swollen skin "blisters" or furuncules, filled with pinkish or reddish fulid, are common on fish with chronic infections. These furuncules may have a purple, reddish or iridescent blue color.

2. Haemorrhaged fin sockets, especially the left pectoral, and frayed dorsal fins are common.

3. The gills also attacked and gross external lesions do not develop. The only apparent sign in cases of this sort is white or pale pink gills. Fish actually bleed to death through the gills. To demonstrate this, press the gill covers and watched for blood coming from the gills of lethargic fish.

Therefore, the clinical signs appear first in the dermis or skin as a small local erosion surrounded by inflammated reddish zone which gradually turns into a large deep ulcer. In acute cases of infection the fish have protruding eyes, and storage of fluid in the body cavity. The bacteria from the blood capillaries move into the muscle tissue where they continue and form ulcers. The gill capillaries may be congested because of clumps of bacteria.

Source-https://www.researchgate.net/figure/Furunculosis-in-Atlantic-salmon-showing-afuruncle-boil-on-its-side-Source-AGDAF_fig5_320451316

(d)Diagnosis:

Confirmation of furunculosis as the cause of an epizootic depends upon the isolation of *A.salmonicida* from typically affected fish. Furunculosis is suspected, however, when some or all of the above signs are observed in host fish and water temperatures average 56° F, where *A. salmonicida* fits with respect to other fish-pathogenic bacteria.

(e) Method of control:

Prevention:

1. Avoid hatchery to hatchery transfer of exposed or infected fish. Disinfect layed eggs with an iodophor disinfectant prior to shipment and again upon receipt.

2. Maintain springs and water supply systems free of fish, including non-salmonids. Hatcheries utilizing stream Water should, if possible, block all fish from migrating above the water intake.

3. Avoid handling marking or transferring fish during or for 2-3 weeks prior to, the expected time of usual outbreak.

4. At spawning fish eggs should be water hardened is an iodophor disinfectant solution of up to 100 parts per million of active iodine for up to 1 hour.

Therapy:

1. Terramycin, fed at the rate of 3.5 grams of active drug per 100 Kg of fish for l0 days is usually effective for the control of furunculosis in fishes provided environmental stresses have been eliminated.

2. Possible infection to layed eggs is prevented by disinfecting them with 0.015% solution of merthiolate, or 0.185% Solution of Arciflavin . One percent providone - iodine solution is highly recommended owing to its relatively less toxicity compared to other disinfectants.

Therefore, the treatment is done by removing the severely infected fishes from the pond and by supplying food containing antibiotics like the sulphonamids or nitrafurans etc.

(ii) Parasite- *Aeromonas hydrophila*

Family- Vibrionaceae

Parasite- *Pseudomonas fluorescens*

Family- Pseudomonadaceae

Disease- General Septicemia

Location-Skin and Fins

Host- Silver Carp (*Hypothalamichthys molitrix*)

(a) Introduction:

Under stressful, adverse environmental conditions the bacteria belonging to the genera-*Aeromonas* belonging family Vibrionaceae and *Pseudomonas* belonging family Pseudomonadaceae may cause serious fish diseases. These truly facultative fish pathogens are common soil and water bacteria found in most natural waters. *Aeromonas hydrophila* isolated from apparently healthy fish in fresh water (Cipriano *et al*., 1984). These bacteria actively break down organic matter of all kinds and do much to “freshen” surface water.

Stresses caused by high water temperatures, low oxygen levels, the accumulation of waste products, handling and marking of fish, and crowded fish population are important predisposing factors that can lead to diseases caused by *A. hydrophila or Pseudomonas fluorescens*. These organisms are opportunists capable of developing increased virulence under optimum condition, *A.hydrophila* outbreaks are most numerous during June, July and August

(Meyer and collar, 1964). The stresses caused by frequent low oxygen levels which weaken fish. The clinical condition is distinguishable between Aeromonas and Pseudomonas septicaemia.This septicemia or Dropsy among carps is a common bacterial disease. *A. hydrophila* and *Myxosporadian* invaded in cattle causing dropsy conditon in rural ponds have observed. In acute or chronic haemorrhagic septicaemia heavy mortality of fishes may occur shortly after the advent of lesions.

(b) Morphology:

Aeromonas hydrophila:

A.hydrophila bacteria occur as Gram-negative, motile, straight rods. It measures as 0.3 - 1.0 x 1.0 - 3.5 pm.

Pseudomonas fluorescens :

P.fluorescens bacteria occur as Gram-negative, motile rods. It measures as 0.8 x 2.0 -3.0 pm.

(c) Disease signs:

1. Superficial shallow, greyish-red, circular or irregular skin ulcers are common.

2. Fish may have distended dropsy with a slightly opaque or bloody fluid.

3. Host fish may have deep furuncules which sometimes break out to the surface producing deep creaters.

4. Fins and fin joints are inflamed.

Source-https://tropical-fish-keeping.com/septicemia.html

(d) Diagnosis:

The determination that mortalities are being caused by *A. hydrophila* or *P. fluorescens* must begin with a recognition of probable adverse environmental conditions. Next would be the observation of moribund fish and the detection of some of the above listed diseases signs. Bacteriological isolation of *A. hydrophila* or *P. fluorescens* and the identification of these bacteria through presumptive tests would then be meaningful and could be interpreted as the likely cause of the mortality. The presence of these bacteria does not necessarily mean mortalities will occur. Many perfectly healthy fish carry these organisms. However if handling, temperature, low oxygen or other stresses predispose fish to infection, then the detection of these organisms, consistently, in moribund fish is sufficient evidence to consider these organisms to be the cause of the difficulty.

(f) Method of Control:

Environmental improvement, especially reduction of organic pollutants, and temperature, where possible, and also removal of dead and dying fishes, is a considerable aid to reduction of losses.

The condition can usually be controlled by treatment with antibiotics or potentiated sulphonamides, but since affected fish are usually anorexic, parenteral treatment may be necessary, a stressor in itself, as well as improvement in environment conditions. Because of the close association of pseudomonas infection with poor environmental conditions, great improvement in the conditions of affected fish may be achieved by reduction of stocking densities or improvement of water quality. Where therapy has been attempted, good results have been claimed for kanamycin injected intraperitoneally and oral oxytetracycline (Meyer and Collor, 1964).

Prevention:

1. Avoid hatchery to hatchery transfers of fish. Fish gradually develop resistance to the local strains of bacteria but may carry their strains of organisms to another hatchery to which resident fish might be susceptible.

2. Provide optimal environmental conditions for the species being reared. Maintain oxygen levels above 5 ppm at pond outlets. Gently handle fish during periods of warm weather, avoid handling altogether if possible.

3. When sorting, handling and moving brood stock in the spring, prophylactic, treatments have been helpful. Intraperitoneal injections of antibiotics into non-food fish have reduced posthandling losses by 80 - 90%. Consulted mg fish pathologist for help with these procedures.

4. Salt, at 0.5% should be added to the water of distribution trucks to reduce stress on the fish and prevent infections.

Therapy:

Terramycin has been effective when incorporated into pelleted fish feed at the mile or coated on the feed at the hatchery. Terramycin should be fed at 3.5 grams of active drug per 100 Kg of fish per day for 10 days. Antibacterial therapy will provide only short-term relief unless adverse environmental conditions such as high-water temperature, low water flows, low oxygen levels or crowding are not promptly corrected.

(iii) Parasite-*Flexibacter columnaris*

Family-cytophagaceae

Disease-Columnaris disease (Cotton wool disease)

Location-Skin, gills and fins

Host-Grass carp and silver carp

(a)Introduction:

Columnaris is caused by the bacterium *Flexibacter columnaris*.

This disease derives its name from the peculiar trait the bacterium has of aggregative into clumps or "haystacks" and eventually into distinctive columns. These facultative fish pathogens are long thin soil and water bacteria that can be highly pathogenic to fish. They move about by bending and twisting (Bullock *et al*., 1986).

Columnaris bacteria-likely enter fish through breaks in the skin or through the gills. The skin or gills have been damaged by handling, by parasites, by waste products, or by other adverse environmental conditions, the bacteria may gain entree and caused disease. Even uninjured gills can be attacked by virulent columnaris bacteria (Wood, 1979).

Water temperature has a major influence on the occurrence of outbreaks of columnaris. Outbreaks seldom occur at water temperatures below 55°F and may be explosive above 65°F. Crowding handling and other stresses are considered the main predisposing factors, but some highly virulent strains of columnaris bacteria will attack apparently healthy fish reared in warm water.

F. columnaris first described by Davis (1922) as Bacillus columnaris, this organism was subsequently known as Chondrococcus columnaris (Ordal and Rucker, 1944) and Cytophaga columnaris (Garnjobst, 1945).

(b) Morphology:

Gram- negative, slender flexible rods 0.5 x 4-12 pm. In wet mount preparations of infected tissue, the organisms may be seen to arrange themselves into the dome-shaped columns which gave the bacillus its specific name and which were previously, erroneously, thought to be fruiting bodies (Ordal and Rucker, 1944).

(c) Disease signs:

1. Skin lesions begin as small circular erosions which rapidly increase in size often the yellowmarginated lesions are dished out, exposing the muscle.

2. Gill lesions often begin at the tip of the filaments and progress toward the base. Highly virulent strains of columnaris bacteria attack the gills causing the epithelium to separate from the capillaries beneath. In advanced cases, lesions will completely denude gill filaments of soft tissue. The fish die of rapid suffocation. Mouth and skin lesions usually occur in more chronic cases caused by the less virulent strains.

That is, the first external sign of the disease is the appearance of greyish white spots which resemble saprolegnia infection, on the various parts of the body of the host fish like head, lip and fins as well. The infections virulent strain cause ‘gill rot condition’ while less virulent may not show any external sign or cutanious lesions.

Sometimes the dermal epithelium and bacteria are loosely attaches to the mouth resembling tiny wool of cotton which is termed by aqua-culturists as ‘cotton wool disease’. In host fishes external infection start with appearance of small circular, greyish blue centre with red margin surrounded by ring of inflamed skin. In host necrotic lesion begins with outer margin of fin and gradually spread towards body. Erosion of gill lamella often observed. Many cases bacteria gain entrance to the dermal tissue as a result of injury, multiplies in the connective, tissue and ultimately reach to the musculature where red ulceration forms.

Source-https://bluegent.ugent.be/screening-columnaris-preventingtreating-products

(d)Diagnosis:

The presumptive diagnosis of columnaris requires the presence of typical lesions bearing massive numbers of long, thin Gram- negative bacteria identifiable as *F.columnaris*. Necrosis of the areas affected is of diagnostic importance, especially on the gills. This characteristics alone distinguishes columnaris of the gills from severe cases of bacterial gill disease. Yellow slime and massive numbers of columnaris bacteria in the lesions are also keys to columnaris detection. Microscopic examination in wet mounts is especially informative for the experienced diagnostician as the aggregation of the bacteria into columns or “haystacks” can be observed. Simple stained (methylene blue) slides of lesions material shows huge numbers of long, thin bacteria.

(e) Method of control: Prevention:-

1. Maintain water temperatures below 60°F for the fishes.

2. Maintain water supplies free of fish. At hatcheries using stream water supplies, fish barriers should be built to prevent all species of fish from migrating above the water inlet.

3. Whenever columnaris regularly occurs, avoided handle fish or over crowd populations during warm water periods.

4. Establish appropriate population densities in advance of hot weather and maintain adequate water flows. Remove dead and moribund from rearing facilities daily.

5. Use recirculated water only with extreme caution during summer months.

Therapy:

1. Various curative measures include, treatment of pond with 1 ppm of copper sulphate solution, supply of antibiotics like terramycin with the artificial food, dip treatment for 2 minutes in copper sulphate (1:2000) solution, or for 10 to 30 seconds in malachite green (1:1500).

2. Since columnaris often begins as an external infection, pre-emptive external treatments could be helpful. Salt baths at 1- 3% or formalin treatments to remove complicating protozoan parasites should be attempted.

(iv**)** **Parasite-** ***Flavobacterium branchiophila***

Family-Mycobacteriaceae

Disease-Bacterial gill disease.

Location-Gill

Host-Catla catla

(a)Introduction:

This disease is caused by mycobacterial infections commonly found in the gills of various freshwater fishes and attributed to a combination of unfavourable environment. Davis (1953) diagnosed the disease in fishes.

Bacterial gill disease is one of the most common diseases of hatchery fishes (Snieszko, 1981). As the name implies, the gill epithelium is covered by large numbers of long thin flavobacteria (Wakabayashi *et al*., 1980). Flexibacters may also cause bacterial gill disease. These infections often lead to the clubbing and fusing of gill filaments and congestion with mucus (Wood, 1979). Distress is caused by the resulting inability of the fish of obtain oxygen and get rid of carbondioxide and ammonia. Gill damaged by Flavobacteria are also prone to invasion by fungus. In acute cases, massive numbers of bacteria develop in a short time and the loss rate may jump from 0 to over 20% in one day with little outward change in appearance of the fish.

Crowding of fish, especially small fingerlings (approximately 100 Kg and smaller) and water reuse are prime factors in the occurrence of bacterial gill disease. Lightly infected fish have been found to recover spontaneously if they can be moved from a pond environment to fresh running water.

(b)Morphology:

Parasites are Gram-negative, non-motile rods, its measures as 0.5 x 1.0 - 3.0 pm in diameter.

(c) Disease signs:

1. Fish first appeared lethargic and some refused food.

2. Fish swim near the water surface, orient themselves with the current, and space themselves equidistant from one and other.

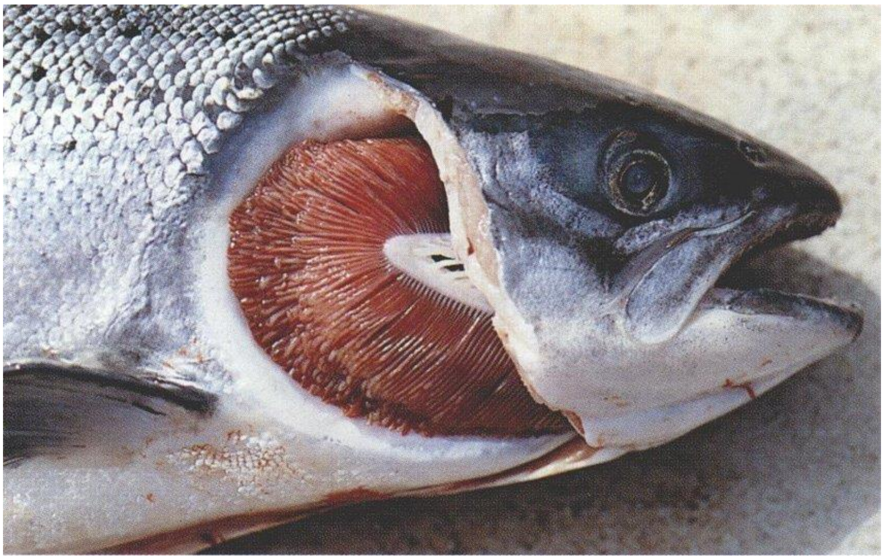
3. Increased or laboured gill activity is noticeable with gill covers opened wider than normal. Oxygen levels in ponds are normal.

4. Gills appeared whitened on the tips and excess mucus may be present.

5. Dead fish may appear to be pale in colour.

6. Gross external signs may be confused with those caused by columnaris in the gills. Bacterial gill disease does not lead to necrosis of gill filaments, as does columnaris.

Therefore, the first indication of bacterial gill disease is loss of appetite. Fish lend to ride high in the water and orient themselves into the flow of water. They appear lethargic and may be pale Haematocrit values increase initially, rising to 50 - 60% in fingerling fish. If the affected fish are not treated after the first symptoms are noted, the mortality increases rapidly, and 50% or more of the fish may be dead in 24 to 48 hours.



Source- https://www.researchgate.net/figure/Farmed-Atlantic-salmon-affected-by-AGDexhibiting-multifocal-patches-of-swollen-gill_fig1_14304047

(d)Diagnosis:

Confirmation of the presence of bacterial gill disease is based upon observation of the above-described disease signs and the presence of tangled masses of long, thin Flavobacteria on the gill filaments. A slide prepared from crushed gill filaments, fixed, and stained with methylene blue will greatly aid in the detection of gill disease bacteria during microscopic examination.

(d)Method of Control:

Prevention:

1. Fingerling host fishes should be reared on first-use well or spring water until they reach at least 100 fish per Kg in size. Rearing of fingerlings on reused water should be avoided.

2. Plan ahead and maintain population densities as low as possible.

3. Maintain the cleanliness of rearing facilities and provide a flow of fresh water sufficient to flush away waste products.

4. Remove mortalities daily, crippled, deformed and “pinheaded” fish may be reservoirs of infection and should be promptly removed.

5. Chemical treatments as described below for therapy can be applied on a routine preventative (prophylactic) basis during the fingerling rearing period to preavent bacterial gill disease.

Therapy:

1. Halt all feeding of fish with bacterial gill disease. This reduces the oxygen needs of sick fish and reduces the environmental degradation caused by waste products and uneaten food. Fish being treated for external bacterial infections or parasites should not be fed on the days treatment are being administered.

2. Benzethonium chloride and benzalk onium chloride may be used at 2 ppm to disinfect water, gear and tanks.

3. Chloramine T, at 8.5 ppm of active ingredient for one hour on three successive days, has been found to be safe and effective. Permits to use this compound should be sought and treatments and results should be documented as required.

Therefore, Bacterial gill disease usually responds to antiseptic baths. Providing adequate oxygen is useful supportive therapy. Reducing stressors is important. It is likely that this organism may occur naturally on healthy fish and possibly in aquatic ecosystems.

CHAPTER -II

STUDIES ON FUNGAL FISH PARASITES AND DISEASES

1. Introduction:

A number of aquatic fungi cause fungal infections of fish and their eggs, resulting in heavy destruction of fish populations. These fungi have been very troublesome in fish hatcheries or impoundments and their sporadic infection might turn into an epidemic without warning. In India, Bharagava *et al*., (1971) initiated fish mycopathological study, followed by Srivastava and Srivastava (1978) who worked on some tropical fishes of Eastern Uttar Pradesh.

2. Diagnosis:

Fungal diseases are diagnosed by examining the affected organs with the naked eye and by microscopic examination. When using the microscope, the lowest possible magnification in used in order to provide the largest field of view. In order to proceed systematically, wet material or compressed preparations are examined from side to side. The preparations are examined immediately after they are prepared.

Skin examination:

During the external examination of fish with the naked eye we can recognize some parasitic fungi. The first of these usually form cotton clusters. Some parasites which are not conspicuously pigmented are observable only when the fish is examined from the slide in which case their outlines and motion appear.

Macroscopic parasites are expressed by the absolute number. After this examination the skin is examined microscopically.

By a scalpel the slime and the outer layers of the skin are scraped from the whole body and fins in the case of small fish, and in the case of larger individuals from the right and left sides of the back and posterior. The scraped material is transferred to a slide, diluted with a drop of clean water, cover-slipped and examined first by a low and then if required by a high magnification microscope.

Some parasites occur in deeper parts of the skin or in the hypodermis where they form white or black spots which are visible to the naked eye. A part of the affected skin is dissected out, transferred to a slide, teased apart by dissection needles compressed by a slide or a coverslip and examined by a microscope.

Gills examination:

To get a better view of the gills, the operculum is lifted or cut off as in the dissection. For parasitological investigation each branchial arch is best dissected separately. With the naked eye or by a lenses we can identify fungal films, changes after fungal infection of gills. For microscopic examination the branchial arches of small fish are compressed between two slides and examined by the microscope.

In the case of large fish the branchial filament is cut and examined likewise by the compression method. Before compression several drops of water are added to the gills.

Fungal fish parasites and disease on skin and gills:

(i)Parasite - *Saprolegnia parasitica*

Family - Saprolegniaceae

Disease - Saprolegniasis

Location - skin and fins

Host - *Labeo gonius*

(a)Introduction:

Saprolegnia is commonly encountered on fish eggs and on fish. It is easily recognized as white, cottony patches of long thin non-septate filaments or hyphae (Holfman, 1969).*Saprolegnia* is commonly known as 'water mould' 'skin fungus' or cotton 'wool disease'. Fungus infection of fish caused by saprolegnia belonging to the order saprolegniales (Hofer, 1904).

Certainly the saprolegniace are 'water moulds' possessing a profusely branching nonseptate mycelium, appearning like cotton-wool tufts in water. The hyphae vary considerably in form between species, but all contain cellulose. Although the hyphae are non-septate, the reproductive structures are separated from the somatic hyphae by means of a septate zoosporangium containing biflagellate zoospores. Some species are found in brackish water but salinities higher than 2.8% limit their distribution (Testrake, 1959).

Fungi of the genera *Saprolegnia* and *Aclya* are also of importance in fish pathology, and these are sometimes known under the name of "fish fungi". In the majority of cases the infection has arisen from open wounds on the body of the fish, while on other occasions they may live on the decaying remains of food.

The Saprolegniaceae is by far the largest family of Saprolegniales, and the members of which occur abundantly both in water and soil as saprobes and sometimes as parasites. Taking the morphological characters into account Coker made a comprehensive study of watermolds. Thereafter, some investigators have contributed a lot to the Saprolegniaceae. Recently, Dick reviewed the general morphology of the Saprolegniales within the preview of zoosporangial dimensions, zoosporogenesis, zoospore characteristics, oosporogenesis, oospore structure etc.

Though the basic characters are already known for genera and species of watermold yet no attempt has been made to establish the correlation between assexual and sexual and reproductive bodies. Therefore, our pursuit is to obtain the correlation between certain asexual and sexual reproductive bodies in Saprolegniaceae.

Mainly three major species of genus-Saprolegnia associated with the disease in fish are *S.ferax, S.parasitica, S.diclina*. A number of non-saprolegniaceous fungi including *Phythium* and *Leptomit* us are less common fungal infection among fishes.

Saprolegniasis has been reported in cultured fishes without any visible prior injury to the fish (Hoshina *et al.*, 1960) and Hoshina and Ookubo (1956). Similarly, Fungal invasion in a variety of fish without any obvious prior injury (Tiffney, 1939). However, microscopic lesions may have been present and Tiffney certainly found that microscopic injury greatly increased the likelihood of fungal infection. Temperature has a significant effect on the development of Saprolegnia infection. While infection following occur at any temperature compatible with fish life, most epizootics occur when temperatures are low for that fish species.

(b)Morphology:

Saprolegnia are characterised by profusely branched non- septate, cotton wool like tufts of mycelium on substratum. They reproduce asexually by releasing biflagellate spores formed in swollen sporangia. The primary zoospore cannot germinate and finally encyst. A reniform zoospore finally germination and formation of hyphae takes place. This type of sporangial proliferation is a characteristics of saprolegniaceae. Saprolegniales are sparophytes attacking stressed fishes.

Saprolegnia fungi species form soft, filamentous films even several centimetres long, the fungi filaments are branched, thickening into sporangia at the ends. Zoospores have conspicuous diplanetism. Their taxonomy is very difficult.

(c)Symptoms:

In initial stages of infection, no definite clinical signs are evident, in latter stages a whitish fungal mesh which looks like cotton wool appears in the infected part of fish body. Fungi can also penetrate or invade tissue are found brushing against solid substratum. Sometimes lesions appear as grey white patches on various parts of the body like skin, fins, eyes, mouth and gills. Colour change to brown or greyish as mycelium invade, uppermost layer of dermis. Fish eggs infected by the disease are seen to be covered by fungus. In microscopic examination of tissue from lesions in wet mount preparations, non septate fungal hyphae is distinctly visible.

Source- veterinaryworld.org/Vol.13/December-2020/22.pdf

(d) Pathognesis:

Typical water mold infection presents as a relatively superficial, cottony growth on the skin or gills. Such lesions usually begin as small, focal infections that can rapidly spread over the surface of the body. It is not unusual for large lesions to suddenly appear within 24 hours.

Newly formed lesions are white due to the presence of the mycelia, with time, the lesions often become coloured red, brown, or green because of the tapering of sediment, algae, or debris in the mycelia mat. If the water mould is observed on a fish removed from the water, the mycelium appears as a slimy, matted mass on the body.

Although they grow rapidly over the skin's surface, typical water mould infections rarely penetrate beyond the superficial muscle layers. Superficial damage to the skin or gills can be total. Loss of serum electrolytes and protein in proportional to the percentage of skin affected (Richards and Pickering, 1979). Thus morbidity and mortality increase as the amount of affected skin or gill tissue increases. With acute lesions, fish usually die within several days or recover within several weeks.

Therefore, *Saprolegnia* lesions are focal grey-white patches on the skin of the fish, which, when examined under water, have a cotton-wool like appearance where the hyphal filaments extend out into the water. The early lesions are often almost circular and grow by radial extension around the periphery until lesions merge. At this later stage the fungal patches are often dark grey or brown in colour as the mycelium traps mud or slit.

Although distribution is usually random, certain parts of the body may be particularly involved e.g. the head region in secondary infection of ulcerative dermal necrosis (UDN) of fishes. Skin and gill lesions are by far the most frequently observed but there have been reports of infection of internal organs.

(e)Treatment:

Prevention of the disease may be aided by maintaining fish under good husbandry conditions. Correct feeding, the avoidance of overcrowded conditions and good water quality are essential. Should fish develop saprolegniasis, a variety of external disinfectant treatments may be used. A bath of potassium permanganate (1 gm. /100 litres water) for 90 minutes has been shown to be a good therapeutic measure. The chance of recovery from saprolegniasis is directly related to the amount of skin or gill infected by fungus.

Therefore, Prophylactic measure by avoiding primary cause like rough handling of fish, injuries, poor sanitation and inadequate water quantities and weakness of fish can be adopted.

Suggested curative treatment infection can be effectively done by bath of Potassium permanganate (1 gm. in 100 lit. of water for 1 hour) and Methylene blue (10-20 mg in 1 lit for 15 min.). Infected fish egg may be treated a daily bath in formalin till recovery from disease (1-2 ml 30% formalin in 1 lit.)

(ii)Parasite-*Branchiomyces demigrans*

Family-Saprolegniaceae

Disease-Branchiomycosis (gill rot)

Location-Gills

(a)Introduction:

A kind of gill disease of freshwater fishes are caused by fungi of genus Branchiomyces. The fungi which obstructs the blood vessels in gill filaments and ultimately causes gill rot.

Branchiomyces sanguinis as a pathogen from cyprinids and tench causes gill rot on common carp in summer month, spreading branched wide hyphae (9-15 µm) growing in the blood vessels in gill filaments and lamellae. *Branchiomyces demigrans* as a pathogen from infected gill region of carp fish, causes gill rot characterised with thicker hyphal wall (0.50.7µm) than *B.sanguinis* in carp fish. Both the species reproduce by spores from in syncytial hyphae.

Therefore, *Branchiomyces* species is generally considered that there are two species of Branchiomyces but both are known only as parasites of fish gill tissue. Both have branched coenocytic hyphae which produce oplanospores by endogenous cleavage.

They are generally separated on the basis of size of spore and hyphal wall, and on specific habitat in the gill. It is possible, however, that both are variants of the same species and that the type of growth and morphology may be partly a function of the growth location, not an associated taxonomic feature.The species, *B.sanguinis* which occurs within the blood vessels of the gill, and *B. demigrans*, which can penetrate through the gill tissues to the surface, are both generally associated with infection of cyprinid fishes (Schaperclaus, 1954; Reichenbach-klinke, 1973).

(b) Morphology:

B. demigrans fungi form thick-walled filaments which are 0.022-0.028 mm. broad at the end of their development, parasitic in the gills out of which they grow on the surface, 0.012-0.017mm.spores are formed in plasmodia.

(c) Symptoms:

Infected fishes show damage of gill filament. In the beginning infection the pale gills show deep red patches. The progressive stages show occurrences of flecking on gill filament which at latter stages become greyish white and finally drop off, causing secondary infection of *Saprolegnia*.

The spores of *B.demigrans* spread through shoughing off of the gill filaments. Obviously healing of gill filament starts. Regeneration depends on the size of the fish- and season. The disease is predominant in summer months. Initial phase of outbreak of disease show changes of behaviour pattern of fish observed with refusal of food (Schaperclaus, 1954) and shoaling near inlet of water body (Amalcher, 1972). The pathogen is clearly identified by microscopic examination of teased out gill preparation.

Although any age group can be affected with infection, maximum loss occurs among carps 1-2 years of old. Water body with high concentration of organic matter, dense stocking with fishes, like common carp, Indian major carps, cat fishes may be infected with Branchiomycosis especially in summer months. Branchiomycosis is mainly a summer disease and occurs when water temperature exceeds 20°C. High level of nutrients in water, phytoplankton bloom, dense population in a limited space, and water temperature accelerates the outbreak of the disease.

Source- https://www.researchgate.net/figure/Branchiomycosis-is-largemouth-bass-Pr-Bowser-Cornell-University_fig73_296089219

(d)Diagnosis:

Diagnosis of branchiomycoysis can be made by examination wet mounts or histopathology of lesions. Characteristic hyphae causing deep branchial infection are diagnostic.

(f) Pathogenesis:

Gill may be mottled in appearance because of areas of thrombosis and ischemia, which cause alternating areas of light and dark regions in the tissue. Histologically, there are branched, aseptate hyphae with intrahyphal eosinophilic (by haematoxylin and eosin), round bodies ("aplanospores"). Which look similar to saprolegnia sporangia. Both Branchiomyces species cause similar patholgoy, except that *B. demigrans* affects the entire gill with hyphae penetrating though blood vessel walls into the lumen, while *B. sangunis* restricted to gill blood vessels (Walke, 1975).

(e)Treatment:

There is no known treatment. Reducing organic loading and reducing the temperature below 20°C have been suggested. But to prevent the infection, organic impurities in water should be avoided, and feeding rate during summer months should be regulated. Regular fresh supply of water into the pond should be provided as often as possible. Draining the pond bottom and disinfecting with Quicklime (CaO) at 200kg-1 ha may be done at the end of each culture practice. CuS04 at 8kg-1 ha may be used in four monthly instalment of 2-3kg-1 ha each. Bath in CuS04 (1 g in 10 lit of water) for 10-30 minuted and Benzal konium chloride (1-4 ppm) for 1 hour kills all pathogens.

(iii)Parasite-*Ichthyophonus hoferi*

Family-Entomophthoraeeae

Disease-Ichthyophoniasis (Swinging disease)

Location-Skin

Host-Carp fishes.

(a)Introduction:

Fungus parasite *Ichthyophonus hofari* caused the disease Ichthyophoniasis that is systematic granulomatosis and is found in both freshwater and marine fish of many species. Out breaks in fishes usually occur in winter and spring and infection is evident as a roughened skin texture described as the “Sandpaper effect” occurring principally on the lateroventral tail region. It is suggested that gross lesions occur in the skin as soon as 30 days after experimental feeding of the fungus. The sandpaper effect in caused by the loss of epithelium over proliferating dermal fungal granulomata. These are usually black in colour, approximately 1 mm diameter and raised above the skin surface. Further growth of the fungus causes local necrosis and results in the formation of either abscesses or ulcers.

(b) Morphology:

I. hoferi morphologically characterised by a spherical or oval shape, yellowish brown in colour with granulated cytoplasm. Therefore, unicellular oral formations with a smooth surface low transparency, yellowish-brown in colour, with a small or large number of black granules. Its size range about 0.02 - 0.15mm (10 - 250 µm) up to 2mm in diameter.

(c) Symptoms and Diagnosis:

Clinical signs in host fish and microscopic examinations of leased out preparation of infected part of infected fish pathogen may be identified. The disease affects a wide variety of freshwater bodies.

Source-https://units.fisheries.org/fhs/wp-content/uploads/sites/30/2017/08/3.2.18Ichthyophonus-2014.pdf

(e) Treatment:

Phenoxyethol soultion 10 to 20 cc of 1% solution diluted in one litre of water is considered a very potent fungal destroyer. It is added to the water containing diseased fishes.

The fishes from this water are later taken out and transferred to the infection free ponds.

(iv) Parasite-*Aphanomyces invadans*

Family-Entomophthoraceae

Disease-Aphanomycosis (Epizootic ulcerative syndrome)

Host-Hetropneustesfossilis and Nandus nandus, Mugil cephalus

(a)Introduction:

Aphanomyces invadans is pathogenic to *Hetropneustes fossilis* and *Nandus nandus.* Recently, common fungus *Aspergillus flavus* and *A.achraceous* and *Fusarium momiliforme* also isolated from fish specimen affected the Epizootic Ulcerative Syndrome (EUS).

Aphanomycosis, generally known as crab or crayfish pest, practically destroyed all the fish populations today.

(b) Morphology:

The causative agent of this disease remained completely unknown for a long time. The name Aphanomyces means difficult to see. The hyphae cross through and destroy the chitinous carapace, which softens and becomes brittle in the points of greatest distruction.

It also attacks the connective tissue and, above all, the nervous system, in exceptional cases it also invades the musculature. The nerve lesions are probably the decisive cause of death, even when the carapace lesions favour the occurrence of bacterial infections which perhaps play an important role in the fatal results of an attack of Aphanomycosis.

(c) Symptoms:

Symptoms are not always immediately visible, but as the disease progresses the host fish show definite symptoms which may justify the suspicion that aphanomycosis is present. The host fish tend to adopt a sukine position and ceaselessly move their legs until they die. They probably lie on their backs because the fungus attacks and destroys the articular membranes, for this reason the diseased animals walk awkwardly, and lose their legs, and at times their claws. If a diseased fish is lifted up, it claws hang downwards as if they were paralyzed. Later on it is possible to observe a generalized lassitude. If the chitinous membrane of the ventral abdominal surface or the articulated membranes of the legs are explored with a pair of fine-pointed forceps, it is often possible to find isolated areas destroyed by the fungus, and these areas are soft and readily yield to pressure, sometimes they possess a yellowish coloration. The anal region is another common place for the attack to take place.

Source- https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.83971

(d) Diagnosis:

The suspected points of the articular membranes are out away and examined microscopically, in positive cases, a fine network of hyphae is seen.

Thus, there is three main method of diagnosis

1. Culture of water mould from typical ulcers.

2. Histology of skin or gills having, broad (7 to 20 µm), nonseptates hyphae with typical ulcers.

3. Wet mount of skin or gills having broad (7 to 20 µm), nonseptate hyphae with typical ulcers.

Physical Examination: Shallow to deep skin ulcers.

(e) Treatment:

There is no known treatment for atypical water mould infection. While various medications Antibiotics to antiseptics have been used, there is no evidence for their efficacy.

Sometimes Epizootic ulcerative syndrome is empirically treated by “improving water quality” by either:

1. Adding 60 to 100 kg of lime/160m and repeating treatment after 3 weeks.

2. Adding 200 to 300 kg of salt/1600 m.

Avoiding exposure to parasite is advisable for fish that are at risk of exposure to this organism.

Therefore, lethargic and dead host fish must be removed from the water and buried. Where possible, a strict quarantine should be maintained on animals used to populate stretches of water and tanks.

CHAPTER-III

STUDIES ON CRUSTACEAN FISH PARASITES AND DISEASES

Introduction:

Crustaceans belong to the phylum Arthropods (segmented appendages) mostly aquatic in habitat with breathing organs as gill. Morphologically body consists of three major parts head, thorax and Abdomen. The head and thorax bears biramous appendages often modified into cylinder legs. The parasitic/crustacean alimentary canal consisting pouch like outgrowth of mesenteron. Sexes are separate, however a few parasitic forms are hermaphrodite (bisexual), pathogenic preproduction commonly occurs. During the parasitic mode of adaptation female grow larger in size than males. Larval development takes place either within eggs (epimorphosis) and young animals come out with adult character, or eggs hatch into a larvae (anamorphosis) which metamorphosis into adult in due course, crustaceans are highly diversified organisms and life cycle completes in freshwater and on land (Chakrabarti, 1994).

Parasite-host relationships:

All crustacean parasites are involved with their hosts in three ways. Their first need is to establish and maintain contact with their host. They must attach, however loosely or securely, in order to begin their parasitic life. Most have evolved morphological “improvemnets” to aid them to this end. Many of the lesions seen are caused strictly by the parasite’s attachment activity .The second need is to feed, at host’s expense. The mouth parts tend to be of the biting-chewing kind or of the tube (sucking) kind in these parasites. Some have abandoned such primitive feeding structures entirely and absorb food directly through their body wall. The third need is reproduce. The previous activities provide the necessary energy source for this function. There is tissue damage in the host caused by one or a combination of these three activities, no matter which parasite is involved. The host in turn reacts to the presence of the parasite. The lesion ultimately seen by the pathologist is then a mixture of parasite damage and host reaction.

Crustacean fish parasites and diseases on skin and gills:

(i)Parasite - *Argulus foliaceus* (Fish louse)

Family - Argulidae (Branchiura)

Disease - Argulosis

Host - Labeo rohita

Loaction – Skin

(a)Introduction:

Argulus have the ability to creep about over the surface of the fish (Meyer, 1966). These saucer shaped parasites are found flattened against the side of the fish. They have jointed legs and two large sucking discs for attachment. Argulides penetrate the skin of the host fish and feed on blood.

The Argulus is harmful ectoparasite of freshwater fishes, they damage the fish directly extracting tissue fluid and hemolymph. Ultimately lesions are formed on body surface, fins, gills, where secondary infection persists. Argulids often causes mortality of fish in fish farm or culture pond by puncturing the skin of the host and infecting a cytolytic toxin through their oral sting.

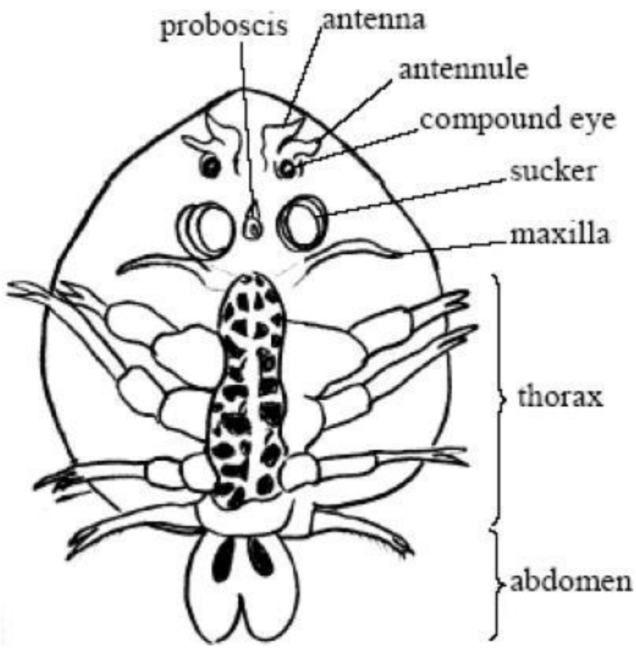
(b) Morphology:

A. foliaceus measures as 8.5mm long. Its abdomen rounded. Lobes of caudal fin rounded and covered with small thorns. Its carapace not exceed the level of the front margin of the caudal fin.

(c) Diagnosis:

Wet mount of skin or buccal cavity with parasites. Diagnosis is easily made by morphological identification of the parasite. Branchiurans are differentiated from caligoid copepods by having suckers and large, compound eyes. Fish lice frequently move on the host and may be seen swimming when they are in an aquarium. They often remain attached when the host is run over from the water, but can be coaxed to move by gentle nudging with a blunt probe. Argulus look like a move scale.

Source- https://www.norfolkflyfishersclub.co.uk/uncategorized/latest-argulus-report/



Source-https://www.researchgate.net/figure/Schematic-representation-of-Argulusfoliacesus-Ventral-view_fig3_221844649

(d) Epidemiology:

There are about 140 species, of branchiuran crustaceans. Virtually the only genus encountered is *Argulus*, also called the fish louse. *Argulus* is uncommon in freshwater aquarium fish but may occur if wild or pond-raised fish are introduced into the tank. *Argulus* is especially common on gold fish and Koi.

(e)Treatment:

(i) As with other crustacean parasites, organophosphates are usually an effective treatment (Papema and Overstreet, 1981). The time needed to complete the life cycle varies therefore, it is useful to rid tanks of eggs contamination by using disinfectant or by allowing the tanks to dry thoroughly for several days. Otherwise, multiple chemical treatments may be needed. Individual parasites can be removed from fish by using forceps, but this does not eliminate parasites in the environment. Mosquito fish can reportedly be used as a biological control in ponds (Langdon, 1992).

Thus, treatment above is in this points-

-Organophosphate prolonged immersion.

-Formalin bath

-Potassium permanganate bath.

(ii)Fish attacked by lice and bathed in Lysol or priasol, or in potassium permanganate or an insecticide. Fish lice in pools may be killed by desiccation.

(iii)As the Fish Louse is quite a large creature, the parasites may be removed easily by means of a pair of forceps if we take the fish in your hand.

If there are too many of them they can be removed by rubbing over the skin of the fish, always going from the head to the tail. Parasites that are sucking so strongly that it is impossible to remove them in this way, may be paralysed by dropping one or two drops of a strong solution of salt on them and then they may be rubbed off. Instead of using a strong salt solution for touching the parasites, a mixture of turpentine, iodine, and kerosene has been recommended. In ponds, it is impossible to remove all fish lice by individual treatment of the fishes and this would be ineffective, too, since the eggs and hatching young parasites are not removed so that new infections should occur very soon. Never on any account add any crystals of permanganate directly to the water, but dissolve them first in a small amount of water and then pour the solution into the pond or tank that is to be treated. After ten days the remedy should be repeated. Dosage of the chemical must be as accurate as possible, since too strong solutions are dangerous to the fish. Its activity depends on the liberation of oxygen in a very active state, which kills parasites.

(ii)Parasite - *Ichthyophthirius multifillis*

Sub class-Holotrichia (Ciliophora)

Disease-Ichthyophthiriasis 'Ich' (white spot disease)

Location-Skin gills and fins

Host-Carp fishes

(a)Introduction:

Some of the most frequently encountered ectoparasites of fish are species of large ciliated protozoans and of these the most important is probably the holotrich *Ichthyophthirius multifillis*, the causative agent of 'white-spot' in freshwater fish (Meyer, 1974). It is the pathogen of white spot disease or 'Ich' disease. It is considered as most detrimental disease in pond culture of freshwater fishes. It is cosmopolitan in distribution.

(b) Morphology:

The parasite having a round or oval body with small rounded mouth. Longitudinal rows of cilia can be found on surface ofthe body. Large macro-nucleus is horse shoe-shaped and has contractile vacuole. Body is 0.5-lmm long. The mature parasites settle at the bottom and attach themselves to submerged object and gradually enclose in gelatinous cysts and multiplies. One adult divides into 2000 number of ciliated bodies. They emerge into water by dissolving cyst wall with that help of enzyme aluronidase. It is the only protozoan parasite that can be seen by the naked eye. "Ich" are \ found under the epithelium on the surface of the skin, fins and gills.

When it is full grown the adult"Ich" may be as large as 0.8mm and appear as gray-white lumps, much like grains of salt.

The most striking identifying feature of the parasite is the large horse shoe shaped macronucleus that is visible in live specimens examined under the low power objective lens on the microscope. More cases of “Ich “occur in August than in any other month of the year.

(c) Symptoms:

“*Ich*” is known as “salt and pepper disease” by aquriasts because of the grey-white speaks opening on the skin. Young fish may display considerable flashing or show erratic spurts of activity. Jumping out of the water and thrashing about as they are irritated by the theront penetrations. In severe outbreaks, losses may precede the appearance of the mature parasites on the fish.

Therefore, the diseased fish appear to be covered with small white spots, and as the disease progresses the spots may join together and form areas of a dirty white colour which later fall away as strikes of skin. The fins are held close to the body and the fish swim violently is an attempt to rid themselves of this annoying skin irritation. The progress of the disease is quite rapid, especially should the water temperature be high. The gills are also affected. Ichthyophthiriasis appears when the fish are in very close contact with each other, as is the case with aquaria and certain type of breeding tanks.

Source- https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.79105

(d) Diagnosis:

The presence of a ciliate encysted within the host's epithelium is pathognomonic. The cilia move constantly while the trophont is within the cyst. *I. multifilis* is a holotrich thus ciliate, are evenly distributed over the entire body surface. Other diagnostic features of the trophont include a 'c' shaped macronucleus (may not be easily visible on small trophonts) large size variations of trophonts and pleomorphic shape.

(e) Treatment:

The non-parasitic stages of pathogen is sensitive of environmental factors which makes it easier to prevent infection. The carrier fish may be destroyed for the prevention of disease. In pond overcrowding may be avoided and mild infected fishes have to be separated in large pond. Encysted parasites are killed in dilute solution of Nacl (0.5%). Drying the pond bed may destroy the ciliated bodies, pH below 5 and dissolved oxygen concentration less than 0.8mg 1° are reported to be fatal to pathogen (Pillay, 1988).

Pond treatment with malachite green 0.1 $mg1^{-1}$ and formalin 15 $mg1^{-1}$ once or twice or thrice have been reported to be effective. Bath in 20 mgl1 of acridine orange for four days is found effective. Though vaccines for immunization of fish against "Ich" disease are not available, it is reported that repeated infections provided relative immunity against the pathogen.

(iii)Parasite - *Trichodina domerguei*

Sub class - Ciliophora

Disease - Trichodiniasis

Location - Skin and Gills

Host - Carp fishes

(a)Introduction:

Trichodiniasis is a serious disease of cultivable food fishes. The causative agent is an obligatory parasite sometimes causing mass mortality of fish. Urceolanid ciliates are the representatives of genera-Trichodina and Trichodinella. The parasitic disease caused by urceolarious are known as Trichodiniasis. Parasites are distributed in almost all parts of the world. Fishes are harbour of numerous species of trichodinid ciliates in the external surface as well as internal organs.

Tripathi (1954) described Trichodina indica from cultivable food fishes of India. Hagargi and Amoji (1979) reported the occurances of Trichodina pediculus from fish peninsular region of India. Trichodia nigra was reported from the body surface and gills of Tilapia, and T. bulbosa from mrigal.

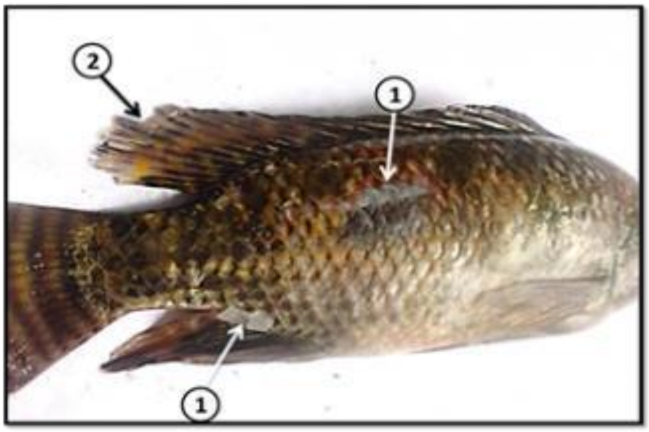
(b) Morphology:

This ciliate is rounded or disc shaped, laterally look as watch glass. The zone directed towards the cell mouth is known as aboral zone having form a spiral zone of cilia of which outer one fuses together forming a peristomal groove. The food particles are guided into cell mouth. The denticles have short and stumpy thorns. On underside of parasite there is a ring of hooks for clinging to the host. The macronucleus is horse shoe shaped.

Therefore, *T. domerguei* is a ciliate rarely giving rise to pathological manifestations of disease. It may be sporadically found in living fish, but it will only multiply in weakened ones. A macronucleus, micronucleus, and numerous food vacuoles are to be seen in the cytoplasm. The body is circular is shape when seen from below, and bell-shaped when seen from the side. The parasite possesses a ring of small hooks resembling a circular saw, and its diameter is 48-50 µ.

(c) Symptoms:

The symptom of Trichodinosis varies from season and also age of fish. In severe attack fishes show blue veil-like coating, slime and epithelial cell with distraction of epidermis. T. domerguei parasites the skin, gills and urinary bladder of the fish, and is found both in freshwater and the sea. A mass mortality from the white lake due to this parasite is on record. The ciliate portion of skin such as between the fin rays in young fish is affected maximum. In pond fishes branchial epithelium distraction have been observed. The body of the host fish becomes dull with a thin film of mucus, the quantity of which depends on the intensity of infection. In severe infection the mucous covers the entire body and may flake-off. When the intensity on infection is high fish shows restlessness loss of body weight and becomes lethargic and congregates towards inlet of the pond. At progressive stages of infection mortality starts.



Source- https://krishimala.com/catalogue/trichodinosis

(d) Diagnosis:

Trichodinids, as a group, include several similar genera of hat-shaped protozoans with rows of cilia around the “brim” (Hoffman, 1967). These protozoans can irritate and damage the skin, fins and gills of fish.

Therefore, Trichodinids are easily recognized. They often exhibit a characteristic scooting motion on tissue surfaces. All Trichodinids are treated similarly, so there is no need for identification to genus (which requires silver staining of fixed samples). The observation of low number (e.g.1per 100 × field of view) of Trichodinids on a skin or gill biopsy is in consequential, other problems should be sought in the clinical work-up. However, because of their tenuous attachment to the tissues, they are easily lost during fixation.

(e) Treatment:

For treatment of infectious fishes, short bath in formalin (con. 250-300ml) for half an hour for small as well as large fishes. Application of Nacl at a concentration of 0.15-0.20% for 1-2 days is also effective. In pond therapy with lime 10 kg ha with repetition at an interval of 3-7 days may be undertaken in summer. Therefore, Trichodinids are easily killed with one application of appropriate treatment. Fish will often recover spontaneously, if water quality is improved.

Conclusion:

The aquatic ecosystems of India are both a source of nourishment and livelihood for millions of people. The sustainability of these ecosystems and the success of the aquaculture industry are intrinsically linked to the health of the fish populations they support.

We have explored the diverse landscape of fish diseases, encompassing bacterial, fungal, and parasitic pathogens, and the multifaceted factors influencing their prevalence. The significance of timely diagnosis and intervention has been emphasized as a critical element in mitigating disease impact.

Management strategies, including vaccination, water quality control, and probiotics, have been revealed as valuable tools in disease prevention. However, their effectiveness hinges on tailored approaches that consider the unique characteristics of fish species, environmental conditions, and regional contexts.

As we navigate the evolving landscape of fish diseases in India, the lessons learned here will serve as a compass, guiding us toward a more resilient, sustainable, and prosperous future for both fish and those who depend on them.

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