COURSE GUIDE

AFM 317
FISH HEALTH MANAGEMENT

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Published by
National Open University of Nigeria

Printed 2016

ISBN: 978-058-699-0

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INTRODUCTION

This course examines fish health and disease from the perspectives of the fish, the pathogen and the environments that they share. Major bacterial, viral and parasitic diseases of cultured fish are explored and the characteristics, epidemiology, prevention, control and management of the causative agents are investigated. While the major diseases covered are particularly important to catfish culture, the principles and practices are applicable to other species, both warm and coldwater.

COURSE AIM

The aim of this course, therefore, is not only to provide the basic background information on fish diseases but also to integrate it with recent developments in vital areas of fish diseases. Capture fisheries, aquaculture and ornamental fish are linked and are both contributing immensely to the supply of food fish as a cheap source of protein in human diets and fishery products for industrial usage and aquarium development. Whatever diseases that affect fish in the wild, pond or race waters also affect fish in the tanks and aquarium.

COURSE OBJECTIVE

The main objective of this course is to provide you with the tools and skills necessary to objectively evaluate the health of fish in culture situations. You will be able to describe the causative agents of the major bacterial, viral and parasitic diseases of fishes and will be able to confidently recognize and evaluate the major factors that contribute to disease outbreaks in culture. You will also be introduced to the tools and techniques available to diagnose and respond to many common diseases. Besides the aforementioned aims, this course is set to achieve some of the following objectives:

a) To understand the gross and external morphology of fish pathology
b) To understand pathological effects of parasites on fish
c) To identify infectious and non infectious parasites
d) To have a basic knowledge of bacterial, viral and fungal infections
e) To be able to describe the causative agents of the major bacterial, viral and parasitic diseases of fishes
f) To highlight various controls and treatments
g) To know how to handle sick fish

WORKING THROUGH THE COURSE

A great effort was put into this course thereby enriching it with a lot of useful information.

This accounts for why you find it an irresistible companion both in the class and for field purposes. However, it requires that concerted effort is made in reading through these materials for appreciating the effort in a commensurable manner so you will be required to spend a lot of time to read it. You are also encouraged to work through and practice all assignments contained in this materials.

COURSE MATERIALS

You will be provided with the following materials course guide and study units. In addition, the course comes with a list of recommended textbooks which though are not compulsory for you to acquire or indeed read, are necessary as supplements to the course material.

COURSE CONTENT

Fish health is a vast and rapidly expanding discipline and this course will provide students with an introduction to the major topics and current issues involved over four modules. A brief description of the course content for each module follows:

STUDY UNIT

Module 1 Identification, morphology, taxonomy and life history of fish parasites

Unit 1 Identification of fish parasites
Unit 2 Morphology and taxonomy of fish parasites
Unit 3 Life history of fish parasites

Module 2 Morphology, Taxonomy and Life History of Fish Parasites

Unit 1 Morphology and taxonomy of fish parasites
Unit 2 Life history of fish parasites

Module 3 Ecological and Pathological Effects of Parasites and Diseases of Fish

Unit 1 Ecological effects of parasites on fish
Unit 2 Differences between Viral Infection and Bacterial Infection
Unit 3 Pathological effects of parasites on fish

Module 4 Epidemiology of Parasite Populations in Water Body; Common Bacterial, Fungal and Viral fish Diseases and Their Control

Unit1 Types of Fish Diseases
Unit 2 Common bacterial fish diseases and their control
Unit 3 Common fungal fish disease and their control
Unit 4 Common viral fish diseases and their control

Module 5 Sensitivity test control and therapy

Unit 1 Fish ponds and public health in general
Unit 2 Fish pond and health hazard
Unit 3 Fish Allergy
Unit 4 International water or Trans-Boundary Waters and Trading

INTRODUCTION

Major Fin Fish Diseases, Their Symptoms and Management Measures
In recent years traditional aquaculture has turned into a science based economic and commercial activity involving heavy inputs and therefore, diseases of all kinds are known to occur on an increasingly large scale. However, fish mortality is not the only criterion to evaluate the effect of fish disease. Even the morbidity which leads to weight losses and poor growth in surviving fish contributes substantial losses to the farmers. With increasing intensification of fish culture we are faced with an increasing number of recognized infectious diseases due to ever changing environment. Therefore, research on the pathogenesis and pathology of these diseases, their prevention and control has become essentially required.

Water Quality – Why Is It Important? Fishes are poikilothermal aquatic animals and need continuous acclimatization to the environmental changes. To a great extent, the success or failure of fish culture is determined by water quality. A successful pathogen must first find a susceptible host for its lodging and multiplication. It is not easy because the body of fish is covered with scales or mucus secreting epidermal cells. Easier way is to get entry into host is a lesion on the skin or through other openings like mouth, eyes, and nostrils.
Stressors for fish: The stressors which elicit morphological and physiological responses in fish fall into 4 categories. Chemical - Stress due to water quality, pollutants, and metabolic wastes.

Physical – Temperature and super saturation of gas

Procedural – Stress due to handling, transportation, stocking or disease treatment.

Biological – Stress due to population density, confinement, diet composition and micro- and macro-organisms.

A fundamental management objective of all fish rearing practices is to avoid and minimize stress on fish.

Stress: The aquatic environment is dynamic and constantly subject to changes in its physical, chemical and biological components. These changes along with culture practices – stressors severely stress the physiological systems of fishes. The physiological response elicited initially is adaptive. However, they may ultimately become maladaptive in chronic situations.

Stress response
↓
Perceived by CNS
↓
Stress hormones Cortisol and epinephrine
released from interregnal cells into blood stream.
↓
2^o Response Blood and tissue alterations
↓
3^o Response Reduction in growth and resistance to diseases

Most fish diseases are stressed mediated. Stress is a physiologic state caused by a procedure, environmental condition or other factor which interferes with the fish's ability to maintain a "normal" state. It extends the adaptive responses of an animal beyond the normal range or which disturbs the normal functioning.

TEXTBOOKS AND REFERENCES

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MAIN COURSE

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MODULE 1

UNIT 1 EXTERNAL ANATOMY OF A BONY FISH

CONTENTS

1.0 INTRODUCTION

A common mistake of fish culturists is misdiagnosing disease problems and treating their sick fish with the wrong medication or chemical. When the chemical doesn't work, they will try another, then another. Selecting the wrong treatment because of misdiagnosis is a waste of time and money and may be more detrimental to the fish than no treatment at all. The majority of fish parasites can only be identified by the use of a microscope. If a microscope is unavailable, or the person using it has no previous experience with one, the diagnosis is difficult and questionable. Successful fish culturists learn by experience. Newcomers to the field need to learn the fundamentals of diagnostic procedures and how to use a microscope to identify parasites by attending short training courses. The following descriptions of common parasites can be used as references for understanding a professional diagnostic report or as a quick reference for the experienced fish culturist.

2.0 OBJECTIVES

At the end of this unit, the student should be able:

- to identify common fish parasite (protozoan)
- to differentiate protozoan and it effect on fish
- to understand how to control protozoan diseases.

3.0 MAIN CONTENT

Protozoa
Most of the commonly encountered fish parasites are protozoan. With practice, these can be among the easiest to identify, and are usually among the easiest to control. Protozoan is single-celled organisms, many of which are free-living in the aquatic environment. Typically, no intermediate host is required for the parasite to reproduce (direct life cycle). Consequently, they can build up to very high numbers when fish are crowded causing weight loss, debilitation, and mortality. Five groups of protozoan are described below: ciliates, flagellates, myxozoans, microsporidians, and coccidians. Parasitic protozoan in the latter three groups can be difficult or impossible to control as discussed below.

3.1 Ciliates

Most of the protozoan identified by aquarists will be ciliates. These organisms have tiny hair-like structures called cilia that are used for locomotion and/or feeding. Ciliates have a direct life cycle and many are common inhabitants of pond-reared fish. Most species do not seem to bother host fish until numbers become excessive. In aquaria, tanks and ponds which are usually closed systems, ciliates should be eliminated. Uncontrollable or recurrent infestations with ciliated protozoan are indicative of a husbandry problem. Many of the parasites proliferate in organic debris accumulated in the bottom of a tank or vat. Ciliates are easily transmitted from tank to tank by nets, hoses, or caretakers' wet hands. Symptoms typical of ciliates include skin and gill irritation displayed by flashing, rubbing, and rapid breathing.

3.2 *Ichthyophthirius multifiliis*

The disease called "Ich" or "white spot disease" has been a problem to aquarists for generations. Fish infected with this organism typically develop small blister-like raised lesions along the body wall and/or fins.

If the infection is restricted to the gills, no white spots will be seen. The gills will appear swollen and be covered with thick mucus. Identification of the parasite on the gills, skin, and/or fins is necessary to conclude that fish has an "ich" infection. The mature parasite (Figure 1) is very large, up to 1000 µm in diameter, is very dark in color due to the thick cilia covering the entire cell, and moves with an amoeboid motion. Classically, ***I. multifiliis*** is identified by its large horseshoe-shaped macronucleus. This feature is not always readily visible, however, and should not be the sole criterion for identification. Immature forms of ***I***. ***multifiliis*** are smaller and more translucent in appearance. Some individuals have suggested that the immature forms of ***I***. ***multifiliis*** resemble ***Tetrahymena*** . Fortunately, scanning the preparation will usually reveal the presence of mature parasites and allow confirmation of the diagnosis.

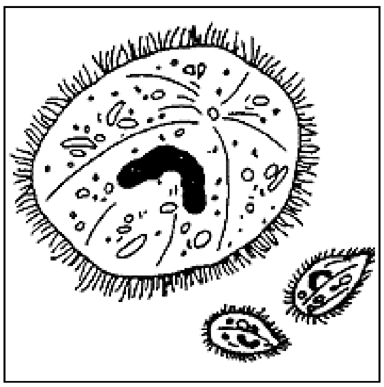

Figure 1: An illustration of I multifiliis parasite

If only one parasite is seen, the entire system should be treated immediately. "Ich" is an obligate parasite and capable of causing massive mortality within a short time. Because the encysted stage (Figure 2) is resistant to chemicals, a single treatment is not sufficient to treat "Ich". Repeating the selected treatment (Table 1) every other day (at water temperatures 68--77°F) for three to five treatments will disrupt the life cycle and control the outbreak. Daily cleaning of the tank or vat helps to remove encysted forms from the environment. For more information, see Extension Circular 920, ***Ichythyophthirius multifiliis (White Spot) Infections of Fish***.

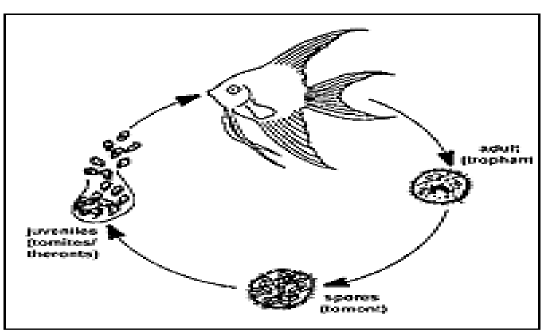

Figure 2: ***The life cycle of I multifiliis***

3.3 Chilodonella

Chilodonella is a ciliated protozoan that causes infected fish to secrete excessive mucus. Infected fish may flash and show similar signs of irritation. Many fish die when infestations become moderate (five to nine organisms per low power field on the microscope) to heavy (greater than ten organisms per low power field). ***Chilodonella*** is easily identified using a light microscope to examine scrapings of skin mucus or gill filaments. It is a large, heart-shaped ciliate (60 to 80 m) with bands of cilia along the long axis of the organism (Figure 3). The organism is easily recognized at 100X magnification.

Chilodonella can be controlled with any of the chemicals listed in Table 1, and one treatment is usually adequate. ***Chilodonella*** has been eliminated in tanks using recirculating water systems by maintaining 0.02% salt solution.

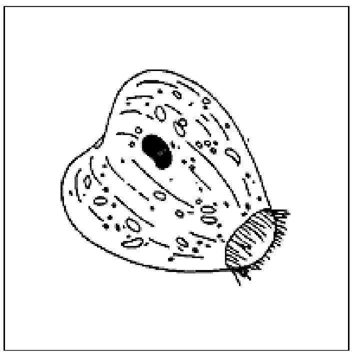

Figure 3: An illustration of a Chilodonella ciliated protozoan.

3.4 Tetrahymena

Tetrahymena is a protozoan commonly found living in organic debris at the bottom of an aquarium or tank. ***Tetrahymena*** is a teardrop-shaped ciliate (Figure 4) that moves along the outside of the host. The presence of ***Tetrahymena*** on the body surface in low numbers (less than five organisms per low power field) is probably not significant. It is commonly found on dead material and is associated with high organic loads. Therefore, observing ***Tetrahymena*** on fish, which have been on the tank bottom, does not imply the parasite is the primary cause of death. One treatment of a chemical listed in Table 1 should be adequate for control.

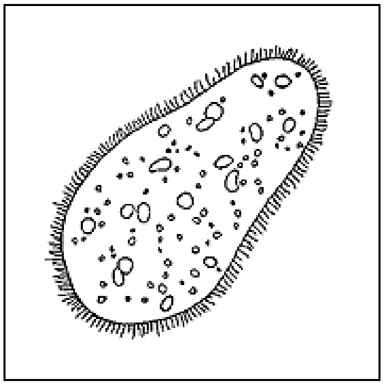

Figure 4: An illustration of a Tetrahymena protozoan

Identification of ***Tetrahymena*** internally is a significant but untreatable problem. A common site of internal infection is the eye. Affected fish will have one or both eyes markedly enlarged (exophthalmia). Squash preparations made from fresh material reveal large numbers (≥ 10 per low power field) of ***Tetrahymena*** associated with fluids in the eye. Fish infected with ***Tetrahymena*** internally should be removed from the collection and destroyed.

3.5 Trichodina

Trichodina is one of the most common ciliates present on the skin and gills of pond-reared fish. Low numbers (less than five organisms per low power field) are not harmful, but when fish are crowded or stressed, and water quality deteriorates, the parasite multiplies rapidly and causes serious damage. Typically, heavily infested fish do not eat well and lose condition. Weakened fish become susceptible to opportunistic bacterial pathogens in the water. ***Trichodina*** can be observed on scrapings of skin mucus, fin, or on gill filaments. Its erratic darting movement and the presence of a circular, toothed disc within its body (Figure 5) easily identify it.

Trichodina can be controlled with any of the treatments from Table 1. One application should be sufficient. Correction of environmental problems is necessary for complete control.

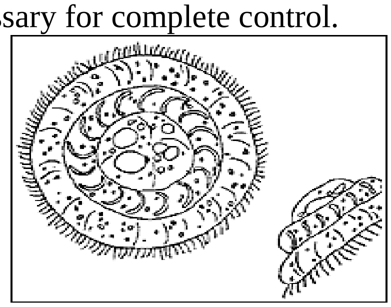

Figure 5: ***An illustration of Trichodina ciliates***

3.6 Ambiphyra

Ambiphyra, previously called ***Scyphidia***, is a sedentary ciliate that is found on the skin, fins, or gills of host fish. Its cylindrical shape, row of oral cilia, and middle bank of cilia identify ***Ambiphyra*** (Figure 6). It is common on pond-reared fish, and when present in low numbers (less than five organisms per low power field), it is not a problem. High organic loads and deterioration of water quality are often associated with heavy, debilitating ***Ambiphyra*** infestations. This parasite can be controlled with one application of any of the treatments listed in Table 1.

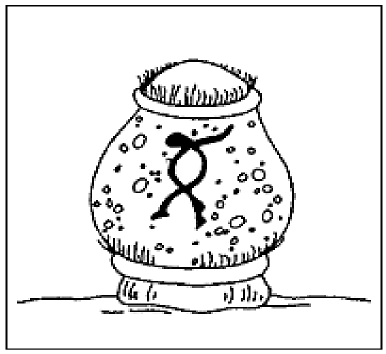

Figure 6: A***n illustration of an Ambiphyra ciliate***

3.7 Apiosoma

Apiosoma , formerly known as ***Glossatella*** , is another sedentary ciliate common on pond-reared fish. ***Apiosoma*** can cause disease if their numbers become excessive. The organism can be found on gills, skin, or fins. The vase-like shape and oral cilia are characteristic (Figure 7).

Apiosoma can be controlled with one application of one of the treatments from Table 1.

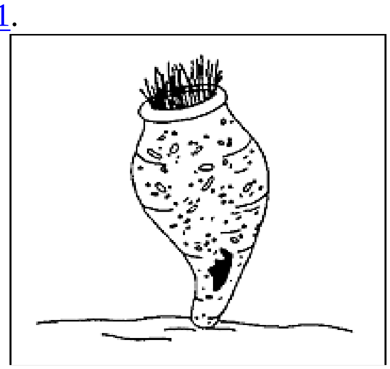

Figure 7: ***An illustration of a Apiosomia ciliate***

3.8 Epistylis

Epistylis is a stalked ciliate that attaches to the skin or fins of the host. ***Epistylis*** is of greater concern than many of the ciliates because it is believed to secrete proteolytic ("protein-eating") enzymes that create a wound, suitable for bacterial invasion, at the attachment site. It is similar in appearance to ***Apiosoma*** except for the non-contractile long stalk (Figure 8) and its ability to form colonies.

In contrast to the other ciliates discussed above, the preferred treatment for ***Epistylis*** is salt. Fish can be placed into a 0.02% salt solution as an indefinite bath, or a 3% salt dip. More than one treatment may be required to control the problem.

Figure 8: ***A microscopic view of the stalked ciliate***

3.9 Capriniana

Capriniana , historically called ***Trichophyra*** , is a sessile ciliate that attaches to the host's gills with a sucker. They have characteristic cilia attached to an amorphous-shaped body (Figure 9). In heavy infestations, ***Capriniana*** can cause respiratory distress in the host. One treatment from a chemical listed in Table 1 should be adequate.

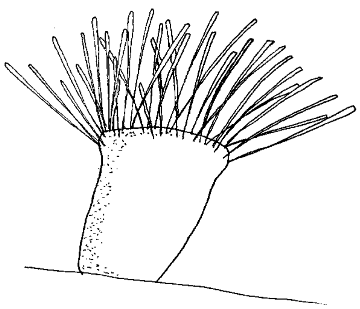

Figure 9: **An illustration of a sessile ciliate**

3.10 Treatment of ciliated protozoan infections

Several chemicals commonly used to control ciliated protozoan in freshwater fish are listed below for your convenience. As stated above, most ciliate infestations respond to one chemical treatment; however, fish that do not improve as expected should be rechecked and retreated if necessary. Overtreatment with chemicals can cause serious damage to fish.

Copper sulfate is an excellent compound for use in ponds to control external parasites and algae; however, it is extremely toxic to fish. Its killing action is directly proportional to the concentration of copper ions (Cu^{++}) in the water. As the alkalinity of the water increases, the concentration of copper ions in solution decreases. Consequently, a therapeutic level of copper in water of high alkalinity would be lethal to fish in water of low alkalinity. Conversely, a therapeutic concentration of copper in water of low alkalinity would be insufficient to have the desired action in water of higher alkalinity. For this reason, the alkalinity of the water to be treated must be known in order to determine the amount of copper sulfate needed. The amount of copper sulfate needed in mg/L is the total alkalinity (in mg/L) divided by 100. For example, if the total alkalinity in a pond is 100 mg/L, the concentration of copper sulfate needed would be 100/100 or 1 mg/L. If you are unsure how to measure the alkalinity of your water, or have never used copper sulfate, contact your aquaculture Extension specialist for assistance. Never use copper sulfate in water that has a total alkalinity less than 50 mg/L.

Because of its algicidal activity, copper sulfate can cause dangerous oxygen depletions, particularly in warm weather. Emergency aeration should always be available when copper sulfate is applied to your system or ponds. Copper sulfate should not be run through the bio-filter on a recirculation system as it will kill the nitrifying bacteria. If possible, tanks should be taken "off-line" during treatment with copper sulfate. If necessary, clean the bio-filter manually to decrease organic debris and residual parasite load. Potassium permanganate is effective against ciliates as well as fungus and external columnaris bacteria, and it can be used in a pond or vat. Multiple treatments with potassium permanganate are not recommended as it can burn gills. Aeration should be available when potassium permanganate is used because it is an algicide and can cause oxygen depletion. Potassium permanganate at the prescribed dosage (2 mg/L) does not seem to affect the nitrifying bacteria in a biological filter; however, ammonia, nitrite, and pH should be closely monitored following treatment.

Formalin is an excellent parasiticide for use in small volumes of water such as vats or aquaria. It is not recommended for pond use because it is a strong algicide and chemically removes oxygen from the water. Vigorous aeration should always be provided when formalin is used. Used in proper amounts, salt effectively controls protozoans on the gills, skin, and fins of fish. This is an effective treatment for small volumes of water such as aquaria or tanks. Use in ponds as a treatment is generally not recommended due to the large amount of salt and high cost of treatment that would be needed to be effective. Salt should never be used on fish that navigate by electrical field such as knife fish and elephant nose fish. When using any treatment for fish, a bioassay (a test to determine safe concentration) should be conducted on a few fish before large numbers of fish are exposed. Fish species can react differently to various concentrations of the chemical; therefore, fish undergoing treatment must be monitored closely for adverse reactions. If the fish negatively react to treatment, the chemical should be flushed immediately from the system, or the fish should be moved to fresh water.

4.0 CONCLUSION

In this unit you learnt: the various protozoan causing fish diseases, the coverings as well as the control and treatment of ciliated protozoan.

5.0 SUMMARY

The parasite commonly causing disease in fish. There are various type and can easily be identified with a light microscope and can be treated with chemical such as parasitcide and algicide. Chemical should be handled carefully not to contaminate the environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. With a well labeled diagram describe the life cycle of I. ***multifiliis***
2. Describe how you will control the outbreak of ich in your pond.

7.0 REFERENCES/FURTHER READING

Maare ciliated protozoan. ddock et al. 1994a; Vaderer,1993.
The Use of Potassium Permanganate in Fish Ponds, **and FA-37,** *Use of Potassium Permanganate to Control External Infections of Ornamental Fish*.
See also IFAS Fact Sheet VM-86 , ***The Use of Salt in Aquaculture .***
See also IFAS Fact Sheets FA-23,

UNIT 2 FLAGELLATES

CONTENTS

1.0 INTRODUCTION

Flagellated protozoan is small parasites that can infect fish externally and internally. They are characterized by one or more flagella that cause the parasite to move in a whip-like or jerky motion. Because of their small size, their movement, observed at 200 or 400x magnification under the microscope, usually identifies flagellates. Common flagellates that infest fish are given below.

2.0 OBJECTIVES

- identify flagellated protozoan
- understand how flagellated protozoan cause infection in fish
- control and treatment of fish infected with flagellated protozoan

3.0 MAIN CONTENTS

3.1 Hexamita *or* Spironucleus

Hexamita is a small (3-18 m) intestinal parasite commonly found in the intestinal tract of freshwater fish (Figure 10). Sick fish are extremely thin and the abdomen may be distended. The intestines may contain a yellow mucoid (mucus-like) material. Recent taxonomic studies have labeled the intestinal flagellate of freshwater angelfish as ***Spironucleus*** . ***Hexamita*** or ***Sprironucleus*** can be diagnosed by making a squash preparation of the intestine and examining it at 200 or 400x magnification. The flagellates can be seen where the mucosa (intestinal lining) is broken. They move by spiraling and in heavy infestations, they will be too numerous to be overlooked.

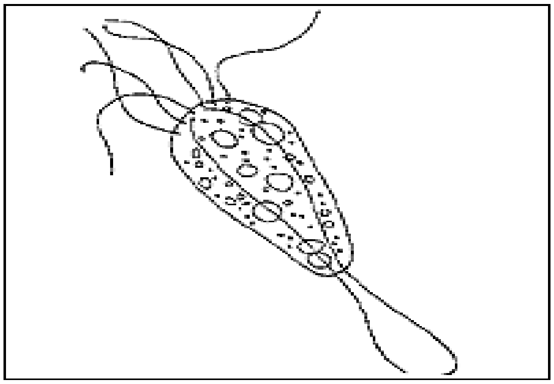

Figure 10: An illustration of a Hexamita parasite

The recommended treatment for ***Hexamita*/*Spironucleus*** is metronidazole (Flagyl). Metronidazole can be administered in a bath at a concentration of 5 mg/L (18.9 mg/gallon) every other day for three treatments. Medicated feed is even more effective at a dosage of 50 mg/kg body weight (or 10 mg/gm food) for five consecutive days.

3.2 Ichthyobodo

Ichthyobodo, formerly known as ***Costia***, is a commonly encountered external flagellate (Figure 11). ***Ichthyobodo-*** infected fish secrete copious amounts of mucus. Mucus secretion is so heavy that catfish farmers popularly refer to the disease as "blue slime disease". Infected angelfish also produce excessive mucus that can give dark colored fish a gray or blue coloration along the dorsal body wall. Infected fish flash and lose condition, often characterized by a thin, unthrifty appearance. ***Ichthyobodo*** can be located on the gills, skin, and fins, however, it is difficult to identify because of its small size. The easiest way to identify ***Ichthyobodo*** is by its corkscrew swimming pattern. With a good microscope, the attached organism can be seen at 400x magnification.

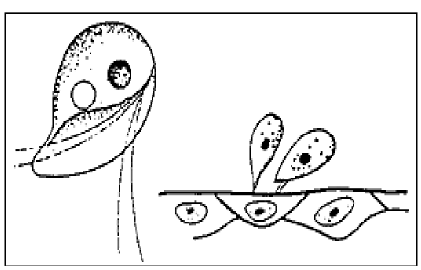

Figure 11: ***An illustration of a Ichthyobodo flagellate***

3.3 Piscinoodinium

Piscinoodinium is a sedentary flagellate that attaches to the skin, fin, and gills of fish. The common name for ***Piscinoodinium*** infection is "Gold Dust" or "Velvet" Disease. The parasite has an amber pigment, visible on heavily infected fish. Affected fish will flash, go off feed, and die. ***Piscinoodinium*** is most pathogenic to young fish. The life cycle of this parasite can be completed in 10--14 days at 73--77°F (Figure12), but lower temperatures can slow the life cycle. Also, the cyst stage is highly resistant to chemical treatment. Therefore, several applications of a treatment may be necessary to eliminate the parasite. For non-food species, chloroquin (10mg/L prolonged bath) has been reported to be efficacious.

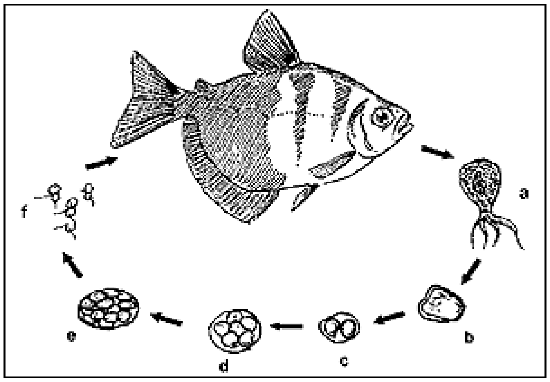

Figure 12: **life cycle of a piscinoodinium sedentary flagellate**

3.4 Cryptobia

Cryptobia is a flagellated protozoan common in cichlids. They are often mistaken for ***Hexamita*** as they are similar in appearance. However, ***Cryptobia*** are more drop-shaped, with two flagella, one on each end. Also, ***Cryptobia*** "wiggles" in a dart-like manner, whereas ***Hexamita*** "spirals". ***Cryptobia*** typically is associated with granulomas (Figure 13), in which the fish "walls off" the parasite. These parasites have been observed primarily in the stomach, but may be present in other organs. Fish afflicted with ***Cryptobia*** may become thin, lethargic and develop dark skin pigmentation.

A variety of treatments are presently being studied with limited success. Nutritional management has proven to take an active role in its control.

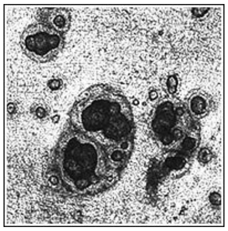

Figure 13: A staining of a *Cryptobia* flagellated protozoan.

3.5 Myxozoa

Myxozoa are parasites that are widely dispersed in native and pond-reared fish populations. Most infections in fish create minimal problems, but heavy infestations can become serious, especially in young fish. Myxozoans are parasites affecting a wide range of tissues. They are an extremely abundant and diverse group of organisms, speculated by spore shape and size. Spores can be observed in squash preparations of the affected area at 200 or 400 x magnifications or by histologic sections. Clinical signs vary, depending on the target organ. For example, fish may have excess mucus production, observed with ***Henneguya (***Figure 14) infections. This is a very large group of parasites which can cause disease in a wide variety of fishes. They are obligate parasites of tissue (histozoic forms that reside in intercellular spaces or blood vessels that reside intracellularly) and organ cavities. Key characteristics of the Myxozoa include development of a multicellular spore, presence of polar capsules in their spores and endogenous cell cleavage in both the trophozoite and sporogony stages. The method of transmission of myxozoans is unknown, but evidence suggests that at least some pathogenic myxozoans have an indirect life cycle. This life cycle may require the completion of two different life cycles involving a vertebrate (fish) and an invertebrate (annelid) host with each life cycle having its own sexual and asexual stages. 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. A few of the more common myxozoan parasites are discussed below.

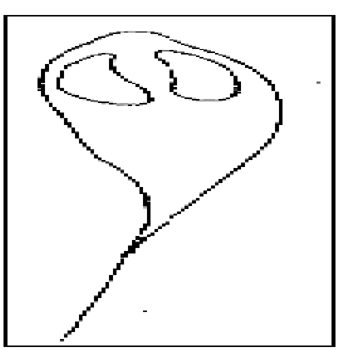

Figure 14: An illustration of a *Myxozoa* parasite

White or yellowish nodules may appear on target organs. Chronic wasting disease is common among intestinal myxozoans such as with ***Chloromyxum.*** "Whirling disease" caused by ***Myxobolus cerebralis*** has been a serious problem in salmonid culture. Elimination of the affected fish and disinfection of the environment is the best control of myxozoans. There are no established remedies for fish. Spores can survive over a year, so disinfection is mandatory for eradication.

3.6 Microsporidia

Microsporidians are intracellular parasites that require host tissue for reproduction. Fish acquire the parasite by ingesting infective spores from infected fish or food. Replication within spores (schizogony) causes enlargement of host cells (hypertrophy). Infected fish may develop small tumor-like masses in various tissues. Diagnosis is confirmed by finding spores in affected tissues, either in wet mount preparations, or in histologic sections.

Clinical signs depend on the tissue infected and can range from no visible lesions to mortalities. In the most serious cases, cysts enlarge to a point that organ function is impaired and severe morbidity and/or mortality results. A common microsporidian infection is ***Pleistophora***, which infects skeletal muscle (Figure15).

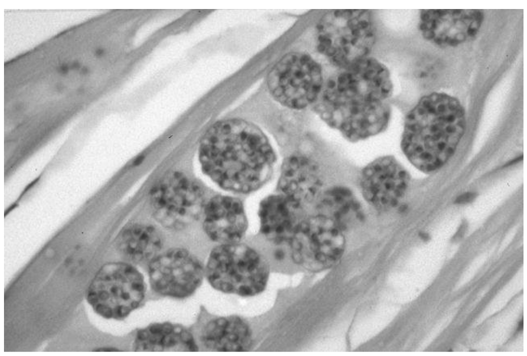

Figure 15: A magnified view of an infected skeletal muscle with Pleistophoral

There is no treatment for microsporidian infections in fish. Spores are highly resistant to environmental conditions and can survive for long periods. Elimination of the infected stock and disinfection of the environment is recommended.

3.7 Coccidia

Coccidia are intracellular parasites described in a variety of wild-caught and cultured fish (Figure 16). Their role in the disease process is poorly understood, but there is increasing evidence that they are potential pathogens. The most common species encountered in fish are intestinal infections. Inflammation and death of the tissue can occur, which can affect organ function. Other infection sites include reproductive organs, liver, spleen, and swim bladder.

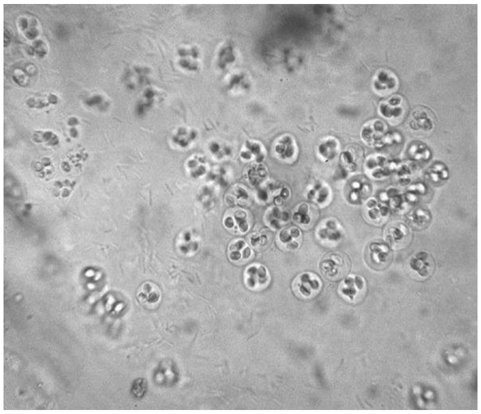

Figure 16: A magnified view of *Coccidia*

Clinical signs depend on target organ affected but may include general malaise, poor reproductive capacity, and chronic weight loss. A definitive diagnosis of tissue coccidia should be completed with histologic or electron microscopy. Several compounds have been used to control coccidiosis with some success; however, consultation with an experienced fish health professional is recommended. Maintaining a proper environment and reducing stress appear to be important in preventing coccidia outbreaks in cultured fish.

4.0 CONCLUSION

In this unit you learnt flagellated protozoan infection of fish, the clinical sign of the infection on the fish and how to control and treat the affected fish

5.0 SUMMARY

Flagellated protozoan infection of fish include ***Hexamita*** or ***Spironucleus,*** Ichthyobodo **,** ***Piscinoodinium, Cryptobia,*** Myxozoa, Microsporidia and ***Coccidia which affect the fresh water fish and tropical fish.*** Elimination of the affected fish and disinfection of the environment is the best control.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the control method for coccidian
2. Draw a life cycle of a piscinoodinium sedentary flagellate

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UNIT 3 MONOGENEAN TREMATODES

CONTENTS

1.0 INTRODUCTION

Monogenean trematodes, also called flatworms or flukes, commonly invade the gills, skin, and fins of fish. Monogeneans have a direct life cycle (no intermediate host) and are host- and site-specific. In fact, some adults will remain permanently attached to a single site on the host.

Freshwater fish infested with skin-inhabiting flukes become lethargic, swim near the surface, seek the sides of the pool or pond, and their appetite dwindles. They may be seen rubbing the bottom or sides of the holding facility (flashing). The skin where the flukes are attached shows areas of scale loss and may ooze a pinkish fluid. Gills may be swollen and pale, respiration rate may be increased, and fish will be less tolerant of low oxygen conditions. "Piping", gulping air at the water surface, may be observed in severe respiratory distress. Large numbers (>10 organisms per low power field) of monogeneans on either the skin or gills may result in significant damage and mortality. Secondary infection by bacteria and fungus is common on tissue with monogenean damage.

3.0 MAIN CONTENT

3.1 *Gyrodactylus* and *Dactylogyrus*

are the two most common genera of monogeneans that infect freshwater fish (Figure 17). They differ in their reproductive strategies and their method of attachment to the host fish. ***Gyrodactylus*** have no eyespots, two pairs of anchor hooks, and are generally found on the skin and fins of fish. They are live bearers (viviparous) in which the adult parasite can be seen with a fully developed embryo inside the adult's reproductive tract. This reproductive strategy allows populations of ***Gyrodactylus*** to multiply quickly, particularly in closed systems where water exchange is minimal.

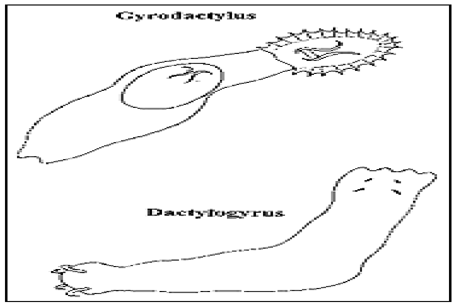

Figure 17: ***Anillustration of a Grodactylus and Dactylogyrus***

Dactylogyrus prefers to attach to gills. They have two to four eyespots, one pair of large anchor hooks, and are egg layers. The eggs hatch into free-swimming larvae and are carried to a new host by water currents and their own ciliated movement. The eggs can be resilient to chemical treatment, and multiple applications of a treatment are usually recommended to control this group of organisms. Freshwater and marine fish. In Africa, *Dactylosoma* has been found in cichlids (species of *Oreochromis*, *Astatorheochromis* and *Haplochromis*) and grey mullets (Mugilidae -*Mugil cephalus*, *Liza dummerelli* and *L. richardsoni*). The latter two species of grey mullets are thus far the only known African hosts for *Hemogregarina*.

Treatment of monogeneans is usually not satisfactory unless the primary cause of increased fluke infestations is found and alleviated. The treatment of choice for freshwater fish is formalin, administered as a short-term or prolonged bath. Fish that are sick do not tolerate formalin well, so they need to be carefully monitored during treatment. Potassium permanganate can also be effective in controlling monogeneans.

3.2 Digenean Trematodes

Digenean trematodes have a complex life cycle involving a series of hosts (Figure 18). Fish can be the primary or intermediate host depending on the digenean species. They are found externally or internally, in any organ. For the majority of digenean trematodes, pathogenicity to the host is limited.

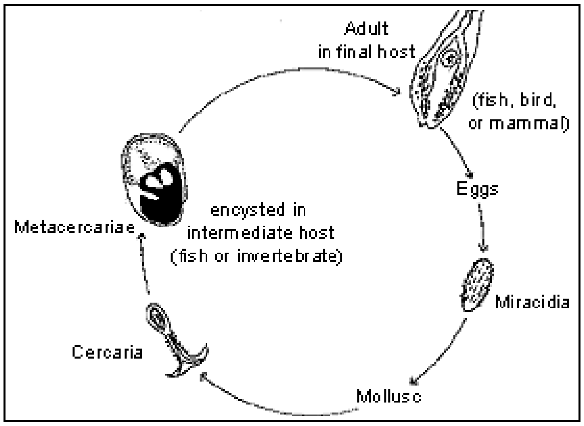

Figure 18: An illustration of the Digenean Trematodes life cycle.

The life stage most commonly observed in fish is the metacercaria, which encysts in fish tissues (Figure 19). Again, metacercaria that live in fish rarely cause major problems. However, in the ornamental fish industry, digenetic trematodes from the family Heterophyida, have been responsible for substantial mortalities in pond-raised fish. These digeneans become encysted into gill tissue and respiratory distress is eminent.

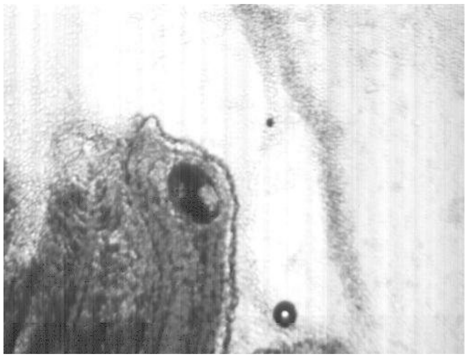

Figure 19: The metacercaria stage of the life cycle

Another example of a metacercaria that could cause problems in cultured fish is the genus ***Posthodiplostonum*** or the white grub. This has caused mortalities in baitfish, but usually the only negative effect is reduced growth rate, even when the infection rate is high. In cases where mortalities occur, there are unusually high numbers in the eye, head, and throughout the visceral organs.

Another fluke is ***Clinostonum*** , often called yellow grub. It is a large trematode and although it does not cause any major problems for fish, it is readily seen and will make fish unmarketable for aesthetic reasons.
The best control of digenean trematodes is to break the life cycle of the parasite. Elimination of the first intermediate host, the freshwater snail is

often recommended. Copper sulfate in ponds has been used with limited success and is most effective against snails when applied at night, due to their nocturnal feeding activity

3.2 Nematodes

Nematodes, also called roundworms, occur worldwide in all animals. Nematodes are very common parasites of fish. The larvae may be found in cysts or coiled in or on the internal organs. Adults are usually found in the intestines. Some are found coiled under the skin. They can infect all organs of the host, causing loss of function of the damaged area. Signs of nematodiasis include anemia, emaciation, unthriftiness and reduced vitality. Three common nematodes affecting fish are described.

3.2.1 *Camillanus*

Camillanus is easily recognized as a small thread-like worm protruding from the anus of the fish. Control of this nematode in non-food fish is with fenbendazole, a common antihelminthic. Fenbendazole can be mixed with fish food (using gelatin as a binder) at a rate of 0.25% for treatment. It should be fed for three days, and repeated in three weeks.

3.2.2 *Capillaria*

Capillaria is a large roundworm commonly found in the gut of angelfish (Figure 20), often recognized by its double operculated eggs in the female worm (Figure 21). Heavy infestations are associated with debilitated fish, but a few worms per fish may be benign.
Fenbendazole is recommended for treatment.

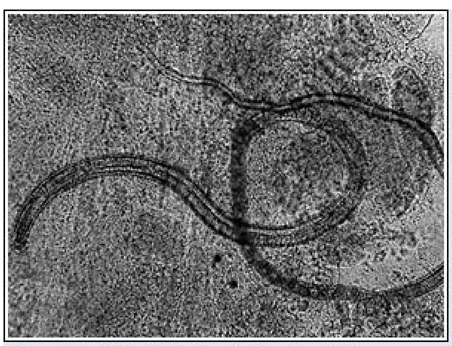

Figure 20: A *Capillaria* in gut of an Angelfish.

Figure 21: A *Capillaria* female with operculated eggs.

3.2.3 *Eustrongylides*

Eustrongylides is a nematode that uses fish as its intermediate host. The definitive host is a wading bird, a common visitor to ponds. The worm encysts in the peritoneum or muscle of the fish and appears to cause little damage. Because of the large size of the worms (Figure 22), infected fish may appear unsuitable for retail sales.

Protecting fish from wading birds and eliminating the intermediate host, the oligocheate or Tubifex (soft-bodied worms), are the best means to prevent infection.

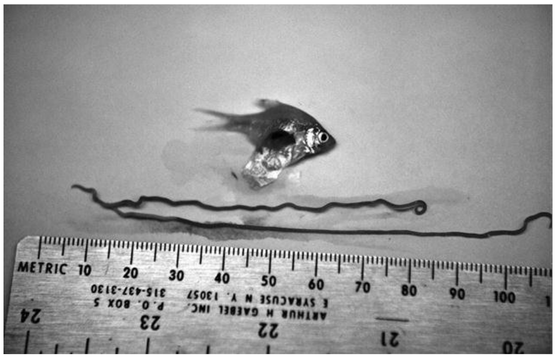

Figure 22: An image of an Eustrongylides nematode.

3.2.4 Cestodes

Cestodes, also called tapeworms, are found in a wide variety of animals, including fish (Figure 23). The life cycle of cestodes is extremely varied with fish used as the primary or intermediate host. Cestodes infect the alimentary tract, muscle or other internal organs. Larval cestodes called plerocercoids are some of the most damaging parasites to freshwater fish. Plerocercoids decrease carcass value if present in muscle, and impair reproduction when they infect gonadal tissue. Problems also occur when the cestode damages vital organs such as the brain, eye or heart.

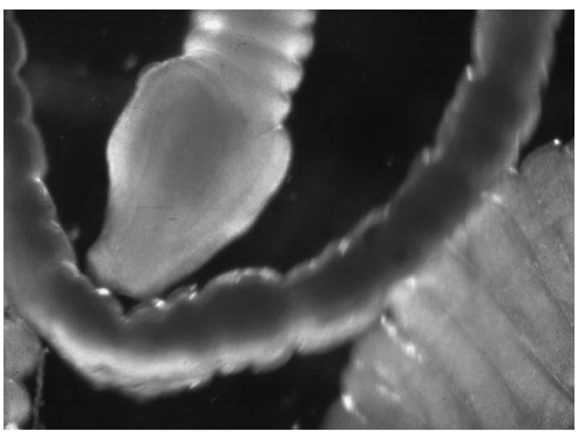
Figure 23: A close-up of a tapeworm

One of the most serious adult cestodes that affect fish is the Asian tapeworm, ***Bothriocephalus acheilognathi***. Praziquantel at 2 -- 10 mg/L for 1 to 3 hours in a bath is effective in treating adult cestode infections in ornamental fish. At this time, there is no treatment that can be used for food fish. Also, there is no successful treatment for plerocercoids. Ponds can be disinfected to eradicate the intermediate host, the copepod.

4.0 CONCLUSION

In this unit you learnt: Freshwater fish infested with skin-inhabiting flukes become lethargic, swim near the surface, seek the sides of the pool or pond, and their appetite dwindles. They may be seen rubbing the bottom or sides of the holding facility (flashing).

5.0 SUMMARY

Worms are common in both wild and cultured fish. Fish frequently serve as intermediate or transport hosts for larval parasites of many animals, including humans. Worms with direct life cycles are most important in dense populations, and heavy parasite burdens are sometimes found. In general, heavy parasite burdens seem to be more common in fish originating from wild sources. Cultured fish are subject to a rapid buildup of parasites by continuous infection and worm transfer to other fish in the tank or pond.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the digenean trematodes life cycle.
2. Explain how monogenean trematodes infect fish.

7.0 REFERENCES/FURTHER READING

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UNIT 4 PARASITIC CRUSTACEA

CONTENTS

1.0 INTRODUCTION

Parasitic crustacea are increasingly serious problems in cultured fish and can impact wild populations. Most parasitic crustacea of freshwater fish can be seen with the naked eye as they attach to the gills, body and fins of the host. Three major genera are discussed below.

2.0 OBJECTIVES

- to identify crustacean parasite in fish
- to study the effect of the parasite on fish morbidity
- to know the treatment of choice for the infections.

3.0 MAIN CONTENTS

3.1 Ergasilus

Ergasilus (Figure 24) are often incidental findings on wild or pond-raised fish and probably cause few problems in small numbers. However, their feeding activity causes severe focal damage and heavy infestations can be debilitating. Most affect the gills of freshwater fish, commonly seen in warm weather.

A 3% salt dip, followed by 0.2 %-prolonged bath for three weeks, may be effective in eliminating this parasite.

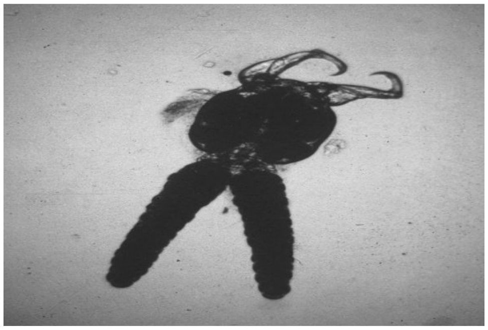

Figure 24: A close-up of an Ergasilus

3.2 Lernaea

Lernaea, also known as anchor worm (Figure 25), is a common parasite of goldfish and koi, especially during the summer months. The copepod attaches to the fish, mates, and the male dies. The female then penetrates under the skin of the fish and differentiates into an adult. Heavy infections lead to debilitation and secondary bacterial or fungal infections. Removal of the parasite by hand with forceps may control lernaeid infestations with careful monitoring of the wound. A 3% salt dip followed by 0.2%-prolonged immersion has been used to effectively control ***Lernaea*** in goldfish and koi ponds

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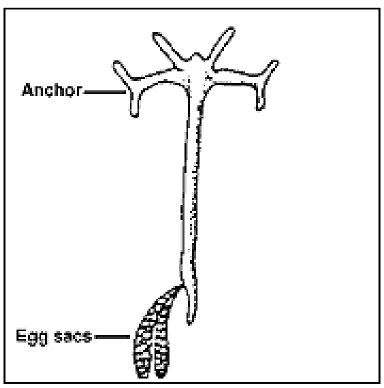

Figure 25: An illustration of an Lernaea

3.3 Argulus

Argulus or fish louse is a large parasite (Figure 26) that attaches to the external surface of the host and can be easily seen with the unaided eye. ***Argulus*** is uncommon in freshwater aquarium fish but may occur if wild or pond-raised fish are introduced into the tank. It is especially common on goldfish and koi.

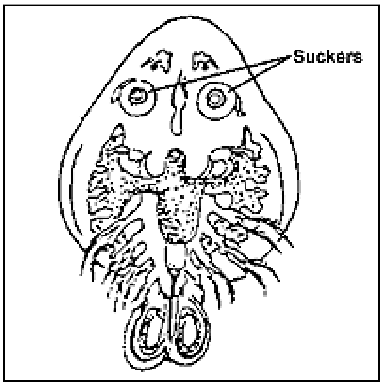

Figure 26: An illustration of a fish louse

Individual parasites can be removed from fish with forceps, but this does not eliminate parasites in the environment. A prolonged immersion of 0.02 - 0.2% salt may control re-infection to the fish host.

3.4 Leeches

Although not a common problem, occasionally, fish will be observed infected with either leeches or copepods. Leeches have long, slender flexible bodies and actively swim for an attack on their prey. Skin and underlying soft tissues are damaged and allow blood to flow into the leeches digestive tract. Leeches are not host-specific, and the damage to the skin and gills is dependent upon the number of leeches present at any time. Small fishes can be seriously injured or die due to excessive leech infestation. Leeches are occasionally seen in wild and pond-raised fish. They have a direct life cycle with immature and mature worms being parasitic on host's blood. Pathogenesis varies with number and size of worms and duration of feeding. Heavily infested fish often have chronic anemia. Fish may develop secondary bacterial and fungal infections at the attachment site.

Leeches resemble trematodes but are much larger and have anterior and posterior suckers (Figure 27). Dips in 3% saltwater are effective in controlling leeches. Ponds with heavy leech infestation require drainage, treatment with chlorinated lime, followed by several weeks of drying. This will destroy the adults and their cocoons containing eggs.

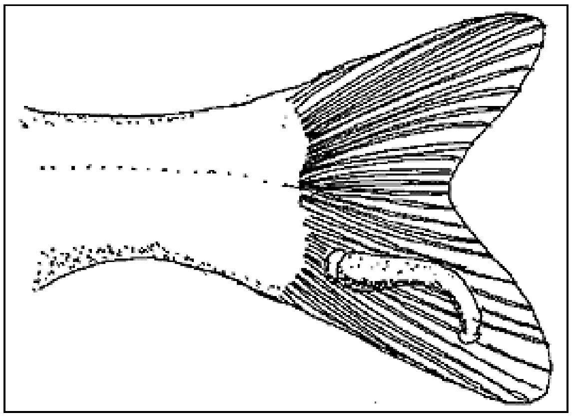

Figure 27: An illustration of a leech on the caudal fin

4.0 CONCLUSION

Most fish health problems occur because of environmental problems: poor water quality, crowding, dietary deficiencies, or "stress". The best cure for any fish health problem is prevention. Good water quality management and proper fish husbandry techniques will eliminate most parasites described here.

5.0 SUMMARY

Table1.

Table 1. Chemical treatments for the control of external ciliates. "X" indicates that the chemical should not be used for this type of treatment.			
Chemical	Dip	Short-term Bath	Prolonged (indefinite) Immersion
Copper sulfate	X	X	total alkalinity/100 (up to 2.5 mg/L), Do not use if total alkalinity < 50mg/L
Potassium permanganate	X	10 mg/L, 30 min	2 mg/L
Formalin	X	150--250 mg/L, 30 min	15--25 mg/L (2 drops/gallon or 1 mL/10 gallons)
Salt	3%, Duration is species dependent.	1%, 30 min to 1 hr, species dependent	0.02--0.2%

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe leech and its control
2. What are the differences between leech and trematodes

7.0 REFERENCE/FURTHER READING

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Parasites, infections and diseases of fishes in Africa. An update

Ilan Paperna Department of Animal Sciences Faculty of Agriculture Hebrew University of Jerusalem Rehovot, Israel. CIFA TECHNICAL PAPER 31 Further Reading:

For more information see IFAS Fact Sheet FA-13, ***Use of Copper in Aquaculture and Farm Ponds.***

See also IFAS Fact Sheet VM-77, ***Use of Formalin to Control Fish Parasites.***

See IFAS Fact Sheet VM-87, ***Sanitation Practices for Aquaculture Facilities.***

See IFAS Fact Sheet FA-28, ***Monogenean Trematodes***.
See also IFAS Fact Sheet VM-67, ***Management of Hexamita in Ornamental Cichlids.***

MODULE 2 MORPHOLOGY, TAXONOMY AND LIFE HISTORY OF FISH PARASITES

Unit 1 Morphology and taxonomy of fish parasites
Unit 2 Life history of fish parasites

UNIT 1 MORPHOLOGY AND TAXONOMY OF FISH PARASITES

CONTENTS

1.0 INTRODUCTION

Good taxonomy is essential for ecological, bio-geographical, and evolutionary studies of any group of organisms. Trichodinids are members of the peritrichous ciliates, a paraphyletic group within the Oligohymenophorea. Specifically, they are mobiline peritrichs because they are capable of locomotion, as opposed to sessiline peritrichs such as *Vorticella* and *Epistylis*, which adhere to the substrate via a stalk or lorica. There are over 150 species in the genus *Trichodina*. *Trichodinella*, *Tripartiella*, *Hemitrichodina*, *Paratrichodina* and *Vauchomia* are similar genera. Trichodinids are round ciliates that may be disc-shaped or hemispherical. The cytostome (cell mouth) is on the surface that faces away from the host; this is termed the oral surface. The other side, or adoral surface, attaches to the skin of the host or other substrate. There is a spiral of cilia leading towards the cytostome and several rings of cilia at the periphery of the cell, responsible for creating adhesive suction and locomotory power. In the taxonomy of trichodinids, the exact number, shape and arrangement of the cytoskeletal denticles is critical for determining taxonomic relationships. These characters are usually revealed by silver nitrate staining of microscope slides, which stains the cell cytoplasm black and leaves the denticles white.

2.0 OBJECTIVES

- to study the morphology of common fish parasites
- to study the taxonomy of fish parasite.

3.0 MAIN CONTENTS

3.1 Cestoda

Cestodes are a taxonomic class of organisms in which the adult stage usually lives in the intestinal tract of vertebrates. Intermediate stages live in a wide variety of body locations in both vertebrate and invertebrate hosts. The bodies of most cestodes are ribbon-shaped and divided into short segments called proglottids, hence the name “tapeworm”. Diagnosis of cestodiasis is dependent upon demonstration of the parasite within the intestinal tract of the fish. Clinical signs of cestodiasis include emaciation, anemia, discoloration of the skin, and susceptibility to secondary infections. Low numbers of pleurocercoids may be located in vital organs such as the brain, heart, spleen, kidney, or gonad and have a devastating effect on the fish.

Cestodes, more commonly known as tapeworms, are entirely parasitic and can be found as adults all over the world inhabiting the intestines of their hosts. They are dorso-ventrally flattened, can reach lengths of several meters and normally change hosts at least once in their life cycle. The scolex or ‘head’ of the worm, which penetrates the intestine wall, is the most distinctive part of the parasite and is often used in determining species. Cestodes posses no gut and nutritional uptake is mediated completely by the tegument which is resistant to attack by the host’s digestive enzymes. Larval tapeworms can be found in other organs of intermediate hosts with transmission to the final host normally via the food chain.

Species found in freshwater fish: *Archigetes sieboldi, Bathybothrium rectangulum, Biacetabulum appendiculatum, Bothriocephalus acheilognathi, B. claviceps, Caryophyllaeides fennica, Caryophyllaeus fimbriceps, C. laticeps, Cyathocephalus truncates, Diphyllobothrium* *dentriticum, D. ditremum, D. latum, D. vogeli, Eubothrium crassum, E. fragilis, E. salvelini, Hepatoxylon squali, Khawia sinensis, Ligula intestinalis, Monobothrium wageneri, Proteocephalus ambiguous, P. cernua, P. exiguous, P. filicollis, P. macrocephalus, P. neglectus, P. osculates, P. parallacticus, P. percae, P. pollanicola, P. sagittus, P. torulosus, P. ocellatus, Schistocephalus solidus, S. pungitii, Scolex pleuronectis, Triaenophorus lucii, T. nodulosus, Valipora campylancristrota* ***Triaenophorus nodulosus*** (Pallas, 1781)

3.1.1 Classification

Kingdom: *Animalia*

Phylum: *Platyhelminthes*

Class: *Cestoda*

Order: *Pseudophyllidea*

Family: *Triaenophoridae*

Genus: *Triaenophorus*

Species: *T. nodulosus*

3.1.2 Size Range

Sexually mature adult worms can range from 65-380mm in length and 2-6mm in width, eggs from 0.052-0.071mm (average 0.063mm) in length and 0.033-0.045mm (average 0.042mm) in width.

Life Stage: Egg/Coracidium
Free Living Environment: On the substrate or free-floating in the water column in shallow zones of fresh waters.

Duration of Stage: Embryonal development in the eggs and the hatching of the coracidia takes between 4 and 7 days at 17-20°C with the coracidium fully formed by day 5. The optimal temperature for development is 20°C. At 18-20°C the coracidium can survive in its free-swimming state for 1-3 days. At lower temperatures the coracidium seems to survive longer; 4 days at 15-16°C and up to 10-13 days at 2.5°C but will survive for less that an hour at 29°C.

3.1.3 Morphology

Originally the coracidium is enclosed in a broad ciliated embryonal membrane, occupies a large amount of space in the egg, and moves actively. Recently hatched coracidia are 45-50µm x 44µm whilst ones that are two or three days old are 100µm x 88µm with an average size of 64.2µm x 58.9µm. The coracidium has cilia uniformly distributed over the body surface except at the anterior where the cilia are long and form a tuft 35-45µm in length. The oncosphere occupies a large part of the coracidium and may reach 35µm in length.

3.2 Nematode

Nematodes, more commonly known as roundworms or threadworms, are found parasitizing plants, humans and other animals and can also inhabit soil, fresh- and saltwater habitats. Ranging from 0.3mm to 8.5m in length the largest roundworm recorded is *Placentonema gigantisma* from the placenta of a sperm whale. Nematodes are unsegemented, bilaterally-symmetrical, pseudocoelomate animals and the mouth can contain teeth or stylets used to penetrate the host. Although they lack a circulatory and respiratory system they have a digestive system in which the food is moved through the tract via internal/external pressures and body movement (as opposed to muscles). Most nematodes are not parasitic but those that are, usually have complicated life cycles involving several hosts or locations within a host.

Anguillicola crassus Kuwahara, Niimi & Itagaki, 1974

3.2.1 Classification

Kingdom: *Animalia*

Phylum: *Nematoda*

Class: *Chromadorea*

Order: *Spirurida*

Family: *Anguillicolidae*

Genus: *Anguillicola*

Species: *A. crassus*
Size Range

Male parasites range from 20-60µm in length with females measuring 47-72µm. Body width ranges from 0.9-2.8µm for males and 3-5.6µm for females.

3.2.2 Life Stages

Life Stage: Eggs/larvae

Transmission In: Eggs are released from the digestive system of definitive host

Free Living Environment: Larvae attach to the substratum by their hooked tails

Transmission Out: Larvae ingested by intermediate host
Life Stage: Juvenile

Transmission In: Free-living larvae are ingested by the intermediate host

Intermediate Hosts: Often a copepod or other crustacean particularly Cyclops vicinus and C. albidus

Transmission Out: Intermediate host is eaten by definitive host.

Life Stage: Adult

Definitive Host: Anguilla sp. (Anguilla anguilla in Britain)

3.2.3 Pathology

Infected eels develop a disease called 'Anguillicolosis' which causes haemorrhagic lesions, fibrosis and collapsed swim bladders as well as inflammatory reactions.

3.2.4 Morphology

The adult nematode has a soft, wrinkled outer cuticle with a small circular mouth opening which is surrounded by 4 dorsolateral and ventrolateral papillae and 2 small lateral amphids.

3.3 Acanthocephala

Acanthocephalans, otherwise known as spiny- or thorny-headed worms, are highly specialized intestinal parasites which use a spiny proboscis to penetrate and attach to host tissues. Nutrient uptake occurs directly through the body surface of the parasite as it lacks both a mouth and an alimentary canal. Acanthocephalan life cycles are usually complex and may involve a number of hosts including invertebrates, fishes, amphibians, birds and mammals. This phylum is currently divided into three classes; Archiacanthocephala (with terrestrial life cycles), Palaeacanthocephala (aquatic life cycles with fish, seals or water birds being the final hosts), and Eoacanthocephala (aquatic life cycles with fish, reptiles and amphibians being the final hosts).

Species found in freshwater fish in Britain and Ireland: *Acanthocephalus clavula, A. lucii, A. anguillae, Echinorhynchus borealis, E. clavula, E. salmonis, E. truttae, Neoechinorhynchus rutili, Pomphorhynchus laevis*
Pomphorhynchus laevis (Zoega in Müller, 1776)

3.3.1 Classification

Kingdom: *Animalia*
Phylum: *Acanthocephala*
Class: *Palaeacanthocephala*
Order: *Echinorhynchida*
Family: *Pomphorhynchidae*
Genus: *Pomphorynchus*
Species: *P. laevis*
Size Range

Size varies between 4 and 30mm and generally increases with age. Acanthocephalans are dioecious: males are usually smaller at 6-16mm with females being 10-30mm. Eggs are 110-121 x 10^-19µm.

3.4 Trematodes

Trematodes, members of Phylum Platyhelminthes, also called flukes, cause a variety of clinical infections in humans worldwide. The parasites are named trematodes because of their conspicuous suckers, which are the organs of attachment (trematode means "pierced with holes"). All of the flukes that cause infections in humans are contained in the group called "digenetic trematodes."

Depending on their habitat in the infected host (generally a vertebrate), flukes can be classified as blood flukes, liver flukes, lung flukes, and intestinal flukes. Flukes causing most human infections are Schistosoma species (blood fluke), Paragonimus westermani (lung fluke), and Clonorchis sinensis (liver fluke). Some less clinically important flukes are Fasciola hepatica and Opisthorchis viverrini, which are liver flukes, and Fasciolopsis buski, Heterophyes heterophyes, and Metagonimus yokogawai, which are all intestinal flukes.

3.4.1 Features of Trematodes

The sexes of the parasites are not separate (monecious). In other words, they are mostly hermaphroditic with the male and female reproductive organs existing complete in each fluke. One exception is the schistosomes, which are diecious.

The flukes are oviparous and lay diagnostically operculated eggs. Once again, an exception is schistosome eggs, which are not operculated. They are unsegemented, dorso-ventrally flattened, and leaf-shaped. The alimentary canal is incomplete, with the anus being absent. The excretory system is bilaterally symmetric. They bear two suckers, one on the ventral surface of the body (ventral sucker) and one around the mouth (oral sucker). These serve as organs of attachment for the fluke.

3.4.2 Taxonomy

Class Trematoda
Subclass Digenea (the digenetic trematodes)
Order Opisthorchiformes
Family Opisthorchiidae
Clonorchis sinensis

3.5 Leeches

Leeches have so far only been reported from a few fish in Africa; *Bagrus docmac*, *Barbus altianalis*, *B. tropidolepis*, carp and *Protopterus aethiopicus.* However, leeches apparently attack a wider range of fish (Claridae, Synodontidae, Mormyridae and Cichlidae) and in a greater number of water systems as is evident from the distribution of leech-transmitted trypanosomes in African fish. Most records of leeches removed from fish in Africa are of *Batrachobdelloides tricarinata*. This leech occurs from the Jordan system in Israel, infecting *Clarias lazera*, throughout tropical West and East Africa to Zululand in Southern Africa (Oothuizen, 1989). Piscicolid leeches are common parasites of Mugilidae in the riverine-estuarine system of the southern Cape Province in South Africa.

3.4.1 Description and Taxonomy

Leeches feeding on fish are Rhynchobdellae and belong either to the Glossiphoniidae or the Piscicolidae (Mann, 1962). Most named records of Glossiphoniid leeches from African fish and many of those found free in the habitat were proven to be synonymous with *B. tricannata*. There is one record of another fish-feeding glossiphonid, *Hemiclepsis quadrata*(Moore, 1939), from Ethiopia (Oosthuizen, 1987). Apart from the piscicolid leeches (as yet undescribed) of Cape grey mullets, the only other African record of a piscicolid leech is of a species of *Phyllobdella* removed from *Barbus* (Moore, 1939).

Rhynchobdellae have a small pore-like mouth on the oral sucker from which a proboscis may be protruded, no jaw is present, the blood is transparent (Gnathobdellae which feed on higher vertebrates have a large mouth with jaws and red blood). Differentiation even between Piscicolidae and Glossiphoniidae is not easy for the non-expert:

Glossiphoniidae	The body at rest is depressed, not divided into distinct anterior and posterior regions; the head is usually much narrower than the body with an anterior sucker either indistinguishable or only slightly distinct from the body. There are usually 3 annuli per segment in the mid-body region and eyes are confined to the head.
Piscicolidae:	The body at rest is cylindrical and (especially when contracted) usually divided at segment XIII into distinct anterior and posterior regions. The head sucker is usually distinctly marked off from the body which usually has more than three annuli per segment. Simple eyes may be present on the head, neck and posterior sucker.

Experts would prefer leeches live, to be fixed to their own specifications. Leeches can survive for a considerable time, even when mailed in a vial inside wet cotton wool. If fixed, it is best in 70% ethanol and preferably the leech should be relaxed first with menthol, ether, or by refrigeration, sometimes, if not too small, under glass slide pressure.

3.6 Lymphocystis Virus

Species affected a variety of marine and freshwater fish; in Africa known only from cichlids; including species of Tilapia, Oreochromis and Haplochromis.

Geographic range:

In cichlid fish in Lakes Victoria (Nyanza) (Oreochromis variabilis and Haplochromis spp.), in Lake George (H. elegans) and L. Kitangiri (Tilapia amphimelas and O. esculentus) in East Africa.

Description taxonomy and diagnosis

Infection manifested in one to numerous dermal clusters of rounded pustules or wart-like growths. Histological sections reveal aggregates of grossly hypertrophic cells (in cichlids 200–330 µm in diameter), enclosed within a thick hyaline (eosinophilic) wall and an extremely large nucleus and nucleolus. Cytoplasm contained basophilic (DNA) inclusions, (numerous, small-rounded in cichlids) and vacuoles. Lymphocystis viruses are large (160–300 nm), icosahedra, DNA viruses (iridovirus-like) replicating within the cytoplasmic inclusions and are released into the cytoplasm to form regular arrays.

4.0 CONCLUSION

Good taxonomy is essential for ecological, bio-geographical, and evolutionary studies of any group of organisms. Fish serve as hosts to a range of parasites that are taxonomically diverse and that exhibit a wide variety of life cycle strategies. Whereas many of these parasites are passed directly between ultimate hosts, others need to navigate through a series of intermediate hosts before reaching a host in (or on) which they can attain sexual maturity.

5.0 SUMMARY

The study of morphology and taxonomy of fish parasites enable the identification and mode of behavior on the host species. Cestodes are a taxonomic class of organisms in which the adult stage usually lives in the intestinal tract of vertebrates. Nematodes, more commonly known as roundworms or threadworms, are found parasitizing plants, humans and other animals and can also inhabit soil, fresh- and saltwater habitats. Acanthocephalans, otherwise known as spiny- or thorny-headed worms, are highly specialized intestinal parasites which use a spiny proboscis to penetrate and attach to host tissues. Leeches apparently attack a wider range of fish (Claridae, Synodontidae, Mormyridae and Cichlidae) and in a greater number of water systems as is evident from the distribution of leech-transmitted trypanosomes in African fish

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the taxonomy of leech and nematodes
2. Describe the adult stage of cestodes

7.0 REFERENCE/FURTHER READING

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UNIT 2 LIFE HISTORY OF FISH PARASITES

CONTENTS

1.0 INTRODUCTION

Aquatic habitats offer ideal conditions for the maintenance and evolution of parasite life cycles. Water provides a physiologically stable, buffered environment, and its viscosity facilitates the dispersal and survival of eggs and fragile free-living stages. Infecting organisms may live inside a host, in which case they are termed endoparasites, or on the external surface as ectoparasites. In fishes, the gill surfaces are usually classified as external environment since they are in constant contact with the external medium, even in species where they are enclosed within opercula. Parasites exhibit a variety of life cycle types. Those that are transmitted from one definitive host (in which they reach sexual maturity) to another are described as having direct life cycles. Parasites that use at least one intermediate host (which harbors sexually immature forms of the parasite) to transfer between definitive hosts are said to have indirect or complex life cycles.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- to study the life cycle of parasite infecting fish
- to understand the life stage of fish parasites.

3.0 MAIN CONTENTS

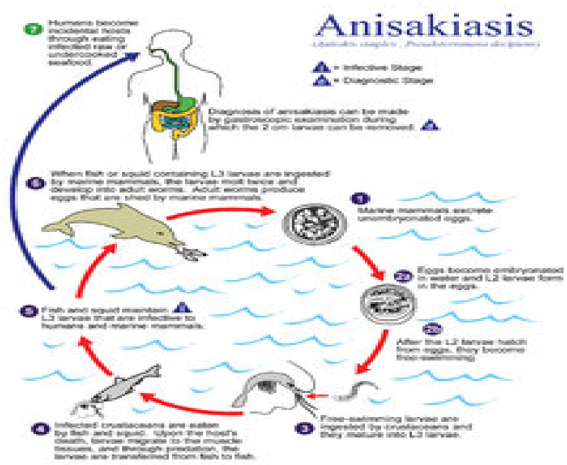
3.1 Life cycle of Trichodinids

Trichodinids have a simple direct life cycle. That is, they have a single host and do not use alternation of generations or mass asexual replication off the host. The reproduce by binary fission, literally cell-splitting. This produces daughter cells with half the number of denticles of the parent cell. The full complement of denticles is restored by synthesis of new denticles from the outer edge of the cell, working inwards.

Trichodinids are typically found on the gills, skin and fins of fishes, though some species parasitize the urogenital system. A range of invertebrates is also host to trichodinid infections, including the surfaces of copepods and the mantle cavity of molluscs. Transmission occurs by direct contact of infected and uninfected hosts, and also by active swimming of trichodinids from one host to another. *Trichodina* cells swim with the adoral surface facing forwards. On surfaces, they move laterally, with the adoral surface facing the substrate.

3.2 Life Cycle of nematodes

A. crassus requires an intermediate arthropod host in its life reduced survival of the host. Transmission to the definitive host is through the food chain and all sizes of eels from cycle to become infective to the definitive eel host. Intermediate host specificity is wide with ***Diaptomus gracilis***, juvenile ***Gammarus*** and the brackish species ***Eurytemora affinis*** all acting as possible intermediates but only ***Cyclops vicinus*** and ***C. albidus*** allowing the parasite to develop into the infective stage. Higher densities of infection can lead to significantly glass eels upwards can be infected. Transmission can also occur from eel to eel through predation. ***A. crassus*** is found in the swim-bladder of eels and gravid adults can contain up to 0.5x10^6 eggs each. Released eggs pass into the intestinal tract and hatch during or after passage through the digestive system. Free-living larvae tend to aggregate in clumps of 10-30 individuals, attaching firmly to the substrate by their hooked tails.

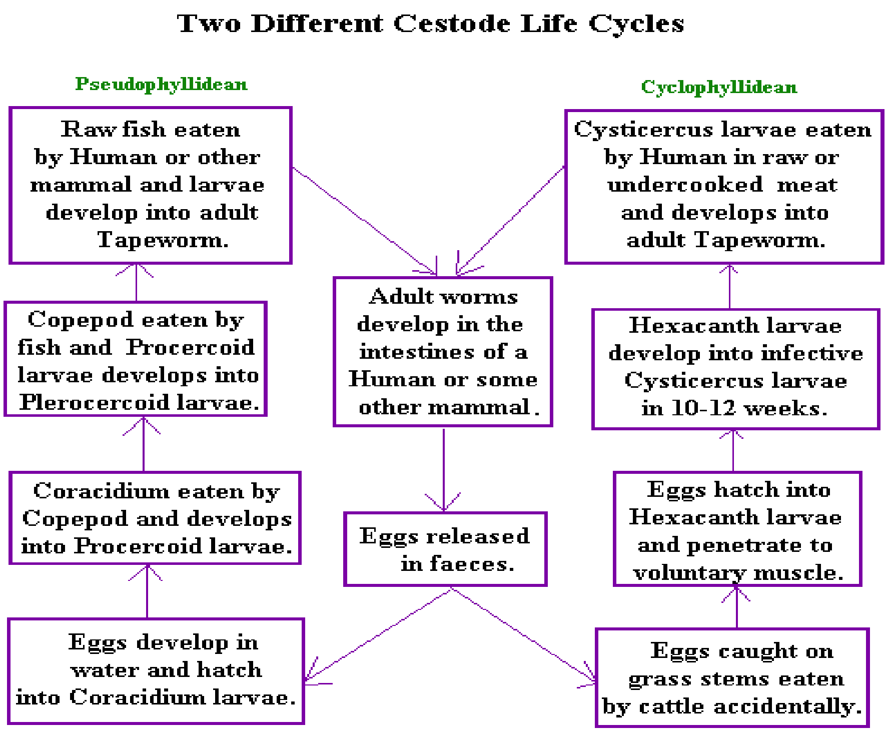


Life Cycle of nematode

3.3 Life Cycle of Cestoda

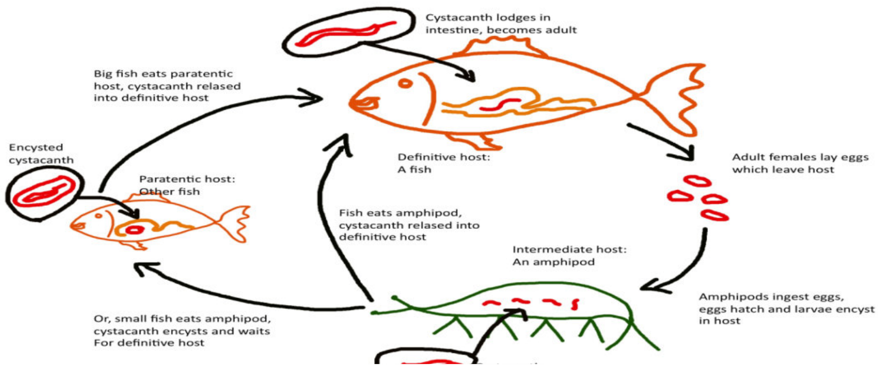
The life cycle is normally completed within 12 months and involves a free-living stage as well as two intermediate hosts and a definitive host. This parasite is hermaphroditic and the structure of the reproductive system in all species of this genus is identical except for the shape of the internal seminal vesicle. In ***T. nodulosus*** the internal seminal vesicle is large (330-440μm in length and 282-385μm in width), and oval in shape. Tapeworms usually release eggs that pass out of the definitive host and complete embryonation in water. They hatch into ciliated, motile and short-lived larvae (coracidia), which are light-sensitive and swim towards the surface of the water body thereby enhancing the chances of the coracidium being ingested by the first intermediate copepod host. The coracidium migrates to the haemocoel (body cavity) of the copepod host before it differentiates and develops into a procercoid stage. The procercoid stage is fully developed in around 9 days and it is transmitted to the second intermediate (fish) host when the infected copepod is ingested. Once ingested it migrates into the muscle and viscera of the fish and differentiates into the plerocercoid stage. The transmission to the definitive host, in this case a species of pike, is through the ingestion of the infected intermediate host. There are thought to be at least 78 species of intermediate host for ***T. nodulosus***.

Adult tapeworms grow and mature in the definitive host during late spring and early summer and release eggs; one sexually mature worm being capable of producing as many as 1,750,000 eggs. Most new infections occur during summer and early autumn but the differentiation into procercoids can be rapid due to high temperatures and there can be sufficient time for the tapeworm to re-infect fish prior to winter. Egg laying occurs during the raining season and although ***T. nodulosus*** can be found in the intestines of pike throughout the year, only young parasites are found during the second half of June-September, and these have no trace of gonadal formation. This 'young' parasite are usually 10-90mm in length during this stage but by the end of September they can range from 90-104mm and the initiation of gonadal development is apparent. Development continues until December/early January at which time growth usually ceases with an average length of 255mm.



3.4 Life Cycle of Acanthocephalan

Copulation within the definitive host can occur within 24 hours of infection but egg production starts between 4 and 8 weeks after infection and lasts for approximately 2 months. Males tend to have shorter life spans than females and may die shortly after copulation. Eggs develop in the fluid-filled body cavity of the female by a process of spiral cleavage which produces an elongated embryo, the acanthor. The number of eggs is dependent upon the size of the female. Acanthors usually bear hooks or spines arranged in spirals or circles at the anterior end and the entoblast (a group of germinal cells within the acanthor) gives rise to most of the organs of the adult form. The eggs, containing a fully developed acanthor, are passed out of the definitive host in the feces and will only hatch when ingested by the intermediate host. The acanthor penetrates the intestine wall with its hooks and enters the haemocoel. These then migrate from intestine and develop through series of acanthella stages in the dorsal haemocoel of the gammarid until an infective juvenile known as a cystacanth (enveloped in a capsule) is formed. ***P. laevis*** has been known to change the appearance and behavior of the intermediate host so as to maximize their chances of being eaten by the next host. This can include appearing more visible to the host predator due to the orange coloring of the cystacanths or altering the behavior so that the intermediate host swims near the surface of the water (possibly a photophilic response), or clings to the surface of vegetation. The life cycle is completed when the final infective cystacanth stage is eaten along with its host by the definitive host although a paratenic host may sometimes be involved.



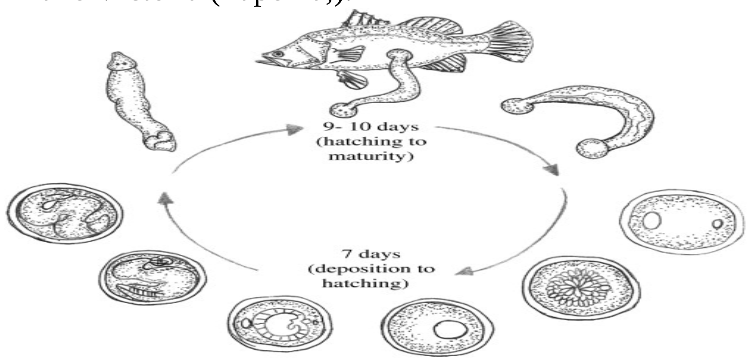
Life cycle of Acanthocephalan

3.5 Leeches

Life History and Biology

Leeches, once engorged with the blood of the host, detach and rest on a protected substrate in the water (under stones or in plant debris) until their next meal. Reproduction takes place after several meals. *B. tricarinata* in tropical and subtropical waters breeds throughout the year (Oosthuizen, 1989). Glossiphoniidae exhibit parental care. The leeches produce a thin walled cocoon and immediately after deposition place their bodies over it and the hatching offspring attach themselves in a brood pouch which forms on the parent's ventral wall. They remain in the pouch until the first feeding stage when they are often brought to their first host by the parent. The entire life cycle may last, depending on availability of hosts, from 24 days to several months. *B. tricarinata* feeds on fish, and if fish are unavailable will also feed on tadpoles and adult anurans (Oosthuisen, 1991). Some glossiphonids also feed on freshwater molluscs but, although *B. tricarinata* enters the mantles of molluscs, it does not feed on these hosts. *B. tricarinata* has been found feeding naturally and induced experimentally to feed on hosts of diverse fish.

Families; *Clarias* spp., *Bagrus* spp., *Oreochromis* spp. *Barbus* spp. goldfish and *Protopterus aethiopicus* (Oosthuizen, 1989; Paperna,). However, populations of a given geographical region or a water system show preference for, or will exclusively occur on, one particular host, for example *Clarias lazera* in the Jordan system, Israel and *Bagrus docmac* in Lake Victoria (Paperna,).



4.0 CONCLUSION

Parasites exhibit a variety of life cycle types. Those that are transmitted from one definitive host (in which they reach sexual maturity) to another are described as having direct life cycles. Parasites that use at least one intermediate host (which harbors sexually immature forms of the parasite) to transfer between definitive hosts are said to have indirect or complex life cycle.

5.0 SUMMARY

Trichodinids have a simple direct life cycle. That is, they have a single host and do not use alternation of generations or mass asexual replication off the host. ***A. crassus*** requires an intermediate arthropod host in its life reduced survival of the host. Cestoda life cycle is normally completed within 12 months and involves a free-living stage as well as two intermediate hosts and a definitive host. Acanthocephalan, **c**opulate within the definitive host can occur within 24 hours of infection but egg production starts between 4 and 8 weeks after infection and lasts for approximately 2 months. Leech entire life cycle may last, depending on availability of hosts, from 24 days to several months.

6.0 TUTOR-MARKED ASSIGNMENT

1. With a labeled diagram explain the life cycle of nematode.
2. Describe the Life Cycle of Acanthocephalan

7.0 REFERENCES/FURTHER READING

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MODULE 3 ECOLOGICAL AND PATHOLOGICAL EFFECTS OF PARASITES AND DISEASES OF FISH

UNIT 1 ECOLOGICAL EFFECTS OF PARASITES ON FISH

CONTENTS

1.0 INTRODUCTION

Emerging infectious diseases are associated with pathogens that have recently increased in incidence, impact or geographic or host range. They may pose a greater threat to biodiversity through biomass loss and extinctions of host species than pathogens responsible for endemic diseases .This is because the dynamics of the host-parasite interactions may differ as the pathogen has not coevolved with the host or the ecosystem in which they emerged. An outbreak of an emerging disease may occur when the parasitic fauna of a species is introduced from its natural range into a new region at the same time as its host, providing the opportunity for host switching. Given the lack of co-evolution between these new host species and the introduced pathogen, transmission rates and infection impacts may be high. Indeed, it has been suggested that the introduction of pathogens into new

Host responses to parasite infection are important to understand as they form the basis of the population response. In coevolved host: parasite relationships, infections tend to negatively impact host fitness, modulate the dynamics of host populations and have indirect consequences for non-host Infection costs are compensated by hosts through, for example, developing immune systems as an infection barrier and tolerance through alteration of life-history traits, particularly in the pre-reproductive life-span. Populations through changes in the strength of inter specific competitive relationships. This then impacts reproductive effort and body size as individuals allocate more resources to reproduction than growth and survival to ensure reproduction before resource depletion, castration or death. How hosts respond to introduced pathogens where there has been no co-evolution is less clear; whilst expectations are of catastrophic outcomes through strong negative effects on host survivorship, these may not always be apparent, areas through human activities is one of the most important factors driving disease emergence in natural populations.

In freshwater ecosystems, the opportunity for fish parasites to be moved between regions by anthropogenic activities is high given that the rate of introduction of non-native fishes has doubled in the last 30 years, mainly due to the globalization of aquaculture. Introduced diseases resulting through fish movements in aquaculture have already resulted in significant impacts in some fish, for example the infection of European eel ***Anguilla anguilla*** with***Anguillicoloides crassus*** has been implicated as a major factor in their global decline. Research on the host consequences of infection by introduced parasites has tended to focus on those that impact immediately on host population dynamics through high mortality rates, with sub-lethal impacts, such as alterations in host behavior and growth rates rarely considered despite their potentially significant consequences for wild populations.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain how infection alter the bio mechanism of fish
- state the effect of infection on fish behavior.

3.0 MAIN CONTENTS

Parasitic species can be found everywhere, and on every living organism. Their presence in their host is generally at equilibrium in aquatic organisms and the most common lifestyle on the planet (Marcogliese 2005). Consequently, it is difficult to find any environment or organism that can be labeled as ‘pristine’ or parasite-free. When researchers describe control sites as being pristine, pathogen or disease-free, they are merely describing the lack of viruses, bacteria and xenobiotics, and are not generally referring to parasites. There are times when changes in the environment (natural or anthropogenic) can change the state of balance of the parasite between host and nature, thus resulting in disease. These changes can be environmental such as temperature, climate, or anthropogenic such as pollution and urbanization When the dynamic equilibrium between host and parasite is lost, some changes can occur within the host. These changes can cause mechanical damage (fusion of gill lamellae, tissue replacement), physiological damage (cell proliferation, immune-modulation, altered growth, detrimental behavioral responses,) and/or reproductive damage. The roles, functions, and life-styles of parasites help to characterize an ecosystem. Knowledge of parasites and parasitic communities, allows scientists to recognize the role of the fish host in the food web or ecosystem.

3.1.1 Mechanical Damage

Fusion of gill lamellae: Many species of parasites invade the gills of fish. They can range from microscopic tubulinea or monogenea, to acroscopic annelida and arthropoda, and all can be viewed on the gill arches or nestled between the gill filaments. Grossly visible reactions to these parasites on the fish may be noncritical and include a mild discoloration of the gill filaments or one or two white spots. In more critical cases, the fish may display heavy eroding, massive discolorations (often paler), numerous white spots, and increased mucus secretion (Toksen 2007).

Tissue Replacement: Parasite loads in individual fish can often rise to such high numbers that they occupy the majority of the total area of a specific organ.

3.1.2 Physiological Damage

Cell Proliferation: Proliferation of a single type of cell can cause detrimental effects in the fish host. This same proliferation of cell types is found in human diseases such as cancer.

Immunomodulation: All parasites have evolved ways to evade the host's immune response and host immune systems have evolved numerous ways to counter these evasive strategies (Sitja-Bobadilla 2008). A trade-off is established that is essential to the survival of the parasite and provokes a state of illness in the host, which is not necessarily lethal (Sitja-Bobadilla 2008). However, when a parasite efficiently evades the host immune system, it may damage the host, but actually reduce damage to the parasite (Sitja-Bobadilla 2008). Some parasites have evolved strategies that use the host immune system to aid their attachment to the fish host.

Detrimental Behavioral Responses: Although parasites generally do not cause negative impacts to their host, occasionally parasites can develop in such a way as to alter their host's behavior. This usually occurs with parasites that have complex lifecycles, as it may be more difficult for them to go from one host to the next. For example, the behavior of arthropods, the intermediate hosts of acanthocephalan parasites, may show various changes when infested, including changes in activity, photoreaction, escape behavior, substrate color choice, and vertical distribution.

Altered Growth: Altered growth is perhaps the most difficult mechanism to validate effects due to parasitism. In many studies, researchers have determined that altered growth (delayed growth, stunting) only occurs in extreme laboratory conditions, and would not be observed in the wild. This may be because parasite infested "stunted" fish may not survive in the wild, and they be taken more readily by predation. For the most part, parasites depend on host-derived energy for growth and development, and so they are potentially affected by the host's ability to acquire nutrients under competitive foraging scenarios. Research by Barber (2005) found that the fastest growing fish developed the largest parasites; therefore, faster growing hosts apparently provide ideal environments for growing parasites.

3.1.3 Reproductive Damage

Parasites often influence their hosts through the diversion of resources either directly by using up energy and nutrients or indirectly by increasing the activity of the immune system.

4.0 CONCLUSION

Parasites affect fish health through mechanical, physical and reproductive damage. These changes can reduce growth, fecundity and survival, change behavior and sexual characteristics, and result in many other maladaptive alterations of the infected host. These changes could have significant consequences at not only the individual level, but population, community and ecosystem levels as well. The use of parasites to discriminate among fish populations inhabiting sites of different environmental quality is conceptually possible.

5.0 SUMMARY

It is difficult to find any environment or organism that can be labeled as 'pristine' or parasite-free. Describing a control sites as being pristine, pathogen or disease-free, they are merely describing the lack of viruses, bacteria and xenobiotics, and are not generally referring to parasites.

The roles, functions, and life-styles of parasites help to characterize an ecosystem. Knowledge of parasites and parasitic communities, allows scientist to recognize the role of the fish host in the food web or ecosystem.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the effects of pathogen parasite on fish behavior?
2. What do you understand by the environment is pristine?

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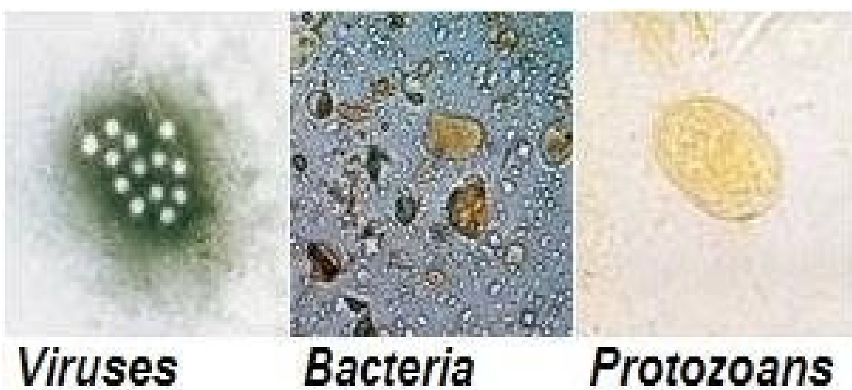
UNIT 2 DIFFERENCES BETWEEN VIRAL INFECTION AND BACTERIAL INFECTION

CONTENTS

1.0 INTRODUCTION

Though they display similar symptoms, and are similar in many respects, there are many differences between bacteria and viruses, and especially the diseases that they cause.



Every infection that the human body is afflicted by is primarily caused by two sources - bacteria or viruses. Both these class of organisms are pathogens (dangerous microscopic organisms), and have the ability to cause some form of illness to human beings. Viruses are parasites, and as a result all viruses cause harm to the body, but bacteria are actually useful to the body as well. Only about 10% of the bacteria actually cause harm to the human body. The infections caused by both sets of pathogens can escalate immensely if left untreated. The fundamental differences between the two sets of organisms are discussed below.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- differentiate between bacterial and viral infections
- have an understanding of what cause some infection
- mode of transmission of bacterial, viral and protozoa infections.

3.0 MAIN CONTENTS

3.1 What is Viral Infection?

Viruses are microscopic organisms that are parasitic in nature. What this means is that they are dormant when they exist by themselves in the air, but when they enter a host's body they get active and begin multiplying and reproducing. Viruses unequivocally require a host in order to get active and reproduce, and share a symbiotic relationship with the host's body. The strain that they generate on the host's body produces an illness in the host, and this is the primary difference between the two. In human beings, the most vulnerable cells of the body that are prone to getting attacked by viruses are the mucous membrane cells. Since there is no protective skin surrounding these cells, they are easily attacked. Common colds, flu and various other viral infections are caused by the viruses attacking these mucous membranes. The following are the 4 basic types of viruses.

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Helical; Enveloped; Complex; Icosahedral

Once a virus enters inside the body it becomes very hard for the body's natural antibodies to locate and fight these viruses, as they hide themselves well behind various cells of the body. But once the infection starts spreading, antibodies are produced to combat these viruses, which eventually knock them out.

3.2 What is Bacterial Infection?

Unlike viruses, bacteria are one celled organisms that are asexual in nature. This means that they are capable of reproducing on their own. There are millions of different types of bacteria present in the air, and they all perform fixed tasks. Not all these bacteria are harmful to the human body, and this is a crucial difference in the study. The four types of bacteria, based on their shapes, are as follows.

Cocci; Bacilli; Vibrio; Spirochaetes

The body releases many types of antibodies to combat the diseases, if they happen to enter the body. In most cases, a certain dosage of antibiotics is also necessary to aid the body in this process. Unlike viruses, bacteria are not parasitic in nature and do not need to depend on a host in order to get active and reproduce.

How Viral Infection and Bacterial Infection enter into the Body:
As is evident from the difference in properties of the two sets of pathogens, the ways they enter the human body are different from each other. The following are the ways that viral infections enter the body through viruses.

Coughing by an infected person; Sneezing by an infected person; Vomiting by an infected person; Bite from an infected insect or animal; Inadequate personal hygiene.

Now we shall see the ways that bacterial infections enter our body through disease causing bacterium.

Close contact with a person who is infected; Food or water that is contaminated; Touching surfaces or objects that are contaminated; Cuts and abrasions on the surface of the skin.

3.3 What is Protozoa Infection?

Protozoa are Single-celled eukaryotes (organisms that possess membrane-bound organelles and nuclei) Protozoa are found as ubiquitous free-living organisms in the environment. They are classified as sporozoa (intracellular parasites), flagellates (which possess tail-like structures for movement), amoeba (which move using temporary cell body projections called pseudopods), and ciliates (which move by beating multiple hair-like structures called cilia).

Infections caused by protozoa can be spread through ingestion of cysts (the dormant life stage), sexual transmission, or through insect vectors. Common infectious diseases caused by protozoans include malaria, giardia and toxoplasmosis.

As components of the micro- and meiofauna, protozoa are an important food source for micro-invertebrates. Thus, the ecological role of protozoa in the transfer of bacterial and algal production to successive atrophic levels is important. As predators, they prey upon unicellular or filamentous algae, bacteria, and micro-fungi. Protozoa are both herbivores and consumers in the decomposer link of the food chain. They also control bacteria populations and biomass to some extent. Protozoa such as the malaria parasites (*Plasmodium* spp.) trypanosomes and leish-mania, are also important disease causing agents in humans.

4.0 CONCLUSION

We have briefly discussed the viral, bacterial and protozoan and how they enter the body. The various ways through which these pathogen cause diseases and how they are transmitted.

5.0 SUMMARY

Every infection that the human body is afflicted by is primarily caused by two sources - bacteria or viruses. Both these class of organisms are pathogens (dangerous microscopic organisms), and have the ability to cause some form of illness to human beings.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe how virus and bacteria enter the body.
2. List the basic types of viral and bacterial infections.

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UNIT 3 POTENTIAL FOOD SAFETY HAZARD

CONTENTS

1.0 INTRODUCTION

Parasites

Parasites (in the larval stage) consumed in uncooked, or undercooked, unfrozen seafood can present a human health hazard. Among parasites, the nematodes or roundworms (*Anisakis spp., Pseudoterranova spp., Eustrongylides spp.* and *Gnathostoma spp.*), cestodes or tapeworms (*Diphyllobothrium spp.*) and trematodes or flukes (*Chlonorchis sinensis, Opisthorchis spp., Heterophyes spp., Metagonimus spp., Nanophyetes salminicola and Paragonimus spp.*) are of most concern in seafood. Some products that have been implicated in human infection are: ceviche (fish and spices marinated in lime juice); lomi lomi (salmon marinated in lemon juice, onion and tomato); poisson cru (fish marinated in citrus juice, onion, tomato and coconut milk); herring roe; sashimi (slices of raw fish); sushi (pieces of raw fish with rice and other ingredients); green herring (lightly brined herring); drunken crabs (crabs marinated in wine and pepper); cold-smoked fish; and, undercooked grilled fish.

2.0 OBJECTIVES

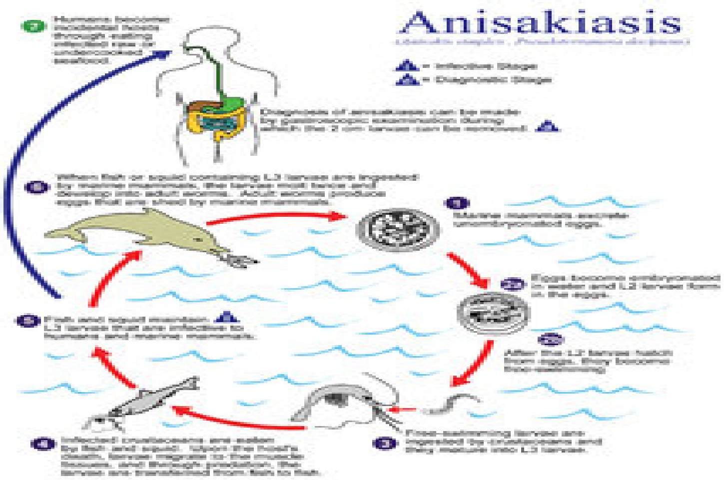
- to understand various parasites those are pathogen in fish
- to have knowledge of accusative effect of fish parasites on human.

3.0 MAIN CONTENT

3.1 Nematodes

3.1.1 Anisakiasis is caused by the accidental ingestion of larvae of the nematodes (roundworms) *Anisakis simplex* and *Pseudoterranova decipiens*. Adult stages of *A. simplex* or *P. decipiens* reside in the stomach of marine mammals, where they are embedded in the mucosa, in clusters. Eggs produced by adult females are passed in the feces, hatch and yield second stage larvae. Upon ingestion by crustaceans, third stage larvae develop that are infective to fish and squid. After ingestion by the fish and squid hosts, the larvae migrate from the intestine to the peritoneal cavity to (upon the host's death) the muscle tissues. Through predation, the larvae are transferred from fish to fish until they are ingested by the marine mammal. In this definitive host, the larvae develop into adults, thus closing the cycle. Humans become infected by eating raw or undercooked marine fish. After ingestion, the anisad larvae penetrate the gastric and intestinal mucosa, causing the symptoms of anisakiasis. Within hours after ingestion of infected larvae, violent abdominal pain, nausea, and vomiting may occur. Occasionally the larvae are coughed up. If the larvae pass into the bowel, a severe eosinophilic granulomatous response may also occur, causing symptoms mimicking Crohn's disease 1-2 weeks following infection. A. simplex and P. decipiens are found worldwide, with higher incidence in areas where raw fish is eaten (e.g., Japan, Pacific coast of South America, the Netherlands).

Anisakiasis is associated with eating raw fish (sushi, sashimi, lomi lomi, ceviche, sunomono, Dutch green herring, marinated fish and cold-smoked fish) or undercooked fish. Freezing and cooking may kill *A. simplex*, but may not protect consumers against allergenic reactions to ingested *A. simplex* antigens.



3.1.2 *Eustrongylides* spp

larvae are large, bright red nematodes, 25-150 mm long and 2 mm in diameter. They occur in freshwater fish, brackish water fish, and marine fish. The larvae normally mature in wading birds such as herons, egrets, and flamingos. If the larvae are consumed in raw or undercooked fish, they can attach to the wall of the digestive tract and penetrate the gut wall with accompanying severe pain. Infections are extremely rare and have been associated with consumption of live minnows and sashimi.

3.1.3 *Gnathostoma spinigerum*

infects vertebrate animals. In the natural definitive host (cats, dogs, and wild animals) the adult worms reside in a tumor which they induce in the gastric wall. They deposit eggs that are immature when passed in the feces. After maturation in water, the egg releases a first stage larva (L1). After ingestion by a small crustacean (Cyclops) (first intermediate host), the L1 develops into a L2. Following ingestion of the Cyclops by a fish, frog or snake (second intermediate host), the L2 develops in their flesh into a L3. When the second intermediate host is ingested by a definitive host, the L3 develops into an adult stage parasite in the stomach wall. Alternatively, the second intermediate host may be ingested by another animal (paratenic host) in which the L3 does not develop further, but remains infective to the next predator. Humans become infected by eating undercooked fish or poultry containing L3s, or reportedly by drinking water containing L2-infected Cyclops.

The clinical manifestations in human gnasthostomiasis are caused by migration of the immature worms (L3s). Migration in the subcutaneous tissues causes intermittent, migratory, painful, pruritic swellings (cutaneous larva migrans). Migration in other tissues (visceral larva migrans), can result in cough, hematuria, ocular involvement, with the most serious manifestations being eosinophilic meningitis with myeloencephalitis. High eosinophilia is present. *Gnathostoma spinigerum* is found in Asia, especially Thailand and Japan

3.2 Cestodes

3.2.1 *Diphyllobothrium latum* (the fish or broad tapeworm), is the largest human tapeworm. Several other *Diphyllobothrium* species have been reported to infect humans, but less frequently; they include *D. pacificum*, *D. cordatum*, *D. ursi*, *D. dendriticum*, *D. lanceolatum*, *D. dalliae*, and *D. yonagoensis*.

The adult *D. latum* tapeworm resides in the small intestine where it attaches to the mucosa. It can reach more than 10 m in length, with more than 3,000 proglottids. Immature eggs are discharged from the proglottids (up to 1,000,000 eggs per day per worm) and are passed in the feces. Under appropriate conditions, the egg matures (in 11-15 days), yields an oncosphere which develops into a coracidium. After ingestion by a suitable freshwater crustacean (copepod) (first intermediate host) the coracidium develops into a procercoid larva. Following ingestion of the copepod by a suitable freshwater fish (second intermediate host), the procercoid larva migrates into the fish flesh where it develops into a plerocercoid larva (sparganum). When the smaller infected fish is eaten by a larger one, the sparganum may migrate into the flesh of the larger fish. Humans (the optimal definitive host) acquire the infection by eating raw or undercooked infected fish. Eggs appear in the feces 5-6 weeks after infection. In addition to humans, many other mammals can also be infected.

Diphyllobothriasis can be a long lasting infection (decades). Most infections are asymptomatic. Manifestations may include abdominal discomfort, diarrhea, vomiting, and weight loss. Vitamin B12 deficiency with pernicious anemia may occur. Massive infections may result in intestinal obstruction. Migration of proglottids can cause cholecystitis or cholangitis. Diphyllobothriasis occurs in areas where lakes and rivers coexist with human consumption of raw or undercooked freshwater fish. Such areas are found in the Northern Hemisphere, and in Uganda and Chile.

3.3 Trematodes

3.3.1 Clonorchis sinensis is the Chinese or oriental liver fluke. The adult flukes (10-25 mm by 3-5 mm) reside in small and medium sized biliary ducts. Embryonated eggs are discharged in the biliary ducts and in the stool. After ingestion by the suitable snail intermediate host, the eggs release miracidia which go through several developmental stages sporocysts, rediae, and cercariae). The cercariae are released from the snail and encyst as metacercariae in the skin and flesh of freshwater fish. Infection of humans occurs by ingestion of undercooked, salted, pickled, or smoked freshwater fish. After ingestion, the metacercariae excyst in the duodenum and ascend the biliary tract through the ampulla of Vater. Maturation takes approximately 1 month. Adult flukes can survive 20 to 25 years. In addition to humans, carnivorous animals can serve as reservoir hosts.

Most pathologic manifestations result from inflammation and intermittent obstruction of the biliary ducts. In the acute phase, abdominal pain, nausea, diarrhea, and eosinophilia can occur. In long-standing infections, cholangitis, cholelithiasis, pancreatitis, and cholangiocarcinoma can develop, which may be fatal.

3.3.2 Opisthorchiasis is caused by *Opisthorchis viverrini* (Southeast Asian liver fluke) and *O. felineus* (cat liver fluke). The adult flukes (*O. viverrini*: 5 mm –10 mm by 1 mm-2 mm; *O. felineus*: 7 mm – 12 mm by 2 mm – 3 mm) reside in the biliary and pancreatic ducts of the mammalian host, where they attach to the mucosa. They deposit fully developed eggs that are passed in the feces. After ingestion by a suitable snail (first intermediate host), the eggs release miracidia, which undergo in the snail several developmental stages (sporocysts, rediae, cercariae). Cercariae are released from the snail and penetrate freshwater fish (second intermediate host), encysting as metacercariae in the muscles or under the scales. The mammalian definitive host (cats, dogs, and various fish-eating mammals including humans) become infected by ingesting undercooked fish containing metacercariae. After ingestion, the metacercariae excyst in the duodenum and ascend through the ampulla of Vater into the biliary ducts, where they attach and develop into adults, which lay eggs after 3-4 weeks.

Most infections are asymptomatic. In mild cases, manifestations include dyspepsia, abdominal pain, diarrhea or constipation. With infections of longer duration, the symptoms can be more severe, and hepatomegaly and malnutrition may be present. In rare cases, cholangitis, cholecystitis, and chlolangiocarcinoma may develop. In addition, infections due to *O. felineus* may present an acute phase resembling Katayama fever (schistosomiasis), with fever, facial edema, lymphadenopathy, arthralgias, rash, and eosinophilia. Chronic forms of *O. felineus* infections present the same manifestations as *O. viverrini*, with in addition involvement of the pancreatic ducts. *O. viverrini* is found mainly in northeast Thailand, Laos and Kampuchea. *O. felineus* is found mainly in Europe and Asia.

3.3.3.Heterophyes heterophyes, a minute intestinal fluke causes heterophyiasis. Adult *H. heterophyes* (1.0 mm - 1.7 mm by 0.3 mm - 0.4 mm) reside in the small intestine, where they are attached to the mucosa. They release fully embryonated eggs that are passed in the feces. After ingestion by a suitable snail (first intermediate host), the eggs hatch and release miracidia which undergo several developmental stages in the snail (sporocysts, rediae, and cercariae). The cercariae are released from the snail and encyst as metacercariae in the tissues of a suitable freshwater fish (second intermediate host). The definitive host becomes infected by ingesting undercooked or salted fish containing metacercariae. After ingestion, the metacercariae excyst, attach to the intestinal mucosa, and mature into adults. In addition to humans, various fish-eating animals can be infected by Heterophyes.

The main symptoms are diarrhea and colicky abdominal pain. Migration of the eggs to the heart, resulting in potentially fatal myocardial and valvular damage, has been reported from the Philippines. Migration to other organs (e.g., brain) has also been reported. *H. heterophyes* are found in Egypt, the Middle East and Far East.

3.3.4 *Metagonimus yokogawai*, a minute intestinal fluke (and the smallest human fluke), causes metagonimiasis. Adult *M. yokogawai* (1.0 mm - 2.5 mm by 0.4 mm - 0.75 mm) reside in the small intestine, where they are attached to the mucosa. They release fully embryonated eggs that are passed in the feces. After ingestion by a suitable snail (first intermediate host), the eggs hatch and release miracidia which undergo several developmental stages in the snail (sporocysts, rediae, and cercariae). The cercariae are released from the snail and encyst as metacercariae in the tissues of a suitable freshwater fish (second intermediate host). The definitive host becomes infected by ingesting undercooked fish containing metacercariae. After ingestion, the metacercariae excyst, attach to the intestinal mucosa, and mature into adults. In addition to humans, fish-eating mammals and birds can also be infected.

The main symptoms are diarrhea and colicky abdominal pain. Migration of the eggs to extra-intestinal sites (heart, brain) can occur, with resulting symptoms.

3.3.5 Paragonimiasis is an infection in animals and humans caused by more than 30 species of trematodes (flukes) of the genus *Paragonimus*. Among the more than 10 species reported to infect humans, the most common is *P. westermani*, the oriental lung fluke. Human infection with *P. westermani* occurs by eating inadequately cooked or pickled crab or crayfish that harbor metacercariae of the parasite. The metacercariae excyst in the duodenum, penetrate through the intestinal wall into the peritoneal cavity, then through the abdominal wall and diaphragm into the lungs, where they become encapsulated and develop into adults (7.5-12 mm by 4-6 mm). Time from infection to oviposition is 65 to 90 days. The eggs are excreted unembryonated in the sputum, or alternately they are swallowed and passed with the stool. In the external environment, the eggs embryonate, hatch and yield miracidia which enter the first intermediate host, a snail. Cercariae emerge from the snail and invade the second intermediate host, a crustacean (crab of crayfish) where they encyst and become metacercariae. Ingestion of the metacercariae closes the cycle. Infections may persist for 20 years in humans, and occasionally other sites than the lungs are involved. Infection occurs also in many animal species.

The acute phase (invasion and migration) may be marked by diarrhea, abdominal pain, fever, cough, urticaria, hepatosplenomegaly, pulmonary abnormalities, and eosinophilia. During the chronic phase, pulmonary manifestations include cough, expectoration of discolored sputum, hemoptysis, and chest radiographic abnormalities. Extrapulmonary locations of the adult worms result in more severe manifestations, especially when the brain is involved. While *P. westermani* occurs in the Far East, other species of *Paragonimus* are encountered in Asia, the Americas, and Africa.

3.3.6 *Nanophyetus salmincola* or ***N. schikhobalowi*** are the names, respectively, of the North American and Russian troglotrematoid trematodes (or flukes). Nanophyetiasis is the name of the human disease caused by these flukes. At least one newspaper referred to the disease as "fish flu." N. salmincola is responsible for the transmission of Neorickettsia helminthoeca, which causes an illness in dogs that may be serious or even fatal.

Knowledge of nanophyetiasis is limited. The first reported cases are characterized by an increase of bowel movements or diarrhea, usually accompanied by increased numbers of circulating eosinophils, abdominal discomfort and nausea. A few patients reported weight loss and fatigue, and some were asymptomatic. The rickettsia, though fatal to 80% of untreated dogs, is not known to infect humans.

There have been no reported outbreaks of nanophyetiasis in North America; the only scientific reports are of 20 individual cases referred to in one Oregon clinic. A report in the popular press indicates that the frequency is significantly higher. It is significant that two cases occurred in New Orleans well outside the endemic area. In Russia's endemic area the infection rate is reported to be greater than 90% and the size of the endemic area is growing. Nanophyetiasis is transmitted by the larval stage (metacercaria) of a worm that encysts in the flesh of freshwater fishes. In anadromous fish, the parasite's cysts can survive the period spent at sea.

3.4 Control Measure

The process of heating raw fish sufficiently to kill bacterial pathogens is also sufficient to kill parasites. Freezing (-20ºC [-4ºF] or below [internal or external] for 7 d or –35ºC [-31ºF] or below [internal] for 15 h) of fish intended for raw consumption also kills parasites. The Food Code recommends these freezing conditions to retailers who provide fish intended for raw consumption. Brining and pickling may reduce the parasite hazard in a fish, but they do not eliminate it, nor do they minimize it to an acceptable level. Nematode larvae have been shown to survive 28 d in 80º salinometer brine (21% salt by weight). Trimming away the belly flaps of fish or candling and physically removing parasites are effective methods for reducing the numbers of parasites. However, they do not completely eliminate the hazard, nor do they minimize it to an acceptable level (FDA, 1998).

3.4.1 FDA guidelines for freezing fish to kill parasites

Freeze and store at -4°F (-20°C) or below for 7 days (total time); or

Freeze at -31°F (-35°C) or below until solid and store at -31°F (-35°C) or below for 15 hours; or

Freeze at -31°F (-35°C) or below until solid and store at -4°F (-20°C) or below for 24 hours.

Note: these conditions may not be suitable for freezing particularly large fish (e.g. thicker than six inches) (FDA, 2001).

3.4.2 Controlling Nematodes HACCP model for controlling nematodes in fish recommended freezing the fish to below -20ºC (-4ºF) at the thermal center and storage at or below -20ºC (-4ºF) for at least 24 h (Howgate, 1998).

Freezing conditions to inactivate nematodes in fish for raw consumption (Karl and Leinemann1989).

Maximal Product Core Temperature (ºC)	(ºF)	Holding Time	Maximal Holding Temp (ºC)	(ºF)
-18	-0.4	24 h	-18	-0.4
-18	-0.4	24 h	-20	- 4
-20	-4	24 h	-18	- 0.4
-20	-4	24 h	-20	- 4
-34	-29.2	24 h	-18	-0.4
-34	-29.2	24 h	-20	- 4

Controlling trematodes

Freezing conditions to kill Trematodes (*Heterophyes* spp.) in frozen mullet (Hamed and Elias, 1970).

Maximum External Temperature	Minimum Time
ºC	ºF
-10	14
-20	- 4

Freezing conditions to kill trematodes (*Clonorchis sinensis*) in frozen cyprinids (*Pseudorasbora parva*)

Maximum External Temperature	Infective After	Not Infective After
ºC	ºF	Days
-12	10.4	18
-20	- 4	7

N/D = Not determined

4.0 CONCLUSION

Parasites of fish are sometimes regional specific. Some occur in fish found in Asia , America etc but due to movement of people (the world been a global village), the parasitic infection are spreading to other regions of the world. The main control of the fish to reduce cross infection is through proper handling using the HACCP model.

5.0 SUMMARY

Parasites (in the larval stage) consumed in uncooked, or undercooked, unfrozen seafood can present a human health hazard. Among parasites, the nematodes or roundworms (*Anisakis spp.*, *Pseudoterranova spp.*, *Eustrongylides spp.* and *Gnathostoma spp.*), cestodes or tapeworms

(*Diphyllobothrium spp.*) and trematodes or flukes (*Chlonorchis sinensis, Opisthorchis spp., Heterophyes spp., Metagonimus spp., Nanophyetes salminicola and Paragonimus spp.*) are of most concern in seafood.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the trematode parasites and their control method.
2. Proper handling of fish is necessary to control spread of infection. How will you control Anisakiasis parasite in fish.

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MODULE 4 EPIDEMIOLOGY OF PARASITE POPULATIONS IN WATER BODY; COMMON BACTERIAL, FUNGAL AND VIRAL FISH DISEASES AND THEIR CONTROL

CONTENTS

1.0 INTRODUCTION

The diversity and abundance of parasites vary widely among populations of the same host species. These infection parameters are, to some extent, determined by characteristics of the host population or of its habitat. Recent studies have supported predictions derived from epidemiological models regarding the influence of host population density: parasite abundance and parasite species richness are expected to increase with increasing host population density, at least for directly transmitted parasites.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain fish diseases

- know the different between infectious and non infectious diseases of fish.

3.0 MAIN CONTENT

3.1 Types of Fish Diseases

There are two broad categories of disease that affect fish, infectious and non-infectious diseases.

Infectious diseases are caused by pathogenic organisms present in the environment or carried by other fish. They are contagious diseases, and some type of treatment may be necessary to control the disease outbreak. In contrast, non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic anomalies; they are not contagious and usually cannot be cured by medications. Infectious diseases: Infectious diseases are broadly categorized as parasitic, bacterial, viral, or fungal diseases. Historically, infectious diseases were the main cause of death in the world and, indeed, in some developing regions this may still be the case. With the development of antibiotics and vaccination programs, infectious disease is no longer the leading cause of death in the western world.

Non-infectious diseases

Non-infectious diseases are disease processes that do not have a bacterial or viral origin. Compared to infectious diseases, non-infectious diseases are not contagious or communicable. Non infectious diseases cannot be transmitted to other humans. Non-infectious diseases are those diseases that are not caused by a pathogen and cannot be shared from one person to another. Diseases caused by these organisms are infectious diseases. There are many kinds of non-infectious diseases. Non-infectious diseases can be broadly categorized as environmental, nutritional, or genetic.

Environmental

Environmental diseases are the most important in commercial aquaculture. Environmental diseases include low dissolved oxygen, high ammonia, high nitrite or natural or man-made toxins in the aquatic environment. Proper techniques of managing water quality will enable producers to prevent most environmental diseases.

Nutritional

Nutritional diseases can be very difficult to diagnose. A classic example of a nutritional disease of catfish is "broken back disease," caused by vitamin C deficiency. The lack of dietary vitamin C contributes to improper bone development, resulting in deformation of the spinal column. Another important nutritional disease of catfish is "no blood disease" which may be related to a folic acid deficiency. Affected fish become anemic and may die. The condition seems to disappear when the deficient feed is discarded and a new feed provided.

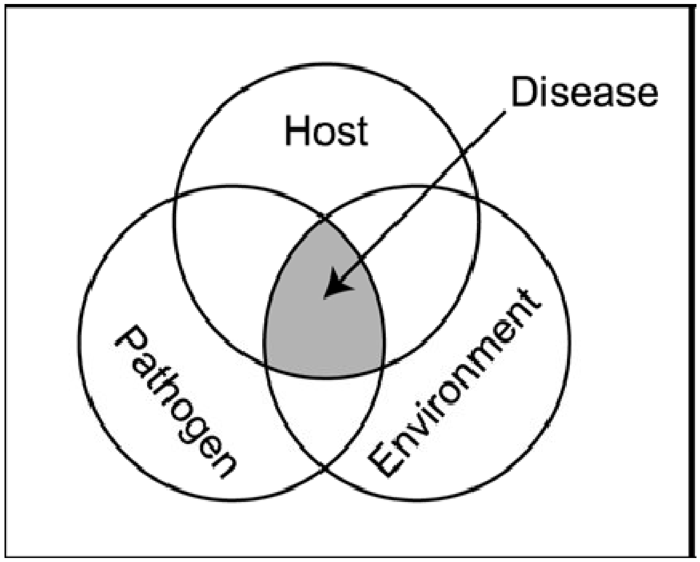
Genetic

Genetic abnormalities include conformational oddities such as lack of a tail or presence of an extra tail. Most of these are of minimal significance; however, it is important to bring in unrelated fish for use as broodstock every few years to minimize inbreeding.

3.2 The Significance of Fish Disease to Aquaculture

Fish disease is a substantial source of monetary loss to aquaculturists. Production costs are increased by fish disease outbreaks because of the investment lost in dead fish, cost of treatment, and decreased growth during convalescence. In nature we are less aware of fish disease problems because sick animals are quickly removed from the population by predators. In addition, fish are much less crowded in natural systems than in captivity. Parasites and bacteria may be of minimal significance under natural conditions, but can cause substantial problems when animals are crowded and stressed under culture conditions.

Disease is rarely a simple association between a pathogen and a host fish. Usually other circumstances must be present for active disease to develop in a population. These circumstances are generally grouped under the umbrella term "Stress" (Figure 1& 2). Management practices directed at limiting stress are likely to be most effective in preventing disease outbreaks.



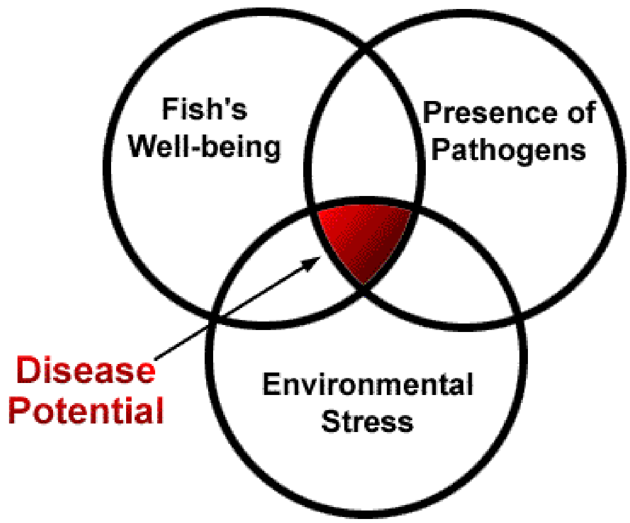


Fig. 1

Disease rarely results from simple contact between the fish and a potential pathogen. Environmental problems, such as poor water quality, or other stressors often contribute to the outbreak of disease.

Fish disease organisms are constantly present in most aquatic environments, and farm and recreational ponds are no exception. Under optimum conditions, healthy fish are able to fight off most forms of infectious diseases. Conversely, fish subjected to stress are often unable to maintain their natural defenses against infectious diseases such as bacteria, viruses, fungi or protozoan parasites.

Stress may result from a variety of conditions, including overcrowding, handling stress, poor water quality, inadequate nutrition and weather-related environmental stress. These forms of stress may kill fish outright, in which case they can be considered non-infectious diseases. More often, however, they do not kill fish outright but lead to outbreaks of infectious diseases. Ironically, a common cause of stress is chemical toxicity from disease or weed control efforts. In summary, three factors are involved in fish disease outbreaks: infectious pathogens (viruses, bacteria, fungi or protozoan parasites) must be present and capable of attacking the fish, the fish must already be in a susceptible state, and certain environmental conditions, such as specific temperatures or poor water quality, must be present.

As mentioned, many fish disease-causing organisms are usually present in ponds, and little can be done to eliminate them or prevent them from recurring. These organisms alone, however, are usually not enough to cause disease problems. For this reason, disease problems will usually reoccur in fish ponds unless the conditions which caused the initial fish stress can be identified and eliminated. Three main practices can minimize the possibility of disease outbreaks. These are maintenance of good water quality, proper nutrition and elimination of contact with wild fish whenever possible. A sound fertilization program can contribute to the first two objectives. The third can be achieved through proper pond design and water management, as well as prevention of fish introductions outside of the established stocking plan.

Common water quality stressors are low dissolved oxygen and/or a buildup of toxic nitrogenous compounds, especially ammonia and nitrite. Dissolved oxygen problems are most common in the early spring and the mid-to-late summer. Nitrogenous compounds are more of a problem in cold water during the winter.

3.3 Determining if Fish are Sick

The most obvious sign of sick fish is the presence of dead or dying animals. However, the careful observer can usually tell that fish are sick before they start dying because sick fish often stop feeding and may appear lethargic. Healthy fish should eat aggressively if fed at regularly scheduled times. Pond fish should not be visible except at feeding time. Fish that are observed hanging listlessly in shallow water, gasping at the surface, or rubbing against objects indicate something may be wrong. These behavioral abnormalities indicate that the fish are not feeling well or that something is irritating them. In addition to behavioral changes, there are physical signs that should alert producers to potential disease problems in their fish. These include the presence of sores (ulcers or hemorrhages), ragged fins, or abnormal body confirmation (i.e., a distended abdomen or "dropsy" and exophthalmia or "Popeye"). When these abnormalities are observed, the fish should be evaluated for parasitic or bacterial infections.

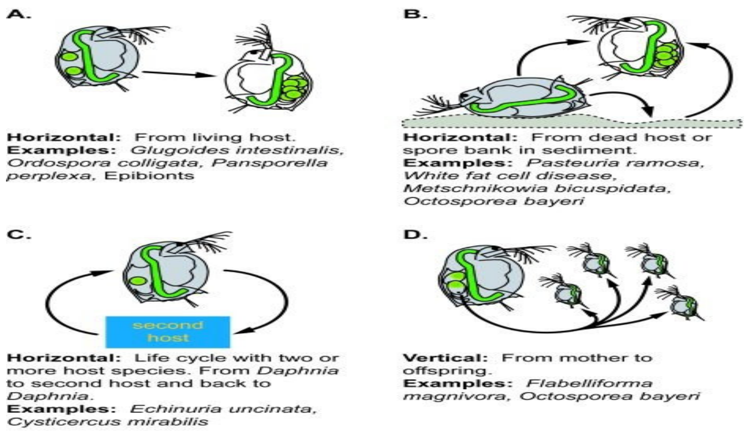
3.4 What to do if Fish are Sick

If you suspect that fish are getting sick, the first thing to do is check the water quality. If you do not have a water quality test kit, contact your county extension office; some counties have been issued these kits, and your extension agent may be able to help you. If your county is not equipped with a water quality test kit, call the aquaculture extension specialist nearest to you (see the list at the end of this publication). Anyone contemplating commercial production of fish should invest in a water quality test kit and learn how to use it. Low oxygen is a frequent cause of fish mortality in ponds, especially in the hot weather. High levels of ammonia are also commonly associated with disease outbreaks when fish are crowded in vats or tanks. The following parameters should be checked and compare with the available data on oxygen cycles, ammonia cycles, and management of these water quality problems. In general, check dissolved oxygen, ammonia, nitrite, and pH, during a minimum water quality screen associated with a fish disease outbreak. The parameters of significance include total alkalinity, total hardness, nitrate saltwater systems) and chlorine (if using tap water). Ideally, daily records should be available for immediate reference when a fish disease outbreak occurs. These should include the dates fish were stocked, size of fish at stocking, source of fish, feeding rate, growth rate, daily mortality and water quality. This information is needed by the aquaculture specialist working with you to solve your fish disease problem. Good records, a description of behavioral and physical signs exhibited by sick fish, and results of water quality tests provide a complete case history for the diagnostician working on your case.

3.5 Epidemiology of parasite population in water body

Epidemiology of infectious diseases attempts to describe the patterns and processes by which diseases are distributed in the host population. The discussion will be on what is known about the transmission of *Daphnia* parasites, about the factors that influence transmission, and how they work together in shaping parasite dynamics. In a parasitological context, epidemiology is the study of infectious diseases and disease-causing agents at the population level. It seeks to characterize the patterns of distribution and prevalence of the disease and the factors responsible for these patterns. In a more applied context, it also strives to identify and test prevention and treatment measures. The key factor to understanding the epidemiology of diseases is to understand transmission, or the movement of parasites from one host to the next.

An important component of epidemiology is the parasite's mode of transmission, or how it moves from one host to the next. Unfortunately, surprisingly few scientific reports include information on parasite transmission. This parasite is transmitted between hosts via waterborne infective stages, which are released from infected hosts and are ingested by the same or other host individuals during filter feeding.



Parasitic diseases of fish are most frequently caused by small microscopic organisms called protozoa which live in the aquatic environment. There are a variety of protozoans which infest the gills and skin of fish causing irritation, weight loss, and eventually death. Most protozoan infections are relatively easy to control using standard fishery chemicals such as copper sulfate, formalin, or potassium permanganate. Information on specific diseases and proper use of fishery chemicals is available from your aquaculture extension specialist

4.0 SUMMARY

There are many diseases of fish which can be troublesome to commercial producers as well as the recreational pond owner. Many disease outbreaks of captive fish stocks are associated with stressful conditions such as poor water quality, excessive crowding or inadequate nutrition.

There are two broad categories of disease which relate directly to selection of appropriate treatments:

1. Infectious diseases are contagious diseases caused by parasites, bacteria, viruses, or fungi. These often require some type of medication to help the fish recover.

2. Non-infectious diseases are broadly categorized as environmental, nutritional, or genetic. These problems are often corrected by changing management practices.

5.0 CONCLUSION

Fish disease outbreaks are often complex, involving both infectious and non-infectious processes. Appropriate therapy often involves medication and changes in husbandry practices.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe parasitic diseases
2. What are infectious diseases of fish?

7.0 REFERENCES/FURTHER READING

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Ruth Francis-Floyd, Professor, Department of Large Animal Clinical Sciences (College of Veterinary Medicine) and Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

UNIT 2 BACTERIAL FISH DISEASES AND CONTROL

CONTENTS

1.0 INTRODUCTION

Fish do not usually suffer bacterial diseases, unless they are farmed fish or fish restricted to a tank or bowl. Under these circumstances of potential stagnation, overcrowding, restricted space, higher concentrations of excreta and higher quantity of nutrients in the water, bacteria can gain the upper hand.

Fish bacterial diseases can be very difficult to deal with, so early detection is extremely important so that they can be treated before becoming lethal to your fish. Bacterial diseases are generally categorized into two types: primary pathogens, which are not normally part of the fish's environment, and opportunistic pathogens, which generally are. Opportunistic bacteria, though the most common problem, normally do not pose a threat to your fish, unless there is some **change** in the fish's environment, such as an overabundance of rotting material or other stress or injury to your fish. These factors allow the bacteria to invade. Most of the time, bacterial diseases in the early stages are localized. These can be indicated by fin rot, body ulcers, and red or inflamed areas on the fins and body. If not treated, these bacterial infections may become *systemic*, spreading throughout the fish's body. This normally happens through absorption through the gills gut, or skin. Other signs of bacterial infection include swollen eyes, swollen gut, or lethargic activity. Gill disease can also be an indication of bacterial disease in fish. These symptoms are usually found when the bacterial infection has begun to spread within your fish. Since it is impossible to accurately diagnose bacterial disease in fish merely by sight, it is important that other tests be performed on the fish, such as mucus sample testing. The obvious signs will, however, help to narrow down problems in your fish. Pet store employees, other fish owners, and veterinarians can also provide helpful information.

3.1 Bacterial Diseases

Bacterial diseases are often internal infections and require treatment with medicated feeds containing antibiotics. Typically fish infected with a bacterial disease will have hemorrhagic spots or ulcers along the body wall and around the eyes and mouth. They may also have an enlarged, fluid-filled abdomen, and protruding eyes. Bacterial diseases can also be external, resulting in erosion of skin and ulceration. Columnar is an example of an external bacterial infection which may be caused by rough handling.

A fundamental management objective of all fish rearing practices is to avoid and minimize stress on fish. .Stress: The aquatic environment is dynamic and constantly subject to changes in its physical, chemical and biological components. These changes along with culture practices – stressors severely stress the physiological systems of fishes. The physiological response elicited initially is adaptive. However, they may ultimately become maladaptive in chronic situations. Stress response
Innumerable diseases are caused in fishes due to bacterial pathogens and several of them. They occur in nursery, rearing and grow out ponds causing serious concern to fish farmers. Some of them often wipe out the entire population of fish. Some of the important bacterial pathogens are Aeromonas hydrophila, A. salmonicida, Pseudomonas fluorescens, P.putrefaciens, Flexibacter columnaris, Edwardsiella tarda, Vibrio alginolyticus and V. Parahaemolyticus which have been identified as the most commonly encountered agents in fish diseases.

3.2 Bacterial Infections

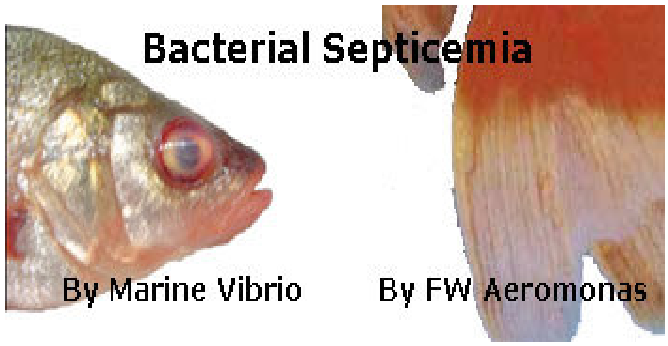
The most common bacterial infections are caused by one of three pathogens: Vibrio, Pseudomonas or Aeromonas. The symptoms (e.g., cloudy eyes, bloody patches, decaying or frayed fins, scratching) of these bacterial infections can be similar, and therefore it can be difficult to determine which pathogen is responsible. Fish with an internal bacterial infection may not show any signs other than a loss of appetite and possibly a swollen abdomen.

With most bacterial infections, all fish in the pond or tank may be affected to varying degrees, so the entire pond may need to be treated. Obviously, if we are dealing with a large pond, this could potentially be expensive. If only one fish appears to be infected and you move the infected fish to a quarantine pond as soon as possible, you may get lucky and not have to treat the display pond. In most cases, tetracycline has been the most effective treatment for infections caused by both Vibrio and Aeromonas, though there are other antibiotics that you can use. Remember to follow the manufacturer's directions and remove any activated carbon from your filter before treating the aquarium. Another option is the use of medicated foods if the fish are eating well.

3.3 *Aeromonas hydrophila* (Bacterial Hemorrhagic Septicemia)

Gram negative motile rods: Effects many freshwater species and usually is associated with stress and overcrowding. The clinical signs and lesions are variable. The most common finding is hemorrhage in skin, fins, oral cavity and muscles with superficial ulceration of the epidermis. Occasionally cavitary ulcers (similar to *A. salmonicida*) are observed. Exophthalmus and ascites are commonly observed. Spleenomegaly and swollen kidneys are common.

Histologically, multifocal areas of necrosis in the spleen, liver, kidney and heart with numerous rod shaped bacteria are observed. Diagnosis is rendered by culturing the organism from affected animals: Remember this is a common water saprophyte with a great variation in virulence in serotypes. Disease is transmitted via contaminated water or diseased fish. Bacterial infections, caused by motile members of the genus Aeromonas, are among the most common and troublesome diseases of fish raised in ponds and recirculating systems. The wide- spread distribution of these bacteria in the aquatic environment and the stress induced by intensive culture practices predisposes fish to infections. Motile aeromonad infections have been recognized for many years and have been referred to by various names, including motile aeromonad septicemia (MAS), motile aeromonad infection (MAI), hemorrhagic septicemia, red pest, and red sore. In this publication, they are referred to simply as aeromonas infections. Aeromonas bacteria causing these infections are called aeromonads. Whether acting alone or in mixed infections with other organisms, the motile aeromonads are responsible for significant financial losses annually. All species of fish, scaled and unscaled, are susceptible to infection. Under certain conditions mortalities can approach 100 percent. Aeromonas infections also occur in other vertebrates, including frogs, turtles, alligators and, sometimes, humans.



Cause

Aeromonas hydrophila, A. sobria, A. caviae, and possibly other aeromonads, are capable of producing disease in fish. While all members of this group are small, motile, gram-negative, rod-shaped bacteria and all share certain biochemical characteristics, their scientific names are constantly under revision and subject to change in the future. Numerous strains of these bacteria exist, and they vary greatly in their ability to cause disease. In general, strains isolated from the environment are less pathogenic than those isolated from diseased fish. The marked genetic diversity among different aero- monad strains has made it difficult to develop effective vaccines.

Clinical signs or symptoms

Signs of disease associated with aeromonas infection are non-specific and may be easily confused with other diseases. Infections vary greatly in appearance and may be seen in the skin only, as an internal systemic disease (septicemia), or as a combination of both. Outbreaks may be chronic (long-term) and affect only small numbers of fish or may produce acute (intense and short-term) infections accompanied by rapidly increasing, high mortality rates. In unscaled fish (e.g., catfish), there is often fraying and reddening of fins, accompanied by irregular, variably sized areas of depigmentation (paleness) that can develop anywhere on the body surface. The skin overlying these sites is eventually lost, exposing the muscle below. These open sores or ulcers may remain superficial or they can be extensive and invade deeply into muscle, revealing underlying bone in some cases (Fig. 3). These ulcers often have ragged white margins bordered by a narrow zone of hemorrhage. In scaled fish (e.g., largemouth bass), skin lesions begin as small hemorrhages within scale pockets (Fig. 4) that can rapidly expand to larger areas. Affected scales are eventually lost and ulcers form. Aeromonas infection may also include any or all of the following external signs: exophthalmia (popeye), abdominal distention (swelling of the abdomen), and pale gills. Scaled fish often accumulate edema (fluid) in their scale pockets. This condition, called lepidorthosis, creates a roughened or bristled appearance. Skin lesions caused by aeromonads often have fungus or columnaris bacteria present.

Fish affected only with skin lesions may continue to feed and survive for extended periods, despite the presence of severe ulceration (Fig. 3). Daily mortalities associated with this chronic form of disease may be low, but can rise to high levels over time. The internal or septicaemia form of disease typically follows a more acute course with a sudden onset of relatively high mortalities. Affected fish usually do not eat and commonly will be seen swimming lazily near the water's surface or in shallow areas of a pond. If disturbed, the fish move into deeper water, but typically return to the surface within a short period of time. The internal organs may be enlarged, reddened or pale, or have a mottled pattern of deep red hemorrhage interspersed with pale areas of tissue destruction or necrosis (Fig. 4). Organs with significant tissue necrosis become weak and are easily damaged when handled. The intestinal tract typically will be devoid of food, reddened, and filled with cloudy yellow or bloody fluid and mucus. The abdomen may be filled with clear, cloudy or bloody fluid. The gall bladder will be filled with large amounts of green bile. Highly virulent (deadly) strains may cause sudden mortalities with few external or internal signs of disease. Losses from aeromonas infections seldom exceed 50 per- cent; however, mortality is strongly influenced by the general health status of the fish population, stress level, and virulence of the particular bacterial strain infecting the fish. Mortalities occasionally approach 100 percent in fry and small fingerlings.

Treatment

Chemical treatments with potassium permanganate (KMnO4), at a rate of 2 to 4 parts per million (milligrams/liter), are sometimes useful in the treatment of infections limited to the skin. Potassium permanganate treatments are of greatest value when fish are feeding poorly or not at all, and medicated feed is not an option. Potassium permanganate is presently on deferred status by the Food and Drug Administration; it may be used but is not officially approved. Systemic infections can only be successfully treated by the use of medicated feeds containing antibiotics. For medicated feeds to be effective, it is essential that an early diagnosis is made and that the fish be fed as soon as possible, before the disease causes them to stop eating. Treatment with medicated feeds will not be effective if a large portion of the fish population has already stopped feeding. Usually there is not enough time to wait for the results of antibiotic sensitivity tests. Sensitivity testing, however, may indicate that a different, more effective medicated feed should be used. Oxytetracycline (Terramycin¤) is approved for control of motile aeromonad infections in catfish. Sulfadimethoxine plus ormetoprim (Romet¤) is approved for controlling Edwardsiella ictaluri (ESC) infections in catfish.

3.4 Fin rot and tail rot

Fin rot and tail rot in hatcheries, nurseries and grow out ponds have been reported in young and adult fishes. The disease is contagious and is capable of causing immense damage. Fin and tail rot in young fish are due to a mixed infection of A. hydrophila and *Pseudomonas fluorescens*. Short motile Gram-negative rods with polar flagella. Lesions similar to *Aeromonas hydrophila* with a hemorrhagic septicemia resulting in hemorrhage of the fins and tail and ulceration of the skin. Most times it is an indication of other problems, such as injury or poor environmental conditions.

Fish rot is indicated by the erosion or shredding of the fish's fin, normally beginning at the outer end. It can be bacterial or fungal, and can be caused by a variety of common reasons, such as poor water conditions, diet, or injury.

Once diagnosed, fin rot is generally easily and quickly treated, as the fish's fins can be regenerated, unless the condition progresses past the base of the fin. This is extremely dangerous to the fish as, with bacterial infections, it can be absorbed into the body of the fish and subsequently kill the fish.

Fungal fin rot usually rots more evenly, and produces a white edge; while bacterial fin rot produces more of a jagged edge. In many cases, both can be present at the same time, creating the need to treat both kinds. In more advanced cases of each, there may be redness or inflammation.

The type of fin rot in your fish will determine the method of treatment you use. Fungal fin rot is easiest to treat, generally by swabbing the infected area with an antiseptic, such as malachite green, (also called aniline green and a number of other names).

Bacterial fin rot in fish is normally treated with a form of antibiotic in a quarantine tank. This can be stressful to your fish, however. I more preferred method is the use of food containing an antibiotic. In advanced cases, the rotted area may be removed, but the fish will have to be sedated.

Fin rot is easy to diagnose and treat, and most times your fish will survive, if treated, properly. It is important to remember, though, that since fin rot is normally the result of some other stress to your fish or its environment; you must also address these issues in order to prevent it from reoccurring.

Control

Control measures adopted are bath treatment in 1:2000 copper sulphates for 2 minutes or swabbing of concentrated copper sulphate solution in the affected fishes.

3.5 Gill and Fin Rot

Diagnosis

Myxobacteria of the genus *Flexibacter* (*Cytophaga*), including *F. columnaris*, the commonest etiological agent of fin rot and skin lesions ("saddle back") of freshwater fish, are readily recognized in direct microscopic examination of a squash of an affected tissue by their long thin (filamentous) structure. Myxobacteria are isolated on *Cytophaga* agar medium, re-cultured on Nutrient, 5% sheep blood,

Pathology

Gill lesions in the acute clinical condition (usually caused by *F. columnaris*) are necrotic and often rapidly expanding, and death is more rapid. On the skin, acute lesions are often confined to the head and back ("saddle back")). Such lesions are white or yellow with reddish zone of hyperaemia around the periphery and comprise of bacterial cells and necrotic tissue covering haemorrhagic ulcers. Histology reveals epidermal spongiosis and a subsequent necrosis which extends into the dermis. Chronic myxobacterial infections cause extensive hyperplasia in the gills, with resulting fusion of the lamellae and sometimes also with proliferation of mucus glands and chloride cells. Proliferation in the skin occurs at the tips of fins and at skin folds.

Other pathological manifestations of myxobacterial infection reported elsewhere, which might also be relevant to African fish are as follows
Fin rot condition has been reported only from fish outside Africa (Richards & Roberts, 1978). It induces a severe epidermal and dermal edema, a fibrinous exudates overlaid with cytophaga bacteria, and cellular exudates, with subsequent sloughing and progressive erosion of the fins. Myxobacteria may be displaced by secondary opportunistic saprophytic bacteria.

Cotton wool disease, affecting tropical aquarium fish, is suggested to result from irritation of gill lamellae, producing catarrhal exudates over the gills which serve as an attractive substance for cytophaga proliferation.

Epizootiology

Myxobacteria are ubiquitous opportunists of the aquatic habitat. Many, particularly those causing gill and skin rot conditions, will colonise only damaged or ulcerating integument, necrotic tissue or irritated mucus excreting epithelium (cotton wool disease). Acute gill and skin infections are most often associated with handling, or mechanical damage of skin and gills in hauling and sorting. Adverse ambient conditions - low temperatures, excessive organic load, ammonia or nitrites, are important contributory factors in such situations. The same environmental parameters, as well as other adverse growing conditions (overcrowding and inadequate feeding or nutrition), predispose fish to chronic myxobacterial diseases. Dispersed toxic substances may play an important role in the etiology of chronic myxobacterial infections (tail rot etc.).

3.6 Dropsy

The symptoms of dropsy in fish are a distended or swollen body with protruding scales. Dropsy is also known as ascites. The affected fish may appear lethargic and may not eat. Dropsy isn't a disease itself, but actually a symptom of another underlying disease in the fish. The reason the fish's body swells is due to a buildup of fluid in its body cavity and internal organs. This may occur if the fish's kidneys are affected, for example. There can be many different causes of fish dropsy, and it is usually difficult to know exactly what the cause is.

Notice the protruding scales on this goldfish with dropsy.

However, one common cause of dropsy in fish is a bacterial infection by*Aeromonas*. *Aeromonas* is normally present in all aquarium water;

however, it sometimes causes illness in fish, especially fish that are stressed due to poor water quality from overcrowding or infrequent partial water changes. Also, some species of *Aeromonas* are more pathogenic than others. Infection by *Aeromonas* will sometimes cause red streaks or sores on the fish's body (but not always).

Dropsy is not a specific disease, but rather a symptom of a deteriorated health condition. The epidermis and body cavities get filled with fluid and scales protrude out from their pockets leading to severe anemic condition. A mixed infection of A. hydrophila and myxozoan parasite or malnutrition is frequently the cause of infectious dropsy in fish. With dropsy, the fish will have visible swelling and projected scales. This is the result of a fish not being able to regulate the amount of fluid in a part of its body. The affected area is typically the abdomen; specifically, it is most often the visceral cavity that houses a number of organs, such as the stomach, intestines, gall bladder and kidneys. The failure to regulate fluids is a symptom; therefore, there is usually some other disease involved that starts the process (caused by poor water quality, stress, internal bacterial infections, parasites, viruses and tumors). Although dropsy is fairly easy to diagnose, the cause is much harder to determine; however, the primary cause is usually attributed to a bacterial infection. The causative agent can be introduced to the pond through food, poor water quality or through the introduction of other fish to an established pond. Although dropsy is not highly contagious, the affected fish should be removed and placed in a quarantine pond. Dropsy can be spread from the affected fish, which can possibly produce stress among the other fish and make them more vulnerable to dropsy or other conditions.

Control

Although there are no present medications that can effectively cure fish stricken with dropsy, your first line of defense is to administer a wide-spectrum antibiotic in the condition's early stages. The affected fishes could be effectively treated by Terramycin in the feed. Application of neem leaf and leaf extract in the pond water, lime in soil, change of pond water with fresh water can control this disease within 2/3 days. Unfortunately, the prognosis of fish affected with dropsy is not very good. By the time the fish has swollen up and the scales project outward, the internal damage may be too expensive to repair and for the fish to recover. Most cases of dropsy are fatal. Treatment for aquarium fish: If you have a fish with a swollen, distended body typical of dropsy, it is best to isolate the fish and treat it in its own treatment tank if possible. You can treat the fish by adding a small amount of epsom salts to the tank. Epsom salts consist of magnesium sulfate as opposed to sodium chloride found in regular aquarium salt (and table salt). Adding epsom salts to your tank will help to draw some of the excess water out of the fish's body cavity and tissues. Don't add more than 2.5 teaspoons of epsom salts per 10 gallons of water. You should feed the affected fish antibacterial fish food for 7-10 days if the fish is still eating. You can also add some Maracyn2 to the aquarium that the fish with dropsy is in. Maracyn2 treats gram negative bacterial infections, such as Aeromonas, and is absorbed through the fish's skin from the water. However, unless you start the treatment early the fish may still not survive. It is also possible that the dropsy may be caused by something other than a bacterial infection, such as a virus, or some other cause. If this is the case then the antibiotics will not be effective. You can often prevent bacterial and other diseases in your fish by doing regular partial water changes (20-25 %) in your tank each week. In fact, if you have the time, doing partial water changes twice a week is even better. And of course, don't overcrowd your fish or over feed them.

Control of Infections by Facultative Pathogenic Bacteria

Antibiotic therapy by use of medicated feeds appears to be a feasible undertaking, as long as the infected fish are still willing to eat. Drug sensitivity tests of the pathogen targeted for treatment must be repeatedly performed to ensure efficacy of antibiotics added to feeds. Application of medicated feeds, as a non-specific prophylactic measure, is economically wasteful, harmful to the environment (damaging nitrification processes and primary production) and promotes drug resistance amongst pathogens in the habitat.

In the case of streptococcal infection, use of medicated feeds in polyculture is not cost-effective as carp, which always comprise the greater portion of the pond biomass, are intractable to infection.

Vaccination has been repeatedly considered as a potential solution and some research is in progress. There are, however, serious doubts as to how effective this vaccination may be and whether it will be economically worthwhile. The feasibility of vaccination use will largely depend on the degree and durability of protection afforded by immersion vaccination or via feeds. Specific immune response has been induced in tilapia to various antigens and to some bacterial infections. Elevation of antibody titers to a level of 100% protection to challenges during two to five weeks was obtained in Nile tilapia (*O. niloticus*) following injection of formalin-killed *A. hydrophila* and Freunds complement adjuvant vaccines (Ruangapan *et al.*, 1986). Attempts to vaccinate reared tilapia (*O. niloticus*) fingerlings with lyophilized *Aeromonas hydrophila* in the Ivory Coast were, however, unsatisfactory (J-P. Coquelet, unpublished report).

Serum agglutinating antibody titer of tilapia hybrids rose following injection with a *V. parahemoliticus* bacterin both with and without Freunds complement adjuvant, while titers for naturally occurring antibodies in the overwintering fish were usually low. Immunisation trials by immersion showed significant efficacy in protecting tilapia from a challenge for about 60 days. Neither significant elevation in agglutinin titers nor protection against challenge was obtained in Nile tilapia immunised with formalin-killed *Edwardsiella tarda*, using the hyperosmotic infiltration method, it was found that vaccination using toxoid, rather than bacterin, elicited a greater antibody response and they recommended the use of detoxified endotoxin in streptococcal infections of yellowtail.

There is a serious risk of introducing bacterial infections into Africa (notably *Streptococcus*, *Pasteurella* and mycobacterium; see 3.2), which are prevalent in countries outside Africa specializing in tilapia culture, with genetically improved culture seed - breeders, fry and apparently also eggs. Only an adequately enforced ban on such imports will secure African habitats from these infections.

5.0 CONCLUION

Bacteria are everywhere. But if bacteria are all bad, why aren't all fish sick? Some bacteria are good, some are bad and some are only bad under certain, specific conditions or circumstances. Fish have defenses against bacteria, but they don't always function properly.

6.0 SUMMARY

This module introduce you to the bacteria world and how they are identified , what causes them to be pathogenic, how they are transmitted and how the diseases associated with then develop. You discover how fish respond to bacterial infection and how he fishes systems and human control methods work. The problem of bacterial pathogens on finfish culture, their etiology and specific control methods.

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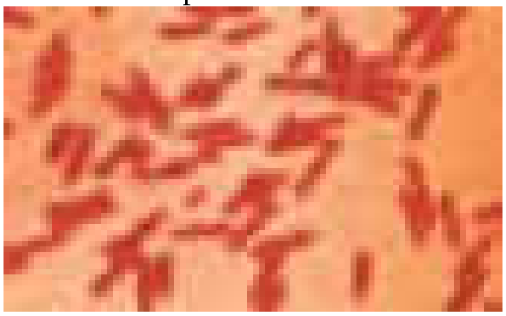
UNIT 3 OTHER BACTERIAL FISH DISEASES AND CONTROL

CONTENTS

1.0 INTRODUCTION

Epidemics of bacterial diseases are common in dense populations of cultured food or aquarium fish. Predisposition to such outbreaks frequently is associated with poor water quality, organic loading of the aquatic environment, handling and transport of fish, marked temperature changes, hypoxia, and related stressful conditions. High concentrations of waterborne bacteria are normally found in ponds and aquaria. Many of these bacteria are opportunistic facultative pathogens, which are activated by an adverse environment, a debilitated host, or a primary pathogen. In sharp contrast, obligatory bacterial pathogens of finfish require the presence of fish for replication and are unable to survive alone for long in the aquatic environment. Most bacterial pathogens of fish are aerobic gram-negative rods. Diagnosis is by isolating the organism in pure culture from infected tissues and identifying the bacterial agent.

Stained Gram-positive bacteria viewed at high magnification



Stained Gram-negative bacteria viewed at high

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify bacterial infections of fish
- how to control bacterial infection of fish
- the best treatment.

3.0 MAIN CONTENT

3.1 Eye Disease

Fish are prone to developing bacterial infections in their eyes. Several different bacteria can grow and have devastating effects on a fish, as well as spread to the other fish in your aquarium. Luckily, many infections can easily be cured by adding medicated drops to your fish pond or tank. Eye diseases and infections in fish can be caused by a variety of factors, including fungus, bacteria, parasites, a kidney infection or a protozoan infestation. Fish can exhibit a variety of symptoms when suffering from an infection or bacterial disease. These include a cottony growth around the eyes, cloudiness in the eyes, eyes that appear to be popping out of socket and film on the eyes. Diagnosing the cause of the fish's eye ailment will depend on the symptoms. Cottony white growth around the eye is caused by a fungus and a cloudy iris is caused by bacteria. If the entire eye looks cloudy, it is a protozoan infestation, and if the eye appears to be popping out, it is kidney failure. A liquefactions infects the eyes of silver carp. The cornea of the eyes gets vascularized leading to opacity and complete necrosis and even mass mortality of fish has been recorded. Investigations have isolated Staphylococcus aureus from the affected eyes of diseases fish.

Treatment

A fungal infection is treated using sulfate drops, which you can administer to the tank water as directed. Other infections are treated with antibiotic drops, which also are administered to the water. The affected fish can be treated with other fish in the tank; the antibiotic drops will prevent the infection from spreading to them. Chloromycetin bath @ 8 - 10mg/L has been found effective in controlling the disease at an early stage. Disinfecting the environment with Potassium permanganate at a dose of 0.1 ppm followed by liming at 300 ppm check the disease. Ulcerative disease bilateral ulcerations of the opercula and the head in catfish are observed in ulcerative disease. In most cases, A. hydrophilic could be isolated, although several other bacterial forms were also present as secondary invaders.

3.2 Enteric Septicemia of Catfish (ESC)

ESC caused by the gram negative bacterium Edwardsiella ictaluri, is one of the most important diseases of farm-raised channel cat- fish (Ictalurus punctatus). ESC accounts for approximately 30 percent of all disease cases sub- mitted to fish diagnostic laboratories in the southeastern United States. In Mississippi, where channel catfish make up the majority of case submissions, it has been reported at frequencies as high as 47 percent of the yearly total. Economic losses to the catfish industry are in the millions of dollars yearly and continue to increase steadily with the growth of the industry. The disease was similar to another disease of catfish caused by the gram negative bacterium Edwardsiella tarda, but differed in several characteristics. ESC was described in a published account in 1979 and the causative bacterium was described as a new species in 198.1

Clinical signs and diagnosis

Behavior Catfish affected with ESC often are seen swimming in tight circles, chasing their tails. This head-chasing-tail, whirling behavior is due to the presence of the Edwardsiella ictaluri in the brain. Affected fish also sometimes hang in the water column with the head up and tail down. In addition, catfish with ESC tend to stop eating shortly after becoming infected.

External Signs (ESC) affected catfish frequently have red and white ulcers (ranging from pinhead size to about half the size of a dime) covering their skin (Fig. 1); pinpoint red spots (called petechial haemorrhages) especially under their heads and in the ventral or belly region (Fig. 2); and longitudinal, raised red pimples at the cranial foramen between the eyes (Fig. 3) that can progress into the hole-in-head condition. Internal build-up of fluid can lead to a swollen abdomen and exophthalmia (popeye) (Fig. 4).

Internal Signs

Clear, straw-color or bloody fluid is often present in the fish's body cavity. The liver typically has characteristic pale areas of tissue destruction (necrosis) or a general mottled red and white appearance (Fig. 5). Petechial hemorrhages can be found in the muscles, intestine and fat of the fish. The intestine is also often filled with a bloody fluid.
Treatment

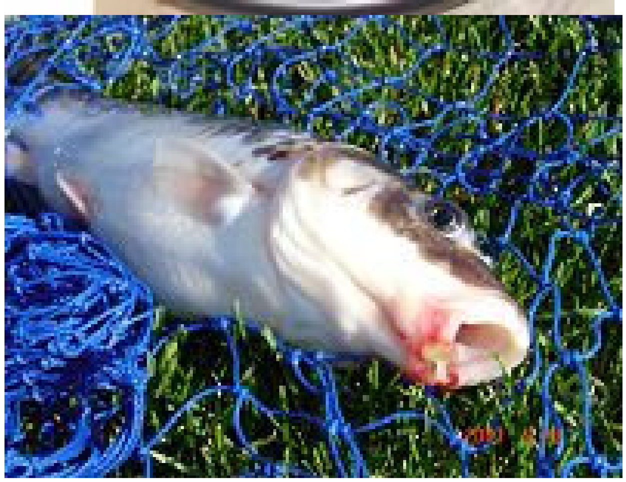
Treatment of ESC can be approached in a variety of ways. A good pond manager makes daily observations on feeding response, behavior and mortality, thus making an early diagnosis possible. Traditionally catfish infected with ESC are treated with feeds containing antibiotics. First, samples of sick fish should be submitted to a fish diagnostic laboratory for a complete diagnosis. The causative bacterium can then be isolated and tested for antibiotic sensitivity. Fish should be treated as soon as a diagnosis has been made because fish progressively reduce feed intake during an infection, making medicated feed treatments less effective.

3.3 Columnaris Disease

***Flexibacter columnaris* (Columnaris disease or Saddleback disease)**

Columnaris, first described by Herbert Spencer Davis in 1922, is one of the oldest known diseases of warm water fish. References tothe disease can be confusing. The causative bacterium has been referred to by different names including Bacillus columnaris, Flexibacter columnaris, Cytophaga columnaris, and most recently Flavobacterium columnare. Columnaris disease is the second leading cause of mortality in pond raised catfish in the southeastern United States. It is second only to enteric septicemia of catfish (ESC) caused by the bacterium Edwardsiella ictaluri. Most species of fish are susceptible to columnaris following some type of environmental stress and when water temperatures are in the upper part of their preferred temperature range. The disease commonly occurs in channel catfish when water temperatures are in the range of 25 to 32oC (77 to 90o F) in the spring, summer and fall.

Clinical signs or symptoms Fish with columnaris usually have brown to yellowish-brown lesions (sores) on their gills, skin and/or fins. The bacteria attach to the gill surface, grow in spreading patches, and eventually cover individual gill filaments (Fig. 1). This results in cell death. Portions of the gills are eroded by protein and cartilage-degrading enzymes produced by the bacteria. Skin lesions produced by columnaris initially are very shallow and may appear as an area that has lost its natural shiny appearance. More advanced lesions may be round or oval in shape, yellowish-brown in color, with an open ulcer in the center. A characteristic lesion produced by columnaris is a pale white band encircling the body, often referred to as saddleback condition (Fig. 2). As the infection progresses, a yellowish-brown ulcer often is found in the center of the "saddle." Additionally, it is not unusual to find a yellowish-brown, mucus-like growth of columnaris bacteria inside the fish's mouth (Fig. 3). The brownish coloration is usually due to mud and detritus particles trapped in the slime produced by the bacteria. When grown in the laboratory the bacteria produce a yellow pigment.



Gram negative slender rods (3-8 microns). The disease is a serious disease of young salmonids, catfish and many other fish. This is a highly communicable disease. Cause external lesions over the body surface. The causative organism has been identified as Flexibactercolumnaris. Lesions usually first appear as small white spots on the caudal fin and progresses towards the head. The caudal fin and anal fins may become severely eroded. As the disease progresses, the skin is often involved with numerous gray white ulcers. Gills are a common site of damage and may be the only affected area. The gill lesions are characterized by necrosis of the distal end of the gill filament that progresses basally to involve the entire filament. *Flexibacter columnaris* infections are frequently associated with stress conditions. Predisposing factors for Columnaris disease are high water temperature (25°C-32°C.), crowding, injury, and poor water quality (low oxygen and increased concentrations of free ammonia). *Flexibacter maritimus*: cause similar problems in salt-water environment. *Flexibacter psychrophilus* causes Cold Water Disease or Peduncle disease. Fish develop dark skin, hemorrhage at the base of fins, and anemia with pale gills with increase mucus. Hemorrhage into the muscles is common. Periostitis of cranial and vertebral bones is common in chronic cases. A chronic meningoencephalitis occasionally is observed with abnormal and erratic swimming.

Treatment for external columnaris infection includes treating the culture water with therapeutic chemicals legal for use on food fish. Potassium permanganate (KMnO4) is a commonly used therapy.

Terramycin®(100) premix(per ton of feed)	Concentration of Terramycin® (in finished feed)	Feeding rate of fish (percent body weight)
100 lbs 50 lbs. 25 lbs.	5.00 g/lb. 2.50 g/lb. 1.25 g/lb	100 lbs0.5 - 0.75 % 1.0 - 1.5 %. 2.0 - 3.0 %

3.4 Bacterial Gill Disease

Bacterial gill disease is caused by a variety of bacteria. *Flexibacter columnaris*, *Flexibacter psychrophilus*, *Cytophagy psychrophila* and various species of *Flavobacterium* (all are gram negative rods) are the primary bacteria involved in this disease. Fry are the most susceptible to the disease, however, all ages may be affected. Clinically the fish become anorectic, and face the water current. Prominent hyperplasia (mucus and epithelial) of the gills is evident on gross and microscopic examination. Microscopically one observes proliferation of the epithelium that result in clubbing and fusion of the lamella. Necrosis of the gill lamella occurs in serious cases. Overcrowding, accumulation of metabolite waste products (particularly ammonia), organic matter in the water, and an increase in water temperature may all be predisposing factors.

Topical application of potassium permanganate or short bath in 500ppm of Potassium permanganate has been found to be very effective in completely curing the disease.

3.5 Proliferative gill disease (PGD)

Proliferative gill disease (PGD) has become common in farm raised channel catfish. It can kill a few dozen fish over several days, or up to 100 percent of the fish in less than 3 days. Recurrence in the same pond is rare.. This disease causes catfish to suffocate because of the severe damage to the gills. Swelling and a red and white mottling of the gills gives them a raw hamburger appearance, and many refer to PGD as hamburger gill disease

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Proliferative Gill Disease (PGD)

Clinical signs and diagnosis

Proliferative gill disease occurs most often in the spring, but it can occur in the fall at water temperatures between 59 and 72o F (15 to 22oC). It sometimes occurs in winter; PGD mortalities have been reported at 43o F (6o C). Though the disease seldom occurs in the summer, deaths have been reported at 92oF (33o C). Even before the disease occurs, signs of PGD can be seen in gills viewed under the microscope. As with other diseases, a common early sign of a PGD outbreak is a reduction of feeding activity by the fish. As the disease progresses, the catfish congregate in the water flow behind an aerator or at incoming water. Fish may also swim listlessly at the water's surface and then lie in shallow water along the edge of the pond before they die. They may die even when dissolved oxygen concentrations are at levels high enough for healthy fish, because the affected gills cannot remove sufficient oxygen from the water. The skin of catfish affected with PGD appears healthy, and while PGD occasionally is found in internal organs (liver, kidney, spleen and brain), it primarily affects the gills. The gills swell and become mottled red and white in appearance, similar to raw hamburger meat. In advanced stages, the gill filaments do not lie flat and filaments on one gill arch are not distinct from filaments on other arches. The gills often look mashed and may bleed when touched or when the fish are simply lifted from the water.

Microscopic examination at 40X magnification reveals extreme swelling of the gills caused by an abnormally large number of cells at the outer edge of the gill filaments. These swollen areas often appear white. PGD causes swelling and red and white mottling of catfish gills, giving them a raw hamburger appearance. Some parts of the gill filaments look red because blood cells are pooled in ruptured or dilated capillaries. The gill filaments may become shorter and wider with rounded or squared tips. The cartilage supporting the gill filament appears as a dark gray band along the side of each filament and may have notches, breaks and gaps. These characteristics are also much more obvious when examined under 40X magnification than at higher magnifications, and are the best features for making an early, presumptive diagnosis. The lesions in the cartilage can be occupied by the parasite that causes PGD. Breaks and gaps in the filaments' supporting cartilage cause the gills to lose their well-defined structure and collapse onto each other, giving the mashed appearance. Parasite cysts are only occasionally seen in wet mounts under the microscope and appear as small, indistinct, round units. PGD diagnosis is confirmed by histology procedures where the parasite can be seen as a blue stained "cluster of grapes" in very thinly cut sections of gill tissue. Cause and disease course Most scientists believe that a sporozoan, probably the myxosporean parasite Aurantiactinomyxon sp., is the causative agent of PGD.

Evidence suggests that an oligochaete worm (Dero digitata) that lives in the mud and grows up to 1/2 inch in length is the invertebrate host. The PGD organism is thought to develop in the worm, which releases infective spores capable of penetrating and infecting the gills of channel catfish. Most parasites inflict less damage to their natural hosts, and mature spores are usually found in the host tissue. Most of the gill damage is thought to be caused by an inflammatory response of the fish to the parasite.

Following is a possible life cycle of PGD:

- Mature parasites (possibly Aurantiactinomyxon sp.) or an infective stage are released from the fish host.
- The invertebrate host (probably Dero digitata) becomes infected.
- The parasite develops in the invertebrate host.
- An infective stage of the parasite is released from the worm.
- This infective stage penetrates and infects the catfish gill tissue.

There has been an ongoing controversy among researchers and diagnostic workers about the occurrence of this disease in new ponds built or reworked within the last 3 years as compared with older ponds. Although PGD occurs in older ponds, it seems to appear more often in new ponds, perhaps because they support larger populations of Dero worms.

Treatment and prevention

Though no treatments or preventive methods for PGD have been scientifically validated, there are some treatments that appear effective. Since fish infected with PGD suffer gill damage and are less able to obtain oxygen from water, aeration should be used when dissolved oxygen concentrations are low or marginally low. Another option is to quickly harvest and process PGD infected fish. However, many fish may die during harvest and have to be discarded; those making it to the processing plant alive can be quickly processed and pose no danger to the human consumer.

3.6 Edwardsiellosis

It is a septicaemic disease affecting brood fish population. Edwardseilla tarda has been isolated from the diseases fish showing anaemia, cutaenous lesions and gas filled abscesses in the muscle.

***Edwardsiella tarda* (*Edwardsiella* septicemia).** Gram negative motile pleomorphic curved rod. The disease affects primarily channel catfish but also observed in goldfish, golden shiners, largemouth bass, and the brown bullhead. This organism is the most serious disease involving the eel culture of Asia. The lesions are similar to *A. hydrophila* with small cutaneous ulcers and hemorrhage observed both in the skin and muscle. Muscle lesions often develop into large gas filled (malodorous) cavities. Diseased fish lose control over the posterior half of their body yet continue to feed.

***Edwardsiella ictaluri* (Enteric septicemia of catfish).** Gram negative motile pleomorphic curved rod. Disease affects primarily fingerlings and yearling catfish. Clinical signs of enteric septicaemia of catfish closely resemble those of other systemic bacterial infections. The most characteristic external lesion is the presence of a raised or open ulcer on the frontal bone of the skull between the eyes (Hole in the head disease). Although treatment with idophor has been found to be effective, water quality improvement in the hatchery is the most essential component for keeping the disease away.

Enteric septicemia of catfish

3.7 Epizootic ulcerative syndrome (EUS)

Epizootic ulcerative syndrome (EUS) has become a matter of great concern not only among fisherman and fish farmers, but also among general public, entrepreneurs, administrators and planners. One common feature of the disease is that it initially affects the bottom dwelling species like murrels followed by catfishes, weed fishes and IMC. The lesions start as small grains to pea sized hemorrhagic spots over the body which ultimately turns into big ulcers of the size of a coin with greyish slimy central necrotic areas surrounded by a zone of hyperemia. The disease affects to such an extent that they starts rotting while still alive and eventually die. A number of bacteria viz.A. hudrophila, A. punctata, Flavobacterium sp., Pseudomonas sp., Edwardsiella tarda, Vibrio parahaemlyticus and Streptococcos sp. have been isolated from the affected specimens.

3.8 Vibrio

Gram negative rod lives primarily in a marine environment, *Vibrio* septicemia: *V. alginolyticus* / *V. anquillarum* / *V. Salmonicida.* Septicemia has similar lesions to *Aeromonas hydrophila*. See hemorrhage in the skin of the tail and fins, ulceration of the skin, hemorrhage in the muscles and serosal surfaces. The spleen may be enlarged and bright red. Histologically may see necrosis of the liver, kidney, spleen and occasionally the gut mucosa. Ulcer Disease of Damselfish: *V. Damsel*, Deep skin ulcers and necrotizing myositis. Lesions similar to *Aeromonas salmonicida*. *Vibrio salmonicida*: Hitra disease or Cold water vibriosis. Histopathological studies revealed complete loss of epidermis in the ulcerative area of the skin where the dermis and hypodermis showed characteristic granulomatous changes. Besides bacteria, virus, fungus and parasites were also reported to be associated with EUS.

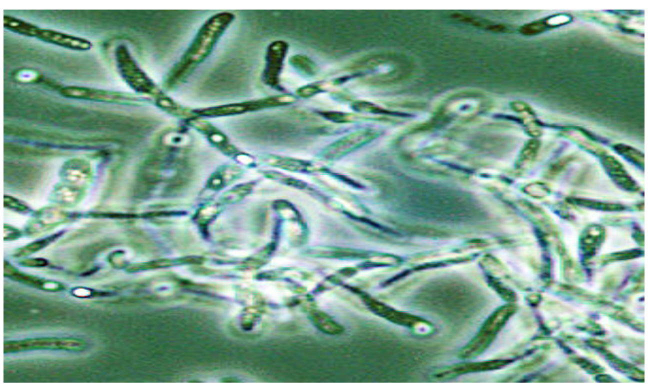
The eyes and fins caused by a bacterium called vibrio

Many antibiotics, sulfonamides, chemicals herbal preparations etc. have been advocated as preventive and curative measures. Lime was accepted widely among fish farmers of the country until the formulation of CIFAX, therapeutics developed by Central Institute of Freshwater

Aquaculture (CIFA). Marked improvement of the ulcerative condition is noticed within seven days of application of the medicine and the ulcers are healed up within 10 -14 days.

Streptococcus iniae

Beta-hemolytic *Streptococcus* (Note: Beta hemolysin may not be present in culture media in all cases leading to the possible believe that this bacteria is a non-pathogen.). Disease of tilapia, hybrid striped bass and rainbow trout. Major problem in the tilapia industry. *Streptococcus iniae* presents either as an acute fulminating septicemia or in a chronic form limited primarily to the central nervous system. The septicemic form may present with hemorrhage of the fins, skin, and serosal surfaces. Ulcers may appear. Microscopically, one observes a meningoencephalitis, polyserositis, epicarditis, myocarditis and/or cellulitis. Cocci/diplococci are present in the inflammation. In the chronic form, granulomas or granulomatous inflammation are evident in the liver, kidney, and brain (meningoencephalitis). In the chronic disease, the brain is the best organ to culture. *Streptococcus iniae* is a problem primarily of closed recirculating culture system. Probably associated with overcrowding and poor water quality - high nitrates. Depopulation, disinfection and restocking with disease free fish are the best means of elimination of the organism. The bacteria is known to be a zoonotic agent. Individuals who have handled infected fish have developed cellulitis of the hands and endocarditis.



Streptococcus iniae infection in aquaculture

***Mycobacterium* species (Tuberculosis)**

Gram positive, acid fast rods (*M. marinum*, *M. chelonei* and *M. fortuitum* are the most common *Mycobacterium* species involved.). All species of fish are affected. This disease affects both saltwater and freshwater aquariums as well as fish raised for food (up to 10 to 25% of pen raised fish). Clinical signs of tuberculosis are quite variable. The most common signs are anorexia, emaciation, vertebral deformities, exophthalmus, and loss of normal coloration. Numerous variably sized granulomas are often observed in various organs throughout the body. Often numerous acid fast bacteria are observed in the granulomas. The aquatic environment is believed to be the source of initial infection with fish becoming infected by ingestion of bacterial contaminated feed or debris. Once an aquarium is infected with this disease, it is difficult to remove except by depopulation of the aquarium and disinfecting the tank. This is a zoonotic disease (atypical mycobacteriosis). Atypical mycobacteriosis may manifest itself as a single cutaneous nodule on the hand or finger or may produce a regional granulomatous lymphadenitis of the lymphatics near the original nodule. Occasional local osteomyelitis and arthritis may also occur.

***Flavobacterium* sp**

Gram- negative rods bacteria. Usually a problem for individual fish. This disease is a cause of concern to primarily hobbyist and producers of ornamental fish. (Mollie granuloma, Mollie madness, Mollie popeye). Infected fish are usually emaciated and pale. Multifocal white nodules are observed in the visceral organs, the retina and choroid and the brain. These nodules may be cystic or mineralized. Histologically the nodules are granulomas with a caseous center, a thin peripheral rim of macrophages and lymphocytes and a fibrous capsule.(Must be differentiated from Mycobacterium). The mode of transmission is unknown.

***Epitheliocystis* (Chlamydial infection)**

Obligated intercellular parasite. Organisms stain red with Macchiavello stain. These organisms have been observed in many species of fresh water and marine fish. Mortality occurs most commonly in heavily infected juvenile fish. Clinically infected fish may be asymptomatic or show respiratory distress or excessive mucus secretions. Multiple white cysts are observed on the gill lamella and skin. Histologically, the cyst consists of distended epithelial cells with numerous basophilic organisms. The means of transmission is unknown.

4.0 CONCLUSION

Most bacterial pathogens of fish are aerobic gram-negative rods. Diagnosis is by isolating the organism in pure culture from infected tissues and identifying the bacterial agent.

5.0 SUMMARY

Most bacterial fish pathogens, suchas *Aeromonas*, *Pseudomonas, Vibrio, Flavobacterium* and *Cytophaga* are Gram-negative bacteria. These are the bacteria that are usually involved with bacterial disease such as ulcers, fin rot, acute septicaemia and bacterial gill disease. Less common pathogens are *Mycobacterium* and *Norcardia sp.* which causes chronic granulomas (or abscesses). While gram negative motile rods effects many freshwater species and usually is associated with stress and overcrowding.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are gram positive and negative bacterial effects on fish?
2. Describe vibrio infection in fish and its control.
3. Outline the possible life cycle of PGD

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UNIT 4 PROTOZOAN DISEASES

CONTENTS

1.0 INTRODUCTION

The most common parasites of fish are protozoa. These include species found on external surfaces and species found in specific organs. Most protozoa have direct life cycles, but the myxosporidia require an invertebrate intermediate host. There are two main types of protozoan- ciliated and flagellated protozoan. Ciliated protozoa are among the most common external parasites of fish. Most ciliates have a simple life cycle and divide by binary fission. Ciliates can be motile, attached, or found within the epithelium. The most well-known organism in the latter group is Ichthyophthirius multifiliis , which has a more complex life cycle than the other ciliates. Ichthyobodo (Costia) spp are some of the most common and smallest (~15 × 5 µm) flagellated protozoan parasites of the skin and gills. They are flattened, pear-shaped organisms with 2 flagellae of unequal lengths. Ichthyobodo moves in a jerky, spiral pattern, and free-swimming organisms are fairly easy to identify in direct smear preparations. Once attached, the organism can be difficult to see and is often missed by the novice, but movement typical of a flickering flame is characteristic.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the common fish parasites caused by protozoan
- identify infections due to protozoan in fish
- explain the various methods of control and treatment.

3.0 MAIN CONTENTS

Protozoan Diseases and their Control.

3.1 Ichthyophthiriasis (Ich)

Ich is a common name for the parasite Ichthyophthirius multifiliis and the disease that it causes. The parasite is capable of killing large numbers of fish in a short period of time. Early diagnosis and treatment are essential for controlling Ich and reducing fish losses. Prevention of this disease is, of course, the best method of avoiding fish mortalities.

The white spot disease or Ichthyophthiriasis is a common disease of freshwater fish. Affected fishes exhibit minute white nodular spots on the skin, fins and gills and are restless. The most common symptom of freshwater ich (***Ichthyophthirius multifiliis***) is the presence of small white spots (trophonts) on the body. Actually, these "white spots" are thickened masses of protective mucus that have covered the attacking protozoan in an attempt to dispel it. Additional symptoms include rapid breathing, cloudy eyes, possible fin deterioration and flashing. The life cycle of ich includes a host organism and the environment. The trophont is the encysted feeding stage of the parasite which enlarges, breaks through the epithelium and eventually settles on the bottom of the aquarium. When on the bottom of the aquarium, the organism, which is now referred to as a tomont, begins to undergo mitosis (cell division) and produces hundreds of ciliated theronts. If the theronts encounter a host fish, they will attach, penetrate and enlarge (and therefore be visible to the aquarist as white spots).

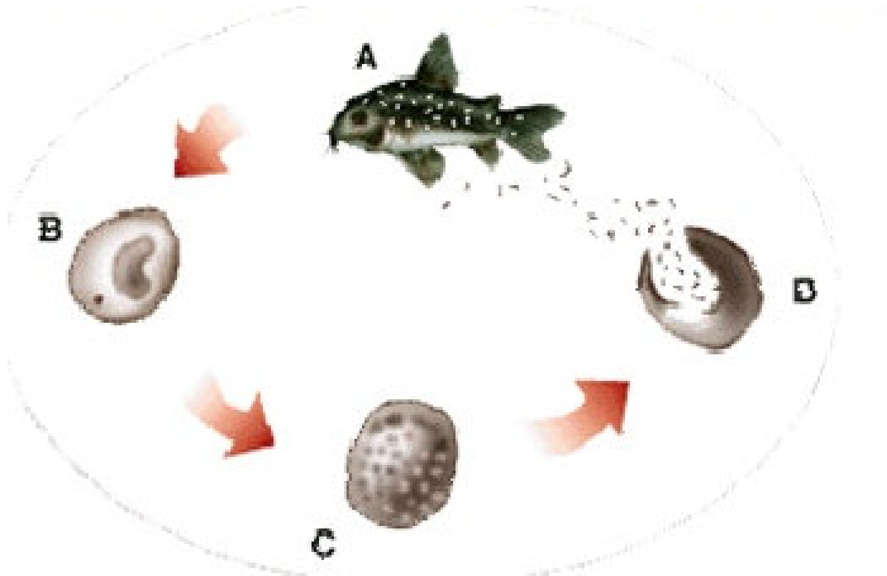
The most common form of freshwater fish disease is Ichthyophthiriasis or "Ich," an affliction characterized by small, white pustules resembling pimples or grains of salt which concentrate mostly on the fish's fins. Regrettably, Ich is much easier to diagnose than it is to treat. Ich is, essentially, a form of parasite which attaches itself to the outer body of a fish in the form of pustules. Eventually, the pustules expand and drop off, floating to the bottom of the aquarium where they dig into the gravel or rock and multiply. If left to their own devices, the parasites will then be able to multiply enough to reattach itself on every fish in the tank.

Identification of Ich

Fish infected with Ich may have white specks on their skin as though they were sprinkled with salt (Fig. 1). Because of this appearance, Ich is sometimes called white spot disease. The skin of the fish may also look bumpy. Mature forms of the parasite are large (up to 1 mm or 1/32 inch across) and can be seen without magnification. Ich often causes the fish to have large amounts of mucus sloughing off of their skin, an appearance which may resemble fungus when viewed from a distance in the water. Many times, however, the only indication of Ichs presence may be dead and dying fish. In some Ich cases the parasite may be present only on the gills and not on the skin.

Fish with Ich may be observed making quick rubbing or scratching movements on objects or on the pond bottom. This behaviour is sometimes called flashing because of the quick and sudden exposure of the fish's light-colour belly as it rolls during erratic movements. Trout have been observed flashing at the water surface, appearing as though they are striking at insects. In the final disease stages, Ich-infected fish also may appear lethargic and sometimes gather around inflowing water. Infected fish usually refuse to eat. Under the microscope, Ich appears as a sphere that changes shape and moves around in a rolling motion, using tiny hairs called cilia that totally cover the parasite. Its method of motility is often compared to that of an amoeba. The center of the adult organism has a C-shaped nucleus (Fig. 2).

The small infective stages do not have the C-shaped nucleus, and they move in the water rigidly, as opposed to the fluid, rolling movement of the adult. In advanced stages of infection, Ich is found burrowed under the mucus and top layer of cells (epithelium) in the fish's gills or skin. After burrowing, Ich is very hard to treat because of the protective layer of mucus and host cells covering the parasite. Prompt treatment is important to help prevent the establishment of an advanced infection.



The protozoa: Ichthyophthiriasis multifilis
A = The trophozoites in the host's skin
B = Trophont leaving the host.
C = The mature trophont with hundreds of maturing tomites
D = The releasing of tomites that penetrate the skin of the host fish
A = The cycle continues all over again.
Treatment

Because not all stages in the life cycle of Ich are affected by treatments, multiple treatments must be administered to catch individual Ich organisms in the vulnerable stages of their life cycle. For example, during the first day when a chemical is added to the water to kill Ich, only a certain percentage of Ich organisms will be susceptible to the chemical. Two days later many of the surviving Ich organisms, which were embedded in the skin, will be entering the vulnerable stage of their life cycle; chemical treatment on this day will kill these susceptible organisms. In order to catch all the Ich organisms in a treat- able stage, from three to seven treatments might be needed (Table 1) depending on water temperature. This parasite can be controlled by hourly bath treatment for 7 days in 2-5% NaCl solution. Pond treatment advocated is application of 15-25mg/L formalin. Malachite green and formaldehyde do not penetrate and kill the trophonts, but instead prevent the motile trophonts from re-infecting the fish.

Treatment effectiveness should be evaluated by a fish health professional after the third treatment to decide whether to continue with the treatment schedule. Mortality rates should be observed, and samples of fish from the infected pond should be examined for Ich under a microscope.

Preventing ich

Ich is a very common disease and if your fish get it, you are going to end up having to treat the entire tank. Therefore, it is a much easier disease to prevent than treat, and the following is a list of suggestions for helping to prevent ich in your tank:

Only purchase healthy fish that are free of all signs of disease.
Never buy fish from a tank that contains a dead or a diseased fish.
Always place new fish in a proper quarantine tank for a minimum of two weeks before introducing them into your tank.

Never buy plants from a source that keeps them in a fish tank with fish. If you do, make sure to quarantine your plants for at least 4 days.
Purchase fish from as direct a source as possible to reduce shipping and handling stress.

Remove to a quarantine tank and treat any fish that begins to show the first signs of ich.

Avoid any fluctuations in temperature, pH, or ammonia levels as these are all very stressful to fish and can result in an outbreak of ich.
Always feed a variety of properly stored food including freeze dried, frozen, and flaked.

Do not overstock your tank. Most tanks have too many fish and not enough cover which leads to stress, disease, and increased mortality.
Maintain excellent water quality and do regular water changes.
While ich may be the most common disease in aquarium fish, it does not have to infect your tank. By following these preventive guidelines and promptly treating any infected fish, you can greatly reduce the damage that can be caused by this deadly disease.

Trichodoniasis
Various life stages of IMC and cat fishes are affected by the parasites. The causative agents are urecolariid ciliate species of the genus

Trichodina, Tripartiella and *Trichodinella*. They attach to the fish gills by means of adhesive disc constituted by skeletal elements. The treatment methods adopted are water quality improvement, diminishing stocking density of fish, bath treatment of fishes with 2-3% NaCl or 50mg/L $KMnO_4$ and pond treatment with 5 mg/L $KMnO_4$ or 25 mg/L formalin.

Coastiasis
Heavy infestations of the genus *Coastia (Ichthyoboda)* causes the disease. It infests the gills and external surfaces of all species of fresh water fishes and is reported to proliferate at low temperature (25^0c). The affected fishes show greyish white shade on the body surface. These parasites are controlled by bath treatment of fishes with 2-3% Nacl or 50 mg/litre $KMnO_4$ and pond treatment with 5mg/litre KMno4 or 5mg/litre formalin.

3.2 Myxosporean disease

Myxosporidia are one of the most important groups of pathogens capable of producing diseases in fish causing heavy loss on the juvenile. Myxobolus cysts of varying sizes have been reported on the gills and kidneys of fish. Larger cysts are located at the distal end of the gill filament whereas smaller ones are seen at the proximal end. Infections damage the respiratory surface of the gill and excretory tubules of the kidney. Diagnosis of the disease can be made on the basis of gross appearance of the pin head sized greyish cysts and large number of myxosporidian spores under the microscope.

3.3 Helminthic parasites

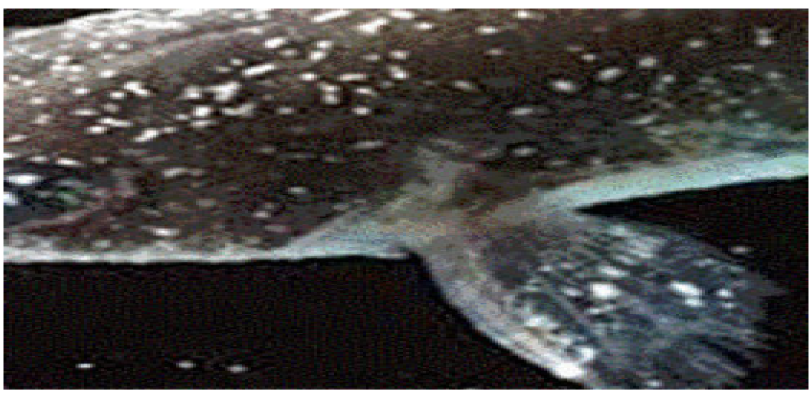
Dactylogyrosis and Gyrodactylosis
Fishes are infected on their gills and skin by monogenetic and digenetic tremetodes. The important monogenetic species belong to gyrodactylus (Skin fluke) and dactylogyrus (Gill fluke). They remain attach to the skin (gyrodactylus) and gills (dactylogyrus) by the help of anchors which causes wounds. Their presence cause hyper secretion of mucous and haemorrhage from blood capillaries. These wounds later get infected with pathogenic bacteria and fungi. Alternate bath in 1:2000 acetic acid solution followed by bath in 2% sodium chloride solution has been found effective. Some workers have advocated dip treatment in 5% solution followed by a bath in 1:5000 formalin.

3.4 Black spot disease

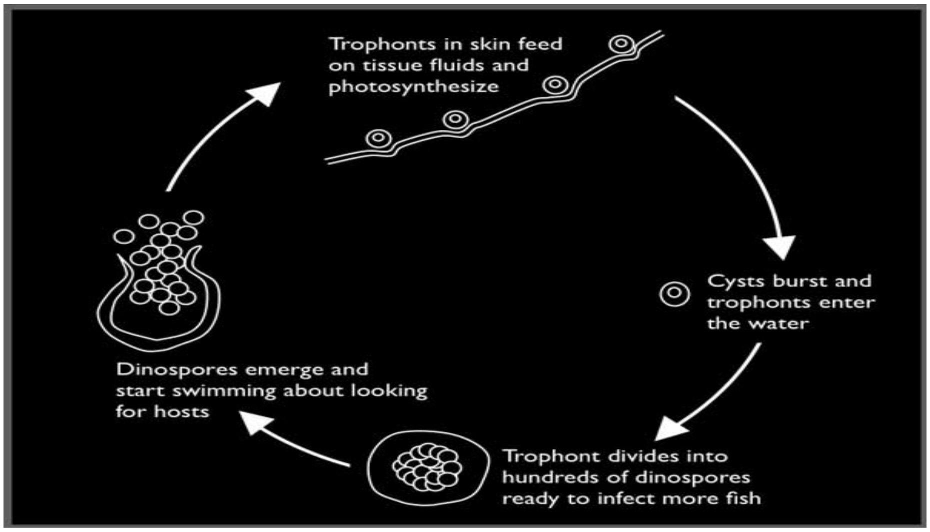
The digenetic trematodes generally infect the alimentary canal, but are rarely harmful. However, in the metacercarial stage they are harmful as they get encysted in any part of the body. I.e. skin, muscle, abdominal cavity, liver ,eyes, and brain. In these cases fish serves as intermediary host, while the final host is generally a fish eating bird. In many carp fingerlings the black spot disease is due to metacercaria of Diplostomatidae.

3.5 Velvet

Velvet disease in freshwater fish is caused by the protozoan Piscinoodinium. The velvet parasite is classified as parasitic algae because it contains chlorophyll and therefore obtains some of its food through the chlorophyll. For this reason, it is often suggested to darken your tank if your fish exhibit a velvet outbreak, as chlorophyll requires visible light to survive. Velvet-infested fish exhibit small yellowish spots that are much smaller than ich spots. Similar to fish infested with ich, fish with velvet may exhibit clamped fins, and they may flash off of rocks and other surfaces in an attempt to dislodge the parasites. If the gills are affected, the fish may exhibit rapid respiration or gasp for air at the surface.



The velvet parasite has two life stages: a free-swimming form and a cyst form. The infective stage of this parasite is the free-swimming stage. During this stage, the velvet parasite has two flagella that enable it to propel itself through the water. It propels itself through the water until it finds a suitable host. Then it will attach itself to the skin or gills of the fish. Eventually, the parasite will form a cyst on the fish, which will remain on-site until it releases several hundred free-swimming Piscinoodinium. These newly released Piscinoodinium go in search of another host, and the cycle begins again. For this reason, velvet is very contagious.



Freshwater velvet life cycle

Fortunately, there are effective treatments for velvet. Copper sulfate appears to be the best treatment. The only downside to using copper sulfate in the pond is that it will kill any invertebrates, such as snails and shrimp. In addition, it is very important not to overdose with copper sulfate, as this compound can easily poison and kill fish. Consequently, once the copper-sulfate treatment is completed, gradually change the water to remove all traces of it. The positive side to using copper sulfate is that it will also kill the ich parasite if it is present. Consequently, you don't need to distinguish between both parasites. Copper sulfate gets rid of all external fish parasites. Keep in mind that only the free-swimming form of the velvet parasite is affected by the copper sulfate - the encysted stage is not vulnerable to treatment. Another alternative is the use of products with acriflavine as an active ingredient; however, it may cause infertility.

4.0 CONCLUSION

Most bacterial infection of fish can be controlled and treated with common chemicals. Chemical like copper sulfate is used in the pond will kill any invertebrates in the pond. Care must be taken to isolate the disease fish for treatment.

5.0 SUMMARY

Ich is a common name for the parasite Ichthyophthirius multifiliis and the disease that it causes. The parasite is capable of killing large numbers of fish in a short period of time. Myxosporidia are one of the most important groups of pathogens capable of producing diseases in fish causing heavy loss on the juvenile. Velvet disease in freshwater fish is caused by the protozoan Piscinoodinium. The velvet parasite is classified as parasitic algae because it contains chlorophyll and therefore obtains some of its food through the chlorophyll.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe 2 protozoan disease and their control measures.
2. Ich is common fish protozoan disease discuss.
3. How will you control or manage ciliated protozoan disease in fish?

7.0 REFERENCE/FURTHER READING

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UNIT 5 FUNGAL FISH DISEASES AND CONTROL

CONTENTS

1.0 INTRODUCTION

Fungi are a group of organisms called heterotrophy that require living or dead matter for growth and reproduction. Unlike plants, they are incapable of manufacturing their own nutrients by photosynthesis. Fungi are present everywhere--in saltwater or fresh water, in cool or warm temperatures. In most cases, fungi serve a valuable ecological function by processing dead organic debris. However, fungi can become a problem if fish are stressed by disease, by poor environmental conditions, receive poor nutrition, or are injured. If these factors weaken the fish or damage its tissue, fungus can infest the fish. All fungi produce spores--and it is these spores which readily spread disease. The fungal spore is like a seed which is resistant to heat, drying, disinfectants and the natural defense systems of fish. The three most common fungal diseases are discussed here. They are known as Saprolegniasis,

Branchiomycosis, and Ichthyophonus disease.
Fungal diseases are the fourth type of infectious disease. Fungal spores are common in the aquatic environment, but do not usually cause disease in healthy fish. When fish are infected with an external parasite, bacterial infection, or injured by handling, the fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cottony growth or may appear as brown matted areas when the fish are removed from the water. Formalin or potassium permanganate is effective against most fungal infections. Since fungi are usually a secondary problem it is important to diagnose the original problem and correct it as well.

2.0 OBJECTIVES

- to have knowledge of fungal infection in fish
- to understand the effect of fungal infection on fish
- to know how to control and treat the infected fish.

3.0 MAIN CONTENTS

Fungal Diseases

The disease is characteristic white, cotton-like growth of fungus on the skin or fins of infected fish. Known as Saprolegnia sp., this fungus readily invades stressed freshwater fish, but is not known to affect decorative fishes. Signs of fungal infection in fish are therefore less dramatic and often difficult to distinguish. *When* present, the fungus appears on fishes as a fine film, dark pigmented areas, or a coating covering areas of the body or gills. This coating can easily be confused with similar signs that are caused by the presence of various types of parasites.

3.1 Saprolegnia sp

Saprolegniasis is a fungal disease of fish and fish eggs most commonly caused by the *Saprolegnia* species called "water molds." They are common in fresh or brackish water. *Saprolegnia* can grow at temperatures ranging from 32° to 95°F but seem to prefer temperatures of 59° to 86°F. The disease will attack an existing injury on the fish and can spread to healthy tissue. Poor water quality (for example, water with low circulation, low dissolved oxygen, or high ammonia) and high organic loads, including the presence of dead eggs, are often associated with *Saprolegnia* infections.

Among the most common and most easily diagnosed fish "diseases" is saprolegniosis. This is a fungal invader that reveals itself with a profusion of white, gray, green or brown cottony tufts protruding from the fish's skin. It can appear anywhere on the fish.

Saprolegnia parasitica infection in the fry and fingerlings of major carps is one of the main problems affecting health of fishes. The disease in fish is characterized by a white to brown cotton like growth consisting of colonies of mycelium and filaments which appear as small to large patches on various parts of the body like fins, gills, mouth, eyes or muscle. The infection starts due to netting injury and overcrowding or lesions caused by other diseases. Saprolegniosis in fish is primarily caused by one of three genera of aquatic fungi; ***Saprolegnia*** spp.

Achlya spp. or ***Dictyuchus*** spp. All their basic characteristics are virtually identical (even fungi specialists have trouble sorting them out), so it's best to think of them as a single fungal invader.

These fungi are found in all freshwaters worldwide and are always present in some form. Healthy fish easily control this fungus disease. The outer slime coat that covers a fish's skin acts as a shield against fungal invasion. However, when fish are physiologically stressed or when they are battling some bacterial or parasitic disease they become susceptible to fungal invasion. In this respect, Saprolegniosis is not a primary disease, but becomes a disease problem after some other serious health problem exists. Once saprolegniosis takes hold it can pose a much greater risk to the host fish than the initial disease. The fungi spread vegetatively below the host's skin tissues, and underlying muscles, flesh and bone are exposed as the dead skin drops away.

Disease Signs

Saprolegniasis is often first noticed by observing fluffy tufts of cotton-like material--coloured white to shades of grey and brown--on skin, fins, gills, or eyes of fish or on fish eggs. These areas are scraped and mounted on a microscope slide for proper diagnosis. Under a microscope, Saprolegnia appears like branching trees called hyphae. With progression of infection fish usually becomes lethargic and less responsive to external stimuli. So fish under such conditions is a target to predators.

Management and Control

Saprolegniasis is best prevented by good management practices--such as good water quality and circulation, avoidance of crowding to minimize injury (especially during spawning), and good nutrition. Once *Saprolegnia* is identified in an aquatic system, sanitation should be evaluated and corrected. Common treatments include potassium permanganate, formalin, and povidone iodine solutions. Over treatment can further damage fish tissue, resulting in recurring infections. Environmental management is essential for satisfactory resolution of chronic problems. Bath treatment in NaOH (10-25g/lit for 10-20min), KmNO4 (1g in 100lit of water for 30-90 min), CuSO 4 (5-10g in 100 lit water for 10- 30min).

Treatment of fungal infections of the body and gills involves the use of various fungicides available commercially. Malachite green and methylene blue have been used successfully to control fungal infections in decorative fish. Various drugs are also useful for controlling both fungal and bacterial infections. Since fungus is a secondary invader, treatment methods must also address the initial cause of the disease, including trauma induced by deteriorated water quality, poor nutrition, or poor handling of the fish.

3.2 Branchiomycosis

Branchiomyces demigrans or "Gill Rot" is caused by the fungi *Branchiomycessanguinis* (carps) and *Branchiomyces demigrans* (Pike and Tench). Branchiomycosis is a pervasive problem in Europe, but has been only occasionally reported by other countries fish farms. Both species of fungi are found in fish suffering from an environmental stress, such as low pH (5.8 to 6.5), low dissolved oxygen, or a high algal bloom. *Branchiomyces* sp. grow at temperatures between 57° and 95°F but grow best between 77° and 90°F. The main sources of infection are the fungal spores carried in the water and detritus on pond bottoms.

Disease Signs

Branchiomyces sanguinis and *B. demigrans* infect the gill tissue of fish. Fish may appear lethargic and may be seen gulping air at the water surface (or piping). Gills appear striated or marbled with the pale areas representing infected and dying tissue. Gills should be examined under a microscope by a trained diagnostician for verification of the disease. Damaged gill tissue with fungal hyphae and spores will be present. As the tissue dies and falls off, the spores are released into the water and transmitted to other fish. High mortalities are often associated with this infection.

Management and Control

Avoidance is the best control for Branchiomycosis. Good management practices will create environmental conditions unacceptable for fungi growth. If the disease is present, do not transport the infected fish. Great care must be taken to prevent movement of the disease to non-infected areas. Formalin and copper sulphate have been used to help stop mortalities; however, all tanks, raceways, and aquaria must be disinfected and dried. Ponds should be dried and treated with quicklime (calcium oxide). A long term bath inAcriflavine Neutral or Forma-Green for seven days helps this condition. Ponds should be dried and treated with quicklime (calcium oxide) and copper sulphate (2-3kg / ha). Dead fish should be buried.

3.3 Ichthyophonus Disease

Icthyophonus disease is caused by the fungus, *Icthyophonus hoferi*. It grows in fresh and saltwater, in wild and cultured fish, but is restricted to cool temperatures (36° to 68°F). The disease is spread by fungal cysts which are released in the faeces and by cannibalism of infected fish. If a fish appears lethargic and exhibits a loss of equilibrium, it may have a fungal disease: Ichthyophonus. Most cases of dropsy are fatal. Although Ichthyophonus fungi are generally considered a fungal disease of marine fish, it does show up in freshwater fish from time to time. Infected fish become lethargic, and if the brain is infected, they may exhibit a loss of equilibrium as well as staggered movements. there is no treatment for this fungal infection, but fluconazole, which is a relatively new antifungal agent active against Saprolegnia fungi, may also be affective against Ichthyophonus fungi. Fluconazole should be administered at the rate of 6 mg/L (22.6 milligrams per gallon) daily for five consecutive days. If there is no improvement over the course of two weeks, you might consider euthanasia.

Disease Signs

Because the primary route of transmission is through the ingestion of infective spores, fish with a mild to moderate infection will show no external signs of the disease. In severe cases, the skin may have a "sandpaper texture" caused by infection under the skin and in muscle tissue. Some fish may show curvature of the spine. Internally, the organs may be swollen with white to grey-white sores. Diseased fish shows curious swinging movements hence the disease is called as swinging disease. Along with liver, particularly severely affected organs are:- spleen(salmonids), heart(herring), kidney(salmonids), gonads, brain(salmonids), gills(salmonids), and musculature and nerve tissue behind the eyes(sea fish).

(Adopted from Fish pathology by Reichenbach-Klinke's)

Management and Control

There is no cure for fish with *Icthyophonus hoferi;* they will carry the infection for life. Prevention is the only control. To avoid introduction of infective spores, never feed raw fish or raw fish products to cultured fish. Cooking helps destroy the infective life stage. If Icthyophonus disease is identified by a trained diagnostician, it is important to remove and destroy any fish with the disease. Complete disinfection of tanks, raceways, or aquaria is encouraged. Ponds with dirt or gravel bottoms need months of drying to totally eliminate the fungus.

4.0 CONCLUSION

Aquatic fungi often are considered secondary tissue invaders that follow traumatic injuries, infectious agents, or environmental insults such as poor water quality. Because many fungi grow on decaying organic matter, they are especially common in the aquatic environment. Fish egg masses, which usually contain tissue debris and dead ova or embryos, are especially vulnerable.

5.0 SUMMARY

Fungal diseases are often indicative of a more serious problem. Saprolegniasis is a common fungal disease which affects the external surfaces of fish. It can be eliminated easily after the primary cause of illness has been identified and corrected. On the other hand, Branchiomycosis, a relatively new problem and has caused high mortalities in cultured fish, and is difficult to control. Ichthyophonus disease is a systemic fungal disease and once it enters the fish, there is no cure. The best control for all fungal infections is good management: good water quality, good nutrition and proper handling.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe Ichthyophonus Disease and how it can be managed.
2. Explain the disease signs of branchiomycosis.
3. Explain how you will manage and control Saprolegniasis in fish

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UNIT 6 VIRAL FISH DISEASES AND CONTROL

CONTENTS

1.0 INTRODUCTION

What Is a Virus?

Viruses are very small infectious agents that multiply only within the living cells of an animal or plant host. Other microorganisms, such as bacteria or fungi, have organelles for their own metabolism, but viruses do not. They must utilize the machinery of the infected host cell for growth and reproduction. A virus has two parts. The internal part is the virion, or virus particle which is composed of nucleic acid, the same material that makes up genes. The virion is enclosed in an external protein coat called a capsid. Viruses are broadly categorized by the type of nucleic acid they contain; the two basic types of nucleic acid are RNA (ribonucleic acid) and DNA (deoxyribo-nucleic acid). Virologists also classify viruses by their shape, for example, "icosahedral" viruses have 20 sides, and "helical" particles are rod shaped.

3.0 MAIN CONTENTS

3.1 Detection of Viral Diseases

Because they are so small, viruses are often difficult to detect. Parasites, bacteria, or fungi are easier to detect than viruses, so diagnosticians first check to see if these other organisms are the cause of a specific disease before considering the possibility that a virus is responsible. Three techniques are used for initial identification of a virus. First, electron microscopy (EM) is used to visualize virus particles within tissue cells. Second, an effort is made to grow the virus in the laboratory using established cell-lines, which are living cells grown in vitro, literally "in a glass," outside of a living organism by feeding them special nutrients. This technique is referred to as cell culture, and cells from specific fish are used for growth of specific viral agents. Finally, identification of the virus is confirmed using serology, in which serum (part of the blood) from animals known to be infected with the virus is tested for its ability to "recognize" the suspected virus; this confirms that the virus in the animal's body is the same as the virus that has been isolated in the laboratory.

Viruses are often both species-specific and tissue-specific. This means that they may only grow in certain types of cells from certain animals. This can make it difficult to isolate viral agents from many fish because there may not be a commercially available cell-line for an individual fish species.

Management and Control of Viral Diseases

Viral diseases cannot be controlled with medication because they use the host's own cells for reproduction and survival. It is therefore prudent to provide "good nursing care" for fish suspected of having a viral infection so that their own natural defense mechanisms can work to eliminate infected cells. This involves maintaining excellent water quality, feeding fish a high quality diet, maintaining clean facilities, and keeping sick or potentially infected stock separate from all other animals. Equipment, boots, and hands should be washed with a disinfectant after either handling or being close to potentially infected stock. Chlorine bleach is an excellent virucidal agent and can be used to disinfect equipment. Concentrations of 10 mg/l for one hour will kill most infectious. When using bleach, however, it is imperative to keep in mind that it is extremely toxic to fish. Residual chemical or strong fumes are lethal to fish. An alternative to bleach is quaternary ammonium compounds. They are effective virucidal agents and can be used to disinfect equipment; they also are suitable for use as a foot bath. Although quaternary ammonium compounds are not as toxic to fish as chlorine, all items must be thoroughly rinsed before being placed in contact with live fish. Before introducing new fish into established breeding populations, a three- to four-week quarantine period should be observed. It is not realistic to design the quarantine period to prevent introduction of viruses because so little is known about viral diseases of fish. Instead the quarantine period should be designed to prevent the introduction of bacterial and parasitic diseases. Methods to accurately identify specific viral diseases of fish are lacking. There is no means of screening fish which may be carrying suspected viral diseases, no way of determining whether or not they may serve as a source of infection to other fish, or how long they may remain infectious. Development of quarantine strategies that are effective against viruses will require answers to each of these questions before reasonable prevention or avoidance recommendations can be made. For many infectious diseases of fish there is a temperature range where the level of sickness and death in a population is most severe. For example, channel catfish virus disease generally causes most severe losses when water temperatures reach or exceed 25°C (77°F). Under experimental conditions, mortality rate decreased dramatically when water temperature was lowered from 28°C (82°F) to 19°C (66°F). For species which are reared in temperature-controlled environments, manipulation of environmental temperature as a means of minimizing the impact of viral disease is worth pursuing.

Vaccination

Although vaccination is used routinely to prevent viral diseases in humans and domestic mammals, it is not widely used in fish medicine.
Vaccine development is extremely expensive and there are only a few viral diseases of fish which have sufficient economic impact to warrant investment in vaccine development. Also, because fish are cold-blooded animals, their immune response to a vaccine is not as predictable as that of warm-blooded animals, and therefore more frequent vaccination may be needed. At present, vaccines used in aquaculture are primarily used in salmonid production and most commercial vaccines have been developed for protection of fish from common bacterial agents. Vaccines are administered by injection or by immersion bath. An oral vaccine has been developed for use in channel catfish to prevent bacterial disease, however, to date; its use has been limited.

Viral Diseases

The major virus common among freshwater fishes and relatively easy to identify from the lesions it produces is lymphocystis. The disease is chronic, meaning that in the majority of cases it will not kill the infected fish. The major consequence of lymphocystis disease is disfigurement of the fish. *The* disease agent preferentially infects the cells of the skin and fins, causing the appearance of lesions. Once the virus infects a cell, it takes over the activities of the cell, forcing it to manufacture more viruses. Viral diseases are impossible to distinguish from bacterial diseases without special laboratory tests. They are difficult to diagnose and there are no specific medications available to cure viral infections of fish.

3.2 Lymphocystis

If a fish has growths resembling raspberries; it may be infected with Lymphocystis. The tumors are caused by a viral infection and in some cases, a variety of environmental factors, such as poor water quality. Lymphocystis can be inherited by the parent fish or transmitted to other fish through abrasions on the skin. Lymphocystis is rarely fatal. Because this is a viral infection, there is no real cure, and most people usually isolate the infected fish and let the infection run its course.

Treatment: There is no known cure for lymphocystis. The use of medications including antibiotics appears to be useless. If the lesions are restricted to the distal area of a fin, it is possible to carefully trim off the infected portion and treat with an antibiotic to prevent a bacterial Infection. In many cases, however, the virus will reappear in the same area.

3.3 **Viral hemorrhagic septicemia virus** (VHSV)

Viral Haemorrhagic Septicaemia Virus (VHSV) is an important fish virus that has caused several large scale fish kills in both fresh and saltwater fish in farmed and wild fish. Viral haemorrhagic septicaemia (VHS) is a highly infectious virus disease predominantly affecting rainbow trout (Oncorhynchus mykiss) in aquaculture.

The virus is an enveloped negative-stranded RNA virus belonging to the family Rhabdoviridae and the genus Novirhabdovirus. The virus can be divided into 4 distinct genotypes and 10 subtypes with different geographical occurrence, host range and infectivity patterns. VHSV have been isolated in the tempered Northern hemisphere, e.g. North America, Asia and Europe. The disease occurs endemically in the continental part of Europe, in Turkey and in part of Finland. Occasionally outbreaks in farmed rainbow trout and turbot have occurred in Scandinavia and the British Isles. The North sea, Kattegat and the Baltic Seahouses endemically infected populations of wild fish. VHSV have been isolated from more than 82 different fish spec.

4.0 CONCLUSION

There are many diseases of fish which can be troublesome to commercial producers as well as the recreational pond owner. Many disease outbreaks of captive fish stocks are associated with stressful conditions such as poor water quality, excessive crowding or inadequate nutrition. There are two broad categories of disease which relate directly to selection of appropriate treatments:

1. Infectious diseases are contagious diseases caused by parasites, bacteria, viruses, or fungi. These often require some type of medication to help the fish recover.
2. Non-infectious diseases are broadly categorized as environmental, nutritional, or genetic. These problems are often corrected by changing management practices.

Fish disease outbreaks are often complex, involving both infectious and non-infectious processes. Appropriate therapy often involves medication and changes in husbandry practices.

5.0 SUMMARY

Viruses are microorganisms which are extremely difficult to study because of their small size and inability to live outside their host tissue. Viruses are classified by the type of nucleic acid they possess, either RNA or DNA, as well as by their size and shape. Initial identification of viral agents which may be causing disease is often based on visualization of viral particles in tissue of dying fish using electron microscopy. Efforts are then made to isolate the virus in the laboratory using special living cells, called cell-lines, and finally serology is used to confirm that the virus in the animal's body is the same as the virus which has been isolated in the laboratory. Identification of viruses and investigation of viral diseases is highly specialized and requires special training and equipment. Once a viral disease is in progress, the course of the disease cannot be altered by medicating the fish. Prevention of secondary bacterial infections and maintenance of a clean environment and good nutrition will help give the fish the best opportunity to overcome the infection using their own natural defense mechanisms. Temperature manipulation provides a method for controlling some viral diseases of fish, and if fish are reared under temperature-controlled conditions, this may be a practical management strategy.

DISEASE	AGENT	TYPE	SYNDROME	MEASURES
Eye disease	Aeromonas liquefaciens	Bacterium	Eye, optic nerves and brain; cornea of eye vascularized and become opaque; subsequently eyeball gets putrefied, leading to death.	Treat affected ponds with 0.1ppm $KMnO_4$ followed by 300ppm lime.
Ulcer	Aeromonaspp: Pseudomonaspp	Bacteria	Ulcerations; exophthalmia: abdominal distension	Destroy badly affected fish; disinfect affected ponds with 0.5 solution of $KMnO_4$ and Sulphadiazine (100mg/kg) or terramycin (75-80mg/kg) to feed for 10-12 days.
Columnaris	Flavobacterium Columnaris	Bacterium	Raised white plaques, often with reddish peripheral zone leading to hemorrhagic spots on body.	Dip treatment with 50ppm $KMnO_4$
Dropsy	Aeromonas sp	Bacterium	Body scales stretch out resembling pine-cone inflammation; ulceration; exophthalmia; abdominal distension.	Disinfect affected ponds with 1ppm kMno4; dip treatment of 5ppm $KMnO_4$ for 2 minutes.
Saprolegniasis	Saprolegnia parasitica	Fungus	Mould grows like cotton wool in body, penetrating into the muscle; morbid muscle rot.	3-4% Nacl bath; $KMnO_4$ bath for 5days at 160mg/litre for 5days; 1-2mg/litre malachite green bath for 30 minutes to 1 hour; add

				formalin at 20ml/litre to affected pond.
Branchiomyosis	Branchiomyces demjgrans	Fungus	Fungus grow out through gill blood vessels and causes necrosis of the surrounding tissues, yellow brown discoloration and disintegration of gill tissues.	Addition of quick lime (50-100kg/ha) to affected ponds; in case of limited infection, use 3-5% Nacl bath for 5-10minutes or 5ppm $KMnO_4$ bath for 5-10minutes.
Ichtyophthirisis	Ichthyophthirius multifilis	Parasite (Protozoan)	Skin, fin rays and operculum covered with white spores; sick fish keep rubbing against hard surface/substratum	Dip in 1:5000 formalin solution for 1hour for 7-10days or in 2% Nacl for 7-10days; affected ponds should be disinfected with quick lime at 200kg/ha.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are viruses?
2. How will you manage and control viral diseases in fish
3. What treatment will you give a fish with Lymphocystis
4. Which method will you use to Management and Control of Viral Diseases?

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MODULE 5 SENSITIVITY TEST CONTROL AND THERAPY

UNIT 1 FISH PONDS AND PUBLIC HEALTH

CONTENTS

1.0 INTRODUCTION

The public health implications of livestock-fish integration are investigated in this chapter. Many of these are as important for specialized, stand-alone livestock and fish production as for integrated systems. Historical associations between human health and livestock production are compared to modern threats and how a large range of inputs to livestock, fish and wider food production systems may impact directly or indirectly on public health. Identifying the hazards and assessing the risks of pathogens including bacteria and viruses and parasites, are considered, and the involvement of integrated farming in influenza pandemics. The importance of both chemical and biological hazards is raised. The current debate about anti-microbial resistance is interpreted from the standpoint of extra risk due to integration. Relative risks from bioaccumulation and toxic algal blooms are discussed.

2.0 OBJECTIVES

- to understand the important of public health in fish culture
- to how to handle chemical products such as antimicrobials, pesticides and a range of chemo-therapy
- to have knowledge of pathogens that can affect human in fish culture system.

3.0 MAIN CONTENTS

3.1 General Considerations

Public health issues can be considered as those of direct importance to both producers and consumers of fish and include broader issues of food production, processing and delivery systems. Linkages have been made between fish or livestock production and health in terms of communicable diseases, non-communicable disease, malnutrition and injury. Clearly, the improved availability of low-cost fish and livestock products for people's nutrition needs to be placed in perspective with likely risks. Threats to public health from both livestock and aquaculture are diverse. Recently, livestock and fish have been implicated in the irregular occurrence of influenza pandemics; the global impacts on public health of promoting livestock and fish integration are huge if these claims are substantiated. Certainly throughout history, infectious diseases have largely entered human populations through animals. It has been known for some time, that common pathogens of warm-blooded animals do not generally cause disease in fish, but the role of cultured fish in the possible transfer of pathogens between livestock and humans is important, particularly in less developed countries.

Livestock and fish are involved in both passive and active transfer of a range of parasites and diseases to humans, broadening the need for risk assessment. The role of fish and warm-blooded livestock as intermediate hosts for a range of human parasites and control strategies are well known. However, the increasing use of a range of technologies, chemicals and feed ingredients in both livestock and fish production poses a relatively new set of risks. Products such as antimicrobials, pesticides and a range of chemo-therapy are often used with little idea of either indirect or long-term risks. Prophylactic use of antibiotics and growth promoters in intensive fish feeds rival their use in the livestock industry. The development of genetically modified organisms, either as feeds of livestock and fish, or the animals themselves has been raised as both a moral and public health issue.

A holistic, balanced assessment of risks involved with integrated livestock-fish production needs to consider the alternative and more specialized, separate intensive systems. An example is the impact of livestock and fish culture on water quality as independent or integrated activities. Pollution of surface and ground water, with direct negative impacts on health may be avoided if wastes are recycled through integrated aquaculture with little to no impacts. The pooling of water has often been related to the spread of insect-vector borne diseases but use of water for aquaculture may reduce this risk. Unmanaged water bodies in rural or semi-urban areas are more likely to harbor suitable micro-habitats for hosts' pests than ponds stocked and managed for fish culture. Adoption of livestock wastes for use in fish culture may already have made important contributions to improving health and hygiene
Risk analysis, in which hazards are identified and their relevance and control methods determined is a logical approach to assessing the implications of integrating livestock and fish production on public health. Identify the hazards associated with the various practices constituting integrated livestock-fish and the risks associated with them will be discussed.

3.2 Pathogens

Pathogens can affect human health through both active and passive contact. There are potential risks from handling livestock and their feeds, their production and slaughter house wastes as occur in stand-alone livestock farming. In addition there is a need to consider hazards associated with transfer and use of wastes for fish culture, in management, harvest and marketing of fish, and in addition, potential risks involved with preparing and consuming waste-fed fish.

Guidelines exist for the use of wastewater in fish culture but are considered to be too conservative and overly restrictive. What is important is not the presence of pathogens in the farming environment but their ability to actually cause human disease. Guidelines should be based on epidemiology and not solely on presence of micro-organisms.
An understanding of the main risk factors and how to reduce them is therefore essential for developing best management practice. Moreover, in order to obtain a holistic view of risk, any comparison of public health and aquaculture produce derived from livestock waste-fed systems should be compared to those from other production systems. On a broader level, the risks associated with disposal of untreated livestock waste in fish ponds should be compared with alternative uses that may present greater risks to public health in developing countries. Fundamentally a fish pond is a treatment system for pathogens present

in organic wastes; large diurnal variations in temperature, pH and dissolved oxygen in shallow tropical fish ponds tend to cause rapid attenuation of pathogens.

3.3 Bacteria and Viruses

Livestock fecal wastes used as inputs into fish culture contain varying quantities of bacteria and viruses that depend on the health status of the stock and the method used for collection, storage and use.

Identifying hazards, assessing risks

All livestock fecal wastes must be assumed to contain pathogens. Most disease is believed to be transferred via feces at slaughter. However, there is variation in the risk to human health based on livestock type, diet and their management. Human disease caused by many pathogens carried by livestock is difficult to diagnose. Typically, little is known about the transferability of such pathogens to humans via fish. It should be assumed that all water used in aquaculture is potentially contaminated with pathogens, whether or not livestock wastes are used. Salmonella and bacteriophage (used as an indicator of viruses) were sometimes present *before* input of wastes, suggesting that surface water is often contaminated. Whilst the levels of micro-organism in manure or pond water are important in understanding risks to the producer, the level of pathogens contained in the fish at harvest is of key importance in determining risk to those preparing and consuming the fish. Levels of microorganisms found in the digestive tract of fish are much higher than in the water illustrating a likely route to infection is via contamination of hands and surfaces during preparation and cooking of fish.

In contrast to bacteria, indicators for pathogenic viruses, such as bacteriophage give a measure of fecal contamination rather than the presence of pathogens. It is thought that enteric viruses are also rapidly attenuated in waste-fed ponds but their low infective dose suggest that serious attention be given to their persistence in fish ponds.

Reducing risks

Risks of passive transfer of pathogens through handling of live fish during production, harvest and processing can be reduced if physical exposure is minimized through use of appropriate clothing, especially gloves. Attention to minimize the risk of cross-contamination during processing should be avoided, as the digestive tract is the major source of pathogens. Depuration, the holding of fish in clean water without feeding, facilitates this task by reducing the amount of digestive tract contents Depuration may not always be an effective method to remove micro-organisms from fish. Depuration in clean water for a six week period is ineffective because the micro-organisms had already entered the muscle tissue. The process was more effective with tilapia raised in optimal growth conditions in wastewater-fed ponds as they contained initially lower concentrations of bacteria, with none present in organs or muscle.

Consumption of raw, certain types of processed, or undercooked fish should be avoided. Removal of visceral and major organs, in addition to the digestive tract, prior to marketing 'whole fish' would also reduce risk.

Pre-treatment or processing of livestock waste prior to its use as a fishpond fertilizer or feed ingredient also reduces risks associated with transfer of pathogens.

Streptococcus sp. infections of fish are a relatively newly identified threat to humans. Increasingly found in cultured tilapias, *S. iniae* and other *Streptococci* that infect fish may also infect humans. Infections have been contracted when people market live fish, or consumers are cut or spined during handling or preparation of the fish. The disease appears most prevalent in intensive tilapia production systems, in which water quality is marginal and/or there is environmental stress or trauma to the fish.

3.4 Parasites

A variety of parasites (Trematodes, Nematodes, Cestodes) may be transferred through livestock waste to aquatic plants and animals (fish, amphibian, molluscs or aquatic vegetables) and then back to humans.
An understanding of current systems and the potential reduction or increase in risk through integration is required. The exposure of livestock to parasites, through foraging on human feces is often a critical part of the life cycle in lesser developed countries lacking adequate sanitation but if animals are penned, risks are minimal. The risks of promoting integration of pigs and fish among groups in which pigs are allowed to forage on human waste may, in contrast, be important.

Key points to reducing public health risks from pathogens in livestock-fish systems

- Good husbandry of the livestock, an adequate level of nutrition, hygienic accommodation and control of scavenging on human waste.

- Storage and/or composting of wastes reduce pathogens and parasites.
- Water quality suitable for optimal growth of fish contains bacteria below the critical concentration that lead to infection of fish organs and muscle.
- Fish digestive tracts typically contain high levels of bacteria.
- Although depuration is not effective when bacteria occur in fish muscle, holding fish for a short time after harvest effectively reduces bacteria in the digestive tract.
- Contamination of hands and surfaces during cleaning and evisceration of fish is a common route of pathogen infection through cross-contamination of other food.
- Adequate cooking of fish ensures fish is safe for human consumption; fish eaten raw, undercooked, or improperly processed or preserved increases risk.

Reducing risks

Improved sanitation or human waste disposal is a key element in the control of parasites, as is the control of pond-side vegetation that provides cover for snails which are often intermediate hosts. Education and the availability of anti-helminthes drugs are also prerequisites for successful improvement of public health at the community level.

Aquaculture may also reduce the health impacts of parasite diseases. Key aspects of this are through habitat modification and host control. Abandoned or poorly managed fish ponds have been associated with schistosomasis in Africa (McCullough, 1990) but well managed, productive systems in which aquatic weeds and molluscs are removed or managed are probably less of a problem.

3.5 Insect-Vector Borne Diseases

Poorly-managed fish ponds often become mosquito-breeding sites (Birley and Lock, 1998). Removal of surface and emergent vegetation, as a part of intensified aquaculture, reduces shelter for mosquito larvae. Introduction of aquaculture has actually decreased the incidence of disease through reduction of the habitats of the vectors or intermediate hosts such as mosquitoes and snails in some countries.

3.6 Influenza Pandemics

A major issue regarding the promotion of integrated livestock-fish production has been the possible connection between such practices and the emergence of influenza pandemics. The farming of pigs, poultry and fish together on the same farm is predisposing the world, to the emergence of new virulent strains of influenza virus. Human influenza viruses are similar to poultry viruses but require change before they can infect humans, a change that can occur in pigs or between chickens.

3.7 Chemical Hazards and Associated Risks

A major issue is how integrating livestock and fish together can reduce the level of chemical hazards and associated risks compared to stand-alone enterprises. Generally, hazards associated with intensive aquaculture, particularly of carnivorous fish, are likely to be greater than less intensive culture of herbivorous and omnivorous species because of the greater likelihood of bioaccumulation and exposure through the higher levels of water exchange required. Wild fish in unmanaged aquatic systems may suffer more from the effects of chemicals than cultured stocks as aquatic habitats often serve to drain effluents and run-off from agriculture and complex natural ecologies are more likely to be disturbed than closely monitored culture systems. Chemicals may accumulate more in slow-growing, carnivorous species than well-fed, short-lived farmed fish. We first explain the range of chemical hazards with a tabulated assessment of their importance to both integrated and non-integrated aquaculture compared to, where appropriate, reference to wild stocks (Table 3.2).

Exposure to chemicals can be accidental or purposeful. Contamination of the surrounding environment, water or feed source for fish or livestock integrated with fish can be either acute or chronic in nature. Chemicals are also often used as part of disease control, general husbandry or as feed additives. The tendency in integrated systems is for the fish culture component to be semi-intensive i.e. relatively low densities of fish feeding low in the food chain and these are less likely to require treatment for disease, intensive disinfection or specialized feed additives.

Range of chemical hazards

Chemical hazards may arise from the use of agrochemicals, chemo-therapy, metals, feed ingredients and organic pollutants. Agrochemicals i.e. chemical fertilizers, water treatment compounds, pesticides and disinfectants are widely used in both commercial and smallholder food production. Chemo-therapy include a range of compounds used to control the impact of disease on both livestock and fish i.e. antimicrobials, parasiticides and hormones. The issue of bacterial resistance induced through prophylactic use of antimicrobials and drug residues that risk human health are of key interest. Exposure to metals, in addition to that from chronic or acute pollution of aquatic systems, may occur due to their use as anti-foulants and molluscides or through their inclusion as growth promoters in livestock diets. Other feed ingredients have come under recent scrutiny and, especially as use of manures as fishponds inputs may increase the pathways through which these compounds can enter the human diet, should be considered. Aquatic systems are particularly sensitive to organic pollution. In this regard exposure to chlorinated hydrocarbons that are persistent and can bioaccumulation.

Integrated management of livestock waste and fish production ideally leads to good practice that reduces the necessity for use of chemicals to control pests and maintain optimal conditions. The frequent collection and use of manure for fish culture can reduce problems associated with its accumulation and storage such as the spread of flying insect-borne diseases or ammonia-related respiratory problems. Moreover, many farmers have found that siting of livestock pens over ponds improves the environment for the livestock through evaporative cooling; this is particularly important in the tropics where more expensive methods of controlling heat losses are uneconomic and heat stress is a major factor predisposing livestock to disease.

4.0 CONCLUSION

Key points to reducing public health risk due to parasites and other biological and biochemical agents is through proper and careful handling. Reduction in risks from parasites in livestock-fish systems needs to consider current feeding and management practice and minimizing contact with intermediate hosts. Improved sanitation, anti-helminth drugs and biological control are also important. Well-managed productive ponds, in which aquatic weeds and molluscs are controlled, reduce risk of parasite transfer and insect vector-borne disease. There is no evidence that livestock-fish integration has been linked to the incidence of influenza pandemics. But multi-species livestock production, especially pigs and poultry should be avoided in specialized units or integrated with aquaculture.

Livestock-fish integration probably reduces the overall risk of contamination with chemicals compared to production of intensive, stand-alone fish production or fish captured from the wild. The risks to human health through microcystins produced by blue-green algae in livestock waste fed ponds are very small. Eutrophication of any surface water, through use of fertilization, or occurring as a result of feeding fish intensively, need to consider the multipurpose use of water.

5.0 SUMMARY

The use of human and livestock waste in semi-intensive fish culture, subject to certain safeguards, can generally be considered positive in any holistic assessment of risk. Semi-intensive systems fertilized within the carrying capacity of the system are healthy environments for fish. The fish production unit can act to 'treat' wastes that themselves may contain pathogens, provided certain precautionary steps are observed. Moreover, non-integrated intensive livestock and fish production carries its own risks to public health, which should be considered in any balanced comparison.

6.0 TUTOR-MARKED ASSIGNMENT

1. what are the health hazard of fish cum livestock farming?
2. Pathogens can affect human health through both active and passive contact. Discuss
3. How will you reduce public health risks from pathogens in livestock-fish systems?

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UNIT 2 FISH POND AND HEALTH HAZARD

CONTENTS

1.0 INTRODUCTION

Types of Hazards

Hazards are activities that could put the life of individuals directly or indirectly at risk or dangers. Hazard assessment in fish production system is therefore a process designed to determine whether activities involved in fish production system constitute hazards of any kinds. The hazards in pond fish production may be grouped into: - Pathogenic and non pathogenic agent-borne hazards. Pathogenic Agent-borne Hazard Pathogenic agent-borne hazard are those due to agents in the water and or in the fish causing infection in fish that are capable of causing disease not only to the fish but also can expose the farmers or those involved in fish handling to hazards. The pathogenic organisms like viruses, bacteria, protozoa and parasites present in the aquatic environment are noted for the potential hazard to fish and consumers. Several authors cited by Ogbondeminu (1993) reported the evidence that fish can act as vector of enteropathogenic bacteria. And they proved that out of the 35 species of bacteria from nine genera isolated from or associated with diseased fish in various parts of the world, 9 species from 7 genera have been detected in association with bacteria diseases of human. Some of these organisms may not be pathogenic for fish, but when consumed by man, infection may occur causing diseases like paratyphoid fever, bacillary dysentery, cholera gastroenteritis, infectious hepatitis and other bacterial food-poisoning (Ogbondeminu (1993). Ibiwoye (1994) added that some of these diseases are a potential health hazard to human because of the risk they present through handling and/or eating of inadequately cooked fish.

Fish are prone to various infections just like livestock that hampers their reproduction, growth, appearance which affect their wholesomeness. The treatment of fish with antimicrobial agent may pose a potential hazard to handlers and consumers, with this reason Ogbondetnnu (1993) indicated that the public health significance of fish contamination lies not only in their ability to cause disease, but also their possible role in the transfer of antibiotic resistant strains with R-plasmid to other common pathogens for homeothermic and poikilothermic animals. Though there is lack of much information on cultured fish and their environment as a probable source of human enteropathogenic bacteria. Ogbondemin (1994) in a study confirmed that fish from tropical .aquaculture system can harbor a variety of gram-negative bacteria in theft intestinal tract, He then stated that the majority of bacteria, that are carried in the gastro-intestinal tract of fish, are of primary significance as a source of occupational hazard to the handlers.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- know the causative agents of hazard in fish pond
- know how to manage fish pond to reduce cross infection
- how to treatment and control strategy of the causal agents.

3.0 MAIN CONTENTS

3.1 The causes of pathogenic agent-borne hazard

Infectious diseases due to bacteria, fungi, viruses, protozoa and helminths can be accidentally transmitted to farmers as a result of association with aquatic environment or handling the fish or eating improperly cooked fish. Ogbondeminu and Okaeme (1985) isolated about 13 bacterial species associated with organic manure and water and reported that the presence of Pseudomonas Escherichia. Aeromonas and Staphylococcus species are of public health significance because of their primary role in occupational disease of fish handlers. Out of the 9 species Aspergillirs species, Mucor species and Candida albican have been reported to cause clinical disease in fish and shell fish and all of them are of public health significance because they cause disease of humans.

The presence of salmonella group in manure or human waste is risky because it has several serotypes which are pathogenic to man and animals. It is worthy to note that pig is well known reservoir of pathogenic salmonella so using porcine manure for fertilization should be with care. Furthermore the occurrence of Salmonella sp and Klebsiella pneumonia are common and are known to have the ability cause variety of human disease (Ogbondeminu et. al., 1992) which then gives the evidence that bacterial contamination of pond with these may have potential human epidemiological hazard. Human consumption and processing of fish grown in the waste-fed pond system increase the possibility of transfer of parasite (e.g. Haplorchis parnllis) or pathogens to human. Parasite is deeply embedded in the dermis or musculature of fish and cause severe necrotic ulcerative granulomatois response. (Ibiwoye et. al. (1996) added that the lesions render the fish unmarketable and very sceptical l to consumers. However protozoa (Ichthyophthirias multifilis), Helmmth (cestodes, trematodes and nematodes) has been reported. Other parasites such as Argulus sp, Ergasilis sp, and Lernea sp are common (Ibiwoye et al. 1996). Encysted worm throughout the muscle can be zoonotic by eating improperly cooked fish.

Although fish are rarely consumed in a raw state, the exposure of fish growers to the infected fish and their culture water may be a predisposing factor in the transmission of potentially enteropoathogens to man. Some of these conditions caused by infectious agent include swimmer itches, schistosomiasis; fasciolasis, salmonellosis, leptospirosis, aspergulosise candicdiasis, helminthiasis etc. Virtually fish production and hazard are interwoven. No wander Jansen 1970 cited by Ogbendimu (1993) postulated that the etiological agents of infection of the eye, ear, nose, throat, gastrointestinal tract and urinary tract in human could be of water-bone, but the sources of infection are rarely traced and need to be traced.

Table 1: Fish pathogen of public health significance

Pathogen	Manifestations in human	Sources
Haplorchis parnilis	Infarction due to eggs in the blood circulatory system	lbiwoye (1994)
Diplostomum sp (so-called eye fluke)	Total blindness due to large number of metacercariae in the eye	
Mycobacterium sp	Tuberculosis	
Salmonella sp	Several serotypes are pathogenic to man and animal	Ogbodeminu and Okaeme (985)
Enterobacteria sp	Have association with disease condition of man and animal	
Escherichia coli	Salmonella species and Gastroenteritis.	
Eugostrongylids species	Severe abdominal pain Septicemia due to perforation of digestive of the tract	ibiwoye (1996).

3.2 Non pathogenic agent-borne hazards

The non-pathogenic hazard is restricted to general management of the pond and possible implication by chemicals.

Potential hazard in Management practices.

i. Siting of pond

Siting is an important factor to note while constructing a pond for fish production. Some safety cautions must be considered before sitting of ponds. It is tempting to think that one can simply dig a large hole in a ground fill it with water to grow fish and quickly make a good profit, but of course this is not the case. The management of water quality is the single most important factor in productive fish farming. Water quality management is an ongoing never-ending process, which requires a certain amount of diligence from the fish farmer. Daily monitoring of the pond's condition and fish behavior, along with accurate record keeping, allow the farmer to recognize and prevent deleterious environmental conditions in the pond and thereby maximizing his production and profit (Sophin 2001).

The pond should therefore not to be located directly to run-off of rain flowing directly into the pond, because the flood may contain waste from human, animals and debris of various kinds that may harbor pathogenic organisms or parasite that may in turn pose public health risk. Michael (1988) observed that pond should not be located close to power station or industrial installation to avoid toxic chemical run off in the pond after heavy down pour of rains.

ii. Hazard associated with management

Aquaculture generally like any other production system may expose farmers to some health hazard; it is therefore worthy to note of the existing hazard associated with the profession especially those of public health concern. These occupation hazards include drowning; break in dams, flood disasters, injuries from the use of equipments, nets sunburns and exposure to radiation. Possible exposure to pollution of hydrocarbons or heavy metals, toxic waste and gas emission may cause chemical injuries. Poisonous stings from scorpions and insect, bites from snakes, reptiles and fishes are possible. Attack from large mammals is common outdoor nuisance observed.

Depending on the site of pond, the environmental management, strict sanitary level of the fish pond, farmers and or attendants may be exposed to hazard to some extent. If sanitary level is not satisfactory in fish pond environment ecosystem may be established which create a good breeding place for animals and other organisms which may expose farmers, attendant visitors to environmental hazard. For example unwanted snails, toads and frogs, snakes, insects, birds, etc may full the environment, posing hazard to both fish and man.

Snails of various species (which are believed to play an important role in the life cycle of some animal and human diseases) can inhabit the place. According to Churchill Livingstone (pocket medical dictionary) freshwater snails are intermediate host for schistosomiasis (bilharziasis). Schistosoma ,spp are human blood fluke which are water bone and can enters via skin or MUCOUS membranes. Edward (1994) reported also that snails serve as intermediate host for parasites like eye fluke (Diplostomum sp), predators like birds, heron in particular and other birds found in the environment may not only predate fish but can introduce parasite such as eye fluke (Edward 1994) to the pond.

Poisonous and non-poisonous snakes found in environment with no proper sanitation can expose the farmer attendant and visitors to hazard of snake bite. Insects also which are important in the ecosystem play an important role as potential hazard e.g. tsetse flies (Glossina sp) found in the riverine area are known as vector for animal and human diseases causing sleeping sickness in man and somorin, chaga disease, etc in animals. Malaria is another disease of hazard caused by mosquito associated with unsanitized environment.

Long standing and contaminated water provide breeding place for leeches. They are believed to serve as vector for trypanosomiasis and they suck blood directly from fish and human. Maintenance of environmental sanitation to the standard including water quality will check this problem.

iii. Hazards associated with husbandry practices

The traditional principles of livestock husbandry cover in general terms, handling of the stock with minimum stress, management of accommodation and environment, feeding prevention of disease and harvesting (Andrew 1994). Appropriate uses of equipment are essential aid to good husbandry. These principles also apply to pond fish farming. The potential hazards from husbandry practices do not spare the farmer, attendant nor the fish themselves. The farmer end the attendant using instrument in handling the fish are possible to sustain injuries exposing the wound to contamination and consequently to secondary infection. For example Newman (1993) reported the possibility of accidental injection in the cause of treatment or vaccination by injection as a result of struggling by the fish. The accidental injection can cause anaphylaxis. Nets or metallic instrument use in handling or catching fish may injure them and expose them to secondary infection by parasites, bacteria or protozoa that are potential hazard.

a) Personal observations

Many other environmental factors can be economic important to fish production systems. Some involve material introduced into the water supply. Fish pond located close to residential area most times serve as collection site for harmful object like, broken plates and bottles, spoons, nails, old bicycle parts, etc. These objects are very hazardous to farmer during test cropping or during harvest of the pond.

b) General environmental issues

Most fish live their entire lives in water. However water as the universal solvent makes prevention and control of physical and chemical contamination of water body much more difficult. Fish can be affected by such contaminants arriving from outside their normal habitant and also arriving from their own activities.

The quality of the water in which fish are contained is therefore very important to their livelihood. Though according to Branson (1993) different species of fish can tolerate different level of contamination, adverse environmental parameters can have direct and indirect effect. Since the main objective in any fish pond production should be to create and maintain water quality within the tolerance limit of fish, it is important to maintain a stable environment.

Oxygen content of water is very import because fish like terrestrial animal require adequate supply of dissolved oxygen. The level of dissolved oxygen content in the water depends on the temperature of the water and varies from specie to species. Another gas of economic importance is carbon dioxide (CO_2), which is very essential for plants growth usually present as free gas or bicarbonate, carbonate or in organic form. Its high level interferes with oxygen uptake causing nephrocalcinosis which has no treatment (Brown 1983). Other gases of economic importance are chlorines, ammonia and nitrites other important water parameters are pH., hardness, temperature. The optimum pH for fish as reported by many authors is between 6.5 and 9 and lives below and above this range has effect.

3.3 Hazards Associated With Chemical Contaminants

The main source of chemicals in fish production system is agricultural runoff and sometimes inclusive waste. N'Daw (1991) reported that pesticides pollution result mainly from wide spread use in agriculture and vector control campaign conducted near fish farms, since the pesticide can enter aquatic environment directly by their introduction to attack particular organisms or directly through atmospheric precipitation and land runoff. Pesticides widely used include DDT, lindane, methylparathion, carbofuran, endosulphan and diazinon. While some common pesticides used in vector control campaign to curb such endemic diseases such, as malaria, onchacerciasis (river blindness) schistosomiasis (bilharziasis) and trypanosomiasis (sleeping sickness), include temphos, chlorphoxin, permetrim, diflametrin, nichlosamide, DDT, carbosulfan, fenitrothion and fenthion (NDaw 1991).

Chemicals used in fish treatment purposes are formalin, malachite green, chloramin, dylox, methyleneblue, etc (Ibiwoye 1994). Edward (1993) observed that most chemicals used in fish treatment purposes are lethal and if applied wrongly could be toxic to fish. Causing direct damaging effect on the gills and causing respiratory distress if over used. Despite the emphasis on the monitoring of chemical contaminant in the environment, the ultimate consequences of pollution are biological. The effect on fisheries may be directed arising from the toxicity of pollutants or indirect as a result of ecosystem modification or reducing the resistances of fish to infection of pathogens by public significance.

3.4 Management related agents caused hazards

For a long time Africa at large was thought to be safe from aquatic contaminations. However in the recent times as a result of high population growth, accompanied by intensive urbanization, increase industrial activities and high exploration o natural resources including culturable land there has been a steady increase in the quantity and diversity of discharges that reach important aquatic environment especially pond. Fish cultured in water heavily contaminated by pesticide, industrial, domestic or animal waste are not only subject to the direct effect of the contaminants but also become more susceptible to disease in the generally crowded condition of a fish pond. Though some waste however can be beneficial to fish production, for example animal manure and crop residues can increase the productivity of fish pond.

Currently receiving world attention is the utilization of organic materials based on the assumption that organic matter of the organic manure provides a source of reduced carbon for heterophic grazing while mineral fraction of the manure is used by both autotrophy and microbial heterotrophs. While organic manure is very important in pond fish production it has also proved by many authors (Okaeme et. al. 1992, Ogbondeminu et. al. 1992,; Ogbondeminu and Okaeme, 1985) that it is a source of contaminants to the aquatic environment and source of organism that may not only stand a potential hazard to fish and consumers but also affect the production quality of fish.

Fertilization of pond with stale manure pile is preferred to the use of wet and fresh manure Okaeme et. al.(1992). This is because fresh manure has high coliform count with high incidence of undesirable bacteria, protozoa, viruses and helmith of public health significance (Okaeme, 1990). Thus he recommended that manure be stored in pile for several weeks (2 weeks minimum) before application.

Fish as the essential commodities when come down with infection from organism of various kinds found in contaminated environment deserved treatment with antimicrobial agents and other chemicals to restore the fish its normal health. Ogbondeminu and Olayemi (1993) observed that the indiscriminate use of antimicrobial drugs and other synthetic chemotherapy to treat fish has resulted in an increased in population of antibiotic resistant bacteria as well as resistance R-plasmid in food producing animals. The potential for transferability of antibiotic resistant plasmid in resistant bacteria isolates from fish and aqueous environment is of public health significant. For example tetracycline is known to induce plasmid encoded drug resistance in different species of bacteria, which are pathogenic to fish. It is because this kind of hazard, that Shepherd and Bromage (1992), reported that in many countries of the world, antimicrobial drugs are closely controlled by the authorities and can only be prescribed by a veterinarian who has satisfy himself that their use are justified. In U.K. the tetracycline antibiotics are classed as prescription-only-medicine (POM) and cannot be purchased without prescription signed by a Veterinarian or a Medical Doctor.

3.5 Treatment and Control Strategy of the Causal agents

(1) Infectious cause

Bacterial causes: - Avoid overcrowding by stocking at the proper rates. Don't over fertilize the pond to avoid excessive algal bloom and the consequent depletion of dissolved oxygen practice feeding at the recommended rates

Fungal causes: - Practice good pond sanitation. Ensure regular feeding proper stocking and pond fertilization to prevent bacterial and fungal disease that could promote viral disease. Feed with balanced ration. Ensure good pond sanitation.

Viral causes: - Practice good pond sanitation. Ensure regular feeding, proper stocking and pond fertilization to prevent bacterial and fungal disease that could promote viral diseases.

Parasitic causes: - Prevent pond being overgrown with weeds; predators of fish can easily gain access to pond that are bushy. Control predators by killing, remove carcass from pond promptly. Apply lime at recommended rates. (Lime is excellent disinfectant).

(2) Management Related Causes

Those occupational hazards whose occurrences are prompted any art of mismanagement on part of the fish farmers. Such acts result nutritional problems poor water quality and low dissolved oxygen availability. Seek technical assistance of extension workers on pond management problem. Ensure proper feeding, fertilization and liming.

4.0 CONCLUSION

The major raw materials in fish production is organic manure which is one other way of introducing micro-organism and parasite into pond exposing those involved to occupational hazard. With this review it seems fish farming is full of hazard but it is not restricted to fish farming only. The aim of this review paper is not to discourage fishermen, fish mongers, attendants and consumers from going into fish and fish farming business. But this is to create awareness of the potential occupational hazards involved- in the profession so that those involved in it will do them with care since prevention is always better than cure. Recommendations For public health consideration pathogen indicators should be used to determine the presence of disease causing organism from sewage or manure before use for fertilization Ogbondemin et. al., (1994) suggested waste water treatment through stabilization should be developed before discharge into natural water being the most effective method of sewage treatment in hot climate. The use of fresh or wet Manure should be discouraged Manure- be dried or stored in pile for several weeks before application.

5.0 SUMMARY

This unit discusses the significance of environmental and occupational hazards associated with pond fish production. The major raw material used in fish production system is the organic manure (cow dung, poultry droppings, and porcine manure) that serves as substrate for heterotrophic production of bacteria and protozoa which act as food for zooplankton and the fish. The pathogenic organisms (viruses, bacteria, protozoans, and parasites), are noted for the potential hazard to the fish handlers and consumers. Nine species from seven genera of bacteria are associated with fish diseases are found to have association with diseases of human such as typhoid fever, bacillary dysentery and other gastrointestinal tract related problems. Also the environmental contaminants in pond fish production become important because of its significance to consumers acceptance of the fish products.

6.0 TUTOR-MARKED ASSIGNMENT

1. Distinguish between non pathogenic and pathogenic agents borne hazards.
2. List treatment and control strategy of the causal agents.
3. How will you manage hazard related to chemical contamination?

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UNIT 3 FISH ALLERGY

CONTENTS

1.0 INTRODUCTION

Seafood is an important part of the human diet, while a healthy source of protein, fish also can cause illness in humans through allergic and non-allergic food reactions. Seafood allergy is a type of food allergy. It is a hypersensitivity to dietary substances from shellfish, scaly fish, or crustaceans, causing an overreaction of the immune system, which may lead to severe physical symptoms. Finned fish can cause severe allergic reactions. This allergy is usually life-long. The protein in the flesh of most fish commonly causes the allergic reaction, however, it is possible to have a reaction to fish gelatin, made from the skin and bone of fish.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- understand the cause of allergic reaction to fish
- identify the signs of sensitivity reaction to fish when eaten.

3.0 MAIN CONTENTS

3.1 Definitions

Allergy: Term for a foreign substance which induces an allergic or hypersensitivity response through the production of immunoglobulin E.
Sensitization: the production of a specific type of allergic antibody by the immune system resulting in a positive allergy test, such as to a

particular food or pollen. It is possible for a person to make a specific allergic antibody to a food, for example, without experiencing allergic reactions when that food is eaten. Parvalbumin: a calcium-binding albumin protein with low molecular weight (typically 9-11 kDa)

3.2 Cause of Fish Allergy

The major allergen responsible for fish
allergy is a protein called parvalbumin, which controls the balance of calcium in the white meat of fish. Parvalbumin is localized in fast-contracting muscles, where its levels are highest, and in the brain and some endocrine tissues. Parvalbumins are very similar between different species of fish – so if a person is allergic to one species of fish, it is very common to be allergic to other fish species as well. Gelatin is another major allergen that is shared among species of fish. When a person who is sensitized to fish comes into contact with or eats fish, an allergic reaction occurs, leading to the symptoms of allergy.

3.3 Symptoms of Fish Allergy

The symptoms of fish allergy are similar to those of other food allergies. Almost all people with fish allergy will experience symptoms within an hour of eating the food. The most common symptoms include generalized itching, hives and swelling, vomiting, and respiratory symptoms such as wheezing and chest tightness – although fatal anaphylaxis can also occur. Some people with fish allergy experience hives and itching when they touch raw fish, but are able to eat cooked fish meat without having allergic symptoms. Proteins released into steam when fish is being cooked can also cause allergic symptoms of asthma and hay fever in people with an allergy to fish.

3.4 Avoidance of Fish

Most people with an allergy to one type of fish should avoid eating any species of fish, given that the major fish allergens are shared among many species of fish. It also seems a good idea for people with fish allergy to avoid seafood restaurants, given the chance of contamination of other foods with fish allergen. Fish proteins may also be present in steam released from cooking fish, which may trigger allergic reactions in people with fish allergy.

Fish proteins can also be hidden in certain foods, and therefore cause unexpected allergic reactions in people with fish allergy. Avoidance of other fish products, such as sushi, caviar, roe, fish oil capsules and cod liver oil would seem prudent in people with fish allergy. Shellfish are not related to fish, and therefore could be eaten by people with fish allergy. However, the danger of cross-contamination between fish and shellfish exists -- meaning that a person with a fish allergy would not want to eat shellfish in a seafood restaurant, since the food could be contaminated with fish.

3.5 Diagnosis and Treatment of Fish Allergy

The diagnosis of fish allergy can be made when a person has experienced allergic symptoms after eating fish, and has as a positive allergy test to fish, either with a skin test or a blood test. Skin testing remains the best way to confirm the diagnosis of fish allergy, although blood testing has the advantage of measuring the amount of allergic antibody against fish. The level of allergic antibody to fish can be helpful in determining whether a person actually has a true fish allergy, has possibly outgrown the fish allergy, or may simply be sensitized to fish, but without experiencing allergic symptoms with eating fish.
A form of food poisoning, called scombroid, involves eating spoiled fish containing large amounts of histamine. Scombroid poisoning usually occurs in large dark meat fish such as tuna and mackerel. Since this poison develops after a fish is caught and dies, where the fish is caught doesn’t really matter. The main factor is how long the fish sits out before being refrigerated or frozen.

The harmful substances that cause Ciguatera, Scombroid, and shellfish poisoning are heat stable, so no amount of cooking will protect you from becoming poisoned if you eat fish that is contaminated. Symptoms depend on the specific type of poisoning. The symptoms of scombroidosis are virtually identical to symptoms of true food allergy, although allergy testing is negative, since no allergic antibody is present. Scombroid poisoning symptoms usually occur immediately after eating the fish. They may include:

Breathing problems (in severe cases), extremely red skin on face and body, flushing, hives and itching, nausea and vomiting.

If you have scombroid poisoning, you may receive:
An antihistamine medication, such as diphenhydramine (Benadryl)
Fluids by IV (to replace fluids lost from vomiting and diarrhea)
Medicines to stop vomiting
Medicines to treat severe allergic reactions (if needed)
Breathing tube (in rare cases)

The treatment of fish allergy mainly involves the avoidance of fish. If a fish-allergic person eats fish, and experiences an allergic reaction, immediate treatment is required. This often involves the use of injectable epinephrine, such as with an Epi-Pen or Twin-Ject device, although mild reactions may be treated with oral antihistamines. People with fish allergy should wear a Medic-Alert bracelet listing their food allergy information, and should carry injectable epinephrine at all times given the possibility of the accidental ingestion of fish proteins.

Other treatment include:
Avoid foods containing the allergen, adrenaline injection if anaphylactic reaction occurs, antihistamines, bronchodilators for asthmatic symptoms
The central concept of management of food allergy is allergen avoidance. When this is not possible or inadvertent allergen exposure occurs, treatment depends on the nature and severity of the reaction.

Treatments include:
Dietary modification and allergen avoidance - with education of children and parents

No treatment - if symptoms are mild and self-limiting
Antihistamines - Useful for allergic rhinitis and some allergy mediated skin conditions. Not helpful in asthma except for mild seasonal asthma where allergy may be a precipitant.

4.0 CONCLUSION

Fish allergy is not an emergency but Shellfish poisoning may be a medical emergency. With sudden or significant symptoms, the person should be taken immediately to hospital.

5.0 SUMMARY

Seafood allergies are usually treated with an exclusion diet and vigilant avoidance of foods that may be contaminated with shellfish or fish ingredients and/or oils. The most severe seafood allergy reaction is called anaphylaxis,[4] which is an emergency, requiring immediate attention. It is treated with Epinephrine, which can be administered with an Epi-Pen.

6.0 TUTOR-MARKED ASSIGNMENT

1. How will you diagnose of fish allergy?
2. What causes fish allergy?
3. What are the Scombroid poisoning symptoms and their treatment?

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UNIT 4 INTERNATIONALWATER OR TRANS-BOUNDARY WATERS AND TRADING

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main contents
4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 Reference/Further Reading

1.0 INTRODUCTION

Fisheries are common-pool resources, and many of world's fisheries are overexploited. At the same time, capture fisheries and aquaculture operations can impinge on public goods provided by marine ecosystems such as marine biodiversity and unique habitat. The common-pool and public goods dimensions of the marine environment justify regulation, but the issues frequently transcend national boundaries. Individual countries have few alternatives to protect the marine environment beyond their own jurisdictions. The international nature of marine conservation thus provides an incentive for countries to use trade policy as an indirect means to protect the marine environment. Because a large share of the available seafood is being traded, trade restrictions can potentially lead to better resource protection and better fishing practices.

The terms international waters or trans-boundary waters apply where any of the following types of bodies of water (or their drainage basins) transcend international boundaries: oceans, large marine ecosystems, enclosed or semi-enclosed regionalseas andestuaries, rivers, lakes, ground water systems aquifers), and wetlands.[1] Oceans, seas, and waters outside of national jurisdiction are also referred to as the high seas or, in Latin, *mare liberum* (meaning *free seas*). Ships sailing the high seas are generally under the jurisdiction of the flag state;[2] (if there is one) however, when a ship is involved in certain criminal acts, such as piracy,[3] any nation can exercise jurisdiction under the doctrine of universal jurisdiction. International waters can be contrasted with internal waters, territorial waters and exclusive economic zone.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- analyze the problem associated with trans-bounder fish transportation
- constrains in international fish trade.

3.0 MAIN CONTENTS

Seafood's high degree of tradability also suggests that trade policy as a means to promote marine conservation can have significant economic consequences. Although seafood has long been traded internationally, trade has increased dramatically in recent decades such that fish and fishery products now constitute the most highly traded food commodity internationally. Many seafood markets have expanded from strictly regional to truly global markets. Freezing and storage technology along with low transportation costs have facilitated this globalization of the fish trade. The seafood trade is characterized by both high degrees of segmentation and market integration. Segmentation results from the fact that there are many product types, most of which are not close substitutes for each other. Still, globalization has led to more integration of certain product types such as the whitefish market, which includes species caught in multiple regions around the globe. The trend is toward further integration. Another important consideration for the seafood trade is that production from capture fisheries has leveled off and even declined in some countries. The increase in seafood trade is thus attributable to growth in aquaculture production and increased exports from developing countries. Developing countries, in turn, may be most affected by trade policies that restrict seafood imports failing to meet environmental standards.

Two features of seafood production complicate the application of standard trade theory to seafood trade restrictions or liberalization. First, seafood production, whether from capture fisheries or aquaculture, has an unusually close connection to the environment. In capture fisheries, producing fish directly feeds back on the ability of the environment to sustain fish production in the future. This feature distinguishes fisheries from most other natural resources. The higher degree of control with the production process in aquaculture makes aquaculture more like traditional industries. Second, many fisheries are open access, an institutional arrangement in which fishermen cannot be excluded from fishing. Open access (or management systems that do little to exclude access) is considered to be the root cause of overexploitation in fisheries, leading to economic waste from excess capacity and environmental harm through degradation of biological stocks and alteration of ecosystems. Biological growth of a fish stock combined with open access or poor management systems can lead to a backward-bending supply curve for fish along which the long-run supply of fish is less when price increases. This characteristic of open access fisheries theoretically can lead to unconventional outcomes from trade liberalization, including the possibility that increased trade may not benefit both parties in the long run.

When a fishery is well managed, standard trade theory applies. Optimally or well managed fisheries will typically operate on the conventional portion of the supply curve that is not backward-bending and also with a larger fish stock than under open access. The literature on policy instruments to achieve optimal outcomes in fisheries focuses mostly on rights-based tools such as individually transferable quotas, which break the non-excludability problem of open access. A complementary literature on regulated open access suggests that biological stocks in many fisheries are maintained at safe levels through input controls and season closures, but failure to exclude access leads to economic losses. Under trade liberalization, regulated open access many not lead to changes in the long-run supply of fish. There is still much debate about the effectiveness of different management types and the resulting impacts on biological and economic outcomes.

The quality of management systems varies substantially across and within countries from poor management systems close to open access to well developed systems close to optimal management. As a result, predicting the effects of trade restrictions or trade liberalization on fisheries must be done on a case by case basis. In addition, there are a number of fish stocks that are subject to Illegal, Unregulated and Unreported (IUU) fishing—some in international waters and some within jurisdictions of individual nations. Fishing practices also differ substantially across countries, and in many developing countries—and for industrial fleets fishing in international waters—the overfishing problem is often exacerbated by subsidies. In contrast to other industries, such subsidies, while wasteful, are unlikely to convey long-run competitive advantages for subsidizing countries.

Many common-pool fisheries problems occur in international waters or involve straddling or shared fish stocks. Regional Fishery Management Organizations (RFMOs) work to establish multilateral agreements on fishing levels and practices and seek to enforce these agreements with the assistance of member countries. In some cases, as with IUU fishing, trade restrictions can be the only way to regulate environmentally problematic practices. At the same time, such measures can also discriminate between countries, and particularly be detrimental to developing countries with limited capacity to manage fish stocks or to document the management.

There is significant momentum in industrialized countries toward rights-based management of fisheries that break the non-excludability problem of open access. But there is also momentum toward more ecosystem-based management of the marine environment that considers a broader set of issues such as spatial characteristics of fisheries. These trends may influence the international fish trade, as they have the potential to alter production of capture fisheries and aquaculture operations and thus can affect demand for imports. Moreover, management trends may influence international environmental norms, which could lead to increased pressure for trade restrictions to promote marine conservation.
Trade actions of individual countries or groups of countries have the potential to fall under the jurisdiction of, and possibly conflict with, a wide range of WTO rules, including sanitary and phytosanitary measures, anti-dumping, subsidies and countervailing measures, and technical barriers to trade and rules of origin. Depending on how broadly protection of human health and the environment are interpreted, efforts to promote marine conservation could lead to a proliferation of trade restrictions that are allowable under WTO rules.

4.0 CONCLUSION

Seafood has been a traded commodity for thousands of years. From early on, the quantity traded was limited. A main reason for this was the perishability of seafood, and conserving fish (e.g., by producing dried fish) was time consuming, costly, and often inefficient. However, improved storage and preservation technologies and cheaper transportation have dramatically increased fish trade over the last 30 years.

5.0 SUMMARY

A number of factors have caused the increased trade in seafood. Transportation and logistics have improved significantly. Substantial reductions in transportation costs by surface and air has promoted the international trade of new product forms like such as fresh seafood.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain trade globalization of fish industry.
2. What is the work of Regional Fishery Management Organizations (RFMOs)?

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