HEALTHY FISH FOR MAN

AN INAUGURAL LECTURE,
2011/2012

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UNIVERSITY OF IBADAN

HEALTHY FISH FOR MAN

An inaugural lecture delivered at the University of Ibadan

on Thursday, 14 June, 2012

By

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Ibadan University Press
Publishing House
University of Ibadan
Ibadan, Nigeria.

First Published 2012

ISBN: 978 – 978 – 8414 – 83 – 4

Printed by: Ibadan University Printery

The Vice-Chancellor, Deputy Vice-Chancellor (Administration), Deputy Vice-Chancellor (Academic), Provost of the College of Medicine, Dean Faculty of Veterinary Medicine, Dean of the Postgraduate School, Deans of other Faculties and of the Students, Distinguished Ladies and Gentlemen.

Introduction

I am deeply grateful to my Head of Department and the Dean of the Faculty for nominating me as the inaugural lecturer for this year and of today. I also thank the Vice-Chancellor and the University for accepting my nomination. The lecture for today is certainly the Lord's doing, to whom I am deeply grateful. Today's lecture is the 30^{th} from the Faculty of Veterinary Medicine and 3^{rd} from the Department of Veterinary Public Health and Preventive Medicine.

I was appointed temporary Lecturer II on 12^{th} April 1978 and was immediately assigned to teach Wildlife (including Fish) Ecology, Management and Diseases by my revered, visionary and academic father, Professor Gabriel Oluwole Esuruoso, to whom I am deeply grateful. He, at that early time, put my feet firmly on the road that led to my becoming the first fully trained Aquatic Veterinary Surgeon in the Faculty of Veterinary Medicine.

Having been swimming with fishes for 34 years, I am at a vantage position to speak on the health of fishes and the corresponding public health implications. Mr. Vice-Chancellor Sir, it is pertinent first to know the sources of fishes.

Earth Surface

The total area of the earth's surface is about 517, 997, 622 Km^2; 362, 598, 335 Km^2 is water and 155, 399, 287 square kilometers consist of land stretching from the South to the North Pole. The large masses of water and land in different parts of the earth constitute a suitable environment for a large variety of life.

Fig. 1: A diagram of the globe

The oceans cover 70% of the surface of the earth. There are five oceans namely:

- Pacific Ocean
- Atlantic Ocean
- Indian Ocean
- Arctic Ocean
- Antarctic Ocean

The oceans hold the most amount of water on Earth.

The Pacific Ocean: It is the largest and deepest body of water. If all the continents were placed in the pacific, there would still be room for another, the size of Asia, the largest continent. The pacific covers more than a third of the surface of the world. It stretches from the frozen North to the frozen South and laps the shores of warm Islands in the Tropics. Its waters wash the coasts of Hawaii, the Philippines, New Zealand, and Japan. The Portuguese explorer, Ferdinand

Magellan looked upon this great ocean and named it Pacific, which means "peaceful". The Ocean has a total of about 165, 200, 000 square kilometers.

The Atlantic Ocean: This is the second largest body of water in the world. The ancient Romans named the Atlantic after the Atlas Mountains. The Atlantic covers about a third of the world's water surface and more than a fifth of the surface of the earth. A map of the world shows that the ocean touches Europe and Africa on its eastern side, North and South America from the western boundary.

The Indian Ocean: Is the third largest ocean in the world. It covers an area of about 73, 442, 479.9 square kilometers. This body of water is somewhat smaller than the Atlantic Ocean. It is less than half of the Pacific Ocean. The Indian Ocean reaches from Africa on the west to Australia and the East Indies on the east. Asia lies to the north and the Antarctic to the south. The north-eastern part of the Indian Ocean is the deepest.

The Arctic Ocean: Lies north of Europe, Asia and North America. The North Pole is about 1, 294.99 kilometers from its center floating masses of broken, piled-up ice known as Polar Ice. This covers most of the Ocean during the greater part of the year. Many geographers consider the Arctic Ocean a sea or a gulf of the Atlantic Ocean, rather than a separate body of water.

The Antarctic Ocean: Is the name sometimes given to waters surrounding the continent of Antarctica. Many geographers consider these waters as not being a separate ocean, but the southern end of the Atlantic, the Pacific and the Indian Oceans. The Antarctic Ocean is an unbroken belt of water that varies in width from 1, 553.99 kilometers off Cape Horn at the tip of South America to 6, 215.97 kilometers off Cape Agulhas, the southern tip of Africa.

Life in the Oceans

Life originated in the world's oceans over the millennia has spread inland and evolved into diverse forms of animals and plants. Some plants live on the shallow ocean bottoms, especially along the coasts. Some plants live in the ocean waters, not attached to the soil. Because plants must have light in order to grow, they do not grow in deep waters. Light reaches into only the shallow parts of the ocean. Animals in the ocean vary in sizes, some are so small, they can only be seen with a microscope, but a whale may be 2,438.4 centimeters long. Not all the animals are fishes; the animals that have shells, such as clam, shrimp and lobster are not true fish, but are called "shellfish". Some animals such as turtles are reptiles, others are mammals. Cows, elephants and human beings are land mammals. Whales, seals and walruses are aquatic mammals. They breathe air, are warm-blooded and feed their young with milk from mammary glands.

Fishes are cold-blooded animals that lay eggs and have scales on their bodies. They are "vertebrates" or animals that have backbones. Shellfish are invertebrates, or animals that do not have backbones. However, shellfish have hard shells, which protect them. All animal life depends upon plants. Most sea plants grow in shallow water. Therefore, most fish are found near continents and not in the open ocean. The three great fishing grounds of the world are—about and to the North of Japan, in the waters about Great Britain, Norway and Iceland, and off Newfoundland. There are some fishes that live in the deepest sea, even in the Mariana trench in the Pacific Ocean.

Seas

If the ocean was a tree the seas would be its branches. Unlike the oceans, the seas have some land surrounding them. The seas have salt water just like the oceans. Different seas include:

The Caribbean Sea: It surrounds the Caribbean. The Caribbean Sea is in the Atlantic Ocean.

The Red Sea: It is called the Red Sea because the algae that live there make it look red. The Red Sea is in the Indian Ocean.

The Black Sea: It is called the Black Sea because the amount of hydrogen makes it appear black. The Black Sea is in the Atlantic Ocean.

The Mediterranean Sea: The Mediterranean Sea is in the Atlantic Ocean.

The South China Sea: The South China Sea is in the Pacific Ocean.

The Caspian Sea: It surrounds Asia and Russia. Even though it is called a sea it is the biggest lake on Earth.

Largest Lakes by Continent

The East African Great Lakes: are a series of lakes and the Rift Valley lakes in and around the East African Rift. They include Lake Victoria, the second largest fresh water lake in the world in terms of surface area, and Lake Tanganyika, the world's second largest in volume as well as the second deepest. Others include Lakes Malawi, Turkana, Albert, Kivu and Edward. Lake Kyoga is part of Great Lakes system, but is not itself considered a Great Lake, based on size alone.

The Great Lakes of North America: are a collection of freshwater lakes located in northeastern North America, on the Canada—United States border. Consisting of Lakes Superior, Michigan, Huron, Erie, and Ontario, they form the largest group of freshwater lakes on Earth by total surface, coming in second by volume behind Baikal in Russia. The total surface is 244,106 km^2, and the total volume (measured at the low water datum) is 22,671 km^3.

Lake Baikal: is the world's oldest at 30 million years old and deepest lake with an average depth of 744.4 metres. Located in the south of the Russian region of Siberia, between Irkutsk

Oblast to the northwest and the Buryat Republic to the southeast, it is the most voluminous freshwater lake in the world, containing roughly 20% of the world's unfrozen surface fresh water. At 1,642 metres, having the typical long crescent shape with a surface area of 31,722 km^2, Baikal is home to more than 1,700 species of plants and animals, two thirds of which can be found nowhere else in the world.

***Lake Ladoga*:** is a freshwater lake located in the Republic of Karelia and Leningrad Oblast in northwestern Russia, not far from Saint Petersburg. It is the largest lake in Europe. The lake's area is 17,891 km^2, its length (north to south) is 219 km, average width is 83 km, average depth is 51m, maximum depth is about 230 m. The basin of Lake Ladoga includes about 50,000 lakes and 3,500 rivers longer than 10 km. About 85% of the water income is due to tributaries, 13% is due to precipitation, and 2% is due to underground waters.

Lake Eyre: is the lowest point in Australia, at approximately 15 m below sea level, and on the rare occasions that it fills, it is the largest lake in Australia and 18th largest in the world. It is the focal point of the vast Lake Eyre Basin.

Lake Titicaca: is a lake located in the Andes on the border of Peru and Bolivia. It sits 3,811 m above sea level, making it the highest commercially navigable lake in the world. By volume of water, it is also the largest lake in South America.

Lake Vostok: is the largest of more than 140 sub-glacial lakes found under the surface of Antarctica. Lake Vostok is located beneath Russia's Vostok Station under the surface of the central East Antarctic Ice Sheet, which is at 3,488 metres above mean sea level. The surface of this fresh water lake is approx 4,000 m under the surface of the ice, which places it at approx 500 m below sea level.

***Lake Chad*:** Lake Chad is located mainly in the far west of Chad, bordering on northeastern Nigeria. According to the Global Resource Information Database of the United Nations

Environment Programme, it shrank as much as 95% from about 1963 to 1998; but "the 2007 (satellite) image shows significant improvement over previous years". Lake Chad is economically important; providing water to more than 20 million people living in the four countries that surround it (Chad, Cameroon, Niger, and Nigeria) on the edge of the Sahara Desert. It is the largest lake in the Chad Basin.

Main African Rivers

The Congo River

Congo River is a river of Equatorial Africa and one of the great rivers of the world. Its discharge of water to the sea is second only to that of the Amazon. Measured from the source of its principal headstream, the Lualaba River in the Democratic Republic of the Congo, the Congo River is about 4,700 km long and drains an area of some 3,900,000 km^2. The river begins in southeastern Democratic Republic of the Congo and flows northward and westward in a giant arc through tropical savannas and rain forests to the Atlantic Ocean. It drains virtually all of the Democratic Republic of the Congo, the largest and most populous nation in the river's basin, and parts of eight other countries.

The Limpopo River

Limpopo River or Crocodile River is a river of South Africa and Mozambique. It is about 1,600 km long. The source of the Limpopo River is near Johannesburg. From there, the river flows north and northeast, separating the province of Limpopo in South Africa from Botswana and Zimbabwe. The river then turns southeast, running through Mozambique and emptying into the Indian Ocean.

The Niger River

Niger River, a river of Western Africa is 4,200 km long, the third longest in Africa (after the Nile and the Congo). It drains an area of about 1,890,700 km^2. The Niger begins in southern Guinea near the Sierra Leone border and flows in a great arc northeastward into Mali, skirting the edge of the Sahara before turning southeastward and flowing through

Niger and Nigeria. It empties into the Gulf of Guinea through a broad delta. The Niger has only one large tributary—the Benue in Nigeria.

The Nile River

The Nile River is the chief river of Africa and the longest in the world. Measured from its remote source, the Nile River is some 6,600 km long. The river system drains parts of 10 countries, from Tanzania northward to Egypt. It is the only major river that rises in the equatorial tropics and flows through the desert. For centuries, millions of North Africans have depended on the water of the Nile for their crops.

The Orange River

Orange River, the chief river of South Africa, begins on the slopes of the Drakensberg range in northeastern Lesotho and flows generally westward for 2,100 km across Lesotho and South Africa to the Atlantic Ocean. The river serves as the boundary between the countries of South Africa and Namibia. It also forms parts of the boundaries of several provinces in South Africa. Its principal tributary is the Vaal River.

The Zambezi River

Zambezi (or Zambeze) River is one of the largest rivers in Africa. From headwaters in eastern Angola and western Zambia, it flows easterly in an S-shaped curve for about 2,600 km to the Indian Ocean in Mozambique. Along its middle course, the Zambezi forms an international boundary between Zambia and three of its neighbours—Zimbabwe, Botswana, and Namibia. The basin drained by the river is about 1,300,000 km^2.

Fig. 2: Rivers in Africa

Rivers in Nigeria

The names of the major Rivers that flow through Nigeria are the River Niger (which is where Nigeria gets its name), and the river Benue. The 'end' region where the Niger River meets the ocean is commonly referred to as a 'delta'. Of course, there are other rivers, including Anambra, Cross River, Gongola, Hadejia, Ka, Kaduna, Katsin-Ala, Kamadugu, Ogun, Osun, Owena, Osse, Sokoto, Yedseram, Yobe, and Zamfara (fig. 3).

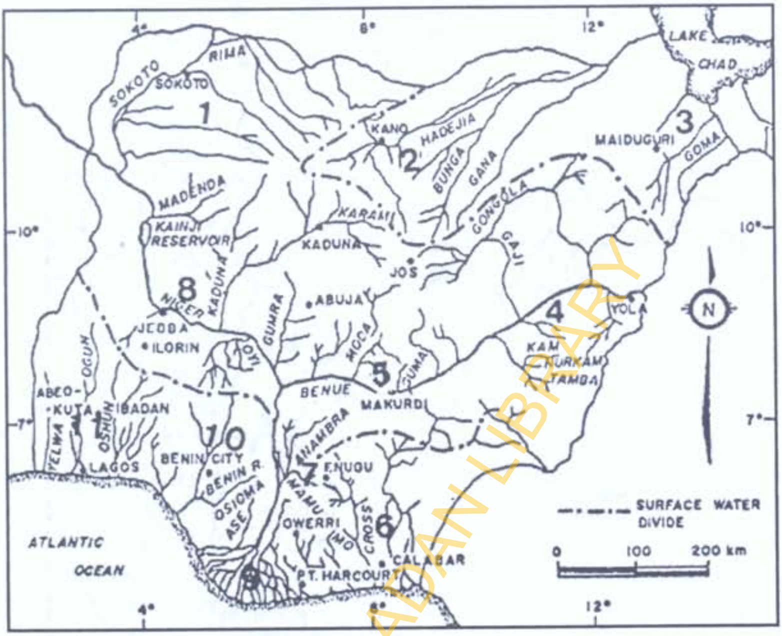

Fig. 3: River systems of Nigeria
Source: Kapetsky 1981

Fish

Mr. Vice-Chancellor Sir, fish is a key ingredient on the global menu; a vital factor in the global environmental balance and an important basis for livelihoods worldwide. The Collins (Thesaurus) dictionary (1987) gave four definitions of fish, which I want Mr. Vice-Chancellor and the audience to note.

- Any of a large group of cold-blooded aquatic vertebrates having jaws, gills and usually fins and a skin covered in scales; includes the sharks, rays, teleosts, lungfish, etc.
- Any of various aquatic invertebrates such as the cuttlefish and crayfish.
- Any of various similar, but jawless vertebrates, such as the hagfish and lamprey.
- The flesh of fish used as food.

In this lecture, the first step of the four definitions is highlighted. Fishes are animals that have backbone and are able to live in the water throughout their lives. They breathe by gills rather than by lungs. In place of legs with toes, they have two pairs of fins. The bodies of most fish are covered with hard scales. These scales are very different from the horny scales of reptiles, the feathers of birds and the hairs of mammals. Fishes, which are scientifically classified as "**Pisces**" were the first animals with backbones. "Fossil fish" are found in rock layers that were formed millions of years before the first land animals with backbones appeared. However, fishes were created on the fifth day of creation (Genesis 1:21-23). There are more fishes than any other animals with backbones. There are more than 30,000 kinds of fish. They live in oceans, seas, lakes, rivers and streams from the Equator to the Polar Seas, and from elevations of more than 5,000m above sea level to depths below 10,000m in the Mariana Trench in the Pacific Ocean.

There are few waters that do not contain at least one kind of fish. Fossils show that this has been true for many millions of years. Fishes have a great variety of forms and habits because they live in many different places. The appearance, body structure, and life way fit each kind of fish to the particular place where it lives. In the open sea, for example, most fish are hard to see because they are coloured metallic blue-green above and silvery below. They are almost perfectly streamlined. There are two reasons for this: (i) In open water, the kinds of fish that are eaten have no place in which to hide. They must swim swiftly to avoid being eaten. (ii) The kinds that eat other fish must also swim swiftly in order to catch their prey.

Fishes that live at the bottom of bodies of water are coloured like the bottom. Many of them are eel-shaped, so that they can slip into burrows or cracks. Others cannot move fast because they have developed a bony armour or strong spines, which is their protection. Fish that live in seaweeds are often marvelously camouflaged. They may even resemble the seaweeds in shape and movements as well as colour. Many fish that live in the dark, deep sea carry their own lights.

Freshwater Fish

Freshwater fish are fishes that live at least part, if not all, of their lives in bodies of fresh water with a salinity of less than 0.5ppt. Forty-one percent of all known fish species are found in freshwater.

Marine Fish

Marine fish are an abundant and valuable resource. However, the ocean's supply is not limitless and therefore careful planning and education must be undertaken to ensure the sustainability of the world's largest food source.

Aquatic Resources in Nigeria

Nigeria is a country rich in natural and mineral resources, which if properly managed can enable the country to develop economically. There are two major rivers in Nigeria (Rivers Niger and Benue). FDF report of 2002 indicated the existence of 853km coastline and 210,900 km^2 Exclusive Economic Zone (EEZ), given the total area of the country's entire maritime waters including the EEZ as 257, 200 km^2. Apart from being a maritime country, about two thirds of Nigeria lies in the watershed of the Niger River, which empties into Atlantic at the Niger Delta, and its major tributaries: Cross-River, Benue, Kaduna, River Osun, River Ogun, Sokoto and Anambra. The extensive network of rivers, inland waters, lake and lagoons is estimated at more than 5 million hectares (Eyo 2003).

Fisheries

Fishery is an area which supplies abundance of fish for commercial purposes. Species of cod, flatfish, herring, sardines and tuna make up the world's most important fishery resources. Many governments practice "Fishery Management" to conserve fish. Rules limit the size and amount of fish that may be caught and the fishing season. The United States (federal and state government) operate fish-culture stations, sometimes called "fisheries". Here, fishes are grown to be placed in various bodies of water.

Capture fisheries refer to the removal of aquatic organisms from inland and marine waters. The term refers to the process of extraction and applies to harvesting from both, unimproved 'wild' and enhanced fish stocks (FAO 1997a). The world's capture fisheries harvested an estimated 1, 731 aquatic species or species groups in 2008. The majority of this diversity was fin fishes (1, 268 species), followed by crustaceans (181 species), mollusks (145 species) and other species. As such, capture fisheries use a greater variety of biological diversity than any other food production sector. Capture fisheries can be either industrial or artisanal fisheries.

Industrial Fisheries

As a general rule, industrial fisheries are confined to the continental shelf where fish are more abundant, although there are exceptions. The fisheries for large pelagics such as tuna and swordfish are ocean-ranging ship using purse seines and longlines (fig. 4).

Fig. 4: A trawling ship used for industrial fishing
(http://www.croatia.org/crown/content_images/2008/fishing_trawler.jpg)

Artisanal /Small-Scale Fisheries

According to FAO glossaries, artisanal fisheries are traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore and mainly for local consumption. In practice, definition varies between countries; for example, from gleaning or a one-man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export (fig. 5).

Fig. 5: Fishing canoes in a fishing community in Lekki-Epe, Lagos

Aquaculture

Aquaculture is "the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc." (FAO Fisheries Glossary). *Aquaculture* implies a degree of human intervention which exceeds that of enhanced fisheries and involves ownership over the stocks. Aquaculture contributes significantly to food availability, household food security, income generation, trade, and improved living standards in many developing countries in Asia. In poor rural communities, aquaculture can be an integral component of development, contributing to sustainable livelihoods and enhancing social well-being. Since 1990, the gap between the demand for and supply of fish as food has been widening rapidly due to the decline of capture fisheries production and a continually growing population. Aquaculture is forecast to dominate, if not surpass, the importance of capture fisheries in providing high quality animal protein to lower income groups, employment, and export earnings.

The practice of aquaculture or fish culture is a very old one. In the Middle Ages, fish culture in Europe was developed with monasteries. Some centuries ago, the Chinese and countries in Indo-Pacific regions practice the art of fish culture. In Pakistan and India, fish culture is an ancient science with the culture of the India Carp. The first carp ponds were built in Wittingau (Czechoslovakia) in 1358 and for the next 400 years in Europe, this was the centre for raising pond fish. From the 15th to 18th centuries; North (1713) and Baccius (1841) presented detailed techniques for raising pedigreed carp and other common fish useful for food. These investigations have been made in an understanding of the many facets composing the pond habitat for fish. In North America, fish culture has developed considerably, since the start of the last century. The aim is to produce fish for food or fish for restocking which, according to the desired purpose can be cold water fish. China has the longest history of aquaculture practice in the world. Currently, its national annual fisheries production and aquaculture production rank the first in the world. The inland aquaculture, especially pond fish culture, has developed rapidly in the past two decades in China which is leading in the world in terms of production and techniques.

Aquaculture in Africa has come a long way since it was first introduced. However, in comparison to the rest of the world, aquaculture production in Africa is still in its infancy at the global level and accounts for about 0.9 per cent (404,571 tonnes) of the total global aquaculture production in 2000 (FAO 2003). In Nigeria, fish culture was first started at about 1944, as a means of increasing the supply of protein in the local villages and towns (Eliott 1968).

Rearing Systems

Extensive Culture System

Extensive aquaculture is characterized by low to no inputs (food, fertilizer, etc.) and low stocking densities. Extensive aquaculture is practiced in lakes, reservoirs and lagoons.

Ponds

The most common production system in use is the earthen pond. Earthen ponds are extremely popular among fish growers due in part to ease of construction, low maintenance, relatively small area requirements and ability to grow a wide variety of species. Additionally, because earthen ponds mimic nature, they may produce fish of an overall healthier appearance than other techniques. A natural supply of food is often available in earthen ponds which may lead to better fish health. Pond culture can vary from all life stages naturally occurring in a single pond to elaborate systems with discrete ponds for holding broodstock, spawning, rearing, growing and catch-out or harvest.

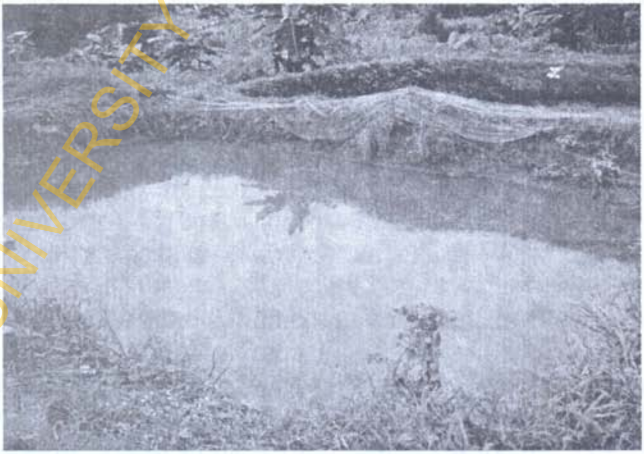

Fig. 6: An earthen pond used as extensive fish culture system

Tanks

Tanks essentially act as ponds but are generally constructed of concrete or fiberglass. Wood can also be used but must first be treated to prevent rotting. Concrete tanks have the advantage of being less expensive, easily constructed and formed into various shapes. It is highly recommended for backyard fish farming, because it requires less space and is easy to manage.

Fig. 7: Concrete tanks used as extensive fish culture system

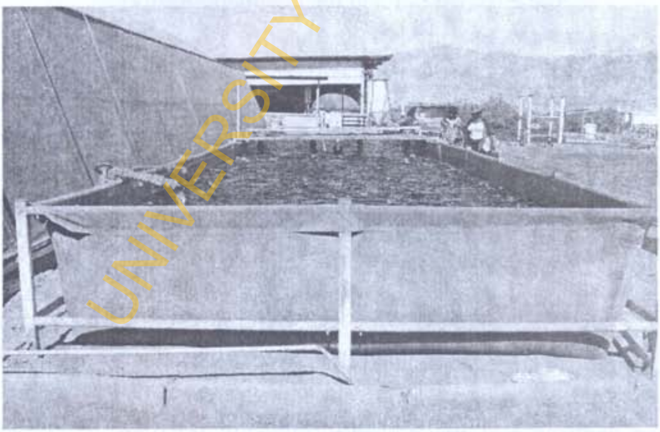

Fig. 8: A plastic tank used as extensive fish culture system

Semi-Intensive Culture System

Semi-intensive aquaculture is distinguished by increased stocking rates and the requirement for some level of input, such as food, fertilizer, aerators, chemicals, etc.

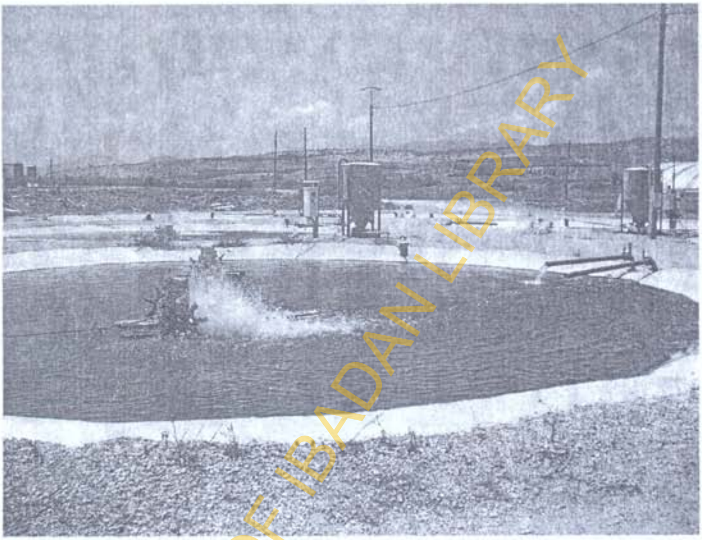

Fig. 9: An earthen pond used as semi-intensive fish culture system (note the aerator and the automatic feeder)

Cage Culture

Cage culture of fish uses existing water resources (i.e. rivers, lakes, ponds, sea) but encloses the fish in a cage or basket, which allows water to pass freely between the fish and the pond or lake. One of the main advantages is the ease of harvesting.

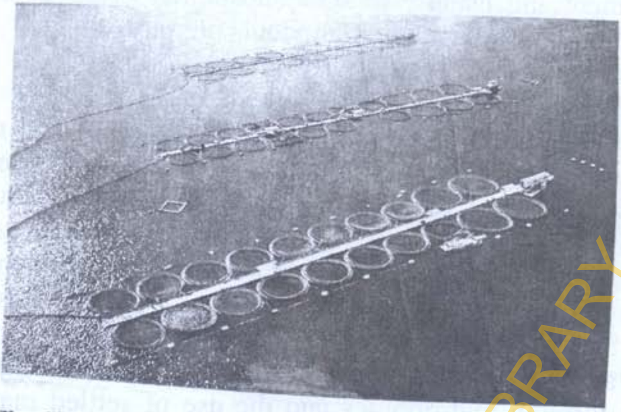

Fig. 10: Cage culture used as semi-intensive fish culture system

Fig. 11: My wife tending to cage-cultured fish on the walkway of a series of cages on the British North Sea

Intensive Culture System

In intensive aquaculture, animals are grown in systems such as tanks and raceways, where the support parameters are carefully controlled and dependence on the natural environment is minimal. Such systems require a high degree of management and usually involve substantial investment and operating costs, resulting in high yields per unit area.

Re-circulating Systems

As the name implies, re-circulating systems filter and reuse all or a portion of the water supplied to the system. Currently, this technique is in very limited use due to its high start-up and maintenance costs. It has several advantages, however, in that this system is highly desirable in areas where a constant water supply may be questionable or a discharge is not appropriate. Additionally, other advantages of this type of system are the ability to incorporate the growth of a second product through hydroponics and the use of settled material as fertilizer. As the technology evolves and water withdrawal and discharge requirements become more stringent, this technique is bound to see an increase in utilization.

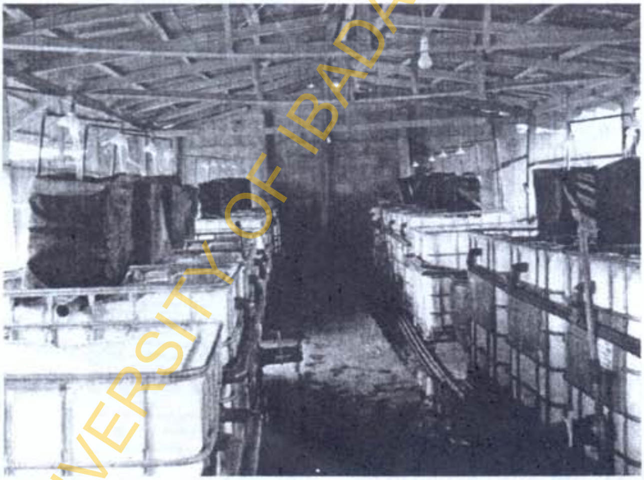

Fig. 12: Fabricated re-circulating system used as an intensive fish culture system

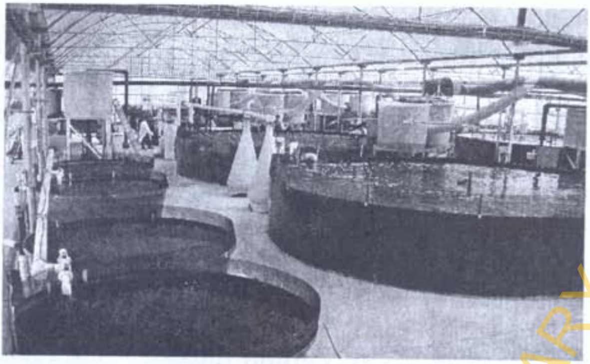

Fig. 13: Fibreglass tanks used in super-intensive Re-circulating fish culture system

Disease Occurrence in Aquaculture

Disease is rarely a simple association between a pathogen and a host fish. Usually, other conditions must be present for active disease to develop in a population. These conditions are referred to as "Stress". Disease occurrence is usually associated with the presence of the "host", in this instance, fish, the "pathogen" or disease agent and one or more "environmental stressor" as depicted in figures 14 and 15. Stress in fish results from environmental or other factors that extend the animal's physiological processes beyond the normal range.

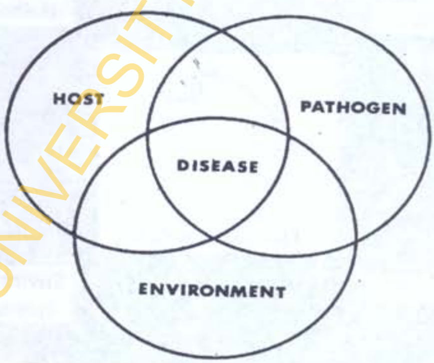

Fig. 14: Venn diagram of the interactions leading to disease occurrence in fish

Physiological stress and physical injury are the primary contributing factors of fish disease and mortality in aquaculture. Many potential fish disease pathogens are continually present in the water, soil, air, or fish. In nature, fish are often resistant to these pathogens, and they are able to seek the best living conditions available. Food fish reared under commercial aquaculture conditions are confined to the production unit and are weakened by stress conditions including:

- increased fish density and poor water quality (i.e. low dissolved oxygen, undesirable temperature or pH, increased levels of carbon dioxide, ammonia, nitrite, hydrogen sulfide and organic matter in the water);
- injury during handling (i.e. capture, sorting, shipping);
- inadequate nutrition; and
- poor sanitation.

These conditions can result in decreased resistance by the fish, resulting in the spread of disease and parasite infestation. Stress and injury initially trigger an alarm reaction (fight or flight response), which results in a series of changes within the fish.

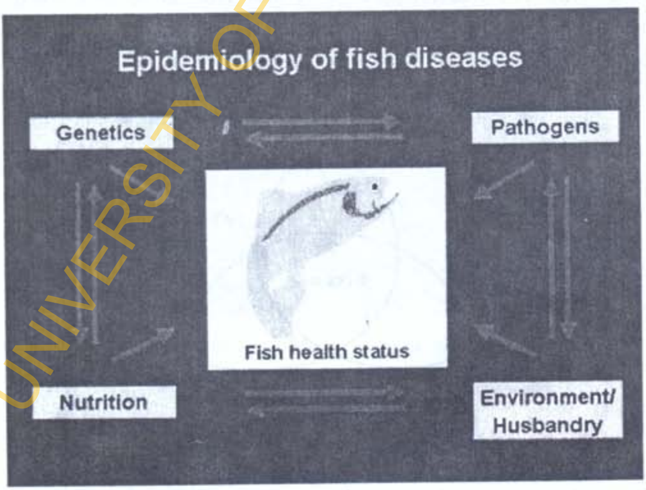

Fig. 15: Diagram showing epidemiology of fish diseases

The Significance of Fish Disease to Aquaculture

Fish disease is a substantial source of monetary loss to fish farmers. 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.

The Host Factor: Fish, Anatomy, Physiology and Biochemistry

Fish have some unique anatomical and physical characteristics that are different from mammals; however, they still possess the same organ systems that are present in other animals. All fishes are poikilothermic and must be able to adapt to changes in water temperature. Fish live in a variety of temperatures ranging from less than 0°C to hot geothermal springs. Yet, each species of fish must live in its particular specific temperature range. Abrupt temperature changes in the water can be lethal to fish. Organ systems of fish vary to some extent from that of mammals due to the aquatic environment they live in. The following are some of the important differences:

Integument

Fish do not have a keratin layer over the epidermis. They are covered by a cuticle composed of mucus, mucopolysaccharides, immunoglobulins and free fatty acids. Ctenoid scales are present in elasmobranchs (cartilaginous fish e.g., shark, rays, skates). Cycloid scales are present in teleost fish. Scales also represent a source of calcium for fish; some fish will utilize the calcium in the scales in preference to the calcium in their skeleton during times of starvation or prespawning activity.

Respiratory System
The gills consist of holobranchs which form the sides of the pharynx. Each holobranch has two hemibranchs projecting from the gill arch. The hemibranchs are composed of rows of long thin filament called primary lamella. The primary lamella has the surface area increased further by the secondary lamella. Gas exchange takes place at the level of the secondary lamella. Pseudobranch lies under the dorsal operculum.

Endocrine System
There is no true adrenal gland present in most fish (exception is sculpins, *Scorpaena guttata*). The thyroid follicles are very similar to mammalian thyroid tissue. Thyroid follicles are distributed throughout the connective tissue of the pharyngeal area and may be observed around the eye, ventral aorta, hepatic veins and anterior kidney. The endocrine pancreas is present in most fish as islet of Langerhans and is associated with the exocrine pancreas. In some species the islets are very large and may be grossly visible (Brockman bodies). During the spawning season, the size and number of islet will increase in some fish. The parathyroid glands are absent in fish, their function is taken over by other endocrine organs (Corpuscles of Stannius).

Ultimobranchial Gland: This gland lies ventral to the esophagus in the transverse septum separating the heart from the abdominal cavity. This organ secretes calcitonin (lowers serum calcium levels) which acts with hypocalcin (secreted by the corpuscles of Stannius) to regulate calcium meta-bolism.

Corpuscles of Stannius: These are islands of eosinophilic granular cells located in paired organs on the ventral surface of the kidney. This organ secretes a protein called hypocalcin (teleocalcin) which acts with calcitonin to regulate calcium metabolism.

Urophysis: This is a neurosecretory organ found on the ventral aspect of the distal end of the spinal cord. These bodies are composed of un-myelinated axons terminating on a capillary wall. The function of the urophysis is unknown.

Pineal Gland: The pineal gland is a light sensitive neuro-endocrine structure which lies in the anterior brain and is a well vascularized organ. This gland secretes melatonin which may play a role in controlling reproduction, growth, and migration.

Pituitary: The pituitary gland produces, accumulates, and stores the gonadotropic hormone(s) which plays a decisive role in ovulation. In so far as reproduction is concerned, the role of the pituitary gland is that of an intermediary between the central nervous system and the gonads. The gonadotropic hormone is produced by sexually mature fish and the cyclical changes in its concentration in the pituitary gland are correlated with the reproductive cycle of the fish. Its concentration is maximum during the prespawning period, while it is very low or almost nil during and after spawning. The release of gonadotropin(s) by the pituitary gland is "ordered" by the hypothalamus through the secretion of gonadotropin-releasing hormone (GRH).

The gonadotropin is also responsible for inducing spawning migration, during which its concentration in the pituitary gland gradually decreases. The gonadal development during spawning migration is most probably directed by the continuously released gonadotropin(s). The pituitary gland is situated on the ventral side of the brain below the hypothalamus, which is connected to the pituitary gland by a funnel-like structure, the infundibulum. The part of the cranium where the pituitary gland is located is known as the sella turcica. The gland is usually embedded in fatty tissue. When the brain is taken out of the skull, the pituitary gland remains connected to the brain in some fishes, while in most fishes the infundibulum ruptures and the gland is left behind on the base of the skull.

Digestive System

The digestive system of fish is similar to the digestive tract of other animals. Carnivorous fish have short digestive tracts when compared to herbivorous fish. Some tropical species of fish e.g. tambaqui (*Colossoma macropomum*) have pyloric caeca which are occasionally confused with parasites. These caeca secrete the digestive enzymes required to digest some food. Fish without the pyloric caeca have digestive enzyme production in the liver and pancreas. It is not possible to divide the intestine into large and small intestine. The liver does not have the typical lobular architecture that is present in mammals. In many species of fish, there are areas of exocrine pancreas (Hepato-pancreas) that are present near the small veins, off the hepatic portal vein. The pancreas is scattered in the mesentery, primarily near the pylorus.

Reticuloendothelial System

Fish do not have lymph nodes and bone marrows. Phagocytic cells are present in the endothelial lining of the atrium of the heart and in the gill lamella. There are no phagocytic cells (Kupffer cells) in the liver. Melano-macrophage centers are present in the liver, kidney and spleen. Melano-macrophage centers increase in number during disease or stress. The fish thymus is the central lymphoid organ. This organ is located subcutaneously in the dorsal commissure of the operculum. Fish have the ability to produce specific immunoglobulins (IgM only) and have both delayed and immediate hyper-sensitivity. Fish have the ability to produce virus neutralizing, agglutinating, and precipitating antibodies. Both B and T lymphocytes are present.

Cardiovascular System

The heart is composed of two chambers: one ventricle and one atrium. Some authors also describe the sinus venosus as the third chamber and bulbus arteriosus as the fourth chamber. Blood flows from the heart through the ventral aorta and the afferent branchial arteries, to the gills for oxygenation. Oxygenated blood returns via the efferent arteries to the dorsal aorta. The dorsal aorta then carries the oxygenated blood to the body. Some oxygenated blood also leaves the dorsal aorta and goes to the pseudobranch to be highly oxygenated and then is sent to the retina which has a high oxygen demand.

Urinary System

The kidneys of fish develop from the pronephros and mesonephros. The function of the kidney is osmo-regulation. In freshwater fish, the kidney saves ions and excretes water. In saltwater fish, the kidney excretes ions and conserves water. The majority of nitrogenous waste is excreted through the gills. The other function of the kidney is haematopoiesis with haematopoietic tissue located in the interstitium of the kidney. This function is primarily in the anterior kidney but can be found throughout the entire kidney.

Special Sense Organs

Lateral Line System: There are two types of lateral line organs.

The Superficial Neuromast: There are two types of superficial neuromast; these are located in pits in the epidermis located primarily on the head. Their function is not completely known but it is believed they aid in movement and orientation.

The Second Lateral Line Organ: This is the lateral line canal system which runs the entire length of the fish with continuous extensions over the head. This organ is sensitive to hydrostatic stimuli and sound.

Environmental/Husbandry Factor

Beyond water, the word "environment" here refers to the water-holding facilities. Abnormalities or contamination of these water-holding facilities will result in a continuous occurrence of disease outbreaks. Fish culture facilities should therefore rely on a disease prevention programme, which includes: water quality and nutritional management, quarantine of new animals, and sanitation.

Water Quality: The chemistry, physical properties and microbial quality of water go a long way to determine the level of survival of fish. Core chemical parameters like dissolved oxygen, temperature, total ammonia nitrogen, unionized ammonia, pH, nitrite, alkalinity, hardness, etc. should be checked in water intended for fish farming. Very high microbial load in water can stress fish since these organisms do produce endo/exo-toxins as normal metabolites. Where the immune system of the fish cannot withstand this "microbial pressure", these microorganisms which are opportunistic, then invade the tissues and cause harm to the fish. It is easier for such a phenomenon to occur when the level of organic matter is high in cement/concrete tanks. The frequency is less in earthen ponds because of larger water volume and lower stocking density.

Nutrition: Poor nutritional quality, high level of mycotoxins and very high level of bacteria and fungi in cfu/gram of feed are major causes of diseases in fish. Deficiency of vitamin C (ascorbic acid) has been associated with bone problems like lordosis, scoliosis and cracked skull syndrome in fishes. Mycotoxins (e.g. aflatoxins) can have adverse effect on metabolism in fishes because of their effect on target organs. This would cause growth problems.

Sanitation: This is one of the cornerstones of fish health management in modern aquaculture. Sanitation practices should include disinfections between groups of fish, cleanliness while fish are growing, and prevention of disease transmission by equipment, personnel, or water. A number of infectious diseases, particularly external fungal infections, may be directly attributed to accumulation of organic material in the culture unit. Ponds may be sanitized between groups of fish by draining, drying, and in some instances by use of chemical sterilant such as hydrated lime. For smaller systems such as tanks and aquaria, debris should routinely be removed from the system by siphon hose. Equipment should be disinfected between culture units, and chemical disinfectant (i.e. sodium hypochlorite) should be used to disinfect fish-holding units between groups of fish. Ultraviolet light and ozone may be incorporated into re-circulating culture systems to minimize the number of infectious particles in the solution.

Poor Management Practices: These are caused by man and they include:

- Poor fish tank hygiene.
- Rough handling of fishes during sorting.
- Use of equipments (e.g. nets) without routine washing and disinfection and rinsing properly with water.
- Feeding dead fishes to others (thus transferring disease agents).
- Overstocking.
- Overfeeding.
- Wrong application of antibiotics and chemicals, resulting in toxicity problems and mortality.
- Poor feed drying and storage.
- Feeding raw chicken e.g. dead day old chicks and raw intestines to fishes, especially catfishes. This may be a major reason why we have been isolating some common poultry pathogens in sick and dead fishes (fresh samples).
- Lack of quarantine facilities for new fishes, especially where re-circulatory system is used.

Pathogen Factor

Types of Diseases: There are two broad categories of diseases that affect fish—infectious and non-infectious diseases.

Infectious Diseases

These are caused by pathogenic organisms present in the environment or carried by other fish. They are contagious, and some type of treatment may be necessary to control the outbreak of the disease. Infectious diseases are broadly categorized as parasitic, bacterial, viral and fungal diseases.

Fig. 16: Furunculosis in African catfish (*Clarias gariepinus*)

Fig. 17: White spot disease caused by a parasite (*Ichthyophthirius multifiliis*) in a catfish
Source: http://www.novalek.com/kordon/articles/images/catfish.jpg

Fig. 18: Haemorrhagic lesions on fish seen in Viral Haemorrhagic Septicaemia

Non-Infectious Diseases

Non-infectious diseases are caused by environmental problems, nutritional deficiencies, genetic anomalies and Neoplasia; they are not contagious and usually cannot be cured by medications. Non-infectious diseases can be broadly categorized as environmental, nutritional, and genetic.

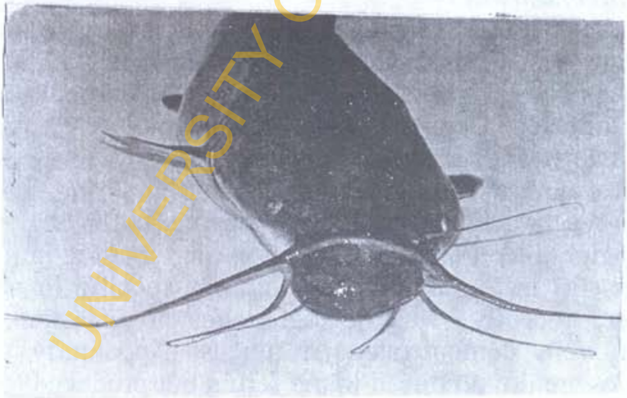

Fig. 19: Ameloblastic odontoma, a neoplastic condition in African catfish (*Clarias gariepinus*)

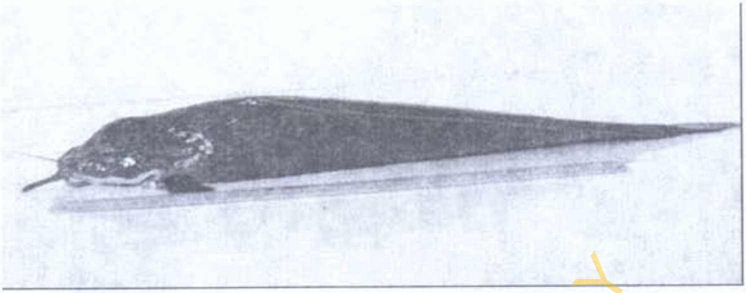

Fig. 20: Congenitally acquired abnormality of frontal bone of the skull in apparently healthy *Clarias gariepinus*

The Immune Response in Mammals

All vertebrates have mechanisms for controlling pathogens—those organisms which are capable of causing disease. However, fish are the most primitive organisms to have an adaptive immune system which is comparatively simple and undifferentiated compared with mammals (fig. 21). The immune system of fish has evolved with both non-specific (innate immunity) and acquired immune functions (humoral and cell-mediated immunity) to eliminate invading foreign living and non-living agents.

Innate Mechanisms

Innate mechanisms require no previous exposure to the particular agent—this includes physical barriers such as skin and mucus layers, specialized cells such as macrophages and natural killer cells and particular soluble molecules such as complement and interferon. The first line of defence which fish have against foreign agents, mucus and skin, contain immuno-reactive molecules (i.e. lysozyme, complement and immunoglobulin). Early research suggested that the immunoglobulin (Ig) in the skin/mucus was non-specific in nature. However, recently, specific antibodies to parasites and bacteria were demonstrated in mucus. Apparently, these antibodies are not produced in the serum but produced locally (i.e. by lymphocytes in the skin). Non-specific humoral molecules in fish include lectins (carbohydrate recognition), lytic enzymes, transferrin (iron binding protein) and components of the complement system.

Non-specific cells of the fish immune system include monocytes or tissue macrophages, granulocytes (neutrophils) and cytotoxic cells. Macrophages function in phagocytosis and in the destruction of invading foreign agents and bacteria. Macrophage activation occurs through cytokines and immune-stimulation (beta-glycan and other compounds) that increases the killing ability of these cells. As far as the complement system is concerned, duplication and diversification of several complement components are striking features of bony fish complement systems. It gives an interesting insight into an evolutionary strategy for the possible enhancement of the repertoire of innate immunity. Recent studies have also confirmed the presence of functional homologues of mammalian cytokines in fish. Some of the elements of the innate defence mechanisms interact extensively with the adaptive mechanisms, which, though present in most vertebrates, are particularly well-developed in mammals and birds.

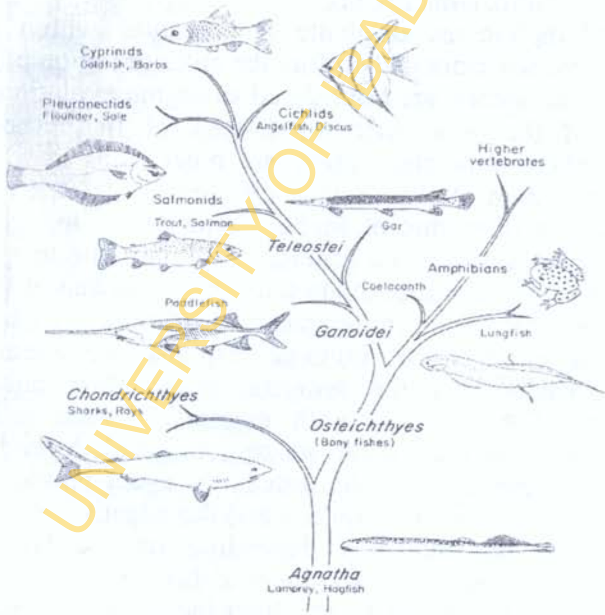

Fig. 21: A schematic diagram to show the evolutionary relationships of various fish groups

The Adaptive Immune System

Acquired immunity in fish includes both humoral and cell-mediated responses. Fish can display typical vertebrate adaptive immune responses characterized by immunoglobulins, T-cell receptors, cytokines, and major histocompatibility complex molecules (HSC). The cell-mediated response in fish is similar to that in mammals and relies on the presence of accessory cells (macrophages) to present antigen to T-cells. The correct presentation of antigen results in a cascade of events that includes cytokine production that regulates or enhances the cellular response. One major difference between fish and other vertebrates is that fish lack bone marrow. The anterior portion of teleost fish kidney is most likely the source of HSCs that will later give rise to the B and T-cell lineages. T-cell development takes place in the thymus of all vertebrates based upon an assortment of criteria. In teleleost fish, progenitor T-cells migrate from the kidney to the thymus for T-cell education (distinguishing self from non-self) and maturation (functional).

The B-lymphocytes originate and mature within the spleen and anterior kidney, therefore the anterior region of the fish kidney and spleen are considered to be the evolutionary equivalent of the bone marrow. B-cells of fish produce antibodies when stimulated. There are other areas in which the immune system of fish is quite different in its efficiency and complexity from that of higher vertebrates. One major difference is that fishes in general are poikilothermic—in other words they adapt their body temperature to that of their surroundings—the water temperature, and their metabolic rates and development of immune response are therefore directly dependent on the temperature of their aquatic environment. Therefore, as with mammals, when a fish encounters an infectious agent, its response will depend on whether it has experienced this infectious agent previously. Aspects of both the innate response and the adaptive immune system will come into play depending on the type of infectious agent, route of infection and history of previous contact with this infectious agent. Other factors such as stress and nutrition status will also have a part to play in the quality of the response.

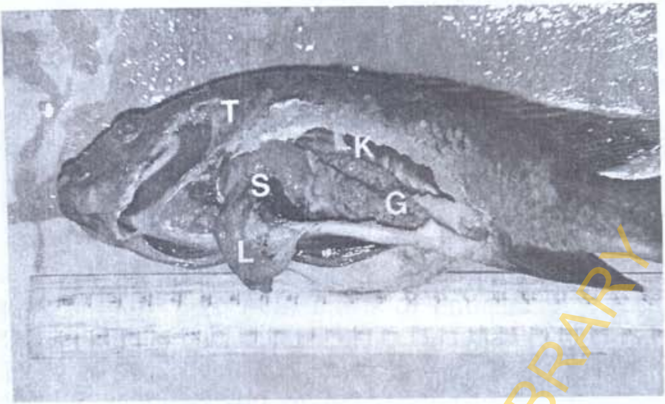

Fig. 22: Lymphoid organs in a dissected Tilapia (*Oreochromis niloticus*) *(L-Liver, S-Spleen, G-Gonads full of eggs, K-Kidney, T-Thymus position)*

Immune Responses in Fish

Fishes are one of the most primitive vertebrates and are an important link between invertebrates and higher vertebrates. They possess the non-specific defence mechanisms of the invertebrates such as the phagocytic mechanisms developed by macrophages and granular leucocytes, and were also the first animals to develop both cellular and humoral immune responses mediated by lymphocytes. The main lymphoid organs of fish are the thymus, the anterior kidney and the spleen (fig. 22). In fish, non-specific immunity is considered as the first line of defence and it represents a considerable part of the immune response (Dalmo *et al*. 1997). The non-specific immunity in fish, similar to those in higher vertebrates, mainly depends on the activity of monocytes/macrophages, melano-macrophagic centres, neutral granulocytes and thrombocytes (Agius and Agbede 1984, Agbede and Adeyemo 2001; Adeyemo *et al*. 2002). Phagocytic activity is an important immunological parameter in the study of bacterial infections in fish. We therefore initiated a study (Agbede 1992, Agbede *et al*. 2005) to ultra-structurally document the main stages of the phagocytic process after intra-peritoneal injection of colloidal carbon to tilapia (*Oreochromis niloticus*).

Lymphocyte Heterogeneity

The presence of mitogenic responses suggestive of lymphocyte heterogeneity has been reported in fishes. Phytohaemaglutinnin (PHA) stimulated leucocytes from the Paddlefish, *Polyodon spathula*; the Stingray, *Dasyatis Americana* and the Sea Lamprey, *Petgromyzonus marinus* (Olson 1967). Lymphocytes of Rainbow trout, *Salmo gairdneri* (Warr and Simon 1983); Brown trout, *Salmo trutta*; Carp, *Cyprinus carpio* and Channel catfish, *Ictalurus punctatus* (Faulmann *et al.* 1983, Clem *et al.* 1984) have all been shown to respond to stimulation by various mitogens. Mitogens are substances that induce blast transformation; DNA, RNA, and protein synthesis; and proliferation of lymphocytes; e.g., concanavalin A, phytohaemagglutinin, or lipopolysaccharide. Concanavalin A and phytohemagglutinin have been used to induce stimulation of peripheral blood leucocytes from the nurse shark, *Ginglymusoma cirratum* (Lopez *et al.* 1974). As with the response of B cells to lipopolysaccharide (LPS) and purified protein derivative (PPD), T-cells undergo division when stimulated by specific mitogen (Etlinger *et al.* 1978). Stone *et al.* (1995) reported that pokeweed mitogen stimulates both B and T lymphocytes.

Contributions to Knowledge

From the basic epizootiological principle, the triad of host, pathogen and environment could be attacked at the weakest link in the chain of disease causation. I opted to study some aspects of lymphocyte heterogeneity in tilapia (a host). Therefore, I started with mapping out lymphoid tissues in this fish (Agius and Agbede 1984, Agbede 1992, Agbede 2000, Agbede, Adedeji and Adeyemo 2000, Agbede and Adeyemo 2001, Adeyemo, Agbede and Magaji 2002). These studies showed that like other fishes, the thymus, spleen and kidney are the lymphoid tissues in tilapia in addition to other different functions. The lymphocyte separated over Ficoll-Paque was described by light and electron microscopy as seen in figures 23-26 below (Agbede 1992, 2000).

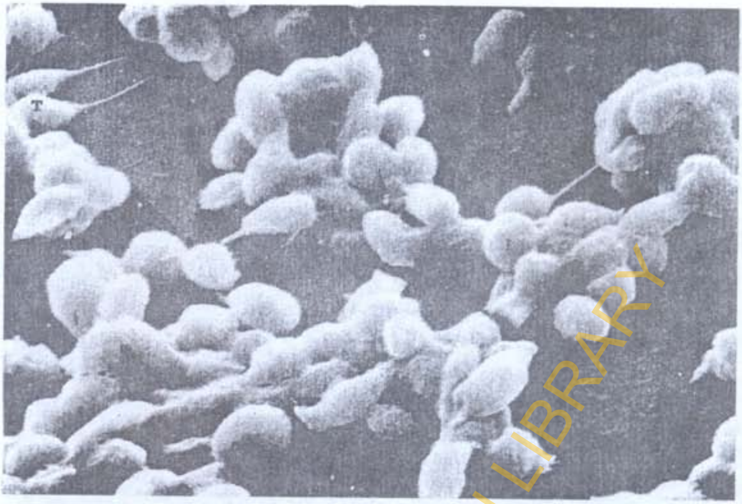

Fig. 23: Scanning electron microscopy (SEM) of tilapia lymphocytes (L) and thrombocytes (T)

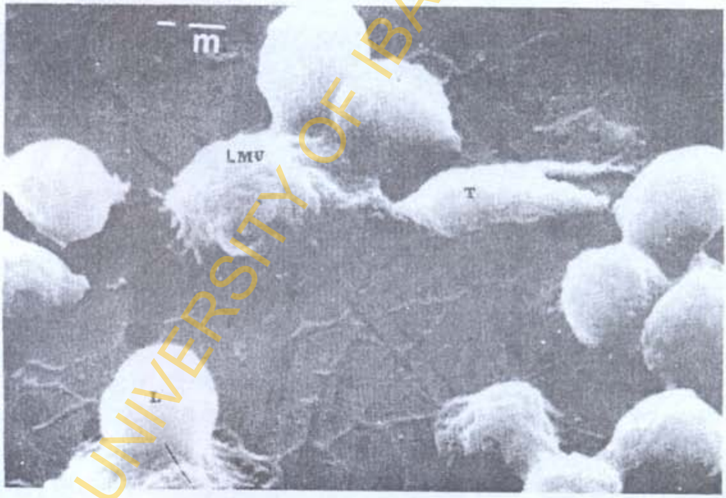

Fig. 24: SEM showing smooth lymphocytes (L), lymphocytes with microvilli (LMV) and thrombocyte (T)

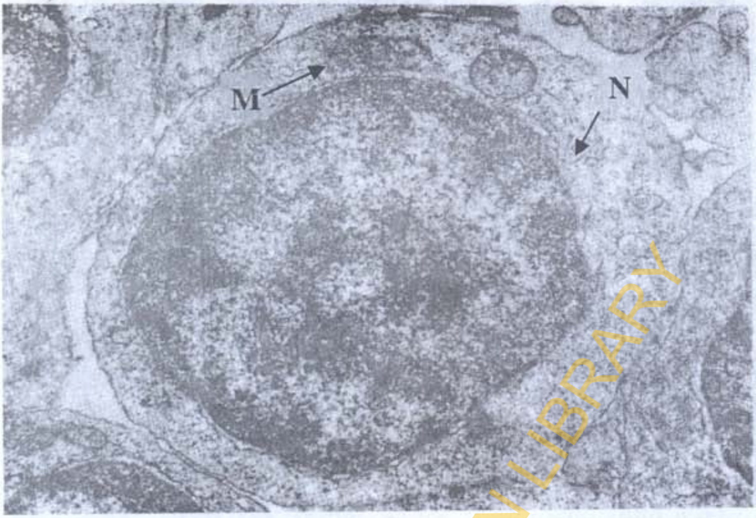

Fig. 25: Transmission electron microscopy (TEM) of lymphocyte showing a nucleus (N) and mitochondria (arrows)

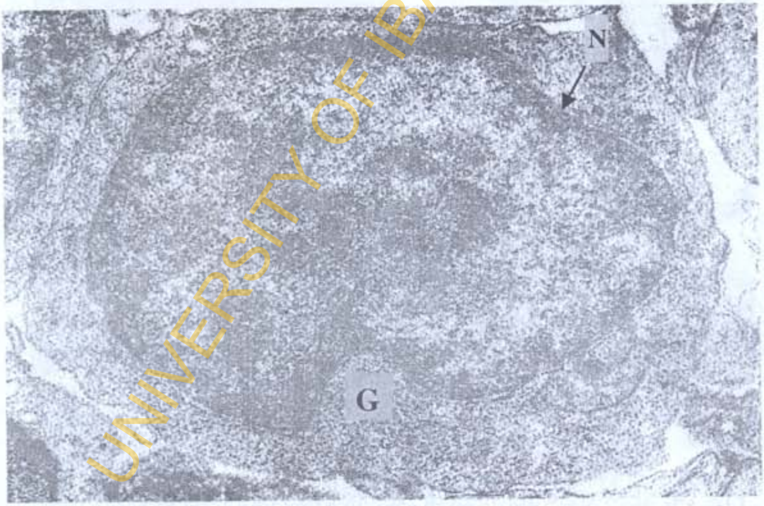

Fig. 26: TEM of lymphocyte with indented nucleus (N) and well-defined golgi apparatus (G) near the nuclear indentation

Using the technique of plaque-forming assay and immune-florescence (Agbede 1992), it was possible to proof that tilapia possess B-like lymphocytes and is thus capable of humoral immune responses. Likewise, using Rossette-formation techniques (Agbede 1992) and delayed hyper-sensitivity test (Agbede 1992, Agbede *et al.* 1999), it was possible to prove that tilapia possess T-like lymphocytes and thus capable of cell-mediated immune responses (Agbede, Adeyemo and Adedeji 2005, Agbede *et al.* 2005).

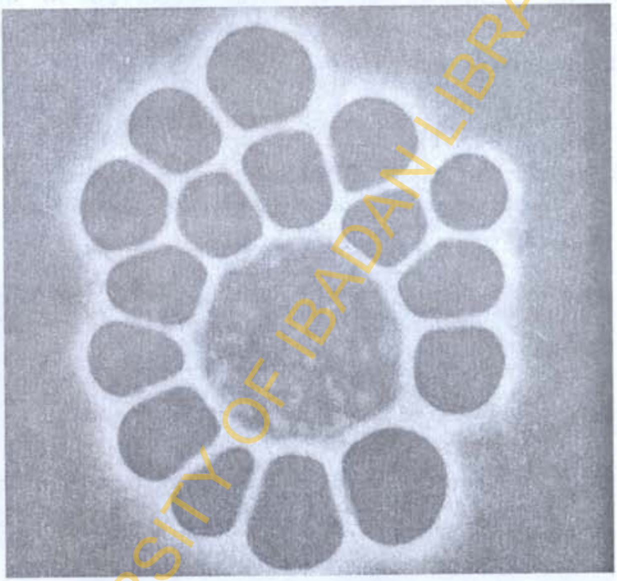

Fig. 27: The blast-like lymphocyte in the center of the rosette was taken from the anterior kidney of a rainbow trout immunized with sheep red blood cell (SRBC). The antibody activity of the isolated fish cell is demonstrated by the gathering of the SRBC around the lynmphocyte

Mr. Vice-Chancellor Sir, to prove further the existence of T-like cells lymphocyte in tilapia cells, stimulation in culture may therefore be examined either by determining the blasto-genic changes or by measuring the amount of radioactive DNA analogue incorporated into the newly synthesized DNA. We conducted a study (Agbede *et al.* 2005) to assess if tilapia lymphocytes were capable of responding to Concanavalin A, a mitogen considered to be a stimulator of T cells in higher vertebrates. A mixture consisting of 0.2ml cell suspension, 1ml medium and 0.2ml Concanavalin A was inoculated into each well of a four-well plate flasks and plates were incubated at 28°C for a maximum of 8 days. Cultures were sacrificed at 2, 4 and 8 days to monitor cell growth and at 5 days for electron microscopy. The growth response to the lowest mitogen concentration was taken as the control level with which responses to the higher concentrations were compared. Enhanced growth was observed in all Concanavalin A treatment cultures, particularly at high mitogen concentrations (fig. 28).

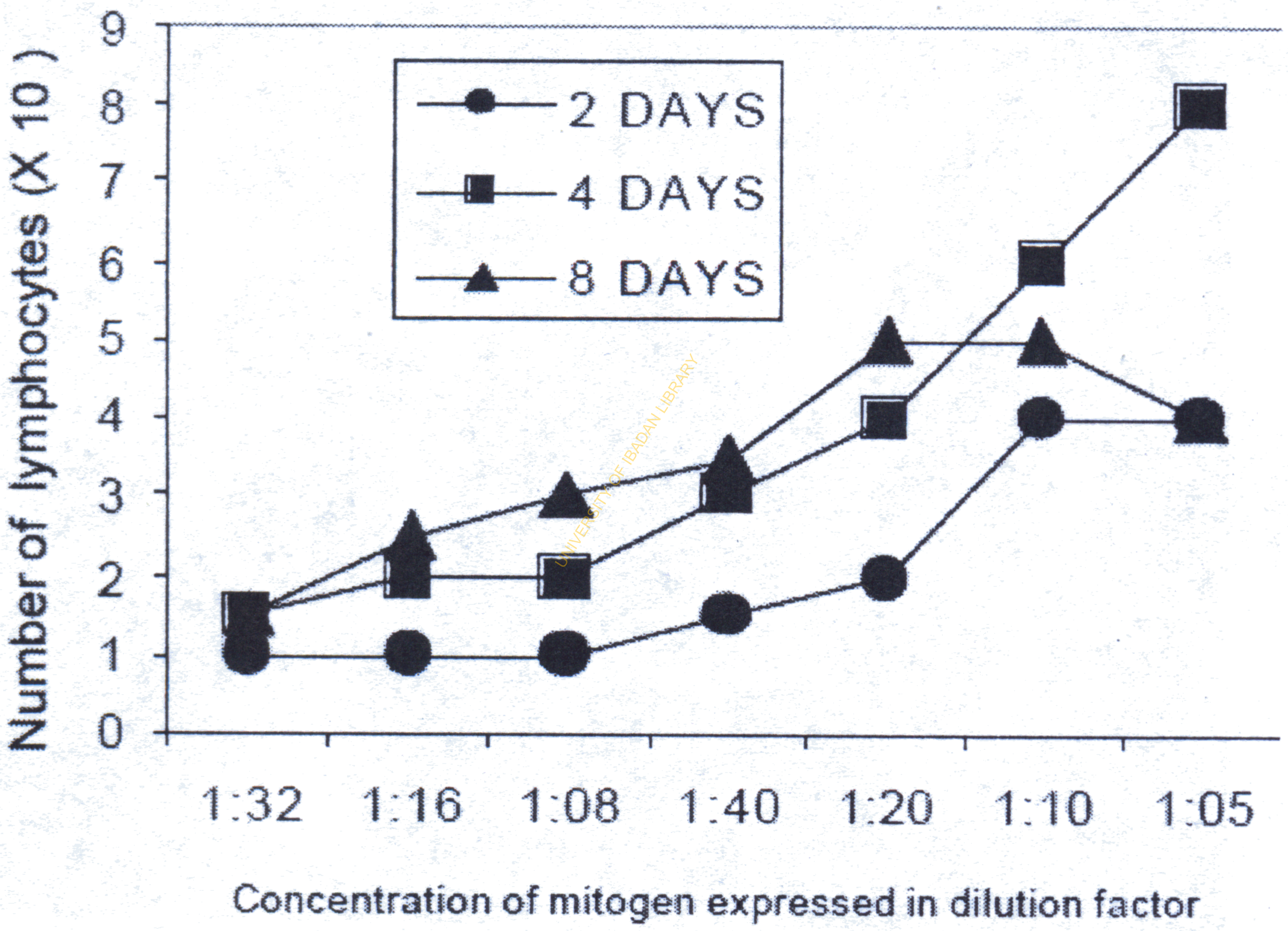

Fig. 28: Dose-response curves of tilapia lymphocytes stimulated by concanavalin A

Intense cell density was observed from 48 hours of culture up to 8 days, when the culture was terminated. At the higher mitogen concentrations, cell death was also similarly rapid, leading to a change in the colour of phenol red (pH). The morphological change in mitogen-transformed lymphocytes differs from the morphology of normal lymphocytes as seen under scanning electron microscope (figs. 29 and 30).

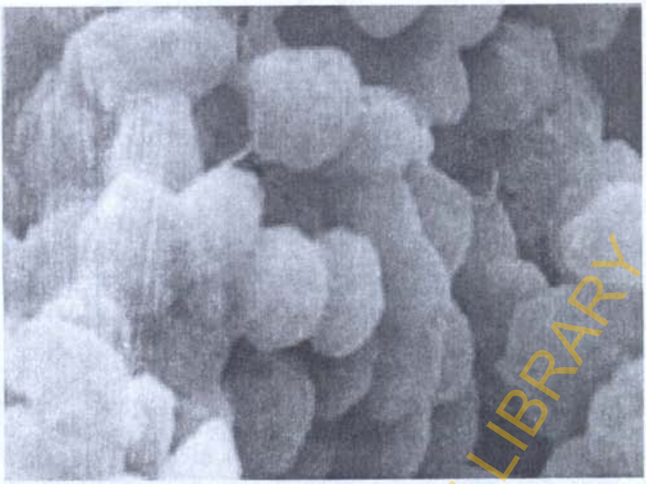

Fig. 29: Lymphocyte aggregation viewed with scanning electron microscope showing microvilli on the surface of some lymphocytes

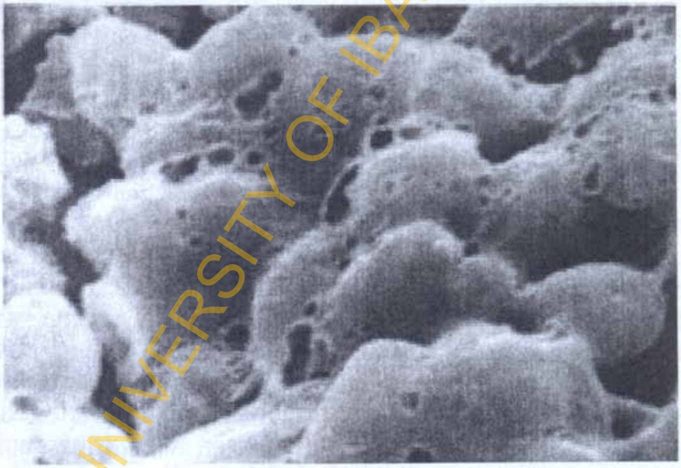

Fig. 30: Scanning electron micrograph of Tilapia lymphocytes stimulated by Con A. Each cell has a smooth surface with or without pores. Cells are attached to form peripheral pores.

Cells examined showed characteristics pore formation (fig. 30) and some tendency to adhere together. Most responding lymphocytes as seen had smooth surfaces with pores. The ultrastructure of mitogen transformed lymphocytes as revealed by transmission electron microscopy showed that the predominant cell type after 48 hours had a rather extensive cytoplasm containing many free ribosome and mitochondria which appeared in some cells to contain electron opaque material (fig. 31).

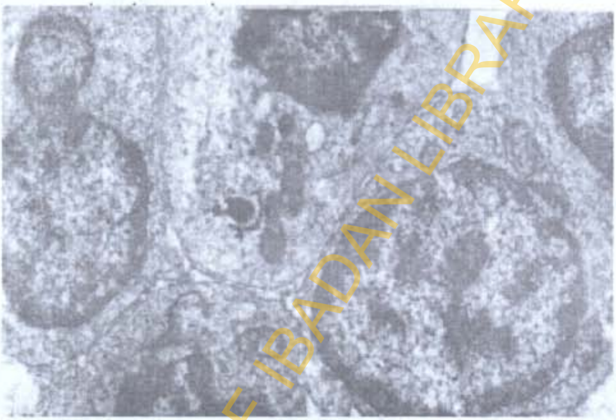

Fig. 31: TEM Cells from 5-day lymphocyte culture stimulated by Concanavalin A showing partial nuclear division of one of the cells. Mitochondria are abundant; one has become electron-- opaque

The nuclear membrane of many of the cells were incomplete and appeared to flake off into the cytoplasm. The blast cells after 4-5 days of culture were large, some with a dividing nucleus and had much cytoplasm rich in ribosome, mitochondria and endoplasmic reticulum in the form of small vesicles or sacs, which were either dilated or flattened (fig. 30). Endoplasmic reticulum were often seen in association with large bodies, usually rounded in outline and containing materials that are similar to electron-opaque dense bodies. Smaller bodies, which were less regular in outline, were occasionally observed in the 2-days cultures. Throughout the 8-day period of culture, small lymphocytes were only seen at the latter sampling periods.

The results therefore indicated that tilapia possess lymphocytes capable of responding to Con A, a mitogen considered to be stimulators of T cells in higher vertebrates. The difference in blastogenic response to the mitogen, can be applied as one of the principal discriminating criteria between T and B cells.

Treatment and Prevention of Fish Diseases

i. Treatment of Fish Diseases

Treatment of fish following infection can also present challenges—in general, medications in the commercial farming situation are administered either in-feed or by immersion. In the case of administration of medicinal products such as antibiotics, the injection route is reserved for small numbers of individual high value subjects such as broodstock.

Bathing or immersion of fish in medicinal products for large numbers of fish of significant size in a marine situation such as salmon in sea cages also can be technically a very demanding operation. Therefore, in-feed medication is the commonest route of administration. However, there are also some problems associated with this route. Not only can some products, such as some anti-bacterials have palatability issues, there are other factors to consider such as bullying where the larger stronger fish will eat more of the medicated feed. The major issue in all of this is that, the first thing which happens when a fish becomes unwell is that its appetite is reduced, so the chances of treating sick fish are therefore much reduced. Therefore in-feed medication will only work on fish which are in the very earliest stages of succumbing to a particular disease.

The other problem in treating fish is that it can be logistically difficult to observe signs—a significant amount of diagnosis is done by post-mortem which can make it difficult to ensure medication sufficiently early in an acute outbreak. Finally, although there are a number of viruses which cause problems in aquaculture, there is no medication available in aquaculture for the treatment of viruses, only the secondary opportunistic bacteria can be gotten rid of.

ii. Prevention of Fish Diseases

Vaccines and Vaccination/Immunization

The main objective of vaccination is to prevent disease. In the aquaculture environment, when fishes are kept in management methods such as in sea cages or in ponds and raceways supplied by environmental water, it is very difficult to prevent fish from coming in contact with either environmental pathogens or pathogens of wild fish origin, since contact with wild fish is often difficult or sometimes impossible to achieve. This is in contrast to many other intensive livestock keeping methods, which can by their nature isolate the livestock from wild members of the same species.

Since the main objective of vaccination is to increase the specific immunity to infections to which the vaccinated fish are likely to be exposed, this general objective can be applied to the individuals of a vaccinated population, just as it does to whole populations, tanks, netpens, sea sites, farms and companies. The associated economic objective is to ensure that, on average, the cost of the vaccines purchased, their application, and any loss of productivity caused by their application, is less than the cost of the disease if vaccines are not used. Unlike any other class of livestock, there are limited opportunities during the lifetime of farmed fish when vaccines can be administered. The earliest point in the life of the fish when it can be vaccinated is after it becomes immune-competent (some time subsequent to when the yolk sac has been absorbed). However, vaccine administration is then limited by the physical size of the fish and may only be possible by the immersion or oral routes which are limited in their duration of immunity.

Types of Vaccines

Vaccine types used in farmed fish can be broadly divided as follows:

Inactivated Bacterial Vaccines

These are produced by fermenting the pathogen in large quantities and then introducing inactivating agents (such as formalin) which kill all of the bacterial organisms. These inactivated organisms still retain the original antigenic characteristics of the live bacteria since their basic shape and structure has not been altered, except for their ability to grow and reproduce (and cause infection in the host). Manufacture of vaccines is carried out under strictly controlled conditions, with quality control tests being carried out at every step in the production process. One of the important quality control tests for an inactivated vaccine is to confirm that the bacteria have indeed been killed, and this is carried out by the sampling laboratory. However, simply injecting a dose of the inactivated bacteria will not produce a long-term immunological response, and hence will not induce a long-term protection against the disease. Therefore, the inactivated bacteria must be combined with an adjuvant compound (Freund's complete or incomplete adjuvant), which not only improves the presentation of the antigen to the immune cells of the fish, but also encourages the antigens to persist within the body cavity of the fish to improve the duration of protection.

Inactivated Viral Vaccine

These are produced by growing the virus in significant quantities in media such as tissue culture. As with the inactivated bacterial vaccines, the culture is then treated with special chemical agents which kill the virus particles without altering their basic shape and structure and hence, antigenicity. Also, as with the inactivated bacterial products, extensive testing is carried out by the vaccine manufacturer during the manufacturing process to ensure that all of the virus particles have in fact been inactivated. There is also extensive testing of the seed materials to ensure they are not contaminated with other disease agents. Again, as with the inactivated bacterial vaccines, an adjuvant will be required to ensure adequate presentation of the antigen to the immune response cells and also to ensure persistence of the antigen.

Subunit (Derived from Recombinant Technology)

Subunit vaccines are produced by implanting the part of the DNA which encodes for the production of the specific antigens to trigger an adequate immune response into another type of organism. The recipient organism is chosen for characteristics such as the ability to be easily produced on a large commercial scale and also to secrete the donor protein antigens in a format which can be readily harvested commercially. Subunit vaccine is safe for the fish which receives the vaccine since there is no possible risk of giving the recipient the disease. The fish is simply receiving a protein—the antigen which will stimulate the specific immune response. This also applies to any humans which consume the recipient animal or fish. There is also little risk of contamination of the vaccine by other microorganisms. It confers the ability to the vaccine producer of manufacturing large quantities of the chosen antigen or antigens at relatively lower cost than growing the original organism, particularly in the case of viruses.

DNA Vaccines

The principle of DNA vaccination is to make the host animal receiving the vaccine responsible for the production of the antigen and then the immune response to the antigen. It is also known as genetic immunization. Basically, DNA vaccination or nucleic acid immunization entails the delivery of DNA (or RNA) encoding a vaccine antigen to the recipient. The DNA is taken up by host cells and transcribed to mRNA, from which the vaccine proteins are then translated. The expressed proteins are recognized as foreign by the host immune system and elicit an immune response, which may have both cell-mediated and humoral components. DNA vaccines offer a number of advantages over conventional vaccines, including ease of production, stability and cost. They also allow the production of vaccines against organisms which are difficult or dangerous to culture in the laboratory.

Development of Vaccines for Fish

The early fish vaccines were very basic formalin inactivated bacterial cultures, which were administered initially by immersion and subsequently by injection. The immersion technique has endured for some bacterial antigens since it is still the most effective method of ensuring short-term immunity to small fish which for a number of reasons, including size, individual value and reaction to the general stress of handling, make ideal candidates for this approach. Although, the immersion technique certainly produced some levels of immunity to certain bacteria, further research was directed at the injectable vaccines. Though a degree of protection can be achieved by simply injecting the killed bacterial suspension I.P., improved levels and duration of protection were dependent on the development of suitable adjuvants (these are constituents of vaccines which enhance the degree and the duration of the immune response). However, the early oil-based adjuvants had the undesirable effect of producing lesions within the peritoneal cavity post-vaccination.

Also, newer technology adjuvant can confer adequate protection using a dose of 0.1mL, which significantly reduces the adhesion and melanization situation. Although, the multi-antigen products currently available have physical space within the vaccine dose for all of the required antigenic content, future addition of other antigens as they are developed may become an issue for this smaller dose volume. Frequency of dosing is another area where the aquaculture vaccination protocols differ from terrestrial animals. Stress induced by anaesthesia use and the injection procedure can in some cases trigger other diseases such as fungal infections which are opportunistic pathogens and are ubiquitous in the fresh water aquatic environment.

Thus, the only potential for routine booster vaccination would be by the oral route. Oral vaccine technology has been seen over the years as the ideal method of administration of vaccines to fish. There has been considerable effort devoted to the research and development of oral vaccination but there are again some major limiting factors. These are basically presentation of the vaccine in a suitable form, ensuring even distribution of the dosage form throughout the population of fish to be vaccinated, duration of immunity and presentation of the appropriate range of antigens.

In summary, a great deal of development is required to produce a safe and efficacious vaccine. The detail and course of this varies greatly depending on the type of disease, and the nature of the vaccine and target stock. In essence, there are a number of identifiable steps, which will be slightly different for fish than for other terrestrial species. They include:

- Isolation and identification of the causal micro-organism.
- Culture of the microorganism itself or of the target antigen in some other way.
- For inactivated vaccines—inactivation to kill the microorganisms.
- Confirmation that the vaccine is free of extraneous agents.
- Confirmation that the vaccine is safe for the target species.
- Confirmation that it is effective in preventing or at least reducing the effects of the target disease.
- Formulation of the vaccine in an appropriate diluent, carrier, with adjuvant or without, and in a package to facilitate storage.

Uses of Fish for Man/Human Health

Protein

Proteins are the building blocks of human life, essential for normal growth. Protein is 90% of the dry weight of blood, 80% constituent of enzymes, hormones and antibodies. Proteins encompass many important chemicals including immunoglobulin and enzymes. In short, they form the foundation of muscles, skin, bone, hair, heart, teeth, blood, brain and billions of biochemical activities going on in our bodies every minute. When we fail to consume adequate amounts of protein, the blood and tissues can become either too acidic or too alkaline. Lack of dietary protein can retard growth in children and in adult, can be a contributing factor in chronic fatigue, depression, slow wound healing and decreased resistance to infections. Meat, poultry, fish, dry beans and peas, eggs, nuts, and seeds supply many nutrients including protein and essential amino acids, B vitamins (niacin, thiamin, riboflavin, B6 and B12), vitamin E, iron, zinc, and magnesium. The amino acid balance in an "ideal" protein (5.5% lysine, 3.5% sulfur-containing amino acids, 4% threonine, 1% tryptophan and 7% leucine) is based on egg protein, the standard to which all others are compared. Lamb, pork, chicken breast, turkey breast, fish—meet all the requirements; beef meets the proportional requirements with the exception of tryptophan. Soy beans (boiled, mature), black beans and kidney beans meet all the proportional requirements except the sulfur containing amino acids.

Fish as Food

That humans evolved as omnivores, consuming both animal and plant materials as food, is generally accepted. They have both canine and incisor teeth for biting, and molars for grinding. Several dietary nutrient requirements can be found only in animal-based tissues (vitamin B12) or only in plant-based tissues (vitamin C, fiber). Fishes are nutritious foods that are considered as healthier alternatives to red meat or poultry. Fish is a good source of digestible proteins, fluoride, iodine, selenium, and vitamin D3 (Usydus *et al*. 2008). The fundamental nutritive benefit is the highly advantageous fatty acid composition, especially the long chain poly-unsaturated fatty acids (PUFA) not found in other food products.

Public/Human Health Considerations: Fish Food Safety

Hazards due to Macro and Micro-Environmental Contamination and/or Conditions

Water is perhaps the first source of concern for any specific type of aquaculture production method and fish species, and as such is addressed in most regulations. Chemical and biological hazards that might affect fish through water are manifold, due to contamination (e.g. pesticides), endemic (e.g. *Vibrio parahaemolyticus* in sea water), under steady state conditions (e.g. pathogenic *E. coli* strains due to the proximity to inhabited areas), or due to seasonal or unusual events (e.g. floods, biotoxins).

Biological Hazards

Currently, the control of most of these macro-environmental hazards is accomplished through water monitoring by means of indicators, but there is evidence that this risk management procedure may not always be effective in practice to control some hazards, such as the potential risk of enteroviruses and hepatitis A virus in mussels—and likely in other bivalves—as discussed by Romalde *et al.* (2002) and Croci *et al.* (2003). Some biological hazards could build up in water within the aquaculture systems (micro-environment). The most common could be the formation of biofilms that may protect pathogenic bacteria (eventually increasing prevalence or concentration) and/or act as a place for spreading microbial resistance to antibiotics. Whereas, this type of hazard is addressed by the periodic cleaning of ponds and equipment, for fish health reasons, there may be a need to analyse such a procedure with a view to ensuring human public health as well (Agbede *et al.* 2001).

Parasites

The problem of parasites associated with aquaculture that might constitute a hazard to humans, in particular trematodiases, nematodiases and cestodiases, has been discussed in some detail (Agbede 1998a and b; WHO 1999). Another interesting example of parasitic hazards is *Cryptosporidium* spp. In particular, *Cryptosporidium parvum,* an oocyst-forming apicomplexan protozoan, is an obligate intracellular parasite that infects the epithelium in the gastrointestinal tract of humans and various animal hosts. Cryptosporidiosis is generally a self-limiting disease, with a high degree of morbidity and a low rate of mortality (the latter related, in general, to vulnerable populations). Children in developing countries are the most exposed to this parasite. *Cryptosporidium* is currently reputed as an emerging hazard in a number of foods, in particular raw or improperly cooked molluscs and vegetables (Millar *et al.* 2002).

Chemical Hazards

Biotoxins

In scientific literature, large numbers of biotoxins associated with molluscs (e.g. conotoxins) appear; however, their importance from the point of view of food poisoning outbreaks in humans may be rather limited, even though they could have local importance. As a matter of fact, there are epidemio-logical indications that some toxins associated with molluscs are of public health importance at national and/or regional level, such as the case of venuripin shellfish poisoning in Japan (usually associated with oyster and clams). The toxin produces fulminant hepatic failure (33% of deaths) and the callistin shellfish poisoning associated with the Japanese callista clam. With the growing importance of freshwater bivalve culture, in addition to the classic hazard represented by human pathogens, there is also the need to search for the possibility of biotoxin production in freshwater environments. The production of paralytic shellfish poisoning (PSP) by freshwater cyanobacteria has been already ascertained (Lagos *et al.* 1999, Pereira *et al.* 2000, Saker *et al.* 2003), as well as the accumulation of PSP from cyanobacteria in freshwater mussels (Negri and Jones 1995).

Toxic Substances

Toxic chemical hazards that might appear due to water, soil and even air contamination are a classic field of study and do not need to be reviewed here. However, it is necessary to point out that there may also be a possibility that the toxic substance is formed inside the fish farm. An example of this type is the possibility of bromate formation in sea water recirculating systems during the oxidation of naturally-occurring bromine by ozone (Tango and Gagnon 2003).

Hazards due to the Contamination of Fish Feeds

Hazards due to the contamination of fish feeds constitute a large chapter of potential hazards in aquaculture. Feeds tend to constitute hazards, in particular chemical hazards (mainly POPs–persistent organic pollutants–and heavy metals), which in turn accumulate in fish. For example, research has consistently found higher levels of PCBs (polychlorinated biphenyls), PBDEs (polybrominated diphenyleters) and OPs (organochlorine pesticides) on farmed salmon than in wild counterparts. This in turn has been linked to the elevated contamination of such chemicals in salmon feed (Easton *et al.* 2002).

Feed should be considered in hazard analysis in very broad conceptual terms. For instance, in South East Asia, integrated fish farming combines intensive husbandry (chicken and pigs) with extensive aquaculture. In such cases, animal manure is excreted into the ponds and subsequently fertilizes the water; this supports the growth of photosynthetic organisms which in turn support fish growth. Whereas, the procedure of utilizing animal manure in this manner does not actually represent fish "feed" in classic aquaculture terms, it is in effect fish feed, and unexpected hazards for extensive fish farming such as antimicrobial resistance could appear as a result of antibiotics fed to the chicken and pigs (Petersen and Dalsgaard 2003).

Changes in the composition of fish feeds, in particular with the increased use of groundnut meals and cereals or other sources of vegetal protein and lipids, may present hazards of natural toxins of vegetable origin like aflatoxins, T-2 toxins, vomitoxin and some toxic natural feed components (e.g. oxalic acid, anti-vitamins, etc.). Again, some producers argue that cultured fish is in itself the control of contamination; however, this cannot be generalized *mutatis mutandis* or extrapolated to the possible effect on humans. Even, if in many countries there are already regulations related to animal feeds, and in particular fish feeds (CFIA 2003), there is a growing consensus that feed production (for food animals, and in particular aquaculture fish) should be produced under HACCP plans (den Hartog 2003).

Hazards due to the Use of Veterinary Drugs

Fish farm antibiotic and pesticide use has also raised concerns about impacts to natural ecosystems and human health (Goldburg *et al.* 2001). The risk of human exposure to antimicrobial drug residues in marketed farmed fish appears to be slightly higher than for terrestrial species. The probability of human exposure to tissue residues of antimicrobial drug residues in wild species captured near fish farms is low and exposure will be largely restricted to areas in close proximity to farms and within narrow time frames. However, drugs used by aquaculture operations could move beyond the immediate vicinity of treated farms if fish escape before the drug withdrawal period expires or if mobile species such as wild fish or crustaceans ingest sufficient drug to develop harmful tissue residues (Agbede 1998a and b).

Drugs are utilized for different purposes in aquaculture. For instance, antibiotics could be used as therapeutants, as prophylaxis and as a growth factor. The regulatory and production tendency is to reserve the use of approved antibiotics only as therapeutants, avoiding their use in prophylaxis and as a growth factor. This tendency is compounded with a move to develop and utilize vaccines rather than antibiotics, as is already occurring in some countries with salmon production, and in general to reduce as much as possible the use of all veterinary drugs.

There are basically three types of hazards due to veterinary drugs:

1. Residues in fish of authorized drugs above the allowed limits;
2. *Use of banned drugs for aquaculture* (or not specifically authorized for its use in aquaculture); and
3. Development of pathogen strains resistant to antibiotics (permitted or not).

Whereas some hazards, e.g. residues of authorized veterinary drugs below maximum residue limits (MRLs), could be reputed to be very low, this does not automatically mean the same can be said for all drugs, in particular to the use of non-approved or prohibited veterinary drugs (Lupin *et al.* 2003). In many countries, a non-approved veterinary drug for aquaculture is not exactly a banned drug, since it can eventually be utilized legally under an "off label" (or "cascade") scheme. Even if regulations are changing to limit that possibility, and single professionals are hardly in a position to assess the risk to humans embodied in most "off label" uses, the problem remains in countries where the dispensing of drugs in aquaculture is not done by professionals. The possibility of selling free, uncontrolled drugs, regardless of whether they are banned or permitted, is usually known as "over the counter" and is practised in some countries. This was certainly the root of the problems experienced by some developing countries with residues of banned antibiotics (e.g. chloramphenicol) in exported shrimp from 2001 to 2003.

The regulatory scenario is also complex in other senses. For example in some countries, a veterinary drug can be legally banned only if it has been a previously approved drug. Some veterinary drugs utilized in aquaculture for many years, such as malachite green (that together with its metabolite leucomalachite green, are reputed to be hazards to humans), have never been formally "approved drugs" for aquaculture in many countries. This creates a rather confusing situation in legal and practical terms which, among other things, is not a good example for developing countries' aquaculture. Developed countries are introducing changes in regulations to prevent this type of situation, but this is not yet a worldwide tendency (Agbede *et al*. 2003a).

Antibiotics can be banned for use in food animals for two basic reasons. Firstly, residues might be toxic for humans (e.g. chloramphenicol) and, secondly, public health authorities have decided to keep such antibiotics exclusively for use in humans. The increasing hazard of antimicrobial resistance in general (Harrison and Leederberg 1998) and in relation to animal foods (NRC 1999) is well known. The epidemiological impact of microbial resistance on human has, by now, been widely documented. The main problem continues to be, to find a balance between responsible animal production and human health aspects; aquaculture is no stranger to this dilemma. Whereas, to assign responsibility for specific antimicrobial resistance to the use of a given antibiotic in a specific context could, in most cases, be elusive; resistance in pathogens associated with aquaculture has been identified in a number of countries and fish products

(Radu *et al.* 2003, Petersen and Dalsgaard 2003, Miranda and Zemelman 2002, Castro-Escarpulli *et al.* 2003).

Zoonoses

Zoonoses are diseases and infections that are naturally transmitted between vertebrate animals and man. Consumption of fish is generally beneficial as it provides a good source of protein, vitamins, omega fatty acids and basic minerals. Additional benefits of consuming fish include a decrease in cardiovascular disease, a reduction in blood pressure in individuals, reduced colon and breast cancer risks, a decrease in pain from arthritis and a decrease in asthma attacks in asthmatics. However, if these fish are contaminated they pose a health risk to consumers (Agbede *et al.* 2001). Aside from food poisonings, the overall incidence of transmission of disease-producing agents from fish to humans is low. An important feature of many of the disease-causing-agents is their opportunistic nature. The development of disease in the human host often requires a pre-existing state that compromises the immune system (usage of steroids, immunosuppressive drugs, or chemotherapy). Although, there is an extensive list of pathogens that are communicable to humans from aquatic species via consumption, pathogens can also be encountered during examination, handling, and treatment of aquatic species.

Economics of Aquaculture

Two major constraints to the establishment of fish culture enterprises in Nigeria include lack of initial capital input and the acquisition, ownership of land (Afolabi and Fagbenro 1998) and fish diseases arising from culture intensification (Agbede *et al.* 1989, Olufemi, Akinlabi and Agbede 1991, Agbede *et al.* 1996, Adeyemo and Agbede 2008a and b). Most importantly, the value of rental price of land that satisfies the technical requirements of modern and conventional pond fish culture varies with its quality and alternative uses. There is considerable potential for achieving Nigeria's objectives in increasing fish protein production most especially in the urban centres by farming fish in family-based homestead concrete tanks (Agbede and Olufemi 1999, Agbede *et al.* 2003b, Agbede, Adeyemo and Ajani 2003). This practice will greatly enhance the current low per-capita fish protein intake, and when widely accepted and extensively practised will probably reduce the existing deficit between fish supply and demand in Nigeria (Agbede and Alegbeleye 1998, Adeyemo, Agbede and Ezeri 1998).

Aquaculture has great potential as source of affordable protein for human nutrition in Africa, given the vast fresh and marine water resources available. Nigeria is a country with an enormous capacity for aquaculture, with abundant fresh water and a coastline that extends about 853 km along the Atlantic Ocean, which offer considerable potential for commercial aquaculture. Notwithstanding the enormous inland open water resources with substantial production potential, their contribution, compared to aquaculture sector, to the countries production basket remains low. Appropriate management and specific technological interventions are necessary to harness their production potential for sustaining livelihood of resource poor fishers (Agbede and Olufemi 1999, Agbede *et al.* 2003b, Adeyemo *et al.* 2007). Resources like lakes, reservoirs and wetlands offers immense scope for enhancing fish production through stock enhancement.

Mr. Vice-Chancellor Sir, *Fisheries Management*, according to FAO Fisheries Glossary, is "the integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries, in order to ensure the continued productivity of the living resources". While this definition implies that to "ensure the continued productivity" means to regulate the extraction of biomass to the extent that the resource remains sustained, most fisheries management policies explicitly aim at an increase in production while, at the same time, sustaining the resource, in its widest sense. *Fisheries enhancement* refers to production systems beyond extractive, unmanaged 'open access' and/or managed capture fisheries. The FAO defines 'enhanced fisheries' as "activities aimed at supplementing or sustaining the recruitment of one or more aquatic organisms and raising the total production or the production of selected elements of a fishery beyond a level which is sustainable by natural processes". Included, among other things are:

- Introduction of new species to exploit underutilized parts of the food chain or habitat.
- Stocking of natural or man-made water bodies to improve recruitment, bias fish assemblage structure to favoured species or maintain productive species that would not breed naturally in such a system.
- Fertilization of the water to raise levels of productivity.
- Engineering of the environment to improve fish reproduction and migration, and provide shelter and other vital habitat, food resources, etc.
- Elimination of predators and other unwanted species.
- Moderate modification of water bodies to cut off bays and arms to serve the purpose of increasing control (Welcomme and Bartley 1998).

Acknowledgements
Glory be to God the Father, the Son and the Holy Spirit. I thank my late parents, Pa Rufus Agbede and Madam Eunice Fabamise Agbede. I appreciate my senior brother, Elder Israel Dada Agbede and his late wife, Mrs. Victoria Bolatito Agbede for their fatherly and motherly care and tutelage since the death of my father in 1953, when I was six years old. They taught me dignity of labour and pursuit of excellence.

I also thank my senior sister, late Mrs. Susannah Ibidapo Bada (Nee Agbede) and my younger brother, Elder James Oluyemi Agbede and their spouses for their love and motivation. I say a big thank you to my step-brother, Professor Olusola O. Agbede and my nephew, Professor Oluwole A. Agbede and other near and distant relations for their evergreen love and support.

I must mention and thank the following for their different roles in my life or academic career:

- Mr. O.B.A. Ogunruku took me from Usi Ekiti to Ikire in 1953 and also boarded and lodged me in 1966, when I was looking for employment at Ibadan as a young School Certificate holder (WASCE).
- Lawyer Clement Babatola facilitated my very first trip to Ibadan in December 1965 to look for work after WASCE.
- Prof. J.A. Oluyemi facilitated my admission to Animal Health School, Moor Plantation (now College of Animal Health and Production Technology, IAR&T, Moor Plantation).
- Kabiyesi, Oba (Dr.) K.A.O. Sansi, my very first boss on the field, who magnanimously transferred me to Ikenne Diary Farm to enable me develop clinically and academically, which invariably culminated in my present position.
- Professor G.O. Esuruoso facilitated my direct concessional entry into the University of Ibadan in 1971 to read Veterinary Medicine; my employment as a temporary Lecturer II in 1978 and my greatest motivator and mentor in my academic career.
- Professor R.J. Roberts, Professor R.H. Richards and Professor C. Agius mentored me to become an expert in Aquatic Veterinary Medicine, when I was in the Institute of Aquaculture, University of Stirling, Scotland.
- It is pertinent at this juncture to express my sincere gratitude to the British Technical Aid and Association of Commonwealth Universities for the financial support of my study and stay in the United Kingdom.
- I thank my senior colleagues in the Faculty—Professor Fatai Olalekan Ayanwale and Professor David Omobamidele Alonge for being very good brothers indeed and my junior colleagues—academic, technical and administrative.

- Equally, I thank all senior professors in the Faculty of Veterinary Medicine and Veterinary Teaching Hospital as well as my juniors—academic, technical and administrative.
- Worthy of special mention and my gratitude is Dr. Olanike Kudirat Adeyemo, for her assistance in the preparation and word processing of this manuscript.
- My gratitude also goes to Professor Ebenezer Babatunde Otesile and Professor Morenike Atinuke Dipeolu for inviting me to the University of Agriculture, Abeokuta as a visiting Professor in 2009/2010 session.
- I have friends, indeed I have friends spread through primary, secondary and tertiary institutions here in Nigeria, overseas and in all communities that I have lived. I thank them all.

My sincere and warmest appreciation goes to my dear wife Florence Olubukola Agbede for her support, love and understanding and to our children Kolawole and Wuraola, Ayodeji and Modupe, Olubunmi and Mission, Olufemi, Oludayo, and my grandchildren. You are the source of my joy and pride. I love you all.

Mr. Vice-Chancellor Sir, ladies and gentlemen, I thank you for listening.

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BIODATA OF
PROFESSOR SAMUEL ADEWUMI AGBEDE

Samuel Adewumi Agbede was born on 15 September 1947 to Pa Rufus (died 1953) and Madam Eunice Fabamise Agbede (died 1997). Professor Agbede went to St. John's Primary School, Iloro, Ilesa between 1955 and 1960, from where he proceeded to the prestigious Ilesa Grammar School, Ilesa in 1961. He obtained the West African School Certificate (WASCE) Grade II in 1965. He was in the labour market in 1966 and up till May 1967. He secured his first appointment at Times Press, Apapa, Lagos in June 1967 and later to Animal Health School, Moor Plantation (now College of Animal Health and Production Technology, IAR&T, Moor Plantation).

He completed the Ordinary National Diploma in Distinction Class in June 1969. He was awarded the Victor Ludurom Trophy as the best student in the Ordinary Diploma class. He served the mandatory one year fieldwork with Kabiyesi Oba (Dr.) K.A.O. Sansi as the then Deputy Veterinary Officer at the Ministry of Agriculture and Natural Resources (M.A.N.R), Secretariat, Ibadan and later at the Government Dairy Farm, Ikenne-Remo, Ogun State.

In September 1970, he returned to Animal Health School for the Higher National Diploma (HND) programme. At the end of the first year of the HND programme, in October 1971, he was admitted by direct concessional entry to the first and the best University in Nigeria, University of Ibadan. He was a recipient of the Cocoa Marketing Board Scholarship for the Veterinary Medicine Programme, which he completed in June 1977 and he was awarded the Doctor of Veterinary Medicine (DVM) degree.

Professor Agbede is a registered Veterinary Surgeon with the Veterinary Council of Nigeria. He served the National Youth Service Corps at Offa, Oyun Local Government, Kwara State in 1977/78. He was offered an appointment at the University of Ibadan as Temporary Lecturer Grade II on 12 April 1978, but resumed in October of the same year. As part of his in-service training at the University of Ibadan and through the financial assistance from British Council Technical Aid, he attended the famous Institute of Aquaculture, Stirling, Scotland in 1980/1981.

He was the first Nigerian to be awarded the MSc. Aquatic Veterinary Studies by the University of Stirling, Scotland and the first overseas student in the institute to receive the Royal Highland and Agricultural Society of Scotland Medal, as the best student overall in competition with first class students throughout the world (Vet Record 1981).

In 1984, he was awarded the Association of Commonwealth University Scholarship to return to the Institute of Aquaculture, Stirling for the technical aspects of his PhD programme, which he completed at the University of Ibadan in 1992. While in Britain, he enrolled for part-time Professional Photography course at the New York Institute of Photography, London and obtained the Professional Photography Certificate in 1987.

He rose through the ranks from temporary Lecturer Grade II to become a Professor in 2000. Professor Agbede taught across faculties as part of his services to the University of Ibadan in the last 34 years as follows:

- Faculty of Veterinary Medicine undergraduate and postgraduate courses, projects, Masters and PhD supervision,
- Faculty of Agriculture and Forestry, Department of Aquaculture and Fisheries Management and Department of Wildlife and Ecotourism—Fish Microbiology, Pathology and supervision of undergraduate, Masters and PhD projects, and
- Faculty of Arts, Department of Communication and Language Arts—Photojournalism.

Professor Agbede is an erudite scholar, an ardent researcher, a prolific writer and a friend to everyone. He has published over 100 peer-reviewed journal articles, proceedings, technical papers and a book. He was actively involved in Departmental and Faculty administration, first as HOD (thrice) and Director of the Veterinary Teaching Hospital. Also, he participated actively in senate committees, internal examinations at the University of Ibadan, external examinations at other universities in Nigeria, internal and external assessor for promotion exercises both within and outside the University of Ibadan.

He is a member of many professional, social and academic societies. Professor Agbede is a Fellow, Business Management Association (FBMA), London; Fellow, College of Veterinary Surgeon Nigeria (FCVSN); and Fellow, Fisheries Society of Nigeria (FFS). He is happily married with children and grandchildren.