Essential of Fisheries and Aquaculture Techniques

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CHAPTER ONE

1.0 FISH FEED FORMULATION USING LOCALLY AVAILABLE FEEDSTUFF

1.1 Introduction

When fish are transferred from their natural environment to artificial one enough food must be supplied in order to make them grow properly. This could be in the form of complete ration, where the artificial diet furnish all the nutrient required by the fish or supplementary diet where part of the nutritional need of the fish is supplied by natural food in the culture system (Dupree and Hunner, 1985).

In Nigeria, the artisanal fishing is decreasing in importance and the trend is toward intensive fish cultures that demand extra feeding. Locally available materials such as yam, plantain, banana, cowpeas, mucuna, maize, cassava, millet and groundnut, brewery waste are considered as potential materials for fish feed.

The prices of ingredients used in formulation of least cost diets keep on rising in Nigeria (especially the protein sources of ingredients). Millet is a good source of protein although poor in mineral it could be regarded as the next potential alternative source of ingredient for fish feed.

Alternative source of plant protein from ground nut, melon, mucuna and others compare favourably with blood meal mixtures. Plant protein can be used to replace the more expensive animal protein feedstuff. If a fish feeds on high protein feed, there is increase in metabolic rate to enable the fish eliminate waste products with higher ammonia content (Abdulkarim and Ipinjolu, 1998).

1.2 Fish Basic Requirements

Oyetayo (1985) stated that like the animals, fish need protein, Carbohydrate, lipid, minerals and vitamins for growth and physiological activities. These they get from the organisms they feed on in the wild. Intensive culture demand extra feed in form of pellets or mash. This has to be added to the system for the fish to attain a table size within a short time.

1.3 Locally Available Feedstuff or Raw Materials

There are lot of breweries companies in Nigeria. Their wastes are turned out in several tones daily, the brewery waste obtained from these companies have not been fully utilized. The waste can be incorporated into fish feed.

There are many kitchen wastes that can be obtained from house hold such as bean chaff, banana, potato, pawpaw, orange, yam and cassava peels. These wastes are thrown out on daily basis. Most of these domestic wastes could be included in fish feeds, despite their low protein contents (7.87 – 11.21%).

Finely ground rice, maize and sorghum bran could be incorporated in fish feed formulation. Mash could be formulated with the bran's and ground nut cake in ratio 2:1 soaked overnight and fed to fish. Note that, fish could not efficiently strain small particles from the water and thus much of the feed will be wasted and tends to foul the tanks. Sorghum can be substituted for maize at 70% level in the diet of carp and tilapia. *Clarias spp., Gymnarchus spp.* and *Heterotis spp.* accept pellet diet made from maize and other local materials. *Penisetum* species are fairly good source of protein (11.6%), good source of starch (67%) and poor source of mineral (5.2%).

Distichodus engycephalus, D. rostrum are herbivorous in their feeding habits. Green leaf, water leaf, garden egg, ground nut, maize leaves can be used as both fibre and filler in fish feed (Oyetayo, 1985).

1.4 Feed Formulation

The feeds type in aquaculture can be represented or classified as starter feeds, fry feeds, fingerlings feeds, grow – out feeds and brood stock feeds. There are many methods that could be used for formulating feed. Starting with Pearson's square method, this is the most common method; it is simple and direct and becomes important when two feedstuffs are involved. A diet with 35% crude protein content is hereby presented in the following sections.

1.4.1 Pearson's square method

First and foremost, there are fixed ingredients for every type of feed to be formulated. The fixed ingredients are determined mostly through nutritional experiments and once known in varying quantities, it becomes part of experience of the nutritionists.

Step 1:Determination of percentage composition (%C) of fixed ingredients

Let adopt fixed ingredients %C according to Abdulkarim and Ipinjolu (1998): Bone meal, 2.50%; Palm oil, 5.00%; Oyster, 0.50%; Vitamin, 0.60% and Salt, 0.25%. This brings the total fixed ingredients to 8.85%. Therefore, the remaining ingredients percentage composition = 100% - 8.85% = 91.15%

Step 2:Determination of percentage crude protein (%CP) to be contributed to the final ration by the 8.85% fixed ingredient

The percentage crude protein of most locally available feedstuffs have been experimentally determined and published in literatures. Among the fixed ingredients Bone meal has 2.89 %CP and oyster has 1.43%CP

2.50% of Bone meal will contribute 2.5 * (2.89/100) = 0.07 %CP

0.5% of Oyster will contribute 0.5 * (1.89/100) = 0.01% CP

Total % CP contributions from Fixed ingredients = 0.07 + 0.01 = 0.08 %CP

This implies that the remaining 91.15% will supply %CP = 35 – 0.08 = 34.92

Step 3: Construction of Pearson's square

Pearson's square comprises energy source and protein source from the varying feed ingredients. Any of these sources could be a single ingredient or combination of two or more ingredients per source. The energy source of the remaining ingredients used in formulating this feed is Maize (8.31%CP) while the protein source is combination of three sources: Groundnut cake

(39.38%CP); Fish meal (70.79%CP) and Blood meal (86.25%CP) combined in ratio of 5:2:1 respectively.

The total ratio = 5 + 2 + 1 = 8 (the choice of this ratio is due to many factors among which is cost of the protein feedstuff, availability of the feedstuff, palatability of the feedstuff for instance blood meal taste bitter and so forth).

The contribution of percentage protein from each source is

5 parts groundnut cake (GNC) = (5/8) * 39.38%CP = 24.61 %CP

2 parts fish meal (FM) = (2/8) * 70.79%CP = 17.70 %CP

1 part blood meal (BLM) = (1/8) * 86.25%CP = 10.78 %CP

The total %CP to be contributed to 91.15 % = 24.61 + 17.70 + 10.78 = 53.09 %CP

Correction factor = (34.92/91.15) * 100 = 38.31 to be in the Pearson's square:

(a) Maize 8.31 (c) 14.78

(e) 38.31

(b) Mixture 53.09 (d) <u>30.00 +</u>

44.78

Figures on the left side of the Pearson's square are cross subtracted from the correction factor to obtain the figures on the right side of the square by neglecting the negative signs if any as follows

e – a = d ; e – b = c and c + d = 44.78 . This sum is used to determine the percentage contribution of the energy source (maize) and protein source (mixture) in 91.15 % comprising the variable feed stuffs.

Step 4:Determination of percentage composition (%C) of variable ingredients

Energy source: (14.78/44.78) *91.15 = 30.08%

Protein source: (30.00/44.78) * 91.15 = 61.07%

30.08% + 61.07% = 91.15 %

The 61.07% of the protein source shall be distributed to each protein feed stuff based on their respective ratios:

GNC = (5/8) * 61.07% = 38.17%

FM = (2/8) * 61.07% = 15.27%

BLM = (1/8) * 61.07% = 7.63%

The total = 38.17% + 15.27% + 7.63% = 61.07%

Step 5: checking the percentage protein contribution (%PC) of each feedstuff to the 35% CP required

%PC of feedstuff = (% CP of feedstuff/100) * % composition

%PC of Maize = (8.31/100) * 30.08 = 2.50%

%PC of GNC = (39.38/100) * 38.17 = 15.03%

%PC of FM = (70.79/100) * 15.27 = 10.81%

%PC of BLM = (86.25/100) * 7.63 = 6.58%

%PC of Bone meal = (2.89/100) * 2.5 = 0.07 %

%PC of Oyster = (1.89/100) * 0.5 = 0.01%

Total = 2.50% + 15.03% + 10.81% + 6.58% + 0.07 % + 0.01% = 35.00%

The Table1.1 summarises the formulated fish feed with the use of Pearson's square method. The metabolisable energy values of feed stuff have been experimentally determined as well.

Similar fish feed can be formulated using algebraic method as illustrated below. Though same outcome shall be obtained but the farmer is at liberty to use any of both methods found easier and it is an opportunity for students to learn another method.

Table 1.1: Fish Feed Formulation

Ingredients	Percentage Composition	Percentage Protein Contribution	Metabolisable Energy (kcal/g)
Maize	30.08	2.50	1.02272
Groundnut cake	38.17	15.03	0.99242
Fish meal	15.27	10.81	0.42756
Blood meal	7.63	6.58	0.23653

Bone meal	2.50	0.07	-
Palm oil	5.00	-	0.40
Oyster	0.50	0.01	-
Vitamin	0.60	-	-
Salt	0.25	-	-
Total	100.00	35.00	3.07923 kcal/g (3079.23kcal/kg)

1.4.2 Algebraic method

Steps 1 and 2 are exactly the same as that of Pearson's square method.

Step 1:Determination of percentage composition (%C) of fixed ingredients

Let adopt fixed ingredients %C according to Abdulkarim and Ipinjolu (1998): Bone meal, 2.50%; Palm oil, 5.00%; Oyster, 0.50%; Vitamin, 0.60% and Salt, 0.25%. This brings the total fixed ingredients to 8.85%. Therefore, the remaining ingredients percentage composition = 100% - 8.85% = 91.15%

Step 2:Determination of percentage crude protein (%CP) to be contributed to the final ration by the 8.85% fixed ingredient

The percentage crude protein of most locally available feedstuffs have been experimentally determined and published in literatures. Among the fixed ingredients Bone meal has 2.89 %CP and oyster has 1.43%CP

2.50% of Bone meal will contribute 2.5 * (2.89/100) = 0.07 %CP

0.5% of Oyster will contribute 0.5 * (1.89/100) = 0.01% CP

Total % CP contributions from Fixed ingredients = 0.07 + 0.01 = 0.08 %CP

This implies that the remaining 91.15% will supply %CP = 35 – 0.08 = 34.92

Step 3: Formulation of algebraic equations on variable feedstuffs

Two equations shall be formulated, one on percentage composition and the other on the percentage crude protein. Let the energy source be X in this case maize (8.31%CP) and protein source be Y which in this case is protein mixture used earlier (53.09 %CP), hence, we have the following equations:

$X + Y = 91.15\%$ equation 1

$8.31\%X + 53.09\%Y = 34.92$ equation 2

Both equations shall be expressed in decimal by converting the percentages to decimals simply by diving each percentage value by 100 and we have

$X + Y = 0.9115$ equation 3

$0.0831X + 0.5309Y = 0.3492$ equation 4

Solving the equations simultaneously using substitution method by making either X or Y the subject of the formula using any of the equations; in this case we are using equation 3 and making X subject of the formula:

$X = 0.9115 – Y$ then, we substitute in the value of X into equation 4

$0.0831(0.9115 – Y) + 0.5309Y = 0.3492$ expanding the bracket gives

0.0757 – Y0.0831 + 0.5309Y = 0.3492 collecting like terms together gives

0.4478Y = 0.2735 dividing both sides of the equation by 0.4478 gives

Y = 0.6108 substituting this value into equation 3 we have

X + 0.6108 = 0.9115 solving for X we have

X = 0.3007 multiplying each of X and Y value by 100 as to obtain their percentages Maize, X = 30.07% and protein mixture, Y = 61.08%.

The slight difference of ± 0.01 in these values compared to the values obtained from Pearson's square method is negligible. Subsequent steps are exactly the same as the Pearson's square method.

The 61.08% of the protein source shall be distributed to each protein feed stuff based on their respective ratios:

GNC = (5/8) * 61.08% = 38.175%

FM = (2/8) * 61.08% = 15.270%

BLM = (1/8) * 61.08% = 7.635%

The total = 38.175% + 15.270% + 7.635% = 61.08%

Step 4: checking the percentage protein contribution (%PC) of each feedstuff to the 35% CP required

%PC of feedstuff = (% CP of feedstuff/100) * % composition

%PC of Maize = (8.31/100) * 30.07 = 2.50%

%PC of GNC = (39.38/100) * 38.17 = 15.03%

%PC of FM = (70.79/100) * 15.27 = 10.81%

%PC of BLM = (86.25/100) * 7.63 = 6.58%

%PC of Bone meal = (2.89/100) * 2.5 = 0.07 %

%PC of Oyster = (1.89/100) * 0.5 = 0.01%

Total = 2.50% + 15.03% + 10.81% + 6.58% + 0.07 % + 0.01% = 35.00%

The Table1.1 has summarised this formulated fish feed as well. There is also soft ware for computer assisted feed formulation. The major advantage is that it allows for making combination of feed stuffs that enhances least cost ration formulation. Commercial feed companies and large scale farmers.

Also Table 1.2 and Table 1.3 provide formulated fish feeds that could be used by farmers.

Table 1.2 Percentage Composition of Fish Feed for Clarias and Tilapia

Ingredients	Diets	
	1	2
Maize	29.49	20.71
Groundnut cake	38.22	37.7
Fish meal	19.29	15.11
Blood meal	7.64	7.50
Millet offal	0.00	10.0
Bone meal	2.50	2.50
Oyster shell	0.5	0.0
Palm oil	5.5	5.0

Vitamin premix	0.6	0.6
Salt	0.25	0.25
Total	100.00	100.00
Protein (%)	35	35
Metabolisable energy Kgcalg^{-1}	2865	2991

Source: Abdulkarim and Ipinjolu (1998).

Table 1.3 Gross composition of feed fed to *Cyprinus carpio* L.

Ingredients	Diets (% composition)	
	1	2
Fish meal	21.40	18.55
Palm kernel meal	0	9.25
Ground nut cake	39.08	39.08
Blood meal	0	1.56
Yellow maize	19.77	19.77
Wheat offal	15.0	7.04
Palm oil	1.0	1.0
Bone meal	1.5	1.5
Oyster shell	1.0	1.0
Vitamin mix	1.0	1.0
Salt	0.25	0.25
Total	100.00	100.00

Source: Ipinjolu *et al*. (1988).

According to Ipinjolu *et al*, (1988) the diets contained protein level of 38.11%. The best food conversion ratio was obtained in diet 1 and 2. Apparent food consumption was highest in diet 1 and 2 due to the physical and chemical attributes of the diets as influenced by palm kernel meal. Note that the declining weight gain (WG) observed percentage weight gain (PWG) from dietary treatment 1 to 2 indicate the quality of the diets with respect to the relative proportions of fish meal and palm kernel meal.

Isonitrigenous feeds are feeds with equal quantity of protein while isocaloric feeds are feeds that have equal quantity of energy level. The diets in Table 1.4 are examples of isonitrogenous and isocaloric feeds.

Table 1.4: Ingredients and percentage composition of Isocaloric (4.2kcalg^{-1}) and isonitrogenous (38%) autoclaved SF-PMM blend diets Fed to *Clarias gariepinus*.

Ingredients	Diets (% composition)			
	1	2	3	4
Soybean flour (SF)	14.5	31.0	50.0	71.9
Poultry meat meal (PMM)	43.6	51.0	16.6	-
Wheat flour	29.2	24.9	20.0	14.2
Soybean oil	4.7	5.1	5.4	5.9
Mineral premix	4.0	4.0	4.0	4.0
Vitamin premix	2.0	2.0	2.0	2.0
Binder	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0

Source: Sadiqu and Jauncey (1998).

Decrease in trypsin inhibitor (TI) activity to tolerable level brought about by heat processing was observed to improve growth rate and protein efficiency ratio (PER) of catfish. PMM is a good source of methionine and lysine, it also reduce the activity of TI to residual level in a diet that have raw soybean flour (Sadiqu and Jauncey, 1998).

1.4.3 Making pellets

A diet within economic limit should be formulated so that a little food is possible to produce 1kg of fish. The use of supplementary feed is recognized as the principal means of fish production through aquaculture.
Residual antitrypsin did not inhibit growth response in carp fed properly heat processed commercial soybean meal. Note that, fish could not efficiently strain small particles from the water and thus much of the feed will be wasted and tends to foul the tanks but making pellet can minimize this problem.

Making pellet is the processing of mash or powder feed into solid size that is consumable to fish based on growth of fish varying in size as they grow. Pellet fish feed are in millimetre (mm) sizes up to 8mm. There is equipment for making pellet of commercial feeds, particularly the floating type of feed. Locally, for small scale farmers, pellet can be made by mixing mash feed with warm water stirring it to form paste. Then, the paste is passed over perforated metal plate. Abdulkarim and Ipinjolu (1998) used perforated metal disc of desired size to make pellet. The pellets were collected in a plate (tray) and sun dried but such type of feed will be non – floating or sinking feed.

1.4.4 Feeding regimes

Fish should be fed at 3 – 4% their total body weight (Viola *et al.,* 1983). Practically, quantity to be fed daily to fish are determined forth nightly or monthly by weighing some fish as samples from ponds containing fish sorted into similar sizes, then,

1. The average weight (AW) of fish per pond is calculated.
2. The biomass = AW * estimated number of fish per pond
3. Daily quantity of feed = biomass * percentage body weight
4. The daily quantity determined are fed in splits at strategic periods of the day prominently 2 – 3 times daily at grow – out stage: early morning hour (6 – 7 am) and early evening hours (6 – 7 pm). Very little quantity should be fed when the day is sunny in the tropics. Clarias respond very well in growth performance when fed in the night as they are nocturnal, that is, they are very active in the night.

1.4.5 Determination of feeding regime

For example, if 10 fish were weighed to the nearest 10g in a pond as 400g, 350g, 350g, 450g, 250g, 300g, 300g, 250g, 300g, 400g and there are 102 estimated numbers of fish in the pond. Daily feeding rate is 3% of body weight (3% = 3/100).

Solution:

Average weight, AW = sum of sample weights/ number of sample weights

AW = (400g + 350g + 350g + 450g + 250g + 300g + 300g + 250g + 300g + 400g) / 10

AW = 3,350 / 10 = 335g

Biomass = 335 *100 = 33,500g

Daily quantity of feed = 33500 *(3/100) = 1005g = 1005/1000 =1kg approximately. So 1000g can be split into 400g, 200g and 400g for morning, afternoon and evening respectively.

Precautionary measures in feed formulation include:

1. Ingredients should be selected for their role as energy, protein, lipid or as a binder
2. Avoid ingredients that are very high in fat content
3. Use minimum amount of ingredients containing fibre
4. When in doubt consult nutritionist

Eyo (1997) stated merits of artificial feeding as follows:

1. Allow for high stocking density
2. Promote fast growth, fish never starved
3. Produces high fish yield

CHAPTER TWO

2.0 EFFECTS OF LOW DISSOLVED OXYGEN AND ALKALINITY ON FISH AND HOW IT CAN BE CORRECTED

2.1 Introduction

Water supplied to catfish ponds is initially of good quality. However, once the water is used for culture, its quality deteriorates. This deterioration of environmental conditions is ultimately traceable to the use of feed. Despite the use of high quality feeds and careful feeding practices, relatively little of the nutrient value of feed is converted to catfish flesh. The remaining nutrients derived from fish wastes stimulate excessive phytoplankton growth. High rates of phytoplankton metabolism cause pronounced diurnal fluctuations in dissolved oxygen concentrations, dissolved carbon dioxide concentrations, and power of Hydrogen (pH). Such fluctuations cause stress to fish resulting in reduced fish growth rates, poor feed conversion, and reduced resistance to disease. In extreme instances, such as depletion of dissolved oxygen, fish may be unable to adapt and will die (Breitburg *et al.,* 1983).

Oxygen is obviously essential to fish health, but how much or how little? Test kits should always be available in the farm, it is recommended to own at least one set of test kit. Oxygen (O_2) is available in water in a dissolved form called dissolved oxygen (D.O.). Minimum levels of dissolved oxygen would be five part per million (ppm). This level will permit fish to live a few days. Levels as low as 3ppm at least partially explains why fish are dying like flies. Pond water with low dissolved oxygen (7ppm) should be improved by aerating with electric aerator or air stone. Air stones are natural rough surface stones with tiny holes all over them, when placed inside the pond they aerate the pond water thereby increase level of D.O. in the pond water. Low Dissolved Oxygen is an underestimated cause of fish losses, particularly because of its synergistic effects with other toxins like Ammonia (William, 2013).

Literarily, hundreds of environmental variables may affect fish health and survival, but fortunately only a few are important in commercial fish culture. Water is scientifically studied as an environment where aquatic fauna and flora thrive through set of some physical and chemical characteristics generally referred to as physicochemical parameters. The concentrations of these parameters change due to several factors because their concentrations may change rapidly, substances most affected by biological activity include dissolved oxygen, carbon dioxide (CO_2), ammonia (NH_3), nitrate (NO_3^-) and nitrite (NO_2^-) and are the most important aspects of water quality and its management in fish pond aquaculture (Boyd, 1982).

The pH of pond water is influenced by the amount of carbon dioxide present. Some lakes and wells mostly on the coastal plains yield water with total alkalinity to total hardness ratio of 5:10. When fish ponds are supplied from such wells or sources, prolonged period of high pH occasionally result in poor growth of fish.

The presence of CO_2 can be a problem when associated with oxygen depletion, but usually not a problem by itself. When D.O. is limited, elevated CO_2 levels may interfere with the ability of fish to take up the remaining oxygen. The mechanical aeration not only increases D.O. in the water, but also lowers the level of CO_2. The application of hydrated lime at a rate of 30-50 kg/acre will reduce the CO_2 value in the water by precipitation as calcium trioxocarbonate (IV) ($CaCO_3$). About 1ppm hydrated lime is needed to neutralize 1ppm CO_2. In ponds with very low alkalinities, care should be taken not to over treat with hydrated lime, which may cause pH to rise to toxic level.

2.2 Oxygen Requirements of Fish and Effects of Low D.O. in Water Bodies

Oxygen requirements are determined by three basic factors

1. Fish species
2. Size of the fish
3. Water temperature

Hypoxia is oxygen starvation. Most ponds are usually well served waterfalls, which produced D.O., but poor pond maintenance, high stocking density of fish and unusual climatic conditions can lead to low dissolved oxygen levels. Low D.O. is likely to occur in dry season. As water becomes warmer it can progressively hold less oxygen due to high temperature and the fish become more active, leading to a greater demand for oxygen; and the bacteria in the pond and filters need more to respire, as do submerged green plants including algae.

The role of submerged plants and algae should perhaps be clarified. During photosynthesis, submerged plants release oxygen into the water, which is why they are often called oxygenating plants. However, they also respire at the same time, extracting oxygen from the water and excreting carbon dioxide. During daytime they produce more oxygen than they consume, but at night, when photosynthesis ceases, respiration continues and they become net oxygen consumers.

Clearly, if the oxygen demand exceeds the oxygen supply by the phytoplankton, then, the D.O. levels will gradually decline and this presents a serious danger to fish in pond. A lot of oxygen can be used in oxidizing organic waste and, under certain conditions; this extra demand may be “the straw that breaks the camel's back”.

Common causes of low D.O., apart from high fish densities, are heavy feeding and a dirty pond or filter. Unfortunately, a D.O. problem often occurs in the early hours of the morning. When we are not there to see its direct effects on the fish, rather than during the day when submerged plants are releasing oxygen from photosynthesis (Bock, 1999).

According to Bock (1999) oxygen concentrations are generally not uniform within the water columns of bodies of water, and the behavioural responses of mobile animals, as well as physiological tolerances, ultimately determine effects on individuals, populations and multispecies assemblages of coastal fishes. In addition to mortality directly resulting from exposure to low dissolved oxygen concentrations, oxygen depletion likely has important effects on the food web by altering distributions (and therefore, encounter rates between predators and prey), predator feeding rates, prey vulnerability and growth rates (and thus, size-dependent trophic interactions). Variation in behavioural responses and physiological tolerances among species are important in determining the effects of hypoxia.

Signs of Low D.O. according to Gietema (1992) include

1. Fish assembling at the margin of the pond
2. Fish not feeding well, or even stopping feeding
3. Piping is the act of fish coming to the water surface in effort to breathe from the better oxygenated surface film.

The development of environment-related off – flavours is another important aspect of water quality management. Off – flavour is unlike the previously listed water quality variables because it does not pose a direct threat to fish health. Rather, it affects the acceptability of fish for processing, which causes delays in harvesting. As such, it increases the cost of production and exposes fish to additional risk of loss to diseases or predators. The combination of low oxygen and anthropogenic Stressors can increase mortality and ecological consequences of low oxygen to fish assemblages. Typical clinical signs of low D.O. are lethargy and a tendency for the fish to gasp at the water surface and congregate around water returns. Many of these signs are the same as for a gill problem so a test for D.O. has to be made to be conclusive. The supply of dissolved oxygen often becomes limiting to fish because the combined respiration of fish, phytoplankton, and mud-dwelling organisms exerts a tremendous demand for oxygen. At high phytoplankton biomass levels (which is the typical condition in fish ponds, particularly, during warm weather), oxygen production by algae is insufficient to meet the respiratory demand of the pond community and a daily oxygen deficit develops. If this deficit is not offset by artificial aeration, dissolved oxygen levels will drop very low and fish will die (James and Ronald, 1982).

2.3 Solutions to Low D.O. in Fish Ponds

If low D.O. is the problem, that is, D.O. is less than 5 to 6 ppm (5-6 mg/litre), then additional aeration will help but it is essential to determine what caused the problem and to take remedial action. The key to successful management is early identification of those ponds that may require supplemental mechanical aeration to keep fish alive. Aeration is initiated when dissolved oxygen concentrations fall to a level considered critical (usually around 3 to 4 mg/l). Under current production practices, nearly every fish pond has dissolved oxygen concentrations less than 2 mg/l at dawn during warm weather condition. The duration of low dissolved oxygen concentrations at night usually ranges from 3 to 6 hours/day. Aeration is continued until past dawn when measurements indicate that dissolved oxygen concentrations are increasing as a result of photosynthetic activity.

High rates of respiration in ponds with abundant plankton and high densities of fish result in rapid loss of dissolved oxygen and accumulation of carbon dioxide over the night time hours during summer months. Dissolved carbon dioxide concentrations of 5 to 10 mg/l are common on summer mornings in catfish ponds and appear to be well tolerated by channel catfish. They can survive in waters containing up to at least 60 mg/l dissolved carbon dioxide provided dissolved oxygen concentrations are high. Higher concentrations of CO_2 may cause death but chronic problems are rare because daytime uptake in photosynthesis normally serves to remove all the carbon dioxide that is produced in overnight respiration.

Bock (1999) summarises Solution to Low D.O. as follows:

1. Mechanical aeration or manually stirring the water or paddling
2. Longer the path of the wind on the pond surface
3. Reduce the number of fish, that is, reducing fish stocking density
4. Increase the flow of well oxygenated and cooler water

2.4 Effects of Alkalinity and Hardness in Water of Ponds

The determination of whether water is acid, neutral or base is defined by pH. However, alkalinity measures the total amount of base present and indicates a pond's ability to resist large pH changes, or the "buffering capacity". The most important components of alkalinity are carbonates and bicarbonates. The total alkalinity concentration should be no lower than 20 mg/l $CaCO_3$ in production ponds. Pond pH can swing widely during the day, measuring from 6 to 10, when alkalinity concentrations are below this level. Large daily changes in pH can cause stress, poor growth and even death of the farmed aquatic animals. Most aquatic organisms can live in a broad range of alkalinity concentrations. The desired total alkalinity level for most aquaculture species lies between 50-150 mg/l $CaCO_3$, but no less than 20 mg/l (Hargreaves, 1999).

Hardness is also important to aquaculture. Calcium and magnesium are the most common sources of water hardness. Calcium and magnesium are essential in the biological processes of aquatic animals, for example, bone and scale formation in fish. The critical component of total hardness is the calcium concentration, or calcium hardness. Environmental calcium is crucial for osmoregulation that is, maintaining precise levels of internal salts for normal heart, muscle and nerve function. Calcium is also important in the molting process of shrimp and other crustaceans, and can affect the hardening of the newly formed shell. Aquatic animals can tolerate a broad range of calcium hardness concentrations. A desirable range would lie between 75 and 200 mg/l $CaCO_3$.

2.5 Mitigation of Low alkalinity in Pond

Hargreaves (1999) reported that if the alkalinity is low, it Indicate even small amount acidic water can cause harm to the fish. Alkalinity decreased over time through bacterial action which produces acidic compound. In order to increase alkalinity of pond water mix a compound that raises pH values such as Calcium carbonate, Limestone or egg shell alternatively Alum – $Al_2(SO_4)_3$, Gypsum – $CaSO_4$. Add small amounts to keep from making the water too alkaline which will create additional problems. The exact quantity to be added can be determined easily by monitoring the water with pond kits that can be used in testing a specific parameter before and after application.

Hargreaves (1999) observed that agricultural limestone will not increase pH beyond a maximum of 8.3. The use of hydrated lime [$Ca(OH)_2$] or quick lime (CaO) is not recommended because either of these compounds can cause the pH to rise very rapidly, to levels that are harmful to aquatic life.

2.6 Effects on Pond Productivity

Hargreaves, (1999) stated the benefit of using agricultural gypsum that it can help to settle muddy water. By clearing the water, gypsum improves light penetration, which is critical to phytoplankton growth. Phytoplankton is group of microscopic aquatic plants that are responsible for most of the dissolved oxygen present in production ponds. In muddy or turbid water, light cannot penetrate to any appreciable depth. This inhibits photosynthesis and aquatic plant growth, and can reduce day time dissolved oxygen levels. These tiny plants absorb most of the toxic nitrogen wastes produced by aquatic animals under intensive culture conditions. The effects of agricultural gypsum on water clarity can improve plant growth, primary productivity and water quality. Similarly, alkalinity has indirect effects on “primary productivity” or phytoplankton growth. In low alkalinity aquatic environments, certain nutrients are unavailable to aquatic plant life (Hargreaves, 1999).

Liming with agricultural limestone increases total alkalinity, augmenting the availability of phosphorus for phytoplankton growth. Pond fertility is improved and primary productivity increases which, in turn, can lower toxic nitrogen wastes and elevate day time dissolved oxygen concentrations. Attentiveness to hardness and alkalinity concentrations, with periodic sampling and concentration adjustments, can profoundly affect water quality and overall pond productivity (Wetzel, 1983).

Fish does almost everything inside water: feed, grow, reproduce and excrete inside water. As fish farm no longer rely on nature to take care of it then, there is need to maintain good water quality. This can be achieved if the fish farmer is able to acquire simple water quality measuring kits. Levels of D.O. greater than 8ppm are desirable to the fish, but 11 or better up to 14 ppm are glorious. If alkalinity and hardness concentrations are below the suggested level, both can be increased by adding agricultural limestone ($CaCO_3$).

CHAPTER THREE

3.0 POLYCULTURE FISH POND SYSTEM FOR TILAPIA AND CLARIAS SPECIES IN CONCRETE AND EARTHEN PONDS

3.1 Introduction

The main objective of Polyculture of fish species in the pond is to raise several compatible fish species in order to obtain maximum benefit. The culture of different species with different food habits is one of the most important management techniques for maximum production. The production technique ensures a proper utilization of the existing ecological niches in the water body. Yield of up to 4 tons per hectare (ha) per year have been obtained with stocking rates of 1000 *Tilapia niloticus per* hectare and 1000 common carp per hectare in first second month of the production cycle. However, polyculture of tilapia and mudfish at 2000/ha in earthen pond fertilized with organic wastes could yield up to 6 tons of fish per hectare per year (Trewavas, 1981).

The polyculture of *Clarias lazera* of minimum size of 100g with *Tilapia niloticus* in ratio 1:10 respectively has shown good result in controlling the excessive breeding of *Tilapia* species (DIFFRI, 1988). According to Trewavas (1981) some progress has been made in the culture of some indigenous and few exotic fish species. Notable is the culture of tilapias whose excessive breeding is an undesirable trait in an intensive system, some means are employed to control or prevent the breeding of tilapias after stocking in earthen or concrete pond. The fish species is either stocked with predatory fish species like Nile perch or mud fish.

Trewavas (1981) also recommended that the predator density should be low as not to extinguish the fish species being controlled. Also, the non-predatory fish species should be larger than the predatory fish species at stocking in rearing medium.

3.2 Polyculture in Earthen and Concrete Pond

Trewavas (1981) observed that there are not many differences in practising polyculture in earthen or concrete pond in terms of management procedures, management programs such as stocking, feeding, water quality assessment and control of diseases are similar to the monoculture's which is a system of rearing single species of fish in a pond. Choice of pond type for polyculture is generally influenced by cost of building materials, soil type, topography and availability of water. In both pond types, environmental conditions could be manipulated to give a similar natural condition for rearing fish.

3.3 Polyculture Techniques

The basic techniques involved are to use fish that are compatible; the desirable species should have varieties of feeding habits, occupy different ecological niches in the same habitat, this will improve the efficiency and conversion of food as well as the use of uneaten food and fish droppings. Such inter-relationship is demonstrated by the polyculture of common carp, grass carp, the grey mullet and *Tilapia* spp. The common carp feeds on the benthos, the grass carp feeds on macrophytes, grey mullet feeds on phytoplankton, grey mullet feeds on both phytoplankton and zooplankton, while *Tilapia* spp. serve to remove deposits of organic material and keep the bottom in good condition (Axelrod *et al.,*1971). Lovell (1991) stated that production of fish in captivity require adequate and balance feeding as well as proper management of the aquatic medium. Tilapia is among the numerous fish that have wider acceptance by the majority of consumers in the developing countries. It is in the realization of the role played by this fish (tilapia) that efficient techniques are adapted to enhance its productivity.

Hackling (1971) stated that tilapia belongs to Perciformes order and to Cichlidae family. Cichlidae are classified into two groups based on their methods of breeding as the mouth breeders to either *Sarotherodon* or *Oreochromis* and the substrate breeders which are the genus Tilapia. Tilapia can withstand brackish water and temperature of above 30^{o}C. The fish feed on microscopic plants such as phytoplankton. Tilapia normally feeds on the bottom of water by sucking in food on a continuous basis, filtering out these particles which are edible and ingesting them. Clarias (mudfish) is one of the easiest and commonest fish to grow and commands a high market price. It is an omnivorous fish and because it has accessory air- breathing organ capable of using oxygen in atmospheric air, it can be densely stocked.

Note that whatever densities of fish you decided to stock in your pond, be it concrete or earth, standard combination ratio is provided below. The average weight of each Clarias was between 60 – 90g when stocked into the pond. They are reared for 6 to 9 months by that time they have attained an average weight of 1.5 to 2.5 kg.

Table 3.1: Species Combinations, Stocking densities and Ratios in Polyculture in either Earthen or Concrete Pond (Hectare)

Species	Stocking density per hectare (Earth Pond – Concrete Pond)	Ratio
Clarias gariepinus + Tilapia Sp.	4500 – 6000	1:3
Cyprinus carpio + Tilapia Sp	5000 – 10000	1:3
Tilapia + Mullet	8000 – 10000	1:2

Source: DIFFRI (1988).

Ponds to be used for rearing fish should be filled and fertilized for 10 to 14 days before the fish are stocked. This is necessary in order to encourage the growth of natural food in the pond. This varies depending on whether water is taken from well or from surface source. Streams and other surface water sources are rich in phytoplankton and zooplankton, thus immediately provide adequate food to the fish Hackling (1971).

3.4 Aspects of Breeding in Polyculture

It is very advisable not to obtain brood stocks raised from a wild because they do not make good stocks as they could have low genetic vigour. Injured fish regardless of the case will probably die within 2 to 3 days after being received, so care must be taken in selecting brood stock. External differences between male and female Tilapia can be determined. The female has three orifices (openings): the anus, the genital and urinary orifices on it belly while the male has two orifices: the anus and urinogenital orifices. The male tilapia has a protruded genital papilla and anal opening while the female has two orifices: anal and genital.

Sex of brood fish must be determined so that females and males can be stocked in equal number or in their commonly used female to male ratio as 2:1 or 3:2. It is advisable to identify the sex of Tilapia at an early age after this the growing pond can be stocked with fish of one sex (monosexculture). If you have Tilapia, you should be warned against releasing them into local ponds. It does not take too long for them to get established. The majority of Cichlids are territorial. Introducing Tilapia into already established pond in which they are many long time residents, will likely cause a serious trouble. Introducing fish in established pond is possible if you provide rocks and hiding places into new position to serve as microhabitats. This will provide equal chance of re-establishing their territories.

3.5 Construction of Artificial Nest for Tilapia in Polyculture Practice

According to Axelrod *et al,* (1971) construction of artificial nest is very important in Tilapia production because when female laid its eggs, they must be fertilized almost immediately for a few moments later will be too late. It is advisable to have many sizeable sandy soils on the bottom of the ponds, with deep base coarse gravel. Submerged logs would be helpful; this will enable a large plant to grow and fairly heavy flower pot.

3.6 Supplementary Feeding of Polyculture Fish

Ekanem (1984) reported that fish can be fed 5% body weight with pellet groundnut cake and rice or brewery waste. They should be fed in the morning between 7.00 and 9. 00 a.m., from Mondays to Saturdays; The feeding ratio is 1kg of rice bran to 1kg of brewery waste and 1kg of groundnut cake or 2kg of rice bran to 1kg of groundnut cake. The feed is soaked in water overnight. Kitchen wastes like beans chaff from *moimoi* (a common Nigerian cuisine mainly prepared from cowpea) as well as chicken intestine and blood should be cooked separately to feed the fish. The supplementary feed is increased every month when the fish are viewed at the feeding spot.

3.7 Management Practices

Water is the medium in which aquatic organisms live, reproduce, feed and grow. It is well known that tropical fish show stress due to insufficient dissolved oxygen at higher temperature. Even with proper aeration of water in the pond if dissolved oxygen concentration is low (3mg/l) the feed conversion ratio will decline. Tilapia survives at temperature of 40^{o}C by gulping from the water surface this is possible because the water has not been robbed of its oxygen by purifying organic matter. Alkaline or neutral water are more productive than acidic water. The death point of Tilapia is reached at a pH of 11.9. It is recommended that the pH of Tilapia should be within 6.9 – 9.2.

Aeration is necessary especially if the tilapia is being cultured, in a large static pond. It is advisable to use either the impeller lift pond or paddle wheel type machine. Liming material such as $CaCO_3$ and $CaCl_2$ in pond can help in reducing the concentration of acid and thus provide favourable medium for tilapia production. Application of manure in the pond is done in order to encourage the growth of natural food in the earthen pond.

3.8 Fertilization of Pond

The fertilization can be done weekly. Poultry droppings at the rate of 250 kg per hectare per week or 13 tons per hectare per year are recommended.

The basic techniques involve in polyculture should be strictly followed and adapted for both concrete and earthen pond with timely consultations of experts in order to ensure success in the business of fish farm.

CHAPTER FOUR

4.0 INTEGRATED FISH FARMING, THE CASE OF FISH – CUM - IRRIGATION

4.1 Introduction

The early inscription of the 13th century in Asia is "in the waters are fish and in the field is rice" this indicates wealth and stability of the people. Irrigation systems using stored or diverted water have increased exponentially during the past 50 years in the region, but fish farming within these irrigated systems has not expanded equally, and therefore, there is now a huge potential for this integrated enterprise. Systematic approach to fish farming development in combination with irrigation system will make integration a viable enterprise (TNau, 2013).

The cultivation of most rice crops in irrigated or rain fed offers a suitable environment for fish. Integrated fish farming offers great efficiency in resource utilization, as waste or by – products from one system is effectively recycled. It also enables effective utilization of available farming space for maximizing production. The rising costs of protein-rich fish food and chemical fertilizers as well as the general concern for energy conservation have created awareness in integration of fish cum irrigation system of farming.

Fish culture in combination with agriculture or livestock is a unique and lucrative venture and provides a higher farm income, makes available a cheap source of protein for the rural population, increases productivity on small land-holdings and increases the supply of feeds for the farm fish. The scope of integrated farming is considerably wide.

Fish Farming is compatible with Irrigation and can be integrated to increase profitability of both production systems. This is especially relevant in this era of increased world demand for basic crop commodities (soybean, maize, sorghum, barley, cotton, sunflower seeds, etc.) and implementation of large-scale green energy and biofuel projects, based on sugar cane, maize, jatropha, and so forth. Integrated Fish Farming and Irrigation is achieved by constructing the fish farm facility between the water source and the irrigated field (RIC, 1972).

4.2 Integration System

According to TNau (2013) fish culture in rice fields may be attempted in two ways, the rice plots are supplied with irrigated water from its inlets; it could be practised as simultaneous culture or rotation culture. In the former, rice and fish are cultivated together and in the latter; fish and rice are cultivated alternately.

The paddy fields retain water for 3-8 months in a year. The culture of fish in paddy fields, which remain flooded even after paddy harvest, serves an off-season occupation and additional income to the farmer. This system needs modification of rice fields, digging peripheral trenches, construction of dykes, pond refuge, sowing improved varieties of rice, application of manure, stocking of fish at 10,000/ha and finally feeding of stocked fish with rice-bran and oilcakes at 2-3% of body weight.

4.3 Simultaneous Culture

For simultaneous culture, rice fields of 0.1 ha area may be economical. Normally four rice plots of 250 m^2 (25 x 10 m) each may be formed in such an area. In each plot, a ditch of 0.75 m width and 0.5 m depth is dug. The dykes enclosing the rice plots may be 0.3 m high and 0.3 m wide and are strengthened by embedding straw. The ditches have connections with the main supply or drain canal on either side of which the rice plots are located, through inlet-outlet structures of the dykes. The depth and width of the supply or drain canal may be slightly smaller than that of the ditches. Suitable bamboo pipes and screens are placed in the inlet and outlet structures to avoid the entry of predators of fish and the escape of fish under culture. The ditches serve not only as a refuge when the fish are not foraging among rice plants, but also serve as capture channels in which the fish are collected when water level goes down. The water depth of the rice plot may vary from 5 to 25 cm depending on the type of rice and size and species of fish to be cultured (TNau, 2013).

The fish species which could be cultured in rice fields must be capable of tolerating shallow water (15 cm), high temperatures (up to 35ºC), low dissolved oxygen and high turbidity. Species such as *Catla catla, Labeo* *rohita, Cirrhina mrigala, Cyprinus carpio, Chanos chanos, Oreochromis mossambicus, Anabas testudineus, Mugil* spp., *Clarias batrachus, Clarias macrocephalus, Lates calcarifer, Channa striatus* and *Clarias marulius* have been widely cultured in rice fields (RIC, 1972).

4.4 Fish cum Irrigated Vegetables

The system of integration of fish and irrigated vegetables is widely practised in some parts of Nigeria for instance; Fish cum irrigated vegetable farms are in Gubi dam, Bauchi, Bauchi State. Many farmers have their farms completely or partially surrounded by rivers or stream for example in *Gadan maiwa*, Bauchi. In these areas vegetables and maize were produced during the dry season.

In these areas, it is possible to adopt this system where there is reliable source of water (river, pond or lake) unlike the case of rice cum fish; the source of water is the rearing media for fish species and source of water supply to the vegetables. The plan here is to prevent the fish from swimming downstream or upstream. Wire mesh of appropriate size should be placed at inlet and outlet points. Fish should be stocked at 35 fish / m^2 and fed supplementary feed at 5% of their body weight. Farm residues such as ground grains, leaves can be fed to fish.

4.5 Utilization of Pond Dykes for Fish cum Irrigation

TNau (2013) suggested that pond-dykes can be used for horticultural and agricultural crop production. The system provides vegetables, mushroom, fodder and grains, in addition to fish. Hence this system provides better production, provides more employment, and improves socio-economic status of farmers and betterment of rural economy.

The top, inner and outer dykes of ponds and canal as well as adjoining areas can be best utilized for horticulture crops. Pond water is used for irrigation and silt, which is high-quality manure, is used for crops, vegetables and fruit bearing plants. The success of the system depends on the selection of plants. They should be of dwarf type, less shady, evergreen, seasonal and highly remunerative. Dwarf variety fruit bearing plants like mango, banana, papaya, coconut and lime are suitable, while pineapple, ginger, turmeric, chilli is grown as intercrops. Plantation of flower bearing plants like tuberose, rose, jasmine, gladiolus, marigold and chrysanthemum provide additional income to farmers (TNau, 2013).

4.6 Utilization of Canals for Fish cum Irrigation

Similarly when banana or coconut is cultivated in rows in wetlands, the ditches made between such rows act as supply or drainage canals. These canals serve as fish culture systems owing to their round-the-clock supply of water and rich insect populations. Larvivorous air-breathing fish species such as snakeheads *C. marulius* and *C. striatus* and tilapia, *O. mossambicus* are ideal species for culturing in this system. This integrated system fetched 20-25% higher return compared to aquaculture alone (RIC, 1972).

4.7 Water is Used Twice

FAO (2007) reported that any water source could be used, including - underground, river, or impounding reservoir, and any water supply system, including - gravitational, pumping, or a combination of both. Water is used for fish production and irrigation.

Advantages of Integrated fish farming irrigation (IFFI) over an irrigation project producing only land crops are:

1. Increase fish output, without reducing output of irrigated crops
2. Diversification into high value consumer food items – fish fillets
3. Diversification into a green-tech bio fuel crops
4. Reduced irrigation costs for bio fuel and food crops
5. Exportation of highly demanded products
6. Overall reduction in production cost by sharing water costs
7. Increase in rate of return on investments in the water supply and distribution
8. Environmentally sustainable system

Table 4.1 Integrate Fish Farming and Irrigation

Parameters	Description
Location:	Fish ponds between the water source and irrigated fields
Potential water sources:	River, reservoir, underground
Potential IFFI systems:	Gravity, pumping, combination
Double water usage:	First for fish, then for plants
Discharge (N & P):	Fertilizers for plants
Minimized investment:	Common facilities
Optimized operation:	Shared operating costs

Maximized profitability:	Combined pond and field output

Source: TNau (2013).

4.8 Rotational Culture of Rice and Fish

Through this practice, fish and rice are cultivated alternately. The rice field is converted into a temporary fish pond after the harvest. This practice is favoured over the simultaneous culture practice as it permits the use of insecticides and herbicides for rice production. Further, a greater water depth (up to 60 cm) could be maintained throughout the fish culture period.

One or two weeks after rice harvest, the field is prepared for fish culture. *C. carpio* is found suitable for this practice. The stocking densities of fry (2-3 cm) or fingerlings (5-8 cm) for this practice could be 20,000/ha and 6,000/ha, respectively. The fry are harvested after 10 weeks, while the fingerlings after six weeks. The average growth of the individual fish under this system has been reported to be about 100 g and a fish yield of about 2,000 kg/ha is possible. Further, it has also been reported that fish yield could exceed the income from rice in the rotational culture (RIC, 1972).

4.9 Management Practices

TNau (2013) recommended the ideal management involves utilization of middle portion of the dyke. Residues of vegetables cultivated could be recycled into fishponds, particularly when stocked with fishes like grass carp.

Grass carps can be stocked at 1000/ha and addition of common carps is beneficial for utilizing faecal debris. In many countries, there is now relatively easy access to fish seed, even in inland areas. Permanent water bodies should be stocked with a central pool of culture species harvested from short-lived habitats which serve as nurseries. A flexible system of moving culture fish within the system of habitats should be feasible. For example, stocking material for reservoirs can be obtained from irrigated rice fields where the short maturation period of the crop only permits the harvest of fingerlings. If a pragmatic and flexible approach is made to use all habitats for fish production, there could be a year-round supply of fish and a minimum wastage of stocks of cultured fish.

RIC (1972) stated that the use of high-yielding fish of good quality is essential for economic viability. In areas where a requisite biomass of desirable species already exists, these indigenous fish can be harvested, but their yields may only be adequate for low-income rural areas. Common carp, *Cyprinus carpio* L., has traditionally been a preferred cultured species. Tilapia is proposed as an alternative because these fish are cheap to raise, give high yields and are also quite palatable.

Aside from economic revenues, this type of integration also involves ecological and social benefits. High densities of fish in irrigation systems enhance the yield of land crops, alleviate the pressure of terrestrial and aquatic pests, and lower the populations of vectors of diseases of man and domestic animals.

Rice field that can retain water can be modified to support rearing of fish species especially if it has water inlets and outlets to support off season integrated fish farming. Species such as, *Cyprinus carpio, Chanos chanos, Oreochromis mossambicus, C. gariepinus* have been widely cultured in rice fields. The use of water in irrigated fish farming makes irrigation to provide maximum profit when it combines production of fish and arable crops.

The top, inner and outer dykes of ponds and canal as well as adjoining areas can be best utilized for fish cum irrigated vegetables. Pond water is used for irrigation and silt, which is high-quality manure, is used for crops, vegetables and fruit bearing plants. Ideal management involves utilization of middle portion of the dyke. Residues of vegetables cultivated could be recycled into fishponds, particularly when stocked with fishes like grass carp. The whole range of aquatic habitats created by irrigation systems can be integrated with fish farming. Small and large irrigation reservoirs, the extensive network of irrigation canals, the irrigated fields themselves, as well as adjacent ponds or aquatic refuges of various sorts are all potentials sites for nursing or grow-out fish.

CHAPTER FIVE

5.0 DISEASES AND PARASITES OF FISH AND THEIR TREATMENT AND CONTROL

5.1 Introduction

Fish suffer from many external diseases especially parasite and bacterial, which respond to topical application of drug. Bathing is an efficient means of treating fish. It is important to test the water before treatment of fish commences in order words physicochemical parameters should be preferably known through water quality analysis. This can simply be done using water quality test kits.

5.2 Diagnosis

The process of identifying the nature of ailment in an organism is medically termed diagnosis. Generally, there are various types of diagnosis and varies in their degree of reliability in ascertaining the specific nature of the disease:

1. Tentative diagnosis: is the common method whereby a doctor uses extrinsic factors like personal experience, prevalence and history of the disease to guess the nature of the disease. It is less reliable but fast and cheap in diagnosing of an ailment as to treat it.
2. Definitive diagnosis: is more reliable as it involves a laboratory test on the patient such as collecting samples of blood, faeces, urine, skin scratches and so forth for analysis in the laboratory so as to identify the causative agent of the disease and subsequently recommending curative measures or developing preventive measures such as vaccine to be administered in future.
3. Post-mortem: is the most reliable and confirmatory diagnostic method but is carried out on carcass of a dead animal in order to detect through physical examination involve visual identification of some histological changes in the carcass known to be peculiar to a disease and even tissue culturing in some cases. This does reveal the main nature of a disease. However, it should be carried out on the dead organism before degradation of the carcass sets in.

5.3 Treatment of Fish

After diagnosis, the next step is treatment of disease. The principles of disease control in fish are basically similar to those applied to higher vertebrates. The poikilothermic nature of fish and the variability of the aquatic habitat carry important environmental effects on their physiology of the fish. In addition, the use of chemotherapeutic agent is also a factor to be considered in treating fish against diseases (Amend, 1970).

5.4 Administration

The most common method of administering therapeutic agents to fish is bathing in water soluble compound. Fish suffer from many external diseases, parasitic and bacterial, which respond to topical application of drug. Bathing is an efficient mean of treating large population and is equally suited for single fish. In treating fish it is important to test the water before treatment commences. The common two methods of administering drugs in fish are:

1. Oral: Medicated feeds are widely used to administer drugs for systemic infection.
2. Topical: Wounds and localized infections of valuable fish are treated with topical application of recommended chemicals as lesions in higher animals are treated.

5.5 General Diagnosis in Fish

Lamai (1996) stated that fish disease diagnosis involves visual recognition of the disease causing organism, which requires the use of magnifying instruments. Daily close observation of the behaviour of fish is necessary. The most obvious signs include:

1. A sluggish feeding response
2. Darkening of the fish body
3. Respiratory difficulties
4. Abnormal swimming
5. Plasting
6. Ulceration
7. Excessive mucus
8. Look for large metazoan.

5.6 Control Strategies in Disease Free Fisheries

The preventive method of diseases in fish lies in observing some physical measures unlike in poultry and livestock where vaccines are administered as a method of controlling diseases. Some of the ways of controlling diseases in fishery include:

1. Observing Pisciculture and general sanitary conditions
2. Pathological control of transport of live fish
3. Supply of balance feed
4. Supply of disease free water into fish ponds
5. Recycled water should be exposed to ultra violet light as to kill potent microorganisms that can cause disease to fish.

In subsequent sections, a guide on the "resume" of common fish diseases in the tropics with emphasis on tropical prevalent types, their treatment and control is provided.

5.7 Types of Diseases According to Their Causative Agents

Diseases and parasites affecting fish in fish farming ponds are major subjects of research today, reflecting on the value of fish as source of food to man and his domestic animals (Lamai, 1996).

Diseases of fish are categorized as: parasitic, bacterial, viral, fungal and nutritional deficiencies syndrome. Parasitic diseases are caused by protozoa, helminths and parasitic crustacean. Bacterial diseases are caused by aeromonas. Viral diseases are the worst type of fish disease; they cannot be treated and may suddenly kill the entire population. Most virus affect only trout and salmon.

Generally fungal diseases are caused by *Saprolegnia*, *Aphaanomyces, Pythium* and so forth. Deficiencies diseases are caused by lack of or insufficient water soluble vitamins, fat soluble vitamins and minerals.

5.7.1 Parasitic diseases

5.7.1.1 Tape worms as causative agent

The species of worm varies with each species of fish involved. Infected fish become resistive and are collected in a large number at the inlet of water.

Clinical signs

1. The gills look pale
2. Sometimes the body covered with mucus
3. Epithelial cells are destroyed.

Susceptible species

Carp and all species of fish in fish farming ponds are susceptible to tape worm.

Treatment

Administer Di – n – butyl tin oxide in the fish feed. The required dose added to the feed is 0.25mg/kg per day for five consecutive days.

5.7.1.2 Protozoan (single cell) as causative agent

They are usually found externally in the fish, but some occasionally infect internal organs and tissues. A characteristic of this organism is their ability to form a very resistant resting stage allowing them to persist after treatment. One of the protozoan diseases is white spot.

5.7.1.2.1 White Spot or Ich (Ichthyophthirius multiplis)

"Ich" is the most commonly occurring disease of fresh water fishes and easily transferred from one to another. The causative agent is the infusion of *Ichthyopthirius multiplis* of the family *Ophryolenidea.* Class: Ciliated, Ovoid and horse shoe shape macronucleus.

Life History of Ich

"Ich" is the largest known parasitic protozoan found on fish. The breeding stage is in form of cysts between the layers of the host skin. When matured it leaves the fish and produces large numbers of free swimming young ones that must find a host within 48 hours or they will die.

Clinical signs of Ich

1. The classic sign of Ich infection is the presence of white spots on the skin and gills.
2. Noticeable on the body and fin of infected fish are salt like specks and excessive slime
3. Loss of appetite
4. Heavily infected fish usually congregate at the water intake and outlet of the pond
5. The fish develop thickened epithelium and excessive mucous
6. Appearance of swell on the skin will be noticed due to their active attack, penetration of the epithelium and growth.

Susceptible Species

Catfish and Carp and other fish might be carriers of Ich.

Treatment of Ich

If fish are maintained indoors in tanks, formalin can be used to treat Ich. A short time bath of 250 mg/l for 30 – 60 minutes can be followed by a water change. A long time bath of 15 mg / l of formalin treatment in the tanks does not need to be flushed out or 30mg/ l of quinine sulphate

Salt treatment of Ich is not practicable in ponds because even light salt of 0.01% (100 mg/l), would require large quantities of salt. Fish can be dipped in a 3% (30,000 mg/l) solution of salt for 30 seconds to several minutes but this has to be done with caution.

5.7.1.2.2 Costiasis (costia)

This is another protozoan parasitic disease that affects young and older fish. Costia are very small pear shape protozoa. They propell themselves using flagella.

Clinical Signs

1. Blue grey film appears over body surface
2. Fish do not feed
3. Damage to the fins
4. Quick erratic movement
5. Fry becomes emaciated
6. Pale gills and covered by mucous

Susceptible Species

Gold fish and Catfish.

Treatment

Add 3ppm of potassium permanganate to pond or dip the fish in baths of 5% to 10% sodium chloride for 5 to 20 minutes daily for up to 1 week. Young fish should be separated from spawners (Lamai, 1996).

5.7.2 Fungal Diseases

Fungi usually affect dead tissues, which is the reason they colonize dead eggs. They also attack site of wound on a live fish body. In more serious infection, they look like tufts of dirty cotton wool once this stage has been reached, it is difficult to dislodge.

General clinical signs of fungal diseases

1. Several fussy appearances usually associated with localized discoloured areas or lesions.
2. There will be loss of equilibrium and stagger movement.

5.7.2.1 Saprolegniasis

Clinically affected fish develop white to brown cotton like growths on skin, gills and dead eggs.

Diagnosis

Diagnosis is by finding broad non separate branching hyphae that produce motile flagellated zoospores in the terminal sporangia.

Treatment

In pond, quick lime or copper sulphate could be used to treat the disease. Give fluconazole at 22.6mg per gallon daily for five days.

5.7.2.2 Gill Rot (Branchiomyces)

Affected fish usually show respiratory distress (breathing hard). There will be gill necrosis.

Treatment

The best treatment is with copper at 0.2mg per litre (0.2ppm) to be repeated once in a few days if necessary.

5.7.3 Dropsy

Amend (1970) stated that dropsy is not a specific disease, rather a symptom of a deteriorated health condition. There will be swelling and projected scale.

Treatment

Give broad spectrum of antibiotic.

5.7.4 Bacterial diseases of fish

Bacteria are normally present in ponds and only become a problem when fish become stressed. Bacteria can infect a single fish and multiply rapidly to cause substantial high mortality of fish in days or weeks. They are often identified by their damage to fish tissues (Amend, 1970). Some bacteria diseases are discussed below.

5.7.4.1 Furunculosis

Furunculosis is a highly contagious bacterial disease of fish. It has the potential to cause high levels of mortality in farmed fish populations. The aetiological agent of furunculosis is the bacterium *Aeromonas salmonicida* is a gram – negative rod of the family Vibrionacieae.

Susceptible species

Furunculosis is a significant disease of freshwater fish.

Clinical signs

1. The clinical signs associated with furunculosis may be seen with almost any septicemia infectious disease of fish.
2. Furuncles (inflammatory lesions) can be seen but are not a consistent clinical sign of the disease.
3. Boil like lesion will be observed.
4. The disease causes ulcers or abscesses in muscle tissue.
5. It then breaks through the skin and eventually, becomes a site for fungus infections.
6. Reduced feeding
7. Older fish develop swelling
8. The disease is detected by the putrid smell arising when freshly dead or dying fish is cut open.
9. It causes death with no further symptoms

Treatment

John (1987) suggested that pond should be drained and treated it with slake lime. Disinfect every tool used in the pond (nets, feeding rings etc.).

5.7.4.2 Bacterial Enteritis

Causative agent is Pseudomonas of intestine

Clinical signs

1. Dissection will reveal an accumulation of liquid in the abdominal cavity and
2. Red violet colour of body surface would be observed.

Susceptible species

Grass carp and Common carp.

Treatment

Anti biotic medicated feed. One capsule is enough to treat dozen of fish. A good anti biotic is chlorophenicol or use tetracycline.

5.7.4.3 Columnaris

This is another bacterial disease with the following clinical signs:

1. Discolour patches are observable on the body of fish and gills
2. Loss of scales and often death
3. Lesions begin on scales of fish as small circular erosions that have a grey – blue centre and red margins while on scale fish lesion begin at the outer margins of the fins and spread inward toward the body
4. High mortality normally occurs in rearing cat fish and bass.

Treatment

Give fish a feed which has terramycin in it. If it is bad, place the fish in a dip of copper sulphate (2 minutes) or in malachite green (10 to 30 seconds). Treat the pond with1ppm of copper sulphate (John, 1987).

5.7.4.4 General and specific bacterial disease control

1. Avoid over crowding
2. Provide best environment
3. Feed balance diet
4. Maintain excellent water quality.
5. Reduction in population of algae bloom
6. Anti biotic should be given in food

In some case like Hemorrhage septicemia (Infectious dropsy of carp)

7. Isolation
8. Prevention of transportation

5.7.5 Vitamin deficiencies

Folic acid: Skin lesions, poor growth.

Vitamin C: Blood problem, poor growth.

Vitamin A: Blood problem, poor growth, poor appetite, eye diseases, Oedema (pod belly).

5.7.6 Mineral deficiencies

Calcium: Skeletal deformities, impairment of nervous transmission.

Phosphorus: Skeletal deformities, poor growth

Potassium: Reduce osmotic regulation of the body fluid.

Sodium: Affect acid base balance (Johnson, 1953).

5.8 Control Strategies of Diseases in Affected Farm

If communicable disease is identified, then get data in the amount of disease fish, number of the affected pond. The clinical picture of the disease and microbial results should be noted and measures for the eradication mentioned. A decision should be made on the quarantine. All transport of fish in the affected farm should be reduced to minimum. New fishing gears in the farm should be isolated. During this period the ponds should be disinfected (Lamai, 1996).

5.8.1 Treatment in Quarantine

1. Place the new fish in quarantine system, systematic observations is necessary at this point, for any unusual behaviour for at least 3 days or until they are feeding normally.
2. Starve all fish for 12 hours and then place no more than 6 in a separate bath. Aerate the water with air pump containing 200 ppm of formalin solution.
3. Leave the fish for 1hr until they appear stressed and gasp for air at the water surface. Transfer them to another pond containing fresh water and leave them to recover for 24hrs.
4. Repeat the treatment to all fish on the following day.
5. Allow the fish for 3 days to recover with feeding and again starve them for 12hrs.
6. Take 6 fish and place them in a separate aerated bath containing 2ppm Zinc free malachite solution, allow them to stay for 1hr until they appeared stressed and then transfer the fish to fresh water pond.
7. Repeat malachite treatment for 3 consecutive days but be sure that the fish appeared to be well before repeating a treatment.
8. Keep the fish in quarantine for a week, feeding and observing them for signs of ill health.

5.8.2 Control measures of parasites and other diseases

Do not transfer infected fish to water that is free of the parasites. Calcium cyanides have been suggested as excellent disinfectant. A dose of 1 kg /m^2 can be administered.

1. Helminths
    a. Cestodes (Tapeworm)
        i. Adult fish entry point into the pond should be prevented. Give metronidazole.
    b. Trematodes
        i. Filtration of water supply
        ii. Removal of snail
    c. Round worm (Nematodes)
        i. Improve sanitary condition
        ii. Therapeutic measures used saturnine at 0.4g\fish

2. Molluscs
    i. 20g of Copper carbonate to 1000 m^2 of pond bottom or
    ii. Copper sulphate should be given at less than 1 ppm (Lamai, 1996).
3. Furunculosis (Aeromononas salmonicida)
    i. Avoidance of pollution with organic matter
    ii. Dead fish must be buried
    iii. Used anti biotic: sulfonamides (Johnson, 1953).
4. Bacterial enteritis
    i. Good quality food
    ii. Annual preventive measures, curative food should be given to fish during the period of outbreak.
    iii. Anti biotic and medicinal plant is recommended such as garlic, onion and eucalyptus leaves.

Fish diseases can cause a serious loss of revenue to aqua culturist. The control of fish disease is mainly their prevention. Prevention is always better, cheaper and simpler than cure. The general steps include observing general piscicultural and sanitary requirements in the course of rearing and maintaining fish pond. Every new batch of fish brought into the farm should go through quarantine**.**

CHAPTER SIX

6.0 INDUCED BREEDING OF CATFISH, *Clarias gariepinus*

6.1 Introduction

Catfish such as *Clarias spp.* and *Heterobranchus spp.* breed naturally only in flowing water of natural habitat. Induced breeding produces seeds of absolute purity. Induced breeding is the set of techniques of enhancing fish to produce artificially and subsequent rearing of the produced off – springs from larvae to fingerlings. The semi- wet method is the best procedure for fertilizing the eggs of catfish. A mill (1ml) of ovaprim should be injected to 1kg of female catfish to encourage maturation of eggs. Newly hatched fries are usually hatched in earthen pond or cement pond until they are 2-3cm or more before they are stocked in rearing tanks. Hatchings must be given appropriate food from an exogenous source for few days before the total absorption of their yolk sack. Immediately after spawning, fry should be fed 1 – 8 % of their initial body weights which are usually estimated quantity that is later mastered with time while fry developing into fingerlings require 5 – 10%, Growers need 1 – 3 % and Brood Fish require 1 – 5 % of initial body weight.

During the first stage of nursing the water in the pond should be 15cm deep in dry season and 20cm deep in cold season. However, the water level should not exceed a depth of 30cm. Encouraging breeding of hybrid fish seeds is the sure way of increasing seed supply and will increase protein supply and intake in Nigeria. Fish farmers should master the management procedure of raising fingerling in order to increase fish production.

Fish farming implies some form of intervention used in the rearing process to enhance fish production. This involves regular stocking, feeding, protection from predators and so forth. Aquaculture will therefore continue to be relevant, due to a number of reasons such as growing population of the world, search for protein source, and the problems of over fishing and pollution of the ecosystem (Eyo, 1988).

The main concern to all fishermen is the scarcity of fish seeds and the inefficient management of fingerlings. When money is a limiting factor, it is advisable to source up to 80% of fish seeds requirement from the wild and 20% from indoor hatcheries. To reduce fish mortality, fish that are free of wound and have good body form, which are disease resistant, active and lively should be chosen for pond stocking.

Tilapia which breeds without any special inducement or modification can produce from several hundreds to about 2000 eggs per batch. *Clarias spp., Heterobranchus spp.,* Mullet spp. and Common Carps are suitable for intensive fish farming in ponds.

6.2 Selection of Brooders or Brood Stocks

First and foremost, identification of the three common used breeds of catfish is very important. The three breeds are alike with common characteristic features which include having barble, smooth skin without scale, darker colour at the dorsal skin with range of white to yellow colour skin ventrally. However, the major distinguishing feature among *C. gariepinus*, *H. bidorsalis* and high breed of the two called Hetero – Clarias mainly lies in their dorsal fins. The dorsal fin of *C. gariepinus* covers the entire body length of the fish. The dorsal fin of *H. bidorsalis* covers about 80% of the fish body length while the high breed, Hetero – Clarias also has its dorsal fin covering the entire body length but with a split or cut at the middle of the body length (See Appendix for diagrammatic illustration).

The genital organ of these males of these catfish species is protruded while the females' reproductive organs have externally round openings. Female catfish with eggs is easily identified because it has a bigger stomach compartment and when massage a little eggs gush out. Brooders should be separated by their sex and health condition at least 2 – 3 weeks before artificial spawning is carried out with each fish having a space of 1 meter square in a 5m x 2 m brooders pond. They should be fed compounded diet thrice daily and the pond water frequently changed with fresh one. The brooders selected should be between 7 to 10 months old and weight not less than 300 grams. At least 1 male Clarias *gariepinus* and 4 female *Heterobranchus* species are enough for the breeding programme aimed at producing Hetero – Clarias which are fast growers.

6.3 Injection of Brood Stocks

Brood stock is also called spawner. The female spawners should be weighed separately before the injection of a hormone. The breeding weight ratio (BWR) of male to female brood stocks in kilogram (kg) is 1: 2.5 that is 1kg of male brood stock can be used to fertilize 2.5kg of female brood stocks successfully. This weight of either male or female must not necessarily be a single individual but can be collections of two or more individual fish weighed to make up the required weight. Only the female brood stock (s) is to be

injected. The dose is 1ml of Ovaprim can be injected to 1kg of female fish thus fish less than 1kg say 300g is equivalent to 0.3kg and should be injected 0.3ml of the hormone. The injection is to be administered at an angle of 30^0 intramuscularly towards the caudal fin and above the lateral line. After the injection, the fish should be kept separately in a plastic tank with a capacity of 36 litres for nine hours with enough water to cover the head of the fish (Hogendoorn.1981).

The waiting period between administering of injection to when the fish shall be stripped for collection of its ripe eggs is known as latency period. The nine hours suggested above in the tropics is an average but latency period generally varies with the water temperature in which the fish is kept before stripping. A model for estimating latency period relative to the water temperature is in appendix.

6.4 Collection of Milt and Stripping of Ova

A male *C. gariepinus* should be dissected and the testes exposed. The testes can be carefully removed and wrapped in tissue paper for the tissue to absorb the moisture around the testes. Sometimes a single large testis could be found in male fish when dissected.

Nine hours after injecting the female fish with ovaprim the head of the fish should be covered with towel and handled by two people preferably. The stomach of the fish should be gently pressed and the ova collected in a plastic bowl. This process of gently pressing the stomach of the fish moving one's fingers towards the tail of the fish making the eggs to gush out and collection of the eggs in a bowl is termed stripping.

6.5 Fertilization

The testes removed from the male fish wrapped in the tissue should be cut with scissor into pieces directly above the plastic bowl containing the ova. A plastic spoon is used in mixing the milt (milky liquid from the testis containing the spermatozoa) with the ova. Water should be added during the mixing and should be thoroughly and gently within a period of one minute as to ensure high percentage rate of fertilization.

6.6 Incubation and Hatching

Water out flow system or water recycling rearing tank should be used for hatching fertilized ova. The fertilized ova could be placed on spawning mat already placed in the tank with water flowing above and below it. Hatching will be achieved within 26 hrs especially if the temperature is within the range of 27 to 29 ^{o}C. About 6 hrs after fry fall down from the mat and swim to the wall of the tank. The spawning mat should then be turned upside down and removed gently. The incubation period for fertilized eggs also varies with water temperature (see appendix).

6.7 Feeding of Fry/Post Larva

Fry should be trained to accept artificial feed such as alternative to artemia. The fry should be fed at least every 2 hrs and the left over feed from the tank should be frequently siphoned out.

Clay (1979) reported that fry can be fed with alternative to live artemia at appreciable quantity for up to 3 weeks. It is convenient to use the dry form of 11% pure artemia designed to provide the ultimate alternative to live artemia in a culture of fry of various fish species.

Typical analysis of artemia composition is: protein, 54%; lipid, 9.0%; Ash, 4.0%; fibre, 6.0% and moisture, 5.0%. Maggots can be cultured and used in feeding fingerlings once a day (Poultry droppings and cow dung can be mixed in a ratio of 3: 1 wrapped with old cotton material and then placed in water to produce maggots).

A small amount of crushed hard-boiled egg yolk passed through a piece of muslin cloth is introduced into the tank where the fries are swimming (excess egg yolk in the water if not eaten by fry will rapidly pollute the water). Feeding of fry/fingerlings should be provided 4 to 6 times daily at 4 to 6 hours intervals. Immediately after spawning the first stage of a hatched fish is called larval stage. At this stage, fish has prominent yolk sac upon which they rely on for their nutritional needs. Three to five days after hatching *C. gariepinus, H.*

bidorsalis and Hetero – Clarias larvae absorb their yolk sacs and start fending for external source of feed, a fish at this stage is called fry. Fries should be fed 1 – 8 % of their initial body weight. Fry developing into Fingerling is characterized by taking the shape of a matured fish but not longer than average length of human fingers. Fingerlings require to be fed at a rate of 5 – 10% of their body weight. Growers could be post fingerlings (6 – 8 weeks old). Juveniles (8 – 10 weeks old) and post juvenile (beyond 10 weeks grow to adult) are generally fed at a rate of 1 – 3 % of their body weights.

6.8 Diseases of Fry

A common disease of fry is slimy disease caused by Trichodina and Scyphidia (protozoa). The Clinical signs include fry floating vertically at the surface of the water and having pale gills. Such infected fish exhibit rotten skin, fins and areas around the lips. Fry infected with trichodinia will have thin white film of mucus on the skin.

Treatment

The disease involves bathing the fry in 25ppm of formalin (25ppm = 25ml of formalin per 100litres or $1m^2$ of pond water (Amend, 1970).

Generally, to prevent fungal and bacteria diseases in hatchery malachite green and broad spectrum antibiotics are applied into the water at recommended dose right from the placement of fertilized eggs into the hatchery tanks to when they attain fingerling stage.

6.9 Problems in Fry Culture

Hogendoorn (1981) observed that Fry are small (1 – 2 mm), they do not feed on static feed, thus require moving particles. Typically live feeds used in feeding fry are: Rotifers: 110 – 230µm, Artemia: 450 – 500µm and Daphnia: 1 – 5mm (Bruton, 1979). These feeds are live feeds and do not require siphoning of left over feed but alternative to live feed demand regular siphoning of left over feed.

Fish farmers should master the management procedure of raising fingerling in order to increase fish production. Government and private fish farmers should provide hatchery centres at strategic areas; this will definitely boost fish production in Nigeria.

CHAPTER SEVEN

7.0 FISH PRODUCTION IN PLASTIC TANK / CONTAINER

7.1 Introduction

Fish lives in water; this means that fish species entirely carry out their physiological and reproductive activities inside aquatic medium. Invariably any container that can hold a pool of water can be used for rearing fish. Fish can be reared in any costless containers and structures such as plastic tank, wooden trough, race way and burrow pits. Fishing within the inland water of Nigeria is characterized by low catch per unit effort. According to Ita (1982) and Abdulkarim *et al* (2005) over fishing have been reported in lake and Gubi dam. Abdulkarim *et al* (2005) also reported a decline in the catch of *Clarias gariepinus* in the dam.

Plastic tanks made from rubber and acrylic are been utilized for rearing hardy and ornamental fish species such as Tilapia, Clarias, Killifish, Malapterurus, Carp etc. These practices have generally improved the financial status of fishermen across the country. The most common plastic tank used in Nigeria is circular in shape with varying water holding capacity ranging from 500 to 7500 litres and their prices range from ₦12, 000 to ₦120, 000. The secret behind fish production in plastic tank is good water quality especially the levels of ammonia, dissolved oxygen and temperature.

Sustained fish production in plastic tank depends on their carrying capacity. Ipinjolu (1996) defined carrying capacity as the maximum biomass which habitat can support and it is a function of available food resources which in turn depend on the available nutrients and the efficiency which the fish species utilized it into flesh. Fish production in plastic tank has come to stay in Nigeria judging from the fact that fisheries in river, dams and lakes continue to deteriorate despite all management practices.

7.2 Cultural Fish Species

Majority of fish species that can be cultured in Nigeria can be grown or reared in plastic container: especially Gee pee tank, plastics bowl and aquarium tank. As in Nigeria, there are fish most commonly cultured in regions or countries of the world the list below indicate some:

Species	**Countries**
Clarias gariepinus	Central Africa
Oreochromis niloticus	Lake Victoria

Heterotis	Gabon
Cyprinus carpio	China
Tilapia zilli	Madagascar
Tilapia mosambica	Taiwan

7.3 Rubber and Plastic Material Used in Making Fish Production Tanks and Container

Rubber tank is made of pliable material derived from the sap of the rubber tree; it is hydrocarbon polymer of isoprene while a plastic is a synthetic, thermoplastic solid, hydrocarbon polymer.

Rubber is a synthetic material (not genuine) with the same properties as natural rubber and thermoplastic solid having the characteristics of softening when heated and hardening when cooled.

Table 7.1 Cost of Gee pee and Liberty Tank Sold in Bauchi, Nigeria as at 2015

Product type	Size (litres)	Amount (Naira)
Circular shape Gee pee	7500	120000
	6000	70000
	5000	65000
	4000	55000
	3000	38000
	2000	31000
	1500	25000
	1000	19500
	750	15000

	500	12500
Circular shape Liberty	7500	-
	6000	-
	5000	65000
	4000	55000
	3000	35000
	2000	26000
	1500	22000
	1000	17000
	750	14000
	500	12000
Aqua fish bowl	1500	30000
	1000	27000
Tanker shape	1000	18000

7.4 Stocking Density of Catfish

Stocking is used here to describe the act of placing fish (stock) into the plastic tank. Stocking density refers to the total number of fish which can be put into (stocked) the plastic container (Chakroft, 1976).

Tilapia or Clarias can be stocked separately in a plastic container or Gee pee tank. It is assumed that, an average table size of catfish is 30cm that is 0.3m. Therefore, a single fish will occupy 0.3m x0.3m = 0.09m^2. The height of water is approximately: 50cm = 0.5m, the volume to be occupied by a single catfish is 0.09 x 0.5 = 0.045m^3 approximately 22 catfish will occupy 1m^3 (10 litres)

Note that:

1dm^3 = 1litre

10dm^3 =1m^3 = 10litres

Hence, the ideal stocking density of catfish is 22/10 = 2.2 catfish per litre but since we cannot stock fraction of live fish, the stocking density can simply be put as 2 catfish per litre. But the fish welfare should be put into consideration as the base area of the fish should permit the fish to be able to stretch its body in the container at the base.

A single fish will occupy $0.09m^2$. Therefore, 100 catfish will occupy $9m^2$

Ideal Stocking Density (ISD) = (Base Area of the container in m^2 / 9) * 100

Ideal Quantity of Water, IQW to be used = (ISD / 2) litres

If the stocking density would be doubled in a container with same area base, then the quantity of water should be tripled.

If stocking density = (2 * ISD) catfish

Then, quantity of water = (3 * IQW) litres

Worked Example

Assuming a plastic tank has a base diameter of 1.2m, height of the tank 1.2m. What will be the stocking density of catfish in the tank? And what will be the required quantity of water for the stocked fish? If you doubled the ISD of the fish will the container contain the require quantity of water?

Solutions:

Area of a circular container = $\pi d^2 / 4$ where d is the diameter

Ideal Stocking Density (ISD) = $[(\pi d^2 / 4) / 9] * 100$

Where $\pi = 22/7$ and d = 1.2m

ISD = $[((22/7) * (1.2^2) / 4) / 9] * 100 = 12.57$, that is, 13 fish approximately

Ideal Quantity of Water, IQW = ISD / 2 = 13 / 2 = 6.5 litres

If the ISD is doubled in same container = 2 * 13 = 26 fish.

Then, the required quantity of water = 3 * IQW = 3 * 6.5 = 19.5 litres

However, the capacity (volume of the container) = area * height

$= (\pi d^2 / 4) * \text{height}$

$= [(22/7) * (1.2^2) / 4] * 1.2$

$= 1.3577 \text{ m}^3$

$= 1.3577\text{m}^3 * 10 = 13.58$ litres

The container cannot be used for the doubled ISD since its capacity (13.58 litres) is lower than the require quantity of water (19.5 litres).

Lamai (2011) recommend that *Clarias gariepinus* should be stocked at stocking density of 80 per 40 litres. The author warned that any increase in stocking density beyond that will result to decrease in both survival and growth.

Example: in gee pee tank with the capacity

1) 7500 litres

(80/40) * 7500 = 15000 *C. gariepinus*

2) 6000 litres

   (80/40) * 6000 = 12000 *C. gariepinus*

3) 1500 litres

   (80/40) * 1500 = 3000 *C. gariepinus*

Note: 80/40 = 2; Stocking Density = 2 * capacity of tank in litres

4) 750 litres

   2 * 750 = 1500 *C. gariepinus*

5) 500 litres

   2 * 500 = 1000 *C. gariepinus*

The earlier work of Huisman (1976) reported that *C. gariepinus* proved to be very suitable species for higher density culture.

7.5 Design and Structures of Plastic Tank and Rubber Fish Container

Rubber tank is made of pliable material derived from the sap of the rubber tree; it is hydrocarbon polymer of isoprene while a plastic is a synthetic, thermoplastic solid, hydrocarbon polymer. Gee pee tanks or any plastic tank for water storage is mostly circular in shape except aquarium tank that were specifically design for fish production which either may be rectangular or square in shape. Using hand saw the top of the Gee pee tank should be removed.

7.6 Rubber Fish Container

A rubber fish tank specially made for fish production is now available in the market. This tank is much stronger than the ordinary Gee pee tank. The tank can be stocked with over two hundred (200) fish. In this type of tank polyculture system of fish farming can be practiced. Clarias and Tilapia in ratio 1:3 is recommended for stocking in the production container. The stocking density will be four (4) fish per meter. This is considered glorious to the fish. The minimum dissolved oxygen should be 5ml per litres.

Table 7.2: Materials/ Equipment Requirements for Fish Production in Tanks/Containers

Materials	Quantities	Remarks
Plastic tanks	2	Moderate
Scoop net	2	Minimum
Bench/stairs	2	Minimum
Buckets/bowls	3	Minimum
pH meters	2	Moderate
Thermometer	3	Moderate
Drugs (antibiotics, vitamins)	1	Moderate

These are the minimum requirements for small scale fisherman or hobbier.

7.7 Wooden Box with Plastic Lining

It is not expensive, construction is fast and materials to be used are available in timber shed.

Materials required for wooden box trough:

1. 12 pieces of wooden planks of 4m length, 20m wide and 3cm thickness
2. 4 wooden pieces of 4m x 8 cm for frame
3. Plastic lining 1.5 – 2 m wide
4. glue

7.8 Water Inlet and Out let

Normally Gee pee tank has inlet situated above the wall and out let below openings for taking water into and out of the tank, plastic pipes can be connected to the inlet fixed with valve to control the flow of water into the tank or water can be placed directly into the tank through the top of the tank. Plastic tanks should be placed in series on a cemented floor each having its separate water inlet and out let. Water coming from the outlets should be directed into a drainage system.

Sources of Water include:

1. Tap water (free of chlorine)
2. Well water (free of sediments and algae)
3. River and stream water (free of pollutants)

7.9 Feeding of Fish in the Production Tanks/Container

The fish in the tank is to be given 5% of their total weight. Let us assume that there are 1000g of *Clarias gariepinus* fish in the tank. The fish is to be fed 5% of their total weight thus

$$\text{Feeding rate} = 5/100 * 1000$$

$$= 0.05 * 1000$$

$$= 50\text{g}$$

This amount (50g) should be split into three rations (Morning, afternoon and evening).

Ration = 50/3 = 16.7g per meal

But the fish tend to feed more when the weather is cool so is better to split the ration at ratio of 2: 1: 2 for morning, afternoon and evening respectively as calculated below:

Split ration = Quantity of feed *(ratio/ sum of ratios)

Sum of ratios = 2 + 1+ 2 = 5

Morning ration = 50g * 2/5 = 20g similarly for evening and

Afternoon ration = 50g * 1/5 = 10g

7.10 Management Practices

General management practices include:

1. The tanks should not be placed in a noisy environment such as close to television , radio and so forth
2. To create micro climate, a roof should be placed above the tanks
3. Tanks should be at the back yard of your house or in the farm
4. Adequate drainage system is recommended
5. Engage the services of a trained plumber
6. Water should be replaced gradually
7. Water should be changed weekly; the tank should be washed and disinfected with lime.
8. The tanks should not be placed where there is a sharp metal object
9. The tank should not be completely filled with water.

It is concluded that an average of 2 fish per litre is proposed for optimum stocking rate of *Clarias gariepinus* in any plastics production tank. This will give maximum yield, growth based on the water quality of the water in the tank. Survival rate of fish in plastic tank depend on the level of ammonia, dissolved oxygen, temperature as well as acidity and alkalinity of the water.

CHAPTER EIGHT

8.0 FISH HARVESTING EQUIPMENT AND THEIR MANAGEMENT

8.1 Introduction

Fishermen are faced with difficult decision to take when it has to do with and nature of a specific fishing gear to be employed in a particular location and on the type of water bodies. More than half of the one hundred and fifty species of fish native to Northern Nigeria waters are important in commercial catches. The habit and habitat of these finny species vary greatly, as they change according to seasons so the gear used to capture them and pattern of fishing must change if fishermen are to earn their daily bread (Holden and William, 1978).

As river rise, fishermen of certain areas may use a particular type of fishing trap to catch fish migrating upstream to spawn at highest water level few weeks later in the same area the swifter current may prevent the use of that gear, but the same fishermen will have to use different fishing equipment such as fish fences and trap place deep inside the flooded forest. A month later different gear may be employed to trap fish as they try to adjust to falling water level. Again during dry season other changes of gear and methods may become necessary to harvest fish in an altered environment.

It is interesting to mention that our local fishermen met these challenges with ingenuity. Few of the traditional gears were made according to tribal pattern. Imported fishing materials were expensive. There are available palms, vines, canes, lianas, reeds, grasses and bark of plants for making locally fabricated fishing gears in Nigeria (William *et al*., 1967).

Effectiveness and efficiency of various type of locally fabricated fishing gear should be assessed and documented to assists policy makers for formulating management programme for the fisheries of the areas.

8.2 Traditional Fishing Gears

Studies show that traditional fishing gears are effective and surprisingly they were better than the supposed miraculous modern fishing gears (Holden and William, 1978). Traditional fishing gears may be classified into:

1. Nets
2. Traps
3. Spears
4. Fish shelter.

8.2.1 Nets

Local nets were hand braided from varieties of fibres of certain local plants, nets are now tailored from imported nylon webbing, coloured nylon webbing is seldom imported, but a few experiments have indicated that coloured nets might bring better catches under certain condition. Nets are of various types.

8.2.1.1 Clap nets

Twin clap net has a Hausa native names of ‘ homa’, ‘foma’ or ‘komo;

They vary in size from about 50cm to more than 2 metres across the month. The nets are tailored from machine made webbing of 10 to 30 mm mesh size. An energetic fisherman might earn the cost of price of a pair of homa in 2 or few days of operations. Koma are used alone or together with certain traps and fish fences. They are used in the dry season to catch fish in isolated pools or swaps.

8.2.1.2 Seine net

Also called in Hausa native name as' kelli – kelli', 'kusa – kusa'
The length of a kell – kelli varies between 10 and 70 metres, mesh size is from 10 to 30mm.The distance between the head and the foot ropes is about 400mm and the sticks to which these ropes are attached are about 1.5 metres apart.

Kusa – kusa or 'angama' the nets are between 10 to 30 metres long and 1 to 2 metres deep. The mesh size is from 10 to 50mm. They float on the head rope, weight on the foot rope, and a pole at each end. Large kusa – kusa are usually operated by two men.

8.2.1.3 Cast net

The Hausa native name is 'birgi'. Birgi are probably responsible in Northern Nigeria for producing more fish than any single type of fishing gear. Children often use birgi net of only 3m diameter and 10mm mesh size while the largest ones are fully 6 to 9m diameters.
Great skill is required to throw a cast net in such away it will unfold in the form of a large circle and cover the greatest possible area. The net is allowed to sink to the bottom and the fish become entangled in it. The net is slowly retrieved until the leads come together and ensure the capture of the fish. Birgi are used to capture most kinds of fish.

8.2.1.4 **Gill net**

'Kalli' is the Hausa native name. Mesh size is from 20 to 50mm. They are crudely mounted by passing the light lead and foot ropes apart these are tied to grass or stakes on the opposite banks of small streams or pools. Many gill nets have no floats or sinkers. Gill nets are set in strategic places where moving fish will become entangle in them. They are more effective byt night due to darkness than in the day due to day light. They are used throughout the year.

Other types of nets include beach net and drifting net natively called 'Babban taru', 'Hauskun – kassa' respectively in Hausa language.

8.2.2 Traps

Traps are effective in catching fish. They bear different names in Hausa native language which include:

1. *Undurtu*
2. *Suru*
3. *Gora.*

8.2.2.1 Undurtu (Open entrance)

A type of double – chambered cane trap named Undurtu. The most common size is about 60cm across the front. Undurtu are made from two rectangular pieces of cane matting, folded together. The non return valves are at right angles to each other. The edges of the second chamber are fastened in such a way that they can easily be done to allow collection of the catch. The trap are set near the grassy banks along the edge of rivers the rising water level when they catch chiefly tilapia.

8.2.2.2 Suru

Suru is used to denote fish trap with a single – chambered trap. *Suru* are made from a single rectangular piece of fish screen, by folding one end inside to form the funnel shaped non return valve. *Suru* are made from thin strips of raffia palm and lianas or cane up to 10mm diameter. They are set near grassy river banks during period of rising water level. They are not baited.

8.2.2.3 Gora

The name implies that these were originally used chiefly by *salkawa* fishermen. The trap is 1.5 to 2.5m long, 60 to 100m diameters and meshes size is about 60 to 90mm. Gora are made from many fine strips of liana or vine bound together into twine, which made them fairly rigid. The entrance is non return valve and is made from local fibre. Lates, Herotis and Tilapia are commonly caught in this trap.

8.2.3 Spears

Mashi is used by Hausa to denote spears including fishing spears. The spears are usually fastened to wooden hafts some two meters long and these have a buoyant wooden bulb in the end. Fish spears are sometimes used alone, but they are commonly used in conjunction with flimsy net and week lines. When a large fish is caught by net or line is usually first speared before being boated. Spears are also used at night with torch lights to capture fish.

8.2.4 Fish Shelter

Fish shelter is called *daikan kiffi* in Hausa language. This means house of fish. They are made of triangular plot of branches staked firmly in the river bed and with the apex of the triangle up stream. The shelters are cited in the mid stream where the shade and slack current afforded by them seem to attract small fish which in turn entices large predators as well. Fish fence around two sides of the triangle and lower end is left opened. When there is evidence of enough fish inside the shelter, a fence is encircling the fish. Fishermen then wade inside, they remove the branches reduce the area of the enclosed space where they can be captured with clap nets. The same shelter is later rebuilt.

8.3 Fishing Gears Management Practices

Local fishermen seldom realise that drying their nylon nets in the sun quickly ruins them. They are used to drying their fibre nets under the sun, so they do the same with their nylon nets.

According to Campbella (1985) old or previously used fishing traps should be replaced with new ones. Nets should not be placed in area where there is tree stakes or aquatic weeds.

Lead and floats when used in conjunction with nets should be adequate to avoid loss of nets. The lead used as sinkers should not be too heavy. Removal of dirt, debris and rotten fish on net should be done daily.

Fishermen are generally amenable to change and they do that without prejudice. Lack of funds to purchase such gear and not a resistance to change seems to be main obstacle in the way of introducing new fishing gears.

Most fishermen have the determination to go fishing but are handicap due to their aging fishing apparatus. It is necessary to regulate the type of fishing gears their mesh size and places where fishing take place otherwise certain fish stock will be over exploited.

CHAPTER NINE

9.0 HARVESTING, PROCESSING AND MARKETING OF FISH PRODUCTS

9.1 Introduction

Eyo (1992) stated that aquaculture is gaining popularity in Nigeria. Fish and fish products contributed 6% of Nigerian domestic product in 2006. Fish made up 40% of dietary protein consumption in the country.

Many fish farmers are engaged in either extensive: house hold (backyard) or Intensive: flow through, recirculation system of fish culture. Majority of the commercial fish farmers harvest their fish when they are up to market size (1kg). The most common fishing gear used in harvesting fish in pond is net: seine and scoop (Connell, 1985).

Fish processing is carried out in other to increase the shelf of fish. Fish processors mostly smoked dried, spiced and fried their fish. Smoke deposits phenols, formaldehyde and other anti microbial substances that delay rancidity and add flavour on fish. It is not common in this part of the country to see a salted sundried fish in the market.

Yunusa (2011) reported that there was high demand of fresh fish by consumers in Plateau State and beyond. Five bacteria species: *Staphylococcus spp*, *Escherichia coli*, *Lacto bacillus* and *Proteaus spp* were isolated in smoked fish in Wase, Bashar and Kapanin zuruk in Wase Local Governmnt area of Plateau State. It is therefore concluded that smoked *C. gariepinus*in in the markets were contaminated due to poor sanitary condition and improper smoking of the product.

Fresh, spice and smoked fish were mostly preferred by consumers. Fish are sold when they reach a market size directly to consumers after weighing out the fish. It is estimated that annual fish demand in the country was about 2.66 metric ton as against the annual domestic production of about 0.78 Mt. The country imported 780,000 metric ton of frozen fish annually from Europe and Latin America. About 90% of the fish produced in Nigeria is sold in the local market as a cheap source of protein.

9.2 Fish Harvest in Dams and Lakes

Koma are used alone or together with certain traps and fish fences. They are used in the dry season to catch fish in isolated pools or swaps.

Birgi are probably responsible in Northern Nigeria for producing more fish than any single type of fishing gear. Large *birgi* are up to 6 to 9m diameters. *Birgi* are used to capture most kinds of fish.

Great skill is required to throw a cast net in such away it will unfold in the form of a large circle and cover the greatest possible area. The net is allowed to sink to the bottom and the fish become entangled in it. The net is slowly retrieved until the leads come together and ensure the capture of the fish.

Kalli are crudely mounted by passing the light lead and foot ropes apart these are tied to grass or stakes on the opposite banks of small streams or pools. Many gill nets have no floats or sinkers. Gill nets are set in strategic places where moving fish will become entangled in them. They are more effective by night than by day. They are used throughout the year.

Suru (trap) are made from a single rectangular piece of fish screen, by folding one end inside to form the funnel shaped non return valve. They are set near grassy river banks during period of rising water level. They are not baited (William *et al*., 1967).

9.2.1 Fish Harvest in Pond

9.2.1.1 Total pond harvest of fish

Fish harvest in pond is accomplished by draining and seining the pond. First the pond should be partially drained (20 – 30%) to concentrate the fish, thereafter the pond can them be repeatedly seined until most of (80%) of the fish are captured. The pond should be drained further and seining process continued. Pond should have a depression or harvest basin where fish will concentrate and netted during final drainage (Gupta, 2006).

Harvest should take place during cool weather (early in the morning hour). It is helpful to have cool well water nearby (William, 2000).

9.2.1.2 Partial pond harvest of fish

Pond is not drained completely or partially drained (20 – 25%). Pond is seined and fish removed at a regular interval throughout the pond period or over the entire year.

9.2.1.3 Selective harvest of fish

Selective harvest is commonly practiced with the multiple harvest technique. Seine mesh size determines the size of fish caught. Seine net length should be about 1- ½ times greater than pond width (William, 2000).

9.3 Methods of Fish Preservation

According to Eyo (1992) no amount of ingredients added will reverse the taste of a spoiled fish. Fish processing should be carried out in clean environment (good hygienic condition) to avoid parthogenic bacteria contamination: *E. colli, Staphylococcus* etc and insets infestation: *Dermestes maculates* and *Necrobia rufipes* (Yunusa, 2011).

9.3.1 Salting

Fish to be salted should be prepared to allow rapid salt penetration and water removal. There is no need to cut fish of less than 10cm into parts, immediately after gutting, the fish can be cured, but fish of more than 15cm can be split opened and for fish of 25cm long, additional cutting should be made in the flesh.

The stronger the brine the faster will be the salt uptake and the consequent attainment of water activity low enough for preservation. According to George (2015) salting is an age old custom method of fish preservation in Nigeria. Common salt (sodium chloride – NaCl) serves both as a chemical preservative and also binds available moisture in fish. Salt loving microorganisms: halophiles thrive on salted fish product and on drying it causes discolouration of the processed fish. The principle behind salting of fish is that common salt

(NaCl) produces an environment of high osmotic pressure that denies bacteria the aqueous surroundings they require to survive and reproduce. Unlike bacteria, moulds can often withstand the effects of high salt or sugar concentrations in foods. Most food poisoning bacteria cannot live in salty conditions and a concentration of 6-10 percent salt in the fish tissue will prevent the activity of this class of microorganisms. During salting or brine salting, two processes take place simultaneously: water moves from the fish into the solution outside and salt moves from the solution outside into the flesh of the fish. Salting requires minimal equipment, but the method employed is important. Salt can be applied in many ways.

9.3.1.1 Salt is applied to fish by the following basic methods

1. For brine salting, the fish is immersed in a solution of salt and water: brining gives product with a low salt concentration. Fully saturated brine contains about 340g in a litre of water.
2. For dry salting, granular salt is rubbed onto the surface of the fish; addition of calcium and magnesium makes the product whiter and firmer cured. Fish oils oxidize readily and become rancid. Fish which contain much oil do not make good salted and / or dried products since the oil act as a barrier to salt penetration and moisture loss. A better product can be obtained by cooking and then drying or by smoking. In cold climate, fatty fish can be pickled in salt. In hot climate, it is advisable not to add salt, if this is attempted, the fish will ferment. The fish will start to break down and pastes or sauces will result.

3. In Kench salting, granular salt is rubbed onto the surface of split fish and the fish are stacked with a sprinkling of salt between each layer of fish. The liquid (Pickle) which forms is allowed to drain away. In the tropics, fish are usually in the kench pile for 22 to 46hours, and then the fish should be dried.

9.3.1.2 Determination of Salt Concentration

A fish processor bought a 200kg of fish in Waya dam in the afternoon. He intends to preserve the fish in common salt. What is the amount of salt to be rubbed on the fish?

Salt concentration = (35/100) * 200kg

= 70kg.

9.3.2 Smoking

Wood is good source of smoke. It makes a hotter fire with less smoke; the fish is charred rather than smoked. Hard wood give a smoke with more phenols which both preserve and give a characteristics medicated flavour to the products. Colour in parted to the fish by smoking process is due to carbonyl amino reaction (Clifford *et al*., 1987).

The low moisture content of smoked fish favours the growth of moulds that originate in the wood used for smoking the products, especially after wrapping the smoked fish, may therefore suffer additional musty flavours deterioration. On storage the fresh aromatic smoke flavour of newly cured fish become weaker, blander or unpleasantly tarry in nature (Eyo, 1992).

Heavily brined, smoked and dried fish will remain edible for several weeks at $0^{o}c$ and for several days at $15^{o}c$ to $20^{o}c$. Fish after smoking is usually warm, it should be cooled in cold air as rapidly as possible to avoid unnecessary spoilage. Packing warm products closely can lead to "sweating" (Hall, 1994).

9.3.2.1 Types of Fish Smoking Process

Generally there are two types of smoking processes commonly in use (cold and hot smoking). Cold smoked fish are not cooked and the end product is similar to keeping qualities to fresh fish. In cold smoking process, the temperature of the smoke does not exceed $30^{o}C$ and in hot smoking process during which the fish is properly cooked with their temperature reaching above $100^{o}C$ while the centre of the fish may be $60^{o}C$. Cold smoking is practised in advanced countries where alternative means of preserving the fish such as refrigeration is available. Cold smoking is primarily to improve the flavour of the fish and retain its nutritive value. Cold fish is not well cooked, has shorter shelf life and is easily infested by micro-organism such as bacteria and moulds if not properly stored in a refrigerator. Moisture retention is usually high and may be in the order of 35 – 45%.

The hot smoked fish are cooked; it is a process which prevents spoilage for only few days if the product is not dried. Hot smoking is the traditional method of fish smoking in the tropics. Fish is smoked until cooked in order to obtain a product with extended shelf-life, since alternative preservation methods such as refrigeration are absent in the remote fishing villages where most fish processing takes place. The primary aim of hot smoking is to preserve the product flavour and colour arising as a result of preservation function (Clucas and Sctcliffe, 1987). During smoking, the heat from the fire dries the fish while the chemicals (phenols, formaldehydes) from the smoked impregnate the flesh (Clifford *et. al.*, 1987). To arrest these problems many workers have invented improved smoking kilns such as Chorkor kiln, Altona/Watanabe smoking kiln, Ivory Coast kiln, etc.

9.3.3 Freezing

Freezing is the process of arresting either partially or completely the deteriorative action of micro organisms and enzymes. It's a type of partial, gentle dehydration in which the water is removed as ice. Micro organisms cease to multiply below – 10^{o}C and the activity of enzymes are reduced as temperature is reduced below freezing point. In remote areas where there is no electricity processor should buy enough ice, the ice should be crushed and placed on the fish. In the absence of all these, water in the container should be changed regularly to keep the fish cool.

At -30^{o}C, 90% of water in fish converted into ice, this happen very slowly. Fresh fish will be in good condition at this temperature for up to 8 to 9 months and will only become inedible through bad texture and off flavour after several years. Fatty fish rancidity occur rather very faster and quality remains good for only about 6 months under same condition (-30^{o}C).

9.3.4 Drying and Freezing

Drying has been used as a technique for long time preservation of fish and other foods since ancient's times. The air – dried product is compact and does not dehydrate fully on soaking in water. The cooked reconstituted flesh is tough and drier than air – dried products. Fish should be procured during the day if they are to be sun dried. According to Connell (1985) freezing – drying produces a better product as it absorbs water well.

Fish in which the flesh is firm are relatively easy to handled, they can be transported without breaking up. Very small fish may be dried whole where weather condition permits. Larger fish must always be cut so as to increase the surface area available for salt penetration and moisture content loss. According to Clucas and Sctcliffe, (1987) drying rate can be increased by

1. Increasing the surface area by spitting the fish
2. Choosing the drying site where the wind is strong.

During the second phase, the drying rate depends on

1. The type of fish
2. The thickness of the fish
3. The temperature of the fish
4. The water content of the fish
5. Humidity.

9.4 Meaning of Market, Utility, Marketing and Selling

George (2014) defined Market as an area for organizing and facilitating business activities and for answering the basic economic suggestions: what to produce, how much to produce, how to produce and how to distribution production.

The fishers who produce fish meal add form utility, because the fresh fish is processed into powder form. The processor who carried out these activities adds form utility. Transportation of fish meal to other places is regarded as place utility. Generally, fish are moved from landing sites to packing plant and then after processing are moved to wholesalers, retailers and finally to consumers. The product is more useful because of the activities of these agencies in getting the production to where it is most desired. Consequently, marketing embraces all the activities relating to the production itself. These activities include the pricing, distribution, promotion, research and sales forecasting. Marketing covers all business functions including production in its broadest sense, it covers also all production decisions. It constitutes a bridge between production and consumption

Marketing covers the process of distribution of goods and services while selling is an aspect of marketing that creates various types of utilities for instance possession, time and place utilities while selling creates only possession utility (George, 2014)

9.4.1 Fish marketing

The first stage at which market considerations entered the production process, is forecasting probable demand. Specific studies of consumer habits and preferences are essential to provide stimulus to fish marketing. Marketing system will have to expand both their coverage and their capacity. Marketing is vital in ensuring that fish products reach consumers in good condition and are presented in a convenient way. Market outlets are important in production planning and there must be somebody who is willing to take responsibility for finding domestic buyers. The following processed fish were mostly liked by consumers: Spiced tilapia/catfish, smoked catfish and fried frozen fish (Abbott and Makeham, 1979).

The common chains of fish market in Nigeria:

Producer → Retailers (middlemen, fish marketers) → Processors → Consumers

Producer → Retailers (Processors, fish marketers) → Consumers

Producer → Wholesalers →Retailers → Consumers

Fish are mostly sold fresh or smoked in Nigeria. Many producers use commission agents to sell their fresh fish:

Producers (Fish farmer) → Commission agents (ASUU) → Consumers

Fish producers in Bauchi mostly sell their fresh fish to commission agents in Jos, Plateau State. Dead fish should not be processed and sold to consumers. The marketers can be wholesalers, processors and or retailers.

Fish is the cheapest source of protein to teaming population of Nigerians and it contribute a lot to the economy of the nation, therefore, there is need for effective preservation of fish. A dramatic increase in fish production in Africa is necessary to increase the consumption of fish. Fish in small pond (5m x 4m) can be harvested with scoop net especially when the water is partially reduced. Fish harvest should be done in the morning or evening.

REFERENCES

Abbott, J.C and Makeham, J.P. (1979) Agricultural Economics and Marketing in the Tropics. Logman. 165pp.

Abdulkarim, M. and J.K. Ipinjolu (1998) Effect of diet containing varying levels of millet offal on the growth performance of *Oreochromis niloticus*.The *34th Annual Proceeding of Agricultural Society of Nigeria* (ASN), pp, 121 – 125

Abdulkarim, M., Bununu, K. and Mohammed, A. (2005) Fish and Fisheries of Gubi Dam Ganjuwa Local Government Area Bauchi. *Journal of League of Researchers in Nigeria,* **7**(1): 7 – 12.

Amend, D.F. (1970) Mycobacterium infection of salmonids-prevention and treatment. Spectrum Publication Amsterdam. Fish. Soc. No 5, pp258-2665

Axelrod, H.R. and Warren, E.B. (1971) African Cichlids of Lake Malawi and Tanganyika. U.S.A.

Bock, A. (1999). *Introduction to fish culture*. International Centre for Aquaculture and Aquatic Environments. Auburn University. Alabama-U.S.A, pp. 1- 4.

Boyd, C.E. (1982). Water quality management for pond fish culture. *Development in Aquaculture and Fisheries Science* **9**: 29 – 36.

Breitburg, D. L., L. Pihl, and S. E. Kolesar (1983) Effects of low dissolved oxygen on the behavior, ecology and harvest of fishes: A comparison of the Chesapeake Bay and Baltic-Kattegat Systems, **58**:241-267

Bruton, M.N., (1979). The breeding biology and early development of *Clarias gariepinus* (Pisces, clariidae) in Lake Sibaya, South Africa, *Trans. Zool. Soc*. London, **35**:1-45.

Campbella, D. (1985). Large scale cage farming of *Sorotherodon nilotica. Agriculture*. **48**:57- 69.

Chakroft, M. (1976) Appropriate Technology for Development Fresh Water Fish Pond Culture and Management. Ed. Volunteer in Technical Assistance (Vita) Manual Series No. 36E, 196pp.

Clay, D., (1979). Population biology, growth and feeding of the African catfish, *Clarias gariepinus*, with special reference to juveniles and their importance in fish culture. *Arch. Hydrobiol*., **87** (4): 453-482.

Clifford, M.N., S.L. Tony and A.A Eyo (1987) Smoking of food. Kainji Lake Research Institute, pp. 1-3.

Connell, J.J. (1985) Control of fish quality. University Press Cambridge. Fourth Edition. 245pp.

Clucas, I.J. and Sctcliffe, P.J. (1987) An introduction to fish handling and processing. Report of the Tropical Products Institute, pp. 143-186.

DIFFRI (1988) Utilization of Agricultural – industrial wastes as fish Feedstuffs in Nigeria. Workshop Organized by DIFFRI, Federal

Government of Nigeria. **In** Falaye, A. E (1992) *Proceeding of Annual Conference of Fishery Society of Nigeria (FISON)* Pp 16 -20.

Dupree, H. and Hunner, J. V. (1985) Nutrition Feeds and Feeding Practices; Third Report to the Fish Farmers . U. S. Fish and Wild Life Service Washington DC.

Ekanem, B.S. (1984) Polyculture: A boost to the green revolution programme. *Proceedings of the Annual Conference of the Fisheries Society of Nigeria,* pp. 117 – 119.

Eyo, A.A. (1988) Wealth creation through fish farming. *FISON.*On the occasion of training workshop for fish farmers in Plateau State.

Eyo, A.A. (1992) Studies on biochemical composition of Clupeid*: Pellonula atzeluisi* and *Sierrathrissa loenensis.* Nigerian Food Journal, **10**:11 – 12.

Eyo, A.A. (1997) Fish Feed formulation and Utilisation. M. tech, FHS 625 note. FUT, Minna.

FAO (2007). Possibilities for Integration of fish farming into Irrigation System.

Report of Irrigation Commission (RIC) (1972) Ministry of Irrigation and Power, New Delhi, 216 pp.

George, F.O.A. (2014) Fish Processing and Preservation and Marketing. Lecture note: FIS 401. www.unaab.edu.ng. 16p

Gietema, B. (1992). *Fish farming in ponds and integrated fish farming*. Gbemi Sodipo Press, Ibadan. Pp. 9-58.

Gupta, M.V. (2006) Challenges in sustaining and increasing fish production to combat hungerand poverty. *International Centre for Living Aquatic Resource Management (ICLARM) Quarterl*y, pp. 4 – 10.

Hackling, C.F. (1971) Fish Culture. Faber and Faber, London, pp. 35-167.

Hall, G.M. (1994). Fish processing technology. Blackie Academic and Professional, USA and Canada, 308 pp.

Hargreaves, J. A. (1999). Control of clay turbidity in pond. Southern Regional Aquaculture Centre (SRAC). SRAC N. 460, pp. 4 – 8.

Hogendoorn, H. (1981). Controlled propagation of the African catfish, *Clarias lazera* (C&V). IV. Effect of feeding regime in fingerling culture. Aquaculture, **24**: 123 – 131.

Holden, M. and William, R. (1978) West African Fresh Water Fish. Longman Group Ltd. London, pp. 61 – 68.

Huisman, E.A (1976) Food Conservation Efficiencies at Maintenance and Production Levels for carp (Cyprinus carpio. L) and Rainbow trout (Salmon gaidneri, Rich). *Aquaculture,* **9:** 1-14

Ipinjolu, J.K., Falaye, A.E., and Tewe, O.O. (1988) Assessment of palm kernel meal in diets of carp (*Cyprinus carpio* L.) *Journal of West African Fisheries*, pp. 220-229

Ipinjolu, J.K. (1996) Strategies for Conservation and Management of the Fishery Resources of the Semi – Arid Zone of Nigeria. Conservation and Management of Fishery Resources. *Proceeding of Conservation of Aquatic Resources,* pp. 285 – 295.

Ita, E.O (1982). Biological Indices of Over Fishing in Kainji Lake and Management Proposal for the Lake Fishery. *Kainji Lake Reasearch Institute Tech. Rep. Series* **8**: 31pp.

James and Ronald, (1982). Recent Advances in Agriculture. Blackie, New York, pp. 21 – 29.

John, B. (1987). Fresh Water Fishing Diseases of Fish: Ed. Madesley, pp. 21 - 35.

Johnson, H.E. (1953). Mortality of Silver salmon from treatments with sulphamerazine. Progue fish cult. **15**:31-32.

Lamai. S.L. (1996). "Resume" of Fish Disease. Note book. FHT 625. Federal University of Technology, Minna.

Lamai, S.L (2011). The African Catfish Culture for the 21st Century. Inaugural Lecture Series 22. Federal University of Technology, Minna, 51pp.

Lovell, R.T. (1991) Nutrition of aquaculture species. *Journal of Animal Science***.** **69**: 10.

Oyetayo, A.S. (1985). The use of locally available material in fish feed production. 141 -143p

Sadiqu, S.O.E. and Jauncey, K. (1998). Utilisation of enriched soybean flour by *Clarias gariepinus. Journal of Aquaculture in the Tropics*, **13** (1): 1-10.

TNau (2013) Fishery: Integrated Agriculture. Farming system portal.

Trewavas, E. (1981). General groupings of Tilapia used in aquaculture in *Aquaculture*, **27**:79-81.

Viola, S., Monkady, S. and Areili, Y. (1983). Effects of soybean processing method on the growth of carp (*Cyprinus carpio*). *Aquaculture*: **32**: 27-38.

Wetzel, R.G. (1983). *Limnology*. Sauders College Publishing. Second Edition London, 134pp.

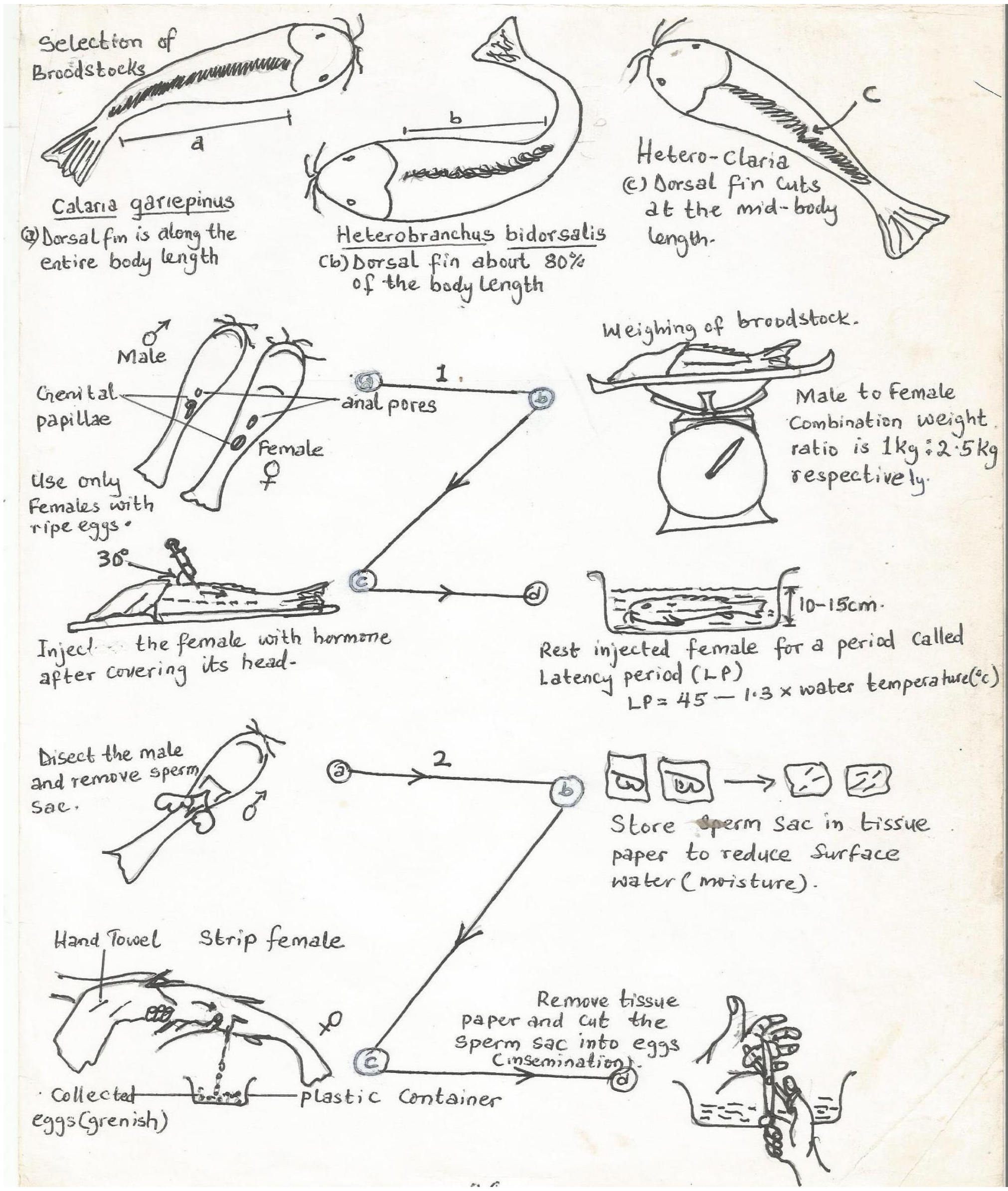
William, A.W (2000) Harvesting fish, *World aquaculture*, **24** (1):56 -57.

William A. W (2013) Alkalinity and Hardness in Production Ponds *World Aquaculture,* **33** (1): 16-17

William, R.B., John, A.J., Hopson, J., Janness and Yaro, I. (1967). Fish and Fisheries of Northern Nigeria. Ministry of Agriculture. Northern Nigeria. Gaskya Cooperation, Zaria, pp. 144 – 177.

Yunusa, M.M. (2011) Evaluation of Insects Infestation and Bacteria Load in Smoked Dried *Clarias gariepinus* in Some Selected Market in Wase L.G.A. of Plateau State. PGD Unpublished thesis, 67pp.

APPENDIX: FOUR Z's STEPS OF ARTIFICIAL SPAWNING



Selection of Broodstocks
a
b
c
Calaria gariepinus
(a) Dorsal fin is along the entire body length
Heterobranchus bidorsalis
(b) Dorsal fin about 80% of the body length
Hetero-Claria
(c) Dorsal fin cuts at the mid-body length.
Male
Female
Genital papillae
anal pores
Use only Females with ripe eggs.
1.
Weighing of broodstock.
Male to Female Combination weight ratio is 1kg : 2.5kg respectively.
30°
Inject the female with hormone after covering its head.
10-15cm.
Rest injected female for a period called Latency period (LP)
LP = 45 — 1.3 x water temperature(°c)
Disect the male and remove sperm sac.
2
Store sperm sac in tissue paper to reduce Surface water (moisture).
Hand Towel
Strip female
Collected eggs (grenish)
Plastic Container
Remove tissue paper and cut the sperm sac into eggs (insemination).