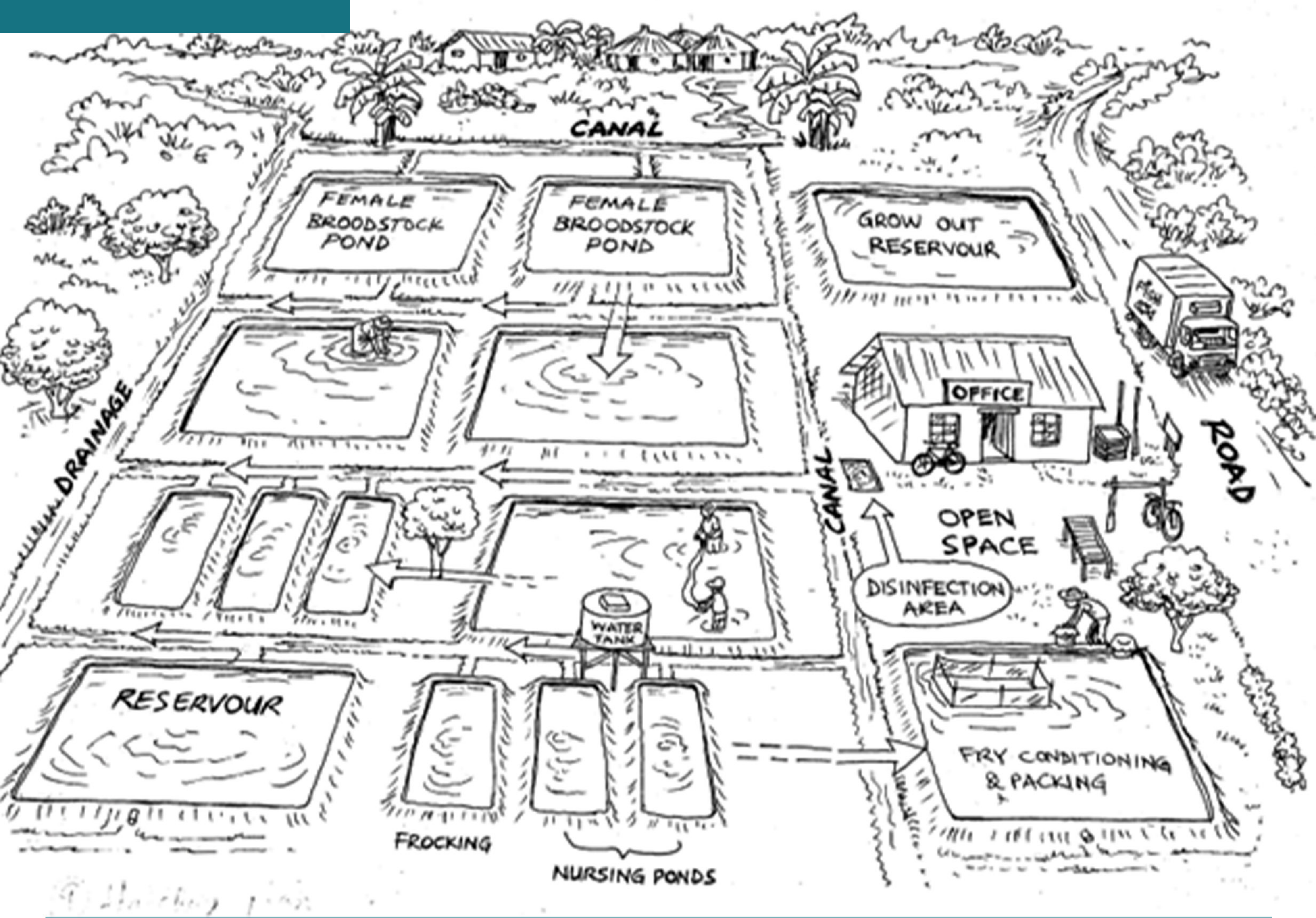


FISH SEED PRODUCTION

Module V of 8

Fish Seed Production

Module V

FOREWORD

The growing demand for fish in Malawi and the Southern African Development Community (SADC) region requires additional efforts by the governments to increase fish production from aquaculture. All Malawi's development policies (Malawi Vision 2063, Malawi Growth and Development Strategy III 2017-2022, National Fisheries and Aquaculture Policy 2016, National Aquaculture Strategic Plan 2021) emphasise the need to promote aquaculture development in order to enhance production from aquaculture to supplement the dwindling capture fisheries production and cannot satisfy the ever increasing demand for fish. The development policies also emphasise the need to pursue sustainable practices and climate smart technologies.

Up until now, there were many reference materials which extensionists from both government and non-governmental organisations have been using to train farmers in aquaculture principles and practice. These manuals, however, were not coherent, often providing conflicting recommendations and were not vetted by the Department of Fisheries under the Ministry of Forestry and Natural Resources as proper training materials for aquaculture. Hence, it is timely that this new aquaculture manual has been developed for use in the aquaculture practice. This manual will become a nationally recognised tool for training in aquaculture practice.

The target users of this aquaculture manual are extensionists from government and non-governmental organisations, fish farmers and trainers of these groups. The manual contains technical information as well as training plans to help the trainers to conduct training in an orderly manner.

The Ministry of Forestry and Natural Resources remains committed to foster the development of aquaculture in the country for nutritional and food security, income generation and job creation.

Yanira Ntupanyama, PhD.
Secretary for Forestry and Natural Resources

PREFACE

This Technical Manual for Trainers on Good Pond Aquaculture Practices has been developed to address the gap that existed when the country did not have a universal, nationally recognised manual as basis for training our extension agents, fish farmers and for use by non-government organisations engaged in the aquaculture sub-sector. This manual will be a reference material for guiding aquaculture practices in Malawi. Accordingly, the manual has been developed to support the implementation of the National Fisheries and Aquaculture Policy 2016 which highlights sustainable aquaculture development as policy priority number 2 and the National Aquaculture Strategy (2021-2029).

There are several challenges that exist in the aquaculture sub-sector that need to be addressed for the benefit of fish farmers and extension workers. The major challenges include: lack of harmonised approaches and information to guide all players in the value chain, inadequate supply and access to inputs i.e. quality fingerlings and feed, unavailability of market structures to aggregate production and measures to increase the resistance of the sector against risks related to climate change.

It is expected that this aquaculture manual will become the necessary tool for all actors along the aquaculture value chain mainly for technical know-how regarding aquaculture production. Where possible, trainers or users may be guided by the aquaculture experts from the Department of Fisheries under the Ministry of Forestry and Natural Resources.

Friday Njaya, PhD.
Director of Fisheries

ACKNOWLEDGEMENTS

The Department of Fisheries (DoF) in the Ministry of Forestry and Natural Resources is grateful to all stakeholders, too numerous to mention, who contributed to the development of the nationally recognized Technical Manual for Trainers on Good Pond Aquaculture Practices. The DoF acknowledges the financial and technical support from the Aquaculture Value Chain Project for Higher Income and Food Security (AVCP) funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit GmBH (GIZ).

The Department also acknowledges the efforts and technical contributions from all the government officers, academicians, technicians and practitioners who took part in the development of this manual. Thanks should also go to the team that finally edited the manual.

Special recognition and gratitude are extended to the GIZ Food and Nutrition Security Program (FNSP) for contributing the chapter on nutritional benefits of fish and all individuals who were involved and contributed in the development of this manual.

INTRODUCTION

The availability and accessibility of quality fish seeds helps a farmer to stock into a rearing facility fish seed with better growth. This allows for a profitable harvest in the shortest possible period as the production of marketable fish begins with stocking of quality seeds. The primary goal of the fish seed production should be to produce "quality fish seed" and subsequent distribution of the same among the farmers for culture or further growing out. In scientific terms, "quality seed" may be defined as those having better feed conversion efficiency, high growth rate, better ability for adapting to changing environmental conditions, disease resistant, and fetching a high market price.

Fish seed can come from the wild; although there is little or no guarantee that adequate numbers with uniform size can be captured and stocked in the time corresponding to optimum production condition. Fish breeding is the only possible technique to ensure timely availability of quality fish seed. Fish hatcheries are places for artificial breeding, hatching, and rearing through the early life stages of fish. They are a reliable source of fish seed. Hatcheries produce larval and juvenile fish, primarily to support the aquaculture industry where they are transferred to on-growing systems, such as fish farms, to reach harvest size. Hatcheries help in the consistent supply of high quality fish seed. Well established hatcheries play an important role in making high-quality seed available whenever farmers need it.

This module describes simple and low-cost methods of seed production and grow-out culture that can also be applied in rural areas and amongst resource-poor fish farmers. Attention has also been paid to tilapia mass fry production through sex reversal technology because this is expanding rapidly in many parts of the world including Malawi. Catfish is one of the fast growing species and its different breeding methods have been captured in this module. Best management practices to minimize losses, especially at the larval, fry and fingerling stages of the production cycle have been discussed.

Some of the factors that a fish hatchery requires for its efficient operation have been elaborated in this module namely: suitable site selection, soil characteristics, and water quality. Adequate facility design, water supply structures, water source, and hatchery effluent treatment has also been considered. This module will identify the more important hatchery requirements and the conditions necessary for an efficient operation. The module further attempts to explain important elements in the production of high quality fish seed for aquaculture viz: hatchery calendar, set-up and management; record keeping, broodstock management, seed production systems, packing and transportation of fish seed, fry nursing, biosecurity measures and hatchery economics.

CONTENTS

Hatchery Calendar

1

Introduction

A good fish hatchery calendar helps a fish seed producer to better plan for the fish breeding process. Fish farmers will need fish seed throughout the year. As they harvest, they will need new seed for restocking. Having a good hatchery calendar will therefore, be beneficial to the operator as it will guide them to know the best possible time to carry out specific activities which will help in ensuring that seed of all targeted species is available at all times.

This chapter highlights some of the basic requirements that need to be considered when drawing up a calendar for a hatchery. It should be noted that fish seed production as an enterprise, also falls within different seasons which influences fish breeding, production, periods of competition for labor and feed, low temperatures, factors influencing markets and best periods for seed breeding, fish harvesting and marketing. The calendar is therefore, an important guide to fish hatchery operations.

Aim

The aim of the sub chapter is to enhance knowledge and understanding of the hatchery calendar and how it can guide a sustainable fish breeding and farming enterprise.

Objectives

- Participants know
  - Importance of a hatchery calendar
  - Challenges one can face if no calendar is developed
  - Benefits of timing of fish seed production

- Acquired skills
  - Aligning different activities in a calendar
  - Proper developing of a hatchery calendar

- Acquired attitudes
  - A hatchery calendar as a relevant tool for fish seed production
  - Planning the seed production

- Relevance to fish seed production
  - Good guide to know sustainable fish breeding and farming enterprise.

This chapter is divided into two sessions:
Session 1: Preparation of ponds and Breeding facilities
Session 2: Conditioning of brooders and setting of brooders in breeding facilities

Mode of delivery

- Lectures, group discussions
- Duration : 45 minutes

Session One

Hatchery calendar

The hatchery calendar has been sub divided into two sessions and these are pond and breeding materials preparation which looks at things that a fish seed breeder will need to indicate in the calendar on what needs to be purchased and when. The session starts be defining a hatchery. The session further looks at when and why breeding facilities have to be prepared. The second session looks at a series of activities which will need to be indicated in the calendar from conditioning of brooders and setting of brooders in breeding facilities.

1.1.1 Pond and Breeding Materials Preparation

i. What is a hatchery?

The process of fish spawning and fry production is one of the important steps in aquaculture. It is also one of the limiting factors for aquaculture growth on a large scale. Remember, it is difficult to satisfy fish seed requirement through collection from the wild and that is the reason controlled propagation of fish through practicing of induced spawning techniques in hatcheries is important. A hatchery is a place for artificial or controlled breeding, egg hatching, and egg rearing through the early life stages of aquatic animals (e.g. fish). The output of a hatchery is normally fry, fingerlings or juveniles. These are later transferred to on-growing systems, such as fish farms, to reach harvest size. For a successful breeding program, a hatchery needs to have a well detailed plan of events.

ii. Purchasing of breeding materials

Before the actual process of fish seed breeding, there is need to purchase the equipment necessary for fish seed production. It is not advisable to start searching for the required equipment or material during the breeding process as this would either compromise on the quality or numbers of the seed to be produced. Some of the equipment and materials to be purchased in advance include the following;

- Handling Equipment
- Harvesting nets,
- Hand nets,
- Scoop nets
- Fry nets
- Fingerlings net
- Floating graders
- Balance
- Digital scale max. 15kg
- Floating grading plate 2 and 4 mm for swim up fry
- Floating Tilapia grader boxes 5, 6, 7 and 8 mm in PVC
- Oxygen cylinder
- Seed packaging materials
- Work Tables
- Fish Counting Table
- Fish Graders
- Towels or Napkins
- Plastic Basins of 20 liters, 60-80 liters
- Small Plastic Bowls

- Hatchery equipment
  - Pipe cleansing brush (4 piece)
  - Plastic brush for cleansing tanks (4 pieces)
  - Plastic brush for cleansing floor (2 pieces)
  - Disinfection tanks for nets etc. (3 pieces)
  - Disinfection tanks for feet (2 pieces)
  - Hand disinfection P3 manodes dispenser (1 piece)
  - Microscope with add-ons needed
  - Disinfection material; Virocid, high
  - Egg or larvae collecting jars
  - Hatching jars
  - Siphon hoses (1/4, 3/8, 1/2 inch, etc.)
  - Chlorine cleaner for tanks, basins
  - Formalin
  - Substrates for hatching
  - Cleaning sponge on stick

- Chemicals and Breeding accessories
  - Stock solution (for induced breeding)
  - Alcohol (for induced breeding)
  - Sex Reversal Hormone (for all males)
  - Ovaprim
  - Dissecting kit
  - Feather for mixing eggs + sperm (for catfish)
  - Hatching frames/screens (for catfish)
  - Syringes
  - Hormone (Motilium or Ova Prim)
  - Suprefact (Accelerator)
  - Quinaldine (Anesthetic)
  - 0.6% - 0.7% Nacl (Saline Solution)

- Spare parts
  - Broodstock hapas
  - Nursery hapas
  - UV device 40 Watts complete
  - UV spares PL light bulbs 40 Watts
  - 40 watt pump
  - Back Up Generator for 24hrs electricity
  - Torch Light
- Water quality equipment
  - pH meter
  - NH4 and NO2 test kit
  - Thermometer
  - Secchi disc
  - Air fill kit
  - Water Test Kit
  - Air pump with air lines & air stones
  - Artemia Tank – 200 liters
- Other management materials

- Hoes, slashers, rakes
- Fertilizer/manure – for fertilizing ponds
- Lime – for treating ponds
- Feed for brooders, fry and juveniles

As some of these equipment and materials cannot be bought once, there is always need for a routine check know if they are still in good condition.

iii. Construction and renovations of ponds

Pond, tank construction and pond renovations can be best done during the off season period which is normally towards the end of the cool-dry season and during the first days of the hot-dry season. This activity also involves mending of hapas for those doing hapa based breeding. The benefits of putting these activities on the calendar during this period include;

- Work is easier and cheaper as soils are not water logged or too dry for easy excavation.
- Allows easy drying of pond bottom for pond mud removal to minimize turbidity on breeding and fry nursing ponds
- Drying of ponds during renovations helps to kill parasites and breaking cycles of disease causing pathogens.
- It will improve availability of nutrients in the pond bottom, the mud will decompose and most pests, water insects, amphibian larvae (e.g. tadpoles) and unwanted eggs, wild fish will disappear

Summary

The session first described that a hatchery is a place for artificial or controlled breeding, egg hatching, and egg rearing through the early life stages of aquatic animals (e.g. fish). The output of a hatchery is normally fry, fingerlings or juveniles. As each and every hatchery has certain of equipment and materials to be used, the session then looked at indicating when to start constructing or renovating ponds, hapas and other breeding facilities in readiness for the new breeding season.

Session Two

1.2 Conditioning of brooders and setting of brooders in breeding facilities

This session looks at things a fish seed producer will need to consider in the hatchery calendar from recruitment of brooders, breeding and nursing of the fish feed and selling.

i. Recruitment of brooders

Planning for recruitment of brooders is important in the hatchery calendar. Once ponds or tanks have been constructed, renovated, treated and water filled, recruiting of brooders will follow. Right procedures must to ensure quality brooders are selected from trusted sources as discussed in Chapter 4. When to stock them in holding ponds or reservoirs before they are taken to conditioning and breeding ponds should be planned.

ii. Selecting, conditioning and setting of breeding program

For a successful breeding exercise, the calendar will have to indicate when selection of brooders will be done. This selection involves choosing good males and females, separating (sexing) males from females and putting them in different conditioning ponds.

iii. Setting breeding

The calendar will need to indicate when to start putting fish in breeding ponds or hapas according to the required male to female ratio. If it is for induced spawning process like for catfish, the calendar should be indicated when the process will start and use of brooders will determine the number of fish seed which needs to be produced.

iv. Preparation of nursing ponds or hapas

Cleary indicate when preparation of nursing ponds or hapas will need to be done. When nursing facilities are prepared too early, they might be infested by unwanted aquatic weeds or insects. These might negatively affect the survival and growth of the fry or fingerlings. When the nursing facilities are delayed to be prepared, turbidity and other pond treatments materials like lime and manure can negatively affect the survival and growth of the fry.

v. Feeding and grading

Proper feeding of fry and fingerlings is necessary for good fish growth. Feeding of each batch of fry and fingerlings will therefore need to be carefully indicated on the calendar. Good size and amount of feed will need to be administered as it will help in

- Easy absorption of the feed by the fish
- Maintaining good water quality. Uneaten feed will lead to poor water quality
- Good and faster fish growth.
- Minimize feed wastage

In the course of feeding the fish, sampling and grading of the fish seed will need to be indicated when to start and at what intervals. Grading will help in

- Giving the right quantity of feed to the seed
- Separating bigger sizes from smaller ones
- Minimizing cannibalism as in the case of catfish
- Improving growth
- Selling of uniform size seed

vi. Removal of eggs and skimming of fry

Depending on the hatchery system and species being involved, the calendar needs to indicate when and at what intervals eggs or larvae will be removed from mouth brooders if they are to be incubated in an indoor hatchery. If it is pond, hapa or tank based, fry or fingerling skimming should be indicated. This will help in

- Removing fry or fingerlings of the same age to nursing facilities
- Creating more room for brooders to continue breeding
- Ensuring right food quantity is be given to brooders
- Control inbreeding
- Improving growth of the skimmed fry

vii. Reconditioning of brooders

For a successful breeding program, brooders that have been put in breeding ponds, hapas, or tanks will need to be moved to conditioning ponds and a new set be put in the breeding unit. Moving of brooders for reconditioning can be done:

- Either after every two to three months or after several collections of fry from their breeding ponds.
- Brooders can be replaced before the stipulated time upon seeing a decline in number of eggs or fry being collected.
- Planning for removal of all brooders after a period of three years must be considered

This will ensure that:

- Brooders are given the right vigor to continue breeding
- Bruised brooders are removed from the breeding unit
- In case some brooders died of were eaten by predators, they are replaced
- Pond is treated so that parasites and all unwanted fish are removed

viii. Marketing of seed

As operating a fish seed hatchery is a business, the calendar will need to indicate when possible sells will start. This will help in

- Creating more space for new seed coming from breeding and nursing ponds
- Avoiding stunting of seed in holding facilities
- Making good profits from sales

ix. Hatchery disinfection

As prevention is better than cure, disinfecting of the hatchery should not only be done when there is an infection threat. There are periods when infectious diseases are prone to occur in farms and hatcheries. The hatchery calendar should indicate periodic disinfection of the hatchery to ensure that

- The hatchery and its facilities are free from infections
- Infected seed is not sent to out growers
- Any suspected possible disease outbreak is put under control
- No economic losses are made

x. Indicating times of high demand and supply of fish seed

There are times of high and low fish seed demand. A good calendar must indicate all these scenarios. For one to make profits, he or she should know how much seed to produce and when. There might be a high demand of fish seed when farmers have harvested either their fish or agricultural crops. Therefore, a hatchery should always do a market research on when fish seed will be on high demand. This is important because

- It will help in planning numbers of brooders to use
- It will help in knowing amount of inputs to procure life feed
- It will help in knowing the area to prepare for conditioning brooders, breeding and nursing fry

- You will know the number of personnel to be involved to minimize expenses
- Possible expenditure on fish seed packaging materials is estimated

xi. Availability of farm outputs and labor

A good fish hatchery calendar has to go together with the seasons and other agricultural related crops as it

- Gives a good guide on the availability of other farm outputs (raw materials for feed)
- Helps in making your own at a cheaper price as they cheap and in abundance. For example like maize bran becomes scarce and yet it is on high demand as it is will be required to be fed to poultry, pigs, and stall feeding cattle.

When doing major maintenance work at the hatchery, labor demands are always unavoidable. Doing some activities when there is high demand in agricultural fields might render one enterprise suffer or become more costly to implement. Therefore, the calendar should indicate the best possible time to carry out any activity which will require more labor force.

Summary

The session looked at key steps which needs to be considered when developing a hatchery calendar but mainly looking at activities from recruitment of brooders, selecting healthy brooders, conditioning, setting breeding ponds or hapas, fry or seed skimming, feeding, grading, procurement of feeds and selling of seed. It has been highlighted that proper planning of the breeding exercise starts with a good calendar of events from broodstock selection to marketing of the produced seed. If seed will not be sold on time, they might be kept for long and congested in nursing facilities thereby compromising on quality.

Record Keeping

Introduction

Records are sets of information systematically collected and appropriately stored for a specific purpose. Running any economic enterprise like a fish hatchery successfully requires comprehensive collection of records. Poor keeping of records has to be one of the major reasons entrepreneurs fail. A fish hatchery therefore must have proper records for all stages of operations. This chapter has two sessions which looks at importance of records and their types and templates of hatchery records.

Aim

The aim of the chapter is to enhance knowledge on the importance of records and understanding on how templates for record keeping can be developed.

Objectives

<u>Acquired knowledge</u>

- Participants know
- Importance of a hatchery calendar
- Challenges one can face if no calendar is developed
- Benefits of timing of fish seed production

- <u>Acquired skills</u>

  Participants to know how to
- Align different activities in a calendar
- Properly develop a hatchery calendar

- <u>Acquired attitudes</u>
- Records are a good management tool

- <u>Relevance to fish seed production</u>
- Tracing age of brooders and seed for distribution of quality seed

This chapter is divided into two sessions
Session 1: Importance of records and their types
Session 2: Templates of hatchery records

Mode of delivery

- Lectures, group discussions

  <u>Duration</u>: 60 minutes

2.1 Hatchery Records
2.1.1 Importance of records

The importance of record keeping in a hatchery includes the following:

- It is the means by which we measure and balance the input and output, evaluate efficiency, and plan future operations
- Source of information on species being used, where they were collected
- Guiding on the numbers of brooders, age and size
- Source of information by which one can make daily management decisions
- Means of evaluating performance and making future decisions
- Ways of monitoring impact of management changes on fish breeding and production
- Help monitor irregularities such as theft, predation, disease occurrences
- Department of Fisheries - fish hatchery records will provide information for policy formulation.
- Accounting and financial information may be required by other stake holders such as employees, suppliers, Government- tax records and the general public.

Record keeping of all hatchery business transactions forms the basis for effective costing. Knowing costs will enable business promoters to:

- Set a seed price that allows profit maximization
- Identify the highest production costs and devise strategies to minimize them
- Avoid over or under-pricing the see out of competition
- Determine the gross marketing margin and net margin

On broodstock collection, records will assist in knowing:

- Numbers collected from different geographical territories,
- Cataloguing of their geographical origin,
- Their genetic characterization and the maintenance of purebred
- Their age for possible renewal of the stock

Records on fish feeds and feeding will help the hatchery operator on feed management and are important in:

- Qualitative feeding with the right and required ingredients. Deficiencies of certain dietary ingredients, such as fatty acids (PUFA), vitamins, and trace elements, exerts a negative impact on maturation, breeding, spawning, larval vigor, and survival
- Periodic health management and other important aspects
- Feeding behavior of the species
- Production and expiry dates of feed being used

Records for different family lines

A hatchery operator will need to keep record of different family lines of domesticated stocks. This is normally done when stocks from different sources are being kept at the farm. Such records help in avoiding potential problems relating to;

- Heredity,
- Impaired growth
- And poor survival due to inbreeding and other related consequences.

Lack of records on breeding individuals, mixed spawning of fish species, and lack of knowledge or awareness on minimum effective population size have been identified as bottlenecks to improve seed production and genetic management in small-scale or farmer-operated hatcheries.

2.1.2 Types of records

As there are two types of hatchery operations thus indoor and outdoor, the first part will lay out factors that should be considered in efficient record keeping for an indoor fish see hatchery operator. These are therefore listed below.

Water

- Volume in cubic meters for each rearing unit and for the entire hatchery (pond, tanks, hapa).
- Liters per minute and cubic meters per hour flow into each unit and for the entire hatchery.
- Rate of change for each unit and for the total hatchery.
- Source and quality
- Average depth.
- Inflow required maintaining pond level.
- Temperatures, oxygen, pH.
- Fertilization (dates, kind, amount, cost, results).
- Algae and zooplankton blooms (dates and secchi visibility in inches; kinds of plankton).

Mortality

- Fish or eggs actually collected and counted (daily pick-off).
- Unaccountable losses (predation, cannibalism) determined by comparison of periodic inventories.

Feed and Diet

- Source of feed, date of manufacture and expiry, date procured, costs
- Composition.
- Cost per kilogram of feed and cost per weight (kg) of fish gained.
- Amount of food fed as percentage of fish body weight.
- Kilograms of feed fed per kilogram of fish produced (conversion).

Fish

- Broodstock
- Species, numbers, source, sex
- Stocked for spawning (species, numbers, and dates).
- Replacements (species, numbers, weights).
- Date when artificial fertilization was done
- Feeding and care (kind, cost, and amounts of food, including data on forage fish production).
- Date of first feeding of fry.
- Fry produced per given area and per female.
- Associated recruitment costs
- Weight and number of fish and eggs on hand at the beginning and end of accounting period.
- Fingerlings
- Species (numbers stocked, size, weight, date)
- Date eggs were taken, number per kilogram, and source.
- Number removed, date, total weight, weight per thousand, number per kilogram
- Supplemental feeding (kind, amount, cost).
- Disease and predation (including insect control, etc.)

Parasites and Diseases

- Occurrence, kind, and possible contributing factors.
- Type of control and results.

- Costs (other than fish food):
- Maintenance and operation.
- Interest and depreciation on investment.
- Analysis of all cost and production records.
- Diseases and parasites (treatments, dates, results).

Organic/Inorganic Fertilizers

- Type of fertilizer
- Source
- Date procured
- Associated costs
- Application rates
- Pond being fertilized, date, quantity

Lime and liming

- Type of lime, source, costs
- Date procured, associated costs
- Date of application
- Quantity
- Pond number

Other things to be considered

- Days in production.
- Weight gain of see square meter per day.
- Cost per batch of fish produced at hatchery.
- Cost per batch including distribution costs.

As these are a general guide on the records one has to keep, there might be different records or variations on what each operator can keep or use according to what the operator see to be helpful when designing the record keeping system.
Broodstock conditioning

For an effective fish seed production process, brooders needs to be conditioned before and after putting them in breeding hapas, tanks, or ponds. Details to be recorded include:

- Date when stocked for conditioning
- Sex and how many?
- Average body weight
- Feeding rate

Sampling records/Grading

Brooders and fingerlings will need to be sampled. This is done either for adjusting feed or separating bigger ones from smaller ones. Details to be recorded include:

- Sampling or grading date
- Species
- Numbers sampled or graded
- Average weight
- Feed requirement

Breeding records

In breeding ponds, tanks or hapas, not all females release eggs on the same day. In the course of fish breeding, records have to be kept on the number of counted females with eggs or larvae. Even though it is time-consuming, the counting of females and recording should be done for each stage of seed collection. This will help in assessing their performance. Details to be captured should include:

- Date of egg/larvae collection
- Count of females that have released egg/larvae
- Estimate of egg/larvae collected
- Count of available females and males
- Recording of any observations (predation, mortalities, bruises)

Water quality records

Environmental factors such as temperature, rainfall, humidity, light, pH, ammonia, nitrite, feed and other management factors affect breeding. These have to be recorded and kept for future use. Water quality in hatchery operations is critical to the survival of both brooders and fry. It is so easy to lose an entire crop due to poor water quality.

Keeping water quality records and observing trends in relation to water quality parameters is necessary. This will provide information on favorable conditions which the hatchery operators will be required to maintain and also the unfavorable conditions that the hatchery operators should try to avoid.

Sales and marketing of spawn or hatchlings

Seed production in hatchery is a business and it needs profits and marketing is an important aspect of seed production. Profits will be known of proper records are even made at the marketing stage. Therefore some of the details to be recorded will include:

- Date
- Species being sold
- Destination
- Number of seed
- Price per seed
- Average weight

Labor costs

Labor costs must be recorded at all stages of operations. In kind and in cash payments should be recorded. If we have paid for labor during loading and offloading of manure, feed or nay hatchery related materials should be recorded. All these will be summed up and calculated in gross margins

Communication, Utility bills records

All related communication costs must be recorded. These can include

- Transport costs

- Internet
- Phone charges
- Water bills
- Electricity

Asset Records (Fixed and Variable)

The hatchery operator will need to carefully record all the fixed and variable costs. Dates and costs should always be recorded.

2.1.3 Templates of hatchery records

Each and every seed production unit has several templates for keeping its records. Here are some of the templates that can be used and kept

i. **Breeding facility records**

Table 2.1: importance of records and their types and templates of hatchery records

Construction of Hatchery, Ponds/Tanks				
Date	Size of Hatchery Pond or Tank	Labour - Man Days	Cost (MWK)	Comments

Table 2.2: Pond Liming Records

Liming of Ponds					
Application Date	Pond/Tank #	Application Rate (Kg/100m^2)	Quantity Applied (Kgs)	Cost (MWK)	Comments

Table 2.3: Pond fertilization records

Pond Fertilization					
Application Date	Pond/Tank #	Application Rate (Kg/100m^2)	Quantity Applied (Kgs)	Cost (MWK)	Comments

Table 2.4: Pond maintenance records

Pond Maintenance								
Pond #___________Description of Maintenance or Repairs								
Date	Cut grass on dikes	Weed removal in ponds	Desilting	Canal clearing	Dike Rebuilding	Others (specify)	Labour Man Days	Cost (MWK)

ii. Stocking records

Pond or Tank Utilization Schedule

If a farm has a number of ponds and/or multiple species in production, records should be kept of the use of each pond. This includes date stocked; species stocked, and expected harvest date.

Table 2.5: Broodstock Conditioning Record

Pond, Hapa or Tank Stocking Records								
Farm: _______________ Period of Management:_______________ Manager: ___________								
Pond No.	Date Stocked	Species	Number Stocked	Stocking Density	Average Weight(g)	Total Weight (kg)	Source of Fish	Comment

Table 2.6: Broodstock mortalities and replacement records

Fish Mortalities						
Date	Pond/Tank #	Number of Fish	Size (Weight, Length)	Number Replaced	Cost (MWK)	Comments

Table 2.7: Broodstock sampling records

Broodstock Sampling Records							
Pond, Tank Hapa No.	Sampling Date	No. Fish Sampled	Total Weight (kg)	Average Weight (g)	Estimated Total Biomass(kg)	Estimated Weight Gain(kg)	Comment

A thing to Remember: when sampling fish, always take all fish sizes and do not select the fish, just scoop and count. Pond sampling should be done every 30 days

Table 2.8: Seed Sampling or Grading Records

Broodstock Sampling Records							
Farm: ____________________	Period of Management:__________________				Recorder: _____________		
Pond, Tank Hapa No.	Sampling Date	No. Fish Sampled	Total Weight (kg)	Average Weight (g)	Estimated Total Biomass(kg)	Estimated Weight Gain(kg)	Comment

A thing to Remember: when sampling fish, always take all fish sizes and do not select the fish, just scoop and count. Fry or juveniles can be sampled every two weeks especially for catfish

Table 2.9: Fish Feeding Templates

Fish Feeding Records						
Pond, Hapa Tank #	Estimated Total Biomass (Kg)	Feeding Rate (%)	Weight of total daily feed ration	Type of feed	Source of Feed	Comments
1						
2						

With High Quality Feeds, fish feeding percentage will be based on type, stage and use of fish – say brooders, fry, juveniles: Remember to always use fresh feed

Table 2.10: Broodstock for fingerling production: In Breeding Pond or Tank

Broodstock for fingerling production: In Breeding Pond or Tank							
Stocking Date	Pond/Tan k # Size	Species	Number Stocked (m,f)	Stocking Density Fish/m^2	Stockin g ratio	Source of Brooders	Comment s

Table 2.11: Reproduction records

Date Fry First Observed	Estimated Number	Comments
Date Fry Skimmed	Estimated Number	Comments

Table 2.12: Fingerling Sampling and Grading Records

Fingerling Sampling and Grading Records								
Farm: ____________________		Period of Management:__________________				Recorder: _____________		
Pond No.	Date of Sample	Days of Production	No. Fish Sampled	Total Weight (kg)	Average Weight (g)	Estimated Total Biomass (kg)	Estimated Weight Gain(kg)	Comment

A thing to Remember: when sampling fish, always take all fish sizes and do not select the fish, just scoop and count. Pond sampling should be done every 30 days. Grading requires removing all fish from the culturing facility

Table 2.13: Data sheet template for sex reversed seed sales

Date	Customer Details Name, Address, Contact	Date of Sex Reversal Completion	Number of Seed Sold (a)	Price of Seed MWK (b)	Total Income = (a x b)	Remarks
14-08-2021	Mai Makumba – 0999 000 000	7-07-2021	10,000	20	200,000	Will need technical support
15-08-2021	Mr. Nyungusale	8-07-2021	20,000	20	400,000	Average weight of seed is 15g
Total			**30,000**		**600,000**	

Table 2.14: Cash flow records

Cash Journal					
Date	Customer/Supplier	Description	Cash Received (MWK)	Cash Paid out (MWK)	Account Balance (MWK)

Table 2.15: Profitability records

Item	Quantity	Unit Price	Total Amount	Remarks
Total Income (Seed sales)	_______pieces _______Kgs	_______/piece _______/Kg		All seed sold
Expenses Feed (kg) Manure (kg)				If several ponds, tanks used, take information from daily records
Other expenses				
Total labor costs				
Casual labor				
Other costs				Specify here
Gross Profit				

iii. Hatchery Production Summary

The Hatchery Production Summary is prepared at the end of each month. Entries on this form are taken from the history production and sales production. Hatchery Production Summaries provide cumulative monthly information for all production lots reared at the hatchery on an annual basis. Once a lot has been entered on a form, the lot should be carried for the entire year.

Session Summary

In this session, it has been seen that record keeping is an important aspect in fish seed production. It helps in the collection and preservation of important information which helps in tracking hatchery activities and serves as a basis for making informed business decisions. It has been seen that a complete set of hatchery records will among other things help in:

- Knowing the source of your broodstock
- Size and age of your broodstock
- Number of seed being produced per given period of time
- Amount of inputs (feed, manure) being used and their costs
- Water quality changes and corrective measures applied
- The total number of mortalities and reasons.

All aspects of records related to seed production must be kept and these include the following:

- Origin and age of brood stock shall be recorded and maintained in a stock register in each hatchery
- The dates of conditioning brooders and stocking in breeding ponds, hapas or tanks.
- Number of brooders, stocking ratio per pond, tank or hapa
- Feeds and feeding records (amount, source and type of feed, response) can be used for day to day management, adjustment of the feed ratios, estimating feed conversion efficiencies and growth rates.
- Feed storage and control records such as date of purchase, expiry dates, number of feed bags used/ remaining
- Parasites and disease treatment records - necessary to track disease occurrence and treatment given.
- Number and date of mortalities occurring in each pond
- Water quality parameters such as Dissolved oxygen and temperature. It is important to monitor water quality in order to detect problems well before they become a threat to the fish (see leaflet on pond management and water quality).
- Investments, input expenses, maintenance costs and sales including prices of inputs and the fish seed sold
- Record keeping and other operational procedures are checked as part of Good Aquaculture Practice (GAP)

Hatchery Set-up

3

Introduction

The establishment of a specialized tilapia and catfish hatcheries and supply of high-quality fry or fish seed has become one of the most profitable businesses in rural and urban areas. This is ensuring that grow out farmers should also make good profits from fish which are maturing early with minimal efforts. Profits are therefore made by both hatchery operators and grow out fish farmers. Therefore, this chapter describes in details some of the aspects of setting up a hatchery.

Aim

The aim of the chapter is to enhance knowledge, understanding and skills on how to come up with a good hatchery plan and how to manage their hatchery

Objectives

Acquired knowledge

- Participants know
  - Good hatchery plan
  - Important facilities in a hatchery

- Acquired skills

  Participants to know how to
  - Design a hatchery

- Acquired attitudes
  - Control and management of a water system to minimize pathogen threats in a hatchery

- Relevance to fish seed production
  - Quality of brooders and fish seed is observed and maintained

This chapter is divided into two sessions

Session 1: Hatchery plan
Session 2: Hatchery Management

Mode of delivery

- Lectures, group discussions
- **Duration** : 45 minutes

Session One

3.1 Hatchery plan

Any business starts with planning and setting up targets. Targets can be in terms of volume, the number of particular product(s) and the net profits to generate. In hatchery operation, the targets are the number of fry or fish seed (per species) to be produced, sold and amount of profits to be generated. Targets may vary depending upon the scale of the business, demand for the product and the objectives of the business. The tilapia hatchery business can be categorized into three types: small, medium and large scale. These sizes are based on the volume of seed that can be produced based on the level of investment and size of operations. In many parts of the country, hatchery business is spreading rapidly, the reason being that it shows very attractive profits.

3.1.1 Site selection and development

Establishing and running a successful hatchery requires technical as well as good managerial skills, and several factors. Proper structures will need to be developed at the site to ease the seed production at all stages till the seed is packaged and transported.

Location

Local demand for tilapia seed and potential profit from the hatchery operation should be kept in mind when selecting a particular site for the hatchery. Hatcheries and nurseries usually tend to be located in clusters. This is like how the Government of Malawi set several hatcheries like Nchena chena and Mphompha in Rumphi, Limphasa in NKhatabay, Domasi and Chinseu in Zomba, Chisitu in Mulanje, Kunenekude in Mwanza and Kasinthula in Chikwawa. These areas were selected as;

- They are easily accessible as broodstock, seed and other hatchery related materials can be transported to and from the hatchery in a reasonably short time and at low cost.
- Distance from grow-out farmers is minimal
- They are not prone to flooding
- Predators can be easily controlled as they can lead to economic losses.

Temperature

A site vulnerable to extreme weather cycles or natural disasters such as floods, storm/wind, etc. should be avoided. In areas with lower temperatures, greenhouses may be needed while in warmer areas relatively deep ponds/tanks and shading may be needed, which add additional costs. It is desirable that water temperature should be in the range of 25 - 32°C and pH should be 6.5 - 9.0.

The basic facilities required for seed production

- Ponds or tanks for holding and rearing an adequate number of broodstock
- Spawning pond, tanks, or hapa
- Nursery pond, tanks, or hapa
- Holding tanks with hapa for recovery from handling stress prior to distribution of fingerlings
- Water supply system and water holding tank
- Air (aeration) system (where applicable)

- Basins, buckets, containers
- Seine nets, scoop nets, grading basket
- A good scale for weighing fry and fingerlings
- Accessories for packing of seed (fry and fingerlings)
- Packing and loading area

3.1.2 Hatchery Farm Layout

A hatchery should have enough space for the pond, hapa or tank for broodstock, incubation/larval rearing and fry nursing and holding. However, the number and size of ponds, hapas or tanks depends on the scale of the operation. A combination of a hapa and tank based hatchery is probably the most common. Hapas are easy to install and less costly. They are also good in terms of maintaining the purity of broodstock.

Some hatcheries, tilapia and catfish are mainly tank and hapa based. Tilapia and catfish hatcheries which are mainly tank based are often heavily equipped with recirculation systems, aeration, light and temperature (heat) control. The most cost effective management of fish stocks amongst many hatchery operators in Malawi is pond-based system as it is the cheapest method. However, survival and purity of the broodstock and fry/fingerlings in ponds cannot be guaranteed as wild fish and other predator organisms can easily enter the ponds. At the same time, stocks cannot be easily recovered from ponds, and can never be recovered completely. However, simply installing hapas in ponds can make it a lot easier to handle fish and maintain pure stock.

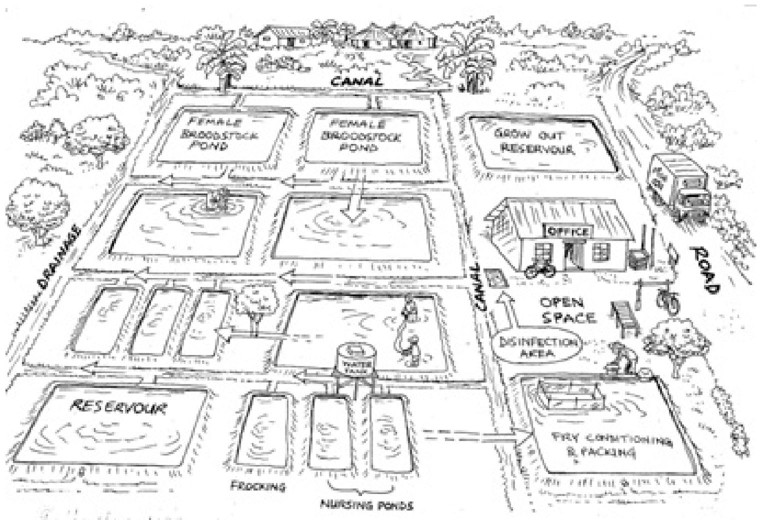


Fig 3.1 Simple farm layout for a hatchery

The artificial egg incubation system will require a simple tank-based water recirculation system; a good example is at National Aquaculture Center in Domasi, Zomba and the Tilapia Solar Powered Hatchery at Bunda Farm. Figure 3.1 shows a simple layout for a farm where the office and fry sales areas are close to the road. Other parts such as broodstock ponds, egg incubation, sex reversal and nursing sections are planned for the inner part of the farm, which can have an internal fence so that any strangers, outsiders and even fry buyers need special permission to enter. A footbath should be installed at the entry to these areas.

These categories of hatcheries can be described as follows:

- Small-scale – fry production of less than 0.5 million per month.
- Medium-scale – fry production of 0.5 – 1.5 million per month.
- Large-scale – fry production higher than 1.5 million per month.

Depending upon the design, actual land area requirements will be about 50% more to accommodate office, store and residential areas, parking, road, pond dykes, reservoir(s), and so on. More importantly, additional land may be set aside for future expansion because adding a hatchery component at another site later to increase the scale of the operation would incur huge costs.

3.1.3 Hatchery Design

In deciding the suitability of a site for a fish seed hatchery, the primary purpose of the hatchery should be considered.

i. Water supply, quality and quantity

An adequate supply of high quality water is critical for hatchery operations. The site should have a reliable perennial source of water with good quality. Water from a river, stream, lake or groundwater can be used in hatcheries. For efficient operation of a hatchery, the site should be below the water source. This will afford sufficient water head to provide aeration and adequate water pressure without pumping. Note that:

- Groundwater generally is the best water source for hatcheries, particularly for intensive culture. Its flow is reliable, its temperature is stable, and it is relatively free of pollutants and diseases.
- Springs and artesian wells are the cheapest means of obtaining groundwater; pumped wells are much less economical. Spring-fed streams with a small watershed can give good water supplies.
- They carry little silt and are not likely to flood. The springs will ensure a fairly steady flow, but there still will be some seasonal changes in water temperature and discharge; storage and control structures may have to be built.
- It is important that such streams not have resident fish populations, so that disease problems can be avoided in the hatchery.
- Larger streams, lakes, and reservoirs can be used for fish culture, but these vary considerably in water quality and temperature through the year, and may be polluted. They all have resident fish, which could transmit disease to hatchery stocks.

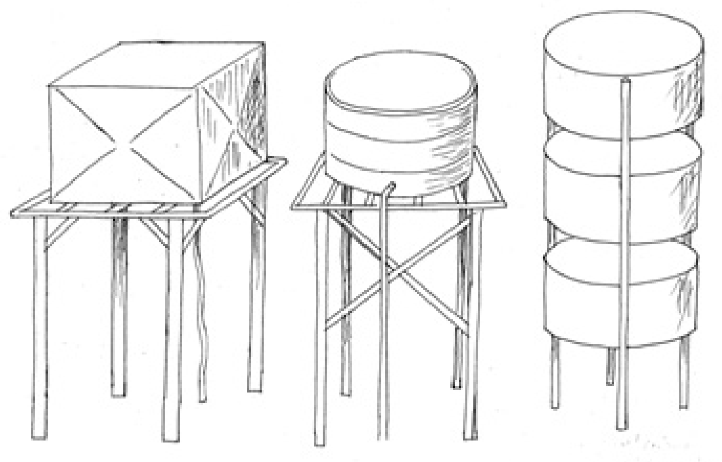


Fig 3.2 Head tanks as water storage facilities for a hatchery

ii. Soil

Site considerations should also include soil characteristics and land gradient. An impervious soil will hold water with little seepage. Land that is sloped provides a good drainage and allows the construction of ponds that can be supplied with water by gravity flow. A gravity fed system is cheap. For earthen pods ponds:

- Sandy or gravel soils should be avoided
- Clay soil or subsoil should be used
- Soils that compact well should be considered where concrete structures are proposed
- Hatchery labor is an expensive item in rearing fish and good hatchery design, including use of mechanized equipment, can eliminate a large percentage of the labor
- Seepage tests at the pond sites are highly desirable.

iii. Land use

Possible pesticide contamination of the soil and the presence of adjacent land use that may cause agricultural or industrial contamination should be investigated. Flood protection is also essential.

iv. Room for expansion

A suitable hatchery site should include sufficient land area for potential expansion of the facilities. Hatchery planners often overestimate the production capacity of the water supply and underestimate the facility requirements.

v. Buildings

The principal buildings of a fish hatchery include

- An office area for record keeping,
- A hatchery building,
- Shed to construct and repair equipment,
- Crew facilities and a laboratory for examining fish and conducting water analyses.
- The hatchery building should include facilities for egg incubation and fry and fingerling rearing and tanks for holding warm water pond- reared fish prior to shipment.
- Storage facilities must also be considered for feed, which may require refrigeration.
- Separate facilities should also be provided for chemical storage.
- Primary consideration should be given to the design and location of buildings and storage areas to create a convenient and labor saving operation.

vi. Earthen Ponds

Breeding ponds are often not deeper as grow out production ponds. Rectangular earth ponds usually are more convenient and efficient, and may range in size from 200m2 to 500m2 or more. Relatively smaller earth ponds do have relatively low water requirements and produce some natural food. Large ponds of irregular shapes are

- More difficult to clean,
- It is harder to feed and harvest fish
- Difficult to control disease in them.

When designing breeding ponds, harvest methods must be considered in the design. Although many of the fish can be seined from the pond before it is drained, ponds must be drainable and contain a catch basin or collection area for harvesting. Remember to ensure that

- The bottom of the pond should slope gradually toward the outlet from all sides.
- Pond banks should be built with as steep a slope as possible to avoid shallow-water areas along the edge of the ponds.
- Topography for construction of earthen ponds should be gently sloping and should have only moderate relief that can be economically removed.
- Pond banks must be stable and well drained,
- Cement is best for water supply lines and drainage canals.

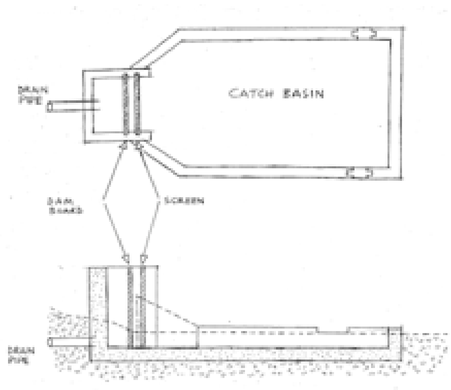


Fig 3.3 Pond outlet with a catch basin

A pond catch basin should have a supply line (arrow) to provide fresh water to the fish when they are collected in the basin.

vii. Selection of Rearing Facilities

In any hatchery construction there are several important objectives that must be kept in mind:

- To provide a compact rearing unit layout that will allow future development of the hatchery;
- To provide adequate intake and outlet water supply facilities to meet the special requirements of pond cleaning, treatment of fish for disease, and collection and handling of fish;
- To allow sufficient slope on pond bottoms for complete drainage and provide for a practical and efficient means of collecting fish for removal, sorting, or treating; and
- To provide adequate water and rearing space to safely accommodate the anticipated production of the hatchery.

viii. Carrying Capacity

Carrying capacity is the animal load a system can support. In a fish hatchery the carrying capacity depends upon water flow, volume, exchange rate, temperature, oxygen content, pH, size and species of fish being reared, and the accumulation of metabolic products. The oxygen supply must be sufficient to maintain normal growth. Oxygen consumption varies with water temperature and with fish species, size, and activity. When swimming speed and water temperature increase, oxygen consumption increases. As fish consume oxygen they also excrete metabolic products into the water. If the fish are to survive and grow, ammonia and other metabolic products must be diluted and removed by a sufficient flow of water. In a hatchery, it should be remembered that;

- Metabolic products increase with increased fish growth and overcrowding, ensue that the water flow must be increased.
- Low oxygen in seed rearing units may be caused by
  - Insufficient water flow, overloading with fish seed, high temperature which lowers the solubility of oxygen in water, or low oxygen concentration in the source water.
- At hatcheries with chronic low oxygen concentrations and comparatively high water temperatures, production should be held down to levels that safely utilize the available oxygen, or supplemental aeration will be required.
- A depleted oxygen supply can occur at night in ponds that contain large amounts of aquatic vegetation or phytoplankton, and fish kills may occur after the evening feeding. Here again, aeration may be necessary to increase the oxygen supply

Summary

A hatchery should have enough space for the pond, hapa or tank for broodstock, incubation/larval rearing and fry nursing and holding. However, the number and size of ponds, hapas or tanks depends on the scale of the operation. A combination of a hapa and tank based hatchery is probably the most common. Hapas are easy to install and less costly. They are also good in terms of maintaining the purity of broodstock.

Some hatcheries, tilapia and catfish are mainly tank and hapa based. Tilapia and catfish hatcheries which are mainly tank based are often heavily equipped with recirculation systems, aeration, light and temperature (heat) control. The most cost effective management of fish stocks amongst many hatchery operators in Malawi is pond-based system as it is the cheapest method. However, survival and purity of the broodstock and fry/fingerlings in ponds cannot be guaranteed as wild fish and other predator organisms can easily enter the ponds. At the same time, stocks cannot be easily recovered from ponds, and can never be recovered completely. However, simply installing hapas in ponds can make it a lot easier to handle fish and maintain pure stock.

Session Two

3.2 Hatchery Management

Introduction

Good husbandry practices in hatchery management are critical for a successful and profitable seed production operation. Most hatchery operators seek technical assistance when they see that there are facing challenges in their fish breeding operations. All this happens because they are missing some basics management aspects in their operations. Apart from seeing that seed is being produced in the hatchery set up, necessary standing operating practices must be followed at all times to ensure quality seed is being produced, raised and sold to out growers.

In this session, hatchery management has not only dwelt much on well-built "hatchery" with egg incubation jars, but also pond, hapa and tank culture (extensive culture). The objective of this session is to improve participants' knowledge on good fish hatchery management practices and enhance their skills in increasing fish seed production through improved husbandry practices. In good hatchery management husbandry practices, recruitment of good brooders, handling, feeding rate calculations, proper feeding, water quality management and keeping hatchery records have been elaborated. This section will therefore highlight the guidelines for hatchery management and also provide some of the important steps that will need to be followed when it comes to good hatchery management.

Aim

The aim of the chapter is to enhance knowledge, understanding and skills on good hatchery management practices

Objectives

Acquired knowledge

- Participants know
- Good hatchery management practices
- Water quality management in hatchery
- Importance of good water quality
- Preseason and post season hatchery activities

- Acquired skills

Participants to know how to

- Applying manure on ponds

- Acquired attitudes
- Control and management of a water system to minimize pathogen threats in a hatchery

- Relevance to fish seed production
- Good hatchery management for increased fish seed production

Mode of delivery

- Lectures, group discussions
- Duration : 60 minutes

3.2.1 Guidelines for Hatchery Management

There are certain guidelines that should be followed for a successful hatchery management and they can be as follows:

a. Predetermination of production goal

The following aspects should be taken into consideration to determine the production goal before any further steps are to be taken:

- The biology of fish species to be spawned
- The targeted number of seed required
- The availability of fish seed at the specific time
- Where they will be required

b. The appropriate production system to be used whether natural, semi natural or artificial

c. The required inputs including broodstock, fertilizers, labour, lime, feed, water

d. Outputs and where they will be utilized

e. Marketing including market capacity and prices taking into consideration seed from other sources and their prices

3.2.2 Basic things to monitor in a hatchery

Water Quality Monitoring

Water quality determines to a great extent the success or failure of a fish cultural operation. Physical and chemical characteristics such as suspended solids, temperature, dissolved gases; pH, mineral content, and the potential danger of toxic metals must be measured and monitored periodically. Careful and periodic monitoring of water quality parameters in a hatchery is therefore necessary. Parameters that must be monitored even on daily basis include:

- Temperature (°C or F);
  No other single factor affects the development and growth of fish as much as water temperature. It must therefore be within the optimal acceptable ranges for an effective seed production exercise. Many biological processes such as spawning and egg hatching are geared to annual temperature changes in the natural environment. It has to be known that:

- The species grown in Malawi, Coptodon rendalli, Oreochromis karongae, Oreochromis shiranus, Oreochromis mossambicus and Catfish, each the species has a temperature range that it can tolerate and within that range it has optimal temperatures for feeding, growth and reproduction Table 3.1.

- Major temperature differences between hatchery water and the streams into which the fish ultimately may be stocked can greatly lower the success of the hatchery operations.

- Within a hatchery, temperatures that become too high or low for fish impart stresses that can dramatically affect production and render fish more susceptible to disease.

Table 3.1 Optimal temperature range for species cultured in Malawi

Life stage	Tolerance oC	Optimal Range oC
Coptodon rendalli	8 - 41	24 – 28
Oreochromis karongae	12 - 40	20 - 35
Oreochromis shiranus	5.6 - 42	20 - 30
Oreochromis mossambicus	>7.9 - 42	17 - 35
Catfish	8 - 42	22 - 35oC

- Dissolved Oxygen (mg/l)
  Oxygen is the second most abundant gas in water as nitrogen is the first and by the most important. Fish cannot live without oxygen. Dissolved oxygen concentrations in hatchery waters are depleted in several ways, but chiefly by respiration of fish and other organisms and by chemical reactions with organic matter (feces, waste feed, decaying plant and animal remains). We should remember that:

- As temperature increases the metabolic rate of the fish, respiration depletes the oxygen concentration of the water more rapidly, and stress or even death can follow.

- Fluctuating water temperatures and the resulting change in available oxygen must be considered in good hatchery management.

- In ponds, oxygen can be restored during the day by photosynthesis and at any time by wind mixing of the air and water.

- In hatchery troughs, hapas and tanks, oxygen is supplied by continuously flowing fresh water.

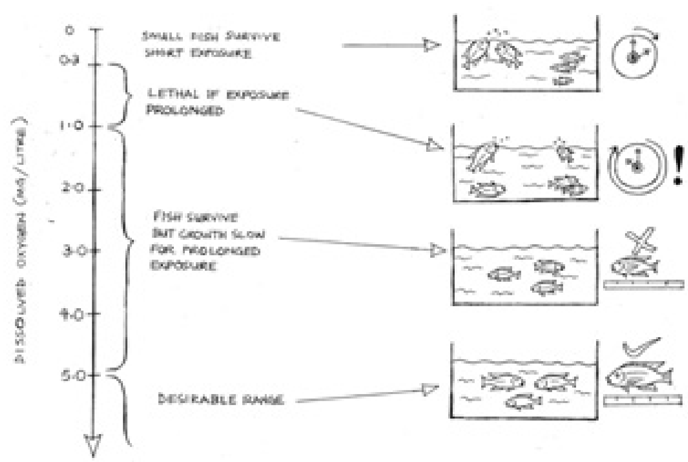


Fig 3.4 Effects of Dissolved Oxygen on fish

- Carbon Dioxide
  All waters contain some dissolved carbon dioxide. Spring and well water, which frequently are deficient in oxygen, often have high carbon dioxide content. Both conditions easily can be corrected with efficient aerating devices.

- Dissolved Gas Criteria

Various fish species have differing tolerances to dissolved gases. However, the following general guidelines summarize water quality features that will support good growth and survival of most or all fish species:

- Oxygen 5 parts per million or greater
- Nitrogen 100% saturation or less
- Carbon dioxide 10 parts per million or less
- Hydrogen sulfide 0.1 part per billion or less
- Hydrogen cyanide 10 parts per billion or less

In general, oxygen concentrations should be near 100mg/l saturation in the incoming water supply to a hatchery. A continual concentration of 80mg/l or more of saturation provides a desirable oxygen supply.

- **Suspended Solids**

"Turbidity" is the term associated with the presence of suspended solids. Analytically, turbidity refers to the penetration of light through water (the lesser the penetration, the greater the turbidity), but the word is used less formally to imply concentration (weight of solids per weight of water). Turbidity has to be controlled in seed production because

- Can make it more difficult for fish to find food or avoid predation.
- Can smother fish eggs and the bottom organisms that fish may need for food.
- Turbid waters can clog hatchery pumps, filters, and pipelines.
- It also restricts light penetration thereby limiting photosynthesis and the production of desirable plankton in ponds.

- **Acidity**

Acidity refers to the ability of dissolved chemicals to "donate" hydrogen ions (H^). The standard measure of acidity is pH, the negative logarithm of hydrogen-ion activity. The pH scale ranges from 1 to 14; the lower the number, the greater the acidity. A pH value of 7 is neutral; that is, there are as many donors of hydrogen ions as acceptors in solution. Fish should not be cultured outside the range of 6.5-9.0. Many fish can live in waters of more extreme pH, even for extended periods, but at the cost of reduced growth and reproduction. Ammonia toxicity becomes an important consideration at high pH.

- **Salinity**

All salts in a solution change the physical and chemical nature of water and exert osmotic pressure. Some have physiological or toxic effects as well. Fish take in water and very actively excrete large amounts of water in the form of urine from the kidneys. Salinity and dissolved solids are made up mainly of carbonates, bicarbonates, chlorides, sulphates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances. Mineral deficiencies in the water may cause excessive mortality, particularly among newly hatched fry.

- **Pesticides**

Many pesticides are extremely toxic to fish. Much lower concentrations may be toxic upon extended espouse. Even if adult fish are not killed outright, long term damage to fish populations may occur in environment contaminated with pesticide. The abundance of food organisms may decrease, fry and eggs may die, and growth rates of fish may decline. It is therefore necessary to ensure that

- Water is not diverted to hatchery unit when pesticides have been used around the area
- You know the crops being grown in an area and pesticides being used
- Know the pesticides application schedule amongst farmers in the area.

- **Aeration**

Water from springs and wells may carry noxious gases and be deficient in oxygen; lake and river sources also may have low dissolved oxygen contents. Toxic gases can be voided and oxygen regained if the water is mechanically agitated or run over a series of baffles.

- **Hatchery Pollutants**

Generally, three types of pollutants are discharged from hatcheries:

- Pathogenic bacteria and parasites;
- Chemicals and drugs used for disease control;
- Metabolic products (ammonia, feces) and waste food.

Pollution by the first two categories, if it occurs,

- Water must be sterilized of pathogens, disinfected of parasites, and detoxified of chemicals.
- Effluent water can be sterilized
- Drug and chemical detoxification should follow manufacturers' instructions or the advice of qualified chemists and pathologists.

The third category of pollutants—waste products from fish and food,

- Is a constant feature of hatchery operation, and usually requires permanent facilities to deal with it.
- Two components; dissolved and suspended solids - need consideration. Dissolved pollutants predominantly are ammonia, nitrate, phosphate, and organic matter.

Fish Feed

Feed also contributes to Biological Oxygen Demand (BOD), commonly used as an index of pollution; it is the weight of dissolved oxygen taken up by organic matter in the water. Uneaten feed reduce the oxygen levels in the water. Right amount of feed and size should always be fed to fish. Any uneaten feed must be removed

3.3 Rearing Unit Management

- **Sanitation**

Sanitation is so important in fish seed production. A number of undesirable situations can arise when waste feed and fecal material collect in rearing units. If fish feed falls into waste material on the pond, tank or hapa bottoms, fish will generally ignore it and it will be wasted.

- Excessive feces and waste feed harbor disease organisms and can accumulate in the mucus of the gills, especially during disease outbreaks.

- Disease treatment is also difficult in filthy rearing units because treatment chemicals may react with the organic matter, reducing the potency of the chemical.

- The waste material may become stirred up as the chemical is mixed in the water; this can be hazardous to the gills of the fish. Tanks, hapas, troughs, and hatchery equipment must be cleaned frequently.

- In large earthen ponds, accumulated waste may reduce the oxygen content of the water. This can become a severe problem during periods of reduced water flow in the warm months.

- **Water Supply Structures**

The water supply for a fish hatchery should be relatively silt-free and devoid of vegetation that may clog intake structures. For this reason,

- An earthen ditch is not recommended for conveying water because of algal growth and the possibility of aquatic vegetation becoming established.
- At hatcheries with a silt problem, a filter or settling basin may be necessary.
- The water intake structure on a stream should include a barred grill to exclude logs and large debris, remove smaller debris and stop fish from entering the hatchery.

- **Screens**

Various materials have been used to construct pond or tanks screens. Door screening and galvanized hardware cloth can be used, but clog easily. Wire screening fatigues and breaks after much brushing and must be replaced periodically. Perforated sheet aluminum screens are used commonly in many fish hatcheries today. They can be mounted on wood or metal angle frames.

3.3.1 Pond Management

- **Preseason Preparation**

Proper management of earthen ponds begins before water is introduced into them. During the dry season it is advisable to dry and disk ponds to promote aerobic breakdown of the nutrient-rich sediments.

- Relatively new ponds with little buildup of organic material, or those with sandy, permeable bottoms that allow nutrients to escape to the groundwater, are less likely than older or more impermeable ponds to require drying and disking.

- They may actually leak if the bottom is disturbed, and it may be necessary to compact their bottom with a sheep's' foot roller, rather than to disk them.

- If a pond is to remain dry for several months it should be seeded around the edges. This cover prevents erosion of pond dikes and it can be flooded in the spring to serve as a source of organic fertilizer.

- The grass should be cut and partially dried before the pond is refilled, or its rapid decay in water may deplete dissolved oxygen.

- Application of agricultural lime during the fallowing period, followed by disking, may improve the buffering capacity of a soft-water pond. Fertilizers are often spread on the pond bottom prior to filling, and nuisance vegetation may also be sprayed at this time.

Wild-Fish Control

Wild fish must be kept from ponds when they are filled, as they

- Compete with cultured species for feed,
- Complicate sorting during harvest,
- May introduce diseases,

Proper construction of the water system and filtration of inlet water can prevent the entrance of wild fish.

- A sock filter is made by sewing two pieces of 3- foot- wide material into a 12-foot-long cylinder, one end of which is tied closed and the other end clamped to the inlet pipe
- This filter should be used only on near-surface discharges, to prevent excessive strain on the screening.
- If the water supply contains too much mud or debris and cannot be effectively filtered, ponds can be filled and then treated with chemicals to kill wild fish.

3.3.2 Fertilization Procedures

Fertilization promotes fish production by increasing the quantity and quality of food organisms. Bacteria are important in the release or recycling of nutrients from fertilizers. Once in solution, nutrients stimulate growth and reproduction of algae which, in turn, support populations of zooplankton and water temperature.

- Not all ponds should be fertilized; fertilization may be impractical if a pond is too large or too small. Turbid or muddy ponds with light penetration less than 15cm should not be fertilized
- In colder areas where winterkill is common in shallow productive ponds, fertilization may be undesirable.
- Inspect ponds before they are fertilized. Use of a secchi disc reading to determine the water turbidity; oxygen determinations on any pond where low oxygen concentrations are suspected, and observation of nesting locations in spawning ponds.
- Measure fertilizer on platform or hanging scales or with pre-calibrated buckets before applying. Calibrate a bucket for each type of fertilizer used as fertilizers vary considerably in density.
- Fertilizer should not be spread in areas where nesting activity is underway or into schools of fry.
- Don't wade on the bottom as it stirs mud, destroy fish nests, eggs, and fry

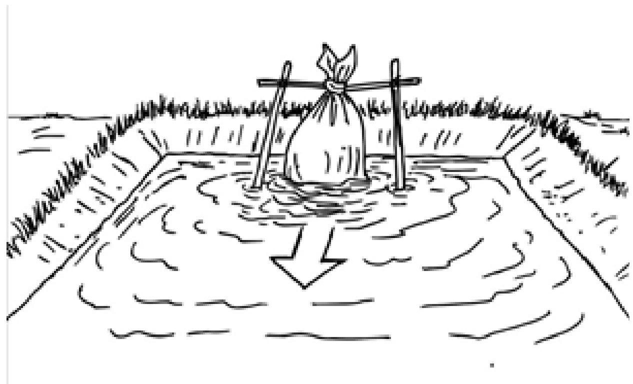


Fig 3.5 Fertilizing a pond by hanging a bag of manure

Organic materials such as composed plant residues, manure, stable drainage, slaughter house waste and municipal sewage are very good sources of nitrogen. They also contain in a large percentage of organic carbon as well as other minerals in small amounts. Organic fertilizers are based. Organic fertilizers are recommended for only seed production to accelerate the production of zooplankton in rearing ponds. The advantages of organic fertilizers are;

- Shorter cycle for plankton production than inorganic fertilizers
- Decomposition to release CO_2, which is used by plants for growth
- Aid in clearing silt-laden waters
- Use as supplemental feed

The advantages of organic fertilizers are;

- Cost might be higher depending on area and its availability
- May deplete the oxygen supply
- May stimulate filamentous algae growth
- Require more labor to apply than inorganic fertilizers

Inorganic fertilizers are relatively inexpensive sources of nitrogen, phosphorus, and potassium, which stimulate algal growth, and calcium, which helps to control water hardness and pH. Fertilizers should only be added when there is a need to do so. If development of phytoplankton is delayed longer than four weeks, nitrogen should be added.

Combining Fertilizers

Combining organic and inorganic fertilizers is a common practice. In hatchery rearing ponds where draining is frequent and time for development of a suitable food supply often is limited, combining organic and inorganic fertilizers in a ratio of 3:1appears to be advantageous.

During critical periods of the summer, the oxygen concentration should be monitored. This is most easily accomplished at dusk and two or three hours later. Dissolved oxygen problems may arise in spite of precautions. Corrective measures for specific problems are suggested below.

- If there has been an excessive kill of pond weeds or plankton that is decaying. Low dissolved oxygen may be caused by excessive rooted vegetation and a lack of phytoplankton photosynthesis

- If the problem is caused by too much supplemental feed, drastically reduce or eliminate feeding until the anaerobic condition is corrected. Drain off foul bottom water. Refill the pond with fresh water Low dissolved oxygen may result from excessive application of organic fertilizers, which over stimulates plankton production.

- If a substantial amount of foul bottom water exists, the pond should never be mixed, because the oxygen deficit in the lower water layer may exceed the amount of oxygen available in the surface layer.

- Drain off the anaerobic water and replace it with fresh water from a stream, well, or adjacent pond.

- An effective technique is to pump water from just below the surface of the pond and spray it back onto the water surface with force.

Aquatic Vegetation Control

Aquatic plants must have sunlight, food, and carbon dioxide in order to thrive. Elimination of any one of these requirements inhibits growth and eventually brings about the death of the plant. Water plants are most easily controlled in the early stages of development. Aquatic weeds must be controlled for the following reasons:

- On a cloudy day they slows photosynthesis;
- On a hot still day they cause stratification;
- They are hiding places for pathogens and predators

Summary

In this session, hatchery management has not only dwelt much on well-built "hatchery" with egg incubation jars, but also pond, hapa and tank culture (extensive culture). For an increased fish seed production, improved husbandry practices must be followed. It has been see that good management includes recruitment of good brooders, good handling to minimize stress and mortalities, proper feeds and feeding, water quality management and keeping hatchery records. Good sanitation in rearing facilities for both brooders and seed has to be observed. Prevention of pathogen and diseases has seen to be very important in a hatchery set up. Fertilization promotes fish production by increasing the quantity and quality of food organisms, the type of fertilizes to be used and their application rates have been elaborated.

Broodstock Source and Management

Introduction

The supply of fry and quality fish seed is one of the major challenges to the development of aquaculture in Malawi. The majority of fish farmers rely on recycling seed from their own ponds, buying seed from grow out ponds of their fellow farmers or catching them from the wild. As poor or stunted broodstock and fish seed is sued, production is always compromised. There is therefore a need for hatchery operators to know the right sources of brooders and the husbandry requirements of the broodstock or the ways in which they might be managed to optimize seed production and improve on the quality of eggs and larvae. An overview on how broodstock can be identified and sex them, feed requirements during condition and how to enhance spawning has been explained. This chapter has been written as a standard guide on broodstock sources and management

Aim

The chapter seeks to improve participant's knowledge, understanding and skills on the identification of brooders, recruitment, selection, sexing, handling and transportation of broodstock. The participant will further have acquired skills on breeding and spawning of tilapia and catfish.

Learning objectives
Acquired knowledge

- Participants know how to
- Identify sources of brood stock
- Understand brood stock feed requirements and transportation

- Acquired skills
  Participants to know how to
- Select, sex and condition the brooders
- Breeding or spawning of fish
- Collect and transport broodstock

- Acquired attitudes
- Quality broodstock and management for improved seed production

- Relevance to fish seed production
- Good broodstock sources and quality is key to improved fish seed quality

Session Overview
This section is comprised of two sessions

Session 1: Sources of brood stock, handling and transportation
Session 2: Selection, counting, sexing and conditioning, breeding or spawning

Mode of delivery: Lectures, Group Discussions and Practical
Duration: 60 minutes

Session One

4.1 Broodstock Sources, handling and transportation

Broodstock are prerequisite and foundation of any seed production programme. Broodstock, or brood fish, are a group of mature individuals used in aquaculture for breeding purposes. Good broodstock assures better breeding responses, increased fecundity, fertilization, hatching and larval survival rates and more viable fish seed.

Collection of broodstock in adequate numbers, cataloging of their geographical origin and maintaining their pure records are important prerequisites for the seed production exercise. Further proper handling, transportation and their health maintenance are important management aspects.

4.1.1 Sources of broodstock

Hatchery operators practice a very diverse set of strategies for sourcing broodstock, based on a variety of opportunities and constraints. The first broodstock should be from a reliable source because it will form the basis of the stock for a considerable time. Broodstock can be sources from the following:

- Wild sources – can be collected from natural water bodies such as rivers and lakes.
- Government, University Farms and Research Institutions – can be collected either from normal hatchery operations or could be collected from selective breeding programs.
- From the first set of broodstock - hatchery operators can produce their own broodstock on-farm with proper management, as this is more reliable and cheaper.
- Broodstock can also be collected from other Farmers. Caution should be taken when collecting broodstock from other farmers not to collect very old fish and also to get information about the source the dates the broodstock was collected by the famer
- Capturing and handling of wild fish populations should utilize methods that minimize stress.
- The farmer should always keep record of the source of broodstock, number collected from each source, costs and any other observations made.

4.1.2 Broodstock Collection, Handling and Management

In fish farming, fish are frequently handled. It is not uncommon to lose an entire collection of brooders from several days' effort during transportation. It is therefore very important that brooders are handled with utmost care right from the time they are collected up to the time they are stocked into the receiving enclosures.

When catching broodstock in the wild, ensure that

- Experienced fishermen must be recruited to catch fish whether in the wild or ponds.
- Fish must be caught using appropriate nets and traps.
- Drag the net early in the morning or late in the evening when it is cool so as not stress the fish
- Minimize the time fish spend in any type of net, even in large trap nets, prior to transportation
- You need aeration when using tanks or you constantly replace water with the water from the water body.

4.1.3 Broodstock conditioning before transportation

Brood stock conditioning is done to make the fish adapted to the transportation process. It enables that only strong fish are taken out of the collected pool.

- Keep broodstock in ponds, concrete tanks or hapas placed in pond, river or lake from where the fish is collected for 24 – 48hrs.

- Stop feeding the fish to reduce metabolic activities. This reduces water contamination during transit.

- Remove weak and dead fish from conditioning Hapas or tank.

- Before stocking, bath the brood stock in 3~5% salt solution (5g of salt in 1 litre of water) for 10- 15 min to remove parasites

- To ensure that mortality is remarkably minimized, sedate fish with tranquilizers especially where broodstock is to be transported over long distances

- One of the tranquilizers mostly used is ethyl-amino benzoate dissolved in 95% ethanol at a ratio of 1 part ethyl - amino benzoate to 99 parts ethanol makes an aesthetic solution. The dose is 700ppm and the fish gets sedated after 60 seconds

- Don't expose fish to direct sunlight

- All surfaces coming in contact with fish, such as nets, hands, or clothes should be thoroughly moistened.

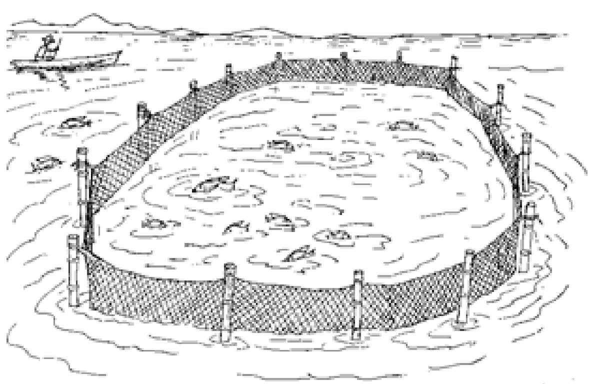


Fig 4.1: Conditioning broodstock before transporting is necessary

4.1.4 Broodstock packaging for transportation

After collecting adequate broodstock numbers, eliminating all fish that are injured and showing signs of sluggish swimming behaviors. The selected broodstock should be transported properly from source to the intended destination.

- Broodstock must be handled very carefully and must not be squeezed
- As a rule, all surfaces coming in contact with fish, such as nets, hands, or clothes should be thoroughly moistened.

- Handle fish with scoop net and not direct with hands
- Don't expose fish to direct sunlight
- Avoid overcrowding of fish in containers.
- To ensure that mortality is remarkably minimized, there is need to sedate the fish with tranquilizers especially where good brood stock is to be transported over long distances
- One of the tranquilizers mostly used is ethyl-amino benzoate dissolved in 95% ethanol at a ratio of 1 part ethyl - amino benzoate to 99 parts ethanol makes an aesthetic solution. The dose is 700ppm and the fish gets sedated after 60 seconds

This transporting process is technically demanding and requires the use of appropriate equipment and competent personnel with relevant skills to ensure that fish are handled with minimum stress and injury to reduce mortalities. Broodstock can be transported using

- Oxygenated polyethylene (plastic) bags,
- Containers,
- Fiber glass tanks,
- Ordinary buckets, and
- Drums

Oxygenated plastic bags

Tank for transporting brooders

4.1.5 Transporting Brood Stock

- **In Tanks**

- Tanks should be used if you are transporting the fish over short distances, unless the tanks are being aerated.
- To reduce fish stress, tightly secure the tank in the truck to avoid its unnecessary movement
- Fill the tank with adequate clean water but not chlorinated water.
- Handle the fish with scoop nets when putting or removing the from the tank to avoid injuries and stress
- Stock tank with brood stock (300-400 pieces of average weight 150g in 1000L tank) or at appropriate densities depending on distance, size of fish and water temperature.
- Cover the opening of the tank with hessian sack tied with a rope to protect fish from direct exposure to the sun and from jumping outside
- Regularly check signs of fish stress (gasping for oxygen, erratic swimming) and replace water when

travelling long distance.
- In some cases, use oxygen cylinder fitted with compression release valve to supply water in the tank through air stones.

Make sure you have extra oxygen cylinder and compression release valve incase oxygen gets depleted in the cylinder and valve gets damaged respectively

- **Transporting Broodstock in Plastic Bags**
- Check for holes in the plastic bags before pouring in water.
- Double the bags by covering one on top of the other.
- Fill ¼ of the bag with water (approximately 7 – 10 L)
- Put 10 to 15 pieces of brood stock weighing about 150 – 200g in each bag.
- Remove atmospheric air in the bag by pressing the top of the bag over the water.
- Fill the bag with oxygen from the cylinder
- Tie the bag tightly with rubber band to trap oxygen filled in it.
- Put bags on a surface free of sand and other sharp objects before loading into truck.
- Count the number of bags to tally with collected number of brood stock.
- Clean the floor of the truck with water and put a wet sac or hapa material to act as a cushion for the bags during transit.
- Pack the bags with fish in the truck in an orderly manner.
- Transport the fish when it is cool preferably early in the morning or in the evening.
- Ensure proper and speedy handling of the fish as this will result in successful live fish transfer.

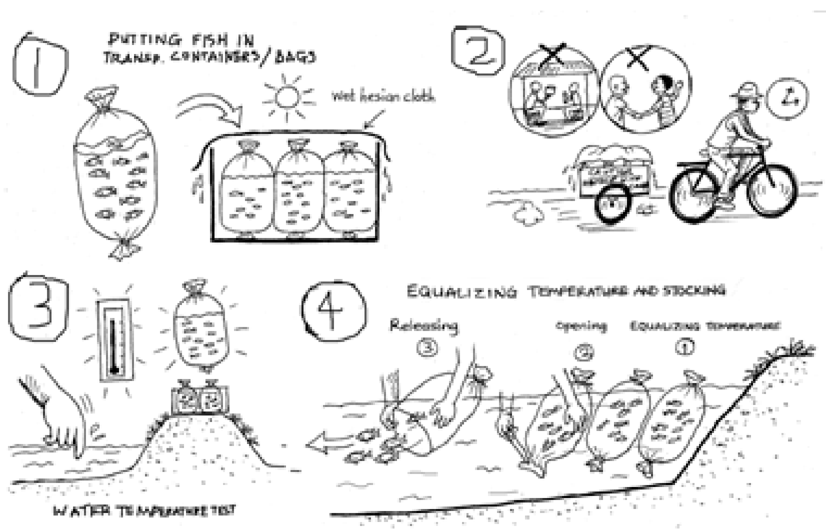


Fig 4:2: Transporting fish in plastic bags, observing temperature and releasing into ponds

4.1.6 Factors to consider when transporting broodstock

The quantity of fish and equipment used for fish transportation takes into account of several factors such as;

- **Mode of Transport**

Success or failure in moving fish from source to the intended destination is dependent on the handling, mode of transport and time taken. Always remember that, the faster and easier the mode of transport, the higher the chances of having a successful exercise. However, fish thrown around in a poor designed transportation unit are prone to stress and increased chances of mortality.


Fig 4.3 and Fig 4.4: Other modes of transporting broodstock

- **Distance and Duration**

In general the shorter the distance moved or the time taken for transportation the less chance there is for mortality and the greater the number of fish that can be carried in a unit volume. For short distances simple containers, such as calabashes, buckets, tubs, bins and cans can be used. Aircraft are sometimes required when long distances need to be covered quickly

- **Temperature of water**

Every fish species has an optimum temperature range for its survival. If the temperature is either too high or too low, it could lead to death of the fish. Also as temperatures increases the amount of dissolved oxygen decreases, therefore it is better to carry fish in water whose temperature has been progressively lowered and maintained.

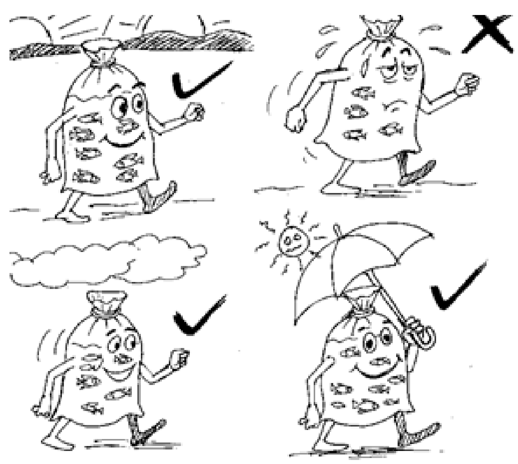


Fig 4.5: Packaged fish should not be exposed to direct sun

- **Relative resistance of the fish**

Some species are more resistant to stress than others and can tolerate being left out of water for short periods. Resistant species include catfish

- **Nature of the container**

The containers used in transportation are varied and tend to be adapted to the size of the fish, species of fish, or the quantity of fish to be carried. Use of containers is ideal for the movement of fish from one pond to another or to a neighboring farm. If buckets are being used, they should be covered with a wet sack to keep the water cool by preventing direct sunlight from reaching it. The number of fish per bucket depends upon the size of the fish and the volume of the bucket and temperature

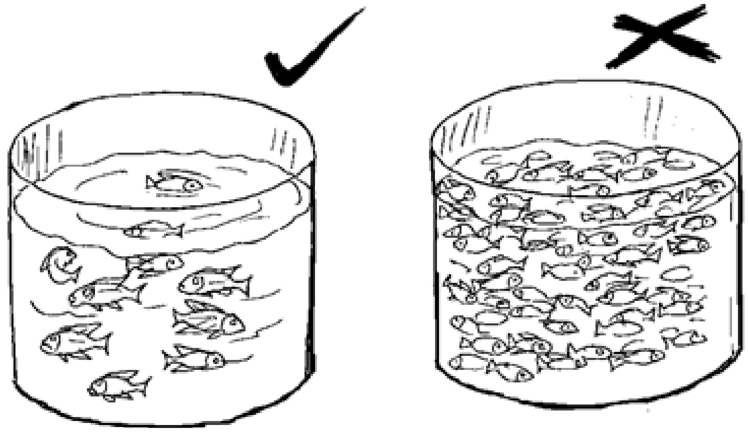


Fig 4.6 Fish should not be overstocked in transporting facilities

- **Water Quality**

- Oxygen

The most important single factor in transporting fish is providing an adequate level of dissolved oxygen. However, an abundance of oxygen within a tank does not necessarily indicate that the fish are in good condition. The ability of fish to use oxygen depends on their tolerance to stress, water temperature, pH, and concentrations of carbon dioxide and metabolic products such as ammonia.

o The importance of supplying sufficient quantities of oxygen to fish in distribution tanks cannot be overemphasized.
o Failure to do so results in severe stress due to hypoxia and a subsequent buildup of blood lactic acid, and may contribute to delayed fish mortality. Ample oxygen suppresses harmful effects of ammonia and carbon dioxide.
o Dissolved-oxygen content of transport water preferably should be greater than 7 parts per million, but less than saturation.
o On oxygen concentration, it is more practical and economical method is to introduce oxygen directly from pressurized cylinders into the circulating water.
o Control of water temperature, starving fish before they are transported, and the addition of chemicals and anesthetics to the water have reduced hauling stress.

4.1.7 Broodstock conditioning after transportation

After the brooders are brought to the hatchery, they have to be acclimated to the hatchery conditions by transferring the brooders to ponds, hapas or tanks containing the water used in the hatchery, and quarantined. Care must be taken to do this slowly in case there is considerable difference in salinity, pH and temperature. After acclimatizing the broodstock, follow these steps;

- Have them treated in a bath containing a mix of 200 ppm formalin and 0.2 ppm malachite green for 1 hour and immediately transfer the fish to freshwater.
- Transfer them to quarantine ponds, which may also act as conditioning ponds.
- Fish should be quarantined in a totally independent and separate part of the hatchery. At this stage the fish may be segregated into sexes and each sex kept in separate quarantine ponds.
- Ponds should be continuously inspected on a daily basis. In case brooders exhibit some sign of

disease such as lying on one side, the fish should be eliminated or if resources may permit

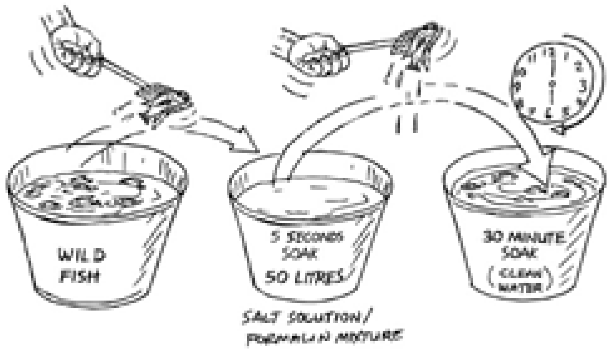


Fig 4.7: Treating fish for pathogens before conditioning

Broodstock Management

Generally brood stock management program is divided into two broad categories and these are:

- The pre-spawning which includes procedures such as
- Selection of suitable brood stock and procurement,
- Acclimatization,
- Maintenance,
- Maturation,
- Spawning, and hatching.
- The post-spawning management program which includes
- Facility maintenance,
- Water quality management,
- Broodstock selection,
- Health management,
- Risk assessment,
- Health management,
- Documentation, and
- Record keeping.

As we know that the quality improvement of brooders is directly related to the nutritional requirement, therefore

- Proper high nutrient feed with balanced ingredients should be provided.
- Tilapia females should be provided high nutrient feed after their incubation period as they starve for the entire period (10–13 days).
- Initiatives should be directed at the development of low cost feed with the desired nutrient quality.

Therefore, alternative feed sources or an appropriate formulation for farmer-made aqua-feeds should be made available for small-scale farmers.

- Mouth-brooding tilapia females undergo a non-feeding stage during buccal incubation which lasts for 10–13 days. Female tilapia need to be fed actively with quality feeds after this period to regain body condition lost during incubation and to obtain energy to support further reproductive activity.

Most small-scale hatcheries may not meet this feed requirement due to the high cost.

One striking area that is lacking in brood stock management is the procedures for brood stock quarantine. Quarantine facilities are essentially a closed holding area where brood fish are kept in individual tanks until the results of screening for known diseases or disorders are known. Quarantine holding facilities should ideally be kept some distance from the hatchery. In cases where this is not possible, measures should be taken to ensure that there will be no contamination from the holding facility to the other production areas.

The success of the fish seed nursing is critical as the fish seed production of a hatchery is measured by the quality output from fry nurseries. Nursery operation can be carried out in two ways:

a. Single-stage operations where hatchlings are raised until fingerling stage and
b. Two-stage operations such as:
i. Raising hatchlings to fry and
ii. Raising fry to fingerlings.

Summary

Broodstock sources are critical for the production of quality seed. We have to take brooders from reliable and credible sources. Careful handling and collection of brooders has to be observed and experienced people have to be used to minimized stress and mortalities. If broodstock is being taken from a distant place, conditioning before transportation will allow fish to rest and not affect water quality during transportation. Broodstock management falls into pre-spawning and the post-spawning periods. Conditioning helps to only take strong brooders. Packaging for transportation and use of proper packaging materials is important. Mode of transport has been discussed. Water quality and temperature amongst other parameters have been seen to be observed during broodstock transportation. Once fish have arrived at our farm, they have to be acclimatized and conditioned before setting up of the breeding facilities man agent is critical for broodstock transportation and must be observed to prevent mortalities. Proper documentation and record keeping has seen to be critical in broodstock collection and management.

Session Two

4.2 Broodstock Selection, Sexing and Conditioning

Aim

The chapter seeks to improve participant's knowledge, understanding and skills on the identification of brooders, recruitment, selection, sexing for c, handling and transportation of broodstock. The participant will further have acquired skills on breeding and spawning of tilapia and catfish.

Learning objectives

Acquired knowledge

- Participants know
- Importance of sexing Sex and condition broodstock
- Understand brood stock feed requirements and transportation
- Stocking rate of brooders in ponds and hapas

- Acquired skills
  Participants to know how to
- Select healthy brooders
- Sexing and conditioning brooders
- Calculate feed requirements for brooders

- Acquired attitudes
- Quality broodstock and management for improved seed production
- Requirements for brood stock conditioning

- Relevance to fish seed production
- Good broodstock sources and quality is key to improved fish seed quality

Session Overview

Session 2: Selection, counting, sexing and conditioning, breeding or spawning

Materials: Study the session notes and print hand-outs, flip- chart paper, markers, brooders, buckets of water

Mode of delivery: Lectures, Group Discussions and Practical

Duration: 60 minutes

4.2.1 Broodstock Selection and Sexing

One of the most common problems in selecting broodstock from rearing ponds is that only undersized and undergrowth fingerlings are left for selection, since the table-sized fish have been sold. The selection of species depends on the purpose and market demand. Broodstock should be selected by skilled personnel using the following selection criteria;

- Well rounded and soft belly, carries good number of eggs
- Healthy fish and not deformed,
- The size of brooders should range from 100g – 250g with bright colors and strong swimming ability
- Without diseases and physical injuries or wounds

When selecting brooders, we should remember that production of fingerlings per kg of female will decrease as the average weight of female increases.

This occurs because of 3 factors:

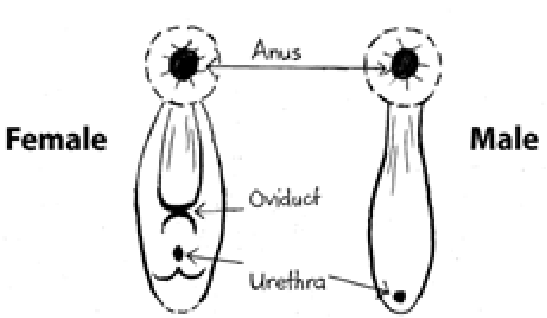
- Fertility decreases as weight increases.
- Frequency of oogenesis decreases as weight increases.
- Males reproduce less frequently with large, aggressive females.
- Among substrate spawners, sex-ratios must be reduced, 2:1 (female to male) ratio like that of Coptodon rendalli

Sexing

Sexing is way of separating males from females before they are put into different ponds for conditioning. The number of males and females reserved should be 1.5 times the amount needed for breeding. During male and female identification, we have to remember that;

- Males have one visible opening while females have two
- Males tend to change colour to dark in the breeding season
- Experienced personnel should be trusted with the separation of males and females

Note: A total of 150 tilapias should be selected at random, their weight and length measured, and get the average values; then use average value to select the brood stock



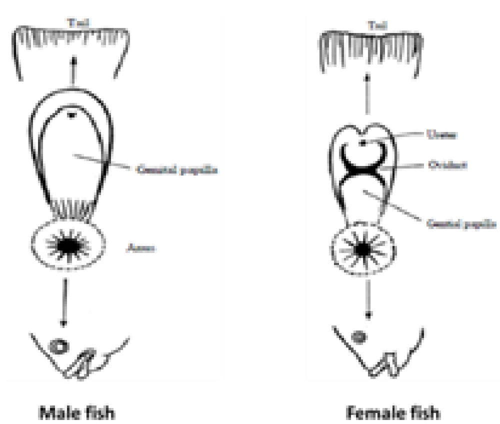


Fig 4.8 and 4.9: Showing sex of male and female fish

4.2.2 Broodstock Stocking Rate

- **Stocking Rate in Ponds**

The ponds are usually stocked at a rate of 100 to 200 kg broodstock per hectare where a sex ratio of 1:3 or 1:4 male to female is maintained. The brooders selected for stocking are not big but usually weigh >100 g. A female brood fish of 90-250g produces as many as 500 eggs per spawning. However, a single brood fish may be used for a period of 2-3 years.

- **Stocking rate of the brooders in hapas**

For tilapias, stocking densities in hapa are generally maintained from 4 - 5 brooders/m2 weighing between 100 and 350 g and sex ratio 3:1 to 7:1 (female:male). The sex ratio is selected on the basis of reproductive behavioral patterns of the species intended for breeding and brooders are generally changed after 24 or 36 months by most of the hatchery operators.

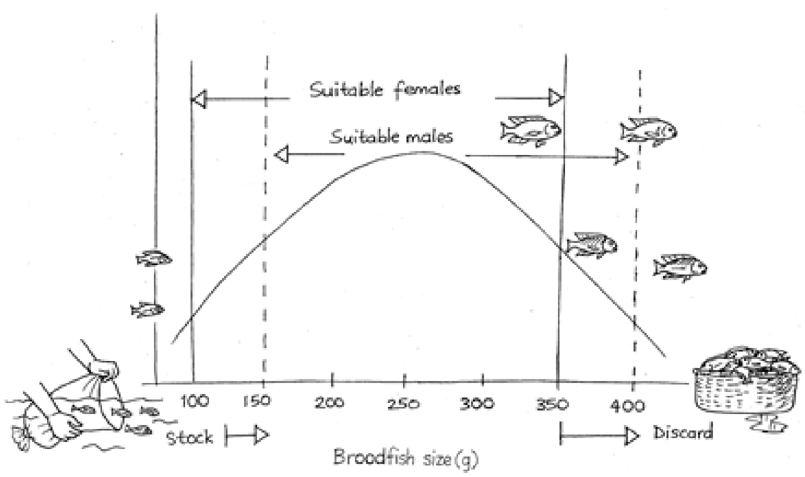


Fig 4.10: Male and female broodstock size range selection

4.2.3 Fish feeding in breeding facilities

When tilapias are in breeding facilities, they should be given good quality feed at the right intervals. It should be noted that

- Brooders should be given feed with higher protein content for them to easily rebuild their bodies after spawning.
- Feed intake can drop as low as 0.3-0.4% of body weight per day during ad libitum feeding, when the fish are fed high- protein diets containing 48-49% protein.
- Fish typically lose 10 -20% of their body weight during spawning season. Much of this is due to release of sperm and eggs, and is most pronounced in females.
- Feeding maybe interrupted during courtship or during periods when the nest and fry are being protected against predators.
- Close attention should be given to the quality and availability of the feed fish is being provided. The feed should be acceptable by the feed and in right amounts.

Therefore, it is essential to recognize the right quantities of feed, number of feeding times and methods of feeding the fish under different culturing systems, in order to achieve high rates of growth and feed conversion

4.3 Tilapia breeding/spawning

Fish breeding is the process of raising fish in enclosed facilities to produce young ones. The process of fish spawning or breeding and fry production is considered one of the most important steps in aquaculture. It is also one of the limiting factors to the advancement of aquaculture in Malawi as it is difficult to satisfy the requirement of fish seed through collection form the natural sources. There are two main methods of spawning tilapia and these are natural spawning and artificial or induced spawning.

4.3.1 Natural spawning in the wild

In this method, fish are left to breed naturally whether in confinement or in their natural environment Natural spawning falls into two categories thus (a) natural in wild (b) natural breeding under open systems (c) natural breeding under indoor hatchery (d) Semi natural spawning

a. Natural Spawning in the wild
- Fish are not controlled in any way in the wild
- Relies on collection of seed from the wild

o Advantages of this method
- Low cost
- No need for advanced technology
- No need for broodstock maintenance
- No spawning and fry nursery required

o Disadvantages of this method
- Dependent on the success of spawning of fish in the wild to get required seed
- Available numbers of seed are dependent on the survival if eggs and fry in the wild
- Difficult to catch single species of fry as undesirable species and sizes are caught
- Collected fish might have pathogens and diseases (e.g. EUS)
- Frequent collection of seed can lead to over exploitation of stock from the wild
- Collection of seed depends on what the fish produce

b. Natural Breeding under Open System (Broodstock are selected)

This method is by simply stocking broodstock in a pond that is used for both spawning, hatching and fry nursery simultaneously. There is continuous skimming of fry from the breeding ponds. Appropriate tools for skimming (triangular shaped frame with fine mesh size in between) can easily be constructed on site.

o Advantages of this method
- Does not require many facilities
- No need for advanced technologies
- Not labor intensive
- More controlled species than the natural breeding in the wild.

o Disadvantages of this method
- Possible predation on broodstock, eggs, larvae, fry and fingerlings
- Possible vertical transfer of pathogens from broodstock to off springs
- Difficult to predict number of seeds to be found
- Difficult to manage production as there are unknown numbers of fish present in the pond
- No size uniformity on produced seeds due to lack of control over the spawning process

- No control of mortality losses during hatching and nursery stage

c. Natural breeding under indoor hatchery

- Spawning and fertilization occurs in the confinement
- Eggs are harvested from hapas for artificial incubation in the hatchery
- Harvested eggs are classified into groups bases on stage of egg development and strain of fish
- Green house can be used to prolong breeding season of the fish into the cold season and for brood stock conditioning

o Advantages of this method

- Controlled growth of seed
- Good number can be achieved
- Uniform sized seed can be produced
- Easy to do sex reversal for tilapia

o Disadvantages of this method

- Requires skilled personnel
- Labor intensive

d. Semi - Natural Spawning

This method is simply by stocking of brooders into ponds, tanks or hapas and eggs or larvae are collected and incubated in other facilities for hatching or rearing.

o Advantages of this method

- Controlled growth of seed
- Good number can be achieved
- Uniform sized seed can be produced

o Disadvantages of this method

- Requires skilled personnel
- Labor intensive

4.3.2 Artificial spawning – Induced Spawning

Fish breeding is done in controlled conditions. This process takes place by stimulating the brood fish by different stimuli to induce the spawning process.

o Advantages of this method

- Can manipulate and induce species that doesn't easily spawn in captivity
- Protection of broodstock and off spring during the critical stages of their life
- Control and avoidance of pathogens and diseases
- Full knowledge of possible numbers of eggs, larvae, fry and seed during different stages
- Allows easy utilization of artificial feeds
- Uniformity of seed produced

o Disadvantages of this method

- Labor intensive
- Requires skilled labor
- Requires a lot of facilities and supplies

- Water quality management is critical
- Requires good fish feeds for both brooders and fry, fingerlings

Any chosen breeding method should ensure that the hatchery operator is propagating fish seed which will have the desired traits. Examples of desirable traits include increased number of eggs, increased number of off springs, increased growth rate and disease resistance.

Spawning grounds and their characteristics

- Spawning grounds depends on the species of the tilapia in question
- Genus tilapia spawns on the available substrate in the pond e.g. Tilapia rendalli
- Genus Oreochromis are mouth brooders and spawning depends on good mating environment such as nest.
- Good spawning site should be level for easy egg collection

Pond conditions for brooders

- Water source should be stable with water flowing all year round of good quality.
- Pond water level should be maintained at a depth of 1.2m.
- Pond area should be between 200m2 and 500m2.
- Pond dike should be solid, without leakage
- The dike should be at least 30cm above the ground, with draining ditches all around to prevent rainwater pouring into the pond which may ruin the dike and cause changes in water quality

Ideal seed production technology encompasses the following criteria:

- Brood stock collection and management along with replacement of stock from nature at certain intervals;
- Collection of good-quality (having the right potency) pituitary gland and its preservation in ideal conditions;
- Selection of ideal breeders;
- Maintenance of an ideal spawning and hatching environment;
- Artificial breeding;
- Hatchery and nursery management

Males and females both exhibit sex play for a short time during which their bodies are twisted round each other. The pressure on the abdomen results in the exudation of ova and milt. Eggs are laid at intervals during which time the pair keeps moving close to each other. Species like O. shiranus, O. mossambicus and O. karongae, the females collects and incubates the eggs in their mouths. As substrate spawners, Coptodon rendalli lays and fertilizes their eggs which are later attached to substrates and both the male and female fish guards the eggs till the eggs hatch and fry reach a certain stage before they are left on their own. Catfish as substrate spawners, they don’t guard their eggs. Survival of fry is highest in mouth brooders than in the substrate most especially in catfish

Summary

Fish breeding is the process of raising fish in enclosed facilities to produce young ones. The process of fish spawning or breeding and fry production is considered one of the most important steps in aquaculture. There are several ways of breeding fish which are categorized into two major areas which are natural and artificial spawning. In natural spawning there where fish breed in their natural environment, and there is natural ways in open ponds, indoor hatchery where semi-artificial can be done. Semi-artificial is where by fish are left to breed naturally but eggs or larvae are collected form the farmed and incubated in an indoor hatchery. Advantaged and disadvantages of each breeding method has been discussed. Semi-natural and artificial methods have been seen to be producing good number of seed of uniform size though they require a good investment.

Seed Production Systems

Introduction

Well-functioning fish production systems are crucial for the advancement of aquaculture in Malawi. Ensuring availability of consistently high quality fish seed to all fish farmers is viewed to be one of the vehicles driving the increased production of fish in the country. Maintaining the quality of the seed from the hatchery to the farmers and devising cost-effective mechanisms for disseminating fish seed systems is therefore vital. In Malawi, the common fish seed production systems are pond based, hatchery based, hapa based and tank based systems. This chapter therefore looks at these different fish seed production systems and their requirements. Advantages and disadvantages of each system have been elaborated.

Aim

The chapter seeks to increase participant's knowledge and understanding on the available fish seed production systems and mono sex tilapia fry production. Enhance skills required to use any of the systems depending on the species will be gained and raising all male tilapias.

Learning objectives

Acquired knowledge

- Participants know
- The different fish seed production systems
- Advantages and disadvantages of each system
- Importance raising all males
- Materials required for each system

- Acquired skills

  Participants to know how to
- Use the different seed production systems
- How to collect eggs in each of the systems
- Stocking rates in each system
- Know how to mix fed and hormone Sex reversal of tilapia
- How to hand sex fish
- Calculate seed to be produced

- Acquired attitudes
- Increased produced fish seed depends on the seed system being practiced.

- Relevance to fish seed production
- Seed production system to be used according to ones level of production and resources

Session Overview

This section is comprised of two sessions

Session 1: Fish seed production systems

Session 2: Mono Sex Fish Seed Production and Rearing

Materials: Study notes, flip charts, markers, sample of a hapa, hand nets, scoop nets, buckets, bowls

Mode of delivery: Lectures, Group Discussions and Practical

Duration: 60 minutes

5.1 Seed Production Systems

Seed of tilapia can be produced using a variety of methods. However, low-cost seed production systems are very important for the average farmer in marginalizing areas, especially where people have limited resources. This session describes several fish breeding systems with emphasis on simple and low-cost methods of seed production for grow-out culture that are therefore applicable in rural, resource challenged areas of Malawi. Attention has also been paid to mass fry production through sex reversal technology because it is expanding rapidly in many parts of the world. The Department of Fisheries in Malawi through its staff offers technical support upon knowing that technical support to hatchery operators serving public or private institutions plays an important role in making high-quality seed available whenever farmers need it. Establishing a good hatchery means helping thousands of farmers by supplying high-quality fish seed.

5.1.1 Hatchery Based Seed Production System

A hatchery is a facility for breeding parent (broodstock) fish to produce fertilized fish eggs and fish seed including larvae, fry and fingerlings for stocking into grow out culture production systems. Hatchery provides an optimum environment for fish eggs to develop and hatch by maintaining proper water temperature and oxygen levels, and providing adequate food supplies and safety from predators.

Advantages of hatchery based seed production system

There are numerous benefits of hatchery based seed production and some of them include;

- Seed production can be done all year round. Production is not based on breeding season.
- Hatchery production provide an opportunity for genetic improvement
- Reduce dependence on wild-caught juveniles
- Ease of fry and fingerling monitoring
- The produced fish seeds are secured from predators.
- There is also high production capacity in hatchery. The other advantage is that one male and a female can be used to produce millions of fry.

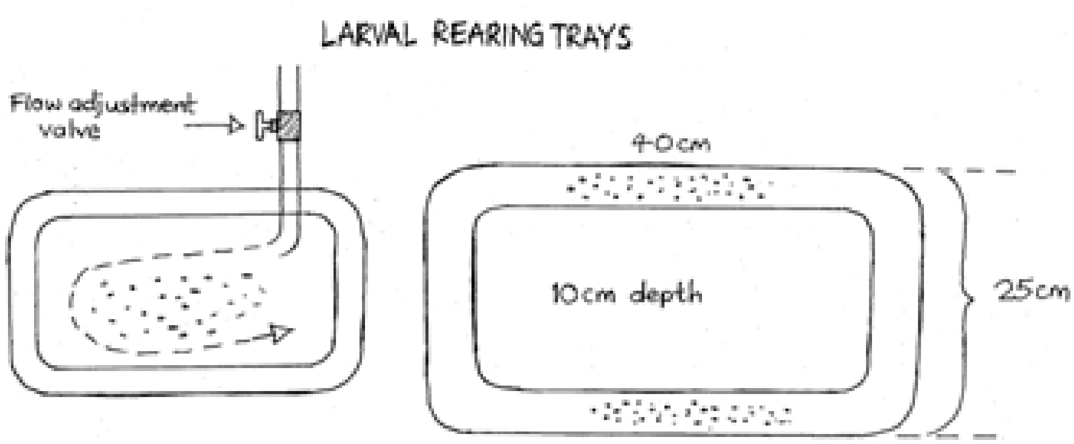


Fig 5.1: Indoor hatchery larval and fry rearing trays

Disadvantages of hatchery based seed production system

Despite the several benefits associated with hatchery based system, there are also some drawbacks of the system including:

- They are so costly to maintain
- They require skilled labor force
- Fish hatcheries have been identified as a source of pollution to environments due to some of its practices.
- Microbial proliferation - since hatchery farmed fish are in very dense conditions, their waste products become more concentrated, which can favor the development of microorganisms that can be directly harmful to the fish.

5.1.2 Tank Based Production System

Tanks which can either be fiber or made of concrete can be sued for seed production. Tilapia or catfish breeding tanks are generally simple and smaller in comparison to the fattening tanks normally used for intensive culture systems.

- Shape of the tanks can be either circular, square, rectangular or oval
- Rectangular tanks are suitable and the size of individual tank may vary from 2.0 – 10.0 m long; 2.0 – 4.0 m wide with a depth of 0.8 – 1.0 m.
- 4 - 6 m diameter circular tank is also most economic size and self-cleaning for tilapia seed production.
- Low cost breeding and fry rearing tanks might not have access to water flowing or recirculation system but can be facilitated for irregular water flashing for cleaning the tanks once a week

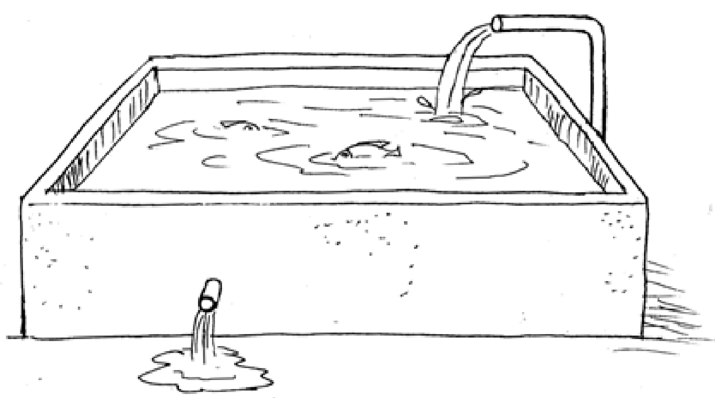


Fig 5.2: Tank based seed production

Advantages of tanks

- Easy handling of the fry and brooders in tanks based seed production system.
- High production capacity per unit area
- There is also assurance of uniform fry of relatively the same age.
- Loss of fry is also minimized
- There is generally higher survival and protection of fry from predators

Disadvantages of tanks

- Expensive to buy fiber tanks or to construct concrete tanks
- Requires intense management practices as compared pond based seed production system.
- Mortalities may occur due to aggressive behavior of fish during spawning.
- Feeding is a must which directly increase the operation cost.

- Requires aeration or continuous supply of clean water
- Uneaten feed compromises water quality leading to low dissolved oxygen levels.

5.1.3 Hapa based seed production

Hapa Based Seed production is one of the simplest and cheapest ways for breeding and seed production of fish on a small scale in rural areas. The breeding hapa is:

- A box-like (rectangular or square) enclosure (2 m x 1.5 m x 1.0 m) stitched out of square- fine mesh netting material and tied on to wooden or bamboo poles fixed in ponds or tanks (Fig4.9).
- Hapas are usually placed at about 0.3m above the water level while its bottom is 0.3 m above the pond bottom. Hapas sizes vary from but ideal size measures 3m long, 3m wide and 1.5m deep.

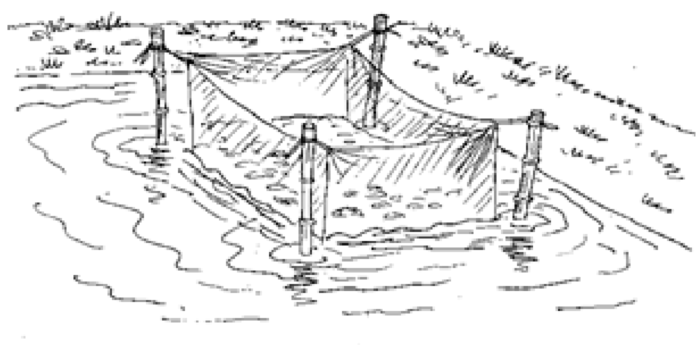


Fig 5.3: Hapa based fish seed production

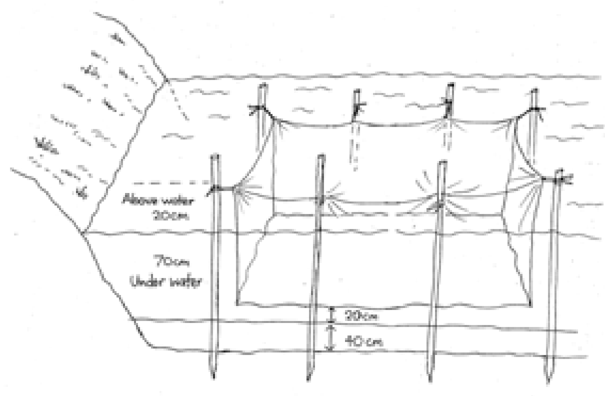


Fig 5.4 Proper setting of a hapa in a pond

Depending on the size of the hapa, you can do mass spawning or pair-wise mating. Usually smaller hapas (1 x 1 x 1 m) are used for pair-wise mating.

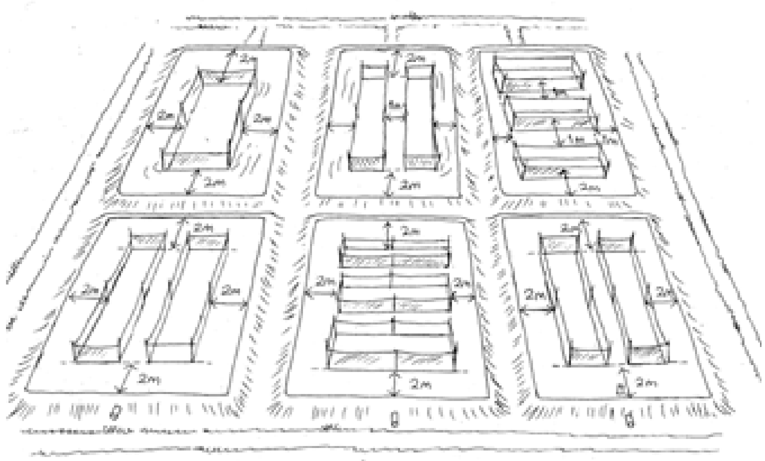


Fig 5.5: Hapa setting and fry nursing in hapas

i. Seed Production Process in Hapa

- Ensure that the mesh sizes are such that the fry inside cannot escape.
- Brooders in hapas should be weighing about 80 -120g at 1:2 to 1:5 males to females.
- Brooders should be stocked at a density of 3 - 5 brooders/m2. Therefore, for a hapa of 10m2, will

have 10 males and 30 female tilapia broodstock.

- The hapas should be inspected from day 5 after stocking for the presence of swim-up fry.
- Hapas are supposed to be inspected for fry every day and fry should be removed using a scoop net after two weeks and stock them into nursery tanks or other hapas or rearing ponds.
- Fry reared in a hapa should be fed 4 times per day using a feed 25 -30% CP until they reach the desired size usually 5g.
- A diet in powder form is recommended to be used at the rate of 5- 10 % of the total body weight per day.
- Use batch weight to of fry to calculate feeding rate
- Scoop the swim-up fry using fine-meshed scoop nets and place the harvested fry in nursery pond or hapa.

Advantages of using hapa based seed production system

- Easy handling of the fry and brooders in hapa based seed production system.
- High production capacity per unit are in hapa based system,
- There is also assurance of uniform fry of relatively the same age.
- Loss of fry is also minimized
- There is generally higher survival and protection of fry from predators in hapas.

Disadvantages of hapa based seed production system

- Hapa method is slightly more complicated and requires intense management practices as compared pond based seed production system.
- Mortalities may occur due to aggressive behavior of fish during spawning.
- Feeding is a must which directly increase the operation cost.
- Hapas can also be destroyed during stormy weather which may enable the fish to escape if the hapa is damaged.
- Hapa mesh may get clogged by the unwanted organisms like algae etc. in the water and uneaten feed which limit water circulation in the hapa and may cause low oxygen problems.

ii. Setting up and stocking tilapia in breeding hapas

- Set hapas in the pond parallel to each other, east-west direction to maximize utilization of sunlight.
- The hapas should be 2m away from the pond edge.
- Hapas should be 20m×6m×1m in size with 250µm mesh size.
- The total area of hapas should not be more than 50% of the pond area.
- When setting up more than one Hapas, make sure the space between every two Hapas is more than 1.5m.

iii. Pairing and breeding

- Only one species of tilapia should be bred in one breeding facility to avoid cross breeding.
- During the peak breeding season (September to December every year, brood stock should be paired as recommended per species.

iv. Feeding of brooders

- Feed brood stock twice a day at 8:00 - 9:00am and 3:00 - 4:00pm.
- The feed should contain 25 - 28% crude protein.
- The daily feeding rate is 3% of the total body weight.
- Green folders (Sweet potatoes, tender maize leaves, tender banana leaves and cabbages) should be fed once every 15 days.

v. **Observing breeding behavior**

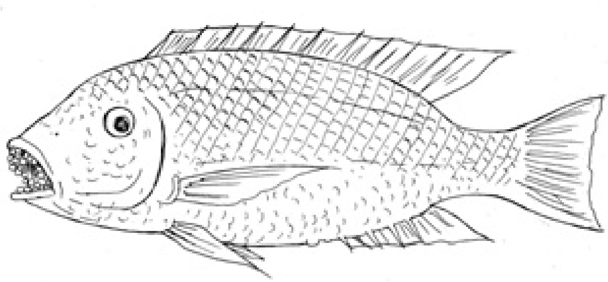
- Early indicators of fish breeding include males changing color to dark (for O. shiranus, O.karongae and O. mossambicus)
- Sampled fish should show reddish colour in the genital organs

vi. **Hatching and post-hatch development**

- Hatched larvae depends on the yolk for food
- Water quality needs to be monitored carefully for DO, pH, Ammonia and Temperature
- After hatching, start providing starter feed when 50% of the larvae deplete their yolk sac.
- Fry which have completed yolk sac should be removed from the hatchery and reared in tanks or nursing ponds.
- Fry should also be skimmed from spawning ponds for nursing
- Continue feeding the fry until they attain fingerling size of 5 to 10 grams.
- Set hapas in the pond parallel to each other, east-west direction to maximize utilization of sunlight.
- The hapas should be 2m away from the pond edge.
- Hapas should be 20m×6m×1m in size with 250μm mesh size.
- The total area of hapas should not be more than 50% of the pond area.
- When setting up more than one Hapas, make sure the space between every two Hapas is more than 1.5m.

vii. **Collecting eggs, larvae or fry in hapas and tanks**

- Collection of eggs, larvae/fry should be done early in the morning on late in the afternoon.
- Hapas or tanks should be inspected for fry every day
- Collect fry after they start to appear, which is usually within 3 – 5 days.
- If it's in hapas or tanks, drive the broodstock and fry to one end of the tank or hapa;
- Leave them for about 3 minutes;
- Use a 250μm mesh size net to collect the fry on the water surface;
- Use a 4,000μm mesh size net to move the broodstock to the original hapa, and finally collect all the fry that are left.
- Removed fry can be stocked in tanks, other hapas, or a rearing pond.



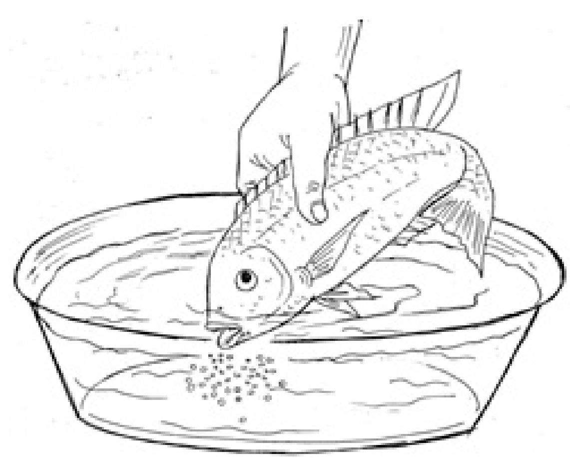


Fig 5.6 Eggs in the month of a tilapia

Fig 5.7 Harvesting eggs from a mouth brooder

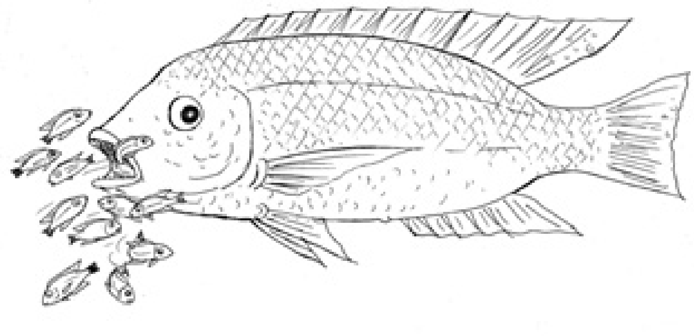


Fig 5.8 Fry that can be harvested from a tilapia

Life History Stages of Fish

The starting point for any fish seed production process is the broodstock which produce eggs that will hatch into yolk-sac larvae and transform into fry and grows further into a fingerling. Fingerlings are the common forms of fish seeds for tilapia and catfish culture in Malawi.

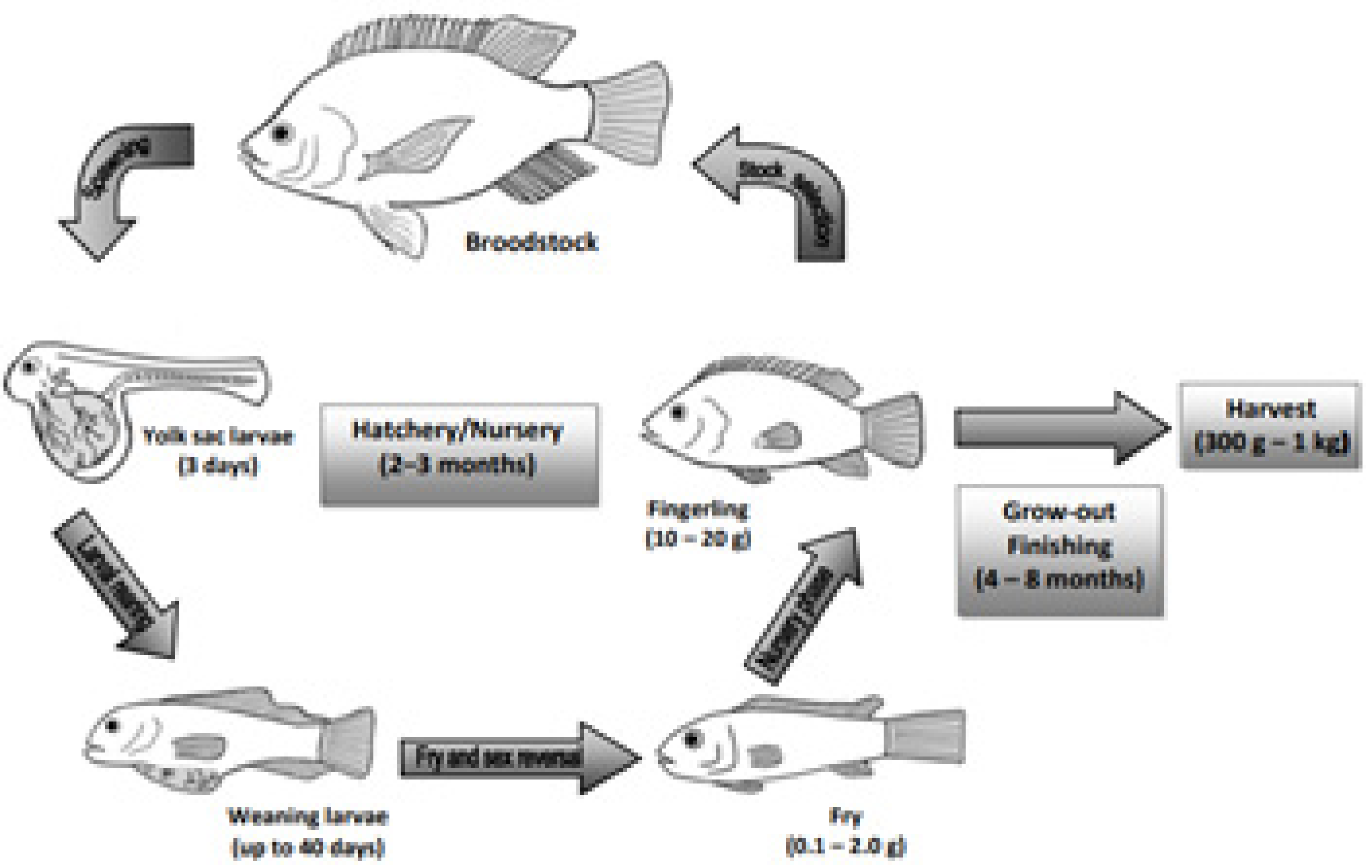


Figure 5.9: Life history stages of fish
Source: Bhujel, R.C., 2014

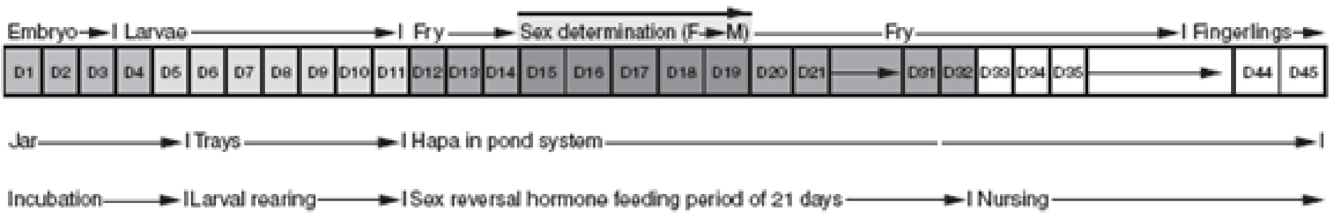


Fig 5.10 Stages of seed and activities from collection of eggs until fry stage

viii. **Fry Nursery**

- The fry are transferred to the nursery hapas or ponds
- Fry and nursery hapas are generally small (< 1–3 m3).
- The fish are nursed until they reach 15-20g from which they may be stocked into grow-out or sold to other farmers.

ix. **Broodstock Conditioning after spawning in tanks and hapas**

- Conditioning is the separation of males and females in different conditioning units, at high densities, for a period of rest between spawnings.
- Broodstock conditioning is an effective tool for improving seed production, spawning synchrony and spawning frequency.
- Broodstock should be conditioned for at least 20 days.
- During this period, the fish must be provided with good-quality feed and appropriate feeding regimes.
- During conditioning the fish should be provided a diet that has 30-45% crude protein content to be given at 3-5% biomass 2 times a day.

5.1.1 Pond Based Seed Production

The open-pond hatchery system is the most attractive and most common among small scale farmers. It is the simplest and the oldest method of seed production. Pond based seed production system is system where fish are let to breed in earthen pond enclosures. The system is mostly used for natural breeding of the fish due to lack of monitoring and control of environmental factors. In this method, a pond serves both for spawning and rearing of the fishes. Resources permitting, fry is nursed in hapas or tanks for different reasons.

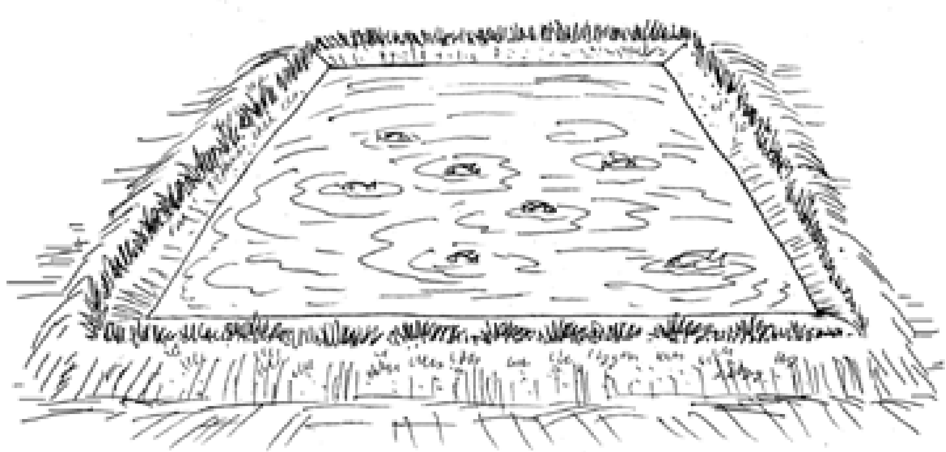


Fig 5.11: Pond based seed production

- **How is a Pond Based Seed Production achieved?**
- Brooders are stocked in separate ponds for a period of at least 1 month and provided a special diet of 25 – 28 % crude protein, a process called broodstock conditioning. Keeping sexes separate helps to achieve synchronized breeding once the sexes are stocked together for breeding.
- After conditioning, males and females are placed together in a breeding pond at a sex ratio of 1:3 or 1:4 (males: females)
- When feeding the brooders in breeding ponds, weigh about 30 fish randomly to determine the amount of feeds that should be administered daily. This prevents feed wastage.
- One to two weeks after stocking, observe the water surface near the edge of the earthen ponds for the presence of swim-up fry.
- Harvesting fry from the pond is done every 15 – 21 days and more frequently when average water temperatures are above 21oC
- Scoop the swim-up fry using fine-meshed scoop nets or seed harvesting net (after lowering the water level) and place the harvested fry in nursery pond or hapa.
- Or a fry net with a floating pipe can be pulled over the top of the pond collecting all free swimming fry without anyone entering the pond.
- A total pond draining can be done where fry and fingerlings are collected form a catch basin.
- If number of fry starts going down, remove all brooders for reconditioning. A new set of brooders should be put in the breeding pond for continuity.
- Brooders can be used for a maximum period of 3 years.

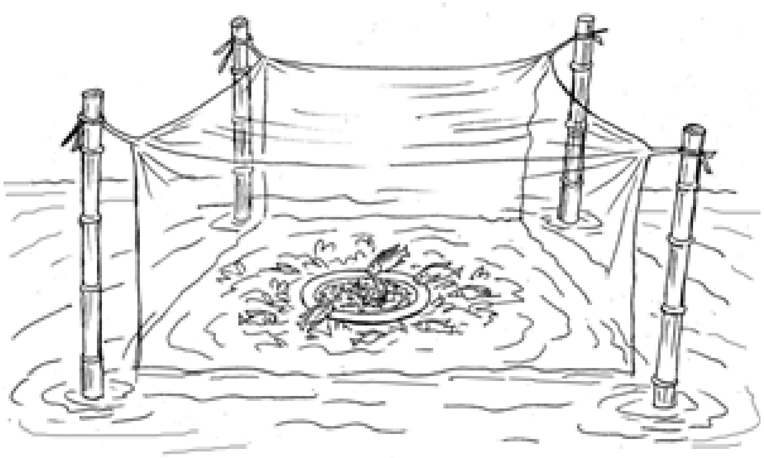


Fig 5.12 Fish feeding on a floating ring in ponds

Fig 5.13 Feeding by broadcasting feed

Advantages of using Pond Based Seed Production System

The system has several advantages over others hatchery based seed production system:

- The simplicity of technique allows small-scale farmers in rural areas to adopt this method.
- It is much cheaper to produce fish seeds using this pond system which translates into cheaper price of fingerlings as there is no advanced technology involved in this practice.
- The overall advantage of pond based seed production is that management of pond is very simple and effective.
- Most ponds used for seed production purposes also serve as rearing of both adults and fingerlings

as such production of the fingerlings is higher as compared to those produced separately.
- The demand for supplemental feeding is much lower compared with hatchery based method, which also reduces the cost of production.

Disadvantages of Pond Based Seed Production System

- There is a considerable reduction in fingerling production per square meter as compared to other production systems.
- Grading of the fish at the harvesting time is required due to uneven size of fingerlings.
- Difficulties in collection of all fries at one time using hand nets and also fries can only be removed when brooders are captured.
- Predation of brooders, larvae, fry and seed is high and this leads to low numbers of seed being produced Partial harvest is carried out by netting and seining and does not require draining the ponds, while complete harvest requires checking of broodstock for seed incubation, along with draining of the pond and harvesting all seed at once.

5.2 Estimating Seed to be produced

Before starting the seed breeding process, a hatchery operator must know the demand of seed on the market and his or her farm will require. All this will help the hatchery operator to properly calculate things like brooders (males and females) to be used, feed, labour and other materials to be required. For the sake of numbers of fry or seed required, this is the simple calculation that can be used. Let's collect fry every 14 days for three months. This will be 6 harvests or collections of fry

Number of brooders	= 1600 (1200 females:400 males) this is a ratio of 3f:1m
Fingerlings per female	= 300
Total fingerlings from 900f	= 1200 x 300 = 360, 000
Assume 5 cycles collected	= 360, 000 x 5 = 2,160,000
If we give 10% mortality	= 2,160,000 x 10/100
	= 2,160,000 x 0.1 = 216 000
Remaining seed for sale	= 2,160,000 – 1,944,000

This shows that with 1200 females and 400 males, a hatchery operator can produce at least 1,944,00 seed which can be sold. With this, a hatchery operator can decide how many brooders to be used. With a controlled mortality on produced seed and brooders, more can be achieved.

Summary

The Selecting of quality broodstock is one of the key steps towards a successful breeding business. Brooders with any deformities, diseased or weak must not be selected for the breeding exercise. There is need to have the right skills for sexing the brooders. This will help in putting the right sex ratio in conditioning and breeding facilities. Right stocking densities of brooders in different breeding facilities must be observed. Broodstock need to be given the right feed quantities for good results. Nobody should be confused about the proper management and being convinced that more feeding will enhance early maturity along with greater numbers of eggs and milt. Uneaten feed in breeding facilities will compromise water quality and their by affecting fish health.

Observations have to be made in breeding facilities and early indicators of fish breeding include males changing color to dark (for O. shiranus, O.karongae and O. mossambicus). For Hatching and post-hatch development, water quality needs to be monitored carefully for DO, pH, Ammonia and Temperature. Collect fry after first appearance and collect fry once every 7 days in the morning to avoid disturbing egg incubation. Use a 250μm mesh size net. To collect the fry on the water surface, Use a 4,000μm mesh size net to move the brood stock to the original hapa, and finally collect all the fry left. A 50% CP feed should be given to fey that have finished yolk absorption till they attain a size of 5 to 10 grams.

Session Two

Introduction

Early maturation and frequent spawning are management challenges when working with tilapia. Tilapia is a very prolific species meaning that the species reproduce uncontrollably. There are several demerits of this uncontrolled reproduction including competition for available resources such as feed, oxygen, space and greater release of ammonia and feces. The resources eventually become limited and affect the general growth of the fishes in the pond. This results in stunted growth and unmarketable fish. To avoid and minimize such effects on the stock, farmers are encouraged to raise monosex stock. A monosex culture is a stock that comprises only a single type of sex; either male fish only or female fish only. Male tilapias are preferred for culture because of their faster growth than females. Most fish species including tilapia, exhibit sexual dimorphism in terms of their sizes; males having different sizes to females. All-male culture of tilapia is preferred because of their faster growth than females. Monosex population culture of the faster growing gender therefore increases the production rate. This chapter therefore looks at producing and raising all male tilapia. Several methods of raising all males will be highlighted but the chapter will dwell much on manual hand sexing with emphasis on sex reversal using hormones

Aim

The chapter seeks to increase participant's knowledge and understanding on why culturing of all males is more profitable than mixed sexes. The chapter further seeks to add skills on how to do manual hand sexing, making and feeding fish with hormone treated.

Learning objectives
Acquired knowledge

· Participants know
- Importance of culturing all male tilapia
- Challenges faced when culturing mixed sex tilapia
- Advantages and disadvantages of hand sexing and use of hormones

· Acquired skills
  Participants to know how to
- Hand sex fish
- How to mix hormone if fish feed
- How to feed fry for sex reversing

· Acquired attitudes
- All males grows faster and are more cost effective

· Relevance to fish seed production
- Increased yields and improved incomes from culturing all males

Materials: Study notes, flip charts, markers, sample of a hapa, hand nets, scoop nets, buckets, bowls
Mode of delivery: Lectures, Group Discussions and Practical
Duration: 100 minutes

5.2 Mono Sex Fish Seed Production and Rearing

5.2.1 What is mono sex fish culture?

Monosex culture is a practice of culturing either males or females only of a certain species like males of Oreochromis shiranus or Oreochromis mossambicus. Monosex tilapia may have many benefits, apart from control of reproduction including:

High growth rates and feed utilization efficiency.

- High tolerance to severe environmental conditions, including temperature, salinity, low dissolved oxygen, etc.
- Higher energy conservation.
- Reduced aggressiveness.
- Greater uniformity of size at harvest.
- Better flesh quality and appearance.
- High resistance to stress and diseases.
- Role in controlling over-reproduction

Production of all-male population

There are a number of methods used for production of monosex population. The following are the common methods for the production of monosex tilapia:

- Manual sorting;
- Hormonal sex reversal;
- Interspecific hybridization;
- Androgenesis and gynogenesis;
- Triploidy;
- Transgenesis.

  In this module emphasis will only be on manual sorting, hormonal sex reversal and interspecific hybridization.

5.2.2 Manual Sexing

Manual sorting of fingerlings is based on anatomy of the fish. Based on the anatomy of the genitals, it is possible to sort fish into males and females when they have reached about 15 - 80g. This is where the sexes are separated by visual observation of the reproductive organs of the fish. In manual sexing

- Sorting is based on assessing the number of openings in the urinogenital papillae: the male has a single urinogenital opening, while the female has two separate openings (Fig 5.14).
- The male genital papilla is simple and smaller with two openings: the urogenital opening where the milt and urine are excreted and the anus.
- The male genital papilla has a cone like shape located behind the anus, whereas the female has a large and wider papilla with three openings: the anus, the urethra and the oviduct where the eggs pass.
- Females have also a slightly wider organ with a wide opening to allow eggs to eject during mating.
- The separation process has to be done when the fish is at young adult stage or when their secondary sexual characteristics are well developed.

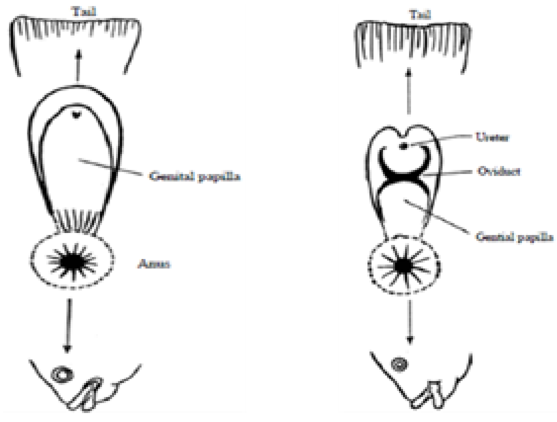


Fig 5.14 showing a single urinogenital opening for male (left) and two openings for female (right)

Main advantages of this method

- It is an easy technique.
- And cheap
- Less skilled personnel can be used

Main disadvantages of the manual sexing are:

- Extremely laborious and does not have high resolution (the error rate is high).
- The procedure allows for a 5 – 10% margin of error
- It is a stressful experience for the fish.
- It requires that fish grows to size large enough to enable sexing. This mean that the farmer has to wait for some months before sexing can be done, which may be time consuming
- It leads to the presence of females and young ones in ponds as a result of human error.

Doing a second check when the fish have grown somewhat larger and distinctive sex-coloration is more discernible. This will ensure that any females that might have been missed during the initial sexing process are removed.

The manual sexing technique is usually useful in subsistence level and in hatchery during brood stock selection, where fish populations are normally small, but in commercial practice their use increases the cost of skilled labor and increases the risk of human error, leading to uncontrolled reproduction.

5.2.3 Hormonal Augmentation (Sex reversal)

Hormonal sex reversal is the most common method for production. Sex in most fish is extremely plastic and sex is not determined until a certain stage. The sex switch is not set during early embryonic development rather sex is determined by an ongoing battle for primacy between male and female developmental trajectories. That sexual fate is not final and must be actively kept superior while suppressing the opposing sexual determinant. The principle behind this method lies on the fact that at the stage when the fish larvae are said to be sexually undifferentiated (right after hatching up to about 2 weeks or up to the swim-up stage), the extent of the androgen (male hormone) and the estrogen (female hormone) present in a fish is equal. Thus, augmenting one of the hormones that is originally present in the fish will direct the fish to either male or female depending upon the hormone introduced. As such exposure of the sexually undifferentiated fish to sex determining hormones such as androgen and estrogen can have an influence of the sex of the fish. The treatment of fish with hormones such as androgens and estrogen to alter their sex is called sex reversal (hormone augmentation).

To produce an all-male population in tilapia, the use of methyl or ethyl testosterone hormone is commonly advocated. Newly hatched larvae are fed with hormone feed for 21–23 days. Feeding for sex reversal begins on the 10th day after hatching, when the gonad of the fry still remains in an undifferentiated stage. In this method, the most common sex reversal hormone is 17 alpha methyltestosterone

Use of MT in Malawi is restricted to specialists who have been trained to properly handle, use and dispose it. Poor handling and management of the hormone would lead to negative impacts both on the ones handling it and the environment where it can be disposed. This module is not advocating the use of methyl or ethyl testosterone hormone. Its purpose is to teach the most commonly used and available techniques.

Procedure for production of all-male population

Sex reversal can be performed in several ways and these include:

- Dietary supplementation or oral administration of feed incorporated with 17- -methyltestosterone or 17- -methyltestosterone.
- In this technique, the fish larvae are fed with feeds that are incorporated with male hormone as such as 17- -methyl testosterone. The fish will develop into phenotypic male physically and function as male but possess the female genotype (XX). The technique is better suited for hatchery and hapa based seed production and can be implemented as follows:
- Fry collection - as the first step, the farmer needs to collect fry at yolk sac of first feeding stage mostly not later than one week after they have been hatched. The fry of uniform size are transferred to the tank or hapa.
- Provision of hormone incorporated diet to the fry. The diet should contain an optimal hormonal inclusion of 60 mg/kg for the best results in most tilapia species for at least 21 to 28 days. The feeding rate should be 10-30% body weight per day at least 3 times a day.

Fig 5.15: Fish feeding cup when in hapas

5.2.4 Sex reversal feed preparation

- **First Step: Stock Solution Preparation.**

As the hormone is insoluble in water, ethyl alcohol or ethanol (organic solvent) is necessary to dissolve it. The alcohol then helps distribute the hormone evenly in each particle of feed/fishmeal; it can then be evaporated off easily and quickly at room temperature. When making stock solution, normally 5 g of 17- -MT hormone is dissolved in 1 l of ethyl alcohol using a magnetic stirrer. The volume is then made up to 10 l (by adding 9 l], which serves as a stock solution and can be stored for about 6 months in a refrigerator at about 7°C. The stock solution contains 0.5 mg of MT hormone per ml of alcohol, which means that 120 ml of stock solution is required per kg of feed or fishmeal to deliver the required dose of 60 mg/kg feed. Another 120 ml of fresh alcohol per kg fishmeal is added when preparing the feed.

- **Second STEP 2: MT feed preparation.**

When preparing MT feed, 10 kg of feed (high quality fishmeal or shrimp starter diet) is churned in a mixer, with the gradual addition of 600 ml of stock solution and then another 600 ml of fresh alcohol (Fig. 2.37). This process is repeated, again doubling the stock solution and hormone. After churning feed for about 15–20 min, it is ready to collect (Fig. 2.38) and dry in the shade. The alcohol is evaporated by spreading the mixed feed out in the shade for about 1 h. Feed should not be dried under intense sunlight because the hormone will degrade. After drying, the feed should be packed in a plastic bag or kept in a container with a tight lid and stored in a room at a low temperature (4–7°C).

- **Alternative method for first and second steps**

Another way of preparing stock solution and MT feed is to calculate the amount of feed requirement. For example, if total feed requirement is 40 kg for a week, the amount of hormone required will be 60 mg × 40 = 2400 mg or 2.4 g. This is dissolved in 2 l of ethanol and kept in a freezer as stock solution. When preparing feed, e.g. 10 kg at a time, they take 500 ml, i.e. one-quarter of the stock solution prepared for 40 kg total feed, and mix it with 1500 ml of fresh ethanol, which is sprayed on to the fishmeal while churning in the mixer.

5.2.5 Feeding MT feed

Normally 20,000–30,000 swim-up fry are stocked in small hapas of 3 ´ 1.8 m (= 5.4 m2, often referred to as a 5 m2 hapa) in size at a density of 5600/m2. They are fed with the MT mixed feed at 15, 30, 50 and 84 g/day for the period of days 1–5, days 6–10, days 11–15 and days 16 –21, respectively (Table 2.7). When preparing the daily amounts of feed, each day's feed for a batch of fry is filled into a plastic bag (which should have an opening but that can be closed to make it airtight). Feed is divided into five equal portions and the fry are fed five times a day. The person feeding them estimates one-fifth of the amount for each meal and feeds that amount each time. Normally feeding times begin after the sun becomes strong, e.g. at 8 am, then every 2 h. However, in some cases it is difficult to obtain 20 000 fry ready to start sex reversal. In this case, some hatcheries use a rule of thumb such as that below 20 000, they feed half of the normal rate. Similarly, if below 10,000 then the rate becomes one-quarter. The calculation of feed is shown in Table 2.7. Alternatively the calculation can be done using a conversion factor, i.e. amount of feed for normal density/30,000 × estimated number of fry.

Using Tables 2.7, feed requirements for a day or more can be calculated. As an example, on 27th Aug, if a technician needs to calculate the requirement of SRT feed to prepare for the following day (28th Aug)

Table 5.1 Feeding amount during sex reversal period 21 days

Days	Amount of feed (g)			
	Normal density (30 000 fry)		Low density (15 000 fry)	
	Per meal	Per Day	Per meal	Per Day
Day 1	15	75	7.5	37.5
Day 2	15	75	7.5	37.5
Day 3	15	75	7.5	37.5
Day 4	15	75	7.5	37.5
Day 5	15	75	7.5	37.5
Day 6	30	150	15	75
Day 7	30	150	15	75
Day 8	30	150	15	75
Day 9	30	150	15	75
Day 10	30	150	15	75
Day 11	50	250	25	125
Day 12	50	250	25	125
Day 13	50	250	25	125
Day 14	50	250	25	125
Day 15	50	250	25	125
Day 16	84	420	42	210
Day 17	84	420	42	210
Day 18	84	420	42	210
Day 19	84	420	42	210
Day 20	84	420	42	210
Day 21	84	420	42	210
Total		**4895**		**2448**

Step 1: Count the number of hapas to feed for days 1–5, i.e. 3 + 2 + 3 + 1 = 9 hapas.

Step 2: Calculate the amount of feed, i.e. number of hapas × normal daily rate × conversion factor for specific number, e.g.

= 3 × (75/2) + 2 × (75/4) + 3 × (75/4) + 1 × 75 = 281.25 g

Step 3: Number of hapas to feed for days 6–10, i.e. 1 + 1

Amount of feed, i.e. 150 + 150 = 300 g

Step 4: Number of hapas to feed for days 11–15, i.e. 1 + 1 + 2

Amount of feed = 250 + 250/2 × (250)/2 = 625 g

Step 5: Number of hapas to feed for days 16–21 = 2

Amount of feed = 2 × 420 = 840 g

Therefore, the total amount of feed required for 3 July = 281.25 + 300 + 625 + 840 = 2046.25 g (i.e. approximately 2.05 kg). In similar ways, feed can be calculated for a week, prepared all at once and kept in cold storage or a simple refrigerator at 4–7°C.

The size of the hapas during hormone treatment for sex reversal depends on the scale of operation. For larger hapas, e.g. 10 m2 or 20 m2 or even larger, the number of fry will be multiples of the density used for 5.4 m2 and so will the amount of feed. For example, the maximum number of fry to be stocked and the amount of feed for a 10 m2 hapa for the first day will be 60,000 fry and 150 g (75 × 2), respectively.

Advantages of the method

- Sex reversal by oral administration of feed incorporated with methyl testosterone is probably the most effective and practical method for the production of all male fish.

Disadvantages of the method

Sex reversal hormones, chemicals, antibiotics and other hormones used in aquaculture pose a threat to natural water bodies when they find their way to the streams and other water bodies

- Hormones may be difficult to obtain
- Hatchery facilities and skilled labour is required
- The technique requires that uniform age of fish be used at the first feeding stage to ensure high reversal rate.
- Widespread use of large quantities of sex reversal hormones in hatcheries may pose a health risk to workers.
- Potential risk of contaminating the water through wastewater due to non-consumed feed

i. Hormone mixing feed preparation protocol

The following materials required are required when preparing hormone treated feed for tilapia sex-reversal:

- Surgical latex gloves and mask
- Best quality hormone, ethyl alcohol and vitamin C
- Hormone mixing machine or liquid sprayer
- Electronic digital weighing scale
- Glass measuring beakers
- Glass bottles for storage 1.5 or 2 litres
- Plastic 5 ml syringe
- Clean plastic bowls and/ or buckets
- Plastic bags or plastic Tupperware boxes for storage of hormone treated feed
- Permanent marker pens for labeling bottles and storage bags and containers.

ii. Key considerations when preparing hormone treated feed

- Wear latex gloves and a face mask when working with hormone powder or hormone treated feed
- Be sure each feed particle has been soaked by alcohol
- Mix the hormone into the feed slowly and thoroughly
- Feed must be properly air dried to evaporate off all the ethyl alcohol, to reduce moisture and humidity levels and to prevent attack by fungus when stored for longer periods
- Pack small amounts of hormone treated feed, sufficient for daily use

It should be noted that farmers can buy hormone treated fish feed from Zambia. Even though this is the case, the following things must be followed and observed

- Proper storage
- Proper handling when feeding: observe wind direction to avoid inhaling it, feed right quantities
- Management water discharge properly

Other methods that can be used for sex reversed all-male population are:

- Immersion – where eggs or fry are immersed in different concentrations of the 17- -methyltestosterone
- Injection – through intramuscular injection of the hormone. The injection technique requires fewer amounts of hormones but it is extremely laborious process.

iii. Hormone Use and Record Keeping

Keeping records is a tiresome work, but it helps hatchery operators to assess the real time situation and correct it if anything goes wrong, preventing a huge loss. More importantly, analysis of time series data and seeing simple trends can help steer the production line based on the seasonal variation in demand and sales. Recording dates when hormones were procured, their date of expiry, usage and amount of all male seed treated using them is necessary. There are always good lessons to be learned and more recently keeping such data has also been necessary from the point of view of Best Management Practices (BMP) and obtaining certification.

5.2.6 Interspecific Hybridization

Sex identification technique in tilapia fry

In tilapia fry/fingerlings larger than 15 –30 g, sex can easily be identified manually by examining their urogenital papilla. But in case of early fry smaller than 2 g, where the manual sexing is not useful, an aceto-carmine squash technique is used. A protocol for sex identification in tilapia fry is described below.

- A sub-sample of fry are killed and dissected using a sharp pointed surgical scissor.
- The tiny thread-like gonad that lies along the anterodorsal abdominal cavity is removed using fine forceps.
- The collected gonad is placed in a glass slide and a drop of acetocarmine stain is added on the gonad. The gonad is lightly squashed with a cover slip.
- Then the gonads are examined under the microscope, the male gonad is composed of fine granular like structure of spermatogonia and the female is characterized with the structure of circular oogonia.

The technique of aceto-carmine stain preparation is as follows:

- o Carmine (granular stain): 0.5 g.
- o 45% Acetic acid: 100 ml.
- o Boil for 2 – 4 minutes, cool and filter.

Summary

Most species of tilapia under favorable growth conditions will reach maturity at an early stage of even less than 30g. And the situation is made worse when the fish are in poor environmental conditions as they mature at a smaller size than those that are in good conditions. Under favorable conditions they will continue to reproduce, the offspring competing with the initial stock for food, resulting in stunted growth and unmarketable fish. There are several ways of producing all male tilapia and the most common being hand sexing and use of hormones. Production of all male population through administration of androgen (17-” methyltestosterone) is considered to be the most effective and economically feasible method for obtaining all male tilapia populations. Of the various techniques that have been developed to provide male tilapia for culture, sex reversal is the most commonly used procedure. When mixing hormone with feed, necessary precautionary measures must be taken. When feeding fry, right quantities and frequencies must be observed and 21 days are the normal number of days hormone treated feed can be given to tilapia for good sex reversal results. Manual hand sexing for tilapia can be done at small scale level as it is labor intensive and prone to 5 -10% error of margin.

Spawning Methods for Catfish

Introduction

Catfish is a commercially important fish species in Malawi and it is the most important farmed species in the country. Due to its fast growth, tolerance to high stocking densities, ability to survive in oxygen low waters and its low fat, high protein and iron content makes catfish an ideal fish species for aquaculture. However, the culture of catfish requires constant supply of good quality seed. Previously the major sources of catfish seed for aquaculture were mainly the capture fishery and other natural water bodies due to the limited capacity of the existing hatchery facilities to produce its seed. The seasonality of spawning is a major problem in the reproduction of African catfish, Clarias gariepinus. However artificial breeding of catfish has provided the needed seed. Artificial breeding refers to a process in which some stimulants, hormones or pituitary extracts are injected in the brood fish, which do not spawn required quantities in the closed water bodies causing the fish to spawn in large quantities.

This chapter therefore covers artificial reproduction; including induced propagation without and through hormone injection, fry nursing, feeding and ploy culture with tilapia.

Aim

The chapter seeks to increase participant's knowledge and understanding on why culturing of all males is more profitable than mixed sexes. The chapter further seeks to add skills on how to do manual hand sexing, making and feeding fish with hormone treated.

Learning objectives
Acquired knowledge

· Participants know

- Artificial reproduction including induced propagation
- Poly culture with tilapia
- Importance of induced spawning

· Acquired skills

Participants to know how to

- Induce catfish to breed
- Mixing hormones
- Injecting brooders
- Sexing males and females

· Acquired attitudes

- Breeding catfish, fry and fingerlings nursing for their increased survival

· Relevance to fish seed production

- Increased yields and improved incomes from breeding and selling catfish

Materials: Study notes, flip charts, markers, ovaprim, syringes, injections, feathers, bowls, towels, didgtal scale, knives, hand nets, scoop nets, buckets, substrates
Mode of delivery: Lectures, Group Discussions and Practical
Duration: 100 minutes

6.1 Spawning methods of catfish

There are three spawning methods which will be discussed in this chapter and these are:

- **Artificial spawning**: Artificial breeding mainly through stripping of eggs as it ensures maximum fertilization. Artificial breeding has hormonal and genetic components. Treatment of appropriate dosage of gonadotropin (crude pituitary extract) or any other inducing agent like gonadotropin-releasing hormone (GnRH) analog (ovaprim) is required to obtain gametes for artificial fertilization.

- **Semi natural Spawning**: Allows the hormone-induced fish to spawn on their own in a "breeding pool." This type of spawning practice is more convenient and economical. To find out a cheap and specific chemical we have already conducted some study at field. We have discovered a specific soil from a certain region of Bengal, India, which is very effective in removing the adhesive component. When a handful of soil is mixed with 10 L of water in a container or jar and the eggs produced out of two successive games are added to it, individual eggs separate from each other.

- **Natural Spawning**: Conditioned brooders are left in ponds or breeding facilities like hapas and after sex play, both the female and male undergo spawning, which ensures fertilization. The natural breeding of catfish has become uncertain due to lower survival of larvae, fry and fingerlings unless they are collected and nursed in separate facilities away from their parents and other predators. Sometimes breeding of catfish is dine in captivity either through simulation of natural conditions in ponds

6.1.1 Production Facilities

The pond or tank in which brood fish are held must be of a suitable size to hold and condition the brood stock. Sex separation enables the brood stock males and females to be subjected to different conditions which enhance their production ability. The characteristics of the water in which the mature brood stocks are held must be manipulated. The aqua culturist must consider the appropriate oxygen concentration, temperature, and pH of the water.

Feeding of catfish brooders

The feeding regime of brood stock requires consideration of timing and composition of the food. Protein, lipid and fatty acid composition is particularly important. The quantity of food which is needed for spawning and maturity, for example low rations have been shown to reduce the number of fish reaching maturity.

Selection criteria of catfish

- The brooders should be of good healthy looking
- Abdomen for females should be swollen and soft
- Females should have round and blunt genital opening
- Should have prominent reddish vent
- Genital papilla should be elongated and pointed out

Fig 6.1 and 6.2: Male and Female catfish

Conditioning of catfish brooders

- Brooders are kept in conditioning tanks 6 -7 hours prior to hormone administration
- Male and female fish are kept separately prior to administration of inducing agents
- Continuous water flow by shower is given in the conditioning tanks to ensure proper aeration.

6.1.2 Preparation of pituitary extract

The pituitary gland can be removed from male or female catfish by the following these steps:

- Choose a matured specimen (preferably male) and kill it for its sperm and take off its head
- Divide the head by the middle and the mouth leaving at surface of the bones of the head
- The gland is found as s small round-shaped organ, pink-white situated at the ventral part of the basis (sella turcica)
- After the removal, the pituitary gland can be placed in a mortar and mixed with a physiological solution (0.9% NACI). The volume of the physiological solution used is 1 ml per kg body weight of the recipient female
- The dose is 1:1 (PG for one female) to 1.5:1
- Instead of using fresh pituitary, acetone dried pituitary can be used as well.

- **The pituitary is dried as follows:**
- After removal, the PG is placed in a bottle containing acetone (1 ml per PG)
- The acetone has to be removed after 10 min and again after 8 hours
- The PG must then be taken out of the acetone 24 hours later
- Finally the PG can be air dried by evaporation in a dark room and stocked in a closed recipient in a safe place. This dehydrated PG is used in the same way as the fresh PG

Hormone administration

Most farms use pituitary gland and Ovaprim for artificial spawning. Dosage of hormone administration for catfish is as follows;

- 3mg of pituitary gland is administered to 1kg of a female fish of catfish
- 0.5ml of Ovaprim is administered to 1kg of female fish
- The male fish is given half the dosage administered to a female fish

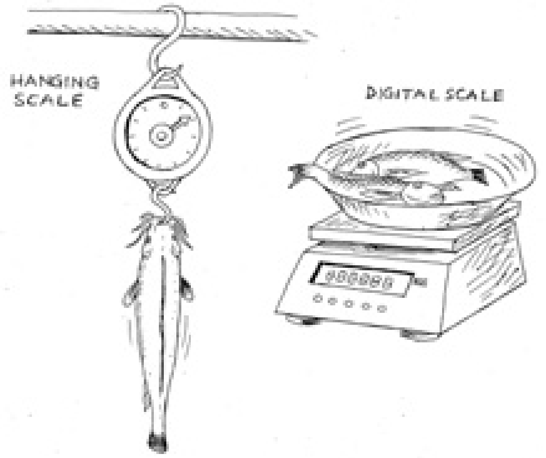


Fig 6.3: Weight of catfish has to be known

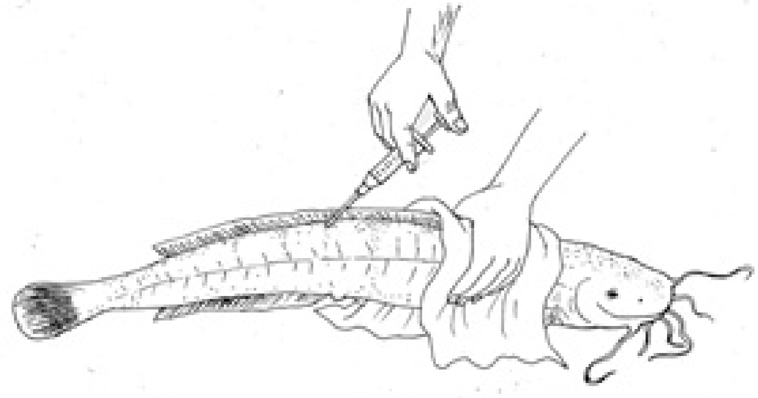


Fig 6.4: Hormone injection into catfish broodstock body

- To ensure proper administration of hormone is done without injuring the brooder there is need to sedate the fish with tranquilizers by adding 14ml of ethyl-benzoate solution to 20 liters of water.
- Wrap the head region of the fish by a wet and soft towel or cloth
- The female fish is intramuscular or intraperitoneal injected with a syringe near the ventral fin.
- The injection should be done carefully with 1 ml syringe
- The needle is inserted at about 45 degrees angle to the body surface.

6.2 Harvest of the gametes

6.1.1 Testes extraction and milt harvest

The testes are situated in the dorsal part of the abdominal cavity of the male fish. They are lobulated and show a white opaque color. Since milt cannot be obtained by stripping a male, the testes are removed by either killing the fish after a surgical operation or sometimes the fish is cut open on the belly and have the testes removed. The male fish can then be stitched. Once the eggs are ready for fertilization, the milt is obtained from the testes by cutting little incisions on the external part of the lobules. The milt can be preserved for a couple of hours in physiological serum (or better, in semen extender) at 4oC in a refrigerator.

6.2.1 Egg Collection

An ovulating female can be known by the thickness and softness of the belly region or canulation. However, 12 hours after the hypophyzation (at 25oC), it is almost sure that the females are ready for spawning. The female has to be taken from the tank, preferably held by two people with wet towels to avoid injury of the fish. The ventral sides of the fish have to be dried and gently pressed to extrude eggs.

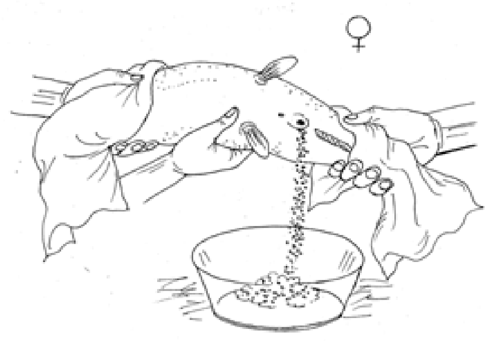


Fig 6.5: Hormone injection into catfish broodstock body

Under favorable conditions, eggs undergo several developmental stages. The swollen fertilized egg becomes a morula that develops to blastula then to gastrula then blastopore is closed. At the stage of closing blastopore, fertilization percentage can be estimated by simple counting methods under a binocular microscope

6.2.2 Fertilization of eggs

- **Dry fertilization Method**

Artificial fertilization takes place when the milt is dispersed on the eggs. After squeezing the testes over the eggs, a small amount of water from the incubation system is added. The eggs are mixed using a feather or a soft rubber spatula for at least two minutes.

- **Wet fertilization Method**

This method includes the dilution of the sperm in a buffer solution before adding it to the eggs. The dilution is then kept at 4oC. The advantage of this method is that it is possible to prolongate the duration of the spermatozoa to up to a day.

6.2.3 Egg incubation

After mixing, more water is added to almost fill the bowl in order to let the eggs hydrate and develop adhesive properties as a result of the deactivation of the micropyle. The eggs are spread in a monolayer on a mesh or over incubation gauze. The frames or substrates are placed at a downward angle to allow free swimming hatchlings leave the frame while dead and unfertilized eggs still hand on. If the eggs do not readily adhere to substrates, an interval of 30 to 60 seconds is allowed to elapse so that the adhesiveness of the eggs may develop.

The incubation has to be supplied with a flow of aerated water. The eggs are maintained under a low light intensity or even darkness. Direct sunlight is fatal to the eggs. The optimum temperature for incubation is 28oC. Eggs are however tolerant to extreme temperatures and will hatch successfully in a range of between 17oC to 33oC.

6.2.4 Hatching of eggs

Egg hatching is temperature dependent and takes between 20 and 24 hours after fertilization within the optimum temperature range. Hatching can be accelerated by raising incubation temperatures. At temperatures below 23oC, mortalities are often high due to the increase in the developmental time and the greater occurrence of fungus (Saproleginia and others) infections. The hatching of a batch of eggs is usually complete within three hours after the first eggs have started to hatch. Incubation frames or substrates are carefully removed from the hatching trough or tank in order to prevent the dislodging of the dead eggs and empty egg cases which promote infections.

6.2.5 Larval Rearing

At hatching, the larvae measure 5mm to 7mm and weigh between 1.2 to 3.0 mg. The free swimming embryos (hatchlings) are photophobic and form aggregations on the bottom of the incubation tank.

- Larvae can be reared in funnel type devices, in aquaria, box type devices, or haps.
- Need to provide well-oxygenated water with optimum temperatures and of good quality
- Needs to be well protected from predators most especially Cyclopes

6.2.6 Fry Rearing (Nursing)

- After egg yolk absorption, the larvae develops to fry stage
- Zooplanktons (rotifers) are considered most suitable, feed them 4 times per day
- Supplement powdered feed with high protein content around 45% CP
- Egg yolk of a chicken can be boiled, crushed and fed to catfish fry
- Water quality must continue to be checked regularly

- Fry grading (uniform seed production)
- To minimise fry or seed stress and mortalities, fry or fish seed should be graded using specially madegraders to rear different sizes separately. Graders can be
  - made from nets of different sizes according to the size of fry or seed
  - plastic gauze of different sizes accruing to the size of fry or seed
- Fry or seed are let to pass through the grader leaving the bigger ones in the grader with the smaller mesh size
- If there are disproportional sizes, an even smaller mesh grader is used to separate the seemingly bigger from the smaller ones.
- Grading should be done every 2 days to remove jumpers
- This in turn reduces cannibalism and competition for feed between the fast growers and slow growers.
- Larvae and fry have to be protected from predators like tad poles and birds.

6.2.7 Feeding

Feeding in catfish starts on the second or third day after hatching, before the yolk sac is completely absorbed. Artemia nauplius in combination with a formulated feed is used as a starter to feed catfish. Continuous supply of feed produces the highest growth in catfish. In practice, larvae are fed ad libitum by hand very 2 to 3 hours for 16 to 18 hours a day. The feeding of Artemia is stopped on the second or theird day when the larvae are big enough to ingest inert feed particles or zooplankton. If no Artemia is available, egg yolk can be cooked crushed and fed to the larvae.

6.3 Packing and transportation of fish seed

Transportation is one of the challenging practices when to comes to fish seed handling. This is because the concept of transportation involves the transportation of as many fish as possible in a little water as possible with no or little loss as possible.

Factors affecting condition and survival of fish during transportation

- Physiological state of fish
  - Fish must be healthy and must not be fed before transportation
  - Fish with full stomachs needs larger amounts of oxygen for digestion
- Oxygen
  - Water with low or depleted oxygen is leads to fish mortality
  - First hour after loading fish is critical for oxygen demand
- Carbon Dioxide
  - Released as respiratory waste by fish and bacteria
  - As CO_2 increases, the more oxygen is required
  - Fish can be transported successfully if CO_2 does not exceed 25ppm
- Ammonia
  - Major waste most especially at high temperatures
  - Make sure to reduce water temperature to lower ammonia and oxygen consumption

- o Change of water is essential to handle ammonia problem
- Temperature
- o When water temperature increases will result in higher oxygen consumption
- o Higher production of wastes
- o Lower affinity of blood to oxygen
- o Higher damaging effect of CO2 and ammonia
- o Cooling of water is the solution
- Bacterial population
- o Bacteria in transport tank feed on and multiply using fish excretory products
- o Don't load fish in tanks with full tracts as bacteria becomes abundant and competes for oxygen
- o Bacteria may become a source of infestation

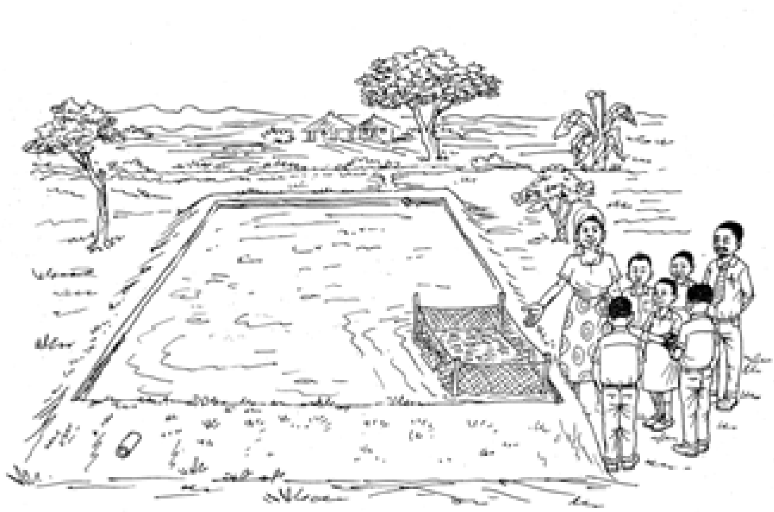


Fig 6.6 Ensure to conditioning fish seed before packaging and transportation

Methods of fish transportation

Tanks

- Rectangular, circular or elliptical tanks can be mounted on a vehicle and supplied with air or oxygen
- Insulation materials are sued as filler between tank walls as a jacket covering the tank

Plastic Bags

- Common method to transport post larvae, fry and fingerlings
- Normally pure oxygen is used to fill the bags
- Corners of bags should be rounded to avoid creating traps
- Standardize the numbers put in each bag
- Gradually release oxygen into the bag to avoid shock caused by high pressure
- Avoid sharp objects wherever plastic bags are to be placed.

Loading rates in plastic bags depends on:

- Distance to be travelled
- Temperature
- Size and species
- Mode of activity
- Aeration devices
- Method of transport

Key Points in Fish Transportation

- Keep water temperature as cool as possible
- Transport healthy fish to minimize mortality
- Condition fish before they are transported for them to empty their stomachs
- Use of anesthetics should not be relied on to increase the loading
- Change water, whenever possible, over long trips

Summary

Catfish is one of the cultured species in Malawi. Propagation of seed is one of the challenges faced by farmers. Before the actual breeding process, sex separation must be done as it enables the brood stock males and females to be subjected to different conditions which enhance their production ability. There are three breeding methods which artificial, natural and semi natural spawning. Artificial breeding has hormonal and genetic components. Semi natural Spawning allows hormone-induced fish to spawn on their own in a "breeding pool." Removing of pituitary gland and how to use it has been elaborated. Management of eggs, fry and larval rearing are a component in the successful breeding of catfish. Seed packaging and transportation are crucial in the survival of seed. Fish can be transported in rectangular, circular or elliptical tanks which can be mounted on a vehicle and supplied with air or oxygen. Oxygenated plastic bags, plastic buckets or clay pots can also be used. Fish should be well conditioned before transportation and recommended numbers be stocked in transporting materials to minimize stress and mortalities. Loading rates depends on distance, temperature and fish sizes amongst others. Keep water as cool as possible at all times even over longer distances

Hatchery Diseases and Prevention

7

Introduction

Pathogens and diseases if not prevented can wipe out an entire production in a hatchery. Seeking help when a disaster has already started in a hatchery will not save the situation. Prevention is the best key to managing pathogens and diseases. Good management of water quality, feeds, equipment and materials would help to minimize introduction of diseases in a hatchery. Health condition of fish depends on feed, water and pathogens, and their interactions. Therefore, prevention is the only way to stop losses due to disease. Prevention requires a proper understanding of fish health management, which involves the management of feed, water and pathogens. In a hatchery, the first thing to know is that broodstock or fry fingerlings should be free of pathogens so that they will not transmit disease-causing organisms (pathogens) later on. For the propagation and distribution of quality fish seed, there should be proper mechanisms of preventing hatchery pathogens and diseases. This chapter therefore looks at fish health management and biosecurity measures in a hatchery.

Aim

The chapter which has one session seeks to improve participant's knowledge and understanding on the different business models in seed production, hatchery economics and economic assumptions. Simple templates for calculating profit and loss have been presented to improve skills on how to know whether the business is making profits or losses.

Learning objectives
Acquired knowledge

· Participants know
- Business models in seed production
- Advantages and disadvantages of each model
- The economic assumptions

· Acquired skills

Participants to know how to
- Calculate profit and loss
- Calculate payback
- Design simple templates for calculating incomes and expenditure

· Acquired attitudes
- Fish seed production is a profitable business

· Relevance to fish seed production
- Profit and loss calculations are a measure of business growth

Session Overview

Session 1: Economics related to hatcheries and business models

Mode of delivery: Lectures, Group Discussions and Practical

7.1 Fish Health Management

Any hatchery operator is required to sell or stock parasite and disease free seed. Don't seek when some fish have either died or are about to die and you are unable to prevent it. As fish stay in water at all times, pathogens can spread very quickly. All fish in the same system, apart from some that may have a better immune system than others, will eventually die because they are exposed to the same pathogens. As disease treatment can be costly, prevention is the only way to stop losses due to disease. Prevention requires a proper understanding of fish health management, which involves the management of feed, water and pathogens. First, broodstock or fry fingerlings should be free of pathogens so that they will not transmit disease-causing organisms (pathogens) later on.

We should remember that the use of certified seed does not mean their fish will not have disease problems. Other conditions favour the occurrence of diseases, for example fish raised in poor water quality can be easily infected, as can poorly fed fish. Therefore, feed and water are other main factors that fish have to interact with or depend on. Feed is the most important factor for growth and survival of any animal. Therefore we should remember that:

- Some feed ingredients can serve as a source of pathogens while others may contain anti-nutritional factors that cause illness in fish.
- Good feed stored in humid and damp conditions can contain moulds that will produce toxins. Fish receive a large quantity of natural food from the water in addition to the feed supplied.
- Feed itself can be a cause for concern if fish are over-fed.
- Similarly, nitrogen from uneaten feed can be a source of ammonia, which can kill fish.
- Feed and the management of feeding are other important aspects of successful fish farming.

Temperature

The temperature of the water is an important parameter that can affect survival and reproductive performance. It should be borne in mind that:
- The temperature comfort zone for tilapia within which they show best growth and reproduction is in the range of 24–34°C.
- When water temperature rises above 34°C, tilapia become stressed, which favours bacterial infection, e.g. Streptococcus spp,. On the other hand, when the water temperature falls below 24°C, parasite infestation can occur.
- We should monitor water temperature regularly and should be measured early in the morning (around 6 am) when it will be at its lowest and in the afternoon around 2 pm when it will be at its highest.
- Water temperature differs with the depth of the water – the highest temperature will be on the surface, i.e. 10 cm below the top, whereas the lowest temperature will be in the deepest water, and so temperatures are usually measured at depths of about 10, 30 and 50 cm below the water level.
- Avoiding these extreme temperature conditions are a major objective of good management practice.

Parasites

Parasites are small animals that require one or more host animals in order to complete their life cycle. Generally they cannot survive outside their host. Their presence may or may not cause health effects in the host animal. Parasites falls into two categories and these are:

- Ectoparasites
- Those that occur outside the fish body for example those that cause Black spot, white spot, fish

louse and Nematode.

· Endoparasites

- Those that get into the body of the fish like Contraceacum, and Ligula intestinalis

Trichodina spp. are one of the most prevalent parasites in tilapia, appearing mostly during the swim-up fry stage while they are in the larval rearing system and then passing on to the subsequent stages. It is a protozoan parasite that

- Looks like a flower or saucer, or is bell-shaped with a sucking disc from the lateral view.
- It occurs especially in winter when temperatures fall below 25°C.
- They feed on bacteria and are found on the skin and gills.

Parasites can be identified by simple scratching of skins and gills and observing the material under microscope (10× magnification). Although they may not be critical, they can be dangerous, as they make the fry and fingerlings weak and ultimately may lead to death.

- Infected fish show abnormal coloration, sluggishness and loss of weight. Hatchery operators usually use saline water or common salt to raise the salt levels up to 5 ppt. This parasite actually comes from brooders via eggs or yolk-sac larvae.
- Dipping eggs and fry in 200 ppm salt solution immediately after cleaning the eggs before transferring to the incubators and trays can break the cycle.
- Most of the parasites can be controlled by using simple salt solution and the other treatments mentioned above.

Translocation of eggs, larvae, fry and fingerlings from one place to another without proper care can spread diseases and parasites. Disease, parasites or pathogens may enter fish through gills, penetration of egg membrane, ingestion, and rupture of skin, wounds or through the digestive tract.

Diseases

"A disease is the sum of the abnormal phenomena displayed by a group of living organisms in association with a specified common characteristic or set of characteristics by which they differ from the norm of their species in such a way as to place them at a biological disadvantage.

Disease is usually the outcome of an interaction between the host (= fish), the disease causing situation (= pathogen) and external stressor(s) (= unsuitable changes in the environment; poor hygiene; stress). Before the occurrence of clinical signs of disease, there may be demonstrable damage to/weakening of the host. Yet all too often, the isolation of bacteria from an obviously diseased fish is taken as evidence of infection. Koch's Postulates may be conveniently forgotten. In fish, diseases are considered to be caused by

- Genetic disorders
- Physical injury
- Nutritional imbalance
- Pathogens
- Pollution.

With a view to maintaining the security of fish, it is necessary to understand some aspects of the diseases and parasites. Disease is the most important factor and needs more attention. Tilapias are well known for their resistance to disease. However, when environmental conditions are extremely unfavourable they become stressed and can be infected by bacteria and viruses. One of the most important factors to be considered is water quality, especially temperature, pH, DO, ammonia and nitrite. Another important factor is feeding management. If managers and technicians are careful about these two factors, i.e. water quality and feeding management, most diseases can be avoided.

There are basically two types of diseases – infectious and non-infectious.

- **Infectious diseases**
  - Are due mainly to entry or attack by bacteria, viruses, fungi, moulds, protozoa and parasites, which are collectively known as pathogens.
  - Fish may exhibit similar symptoms but they are not transmissible, for example nutritional deficiencies, presence of toxic substances, other chemicals or heavy metals. There are various types of bacteria that can attack tilapia: Streptococcus iniae and Streptococcus agalactiae, Edwardsiella tarda, Edwardsiella ictaluri, Flavobacterium and Yersinia ruckeri.
  - The most common symptoms of these bacterial diseases are gill damage and tissue necrosis (
  - Among the bacterial diseases, those caused by Streptococcus spp. have emerged as common diseases in tilapia.
- Non-infectious diseases
  - Are diseases that cannot be transmitted by a pathogen and is caused by a variety of other circumstantial factors

As best management practice, in a fish seed production hatchery, each farmer has to always follow these steps so that the risks of parasites and diseases are minimized.

a. When feeding fish, be observant and keep records or report if fish show abnormal behavior, movements or responses to the feed.
b. Collect or remove any dead fish, even if just a single dead fish is seen on the surface of the pond water, and record/report.
c. Don't wash any dead fish in the pond, tank or hapa
d. Observe the dead fish and try to determine where the damage is; take pictures to keep as records.
e. If more fish have died by the next feeding time, collect the dead fish, handling them carefully so that tissues are not damaged.
f. Sample some live fish from the ponds, hapa or tanks to see whether any of them have any wounds or damaged tissues.
g. Observe/record and take pictures of the general appearance (shape, colour, etc.) of the whole body as well as that of scales, fins, tails and gills of both the dead fish and those that are alive but suspected to be infected.
h. Check the water quality in pond, hapa or tank

7.2 Biosecurity

Introduction

Biosecurity is the establishment and implementation of a system or procedures to prevent the introduction of pathogens into a fish hatchery from outside the facility or into a section of the hatchery from another section in the same hatchery. Biosecurity consists of practices that minimize the risk of introducing an infectious disease and spreading it to the fish at a facility and the risk that diseased fish or infectious agents will leave a facility and spread to other sites and to other susceptible species. Biosecurity measures also include practices that also reduce stress to the fish, thus making them less susceptible to diseases.

Over the past decades, South Eastern part of Africa has registered case of diseases including Tilapia Lake

Virus. More recently, Malawi in particular has registered cases of Epizootic Ulcerative Syndrome (EUS). With these recent events of diseases, there is a need to be on a high alert to minimize any risk of introducing diseases in the hatchery. What we should know about biosecurity:

- It is a set of preventive measures designed to reduce all sorts of risks.
- It entails the prevention of cultured species being attacked by disease-causing organisms and parasites, minimization of impacts of invasive alien species on the environment and avoiding the possibility of zoonosis or any human health hazards through the consumption of food, and genetically modified organisms (GMOs).
- Security of cultured animals has a direct relationship with economic losses. Sudden outbreaks of disease have often caused huge losses.
- Biosecurity is an integrated approach that encompasses the policy and regulatory frameworks that analyze and manage risks.
- The ultimate goal of biosecurity is to prevent, control and manage risks to human health, achieve food security and improve livelihood of people.

Goals of Biosecurity Measures

Biosecurity should be integrated in the hatchery and should be part of the good practice to use in any hatchery. The key goals of biosecurity measures include:

- **Fish management**—obtaining healthy stocks and optimizing their health and immunity through good husbandry
- **pathogen management**—preventing, reducing or eliminating pathogens
- **people management**—educating and managing staff and visitors

7.2.1 Biosecurity protocols for Hatchery

Hatchery investment is huge and hatchery owners invest a substantial amount of money to produce fish seed. Therefore, care must be taken from the beginning to ensure the hatchery is properly designed so that routine operations can run smoothly. Incidences of diseases and pathogens can have devastating effects on a hatchery. Biosecurity measures are needed to minimize the risk of financial loss. In a hatchery, high priority is usually given to breeding and maintaining broodstock. Biosecurity allows hatchery owners to achieve the following:

- Reduce disease introduction and occurrence of a disease outbreak
- Reduce spread of diseases and pathogens on-farm or to new areas
- Promote fish health
- Protect economic investment in relations to high financial losses from the loss of fish
- Protect human health, especially in relation to Zoonotic diseases and food safety.
- Loss of clients, who will no longer trust the quality of the fry/fingerlings.

Biosecurity Principle

Any hatchery operator has to plan operations based on the three aspects of biosecurity:

- Bio-exclusion, the prevention of any outside agent from entering a production animal operation.
- Bio-management, the activities implemented to prevent agents from spreading within a facility (including the use of vaccines).
- Bio-containment, the protocols that prevent bacteria and viruses from spreading outside of the facility, even when their presence is unknown.

7.2.2 Bio-Exclusion Measures

Bio-exclusion relates to preventive measures (risk reduction strategies) designed to avoid the introduction of pathogenic infections (hazards). They are protocols that keep disease causing agents out of your hatchery or farm. Bio-exclusion measures are applied to all incoming fish (broodstock), water, feed, items such as materials, equipment, and vehicles, and people, predators, scavengers and pests. These measures include:

i. Fencing of Hatchery perimeter

- A barrier in form of a fence or weir could be constructed around the hatchery to prevent any unregulated entry of foreign animals and people who may be potential carrier of diseases and pathogens. Barriers are also very effective in minimizing predation from otters

ii. Water safety and quality

It is important to ensure water coming into your hatchery facility or farm does not have the disease agents that you do not want to come in. You can ensure this by:

- Using a water source that is free of the diseases, such as groundwater.
- Install a water treatment system to eliminate the diseases. The water treatment systems which may
- – Physical water treatment systems such as sand bed, filters or UV light
- – Chemical water treatment systems such as chlorine.
- Monitoring the water treatment system continuously and have a contingency plan in case of its failure.
- Using screens or nets on surface water intakes to keep wild aquatic animals from entering.

iii. Having proper fish introduction protocol

Fish collected from the wild or other farms are potential source of parasites and diseases.

- Purchase aquatic animals from facilities, farms or region known to be free from the diseases.
- Establish receiving and quarantine ponds away from the hatchery.
- Once the fish arrive on the farm, stock them in quarantine ponds and
- Disinfect the fish with necessary disinfectant to inactivate the diseases on their surface
- No fish or water should be allowed to escape from quarantine facilities.
- The equipment used in quarantine facilities should not be moved to non-quarantined areas until it has been disinfected.
- Observe on a daily basis for any signs of diseases.
- If resources permit, confirm the disease status by testing them before the fish can be transferred to the hatchery facility. You could also engage the Government personnel to conduct the disease screening.

iv. Bird Netting or Roof over ponds

- Predation can have very devastating effects on a farm and need to be controlled. Birds are among the major predators as such there, farmers are advised to install netting material or roof (made from transparent polythene plastic over the ponds.

v. Entrance Control

Various agents including people, vehicles and pets, provide an excellent vector through which disease can spread from one location to another.

- Establish a Disinfection of all equipment with suitable water and power supply for sanitation of vehicles.
- Establish a hand washing facility at the entrance.
- Maintain record for visitors and their purpose - All visitors need to understand the possible risk they present when entering a hatchery facility, what is expected of them, and what precautions need to be taken when in the hatchery.

vi. Feed inputs

In most cases, feed is brought in from other sources; it is also a potential source of diseases and pathogens in the hatchery. Even in a case where the feed is manufactured on-site, ingredients that are added to the feed may also be brought in from outside. Incoming feed and feed ingredients should be free of the diseases and pathogens. To minimize the chance for disease introduction through feed, the following are recommended:

- Use of commercial feed – most commercial feeds are manufactured in a manner that inactivates the diseases
- Avoid sharing of feed with other farms to avoid transferring disease from other farms.

vii. Feeding

- Always wash hands before feeding the fish and ensure that sterilized equipment utensils are used for feeding
- After feeding, make sure that all feeding utensils are disinfected and dried in direct sunlight.

viii. Bio-Management

Even with strict entry measures, most facilities will eventually encounter some problems with infectious diseases. Bio-management is a set of activities implemented to prevent agents from spreading within a facility. It is recommended that hatchery operators should follow the following key Bio-management strategies:

ix. Biosecurity Signage and entry

- Provide a farm gate sign indicating biosecurity levels in effect on the hatchery.
- Place restricted entry notices on the doors to animal facilities
- Establish one entry point at the farm where visitors can enter.
- Keep visitors log and names, dates and vehicle registration number.

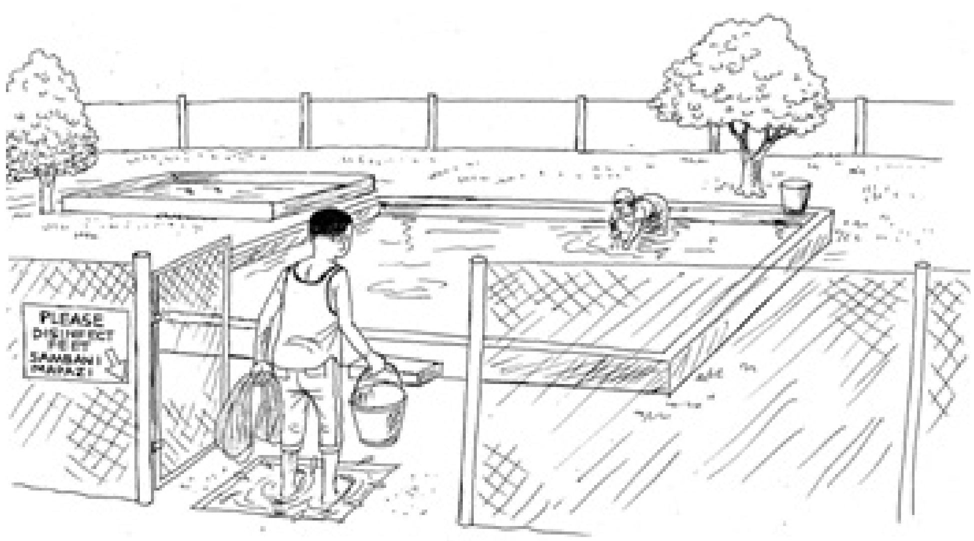


Fig 7.1 An entry point to the hatchery with a biosecurity measure – basin for dipping legs

x. Staffing

- Hatchery staff responsible for feeding and daily farms operations should be trained to carefully observe feeding and general behaviors of fish. Appropriate training of husbandry and investigative staff in understanding the importance of control of infectious diseases and procedures to avoid pathogen exposures is critical

xi. **Routine monitoring**

- When moribund and dead fish are observed in the ponds or hatchery, they should be removed immediately.
- Older fish (>5 years for tilapia) in a hatchery should be culled as these are often susceptible to chronic diseases
- If available, hatchery operators must use hatchery-based personal protective clothes and equipment (clothes and boots) when working in the hatchery to prevent potentially harmful biological agents, which may come from home clothes
- Cleaning and disinfection of protective clothing and fish husbandry equipment.

7.2.3 Bio Containment

Bio containment relates to measures to limit within-farm transmission of infectious hazards and onward spread to other farms. Hatchery owners and operators always need to make sure that whatever is coming from their farms is well decontaminated and disinfected. This included disinfection of all equipment and all materials after use in the hatchery. Some of the key bio containment strategies include:

- Hands and equipment must be disinfected after any form of fish and feed handling in the hatchery. Any non-living (inanimate) objects such as dip nets, brushes, gloves, buckets, raingear, etc. that can carry a disease-causing organism.
- Ensure pond/raceway discharge can be sealed off, should a major disease outbreak occur, to prevent untreated discharge risk.
- All discharge pipes have screens installed to avoid fish escapement.
- Make sure that all effluents from the hatchery is treated, decontaminated or disinfected before releasing the water to natural water system.
- Farm should have equipment and contingency plans to manage high mortality events, such as pre-arranged high volume disposal sites.

The strength of any fish seed hatchery operator should be a monitoring the production exercise program that will determine the range of serious fish pathogens and detect new outbreaks of disease. Control and containment of fish parasites and diseases require the periodic examination of hatchery populations as well as fish that are free-ranging in natural waters. Good health of hatchery fish extends beyond their cultural confinement to natural populations which they contact after being stocked.

A monitoring program should include:

- A hatchery must maintain good water quality at all times.
- Most fish diseases are water-borne and are readily transferred from one rearing unit to another by equipment such as brushes, seines, and dip nets. All equipment used in handling and moving fish can be easily sanitized by dipping and rinsing it in a disinfectant
- Dead and dying fish are a potential source of disease organisms and should be removed daily.
- Empty rearing units should be cleaned and treated with a strong solution of disinfectant and then flushed before being restocked.
- Direct sunshine and drying also can help sanitize rearing units. If possible, ponds, tanks or hapas should be allowed to air-dry in the sun for several weeks before they are restocked.
- Many times, the pond bottoms are disked, allowing the organic matter to be oxidized more quickly. After the pond soil has been sun-baked, remaining organic material will not be released easily when the pond is refilled.
- Disease control;

- Elimination of animal competitors;
- Destruction of aquatic weeds, among others.
- Disinfection of ponds with lime is a common practice. This is particularly useful for killing fish parasites and their intermediate hosts (mainly snails), although it will also destroy insects, other invertebrates, and shallow rooted water plants for a few weeks.
- Normally, a limed pond will be safe for stocking within 10 days after treatment, or when the pH has declined to 9.5. However, a normal food supply will not be present until three to four weeks later.
- Feeds should be well taken care of and feed free from molds should be used

Summary

Pathogens and occurrence of diseases must be prevented in a hatchery as it can lead to heavy economic losses. A disease is rarely a simple association between a pathogen and a host fish. A simple contact between the fish and a potential pathogen leads to a disease. Management practices directed towards at limiting stress are likely to be most effective in preventing diseases outbreaks. Broodstock must be collected from reliable sources and should be acclimatized once they reach our hatcheries. Water quality parameters such as temperature, pH, and dissolved oxygen must be regularly checked to prevent stressful conditions for the fish. Water temperature also affects other properties of the aquatic environment important for fish health. Feeding fish with good quality feed, at the right time and intervals must be observed. Fish should not be overstocked in breeding or rearing facilities to avoid stressful conditions for fish. Biosecurity measures must be put in place to prevent or limit within-farm transmission of infectious hazards and onward spread to other farms. Hatchery owners and operators always need to make sure that whatever is coming from their farms is well decontaminated and disinfected. This included disinfection of all equipment and all materials after use in the hatchery. Hands and equipment must be disinfected after any form of fish and feed handling in the hatchery. Any non-living (inanimate) objects such as dip nets, brushes, gloves, buckets, raingear, etc. that can carry a disease-causing organism. Ensure pond/raceway discharge can be sealed off, should a major disease outbreak occur, to prevent untreated discharge risk. All discharge pipes have screens installed to avoid fish escapement.

Economics related to hatcheries

Introduction

Each and very farmer selects a business basing on several available options. One might be convinced that the hatchery business will give them the highest profit compared to others in a particular situation. In some cases, it may not be the highest earning but will have other good reasons for being chosen. Whether a farmer should choose a hatchery or nursing business, or grow out farming, depends on several factors. In general, a hatchery business requires specific skills, techniques and proper planning of financing and human resource training. In the case of tilapia and catfish, it is capital- and labour-intensive, but it is more profitable than nursing and grow-out production. Some farmers may choose nursing of fry to fingerlings as a business, acting as middlemen between hatcheries and grow-out farmers. The level of seed production and the seed production system being used will depend on economics. As level of production increases, more investment is required in numbers of brooders, feed, and overall production costs will increase. Financing, staffing and all other planning depend on production and sales targets. Planning for expansion or is always good even if starting up on a small scale. In many cases, farmers start off by planning on a small scale and then eventually expand their businesses. Levels of production and sales can be easily doubled without the need to double up on everything. For example, producing 1 million fry a month can be achieved by 4 ponds and five staff, but 2 million per month can be achieved by adding only another 2 ponds and 2 or three staff instead of doubling the amounts.

Aim

The chapter which has one session seeks to improve participant's knowledge and understanding on the different business models in seed production, hatchery economics and economic assumptions. Simple templates for calculating profit and loss have been presented to improve skills on how to know whether the business is making profits or losses.

Learning objectives

Acquired knowledge

- Participants know
- Business models in seed production
- Advantages and disadvantages of each model
- The economic assumptions
- Acquired skills

Participants to know how to
- Calculate profit and loss
- Calculate payback
- Design simple templates for calculating incomes and expenditure
- Acquired attitudes
- Fish seed production is a profitable business

- Relevance to fish seed production
- Profit and loss calculations are a measure of business growth

Session Overview

Session 1: Economics related to hatcheries and business models

Mode of delivery: Lectures, Group Discussions and Practical

8.1 Economics related to hatcheries

8.1.1 Business Models in Seed Production

There are many definitions of a business model, but basically "a business model is a simplified and aggregated representation of the relevant activities of a company. It describes how marketable information, products and or services are generated by a means of a company's value added component.

- **Fry nursing to fingerlings**

Nursing of fry to fingerlings is one of the business options. The fry nursery acts as middleperson between hatcheries and grow-out farmers. They buy fry from reliable hatcheries, transport them to locations near farmers, and grow it to a larger size. These can be lead farmers in an area and they and important roles in supporting fellow fish farmers by

- By supplying quality fish seed,
- Feed
- Fertilizer, lime and other materials like netting materials to grow - out farmers.
- Fish growing techniques and other fish farming related extension messages and skills
- Providing valuable market information,

Some farmers produce only small fry of 0.2–0.3 g while others do the nursing of these fry to 5–10 g fingerlings (30–45 days). The nursing is done to produce larger fingerlings of 30–50 g in size to stock in ponds or cages so that grow-out farmers can produce to table size. This model is relatively easier but takes a longer time to get a return and requires more space.

- **Seed from hatchery to grow out**

In this model, grow-out farmers do directly reach the hatcheries and buy the seed. A grow-out farming business is relatively easier but takes a longer time to get a return and requires more space. If the hatchery producer has sold small fry of 0.2 – 0.5g, grow - out producer will take the role of nursing them to the right size at which the can be stocked in grow out facilities. Grow-out is relatively easier because

- A large numbers of farmers can do it in groups. This gives back to the communities a chance of doing business and allows them to get involved in income generating activities.
- It minimizes transportation costs thereby increasing on their profit margins

Hatchery, nursery and grow-out Model

The most successful businesses are specialized hatcheries. However, most hatcheries in Malawi are either vertically integrated or have at least two components such as hatchery and nursing, or nursing and grow-out. As grow-out farming is the easiest, most farmers who are not as interested in learning techniques do it as an occupation along with other traditional farming.

Technical Agents

These are technical experts who supply fingerlings, handle transport and marketing and provide technical advice. The technical agents implements an innovative, sustainable, for-profit business development services (BDS) model that links smallholder fish producers with new and existing small and medium enterprises (SMEs) in the sector. They provide needed technical assistance to small holder producers in the communities where they live and work, as well as to sell quality fish seed, fish feed and other inputs at a profit.

8.1.2 Hatchery economics

Like all enterprises, fish hatchery operations should be economical if it is to be undertaken as a commercial venture. The cost versus returns must be weighed for every input and management practice before it is implemented. If the return is not does not justify the cost, the input should not be used regardless of the increase in production. In fish hatchery, as the intensity increases, it becomes more profitable up to a point where marginal return from the ever more expensive inputs begins to decline. In extreme cases, the business maybe losing money even though the production is very high.

For easy calculation of profits and losses, the hatchery will need to have a detailed budget. A budget is generally defined as a structured system for estimating values of the revenue generated and the costs incurred. Thus, the enterprise budget itemizes the types, quantities, and prices of products to be sold by the enterprise. All costs associated with that particular production activity are also itemized by types, quantities, and prices. The revenues are then compared to the costs to determine whether there is adequate revenue to cover all costs. If so, the enterprise is profitable. Outlined in here is a simple economic analysis on a simple catfish hatchery.

Economic assumptions

The hatchery will require an initial capital investment and with some annual operating costs estimated for the first year's operation. And the following should be put into consideration:

- Number of production cycles per annum (each culture cycle how many days)
- How many full time employed workers
- Number of broodstock ponds
- Number spawning tanks
- Number of egg hatching tanks
- Number of larval rearing tanks
- Depreciation rate is % per annum (20%)
- Number of seed produced per year
- Price of a fish seed in MWK
- Number of seed produced and sold
- The standard lease/rental fee for the hatchery land is 10% of net annual sales.

Calculations

To assess the various components of starting and operating a small-scale fish hatchery, the economic analysis is split into:

- Capital Investment,
- Operating Expenses,
- Non-operating Expenses,
- Profit and Loss.
- Profitability measures

Capital Investment

- Capital investment involves all the expenses on the construction and infrastructure for the hatchery.
- The cost items generally have a life span longer than one year, and they are used to generate income for the hatchery. These include
    - Buildings
    - Ponds and tanks
    - Infrastructure (electricity, telephone, roads)
    - Piping, drains

- o Large equipment (pumps, blowers,)
- o Small equipment (weighing scales,)
- o Vehicles

Table 8.1: total capital investment cost calculation

Capital Investment Items	Value (MWK)
Hatchery building	
Ponds, tanks, hapas, egg hatching jars	
Pumps, aerators	
Power installation	
Standby generator	
Egg recirculation system	
PVC Piping	
Oxygen Cylinder	
Miscellaneous	
Total Costs	

Operating Expenses

This component is for the expenses that are generated during each production cycle and are essential for the routine operation of the hatchery. The items included in this component are:

- Broodstock feeds
- Fertilized eggs (from a larger hatchery)
- Starter feeds electricity
- Workers' salaries
- Land lease costs
- Miscellaneous (e.g. fertilizers, chemicals, accessories, etc.,)

Profit and loss

Profit and loss consists of the income generated from sales of hatched larvae or seed minus all the operating and non-operating expenses.

Table 8.2: Profit and loss calculation

Profit (or loss)	Value (MWK)
Income	
Annual cost	
Annual profit (income - annual cost)	
Non-operating expenses	
Profit (or loss) after depreciation	

Profitability Measures

- Payback Period
- Internal Rate of Return (IRR)
- Equivalent Annual Return

Payback Period

- Payback period is the time required for the investor to payback his original investment made.
- It is a measure of how attractive project is for making an investment.
- The project with the shortest payback period is preferred.

Payback Period (PP)

- Payback period = (Capital Investment / Profit)
- For example, we should calculate a payback the total investment cost is MWK7, 000,000 and yearly profit is MK1, 500,000
- Payback Period will be MWK5 ,000,000/MWK2,800,000 = 2.5 years

This assumes that the hatchery operation is running smoothly and the price of the fingerlings and cost of expenses remain stable during this period.

Payback Period

To easily understand the Return on Investment, let us use payback period to measure how rapidly the small scale hatchery can provided a return to the initial investment

Table 8.3: Payback calculation

Payback Period	Value (MWK)
Capital Investment	
Profit	
Payback (Years)	

Internal Rate of Return (IRR)

- The discount rate at which the hatchery has an NPV of zero is called the internal rate of return.
- The IRR represents the maximum rate of interest that could be paid on all capital invested in the project.
- If all funds were borrowed, and interest charged at the IRR, the borrower would break even, that is, recover the capital invested in the project.

Equivalent Annual Return

- The NPV is the difference between the present value of cash inflows and the present value of cash outflows over the life of the project. If the NPV is positive the project is likely to be profitable.
- When the NPV is converted to a yearly figure it becomes annualized.
- In this report the annualized return is called the equivalent annual return.
- It is a measure of annual profit after deducting capital, operating and labour costs generated over the life of the project expressed in today's dollars.

Summary

For one to make profits in the seed production business, he or she will require specific skills, techniques equipment and proper planning of financing and human resource training. It should be known that the level of seed production and the seed production system being used will depend on economics. As level of production increases, more investment is required in numbers of brooders, feed, and overall production costs will increase. The hatchery operator will need to have an understating of the different fish seed business models which he or she will feel to be beneficial. Some basics of calculating profit and loss will need to be acquired. Record keeping is required to assist in making calculations, this means that record keeping must be done at all levels of operations till after marketing of the fish seed

FISH SEED PRODUCTION

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