PRACTICAL MANUAL FOR THE CULTURE OF THE AFRICAN CATFISH (CLARIAS GARIEPINUS)

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PREFACE

In 1977 the Department of Fish Culture and Fisheries of the Agricultural University of Wageningen approached the International Research and Technology Programme (DPO/OT) of the Directorate General for International Technical Cooperation of the Netherlands to discuss the possibilities of applied research into the culture of the African catfish under tropical conditions.

This led to the financing of two related projects:

i) Reproduction and fingerling production of Clarias lazera in fish culture
A more applied research project implemented in Bangui, Central African Republic, involving collaboration between the National Fish Culture Station, the FAO and the Agricultural University of Wageningen.

ii) Dutch-Israeli project for the culture of African catfish, Clarias lazera, which can produce viable eggs throughout the year
A more fundamental research project implemented within the Netherlands-Israel collaboration programme for development cooperation and involving collaboration between the University of Utrecht, the Agricultural University of Wageningen, and the Kinneret Limnological Laboratory, Israel.

Both projects developed, in accordance with the main objective of the Research and Technology Programme, a new technology applicable in developing countries. The results of this research ultimately aimed at improving the nutritional status and income-generating capacity of developing countries, have been elaborated in this "Practical Manual".

The Manual is only the first step towards overcoming the considerable gap between the development of a technology and its application. In order to bridge this gap, action must be taken not only by the extensionist at whom the Manual is directed, but by all those who take an interest in increasing rural production and well-being.

CONTENTS

Appendices

INTRODUCTION

In the past, rural fish farming in Africa has concentrated on tilapia. Various manuals, primarily written for the guidance of the "small farmer", have already appeared for that species. For catfish farming, general guidelines have been formulated by some research stations in Africa. A comprehensive manual, however, has yet to be compiled.

In the preparation of the present Manual covering the culture of the African catfish, Clarias gariepinus, use has been made of the results obtained in recent years in the:

- Hatchery of the Department of Fish Culture and Fisheries at the Agricultural University of Wageningen, the Netherlands.

- Project "Reproduction and fingerling production of **Clarias lazera** in fish culture (GCP/CAF/007/NET)" carried out under the management of the Food and Agricultural Organization of the United Nations at Fish Culture Station La Landjia, Bangui, Central African Republic.

- "Dutch-Israeli project for the culture of African catfish, **Clarias lazera,** which can produce viable eggs throughout the year (LH 867)" carried out at the hatchery of the Kinneret Limnological Laboratory in Tabgha and the Intensive Fish Culture Station in Ginossar, Israel.

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The authors wish to express their appreciation of the painstaking artwork produced by Mrs. L.C.M. Viveen, illustrator.

The Manual is written for Africans who after secondary school have been trained in fish farming. Consequently, relatively advanced techniques are dealt with, but information about simple practical operations is also presented. These are additionally illustrated in a large number of drawings to guide the less fully trained user as well. The authors anticipate that, with the aid of these drawings, summarized guidelines could be published in local languages, specially attuned to regional fish farming conditions. A number of appendices have also been included for users with a higher level of training who wish to concentrate on the intensive culture of catfish. To make the Manual easier to study, no references to scientific publications have been incorporated.

The contents of the individual chapters can be summarized as follows:

Chapter 1. A number of anatomical characteristics that are particularly relevant for catfish farming are presented. The terminology for the various development stages is introduced.

Chapter 2. A number of aspects of catfish pond construction are discussed. The aim of the construction techniques presented is to minimize the excavation work required for pond wall construction, so that, in principle, ponds can be excavated manually.

Chapters 3 and 4. In most tropical countries there is a chronic shortage of fry to stock the available ponds.
Techniques for artificially induced reproduction of spawners and the breeding of fry under hatchery conditions will have to be introduced more and more in the future. This is why these techniques are extensively discussed.

Chapter 5. Nursery pond management in the tropics is an onerous business with most fish species. The problems arise with the stimulation of plankton development by applying fertilizers while maintaining optimum water quality. Predators form a constant threat for the growing fry; of those predators, frogs and toads in particular have to be eliminated.
The Bangui Fish Culture Station in the Central African Republic provided guidelines for liming and fertilizing. Although largely attuned to those local circumstances, they may serve as a basis for work in other regions.

Chapter 6. In various regions of Africa experiments are being conducted with stagnant fattening ponds, in which a small degree of fertilization and/or feeding with carbohydrates is practised. Farming is carried out with tilapia, but only low production figures are achieved. This is also caused by the serious overcrowding of the ponds as a result of excessive reproduction by mature fish. This leads to stunting of the growth of the entire pond population.
This chapter also elaborates present practice by discussing the semi-intensive polyculture of the Nile tilapia and the African catfish. Fertilization and feeding with agricultural wastes, however, is being intensified in order to allow larger harvests. Catfish play an important role as tilapia fry predators in this polyculture.
The second part of this chapter deals with intensive catfish monoculture with pellet feeds. On the basis of practice in Asia, it is expected that intensive catfish culture - not only in stagnant ponds but also in flow-through ponds - will play more and more an important role in Africa as well.

Chapter 7. In this chapter, information about the commonest diseases affecting catfish is presented. The symptoms described are not always specific, and neither can the diseases always be identified with certainty. This chapter should therefore be read as a whole. Emphasis is laid on prophylaxis and therapy.

Finally, the Manual draws particular attention to the behaviour of the fish. This is often an indicator of the well-being of the fish and may enable timely intervention if environmental conditions are less than optimum. The ultimate success of fish culture largely depends on such timely intervention.

The authors

Geographical distribution of catfish

- ○ *Clarias lazera*
- ⊙ *Clarias senegalensis*
- ⊕ *Clarias mossambicus*

} = *Clarias gariepinus*

- ● *Clarias gariepinus*

1. THE AFRICAN CATFISH (Clarias gariepinus, Burch.)

1.1 Geographical distribution

The African catfish is widely distributed throughout Africa (Fig. 1). It inhabits tropical swamps, lakes and rivers, some of which are subject to seasonal drying. In the Northern and Central part of Africa it has been described as Clarias lazera, in the Eastern part as C. senegalensis, in the Western part as C. mossambicus and in the Southern part as C. gariepinus. In all regions, however, we are dealing with one single species, Clarias gariepinus.

1.2 Biological description

Skin

Catfish have a scaleless slimy skin, which is darkly pigmented in the dorsal and lateral parts of the body.
The fish turn lighter in colour when exposed to light. During stress they will show a mosaic-like pattern of dark and light spots.

Mouth

With the wide mouth the African catfish has the ability to feed on a variety of food items, ranging from minute zooplankton to fish.
It is able to suck benthos from the bottom, to tear pieces of cadavers with the small teeth on its jaws and to swallow prey such as fish whole.
The mouth circumference of this gape-limited predator, which is about 1/4 of its total length, determines the maximum size of its prey. A catfish of 30 cm (approx. 200 g) has a mouth circumference of about 7.5 cm. This is able to encompass the body circumference of small Tilapia nilotica of up to 8-10 cm, which makes the African catfish an excellent predator for controlling overpopulation of tilapia in ponds.

Barbels and olfactory organs

Around the mouth eight barbels can be distinguished (nasal, maxillary, outer mandibular and inner mandibular) (Fig. 2). The catfish can move the maxillary

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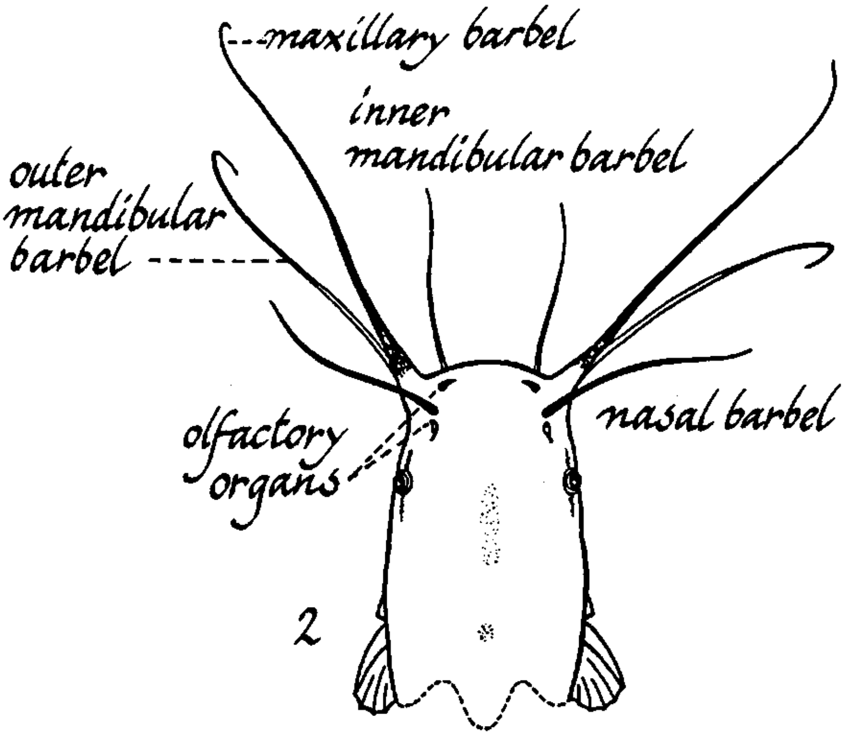
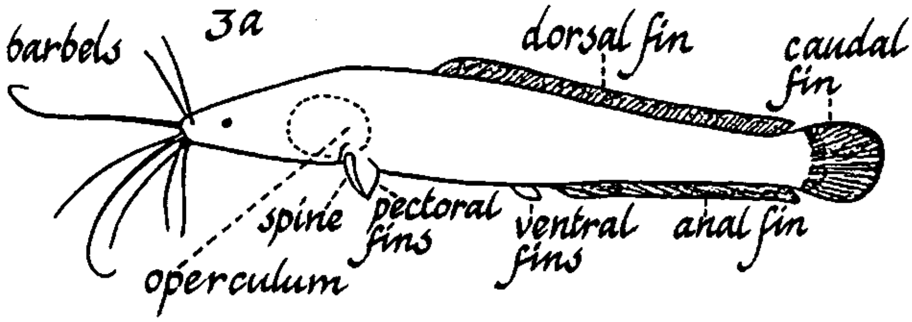


maxillary barbel
inner mandibular barbel
outer mandibular barbel
olfactory organs
nasal barbel

3a



barbels
dorsal fin
caudal fin
spine
pectoral fins
ventral fins
anal fin
operculum

3b

arborescent organs
gill filaments
gill rakers
branchial arches located underneath operculum
1 2 3 4 5

barbels independently of its mouth. The barbels serve as tentacles.
Close to the nasal barbels two olfactory organs are located (Fig. 2).
Catfish recognises its prey mainly by touch and smell. This is of relevance during feeding at night and in highly turbid or muddy waters, visibility being of less importance.

Fins

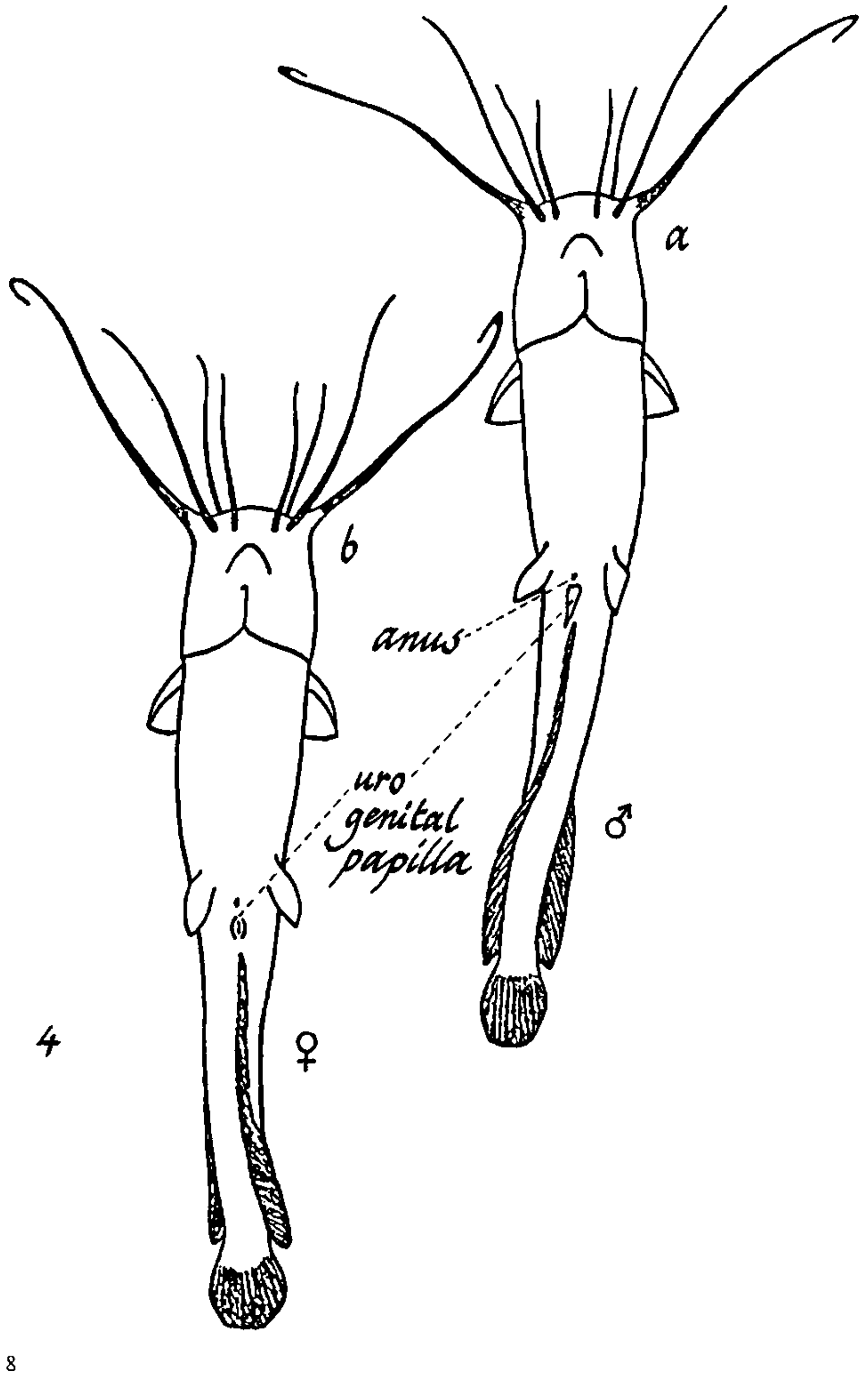
In the African catfish the median fins consist of a dorsal, a caudal and an anal fin, while the paired fins consist of the pectoral and ventral fins (Fig. 3a). The pectoral fins have developed strong spines (Fig. 3a) which have a locomotory and protective function. The fish is capable of migrating over land by sculling with its tail as it elbows along on its spines. The sharp spines are not poisonous.

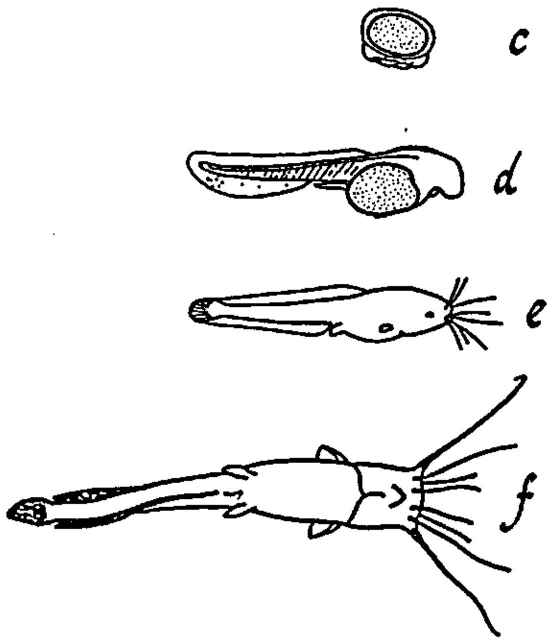
Gills and arborescent organs

The distribution of the gills and the arborescent organs over the five branchial arches is given in Fig. 3b. They can be observed by cutting away the operculum. For the purpose of respiration, water is taken into the mouth, passes over the gills for gaseous exchange and is then expelled through the opercular opening. Especially when the water's dissolved oxygen content is depleted or if the fish is out of the water, air is periodically gulped in at the mouth. Gaseous exchange takes place via the arborescent organs in air chambers above the gills. The air is also expelled through the opercular openings. Due to its atmospheric respiration the African catfish is capable of existing in mud during the dry season. It is even able to survive out of the water for some hours depending on the humidity of the environment.
Because the catfish can tolerate low oxygen levels in the water, it is very suitable for fish culture.
Along the concave anterior border of the branchial arches long slender gill rakers are present. These mainly serve as filters for feeding on small vegetable matter and invertebrates (Fig. 3b).

Urogenital system

In both sexes of catfish the urogenital opening is situated at a papilla just behind the anus.


a
b
anus
uro
genital
papilla
♂
♀
4



	Size range	Weight range	
Eggs	1 - 1,6 mm	1,2 - 1,8 mg	(c)
Larvae	5 - 7,0 mm	1,2 - 3,0 mg	(d)
Fry	8 - 30,0 mm	3,0 - 1000 mg	(e)
Fingerlings	3 - 10,0 cm	1 - 10 g	(f)
Adult fish	32 - 140 cm	0,3 - 16 kg	(a/b)

The adult male (♂)can be distinguished from the female (♀) by the elongated backwards projecting form of this papilla (Fig. 4a). In the female the papilla has the form of an oval eminence (Fig. 4b). Fingerlings have not yet developed a papilla.

1.3 Reproduction in nature

The reproduction cycle of the catfish starts in most African countries at the beginning of the rainy season. The final stimulus to spawn appears to be associated with a rise in water level and inundation of marginal areas. Spawning takes place in large shoals of adult males and females in water which is often less than 10 cm deep and situated at the edges of lakes and pools. The African catfish spawns in captivity on a variety of other substrates including sisal fibres, palm leaves and stones.

During courtship which can last several hours the female catfish lays her eggs (Fig. 4c) in several batches. The partner fertilizes at the same time each batch of eggs by releasing a cloud of sperm on top of the eggs. Within some seconds the female distributes the fertilized eggs over a wide area by wiping them with her tail. The eggs will finally adhere to the flooded vegetation.

After spawning the shoal of catfish migrates back to deeper water. There is no parental tending of the eggs. After a few weeks the African catfish will often have developed a new batch of eggs, and is prepared to spawn again. A second spawning can be induced by rainfall or by inflow of water from an upstream source. In this way several spawnings per year can take place. Depending on the water temperature the eggs will hatch after 24-36 hours. These so-called yolk-sac larvae (Fig. 4d) hide underneath the vegetation. Probably due to a high mortality rate among the eggs and larvae in nature, fry (Fig. 4e) and fingerlings (Fig. 4f) from the African catfish are difficult to find. The fish culturist prefers, therefore, to rear eggs and fry in a hatchery. This will be explained in the following chapters.

NOTES

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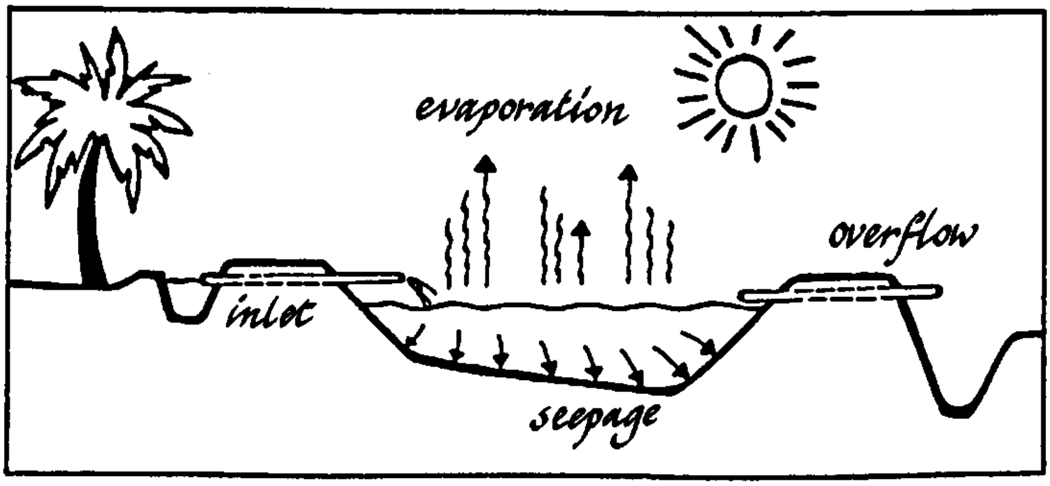


2. POND CONSTRUCTION

2.1 Site selection

Before deciding where to build a pond, the site has to be studied. The following factors should be considered:

- Avoid areas with trees, rocks or termitaria. They will cause many problems during construction and subsequent pond management (seepage, netting etc.).
- Do not dig ponds at places where floods occur during the rainy season.
- Construct the fishpond close to a water source (river, lake, barrage, ground water etc.), and not too far from the fish-farmer's residence, so that he can look after his fish daily. A constant water supply is often given by wells and springs. In most cases, however, the water source will be runoff water, such as a river or a stream. This means that the water quantity fluctuates and is often considerably diminished by the end of the dry season. For fish culture enough water is needed throughout the year. This is not only to fill the pond, but also to make up for the losses caused by seepage and evaporation (Fig. 5).
- Build the pond where the soil is not too sandy in order to avoid seepage as much as possible. Heavy clays are very good for impoundments.

The following two tests may indicate whether the site is suitable for fish culture or not. The tests should be performed at the end of the rainy season, while soil is still soft and ground water near maximum levels.

The ground water test

- Dig a hole with a depth of one metre and cover it with, for instance, leaves for one night to limit evaporation (Fig. 6a and 6b).
- If the hole is filled with ground water the next morning (Fig. 6c), a pond could be built, but it must be realized that a pump will probably be needed during harvesting.
- If the hole is still empty the next morning (Fig. 6d), no problems will be incurred with high ground water levels and the site will perhaps be suitable for fish culture. But this should be checked with the water permeability test.

The water permeability test

- Fill the hole with water to the top (Fig. 7a) and cover it again with leaves (Fig. 7b). The next day the water level will be lower due to seepage (Fig. 7c). The walls of the hole have probably become saturated with water and might hold water better now.
- Refill the hole with water to the top (Fig. 7d) and cover it once more (Fig. 7e). The next day the water level should be checked again.
- If the water level is still high the soil will be impermeable enough and is suitable for stagnant ponds and flow-through systems (Fig. 7f).
- If the water has disappeared again, the site is not suitable for fish culture.

2.2 Water supply rate and pond design

Stagnant ponds

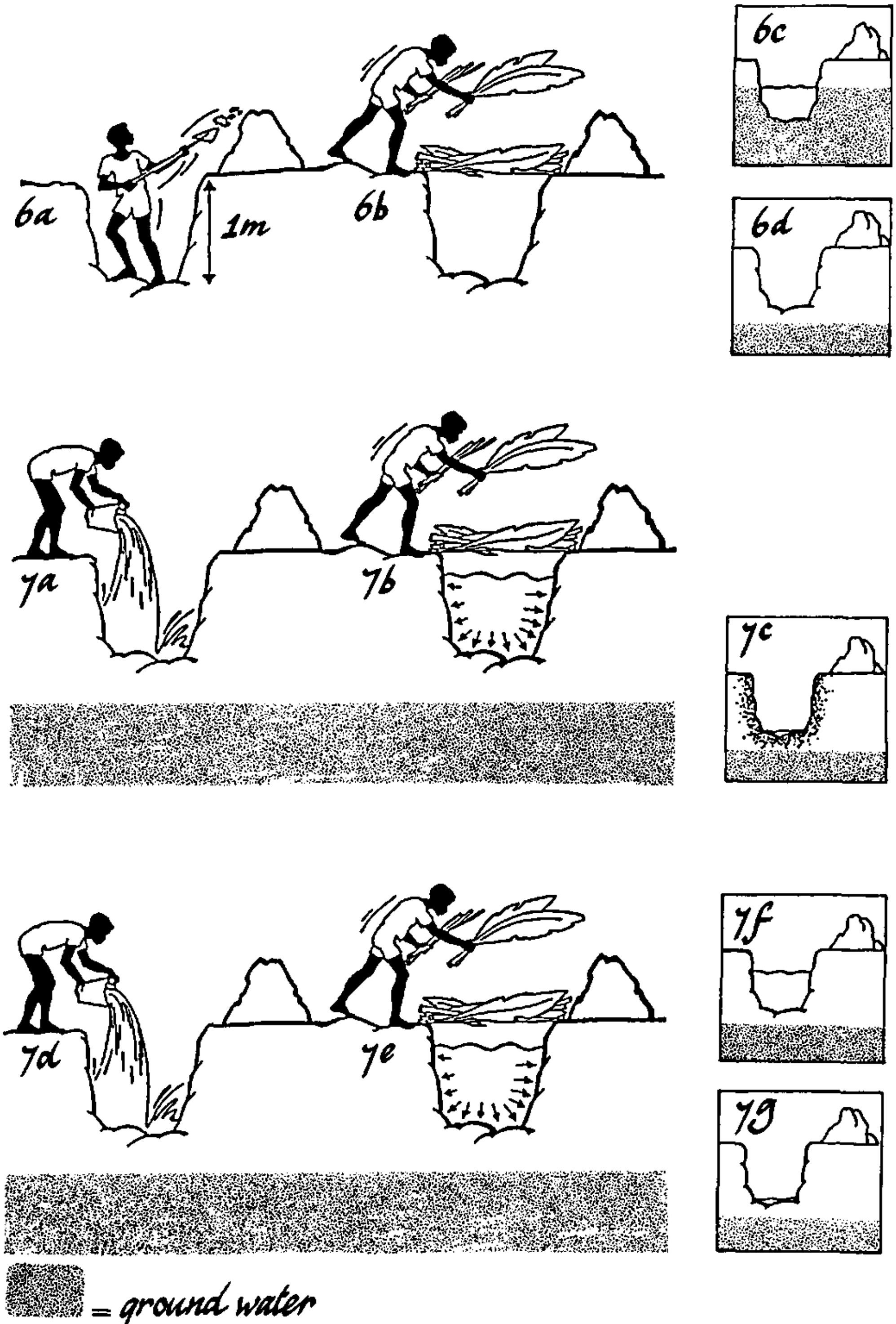
When only the same amount of water that is lost due to seepage and evaporation is added to a pond, the system is called a stagnant pond. Seepage and evaporation on suitable fish farming soils will not exceed 1-2 cm/day, corresponding to 0.75-1.5 l/min/100 m^2 (100 m^2 = 1 are). Production capacity depends on a variety of factors such as:

. the various fish species cultivated,
. water quality (see appendix 1),
. bottom fertility and
. climatological conditions.

Production can be increased by the applications of organic or inorganic fertilizers if the natural productivity of the pond cannot yield enough food organisms for the fish stock. These ponds do not necessarily need a discharge. Pumping or siphoning could be employed to empty the pond. An inlet and an overflow are, however, indispensable (Fig. 5).

Flow-through ponds

If enough water throughout the whole year is available, flow-through ponds could be constructed. In these systems water is continuously flowing through the ponds. Natural food productivity is of no concern. Fish production potential of these ponds mainly depends on:


6a
1m
6b
6c
6d
7a
7b
7c
7d
7e
7f
7g
= ground water

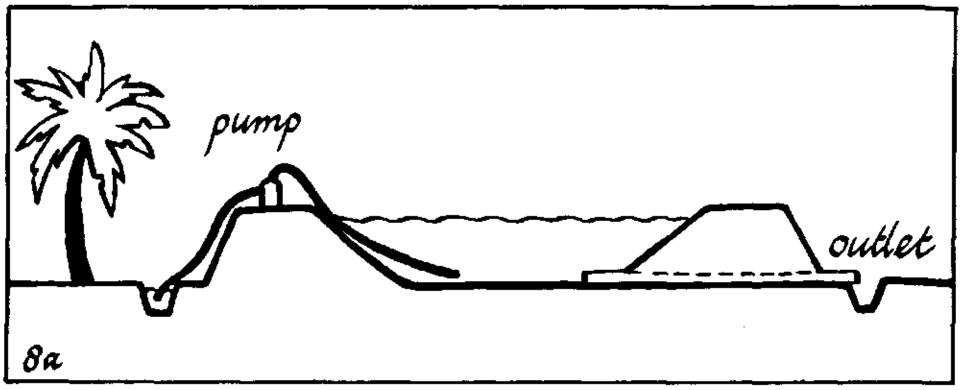
. the fish species cultivated,
. water quality,
. climatological conditions,
. flow rate of the water,
. the density of the fish stock in relation to the distribution of complete feeds.

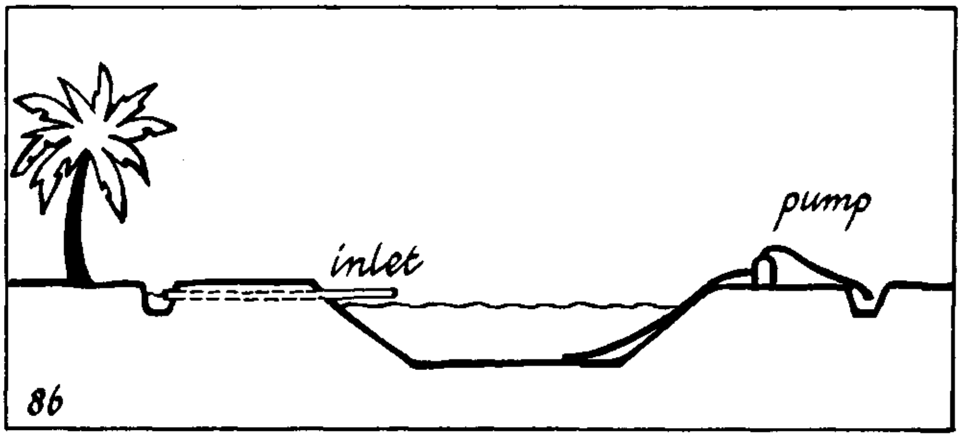
Since the production of fish in running water systems is totally dependent on the supply of food from outside the pond it is obvious that this type of culture is only possible where complete feeds are available for fish culture purposes.
The continuous flow of water through the pond can be achieved by the construction of a sluice with an inlet and a draining installation, the monk (see later, Fig. 15a).

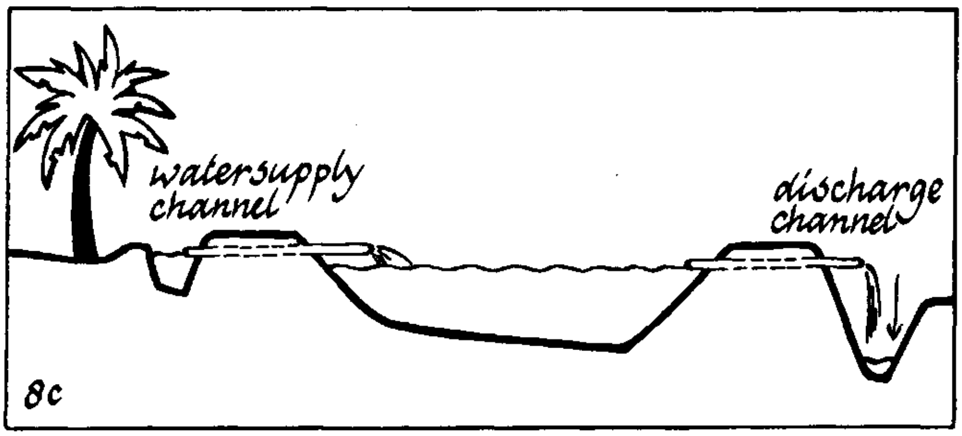
2.3 Pond types

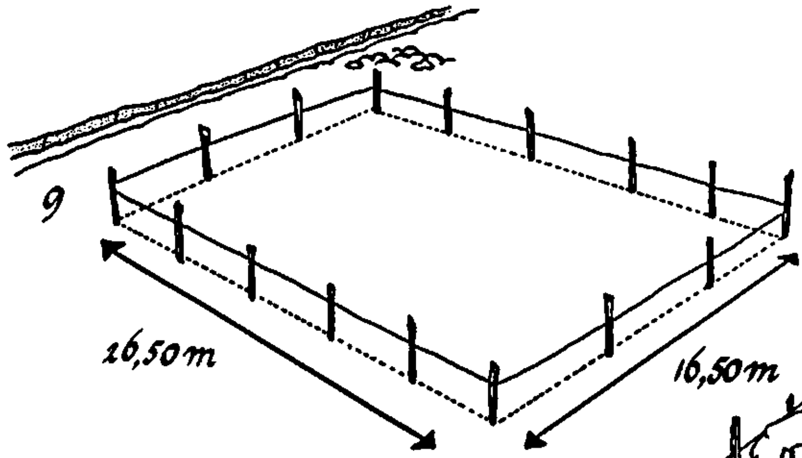
Depending on the site one of the following types of pond could be constructed.
Embankment ponds. These ponds are build by constructing walls above ground level to impound water. This type of pond is difficult to fill with water but easy to drain. Pumping is needed to fill the pond (Fig. 8a).
Excavated ponds. These ponds are build by digging out the soil. The excavated pond is easy to fill with water but difficult to drain. Pumping is needed to empty the pond (Fig. 8b).
Partially excavated ponds with low walls. Soil from excavation is used to build the low walls of this pond. The ideal site has a slight slope so that the water supply channel can be constructed slightly above and the discharge channel slightly below the level of the future pond. In this way pumping is neither needed for filling nor for draining (Fig. 8c).

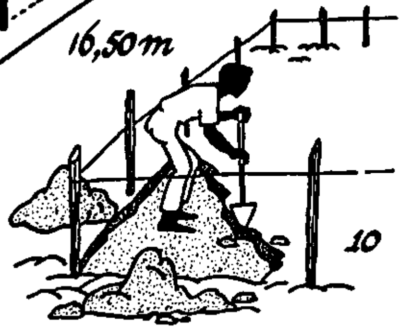
Let us give an example of how to build a partially excavated pond with low walls:
- When a good site has been identified, it is necessary to mark out exactly where the pond will be. Ponds should not be planned too large; a suitable size is between 2 and 10 are in a rectangular shape. A rectangular pond allows easier pond management and has a low border length to surface


pump
outlet
8a


inlet
pump
8b


watersupply
channel
discharge
channel
8c


9
16,50m
16,50m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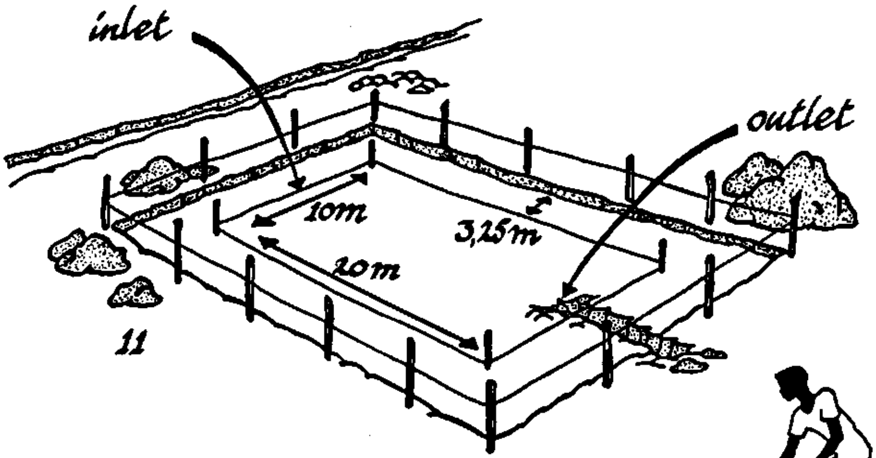
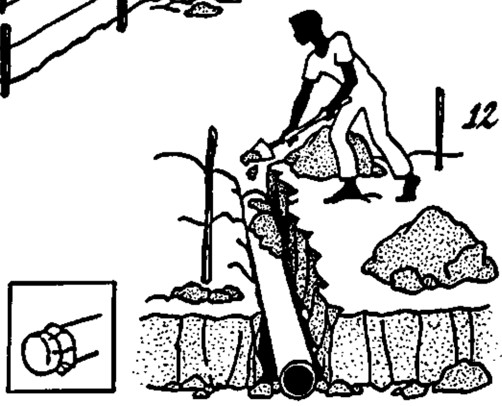
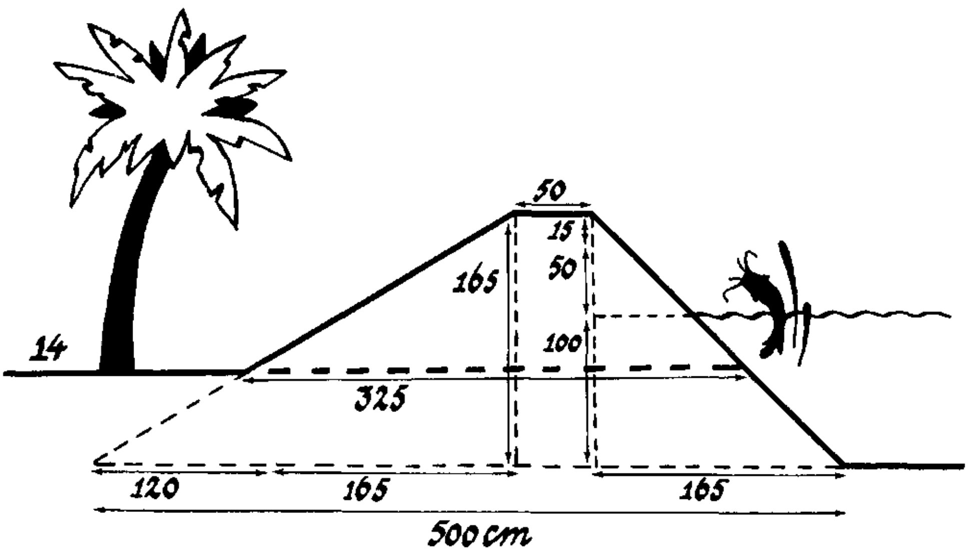

inlet
outlet
10m
3,25m
20m
11

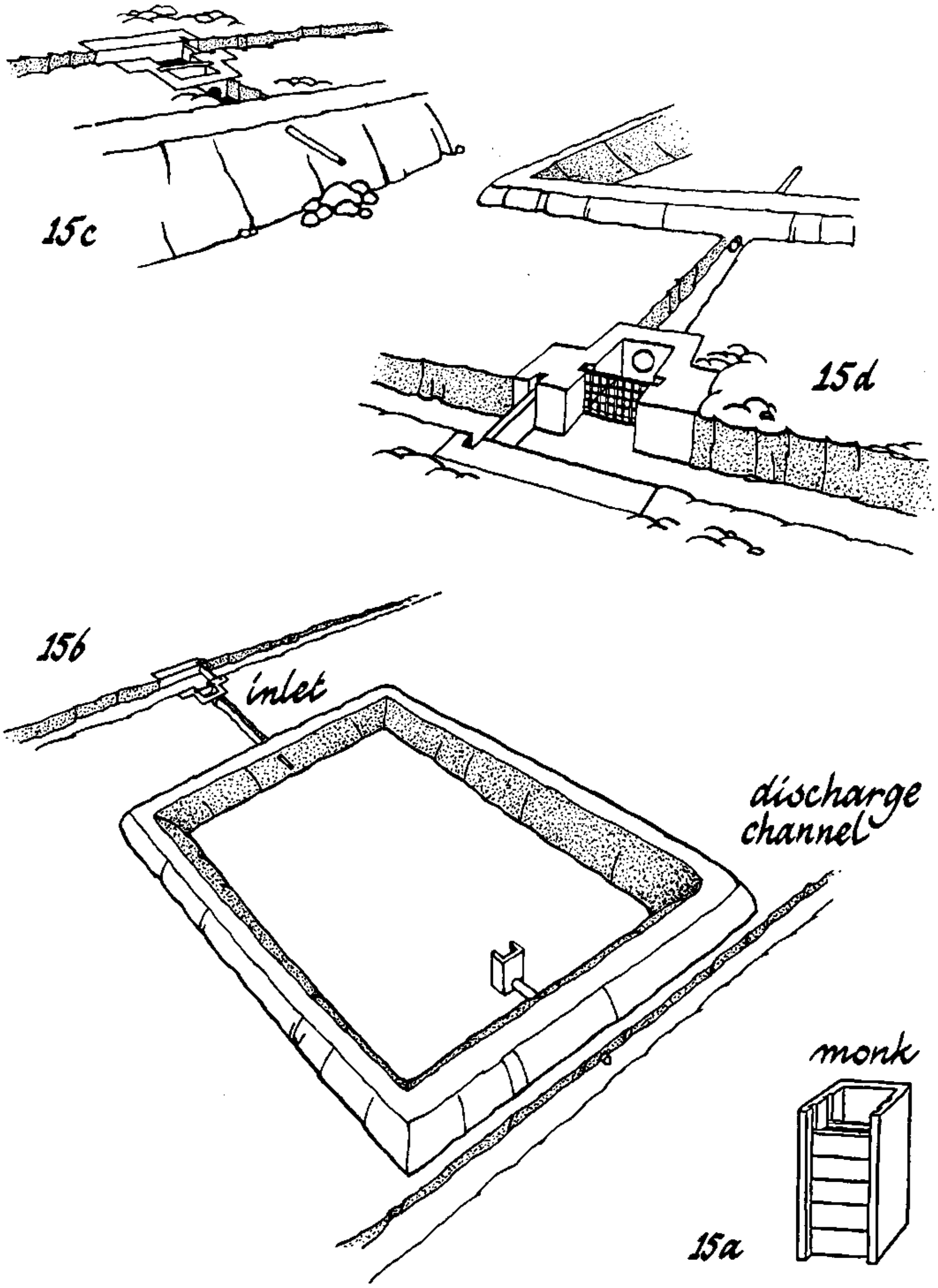

12

ratio which will reduce maintenance costs of walls. When planning the rectangle of the pond the sizes of the walls must be taken into account. For a pond of 10 x 20 metres (2 are) a wall with a base of 3.25 metres should be taken. Then a rectangle of: (3.25+10+3.25) x (3.25+20+3.25) = 16.5 x 26.5 m has to be set out. After having marked out the rectangle with sticks and a string it will be seen where the outside of the walls will be (Fig. 9).

- The top-soil of the site which often contains leaves, roots and small stones, is not suitable for the construction of the walls.
  Remove about 15 - 20 cm of the top-soil from the surface between the strings and pile it in heaps outside the strings (Fig. 10).
  Later this top-soil could be used to cover the clay walls.
- Mark with new sticks and a second string another rectangle of 10 x 20 metres within the first one, the shortest distance between the two strings being 3.25 metres (Fig. 11).
- Plan the location for the water inlet, and also for the outlet (the monk) if one is to be constructed. If so dig a trench of about 65-70 cm deep to put the outlet pipe, starting 1 metre from the inside of the marked location, cutting at a right-angle through the planned wall (3.25 metres) and continuing to 1.75 metres outside the planned outer rectangle.
  Put a 10-15 cm bore pipe of 6 m in the trench (Fig. 12). Close both ends of the pipe temporarily with plastic bags or pieces of wood. Lay it along a gradient of 1 in 100 which is equivalent to 6 cm per 6 m, so that the pond can be drained easily.
- For building the walls take the soil from inside the smallest rectangle (Fig. 11). It is necessary to dig about 65 cm deep in order to have enough soil (130 m^3) to build the walls. The pond bottom should slope toward the outlet location along a gradient of 2 or 3 in 1000, which is equivalent to 5 cm per 20 m. During digging some roots and stones might be encountered. These must not be discarded onto the walls but removed from the pond site.
  For maximum strength, after every 20 cm layer of material has been placed on the wall, it must be wettened and then tightly packed using compacting tools (Fig. 13). Realize that these walls have to retain water and that people will walk along the top (crest).
  To allow good pond management a minimum water depth of 80 - 100 cm


13


14
50
15
50
165
100
325
120
165
165
500 cm


15c
15d
15b
inlet
discharge channel
monk
15a

is needed. But the walls have to be 50 cm higher to prevent the African catfish from escaping as it otherwise can climb out of the water.

The settling of the material used has to be taken into consideration as well: this can sometimes amount to as much as 10% of the total construction height.

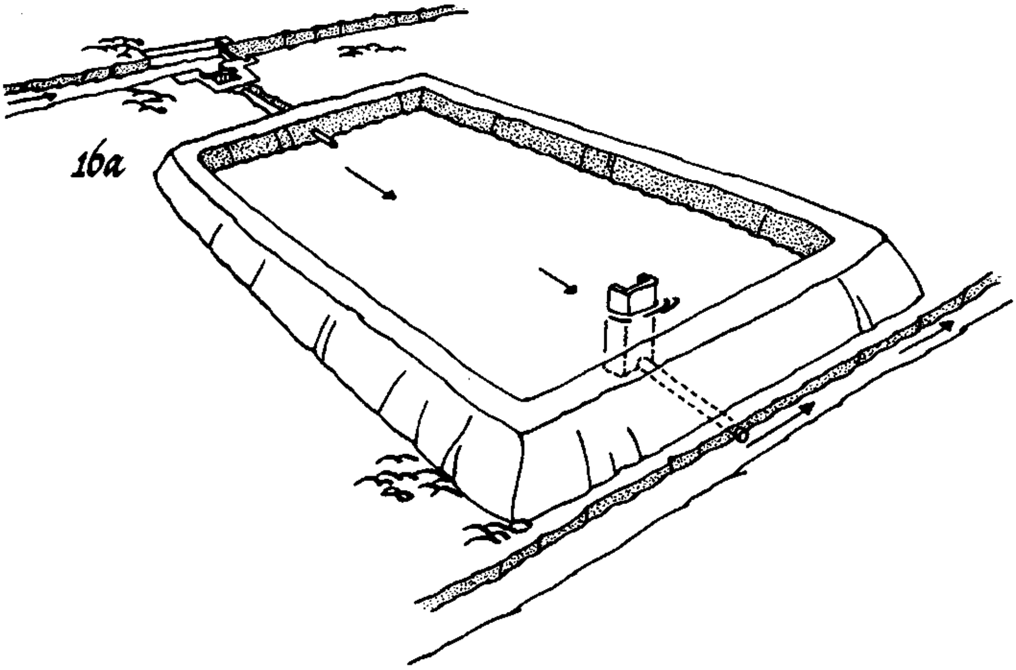
The total height of the walls measured vertically from the bottom to the crest should be (100 + 50) + 15 = 165 cm (Fig. 14).

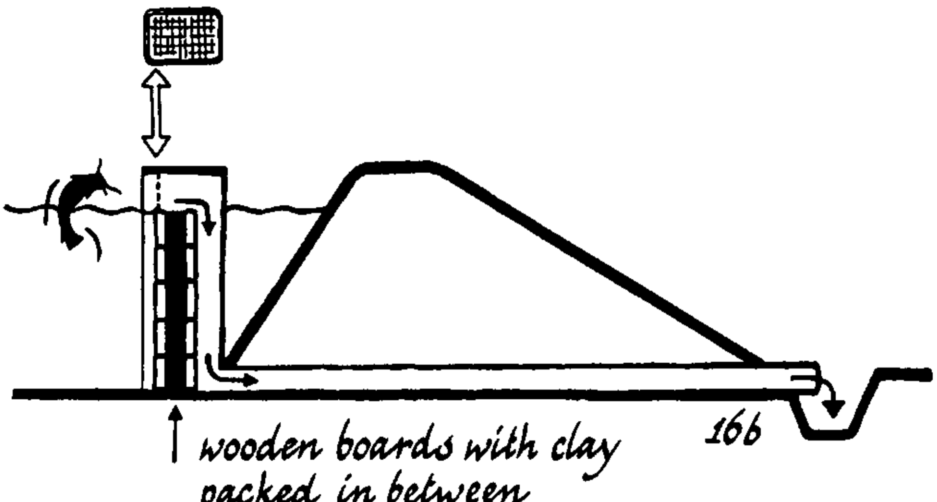
It is also important for the strength of the wall to build it sloping on both sides. The slope of the inside of the walls should be about 1 : 1 (vertical - horizontal) and the slope outside about 1 : 1.7 (vertical - horizontal). The crest of the wall should be 50 cm wide (Fig. 14). It would be preferable to have a wider crest but for every 10 cm extra width about 10 m^3 soil would have to be brought in from elsewhere.

- Stop digging when the correct depth has been reached and check the slopes of the walls and of the bottom. The depth near the inlet will be 145 cm and near the outlet about 150 cm. As the water level slowly falls during draining, the fish will amass in front of the outlet.
- Construct a wooden or concrete monk (Fig. 15a) to link up with the pipe that has been buried. This pipe will be connected to the discharge channel (Fig. 15b).
- Lay a pipe inlet through the wall to link up with the water supply channel and put rocks on the bottom of the pond under the inlet (Fig. 15c).
- Make a wooden or concrete sluice in the water supply channel (Fig. 15d) so that the rate of the water inflow can be regulated.
- The sluice should be screened to prevent wild fish, branches and leaves from entering your pond. A screen mesh size of 1 cm is often suitable.
- Start filling the pond till a water depth of 80 - 100 cm is reached (Fig. 16a). Regulate the water level of the pond with the wooden boards of the monk. Put a screen on top of the boards to prevent the fish escaping from the monk (Fig. 16b). The mesh size depends on the size of the fish.
- In order to prevent erosion of the walls, they should be covered with the fertile topsoil that had been set aside, and grass such as Rhodes grass (Chloris gayana) or Star grass (Cynodon dactylon) should be planted on top.

Do not use plants with long roots or trees because they will weaken the strength of the walls and may cause leaks.

16a

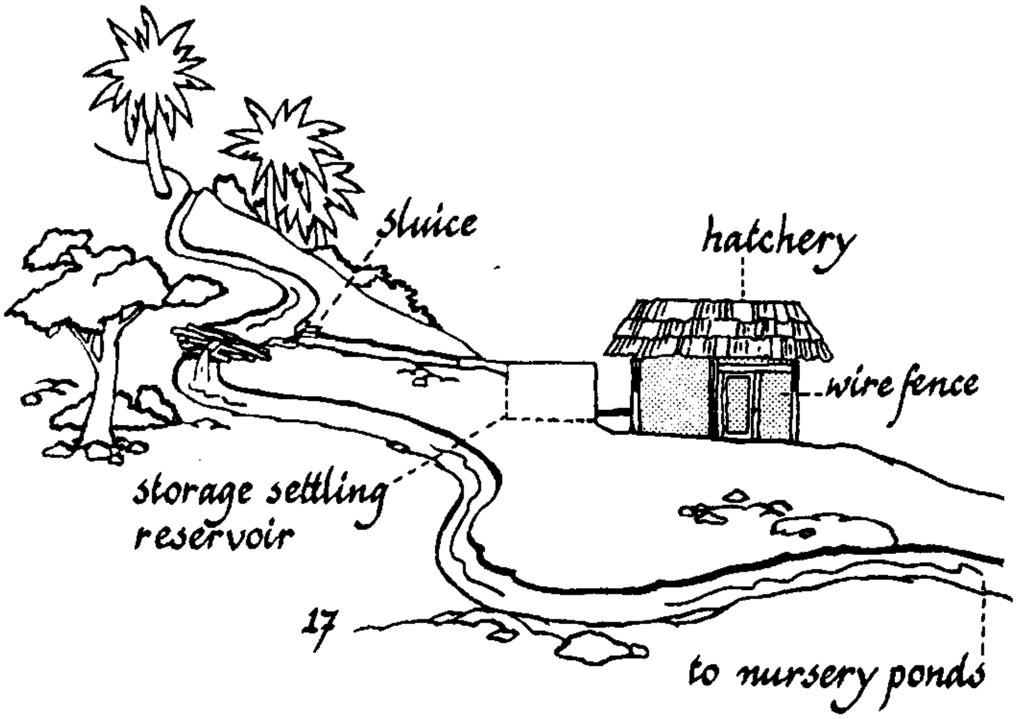




16b

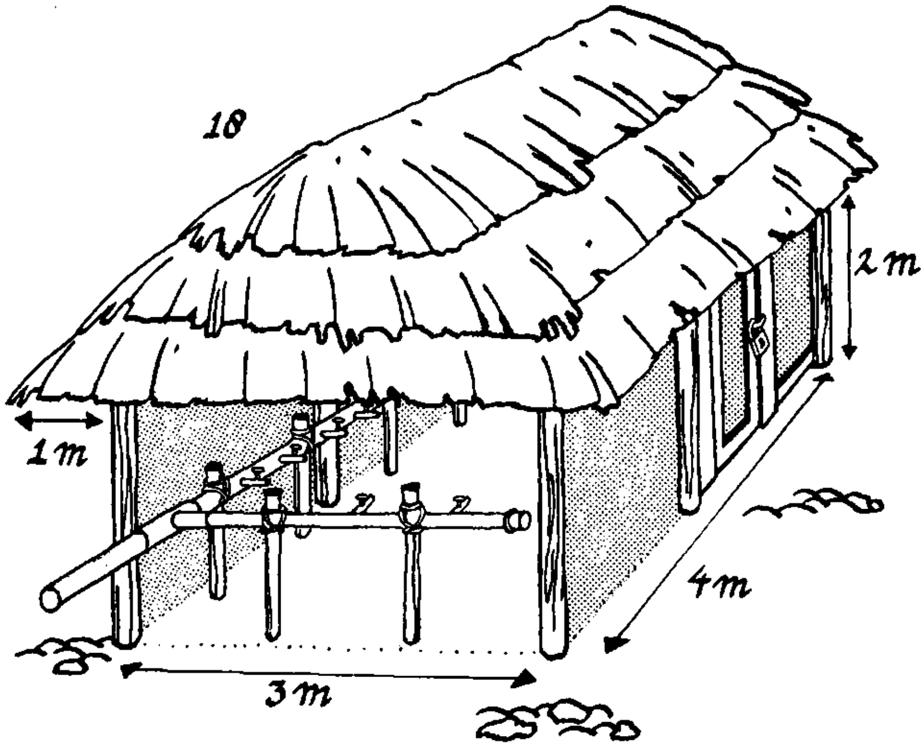
If several ponds are to be built it is best to construct them in parallel and not in series so that ponds can be independently harvested and downstream ponds do not have to use polluted discharge water from upstream ponds.

NOTES


sluice
hatchery
wire fence
storage settling reservoir
to nursery ponds

17

18


2 m
1 m
4 m
3 m

3. A SET-UP OF A SIMPLE HATCHERY

3.1 Introduction

A hatchery could be constructed to raise larvae in order to stock the farm's own ponds. It is also possible to use the hatchery as a breeding centre for larvae that might be sold to other fish farmers.

3.2 Site selection

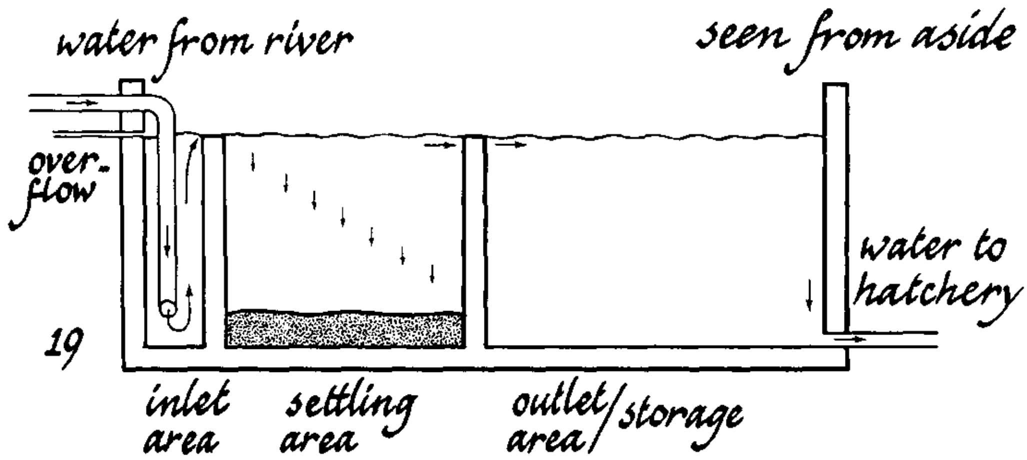
It is preferable to plan the hatchery on a slope so that water can enter by gravity (Fig. 17). The best possible water quality is required for the incubation of eggs and rearing of larvae. The availability of enough running water during the dry season is an important factor as well. It will be advantageous to have a separate water supply channel with unpolluted water.

3.3 Construction of a hatchery

An area of 5 x 6 m should be cleaned and levelled for the construction of a hatchery of 3 x 4 m. Construct first a roof of about 2 m height on top of the future hatchery surface with an overhang of 1 m on all sides (Fig. 18). All sides should be covered with wire fencing. The door should have a lock to keep out intruders.

3.4 Water distribution

The requisites for water quality are given in appendix 1. The water quantity in a hatchery will influence the production capacity. The set up of the hatchery described in this chapter is designed for the production of about 65,000 larvae per week. Taking into account the fact that spawners from the broodfish ponds remain mature for about 4-6 months (corresponding to the rainy season which is about 20 weeks) a total yield of approx. 65,000 x 20 = 1,300,000 larvae/year is feasible. In a hatchery the water is needed to supply oxygen for eggs, larvae and broodfish, to remove faeces and other dirt and to clean the hatchery.



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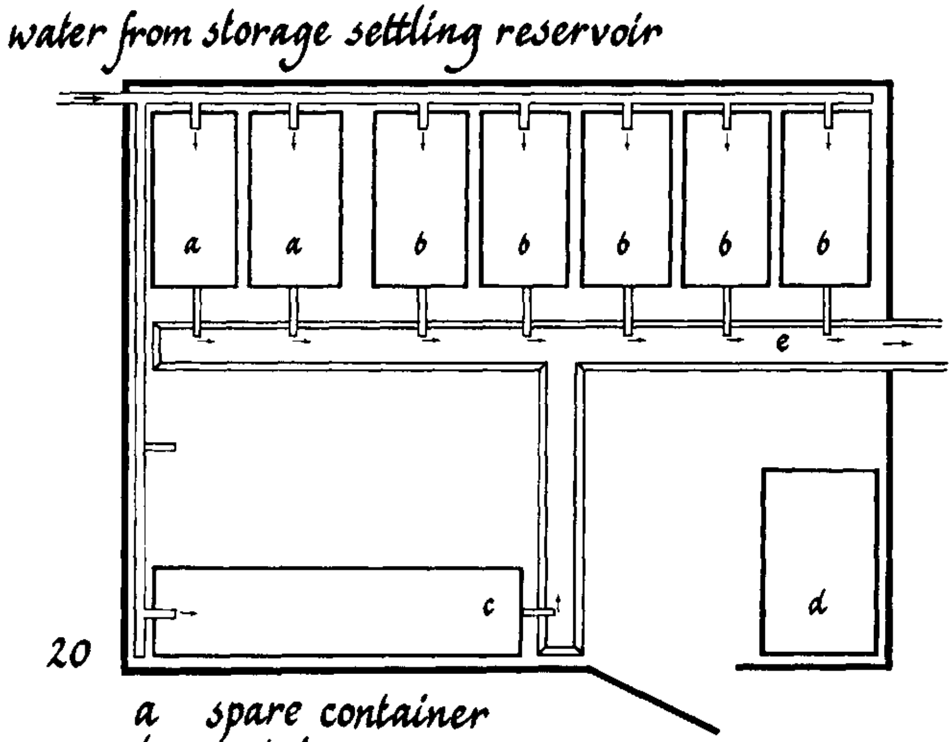


20

a spare container
b container
c incubation gutter
d table
e drain

seen from above

Total water consumption is specified in the following table:

	Flow through:
5 containers of 100 l each, one per one broodfish:	7,500 l/day
1 incubation gutter of 150 l, for 200 g eggs:	4,500 l/day
2 spare tanks, for cleaning and filling, etc.:	2,000 l/day
	14,000 l/day

For the above mentioned hatchery about 14,000 l (14 m^3) water per day, equivalent to approx. 10 l/min will thus be needed.

The water needed should preferably flow by gravitation from a river or a lake via a channel, pipe or flexible tubing to a storage-settling reservoir (Fig. 17). Different kinds of storage units can be built, such as a barrage reservoir, pond, or wooden or concrete container. To improve the settling out of suspended particles in the water it is advisable to construct, in a reservoir of 3.0 m length, 1.5 m width and 1.3 m height, two walls of 1 metre height, one about 0.50 m away from the inlet and the other in the middle of the reservoir (Fig. 19). In both walls a sluice should be constructed. The inlet area serves to reduce turbulence and inlet velocity of the water. Water should flow smoothly from the inlet area over the wall of 1 m height and be evenly distributed over the settling area which requires low water flow. Water from which suspended particles have settled out will flow smoothly over the second wall into the outlet area.

The volume of the outlet area is about 2.3 m^3, and it serves as a storage unit as well. The incubation gutter and containers are connected by taps and pipes with the reservoir. The water leaves the hatchery by overflow and centrally located draining pipes or channels (Fig. 20).

3.5 Hatchery equipment

As regards the hatchery equipment, the following may serve as a guide:

- Containers are needed to stock broodfish for a few days. They can be built from wood but barrels or concrete or wooden tanks can also be used. PVC barrels are preferred to iron ones (Fig. 21a).

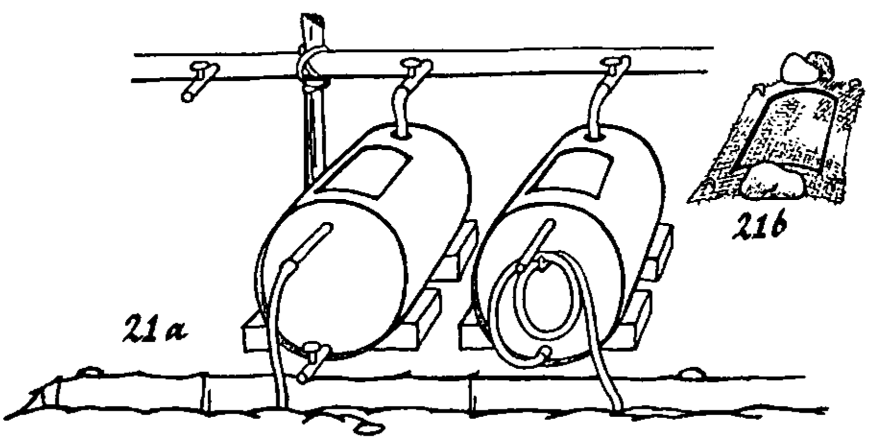
  Place 7 containers in a row at one side of the hatchery on stones or wooden beams, 5-10 cm above the ground (Fig. 21a).

  Each container has a water inlet and outlet and an overflow. It is often handy to fix a plastic tube on the outlet to empty the container. The plastic tube can also be used to regulate the water level inside the container. In order to reach a certain water level in the container the tube should be looped around a hook (Fig. 21a). With a little experience any desired water level can be attained inside the tank.

The opening of the tank should be provided with a well-fixed wire fence. Catfish are excellent jumpers and it will be necessary to put some heavy stones on the screen to prevent fish from escaping (Fig. 21b). Catfish should be maintained individually to avoid fighting. For a routine artificially induced breeding cycle about 4-5 female and 2 male spawners are needed.

A gutter is needed for the incubation of eggs. The dimensions of a suitable incubation gutter are 200 x 50 x 30 cm (Fig. 22a). It can be made from wood, polyester or concrete. Iron and copper should not be used as they are often poisonous for fish. The bottom and sides of the tank have to be very smooth. At one side of the gutter an overflow should be constructed (Fig. 22b). With the overflow the water level in the tank can be influenced (Fig. 22c, 22d). A screen should be placed in front of the overflow to prevent larvae from escaping. The screen consists of two frames of wood (Fig. 23a), which exactly fit in the gutter. In between the frames plastic mosquito netting, with a mesh size of 0.5 - 0.7 mm, is fitted. The netting should be properly fixed between the two frames. Driving in the nails at different angles will prevent the screen from falling apart after saturation of the wood with water (Fig. 23b). The screen should be provided with a strip of foam plastic before it is put into the gutter (Fig. 23c) to block chinks. Put the gutter on a table (1 m height), in a slightly sloped position (Fig. 22a).

- The following equipment is needed for the artificially induced breeding of catfish (see later), to check the water quality and to keep the hatchery clean (Fig. 24):
  - A table of about 50 x 100 cm
  - Netting
  - Scale
  - Ruler
  - Trays
  - Towels (tissue paper)
  - Canules (outer diameter 2-2 1/2 mm; inner diameter 1.2-1.5 mm)


21a
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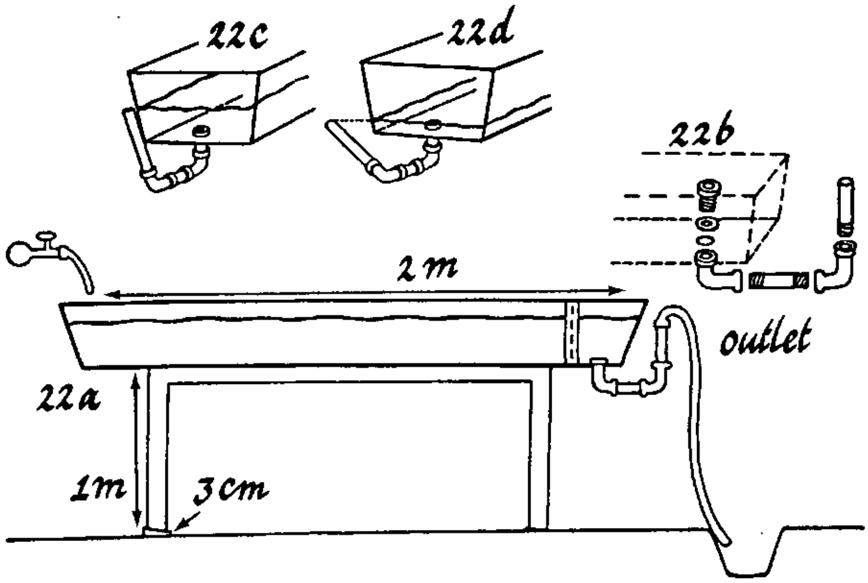
22c
22d
22b
2 m
outlet
22a
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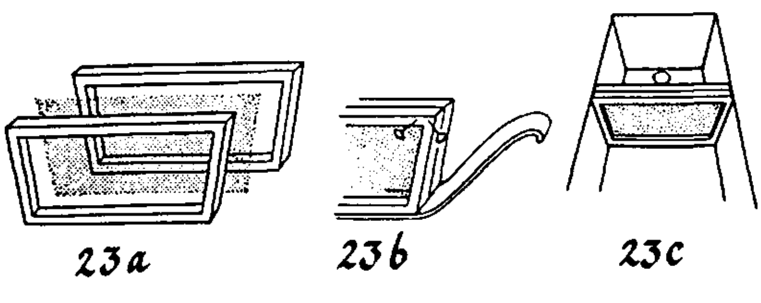
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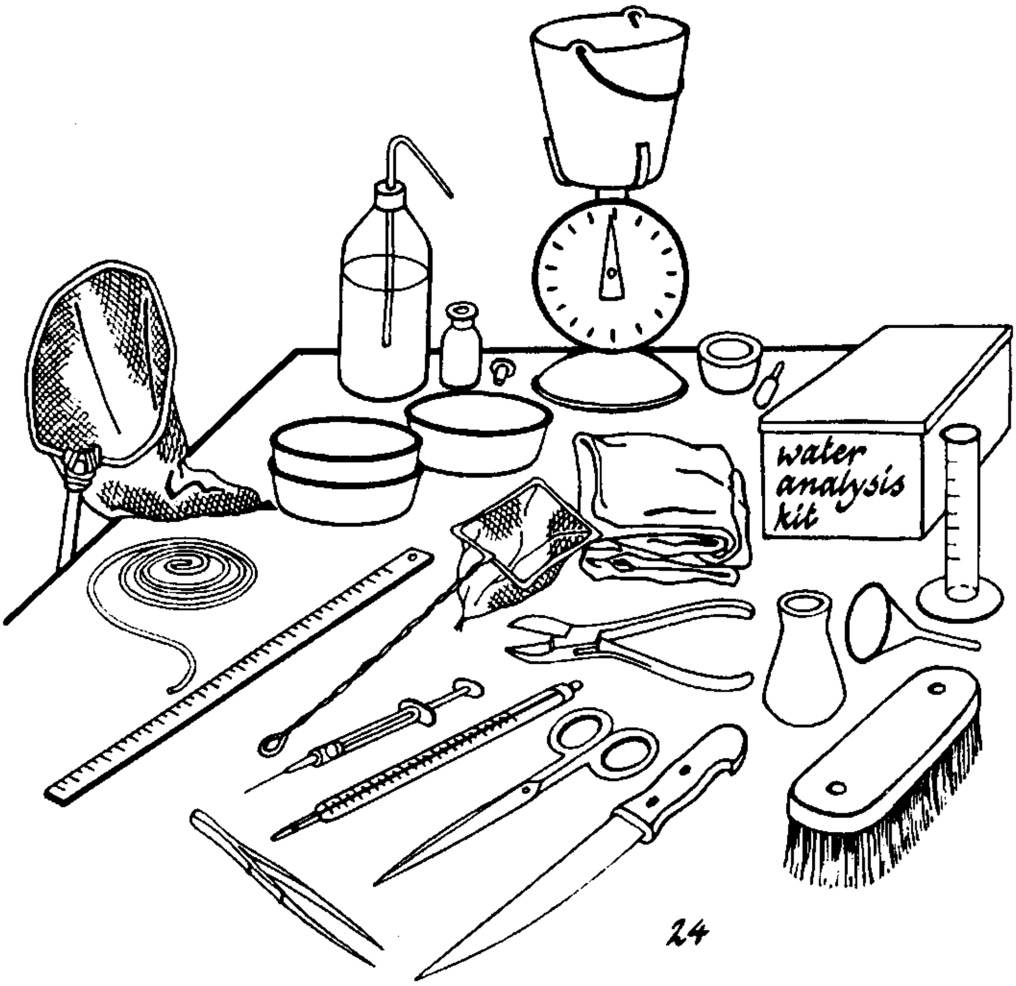


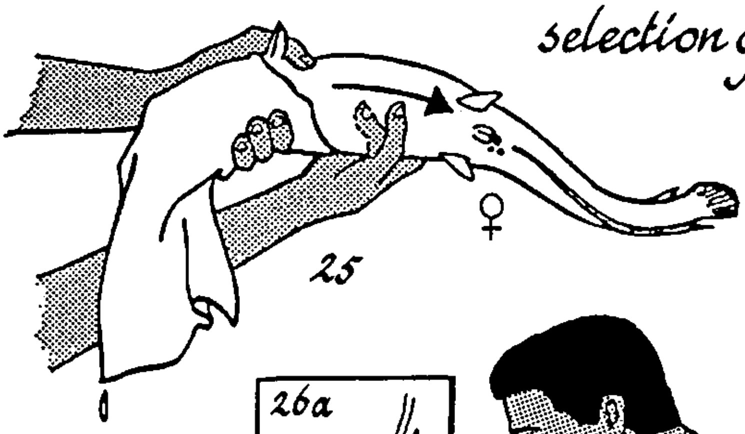
24

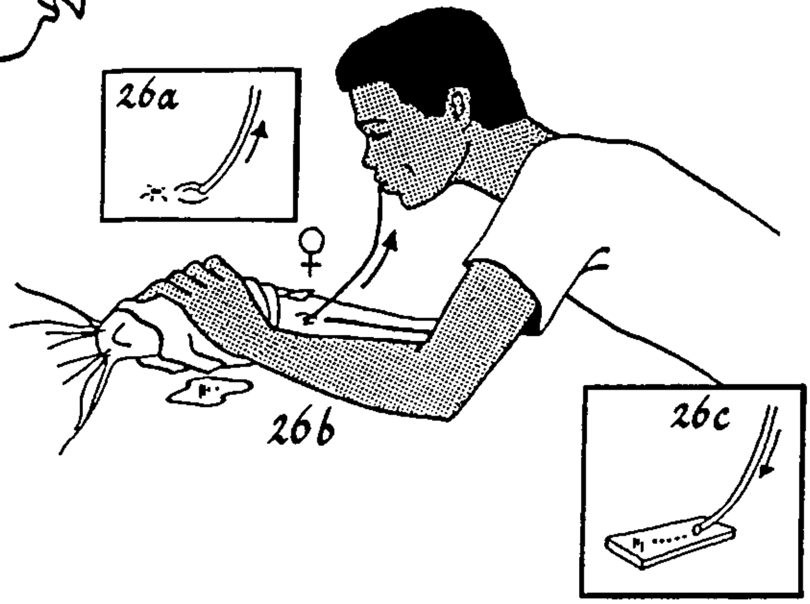
. Syringes 1 ml and needles
. Sharp knife, wire cutter
. Mortar
. Pair of scissors, pair of sharp-pointed tweezers
. Bottle of physiological salt solution 0.9 %.
. Water analysis kit
. Thermometers
. Glassware
. Brushes

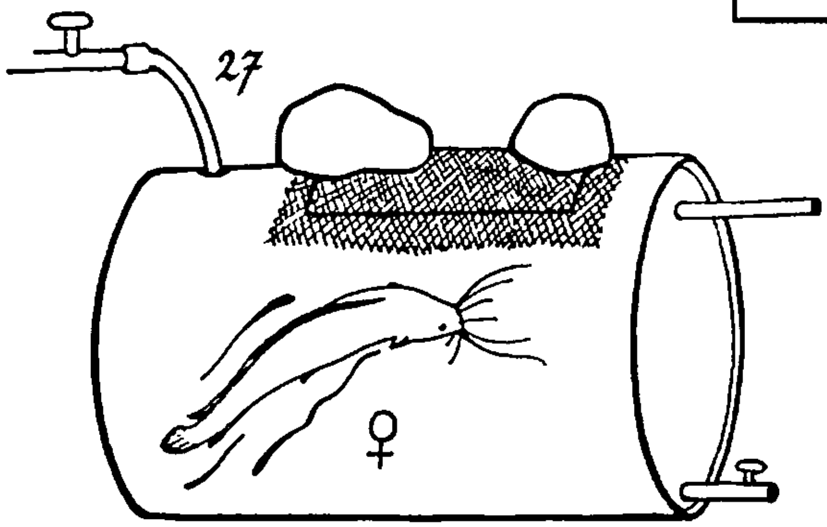
NOTES

NOTES

selection of spawners







4. HATCHERY MANAGEMENT

4.1 Introduction

In nature catfish mature after 2-3 years and spawn between the onset and the end of the rainy season. After this period the gonads gradually regress and the fish do not spawn until the rainy season of the next year.
Under pond conditions catfish mature after 7-10 months at a weight of 200-500 gram. Spawning normally does not happen since the final stimulus associated with a rise in water level and inundation of marginal areas does not occur. The fish can be spawned, however, by hormonal treatment using pituitaries. The broodfish raised in ponds normally remain mature during several months of the year, corresponding to the natural reproduction cycle. A broodfish can be artificially reproduced several times during these months. Catfish raised from egg to maturity in a hatchery remain mature during the whole year, and regression of the gonads does not occur. This means that viable larvae can be easily obtained throughout the year.

4.2 Selection of spawners

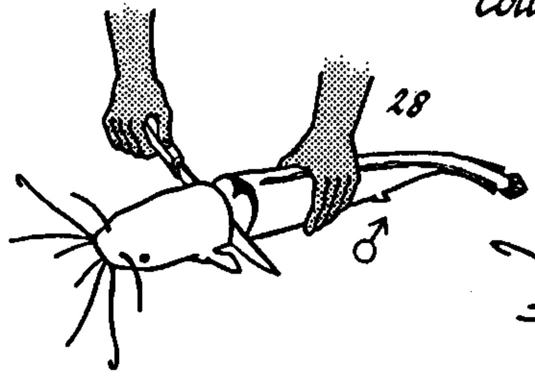
Males and females are collected from the broodfish ponds (see 6.3, page 82). It is advisable to disinfect the fish with a 50-150 p.p.m. formalin bath for three hours before they are brought into the hatchery. This precaution is taken to prevent pathogens from being transmitted to eggs and larvae. Females with soft and swollen bellies are often mature. This should, however, be checked as follows:

- Cover the head with a towel and put the fish on its back.
- Press with a finger or thumb on the abdomen towards the tail.
- If the fish is mature, greenish eggs will appear (Fig. 25).

A more reliable method is the following:

- Insert gently a canule (for diameter see 3.5, page 30) in the papilla (Fig. 26a), 4-6 cm inside the ovary (Fig. 26b).
- Put the other end of the canule in the mouth and suck carefully.
- Withdraw the canule and gently blow out about thirty eggs onto a glass slide (Fig. 26c).

collection of pituitaries



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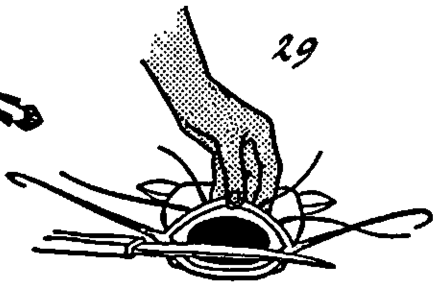

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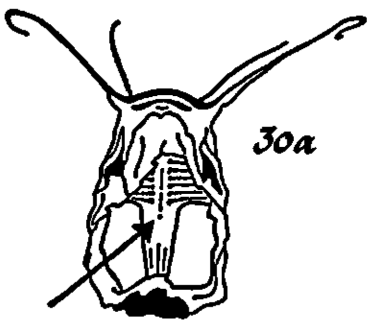

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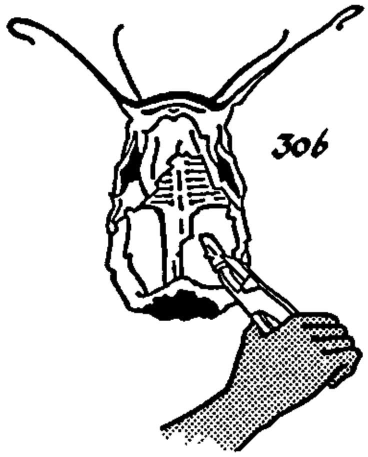

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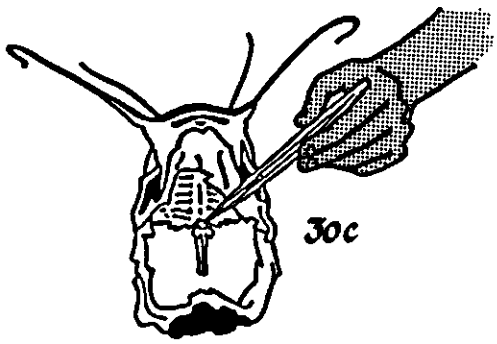

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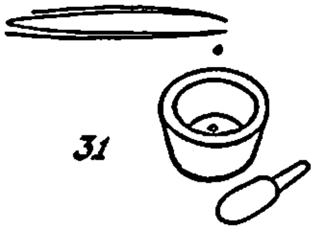

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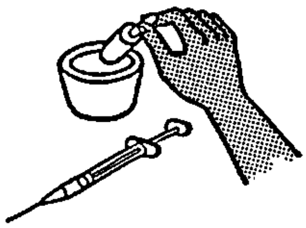

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- Measure the diameters of the eggs immediately with a ruler or with a microscope if available.
- If about 90% of the egg diameters are larger than 1.0 mm, the female will be suitable for artificially induced breeding.

The female should be stocked without food for about 36 hours in a container with water (23-25°C), so that the alimentary system will be empty at the time of stripping (see later).
Avoid any temperature shock that might be caused by a difference in water temperature between pond water and water of the container. Put some heavy stones on the lid of the container so that the fish cannot escape (Fig. 27).
About 24 hours after being stocked in the container the female catfish should be injected with pituitaries.
Male spawners cannot be specifically selected for artificially induced breeding.

4.3 Collection of pituitaries

Pituitaries can be collected from both male and female catfish and this can be done as follows:

- Take for each female spawner two donors average weight 500 g each and preferably male so that their testes can be used as well.
- Kill and decapitate the donors (Fig. 28) but not sooner than one hour before the planned time of injecting the female spawner.
- Put the head upside down and cut the lower jaw away (Fig. 29).
  The pituitary is located inside the skull (Fig. 30a).
- Open the palate of the mouth with a pair of pincers at the point indicated in Fig. 30b. The pituitary is a pinky-white globule-like organ, situated on the ventral side of the brain (Fig. 30c).
- Collect the pituitaries from the donors with a pair of tweezers and put them in a mortar containing 2 ml of a physiological salt solution (Fig. 31).
  The physiological salt solution can be made by putting 9 g of common table salt in 1 litre of filtered water.
- Grind the pituitaries in the mortar immediately (Fig. 32) and draw the pituitary suspension into a syringe.
- Inject the suspension of the freshly collected pituitaries as soon as possible.

There is a simple way to store freshly collected pituitaries for months but then acetone will be needed:

- Put the pituitaries immediately after extirpation in a vial, filled with some acetone (1 ml acetone per pituitary)
- Refresh the acetone after ten minutes
- Renew the acetone again after eight hours
- Drain the acetone completely 24 hours later
- Dry the pituitaries in the shade by evaporation
- Store the dry yellow-brown pituitaries at a cool place in a sealed vial.

Ten minutes before a female spawner is to be injected, two of the stored globules should be taken and prepared as follows:

- Put the pituitaties in a mortar
- Add 1 ml glycerin together with 1 ml physiological salt solution (or 2 ml physiological salt solution only)
- Grind the pituitaries thoroughly
- Inject the suspension immediately.

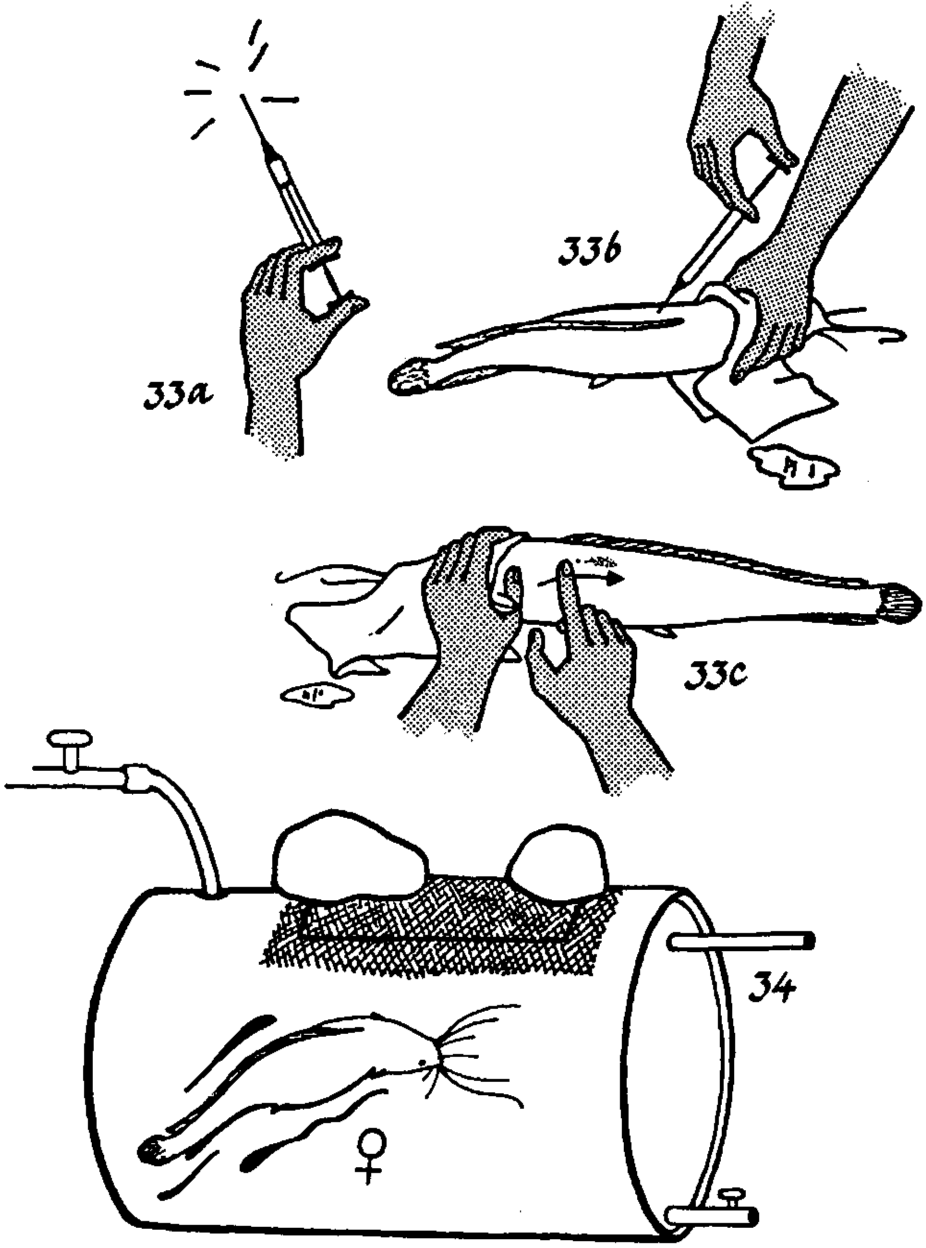
4.4 Injection of female spawners

The suspended pituitaries can be injected in the following way:

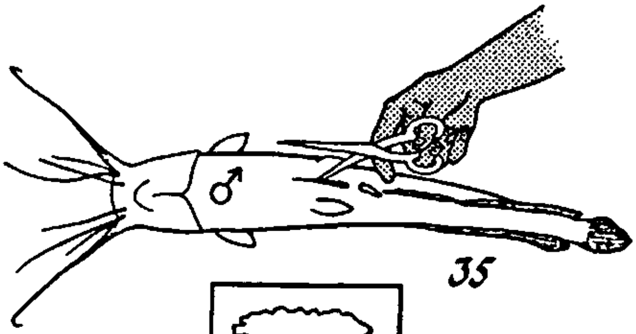
- Fit on the syringe a needle of 2.5-3.0 cm with a diameter of 0.6-0.7 mm.
- Point the syringe upwards and try to eliminate the air (Fig. 33a).
- Cover the head of the female spawner (average weight 500 g) with a towel and insert the needle 2-2.5 cm at an angle of 30-45° in the dorsal muscles in the direction of the tail (Fig. 33b).
- Slowly inject the suspension intra-muscularly while retracting the syringe a few mm.
- After injection finger-rub the injected area, so that the suspension will be distributed evenly throughout the muscles (Fig. 33c).
- Put the fish back in the container and wait about 12 hours until all eggs have maturated and ovulated in the ovary (in appendix 2 this latency time is given in relation to water temperature).

During ovulation the belly of the female will swell considerably due to water absorption of the ovary (Fig. 34). In some tropical countries the fish farmer

injection of female spawners



collection of milt



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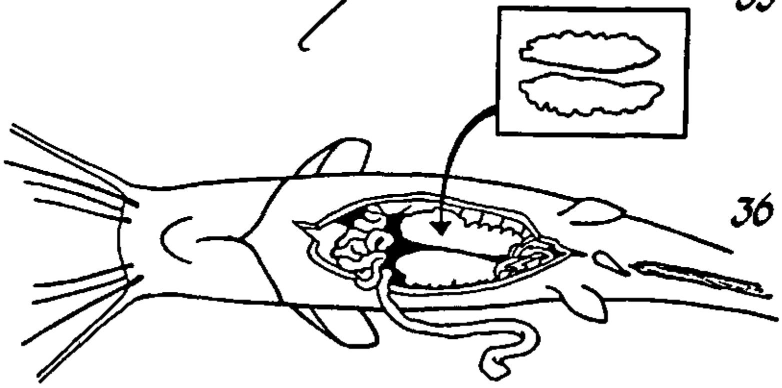

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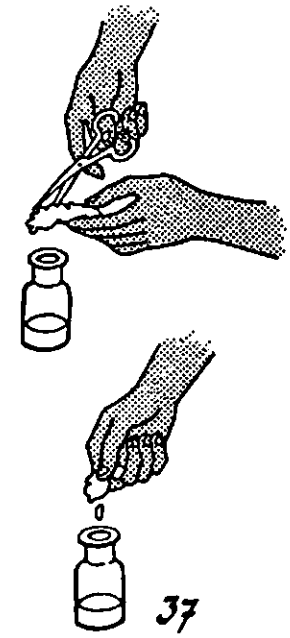

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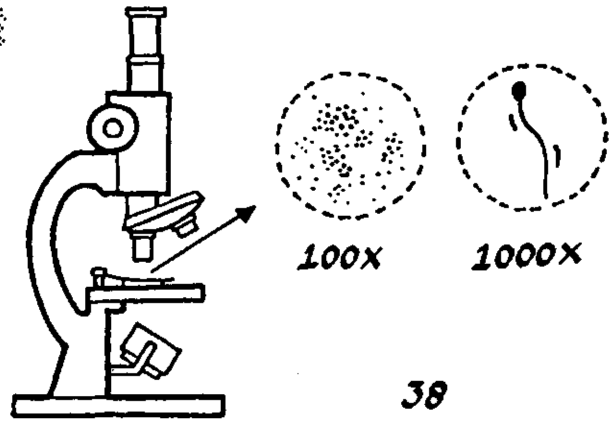

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uses other products for artificially induced breeding (see appendix 2).

4.5 Collection of milt

For the fertilization of the eggs milt from a male spawner will be needed. Milt cannot be collected by stripping the male. It can only be obtained by sacrificing the fish and dissecting the testes. This can be done as follows:

- Put the killed male (average weight 500 g) on its back and open the body cavity with a pair of scissors (Fig. 35). Do this carefully without damaging the inner organs.
- Pull the intestines aside to make the two yellow-pink testes visible (Fig. 36). Between the testes and the urogenital papilla several wormlike lobes can be noticed. These do not contain milt and cannot be used.
- Entirely remove the two testes without squeezing them and dry them with a piece of filter paper. 30-60 Seconds after contact with water, the milt will lose its activity. It is therefore of importance that the testes do not come into contact with water! Most of the ripe milt is located in the cream-coloured lobes.
- Make with a pair of scissors small incisions in the lobes and squeeze the milt out (Fig. 37). Take care that fingers are dry during the preparation of the milt.

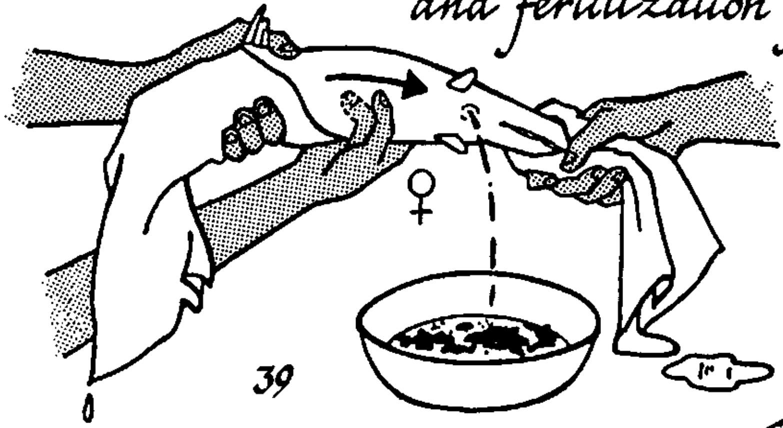
Two procedures of milt collection can be followed:

- If a refrigerator is available the sperm drops can be collected in a small bottle with about 5 ml physiological salt solution (Fig. 37). Shake the bottle gently, close it, and store the sperm solution at 4°C for no longer than two days. In this way milt of a pituitary donor might be used (see 4.7, page 45).
- If a refrigerator is not available, killing of the male and collecting of milt should be done just prior to stripping the female (see below). In this case, the sperm drops are added directly to the eggs by squeezing the testes (see 4.7, Fig. 40).

To be sure that the sperm (solution) will be suitable for fertilization the following check by means of a microscope should be performed:

- Put a droplet of the solution on a microscope glass and add a droplet of

stripping of female spawners and fertilization of eggs



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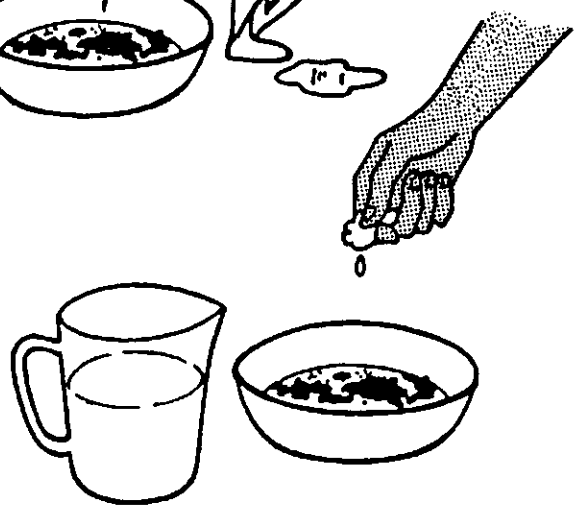

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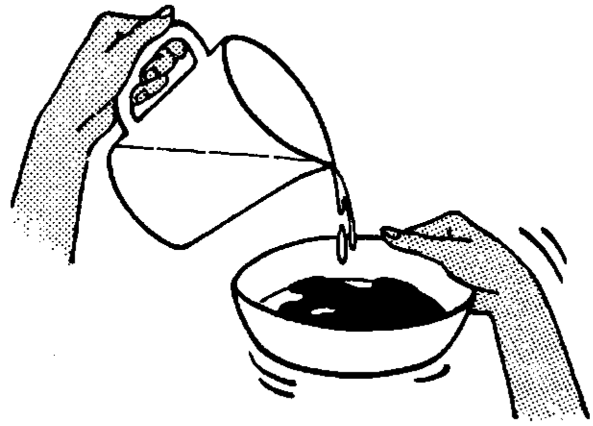

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water.

- Check immediately at a magnification of 100 x the motility of the spermatozoids (Fig. 38).
- If they are actively moving in the watery solution for a period of about 30 seconds, the sperm will be of good quality.

4.6 Stripping of female spawners

If the female has responded well to the injection, the ovulated eggs will easily run out from the genital papilla.

To collect the eggs the following may serve as a guideline:

- Catch the female carefully with a net.
- Hold with two persons the spawner tightly with wet towels (Fig. 39).
- Strip gently the fish (Fig. 39) till some blood appears. This is often a sign that the ovary is empty. The mingling from the blood with the eggs should be prevented.
- Estimate the weight of the egg mass (1 g egg mass contains about 700 eggs) to obtain the number of eggs that can be fertilized. Do not use more than 200 g of the collected eggs for the fertilization.

4.7 Fertilization of eggs

The artificial fertilization of eggs should be done as follows:

- Squeeze the freshly dissected testes and distribute the droplets evenly on top of the egg mass (Fig. 40). The same method should be applied if stored chilled milt is used.
- Add immediately afterwards some clean water to the tray and mix the eggs with the sperm by gently moving the tray (Fig. 41).
- Pour the fertilized eggs in a single layer in the incubation gutter (Fig. 42).

The gutter should be properly disinfected beforehand with Benzalkonium chloride 0.1 % for 30 minutes or with other disinfectants.

4.8 Incubation of eggs

The development of the eggs in the incubation gutter can be briefly described as follows. Within a few minutes after fertilization the eggs will absorb water and sticky attachment discs will develop. During this process they can easily stick together and therefore they should be distributed in a single layer. The gutter should be covered with foam plastic (Fig. 42) and transmission of any pathogens to the water should be avoided (see prophylactic treatments to avoid diseases, chapter 7).

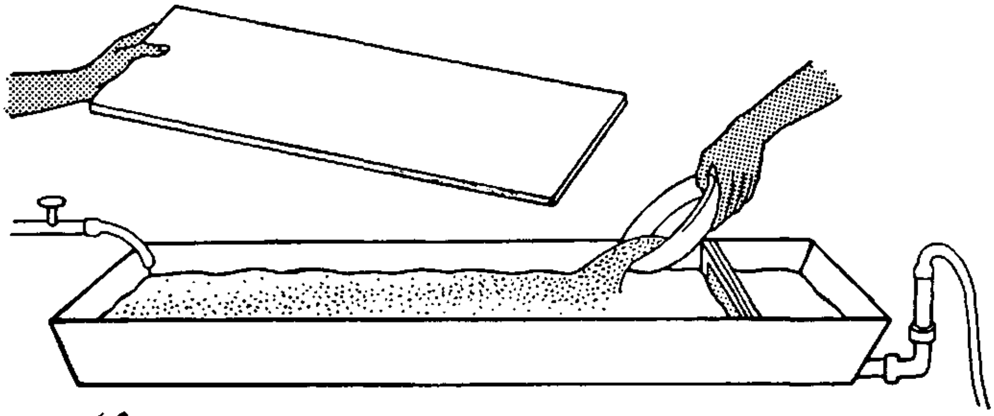
Incubate the eggs in water with a flow-through rate of 1-3 l/min. Depending on the temperature of the water it will take 20-57 hours for the eggs to hatch (see appendix 2). During this time the eggs should be regularly monitored. Healthily developing eggs have a transparent green-brownish colour. If all eggs turn a white colour, the batch should be discarded. White eggs, which are always present amongst the developing ones, should be removed to avoid the development of fungi. Removing can be easily done by siphoning. In general the mean hatching percentage of eggs will be between 50-80%.

4.9 Rearing of larvae

The hatched larvae are 5-7 mm in size and weigh about 1.2 - 3.0 mg. They look like tiny needles each with a green globe, the yolk-sac. After hatching, the egg shells remain on the bottom. The yolk-sac larvae will look for shelter and will cluster together in the dark places of the tank. At that stage of incubation it is a good idea to cover only the inlet of the gutter so that the healthy larvae will swim to the shadow under the cover. Egg remnants as well as crippled and dead larvae can then be easily removed. This should be done by siphoning so that any form of stress can be avoided (Fig. 43). Within 3 days of hatching the yolk-sac will be absorbed and the so-called fry will start to search for food. With good management 90-95% of the yolk-sac larvae will develop into fry.

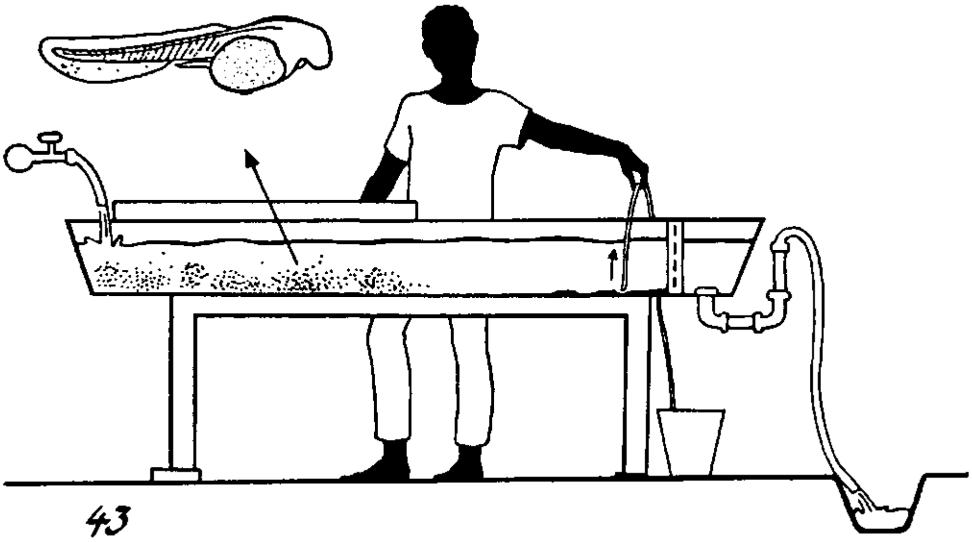
The fry are too vulnerable to be collected with nets. This should be done by siphoning. Place a bucket into which the fry will be siphoned not more than 20 cm below the bottom surface of the gutter. In this way the current of the siphon will be limited and damage of the fry minimized. Transport the fry in buckets to the nursery pond (see further chapter 5).

incubation of eggs



42

rearing of larvae



43

The production capacity of an incubation gutter can be summarized as follows:

4 female broodfish, mean weight 500 g, will produce about 10% of their body weight in eggs	200 g eggs
200 g eggs is equivalent to	140,000 eggs
the hatching of fertilized eggs is 50%	70,000 larvae
the survival rate after yolk absorbtion is 93%	65,000 fry

4.10 After-care of stripped broodfish

It is advisable to disinfect the stripped broodfish with a 50-150 p.p.m. formalin bath for 3 hours. They should be subsequently stocked again in the broodfish ponds. The broodfish containers should be cleaned with a disinfectant such as Benzalkonium chloride 0.1 % for half an hour. Rinse the container with fresh water afterwards.

NOTES

NOTES

5. NURSERY PONDS

5.1 Introduction

The factors involved in site selection and pond construction have already been dealt with in chapter 2, but some requisites for nursery ponds should be mentioned here:

- They should be free from inundations,
- protected against wind,
- well exposed to sunshine.
- Supply of good quality water (free from chemical pollution, low iron content, pH 6.5 - 8.0) should be available (see appendix 1).
- The nursery ponds should be located close to the hatchery.

5.2 Construction and preparation of the nursery ponds

The number and size of nursery ponds needed depend on the production of fry by the hatchery.

With an output of 65,000 fry (see chapter 4) and a stocking density of 65 fry/m^2, five nursery ponds of 200 m^2 will be sufficient. The depth should be about 50-60 cm.

To fill in one day 5 nursery ponds of 200 m^2 each, about 425 l water/min will be needed, which corresponds to 7 l water/s in the supply channel.

Rearing of fry is carried out in stagnant ponds. A continuous water flow of 7.5-15 l/min will be necessary to compensate for seepage and evaporation of the 5 ponds. It is preferable, however, to have a constant surplus of water of at least 200 l/min in the supply channel. This surplus will enable the water in the ponds to be exchanged if oxygen depletion or water pollution occurs.

To improve the survival and growth rate of the fry the nursery ponds should be protected against predators and should be well prepared by liming and fertilizing before stocking.

Predator control

Predators may enter the pond in the incoming water (eggs or larvae of predator fish, frogs and toads), by land (frogs and toads) and by air (birds). The following provisions should be made to eliminate the entrance of predators:

- The penetration of wild fish or amphibians can be prevented by tying a screening sleeve made of synthetic fibres, eg. plastic mosquito-netting mesh-size 1-2 mm, to the end of the water-inlet pipe (Fig. 44). The length of the sleeve should be about 1 m, and it is closed tightly at one end. After each culture cycle the sleeve should be cleaned and checked for holes.
- The pond should be surrounded by a fence of fine mesh netting (mosquito netting height 80 cm) that should be embedded about 10 cm below ground level (Fig. 45).
- Herons and pelicans are good fish hunters. If they are present a number of strings should be secured across the pond to make it difficult for the birds to land on the water (Fig. 45).

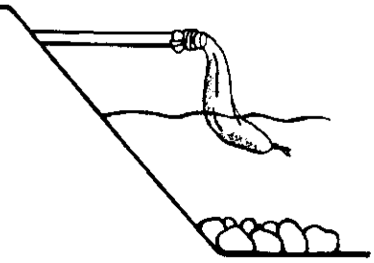
Liming

Ponds that have just been excavated need different treatment to ponds that have already been limed before.

Newly excavated ponds. These should be treated with 20-150 kg agricultural lime per are (see appendix 3). This is mixed with the upper layer (5 cm deep) of the pond bottom. The pond is subsequently filled with water till 30 cm. Within one week the pH of the pond water should have reached its desired level (6.5 - 8) and fertilization can be commenced.
Ponds used before. These should be treated with 10-15 kg quicklime per are, added to the damp pond bottom, to eliminate pathogens, parasites and invertebrate predators. A period of 7-14 days should elapse before the ponds are refilled. After filling the pond to a depth of 30 cm the pH of the water can be adjusted by adding agricultural lime.

Fertilizing

After liming the pond should be fertilized to increase natural food production. Fertilization can be done by adding organic or inorganic fertilizers or both (see appendix 3). The quantity and quality of the fertilizer needed depend on the natural fertility of the pond and on the density of the stocked fish. Supply about 20 kg organic manure per are. In some cases it is preferable



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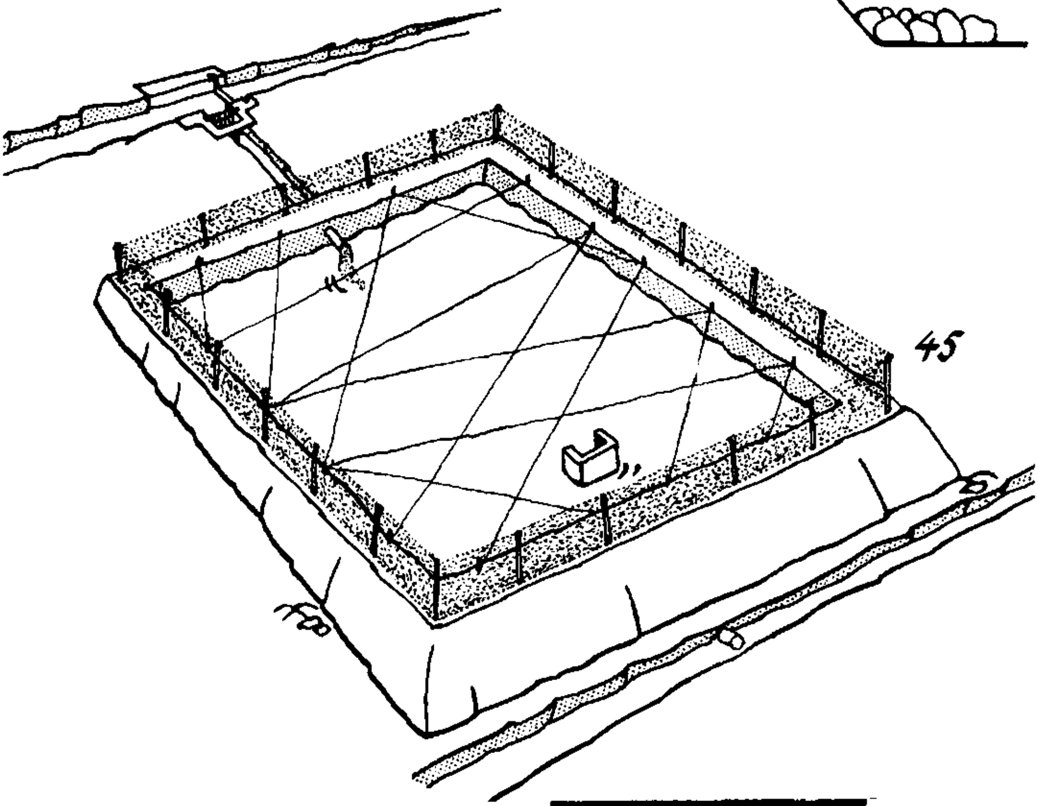

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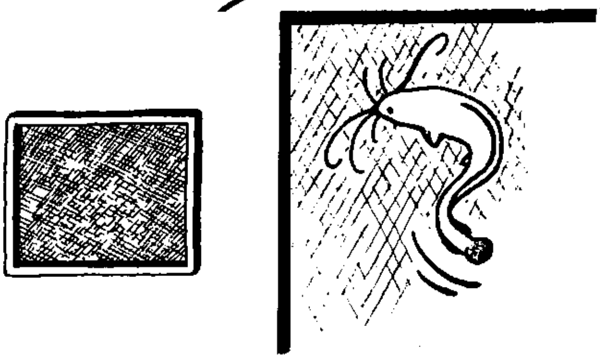

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to add the following inorganic fertilizers as well: 0.5 kg single superphosphate/are and 0.5 kg ureum/are (for alternative inorganic fertilizers, see appendix 3). The organic manure and ureum should be distributed equally over the water surface. Dissolve the superphosphate in a bucket with water and pour the substance into the pondwater at several points. It will take at least four days for phytoplankton and zooplankton (rotifers and daphnia) to develop in large quantities. During nursing, catfish fry depend on this natural food. In the first week they have still small mouth-openings and only zooplankton of 0.2 - 0.5 mm can be ingested. Nevertheless, fry are to be stocked on the first day after the pond has been filled. The small amount of food present in the water will cover the relatively low requirements of the fry during the first few days.
By stocking the fry immediately after filling the pond, fry may gain a head-start in development over predacious tadpoles.
The presence of predacious water insects such as water boatmen and water beetles can effectively be controlled by applying some diesel fuel as a surface layer or Dipterex ^{R} (organic phosphoric acid ester) at a dose of 0.5-1 p.p.m. Avoid any outflow of water from the pond.
The temperature range of the water of the nursery pond should be between 20 and 30°C (see appendix 1).
The sluice gate of the outlet should be screened to prevent the escape of fish. The mesh size of the (iron) screen should correspond to the size of the fry (Fig. 46). At the beginning of the nursery period the mesh size should be about 1 mm. At the end of the period this might be 4-5 mm.

5.3 Stocking of fry and maintaining the fertility of the water

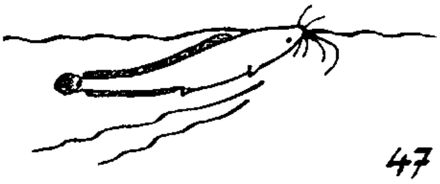
After yolk-sac absorbtion the fry should be transported from the hatchery in clear water which has the same temperature as the pond water. The fry should not be submitted to a temperature shock. Stock about 65 fry/m^2.
After stocking the farmer should check every 2-3 days the fertility of the pond water with a Secchi disk. How this should be done is described in appendix 4. If the transparency of the water is about 25 cm, due to the development of plankton, natural food production can be assumed to be sufficiently high. Start to fertilize when the reading is between 25 and 50 cm.
On the basis of the reading it might be necessary to fertilize once or twice

per week during the 28-30 day nursing period. Fertilization might be done by adding organic manure (5 kg of cow manure or 3 kg of chicken or pig manure per are) and/or inorganic fertilizers (50 g superphosphate and 100 g ureum per are). An addition of phosphates together with organic manure is preferred. See appendix 3 for further informatons.
About two weeks after stocking, the plankton production rate of the pond will no longer cover the needs of the growing fry. They will start to eat organisms from the pond bottom (such as mosquito larvae) but cannibalism will frequently occur. Without supplementary feeding a maximum survival rate of 30% can be reached within the 30 day nursing period. The fingerlings will have a mean weight in the 1-3 g range.
In appendix 5, alternative guidelines are given for nursery operations in a hatchery, with the aim of obtaining higher survival rates.

5.4 Daily monitoring of the nursery ponds

The pond should be checked at least once a day in the early morning. The following points together may serve as a checklist:

- Monitor the behaviour of fry. They should be actively searching for food on the pond bottom or at the water surface (Fig. 47). After three weeks they will have developed their arborescent organs and will regularly rise to the surface to breathe air (Fig. 48).
- Check the transparency of the pond water. A green colour is a sign that natural production is optimal. If the transparency is less than 20 cm plankton have been developing at too fast a rate (see appendix 4). This could lead to depletion of oxygen in the pond water, a phenomenon that occurs mainly at dawn. A low oxygen level is often indicated by the fry staying in the vertical position at the water surface (Fig. 49). In that case the water flow rate must be increased and fertilization temporarily halted until the fry swim normally again. It might be necessary to drain the pond down to 1/3 and refill it again with fresh water.
  Some of the fertile water and natural food will then have been flushed out. Fertilize the pond again but add less than before to avoid recurrence of oxygen depletion.
- Measure the temperature, oxygen level and pH of the water.
- Clean the screens of the pond and the sleeve of the inlet. If damaged,



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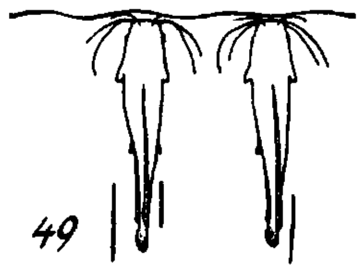

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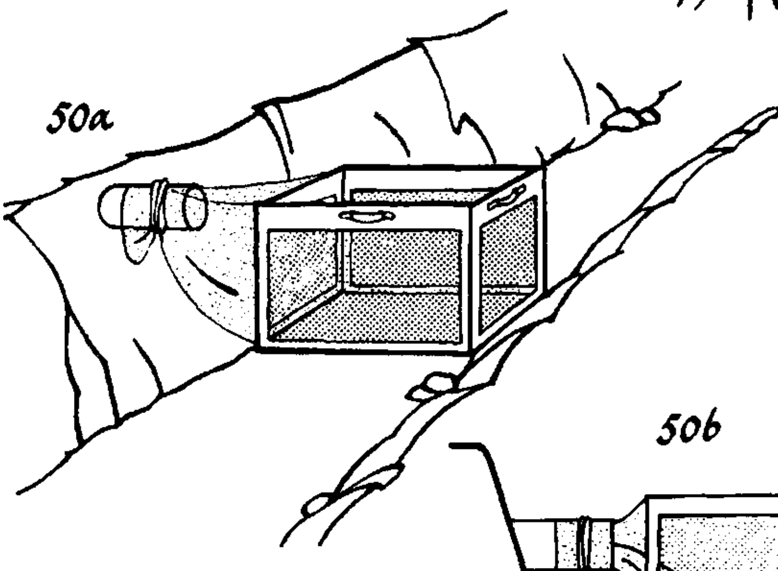

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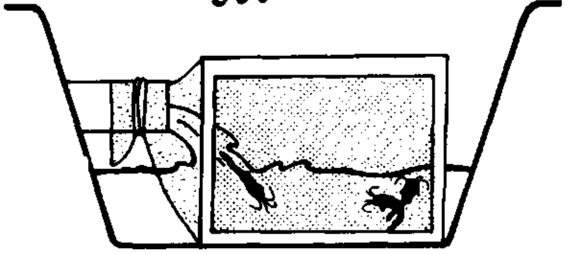

they should be repaired.

- Check the condition of the pond walls. Weak points and leaks should be repaired.
- Walk around the pond and check the fence for holes. Do repairs immediately. Frogs, toads and tadpoles and their eggs should be removed.
- Remove submerged water weeds. The plants reduce light penetration in the water, they compete with plankton for the nutrients and may cause difficulties in collecting the fingerlings during harvesting.

5.5 Harvesting of fingerlings

In order to harvest the fingerlings the following instructions are of value:

- Start emptying the pond a few hours before dawn while it is still cool. The water level should fall slowly and a small-mesh screen should be put in front of the outlet pipe to prevent fingerlings from escaping.
- A box with screened walls should be connected to the outlet in the discharge channel when the water level has almost reached pond bottom (Fig. 50a).
- The fingerlings should accumulate in the harvest box when the lowest shelf in the monk and the small-meshed screen are taken away (Fig. 50b).

The mean size and weight of the harvested fingerlings will vary between 3-6 cm and 1-3 g respectively. The survival rate will vary between 0 and 30%. This means that a harvest of about 20,000 fingerlings can be obtained. During the nursing period some of the fry will develop faster than the others, which may result in cannibalism by the larger specimens.

At the time of harvesting the size of the biggest fingerlings may be 2-4 or even more times those of the smallest specimens.

From a group of fingerlings with such variation, the largest should be removed from the others before they are stocked in the fattening ponds. Otherwise severe losses due to cannibalism could occur during the fattening period. The simplest and best way to separate the different sizes is:

- Put the fish on a smooth table with frames along the sides and holes in the corners. For each size-class one hole is used. Containers with water are placed under the holes of the table (Fig. 51).
- Separate 2 or 3 different size classes with wet hands.
- Do not put more than 500 fingerlings of 2 g per 3 l water. The fingerlings

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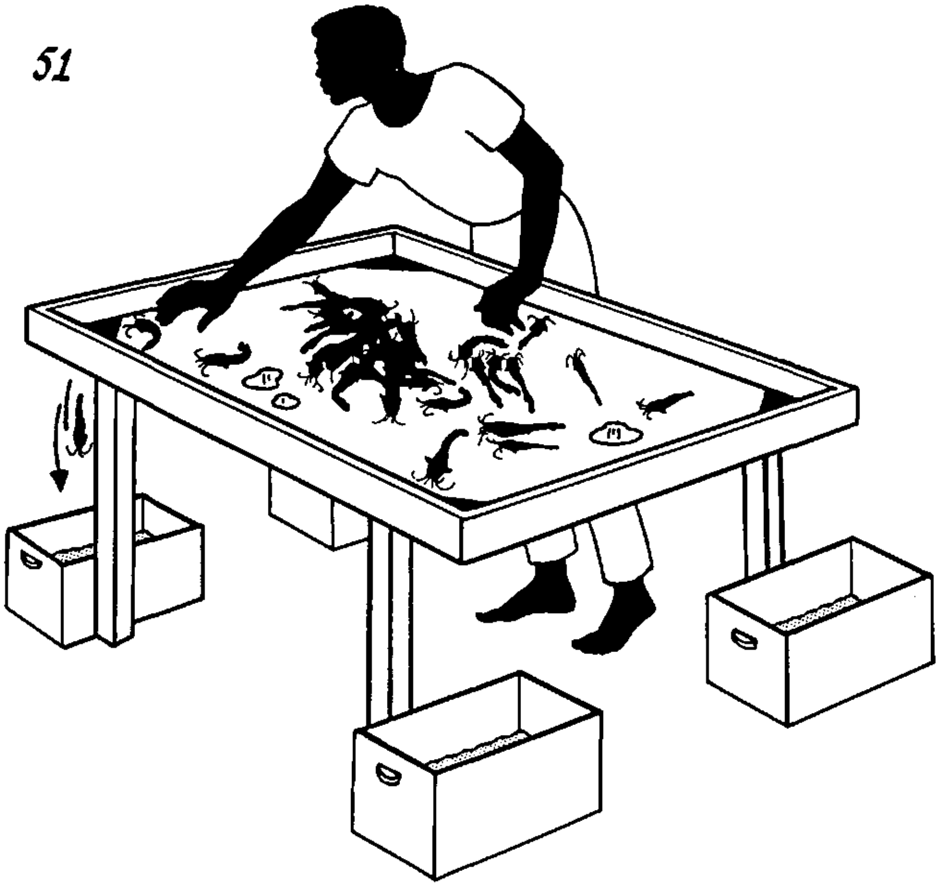

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should have enough space to be able to breathe air at the water surface (Fig. 52).

- Do not expose the fish to direct sunlight.
- The fattening ponds should be stocked immediately afterwards with fingerlings of roughly the same size.

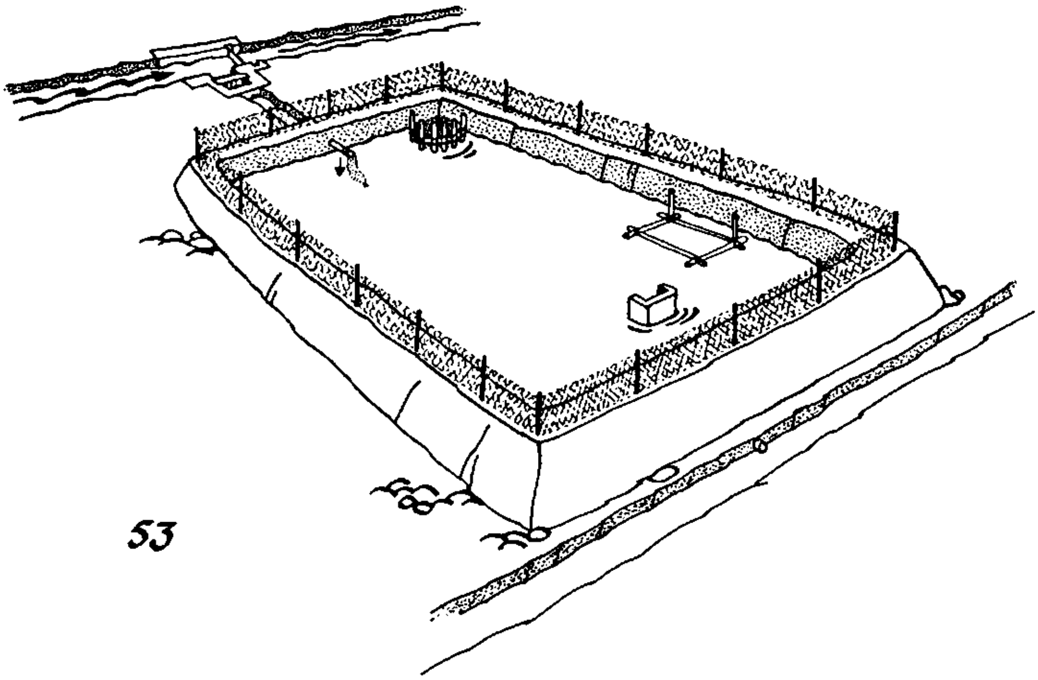
5.6 After-care of nursery ponds

Before the nursery pond can be used for a following cycle, it should be prepared again.

- During production a silt layer may accumulate over the pond bottom. The accumulation rate depends mainly on the amount of suspended clay brought in by the inlet water. A few centimetres of this fertile layer will improve natural food production but excessive accumulation will cause the opposite due to anaerobic activity.
- Remove excess silt from the pond bottom and use it to improve land.
- Disinfect the damp pond bottom with quicklime (10-15 kg/are).
- Let the pond dry out for several days till the clay cracks and start the preparations, as described in this chapter, again.

NOTES

NOTES



53

6. FATTENING AND BROODFISH PONDS

6.1 Introduction

In this chapter the management of semi-intensive polyculture (the African catfish together with the Nile tilapia) and intensive monoculture (the African catfish) will be discussed. The results of both cultures must only be taken as a guideline.
The fish farmer should learn the capacity of his pond by trial and error and with the experience obtained he might be able to improve total yield.

6.2 Fattening ponds

Number and preparation of ponds

The number of ponds to be stocked with catfish fingerlings will depend on the harvest of fingerlings from the nursery ponds and the stocking rate of the fattening ponds.
For polyculture the stocking rate is 3 catfish fingerlings per m^2. With a harvest of about 20,000 fingerlings (see chapter 5) approx. 35 ponds of 200 m^2 can be stocked. With monoculture the stocking rate is 10 catfish fingerlings per m^2. Thus to stock 20,000 fingerlings about 10 ponds of 200 m^2 are needed. For fattening ponds the depth should be 80-100 cm.
Semi-intensive polyculture and intensive monoculture are carried out in stagnant ponds. To fill a fattening pond of 200 m^2 within 2 days about 70 l/min will be needed. Besides the required waterflow of 1.5-3 l/min for a 200 m^2 pond to compensate for seepage and evaporation losses it is best to have a minimum surplus of water in the supply channel of 50 l/min (Fig. 53). With this flow rate a turnover time of about 3 days per pond can be reached. This relatively short turnover time is needed in the event of acute oxygen depletion of the water or therapeutical treatment of fish diseases.
The elimination of pests and predators and the liming and fertilization of the pond bottom prior to filling the pond are described in chapter 5. It is advisable to surround the fattening ponds with a fence of wire netting or bamboo to prevent fish escaping from the pond if the walls of the pond are lower than 50 cm (measured vertically from water level to crest of wall). To prevent fish-theft, bamboo or branches might be put in the pond, which

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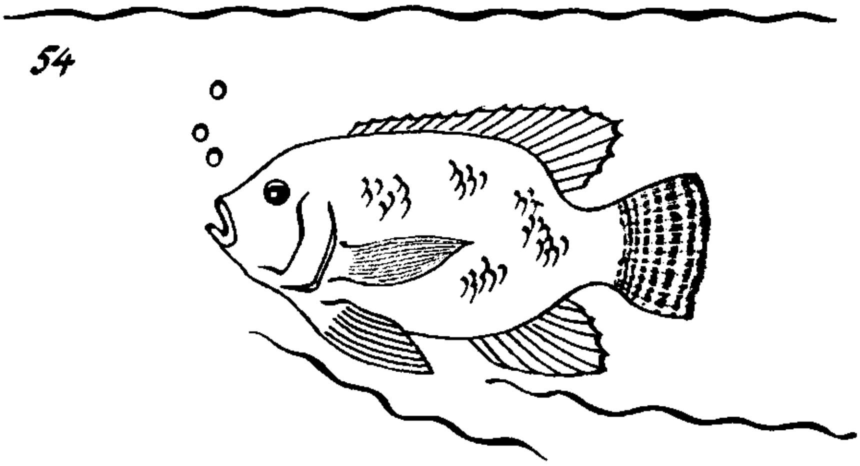


Tilapia nilotica
Sarotherodon niloticus } = *Oreochromis niloticus*
Oreochromis niloticus

makes netting and rod-and-line fishing impossible.

6.2.1 Semi-intensive polyculture of catfish and tilapia

Introduction

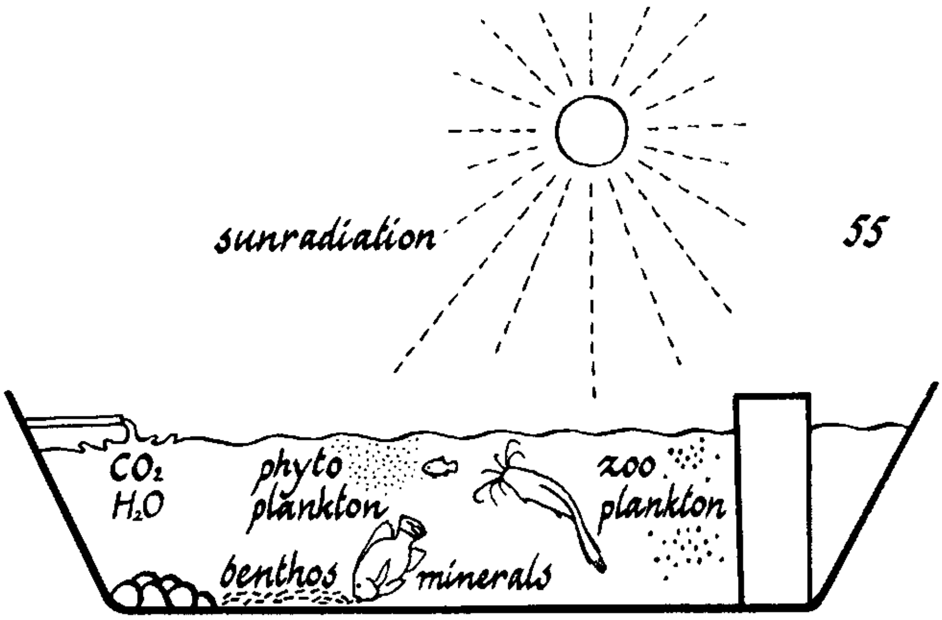
The mouth breeding Nile tilapia, which is indigenous to Africa, belongs to the family of the Cichlidae (Fig. 54). It is suitable for fish farming because of its high yield potential, resistance to crowding and diseases and ability to survive low oxygen levels of the water. In spite of the above mentioned advantages, tilapia makes a relatively small contribution to fish culture in most African countries because of its abundant production of offspring in fattening ponds. Specimens 4 months old weighing about 40 g are already able to reproduce. Spawning is difficult to prevent and often results in severe overcrowding of the pond and thereby in the stunting of fish growth. Raising of catfish with tilapia will result in the predation of the offspring. The fry is an ideal food for catfish. Tilapia fingerlings should, however, be stocked when they have grown too big for predation by catfish. The Nile tilapia is omnivorous and will particularly consume the phytoplankton, a pond food source, that will be less exploited by catfish (Fig. 55). In most African countries tilapia fingerlings are available at reasonable prices.

Stocking of fingerlings

Catfish of 1-3 g and tilapia of 5-15 g should be stocked in densities of 3 and 2 specimens per m^2 respectively. The initial difference in weight between the two species is needed to eliminate predation of stocked tilapia by catfish.
Temperature shocks during transport of the catfish fingerlings from the nursery ponds to the fattening ponds should be avoided. Release the young fish into the pond by gently tipping the container into the water.

Fertilization of water

After stocking, the pond's natural food production should be maintained by adding organic or inorganic fertilizers. This might be done by constructing a compost crib and/or by adding manure to the water (see appendix 3).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CO_2
H_2O
phyto
plankton
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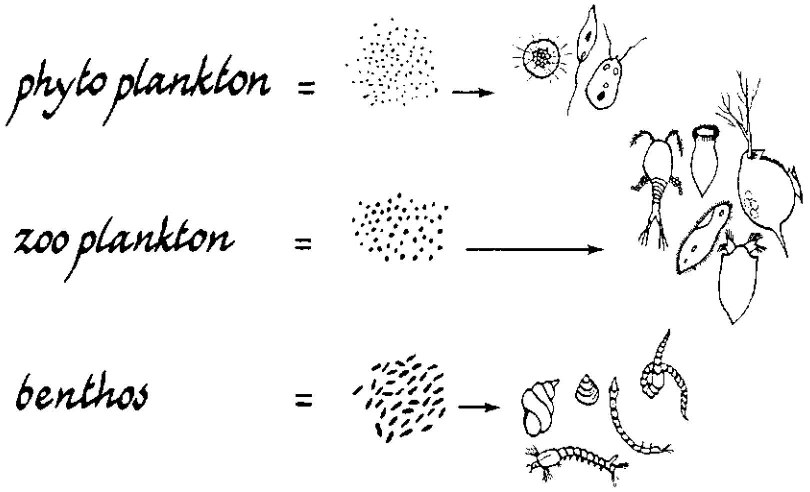
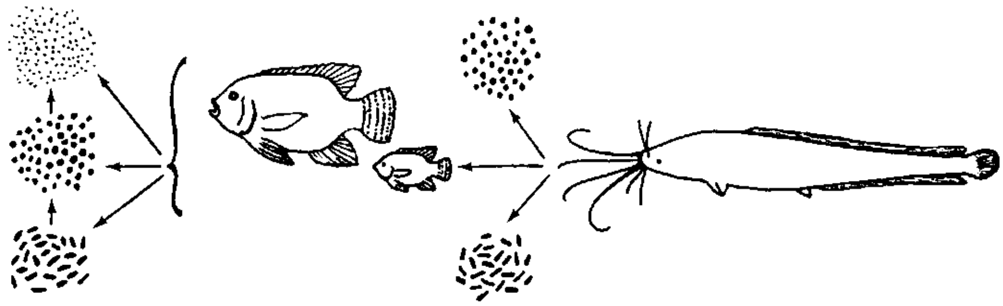
plankton
benthos
minerals


phyto plankton =
zoo plankton =
benthos =



The compost crib. The construction of a compost crib is briefly described below:

- Build a bamboo compost crib with a radius of 1.5 - 2 metres in a corner near the inlet of the pond (Fig. 53).
- Fill it up with layers of grass alternating with fresh wastes such as kitchen offall (Fig. 56a).
- Put heavy stones on the crib to stop the compost floating away (Fig. 56b).

Plankton development will start within a few days, depending on the degree of decay of the compost.

Manure. The manure should be mixed with water and equally distributed over the water surface. The addition of large quantities of manure should be avoided because this can cause oxygen depletion in the pond. Some of the manure will be directly consumed by the fish. Add 3 kg poultry, 3 kg pig or 5 kg cattle manure/are per week (see appendix 3).

Livestock husbandry can also be integrated with fish farming (Fig. 57). In that case 15-30 chickens or 10-15 ducks or 0.5-1 pig are needed per are (see appendix 3). The optimum number of animals differs from pond to pond.

Natural food production might be increased by application of inorganic phosphate fertilizers (see appendix 3).

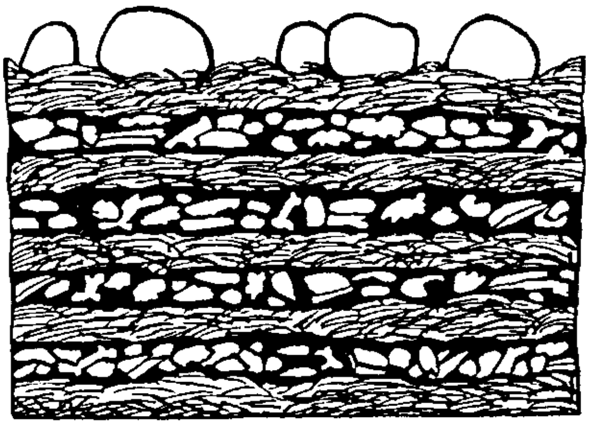
Feeding

Even if the pond's natural food production has been increased by fertilization, the pond will be unable to meet the demand for food of the stocked fish. Natural foods like benthos and zooplankton are generally rich in proteins. With not so high fish densities additional foods which are only rich in carbohydrates and fats, like brewery waste, corn or rice bran, will suffice.

But for the fish densities mentioned in this chapter fairly complete foodstuffs such as cottoncakes have to be used in addition. Cottoncakes are not only rich in carbohydrates and fats but also in proteins. Add the supplementary food at 7 a.m. and 5 p.m. at the same place in the pond. The fish will learn to feed at that spot.

To stop the food floating away, a feeding frame should be used (Fig. 58). Some of the food will not be eaten and serves to fertilize the pond water. The daily amount distributed to the pond should be 200 g, 300 g, 400 g, 500 g, 600 g, 700 g in the consecutive six months (Fig. 59).

56a



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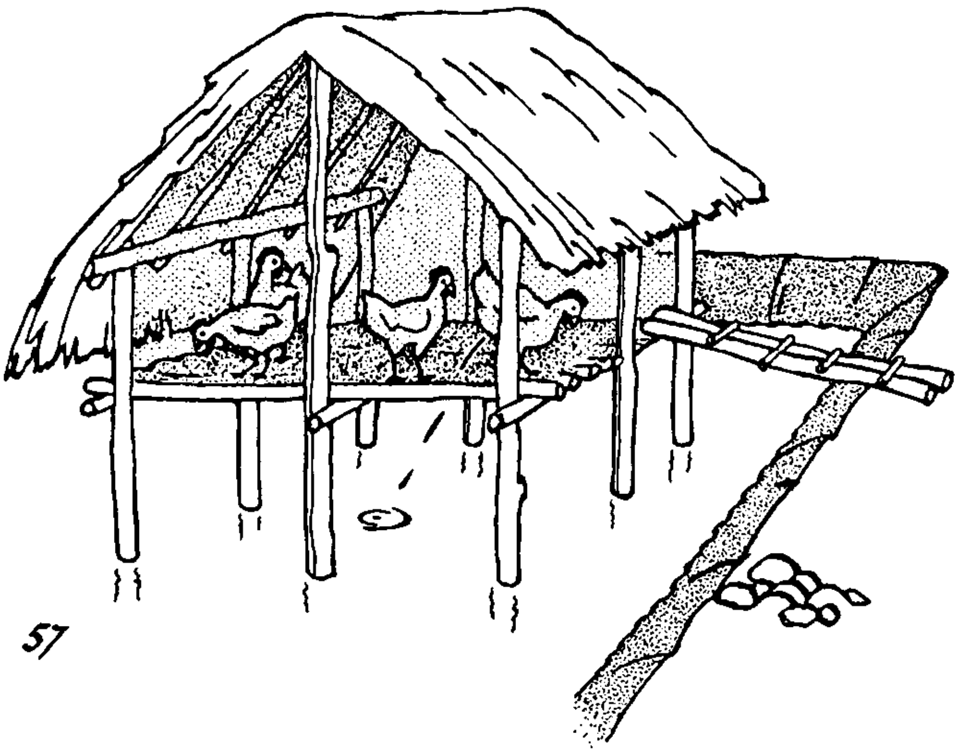

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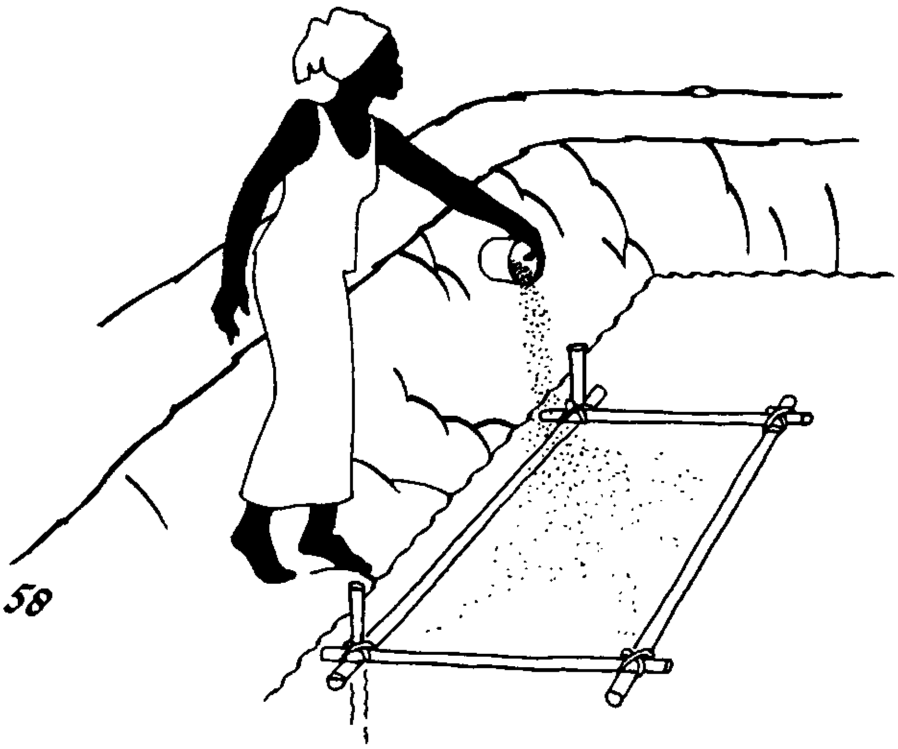


58

59

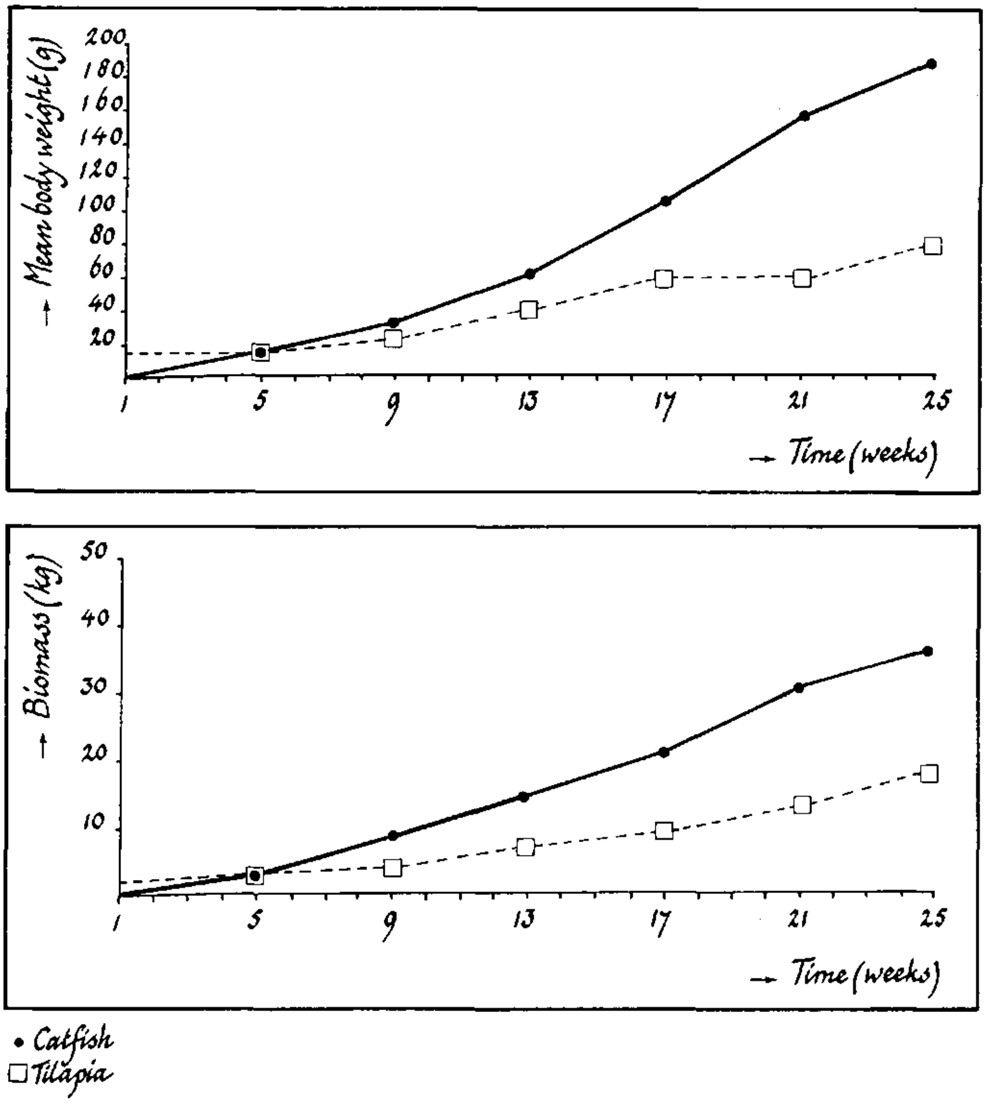
Semi intensive polyculture
C. gariepinus + O. nitolicus
Stagnant ponds

Stocking density
Catfish (1-3g) - 300/are
Tilapia (5-15g) - 200/are

Compost crib: Ø 1,5-2 m
Additional feeding: Cotton cake

	Catfish			Tilapia		
Week number	Mean body weight (g)	Survival (%)	Biomass (kg/are)	Mean body weight (g)	Survival (%)	Biomass (kg/are)
1	1	100	0,3	10	100	2,0
5	10	85	2,6	14	95	2,7
9	28	80	6,8	26	90	4,7
13	64	70	13,5	44	77	6,8
17	104	65	20,3	60	79	9,5
21	152	65	29,7	62	105	13,0
25	184	65	36,0	80	103	16,5

Week number	Feeding level (% biomass - Catfish + Tilapia)	Cotton cake (g/day/are)	Harvest (kg/are)
1	8,5	200	2,3
5	5,5	300	5,3
9	3,5	400	11,5
13	2,5	500	20,3
17	2,0	600	29,8
21	1,5	700	42,7
25	--	harvest	52,5



Mean body weight (g)
200
180
160
140
120
100
80
60
40
20
1
5
9
13
17
21
25
Time (weeks)
Biomass (kg)
50
40
30
20
10
1
5
9
13
17
21
25
Time (weeks)
• Catfish
□ Tilapia

During the production cycle, fish growth might be monitored by stock assessments.

This should be done as follows:

- Add some food in the water near the feeding place to lure the fish (Fig. 60a).
- Collect some catfish by means of a castnet (Fig. 60b) or a seine.
- Compare the mean weight of the caught fish with the numbers given in Fig. 59.

It might be necessary to adjust the food supply.

The amount of food which has to be given can be calculated in the following way:

- Estimate total fish weight in the pond (biomass) by multiplying: number stocked fish x survival rate (Fig. 59) x measured mean weight.
- The amount of food to be given is: biomass x feeding level. The feeding level is given in Fig. 59 as a percentage of the biomass in relation to the mean body weight.

It might happen that a sudden abnormal increase of the growth rate may occur. This may indicate a serious drop of your fish density (mortality). In that case it is worthwhile to empty the pond in order to weigh total biomass (total fish weight). Having obtained this information the exact amount of cottoncake to be given can be calculated.

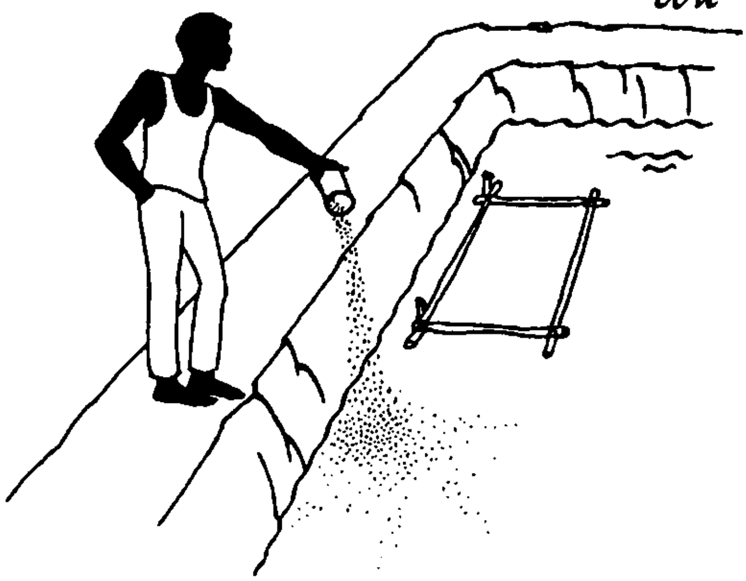
Daily monitoring of the fattening ponds

Every day, at least once, the fattening ponds should be checked (see the guidelines given for nursing ponds in 5.4, page 55). Oxygen depletion of pond-water in semi-intensive polyculture is often indicated by the behaviour of tilapia. They will come up at the water surface to gulp air (Fig. 61). For further instructions see 5.4.

Harvesting

At the end of the production cycle the catfish should be harvested. Stop feeding 2 days prior to harvesting (remove the bamboo or branches from your pond). Empty the pond slowly a few hours before dawn in order to collect the fish while it is still cool. If it is not possible to drain the pond completely

60a



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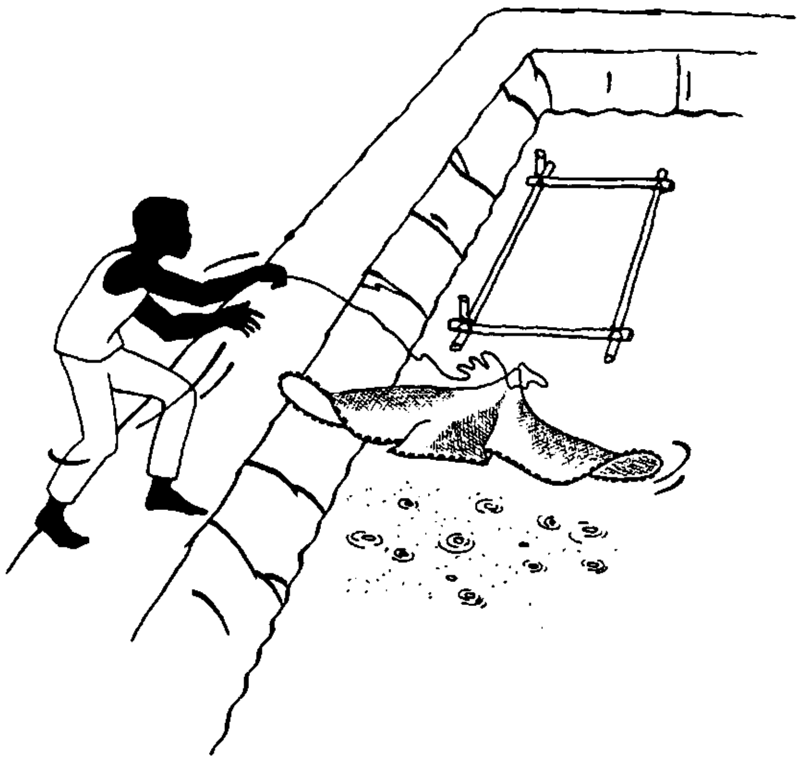

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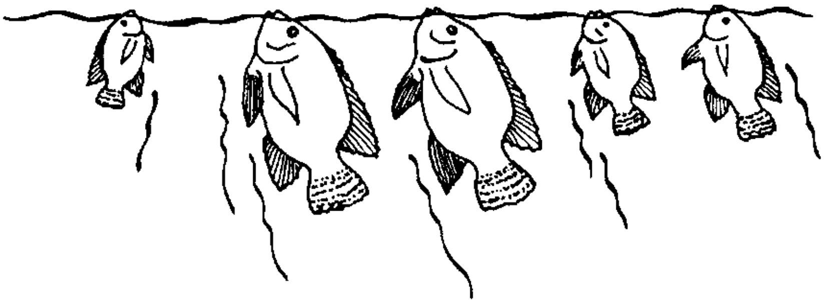

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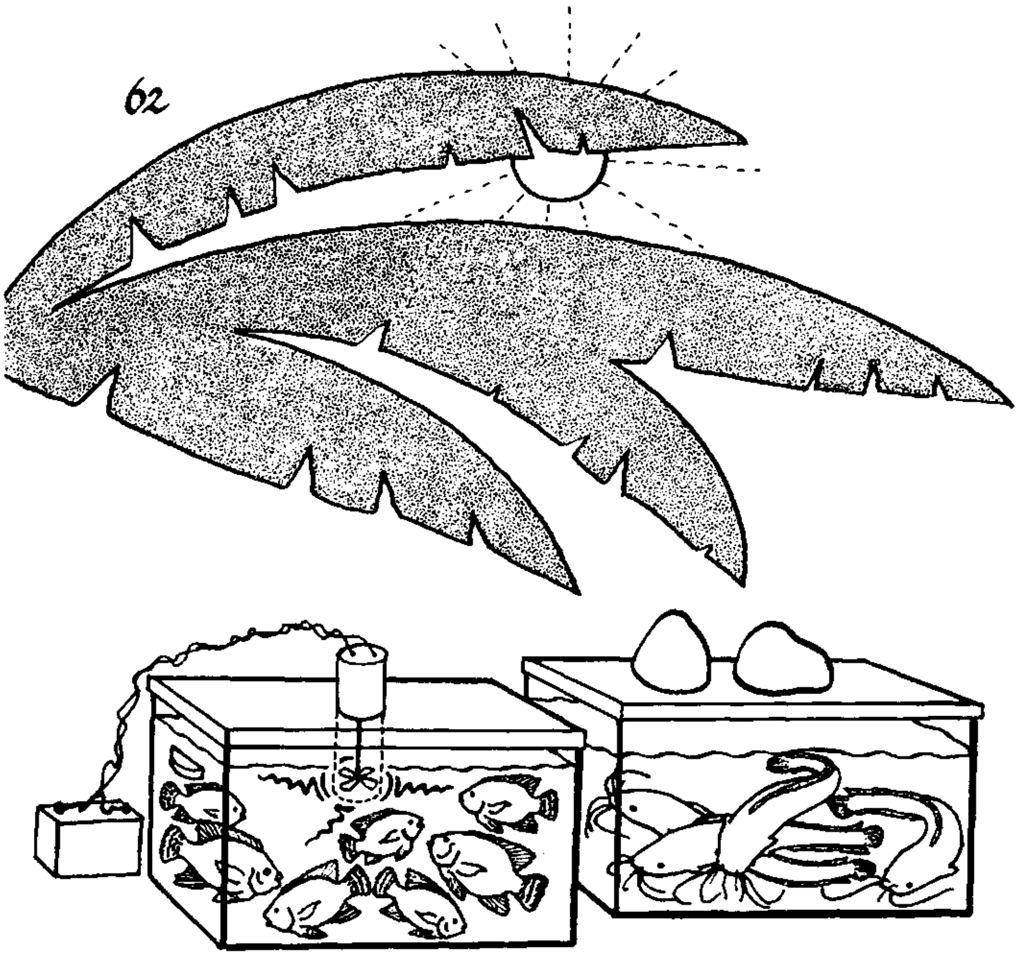


a pump or a seine will be needed.

If harvesting is carried out 25 weeks after stocking the following typical results can be expected:

- . Catfish - mean weight 185 g, - survival rate 65%, - production 36 kg/are;
- . Tilapia - mean weight 80 g, survival rate 103% (which means that the catfish was unable to completely control the tilapia offspring by predation) and production 16.5 kg/are (Fig. 59).

The effect of feeding on fish production should be quantified to enable the results of various ponds or production cycles to be compared with one another. This can be done with the relative food conversion (RFC).

$$RFC = \frac{\text{food (kg)}}{\text{harvest(kg)-stocked fish(kg)}}$$

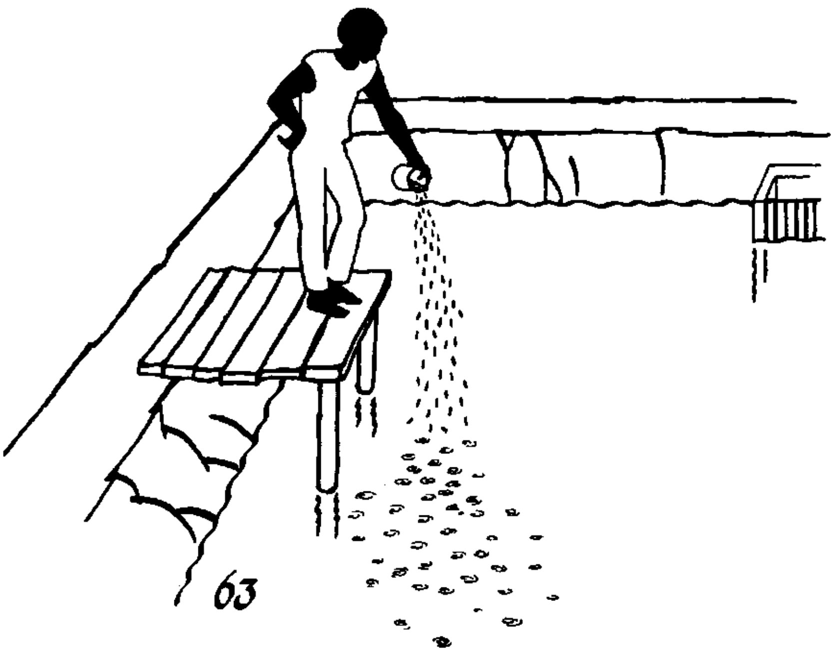
With the data from Fig. 59 the RFC can be calculated:

$$\frac{\text{76 kg cotton cake}}{\text{52.5 kg(catfish + tilapia) - 2.3 kg(catfish + tilapia)}} = 1.5$$

The RFC often gives over-optimistic (that is low) values because the yield due to natural food production of the pond is credited in this formula to the added food.

Each pond will show different results, but a generally low final catfish weight (e.g. 120 g) or too high tilapia survival (for instance 200%) is indicative of something wrong in pond management. Daily monitoring notes should first be reconsulted. Possibly, the catfish were unable to prey sufficiently on tilapia offspring because the offspring could find perfect hiding places in water plants that had not been cleared. By investigating the causes of such problems, the best way of raising fish to marketable size will ultimately be found.

After harvesting, the tilapia should be stocked in clean water with sufficient aeration until the fish are sold or processed. The fish should not be exposed to direct sunlight (Fig. 62).



63

6.2.2 Intensive monoculture of catfish

Introduction

The number and preparation of fattening ponds for intensive monoculture of catfish are described in paragraph 6.2, page 63.
The stocked density of catfish is so high that natural food production in the pond does not play an important role in relation to the total demand for food. The stocked Clarias depend totally on the supply of food from outside the pond and this type of culture is only possible where suitable complete feeds are available.
It would not be profitable to fertilize the pond during the production cycle.

Stocking of fingerlings

Catfish of 1-3 g should be stocked in a density of 10 specimens per m^2 (see also 6.2.1, page 65).

Feeding

The composition of feed for the catfish fingerlings is based on vegetable and animal products supplemented with vitamins and minerals. To obtain a good growth rate, the pellets should contain 30% - 40% digestible protein and 3000-4000 kcal digestible energy/kg food (see appendix 6). Add the pellets at 7 a.m. and 5 p.m. from one fixed place (eg. platform) (Fig. 63) to the pond according to the weekly quantities given in Fig. 64.
The pellets should be distributed with one cast over a surface of about 2 m^2 so that competition amongst catfish will be reduced to a minimum.
It will be difficult to observe the feeding behaviour of the fingerlings. Most of the crumbs/pellets will sink to the bottom and only tiny airbubbles will indicate that the fish are eating the food. From time to time during a feeding they will come up at the water surface to take air. It will be difficult to estimate if all food has been consumed. Once a while the pond bottom should be checked at the feeding place for food remnants half an hour after feeding. If food remnants have accumulated, the quantity of pellets distributed should be reduced. Pollution of the pond water due to over-intensive feeding should be prevented.
For monitoring fish growth and feeding levels, see 6.2.1, page 74.

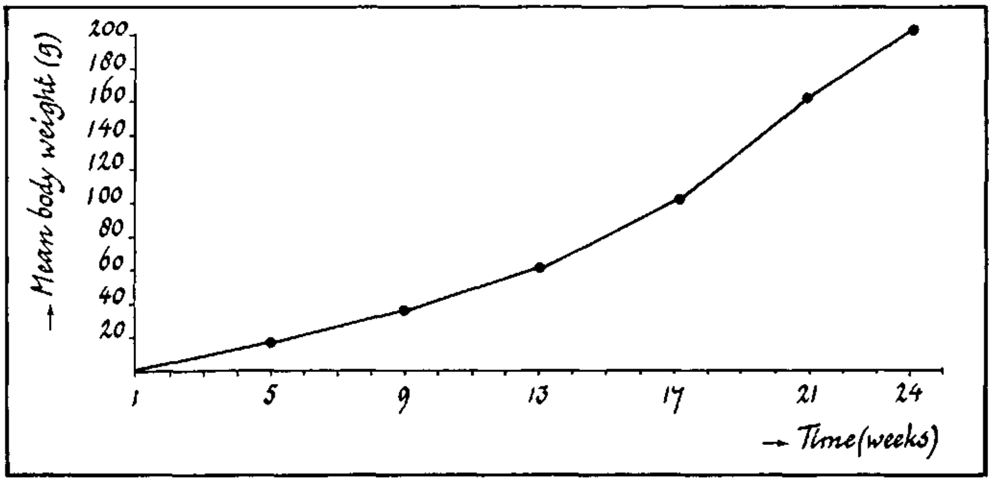
Intensive monoculture
C. gariepinus
Stagnant ponds

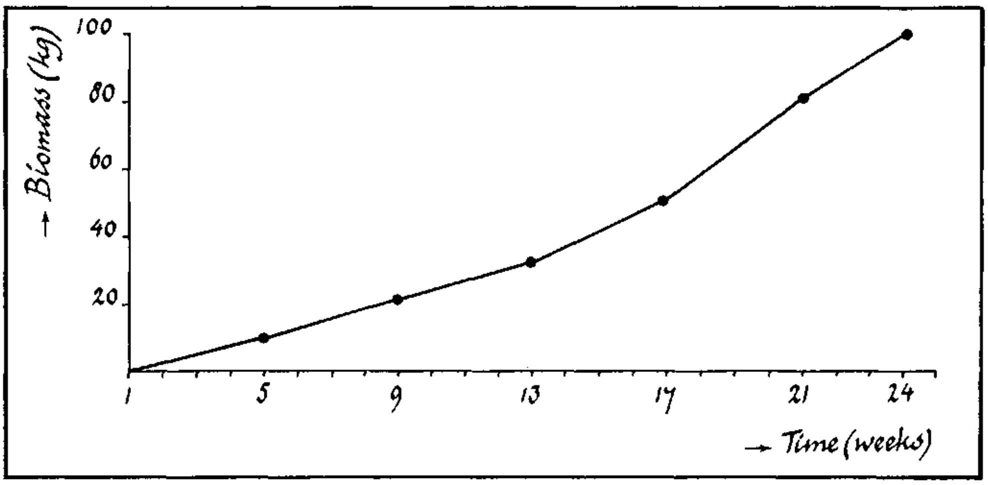
64

Stocking density
Catfish (1-3g): 1000/are

Feeding: pellets
30% digestible protein
3000 KCal digestible energy/kg food

Week number	Mean body weight (g)	Survival (%)	Biomass (kg/are)	Feeding level (% biomass-Catfish)	Pellets (g/day/are)
1	1	100	1	25	250
2	3			10	250
3	6			7	300
4	10			4,5	350
5	15	70	11	4	400
6	19			3,5	450
7	24			3	500
8	30			3	600
9	37	65	23	3	665
10	43				700
11	48				700
12	55				800
13	62	55	34	2,5	900
14	70				950
15	78				1050
16	88				1050
17	100	50	50	2,25	1150
18	115				1250
19	125				1300
20	140				1400
21	160	50	80	2	1600
22	175				1600
23	190				1700
24	200		100	2	harvest


200
180
160
140
120
100
80
60
40
20
→ Mean body weight (g)
1
5
9
13
17
21
24
→ Time (weeks)


100
80
60
40
20
→ Biomass (kg)
1
5
9
13
17
21
24
→ Time (weeks)

• Catfish

Daily monitoring

The pond should be visited at least once a day in the early morning. For the daily monitoring a checklist is given in 5.4, page 55.
One way of observing some of the catfish is to supply the pellets a few at a time at a particular spot during feeding time. The strongest catfish will compete at the surface for the feed.
Do not make a custom of this way of feeding.

Harvesting

The preparations prior to harvesting are described in 6.2.1, page 74.
If harvesting is carried out 24 weeks after stocking the following results can be expected:

- Catfish - mean weight 200 g, survival rate 50% and a production of 100 kg/are (Fig. 64). The relative food conversion is about 1.4.

6.3 Broodfish pond

The characteristics of fattening ponds also apply for broodfish ponds. One broodfish pond of 100 m^2 will be needed for the maintenance of about 100 broodfish (50 adult males and 50 females of about 500 g). For the management of this pond see paragraph 6.2.2. The quantity of pellets needed will be about 1% of the total biomass, which corresponds to 500 g/are/day.

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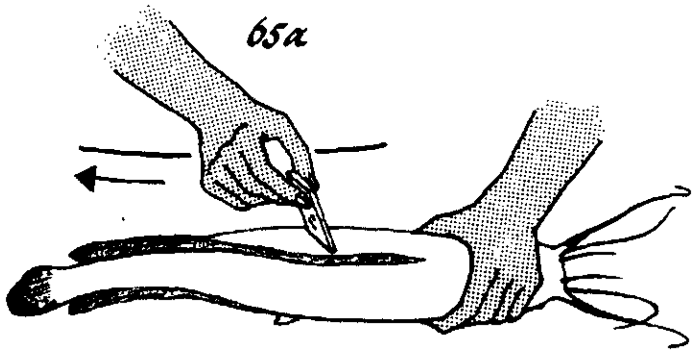
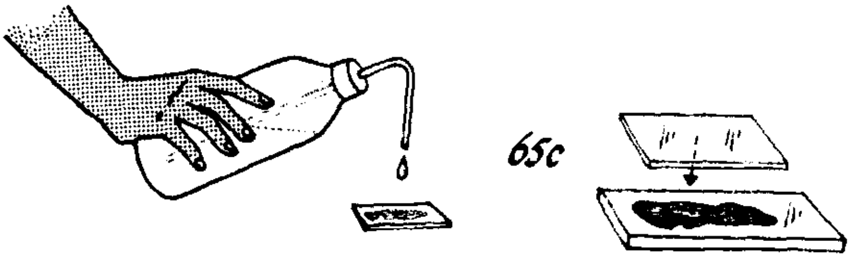
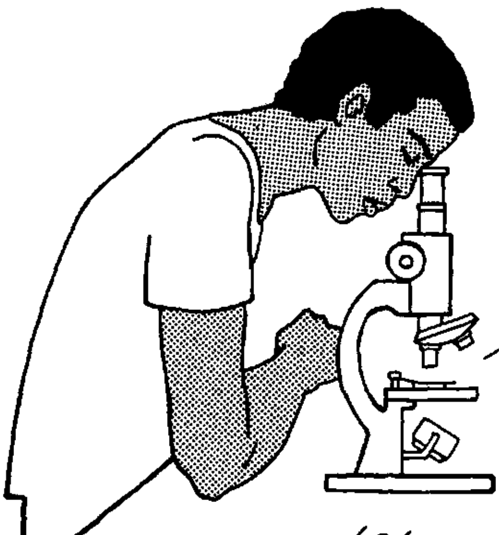


65a

65b



65c



65d

66

Myxobacteria

7. CATFISH DISEASES

7.1 Introduction

In water pathogens are easily transmitted from fish to fish via gills and skin. The African catfish raised under optimum conditions can, in general, resist the pressure of infectious agents in the water such as viruses, bacteria and parasites. Poor water quality, bad feeding regime, rough manipulation of fish and an unquiet environment can disturb this stress-sensitive fish species. This can result in decreased activity of the immune system, and a sudden outbreak of a disease can occur. Fry and fingerlings are most vulnerable as they have still to build up immunity.

Stressed or diseased fish can often be recognized by abnormal behaviour, such as decreased appetite, nervous or "waddling" swimming, staying in vertical position at the surface or by clinical symptoms such as mutilated barbels or fins, white or red-brown spots on the skin, pop-eyes etc. However, one must keep in mind that these symptoms are not specific, so the laboratory techniques, described below, are necessary to diagnose the disease. The ponds should be monitored daily for diseases, especially during feeding time when catfish usually frequent the surface of the water. In case of doubt fish should be collected alive for examination. In order to diagnose bacterial, fungal and parasitical diseases, squash preparations of the skin, the gill filaments, intestines etc. have to be made and examined (Fig. 65a, 65b, 65c, 65d). A microscope with magnification from X 40 to X 1000 is needed for the identification of a disease. After the diagnosis of a disease, specific therapy can often be immediately started.

7.2 Bacterial diseases

Symptoms: Fish remain in vertical position at the water surface or exhibit a "waddling" swimming behaviour. White spots on the skin, particularly around the mouth and on the fins, are present.

Take a smear of gills and skin and examine it under the microscope. Elongated motile rods are present.

Diagnosis: Myxobacteria (Fig. 66).

Prophylaxis
and therapy: Antibiotics, such as Chloramphenicol, Terramycin or Oxytetracycline are applied as additives into the feeds. Dosage in feeds ranges from 5 to 7.5 g/100 kg fish per day, for 5-15 days. Furaltadone, a chemi therapeutic, is water soluble and is well absorbed through the skin and gills by larvae. Furaltadone at a dose of 50 ppm/hour might be given as prophylactic or therapeutic treatment in the water of the incubation gutter.

7.3 Fungal diseases

Symptoms: Infected catfish have cotton-like growths on the skin, mouth and barbels. The fungus especially occurs on skin injuries caused by handling, netting or ectoparasites. Heavy infections result in "waddling" swimming behaviour and can finally cause mortality. Cotton-like growths can also occur on the eggs. During the incubation period fungal infections may cause high losses amongst eggs and larvae.

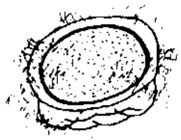
Diagnosis: Saprolegnia (Fig. 67a + 67b)

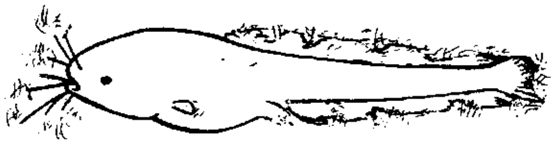
Prophylaxis
and therapy: Fry, fingerlings and adult fish can be treated with malachite green oxalate. This is added to the pond water till a final concentration of 0.05-0.1 p.p.m. is reached. In a stagnant pond, the malachite green added will be broken down within a few days.

As a prophylactic treatment eggs should be disinfected with Wescodyne^{R} at a dose of 25 p.p.m. for 5-10 minutes, within one hour after stripping. This could be also done with malachite green oxalate (zinc free) at a dose of 0.10-0.20 p.p.m. for one hour or at a dose of 5-10 p.p.m. during 15 minutes.

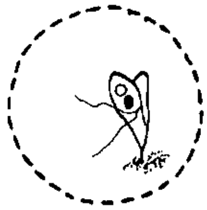
7.4 Parasitical diseases

Symptoms: Hyperinfected catfish often stay in vertical position at the water surface or nervously rub their heads or flanks over the pond bottom. Sometimes the skin is covered by a greyish white mucoid film. Mass mortality can occur. Parasite identification



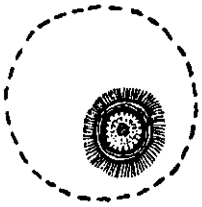


67a *Saprolegnia* 67b

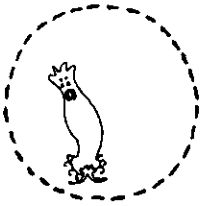


68 *Costia*

69 *Chilodonella*

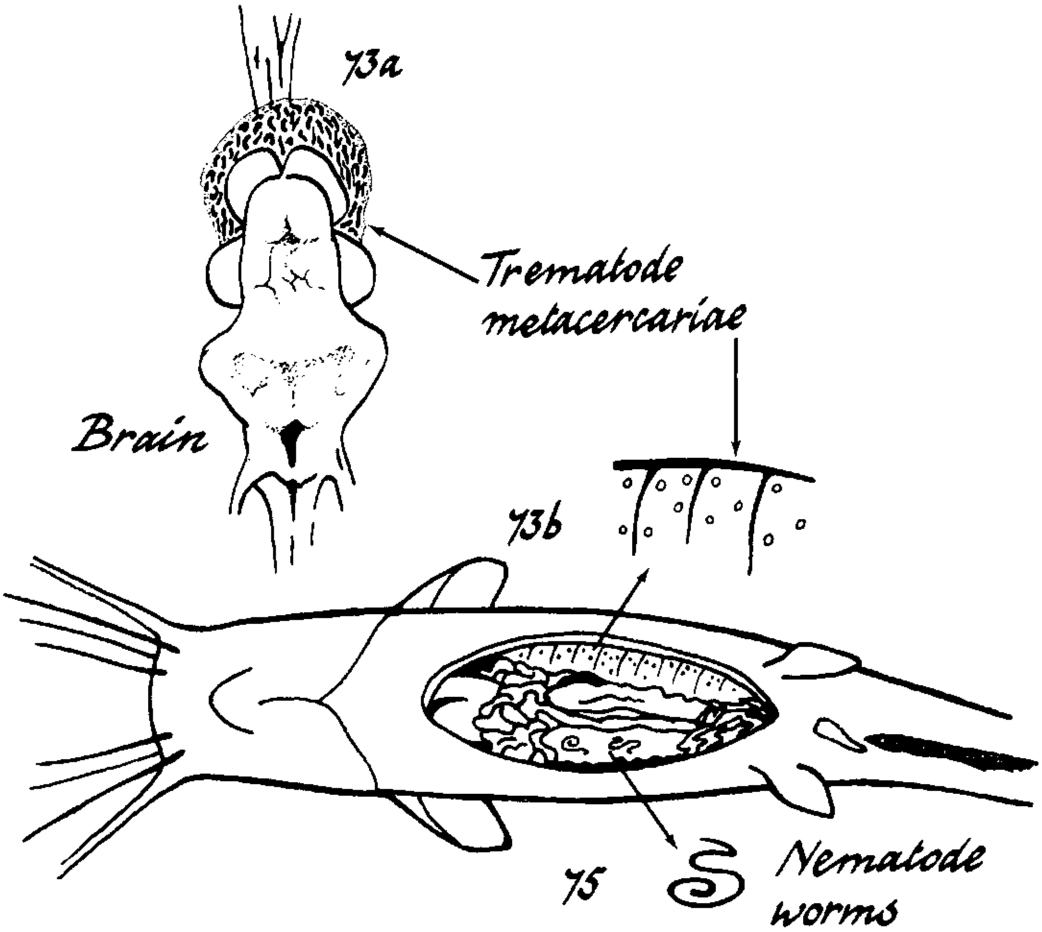


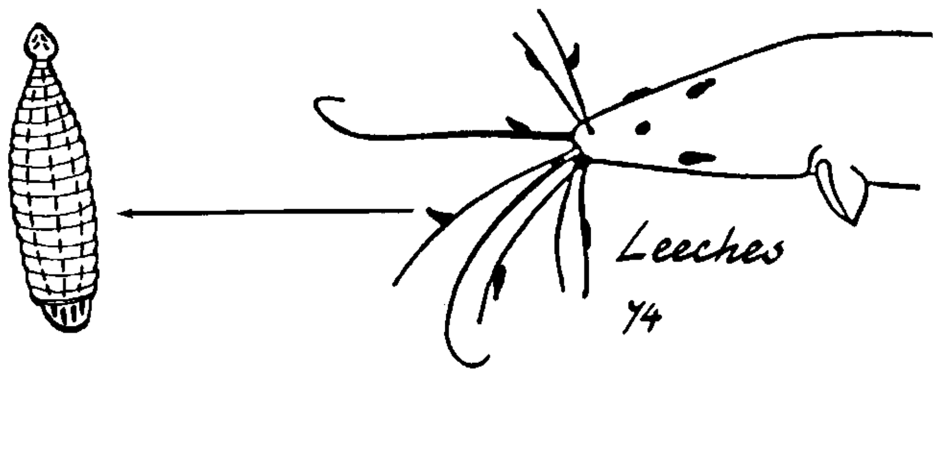
70 *Trichodina*



71 *Dactylogyrus*

72 *Gyrodactylus*


73a
Trematode
metacercariae
Brain
73b
75
Nematode
worms


Leeches
74

must be done microscopically with freshly prepared tissues. Take pieces of gills and infected skin by scraping the fish with a slide. After adding a drop of (boiled) water on the tissue smear the preparation should be enclosed with a coverslip.

Diagnosis: The following parasites might be found:

Protozoa: Costia (Fig. 68), Chilodonella (Fig. 69) and Trichodina (Fig. 70).

Trematoda: Dactylogyrus (Fig. 71) (only on gills), Gyrodactylus (Fig. 72).

Prophylaxis and therapy: Fry, fingerlings and adult fish can be treated with formalin at a dose of 25-50 p.p.m. applied to ponds. For pond treatment also 0.12 p.p.m. Bromex^R, or 0.25 p.p.m. Dipterex^R (Dylox^R, Masoten^R) are suitable.

Remark: The catfish is also an intermediate host for Trematodian metacercariae. They are particularly present in high numbers in the connective tissue around the brain as well as in the muscular tissues (Fig. 73a + 73b). The fish apparently do not suffer from this parasite. Long term effects and control of the infection have not yet been studied.

Symptoms: Red-brown worms are present on skin and barbels. Heavy infections can cause anaemia and stunted growth.

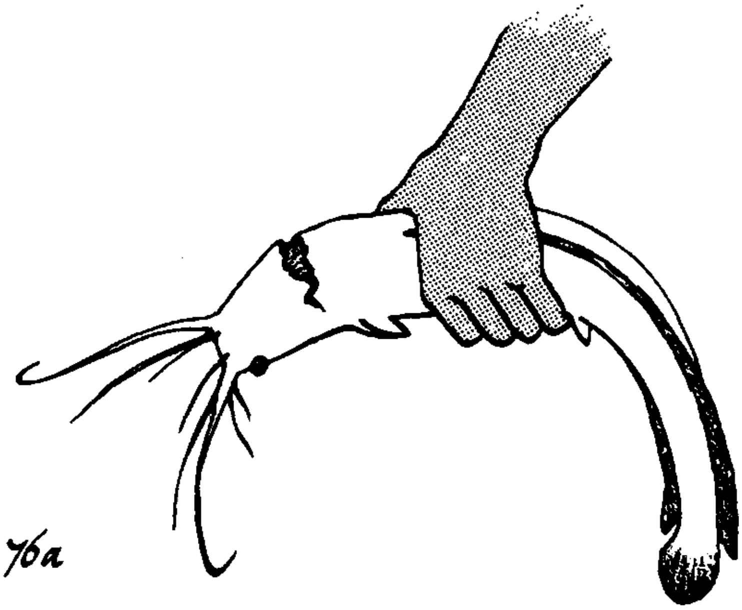
Diagnosis: Hirudinea: Leeches (Fig. 74)

Prophylaxis and therapy: Leeches may be eradicated from ponds by application of 0.5 p.p.m. Dipterex^R or by Masoten^R at doses ranging from 0.25 up to 0.8 p.p.m. (AI).

Symptoms: Encapsulated larvae are present in tissues and non-encapsulated worms are found in the abdominal and pericardial cavity.

Diagnosis: Nematode worms (Fig. 75)

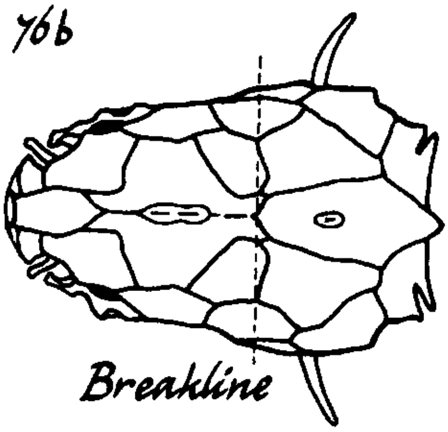
Remark: The fish apparently do not suffer from this parasite. Long term effects and control of nematode infection have not yet been studied.

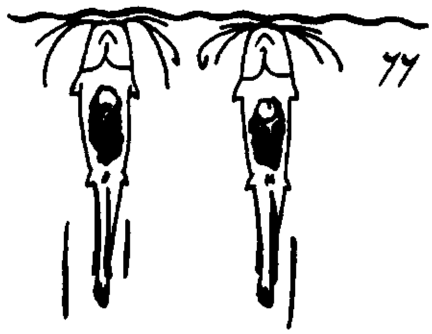


76a

Broken head disease

76b





77

Open belly disease

7.5 Diseases without known causes

Symptoms: Pop-eyes, soft skull and sometimes deformed caudal fins are present. In a later stage of the disease a gradual destruction of the arborescent organs occurs. This can cause an exudative inflammation of the skull with gas production. The skull will finally break laterally, parallel to the joins of the skull plates. The disease is particularly prevalent in catfish larger than 10 cm. The recovered fish often have thickened and curved skulls.

Diagnosis: Broken head disease (Fig. 76a and 76b)

Prophylaxis and therapy: Adverse raising conditions such as polluted water and bad food quality should be avoided. The pond water should be exchanged and the flow rate of the water should be increased when the first symptoms of the disease appear. The supply of food should be stopped for a few days and preferably replaced by fresh food rich in minerals and vitamins that is distributed in smaller quantities until the fish are recovered again (normally after 3-6 weeks).

Symptoms: Fry or fingerlings stay in vertical position at the surface of the water or are swimming actively with swollen bellies. The intestines become necrotic. Bacteria originating from the intestines invade the abdominal cavity and cause lysis of the abdominal wall with gas and fluid production. The belly will expand and finally break open. The disease occurs especially when fry or fingerlings are raised in high densities with an intensive feeding regime on artificial feeds containing 40% digestible proteins. Within one or two days high mortality can occur.

Diagnosis: Open belly disease (Fig. 77)

Therapy: Decrease the feeding regime and eliminate all the fish bearing the first symptoms of the disease.

Appendix 1

Water quality requirements of catfish maintained in hatcheries and ponds

Water analysis can be carried out by means of standard kits*). Only a little knowledge of chemistry is required to obtain reliable data.

The water quality requirements of the African catfish for optimal production are not fully known. The requirements given in Table 1 are either based on practical experience in hatcheries or derived from the requirements of a sensitive fish species the rainbow trout (Salmo gairdneri).

Table 1.

African catfish water quality requirements

	Eggs Larvae-fry	Fingerlings	Adults
O_2	close to saturation**	> 3 p.p.m.	> 3 p.p.m.
t °C	20-30°C,opt. 27°C	20-30, opt.27°C	20-30, opt.25°C
pH		6.5-8	
N_2		< 102 % saturation***	
CO_2		< 15 p.p.m.	
NH_3		< 0.05 p.p.m.	
NH_4^+		< 8.80 p.p.m. (pH 7)	
NO_2^-		< 0.25 p.p.m.	
NO_3^-		< 250 p.p.m.	
Cu		< 0.03 p.p.m.	
Zn		< 0.1 p.p.m.	
Cd		< 0.0006 p.p.m.	
Salinity		< 15000 p.p.m.	

** see table 3

*** see table 4

*)water analysis kits: - Hach Chemical Company, Loveland, Colorado U.S.A.
- Merck, P.O.B. 4119, 6100 Darmstadt, Germany.

It is noteworthy, however, that catfish can tolerate high concentrations of

CO_2 : 40-45 p.p.m.

NH_3 : 0.1 p.p.m.

NO_2 : 10-15 p.p.m.

NO_3^- : 300 p.p.m.

and with a full grown arborescent organ it can survive low concentrations of O_2 : 0-3 p.p.m.

If the catfish are raised in stagnant ponds, where they depend on natural food production, water quality must also suit the demands of organisms such as phyto and zooplankton. In flow-through systems the water quality only needs to meet the requirements of catfish.

The following physical and chemical characteristics of the water could serve as a general guideline (see table 2).

Table 2.

	Stagnant pond	Flow-through pond
O_2	5 p.p.m.*	5 p.p.m.*(preferably sat.)
pH	6.5 - 8	6.5 - 7
alkalinity	50 p.p.m.	30 p.p.m.
turbidity	no clay turbidity	clear water

* see table 3

Table 3. The solubility (100% saturation) of oxygen (O_2) in p.p.m. in relation to the water temperature (°C) at an atmospheric pressure of 1 Atm.

°C	p.p.m. O_2	°C	p.p.m. O_2
20	9.1	26	8.1
21	8.9	27	7.9
22	8.7	28	7.8
23	8.6	29	7.7
24	8.4	30	7.5
25	8.2		

Table 4. The solubility (100% saturation) of nitrogen (N_2) in p.p.m. in relation to the water temperature (°C) at an atmospheric pressure of 1 Atm.

°C	p.p.m. N_2	°C	p.p.m. N_2
20	14.9	26	13.4
21	14.6	27	13.2
22	14.4	28	13.0
23	14.1	29	12.8
24	13.9	30	12.6
25	13.6		

Appendix 2

Standard procedure for administration of carp Pituitary Suspension (cPS) for induced breeding of the African catfish (Clarias gariepinus)

Table 5. Latency time (time interval between injection and stripping of the female broodfish) and incubation time (time interval between fertilization and hatching of eggs) in relation to temperature.

Water temperature (°C)	Latency time (h)	Incubation time (h)
20	21	57
21	18	46
22	15.5	38
23	13.5	33
24	12	29
25	11	27
26	10	25
27	9	23
28	8	22
29	7.5	21
30	7	20

Remarks

1) cPS dosage is 4 mg/kg body weight.
2) cPS dosage can be replaced by catfish pituitaries see chapter 4.
3) cPS dosage can be replaced by human Chorionic Gonadotropin (hCG, Chorulon*). In that case a dosage of 4000 IU/kg body weight with a latency time of 16h at 25°C is recommended. Incubation time 27 h.

* Chorulon (Intervet International, P.O.B. 31, 5830 AA Boxmeer, The Netherlands).

Appendix 3

Liming and fertilization of ponds

Introduction

In stagnant ponds where fish production depends on natural food, fish yields can be increased by adding lime and fertilizers.

The effects of lime and fertilizers depend greatly on the nature of soils and water quality.

Until now liming and fertilizing rates have been determined empirically.

In this appendix some general information is given about this complex matter.

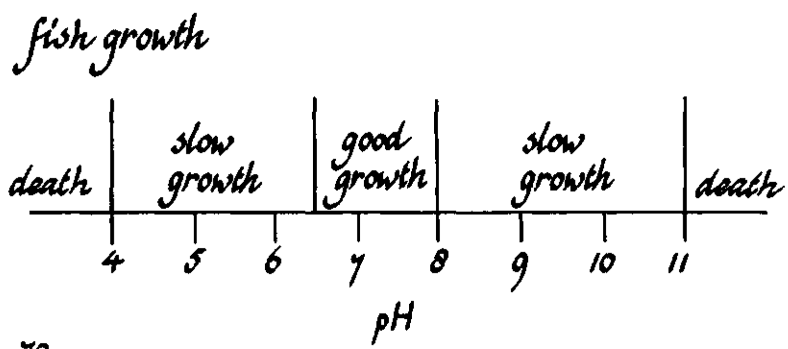
Liming

- Aim of liming

The aim of liming is to increase:

- the pH of the water and the pond bottom to more desirable levels (6.5-8) (Fig. 78).
- alkalinity (improvement of Acid Binding Capacity, ABC).
- availability of minerals in the pond bottom.

The use of quicklime as disinfectant has been treated in 5.2, page 52.



78

- Characteristics of liming materials

The principal liming materials to be used are agricultural lime, slaked lime and quicklime.
Agricultural lime is often applied by fish culturists because it is safe and very effective and often less expensive.
The neutralizing capacities of the various sorts of lime compared with 1 kg agricultural lime ($CaCO_3$) are listed below:

0.7 kg Slaked lime (hydrated lime)($Ca(OH)_2$)
0.55 kg Quicklime (unslaked lime)(CaO)
2.25 kg Basic slag ($CaCO_3 + P_2O_5$)

For example: 550 kg pure CaO will neutralize as much as 1000 kg pure $CaCO_3$.

The efficiency of liming will decrease with increasing particle size of the liming material. If necessary, crush the product before application.

Best results with liming are obtained when it is equally distributed on a dry pond bottom (quicklime, as disinfectant, however, requires moisture).

- Application of liming materials

Ponds with acidic soils or acidic water and/or ponds with soft water of low alkalinity require an application of lime.
The following data should serve as a guideline for estimating the required amount of lime, expressed as kg/ha of pure agricultural lime ($CaCO_3$) (table 6).

Table 6.

pH pond bottom	Heavy loams or clays	Sandy loam	Sand
5.1 - 5.5	5400	3600	1800
5.6 - 6.0	3600	1800	900
6.1 - 6.5	1800	1800	0

If the selected rate is adequate, pH and total alkalinity will be above 6.5 and 20 mg/l respectively after 2 to 4 weeks.

Fertilization

- Aim of fertilization

By means of photosyntheses, inorganic nutrients are converted into organic matter by phytoplankton. Most important inorganic nutrients are phosphorus (P) and nitrogen (N).

The aim of fertilization is to increase the availability of inorganic nutrients. This will stimulate phytoplankton production and thereby result in greater abundance of fishfood organisms and greater yields of fish.

In pond water natural concentrations of phosphorus are usually limited and consequently phosphate fertilizers are nearly always worthwile.

Nitrogen fertilizers are often applied as well. However, fish culturists disagree about the need for them because of possible nitrogen fixation by blue green algae and/or bacteria in the water.

- Characteristics of inorganic fertilizers (chemical fertilizers)

Inorganic fertilizers are easy to store and to apply and have high concentrations of the necessary nutrients.

The nutrient content of fertilizers is expressed as percentage (on weight basis) of equivalent N, P_2O_5 and/or K_2O.

The most common employed fertilizers are

P-fertilizers: superphosphate, triple superphosphate;

N-fertilizers: urea, sodium nitrate, ammonium sulphate.

The grade of these commercial fertilizers is approximately:

	P_2O_5	N
superphosphate	16-22 %	
triple superphosphate	42-48 %	
urea		46%
sodium nitrate		15-16 %
ammonium sulphate		20-22 %

Some commercial fertilizers contain more than one nutrient (mixed fertilizers). Their grade is expressed as the percentage of N, P_2O_5 and K_2O.

For example: 10 : 10 : 5 fertilizer contains 10% N, 10% P_2O_5 and 5% K_2O.

- Application of inorganic fertilizers

a. Phosphate fertilizers (P_2O_5)

Phosphorus is easily absorbed by the pond bottom. Therefore it is of utmost importance to avoid any contact between phosphate fertilizers and pond bottom. It is advisable to pay attention to the following aspects.

The solubility of the phosphate fertilizer in the water depends on its chemical composition and on its particle size. The better the solubility, the more P-nutrients will become available to phytoplankton.

In many cases the fertilizer can be effectively applied by means of a platform installed 30-40 cm above the pond bottom or the fertilizer can be dissolved with water before distribution over the pond area. Distribute the fertilizer frequently and in small amounts. Never apply P_2O_5 fertilizers simultaneously with or within a week of liming. The required doses must be empirically determined. In general a dose of approximately 100 kg/ha/year will suffice. 100 kg P_2O_5 corresponds to about 550 kg superphosphate 18%. This total dose should be spread over several applications at 2- or 3-week intervals.

b. Nitrogen fertilizers (N)

Nitrogen fertilizers dissolve readily. The required nitrogen fertilizer doses must be empirically determined.

In Israel doses of 8-12 kg of N-fertilizer/ha in the form of ammonium sulphate are supplied at 2 week intervals (8-12 kg N corresponds to 40-60 kg ammonium sulphate).

- Characteristics of organic fertilizers (manure)

Organic manure such as pig manure, industrial wastes from distilleries and agricultural wastes are often cheap and easy to obtain.

Organic manure may serve as a direct food for invertebrate organisms and fish or they may decompose, inorganic nutrients being released.

Decay consumes oxygen and only limited amounts of organic manure should be applied at a time to avoid oxygen depletion of the water.

- Application of organic fertilizers

The required amount of organic manure must be empirically determined.
Distribute organic manure frequently (daily or at least weekly) and equally in small quantities over the water surface.
Based on dry matter (dm) of the manure (see table 7) about 50-100 kg dm/ha might be applied each day or, as fish culturists do in Israel, distribute at a rate equivalent to 3-5% of the fish biomass in kg dm/day. It is of utmost importance to check oxygen content of the water at dawn. In the event of oxygen deficit stop fertilization.

Organic manure can also be applied in compost cribs. Especially household wastes, agricultural wastes and animal wastes can be used to fill the crib. Experience will teach whether one compost crib will be sufficient to fertilize the pond.

Table 7. Manure production by various livestock

		fresh manure production as % body weight per day	kg fresh manure per year per head	kg dry matter per year per head
cattle	dairy cow	9.4	6000	1260
	beef cow	4.6		
pig		5.1	3000	810
goat/sheep		3.6	800	290
chicken		6.6	25	6 - 11
duck		-	55-75	24 - 32

NOTES

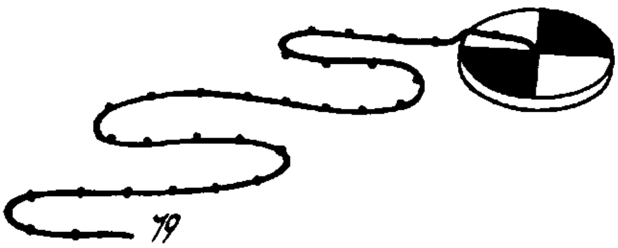
Appendix 4

Water transparency as fertilization indicator

The transparency (opposite: turbidity) of pond water varies from almost zero to very clear, and is dependent on the amount of suspended particles (phyto-plankton, zooplankton, humic matter or clay particles).
Generally plankton blooms change the colour of the water into green.
Measuring the transparency of a green coloured pond will give an idea of the density of phytoplankton blooms, or of the fertility of the pond.

Transparency can be measured by immersing the arm or with a Secchi disk (Fig. 79); using a Secchi disk is the more reliable method.
The disk is in fact an indispensable tool for a fish culturist.

A Secchi disk is a white or a white-and-black disk of 25-30 cm in diameter (Fig. 79) and can easily be made by hand.
The disk is fixed to a cord that is marked every 10 cm along its end.



79

To measure the transparency the disk is lowered into the water until it just disappears from sight.
The depth which can be read of the cord is the measurement.

Different actions in relation to the measured water transparencies are given below:

Water transparency	Action
1 - 15 cm	Too much phytoplankton present. Risk of oxygen depletion especially at dawn. Stop fertilization. Observe regularly fish behaviour. Water exchange might be needed.
15 - 25 cm	Abundant phytoplankton present. Stop fertilization. Observe regularly fish behaviour.
25 - 50 cm	Optimum abundance of phytoplankton for fish production. Continue with (routine) fertilization.
> 50 cm	Low density of phytoplankton. Stimulate phytoplankton blooms by adding more fertilizers.

Appendix 5

Rearing of fry in hatchery

Introduction

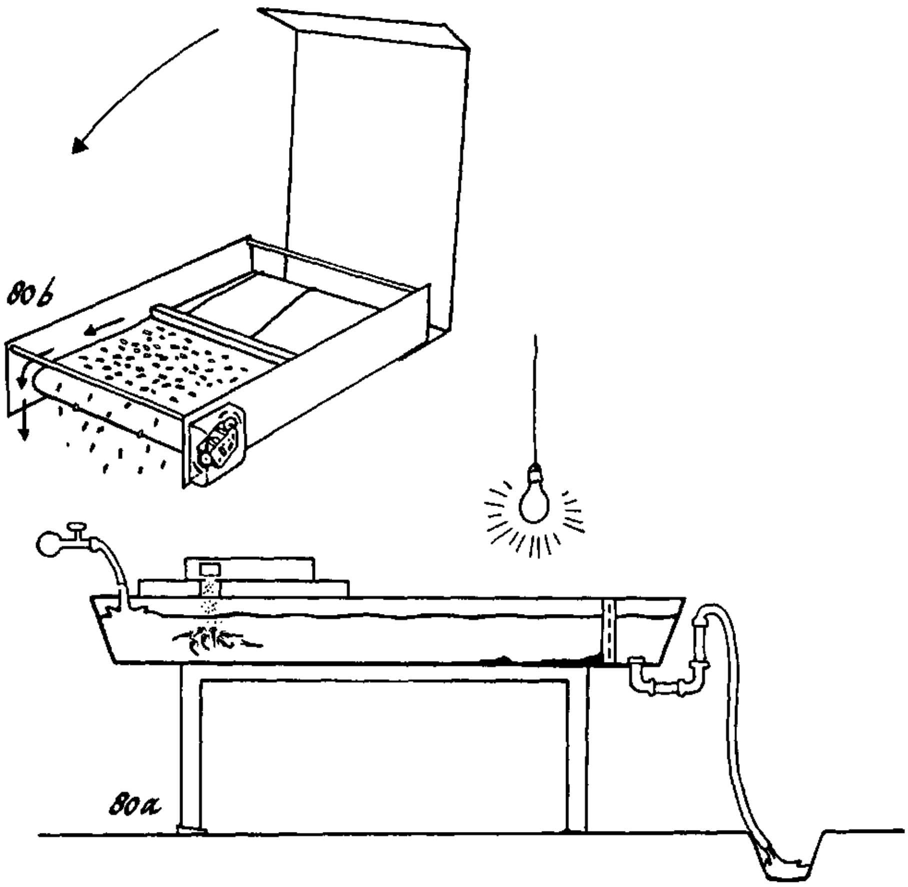
The yolk-sac larvae (see 4.9, page 46) can be raised to 1 gram fingerlings in nursery ponds (see chapter 5, page 51) or in a hatchery. Some advantages and disadvantages of the methods are listed below:

Nursery pond	Hatchery
Low survival of fry due to presence of predators	High survival of fry
Diseases less frequent, but are difficult to control	Diseases can suddenly arise due to intensive raising conditions. They can be easily controlled
No need to purchase expensive feeds	Need to purchase expensive feeds
No need for special equipment and electricity	Need for special equipment and electricity

The information given in this appendix is based on practical experience. The guidelines given for water quantity and quality, density, feeding regime and health control of fry are interrelated. They should be followed during the five week nursing period to obtain successful results.

Nursery gutters

In the first and second week of nursing, the raising conditions described for the incubation gutter (see 4.9, page 46) can be maintained. After the second week the total biomass of the fry will be so high that it should be distributed over four nursery gutters to provide enough water volume for growth and to maintain a good water quality that might be jeopardized by more intensive feeding. The incubation gutters should each be provided with a 60W lamp, installed above the outlet and an automatic feeder placed on the cover above the inlet (Fig. 80a + 80b). In this way a transition between light and dark is made between the outlet and inlet that stimulates the photophobic fry to aggregate in the darkest place near the inlet, where the water is oxygen rich and where the feed enters the gutter. The mesh size of the screen, located in front of the outlet, should correspond to the size of the fry and has to be adapted during the nursing period (1-5 mm).



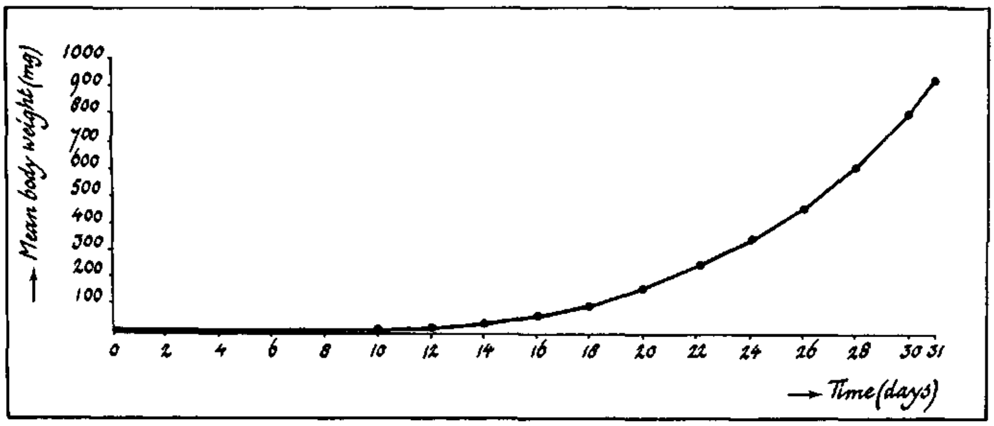
Water

The water quantity in the gutter should be 150 l during the first week and 200 l during the subsequent four weeks. The temperature of the water should be 30°C and the water flow rate 2-5 l/min during the first and second week and 4-8 l/min during the three subsequent weeks. The oxygen content of the water, measured in front of the outlet, should be at least 3 p.p.m. Three week old fry will have developed arborescent organs and will regularly rise to the surface to breathe air. From that moment they will be less dependent on the dissolved oxygen in the water. With the guidelines given below, no water quality problems are to be expected.

The fry

Within 3 days of hatching the yolk-sac will be absorbed (see 4.9, page 46). During that time the mean weight of the larvae will have increased to about 3.0 mg due to water absorption.
The number of fry will decrease from 65,000 to 60,000 in the first and second week and from 60,000 to 48,000, in the third, fourth and fifth week, due to mortality. The increase in mean weight of the fry during the total rearing period is schematized in Fig. 81.
The expected fry biomass will be:

195 g/150 l	on the first day (one incubation gutter)
3200 g/200 l	at the end of the second week (one incubation gutter)
800 g/200 l	at the end of the second week (after distribution over 4 nursery gutters)
12000 g/200 l	at the end of the fifth week (one incubation gutter)



•Catfish 81

Feeding

During the first two weeks fry will be fed 4 times per day with live zooplankton or with Artemia nauplia till satiation is reached.

- Zooplankton feeding

Fresh zooplankton (rotifers, cladocerans, copepods) has to be collected every day from natural sources or from ponds that have been fertilized to stimulate plankton development (see 5.2, page 52). It should be borne in mind that, with the pond water, fish diseases may be easily introduced into the nursery gutter. For further guidelines see Artemia feeding.

- Artemia feeding

Canned cysts of Artemia can be purchased nowadays in many tropical countries. The cysts are incubated in aerated water, temperature 28-30°C, that contains 35 g sea salt/l (common table salt might be used as well). The oxygen content should not drop below 3 p.p.m. Within 24-36 hours the cysts will hatch and the Artemia nauplia should be separated from the floating cyst shells. The nauplia can be administered alive or in frozen condition to the fry. Stop the water flow in the gutter for 10-15 minutes during feeding.

- Satiation

Satiation is reached when the digestive tract of the fry is filled with zooplankton or Artemia. It can be observed by eye due to the transparency of the fry. Satiated fry will cluster in the dark bottom areas of the gutter. No list of feeding levels is given but the following information may be useful. About 4 kg dry cysts are needed to raise 65,000 fry, mean weight 3.0 mg, to 60,000 fry, mean weight 55 mg, during the two week nursing period.

- Transitional period to trout starter feeding

About 3 days before the end of zooplankton or Artemia feeding, fry should be introduced to fine powdered trout starter (see appendix 6). Small quantities of powder should be administered for 10 minutes before the regular Artemia feeding. In this way the hungry fry will gradually be taught to accept the less preferred powdered feed.

- Trout starter

After the distribution of the fry over the four nursery gutters, when they have reached a mean weight of 55 mg, they are only fed with trout starter. Trout starter can be administered manually (10-12 times per day) or automatically (during 12 hours) with feeders (Fig. 80b). Feeding has to be continued till satiation is reached and the following information might therefore be useful (Table 8).

Table 8.

Time	Total biomass (g)	Feeding level (%)	Trout starter distributed (g)
End second week	3,200	22	704
End fifth week	48,000	8	3840

About 40 kg trout starter is needed to raise 60,000 fry, mean weight 55 mg, to 48,000 fingerlings, mean weight 1 g, during the three week nursing period.

Daily monitoring

The water flow in the gutter should be checked. Too strong a flow rate will cause the fry to expend too much energy on swimming against the stream. This should be prevented.

When the water flow rate is optimal, the healthy fry will amass in the dark near the inlet while the unhealthy and dead fry together with the excrements and feed wastes will accumulate in front of the outlet. This area should be cleaned at least twice a day by siphoning. Feed wastes and fry excrements should be removed from the screen to avoid clogging. If the fry swim over the total gutter area, this can indicate that they are either stressed or hungry. In the latter case extra feeding will be needed. Too much feeding should also be avoided. It can cause an accumulation of feed wastes on the bottom of the gutter followed by oxygen depletion.

Check the temperature and oxygen content of the water.

Examine some fry every day for parasites or diseases (see chapter 7, page 87).

NOTES

Appendix 6

Complete feeds for the African catfish

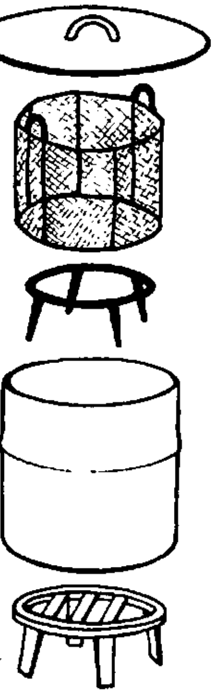
Table 9. Trouvit starter* fed to fry of the African catfish raised from 55 mg to 1 g.

Analysis of contents			Composition of products	
Crude protein (estimated digestible)	50.0(38)	%	Animal by-products	17.5%
Crude fat	9.5	%	Milk by-products	5.0%
Crude fibre	1.6	%	Oils	2.7%
Minerals	9.0	%	Yeast	5.0%
N.F.E. (nitrogen-free extract)	19.9	%	Fish by-products	32.5%
Moisture	10.0	%	Cereals	5.0%
Vitamin A	20.000	IU/kg	Vegetal by-products	30.7%
Vitamin D_3	2.000	IU/kg	Minerals	1.0%
Vitamin E	50	mg/kg	Vitamins	0.4%
Vitamin C (added)	1.000	mg/kg	Synth. amino acids	0.1%
Gross energy (estimated digestible)	5200(3600)	kcal/kg	Antioxydantia	0.01%

*Trouvit starter (Trouw and Co., P.O.Box 40, 3880 AA Putten, The Netherlands).

Table 10. Dry pellets compounded at the Fish Culture Station La Landjia, Bangui, Central African Republic, fed to fingerlings of the African catfish raised from 1 g to 200 g.

Analysis of contents			Composition of products	
Crude protein (estimated digestible)	40(30)	%	Brewery waste, dry	10%
Crude fat	10	%	Rice bran	15.0%
N.F.E. (nitrogen-free extract)	30	%	Ground maize	6.25%
			Cotton seed oil cake	25.0%
Minerals, moisture, crude fibre etc.	20	%	Groundnut cake	25.0%
Gross energy (estimated digestible)	4300(3000)	kcal/kg	Sesame oil cake	10.0%
			Blood meal	5.0%
			Vitamin/mineral mix.	0.25%
			Dicalcium phosphate	1.0%
			Bone meal	1.0%
			Salt	0.5%
			Palm-oil	1.0%



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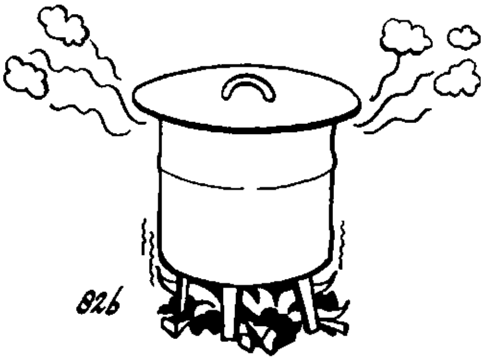

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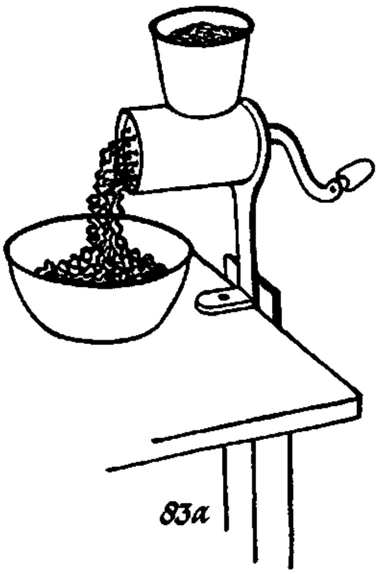

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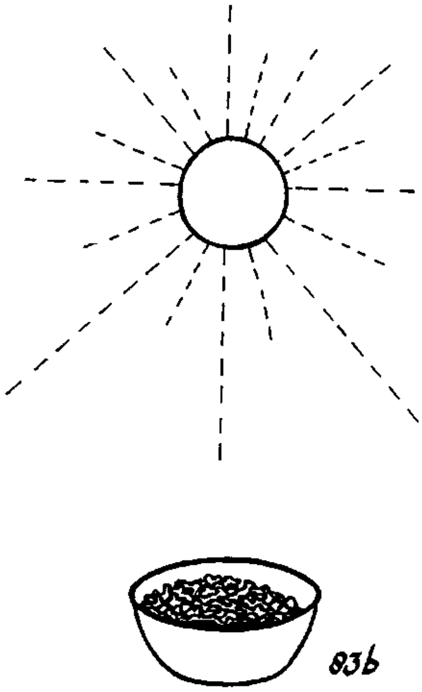


83b

Moist pellets

The composition of the moist pellets is about the same as that of the dry pellets of table 10.
The production of moist pellets does not require advanced pelleting machinery and thus can be undertaken anywhere.

Mix the moist and dry components (table 11) separately. Then the moist components are steamed for 30 minutes in order to gelatinize starch to make the mixture sticky (Fig. 82a + 82b). This adhesive property will be important later on for the water stability of the pellet.
After steaming, mix the moist cake in the dry mixture, together with 4 l of cold water.
The final mixture should be processed through a hand-cranked meat grinder to give moist strands of feed. Break these strands into the desired pellet size and lay the pellets out in the sun to dry them (Fig. 83a + 83b). After being sun-dried, pellets are ready to be supplied.

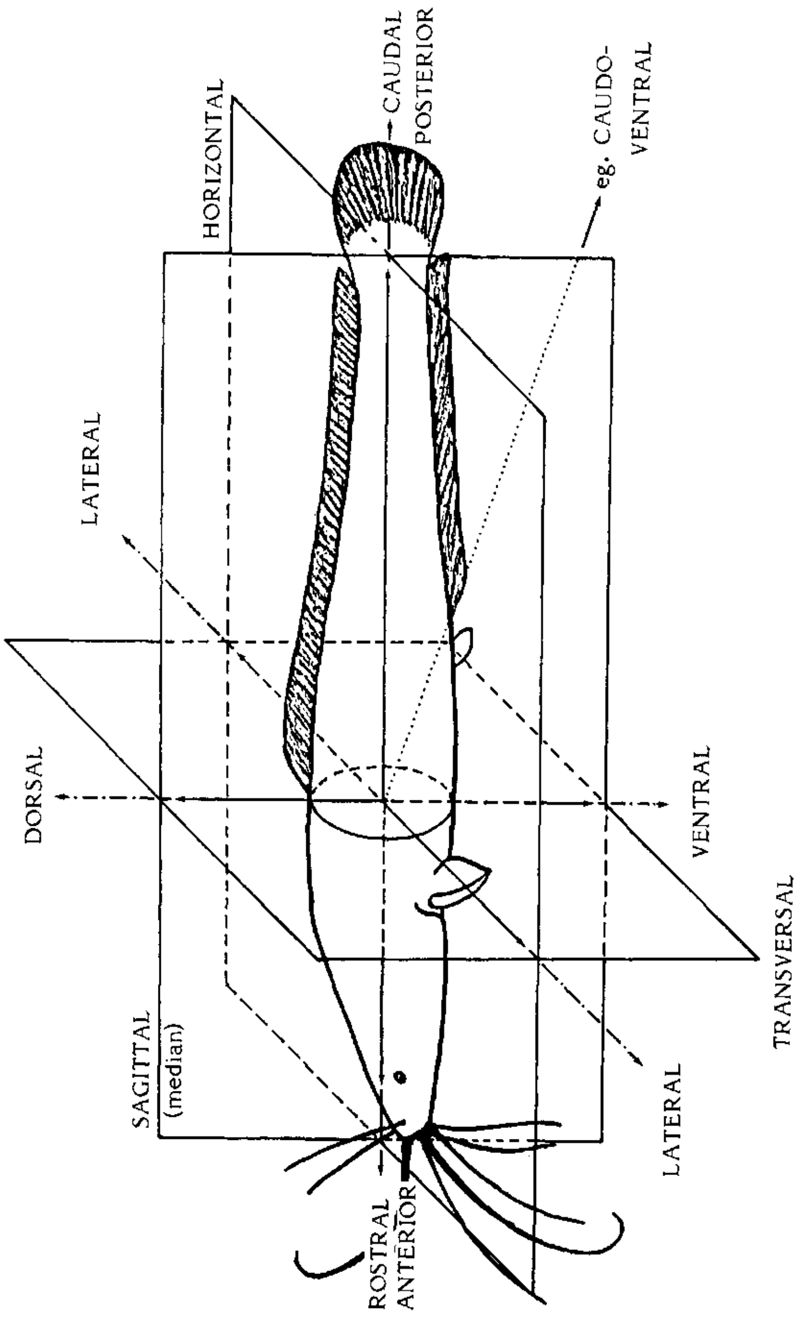
Table 11. Moist pellets compounded at the Fish Culture Station La Landjia, Bangui, Central African Republic, that were suitable for feeding (instead of dry pellets) to fingerlings of the African catfish.

Moist components:	
Maize breweries spent grains (wet)	7.5 kg
Brewery waste (wet)	7.5 kg
Ground maize	4.5 kg
Gentian violet as mould retardant	1.25 g
Dry components	
Blood meal	2.5 kg
Cottonseed oil cake	5.0 kg
Groundnut oil cake	5.0 kg
Dicalcium phosphate	0.5 kg
Vitamin/mineral mixture	62.5 g

NOTES

Appendix 7

Some descriptions used in morphology



Some descriptions used in morphology

Appendix 8

Conversion tables

Conversion of degrees centigrade (°C) to degrees Fahrenheit (°F)*

°C	°F	°C	°F
15	59	25	77
16	61	26	79
17	63	27	81
18	64	28	82
19	66	29	84
20	68	30	86
21	70	31	88
22	72	32	90
23	73	33	91
24	75	34	93

* $\frac{(F - 32) \times 5}{9} = C$; $\frac{C \times 9}{5} + 32 = F$

Conversion of centimetres (cm) to inches (in.)**

cm	in.	cm	in.
1	0.39	6	2.36
2	0.79	7	2.76
3	1.18	8	3.15
4	1.57	9	3.54
5	1.97	10	3.94

**1 centimetre = 0.394 inch ; 1 inch = 2,540 centrimetres

Conversion of metres (m) to feet (ft)***

m	ft	m	ft
1	3,3	6	19,7
2	6,6	7	23,0
3	9,8	8	26,2
4	13,1	9	29,5
5	16,4	10	32,8

*** 1 metre = 3,281 feet ; 1 foot = 0.305 metre

Conversion of ares (a) to acres (acre)*

a	acre	a	acre
1	0.02	6	0.15
2	0.05	7	0.17
3	0.07	8	0.20
4	0.10	0	0.22
5	0.12	10	0.25

* 1 are = 0.025 acre ; 1 acre = 40,467 ares

Conversion of litres (l) to British gallons (gal)**

l	gal	l	gal
1	0.22	6	1.32
2	0.44	7	1.54
3	0.66	8	1.76
4	0.88	9	1.98
5	1.10	10	2.20

** 1 litre = 0.220 gallon (Brit.) ; 1 gallon (Brit.) = 4,546 litres

Conversion of kilograms (kg) to pounds (lb)***

kg	lb	kg	lb
1	2.20	6	13.23
2	4.41	7	15.43
3	6.61	8	17.64
4	8.82	9	19.84
5	11.02	10	22.05

***1 kilogram = 2.205 pounds ; 1 pound = 0.454 kilogram

Glossary

The definitions are restricted to the usage in this Manual.

Arborescent organ	A branched accessory vascular structure in the gill chamber of certain fishes.
Barbels	Slender processes around the mouth of certain fishes, having the sense of touch, smell or taste.
Benthos	Organisms that live on or in the bottom of water bodies.
Biomass	The total weight of all members of a species or group of species in a given area at an instant in time.
Branchial arch	One of the bony arches, supporting the gills of fishes.
Broodfish	Fish maintained for reproduction.
Cast net	A circular or conical weighted net designed to be cast mouth downward by hand and withdrawn by lines attached to the centre.
To diagnose	To identify a disease by symptoms or distinghuishing characteristics.
Fecundity	An organism's capacity to produce offspring.
Hormone	Substance, formed by internal secretion, that passes into the blood and stimulates organs to action.
Incubation time	The period of maintaining the eggs under prescribed and controlled conditions to bring them to hatching.
Indigenous	Native to a region or a country.
Intra-muscularly	Going into a muscle.
Latency time	The period of development.
Mandibular	Of, relating to, or located near the lower jaw.
Maxillary	Of, relating to, being or associated with the upper jaw.
Migration	The movements of fish from feeding ground to spawning ground and back again, from nursery groud to feeding ground, and from spawning to nursery ground.
Olfactory organ	An organ concerned with smelling.
Omnivorous	Eating both animal and vegetable substances.
Operculum	Fish gill-cover.
Parasite	An organism living in or on another and drawing nutriment directly from it.

Pathogen — A specific cause of disease.

Photophobic — Shunning or avoiding light.

Pituitary — Small organ at base of brain which has important influence on growth and bodily functions like reproduction.

P.p.m. — Parts per million. A concentration at which one unit is contained in a total of a million units: 1 mg/1 kg or 1 mg/1 litre, based on density of 1 gram/ 1 ml for the solvent.

Prophylaxis — Preventive treatment against disease etc.: measures necessary to preserve health and prevent the spread of disease.

Seine net — A large net having one edge provided with sinkers and the other with floats that hangs vertically in the water and encloses fish when its ends are brought together or drawn ashore.

Shoal — A great number of fish swimming in company.

Symptom — Perceptible change in the body or its function indicating injury or disease.

Siphon — Pipe or tube shaped ike inverted V or U with unequal legs for conveying liquid over edge or vessel and delivering it at lower level by utilizing atmospheric pressure.

Termitaria — Nests of termites.

Turn over time — The time needed to replace water in a body as a pond or aquarium.