Chapter 6
Production and shipping

Pond management and maintenance
The care of the cultured fish (fish husbandry) is one of the most basic aspects of fish farming, yet one which is often almost ignored in many manuals on fish farming. In all aspects of their lives, fish need to be maintained in conditions that allow them to thrive and grow, or to reproduce well. This chapter focuses on how to achieve these conditions.

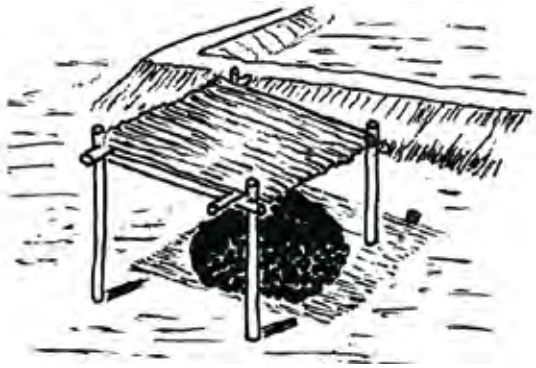
Fertilizing ponds with compost
Once the pond is full of water there are a few things that need to be done to ensure that the fish will have a place where they will be unstressed and will grow well. Making sure that there is an abundance of suitable food in the water is an important aspect. With tilapia, carp or catfish, making a compost heap can be done while the pond is being built so that it is ready when the pond is ready. Compost is then added to the pond to produce a bloom of zooplankton and phytoplankton, which serves as a food source for the fish.

You will need to make a compost heap from where you can remove compost to fertilize the pond. To make a compost heap, find an area near the pond in a shady place protected from the rain. First make a layer of plant material, like cut grass or leaves mixed with a few spades of topsoil. Water it to make it rot faster. Add another layer of animal manure (pig, sheep, cow, goat, chicken or duck) mixed with some soil. Again, add water to speed up the rotting process. Make another layer of plant material then another one of animal manure, remembering to water as you go. Build many layers until you have a large compost heap to use for fertilizing your pond as well as your fields. If you do not have any animal manure then just use layers of plant material, which can also include waste from home (spoilt fruit, potato skins, cold ash from the fire).

Keep the compost heap damp by watering it every few days. After about a month the compost will have rotted and you can remove the best compost from the bottom or oldest part of the pile. Remember to add new layers to your compost every week otherwise you will run out. If you have too much compost you can use it to fertilize your vegetables in your fields.

A compost cage then needs to be built in one of the shallow corners of the pond to hold the compost. This can be made using sticks and should sit about 60 cm under the water and 1 m from the edge of the water enclosing the corner of the pond. If the pond is bigger than 500 m^2, two cages should be built, one in each of the two shallow corners or halfway on opposites sides of the bank.

To start, put enough compost in the cages and pack it down well to fill them up to the water level (50-60 kg per 100 m^2 pond area). Be careful not to pack it too hard as you may break the sticks holding the compost in the cage. Afterwards you will need to add 10 kg of compost per week for every 100 m^2 of pond. If



Compost is made from successive layers of chopped leaves, grass, animal manure and a little topsoil. Add water to keep it damp. Keep the compost heap in the shade and near the pond.

you only have animal manure to fertilize your pond you only need 2-3 kg of chicken droppings, or 8-10 kg of pig dung, or 10-15 kg cow dung per week per 100 m^2. This is because manure is much stronger than compost, so less is needed.

Once you have added the compost or manure the water will start turning green within a week. When it starts turning green it means that the food is growing in the pond and that it should be ready in about a week. To test if the water is ready for fish, put your arm in the water up to your elbow. The water is ready for fish if you can just see the ends of your fingers, as shown below. Putting fish into the pond before it is ready may result in poor growth of the fish due to inadequate food being available.

INFO BOX: NATURAL FERTILIZERS REQUIRED TO ENRICH A POND PER WEEK

- 10 kg compost per 100 m^2 pond area
- or 2-3 kg chicken droppings
- or 8-10 kg pig dung
- or 10-15 kg cattle dung.

Pond maintenance

Like a farm field, the bottom of a pond must be looked after. Between harvests, pond preparation involves the following steps:

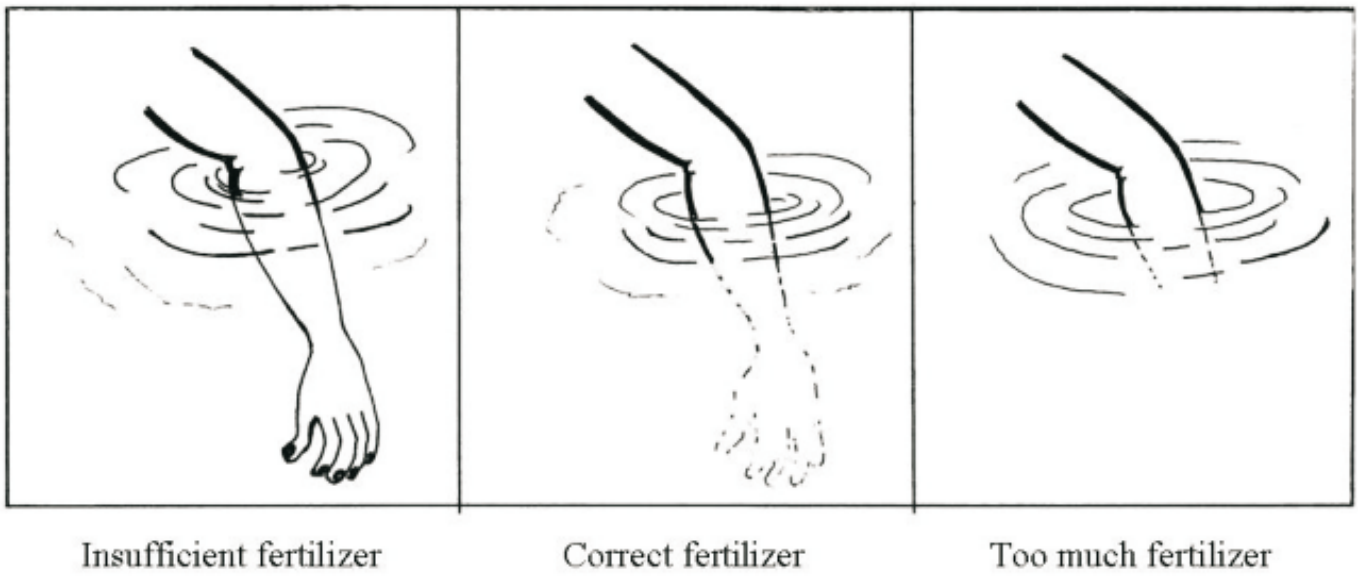
- Draining and drying the pond
- Turning the soil
- Disinfection and liming
- Fertilizing.

The bottom of the pond should be allowed to dry out for 2-4 weeks between harvest cycles. This is to help the bacteria break down the soil. Drying the pond also kills any pathogens and parasites as well as undesirable filamentous algae. Any weeds or plants that are not eaten by the fish should be removed. Removal of the weeds reduces the number of breeding areas for mosquitoes and snails, both carriers of human disease (malaria and bilharzia, respectively).

The soil should then be ploughed, and depending on the health of the soil, compost and chemicals such as lime can be added. The compost provides nutrients for the algae and plants in the next production cycle. Lime is required as it –

- conditions the soil and makes it suitable for keeping fish;
- corrects the pH of the soil (if applied properly);
- prevents the build-up of chemicals that are poisonous to the fish;
- speeds up the breakdown of compost and fish waste;
- reduces the chance of fish disease, especially gill-rot.

Lime is available in various forms and so the most cost-effective method should be used, with agricultural lime or limestone ($CaCO_3$ or $MgCO_3$) being the cheapest and most popular. Other forms of lime are slaked lime ($Ca(OH)^2$) and quicklime (CaO). The amount of lime required for the pond depends on the pH of the pond soil. Soil with a pH less than 4 requires around 4000 kg $CaCO_3$ per hectare while soil with a pH around 6 requires around 1000 kg/ha. Quicklime should be spread evenly over the bottom of the pond at a concentration of 100-200 kg per hectare.



Testing for the correct amount of fertilizer in your pond before adding fish.

Fertilizers
To ensure pond phytoplankton productivity, various nutrients such as nitrogen, phosphorus, potassium, carbon and calcium need to be added regularly. Fertilizers can be inorganic fertilizers or mineral fertilizers, or else organic fertilizers or manures of plant and animal origin.

Organic fertilizers
Organic manures have been used for a long time. They can be obtained from a number of places: dung of cows, sheep, goat and pig, and poultry and duck droppings. They can also be found in farmyard manure, compost, green manures, sewage, etc. Of these, cow dung is the most widely used in undrainable pond culture systems. As most of the organic manures are waste products of local agriculture they are generally cheap and easily obtainable. They provide all the basic nutrients required for biological production. Several of these manures are quickly used by the pond organisms, especially by the zooplankton and even by some species of carp. By improving the quality of the pond's bottom mud they encourage the growth of bacteria, which leads to more zooplankton. Though the major elements are present in manures, their levels are generally low, which means that large amounts may be required. Unless proper care is taken in using manure, the level of dissolved oxygen in the pond water is likely to drop.

Inorganic fertilizers
Commercially available inorganic compounds containing major nutrients (nitrogen, phosphorus and potassium) are known as inorganic or chemical fertilizers. They contain a high and fixed percentage of the three basic kinds of nutrients: nitrogenous, phosphatic and potassic, or mixed. As they can easily dissolve in water, these nutrients are quickly available to the pond.

Nitrogenous fertilizers usually contain nitrogen as the main element and are commercially available as ammonium sulphate, ammonium nitrate, or urea. Most of these fertilizers make the pond soil acidic and it is therefore important to select a fertilizer based on the soil of the pond. Nitrogenous fertilizers are essential for newly constructed ponds poor in nitrogen and without sufficient organic matter on its bottom. Older ponds tend to have a good layer of organic mud which is able to produce nitrogen by itself. To further complicate matters, the strength of nitrogenous fertilizers depends on how much phosphorous is available. It is best to maintain the phosphorous : nitrogen ratio at 1 : 4.

Phosphatic fertilizers are the best fertilizers for fish culture. This is important because almost all fish ponds do not have enough phosphorus. The most common phosphatic fertilizers are the orthophosphates. Superphosphates are the most soluble in water, and single superphosphate is the most widely used and is easily available. The more concentrated triple superphosphate is also used. Phosphatic fertilizers are released slowly over a number of years depending on the nature of the pond bottom.

Tank and cage management
Tanks, raceways and cages are all artificial enclosures that need daily management to work efficiently. The life of the fish contained in these structures is entirely dependent on the lifesupport systems installed (pumps, blowers, water flow and climate control in the case of tanks and raceways; feeding and water quality in the case of cages).

Inlets and outlets, water temperature and other water-quality parameters need regular checking. Maintenance of predator proofing, pumps and plumbing, tunnel plastic coverings, cage integrity, growth recording and size-sorting of fish are all daily demands on the fish culturist's time. The more intensive the management and the greater the amount of care in fish husbandry, the better will be the results in terms of fish yields and quality. Slack management will result in system failures, which may happen over weekends or at night, when heavy fish mortalities can occur in the absence of anyone to fix the problem.

While a regime of regular fish feeding is indeed essential, there is far more to fish husbandry than just providing the fish with food. It only takes a failed pump to wipe out all the stock in an intensive system, or a damaged cage to lose most of the stock from cage culture, thus regular servicing and checking of such fish-farm hardware is essential. Where possible, pumps and blowers should have a back-up, or if this is too expensive, stocking rates must be kept at a low-enough level whereby an electrical failure does not cause immediate stock loss.

As a cattle or sheep farmer gathers his herd together to do daily checks, with regular dipping against ticks, so should a fish farmer check the health and growth of his/her stock at regular intervals. This means sampling the ponds with a throw-net or other least-disturbing collecting method, and checking for health, growth, or any signs of stress. Several times after the initial

stocking, the ponds, tanks or cages may need to be drained and emptied of fish to size-sort them, such that growth of the slower-growing individuals is not affected by the fastest-growing ones. At the same time predators can be eliminated, and the pond bottom remodeled or fertilized accordingly. The fish can be size-sorted and distributed to other ponds that have been prepared. All this activity requires equipment, planning and manpower such that the whole operation does not overly stress or kill the fish. A rough schedule of essential activities is illustrated in the table below. These activities are not all that the farmer needs to do, but he will soon acquire a sense of how well his stock is doing by regular observations of feeding or shoaling behaviour of the fish, in just the same way as a cattle, sheep or goat farmer can tell the state of his animals by regularly observing them.

An essential ingredient to successful fish husbandry is to prepare well in advance for any operation that involves catching or moving any of the fish stock, to reduce stress to a minimum.

Attention to such details as sufficient buckets or containers, water temperature differences between waterbodies, adequate and suitable

INFO BOX: CHECKING FISH HEALTH AND CONDITION

A common way to check on the condition, size and health of your fish is to observe them at feeding time when they rise to the surface. Healthy fish will rise actively to the surface and feed voraciously. Unhealthy or stressed fish will be lethargic and will hardly rise to take the feed from the surface.

Regular activities that are essential to efficient fish production

FREQUENCY	ACTIVITY
Twice daily	Feed fish, twice daily for juveniles
	Check inlets and outlets, or pond levels
	Observe fish for signs of ill-health or unusual behaviour
	Remove any dead fish
Daily	Check water temperature
	Check pumps or other electrical equipment
	Check predator or anti-theft protection
Weekly	Check water quality and recording parameters
	Estimate use and replacement of feeds and other consumables
Monthly	Sample and estimating growth of fish
	Drain of ponds to size-sort stock
	Remodel and fertilizing of ponds
	Redistribute stock according to size and growth stage
	Maintain plumbing and other equipment
	Breeding and preparation of fingerlings for restocking
3-month intervals	Draining and harvesting from ponds or tanks, or cages
	Processing of catch
	Marketing of processed harvest
	Remodeling and fertilizing of ponds; make repairs to tanks or cages
	Restocking with fingerlings
	Clean and dry nets used in harvesting
Yearly	
	Building of new structures, additional ponds, tanks or cages
	Make improvements to storage or processing facilities
	Accounting and annual record-keeping
	Plan for improvements
	Replace broodstock
	Replacement of equipment such as nets, buckets, vehicles
	Maintenance of serviceable equipment (pumps, plumbing, etc.)
	Maintenance and upgrade of anti-theft and predator protection.

nets for the job, enough staff to carry all the equipment, prepared tanks to put the fish in that are to be moved, and many other factors, are all vital components of good fish husbandry.

Transporting live fish

One of the most frequent activities on any fish farm is the moving of fish around from one tank to another, or from pond to pond, or even the collection of broodstock from elsewhere. Sorting stock, stocking grow-out tanks, moving broodstock, harvesting fingerlings, sampling growth rates, and catching adult fish for selling are all examples of why you would need to move fish. There are three important considerations to remember when moving fish:

- Crowded fish soon die of oxygen starvation in buckets or small containers.
- Fish should not be moved to water of a different temperature.
- Moving fish stresses them by the simple act of catching them and confining them under crowded conditions. Stress makes them more susceptible to disease.

Short distances

When moving fish short distances within the hatchery itself, they can be transported in buckets. Remember that certain fish almost invariably try to leap out of buckets (*Tilapia rendalli* and catfish) so the buckets need lids or netting covers. Fish that leap out of buckets and fall into dust or earth lose their protective coating of slime, and will often die some days thereafter.

Long distances

A particular procedure is required when moving fish over longer distances, such as when stocking ponds with fingerlings or obtaining broodstock. These fish should never be fed for at least 24 hours (preferably 48 hours with tilapia, due to their long gut length) before transporting them as they will foul the packing water and poison themselves and the other fish in the packing container. To purge or 'starve' fish prior to packaging and transporting them, they should be held unfed in clean algae-free water in containers or tanks like plastic or concrete pools, with clean through-flowing water. This also allows for them to be size-sorted as different size classes of fish should never be packed together (the larger ones will damage the smaller ones).

Packing small fish or fingerlings

Small fish the size of fingerlings (3-8 cm) can be packed in double plastic bags which are then placed in boxes for transport. Packing water must be prepared in advance and should be absolutely clean and of the same temperature and quality as what the fish are used to. Never pack fish using water from the containment that the fish are in as ammonia concentrations may be high and the oxygen level low. Use new water. Plastic bags should be of minimum 40 micron thickness for small fish and preferably 60-80 microns for fish like tilapia with fin spines. The inner bag is filled one-third with water and inflated with oxygen. The neck is twisted several times, then bent over and tied tightly with strong rubber bands. This is then placed upside-down inside the outer bag, to prevent

Transporting juvenile fish

(1) Do not feed fish for 2 days prior to packing them.

(2) Prepare clean water for packing and keep it at the same temperature.

(3) Assemble all nets, buckets and essential equipment.

(4) Pack small fish in plastic bags that are 1/3rd filled with clean water.

(5) Invert the inner bag in the outer one.

(6) Place bags in boxes.

small fish becoming trapped in the corners. This is essential and an often overlooked procedure; if a few fish become trapped in the corners and die, they will rapidly decompose in warm weather and poison many of the others. The bags are then placed within a cardboard box, bucket or polystyrene box to prevent them being punctured. The polystyrene boxes will help insulate the fish from rapid temperature changes.

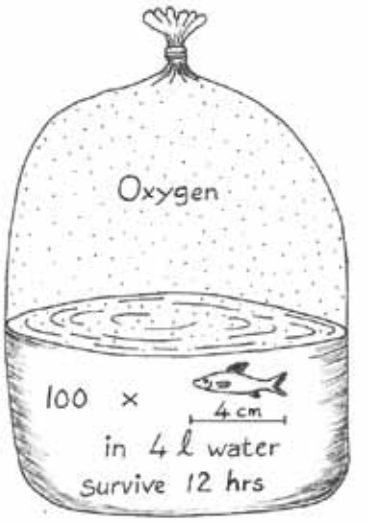
When transporting the boxes they should not be placed in the back of an open bakkie, exposed to the sun or cold, as the small volumes of water will rapidly either overheat or cool down, so a canopy is essential. On arrival at the destination the fish will be considerably stressed, and the bags should be carefully floated in the water for 15 minutes to equalize the temperature differences. Once this is done the bags can be cut open and the fish released.

Packing large fish

For large fish over 10-12 cm, plastic bags puncture too easily and other containers are used. The best are the blue or green plastic 50-200 ℓ drums with an open top that can be clamped on. For short time intervals (<15 minutes) large fish can be moved around the farm in these drums without oxygenation, if not over-packed (not more than 20 adult-sized fish per 100 ℓ drum). If the fish are likely to be in the drum for longer periods, portable battery-operated air-blowers can be used to oxygenate the water using an air line and airstone in each drum. These are both inexpensive and very useful pieces of equipment in any fish-moving exercise and well-worth obtaining. Alternatively, the type of air pump used to inflate car tyres and that plugs into the cigarette lighter can be used for short periods. The fitting that usually clamps over the tyre-valve fits well over an aquarium air line!

Drums should be filled to about 30% full when packing the fish, then lifted into the vehicle, and then topped up to 80% full with clean water to prevent too much sloshing and damage to the fish on rough roads. All this must be done in the cool shade to prevent the water warming up to the point where oxygen levels decrease to the point where the fish die from suffocation. If road transport is to be long (2 hours or more), then consideration must be given to providing the fish with oxygen. A small air pump working off the vehicle battery is adequate, and actual oxygen bubbled through the water is not essential, except for trout or if the densities are very high.

At the destination, the drums should be first partially emptied using buckets, then the drums lifted down and the fish emptied into the dam, pond or other container. If the receiving water is different to the drum-water temperature, then some of this water should be added to the drum-water slowly, over half an hour, to equalize temperatures. While this is being done, the flow of air or oxygen to the tanks must be kept operating.



Packing small fish for transport.

Packing un-purged fish taken from a dam or pond

It is unwise to pack fish that have been caught from ponds or tanks where they have recently eaten. This is because they have a gut full of food that will be expelled in the packing water, thus polluting it. Tilapia are especially difficult in this respect due to their long gut length and their continuous eating habits. Tilapia caught and packed directly after capture will quickly foul the water to such an extent that it will be black

Tilapia fingerlings transported in oxygen-inflated plastic bags (far left). Another method of transporting the fish is to place them in one large tank (left). In this case, trout are being transported from Cape Town to Lesotho, a 24-hr journey. As such the water in the tank is filtered and oxygenated, and at regular intervals fresh water and ice are placed in the tank.

and filthy within half an hour, and all the fish will soon die thereafter. Only very short journeys are possible without in some way purging the fish prior to packing them. One solution is to hold them in a portable plastic pool, at the pond-side in the shade, with clean water, for some hours after netting them to attempt to purge them of most of the gut contents. Use of one or more portable air-blowers can assist in keeping this holding water well oxygenated. If purging is not possible, the maximum packing density recommended for tilapia is no more than 6-10 adult fish per 100ℓ drum for travel that is not more than 4-6 hours. Aeration will be essential.

Packing larger fish for transport.

Size-sorting the fish

After the fish have been collected in buckets, they should be sorted by sizes or species. If sorting is done quickly, small fish can be returned to the pond to allow them to grow further. If size-sorting is needed, it is recommended that one or more portable fish pools be erected in a shady area near the pond to be harvested. All undersized fish can be immediately placed in these pools to rid them of the mud and other plant debris that invariably clogs their gills and fins while being netted. If large quantities of fish are to be caught, a flow of fresh water from a pipe may be required to keep the water in the portable pools satisfactory for the fish. Fish will die very quickly in over-warm or mud-polluted water after the stresses of being netted. Avoid mixing very large fish with juveniles in the same pool.