Chapter 3
Aquaculture species

Selection of species

The choice of what species should be cultured in a particular region depends on a number of factors, as discussed below.

Location

Several introduced (exotic) species have caused or threaten conservation problems to indigenous species due to their hybridisation, the introduction of parasites, or by out-competing naturally occurring species for food or other resources. The reasons for culturing exotic species are:

- Some exotic fish grow better and faster than local species.
- Some exotic fish are preferred by people for eating (over local fish).
- The offspring of a cross between a local fish and an exotic fish sometimes grow faster and taste better than either of the parent fish (this is called hybrid vigor).
- Each species has a preferred range of water-quality and temperature parameters. It is important that only species whose water-quality requirements are within the range of those found in the region are considered.
- Availability: If there is a problem with fingerling supply, the farmer may need to build a hatchery, which is both expensive and requires highly technical expertise.

Biology of the species

- Growth rate – Species that grow quickly reach market size in a shorter time. However, under similar conditions, higher-valued species may sometimes be more cost-effective to culture as compared to cheap, fast-growing species.
- Feeding habits – The species being cultured must have dietary requirements that can be met by the pond and the farmer. Producing fish at a low cost relies on the fish using as much of the pond's natural food as possible. If greater production is wanted, additional feeding will be required, but this adds to the expense of fish farming. For example, catfish require a high-protein diet which cannot alone be provided from the natural food in the pond.
- Reproductive biology – It is usually best to choose a species that breeds easily and therefore produces many young.
- Hardiness – The commonly cultured species are popular around the world mainly because they adapt well to being cultured.
- Market – Many aquaculture businesses that fail, do so because they did not check properly that there was an economic market for their fish.
- Profitability – It is very important that a careful cost analysis is done concerning the costs of maintaining the ponds, buying the young fish, feeding them, and any other costs incurred while they grow. Once all the costs have been worked out it is possible to calculate the minimum price that each fish can be sold for.

If at all possible, farmers should be encouraged to start their ponds using a tested pond fish that

Examples of successfully cultured warmwater aquaculture species

Country	Species	System used	Tonnage/year
China	Tilapia	Ponds	706 000
Philippines	Tilapia	Ponds/Cages	122 000
Brazil	Tilapia	Ponds	110 000
Europe	Tilapia/Catfish	Intensive	n/a
West Africa	Catfish	Ponds/Tanks	Cottage industry
Zimbabwe	Tilapia	Ponds/Cages	n/a
Some cooler regions in the world			
UK, USA, Chile, NZ, Canada	Trout	Intensive/Cages	n/a

is locally available and well-liked by people in the area. If the fish can grow in ponds and the farmer is able to sell the fish or use them for his/her family, more or larger ponds could be built.

To decide which fish species are suitable for aquaculture in South Africa, we should look at case studies from other countries.

Sharptooth catfish (*Clarias gariepinus*)
The sharptooth catfish or barbel is a freshwater species and is distributed throughout southern Africa. This is a warmwater species that prefers temperatures between 20-30˚C. Unlike most other fish, catfish do not have scales but rather a naked skin; this makes handling them easier as scales are not lost causing damage to the skin. *Clarias* species possess a breathing apparatus that allows them to breathe air as well as 'breathe' in the water. As long as the skin of the fish remains moist, the fish is capable of moving across land in search of water. Although they will actively prey on smaller fish, rodents, birds and frogs, they are omnivorous bottom feeders and can be fed a variety of feeds.

Clarias gariepinus can be identified by the following anatomical features:
Head large and bony with small eyes and a terminal large mouth. Dorsal and anal fins long. No adipose fin. Pectoral fin with thick serrated spine used for defense or 'walking' on land. Four pairs of barbels. Colour varies from sandy-yellow through gray to olive with dark greenish-brown markings, and white belly (see photograph).

Spawning
Maturation of the gonads begins in winter and is associated with increasing water temperatures. Spawning normally takes place in spring and summer at water temperatures above 18˚C, and usually above 22˚C. These catfish reach sexual maturity between 150-750 mm total length, at an age of 1-4 years; however, there is a highly significant correlation between female size and fecundity, with the average relative fecundity in the region of 20 000-25 000 eggs/kg fish.

In the wild, spawning usually takes place in shallow water, where the fertilized eggs stick to the leaves and stems of plants. Spawning generally takes place at night in recently inundated marginal areas, typically between 20h00 and 02h30 hours and usually after heavy rain. Artificial spawning techniques are detailed in Chapter 10 on broodstock and breeding techniques.

Once the larvae have developed into juveniles (usually after a 10- to 15-day intensive hatchery period), they are transferred outdoors or to indoor tunnel nursery ponds at a density of 2000 fry per m^2 or more. The juvenile fish are fed every four hours, with a 38% protein diet, and must be graded into three size classes at least two times during the following 4-6 weeks. When the fish reach an average weight of 4-5 g they are either sold to producers or put into the farm's production ponds. The average survival rate from hatching to the end of the nursery phase is approximately 40%.


Sharptooth catfish is favored by many fish farmers as it grows well, is easy to breed and can be kept in high stocking conditions. However, there is some work to be done to develop the market for this fish in South Africa.

Grow-out
Ponds with no water circulation stocked at a density of 10 fingerlings/m^2, reached 10 000

Considerations for catfish *Clarias gariepinus* as a candidate species for aquaculture:

Advantages	Disadvantages
Robust	Specialized breeding techniques required
Fast-growing	Can easily escape from ponds
Wide tolerance of temperatures and water quality	Requires high-protein feed
Can breathe air	Market resistance in some places
Wide eating habits, but needs substantial protein	Larger specimens (>2kg) taste poor
Can be grown in high densities	Cannibalism by juveniles

kg/ha at an average weight of 200 g after 6 months. Higher stocking densities are not used because the poor water-quality conditions at the end of the production cycle are difficult to manage.

Crops of 40 000-100 000 kg/ha have been attained in ponds with a 25%/day water exchange. The daily water exchange is essential to maintain water quality as this otherwise

An example of how catfish can be grown in high densities. Their ability to breathe air is a contributing factor to this.

rapidly deteriorates due to the build-up of uneaten food and excreta, stressing the fish and possibly leading to an outbreak of disease. Due to these potential problems, it is recommended to initially stock the ponds at a maximum density of 10 fingerlings/m^2 and to thin the population out at regular intervals, maintaining a maximum standing crop of 40 000 kg/ha with a constant daily water exchange rate of 25%.

One of the main problems encountered with growing catfish is related to water quality. For instance, overfeeding leads to poor environmental conditions, including low oxygen, high ammonia, and high suspended solids. Adverse water conditions are also linked with dense algae concentrations followed by scum from algae appearing on the water surface. This causes low oxygen levels at night and pre-dawn. By flushing the pond with fresh water and reducing the dietary feeding level, the water quality will start to improve.

Feeding

Catfish has a high dietary protein requirement and therefore feeding with a formulated feed is a prerequisite for intensive culture of the species. Optimal growth rates and food conversions are achieved with diets containing 35-42% crude protein. The artificially formulated diets are composed of vegetable and animal

INFO BOX: CATFISH

- Feed needs to contain 35-42% crude protein.
- Adequate water quality control can be difficult due to high fish density.
- Can be cultured semi-intensively or intensively.
- Production of 40-100 tons/ ha have been achieved.
- Management input is high due to the need for size sorting.

feedstuffs that are supplemented with vitamins and minerals.

It is difficult to give a standard formulation for a balanced diet for catfish as the composition of the formulated diets depends on the availability and prices of locally available feedstuffs. In order to help acclimatize the fish to the feed and feeding place in static ponds, slightly higher feeding levels may be applied during the first three months. However, due to deteriorating water quality, lower feeding levels should be applied during the last three months of culture. After about six months the pond can be harvested, with a net production of 4-8 tons/ha.

Common carp (*Cyprinus carpio*)

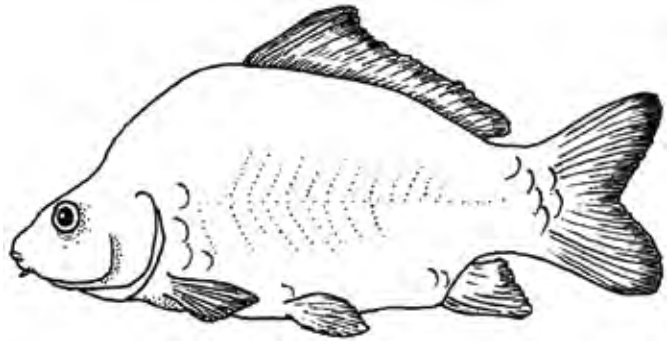
Common carp is the most commonly cultured aquaculture species in the world, with more than 10 million tons being produced in 1995. Like cattle, it is domesticated as it is very different to its wild form, both physically (e.g. its shape and scale types) and in its biology (spawning, growth and feeding habits).

In Europe and Asia, carp is popular as an aquaculture species as it feeds mainly on plant material (which is cheaper than animal feed) and the small insects that live in ponds. This makes the production of carp much cheaper than catfish, for example, as the expense of the feed is reduced. Carp grow quickly and can reach a length of 80 cm and weight of 10-15 kg. They are tolerant of a wide range of temperatures, from 1-40˚C. They grow best at temperatures above 13˚C and spawn at temperatures above 20˚C. Another good characteristic of carp is that they do not get sick easily. While carp may be a good species to use by farmers who are fish farming for the first time, their commercial production must be market-driven.

Spawning

Carp mature after three years and in the wild, and spawn every year in the spring, releasing up to 100 000 eggs per kg of fish body weight.

In captivity, male and female fish are placed in spawning ponds or tanks during the spawning season. To make captive broodstock breed, fish can be injected with hormones that stimulate the production of eggs and sperm. The hormones can be obtained from the pituitary gland (part of the brain), from other adult fish, or from a commercial source.



Common carp (*Cyprinus carpio*)

Grow-out

The most suitable ponds for growing out juvenile carp should be shallow, weed-free and drainable (about 0.5 to 1.0 ha in size). The nursery ponds should be prepared prior to stocking to encourage the development of a rotifer population as this provides the fry with their first food. The ponds should be inoculated with other livefood (such as daphnia, see glossary) after stocking, and then supplementary feeds, such as soybean meal, cereals, meat meal or mixtures of these materials, should be provided. Fry should be stocked at a density of 100-400 fry/m² for 3 to 4 weeks. Final fish weight is 0.2-0.5 g, with a survival rate of around 50-70%.

Tanks of 5-100 m² surface area, made of concrete, bricks or plastic, can be used for nursing fry up to 1-2 cm in size. By adding compost and manure, dense populations of zooplankton can be established in these tanks. Large ponds (bigger than 2 ha) have been shown to be better for growing fry. Fry grown under optimal temperature conditions (around 25˚C) can reach 500 g in six months. Cooler temperatures result in slower growth.

In extensive aquaculture ponds, a crop of 600-700 kg/ha of market-size fish can be obtained when stocked at 120-200 kg/ha one year earlier.

INFO BOX: CARP

- Easy to breed and grow
- Fast-growing
- Some marketing and conservation resistance to their use.

Advantages and disadvantages of common carp (*Cyprinus carpio*) as a candidate species:

Advantages	Disadvantages
Successfully cultured around the world	An alien and often invasive species
Survives a wide range of water quality	Flesh has many fine bones
Disease resistant	Some cultural resistance in marketing
Easily bred	
Can be grown at high densities	
Grows fast	

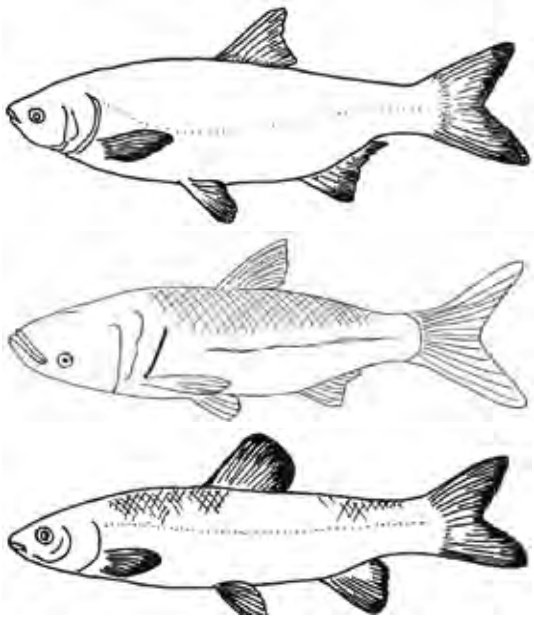
Yield of carp in extensive type ponds (from Horvath et al., 2002)

	Stocking		Survival		Yield
	fish/ha	kg/ha	fish/ha	%	kg/ha
From larvae to 1st summer	100 000-200 000	1	10 000-40 000	5-30	200-400
From fry nursed to 1st summer	40 000-60 000	8-15	20 000-35 000	50-60	300-700
From 1st summer to 2nd summer	5 000-7 000	100-200	3 000-4 000	50-70	600-800
From 2nd summer to market size	600-800	120-200	400-500	50-70	600-700

Feeding
Common carp are omnivorous, preferring to feed on aquatic insect larvae. In poor conditions, artificial feed is added to improve growth rates. To maximize growth, the feed should be of high quality.

Other carp species
Other kinds of carp, besides the common carp, are grown in ponds. Most commonly used are the Chinese carps. Some of these are –

- Silver carp (*Hypophthalmichthys molitrix*). This fish eats phytoplankton, but will accept rice bran and bread crumbs. The silver carp gets its name from its silver color. It has very small scales.
- Bighead carp (*Aristichthys nobilis*). This fish feeds mainly on zooplankton. It is a dusky green color on top, fading to a pale green color on the abdomen. It has small scales.
- Grass carp (*Ctenopharyngodon idella*). This fish is a herbivore and eats water vegetation (but will eat almost anything). The grass carp is also silver-colored, but has a darker grey area running along the top of the body. It grows larger and has larger scales than a silver carp.
- Other Chinese carps, like the black carp (*Mylopharyngodon piceus*) and mud carp (*Cirrhinus molitorella*), are bottom feeders. This difference in eating habits is very important in fish pond culture. It is the reason why polyculture, or growing a number of different fish species in one pond, can be successful. When one kind of fish is stocked alone (monoculture), the foods in the water that are not eaten by that type of fish are wasted. In a polyculture of three species of Chinese carp, for example, three kinds of food are being eaten.



Silver carp (*Hypophthalmichthys molitrix*); Bighead carp (*Aristichthys nobilis*); and Grass carp (*Ctenopharyngodon idella*).

Tilapia
Tilapia are often referred to as the 'aquatic chicken'. This is because tilapia are cultured so widely and successfully around the world that they now occur on every continent apart from Antarctica. Tilapia are even grown in cold climates, such as in the UK, where tilapia farms exist in huge heated warehouses.

Whereas tilapia farming took off just after the Second World War, with *Oreochromis mossambicus* (then called *Tilapia mossambica*) and a few other hybridized species being used, the main species now used for its better growth rates are genetically improved strains of the Nile tilapia *Oreochromis niloticus*.

Tilapia are herbivores, with some species eating plants and others eating phytoplankton. The Nile tilapia do well in very enriched waters (enriched by organic fertilisers). All tilapia have slightly different eating habits, depending on the species.

Tilapia species have many possibilities for pond culture. Their fast growth rates, ease of breeding, good taste and hardy bodies make them a good choice, particularly for the first-time fish farmer.

Spawning
Once they become sexually mature, tilapia reproduce once every few months. The adults take very good care of their own eggs and fry. If the farmer plans to breed and raise fry, this fish

Women in a rural town selling tilapia. This fish has a lot of potential in South Africa as many people prefer eating this species.

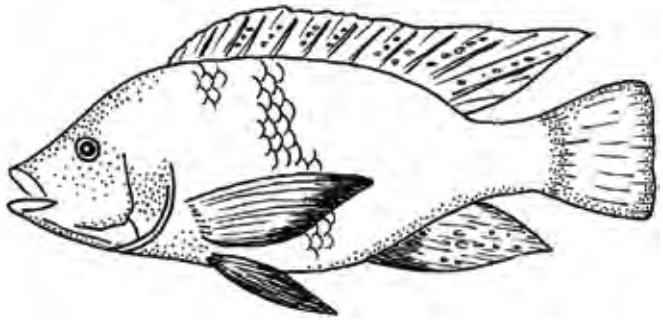
Species of tilapia widely used in aquaculture

Tilapia species	Years used for culture	Attributes
Oreochromis mossambicus	From 1938 to the 1970s, especially in the Far East and southern Africa	Readily available, but poor growth and over-populates easily
O. hornorum, O. macrochir, O. shiranus, O. aureus	From 1960s to 1980s, especially hybrids in the Philippines and Indonesia	Near all-male offspring produced with better growth
O. niloticus	From the 1960s in Israel, to the present day worldwide	Better growth than other species
'GIFT tilapia' (*O. niloticus* in genetically improved strains)	From the late 1980s to the present day; developed in the Philippines	Better growth and colour enhancement to include red colour strains.

is a good choice because the fish themselves take care of the fry at a stage where many fish of other species die easily. However, the wild spawning of tilapia in ponds is an inefficient way to produce fingerlings as no control is possible over production, and variable quantities of mixed-size fingerlings of unknown parentage are produced. The use of circular concrete tilapia spawning tanks, with a central arena for the adults and a peripheral shallow area to attract the juveniles, is preferred (see later section on broodstock and breeding). Another problem with raising tilapia in fish ponds is that they become sexually mature at a small size and begin to reproduce instead of growing. It may therefore be necessary to separate the tilapia by sex before they are old enough to reproduce. Another simple but not very efficient way of controlling unwanted spawning is to introduce a few catfish into the pond to eat the small fish.

INFO BOX: TILAPIA

- High-potential aquaculture species
- Suitable for pond culture
- Wide market acceptance



Tilapia (*Oreochromis mossambicus*)

Feeding

Oreochromis mossambicus are used to control filamentous algae, which is a habitat for mosquito larvae, thus the tilapia is used to help with malaria control. Tilapia are omnivorous and will feed on an artificial diet in addition to the zooplankton in the pond.

Grow-out

Under monoculture conditions, fry (about 1 g) are stocked into nursery ponds and once they reach 30 g are stocked into grow-out ponds. Stocking density is usually at 1 to 2 fingerlings per m^2. The pond is then fertilized to maintain high levels of plankton. Supplemental feeding of an artificial diet will improve production. With fertilizing and supplemental feeding, the pond

Advantages and disadvantages of tilapia (*O. mossambicus*) as a candidate species:

Advantages	Disadvantages
Feed at a low trophic level (they can eat a wide variety of feeds)	Mature early and over-reproduce in ponds, leading to stunting
Are excellent table fish	Do not grow well at temperatures below 20˚C
Fast-growing, robust, disease resistant	Lack of local access to better strains
Genetically improved strains have been developed for better growth	

can be harvested after six months and will yield between 1500 and 4000 kg of fish per hectare per year (750-2000 kg per harvest).

At harvest, the percentage of the total pond fish weight is around 70%, with the remaining 30% made up of fry and fingerlings. These smaller fish can be kept back from harvest and added to the pond during the next production cycle.

A yearly production of 15-40 kg of fish in a 100 m^2 pond may not seem like much; however, if it feeds a fish farmer and his/her family, this extra protein is of great nutritional benefit.

Rainbow trout (*Oncorhynchus mykiss*)
Trout is the most well-established aquaculture species in South Africa. It is very popular as a fishing species as well as a high-value food fish. Trout is not native to South Africa and was introduced over 100 years ago by people who wanted to catch them on a rod and line. Since then they have become established in many of our rivers where they have destroyed the local fish species. This is a good example of how important it is to ensure that an aquaculture species that is not local never has the chance of getting into the environment. There are laws to protect this from happening by not allowing trout (and some other species) to be cultured in areas where they are not currently found.

Trout prefer cooler temperatures (12-18˚C) and begin to show signs of stress at temperatures above 21˚C. The successful culture of trout requires culture systems with plenty of clean, oxygen-rich water. They cannot be cultured in stagnant ponds or those with a slow water-exchange rate.

Spawning
Rainbow trout is easy to spawn and the large fry can be easily weaned onto an artificial diet (they usually feed on zooplankton). However, the hand-stripping of trout to breed them is a demanding job that requires careful planning and considerable equipment to hatch the eggs and rear the fry successfully (see section on broodstock and breeding). Temperature and food availability influence growth and maturation, causing age at maturity to vary (usually age 3-4 years).

Females produce up to 2000 eggs/kg of body weight and the eggs are relatively large (3-7 mm). In nature, most fish only spawn once, in spring (January-May), although in captivity they can spawn all year round. Trout will not spawn naturally in culture systems; thus juveniles must be obtained either by artificial spawning in a hatchery or by collecting eggs from wild stocks. Trout larvae are well developed at time of hatching.


Trout need cold water and are commercially grown in South Africa. There is a very good market for this fish. Trout can be processed for added value, e.g. smoked and trout paté.

Feeding
In the wild, trout feed on aquatic and terrestrial insects, molluscs, crustaceans, fish eggs and other small fishes. The natural diet is rich in pigment and this is responsible for the orange-pink colour in the flesh. In aquaculture, the addition of pigments in the fish food causes this pink colouration.

Trout feeds have been modified over the years, with a variety of compact nutritious pelleted diets for all life stages. The pellets are high in

Advantages and disadvantages of trout as an aquaculture species:

Advantages	Disadvantages
Popular angling, recreational and table fish	Not tolerant to low oxygen or high temperatures, restricting their distribution
Fast-growing	Susceptible to disease
Can be cultured at high densities	Regarded as an alien invasive species by conservation agencies
Suitable for pond, tank or cage culture	Fingerlings only obtainable from hatcheries
An established species with good markets	

fish oil, with over 16% fat. The feed uses fish meal, fish oil, grains and other ingredients, with the amount of fish meal being reduced to less than 50% using alternative protein sources, such as soybean meal. These diets are efficiently converted by the rainbow trout, often at food conversion ratios of around 1:1. Hand-feeding is best when feeding small pellets to small fish. Larger fish are usually fed using mechanical feeders; these can provide set amounts at regular intervals depending on temperature, fish size and season.

INFO BOX: TROUT

- A well-established aquaculture species with proven markets
- Can be cultured at high densities
- Has both culinary and recreational attributes
- Obtains high prices at market.

Grow-out

Trout eggs are relatively large compared to most other fish eggs. After the fry have hatched and used up their egg sac, they can be fed on an artificial diet. The fry are usually reared in circular fibre-glass or concrete tanks to maintain a regular current and uniform distribution of the fry. Water is sprayed in from the side of the tank to create a circular flow of water. The drain is placed in the centre of the tank and protected by a mesh screen.

Specially prepared starter feeds are fed using automatic feeders when about 50% have reached the swim-up stage. To ensure overfeeding does not occur, hand-feeding is recommended for the early stages, although demand feeders may be more efficient for larger fish. Dissolved oxygen must be monitored as growth continues, with the fish moved to larger tanks to reduce density.

When the fry are 8-10 cm in length they are moved outdoors. (The detailed method of cage-rearing of trout is described in Chapter 11). Typically, individual raceways and ponds are used (2-3 m wide, 12-30 m long, 1-1.2 m deep). Raceways provide well-oxygenated water. The water quality can be improved by increasing flow rates. Fry are stocked at 25-50 fry/m² to produce up to 30 kg/m² with proper feeding and water supply.

Within nine months, fish are grown to marketable size (30-40 cm), although some fish are grown to larger sizes over 20 months. The fish are graded (at 2-5 g, 10-20 g, 50-60 g and >100 g) during the first year. Fish quantity and size sampling (twice a month) allows estimations of growth rates, feed conversions, production costs, and closeness to carrying capacity to be calculated; these are all essential considerations for proper trout-farm management.

Another method for growing trout is the use of cages (6m x 6m and 4-5m deep) where fish are held in floating cages to ensure good water supply and sufficient dissolved oxygen. This is a simple method as it uses existing waterbodies rather than flow-through systems. Stocking densities are high (30-40 kg/m²). However, the fish are vulnerable to external water-quality problems and predators (rats, otters and birds). In less than 18 months, trout fry of about 70 g can attain 3 kg.

Ornamental species

Fish bred for the aquarium (pet-shop) trade are known as ornamental species (as they are pretty to look at, like an ornament). They are not bred as food and are sold per fish rather than by the kilogram. The fish tend to be small (2-15 cm) and therefore the farm areas are small. Although ornamental fish farms are small, they require more technical equipment and knowledge to operate than a pond culture system. However, as ornamental species are sold live, no further processing or storage is required.

The farming of ornamental fish has an advantage over that of food fish in that it can be a very small-scale but still profitable enterprise, and these can operate at the family business level. In the Far East, numerous family-run farms using only one or two ponds and a number of tanks may raise one or more species of ornamental fish to sell live to cooperatives, which then distribute them worldwide. This can be a low-tech industry ideally suited to Africa, where both water availability and specific fish-husbandry skills may be lacking. There is a huge scope for satellite farms to produce both warmwater and coolwater species for the ornamental fish trade. At present, hundreds of boxes of ornamental fish are imported weekly to Johannesburg airport, mainly from the Far East, and opportunities lie in import-replacement for these by local producers.

There are many species of ornamental fish and their culture techniques and methods depend on the species being bred. It is important that fish are of high quality as the pet-shop trade is very fussy about the quality of the fish and will not pay a good price for average or poor-quality fish.

There are hundreds of species that can be farmed in the ornamental sector. Farmers need to know the market before deciding what species to select. Here are two farms, one in Gauteng (far left) and the other in the Northern Cape (left).

The species discussed in detail in this manual are livebearers: guppies, mollies, swordtails and platies. These species are all relatively hardy and easy to keep, all preferring warm water around 24˚C. All these species are small compared to the other fish mentioned in this manual, reaching only 5-10 cm depending on the species. These are species that although fairly easy to produce, do not fetch a high price, as they are mass-reared in the Far East and thus imported at relatively low prices. In some circumstances, a better return could be made by culturing higher-value fish, which then need to be sold to specialized outlets that trade in these species.

Spawning

The males and females are placed in a fish tank where they mate. As their name suggests, livebearers give birth to live young, which means no problems with trying to incubate eggs. As the young are born they are able to swim, feed and fend for themselves. However, if there is nowhere for the babies to hide, the adults will eat them as they are born. It is therefore very important to provide cover, such as weed or artificial shelter, for the babies to swim into. Daily inspection of the tanks will reveal the presence of babies which can be netted out and moved to another grow-out tank or pond. The pond should be inside a greenhouse to help raise temperature and control predators.

Feeding

Juveniles will feed on an artificial diet (33-35% protein) or homemade diets using fishmeal, beef heart, and liver. The fish will also feed on the natural zooplankton in the pond. Adults are fed a formulated diet or flake at a ration of 3-10%, depending on size and species. The food should contain pigments to enhance the bright colours of the fish.

Grow-out

Size grading should be performed often to remove stunted individuals. Sex-sorting should be done when the fish start maturing in order to prevent uncontrolled spawnings which not only reduce the quality of the fish (due to inbreeding) but also slow down the growth rate (as the fish put energy into reproduction rather than growth).

In indoor ponds stocked with juveniles, survival up to market size is greater than 70%. If fed regularly and maintained at their optimal temperature, livebearers reach market size in three months. Care must be taken during harvesting as the fins and scales are easily damaged, reducing the quality of the fish. Before selling it is necessary to grade the fish and assign them to different levels of quality (colour, shape, size) such as high, medium and poor. A better price can be obtained for high- quality fish compared to medium-quality fish. Poor-quality fish should be culled (killed).

Before packing, the fish should be starved for 48 hours. This is to reduce the excretion of feces into the water during transportation. The fish should be packaged in sealed plastic bags with added oxygen and shipped in insulated boxes (to reduce the change in temperature). If packed properly the fish can survive for up to 48 hours.

Examples of higher-value ornamental fish: cichlids from Lake Victoria (far left) and Koi (left).

INFO BOX: ORNAMENTAL FISH

- Numerous species
- Marketing established
- Small-scale ventures can be viable
- Relatively sophisticated infrastructure required
- Requires lower volume of water than food-fish aquaculture.

A summary of good candidate fish species for local aquaculture:

Algae-eaters	Silver carp *Hypophthalmichthys molitrix*; milkfish *Chanos chanos*; mullet *Mugil cephalus*
Zooplanktivores	Bighead carp *Aristichthys nobilis*
Plant-eaters	Grass carp *Ctenopharyngodon idella*; tilapia, *Tilapia rendalli*
Carnivores (predatory fish that eat other fish)	Sharptooth catfish *Clarias gariepinus*; rainbow trout *Oncorhynchus mykiss*
Omnivores (eat small animals and plants)	Catfish species, *Clarius* spp.; common carp *Cyprinus carpio*; Crucian carp *Carassius carrasius*; *Oreochromis* spp.; *Tilapia* spp.
Ornamental species	*Poecilia* spp.; *Xiphophorus* spp.; numerous cichlid species, livebearers and egg-layers