Aquarium fish as larval predator

Using conventional techniques like spraying of insecticides, repellants, fogging and other chemicals to reduce the growth of mosquitoes not only pollutes the environment, but also allows the mosquito to enhance its resistance. As a result, the mosquitoes remain intact and simply refuse to die. However, the population of mosquito could be effectively tackled using the aquarium fish, which primarily feeds on the mosquito larvae. Experience has shown that biological control using fish is best achieved as part of an integrated vector control strategy.

Larvivorous: feeding mainly on insect larvae and pupae.

Types of larval habitat

The larvivorous fish can be used in a variety of aquatic habitats for control of mosquito breeding:

a) Man-made habitats: Water tanks (domestic and industrial), lakes, fountain pools, cattle troughs, swimming pools, cisterns, ponds, shallow wells, waste ditches, husk pits, drains, water storage tanks at construction sites, seepage water pools and water reservoirs of different types, especially in desert locations, irrigation cisterns and canals, shallow ponds, small dams and rice fields.

b) Natural habitats: Ponds, lakes, riverbed pools, slow moving small streams, swamps and temporary water collections during rainy season.

Criteria for species selection:

i) Larvivorous fish must be small, hardy and capable of getting about easily in shallow waters among thick weeds where mosquitoes find suitable breeding grounds.

ii) They must be drought resistant and capable of flourishing in both deep and shallow waters.

iii) They must have the ability to withstand handling and transportation for long distances. Larvivorous fish must be prolific breeders having shorter span of life cycle. They must breed freely and successfully in confined waters.

iv) Should be surface feeders and carnivorous in habit.

All larvivorous species should be its appearance. They should not be brightly coloured or attractive. They should have no food value, so that the fish-eating people discard them.

For anopheline control, a potential larvivorous fish should possess the following characteristics:

i) have a high preference for mosquito immature among a wide variety of food, e.g. plankton available in the natural habitats.

ii) surface feeder, since anopheline larvae stand on the surface strata of aquatic habitats.

iii) have terminal or superior mouth with teeth and swim above the surface stratum of aquatic habitats.

iv) be small in size, more or less fusiform in shape, agile and swift in movement so that it can navigate in shallow and/or weed-infested waters and escape from the predators.

v) have high fecundity (breeding potential) and ability to breed throughout the year under natural conditions and in confined waters.

vi) hardy, to withstand transportation and stressful environmental conditions in terms of temperature, pollutants and turbidity.

Categorization of larvivorous fish

The position of mouth is one of the important characteristics to determine the larvivorous capability of a fish. From the point of view of their efficacy in controlling mosquito larvae, Hora and Mukherjee (1938) classified the larvivorous fish into the following categories:

(i) Typical surface feeders such as *Aplochelius* and *Gambusia*, which fulfill the characteristic features of larvivorous fish

(ii) Some surface feeders, which are less efficient owing to their mode of life, *e.g., Oryzias, Aphanius, Poecilia*

(iii) Sub-surface feeders like *Amblypharyngodon mola*, *Danio*, *Rasbora*

(iv) Column feeders like *Puntius* sp., *Colisa*, *Chanda*, *Anabas*, which feed on mosquito larvae when chance permits

(v) Fry of carps and mullets, which are helpful in controlling mosquito larvae

(vi) Predatory fishes like *Wallago*, *Channa*, *Notopterus* and *Mystus* whose fry may destroy mosquito larvae but whose adults may predate upon other fish including larvicidal fish species.

Potential indigenous larvivorous fishes

1) Dispar topminnow (*Aphanius dispar*)

Good larvivorous fish, suitable for drains and polluted water bodies and useful for stagnant water bodies, disused wells etc. Fish are applied at about 3 fish per square meter water surface. *A. dispar* effectively reduced the breeding of *Anopheles arabiensis* and *An. gambiae* breeding in barrels and containers etc.

2) Dwarf panchax (*Aplocheilus blockii*)

Useful for introduction in overhead tanks, ornamental pools, streambeds and margins, reservoirs and wells for malaria disease vector control.

A. blockii reduced the larval population of *An. stephensi* by 75% along the coastal belt of Goa (Kumar *et al*., 1998).

A. blockiiis a potential larvivorous fish controlling the spread of chikungunya fever by controlling *Aedes albopictus* (Chandra *et al., 2008*).

3) Giant gourami (*Colisa fasciatus*)

Found in fresh water rivers, lakes and estuaries generally preferring weedy environment. *C. fasciatus* controls vectors of brugian filariasis and malaria namely *Mansonioides indiana* and *Anopheles annularis* respectively.

4) Elongate glass perchlet (*Chanda nama*)

Widely distributed in fresh waters with thick vegetation and breeds freely in confined waters as well as rivers. It controls the population of *An. culicifacies*.

5) Zebra fish (*Danio rerio*)

surface feeder, slow moving stream with grassy margins and shallow earth wells, seepages for control of malaria. *D. rerio* controls mosquito breeding in rice fields rich in *Anopheles* sp. and *Culex* sp.

6) *Puntius* sp.

Puntius sophore, *P. ticto* are hardy and have comparatively little food value. They feed on crustaceans, insects and plankton. Spawning takes place during the monsoon season. They are found in shoals in confined, shallow and marginal waters of rivers, freshwater ponds, pools, canals and perennial water bodies and are also useful for introduction in rain pools and slow streams. Low population densities may be maintained in carp-culture ponds for mosquito control.

7) *Rasbora daniconius*

Rasbora can be identified by a dark blue lateral band extending from its nostril through the opercle to the base of its medium caudal rays. Its sides are silvery, its belly is white and its dorsal, anal and caudal fins are orange in colour.

These fishes are widely distributed in tropical areas (water temperature: 24–26°C) in freshwater ponds, hill streams, rivers, ponds, canals, inundated fields and tanks with abundant aquatic vegetation. It is a surface feeder and feeds mainly on aquatic insects and detritus.

Potential exotic larvivorous fish

1) Goldfish *(Carassius auratus)*

Most goldfishes are readily eat mosquito larvae. Comets and shubunkins with darker coloration have a higher likelihood of ingesting more mosquito larvae than brightly colored goldfish varieties. Smaller goldfish are better able to adeptly maneuver about the pond, particularly if the pond has lots of plants and other obstacles that double as hiding places for larvae.

2) Top minnow/Mosquito Fish *(Gambusia affinis)*

Perhaps the most efficient and voracious mosquito-eating species throughout the world, a single mosquito fish can eat 100 to 500 mosquito larvae in a day. They also eat water beetles, mayfly and caddisfly larvae and other aquatic invertebrates that may create nuisances in the pond.

They are very small (1.5- 3 inch long), multiply very quickly, majestic for keeping mosquitoes and other pests under control but could overload pond if left unchecked.

In Hyderabad city of India, an operational release of *Gambusia affinis holbrooki* in 1967 controlled the breeding of *An. stephensi* in hundreds of wells in about 2 years.

3) Guppy *(Poecilia reticulata)*

A typical guppy is capable of eating nearly their body weight in mosquito larvae daily. Due to their very small size, they can easily zip about the pond and find larvae in even the most obscure areas.

It is a very prolific breeder and a gravid females gives birth to about 20–50 hatchlings up to four times in a year. Thus, on average, it can produce up to 200 offspring/year. Guppies cannot tolerate temperatures below 10°C. They can withstand moderate organic pollution, and thus are highly suitable for mosquito control in urban drains, polluted waters and wastewater pools, in addition to freshwater habitats.

4) Koi carp *(Cyprinus carpio)*

They are not as well-adapted to eating small mosquito larvae and will not actively seek them out. However, they will eat the larvae if they happen across them.

5) Golden orfe *(Leuciscus idus)*

Orfe is a beautiful, bright golden-orange fish that loves preying on aquatic pests, including water beetles and mosquito larvae. Adults jump out of the water and catch adult flying mosquitoes. Orfe are large growing up to 20 inches in length and are a social fish, preferring to swim about in small schools. Since they are large and considered predatory, it is not widely used in the pond, as they may eat small fishes if they are hungry.

However, golden orfes are non-aggressive hardy fish that can be kept with koi and larger varieties of goldfish. Having a combination of these three fish species would certainly put a dent in mosquito populations with minimal effort.

6) Minnows *(Phoxinus phoxinus)*

Minnows feed heavily on mosquito larvae and reproduce quickly, meaning they can really put a dent in mosquito populations. Aquatic insect larvae and detritus floating in pond make up the majority of their diet. However, if any larger fish present in pond, such as goldfish and koi, may eat the minnows if they are hungry enough.

The University of Wisconsin (2009) reported that fathead minnows as a natural, biological control option for mosquito populations and found the minnows to be a better long-term solution that are also more ecologically and economically friendly than chemical options.

7) Common Pleco *(Hypostomus plecostomus)*

Common Pleco is a South American native bottom-dwelling sucker catfish that eat just about anything. It consume mosquito larvae, though not in as large of quantities as some other species. They are a nice last-line-of-defence as they will eat anything that other fish leave behind.

Conclusion

Fish can be used cost-effectively, especially when there is also community participation, such as in the maintenance of fish stocks and hatcheries, removal of weeds from water bodies, distribution of fish, replenishment of fish in mosquito breeding habitats and the use of larvivorous fish with food value.

In Afghanistan, the total operational cost of introducing *Gambusia* for malaria control was US$ 0.02 per capita (1972), compared with US$ 0.50 per capita (1971) using DDT (75% water dispersible powder) indoor residual spraying.

Colisa fasciatus, Oreochromis mossambica, Esomus danricus, Oryzias melastigma, Puntius sophore, P. ticto, Rasbora daniconius, R. elegans, Aplocheilus panchax, and *Danio rerio* possess high-level larvivorous potentiality in nature and are recommended for malaria control in Ranchi district in Jharkhand, India (Das *et al*., 2018). These native larvivorous fishes could be used in the integrated mosquito control programmes. However, there is an increasing threat on fish fauna due to several anthropogenic activities like fishing, human interference, loss of habitat, overexploitation, pollution, siltation, trade, and diseases are causing the threat to the fish fauna. Conservation measures need to be implemented against these factors for developing a comprehensive action plan.

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"Don’t believe in luck, believe in hard work”

Common characters and Sexual dimorphism

Sexual dimorphism: differences in appearance between males and females of the same species, such as in colour, shape, size, and morphology that are caused by the inheritance of one or the other sexual pattern in the genetic material.

Sexual characters in fishes: fishes are grouped into three categories.

1. Monomorphism

No external characters to distinguish the sexes even when they are sexually matured, includes most of the pelagic fishes like sardine, seer fish, carangids etc.

2. Sexual dimorphism

In many species, it is possible to determine the sex from their external body features. This phenomenon of differentiation of male and female sexes by external characters is called "**sexual dimorphism**".

2.1. Permanent dimorphism

Sexes can be distinguished after the onset of sexual maturity including the colour and/or form. *e.g.,* fighter fish (*Betta splendeus).*

2.2. Temporary dimorphism

Sexes can be distinguished only during spawning season. During other times, sexes cannot be distinguished. *e.g.,* common carp (*Cyprinus carpio)*

In respect of species which do not exhibit sexual dimorphism, the separation of sexes mostly rely on internal examination and observation of the gonads.

3. Sexual Polymorphism

Both the sexes can be distinguished by more than one character. *e.g,* Salmon.

Sexual differentiation can be made by observing the gonads only after attaining the maturity. There are two types of characteristic:

A) Primary characters: associated with reproductive process; in case of males – testis and ducts, in case of female – ovaries and ducts, observed by dissecting the fish.

B) Secondary characters : fish need not be sacrificed or killed, characters occur in mature fishes. *e.g.,* Claspers, Gonopodium, Papillae etc.

However in certain species of finfishes, variations occur in the morphology of fish.

i) Body shape:

Females are heavier and larger in size compared to the males because of the ovaries.

Genital papillae: It is a small tube in cloacal aperture and which distinguishes male from females *e.g.,* darters, lampreys etc.

Pearl organ (Nuptial tubercles): These are horny short structures seen on the snout, cheek (head region) only in males. Once spawning is over nuptial tubercles will disappear. *e.g.,* common carp, minnows.

ii) Fins: Generally fins are larger in males than the females. In some fishes, pectoral fins can be used to distinguish between males and females. In males, they are rough and grainy in nature (Indian major carps). In some fishes, the caudal fin can be used to distinguish. *e.g.,* male sword tail has lower lobe much longer.

iii) Coloration: Most male fishes are brightly coloured and more intense when compared to females. This is common in most of the aquarium fishes. *e.g.,* parrot fishes.

In Bow fish (*Amia* sp.), the juvenile develop a coloured circular spot in their caudal fin of both sexes but when they attain maturity, it disappears in females and it becomes very intense in males.

Accessory sexual characters: It Includes modification of anal fin to an organ called gonopodium (in males) which helps in the transfer of sperms during maturity. *e.g.,* mosquito fish, guppies.

The pelvic fins are modified into claspers in males and serve as claspers in many elasmobranches.

Female accessory sexual characteristic is seen in the form of egg laying tube or ovipositor. *e.g.,* Asiatic lump sucker.

iv) Head characters: In chimaerids, especially the males develop a spiny stout retractile knob like structures called frontal claspers. This sort of structure is also seen in forehead brooders. In salmons, males develop knob like hook called as **leype**, seen at the tip of both the jaws.

v) Size: Deep sea male angler fish parasitic on the body of female. Fishes which have parental care, the secondary sexual characters are more pronounced. Sexual dimorphism is least pronounced in case of fishes which don't exhibit parental care.

Guppy (*Poecilia reticulata*)

Small, freshwater, hardy, prolific breeder, live-bearing fish, known as **millionfish** or **rainbow fish** (Order-Cyprinodontiformes; Family-Poecilidae).

They are highly adaptable and thrive in many different environmental and ecological conditions. Male guppies are smaller than females, have ornamental caudal and dorsal fins. Females are grey in body color while males have splashes, spots or stripes of a wide variety of colors. Wild guppies generally omnivorous, feed on a variety of food sources, including benthic algae and aquatic insect larvae. Guppies are used as a model organism in the fields of ecology, evolution, and behavioural studies.

Maximum size: 27mm for females and 21mm for males in (Sublette *et a*l., 1990).

Coloration: The guppy is an extremely colourful fish, displays elaborate patterns on its tail fin. Males usually, with one to three ocelli on sides and one rounded to irregular spot on caudal base, base of gonopodium with an irregular dark spot.

Body shape: Back slightly arched, fewer than 9 (usually 7 or 8) dorsal fin rays.

Mouth position: Mouth small, superior, with villiform teeth; anterior row largest, rows diminishing in size posteriorly.

External morphology: Members of Poeciliidae are characterized by having pectoral fins placed high on the side of the body, pelvic fins placed in an anterior position. Caudal peduncle longer than head. Males (2.5–3.5 centimeters long) are about half the size of females (4–6 centimeters) with colorful tail and caudal fin; Adult males with a modified anal fin forming a **gonopodium** for internal fertilization; Caudal fin rounded.

Dorsal spines: 0; Dorsal fin rays: 7-8; Anal spines: 0; Anal fin rays: 8-10

Males are continuously chasing and mating females. Females can store sperms for later fertilization and may produce young every four weeks. Pregnant females are recognizable by black triangle between anal and pelvic fins. After a gestation period of four to six weeks females give birth to 20-40 live young. No parental care is exercised and parents may even prey on their young.

Guppies are frequently introduced to both natural and artificial water bodies as a mosquito control.

Molly (*Poecilia*)

(Order-Cyprinodontiformes; Family-Poecilidae)

Varieties

Short-finned molly or **common molly**: wild-type fishes are dull, silvery in colour (*Poecilia sphenops*).
Black molly: melanistic breed, black all over.
White molly: white coloured.
Golden molly: Nicknamed the "24 karat".
Balloon molly: has a deformed spine due to a genetic defect that gives it its appearance. Through selective breeding it is now widely available.
Lyretail: A breed with an altered caudal fin structure.
Dalmatian molly: silver coloured breed with black speckles

Description

The fish has an elongated body a bit flattened from sides. Its eyes and upward mouth are relatively large. The male fish grows up to 6–7 cm long and the female is about 10 cm large at the age of about 6 months. The fish beautiful fins get their maximum beauty and size only during the 2nd year of the fish life.

Due to their small size, mollies have numerous natural predators within their environment, with larger fish being the most common predators of the molly. Aquatic birds and even reptiles are also known to hunt them.

Feeding

Mollies are omnivorous, consumes both plant and animal matter. Mollies primarily eat small invertebrates including insects and bloodworm, along with algae and food particles in the water.

Sexing

Molly fish females are larger and have large rounded abdomen. The anal fin of male fish is modified into a tube (gonopodium) whereas in females anal fin is of triangle shape.

Males are brightly coloured. The females have no colour on body, just grey but might have colour on tail. The male mollies are more slender than the female mollies and have a slightly longer tail fin. Fins are shorter and the anal fins are triangular in female.

Swordtail (*Xiphophorus hellerii*)

(Order- Cyprinodontiformes; Family-Poeciliidae).

Description

Swordtail size may be quite large. Males may grow up to 11 cm long and females are about 12 cm long excluding the tail length. Lifespan is about 3-5 years.

The fish body is elongated and flattened from sides. The feature of the fish is its unusual tail in a shape of sword, which actually gave the name to it. The tail may be either rounded with one ray or it may have several rays.

Dorsal fin rays: 11-14; Anal spines: 0; Anal fin rays: 8-10.

Midlateral stripe may be dusky or brownish or red; 2 additional reddish stripes may be present above midlateral line and one beneath. For the fish coloring, it is difficult to select just one pattern, though red with black tail seems to be the most spread one. It is quite complicated task to describe all the species, since there is a large variety of its hybrids (koi swordtail, pineapple swordtail, neon swordtail).

The fish is closely related to the platy and has been used extensively in genetic and medical research.

Feeding

Swordtails are omnivores, feed on a variety of invertebrates, insects, plant matter and algae.

Sexing

Only male fish has a sword on its tail. This is a long outgrowth due to which the fish got its name. Like other live-bearing fish the anal fin of the male fish has been modified into a tube (gonopodium) and the female fish has a wide anal fin.

Goldfish (*Carassius auratus*)

(Order-Cypriniformes; Family-Cyprinidae)

The Goldfish is one of the most commonly kept aquarium fish in the world. It is comparatively a small member of the carp family.

Physical Description

As there are over a hundred varieties of goldfish, coloration and physical characteristics vary greatly. The common goldfish has two sets of paired fins - the pectoral fins and pelvic fins and three single fins- the dorsal, caudal and anal fin. They lack barbels on the upper jaw and lack scales on the head. Goldfish have exceptionally large eyes and acute senses of smell and hearing. Lateral line complete, have 27-31 scales along their lateral lines. Goldfish have (rather than true teeth) pharyngeal teeth in their throats, which they use to

crush food. Dorsal spines: 3-4; Dorsal fin rays: 14-20; Anal spines: 2-3; Anal fin rays: 4-7. Caudal fin with 17-19 rays.

Food Habits

Goldfish are omnivores, eat plants, insects such as mosquito larvae, small crustaceans, zooplankton and detritus. They eat almost everything offered.

Sexing

The female varieties tend to be slightly more round than males and just bigger in general, the vents of female goldfish are usually larger and more circular than those of males. Male vents are long and often have a triangular outline. During the breeding season, males have breeding tubercles (white pimples) on the gill covers and on the leading edge of the pectoral fins.

Angelfish (*Pterophyllum scalare*, *P. altum*, *P. leopoldi*)

(Order- Perciformes; Family- Cichlidae)

Description:

Greatly laterally compressed, with round bodies and elongated triangular dorsal and anal fins. This body shape allows them to hide among roots and plants, often on a vertical surface. In freshwater angels, colours and patterns, while striking, are not as dramatic as those of the ocean angels. Both have long ventral fins that look like tendrils.

Dorsal fin is moderate with distinct spinous and soft parts. Interdorsal space narrow or absent. Head not depressed, without spines and bony ridges. Anal spines are 12-16.

Feeding:

Angelfish naturally carnivorous, normally eats algae, jellyfish, plankton, tunicates, hydroids and bryozoans.

Sexing:

Nearly impossible. However, there are few characteristics those identify the male as well as female fish:

- Males are more territorial than females.
- Male angel's body is usually more circular than the female's and there is a slight bump on his crown.
- Males sometimes develop a small lump on their forehead known as nuchal hump, unlike females.
- The male's ventral fin is forked, whereas the female's is not.
- The breeding organ (papilla) of the male is more pointed, while in female it is wider.

Both sexes have an organ called a papilla located between anal and ventral fins. When the female becomes gravid, carries eggs, her papilla becomes slightly enlarged and has a blunt tip. When the male senses a gravid female, his papilla also enlarges slightly, but it has a more pointed tip.

Males court females during the breeding season. Both male and female guard the eggs, which are attached to the surface of aquatic vegetation in a nest area. During the entire brooding cycle, bonding of the original pair of parents is maintained complete with defense of each partner against aggression or potential rivals.

Bluemorph/Blue acara: *Andinoacara pulcher*

(Order-Perciformes; Family-Cichlidae)

Description:

Body laterally compressed, oblong. Anal spines: 12-16.

Live up to 10 year.

Behavior: very territorial and need lots of hiding places

Colouration: Olive green, with eight obscure transverse bands on the body; numerous bright bluish-green lines on the cheek. A distinctive black line is present going from the eye down the cheek.

Males grow to be around 17 cm long and females closer to 11 cm long, The body is compact and stocky, while the fins are long and flowing, with a rounder head.

Parental care: cichlids are mouth brooders, which means the female cichlid carries the babies in her mouth until the babies are big enough. Young usually take around 6 months to mature, during which time both parents care for their young and carry out several parenting tasks.

Sexing:

Males are more colorful and larger than females; males blue in color during the reproductive season. They have more pointed ventral, dorsal and anal fins, which often extend into filaments. In addition, older males frequently develop vestigial fatty lumps on their foreheads. Spots are on anal fin in male whereas no spots in anal fin in female.

Feeding:

Omnivores, diet composed of various prey, including crustaceans, small fish, insects, worms, plants and algae.

Clownfish or **anemone fish** (*Amphiprion ocellaris*)

(Order-Perciformes; Family-Pomacentridae)

Characteristics

Bright orange with three distinctive white bars, clown anemone fish are among the most recognizable of all reef-dwellers. They may grow up to 4 inches in length and are named for the multicoloured sea anemone in which they make their homes. The tail is rounded and the dorsal fin is lined with 11 spines. Females are larger than males in this species.

Diet

Clownfish are omnivores, feeds on small invertebrates, which could otherwise potentially harm the sea anemone, and the faecal matter from the clownfish provides nutrients to the

sea anemone. Clownfish are omnivores and eat live food such as algae, plankton, molluscs and crustacea with algae accounting for around 20 to 25% of its diet.

Relationship with Anemones

Clownfish perform an elaborate dance with an anemone before taking up residence, gently touching its tentacles with different parts of their bodies until they are acclimated to their host. A layer of mucus on the clownfish's skin makes it immune to the fish-eating anemone's lethal sting. In exchange for safety from predators and food scraps, the clownfish drives off intruders and preens its host, removing parasites.

Changing Sex

Two large fish are the only sexually mature; a male and female breeding pair. All of the smaller fish are male. If the large breeding female is removed, her male mate changes sex to female and the next largest fish in the group rapidly increases in size and takes over the role as the sexually mature male. This life history strategy is known as sequential hermaphroditism. Because clownfish are all born as males, they are protandrous hermaphrodites.

Sequential hermaphroditism is a common reproductive strategy, maturing as a male and changing sex to female during the life history (Branch, 1981).

Protandrous (proto -first, androus -male) **hermaphrodites:** females are derived from sex changed males.

Butterflyfish (*Chelmon rostratus*); Crown Butterfly fish (*Chaetodon paucifasciatus*)

(Order- Perciformes; Family-Chaetodontidae)

Characteristics:

- Brightly colored salt-water organisms, have a variety of colors like black, silver, yellow, white and orange.
- Depending on the species, butterflyfishes range from 9-30 cm in length.
- Live in coral reefs located in oceans, found in Indian, Pacific and Atlantic Oceans.
- Eexhibit unique defense strategies.
- Cling to a mating partner throughout their lifetime.
- They are difficult to breed.
- Their life span range from 6 – 12 years.
- Head not depressed, without spines and bony ridges.
- Pectoral fins neither long nor reaching caudal.
- Dorsal spines: 9; Dorsal fin rays: 28-30; Anal spines: 3; Anal soft rays: 19 - 21.
- The butterfly fish is most closely related to the marine angelfish which is similar in colour but the marine angelfish is often much larger in size than the butterfly fish. Butterfly fish can be distinguished from angelfish by the dark spots on their bodies, dark bands around their eyes and the fact that the mouth of the butterfly fish is more pointed than the mouth of the angelfish.

Behavior:

Butterfly fish exhibit a unique and interesting behavioral trait while escaping from their predators. They hide themselves in cervices located in the coral in order to escape being detected by its predator. This is aided by their small size. Their predators include sharks, eels and snappers. There are over 100 known species of butterfly fish and they often cluster together and live in large groups. This large group habitat is called school.

Food Habits:

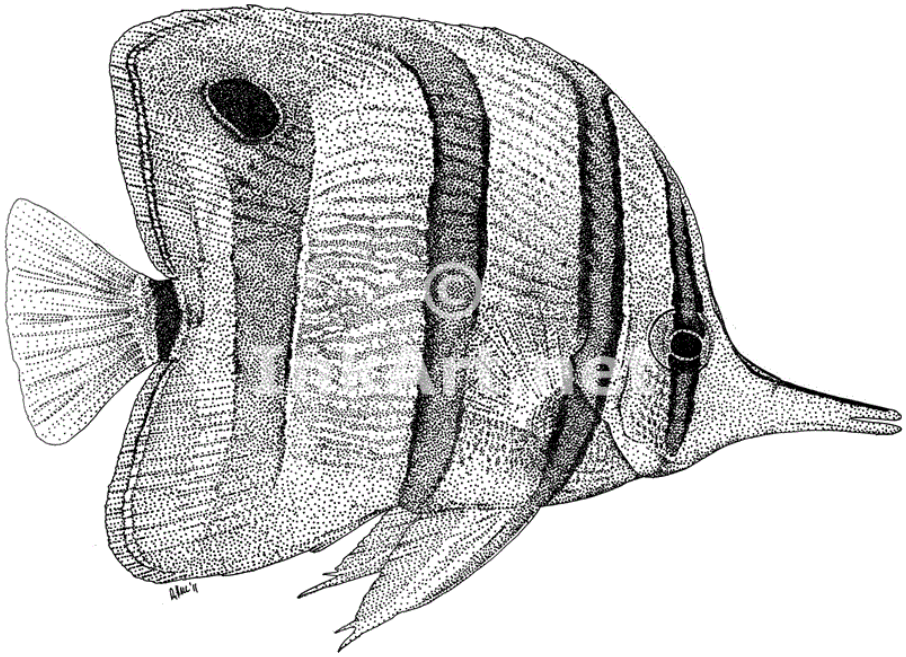
Generally benthic feeders, many butterflyfishes eat small invertebrates, sponges or polychaete worms. Some feed on zooplankton and others exist exclusively on coral polyps. Another feeding method is scraping the surface of live coral to obtain algae, attached invertebrates and mucus from the coral. Some are herbivores, grazing on the filamentous algae covering coral reefs and a few eat sea grasses and algae on reef flats.

Butterflyfishes have long snouts, with the degree of elongation depending on the species and the type of food it consumes. *Forcipiger flavissimus*, have extremely long jaws that can grasp invertebrates from narrow crevices.

Chaetodon ornatissimus, have short jaws for nipping off live coral polyps. The jaws of some butterflyfishes can measure more than 25% of their body length.

Sexing:

Butterflyfishes are in general, sexually monomorphic (males and females look alike), although occasionally males have been found to be larger than females.



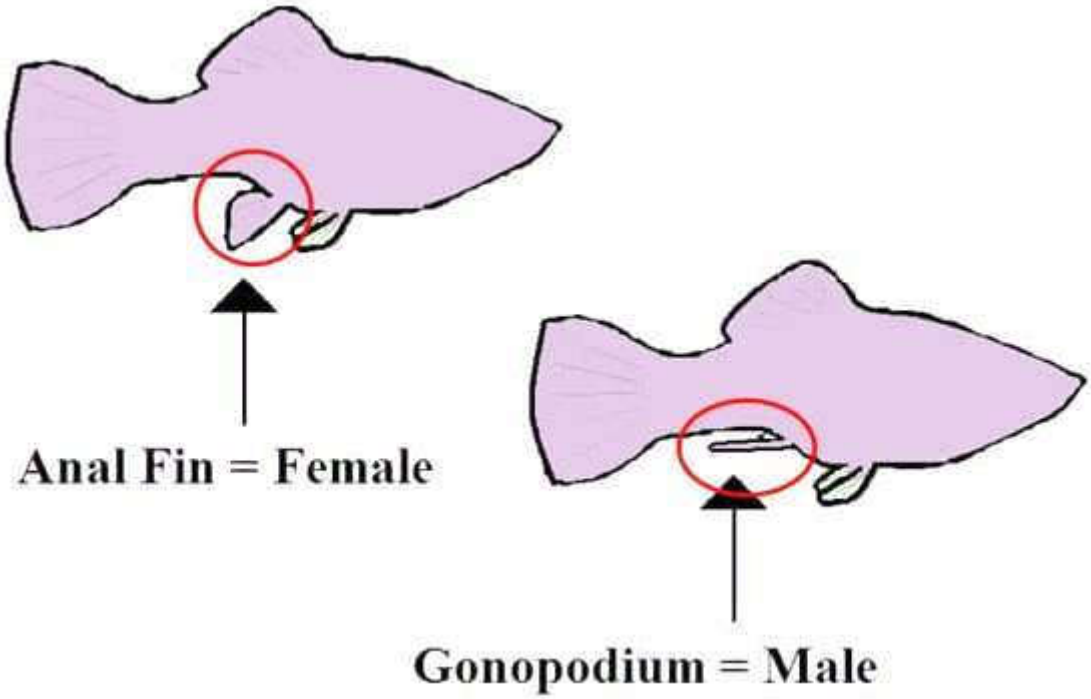
Butterflyfish

Changing sex

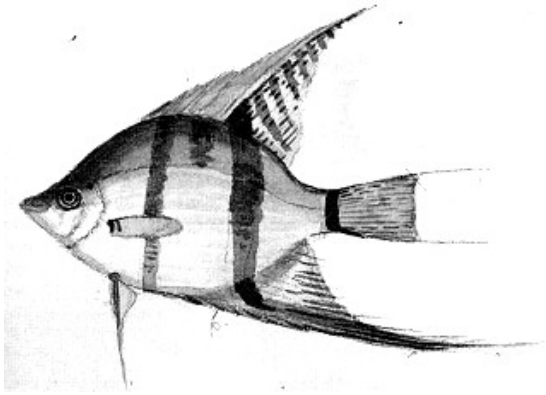
Group-living fish

- Clown fish live in groups with a large dominant female and a number of smaller males.
  - If the female is removed, the largest male becomes female.
- Bluehead wrasse have one male with a group of females.
  - Removal of the male causes the largest female to grow twice its size and change its colouration.

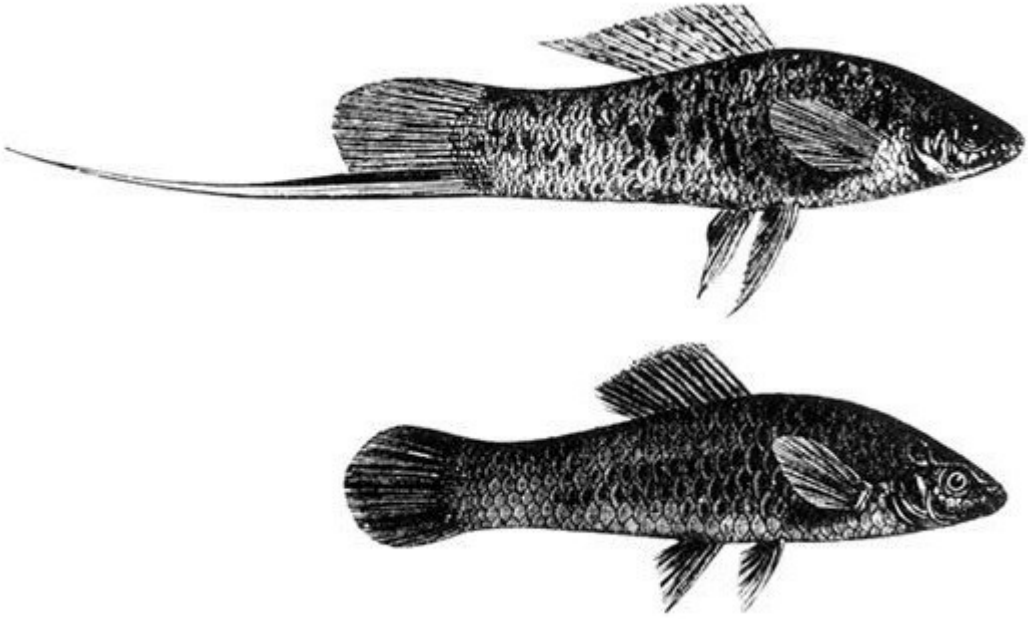
- This sex change is influenced by aromatase, an enzyme that controls the androgen:oestrogen ratio.



Molly

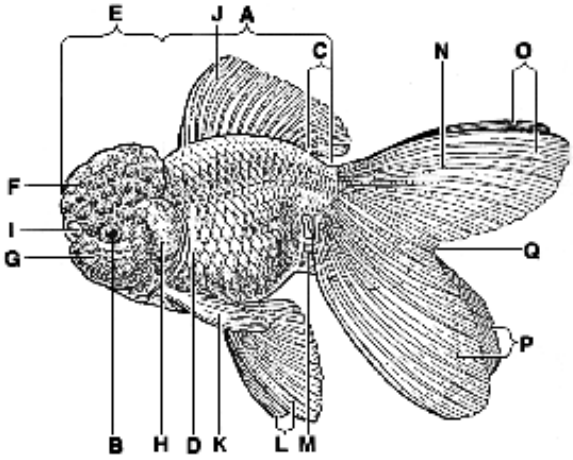


Angel fish

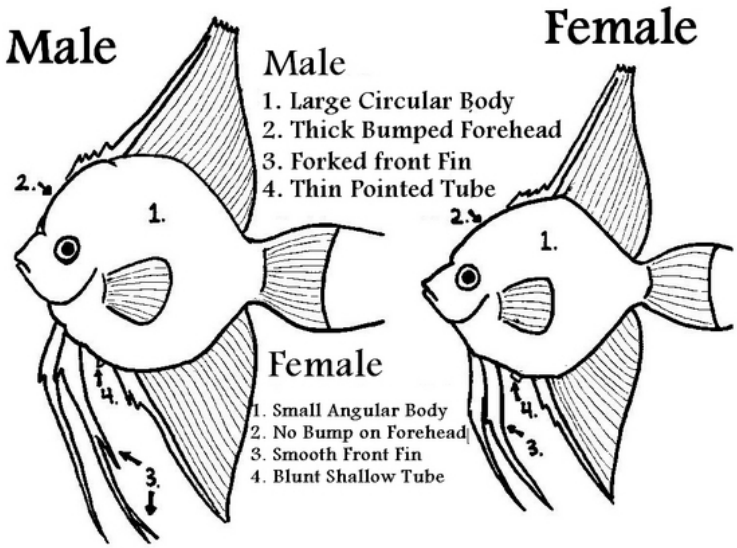


Swordtail

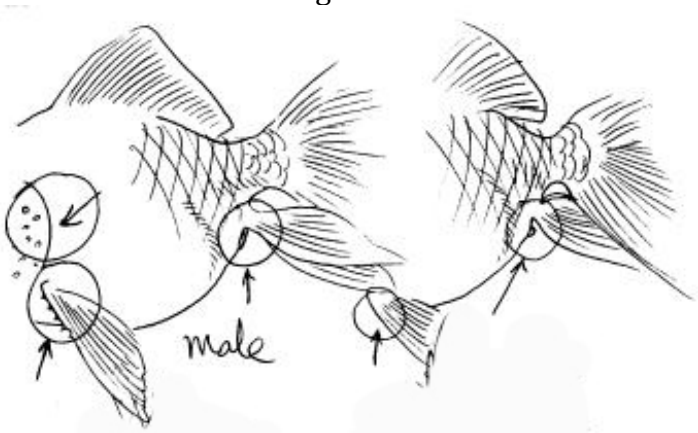
Goldfish Anatomy



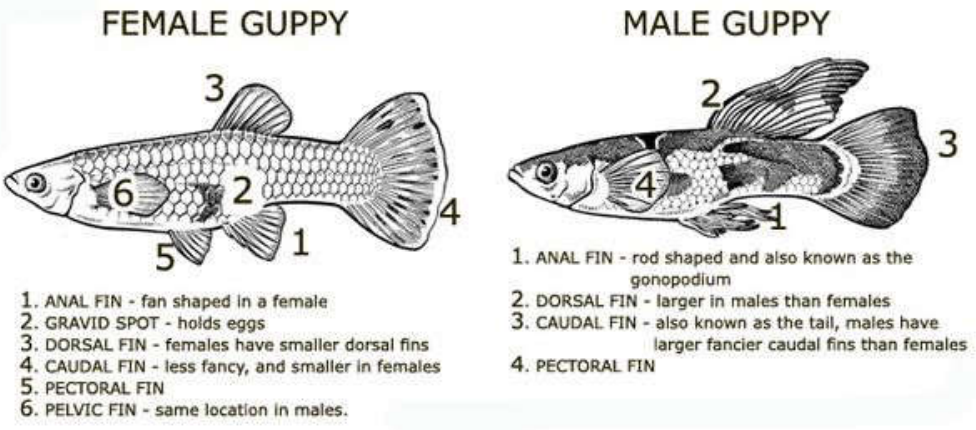
A - Body
B - Eye
C - Caudal Peduncle
D - Lateral Line
E - Head
F - Crainal Region (of head)
G - Sub Orbital Region (of head)
H - Operculum
I - Nasal Septum
J - Dorsal Fin
K - Pectoral Fins
L - Pelvic or Ventral Fins
M - Anal Fins
N - Caudal Fins
O - Upper Caudal Lobes
P - Lower Caudal Lobes
Q - Fork



Angel fish



Goldfish



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"Don't believe in luck, believe in hard work"

Fish Transportation

The mortality of fish, which may be expected during transportation, is mainly due to the depletion of dissolved oxygen and accumulation of gases like ammonia and carbon dioxide in the medium (water) of carriers. These gases are lethal as they may reduce the oxygen carrying capacity of fish blood. For example, if the concentration of dissolved free ammonia exceeds 2 ppm, the seed fish may die. However, the lethal limits owing to carbon dioxide in fish depend on the level of dissolved oxygen.

There are two basic transport systems for live fish: closed system and open system. The **closed system** is a sealed container in which all the requirements for survival are self-contained. The simplest of these is a sealed plastic bag partly filled with water and oxygen. The **open system** consists of water-filled containers in which the requirements for survival are supplied continuously from outside sources. The simplest of these is a small tank with an aerator.

The traditional way of fish transport in earthen pots still exists in some parts of our country. This method, however, has several drawbacks such as:

- The earthen pots are likely to break in transit.
- May be injured owing to the shaking of pots.
- Possible only for short distances and short duration
- Frequent changes of water may result in mortality of fish owing to differences in water quality.

Considering these, modern methods in which fish are transported in closed metal containers with oxygen packed medium, have now been advocated.

Fish are generally transported in containers such as cans of different sizes, pots of ceramic or metal, wooden or metal buckets, vats, barrels, plastic bags, styrofoam boxes, bottles, jugs, animal skins and bamboo sections. In fact, almost any clean, waterproof container may be used. Certain containers provide good insulation from heat, e.g., wood or styrofoam. Containers like metal or plastic are poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down.

Factors and Principles associated with fish transport

1) **Quality of Fish:** The quality of fish transported is a main criterion. The fish to be transported must be healthy and in good condition. Weakened specimens should be eliminated from the shipping, particularly when the temperature during shipment is high. Weak fish dies at higher rate than fish in good condition when the transport time is longer.

2) **Oxygen:** The most important single factor in transporting fish is providing an adequate level of dissolved oxygen. However, an abundance of oxygen within a tank does not necessarily indicate that the fish are in good condition. The ability of fish to use oxygen depends on their tolerance to stress, water temperature, pH, and concentrations of carbon dioxide and metabolic products such as ammonia. Heavier fish and those transported in warmer water need more oxygen. For instance, if the water temperature increases by 10˚C, oxygen consumption is about doubled. Oxygen deficit may occur when the density of fish is too high or the transport is longer than the fish can stand.

The dead fish compete with living ones for oxygen, increase bacterial multiplication requiring much oxygen and produce toxic metabolites. The slime produced by the fish is another substrate for bacterial growth resulting in a decrease of oxygen content in water. This process is intensified when water temperature is higher.

3) **pH, Carbon Dioxide, Chlorine and Ammonia:** Water quality is a function of the load of fish concentration and the length of time for which the fish are transported. The source of the water used during transport must have been tested before dispatching a mass consignment of fish. The water pH level is a control factor because the proportions of toxic ammonia and CO_2 contents are direct functions of pH.

   With increasing transport time, CO_2 production through fish respiration shifts water pH towards acidity. Water pH levels about 7-8 are considered as optimum. Rapid changes in pH stress fish, but buffers can be used to stabilize the water pH during transport. The organic soluble buffer trishydroxylmethylaminomethane is quite effective (1.3-2.6 g/L).

   Fish transported in tanks are exposed to gradually increasing concentrations of carbon dioxide. Adequate ventilation is necessary for transport units. Aeration of water will reduce concentration of dissolved CO_2.

   Chlorine is removed from the water by aeration (0.5 mg/L is considered as dangerous).

   Ammonia (NH_3) builds up in transport water due to protein metabolism of the fish and bacterial action on the waste. Decreasing metabolic rate of the fish by lowering the water temperature and thus diminish fish activity, reduces the production of NH_3. The production of NH_3 by bacterial action can be decreased by shipping fish only after food has been withheld long enough to void the stomach and intestine.

4) **Temperature:** Water temperature is an important factor. When water temperature is low, the pH remains higher and fish metabolism decreases. A need for adapting the fish to a lower water temperature may also arise before transport. Natural ice is used to the water @ 25 kg of ice will cool 1000 L of water by 2˚C.

5) **Density: T**he ratio of the volume of the fish transported and the transport water should not exceed 1:3 for heavier specimens but with smaller specimens, this ratio decreases to 1: 100/200. Stock density of the fish in container also depends on the length of transport time. Higher temperature of water allows a lower total stock weight.

6) **Biochemical changes and stress in transported fish:** Shipment conditions influence the composition of blood and the parameters of blood serum biochemistry. When fish are transported at higher densities, the levels of corticoids and glucose in the plasma increases and retains when the transport was finished.

   It should also be noted that release of fish at the destination can be the most critical stage of the transport process. The fish are under some degree of stress in the transport unit and sudden exposure to water of different characteristics or low quality will further stress the fish, often beyond what they can stand. Poor-quality water may mean freshly pumped ground water with low oxygen or high carbon dioxide content. Different characteristics of water often mean a pH, temperature or gas saturation difference between the transport unit and the receiving water.

Methods used for transporting fish

It is essential to maintain adequate oxygen in the water while transporting fish. The technique recommended for oxygenating water during fish transport is use of pure bottled oxygen. It may be bubbled continuously into an unsealed container during transport, or injected into a plastic bag containing water and fish, which is then sealed air-tight for transport.

When plastic bags are used, oxygen is added after water and fish. One-fourth of the bag usually contains water and fish and three-fourths contains oxygen. After adding oxygen the bag is sealed shut with a twisted rubber band, string or other material. As a precaution against leakage, the first plastic bag should be placed inside a second bag whenever possible. The sealed double bag of fish is then placed in a box, woven grass bag or other container for added protection and loaded onto a vehicle for transport. If properly packaged and insulated from heat, these containers can transport fish for 24 to 48 hours without water exchange.

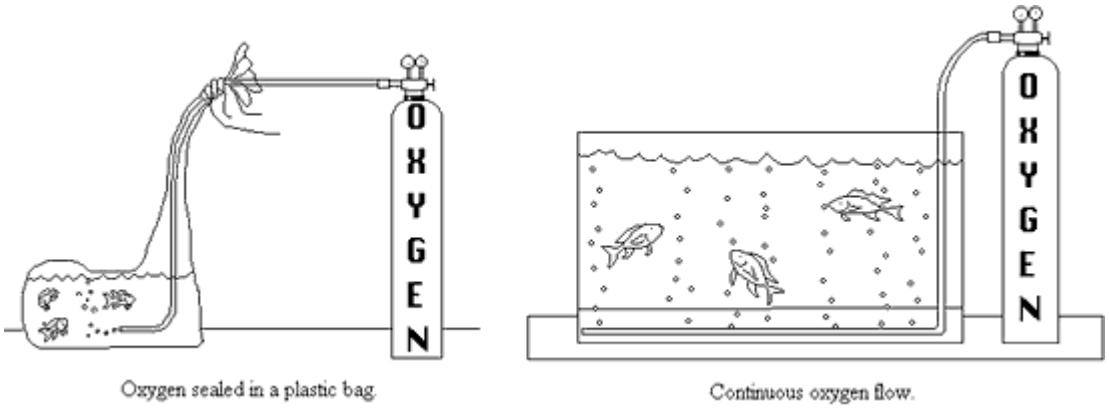

Fig. Illustrate the use of plastic bags and bottled oxygen in fish transport.

Chemical methods for water and fish treatment during transport

The chemical methods of treating the transport medium, aimed at increasing the capacity volume of the transport units and preventing physiological and health damage to the fish, constitute an integral part of the complex problem of fish transport.

1. Use of Tranquilizers

During transport, sedation of the fish is desirable, since oxygen consumption and CO_2 and NH_3 production are all decreased. Anesthesia usually applies only to transported brood fish. Tricaine methanesulfonate (MS-222) and quinaldine appear to be used most frequently. MS-222 (10-35 mg/L) is a very mild tranquilizer and fish easily recover from its effects even after a long stupor. Quinaldine (2–4 methylchinolin) (@15-30 mg/L) is a toxic liquid and must, therefore, be handled with care. The fish are usually treated with it when they are held in a large volume of water, such as a large tank.

2. Application of Sodium Chloride and Calcium Chloride

Handling stress and delayed mortality of fish can be decreased by the addition of sodium cloride (NaCl) and calcium chloride ($CaCl_2$) to the transport water. The sodium ion tends to "harden" the fish and reduce slime formation and the calcium ion suppresses osmoregulatory and metabolic disfunction. Calcium chloride may not be needed in hard

water already containing high concentrations of calcium. Huner (1984) recommended the addition of 0.1-0.3% NaCl and 50 mg/L $CaCl_2$.

3. Bacteriostatic Chemicals

Antibacterials are also used to check the development of bacteria in transport units. Among the wide spectrum of bacteriostatic drugs, the following are used most frequently: nitrofurazone (furacin) @ 10 mg/L, acriflavin @1-2 mg/L, oxytetracycline (terramycin) @ 20 mg/L.

4. Buffers

Among other chemical additives, buffers such as "tris-buffer" (tris-hydroxylmethyl-amino methane) are helpful in controlling pH at a favourable value of 7-8. The accumulation of carbon dioxide in bag transport allows for a decrease in pH, because carbon dioxide is an acid. 2.2-4.4 g/L (Johnson, 1979; Amend *et al.*, 1982) or 1.1-2.2 g/L (Dupree and Hunter, 1984) of tris-buffer are required to control pH in bags with only moderate loads, the use of tris-buffer in tank transport usually is impractical because of cost.

5. Ammonia Control

To control ammonia concentration in the transport bags when the transport is expected to be long, it is recommended to use clinoptilolite, a zeolite mineral. Amend *et al.*, (1982) tested with success the dose of 14 g of clinoptilolite/L.

6. Antifoam Chemicals

The formation of foam and scum, especially when drugs are used in transporting fish or on water which is heavily laden with organic material (secretions and excretions, such as mucus and excrements) often becomes quite bothersome. The foam interferes with oxygen exposure at the water surface and makes it difficult to observe the fish being carried. In some cases, 10% solution of Dow Corning Antifoam AF Emulsion is used at the rate of 0.05 ml/L of water (Leitritz and Lewis, 1976; Dupree and Huner, 1984). The advantages of using anti-foam chemicals are not so great, but their use does keep the water more clear so that the fish can be observed better.

Transport of breeders

Breeders have to be transported without shock and injury. This may be done using canvas carriers (1 × 1.25 m) or in splashless, closed and foam lined containers with compressed air. It is always better to give dip baths to the breeders in any of the antiseptics or antibiotics, such as methylene blue (2 ppm), copper sulphate (0.5 ppm), potassium permanganate (3 ppm) or sodium chloride (3%), so as to protect them against infectous bacteria, fungi etc. Further, before transport, the breeders have to be tranquilized using any one of the following anesthetics:

- Phenoxy ethanol (0.01-0.05%)
- Tertiary amyl alcohol (0.05%)
- Sodium amytal (50-170 ppm)
- MS222 (tricane Methane Sulphonate-0.1 ppm)
- Quinaldine (2-methyl quinoline) (0.01-0.05%)

Ensuring fish's safety prior to traveling

1. **Plan for transporting fish:** Most of fishes can survive for around 48 hour of travel, but beyond that risk increases and they will not survive. When you stop for the night, you need to take care the fish.

   Once fish have been placed in their transport container they are brought to their destination by the quickest possible means that will provide a relatively smooth and direct route. This may be by foot, animal cart, bicycle, boat, motorized land vehicle, train or plane.

2. **Change the water for a few days before moving fish:** Some of the water in aquarium should be changed prior to moving and transporting the aquarium. This helps ensure that the water in the tank is clean. Switch out 20 percent of the water in the aquarium daily for five days prior to transporting the aquarium.

3. **Avoid feeding for one to two days before moving fish:** Fish can go around a week without food, so they will be fine during transportation. Do not give food for 24 to 48 hour prior to transporting them.

4. **Wait until the last possible moment to pack the fish.** Should not pack the fish until you are ready to go and waiting to be transported. Should also plan to unpack your fish as soon as you reach your destination. They should be the first thing you unpack.

5. **Avoid unnecessary travel with your fish:** Fish are not pets that are easily transported. Should not take them on vacation with you or carry them around in a vehicle for fun. Fish are very fragile, which means you should only transport them when it is absolutely necessary, like when you are moving.

Choosing container for transportation of fish

1. **Place fish in plastic bags:** One way to transport fish is to put them in plastic bags. Fill the bag a third of the way full with water from the aquarium. Then, place one fish into each plastic bag. Don't put multiple fish in the same bag. Place a second bag over the first bag so that it is extra protected. Use a rubber band to secure the bags so the fish and water cannot get out. Going to have the fish in bags for longer than an hour, get some pure oxygen from store to place in the bags with them.

2. **Transport the fish in five-gallon buckets:** A five-gallon bucket can be an easy way to transport multiple fish in the same container. Buy a new bucket and don't use chemical or debris contaminated bucket. Make sure to cover the bucket with a watertight lid. Fill the bucket with water from your tank.

3. **Put the fish in a container:** Another way to transport fish is in a sturdy container that has a lid. Fill the container with water from the tank. Make sure the lid is secure so the fish doesn't fall out and water doesn't leak out. This may be good for fish with sharp fins or who may get out of a plastic bag.

4. **Transport the aquarium if it is small:** Small tanks can be moved with the fish and water in it. If you move the aquarium with water and fish, make sure to remove all other objects. Take out all rocks, decorations and filters. These may come loose and injure fish. Should also remove some of the water to reduce the risk of spillage.

5. **Transport fish in an insulated, secure container:** Placed fish in a bag or small containers and then pack them in a secure carrier. Place bubble wrap between the fish bag and the container. If have an insulated container, consider transporting fish in it.
6. **Choose a container large enough for fish:** No matter which container choose for transport of fish, should enough for swim around in. Large container has enough space with water has enough oxygen for the fish. Fill the container around a third of the way full and the rest of the container should be open for oxygen.
7. **Place all plants in plastic bags:** If you have live plants in your aquarium, put them in plastic bags filled with water from the tank. This will keep the conditions close to what they are in the tank and help keep good, essential bacteria alive on the plants.

Keeping fish safe during traveling

1. **Fill the containers with water from the top of the tank:** place fish in water from the overhead tank, not from the direct tap. Fill the transport container with water from the top of the tank. If water is collected from the bottom, wastes are in small container and potential exposing them to bacteria that has settled at the bottom.
2. **Avoid placing items in the container with fish.** Should not add fish's favorite rock or plant into the bucket or container with them. Any extra items may move around and harm the fish.
3. **Regulate the temperature.** Fish need to stay at their normal water temperature. Any fluctuations in water temperature can cause fish to get sick. Try to keep fish's water the same temperature of their normal aquarium. The fishes are transported in the part of vehicle where cooling and heating facility is available. insulation may also use to the transportation container which help regulate the temperature.
4. **Place fish in a dark place.** Transporting the fish in a darker state can help keep them from getting too stressful. Fish are active and awake during the day when it is bright outside. At night, they are less active. Place a sheet or rug over the container where they can get light during the day.
5. **Avoid feeding during travel.** Travel is very stressful for fish. Do not worry about opening bags or containers to feed fish. This also helps reduce the need for elimination, which can make the water it is traveling in dirty.
6. **Reintroduce the fish to the tank when you arrive.** If fish are transported in bucket, pour them and the water directly into the tank. Use a net to move them from the bucket to the tank. If the fish are in bags, place the bags on top of the water and let them float. This helps regulate the temperature of the water in the bags. When the temperature of the water in both are similar, pour the fish into the tank.

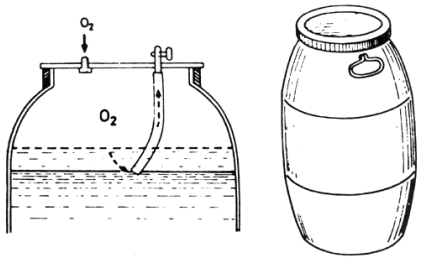

Fig. Plastic tanks

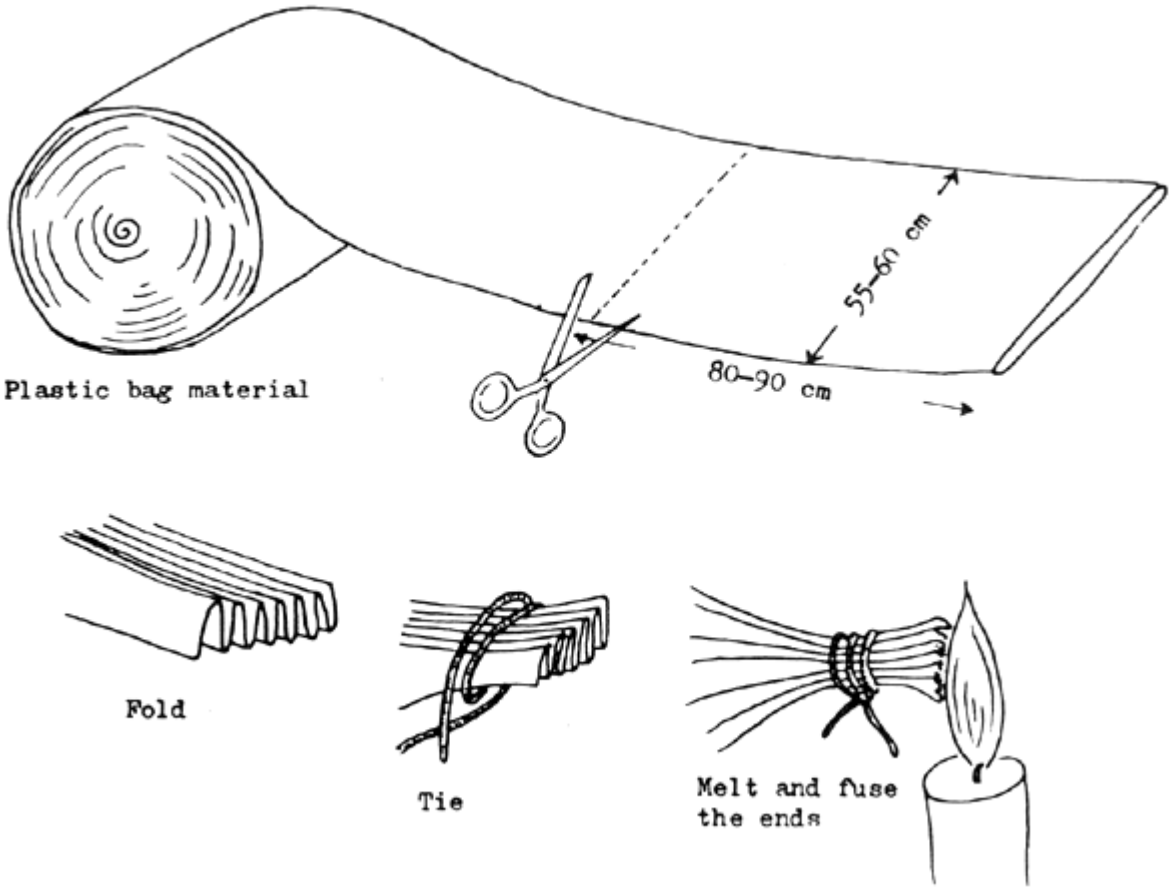

Fig. Procedure of closing the bottom end of a polyethylene sleeve

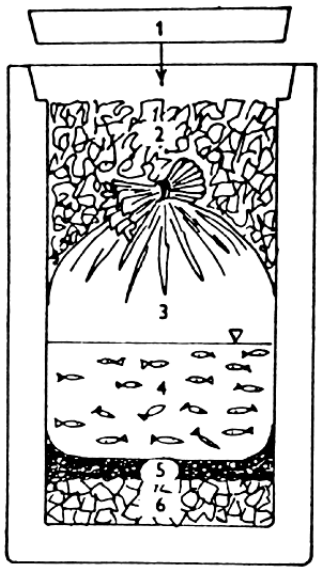

Fig. Transport of a bag in styrofoam case

A lower individual weight of fish means a much lower total weight of the fish that can be kept in a transport container due to the higher oxygen consumption and greater demand for space (the space factor increases considerably).

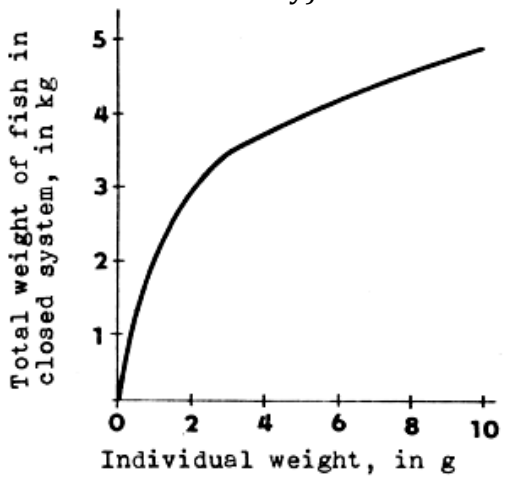

Fig. The dependence of cyprinid stock density in closed systems on the individual fish weight, in water temperature 20°C and transport time 5 h (Orlov *et al.*, 1974).

Stock density of the fish in container also depends on the length of transport time. The pattern of this dependence is characterized by hyperbolic curve, not straight line.

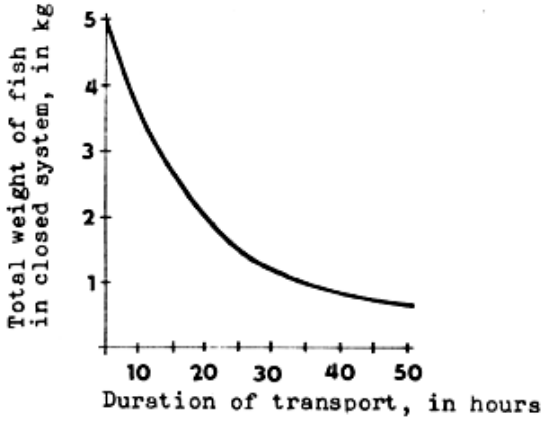

Fig. The dependence of the stock density of cyprinids in a closed system on shipment time; individual weight 10 g, transport time 5 h, water temperature 20°C (Orlov *et al.*, 1974).

The relation between the fish stock density in the container and water temperature is shown. Higher temperatures mean a lower total stock weight.

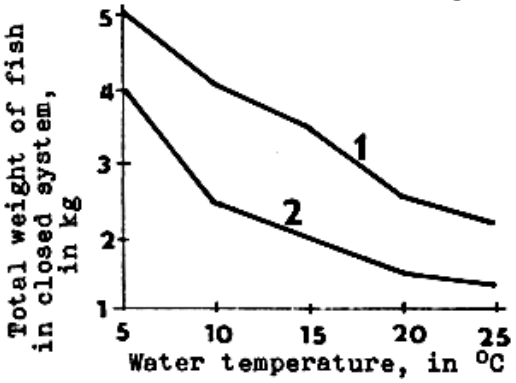

Fig. The dependence of cyprinid stock density in a closed system on water temperature; 1 - individual weight 10 g, transport time 15 h; 2 - individual weight 5 g, transport time 25 h (Orlov *et al.,* 1974)

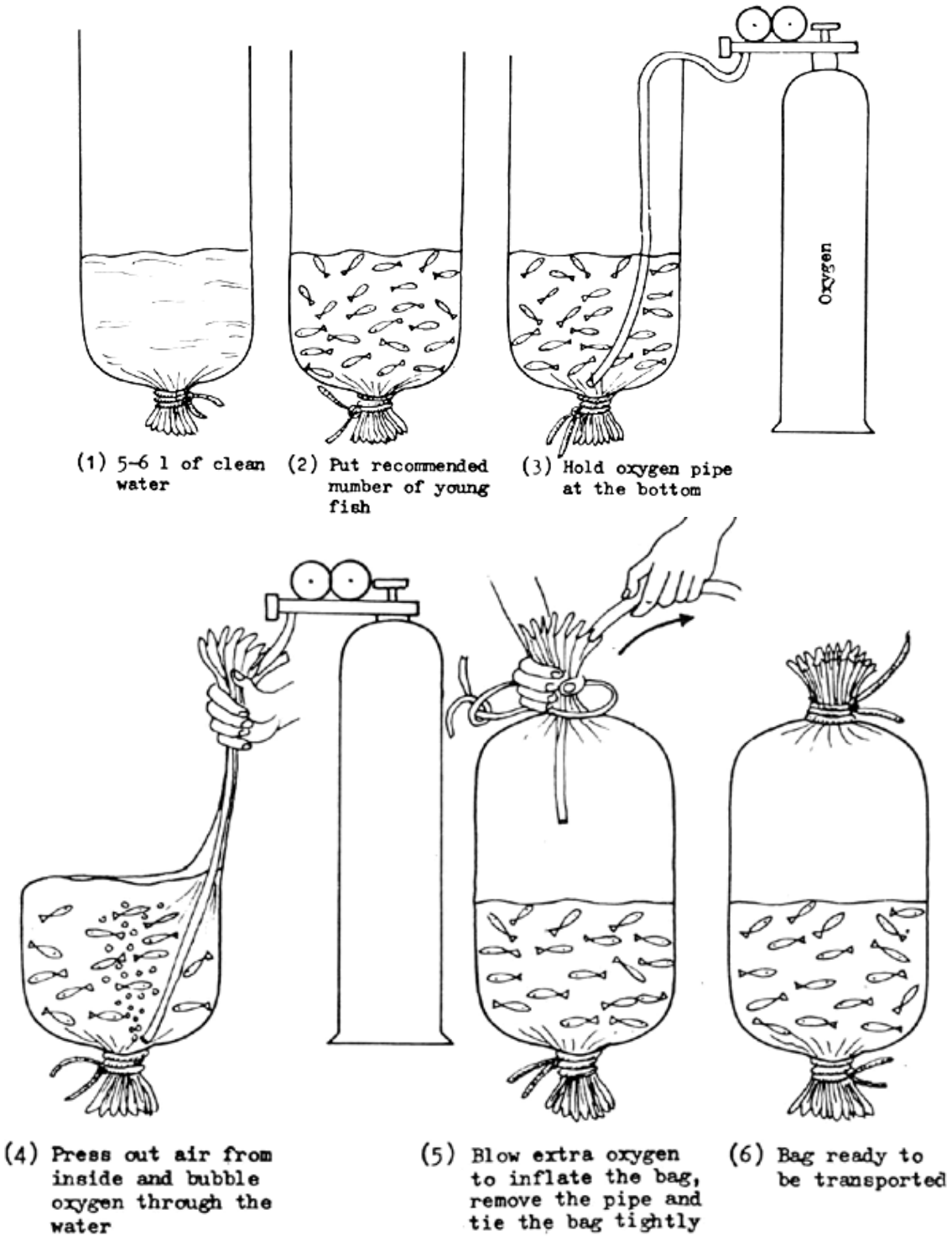

Fig. Procedure of filling the bag with water, stocking with the fish, displacing the air, introducing oxygen and closing the upper end (Woynarowich and Horváth, 1980)

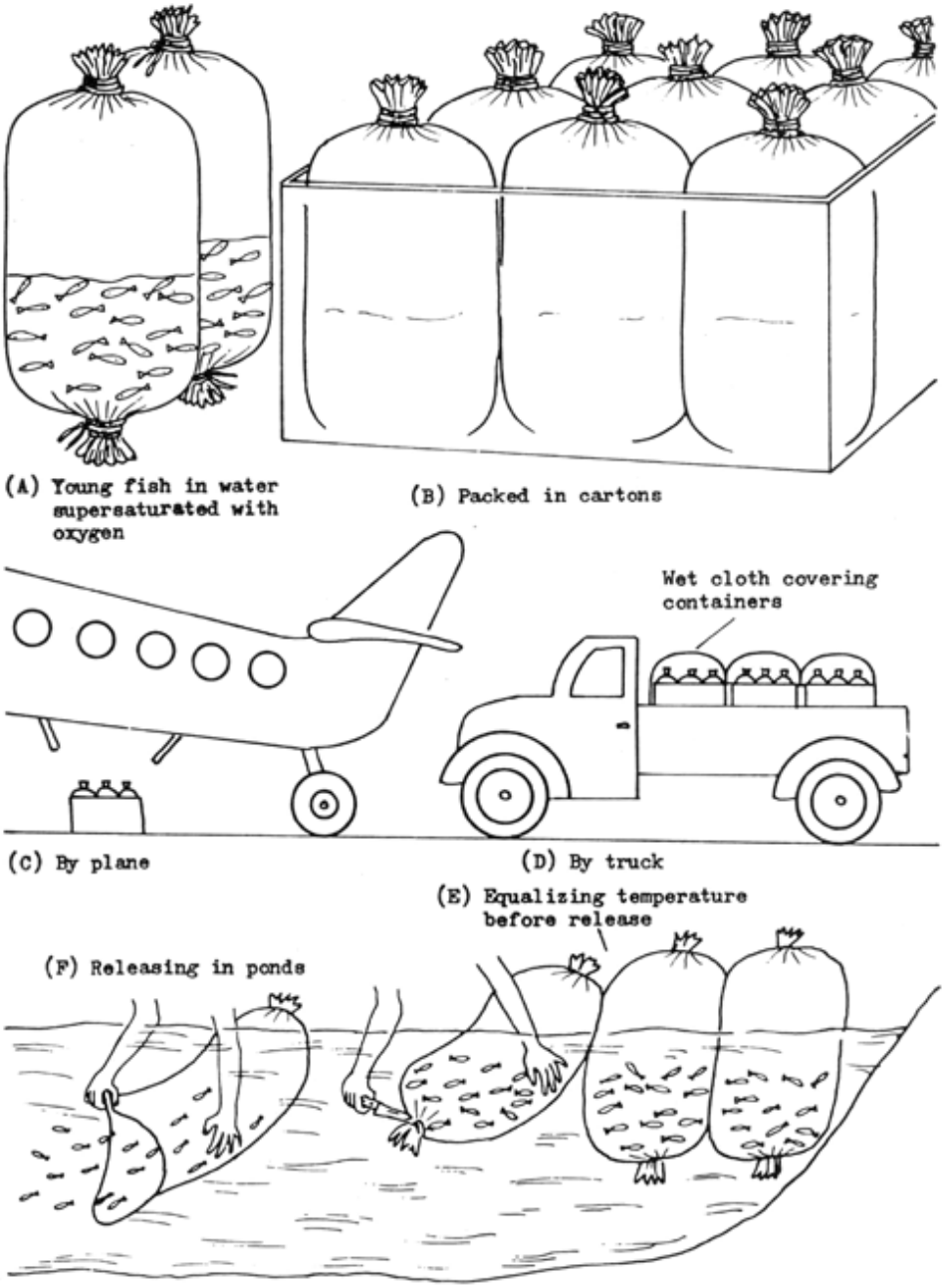

Fig. Transport of young fish packed in plastic bags (Woynarowich and Horváth, 1980)

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Potential scope of aquarium fish industry

Cottage industry: any relatively small-scale business operation carried on as from the home.

Cottage Industry is a specialized form of small-scale industry where the production of the commodity takes place in the homes and the family members usually supply the labour. The machineries utilized for the production of the commodities generally are the common ones used at homes. The basic characteristic feature of cottage Industry is that it is unorganized in nature and come under the group of small-scale industry type.

Next to birds, fishes are perhaps the most colourful among animals. Ornamental or aquarium fish keeping is emerging as one of the most popular hobbies across the world. The art of rearing and keeping fish in aquarium is a very primitive one. It first appeared in China towards the end of 800 BC with gold fish reared in glass bowl. Ornamental fishes are referred as the **"Living Jewels**" due to their colour patterns, elegant swimming styles, body shapes, admirable behaviour etc. Ornamental fish keeping and its propagation rainbow evolution has become an interesting activity not only for pleasure but also financial openings. In United States, aquarium keeping is the most popular hobby next to stamp collection.

Origin and History of fish keeping

The rearing of fish in confined or artificial environment is called **fish keeping**.

The name '**aquarium**' was first used by the English naturalist, Philip Henry Goose in 1853. The word aquarium is derived from Latin words *Aqua* = water and *arium* = a palace. Aquarium is a transparent container, containing aquatic animals and plants inhabit in it as well as their care and breeding.

Modern aquarium keeping of fish began in 1805. Anne Thynne (1846) built the first stable sustained marine aquarium and maintained corals and sponges for 3 years. In United Kingdom, aquaria in cast iron frames were featured at the exhibition in 1851. In 1853, the first large public aquarium was opened in the London Zoo, later known as Fish House. During the second half of the 19th century, a variety of aquarium designs were explored such as hanging aquarium on a wall, mounting as part of a window, combining with a bird cage etc.

Aquaria became more widely popular as houses had an electricity supply after world war-I. Electricity allowed artificial lighting, aeration, filtration and heating of the water. Plastic shipping bags were introduced in the 1950s, making it easier to ship the fish. The eventual availability of air freight allowed fish to be successful imported from distant regions.

In 1960s metal frames made marine aquaria almost impossible due to corrosion, but the development to tar and silicone sealant allowed the first all glass aquaria made by Martin Horowitz in Los Angeles.

One of the best facilities exists at Singapore, located on the Sentosa Island. Initially called oceanarium with room sized aquaria is renovated and designated the Corallium with a tunnel like facility where one moves on the horizontal escalator with kinds of marine fish

around him. Some large aquaria exist in Thailand and aquarium of Hawaii is another great attraction. At present, there are 60 million aquarists all over the world.

World scenario

The growing interest in aquarium fishes has resulted in steady increase in aquarium fish trade globally. The trade with a turnover of US $ 5 Billion and an annual growth rate 8% offers a lot of scope for development. The USA is the largest market for ornamental fish import followed by Japan and Germany. The Asian countries control more than 50% of the export trade in aquarium fishes and Singapore is the largest exporter. Home aquaria control an overwhelming 99% of the market for ornamental fishes while only 1% of the market controlled by public aquaria and research institute.

About 1600 species and varieties are commercially traded the world over. Singapore, Thailand, The Philippines, Hong Kong and Indonesia are the top five exporting nations. The most imported species are: guppy, neon tetra, platy, betta, Chinese algae eater and goldfish. Singapore being the largest producer of farm-bred ornamental fish handling about 50% of the available species and varieties called "**Ornamental capital of the World**". There are about 64 ornamental registered fish farms in Singapore, 10 of these engage for breeding of Dragon fish-occupying 133 ha. The Dragon fish or Royal fish has a life span about 100 year is a protected species and can be traded only by permit.

South America is the second largest exporting region, accounting 14% of the total annual value. Columbia, Brazil and Peru were the major suppliers.

Ornamental fish and aquatic plants were assigned a priority in the 3rd National Agricultural Policy (1998-2010) of Malaysia with plans to produce 800 million ornamentals by 2010. In recent, a mass propagation technique has been developed in Thailand to conserve the wild types and is becoming an important industry. The Government is promoting the ornamental fish industry and has set up an Ornamental Fish Research and Development Institute to provide training and technical knowledge to the local breeders for export promotion.

About 80% of the world's ornamental fishes that are traded come from the freshwater resources, remaining 20% from marine resources whose contributing increasing with advances in breeding and rearing technology. Presently, 5% of the marine fish are being bred and 95% collected from wild. On contrary, most of freshwater species are bred and cultured, the overall contribution of the culture species is 90% and only 10% being collected from the wild.

Indian scenario

Ornamental fishes of India are contributing about 1% of the total ornamental fish trade. These fishes are exported to the tune of 69.26 tons, having the value of Rupees 566.66 crores in 2014-15. On an average, an annual growth rate of about 11% has been recorded during the period 1995-2014. The MPEDA (Marine Products Export Development Authority) has estimated that India has the potential to earn about US $ 5 billion as foreign exchange by export of ornamental fishes.

India has great potentials in ornamental fish production due to the presence of rich biodiversity of species, favourable climatic conditions and availability of cheap labour. Kerala, Tamil Nadu and West Bengal mainly practice ornamental fish farming in India.

Indian water can be considered a **"Jewel mine"** for traders and hobbyists of ornamental fish.

Over 500 species of ornamental fishes are available in Indian waters, about 300 in marine and over 200 in freshwater. The ornamental species are categorized into indigenous and exotic. India is blessed with a rich diversity of freshwater fishes both in the North-Eastern hills and Western Ghats. Among the 300 species of freshwater fishes in the Western Ghats, 155 are considered ornamental; of which 117 are endemic to the Western Ghats. North-eastern states, West Bengal, Kerala and Tamil Nadu are also blessed with potential indigenous species. About 90% of native species (85% are from northeast India) are collected and reared to meet export demand. Presently, nearly about 100 native species are reared as aquarium fish.

There is a great demand for exotic species due to its colour, shape and appearance. More than 300 exotic species are covered in the ornamental fish trade, but a greater demand for this exists. About 200 species are bred in India. In our country 90% of exports go from Kolkata followed by 8% from Mumbai and 2% from Chennai. The top ten groups of ornamental fishes are: tetra, guppy, goldfish, catfish, molly, gourami, platy, loach, cichlid and barb. All the ornamental fishes marketed in India are exotic. Even though there are quite a lot of indigenous fishes, having high potential as ornamental fishes, they have not been properly exploited. MPEDA is working towards the goal by developing captive breeding for indigenous varieties of ornamental fish.

Benefits of keeping ornamental fish

- It gives pleasure to young and old people.
- It enables relaxation of the mind and thereby contributes to a healthy living.
- Children gains knowledge and skill.
- It develops attachment with nature and responsibility towards the welfare of other living beings.
- It creates a self-employment opportunity.

Ornamental fish species may e defined as fishes, which are reared as pets and not for consumption. They are smaller in size and coloured with majestic movement. The culture of ornamental fishes is called as **aquariculture**. Ornamental fishes are usually under eight closely related families: Anabantidae, Callichthyidae, Characidae, Cichlidae, Cobitidae, Cyprinodontidae, Cyprinidae and Poeciliidae.

Endemic ornamental fishes: Indian origin (Indigenous or native)

Classified Indian Ornamental fish: attractive, vibrant colour, smaller in size , compatible with other species

Non-classified Indian Ornamental fish: Less colourful but peculiar in morphology

Commercially important indigenous species

Common name	**Scientific name**	**Family**
Mourola	*Amblypharyngodon mola*	Cyprinidae
Zebra fish	*Brachydanio rerio*	
Kash koira	*Chela laubuca*	
Darke	*Esomus dancricus*	
Bata	*Labeo bata*	

Rosy barb	*Puntius conchonius*	
Saral punti	*Puntius sarana*	
Punti	*Puntius sophore*	
Teeta punti	*Puntius ticto*	
Dankuni	*Rasbora daniconius*	
Black shark	*Labeo calbasu*	
Nama chanda	*Chanda nama*	Centropomidae
Lal chanda	*Chanda ranga*	
Bengal loach	*Botia dario*	Cobitidae
Reticulated loach	*Botia lohachata*	
Honey gourami	*Colisa chuna*	Belontiidae
Banded gourami	*Colisa fasciata*	
Bele	*Glossogobius giuris*	Gobiidae
Stripped spiny eel	*Macrognathus aculeatus*	Mastacembelidae
Tiretrack spiny eel	*Mastacembelus armatus*	
Pankal	*Mastacembelus pancalus*	
Tangra	*Mystus vittatus*	Bagridae
Nona tangra	*Mystus gulio*	
Pabda	*Ompok pabda*	Siluridae
Black knife fish	*Notopterus notopterus*	Notopteridae
Nandos	*Nandua nandus*	Nanidae
Payra chanda	*Scatophagus argus*	Scatophagidae (Brackish water)
Pearl spot	*Etroplus suratensis*	Cichlidae (Brackish water)
Therapon	*Therapon jarbua*	Theraponidae (Brackish water)
Tepa	*Tetradon cutcutia*	Tetradontidae
Kankle	*Xenentodon cancila*	Belontidae
Kuche	*Monopterus cuchia*	Synbranchidae
Trigger fish	*Odonus niger*	Balistidae (Marine water)
Lion fish	*Pterios volitans*	Scorpaenidae (Marine water)
Butterfly fish	*Chaetodon unimaculatus*	Chaetodontidae (Marine water)
Surgeon fish	*Acanthurus glaucopareius*	Acanthuridae (Marine water)

Exotic ornamental fishes: non-indigenous having their origin in another country and has been introduced into the Indian waters. They generally have established culture technologies and marketability.

Categories based on breeding habits

Aquarium fishes are mainly categorized into two groups:

1. Live bearers (ovo-viviparous)**:** Fertilization internal, characterized by:

- Small sized for breeding and handling
- Lives in shoals
- Hardy and thrive on alkaline water
- Prolific breeders
- Omnivorous, diet consists of brine shrimps, white worm, blood worm, small pieces of fish, shrimp, clam and vegetable based frozen foods.
- Distinct sexual dimorphism is noticed.

Male	**Female**

1) Smaller in size	1) Larger in size
2) Brightly coloured	2) Dull coloured
3) Dorsal and caudal fins larger	3) Comparatively smaller
4) Belly flat	4) Belly bulged
5) Anal fin is modified into gonopodium	5) Anal fin is normal in shape

e.g., Guppy (*Poecilia reticulata*), Molly, Platy (*Xiphophorus maculatus*), Swordtail (*Xiphophorus helleri*), Gambusia

Ghosh (2007) reported parthenogenesis in golden guppy (*Poecilia reticulata*). Parthenogenesis is an unusual occurrence among live bearers.

2. Egg layers (oviparous)**:** Majority of aquarium species are egg layers and normally external fertilization occurs. Goldfish, Barb, Tetra, Zebra fish, Angel, Gourami, Fighting fish, Discuss, Shark, Koi carp. Because of their different breeding habits they are categorized into the following types:

2.1. Egg scatters with adhesive eggs: Tetra, Barb and Gold fish. Rainbow fish also lays adhesive eggs.

2.2. Egg scatters with non-adhesive eggs: *Danio*, *Brachydanio*

2.3. Egg depositors: Rasboras, Angel, Cichlid and Cat fish
Egg depositors either show parental care or do not care the offspring. The parental care is seen by most of cichlids and catfishes. Guarding the offspring either in open water or in protecting them in mouth cavity or body cavity.

2.4. Bubble nest builder: Gourami, fighting fish (*Betta spelndens*)deposit their eggs by building bubble nest. Males use to pick up the releases eggs o female by mouth and put them in the bubble nest. The female is taken out immediately after spawning as male drives the female away or otherwise shall chase the female till to death.

2.5. Mouth brooders: Include some cichlids in which female take care the fertilized eggs by carrying them in mouth. They are distinguished into:
2.5.1. Egg loving mouth brooders are categorized as ovophile. e;g., Cichlids
2.5.2. Larvae loving mouth brooders are categorized as larvophile. e.g., earth eater

2.6. Egg buriers: Deposit their eggs in a peat moss substrate. The eggs of Killi fishes remain viable and fertile for more than 1 month even the peat moss substrate dries up during summer.

Commercially important Exotic egg layers

Scientific Name	**Common Name**
Astronotus ocellatus	Oscar
Balantiocheilus melanopterus	Bala shark / Silver Shark
Betta splendens	Siamese Fighting Fish
Carassius auratus	Goldfish
Cichlasoma meeki	Firemouth cichlid
Cyprinus carpio var koi	Koi carp

Helostoma temmincki	Kissing gourami
Labeo bicolor	Red-Tailed Black Shark
Paracheirodon axelrodi	Cardinal Tetra
Paracheirodon innesi	Neon Tetra
Pterophyllum scalare	Angelfish
Rasbora heteromorphy	Rasbora, Harlequin Fish
Scleropages formosus	Asian arowana
Symphysodon discus	Discus/Pompadour fish
Trichogaster trichopterus	Three spot gourami

Commercially important Exotic livebearers

Scientific Name	**Common Name**
Poecilia reticulata	Guppy
Poecillia sphenops	Marble Molly
Poecillia velifera	Sail fin molly
Xiphophorus helleri	Swordtail
Xiphophorus maculatus	Platy

Constraints

- Ornamental fish industry in India is scattered and not well organized.
- Inadequate transport facility, high airfare and lack of packing
- Unavailability of funding.
- Absence of local exporting agencies.
- Scarcity of quality brood fish and lack of suitable low cost breeding technology.
- Present about 90% of the ornamental fish export based on wild collection. Capture based export is not sustainable, hence focus be given on culture based development.

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"Don’t believe in luck, believe in hard work”

General aquarium maintenance-budget for setting up an aquarium fish farm as a cottage industry

Build a homemade aquarium?

First, decide the size of your aquarium. The aquarium must be big enough to house all the fish. Fishes must have enough space to swim in the fish tank. Congested living space will negatively affect the health of the fish. After deciding the size of the aquarium, you may buy aquarium glass. Aquarium glass of different width and length are available in many stores. Assemble the glass pieces together with water-tight glue. The aquarium must also have a beautiful roof. They are available at pet shops. Choose a roof with a sliding window so that fish can be fed.

Now fill the bottom of aquarium with sea-sand for about 3 inches deep. Find some aquarium plants and embedded them deeply in the sand. Cover the bottom with ornate stones. Most of the aquarium fishes are pure-water fishes. Do not use chlorinated water in the aquarium. It will be better to use the water from a well or a bore well. Pour the water gently to the aquarium, without disturbing the sand at the bottom. Fill the tank up to 4 inches below the surface.

Don't put the fish directly to this aquarium. Change the water regularly for two days. This is to wash away any unwanted elements in the tank. During these two days, introduce the fish gently to a sample of aquarium water in another tank or bowl. This will help the fish to be habituated to the water in the aquarium. After two days, gently transfer the fish from the bowl to new aquarium. The fishes are disinfected with 2% potassium permanganate solution before introducing into the tank.

Now-a-days, acrylic fish tanks and aquariums, which are cheaper and more efficient than glass aquariums, are available.

Which fish to choose for aquarium?

This is the part where an aquarium becomes most difficult business. There are some of the most popular fishes in the market. Remember to choose some aquarium fishes that add light to your aquarium and economic.

Gold fishes are bright orange in colour. They are fluffy and cute, perfect companions to any aquarium. They are an inevitable part of many beautiful aquariums.

Angel fish is multicoloured. They have a wide and diamond body that often resembles an angel with wings. They are elegant and noble members of any aquarium.

Eel fishes are famous for their snake-like appearance. They have pride and elegance in an aquarium. Some species can produce electricity, so do not put other poor fishes along with eel.

Cat fish have nosy appearance and long whiskers. They are normally black or grey in colour.

Guppy is another popular aquarium fish, which can adopt well with the artificial eco-system within the aquarium. They come in many colours, and belong to the group of inexpensive aquarium fishes.

Betta are blue, electric and feathery. They are a cute and vibrant companion to your aquarium.

There are many other varieties of fishes to choose from. Before buying small family of fishes, make sure they contrast each other in appearance. Different types of fishes make an aquarium lively. But don't put dangerous fishes like fighter fish with other innocent fishes! Also, stick to your budget.

How to take care of aquarium?

Taking care of an aquarium is an important process. An aquarium is an artificial ecosystem created by man. A small error can disrupt the whole aquarium. Common aquarium maintenance tips are:

Adding filter pumps

Filter pumps are placed in an aquarium to purify water. Filter pumps expel excess carbon dioxide and pump oxygen to the water. Thus they help to maintain the oxygen level in the water at an optimum. Once you install efficient filter pumps in an aquarium, you have to change the water only once in a week. If more than one efficient filter pumps are added, you may change the water only once in two weeks.

The aquarium filter should be serviced monthly. A densely stocked aquarium may require more frequent filter cleanings. Do not use soap, bleach or chemical cleaners, because they will kill the beneficial bacteria required for healthy aquarium life.

Keeping ammonium content at a minimum

Increasing ammonia content should be checked in an aquarium. Many small leaves and plant residues decays and produce ammoniac content. This will affect the health of the fishes, especially their vision. If you recognize a pungent smell arising from the aquarium, you can assure increasing ammoniac content. You can shift this by changing the water.

Checking fungal infection

If the plant leaves experience yellowness before their ageing, it indicates fungal infection in aquarium plants. This too affects fishes adversely. If you spot fungal infection in aquarium plants, carefully uproot them.

Clean water and keep aquarium crystal clear

Aquarium always looks good when the water is crystal clear. Clogged and clouded water give a suffocating look. They are unhealthy to fishes as well. To keep the water clear, avoid dropping excess food in the water. Remove decayed plants regularly and any fungus that may creep up on the walls of the aquarium.

Aquarium maintenance: General tips

1) Do not put mutually fighting fishes and carnivorous fishes with other fishes in the same tank.
2) Gold fishes are the best in social behaviour.
3) Do not place aquarium in dangerous places, high altitudes, places where children can reach etc.
4) Do not place the fish tank where direct sunlight falls. This will cause fungus growth.
5) Do not use chlorinated water in aquarium.
6) Before planting plants, dip them in potassium permanganate solution.
7) Do not touch fishes with bare hand. Always use fish net.
8) Make sure to keep the aquarium water crystal clear and clean. Do not put excess food, decayed leaves etc.

Aquarium Maintenance Routine

A complete aquarium maintenance schedule includes daily, weekly, bi-weekly and monthly tasks

Daily

- Make sure the equipment is running properly.
- Watch your fish during feeding. Behavioral changes are a good indicator of a potential problem.

Weekly

- Count your fish. In case of fish death, smaller species can decompose quickly, resulting in ammonia and nitrite spikes and eventually high nitrate levels.

Every other Week

- Test your water for vital parameters: pH, carbonate hardness, nitrite, and nitrate.
- Clean the aquarium walls. Filter floss is fairly cheap and very efficient. Start from the bottom upward and rinse filter floss or scrubber frequently.
- Vacuum the gravel.
- Change 10-15% of the water.
- Rinse filter inserts with the extracted water.

Monthly

- Replace filter inserts, cartridges, floss, carbon, and Algone. Rinse entire filter if needed.
- Inspect tubing, connections, airstones, skimmers and other parts for proper operation.
- Clean aquarium top to assure your lighting is not affected.
- Check the expiration dates printed on the boxes and bottles of the aquarium supplies you use. Do not use after the imprinted date. Expired test kits will give false readings and may prompt you to take unnecessary action.

Goodies and accessories for the aquarium

There are a large number of goodies and accessories for aquarium that are available in the market. Some of them are for purpose, whereas some are for luxury. However, since the main purpose of keeping an aquarium is leisure, you may like to add some goodies to your aquarium. Here are some of them:

Aquarium tanks: Standard glass aquarium tanks have little market nowadays. Most people prefer acrylic, wall and corner aquariums. They range from about 100 $. Test the tanks for any leak before installation.

Filter Pumps: The function of filter pumps is to purify the water. They are available in many interesting models. Filter pumps shaped like oysters, scuba-divers, wrecked ships, treasure chests, sea horses etc are available in the market. The price of a filter pump is around 18$.

Thermometer: Thermometer helps to understand the temperature within the aquarium. This is important if you are keeping temperature-sensitive fishes. Price – around 3$ (150 Rs.). maintain the temperature of the aquarium at its natural level *i.e.*, 24˚C.

Eclectic heater: raise the water temperature whenever the water temperature is goes down. A thermostat is connected to the electric heater and senses the water temperature of tank.

Lighting proper way.

Fish nets: Fishnets are used for transferring fish from one fish tank to another. They are inexpensive and their price starts from 0.5 $ (25 Rs).

Water Pumps: The use of water pumps is to avoid the manual changing of water. Water pumps pump pure water from one corner while expelling used water from another corner. They can cost around 15 $.

Plastic plants: Live plants are always better, because they oxygenate the water. But plastic plants have some merits – they don't decay and cause ammoniac infection.

Coloured and ornate gravels and rocks: They are available in the market in various shapes and size. They help in beautifying the aquarium, they protect the sand from disruption and also fix the root of the plants. The bottom of the tank have slope slightly towards the front for better vision.

Backgrounds: Aquarium backgrounds are merely for entertainment. Picture backgrounds with seashells, sponges and treasure chest adds to the beauty of aquarium, in every way.

The aquarium glass is cleaned of from algae and other dirt by steel wool or a razor blade.

Stocking density of aquarium

Stocking density refers to the number of fishes in a tank can support the long life and survival. It is based on:

- Length of fish
- Volume of water (volume of the water is measured by multiplying the length, width and height of the tank).

The ideal stocking density is as follows:

1 cm long fish /1L of water or 2 Inch long fish /1 gallon of water.

The recommended space is 75 cm^2 for every 2.5 cm of fish body length.

Aquarium water changes

Water changes are the most important part of routine aquarium maintenance. An average water change of 10 – 15% is every two weeks. Maximize your efforts by using a siphon to extract aquarium water while "vacuuming" the gravel. This will remove uneaten fish food, fish excreta and other harmful waste settled at the bottom of the aquarium. When performing aquarium maintenance, test the water parameters of both, the aquarium and replacement water.

Tap water (municipal water) contains chlorine or chloramine. Chlorine will air out if kept in an aerated bucket for 24 hours. Chloramine will not. Chloramine = chlorine + ammonia. Either way, it is best to use a water conditioner to neutralize the chlorine. Ammonia will remain in the water if it contained chloramine, even after treatment with a conditioner. Nitrifying bacteria will break down the ammonia after adding the water to the aquarium.

Other elements of municipal water may be phosphates, iron and other heavy metals. Generally, well water is harder than municipal water, but it should be chlorine and chloramine free.

Do not overfeed or over stock the aquarium. The increased waste will result in difficulty maintaining a healthy fish tank.

Testing the Aquarium Water

Vital parameters to test as part of routine aquarium maintenance include nitrate, nitrite, pH, carbonate hardness and salinity (saltwater only).

Nitrates should be kept below 10 ppm in freshwater and 5 ppm or lower in saltwater and reef aquariums.

Nitrites should be undetectable at all times (except during cycling). If nitrite is detectable, be sure to test for ammonia as well.

pH must remain stable. pH in the range of 6.5 – 7.5 is suitable for most species, but they should be fine if it's slightly out of range.

KH (carbonate hardness) is a measure of pH stability. If KH drops close to 4.5 dH (degree hardness) or 80 ppm, you should monitor it frequently. If hardness drops below 45 dH, the pH of the aquarium water will crash. A half teaspoon of baking soda per twenty-five gallons of water, raises kH by approximately 1 dH (17.8 ppm).

Fish food and how to feed them?

Pet fishes should be fed twice in a day. Do not feed aquarium fishes too much. Usually fish food bought from pet stores is used to feed fishes. Sometimes, small plants like azola are used to feed fishes. Feeding other food items may cause pollution of aquarium water. Similarly, never drop fish food for 3-4 days in the aquarium all at once. This also will cause clogging of water.

The feed may be placed in a **feeding ring** fixed on the surface of the water. The cup device is usually for holding *Tubifex*.

Fish diseases and how to cure them

Fish diseases are extremely contagious. Therefore, whenever you spot a fish with symptoms of a disease, shift it to another tank and provide treatments for the fish immediately.

Usual fish diseases, symptoms and treatments

1. **Bacterial infection:** A rash-like appearance in the gills and outer skin of the fishes indicate bacterial infection. To prevent bacterial infection, dissolve oxydedracyclin (500 ml) in two litre water and add this water to the fish tank.
2. **Fungal infection:** The main symptoms of fungal infection are wounded and bulging body. Some fishes also experience a loss in scales.
3. **Ulcerative enteritis** infection occurs through water. This can be prevented only by ensuring that the water is 100% pure each time. Once spotted, shift all the fish to a tank filled with clean and pure water.
4. **Columnaris:** Bacterial disease, the main symptom is grey patches in the body, especially around mouth. Medicines against bacteria should be provided.
5. **Gill disease** is easy to recognise. The fish will flutter its gills as if it is rushing. This is a parasitic disease. Water should be cleaned fast. Chlorine and impure water is a major reason.
6. **White spot disease (Ick disease):** Parasitic disease. Ash spots on the body of the fish are the main symptom. Ick is a kind of protozoa that grows within fish skin. Later they will be shed and this will multiply. This disease is highly spreading. Proper medicine should be given.
7. **Fin-rot disease:** As the name suggests, the fin of the fish will gradually become hard and will decay. Anti-bacterial medicine can help.
8. **Pop-eye disease:** The eyes of the fish become protruding. The reason for the disease can be over-oxygenated water. This disease can't be really cured. However, shifting the fish to less oxygenated water and treating with anti-bacterial medicines is generally done.

Aquarium fish farm as a cottage industry

A small-scale ornamental fish farming is a profitable business and any one can start this business as home-based. Ornamental fish farming is a financially lucrative project and also self-rewarding. In addition, keeping aquarium fishes is one of the oldest and most popular hobbies in the world. However, need some basic skill and knowledge about the breeding and rearing. Broadly, there are 2 categories according to the breeding behaviour: egg layers (oviparous) and livebearers (ovo-viviparous). The growing interest in aquarium fishes has resulted in a steady increase in aquarium fish trade globally.

The growing interest in aquarium fishes has resulted in a steady increase in aquarium fish trade globally. The top exporting country is Singapore followed by Honking, Malaysia, Thailand, Philippines, Srilanka, Taiwan, Indonesia, and India. However, the largest importer of Ornamental fish is the USA followed by Europe and Japan. The growth of ornamental fish trade globally is very much encouraging. Most of the ornamental fishes cultured and marketed are exotic species.

Basic requirement to start ornamental fish farming business

Tanks

The tanks can be of reinforced cement concrete water tank or brick masonry work having flat bottoms with inlet and outlet pipes. Now a day clay, cement, fiberglass or plastic tanks are also used. The size of the tanks varies according to space, the number, and type of fish culture. Rearing of fishes are in large tanks.

Aquariums

Glass tanks of varying size are required for breeding. Small glass bottles of 250 ml for keeping individual male fighter fishes are used. Number and size of the glass tanks depend on the specific breeding/spawning behavior of the species selected.

Overhead tank

An overhead tank of suitable size for storing and to enable sedimentation of water is required.

Water Supply

Deep tube wells are the best source of water. Users can try recycling water through bio-filters or another sort of filtering mechanism. Other sources like dug wells, municipal water if available can also be used. Furthermore, need a small pump to lift the water to the overhead tank and a network of pipes to feed the culture tanks.

Work Shed

Work shed should be designed in such a way that the tanks get filtered sunlight. Translucent high-density polyethylene sheets can be used. This also protects the culture tanks from falling debris and bird dropping etc.

Aeration equipment

A blower pump with a network of tubes for aeration is necessary. Additionally, you must ensure continuous power supply through generator set or UPS or inverter.

How to start ornamental fish farming business

Like any other livestock farming, ornamental fish farming may attract financial losses because of poor management and disease attack. Therefore, it is very important to handle the farm carefully. The basic requirements for successful breeding and rearing of ornamental fish are adequate space, quality water and sufficient feed.

Business plan

This is the first of any business. There are several factors you must determine before the business plan. Determine whether you want to initiate a breeding and rearing farm or only rearing farm. Because you will need to put the other things on the basis of this. Then select the fish species. It is advisable to start with small. Create a financial projection and of course, determine the marketing plan. Where to sell the fishes and how you would go to compete with other sellers.

Select farm location

First, fix a location. You can start from your backyard. You can also initiate the business from a rental location. However, try to ensure a location nearby a market. Therefore, you can access easily the market and transportation facility both.

Prepare fish tank or Pond

You can start ornamental fish farming with the tank. You can use plastic, cement or glass tank. If you want to offer, retail sale from your farm, then it advisable to use a glass tank. However, you can also use the pond. You will need to procure small and big tanks. Generally, small tanks are used for growing fish fingerlings. In addition, you can use a large tank or pond for rearing big fishes.

Select fishes

According to the local market demand select the fishes carefully. However, you can also initiate a fully export-oriented fish farm. In addition, for that, you must depend on the international market demand. However, some of the most popular aquarium fish species are Molly, Guppy, Platy, Swordtail, Blue Gourami, Pearl Gourami, Rosy Barb, Gold Fish, Fighter, Angel etc.

Fish rearing

In ornamental fish farming, you must manage the farm efficiently. Generally, you can use cement tanks. Cement tanks are easy to maintain and durable. You can sock one species in one tank. However, in the case of compatible species, two or three species can occupy the same tank. Groundwater from dug wells / deep tube wells/ bore wells is the best for rearing fish. The fishes reach marketable size in around 4 to 6 months. You can harvest eight to ten crops in a year.

Feeding

Young fish are fed mainly with infusoria, *Artemia*, *Daphnia*, mosquito larvae, *Tubifex* and Bloodworms. For rearing, you can use formulated artificial or prepared feed. However, try to develop a feed that has a low polluting effect, cheap to prepare and easy to store.

Promote ornamental fish farming business

Proper promotion of the product is important. Aquarium shop is a very good option. You can sell you fishes from your own shop. In addition, you can also distribute the fishes to the other retail outlets. Register your business with local b2b directories. Create your business website and join the fish farming associations. Finally, try to build a wide and strong distribution channel to promote your ornamental fish farming business.

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Use of live fish feed organisms

Live food organisms include all plants (phytoplankton) and animal (zooplankton) lives grazed upon by economically important fishes. Phytoplanktons are generally eaten by zooplankton. Thus, phytoplankton forms the basis of the food chain. In an aquatic ecosystem, the live food organisms constitute the most valuable resource for aquaculture. Most of the fish and shellfish larvae in nature feed on small phytoplanktonic and zooplanktonic organisms. However, natural fish food organisms are usually not abundant in clear pond water, but are abundant in ponds having greenish water. The green colour indicates the presence of phytoplankton and other natural food organisms. In the natural food web, zooplankton constitutes a major part of the diet for marine fish larvae and it is generally believed that copepods can meet the nutritional requirements of fish larvae.

In the wild, fish eat a range of foods and their diet is dependent upon the availability of food in the particular environment. However, when the ornamental fish are maintained in aquariums, tanks, ponds etc. there is utmost necessity of balanced nutrition in natural foods and artificial diets for their maintenance, growth, reproduction and health. Ornamental fish prefer live foods due to its small size as well as movement of live foods induce fish to catch them. Live food organisms contain all the nutrients such as essential proteins, lipids, carbohydrates, vitamins, minerals, amino acids and fatty acids and hence are commonly known as **"living capsules of nutrition"**. Some time live food can be freeze dried and used for feeding of ornamental fish.

Classification of Natural live foods

1) Plankton
2) Periphyton
3) Macrophytes
4) Benthos
5) Others

1. Plankton

Planktons are microscopic passively or weakly free floating organisms. On the basis of their size, planktons are classified as:

i) Ultraplankton (0.5-1 µm)
ii) Nanoplankton ((10-50 µm)
iii) Micro or Netplankton (50-500 µm)
iv) Macroplankton (>500 µm)

1.1. Phytoplankton

Plant origin, consists of chlorophyll, microscopic autotrophic algae. Planktonic algae are classified mainly based on their pigmentation and food storage:

1.1.1. Chlorophyceae (Green algae): Green pigmented algae with chlorophyll

1.1.1.1. Unicellular free floating non colony forming: e.g., *Chlamydomonas*, *Chlorella*
1.1.1.2. Unicellular colony forming: e.g., *Volvox*, *Eudorina*
1.1.1.3. Multicellular unbranched filamentous: e.g., *Spirogyra*, *Ulothrix*

1.1.1.4. Multicellular nonfilamentous: e.g., *Pediastrum*, *Cosmerium*

1.1.2. Bacillariophyceae (Diatoms): Golden brown colour due to chlorophyll c and carotenoid pigment β-carotene and xanthophylls.

1.1.2.1. Centric diatoms: round and radially symmetrical e.g., *Stephanodiscus*, *Cyclotella*
1.1.2.2. Pennate diatoms: elongated and bilaterally symmetrical e.g., *Fragilaria*, *Skeletonema*

1.1.3. Cyanophyceae/Mixophyceae (Blue green algae): Presence of chlorophyll a, b, carotenes, xanthophylls and phycobilins, with a gelatinous sheath. These planktons are not used for ornamental fish feeding. e.g., *Nostoc*, *Anabaena, Spirulina*

As having good nutritive value, *Spirulina* can be used as one of the ingredients of artificial feed.

1.1.4. Euglenophyceae (Euglenoids): Green colour due to chlorophyll a, b, β-carotene and xanthophylls. These are unicellular flagellates, mostly free swimming. e.g., *Euglena*, *Phacus*

Among these all phytoplanktons, *Chlorella* is important for ornamental fish feeding and zooplankton production.

1.2. Zooplankton

Zooplankton, the microscopic free swimming animal components of aquatic ecosystems, are represented by a wide array of taxonomic groups:

1.2.1. Protozoa: Microscopic, soft bodied, serve ideal live food for ornamental fish. e.g., *Paramoecium*, *Vorticella*

Infusoria refers to microscopic single celled animalcules belonging to the Class-Ciliata of Protozoa. They are minute in size, soft bodied and nutritionally very rich and therefore, serve ideally as starter diet for early stages of fish larvae.

1.2.2. Rotifera: Slow moving rotifers are most important for culture and seed production of ornamental fishes. e.g., *Brachionus*, *Keratella*, Filinia

Brachionus is more popular live food because of its high nutritive value, small size, worldwide distribution, fast multiplication and easy adaptability to captive culture.

1.2.3. Crustaceans: Characterized by two pairs of antennae, appendages are typically biramous. Important crustaceans are:

1.2.3.1. Cladocerans: Commonly known as **water fleas** e.g., *Daphnia*, *Bosmina*, *Moina*

1.2.3.2. Copepods: Free swimming, abundant in fresh and marine habitat, occupy important place in the aquatic food chain. e.g., *Cyclops*, *Diaptomus*

1.2.3.3. Ostracodes: Bivalved crustaceans with laterally compressed body, usually known as seed shrimps. They are oval or bean shaped, found in pools, streams especially in shallow water where aquatic weeds or algae are abundant. e.g., *Cypris*, *Stenocypris*

1.2.3.4. Anostraca: The most common anostracans is Brine shrimp (*Artemia salina*), most accepted live feed for ornamental fish, contain all essential fatty acids and significant concentration of vitamins and carotenoids in addition to protein content (50-60%).

Zooplankton is required as a first food for many cultured fish; for others it contributes to faster growth and higher survival. Larvae of fish cannot feed artificial supplemented feed. They require small size live foods for their nutrition. Live foods are easily digestible protein rich diet for fish.

1.3. Bacterioplankton

Free floating bacteria, are not important live food for ornamental fish in captive condition.

2. Periphyton

Microscopic organisms (plants mainly algae and animals mainly microbes) which grow attached on materials submerged in water, not important live food for ornamental fish in captive condition.

3. Macrophytes

Microscopic plants confined themselves to shallow euphotic zone of the water bodies, not important live food for ornamental fish.

4. Benthos

Benthos, the assemblage of organisms inhabiting the bottom, show marked diversity upon the change of depth and properties of the sediments.

Some species of crustaceans (Isopods), chironomid larvae, oligochaetes worms (*Tubifex*), Hemipterans (water bugs), Coleopterans (Caddisflies), Dipterans (True flies, mosquitoes), Molluscans (*Pila*) constitute a bulk of the benthic fauna, its larval forms are good live food for ornamental fishes.

5. Others

There are so many other miscellaneous live foods available for ornamental fishes such as earthworm, white worm, micro worm, eggs of ants etc.

Sources of Live foods

1. Natural collection

Planktons can be collected from natural sources with the help of plankton net for ornamental fish culture and breeding. *Artemia* can be collected from natural marine water source. *Tubifex* worm can be collected from sewage drain.

2. Production in semi-intensive culture system

A combination of organic manures and inorganic fertilizers is preferred in ponds for natural feed production.

3. Mass culture of live foods

Cultured under controlled condition for its regular availability.

3.1. Culture of Infusoria

Collection of banana peelings >> Place in clean big jar (50L) >> Add water >> kept in cool place >> covered with mosquito net >> kept the culture undisturbed for 2 days >> water turns yellow, smell foul due to decomposition of banana peelings by bacteria >> A film of

32transparent light yellowish colour >> slime on the water surface breaks up and disintegrates, harvest infusoria with the help of plankton net.

3.2. Culture of Crustaceans

Cemented culture tanks (500 L capacity) filled with freshwater >> Fertilization with GNOC (@75 ppm), SSP (@20 ppm) and Urea (@8 ppm) >> Inoculated with *Moina*/*Daphnia* (@ 40-50 individuals/L) >> attains a peak density of 20,000-50,000 individuals/L within 5-7 days >> harvest with the help of plankton net.

3.3. Culture of *Artemia*

Collected commercially available *Artemia* cyst and cyst can be hatched out under controlled condition for production of *Artemia* naupli.

Step-I: Hydration of cysts: Dry cysts are put in a container with water (20 ml water for 1 g cysts). About 1 hr the cyst is hydrated and turns spherical. The hydrated cysts are then filtered by 100 µm mesh silk cloth.

Step-II: Removal of the shell: Two types of chemicals are available for the purpose either sodium hypochloride (NaOCl) or bleaching powder. Chorion of the cyst is dissolved and the colour of cysts turns white.

Step-III: Hatching of decapsulated cysts: Decapsulated *Artemia* cysts are hatched in cylindrical FRP jars of varying capacity (5-500 L) depending on requirement. The optimum water quality conditions required for hatching: Temperature 27-30˚C, pH 7.5-8.5, Salinity 25-30 ppt, Light 1000 lux and dissolved oxygen saturation point. The decapsulated cysts in the jar are stocked @0.5-1 g/L. Vigorous aeration provided at the cone of the jar. The cysts hatch into naupli in about 12-24 hr depending on strain of *Artemia*, quality of cysts and water temperature.

Step-IV: Harvesting of nauplii: The freshly hatched *Artemia* nauplii are harvested in 100 µm mesh net by taking advantage of their photostatic nature.

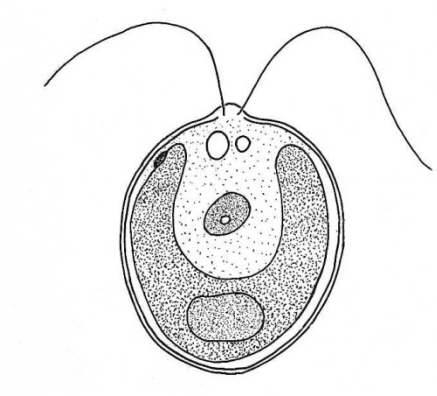
After collection, the nauplii are thoroughly washed and stocked in a container salt water of similar salinity of hatching jar. Then these nauplii are used for feeding of larvae and ornamental fishes.

Feeding of ornamental fishes

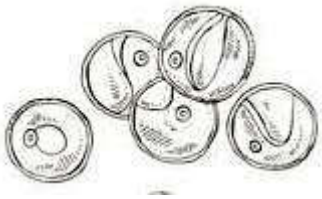
Most commonly made error fish owners make is overfeeding fish. Choosing right food is a key factor in maintain the health and long life of your pet. The sensible approach is often the fish just give a small amount of food and keep observe to ascertain how quickly they consume it. Ornamental fishes should be fed 4-5 times/day. Giving single large meal to fishes should be avoided.

Conclusion

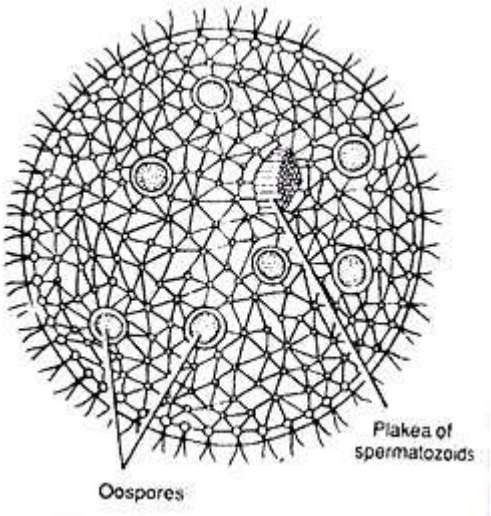
- Live foods are called “living capsules of nutrition.
- In semi-intensive culture by proper manuring and fertilizing, natural live food can be produced for feeding of fishes.
- Mass culture techniques can regularly supply live foods for culture and breeding of ornamental fishes.



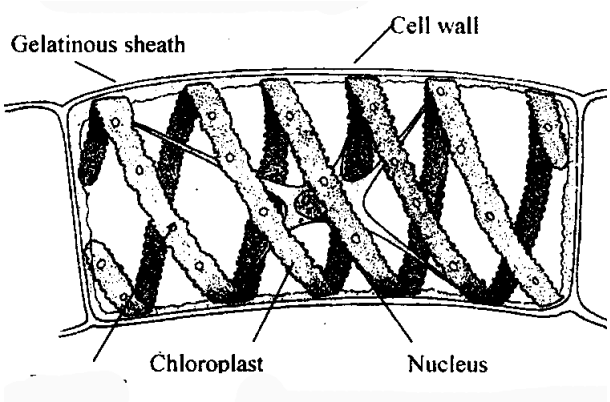
Chlamydomonas



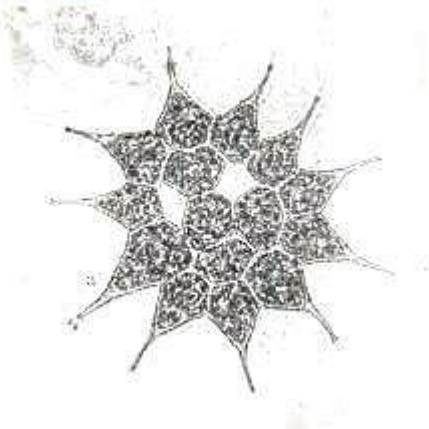
Chlorella



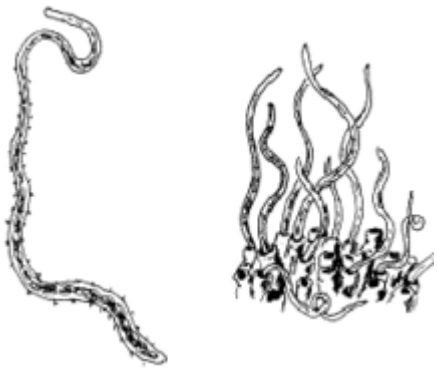
Volvox



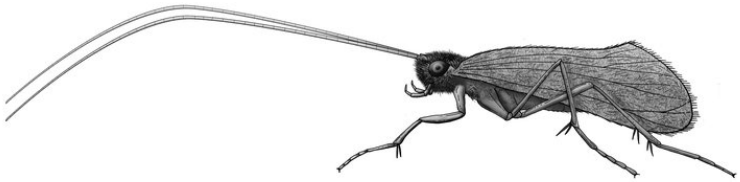
Spirogyra



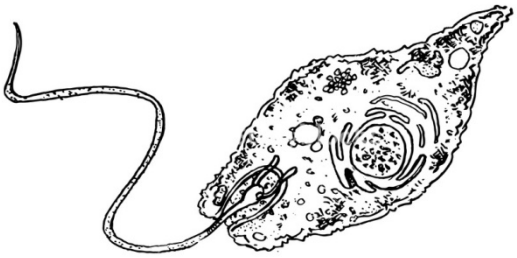
Pediastrum



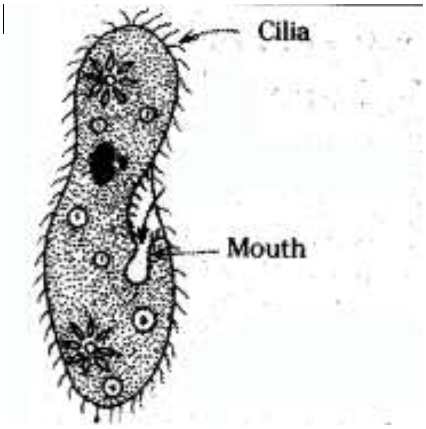
Tubifex



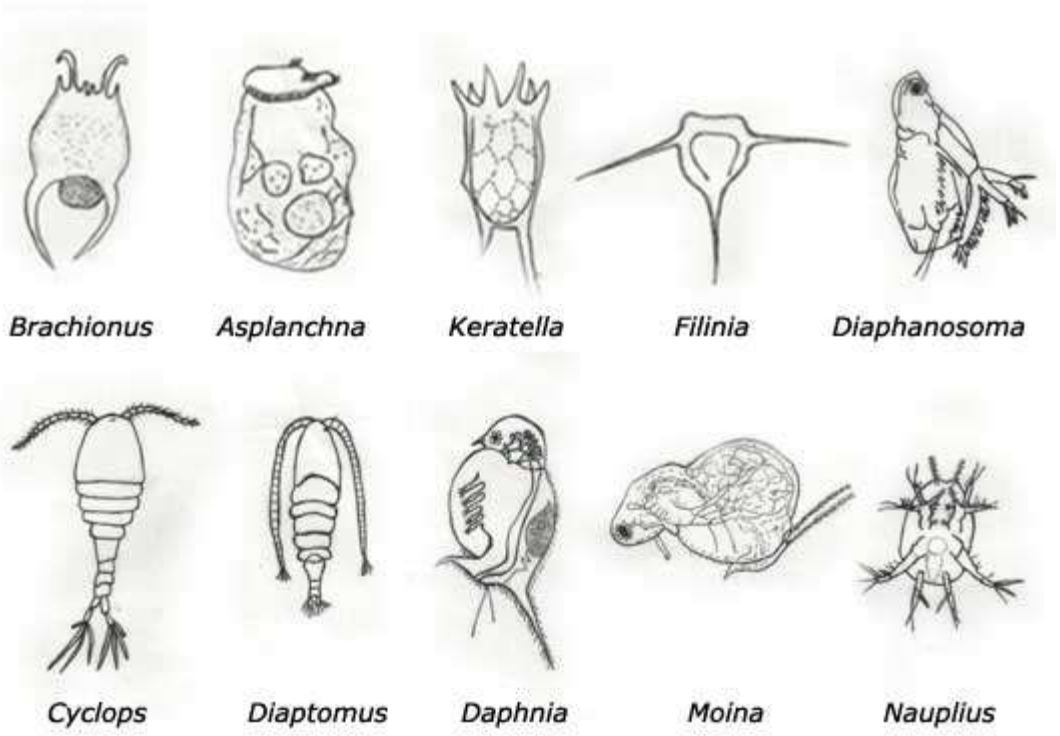
Caddisfly



Euglena



Paramoecium



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"Don’t believe in luck, believe in hard work”