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FISH CULTURE
in India

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI

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This is the twentieth of the series of Bulletins planned by the Indian Council of Agricultural Research to meet the paucity of literature in a simple, yet authoritative form and dealing with farming and animal husbandry subjects. Each of the Bulletins is so written as to give a general picture of farming practices in vogue in the country, and suggest improvements based on research results. The Bulletins, it is hoped, will be found useful by the farmer, the agricultural student and the Extension worker alike.

Editor: M. G. Kamath

FISH CULTURE
in India

BY

K. H. ALIKUNHI
Research Officer (Pond Culture)
Central Inland Fisheries Research Substation
Cuttack

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Contents

FISH CULTURE IN INDIA

FISH CULTURE in tanks, though on a limited scale, has been practised in India since as early as 350 B.C. The industry apparently became more popular in later ears, as is seen from old records which show that even temple anks were regularly stocked with fish and their fishing rights leased out periodically.

Fish culture is very popular in the States of Bihar, Bengal and Orissa. In other states, too, there has been a marked awakening of interest in inland pisciculture.

At present, about 6,10,000 acres of inland waters are under fish culture in our country. This area is very small when compared to the actually cultivable inland waters. In Madras State alone, there are over 8,50,000 acres of inland waters, including estuaries and backwaters. There are over 40,000 tanks of widely varying areas. In India as a whole, irrigation canals exceed 70,000 miles in length and wells 13.5 million in number. Ponds and tanks are much more numerous in Bengal, Bihar and Orissa than in Madras.

Cultivable waters are of all types, perennial or seasonal, and of every description—ponds and tanks, natural lakes and artificial reservoirs, backwaters, irrigation canals and wells, paddy fields, *jhils*, *bheels*, borrow-pits, quarry pools, swamps, and even short-season accumulations of water in shallows.

There is little or no natural fishery in these waters. A systematic cultivation of quick-growing species of fish in the extensive, widely distributed inland waters will be one good way of ensuring an adequate supply, in the fresh condition, of a heap, wholesome protective food containing animal protein hich is badly lacking in the diet of our people.

As it is still very difficult for sea fish in good condition reach the inland consumer because of limited facilities for pre-ration and transport, freshwater fish is always in high de-d and fetches a comparatively higher price. The systematic ation of quick-growing fish in all cultivable inland waters is thus the ultimate aim of inland fisheries development in India.

Indian carps form the most important group of fishes used for fish culture. Other species, including the predatory *murrels* (*Ophicephalus* spp.), and selected salt-water species such as Pearl Spot and Milk Fish are also cultivated on a limited scale in certain areas.

The larger Indian carps live in rivers and spawn during the monsoon months of June to August, when millions of eggs, hatchlings and fry are collected for stocking in tanks and ponds, particularly in Bengal, Bihar, Orissa and Assam. These carps do not ordinarily breed in ponds. In Bengal, there is a flourishing seasonal fish fry trade. Fishermen collect the fry in large numbers in special fry-catching nets and transport them in earthen *hundies* by rail to Calcutta for sale. Pond owners purchase their fish seed requirements from this market and release them in their ponds.

In several states in India, major carps are not available and quick-growing local species suitable for cultivation are few in number. These states, therefore, import the seed of the major carps mainly from Bengal, Orissa and Bihar every year. Apart from the open market, fish seed supplies are also obtained from the Fish Seed Syndicate, organized under the auspices and technical guidance of the Central Inland Fisheries Research Station, Calcutta. In Madras, Andhra and the Punjab carp fingerlings are collected from rivers, canals and paddy fields for stocking fish ponds.

Collecting the fry and rearing them in nursery ponds is a paying profession, but yet to be developed in these states. Most fish farmers employ empirical cultural practices. They feel that they have done their duty when they have released a cupful of fry in the pond, and wait for the proper season to reap the harvest.

Due to faulty methods of collecting and handling, the tiny fry suffer serious mortality from the stage of catching them in the rivers to that of rearing them in ponds. Ponds are not properly cleared of predatory animals before introducing the baby fish. Adequate steps are not taken, due mainly to ignorance to ensure sufficient food for the young fish. Ponds are indiscriminately stocked. Even the expert professional fish farmer therefore, is never sure of a successful crop of fry or fingerlings in his ponds. Total failures of the fry to survive in such nursery ponds are not uncommon. Only a very small fraction of the millions of fry collected grow up to a marketable size.

It is the purpose of this Bulletin to show that scientific methods of fish culture can not only appreciably control the heavy mortality of the fish seed and raise the percentage of survival of the fry, but also improve fish production in the nursery and stocking ponds manifold with the minimum rearing expenses.

CULTIVABLE WATERS

WE have in our country a large variety of inland waters, ranging from the icy cold Himalayan streams and lakes to the tropical warm water ponds. In all these waters there is life, and in the majority of them a natural fish fauna also. Fish production in these waters, however, is small.

The extent of these waters, though not assessed properly yet, is indeed enormous, and with the number of large multi-purpose river projects nearing completion, the area of the inland cultivable waters will increase by several million acres.

There are vast swamps and other low-lying accumulations of water which only act as breeding grounds for mosquitoes, thus endangering public health. Converting them into productive fish farms will not only check water-borne diseases, but also increase fish production in the country. Continued neglect of even cultivated waters often results in an overgrowth of aquatic weeds in them. This changes the quality of the waters and results in a reduction in fish productivity. With the adoption of scientific methods of culture any piece of water can be made to yield a better crop of fish.

Our waters vary widely in the different parts of the country owing to differences in the soil and rainfall and other biophysical factors. Hence, they vary in their productivity. The water on acid soils, for example, is generally less productive than that on alkaline soils. Acid soils are mostly found in certain parts of Assam, Travancore-Cochin and in some of the upland hilly areas. A recent survey shows that hardly seven per cent of the waters in Uttar Pradesh are acid.

The majority of our inland waters are alkaline. Extreme alkaline conditions which are not too good for optimum fish production are also met with in some waters of the dry belt region. A total alkalinity of over 500 parts per million has been recorded in certain waters in the former Hyderabad State.

Fish production in ponds depends on biological factors also. A pond with abundant submerged weeds may harbour a variety of life like small fish, insects, snails and worms, but the production of edible fish in such a pond, almost every time, is poor.

At present, we have very little information on the natural production of fish in our waters. The inland waters of Madras State have been tentatively classified into the following different groups, based on the scattered observations made in the State.

Pond type	*Nature of food organisms*	*Colour of water*	*pH*	*Nature of pond bottom*	*Average yield of fish per acre (in pounds)*
I.	Permanent bloom of Blue green algae like *Microcystis Anabaena*, or *Oscillatoria*	Greenish	8.0	Black rotting organic matter	2,000
II.	Abundant macrovegetation, *Hydrilla*, *Vallisneria*, *Potomogeton*, water lilies, etc.	Colourless	7.5 to 8.5	do.	1,000
III.	Abundance of zooplankton and a few plant organisms	Brownish	7.0	do.	500
IV.	Clear throughout with an occasional bloom	Clear	6.5 to 7.5	Brownish	300
V.	Few phytoplankton and zooplankton	Clear	6.5 to 7.5		200

The above classification, though very general, gives a rough idea of the yield that can be expected even from the best type of water. In Bengal, the production of major carps (*Catla*, *Rohu* and *Mrigal*) is reported to vary from 264 to 792 pounds per acre ; with artificial feeding it is about 968 to 2,112 pounds per acre. The average yield of fish from the sewage-manured Bidyadhari fisheries in Bengal is only about 600 pounds per acre per annum. But by properly selecting quick-growing fish, stocking them in optimum densities and combinations and systematic artificial feeding, this yield can definitely be increased.

THE FISH POND

IN a typical pond, the water is essentially standing or stagnant. Water constitutes the immediate environment of all aquatic organisms. The dissolved substances and nutrients contained in the water undergo changes which affect the conditions of existence of the aquatic organisms.

For the successful rearing of fish, the water should not only contain the necessary energy and nutrients in the optimum concentrations, but also food organisms of the fish. Certain basic elements like carbon, hydrogen, sulphur, nitrogen, phosphorus, potassium, calcium, magnesium and iron should be present in certain proportions. Sodium, chlorine, flourine, silicon, manganese, iodine and arsenic are also essential for fish growth. These substances are obtained from the air and the soil which are in continuous contact with water. Thus, the water conditions will largely depend on the nature of the soil on which the pond is situated.

In each pond, various groups of organisms, inhabiting particular niches or zones are present. The life activities of these are complicated. There are two important phases of activity in the life history of any organism—the constructive and the destructive—taking place almost simultaneously. For the productive phase, the ultimate basic substances in the pond are the inorganic nutritive materials dissolved in water and certain energies (light and heat) and gases (oxygen and carbon dioxide) from the atmosphere.

The green coloured microscopic plants that float in water (called phytoplankton), the submerged larger plants and certain bacteria synthesise these inorganic nutrients into complex living matter in the presence of sunlight and dissolved gases. The large submerged soil-rooted plants also use up the nutrients found in the mud. The microscopic free-floating plants in water are eaten by minute animals, the zooplankters. Both these groups of organisms are directly consumed by several species of fishes. The submerged plants, both in the fresh and in the decaying conditions are not only eaten directly by certain species of fish, but they also harbour a host of herbivorous and creeping animals like the snails and insect larvae which, in turn, are preyed upon by predatory animals.

A large number of organisms, collectively termed as the bottom fauna, feed on the bottom debris. These form the food of the fishes and other carnivorous animals in water. The latter which feed also on the free swimming animalcules (zooplankton), are in their turn fed upon by predatory fishes which grow and multiply. Thus, this building up phase in the pond culminates in the production of fish.

At each stage of this constructive phase, there is also an active destructive cycle, the different organisms being either consumed as food by the larger organisms, or dying a natural death. After death, they settle down at the bottom as organic debris and are gradually decomposed by bacterial action into the component inorganic substances or eaten by bottom animals and bottom-feeding fishes.

The cycle of life in the pond is thus a continuous process of building up of substances into more complex ones and a process of breaking up of these substances into simpler ones through bacterial action. In a cultivated pond, we help to stimulate the different phases of the constructive cycle by cultural methods and periodically harvest the final product, the fish.

The vital life-processes in the pond are at the optimum, when the physical and chemical conditions of water are normal. The important physical and chemical conditions of water which have a great effect on fish production are given below.

Depth. When the water is shallow, light will penetrate even to the bottom, warm up the water and facilitate increased production. When the water is too deep, the bottom layers will be cold and less productive, and will gradually accumulate poisonous gases which reduce normal production. A water less than three feet in depth, however, is likely to get heated up too much on hot, sunny days.

Turbidity. The turbidity of water may be due to the abundance of plankton or to the suspension of fine particles of silt. When the water is too turbid, light penetration is interfered with, resulting in reduction in biological production.

Temperature. This is one of the most important factors. The temperature varies at different times of the day and also during different seasons of the year, and from place to place. In tropical waters, biological production and growth are much more rapid than in temperate waters. Warm water fishes are, therefore, ill-adapted to life in cold waters, a fact to be remembered when fishes are selected for stocking. In certain parts of India where the summer is very hot and the winter correspondingly cold, the amplitude of water temperature is sometimes as much as 20°C or more. The major Indian carps usually tolerate this wide range of temperature, but during winter, their growth is very much retarded.

Dissolved oxygen. Aquatic animals get their supply of oxygen for breathing from the air dissolved in water. The specialized respiratory structures called gills in fishes are capable of absorbing oxygen from the water and giving out waste gases (carbon dioxide) from the blood into the water. As the water surface is always in contact with the air, oxygen gets dissolved in water almost continuously. The photosynthetic activity of water-plants also enriches the water with oxygen.

An ordinary pond will generally contain sufficient dissolved oxygen to support its fish population. When weeds and phytoplankton are abundant, the dissolved oxygen in water undergoes wide fluctuations, sometimes even reaching dangerous limits during the night. Oxygen is bound to be deficient when the water is highly contaminated with organic matter.

Different fishes need different quantities of dissolved oxygen. The common trout requires much more oxygen than the carp. While the oxygen consumption of fish depends on different environmental factors, a concentration of three to five parts per million of water is sufficient for most of our indigenous fishes. Under certain conditions, our major carps have been found to tolerate even a much lower concentration of dissolved oxygen.

When the dissolved oxygen in water is not sufficient for respiratory purposes, the fish comes up in distress to the surface to gulp in air, and if not transferred to fresh, well-oxygenated water, gets easily asphyxiated.

Carbon dioxide. Though essential for the photosynthetic activity of the plants, carbon dioxide is a waste product for fish. The gas, which is dissolved in water from the air, is often abundant in the subsoil spring water. Considerable quantities of this gas are formed when there is excessive organic decomposition like the rotting of plants. In all natural waters, some carbon dioxide is usually present, but even up to 15 to 20 parts per million it has no adverse effect on fish life. It becomes dangerous only when this concentration is exceeded.

Acidity, alkalinity and neutrality of water. Natural water, like any other liquid, may be acid, alkaline or neutral. The reaction is expressed in terms of what is called "*p*H" value. When the reaction is neutral, it is generally expressed as *p*H 7. When the *p*H is above 7.0, the water is alkaline in reaction and when the *p*H is below 7.0, the water is acidic in reaction.

The majority of natural waters are alkaline. Acid waters with *p*H below 6.0 are much less productive than alkaline waters, and the fish in such waters often get diseased and gradually die.

Alkalinity of the water is mainly due to calcium salts in the form of bicarbonates and carbonates. In highly productive waters, the bicarbonate content will ordinarily be high, over a 100 parts per million of water.

Dissolved nutrients. Phosphates and nitrates are the important nutrients necessary for the production of fish and fish food in water. In all natural waters, these nutrients are found in varying quantities, dissolved from the surrounding soil. The atmosphere is a source of nitrogen, which is available as nitrates, nitrites or ammonia in water. When these nutrients are deficient, production and growth of organisms in the water are affected.

Deficiencies in one or more of these important environmental factors have to be artificially made good in fish culture practices, as in agriculture.

To sum up, a good pond water for fish cultivation should have a slightly alkaline reaction (*p*H ranging from 7.5 to 8.5), a fair amount of dissolved oxygen of the order of five to seven parts per million parts of water, a concentration of 0.2 to 0.4 parts of phosphates, and 0.06 to 0.1 parts of nitrates, and about 100 or more parts of total alkalinity in a million parts of water. As the natural productivity of the pond, like any piece of cultivable land, will steadily decrease with the continued cultivation of fish in it, the maintenance of water conditions at the optimum level by periodic application of manures will be necessary. A regular chemical analysis of water samples from the pond to find out when and what corrective treatments are to be applied thus becomes essential.

The aquatic fauna, like the common plants found in fish ponds, can be conveniently classified as animal plankton (zooplankton) or free water organisms, weed-dwelling organisms and bottom-dwelling organisms.

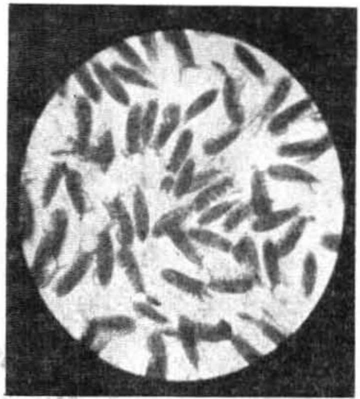
Zooplankton. Important zooplankters usually found in Indian freshwater fish ponds belong to the Protozoa or single-celled animals, viz., *Arcella*, *Difflugia*, and Ciliates, the Rotifera or wheel animalcules (e.g., *Brachionus*, *Filinia*, *Polyarthra*, *Pedalia*, *Keratella*, and *Asplanchna*) and the Crustacea dominated by the Cladocerans or water-fleas (e.g., *Daphnia*, *Moina*, *Ceriodaphnia*, and *Simocephalus*) and the Copepods—several species of *Diaptomus* and *Cyclops* and their young ones, the *Nauplius* larvae. Ostracods are relatively less common.

The Cladocerans and Copepods, almost universally present, form the most important food items of baby fish. Rotifers are also equally relished. In manured ponds, these often appear in dense swarms, but last only for a few days.

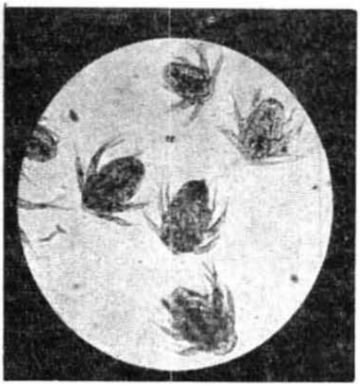
Weed-dwelling fauna. Several rotifers, flatworms and water mites (hydracarina) which creep among the leaves of water plants, the common *Hydra*, the snails, the bristleworms

PLANKTON FOOD OF TENDER CARP FRY

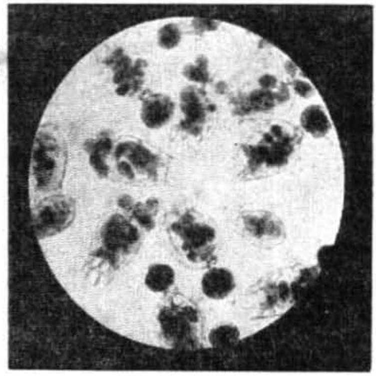
Cyclops **spp.**



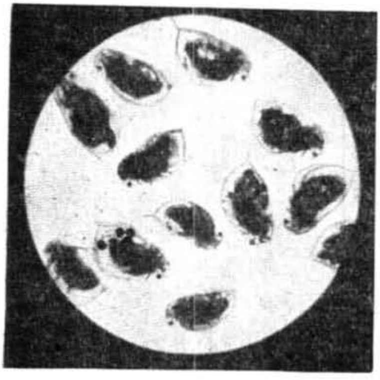
Diaptomus **spp.**



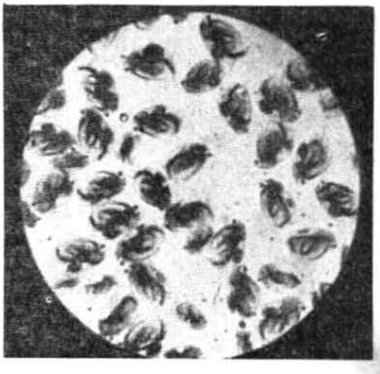
Nauplius larvae



The Rotifer, *Brachionus pala*



The water-flea, *Daphnia pulex*



The water-flea, *Moina brachiata*

(Oligochaetes) and the numerous insect larvae are included under this category. Some of these, like the *Hydra*, are attached to the leaves and derive their subsistence from the deposits on the leaves, the small organisms that come near the leaves and also on the tender leaves of plants. This category of fauna constitutes an important source of food for fish of omnivorous feeding habits.

Bottom-dwelling fauna. Animals living near or in the bottom mud of the pond are included in this group. The red mudworms (*Oligochaetes*) and the bloodworms or Chironomid (insect) larvae are two of the important constituents of this bottom fauna. The Chironomid larvae live inside small tubes made of sand and the debris. The mud snails (*Limnaea* and *Vivipara*) dragon-fly nymphs, and fresh water crabs are also commonly met with in most ponds.

Fishes which frequent the bottom regions largely feed on these organisms.

WEEDS IN FISH PONDS

WEEDS in ponds are of different types, ranging from the minutest floating plants (technically termed phytoplankton) to the larger aquatic plants which may be submerged, floating or emergent.

On the basis of their habits, the common weeds may be conveniently grouped as below.

Phytoplankton. These are minute, microscopic plants, passively floating in water, often multiplying rapidly and occurring in millions, imparting a turbid green, brown or yellowish brown colour to the water. Such a condition is known as a 'water bloom', and the plants are generally called algae. The majority of planktonic algae in the Indian freshwaters belong to the groups green algae (*Chlorophyceae*) and blue-green algae (*Cyanophyceae*), though a number of diatoms (*Bacillariophyceae*) and flagellates (*Euglenineae*) are also commonly found. The algae which have been often found to cause water blooms in fishery waters are *Eudorina*, *Volvox*, *Closterium*, *Actinastrum*, *Scenedesmus*, *Pediastrum*, *Microcystis*, *Anabaena*, *Oscillatoria*, *Euglena*, *Ceratium* and *Melosira*.

The microscopic plants are eaten as food by most of the higher animal organisms in water. Owing to their resistant cell wall, some of them, at least during certain stages, have been found to be unsuitable as food for baby fish. Experiments at Cuttack have clearly shown that phytoplankton have very limited food value so far as the tender carp fry are concerned.

Hair weeds or filamentous algae. These are ordinarily submerged in water though when growing in profusion they float up in masses. The common forms encountered in fish ponds are *Spirogyra*, *Cladophora*, *Oedogonium*, *Pithophora* and *Draparnaldia*. Two common forms *Nitella* and *Chara* which much resemble higher aquatic plants are, however, considered closely allied to algae.

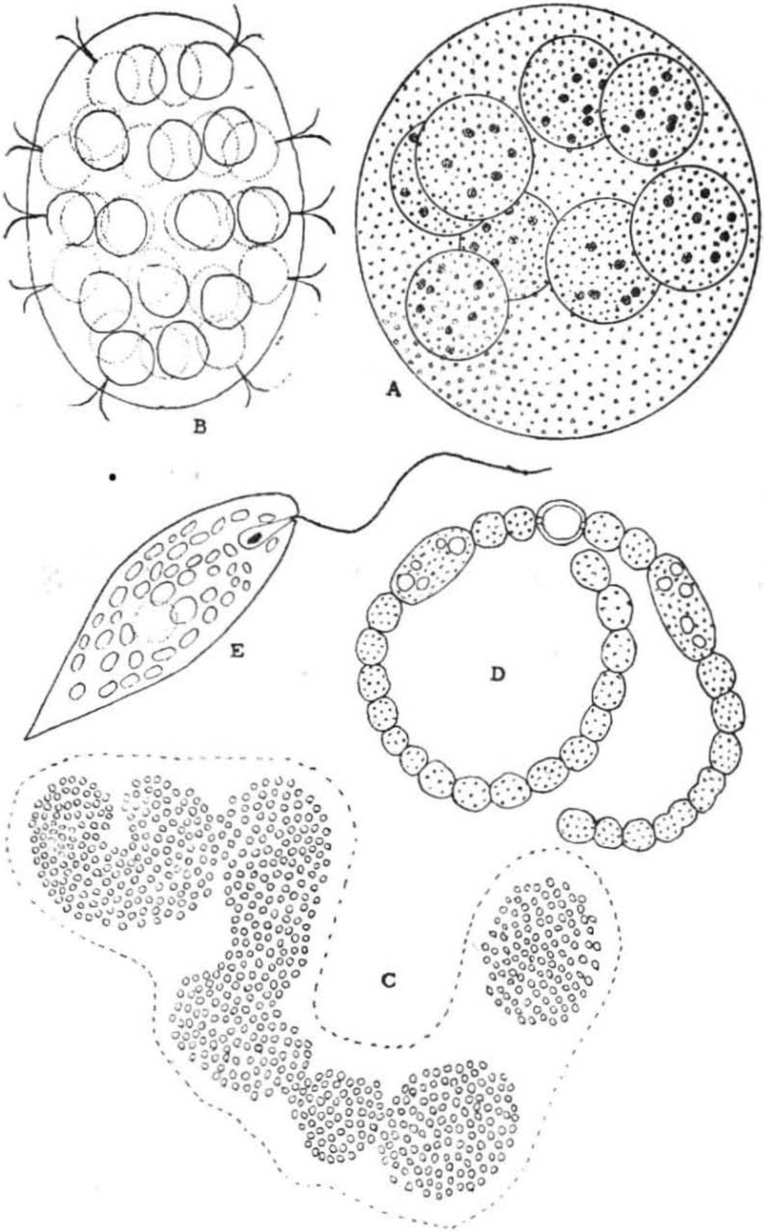
Like the plankton, many of these are eaten by fish, but opinion is divided as to whether they are really being digested and assimilated. In certain cases it has been reported that they are passed out undigested. Filamentous algae are very often encountered in the gut of the majority of freshwater fishes at some time or other.

The overgrowth of filamentous algae restricts movement of fish and often becomes fatal to fish fry which are trapped among the filaments. Ordinarily, when these algae abound in water, plankton will be poor.

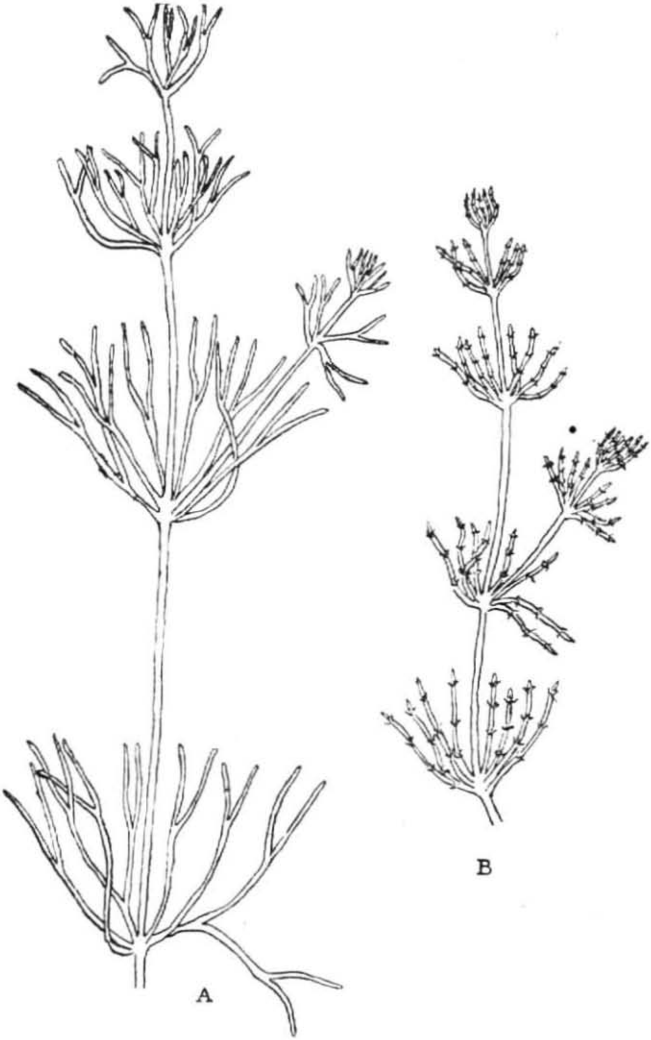
They are undesirable in nursery ponds and their overgrowth is to be prevented in other waters.

Marginal and emergent weeds. These are rooted higher plants which abound in the shallow marginal areas of ponds and in swamps—the transitional zone between the terrestrial and the aquatic habitats. The reeds and sedges like *Phragmites*, *Typha*, *Scirpus* and *Acorus* are commonly found. Species of *Marsilia*, *Herpestes*, *Comellina*, etc., often form a continuous marginal belt of plants, while *Ipomea*, *Jussiaea* and others trail on the water surface. A continued immersion in water for days does not affect these plants adversely, and they thrive on the ground just above the water edge as well.

In nursery ponds they serve as shelter and as breeding spots for predatory aquatic insects and should, therefore, be carefully removed and kept in check.

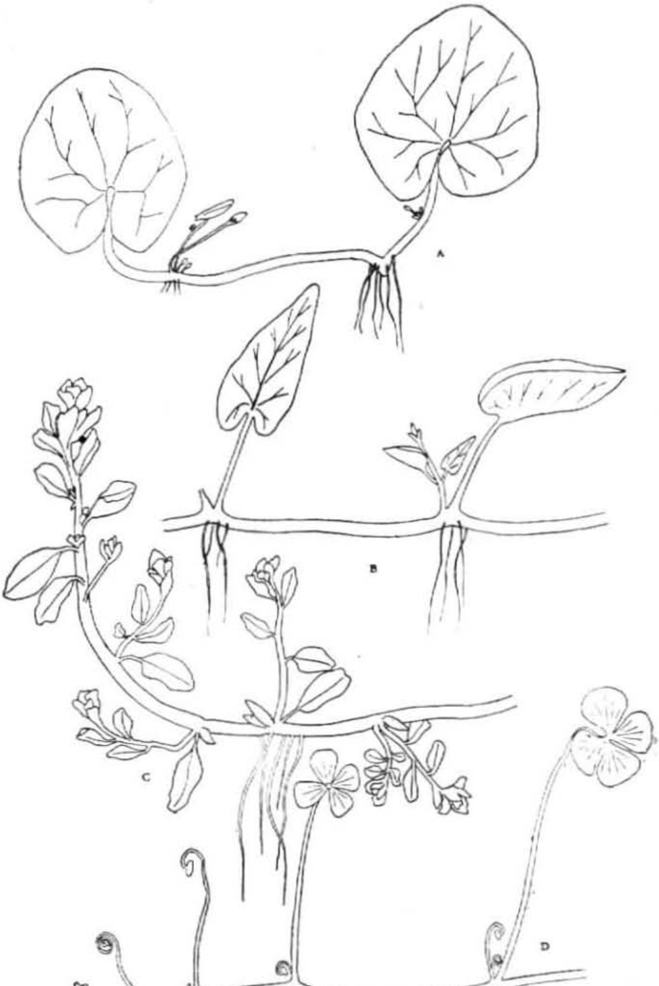


Common algae which are not generally relished as food by the baby fish and which often cause water blooms: A. *Volvox,* **B.** *Eudorina,* **C.** *Microcystis,* **D.** *Anabaena* **and E.** *Euglena*



Common submerged aquatic weeds: **A.** *Nitella* **B.** *Chara*

Surface-floating weeds. The obnoxious water hyacinth (*Eichornia*) is a typical example. *Pistia* is another which often chokes up the water surface. The duck weeds *Lemna* and *Azolla* usually form green mats on the water surface.



Common aquatic weeds: **A.** *Limnanthemum cristatum*, **B.** *Ipomea aquatica*, **C.** *Jussiaea repens* and **D.** *Marsilia quadrifolia*

Wolffia is one of the smaller duck weeds, small, green and grain-like, floating on the surface.

These often form a complete screen on the surface, shutting off sunlight and gases so that food production in the lower layers remains very poor. Overgrowth of these weeds is, therefore, to be prevented in fish ponds.

The duck weeds *Lemna* and *Wolffia* are reported to be used as food for the Chinese carps.

Pistia is known to harbour the dangerous *Mansonia* mosquitoes among its roots.

Submerged plants. The majority of the submerged plants are rooted to the bottom. Typical examples are *Hydrilla*, *Otellia*, *Vallisneria*, *Potamogeton*, *Naias* and *Lagarosiphon*. These plants are ordinarily confined to the column of water and choke the surface only when there is excessive overgrowth during summer when the water level falls steadily and rapidly.

Some of the submerged plants like *ceratophyllum* and the bladderwort *Utricularia*, have no typical roots, and, therefore, merely float in the water column. These plants are completely adapted to life in water and the latter (*Utricularia*) develops a series of characteristic round bladders, which trap minute aquatic animals to be used as food.

Other plants like the lilies and the lotus (*Nymphea*, *Nelumbium* and *Limmanthemum*) are firmly rooted in the mud but their leaves often float at the water surface.

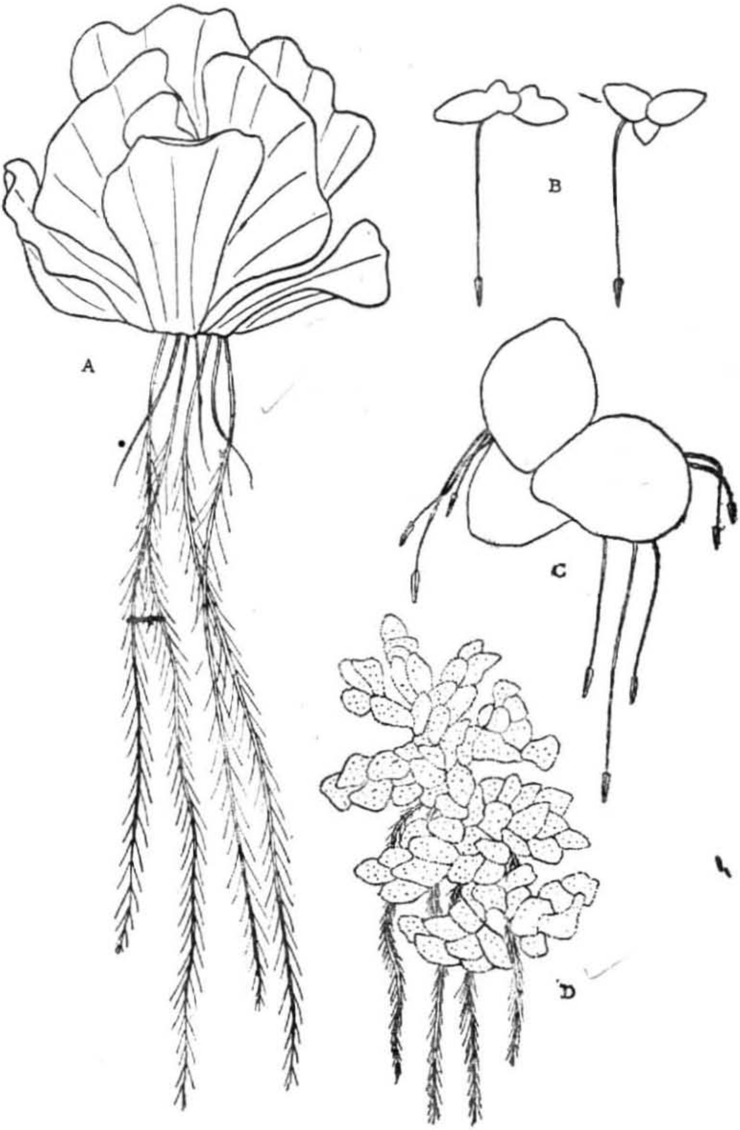
These true aquatic weeds often grow in such profusion that within a few weeks' time the whole pond gets choked, the water is impoverished of nutrients and the growth of plankton is thereby hampered. A few fishes like the *Gourami* are known to make use of these plants as food. In the case of others, these hamper their movements and badly affect their food supplies. Fishing also becomes difficult in such ponds.

When weeds abound, wide fluctuations in water conditions occur, which affect the well-being of the fish.

Some of these weeds, at least in the rotting condition, are eaten by carps, but whether this is actually of any appreciable nutritive value for the fish is not known. Observations show that of the major carps, *Catla* does not eat submerged weeds to any appreciable extent, though *Rohu* and *Mrigal* probably utilize them to a limited extent.

WEED CONTROL

It is not ordinarily possible to control the algae or weeds by chemical agents without adverse effect on the animal



Common floating aquatic weeds: **A.** *Pistia stratiotes,* **B.** *Lemna minor,* **C.** *Lemna polyrrhiza,* **D.** *Azolla pinnata*

Common submerged rooted aquatic weeds : A. *Otellia alismoides*, **B**. *Vallisneria spiralis*

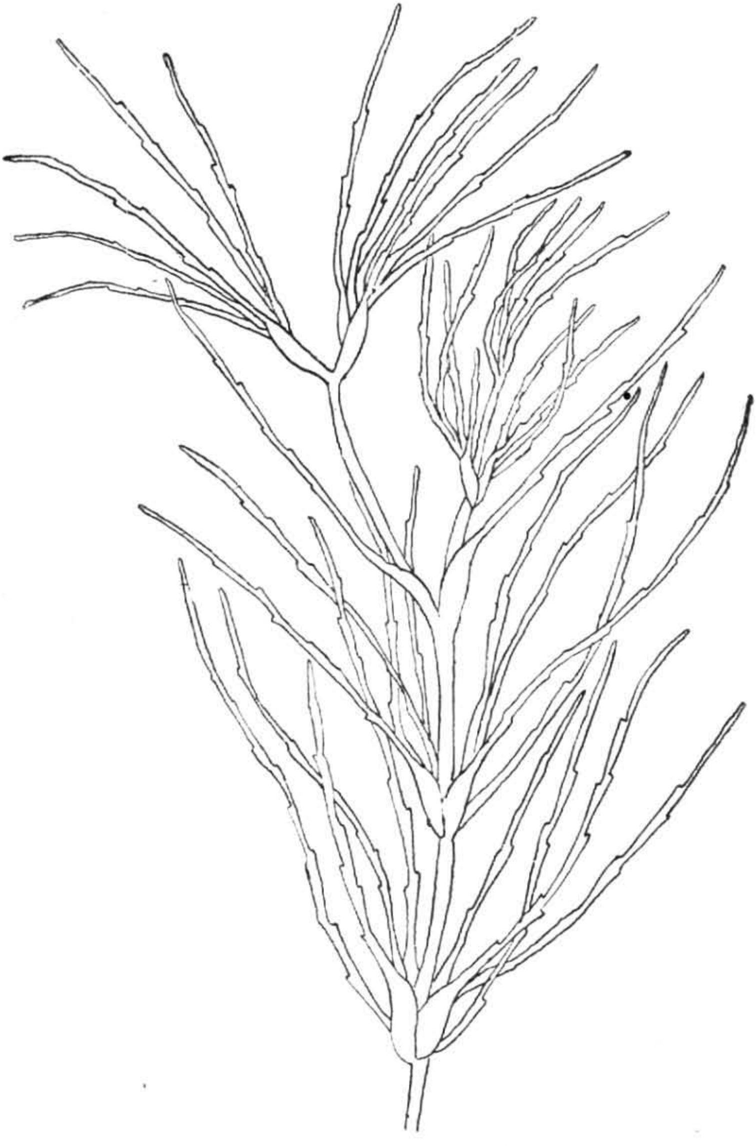
populations in water. Copper sulphate is one of the well-known algicides used for controlling algae in filterbeds in water works. As it is poisonous to fish and zooplankton, it cannot be employed in nursery ponds. However, application of copper sulphate at a daily dose of 0.3 parts per million parts of water for several days has been reported to have

Common submerged aquatic weeds: C. *Hydrilla verticillata,*
D. *Lagarosiphon Roxburghii*

given satisfactory results in the control of filamentous algae, without affecting the large fish.

Mechanical removal of weeds by human labour or by weed-cutting machines would appear to be the most satisfactory method at present in nursery ponds.

When labour is cheap, mechanical removal of weeds can be attempted in larger waters also. Once the weeds are thus removed, a careful watch and periodical removal of any new sprouting plants would effectively keep them in check.



A common submerged aquatic weed: *Naias* **sp.**

Common submerged aquatic plants: B. *Ceratophyllum demersum,* **C.** *Utricularia* **sp.**

Hormone weedicides like *Methoxone*, *Agroxone* and 2,4-D have all been reported to be effective under certain conditions. "Dicotox", containing the ethyl ester of 2,4-D, at a dose of one ounce per 100 square feet has been reported to effectively destroy submerged weeds like *Hydrilla*, *Naias*, *Vallisneria* and *Nymphea*, in about 20 days. When the dose is doubled, the plants are killed in about 16 days. With either of the above doses, no harmful effect has been observed on fish or other animal life in the water.

When the alkalinity in alkaline waters is first lowered by the addition of commercial sulphuric acid (ordinarily not more than 10 parts per million of water is required for this) and then copper sulphate is applied at 10 parts per million of water, submerged weeds like *Hydrilla*, *Naias* and *Otellia* are effectively destroyed within 20 days. Copper sulphate alone has very little effect on these weeds. Fish, however, are fatally affected at the above dose of copper sulphate.

Sodium arsenitc, though poisonous, has also been successfully used for killing surface and submerged weeds.

CULTIVABLE SPECIES OF FISHES

A LARGE variety of suitable indigenous species of fishes are available in various parts of India for cultivation in ponds. Some exotic species of food fishes have also been introduced into this country. The cultural value of these fishes varies considerably, depending upon their relative growth, size, adaptability to different types of waters, and easy availability.

The large majority of these fishes belong to the group of carps which are utilized for culture. *Murrels*, a few species of catfishes and perches, and a few quick-growing salt water fishes are also commonly utilized for cultivation in brackish water and freshwater ponds.

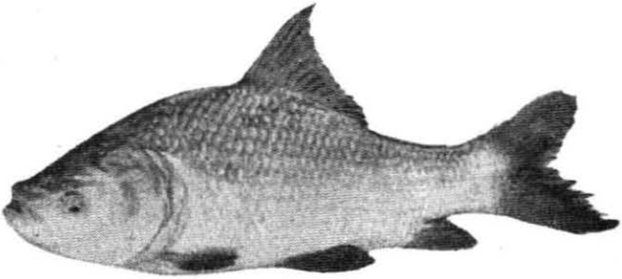
CARPS

The common carps of cultural value are mentioned below in the order of their present economic importance.

The Catla (*Catla catla*). It is commonly called *Catla* in Assam, Bengal, Bihar and Uttar Pradesh; *Bhakur* in Orissa, *Thaila* in the Punjab; *Bocha* in Andhra; *Thoppameen* in Madras and *Karakatla* in Malabar. Though its natural distribution extends only to the Godavari river in Andhra Pradesh, it is now common in the Kistna and the Cauvery rivers also. It is the fastest growing carp in India.

A characteristically deep body with a conspicuous head, large upturned mouth, non-fringed lips devoid of barbels and a broad dorsal fin with 14 to 16 branched rays distinguish the adult fish and advanced fingerlings. The body is ordinarily dull, silver white, but tends to be rather darkish in weedy waters. The fry, from half to one inch in size, are distinguished by the relatively large head with reddish gills, broad dorsal fin with a greyish margin and the rather pale body colour owing to a scarcity of pigment spots.

Catla is a surface and column feeder and its upturned mouth and the large gill rakers are adapted to feeding on the numerous organisms floating in water. Submerged aquatic weeds are not of any value as food for *Catla*, and in ponds with an overgrowth of submerged weeds its growth is generally unsatisfactory. Young ones, from the time they begin feeding until they reach a length of about 15 to 20 millimetres, feed



The Catla (*Catla catla*)

almost exclusively on water-fleas and other animalcules in the water. After that stage they are probably capable of making use also of the microscopic plants floating in the water, though at all stages water-fleas and other animalcules in the water constitute an important item of food.

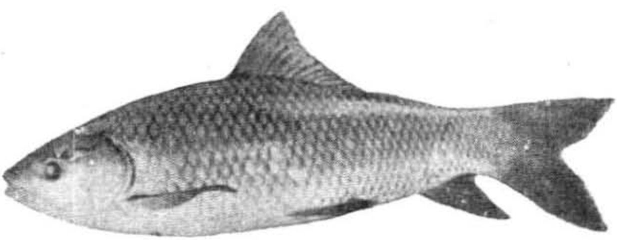
Catla is reported to grow very quick, even up to three to four inches per month. This phenomenal growth may often be due to extreme, and perhaps uneconomical, understocking in virgin waters. In normally stocked waters, a growth of 15 to 18 inches in the first year can ordinarily be expected. *Catla* grows to over four feet in length.

If understocked, *Catla* grows to over 20 inches in length in the first year; it does not, however, attain sexual maturity at that age. Fish in the second year are ordinarily sexually ripe. Specimens 22 months old measuring 18 inches in total length and weighing about three pounds have been observed in ponds with the ovaries almost ripe in June. They are, therefore, ready to breed in the third season after hatching.

Catla breeds in rivers during the rainy months of June to August. It does not breed in ordinary ponds, though in certain ponds in Bengal and Bihar, known as *bundh* type tanks closely akin to the minor irrigation tanks of South India, it is known to breed during the South-west Monsoon after sudden heavy rains. Early fry are available in large numbers during June-July in Assam, Bengal and Bihar and during July-August in Orissa, the Punjab and Andhra, and are collected in millions and stocked in nursery ponds.

The Rohu (*Labeo rohita*). A very quick-growing carp, with almost the same natural distribution as *Catla* and considered a tastier fish than any other Indian carp, it is known as *Rohu* or *Rui* in Bengal, Bihar, Assam, Uttar Pradesh and Punjab, *Rohi* in Orissa and *Bocha-gandumeenu* in Andhra, in which State it is reported to occur in small numbers in the river Godavari. Like *Catla*, it has also been transported to the South, but has not yet established itself in any of its rivers.

Rohu is easily distinguished by its relatively small or pointed head, almost terminal mouth with fringed lower lip, dull reddish scales on the sides and pink reddish fins. The dorsal fin has 12 to 13 branched rays. The body is more linear than that of *Catla*. Young ones $\frac{3}{4}$ to one inch long are



The Rohu (*Labeo rohita*)

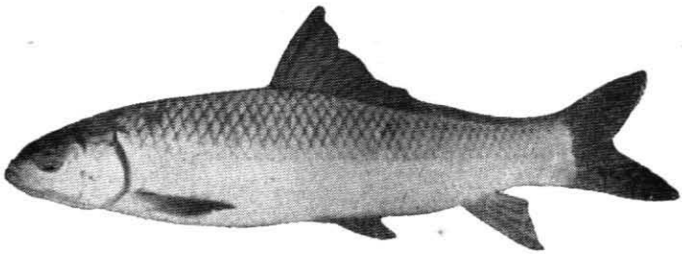
distinguished by their fringed lips, dorsal fin rays and a conspicuous vertical, blotch-like dark spot at the base of the tail, which disappears in fingerlings.

Rohu is a column-bottom-feeder and its rather anterior fringe-lipped mouth is well adapted to browsing on shallow pond bottoms also. Considerable quantities of bottom sand or mud, vegetable debris or decaying leaves of aquatic plants, planktonic algae, etc., constitute the stomach contents. Water-fleas and other animalcules are rarely found among the food items consumed, but as in *Catla*, the young ones commence feeding on water-fleas and animalcules.

Rohu grows very quick, though perhaps relatively a little slower than *Catla*. A growth of 14 inches to 16 inches can normally be expected in the first year in a well stocked pond. Sexual maturity is attained towards the end of the second year. *Rohu* grows to over three feet in length.

Like *Catla*, the *Rohu* also breeds in the rivers and in the *bundh* type tanks during the monsoons, and its fry are collected from these habitats for rearing.

The Mrigal (*Cirrhina mrigala*). Next in importance to *Catla* and *Rohu* for cultural purposes is the *Mrigal*, common in the major river systems as far south as the Godavari. Locally called *Mori* in the Punjab, *Naini* in Uttar Pradesh and Bihar, *Mrigal* in Bengal and Assam, *Mirikali* in Orissa and *Yerrameen*



The Mrigal (*Cirrhina mrigala*)

in Andhra, it is easily distinguished by the relatively linear body, small head with rather blunt snout, terminal mouth with thin non-fringed lips, bright silvery body and reddish fins. The dorsal fin has 12 to 13 branched rays. The young ones,

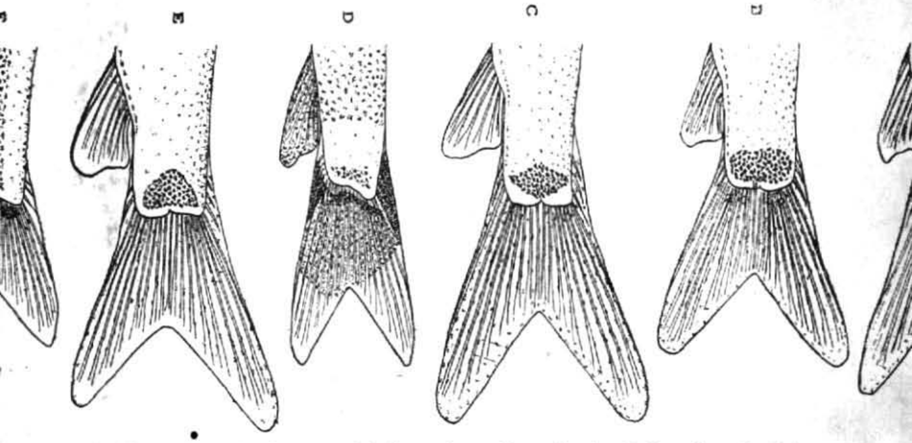
$\frac{3}{4}$ to one inch long, are distinguished by their rather blunt snout, thin lips and a rather small, somewhat diamond-shaped dark spot at the base of the tail, besides the faint greenish tinge on the dorsal aspect of the body. In slightly larger specimens, the scales at the sides of the body have their edges pigmented dark. The fins also become reddish.

Mrigal appears to be a bottom feeder, though the young ones, as soon as they commence feeding, have the same feeding habits as those of *Catla* and *Rohu*. The fingerlings and adults take in relatively larger quantities of decaying organic and vegetable debris, phytoplankton organisms and sand and mud than in the case of *Rohu*. The proportion of animal matter in the diet is generally poor. The thin terminal lips are adapted to picking up things from the mud and from the invariable presence of appreciable quantities of sand and mud in the gut, it is presumed that algae in the fresh or decaying condition are also picked up from the bottom.

Mrigal grows slower than *Catla* or *Rohu*. In a pond stocked at the rate of about 6,000 fingerlings per acre, an average size of eight inches may be attained within eight months. If the stocking is thinner, quicker growth may be expected. The species attains a length of over three feet. Like *Catla* and *Rohu*, *Mrigal* becomes sexually mature only when about two years old. Fingerlings, however much grown in the first year, do not attain maturity, but second year fish (third season from hatching) become sexually ripe, even if stunted in growth.

The breeding season and sources of fry are the same as those of *Catla* and *Rohu*.

The Kalbasu (*Labeo calbasu*). The *Kalbasu* occurs almost throughout India, excepting in Malabar. It is called *Kalbasu* or *Kalbaus* in Bengal, Bihar and Uttar Pradesh, *Mahhi* in Assam, *Kalbainsi* in Orissa, *Kalahan* in the Punjab, *Nalla Gandu Meenu* in Andhra and *Kakkameen* in Madras. It does not generally occur in large numbers, but whenever available, it is stocked in ponds. Though attaining a maximum length of $2\frac{1}{2}$ feet or more, it is a relatively slow-growing fish. The conspicuous, uniform dark colour of the body, the small tapering head with the subterminal fringe-lipped mouth and the conspicuous black barbels are its distinguishing characters.



Tail portion of $\frac{3}{4}$ inch to 1.0 inch long fry of A. *Catla catla*, **B.** *Labeo rohita*, **C.** *Cirrhina mrigala*, **D.** *Labeo calbasu*, **E.** *Labeo bata* **and F.** *Cirrhina mrigala*, **showing differences in pigmentation which are visible to the unaided eye**

The dorsal fin has 12 to 13 branched rays as in *Rohu* and *Mrigal*. The fry of *Kalbasu* are easily distinguished from those of other Indian carps by their peculiar pigmentation. When about 10 millimetres long, the caudal fin has at its base a prominent concentration of chromatophores. Slightly larger fry, 12 to 15. millimetres long, have further concentrations of pigment at the base of the tail, at the nape, at the pectoral region and at the base of the dorsal and anal fins. The barbels are conspicuously black in colour.

The *Kalbasu* feeds on snails and worms at the bottom of the pond, in addition to the usual algae and other elements on which *Rohu* and *Mrigal* feed, but the animal portion of the diet is generally very small. The early fry of *Kalbasu* resemble those of *Catla* and other major carps in their feeding habits.

When only a few specimens of *Kalbasu* are kept in ponds, the growth is rapid. In well stocked ponds, an average annual growth of 10 to 12 inches may be expected in the first year. Though often small specimens, about 8.5 to 9.0 inches long, are sexually ripe there is no direct evidence that they attain maturity in the first year. As in the larger species, maturity is probably attained in the second year only.

The breeding season and the sources of seed are the same as in *Catla*, *Rohu* and *Mrigal*.

The Fringe-lipped Carp (*Labeo fimbriatus*). Occurring chiefly in Madras, Andhra and Mysore and extending north through Orissa and Bombay up to the Punjab, *L. fimbriatus* is extensively used for stocking ponds in Madras. It is known as *Chel Kendai* in Madras, *Gandu Meenu* in Andhra, *Bahrum* in Orissa and *Tambra* in Bombay. Though a somewhat slow-growing fish, it attains a maximum length of over two feet (weighing about seven pounds).

The body is deeper than that of *Rohu* or *Kalbasu*; the dorsal fin has 15 to 18 branched rays, the head is small, both the lips fringed and the body generally yellowish in colour, particularly in specimens from rivers. The middle rows of scales on either side of the body have reddish central spots. Young ones, about 10 millimetres long, resemble the corresponding size of *Catla*, but can be easily distinguished by their relatively small head, terminal mouth with thick lips, more uniformly distributed dark pigment on the dorsal fin and the more conspicuous caudal spot.

L. fimbriatus resembles *Kalbasu* in feeding habits but the long gut which is often almost double the length of that of *Kalbasu* suggests a more predominantly herbivorous diet than the latter. Mud and sand are invariably found in appreciable quantities in the gut besides planktonic algae and vegetable debris. Fingerlings have almost the same feeding habits as the adults, but the early fry subsist largely on water-fleas and other animalcules.

A maximum growth of 15 inches in the first year has been reported, but if the pond is stocked with a large number of fingerlings, the average growth may be less.

Like other major carps, *L. fimbriatus* also breeds in the rivers during the rainy months, June to September. Even when the monsoon fails and extreme summer conditions prevail, the fish has been reported to breed in the rivers.

The White Carp (*Cirrhina cirrhosa*). Indigenous to the Cauvery river system in Madras, *C. cirrhosa* is the most abundant carp in that river. Though Day recorded this fish from the Godavari and the Kistna, it has not been found in recent years in these rivers, where there is no fishery of this species. Known as *Kendai* or *Venkendai* in Tamil, it grows to a maximum length of about two feet.

The rather small head with blunt snout and thin lips, the conspicuous dorsal fin with 14 to 15 branched rays, upper margin concave and the first few rays very elongated, and the silvery body with scales having a red centre except on the abdomen, are the distinguishing features. Fingerlings resemble the adult except that the first few dorsal fin rays are not too elongated and the red spots on the scales have not been formed. The life history of the species and the distinguishing features of the early or advanced fry are still unknown.

C. cirrhcsa appears to be a bottom-column feeder like the *Mrigal*. Mud and sand grains mixed with dark mucilaginous matter form the bulk of the food. Vegetable remains, algal filaments and planktonic algae form about a fourth of the gut contents. Animal remains are few. More or less similar feeding habits are found in the fingerlings also.

It attains 10 to 12 inches in the first year in fairly well stocked ponds. It breeds in the rivers during the rainy months and fingerlings of different sizes are available from July to November.

The Pig-mouth Carp (*Labeo kontius*). Like the white carp, *L. kontius* is also a medium size carp, indigenous to the Cauvery river system in Madras. Locally called *karimulee*, *kalchel* or *pannivayi kendai*, it has a characteristically prominent snout and a somewhat subterminal mouth with a fringed lower lip. The dorsal fin has 12 to 13 branched rays. Adult specimens have a deep slaty colour with the scales along the sides having a red centre. A rather inconspicuous caudal spot extending forward along the sides of the body as a distinct but thin band of pigment is characteristic of the young ones, about an inch and a half long.

Labeo kontius is a predominantly vegetable feeder, the animal part of the food being only about five per cent. Sand and mud constitute about 30 per cent of the feed and filamentous algae and aquatic macrophytes (decaying) about 33 per cent, while the rest of the feed is formed of planktonic algae.

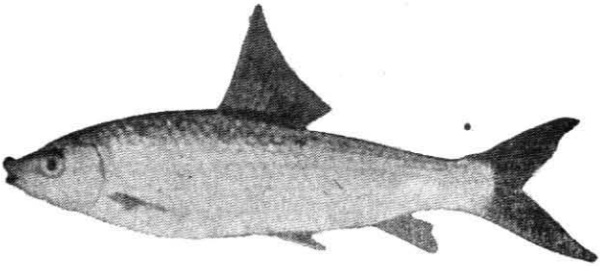
The proportion of algae to sand and mud in the gut contents of the specimens from freshwater ponds appears to be fairly high. The nature of the food consumed and the structure and position of the mouth indicate that the species is a bottom and column feeder, browsing on filamentous algae, etc., on stones and other objects in the marginal shallows.

L. kontius attains a maximum length of about two feet. Specimens 12 to 14 inches long are sexually mature, and in ponds this size is attained at the end of the first year of its life. Like other carps, it breeds in rivers during the rainy months (June to August). Laid eggs with a pale transparent blue tinge are collected in large numbers from the Cauvery and Bhavani rivers. They hatch out within 20 hours after fertilization. In laboratory aquaria, the hatchlings just over five millimetres in length are fully differentiated within the next 14 days. They feed voraciously on planktonic crustacea and grow quickly.

The Reba (*Cirrhina reba*). *Cirrhina reba* is a widely distributed minor carp, but has not so far been recorded in Malabar. It is called *arinjan* in Madras, *elemoose* in Andhra, *podha* in Orissa and *khorkebata* in Bengal and Bihar. Though its maximum recorded size is only 12 inches, it is extensively used for stocking purposes in Madras.

The characteristic hexagonal scales on the body, the lateral dark pigment band on either side and the small tapering head are its distinguishing features. The dorsal fin has only eight to nine branched rays. The fry, 10 to 15 millimetres long, have three characteristic dark spots at the tail, one at the tip of the caudal peduncle and two at the base of the tail proper. A dark pigment band originating on the snout and extending up to the tail end on either side is also a distinguishing characteristic.

C. reba appears to subsist largely on planktonic algae which form about 60 per cent of the food. Considerable quantities of mud, sand and debris are also met with in the gut contents. The young ones feed voraciously on zooplankton and grow faster than even the young ones of *Catla*. The limited quantity of decaying leaves and debris found in the gut probably indicates its more pronounced plankton feeding habits. However, as mud and sand are also almostinvariably found in the gut, it may be inferred that the fish occasionally feed in the marginal shallows also.



The Reba (*Cirrhina Reba*)

Though a minor carp, *C. reba* grows fairly quickly and by the end of the first year of life, attains a length of about 11 inches. It breeds in rivers during the monsoon months. Carp fry collections made from riverine habitats invariably contain a large number of fry of *C. reba*. In Bengal, Bihar and Orissa, they are removed from stocking ponds at the fingerling stage. The fully swollen fertilized egg is 2.8 to 3 millimetres in diameter and has a pale or light gray tinge. The eggs hatch out within 15 hours after fertilization at a water temperature of 28°. Under laboratory conditions, the hatchlings, about 3.25 millimetres long, are fully differentiated in about 12 to 14 days, provided they are adequately fed.

The Bata (*Labeo bata*). A medium size carp, attaining a length of about two feet, it is fairly common in Andhra, Orissa, Bengal and Assam. Esteemed as a food fish, it is cultivated in ponds along with the major carps. It is known as *bata* or *bhangan bata* in Bengal, Bihar and Assam and *raj podah* or *raj bata* in Orissa.

Adult fish largely resemble *Mrigal*, but the body appears more stumpy with a distinct silvery shine. The base of the scales has a greenish iridescence in fresh specimens. The snout is rather blunt, the lips thin and the mouth wider than in *Mrigal*. There is a characteristic conspicuous bluish-green shoulder spot on either side of the body at the fifth-sixth scale. The dorsal fin has only 9 to 10 branched rays. The young ones resemble *Mrigal* very much, except that the black caudal spot is larger, almost semi-circular, more conspicuous and often deeper in colour than in *Mrigal*. The shoulder spot appears in specimens over 1½ inches long.

The feeding habits of *L. bata* are very similar to those of *Mrigal*. Being a bottom fish, the gut contents invariably contain large quantities of sand or mud, with very little animal matter. Organic debris, including decaying vegetable matter and planktonic algae, forms the main item of food.

Bata grows rather slowly, its average growth being 8·5 inches in the first nine months of life in ponds stocked at the rate of about 1,500 per acre along with other carps. When the population is thin, quicker growth may be expected. Sexual maturity is attained when the fish is 200 millimetres long and is at the end of the first year of its life. *L. bata* also does not breed in ponds. During the rainy months, it breeds prolifically in rivers and *bundhs* and the young ones are collected from these habitats along with those of major carps.

The Nagendram fish (*Osteochilus thomassi*). Common in the Godavari and the Krishna rivers and attaining a maximum length of 24 inches, *O. thomassi* is utilized to a limited extent for stocking ponds in Andhra. Known as *nagendram* in Andhra, it constitutes a fishery in the Tungabhadra river. The conspicuous snout overhanging the mouth, the fringed upper lip, large pores on the snout, 11 to 12 branched rays on the dorsal fin which has a dark band, and the dark outer edge of the tail are characteristic features.

It is reported to be a plankton feeder, subsisting mainly on planktonic and filamentous algae and also on some planktonic crustacea. It attains sexual maturity in the first year of life when it is 9 to 12 inches in length. It breeds in rivers from June to September, and fry and fingerlings are usually available till the end of December.

The Sandhkol Carp (*Thynnichthys sandhkol*). A medium size carp attaining a maximum length of about two feet, *T. sandhkol* (known as *aku chapa* in Andhra) is indigenous to the Godavari, Krishna and Tungabhadra rivers, with its nearest relations found only in Malaya. The rather flat body, prominent head, terminal mouth, thin lips, very small scales and silvery sheen of the body are characteristic features. The dorsal fin has only nine-branched rays. It is utilized to some extent for stocking ponds.

Planktonic algae predominate in the gut contents of fingerlings and adults. However, organic debris, sand grains and mud particles are found in appreciable quantities in the gut of the majority of specimens. The fish is probably, therefore, a column-surface feeder which by virtue of its terminal mouth could pick up food from marginal shallows also.

It is a slow-growing fish attaining a length of about 12 inches in the first year, at which size sexual maturity is also attained. It breeds in rivers from June to September. Very little is known of the life history and growth of the species.

The Carnatic Carp (*Barbus carnaticus*). The *Carnatic* carp has a restricted distribution in the rivers along the base of the Nilgiris, the Wynaad, the South Kanara hills, in Madras and in Mysore. It is one of the major barbels of the Cauvery, and is an excellent sporting fish, attaining a length of over two feet and a weight of about 25 pounds. Known as *pouri* in Madras, it is distinguished by the relatively deep body, small head, large scales and the distinct greenish body colour, particularly on the dorsal aspect. It closely resembles *B. hexagonolepis*, which is also available in the Cauvery. The young ones of the two species are distinguished in the field as follows:

Distinguishing features	*B. carnaticus (Pouri) 0.5 inch to 2.0 inches long*	*B. hexagonolepis (Karambai) 0.5 inch to 2.0 inches long*
Caudal spot	Distinct, conspicuous, dark	Rather diffused and inconspicuous
Dorsal fin	Not pigmented; eight branched rays	Anterior and outer margins black or dark grey in colour; Nine branched rays
Pectoral and ventral fins	Colourless and transparent	Outermost ray milky white or light yellow in colour
Barbels (2 pairs)	Conspicuous, easily visible to the naked eye	Rather inconspicuous and not so easily visible to the naked eye

B. carnaticus is predominantly a vegetable feeder, animal matter constituting one-sixth of the gut contents. Filamentous algae, leaves of aquatic plants, marginal grass and other vegetable debris constitute the bulk of the feed. Sand grains are rarely seen in the gut and so the fish cannot be called a bottom feeder. Insects, and occasionally, fish scales and other fish remains may also be seen in the gut. It is a voracious feeder, as is very often seen from its gorged gut. It appears to be active during the night also.

Sexual maturity is attained when it is relatively small in size. Mature oozing males about five inches long and ripe females about six inches long are not uncommon. Sexual maturity is thus attained probably during the first year of its life. The fish breeds in rivers during both the monsoons, June-July and November-December. The young ones are collected in large numbers from various centres along the Cauvery and Bhavani rivers.

B. carnaticus is used for stocking ponds in Madras. The growth, however, is slow; being 9 to 10 inches in the first year of life.

The Chocolate Mahaseer (*Barbus hexagonolepis*) : Believed to be a species of the Assam-Himalayan streams. *B. hexagonolepis* is found also in the Cauvery river in Madras. It is called *katli* in Bengal, *bokar* in Assam and *karambai* in Madras. Specimens 27 inches long and about 10 pounds in weight, are not uncommon in the Cauvery river. They are easily distinguished from the allied *B. carnaticus* by the characteristic bluish tinge of the dorso-lateral region of the body. It is an excellent sporting fish caught with inexpensive baits like bananas, earthworms, oilcake paste, grasshoppers, flowers of cucumber and aromatic leaves like those of the *Tulsi* plant (*Ocimum sanctum*).

Being a voracious feeder, its stomach and gut are usually gorged with food. Gastropod shells, filamentous and planktonic algae, vegetable debris and sand or mud are the main items encountered in the stomach. Bottom-feeding near the marginal shallows is clearly indicated. In the early fingerling stage, this species (*karambai*) feeds mainly on insect larvae, aquatic beetles and flies. Aquatic vegetation and marginal grass constitute the main food found in the gut of advanced fingerlings and adults.

The species is used for stocking ponds in Madras, though the growth is not more than nine inches in the first year. As in *B. carnaticus*, sexual maturity is attained fairly early in life, the males having been reported to become mature even when they are only 91 millimetres long. The breeding season is during the rainy months.

The Kozhimeen (*Barbus dubius*). Known as *kozhimeen* in Madras, this medium-sized carp, attaining a maximum length of about two feet, is also used for stocking tanks in Madras. It also is indigenous to the Cauvery river system. The characteristic tapering head with a protracted snout, the stout ray on the dorsal fin and the general pink colour of the body distinguish this species from its allies.

Bottom-feeding habits are evident in the adults as well as fingerlings, as seen from the gut contents which consist of sand and mud along with gastropod shells and insects. Adults may also feed on planktonic algae. In riverine habitats, young ones of *B. dubius* feed in shoals along the shallow margins as may be inferred from the shallow pits in the mud made by their protruding snouts while in search of worms.

The fish breeds in rivers during the North-east monsoon months and fingerlings are collected during January-February for stocking. Very little is known about their rate of growth in ponds.

The Sarana (*Barbus sarana*). This is a medium size barbel attaining a length of over a foot and is distributed throughout India. It is known as *kuruka* in Kerala, *panjelli* in Madras, *kannaku* in Andhra, *sarana* in Orissa and Bengal, *potah* in Uttar Pradesh, *sennee* in Assam, *juudoori* in the Punjab and *kudali* in Bombay.

Though there is no regular culture of the species, in certain localities, particularly in Madras, fingerlings are collected for stocking in ponds. It is a voracious feeder, consuming quantities of decaying macro-vegetation, gastropod shells, worms, insects and filamentous algae. It breeds in rivers during the monsoon months but not in ordinary ponds. The young ones are caught along with the fry of major carps and stocked in ponds. Usually, only a few specimens survive and grow rapidly, attaining a length of about 10 inches in the first 10 months of their life, and sexual maturity also at the end of this period.

The young ones, 15 to 30 millimetres long, have a dark caudal blotch and a smaller dark spot on the body dorsally at the commencement of the dorsal fin. Barbels are also conspicuous. In larger fingerlings the spot at the dorsal fin disappears while the caudal spot persists.

The Common Carp (*Cyprinus carpio*). The Common Carp is an exotic fish introduced into India from Ceylon in 1939. It is essentially a cold-water fish, but being very hardy, it easily adapts itself to warm water conditions of the tropics. Originally stocked in the Nilgiri Hills in Madras, it has now been distributed to other states also. It is a major carp, growing to about three feet in length. Specimens weighing up to 32 pounds have been caught in the Vellore Fort Moat Farm in Madras.

Three varieties of the Common Carp are available in India. They are:

1. The Mirror Carp (*C. carpio* var. *specularis*), with large, shiny yellowish scales over the body,
2. the Scale Carp (*C. carpio* var. *Communis*), with rather small scales completely covering the body and
3. the Leather Carp (*C. carpio* var. *Nudus*) with scales almost completely absent on the body which consequently has a leathery appearance.

The Leather Carp is not as common as the other two.

C. carpio is an omnivorous feeder with a variety of items included in its menu. It browses on the shallow bottom and margins, takes in vegetable debris, insects, worms, crustaceans and also planktonic algae. They are active generally in the evening in the marginal shallows as may be seen by the considerable splashing made at the surface water. The young fry feed largely on planktonic crustacea.

In upland waters, *C. carpio* attains sexual maturity at the end of the first year of life, when it grows to 15 to 18 inches in length and two to three pounds in weight. In the warmer waters of the plains also the growth is quick, to the extent of about two inches per month. The fish breeds almost throughout the year with a peak period from January to April. Though the species grows rapidly and the gonads mature in the warmer waters of the plains, there is so far no record of their breeding in them.

Unlike the major Indian carps, *C. carpio* breeds in ponds.

Being adhesive, the eggs are found sticking to the leaves of submerged aquatic plants. The young ones hatch out within four or five days. The fry are very hardy and can be transported under a wide range of conditions.

The Golden Carp or the Crucian Carp (*Carassius vulgaris*). The Golden carp is also an exotic fish in India, introduced from Europe as early as 1874. It is a fine-looking fish with a rather deep body covered with bright golden scales. The rather small mouth devoid of barbels also distinguishes it from *C. carpio*. It grows to a length of about 18 inches and a weight of about three pounds. The species appears to be a pure plankton feeder, consuming large number of water-fleas and other animalcules. It breeds in ponds almost throughout the year with a peak period from February to April. Sexual maturity is attained early in life. The males of over four inches in length are usually fully ripe and oozing, while the females over six inches in length are likewise sexually ripe. Stripping and artificial fecundation of eggs are possible and have been successfully attempted. The eggs are adhesive as in *C. carpio* and are attached to the leaves of submerged aquatic plants.

The growth is rather slow, being only six to eight inches in the first year. Sexual maturity is probably attained in the first year of life. The species has been reported to have bred at the Sunkesula Fish Farm in Andhra State.

The Tench or the Doctor Fish (*Tinca tinca*). An exotic fish like the Common and the English carps, Tench was introduced into India as early as 1874. It is a medium size carp which in its home waters in Europe, Asia minor and western Siberia, is reported to grow to a length of 22 inches and a weight of over seven pounds. Essentially a cold-water species, Tench thrives satisfactorily in the Ootacamund Lake in Madras and has been reported to have acclimatized and bred in the Sunkesula Fish Farm in Andhra State also. The small scales, the rather dark golden-greenish colour of the body and the rounded tail are the distinguishing features.

Tench prefers still waters and is generally regarded as a bottom fish. A study of the stomach contents of specimens from the Ootacamund Lake shows that the fingerlings feed

OTHER INDIGENOUS CARPS

Name of fish Technical	*Name of fish* Local	*Maximum size attained*	*Maximum growth in one year*	*Region where available*	*Source*	*Breeding season*
Labeo gonius	*Goni* (Bengal) *Khursa* (Orissa) *Courie* (Assam)	Over two feet		The Punjab, Bengal, Orissa, Assam, Uttar Pradesh and Bihar	Major rivers	June-August
Labeo nandina	*Nandin* (Bengal)	About three feet		Northern Bengal and Assam		do.
Labeo dussumeiri	*Thooli* (Malabar)	About 18 inches	10 to 12 inches	Kerala, South Kanara, Bombay	Rivers	July-August
Labeo sp.	*Parel* (Madras)	Over two feet		Madras	Cauvery river	do.

appreciably on planktonic crustacea and the adults on insects, vegetable debris, algal filaments and planktonic algae, though planktonic crustacea still continue to be an item of food. Early fry are almost exclusively zooplankton feeders.

Tench breeds freely in the Ootacamund Lake, the peak period being February to April. Stripping and artificial fecundation are possible and have been successfully attempted. Sexual maturity is attained at a relatively small size, the smallest mature male and female specimens so far encountered being 5.2 inches and 6.2 inches, respectively, in total length. As the eggs are very sticky, they are easily attached when laid to the leaves of submerged aquatic plants. The eggs hatch out in five to six days. The growth is rather slow, being six to eight inches in the first year.

Other indigenous carps. There are a few other carps besides the species detailed above which could be utilized for stocking purposes (see page 40).

Though these are large or medium size carps, their utility for purposes of pisciculture is yet to be studied.

SALT-WATER FISHES

The fish seed resources of brackish waters offer an easy means of meeting the increasing demand for fish seed for stocking inland waters, fresh and brackish. There are several species of salt water fishes the young ones of which are available in various seasons of the year in shallow creeks and lagoons all along the coast. Elaborate methods have been developed, particularly in Madras, for quick acclimatization of selected brackish water fish seed to fresh water conditions. The natural history of the important species now utilized for stocking inland waters is briefly discussed below.

The Milk Fish (*Chanos chanos*). *Chanos*, which grows to about four feet in length, is one of the common marine fishes frequently occurring along the coast, in estuaries and in back-waters. It is called *poomeen* in Kerala, *kuzhal* or *paalmeen* in Madras and *paaluchapa kanisalu* in Andhra. It is extensively cultivated in brackish-water ponds in the Philippines. In India, *Chanos* fry are collected in considerable numbers from coastal creeks, particularly in the Gulf of Manaar, and stocked in inland fresh waters.

In fresh water, the fish is predominantly a plankton feeder, though in the brackish water ponds in Indonesia and the Philippines it has been found to subsist mainly on filamentous green algae. It has been shown that to a certain degree it can adapt itself to live on any kind of available food in its environment, even if it results in some structural modification in the alimentary system.

The spawning habits and spawning grounds of *Chanos* are yet to be discovered. However, millions of fry are caught every year from the tidal creeks near Pamban, Pulicat, Ennore, Covelong, Chunampet, Adyar, Cuddalore, Porto Novo, Muthupet, Tuticorin, etc., in Madras, Coondapoor and Narakkal on the West Coast, and in almost all the tidal creeks along the Andhra coast. April, May and June constitute the peak period for collecting fry. The transparent larvae, 13 to 15 millimetres long, can be directly transferred from salt water to fresh water and transported by rail over a period of 12 to 18 hours without heavy mortality. Early fingerlings do not appear to be as hardy as the early fry, as is seen from records of mortality during acclimatization and transport.

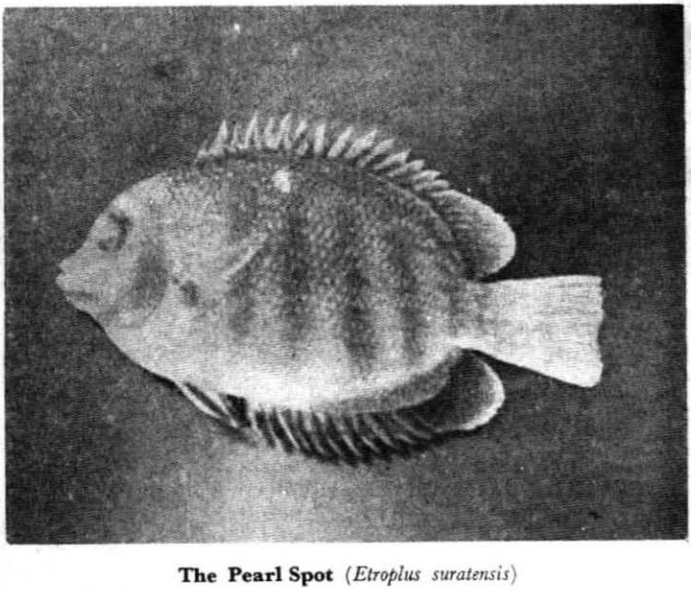
Chanos is reported to grow quicker in fresh water than in salt or brackish water. In India, the maximum growth reported in the first year is 15 inches in salt water, 19 inches in brackish water and 25 inches in fresh water. The rapid growth, the non-predacious habits and the rich flavour of its flesh are features that favour its extensive cultivation.

The Pearl Spot (*Etroplus suratensis*). *Etroplus suratensis*, belonging to the Cichlid family, with its nearest relatives in Africa and Madagascar, is a brackish-water perch indigenous to India and Ceylon. In India, it is confined to Peninsular India—Travancore-Cochin, Malabar and South Kanara along the West Coast, and as far north as the Chilka Lake on the East Coast. It occurs in estuaries, back waters and creeks as also in fresh-water ponds. It is called *karimeen* in Kerala, *sethakendai* in Madras, *duvvenachapa* in Andhra and *kundal* in Orissa.

The deep, laterally compressed body and dark greenish scales with occasional pearl-like white spots on them and a series of vertical dark bands are characteristic features. Fingerlings up to 1½ inches long have a conspicuous eye spot (ocellus) on the hind part of the dorsal fin. Advanced fry have a series of vertical dark pigment bands on either side of the body and a spot on the caudal peduncle.

Pearl Spot is essentially a vegetable feeder subsisting mainly on filamentous algae, aquatic macro-vegetation and planktonic organisms. Worms, shrimps and insect larvae often form appreciable portions of its feed. It is known to feed on fresh sewage also. The young ones feed almost exclusively on zooplankton and the advanced fry take in plenty of aquatic insect larvae, but when they are about $\frac{3}{4}$ inch long or upwards, they begin to feed on filamentous algae and other vegetable matter. *Etroplus* is known to have a special liking for the hair weed (*Spirogyra*).

Though essentially a brackish-water fish, Pearl Spot is equally at home in fresh water and breeds freely in both,



The Pearl Spot (*Etroplus suratensis*)

almost throughout the year, with a peak period during December-February. Sexual maturity is attained when at a length of about six inches. The males are generally larger than the females.

During the breeding season, the breeders swim about in pairs (male and female), selecting suitable sites in shallow water for breeding. Eggs are attached to submerged objects like bricks, stones, twigs and planks and are guarded by the parents. Fecundity is fairly high, judging from the number of eggs (about 2,000) seen in each patch of egg mass. The brownish laid eggs are 2 m. × 1 m. in dimensions and hatch out within three to five days of laying. The parents zealously guard their offspring for about a month, by which time they grow to about $\frac{3}{4}$ inch in size. They seem to grow fairly rapidly as in about eight to nine months they attain sexual maturity and a length of six to seven inches. They grow to over a foot in length and over three pounds in weight.

Pearl Spot is hardy and thrives well in various types of waters such as are found in irrigation wells, domestic ponds, step-wells and temple tanks. As it thrives and breeds even in ornamental cisterns, it has been acclimatized to inland waters in many parts of the country including Bombay, Bengal, Hyderabad, Mysore and Coorg where it appears to have established itself.

Though a hardy fish, the fry and fingerlings do not stand direct transfer from salt water to fresh water. For utilizing the vast brackish water seed resources for stocking fresh waters, the fry and fingerlings have to be acclimatized to fresh water by the gradual lowering of the salt content of water. It has been found that with half a day's conditioning in the natural habitat and half a day's stay in each of the three grades (quarter, half and three quarters fresh water) of salt and fresh water, the fish can be acclimatized without any mortality.

Fingerlings from fresh water netted out from ponds and directly put in *hundies* without any conditioning have been found to stand transport of over a thousand miles by rail. The fingerlings and breeders collected from the brackish water in the Chilka Lake were found to stand direct transfer to fresh water and could be transported to Cuttack (over 80 miles) with negligible mortality.

Pearl Spot is an esteemed food fish. Its non-predacious habits and easy adaptability to different kinds of waters are useful features for its successful cultivation in ponds. The strong spines on the dorsal and anal fins are to some extent defensive in nature and the medium-size predators are generally incapable of doing appreciable harm to Pearl Spot.

The Grey Mullet (*Mugil cephalus*). Among the score or so of species of grey mullets found in the Indian waters, *M. cephalus* is perhaps the largest and the most widely distributed. It is called *thirutha* in Kerala and *chaala madavai* in Madras. The distinct greenish colour of the body, the conspicuous blue patch at the base of the pectoral fin and the more or less constant dark patch on the edges of the tail are characteristic features of the species. The young ones of this mullet, along with those of other species, often abound in shallow brackish water creeks and lagoons, the season of availability varying to some extent in different places.

Filamentous and planktonic algae, vegetable debris and mud are generally found in the gut of the grey mullet, which feeds at the bottom in shallow expanses where the algae are picked up together with mud and sand particles.

The young ones can be acclimatized easily to fresh water conditions both in the natural habitat where when given free access to fresh water areas they migrate into them, and artificially by suitable dilutions of brackish water. The growth is fairly rapid, about 16 inches in one year in brackish water (Narakkal Farm, Travancore-Cochin), 12 inches in 14 months and 24 inches in two years in some of the Madras fresh waters. Specimens weighing three to six pounds have been obtained from the Vellore Moat Fish Farm in Madras. *M. cephalus* is extensively cultivated in brackish water ponds in the Philippines and in fresh waters along with carps in China and Japan. It grows to about three feet in length.

Of the common grey mullets, *M. seheli*, *M. troscheli* and *M. waigiensis* are also more or less easily acclimatized to fresh water. Acclimatization of mullet fry and fingerlings and their stocking in inland fresh waters are a routine practice in Madras.

The Freshwater Grey Mullet (*Mugil corsula*). One of the medium size grey mullets, attaining a length of about 18 inches, *M. corsula* is common in estuarine and brackish waters in Bengal and Orissa and also far above the tidal influence in the Ganga and the Mahanadi river systems. Unlike other mullets, it is essentially a surface fish, which has developed aerial vision and swims at the surface with the eyes and the adjoining region of the head projecting out of water. The food and feeding habits of *M. corsula* are more or less similar to those of other mullets, consuming mainly as it does bottom mud, algae, insects, etc. The young ones voraciously feed on planktonic crustacea.

M. corsula breeds in brackish as well as fresh waters. Unlike most other mullets, it breeds from May to September, with a peak period during June-July, corresponding to the South-west Monsoon. The eggs are pelagic or semi-pelagic, 0.90 to 1.035 millimetres in diameter, and hatch out within 16 to 18 hours after fertilization. The hatchlings are a little over two millimetres in length and float on the water surface. Larval and post-larval stages are often caught in appreciable numbers in carp fry collection nets along with fry of carps. They are active and swim about on the surface with a characteristic motion of the rather darkish tail region.

M. corsula is often cultivated, though in small numbers, in ponds along with carps. No reliable data on its growth in fresh water are, however, available. Specimens eight to nine inches long are sexually mature.

The Cock-up (*Lates calcarifer*). This most popular game and table fish is an estuarine or brackish-water perch commonly found in coastal waters. It grows to a maximum length of five feet. It is known as *narimeen* in Kerala, *koduva* in Madras, *pandugopa* in Andhra, *bhetki* in Bengal and *khajura* in Bombay.

Lates is a highly carnivorous fish and lives on other fishes, prawns, shrimps and snails.

It can tolerate wide ranges of salinity of water, ascend the rivers and get naturally acclimatized to fresh water, where it attains a length of about 18 inches in the first year. Breeders range from 20 to 24 inches in length and breeding occurs probably during the cold season. The young ones can be acclimatized to fresh water.

On account of its predatory habits, this species is not used for stocking with carp, although in Bengal a few specimens of *bhetki* are deliberately introduced into carp ponds in the belief that the carps will have ample run and exercise in escaping their predators. In the salt-water *bheries* in Bengal, the species is cultivated on a small scale. The successful cultivation of *Lates* will depend upon the number and quality of forage fish present in a pond or bred for the purpose.

The Indian Tarpon (*Megalops cyprinoides*). This is a medium-size food and game fish of the coastal region, migrating into the adjoining inundated tanks and ponds during the rainy months. It is called *vaalathan* in Kerala, *moraankendai* in Madras, *kannangi* in Andhra and *naharm* in Orissa. It grows to about two feet in length.

Tarpon is a predator, feeding largely on shrimps, insects and young fish. In addition to the above, the fingerlings feed also on planktonic crustacea and algae. Though it grows well in fresh water, it does not breed in ponds. Sexual maturity is attained when it is about 10 inches long. Breeding grounds and early life history of the species are not known. Flat, ribbon-shaped, leptocephalus-like young ones, 26 millimetres long or smaller, found on the coast in large numbers during June-July and November-December, enter brackish waters. They are extremely hardy and can, therefore, be transferred directly to fresh water without any casualty. The fingerlings,

A collection of ribbon-shaped young of the Indian Tarpon—*Megalops cyprinoides* **(transparent when alive ; turned opaque white on fixing)**

however, are less hardy and suffer fairly heavy mortality even when gradually acclimatized to fresh water.

The growth in freshwater ponds is fairly rapid and a length of 12 to 16 inches may be attained in the first year of life.

LIVE FISHES

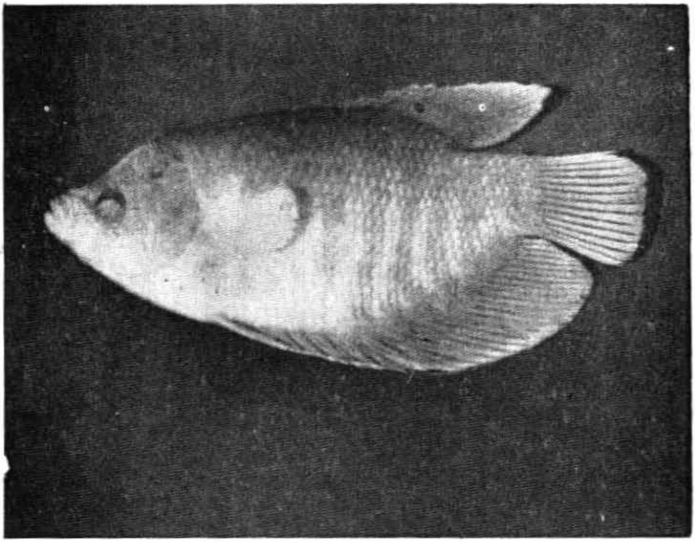
These comprise an important group of extremely hardy fresh-water fishes breathing atmospheric air directly by means of specialized accessory respiratory organs. As the flesh of some of these fishes is reported to possess highly nutritive, recuperative and medicinal properties, the live fishes are often in high demand and fetch a high price. All the indigenous species are predatory in habit and thrive in natural weedy waters of a semi-marshy nature. The exotic *Gourami* (*Osphronemus gorami*) is an exception. In India, no well-organized scientific method of cultivation of these fishes is practised at present. A brief account of the natural history of the more important species are given below.

The Gourami (*Osphronemus gorami*). This is an exotic fish introduced into India from Java and Mauritius, and which has established itself fairly well in Madras, including the Cauvery river system. Considered the best fresh-water table fish in the world, it is a hardy fish that thrives in a variety of waters. From Madras it has now been introduced into other states in India where it has successfully bred.

Being primarily a vegetarian fish in its natural habitat, the *Gourami* subsists largely on aquatic plants like water-lilies, lotus, submerged weeds, surface creepers, marginal grasses and algae. Insects, shrimps, worms, etc., found on aquatic vegetation have also been found in its stomach occasionally. Under captivity, it can be fed on meat, fish, prawns and eggs.

Gourami breeds almost throughout the year. Eggs are laid in a fairly large nest made out of aquatic weeds and marginal grass. The nests are generally made amidst weeds at the shallow margin where the depth of water does not exceed a foot. In ponds devoid of weeds, artificial facilities for nest-building may be provided by introducing bits of dry palm leaf or fibres. The nests are guarded by the parents. About 500 to 3,000 eggs are laid. They are large, spherical and 2.2 to 2.4

millimetres in diameter, and hatch out within 10 days of being laid. The hatchlings which at first float on the surface, cling on to weeds and grow to fingerling size (three inches long) in



The Gourami (*Osphronemus gorami*)

about three months. The growth thereafter is rather slow, a length of eight to nine inches being attained at the end of the first year.

As parental care is restricted, the hatchlings are helpless and have practically to fend for themselves. In natural ponds where other fishes may also be present, the number of fry and fingerlings of *Gourami* will be limited, as a good number will be preyed upon by predatory and other fishes. If the fry are segregated soon after hatching in the pond and carefully fed on zooplankton, almost all of them survive and reach the fingerling size.

The Common Murrel (*Ophicephalus striatus*). *Murrel* forms the bulk and mainstay of the pond fisheries in several parts of peninsular India. It is regarded as an excellent table fish in the Punjab, Madhya Pradesh, Hyderabad, Mysore and Travancore-Cochin, and is more highly priced and in greater demand than carps.

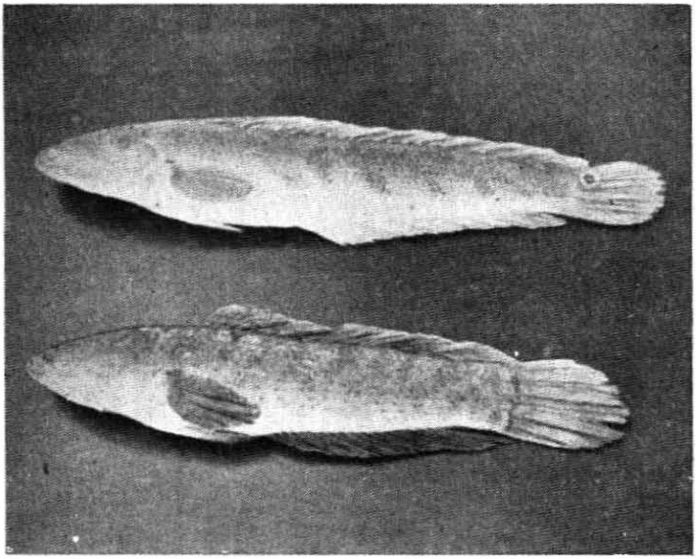
Of the several species commonly found in the Indian waters, *O. striatus* is perhaps the commonest and, economically, the most important. The different species of *murrels* resemble each other closely. A field key based on external characters and colour is given below (see page 52) to facilitate their correct identification.

Being a predator, *Murrel* feeds on minnows, minor carps, major carp fingerlings, insects, frogs, and other live food. Early fry of *Murrel* probably largely feed on zooplankton and the fingerlings mainly on insect larvae and young fish if available.

A catch of almost 100 per cent *murrels* (*O. striatus*) from one of the natural paddy field ponds in Cranganore, Cochin

O. striatus breeds in ponds almost throughout the year with a peak period immediately preceding and during the monsoon months. Sexual maturity is attained at a length of about 9½ or 10 inches. The floating eggs are laid in nests which are mere clearings made among shallow, marginal weeds. Both the parents guard the nest in which the eggs hatch out within 24 to 40 hours after fertilization. Larval development is very quick and a length of over 31 millimetres, on an average, is attained within 18 days after hatching. In natural ponds under limited forage conditions, the young one grows to a length of 10 to 12 inches at the end of the first year. Under favourable conditions, a quicker growth of up to 19 inches has been recorded.

The Large Murrel (*Ophicephalus marulius*). Probably the largest among the *murrels*, *O. marulius* attains a length of about four feet and is found almost throughout India. It prefers large pieces of waters like lakes, reservoirs and



The Large Murrel (*Ophicephalus marulius*—**advanced fingerling**) **(top) and the Koravai Murrel** (*Ophicephalus punctatus*)

swamps, though it is also found in rivers. It does not breed in small ponds. It is so highly predacious, even cannibalistic, that when stocked in confined waters like irrigation wells, the survival is limited to only a very few or often only one. Even carps in the first year are preyed upon by this *Murrel*.

It breeds from April to June, and the breeding habits are similar to those of *O. striatus*. The young ones grow fast,

FIELD KEY FOR INDENTIFICATION OF COMMON MURRELS

Distinguishing features	' *O. marulius* '	' *O. striatus* '	' *O. punctatus* '	' *O. gachya* '
Dorsal fin rays	45 to 55	37 to 45	29 to 32	32 to 37
Anal fin rays	28 to 36	23 to 26	21 to 23	21 to 23
Scales from snout to dorsal fin	15 to 16	18 to 20	12	12
Pectoral fin	Plain, not spotted or striped	Plain, not spotted or striped	Plain, not spotted or striped	Vertically striped, yellow and dark alternating
Body colour—adults	Dark brown or greenish grey above lateral line; dull white below; dark spots on sides	Very dark brown above lateral line: and continuing below the line as irregularly shaped steaks oblique and roughly parallel, lower half yellow or pale pink	Brown on the back, lighter beneath; dull or dirty yellow ground colour; dark spots on body; rarely vertical bands	Brown on the back, lighter below lateral line, becoming distinctly bluish. No spots; rarely vertical bands forwardly sloping
Body colour—young ones	wide orange red band on each side; Ocellus—a brown spot surrounded by paler ring at upper half of base of tail	Broad, lateral reddish orange band from eye to tail; iris golden with a red flush; bright golden occipital point; base of anal fin black all along	Blackish ground colour; lateral, bright golden yellow band; yellow spot on snout; base of fin not black	Two dark brown horizontal bands on either side, with lighter pigmented area in between the two bands; in larger fry a conspicuous ocellus at the hind end of the dorsal fin may be present
Maximum size attained	Four feet	Over two feet	About a foot	About eight inches

attaining a length of about 26 millimetres by the 19th—21st day after hatching. A maximum growth of about 30 inches at the end of the first year of its life is on record.

The Koravai Murrel (*Ophicephalus punctatus*). This is one of the smaller species of the genus attaining a foot in length and subsisting largely on small fishes, aquatic insects, micro-crustacea, shrimps and, occasionally, molluscs. The young ones feed almost exclusively on planktonic crustacea and insects.

Breeding season and habits are similar to those of *O. striatus*. Very little is known about its growth, but sexual maturity is probably attained in the first year of its life as in *O. striatus*.

Of the other species of the genus, *O. gachua* is of very limited economic significance, while our information on the life habits of *O. stewarti*, *O. micropeltis* and *O. amphibius* is extremely meagre though these species attain a fairly large size and are of potential value for cultural operations.

The Climbing Perch (*Anabas testudineus*). Widely distributed throughout India and also in the South-east Asian countries, *A. testudineus* grows to a maximum length of about nine inches and is a highly esteemed food fish in several places, fetching a higher price than the best carp. Though predatory in nature, it is not highly piscivorous and does very little harm to carp fingerlings over four inches in length. Though the young ones feed voraciously on micro-crustacea and insects, the adults are predominantly insectivorous, though shrimps, ostracods, gastropod shells and young fish are also taken.

The breeding season and habits are similar to those of the *murrels*. Under favourable conditions, it attains sexual maturity in the first year of its life.

The Singhi (*Heteropnuestes fossilis*). This is a common catfish with accessory respiratory organs and, therefore, able to breathe atmospheric oxygen. It is available throughout India and attains over a foot in length. Though not as highly priced a food fish as *Anabas* or *Murrel*, its flesh is supposed to have invigorating qualities. The fish is very much dreaded for its poisonous pectoral spines which can inflict very painful wounds leading to local inflammation and even fever.

It is predacious in habit but not markedly piscivorous. Insects, ostracods, worms, algal matter, organic debris and fish and fish remains constitute the main items of food. Varying quantities of mud or sand are also often taken in. It breeds during April-June but very little is known of its life history or growth.

The Magur (*Clarias batrachus*): This is another catfish with habits very similar to that of *Singhi* but not so common as the latter, though found throughout India and growing to a much larger size. Being an esteemed food fish, it is always in high demand and fetches a good price. As in *Singhi*, the pectoral spines of *Magur* can also inflict painful wounds.

Magur is a predator like *Singhi* but not so markedly piscivorous. Medium size specimens have been found to take prawns in appreciable numbers, aquatic insects and their larvae and sand or mud occasionally mixed with algal filaments.

The fish breeds in ponds during April-June but very little is known about its life history or growth in different types of environments.

OTHER FISHES OF CULTURAL VALUE

Besides the carps, salt-water fishes and live fishes dealt with above, there are a few others which are valued for culture. The most important of these are the Feather-back, *Notopterus chitala*, and the catfishes *Wallago attu*, *Mystus seenghala*, and *Pangasius pangasius*.

The Chital (*Notopterus chitala*). This is the largest of the three species of the genus found in India, confined to the major river systems like the Indus, the Ganga, the Brahmaputra and the Mahanadi. It grows to over four feet in length and is considered a tasty fish in several places. The laterally compressed deep body with the characteristic dorsal hump, small head, very long anal fin continuous with the tail and the blotch-like markings on the sides of the body, particularly at the hind region, are distinguishing features.

The adult *Chital* is a predatory fish which subsists mainly on small fish. In the early fry stage, it feeds voraciously on carp fry and aquatic insect larvae. The fish breeds in confined waters, attaching the eggs to submerged objects. The parents are reported to guard the nest. The young ones grow quickly, attaining a length of about 12 inches within 60 to 70 days.

The species is neither cultivated at present nor is anything known about its cultural possibilities.

The Freshwater Shark (*Wallago attu*). One of the largest of the freshwater catfishes attaining a length of about six feet, *W. attu* is widely distributed all over India. It is highly predatory in nature and is extremely destructive to carps. Its large mouth, well-armed with teeth, enables it to successfully attack and destroy even medium size carps. A variety of items including even limbs of human beings has been observed in its stomach. *Wallago* breeds in rivers during the rainy months. It is reported to attain a length of about 30 inches in the first year of its life.

On account of its predacious habits, this species should be carefully removed from carp ponds. No attempts appear to have been made to culture this quick-growing species in ponds on scientific lines.

The Catfish (*Mystus seenghala*). This is another of the larger riverine catfishes found almost throughout India in the major river systems and connected waters. It attains a length of about six feet and is in still greater demand than *W. attu* as a food fish.

The fish is a predator with marked piscivorous tendencies, *Barbus fi am:ntosus* and *Cirrhina reba* having being found most frequently in its stomach in the Cauvery river. Insects and their larvae, crustaceans, gastropods and very rarely aquatic weeds are also consumed.

The fish breeds in rivers as well as in ponds during April to July. Its breeding habits are peculiar in that a sort of nest in the form of a depression is made at the bottom by scooping out the earth. The eggs are laid in this nest and are guarded by the parents. Very little is known about the development and growth of the species.

The Pangas (*Pangasius pangasius*). This is yet another of the common major riverine catfishes attaining a length of about four feet and found all over India. It is a predatory fish in its natural haunts, but unlike *Wallago* and *Mystus*, it seems to live largely on gastropods whose shell-remains appear to constitute the largest single item amongst its stomach contents. As many as 400 shells have been found in the stomach of a specimen 24 inches long. The remains of insects and fish have also been found in addition to a small proportion of vegetable matter. The fingerlings are almost completely insectivorous.

The fish breeds during the monsoon months. Very little is known about its cultural possibilities although it is reported that in certain parts of East Bengal this catfish is introduced into carp-stocking ponds. Its marked partiality to a molluscan diet may be utilized to control the excessive multiplication of molluscs in ponds and reservoirs, though its piscivorous habits have to be given due consideration.

FOOD AND FEEDING HABITS OF FISHES

FOR successful fish farming, a thorough knowledge of the feeding habits of the selected species of fish is essential to ensure that all available food in the pond is used by the species stocked. As the food resources in ponds are varied, as also the kinds of fish and their feeding habits, a judicious combination of species for rearing would achieve this object.

The majority of our commercial carps are omnivorous and draw their sustenance from more than one source of food in the pond. Among the major carps, *Catla* is primarily a plankton feeder, and is, therefore, confined to the upper column or surface layers, while *Rohu* and *Mrigal* feed at the bottom.

The main items of food are given in the Table on page 57 as shown by an analysis of the gut contents of a large number of *Catla, Rohu* and *Mrigal* in the various stages of their growth.

Our knowledge about the food and feeding habits of our cultivated fishes is still very limited. All available information is summarized and given on pages 59 to 61 to enable

FOOD CONSUMED BY THE MAJOR INDIAN CARPS, CATLA, ROHU AND MRIGAL DURING VARIOUS STAGES

Name of fish	*Length in millimetres*	*Average percentage of items of food generally encountered in the stomach and gut*					
		Unicellular algae	*Filamentous algae*	*Vegetable debris*	*Animalcules and water fleas*	*Insects*	*Sand or mud*
Catla catla (*Catla*)	11.0 to 20.0	10.0	—	3.0	87.0	—	—
	21.0 to 40.0	9.9	—	2.5	87.6	—	—
	41 0 to 100 0	10.0	—	18.5	70.0	—	1.5
	101.0 and longer	8.3	0.7	38.0	44.1	—	8.9
Labeo rohita (*Rohu*)	11.0 to 20.0	—	—	20.0	60.0	—	20.0
	21.0 to 40.0	14.9	4.0	7.0	37.1	—	37.0
	41.0 to 100.0	14.0	12 5	41.5	18.0	—	14.0
	101.0 and longer	27.9	0.7	56.0	0.5	0.4	14.5
Cirrhina mrigala (*Mrigal*)	11.0 to 20.0	19.0	2.0	26.9	33.5	—	18.6
	21.0 to 40.0	22.3	3.0	43.0	15.2	—	16.5
	41.0 to 100.0	25.0	—	55.0	—	—	20.0
	100.0 and longer	26.2	6.7	45 5	—	—	21.6

the fish farmer to select the right species of fish which can use the maximum food resources available in his pond.

Several of the cultivated species of carps have very similar feeding habits, the bulk or, at least, an appreciable part of food consumed being sand and mud with decaying vegetable debris. These fishes are non-predators with toothless jaws, and cannot, therefore, bite their food. They can, however, swallow food which is crushed with a set of teeth at the throat before it is passed down into the stomach. They have certain structural adaptations suited to their peculiar feeding habits.

Catla has a slightly upturned mouth which enables it to gulp in quantities of water which are filtered through its gills, all the particulate organisms which give it sustenance being retained. It seems generally incapable of picking up food from the bottom of the pond or of browsing on weeds.

In *Rohu* the mouth is a little sub-terminal in position with thick fimbriated lips. The structure of the gill rakers shows that they are not adapted to filtering minute plankton organisms. The structure and position of the mouth and lips are adapted to sucking out the debris from the bottom and for browsing on weeds.

In *Mrigal* and *Bata*, the mouth is clearly terminal with thin lips, enabling them to pick up the bottom mud and debris easily. The gill rakers are ill-adapted for filtering water and retaining particulate organisms.

These differences in the structure of the mouth and the intestine appear only in the early fingerling stage. The highly coiled intestine, characteristic of the adult fish, seems to be formed later when the baby fish, with its straight tube-like intestine resembling that of adult predatory fishes, changes its feeding habits. There is hardly any difference in the position of the mouth also in the tender fry of most of the cultivated species of carps. That the baby fish are exclusively animal plankton feeders in the first few days of their life is proved by the structure and position of their mouth and intestine. As the young fish grows, the intestine becomes more and more coiled, and with this change the position of the mouth also shifts. Feeding habits thus differ at different stages.

NATURAL FOOD CONSUMED BY THE IMPORTANT FRESHWATER FOOD FISHES OF INDIA

(*Mentioned in the order of importance*)

Species of fish	Major items of food consumed by			Remarks
	fry	fingerlings	adults	
Catla catla	Animalcules and water-fleas	Water-fleas, a few planktonic algae and some vegetable debris	Water-fleas, vegetable debris including some algae	Mainly plankton feeder
Labeo rohita	do.	Vegetable debris, microscopic plants, few water-fleas, debris and mud	Vegetable debris, microscopic plants, detritus and mud	Bottom-column feeder
Labeo calbasu	do.	Vegetable debris and microscopic plants (mainly), few water-fleas, detritus and mud	Vegetable debris, microscopic plants, detritus and mud	Bottom feeder
Labeo fimbriatus	do.	do.	do.	Bottom-column feeder
Labeo kontius	do.	Filamentous algae and rotting leaves of aquatic plants, unicellular algae, Insect remains, detritus and mud	Rotting leaves of aquatic plants, detritus and mud, insect remains, algae	Marginal and bottom feeder
Labeo gonius	do.	Vegetable debris, unicellular algae, detritus and mud	Vegetable matter, microscopic plants, detritus and mud	
Labeo nandina	do.	No detailed study made	No detailed study made	
Labeo bata	do.	Vegetable debris, detritus and mud, unicellular algae	Vegetable debris, detritus, mud, unicellular algae	Bottom feeder
Labeo sp. (' *Parel* ')	do.	do.	do.	

Labeo dussumeiri	do.	No detailed study made	No detailed study made	
Cirrhina mrigala	do.	Vegetable debris, unicellular algae, detritus and mud	Vegetable debris ; unicellular algae, detritus and mud	Bottom feeder
Cirrhina cirrhosa	do.	Vegetable debris, sand or mud and detritus, algae	Detritus, sand and mud ; rotting leaves of macrophytes, planktonic algae	Bottom feeder
Cirrhina reba	do.	Vegetable debris, unicellular algae, detritus and mud	Phytoplankton organisms, detritus and mud, rotting leaves	
Osteochilus thomassi	do.	Unicellular algae, detritus and mud	Filamentous algae and debris, detritus and mud	
Thynnichthys sandhkol	do.	Microscopic plants, organic debris and sand	Planktonic algae, detritus and mud.	
Barbus carnaticus	do.	Insects, filamentous algae	Filamentous algae, leaves of aquatic macrophytes, detritus, insects	
Barbus dubius	do.	Dipteran larvae, detritus and mud	Dipteran larvae, corixid bugs, micro-crustaceans, detritus and mud	Bottom feeder
Barbus hexagonolepis	do.	Insect larvae, beetles and flies	Aquatic macrophytes, marginal grass, gastropod shells	Vegetation and molluscan feeder
Cyprinus carpio	do.	Water-fleas, few algae, vegetable matter	Vegetable matter and detritus, unicellular algae, Insects	
Carassius vulgaris	do.	Animalcules and water-fleas	Animalcules and water-fleas, vegetable debris, unicellular algae	Plankton feeder
Tinca tinca	do.	Water-fleas, filamentous algae, vegetable debris	Filamentous algae, vegetable debris, algae	
Etroplus suratensis	do.	Animalcules and water-fleas, filamentous algae, unicellular algae	Diatoms, filamentous algae, water-fleas, insects, leaves of aquatic plants	

Osphronemus gorami	do.	Insects, crustacea	Macro-vegetation, insects	Vegetablefeeder
Lates calcarifer	?	—	Fishes, prawns	Predator
Anabas testudineus	Animalcules and waterfleas	Insect larvae, water-fleas	Insects, water-fleas, vegetable debris, fish	Predator
Mugil cephalus	?	—	—	
Mugil. sp.	?	—	—	
Mugil corsula	Animalcules and water-fleas	Microscopic plants, water-fleas, detritus and mud	Detritus and mud ; unicellular and filamentous algae, insects	
Wallago attu	Waterfleas, insects, fish fry	Insects, other fish ry and fingerlings	Small and medium size fish	Predator
Mystus seenghala	do.	do.	do.	Predator
Clarias magur	Water-fleas (?)	Insects, ostracods, debris	Prawns, shrimps, insects	Predator
Hateropnuestes fossilis	do.	Insects, ostracods	Insects, ostracods, debris and algae	Predator
Chanos chanos	?	Microscopic and filamentous algae	Microscopic and filamentous algae	Plankton feeder
Megalops cyprinoides	Animalcules and water-fleas	Insects, zooplankton, fish fry	Small fish, insects	Predator
Ophicephalus marulius	do. and insect larvae	Insect larvae, fish fry	Small and medium size fish	Predator
Ophicephalus striatus	do.	Dipteran larvae, zooplankton, fish fry	Small fish like *Barbus* spp. *Chela* and *Esocus*	Predator

Carps which pick up or dig out their food matter from the mud at the pond bottom have the lips somewhat protrusible as in *Barbus dubius*. This fish feeds largely on worms, insects and snails at the bottom. With their protrusible lips they scoop out the bottom silt in search of prey, making small shallow pits in the process. If such small pits are found in shallow river margins, it is a clear indication that *B. dubius* has been feeding in that area. Some of the minor carps like *Rohtee* spp. (*cotio* and *vigorsi*) and Pearl Spot (*Etroplus suratensis*) have similar feeding habits. The latter, though not a marked predator, bites off portions of aquatic weeds and algae with the teeth in its mouth. *Gourami* has also similar habits.

In predatory fishes, the mouth is generally large and provided with a number of teeth, which, however, are not so much for chewing the prey as for preventing its easy escape. With its terminal mouth, the predator can easily snap at and catch relatively larger victims. Unlike the non-predators, the intestine is very short with a distinct bag-like stomach. The *Large Goby* (*Glossogobius giuris*), the *Murrel* (*Ophicephalus* spp.) and the freshwater shark (*Wallago attu*) are familiar instances.

CULTURE OF CARPS

As in China, the annual seasonal collection of millions of early fry of major carps from rivers in the States of Bengal, Bihar and Orissa in India and their stocking in nursery ponds for rearing, is a very important step in our fish cultural practices. Different types of ponds are utilized as nurseries and different methods of 'preparation' of the ponds are followed. There is, however, very little reliable information about these practices, most of which constitute family secrets in peasant families handed down from generation to generation. It is a common practice to purchase and liberate some fry or fingerlings in ponds without any attention being bestowed on the fate of the stock. Only a few attempt to clear the pond of unwanted fishes or predators, while still fewer people manure the pond or feed the fish artificially. Reliable data on such important aspects of pisciculture as the density of stocking for given waters and the percentage of survival of the different species at different stages, are lacking. Even an expert fish farmer is unable to ensure a satisfactory yield of fish in his pond. Reports of total failures of nurseries managed even by experienced fish farmers are not uncommon.

Against this background, the various fish cultural techniques outlined and suggestions made, which are based on experimental data and repeated field observations, should be of particular help to the fish farmer and the Extension worker.

Every area of perennial natural waters has a crop of fish in it. But every type of water, whether perennial or seasonal (long or short), can be utilised for raising a better crop of fish by adopting proper methods of cultivation.

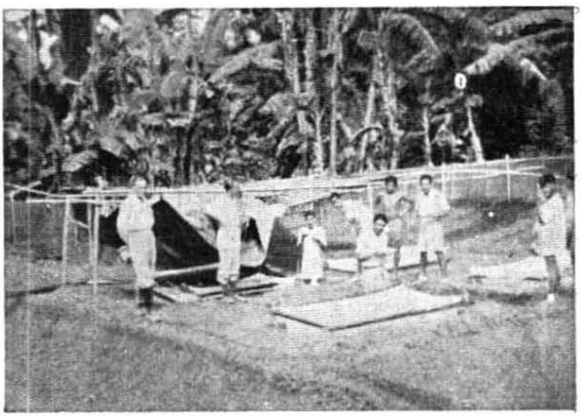
Ponds vary in location, size, depth, soil, shade, etc., besides in the qualities of water, fish food resources and natural stock of fish. In other words, no two ponds can be considered exactly alike for fish production, because each has its own physical and biological characteristics. Though most ponds fall into well known categories in respect of their fish production or physico-chemical conditions, they require special treatment for increased fish production. Different categories of ponds are required for cultivating different species of fish and also for rearing the different stages of life of each species. The important phases of carp culture and the types of ponds required for each phase are given on page 64.

Hatching pits. These are to be located close to the breeding *bundhs* (as in Midnapore and Bankura districts of West Bengal) or to the riverine collection grounds (like Nazira in Assam, Satyamangalam and Bhavani in Madras) from where fertilized eggs are collected in large numbers. The size of the pits may vary, but 8 feet x 4 feet x 2 feet is a convenient size.

Phase of carp culture	*Category of ponds required*
Hatching of laid eggs collected from rivers or *bundh*-type tanks	Hatching pits, 8 feet × 4 feet × 2 feet, with rectangular, coarse and fine-meshed miniature cloth tanks with or without arrangements for running water.
Nursing the hatchlings during the first two weeks to one month	Nursery ponds, preferably shallow (3 to 5 feet deep) small, seasonal; if perennial, four to six feet deep, long and narrow to facilitate netting
Nursing advanced fry or early fingerlings to the late fingerling size (four to six inches)	Rearing ponds, long-seasonal or perennial, depth four to six feet, preferably long and narrow
Rearing fingerlings to adult size	Stocking ponds, perennial, 5 to 10 feet or even deeper; preferably narrow (up to 100 to 150 feet) and long
Inducing mature carps to breed	Breeding ponds—*bundh* type or ordinary and small, with weeds for species which breed in ponds

A series of such pits, preferably interconnected so as to allow the water to flow from one pit to the other, should be

A unit of hatching pits at Nazira, Sibsagar, Assam. Note the cloth tanks in which eggs are laid for hatching



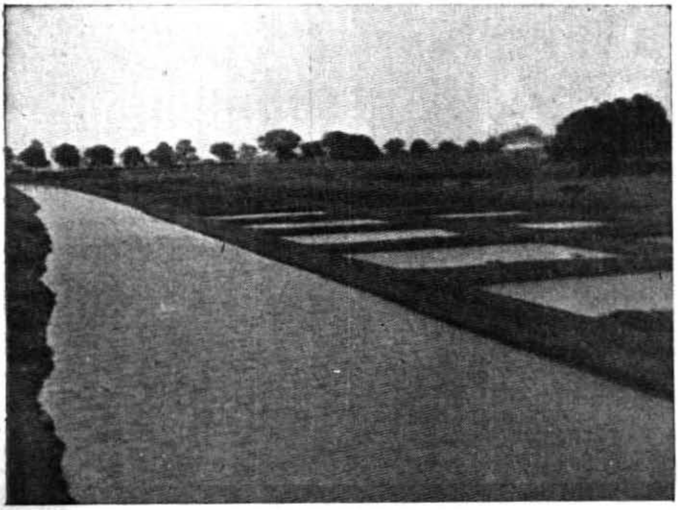
available. There should preferably be a continuous and slow flow of water either from a natural source or from an artificially created flow (by a pump) in and out of the pit, so that the eggs when laid for hatching are well aerated.

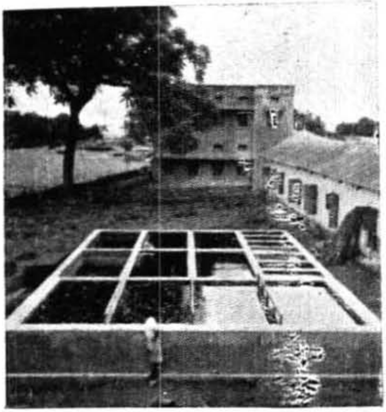
In each pit, a smaller rectangular cloth tank, 6 feet x 3 feet x 1½ feet, made of cheap coarse cloth should be tied to bamboo poles fixed in the pit. A similar open tank, but of smaller dimensions (5 feet x 2½ feet x 1 foot) made of round-meshed mosquito curtain cloth may be fixed within the outer course cloth tank, with its upper edges projecting out of the water surface by three to four inches only.

Smaller hatching pits, without the cloth tanks or *hapas* inside, are commonly used near the *bundh*-type tanks in Midnapore district. The survival of hatchlings in these pits is reported to be low as usually several hatchlings get injured while being collected from such pits.

Nursery ponds. Wherever possible, the nursery ponds should be located close to the collecting ground so that fresh fry could be released directly into them without conditioning

A view of the experimental nursery ponds at the Killa, Cuttack. The series consists of 48 ponds, all of equal size, with an adjacent canal that is fed from the Mahanadi





A set of experimental cement cisterns at Cuttack. The small cisterns are 6 feet × 3 feet × 3 feet and the larger ones 12 feet × 6 feet × 3 feet in dimensions

Two to three weeks old fry netted from one of the nursery ponds. The fishermen are engaged in creating a mild current of water to induce the fry to swim against and get segregated from the numerous aquatic insects

Tender carp fry being measured in specially made cups before stocking in nursery ponds at the Killa, Cuttack

The haul—two weeks old fry being measured in special cups before restocking in rearing ponds and transport. Small ponds, 50 feet × 50 feet, which can be easily controlled, are preferable to large ones. They should be seasonal and shallow, with not more than three to four feet of water, and should dry up completely during the summer months. Even short-season ponds containing a depth of three to four feet of water for about three months of the monsoon season may perhaps be better for this purpose, as they have the additional advantage of all the fish enemies being eradicated when this water dries up.

Though such an annual exposure of the pond bottom to the sun is not essential, it not only helps to eradicate the fish predators, but also to improve the general hygiene of the pond bottom by getting rid of the poisonous gases, if any, and enriching the same by contact with air. If the ponds are not seasonal, they should preferably have outlets for dewatering, so that they could be drained when required. In the absence of such facilities, the pond should be dewatered by baling or pumping out water once every four or five years.

Nursery ponds should, as far as possible, be located far from the river banks so as to avoid fluctuations of the water level in the river during flood and dry season.

Rearing ponds. They may be perennial or seasonal, retaining water for a long period. The advanced fry or early fingerlings should be kept in such ponds for two to three months when they attain advanced fingerling size (four to six inches in length). Netting is greatly facilitated if the ponds are long and narrow, and have gently sloping sides and the depth of water does not exceed six feet. Old silted ponds are not suitable for rearing fry. Paddy fields holding water to a depth of 1½ feet to 2 feet for two to three months may also be utilized for rearing early fingerlings.

Stocking ponds. All perennial ponds, a third of an acre or larger in area, and over six feet in depth, are better used as stocking ponds. As all available standing waters are to be used for fish culture, the size of a pond need not be taken into consideration, but if new ponds are constructed, a long run for the fish and easy netting facilities may be borne in mind. Long and narrow ponds, not exceeding two to three acres in extent, may prove to be of a manageable size for netting by a group of six fishermen using a relatively small net of 100 or 150 feet in length.

Breeding ponds. The most important of these are the *bundh*-type tanks in which the major Indian carps are known to breed. These are minor irrigation tanks, some perennial and others seasonal. The rain water, flowing down the sloping catchment area, is suitably blocked in a natural or excavated depression by erecting an earthen *bundh* across the outflow. With the continued accumulation of water in the depression, the level of water rises, submerging the adjoining shallow areas or fields. A weir is constructed for the overflow of water when the depression is full, and the adjoining extensive shallow fields are submerged.

Breeders of carp are reared or introduced from elsewhere into the pond. Early in the monsoon, the pond gets rapidly filled up, and later the rains cause sudden floods by enhanced flow of water from the catchment area. Whether the water flows out through the outlet or not, the fish move up to the shallow, inundated grounds or fields (a foot or two in depth), for the purpose of spawning.

The irrigation tanks of South India are similar to the *bundh*-type of ponds of the North. They may be utilized for stocking with breeders, where required, for development purposes.

The exotic carps *Cyprinus carpio*, *Tinca tinca*, and *Carassius vulgaris*, breed in ordinary ponds. Though no systematic breeding of these fishes in special breeding ponds is practised at present in our country, the method followed by fish breeders in Europe whence the fish had been brought to India, is as given below.

Spawning ponds are generally 50 feet × 20 feet × 8 inches to 12 inches with a ditch of about $1\frac{1}{3}$ to $1\frac{2}{3}$ feet deep all round to serve as a refuge for the breeders and also to facilitate fishing out of the brood. The bottom of the pond is covered with grown grass on which the eggs are to be deposited. The bottom of the pond generally slopes down towards the outlet so that draining of the water is easy. The male and female brood-fishes are stored in separate ponds. As soon as the spawning pond is filled with water, the breeders are introduced into the pond. Generally, only one pair of spawners is put in each pond. Often, however, one to three sets (a set consisting of two males and one female) of spawners are put in a pond 100 square metres in area.

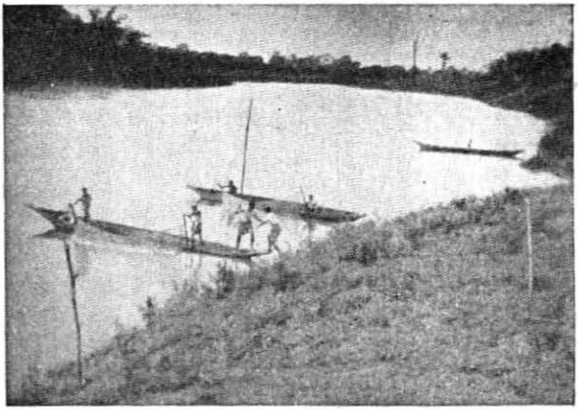
In Thailand, the fish was recently found to spawn in small artificial cisterns in which palm leaf or bamboo mats were specially provided for the attachment of eggs. The bamboo mats with the attached eggs are later removed to hatching ponds.

CULTURAL METHODS

Seed collection, handling and mortality. Our major rivers are the most important sources of seed of Indian carps. From these, millions of eggs, hatchlings and tender fry are collected every year during the monsoon months. A fair quantity of eggs is also collected from the *bundh*-type ponds of Bengal by the simple process of disturbing the ground on which the eggs are laid so as to float them up and catch them with simple cloth nets.

A systematic collection of carp eggs in this country appears to be in vogue only in Assam, particularly at Nazira on the river Dikhow in Sibsagar. A large number of eggs are collected there for a few days every year, a simple method for

Two nets in operation (collecting carp eggs in millions) in the river Dikhow at Nazira, Sibsagar, Assam



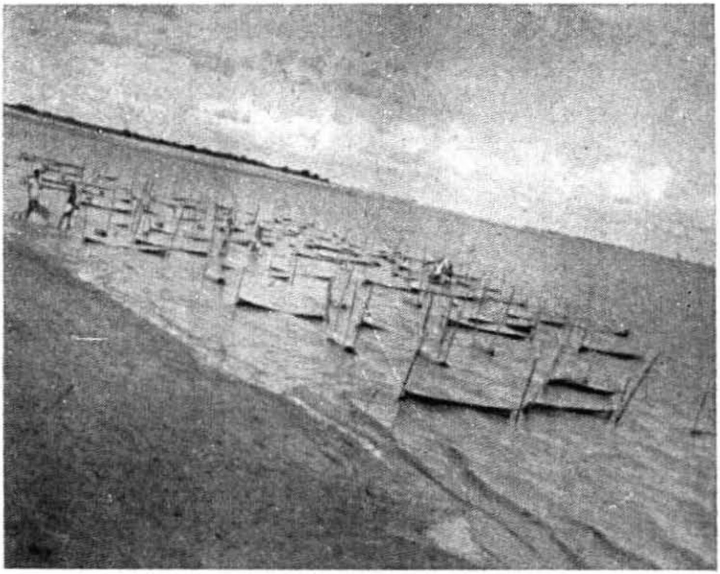
the purpose being employed. The eggs drift in the main flow of water. At the collection spot (at Nazira) where the river bank is steep and the depth of water considerable, two long bamboo poles are fixed near the bank with a boat tied on to them across the current. A piece of round-meshed mosquito netting, about 15 feet × 6 feet in dimensions, is fixed to two small bamboo poles at either end and held by two persons, one at each end, in position against the current. Every 10 or 15 minutes this net is lifted up and the eggs caught are collected and removed to a *hundi*.

Two persons and a boat are thus required for operating one net in the above fashion. It would, however, be more economical if, at the commencement of the season, bamboo poles are permanently fixed at different levels and nets of the type used for carp fry collection in Bengal or Orissa, but made of round-meshed mosquito netting and with larger open rectangular tank-like tail cloth, are substituted in place of the simple rectangular netting now in use. One person with a boat could then operate successfully at least five nets, the position of which could be shifted as and when required, depending on the water level.

Hatchlings and fry are collected mainly from rivers in specially made fry nets. These are conical or funnel-shaped nets made of cheap coarse cloth so as to allow easy filtering of water.

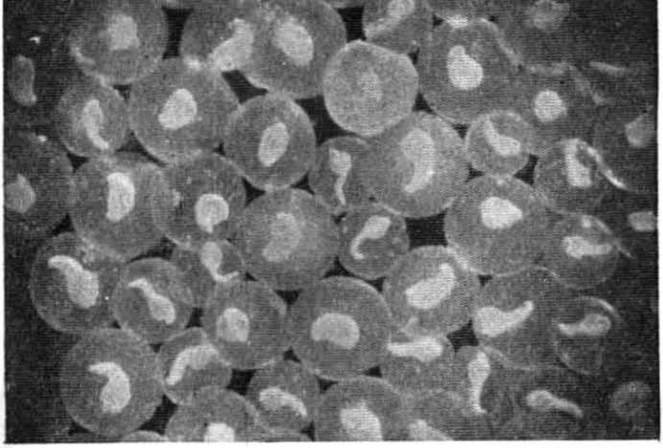
The length of the net varies (10 to 22 feet) at different places. It is open at both ends. The narrow tapering end is fitted with a ring (9 to 12 inches in diameter) made of reeds or cane. The mouth of the net is provided with tape or rope for proper fixation on to the poles. The capacity of the net is often enhanced by adding two "wings" at the mouth.

The net is fixed in shallow water where the flow is slow or gentle. It is fixed to poles with the mouth facing the current. The hind portion will drift in the direction of the current in which position it is fixed to the poles, just below the surface. The upper edge of the mouth of the net will be seen above the water. To the hind ring of the net is tied a tailpiece cloth, often two feet long and a foot deep, and tapering posteriorly. This tailpiece, usually called *gamcha*, is also



A battery of fry-catching nets in operation in the Mahanadi at the Nuapatna Fry Collection Centre, Orissa. Note the position of the nets in relation to the bank and the shallowness of water

A collection of carp eggs in various stages of development



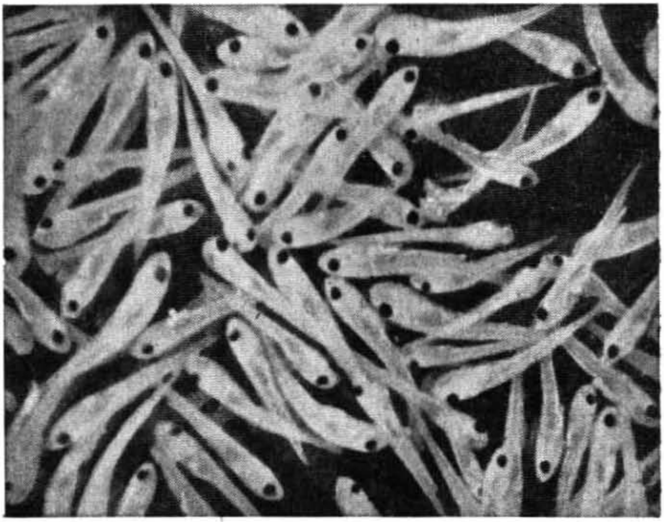
tied with the upper edge just above the water. The carp fry drifting with the current pass through the mouth of the net, get collected in the *gamcha* and are periodically removed and temporarily stored in small pits or in miniature cloth tanks fixed in the river itself.

A critical study of this common practice will reveal that during collection the tender fry get injured in several ways. If the net is not properly fixed, resulting in resistance to the fast current, several fry are either injured in the net or die. The damage to the fry can be greatly prevented if the net is fixed mouth first, allowing the tail portion to drift in the direction of the current and then fixed to the poles in the fully stretched position.

Usually, flood waters wash down large quantities of debris which are often caught in the net. These accumulate in the *gamcha*, and physically choke and injure the tender fry. This choking can be appreciably minimized if the form of the posteriorly tapering *gamcha* is changed to an open rectangular tank-like one, roughly $2\frac{1}{2}$ feet $\times$ 1 foot $\times 1\frac{1}{2}$ feet, and by introducing a net screen of about half inch mesh at the mouth of the net. The large-sized debris will be caught against the net and can be removed from time to time so as to allow the free flow of water and the movement of the fry contained in it.

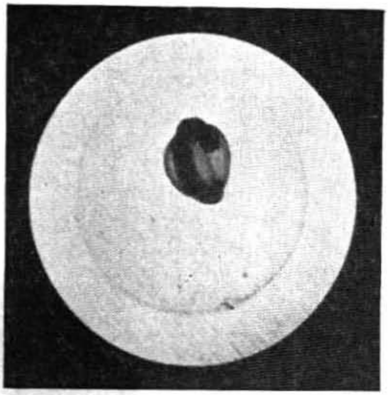
The collection of fry from the nets is usually cleared at long and irregular intervals, more particularly at night. When the collection is heavy and the fry are not cleared at regular, shorter intervals, there is bound to be considerable overcrowding in the *gamcha*, particularly when the choking due to accumulation of debris is not cleared. It is, therefore, essential to have the nets cleared at regular fixed intervals.

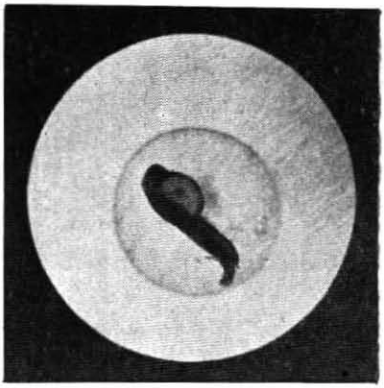
In collecting the fry from the *gamcha*, even trained fishermen lift it very often out of the water to drain and transfer the whole mass of fry and debris together to a bucket of water. This results in injury to the delicate fry from which recovery is often impossible. The correct method of clearing the *gamcha* is to lift up its nearer end by passing a hand underneath, driving the fry to the farther end, and passing the hand forward till all the fry congregate in a limited volume of water which can then be scooped up with a small vessel to be transferred to the water in the bucket.



A collection of carp fry at the stage at which they are ordinarily collected from rivers

A developing carp egg with the embryo just differentiated; same with advanced embryo inside





The fry thus collected are carefully separated from the debris by passing the collection through a fine-meshed sieve through which the fry will pass. When the sieve is placed on the mouth of a *hundi* and the collection poured over it, the debris is caught on the sieve allowing the fry to fall into the *hundi*, a process that entails considerable injury to the fry if the sieve is not kept immersed in water.

If the fry are to be temporarily stored in *hundies*, pits, or *hapas*, when they are collected, care should be taken not to overcrowd them with the fry. Overcrowding results in quick loss of dissolved oxygen and accumulation of carbon dioxide in the water and finally in the death of the fry. Even if the exact number of fry that could be safely kept in any particular container is not known, a careful watch maintained over the fry would reveal gradual overcrowding of the fry on the surface, which is an indication that the water needs partial or complete renewal.

This is easily done by pushing a coarse-meshed cloth down into the centre of the water in the *hundi* and then quickly removing the water with a cup without handling the fry. Fresh water is forthwith sprayed or gently poured into the *hundi* to replace the foul water removed already. In spite of all these precautions, someweak fry may succumb to the strain during collection.

The hatchlings and fry have often to be stored for a few days, until they are ready for transport in *hundies* to distant places. Both in storage and transport, they are liable to suffer injury or advserse conditions, ultimately leading to death.

When the conditions of water at the place of collection, in the conditioning pit, or in the container are significantly different and the fry are suddenly transferred from one to the other, they are likely to be adversely affected. The safest course in such cases would be to gradually mix the two waters before transferring the fry.

On bright sunny days, the water in the shallow conditioning pits or containers is likely to get heated up, particularly when they are not in shade, resulting in large-scale mortality of fry. The containers should, therefore, be kept either in the shade of a tree or protected by a temporary shed erected for the purpose over the *hapa* pits.

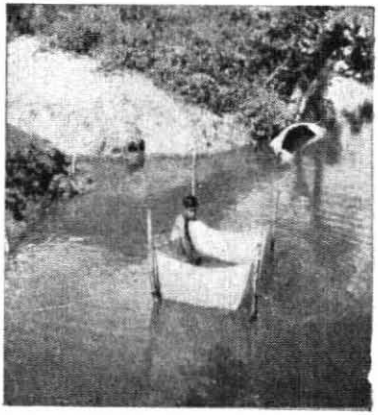
A series of *hapa* pits for temporary storage of fry collected from the river Mahanadi at the Nuapatna Fry Collection Centre, Orissa. Note the superstructure providing shade over the pits

Overcrowding in the *hapa* or the container should be avoided to prevent depletion of oxygen which results in mortality.

In *hapas* or containers with stagnant water, the weak and injured fry are susceptible to early attacks by fungi or bacteria. Whenever possible, running water should be readily available in *hapas* to prevent this. If such an arrangement is not feasible, common salt may be added to the water to make it a weak solution (0·1 per cent). This will not in any way adversely affect the fry but the fungal and bacterial infection will be checked and better hygiene will prevail in the *hapa*.

Conditioning of the fry and fingerlings is a common practice in many parts of India. This consists of keeping a number of them in a limited volume of water for a definite period during which the gut contents are voided through the vent and the fish get accustomed to the limited volume of water in the container. As conditioning involves starvation of both the fry and

A cloth *hapa* for keeping carp fry in the Taldanda Canal, Cuttack



fingerlings, it should not be prolonged so as to prevent mortality. The larger fry jump against the net or container in attempting to escape and injure themselves, thereby rendering themselves liable to fungal and bacterial infection.

It has been found that fingerlings of *Mahseer*, the *Carnatic Carp* and the *Indian Tarpon* are capable of being transported over long distances in an excellent condition if they are regularly fed on mosquito larvae during the journey. It is possible that young carp fry might also stand the ill-effects of long distance transport, if they are given their natural food (*Cladocerans*, etc.) during conditioning and transport. The feeding of fry and fingerlings with cultures of animalcules during conditioning and transport should, therefore, prove to be a wholesome practice.

Although sieving the fry collection results in the separation of most of the larger fry of predatory fish from the carp, the fry of smaller predatory species and some insect larvae escape through the meshes of the sieve into the container to feed on the carp fry. There is little doubt that in the unsieved collection of fish fry the carp fry suffer injury and death due to the presence of a large number of predatory fish fry and insect larvae in the limited space of the *hapa* or *hundi*.

The fry are liable to suffer injury if netting them out and measuring are not done with the utmost care.

Seed transport and mortality. The fry and fingerlings are transported in earthen *hundies* or in tin carriers of various capacities and shapes and sometimes in sealed containers with oxygen. At the temperature that prevails during the

A series of tin carriers being filled up with river water for transporting fish fry from the Nuapatna (Orissa) Fry Collection Centre

rainy season, the dissolved oxygen requirements of fry and fingerlings carried in a five-gallon container with river or pond water are not unduly high. The number of fry or fingerlings that could thus be safely transported is given on page 78.

This data is in respect of a closed container at rest. When the fish seed is transported in open containers, the constant jolting brings about an appreciable replenishment of atmospheric oxygen in the water. This will afford a longer safe period for the fry than is shown in the table.

In rail transport, using ordinary open earthenware *hundies* with about six gallons of water, part of which is renewed repeatedly *en route*, the number of fry that can be transported safely is given on page 79.

Volume of water in the container	*Initial dissolved oxygen content*	*Size of fry to be transported*	*No. of fry to be put in each container*	*Approximate safe period in minutes during which transport can be effected*
5 gallons	4 ppm	6-7 mm	50,000	19
,,	,,	,,	30,000	31
,,	,,	,,	20,000	47
,,	,,	15 to 20 mm	1,000	40
,,	,,	,,	500	80
,,	,,	30 mm	300	120
,,	,,	,,	150	240
,,	5 ppm	6 to 7 mm	50,000	25
,,	,,	,,	30,000	42
,,	,,	,,	20,000	62
,,	,,	15 to 20 mm	1,000	60
,,	,,	,,	500	120
,,	,,	30 mm	300	165
,,	,,	,,	150	330
,,	6 ppm	6 to 7 mm	50,000	31
,,	,,	,,	30,000	51
,,	,,	,,	20,000	77
,,	,,	15 to 20 mm	1,000	75
,,	,,	,,	500	150
		30 mm	300	207
		,,	150	414

Length of fry	*No. per hundi*	*Duration of transport (in hours)*	*Percentage of mortality*
½ to ¾ inch	1,500	up to 24	2.0 to 5.0
,,	1,200	up to 36	2.0 to 5.0
¾ to 1 inch	1,000	up to 20	2.0 to 5.0
,,	800	up to 30	2.0 to 5.0
1 inch to 2 inches	500 to 800	up to 24	10.0
2 to 3 inches	200	up to 8	10.0

When the dissolved oxygen content in the water goes below the minimum required, the fry show signs of distress and come up gasping to the surface. This is an indication that the water should be renewed immediately. This is done by carefully removing some water from the container and replacing gently with an equal volume of fresh untreated water. Chlorinated water should not be used, as it is harmful to fish.

As fry or fingerlings which die in transit begin to rot and foul the water, making it unsuitable for the other live fish, the dead fish should be removed periodically. Likewise, specimens infected with fungi or bacteria and which swim feebly with partly damaged whitish fins, are likely to infect the healthier fry in the container ; they should also be removed.

When fry are transported over long distances in open

A series of earthen *hundies* with carp fry kept for sale at the Sealdah fry market, Calcutta

vehicles, the metal containers and the water in them get heated up. This results in the death of the fry. If cheap woollen or gunny coverings are provided for the containers and kept moist by sprinkling water on them, the temperature of the water can be kept down. Alternatively, earthen pots which keep the water cool may be used as containers. As the transport of fry of different sizes in the same container also contributes to the mortality of fry, they should as far as possible be sorted out according to size in different containers. The fry of predatory fish and insects and their larvae should be scrupulously eliminated from the containers.

The fry can successfully be transported by air in sealed containers with oxygen for long distance transport. New, four-gallon kerosene tins fitted up with air-tight screw cap lids for filling in water and fish, and with tubes for letting in oxygen from an oxygen cylinder and displacing water, have been successfully used. When the tin is filled two-thirds with water and a third with oxygen, the number of fry that can be safely transported is given below:

Length of fry	*Number per tin*	*Duration of transport (air)*	*Mortality (per cent)*
½ to ¾ inch	800 to 1,100	12 hours and 8 hours by road	5 to 12
1½ to 2 inches	400	24 hours	30
1 inch to 1¼ inches	325	16 hours	3

The fry and fingerlings are to be conditioned for about six hours before packing in the tins. Fingerlings over two inches in length are unsuitable for economical transport over long distances.

SEED STOCKING, REARING AND MORTALITY

If there are appreciable differences in the temperature and other conditions between the water in the container and that in the nursery pond, the fry released in the latter are likely to be adversely affected. As a rule, therefore, the fry should not be directly released into the pond. The container with the fry should be kept partly immersed in the pond for some time allowing the temperature to equalize. Small quantities of the pond water should be occasionally sprinkled into the container. After about half an hour of this acclimatization the container may be tilted so as to allow the fry to escape into the pond.

The fry stocked in the pond should be provided with enough quantities of suitable food. The general practice of releasing the tender fry into the pond without previous "preparation" to receive the stock followed in many places is definitely harmful and uneconomical. A systematic preparation of the nurseries is essential for ensuring satisfactory survival of the seed.

The fry of predatory fish, which take a heavy toll of carp fry, are often inadvertently introduced into the pond along with the latter. Improved methods of collection and careful segregation of all unwanted fry by careful sieving alone will help reduce mortality of valuable fish seed.

Apart from the predatory activities of the numerous aquatic insects, minnows and other unwanted fishes in the water, the cannibalistic tendency of the carp fry themselves in their early stages has also to be remembered when fry of different sizes are stocked together in the same pond at intervals of two to three days, as some of the smaller and weaker fry are eaten by the larger and stronger ones. To avoid this, fry of the same size should, as far as possible, be used for stocking in a single day. Further stocking in the same pond should, as a rule, be avoided at least till 10 days of the first stocking. A second stocking, if found necessary, is best done after the first stock has been removed after a lapse of about 12 to 14 days.

In certain ponds, the microscopic floating algae multiply rapidly and turn the water bottle-green in colour. Such blooms occurring on sunny days utilize the carbon dioxide in water, releasing oxygen quickly to the point of supersaturation. Oxygen, though essential for life, is harmful when present in excessive quantities. Tender carp fry present in such a water are soon affected. The excess oxygen usually accumulates in the form of small bubbles in the gut and other body spaces, including blood vessels, making the fry unstable and float on the surface. The continued accumulation of gas eventually results in the bursting of the stomach or gut, and death. As already stated, algae are not preferred as food by the tender fry. The release of fry into ponds having thick algal blooms is, therefore, not advisable except when the bloom is on the decline. Advanced fingerlings may, however, do well in such ponds.

Overgrowth of submerged or floating weeds and filamentous algae are as unsuitable as algal blooms for carp fry in nursery ponds, as they are not used as food. In a pond full of such weeds, the plankton contents on which carp fry generally thrive will also be very poor.

Thus several favourable factors should prevail in the water from the moment carp fry are released in the ponds up to a period of a week or 10 days thereafter, so that a satisfactory growth of the fry may be obtained. Unless suitable steps are taken to create and maintain such favourable conditions during the critical period, the majority of fry will perish, making pisciculture an unprofitable concern.

PREDATORY FISHES IN NURSERY PONDS

The common predatory fishes met with in nursery and stocking ponds have different local names. they are *Ophicephalus marulius*: *sal* (Bengal), *gajar* (Assam); *bhor* (Bihar); *salo* (Orissa); *pula chapa* (Andhra); *poo verall* (Madras); *vaaka braal* (Kerala)

O.striatus: *shol* (Bengal), (Assam); *sowra* (Bihar); *sheulo* (Orissa); *sowarah* (Andhra); *veraal* (Madras); *braal* (Kerala).

O.micropeltis: chaerumeen (Kerala)

O.stewarti: *dudu-cheng* or *tel cheng* (Bengal);

O.Punctatus: *taki*, *lata* (Bengal); *cheng* (Assam); *gotisha* (Orissa); *koravai* (Madras).

O.gachua: *cheng* (Bengal), (Assam); *chainga* (Bihar), *chengo* (Orissa); *para koravai* (Madras) *vattudi* (Kerala).

Anabas testudineus: *koi* (Bengal), (Assam); *kobhai* (Bihar) *kou* (Orisa), *thattimata* (Andhra); *panayeri kendai* (Madras); *karipidi* (Kerala).

Nandus nandus: *nandus* or *dudhurkal* (Bengal); *bao-vaadhi* (Assam); *vaadhul* (Bihar), (Uttar Pradesh); *meussoassal* (Punjab); *bodari gossipora* (Orissa); *septi* (Andhra); *andi kalla* (Kerala).

Glossogobius giuris: *beley bhalia* (Bengal), *bhula* (Bihar) *kharpa* (Bombay), *boul la goo-loo-wah* (Punjab), *gula bali gira* (Orissa); *esakadondhu* (Andhra); *uluvai* (Madras); *paichi*, *poozhan* (Kerala).

Notopterus notopterus: *pholui* (Bengal); *kamdoolee* (Assam); *golhi* (Bihar); *pholi* (Uttar Pradesh); *chatal chambaree* (Bombay); *purri* (Punjab); *pholi* (Orissa), *ampattankathi* (Madras).

N. Chitala: *chital* (Bengal); *seetul* (Assam); *mohi* (Bihar) *chittala*(Orissa).

Lates calcarifer: *bhetki* (Bengal); *fitada*, *kajura* (Bombay); *bekti* (Orissa), *pandu meenu*,*pandugopa* (Andhra); *koduva* (Madras); *narimeen* (Kerala).

Heteropnuestes fossilis: *singee*, (Bengal), *singhee*, *sheenee* (Assam); *sinhi* (Bihar); *singi* (Uttar Pradesh); *lahoord nullie* (Punjab); *singee* (Orissa); *ramalu* (Andhra); *thaeli* (Madras); *kadu* (Kerala).

Clarias batrachus: *magur* (Bengal); *mah-gur* (Assam); *mangri* (Bihar); *kug-ga* (Punjab); *maguro* (Orissa); *marpu* (Andhra); *anai* (Madras); *musu* (Kerala).

Wallago attu: *boal* (Bengal); *boal* (Assam); *bowali* (Bihar); *baliat* (Orissa); *vaaluga* (Andhra); *vaalai* (Madras); Vaala (Kerala).

Silonia silondia: *shilon* (Bengal), (Assam), *silond* (Punjab), *shilond* (Orissa); *wanjou* (Andhra); *ponathi* (Madras).

Pangasius pangasius: *pangas* (Bengal), (Assam), *jellum* (Orissa); *aikelathe* (Madras).

Ompok spp: *pabda* (Bengal); *patboh* (Assam); *chechora* (Bihar); *gugli* (Bombay); *pallu* (Punjab); *pabtah* (Orissa), *duka dumu* (Andhra); *vaalapottu*, *chotta-vaala* (Kerala).

Mystus seenghala: *air* (Bengal), (Assam), (Bihar); *pogal* (Uttar Pradesh); *tengra* (Punjab) *aadi* (Orissa), *shengal* (Andhra); *cumboo-kellettee* (Madras); *aetta* (Kerala).

M. aor: *air* (Bengal); *seengala* (Punjab); *aadi* (Orissa); *mukul-jellah* (Andhra); *aetta* (Kerala).

M. cavasius: *kavasi tengra* (Bengal); *shingti*, *shingata* (Bombay); *kontia* (Orissa); *nahra jella* (Andhra); *vella kellettee cutta* (Madras); *koori* (Kerala).

Megalops cyprinoides: *punnikown*, *naham* (Orissa); *kannangi* (Andhra); *morankendai* (Madras); *vaalathan* (Kerala).

Anguilla benghalensis: *kuchia* (Bengal); *ahir* (Bombay); *malugu* (Andhra); *velaangu* (Madras); *malinjeen* (Kerala).

Amphipnous cuchia: *kuchia* (Bengal), (Assam), (Orissa); *dondoopaum* (Andhra).

Predatory fishes, are almost invariably present in ponds, though in varying number. Even in ponds completely isolated from other sources of water, some of the predatory fishes like the *murrels*, *Anabas*, and others, crawl in over wet ground from neighbouring waters. And once they get into the pond it is extremely difficult to eradicate them by the usual netting operations. All the predators feed on carps, adult specimens preying upon fingerlings and yearlings, and the young ones destroying the carp fry. A fry of *Wallago attu* kept in an aquarium with 100 carp fry, with the number devoured by it made good every 24 hours, has been reported to have consumed 1,096 fingerlings of carps in 40 days.

Some of the predatory fishes like the *murrels*, *Anabas*, *Nandus*, *Heteropnuestes*, *Clarias* and *Notopterus* breed in ponds a little prior to or at the commencement of the monsoon. Their young ones, feeding on the plankton in the nursery ponds, grow so fast that when the carp fry are ready to be introduced into the pond, they are large enough to destroy them in large numbers.

Young fry of *Chital* (*N.chitala*), *Silund* (*Silona silondia*), *Pangas* (*Pangasius pangasius*), etc., which are very often caught in the rivers along with the carp fry have been found to be highly destructive. In most of them the stomach is gorged with carp fry which very often form 100 per cent of the feed. Even the spiny eel (*Mastacembelus pancalus*) with its small mouth is partial to carp fry. The young ones of *Chital*, the larger riverine catfishes like *Wallago*, *Silonia* and *Mystus*, the *murrels*, and the climbing perch (*Anabas*) are exceedingly destructive to tender carp fry.

OTHER PREDATORS IN NURSERY PONDS

Aquatic insects usually abound in all fresh waters. Some of them, particularly the back-swimmers (Notonectids), occur in thousands during the rainy months in the manured nursery ponds in Bengal, Bihar and Orissa. Several species of dragon-fly nymphs, aquatic beetles and bugs and their larvae, the water-scorpion (*nepa*), the water-stick insect (*Ranatra*) and others are also commonly seen in ponds. All these insects are extremely destructive to the tender fry which are planted in nursery ponds.

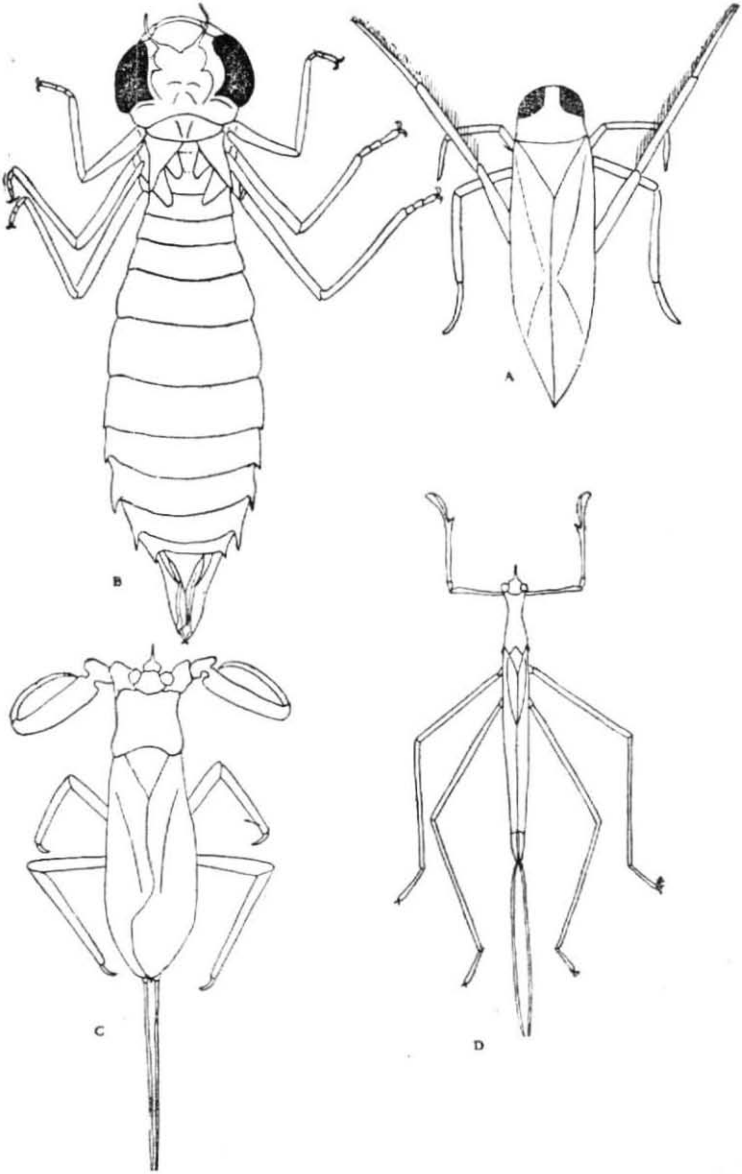
The back-swimmers are found in the column of water all over the pond, occasionally coming up to the surface to breathe. The dragon-fly nymphs are generally found at the shallow bottom or creeping amidst weeds. Most of the other aquatic insects also have to come up to the surface of water to breathe.

As soon as the tender carp fry are released in nursery ponds these insect predators, particularly the back-swimmers attack and start eating them. Within a few minutes of releasing the fry in the marginal waters, almost every specimen of backswimmer (*Notonectidae*) in the water within sight may be seen holding a fry each in its jaws. In this way, these predatory insects often destroy some thousands of fry almost immediately after introduction into the nursery ponds.

Laboratory experiments have shown that the back-swimmers are capable of attacking and killing carp fry even when they are four to five days old (half an inch in length). The larger insects like *nepa* and *Ranatra* can kill larger fry even up to an inch in length. The olive beetle (*Cybister*) and its larvae are highly predatory and kill even early fingerlings, upto two inches in length. As the harm done by aquatic insects in nursery ponds during the first three to four days after stocking is immense, these predators should be completely controlled so that carp fry may be reared with success.

The back-swimmers (*Notonectidae*) are of almost the same size as a week-old carp fry. When nursery ponds are netted with a fine-meshed net either for thinning out the stock or for collecting the fry for sale, a very large number of these insects are also caught in the net. When the fry are taken from such ponds for transport in *hundies* or kept in *hapas*, these insects again cause immense harm to the fry by clinging to the body of the fish fry already weakened owing to lack of oxygen in the congested container.

The insect predators should be completely eradicated



Enemies of carp fry—the common predatory aquatic insects: A. the back-swimmer *Anisops*, **B. the dragon-fly nymph, C. the water scorpion and D. the water stick-insect**

from the nursery ponds immediately before stocking and during the first few days after stocking. The same applies to the *hapas* in which the fry are temporarily stored, and to the *hundies* in which they are transported.

WEED FISHES IN PONDS

As no attention at present is being paid to the careful preparation of the pond in carp culture, the nursery rearing and stocking ponds generally contain a varying population of minor carps, carp minnows and predatory fishes. The several species of small fishes belonging to different families are collectively called "weed fishes" as they, like the weeds in the field, are harmful to cultivated carps. Multiplying rapidly in the ponds even before the commencement of the rains, their young ones get sufficiently grown, not only to compete with the major carp fry for food but also to directly prey upon them.

Laboratory experiments have clearly shown that all species of weed fishes, big or small, take a direct toll of the tender carp fry and devour them as they do with water-fleas when introduced into water. Field experiments on the rearing of carp fry in ponds containing weed fishes have also clearly demonstrated that only a small percentage of the fry introduced actually survives to reach the fingerling stage.

The early fry of the major carps are to some extent cannibalistic in habit. The weaker ones are easily preyed upon by the stronger and larger ones. This habit is more pronounced when the fry are conditioned in *hapas* or *hundies* for some considerable time, as in the absence of adequate food they feed on the dead or dying ones.

ERADICATION OF PREDATORY AND WEED FISHES

Among the predatory fishes, the *murrels*, *Anabas*, *Heteropnuestes*, *Clarias*, etc., are hardy species, breathing atmospheric air but capable of staying at the bottom of the pond or buried in mud for considerable periods. It is, therefore, extremely difficult, if not impossible, to eradicate them from the ponds by netting. As a rule, the predators are fished out by stirring up the bottom silt, when the water level in the pond is very low, and then quickly drag-netting the pond. This is repeated at intervals of several days. Large numbers of predatory fishes as also the majority of carps and other fishes can be caught in this way. As a complete eradication of the predators is seldom possible by this method, those that have escaped the drag-net soon multiply in the pond.

In deeper waters, netting operations are hardly effective. The *murrels*, for instance, burrow in the bottom mud and escape the nets. Complete dewatering in summer, partial desilting and exposure of the pond bottom to the sun for some days are the only effective methods for eradicating the *murrels* from shallow ponds.

In deeper ponds which can be dewatered only at great cost, a thorough and repeated netting should be followed by systematic baiting with hooks. Carp minnows (*Chela*, *Amblypharyngodon*, *Barbus*, etc.) serve as very convenient live baits. Short, baited hooks suspended from floats scattered all over the ponds, or a long series of hooks suspended from a long floating line at fixed intervals, will serve the purpose. In relatively small ponds, the two ends of the long line are fixed on opposite banks, but in larger sheets of water they are tied to floats provided at either end, or with one end fixed and the other floating. Baited and set at dusk, the line is left overnight and drawn up the next morning. Repeated use of such baited hooks can effectively check the predatory fish population in the pond.

As stated above, some of the predatory fishes (*murrels* and the *Climbing Perch*) breed in ponds, with a peak period in April-May. The gregarious young of *murrel* move about in a single large shoal, often guarded by the parent fishes. If a hook baited with a live minnow or worm is introduced near the shoal, the parents will forthwith take it. As soon as the parent fish are removed in this manner the fry could also be carefully netted out with a piece of cloth. This method can be effective only during the breeding months when the broods can be located by their conspicuous reddish colour.

The *Large Goby*, *Glossogobius giuris*, also breeds prolifically in ponds almost throughout the year, with the peak coinciding with the rainy months. The eggs, protected by tube-like capsules, are attached to the underside of bricks, wooden planks, etc. Hard objects like these, if deliberately provided in the marginal shallows of ponds, facilitate the deposition of the eggs on their underside. Laid eggs hatch out within $2\frac{1}{2}$ to 3 days.

The eggs may be collected and destroyed, thus controlling the population of *Gobies*.

Poisoning is an effective method of eradicating predatory fishes. Several indigenous fish poisons are known. Tuba root powder or Derris powder, a well known insecticide, is largely used as a fish poison also. The active principle known as rotenone is present in the commercial Derris powder to the extent of five per cent only. As it is a contact poison, the delicate gill membranes of the fish are damaged, resulting in their inability to take in sufficient respiratory oxygen from the water, and finally in death.

Though different species of fishes are affected differently by the poison, a high dose of it brings about death in most cases, while a mild dose is enough to paralyse their normal activities. Generally speaking, the predatory fishes are hardier than the non-predatory ones and require a fairly heavy dose of Derris Powder for effective stunning. The common predators in nursery ponds, namely, *O. punctatus*, *O. gachua*, *A. testudineus*, *H. fossils* and *Amphipnous cuchia*, are killed by a dose of 0.3 to 0.5 parts of rotenone per million parts of water. Young ones of *G. giuris* are fatally affected even at a dose of 0.05 parts of rotenone, but complete stunning of the larger adult specimens is effected by a dose of 0. 2 parts of rotenone per million parts of water.

The quantity of poison required is calculated on the basis of the volume of water in which the fish live. The area of the pond is calculated first by multiplying the length by the breadth if the pond is roughly four-sided and by multiplying the square of the radius (half the diameter) by 3.143 if circular. When of irregular shape, the pond is considered to consist of a number of squares or circles, the individual areas of which are calculated and added up to get the total area. The average depth of water in the pond is determined by a number of soundings at representative points, preferably along the length of the pond or diagonally.

One cubic foot of water weighs about 64 pounds. The total weight of water in the pond could thus be obtained by multiplying the total water content in cubic feet by 64. As Derris powder contains only five per cent rotenone, the quantity of rotenone calculated at a particular dose should be multiplied by 20, so as to get the quantity of Derris powder required.

The following formula may be used for determining the quantity of Derris powder required to be put in at a given dose. Water content in cubic feet × 64 × dose of rotenone × 20 = Weight of Derris powder required in pounds.

For a given dose, this may be simplified as follows:

Dose of rotenone in part per million	*Corresponding dose of Derris powder*	*Quantity of Derris powder required (in grammers)*	
0.01	0.2	water content in c. ft.	x 0.0058
0.02	0.4	,,	x 0.0116
0.03	0.6	,,	x 0.0174
0.04	0.8	,,	x 0.0232
0.05	1.0	,,	x 0.0290
0.06	1.2	,,	x 0.0348
0.07	1.4	,,	x 0.0406
0.08	1.6	,,	x 0.0464
0.09	1.8	,,	x 0.0522
0.10	2.0	,,	x 0.0580
0.20	4.0	,,	x 0. 116
0.30	6.0	,,	x 0.1740
0.40	8.0	,,	x 0. 332
0.50	10.0	,,	x 0. 290
0.60	12.0	,,	x 0. 348
0.70	14.0	,,	x 0. 406
0.80	16.0	,,	x 0. 464
0.90	18.0	,,	x 0. 522
1.00	20.0	,,	x 0. 580

The required quantity of the poison is weighed and dissolved in water to make a thick brown solution which is taken in a cup or any small handy vessel and sprinkled all over the surface. The surface water is then splashed about by a few persons getting into the water and wading through or swimming across, so that the poison gets quickly mixed with the water. Within a few minutes, fishes will be seen coming up to the surface in distress. Soon they get weak, gasp for breath, lose equilibrium, dash about violently, float for a few minutes, making occasional convulsive movements and die and quickly go down to the bottom. The fishes should be collected in a net dragged near the surface of water while they are still floating on or near the surface of water, as otherwise, they will drop to the bottom dead, and float up in a rotten condition the following day.

Fishes which habitually live at or near the bottom are killed much later than those that live near the surface of water or in the column. The live fishes, however, come up to the surface occasionally to take in air when they come into contact with the poison. Most fishes die within three to four hours after application of the poison.

Among the common weed fishes, the glass fishes *Ambassis ranga* and *A. nama* are very quickly affected by rotenone. *Chela bacaila* and *Barbus stigma* are more resistant, but a dose of 4.0 parts of Derris powder per million parts of water kills almost all weed fishes.

Although Derris powder kills the microscopic animals (zooplankton) in the water at once, the floating microscopic plants (phytoplankton) are not affected. The toxic effect of the poison persists in water for four to five days if the dose is up to 6.0 parts per million and for 8 to 12 days if it is up to 20.0 parts per million. At the close of the period mentioned in each case, the toxicity disappears and the zooplankters begin to appear in the water.

Derris powder is lethal to other aquatic organisms also. Thus frog tadpoles are killed within two to three hours by a dose of 3.0 parts of the powder to a million parts of water, though toad tadpoles are more resistant to the poison. Dragon-fly nymphs, back-swimmers, snails, etc., are also killed to some extent. Even bottom-living organisms like chironomid larvae and worms are also destroyed.

The poison is very effective in shallow waters (up to five feet) on hot sunny days. When the temperature of the water is below 25°C, the action of the poison on the fish is comparatively delayed. In deeper waters, the effect will be felt only gradually and beyond a depth of 20 feet the action is insignificant. Better results have been reported in China where Derris powder is applied along with lime.

CONTROL OF INSECTS IN PONDS

An effective control of aquatic insects in nursery ponds is one of the fundamental and essential steps to ensure successful rearing of carp fry in them. In the absence of suitable control measures, the rate of survival of fry will largely depend on the population of insects present in the pond at the time of stocking.

A simple method of control of insects is to drag-net the pond repeatedly with a fine mesh cloth net a day or two before the carp fry are to be stocked in them, and destroy all the insects thus caught. This substantially increases the survival of fry and production of fish in the pond. This operation should be carried out very carefully so that the water is not unduly disturbed and the favourable ecological conditions for the zooplankton population in the water are not upset. As the insects cannot be eradicated completely by this operation, the aim will be to reduce their number to an appreciable extent.

Many aquatic insects (beetles and bugs) can migrate from pond to pond as they can fly out of water. Even if a pond is effectively cleared of its insect population, it will be repopulated very shortly from other adjoining waters. The netting out of insects should be so timed as to leave little interval between such removal and the stocking of the pond with fish fry and the plankton in the pond should be as little disturbed as possible. In view of the above, insecticides like lime and Derris powder which are lethal to the microscopic animals and render the water toxic for the succeeding few days, cannot be applied for the control of insects in nursery ponds.

Experiments at the Pond Culture Substation at Cuttack show that many species of aquatic insects, including the destructive back-swimmers (Notonectids), can be effectively controlled by spraying common vegetable oils. Oils of mustard, coconut, *til*, linseed, castor and groundnut can be used without any adverse effect on either zooplankton or on carp fry. (Linseed oil at 50 pounds per acre, however, though very effective against notonectides, has a slightly unfavourable effect on zooplankton and also carp fry. It should not, therefore, be applied in nurseries immediately before or immediately after stocking them with fry.)

Owing to high viscosity, these oils do not readily spread on the water surface. This can, however, be overcome if any of the relatively less viscous oils like mustard oil is made into an emulsion with about a third of its weight of any cheap washing soap. When sprayed, this emulsion spreads quickly, forming a thin film over the water surface. The back-swimmers, which have the habit of coming up to the surface of the water to breathe air, come into contact with the oil film which chokes the respiratory tubes and brings about their death.

The required quantity of soap is dissolved in a limited volume of water by boiling, and in this solution, when lukewarm, weighed quantity of the oil is thoroughly stirred to form a yellow emulsion. Before the emulsion is sprayed over the water surface, it is diluted with the pond water. Small quantities of the emulsion taken in a cup or can are sprinkled with force over the water surface so as to spread the same over the water.

As the wind will bank the film of emulsion to one side of the pond, many insects may escape the effect. It is, therefore, advisable to choose a still and windless day for spraying. On a windless day, the back-swimmers in a pond can be completely killed within four hours of the application of the emulsion.

The quantity of oil to be applied is calculated on the basis of the water surface of the pond. An emulsion made of 50 pounds of mustard oil and 16 to 18 pounds of soap per acre of water surface yields satisfactory results under field conditions, but the effect will last only for 8 to 12 hours after which the pond could be repopulated by insects. A nursery pond is, therefore, treated with the emulsion a day before it is stocked with carp fry. Ponds so treated have given very satisfactory results, the survival of fry being as high as 90 per cent or above. The additional expenditure involved is fully compensated for by the substantial final results in the yield of fingerlings.

As the oil emulsion has no adverse effect on carp fry or plankton and as its effect on insects lasts only for a few hours after application, a supplementary treatment, a day or two after stocking, may be found necessary and even advantageous.

Larger insects like the water-scorpion, the water-boatman and the olive beetle, the larvae of other beetles and bugs and dragon-fly nymphs, are not generally killed by the dose which is fatal to back-swimmers (Notonectids). Laboratory experiments with stronger doses of the emulsion have proved their efficacy in the control of the population of the larger insects also.

Depending on their cost and availability, mustard, coconut or *til* oil may be used with effect. Castor oil is too thick to make a satisfactory emulsion.

As aquatic insects attack even advanced fry and early fingerlings during netting, conditioning and transport, the application of mustard oil-soap emulsion is recommended for ponds containing those phases also.

When a week to 10-day old fry are netted from nursery ponds, they will be mixed with a large number of Notonectids. These should be completely segregated from the fry, not by the casual method of producing a mild artificial current and allowing the fry to swim against it, but by the entire haul being kept in a medium-sized cloth *hapa* into which a little mustard oil soap emulsion is sprayed on the surface to kill the Notonectids and removing them. If this precaution of separating the Notonectids from the fry is not taken before the latter are introduced into *hundis* or tin carriers, very few fry will survive the attack of these insects in the limited space of the container.

MANURING OF NURSERY PONDS

The main object of nursing carp fry in specially prepared ponds is to raise a short-term crop of as many healthy fingerlings as possible in the limited area of the pond. As the number of fry that the natural resources of a pond can support until they attain the fingerling size is generally very limited, the pond must be specially prepared to support a much larger number of fry than its size and resources warrant. One important way of doing this is to manure the pond to increase temporarily the supply of food for the fry.

The manures used are either inorganic (chemical fertilizers) or organic. The common inorganic fertilizers are superphosphate, ammonium sulphate and sodium nitrate. Very little information regarding the relative utility and dose of these is available in India at present. Preliminary experiments at Cuttack, however, have confirmed the findings of workers in the U. S. A. that inorganic fertilizers tend to increase the production of microscopic floating algae.

In view of the fact that water-fleas (zooplankton) are relatively more valuable as a food for early carp fry than floating algae (phytoplankton), the application of inorganic manure does not seem to be advisable in nursery ponds. The choice, therefore, falls on organic fertilizers.

The commonest and the cheapest available organic manure in the country is cow-dung. Experiments show that cow-dung is one of the best manures for carp nurseries. Heavy manuring with cow-dung in experimental pots or in cement cisterns (dose ranging from 10,000 to 1,00,000 pounds per acre) results invariably in the production of a rich crop of wheel animalcules (Rotifera) and water-fleas (Cladocerans and Copepods) which appear in thick swarms in the entire column of water within 9 to 12 days. As very few algae are produced at this stage, there is almost a 100 per cent preponderance of animal organisms during a period of about 7 to 10 days, depending on the dose of the manure applied. Appreciable numbers of planktonic algae begin to appear only when zooplankton swarms decline.

Though microscopic algae are known to be the first link in the food chain in a watery medium, their conspicuous absence in the initial stage of heavy manuring with cow-dung seems to be due to the fact that the animalcules which appear first in the water are capable of directly utilizing the large quantities of suspended and dissolved organic matter found in the cow-dung.

Heavy manuring with over 20,000 pounds of cow-dung per acre has not yet been attempted in natural ponds. It is true that an application of 10,000 to 20,000 pounds of cow-dung per acre results in a marked increase in plankton populations, but what proportion of it will be zooplankton initially has not yet been definitely ascertained.

In current fish cultural practices the nursery ponds are usually manured after they are cleared of all predatory and other fishes. Cow-dung applied at 10,000 pounds per acre produces in about 24 days on an average the maximum quantity of plankton. The dates for manuring the pond and stocking it with fry will depend on the period of maximum production of plankton and the expected dates of availability of the fry. If, for instance, the fry would become available in the second week of July, the ponds should be manured by the 20th of June, but as local conditions vary, no general principles can be laid down as to the interval that should be allowed to lapse between manuring and stocking in successful pond management.

The manure may either be broadcast over the entire bottom if the pond is dry, or over the water surface if it is full, or deposited in small heaps on the sides at selected points. Dumping of manure at one point is inadvisable in view of the fact that the desired heavy crop of plankton in a short period and on a given date is not produced.

The application of raw cow-dung brings about a quicker production of plankton probably because of the fact that the nutrients present therein are more readily available than in cow-dung manure or dry cow-dung.

With the simultaneous addition of green manure (leaves of plants like *Lantana*) and cow-dung, the plankton produced is proportionately greater, but is very often preceded by an algal bloom in place of the zooplankton swarms obtained with cow-dung alone.

CONTROLLING WEEDS IN NURSERY PONDS

In manured nursery ponds, weeds, particularly the submerged ones, grow very rapidly, utilizing the readily available rich nutrients in the water. The growth is often so quick that a 0.1 acre pond is covered almost completely within a short period of 15 to 20 days. When weeds abound, the plankton in the water is generally very poor. As tender baby fish cannot feed on weeds and as the presence of weeds results in poor production of plankton, it is essential to have them removed from the nursery ponds. As their removal by chemical means adversely affects the plankton, it cannot be resorted to in nursery ponds. The mechanical removal of weeds at regular intervals with human labour or with weed-cutting mechines is perhaps the best in shallow nursery ponds.

Marginal weeds offer excellent shelter for predatory insects such as the diving beetle (*Cybister*). They lay their eggs boring into the stems of those plants. It is, therefore, of importance that marginal weeds and grass, both on the slopes and on the *bundhs* of ponds, should be trimmed to keep the insects under check.

To sum up, the important operations in preparing nursery ponds are:

(a) removal of marginal, emergent, floating and submerged weeds (macro-vegetation);

(b) a regular watch to keep the weeds in check by prompt removal as and when they come up;

(c) eradication of the entire predatory or, otherwise, harmful fish populations in the pond by poisoning with Derris powder in suitable doses;

(d) manuring the pond with cow-dung at 10,000 pounds per acre about 10 days after poisoning and 20 to 24 days before the expected date for stocking, and

(e) application of mustard oil-soap emulsion, 12 to 24 hours before stocking, to kill predatory aquatic insects, particularly the common back-swimmers (Notonectids) which are the most abundant and, consequently, the most destructive among insect predators.

FRY FOOD

Manuring the pond enhances the production of plankton, the food for the growing baby fish.

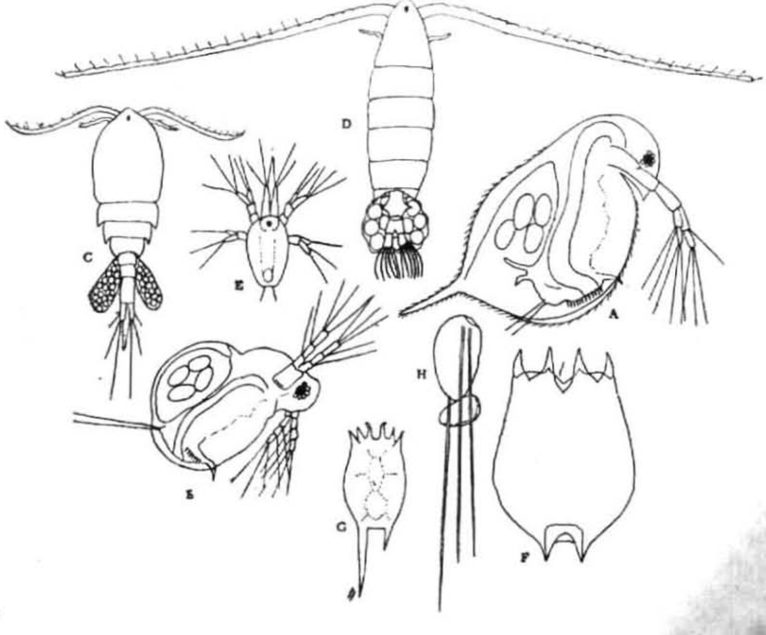
The quantity and quality of plankton fluctuate, and a clear idea of these fluctuations in the pond is essential to fix the time for stocking and also the number of fry to be stocked. It is necessary to estimate the plankton quantitatively every week or, preferably, every fourth day after manuring the pond. A small conical net (called tow-net) made of mull or muslin cloth, open at both ends and fixed on to a circular metal frame 9 inches to 12 inches in diameter and provided with a short handle is used for making collections. A glass tube, three or four inches long and one inch in diameter, is tied firmly to the tapering tail-end of the net.

About 12 gallons of water taken from 12 different and representative places in the pond area are poured through the broader mouth-end of the net. Samples of water are collected in a mug of one-gallon capacity by a person standing in knee-deep water near the edge of the pond and stretching out his arm towards the centre of the pond.

The surface of the pond is first disturbed slightly to disperse or mix the algal scum, if any, and the mug is held with its mouth downward to about six inches below the surface of the water, and gradually tilted to collect the water. The tow-net is held in the left hand with the net portion immersed in the water up to an inch or two from its mouth, and the water in the mug is gently poured into the net. This process is repeated with water collected from eleven other selected points in the pond to filter 12 gallons of water. The net is moved up and down in the water without immersing the mouth so that the water is rapidly filtered and the fish food organisms are washed down into the glass tube tied to it's lower end. The tube is then untied from the net and 15 drops of strong formalin are added to the water in the tube to kill the plankton organisms. Within 15 to 20 minutes of adding the formalin, most organisms settle down at the bottom of the tube, as a sediment.

If this column of plankton sediment is $\frac{1}{4}$ to $\frac{1}{3}$ inch high from the bottom of the tube, and is found to consist mostly of

The common water-fleas and wheel animalcules — the choice food of tender carp fry: A. *Daphnia*, **B.** *Moina*, **C.** *Cyclops*, **D.** *Diaptomus*, **E.** *Nauplius*, **F.** *Brachionus*, **G.** *Keratella*, **and H.** *Filinia*



water-fleas and other animalcules, the water in the pond may be considered to be sufficiently rich in plankton to be stocked at the rate of two to three lakhs of fry per acre. The animal or plant nature of the plankton sediment is roughly indicated by a pale brownish or green colour, respectively.

When not required for further study in the laboratory, a rough determination of the quantity and nature of the plankton may be made by the addition of a pinch of powdered common salt which would serve the purpose of quickly sedimenting the plankters equally well as formalin. After noting the approximate height of the sediment in the tube, the collection could be thrown out and the tubeused for fresh collections after rinsing.

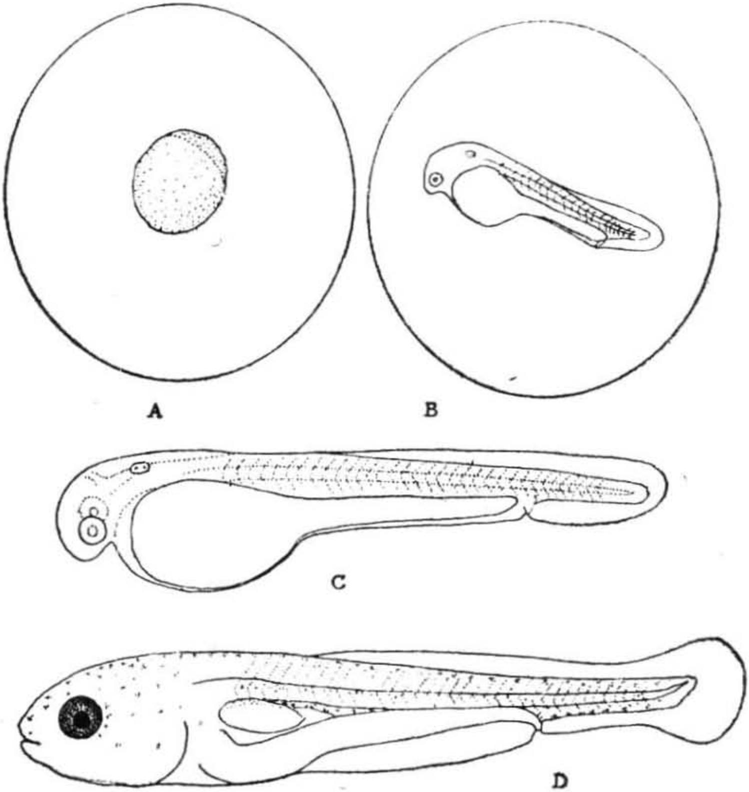
NURSING EGGS TO HATCHING

The hatchery pits with the *hapas* fixed in position and water running through them should be kept ready for receiving fish eggs for hatching.

Whether from *bundh*-type tanks or from rivers, the eggs collected usually consist of a mixture of several species of major carps, minor carps and minnows, and probably of catfishes as well. With these, there will also be aquatic insects, insect larvae and vegetable debris. The fish eggs, therefore, will have to be sorted out from all these before they are transferred to the hatching pits. On collection, the fish eggs should be examined in shallow flat dishes to carefully separate them out from aquatic insects and the debris.

They should then be transferred to a sieve with mesh 3.0 to 3.5 millimetres in diameter, kept partly immersed in water and gently moved about as in sieving. Eggs less than 3.5 millimetres in diameter and which will pass through the sieve may be discarded, as the swollen fertilized eggs of the major carps are larger than these. Those retained on the sieve may now be transferred to the inner cloth tank or *hapa* made of round-meshed mosquito netting. A number suffic ent to cover the bottom in a single layer may be kept in each *hapa* for hatching.

The eggs thus collected will be in different stages of development, with the embryo not formed in some and fully formed and active in others. They will hatch out within a period varying from 2 to15 hours after collection. Being slender and small,



Stages in the development of a carp: A) fertilized egg with the fully swollen egg membrane; B) fertilized egg with the young fish fairly well developed inside, C) baby fish just hatched out of the egg, D) baby fish two days after hatching. All these stages are collected from rivers and bundh-type ponds

the tiny hatchlings pass easily through the meshes of the *hapa* into the outer cloth tank, while the burst egg membranes are left over in the inner one. About 20 hours later, when all the eggs have hatched out and the hatchlings have passed into the outer tank or cloth, the inner mosquito-net *hapa* may be carefully removed along with the egg membranes.

When the hatchlings come out of the eggs with their conspicuous yolk-sac, they are about 4 to 5.5 millimetres long and subsist on the yolk in the yolk-sac for at least two days; after this they begin to feed on organisms found in the water. As the baby fish in the small hatching pits cannot get much food in the flowing water that passes through, it is essential to transfer them carefully to well-prepared nursery ponds on the third day after the collection of eggs. As the hatchlings are kept in *hapas* in the hatchery pits, they are collected easily in *hundies* and transported to nursery ponds.

NURSING THE FRY (HATCHLINGS AND LARVAE)

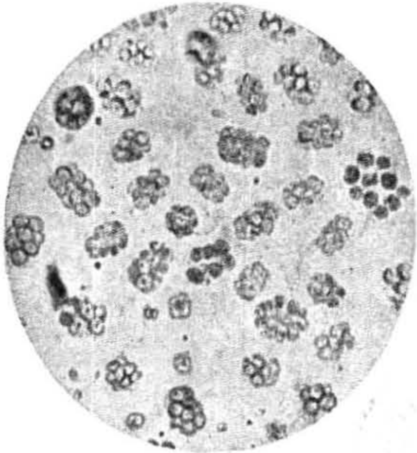
The fry collected from rivers are generally a few hours to two to three days old after hatching from the egg. Within a few hours to two to three days after collection from the river, they are released into nursery ponds in which their rate of survival is usually very low and fluctuating.

In experiments in laboratory aquaria, over 50 per cent of the tender fry survived when kept in pond water without food for seven days. A much larger percentage (80 to 96) of the fry survived during the first week when the water in the aquaria was even partially renewed. Daily feeding with freshly collected water-fleas and other animalcules helped to maintain the fry in an excellent condition, contributing to 96 to 100 per cent survival during the first week. In these experiments, predatory organisms and other enemies of carp fry were completely eliminated.

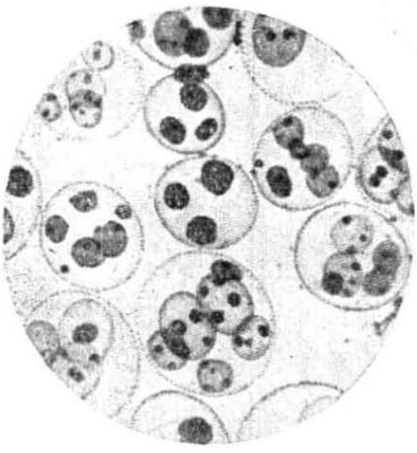
These simple experiments showed that when the enemies of fish fry are totally absent in their habitat, a large scale mortality of fry does not occur during the first few days no matter how starved the fry might be. The experiments also showed that under similar conditions but with a regular supply of artificial or natural fry food, the survival rate is almost cent per cent, except when the fry has suffered injury. If such favourable conditions prevail in the natural nursery pond also, the rate of survival of fry will be high.

The laboratory findings were tested on a miniature field scale, in open cement cisterns, 12 feet $\times$ 6 feet $\times$ 3 feet in dimensions. Swarms of water-fleas (Cladocerans) and other animalcules (Rotifers) were induced in the water in the cisterns by heavy manuring with cow-dung and the cisterns were kept covered with fine-meshed wire-netting to keep away flying acquatic insects. At the time of stocking with fry, the water in the cisterns was dark, chocolate-coloured and had very low dissolved oxygen (0.8 to 1.4 parts per million only). The

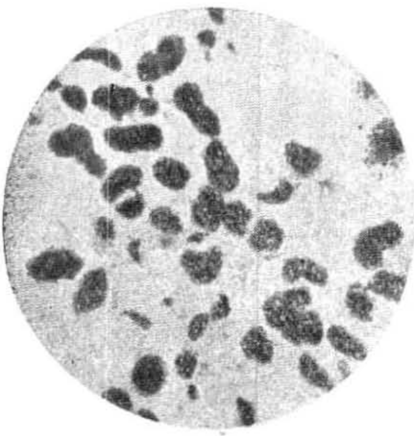
PLANKTONIC ALGAE TAKEN ONLY AS EMERGENCY FOOD BY YOUNG CARP FRY



Pandorina



Volvox



Microcystis

cisterns were fished on the 10th day after stocking. The number of fry stocked ranged from 3,500 to 6,000 per cistern. Mortality was negligible and the survival ranged from 90.7 to 99.3 per cent. These results, besides fully confirming the laboratory findings, showed that the control of fish fry enemies can successfully be attempted on a larger scale than in the laboratory. It also showed that with the provision of ample food, the tender fry would tolerate even dangerous living conditions, particularly a low dissolved oxygen content.

Further experiments showed that the maximum growth and maximum survival of fry are obtained when they are fed on zooplankton consisting mainly of water-fleas. The growth and survival of fry were considerably low when they were given only algal food.

Experiments have also revealed that very young carp fry, with their relatively short, straight intestine, characteristic of carnivorous animals in general, are incapable of digesting at least some of the planktonic algae either because the algae are resistant to the digestive secretions if any, in the gut, or because these items are not retained in the gut sufficiently long to be digested. On the other hand, the water-fleas and animalcules consumed are digested very quickly, judging from the remains voided through the vent within two hours of feeding on them.

The number of fry to be stocked in a pond depends both on the feeding capacity of the fry and the quantity of plankton available in it. As at present, no reliable data on this important aspect are available, the number of fry recommended to be stocked in a pond would be largely arbitrary.

Laboratory observations on the habits of carp fry show that they commence feeding at a very early stage, even before the yolk is fully absorbed, and that they feed almost continuously on their favourite food, planktonic crustacea and rotifers, if present in abundance. Under full feed, the gut contents of fry have been found to consist of the following:

Length of fry in millimetres	*Number of water-fleas*	*Number of wheel animalcules*
6.8	10	1
7.6	21	1
8.0	34	2
9.8	23	14+2 algal filaments

A single carp fry 6.5 to 7.2 millimetres long consumes within an hour 3 to 34 water-fleas, the actual number depending on the size of the fry and the stage of absorption of its yolk. Fry of the same size take in about 130 to 150 water-fleas within 24 hours. The number of organisms consumed within a given period will depend on their availability in the environment and also on the number of fry feeding there.

When the density of zooplankton under field conditions was taken as the criterion for stocking nursery ponds with carp fry, the rate of survival of fry was seen to be very satisfactory in several ponds but poor in others. Ponds with satisfactory rates of survival of fry contained abundant zooplankton at the time of stocking, and very little sign of planktonic algal bloom during the entire period of rearing. Ponds having algal blooms at the time of stocking or during the period of rearing gave only medium rates of survival of the fry stocked.

As no measures for the control of predatory insects are taken in the ponds, the high rates of survival (even up to 90 per cent) obtained in some of them can be said to be due alone to the deliberate choice of the time for stocking. When the insect population is poor, a larger number of fry survive, and conversely, when this population is heavy, the majority of the fry do not have a chance to survive even if the food supply is plentiful in the water. Ponds in which the insect population is controlled by suitable treatment give decidedly better yields of fish than ponds not so treated.

ARTIFICIAL FEEDING

It is difficult to maintain a continued high level of production of zooplankton for more than a few days in ponds. Even if the ponds are rich in zooplankton at the time of stocking, they suffer depletion within two to three days of introducing the fry. It is, therefore, difficult to maintain the same density of zooplankton with a heavy population of fry in them. In certain ponds, however, the reproductive capacity of plankton at the time of stocking is so great that even after a large number have been consumed by the fry, the volume of plankton remains undiminished in the first few days. If the insects are controlled in such ponds, the rate of survival of fry can be maintained at a high level.

When the plankton density in the pond goes down rapidly, there is great competition for food amongst the fry which have fewer chances of survival and growth if the food resources are not maintained at a high level. Besides, there are at present certain practical difficulties in maintaining a high level of zooplankton incidence in ponds. Manuring alone may not increase the production of zooplankton, as algal blooms often intervene, affecting their growth. Similarly, the duration in which manuring takes effect with reference to production of plankton can also never be forecast. These uncertainties, together with the fact that the supply of fry is restricted to a few places and to a very short period, not exceeding a couple of weeks in the year, make it difficult to have satisfactory fish cultivation.

Laboratory experiments have shown that the tender carp fry feed avidly as soon as they are able to do so, on artificial foods such as rice bran and groundnut oilcake or a mixture of the two.

The experiments show that carp fry grow decidedly better when equal quantities of zooplankton and artificial food, rather than an excess of artificial food alone, are given and that they consume more of the zooplankton than of the artificial diet in a given time. As such, an excess of the zooplakton over artificial food helps their growth better than an excess of artificial food over zooplankton. The fact that for the first two days the fry make hardly any use of the artificial food will have some bearing on their condition and capacity to withstand enemies in the water.

It is, therefore, clear that for the successful rearing of fry, the nursery pond should be rich in zooplankton at the time of stocking, and that from the second or third day after stocking, the natural zooplankton food should be supplemented by the artificial foods such as rice bran and oilseed cake.

Under field conditions, the fry have to be fed once or twice a day with rice bran, and/or oilcakes (groundnut, coconut and mustard). These are more easily assimilated by the delicate fry if they are in a finely powdered state, when they will also remain suspended in the column of water for a much longer period. The rice bran should be passed through a fine-meshed sieve to remove the husk. Similarly, the powdered oilcakes should also be sieved to ensure uniformity in the size of particles. In a series of experiments with coconut, mustard and groundnut oilcakes and rice bran, which gave very satisfactory results, the daily dose of artificial feed given ranged as follows:

First five days after stocking	Daily, twice the weight of fry at the time of stocking
6th to the 10th day after stocking	Daily, thrice the weight of fry at the time of stocking
11th to the 15th day after stocking	Daily, four times the weight of fry at the time of stocking

With mustard oilcake, however, the dose should be lower. Start with the weight of the cake almost equal to the weight of the fry and double it in two stages. In actual practice, it is difficult to weigh a sufficient number of fry to calculate the exact weigh of food to be given to them. Normally, a mixed collection of a lakh carp fry (consisting of sizes from 6 to 6.5 millimetres in length and each weighing, on an average, 0.0014 gm.) which will be contained in a cup or *kunka* will weigh about 140 grammes. From this, the quantity of food required for any given number of fry can be easily calculated. The following proportions of artificial food in terms of the volume of fry would be helpful.

Volume of fry (in 'bati')	*Approximate volume (in 'batis') of artificial food*			
	Rice bran	*Groundnut oilcake*	*Coconut oilcake*	*Mustard oilcake*
1	2.0	1.25	2.0	1.5

Very little experimental work has been done on artificial feeding of carp fry in India. The information given above is based on the preliminary experiments carried out at the Cuttack Substation and can at best serve only as a basis for further experimentation on those lines. With regular daily feeding with selected items of artificial food at doses varying from one to four times the initial weight of the fry, the average production of early fingerlings for the first 15 days of rearing has been as follows:

Artificial food provided	*Number of ponds used for rearing*	*Percentage of survival range*	*Average*	*Average production number per acre*
Rice bran	4	47.0 to 99.0	77.2	3,85,930
Groundnut oil-cake	5	13.2 to 71.8	36.6	1,93,070
Mustard oilcake	4	4.5 to 51.0	28.2	1,41,020
Coconut oilcake	2	47.8 to 61.0	54.4	2,72,120

The highest rate of survival of fry was in the pond to which rice bran was added daily at twice the initial weight of the fry. After 15 days of rearing, the pond was thoroughly fished and the early fingerlings removed. The pond was re-stocked with another lot of early fry and fed daily as before. During the second 15 days of rearing also the rate of fry survival was extremely satisfactory, though the pond was not manured afresh after the first fry crop was removed.

Within a period of five weeks, a total of 94,000 advanced fry and early fingerlings was raised in two crops in a 0.1 acre pond. With the application of the well-tried methods of nursery preparation, stocking and feeding the fry, such a high rate of production of advanced fry and early fingerlings should make fish culture a really lucrative undertaking. In the present instance, the yield of fry ¾ inch in length in both the crops should fetch in all Rs. 400 at a nominal rate of rupees five per 1000 fry, making allowance for a mortality of as many as 14,000 (roughly 15 per cent) during collection and transport.

NURSING ADVANCED FRY

The preparation of rearing ponds is no less essential, though less elaborate, than nursery ponds. Here, the essential steps are elimination of all fish from the pond and manuring it prior to stocking with fingerlings.

The feeding habits of the fingerlings are different from those of the young fry, though *Catla* in the fingerling stage also takes in large quantities of water-fleas. In weedy ponds, the growth of *Catla* is very slow. Although *Rohu* and *Mrigal* feed largely on decaying weeds and plankton, their growth is usually unsatisfactory in ponds overgrown with weeds. The overgrowth of weeds should, therefore, be controlled in rearing ponds. A sparse distribution of submerged weeds—altogether about 1/8th the area of the pond—without appreciably impoverishing the water, may be ample for a healthy growth of *Rohu* and *Mrigal*. However, no reliable data are available at present on the extent to which weeds are used as food by fingerlings of major carps.

The mortality rate of fingerlings is relatively much lower than that in the fry stage. Fingerlings transported over long distances are liable to be weakened for want of food or are liable to be injured, and suffer heavy mortality in ponds. But those exceeding an inch in length and in a healthy condition suffer less mortality. In seven months of stocking healthy fingerlings, the mortality has been found to vary from zero to five per cent in *Catla*, and 5 to 10 per cent in *Rohu* and *Mrigal*. From 6,000 to 8,000 advanced fry or early fingerlings (0.75 inch to 1.5 inches in length) may be maintained in a healthy condition in a 1/10 acre pond for a period of about two months if regularly fed with groundnut oilcake. At the end of this period they will have grown to a length of 2 to 2½ inches. But the poor growth attained in this period despite artificial feeding would indicate that the stocking rate is too high for the area of the pond. It is, therefore, necessary to thin out the stock if, on periodic examination, the growth registered is too little for the area of the pond.

One of the most important aspects of successful rearing of fingerlings and adult fish is the correct stocking of the ponds.

REARING PONDS

As the nursery ponds are heavily stocked and the food requirements of the growing fry increase tremendously, the stock has to be transferred to other ponds. Advanced fry or early fingerlings are generally released in rearing ponds in which they are kept till they attain the advanced fingerling or yearling size. To secure optimum growth and production in carps in such rearing ponds, the fry or fingerlings should be sorted out according to their size and stocked in known combinations.

STOCKING FRY AND FINGERLINGS

How many fish are to be put in a pond is an oft-repeated question. For want of reliable data, no satisfactory answer can be given for it at present. As the growth of the different species of fishes, like their food and feeding habits, varies, the rate of production of fish in a given pond will depend on the species of fish selected and the proportions in which they are introduced so as to make the fullest use of all the food available in the water.

As a single species farming helps in the utilization of only a few of the several food resources of the pond, a combination of two or more species which can utilize all the available food in the pond should be chosen as such a mixed farming is an economic proposition. It is important, therefore, that the species chosen should be mutually compatible, that is to say, they should neither compete for food nor prey upon one another.

The proportions of these compatible species should be based upon the estimated stock of the various types of available and renewable food resources in the pond. As the stock of available food varies from place to place depending on soil conditions, rainfall, temperature, depth of water, vegetation, etc., in the pond, the proportions will naturally vary for different ponds. As a correct stocking based on these several factors will alone ensure a satisfactory and economical rate of growth, care must be exercised in selecting the species and calculating their numbers and proportions for each individual pond.

As has already been stated, nursery ponds (ponds for stocking tiny fry) and rearing ponds (ponds for rearing fingerlings) have to be carefully prepared before they are stocked. A similar but less elaborate treatment is necesssary for stocking ponds with yearlings and adults as well. Eradication of predators, manuring and artificial feeding will ensure high returns in stocking tanks.

As the species are indistinguishable in the nursery stage, the tender fry of several species are all stocked together. While there are no hard and fast rules regarding the numer of fry to be stocked, the number should depend upon the available nutrients in the pond or its food-producing capacity. It has been suggested that small nursery units be stocked with tiny fry at the maximum rate of 1,500 per *cottah* (which works out to just over 90,000 per acre). Stocking as many as 200 fry for every cubic foot of water has also been recommended. This works out to 87,12,000 fry per acre of water only one foot deep—an unusually heavy rate of stocking.

In the nursery ponds at Cuttack, the highest rate of stocking in general rearing experiments with artificial feeding was 5,00,000 fry per acre of water surface. This resulted, in some cases, in over 90 per cent survival in the course of the first 15 days. A much heavier rate of stocking was possible in cement cisterns (12 feet $\times$ 6 feet $\times 2\frac{1}{2}$ feet) with about 5,600 fry of which over 5,400 survived within the first 10 days when the stock was thinned out. There was no artificial feeding. The rate of stocking works out to approximately 34 lakh per acre of water surface. It should not be very difficult to increase this number with artifiical feeding. From theoretical considerations, such a heavy stocking in natural nursery ponds should be a distinct possibility.

Repeated laboratory experiments have shown that regular feeding with zooplankton produces excellent results in growth. Thus, a 100 tiny fry stocked in three litres of water in a glass jar were successfully reared to over half an inch size within 15 days. This works out to about 900 fry per cubic feet of water.

The food requirements of the fry increase with their growth. As the nursery pond cannot cope up with such heavy demands for food, the grown up fry should be transferred to other ponds which are free from all other fish and are manured heavily. In these rearing ponds also, selective stocking of fry will not be practicable, as individuals $\frac{3}{4}$ inch to one inch long are usually indistinguishable from one another and repeated handling in sorting at that stage results in fatal injury to a large number of them.

It has been stated that a pond 50 feet $\times$ 50 feet $\times$ 10 feet will support 2,000 inch-long fry for four months. Such deep ponds are not required for rearing advanced fry. Taking the area alone, the rate of stocking should be about 35,000 per acre, although a higher rate of stocking (about 60,000 per acre) has also been suggested.

In experimental rearing ponds four to five feet deep, $\frac{3}{4}$ to one inch long fry can be stocked at the rate of about 10,000 per acre, when a majority of them will survive and grow to about three to four inches in length in the course of about three months. No artificial feeding need be resorted to in this case. If the pond is more heavily stocked, the percentage of survival generally goes down. With daily artificial feeding with finely powdered groundnut oil-cake, the stocking rate may be raised to about 80,000 per acre, with the survival rate exceeding 90 per cent during a period of about six weeks in which they attain an average length of about two inches. For further satisfactory rearing in the same pond, the stock has to be thinned out to about half.

The necessity for selective stocking even at the early fry stage is indicated by the fact that in heavily stocked ponds *Catla* does not grow satisfactorily in spite of artificial feeding. Though it registers the fastest growth among the major carps, if its population in a given pond happens to exceed its stockable capacity, its growth is very much retarded, particularly since it makes the least use of the artificial food provided, with its upturned mouths adapted to plankton feeding. Laboratory experiments have confirmed that *Catla* takes a very limited quantity of artificial food in the form of oilcakes.

Only advanced fingerlings are released in stocking ponds. The number and kind of such fingerlings should be decided on the basis of the size of the pond, its food resources and the species of fish available for stocking. The stocking ponds, like the nurseries and rearing ponds, should also be cleared of all predatory fishes and minnows. Old tanks with excess of bottom silt should be dewatered and partially desilted and all overgrowth of macro-vegetation also removed. As in the case of the nursery or rearing ponds, the stocking pond should be manured, but in smaller doses and at monthly intervals.

COMPATIBLE SPECIES

Before stocking, the food resources in a pond should be assessed. Plankton, macro-vegetation, weed-dwelling fauna, bottom fauna and organic detritus are the main natural food resources in the pond. The relative approximte abundance of these may be judged by random collections from known areas and estimating their volume or weight. This information, together with that available on the food and feeding habits of the different species of fishes will enable a judicious selection of the right species for the pond.

Catla and the Crucian Carp (*Carassius vulgaris*) feed largely on zooplankton even after the fingerling stage, while the Pearl Spot (*Etroplus suratensis*), the Milk Fish (*Chanos chanos*) and the Sandhkol Carp (*Thynnichthys sandhkol*) sustain themselves on a mixed diet of zoo- and phytoplankton, besides other items of food. The species of the genera *Labeo* and *Cirrhina* are bottom or column feeders taking in large quantities of bottom mud and debris besides rotting aquatic plants. *Gourami* (*Osphronemus gorami*) and the Chocolate *Mahseer* (*Barbus hexagonolepis*) feed largely on fresh macro-vegetation. The latter takes in snails also.

A satisfactory combination of fishes for a pond should include a plankton-feeding species (column-surface feeder), a detritus or bottom fauna feeder (column-bottom feeder) and a macro-vegetation feeder. As already stated, the proportions of these species will depend on the relative abundance of the different types of food present. If algal blooms are the dominants as in most religious institutional tanks of South India, *Chanos* or *Thynnichthys* should do well. If zooplankton is rich, *Catla* will find the condition good. When there is luxuriant vegetation, *Gourami* should be introduced. Pearl Spot will feed on insects and worms, besides taking in filamentous algae and leaves of aquatic plants. *Rohu* and *Mrigal* grow well in ponds with abundance of decaying vegetable matter, including decaying phytoplankton.

Mixed farming of carps is practised in different countries, particularly in China, where a great variety of stocking has been evolved for ponds in the different regions of the country. In India also, the major carps *Catla*, *Rohu* and *Mrigal*, often with a varying number of *Kalbasu* and *Bata*, are stocked together in ponds in Bengal, Bihar, Orissa, the Punjab and Assam.

No fixed proportions for the different species have, however, been evolved, though a combination of 30 per cent *Catla,* 30 per cent *Rohu* and 40 per cent *Mrigal* is reported to be in vogue in certain Bengal fish farms. In view of the fact that most Bengal fish farmers do not sort the fry or fingerlings into species, the above proportions are not adhered to in actual practice. Reliable data on the proportions of species and the density of stocking for Indian waters are wanting.

DENSITY OF STOCKING

Preliminary experiments in stocking fingerlings of *Catla, Rohu* and *Mrigal* in various combinations and densities have been in progress at the Central Inland Fisheries Research Substation at Cuttack for the last three years. The rearing period each year is only about seven to nine months, and the yearlings are either stocked in larger tanks or marketed.

Satisfactory growth was found in these experiments when the three species were stocked in equal numbers, making a total of about 3,000 fish in all, per acre. In such cases, however, the growth of *Mrigal* and *Rohu* was at least as quick as or, even quicker than, that of *Catla,* indicating that the pond could hold a larger stock of these two species. The growth of *Catla* is slow when the stock exceeds 1,000 fingerlings per acre, but in the case of *Mrigal* even at 6,000 fingerlings per acre satisfactory growth has been observed.

Unless these experiments are carried out under varying conditions and repeated several times over a fairly long period, no definite guidance could be given to the practical fish farmer in regard to the number of fry of different species of carp that may be grown satisfactorily in a given type of pond.

The exact stock figure or the number of fish to be introduced in any particular pond will depend on the species concerned, their rate of growth, and the nature of available food. However, as reliable information on these aspects is not yet available, no general recommendation on the stocking capacity of the different waters is at present possible.

GROWTH

An unusually quick growth in fish is very often the direct result of understocking which, though enabling a few of them to attain marketable size in a relatively short time, may not be very economical from the point of view of total weight of fish produced. In two virgin waters at Kancheepuram, Madras, in which *Catla* were stocked at the very low rate of 9 to 46 per acre, a weight of seven pounds in six months, representing a growth of 3 to 4 inches per month, was registered.

From observations made on the growth of the major carps, it is clearly seen that the normal average growth in weight in the first year of their life is about 2 pounds, 1.5 pounds and 1 pound, respectively, for *Catla*, *Rohu* and *Mrigal*. Exceptional growths of a foot in six months; 18 inches to two feet in the first year and 3 to 3½ feet in 2½ to 3 years have been recorded for *Catla* in Madras. In the Kurla tank, Bombay, *Catla* attained eight pounds in weight in the first year. A very fast growth of 12 inches (one pound, two ounces) in just 2½ months is also on record for *Catla*. *Mrigal* has been reported to attain over 16 pounds in three years.

STOCK-FIGURE

The general yield of fish per acre of freshwater pond in India ranges from 1,500 to 2,500 pounds in various parts of the country. In an organized sewage-irrigated fishery in the Bidhyadhari spill area near Calcutta, the annual yield is reported to be 600 pounds per acre. Annual yields of 357 to 1,278 pounds per acre have recently been reported from Uttar Pradesh. The Dyke's Pond at Vishakhapatnam (Andhra) yields 552 to 2,540 pounds per acre every year. Now, if we take the normal growth of *Catla*, *Rohu* and *Mrigal* in a well stocked pond to be 2 pounds, 1.5 pounds and 1 pound, respectively, in the first year, and if we expect an annual production of 2,000 pounds per acre of water, the number of fingerlings to be stocked would be

1,000 of *Catla*
1,334 of *Rohu* and } When individual species alone are stocked in ponds
2,000 of *Mrigal*

An additional 5 to 10 per cent of the number of fingerlings introduced should compensate for the expected natural annual mortality.

If a 30:30:40 combination of *Catla*, *Rohu* and *Mrigal* is stocked, the proportional numbers of fry would be 414 of

Catla, 414 of *Rohu*, and 552 of *Mrigal* plus 10 per cent of each species as allowance for natural mortality.

With these tentative figures, the fish farmer could use his discretion in choosing different combinations and densities of fry to experiment upon and gain experience.

When ponds are stocked in relation to their available food resources and expected annual production, the subsequent thinning out of the stock may not be necessary. If a larger number than the warranted stock figure for the pond is introduced, a stage will be reached when the available food is quickly exhausted and the growth remains unsatisfactory till part of the stock is removed to another pond.

INTRODUCING PREDATORS

Predators (*Murrels*, etc.) and non-predatory species (carps, etc.) do not go together in the same pond. *Catla*, *Rohu* and *Mrigal* grown in stocking ponds do not seem to feed on aquatic insects and control them. Some of the smaller predatory fishes like *Anabas testudineus*, *Ophicephalus punctatus*, *Heteropnuestes fossilis*, *Clarias batrachus* and *Glossogobius giuris*, which are predominantly insectivorous in habit, do not cause appreciable harm to other fishes. Besides, because of their relatively small size, they are generally incapable of doing any harm to grown up fingerlings (five to six inches) of major carps.

It has been stated that some fishes need exercise for their healthy growth which is provided by their being chased by predators deliberately introduced into ponds. Whether such exercise is really necessary and whether or not the introduced predators take a toll of the carps cannot be definitely said. However, if a small predator which does not harm the carps is introduced, it may increase the total yield of fish to some extent, feeding on the insect population in the pond. Carp fingerlings below a particular length (say, five inches) should not then be stocked. The predator should also be stocked preferably at three to four inches fingerling size.

The high market value of *A. testudiueus* as a food fish, its small size and its pronounced insectivorous tendencies make this fish an obvious choice for introduction into carp ponds. *H. fossilis* and *C. batrachus* may also be included in this category, though the latter grows to a fairly large size. *O. punctatus* and

G. giuris have relatively larger mouths and should, therefore, be utilized with care.

Even a full-grown medium-sized predator like *O. striatus* would be incapable of causing appreciable harm to a stock of carps of a minimum length of a foot. The large catfish *Pangasius pangasius* is reported to have been stocked in carp ponds in certain parts of East Pakistan. Though definitely piscivorous in habit, it feeds largely on water-snails and is believed not to cause havoc to the crop of carps.

POND MANAGEMENT AND HARVESTING

After the pond is stocked, the condition of the fish should be periodically given a check up to ensure that they are thriving well.

If weeds overgrow, the excess of growth should be periodically removed. One or two small patches of submerged or floating weeds occupying about one-tenth of the water area, however, may be maintained in the pond without harm. Weeds in moderate numbers not only serve as anchorage for snails and insects, but also as a source of natural decaying vegetable debris. Floating vegetation like duckweeds should never be allowed to cover up the entire water surface.

Unless the ponds are shallow (depth of water below three feet), shade is not essential. Too much shade is not desirable, and when trees are present on embankments, care should be taken to periodically remove the leaves falling into the water.

Netting the pond once a fortnight, or at least once a month, with a drag-net will provide sufficient run and exercise for the fish besides enabling us to examine them. If they have an emaciated or weak appearance, part of the stock should be removed to another pond. Unwanted fish (minnows) should be removed at every netting.

During the summer months, with the level of water falling steadily in the pond, the fish are prone to infection by parasites. Periodic netting will enable timely detection of such infection, if present, and the taking of suitable remedial measures.

If ponds have inlets or outlets or both connecting them with other ponds or water sources, these should be fully secured by wooden or wire-net doors or screens so that the fish stock from the pond do not escape and no unwanted fish get into the pond. Live fishes like *murrels* and the climbing perch from neighbouring waters cannot, however, be prevented from crawling over moist land into the pond. By cutting the outer side of the embankment vertically to a height of 1½ feet at the top or by fixing a fine wire net fencing about a foot high on the top of the embankment, or by constructing a cement parapet 1½ to 2 feet high all round, unwanted fishes and fish enemies like snakes and tortoises, can be prevented from gaining entry into the pond. Fish-eating birds like cormorants, king fishes and gulls should either be scared away or their number reduced by periodical shooting. Crocodiles and otters should likewise be destroyed.

As the growth of fish varies, individuals of the same size and age belonging to the same species show different rates of growth, though all of them grow in the same pond under the same environmental conditions. If there is very considerable difference in the size of individuals of the same species in a pond, it shows that the smaller fish are not growing properly. When the ponds are periodically netted, the fish should be sorted out according to size and the bigger ones removed to another pond, thus giving a chance to the smaller ones to grow quicker.

Under normal conditions, our carps have their maximum growth in length in the first year of their life, but the maximum growth in weight is probably in the second or third year. When such growth in weight has been attained, the fish should be removed, enabling the smaller fish to grow rapidly. This is a fundamental principle in fish farming where the harvesting of the fully ripe fish crop, as in the case of agricultural crops, should never be postponed.

When seasonal waters reach their lowest level in summer, the fish found in them should be transferred to deeper perennial ponds, if available, for further growth and fattening. Otherwise, the yearlings may be marketed. When the pond is understocked, the young fish have a chance to grow rapidly and attain a marketable size even by the end of the first year.

Ponds should not be netted during the breeding season or soon after fishes have bred in them. This will result in injury to and mortality of their progeny, apart from scaring away the breeders from the breeding grounds to which they may not migrate again to breed.

The best season for harvesting a pond is summer when netting is easy because of the low level of water, but the date and time of netting should be so arranged as to coincide with the demand in the market. Netting is best carried out early in the morning before the water gets heated up, so that the residuary fishes in the pond are not adversely affected. The use of a large-meshed net (one inch) helps catch only the larger fish, leaving the smaller ones uninjured in the process of netting and less exposed to the chances of catching parasitic or other infection.

POND BREEDING OF CARPS

As far as is known at present, in confined waters the major Indian carps breed only in the *bundh*-type tanks or ponds of the Midnapore and Bankura districts of West Bengal. Breeders are generally present in wet *bundhs*. In dry *bundhs*, they are introduced from ponds when rain water accumulates in them in the rainy season. In most *bundhs*, the carps spawn in the shallow areas adjoining the outlet. When the water level in the *bundh* suddenly rises as a result of the inrush of water from the catchment area flooding the spawning grounds, the breeders play about and breed in the shallows. The water from the *bundhs* may be overflowing through the outlet at the time of spawning. However, in certain years, the fish have been observed to breed even when the usual spawning ground was not at all flooded and no water was flowing out of the *bundh* through the outlet. The factors which induce the fish to spawn are not yet clearly known.

As in the existing practice of carp-breeding in *bundhs* no precaution of eliminating unwanted fishes including the predatory species is taken, the eggs or fry obtained from the *bundhs* (particularly the wet ones) are no less mixed in quality than those obtained from the rivers.

The eggs collected from *bundhs* are hatched in adjoining *hapa*-pits and sold on the spot within two to three days of hatching. The owner generally does not keep the fry in the *hapas* for a longer period than is essential to avoid heavy mortality, but this compels him to sell his stock of fry at very low rates. The loss incurred thus can be minimized or eliminated in two ways:

1. By keeping heavily manured pits ready at hand for maintaining a regular supply of zooplankton with which the fry could be fed from the second day after hatching. A 6 feet x 3 feet x 3 feet manure pit with at least $2\frac{1}{2}$ feet of water in it, manured with 40 to 50 pounds of cow-dung would be enough to produce, in about a week's time, all the zooplankton necessary to feed about 5,000 fry for 8 to 10 days.

An adequate supply of zooplankton is judged by the brown colour of the water. The pit should be manured a week before the expected date of spawning of fish. The number of such pits could be increased if required.

The fry should be fed from the second day after hatching to prevent mortality.

2. By maintaining, as detailed already, previously prepared miniature nursery ponds into which the hatchlings could be reared and kept ready for sale as per demand.

In the breeding of carps in *bundhs*, it is necessary to estimate the exact number of breeders of both sexes of different species present in them and maintain a stock of only known proportions of selected species. Improved methods of egg and seed collection are also likely to contribute to increased fish seed sources for us.

The Common Carp (*Cyprinus carpio*) breeds in ordinary ponds with plenty of submerged vegetation to which the eggs are attached. In India, this fish breeds only in the colder waters of the hills (the Nilgiris, the Shevaroys and the Kumaon Himalayas). No special propagation methods are adopted in any of these places. Though it is known to breed even in medium-sized cement cisterns in some of the South-East Asian countries, this has not yet been attempted in India.

CULTURE OF OTHER FISHES

THOUGH several species of quick-growing salt water fishes occur in our coastal and brackish waters, very few of them are cultivated. Young ones of Milk Fish, Pearl Spot, Tarpon, Cock-up, Mullets, Perches, etc., are stocked in small numbers in freshwater ponds.

Brackish-water fish farming in India is restricted to the few experimental farms like the Narakkal Farm in Cochin, the Aayiramthengu Experimental Farm near Kayamkulam in Travancore-Cochin, the Adyar Fish Farm in Madras, the *Bhasa-badha* embanked fisheries in the Sundarban areas of Bengal and the paddy-cum-prawn fields in Travancore-Cochin.

In all these cases, low-lying areas or fields under reclamation are embanked and provided with sluice gates which are regulated for taking in tidal water. There is no planned stocking, but fish seed and the young ones of prawns which come up with the tide are allowed to enter the embanked fields in large numbers and held behind in the receding tide by bamboo screens or nets at the sluices. The young fish thus caught in the fields grow quickly and are fished within four to five months, without the aid of methods of deliberate culture.

The culturable non-predators which occur together with predators in these fisheries are not segregated. In the *Bhasa-badha* fisheries in Bengal, the fry are allowed to enter the fisheries during the monsoon months when the water is less saltish, and grow for a period of only four to five months until they are caught in the winter months. In the embanked prawn fisheries of Travancore-Cochin, after the paddy harvest during July-September, the water containing fish seed is let into the fields during high tides from October onwards. Within two to three months (from December onwards), the fishing starts. The Narakkal Farm in Cochin is mainly a mulletry though other fishes like Milk Fish, Bekti and Pearl Spot, are also caught in appreciable numbers. A few mullet fingerlings are collected from neighbouring waters and put into the ponds which get naturally stocked during the tides also. In the Adyar Farm in Madras, the natural stocking during the tides is not depended upon, but is supplemented by fingerlings of Betki, Pearl Spot, Tarpon, Milk Fish, etc., collected from the adjacent backwaters.

As the present system of brackish-water fish farming in India is purely empirical, there is excellent scope for augmenting the yield of fish from this source by adopting scientific methods of fish culture.

LIVE FISHES

The live fishes, unlike the carps, are capable of directly breathing atmospheric air, and have very often to come up to the surface of water to do so. Being thus practically independent of the oxygen fluctuations in the water, the live fishes are capable of tolerating even foul waters in which ordinarily no other fish will thrive. The common live fishes of cultural value in the country are the following:

Gourami,	*Osphronemus gorami*, an exotic perch introduced into Madras from Mauritius and now transported to almost all the states in the country
The Large *Murrel*,	*Ophicephalus marulius*, found throughout India
The Common *Murrel*,	*Ophicephalus striatus*, found throughout India
The *Koravai Murrel*,	*Ophicephalus punctatus*, found throughout India
The *murrel*, *Ophicephalus stewarti*,	found in northern Bengal and Assam
The *murrel*, *Ophicephalus micropeltis*,	found along the West Coast, particularly in Kerala
The *Murrel*, *Ophicephalus amphibius*,	found in northern Bengal and Assam
The Climbing Perch,	*Anabas testudineus*, found throughout India.
The *Singhi*,	*Heteropnuestes fossilis*, found throughout India
The *Magur*,	*Clarias batrachus*, found throughout India

All these fishes, excepting *Gourami*, are predators breeding in ponds. Under natural conditions, some of them breed in rivers also, but ponds, swamps and lakes constitute the main seed sources.

As *Gourami* feeds predominantly on macro-vegetation, it should be stocked in weedy waters. Being a perch with strong spines on the dorsal and ventral aspects of the body, advanced fingerlings, six inches and over in length, are capable of holding their own against medium-sized predators and can, therefore, be stocked even in ponds from which complete eradication of predators is not possible. As it does not directly compete for food with the major carps, *Gourami* could also form a supplementary stock in carp ponds. Being a nest-builder, breeding facilities in the form of submerged and emergent vegetation should be provided for their satisfactory propagation. In ponds devoid of weeds, objects such as dried grass and coconut palm leaf fibers should be introduced to enable the fish to build its nest.

Gourami guards the nest till the eggs hatch out. Once the young ones come out of the nest, the parents do not attempt to protect the brood. At this stage, the young ones, which are still more or less helpless, often fall easy victims to the numerous enemies in the water which include predatory insects, minnows, gobys and all other fish in the pond including their parents. The survival rate of young ones is, therefore, limited. To improve the survival rate, one of the two methods described below can be adopted.

1. Special breeding ponds, small and shallow with a constant level of water and an abundance of submerged vegetation should be selected and all other fish removed. After heavy manuring with cow-dung, the ponds may be stocked with a known number of breeders. The males and females are distinguished by their external features; the male with brighter colour, a smooth knob-like prominence at the nape and rather thick lips, and the female without them and with rather thin lips. When these fish breed, the young ones will be comparatively safe from enemies but the large number of insects and insect larvae in the water will still take a toll of them. Besides, the young fish generally require water-fleas and animalcules (zooplankton) as their main food which can be produced only in very limited numbers in the pond, as manuring has little effect on their production because of the abundance of weeds.

2. In view of these limitations, an alternative method

is to have a few cement cisterns about 12 feet x 6 feet x 3 feet. The breeders are introduced into a weedy pond where careful watch is kept over their nest-building activity. When the nests are completed, the cisterns should be filled with water to a depth of 2½ feet and immediately manured by adding about 60 to 70 pounds of cow-dung in each. The cisterns should be kept covered by fine-meshed wire-netting on a suitable frame so that the flying aquatic insects will, to a large extent, be prevented from entering the cistern.

Within 10 to 12 days of manuring, millions of water-fleas and other animalcules are produced in the water, by which time the eggs will hatch out in the nest. Within the next two to three days, i.e., before the young ones go out of the nest, they should be carefully scooped out and transferred to the cement cisterns. With an abundance of the desired food, they grow quickly, the mortality is very low and the fry attain the early fingerling length of about one inch within a month. The hatchlings from two or three nests may be kept in a cistern. When they grow to about an inch in length they should be transferred to small natural nursery ponds, also manured heavily beforehand with cow-dung or stable refuse. After rearing them to two to three inches, they may be transferred to the weedy waters for growing.

THE MURRELS

Experiments on the culture of *murrels* have been attempted in the Punjab, Bombay and Madras with disappointing results. Though the *murrels* breed in ponds, the larvae are reported to be extremely difficult to rear after a certain stage on account of the specialized live food they need.

In the Punjab and in Bombay, the survival of fingerlings stocked in ponds was found to be very low, though the growth was quite satisfactory. These early failures are no doubt discouraging, but certain fundamental points have to be considered in finding out the causes of such failures. The *murrel* is a predatory fish with pronounced piscivorous tendencies. For its proper propagation an abundance of small fish which is its main food must be ensured. No attempt appears to have been made in the early experiments referred to above to provide enough forage fish for the *murrels* to feed on. Thus no scientific method of cultivation of *murrels* has yet been attempted in India. As in America, where predatory fishes are very successfully cultivated in ponds, the Indian *murrel* could also be cultivated similarly in ponds if suitable methods are adopted.

As the *murrel* breeds in ponds and the conspicuously coloured young ones usually move about in shoals protected by the parents, the natural seed resources may be depended upon for stocking purposes. Laid eggs collected and kept in the laboratory for hatching die in large numbers, even when artificially aerated. The hatchlings (soon after absorption of yolk) also begin to die in considerable numbers in the laboratory. Rearing the young ones through these two stages may well be left to nature and the fry, $\frac{3}{4}$ to one inch long, collected from natural habitats. The fry feed largely on water-fleas and other animalcules besides larvae of aquatic insects. They should, therefore, be released in nursery ponds prepared in the same manner as for the carp fry, i.e., heavily manured and with all fish eliminated, and allowed to grow there for about two months by which time they will have attained the fingerling stage, about three inches long.

Stocking-ponds for fingerlings should be carefully prepared. Common forage fishes like *Amblypharyngodon*, *Chela*, *Rohtee*, *Ambassis*, *Rasbora*, *Barbus*, etc., should be reared in the ponds before the *murrel* fingerlings are released in them. Most forage fishes breed in ponds during April-June and by the time *murrels* are to be stocked, the young ones of the former will have grown to a length of an inch or two to be fed upon by the *murrels*.

Preliminary experiments on the culture of forage fishes at Cuttack have shown that the common species like *Barbus stigma* and *Chela bacaila* breed prolifically in ponds, and that starting with just 20 pairs of breeders the progeny of over 8,000 are obtained within five months when the latter have already attained maturity and the production has been about 415 pounds per acre. No definite data on the forage fish-predator ratio in respect of our predatory fishes are now available. However, satisfactory growth and yield of *murrels* may be expected under the following conditions:

1. Stocking-ponds may have marginal weeds to harbour aquatic insects but should not have weeds

in the deeper portions.

2. Breeders of forage fish like *Amblypharyngodon*, *Chela* and *Barbus* or some other suitable combination of species to be introduced into stocking ponds sometime in May, at the rate of 500 to 600 of each species per acre; the pond to be manured before with cow-dung or farmyard refuse or compost for enhanced production of food for the fry of forage fish;
3. *Murrel* fingerlings, three to four inches long, to be introduced sometime in August, at the rate of about 1,000 per acre.

THE CLIMBING PERCH

The Climbing Perch (*Anabas testudineus*) like the *murrel* is also not cultivated on scientific lines in India at present.

Being a hardy fish and capable of utilizing atmospheric air for breathing on the land, it often migrates over the land by crawling on moist ground with the help of the spines on the gill cover. Occasionally, it enters prepared carp nursery ponds and breeds there, the fry attaining a length of $\frac{3}{4}$ to one inch within about 20 days. 2,000 and 4,000 fingerlings, respectively, were obtained from two such ponds in each of which only one pair of breeders was found when completely fished by poisoning. It would appear from the above that well prepared nursery ponds cleared of all fish predators and manured to produce a rich crop of water-fleas and other animalcules are equally favoured by *Anabas* to breed and their young ones to thrive and grow.

As *Anabas* is predominantly insectivorous, the cultivation of forage fishes does not appear to be essential for its propagation. In weedy ponds with a fair population of small minnows and minor barbels, *Anabas* fingerlings should find suitable conditions for quick growth.

The *Singhi* and the *Magur* also are not cultivated at present on scientific lines in India. They are bottom fishes and are not so markedly piscivorous as the *murrels*. Weedy waters abounding in shrimps, insects and molluscs are likely to be favourable for their growth and propagation.

OTHER PREDATORY FISHES

The problems in successful cultivation of predatory fishes are akin to those of live fish culture. The important predatory fishes other than live fishes which are suitable for cultivation are *Chital* (*N. chitala*), *Pangas* (*P. pangasius*), the *seenghla* (*M. seenghla*) and the salt-water Cock-up (*L. calcarifer*). The fresh-water shark (*W. attu*) being extremely predatory might be difficult for cultivation in ponds, but its very quick growth is a favourable factor for consideration.

No scientific work has so far been done in India on the cultivation of these predatory fishes. As in the case of *murrels*, it will be necessary to provide sufficient forage fish in the pond for the predators to feed on. The most prolific and quick-growing species of the indigenous forage fishes have to be selected after conducting suitable experiments as the first step in the culture of predatory fishes.

FISH ENEMIES

THE enemies of fish in ponds belong to diverse groups of the animal kingdom as follows:

1. The common aquatic plant or bladderwort (*Utricularia* spp.) which traps and kills small fish fry.

2. A variety of aquatic insects, including the more common water-boatman, water-scorpion, back-swimmer, diving beetle, giant water-bug and dragon-fly and their nymphs, which attack and eat fish fry and even early fingerlings.

3. Minor carps, carp minnows and other miscellaneous small fish found in ponds, feeding on the tender carp fry.

4. Predatory fishes, destructive to carps at all stages.

5. Frogs and tadpoles. The latter though known to be herbivorous, have been found to have eaten carp fry.

6. Water-snakes and tortoises, harmful mainly to fingerlings.

7. Crocodiles, causing havoc among grown-up fish.

8. Cormorants, gulls, king-fishers, kites, crows, herons, storks, ducks, etc. Fish-eating birds destroy large numbers of even one-year old fishes.

9. The common otter is destructive to large fish.

Parasitization of fresh water fishes and frequent mortality among them prevail particularly during the summer months when the water level is low and stagnating. There are several kinds of fish parasites which affect fishes of all kinds resulting in their death. The fry and fingerlings of carps which suffer from frequent handling during collection, conditioning and transport are more liable to be infected than adult fish.

Fin rot is a common disease in fishes caused by bacteria and the water-mould *Saprolegnia*. Infection by bacteria can be detected by the whitish opaqueness of the infected part while fungal infection gives the infected part a white fluffy appearance. Roughly handled and bruised fish are more prone to infection by them. The fins are usually affected, their margins being gradually eaten off, hampering normal movements. Acute cases in which the entire tail fin is eaten off, spells danger to the hind region of the body which swells, resulting in the death of the fish.

The mould called *Branchiomyces* causes gill rot by obstructing the veins in the gill filaments. If the infection is limited to a few specimens, their treatment for 5 to 10 minutes in a bath of three to five per cent salt solution will stop the infection. If the infection is due to bacteria, a similar bath in a weak potassium permanganate solution (five parts in a million parts of water) gives good results.

Injured young fry of carps kept in *hapas* or pits catch the bacterial infection quickly. Preventive measures such as careful handling during collection, reducing the number of fry in a *hapa* and keeping them in gently flowing water till they are released in ponds, go a long way in keeping down infection, but treatment of fry with a solution of potassium permanganate or common salt arrests its spread.

If there is a large scale infection in ponds the fishes should be transferred to clear ponds, and the water in the infected ponds drained completely and the pond bottom treated with lime.

As protozoan parasites (*Myxosporidians*), which often form yellowish or pale cysts on the body or on the gills, are not easily killed by saline or permanganate baths, the infected fishes are best removed and destroyed.

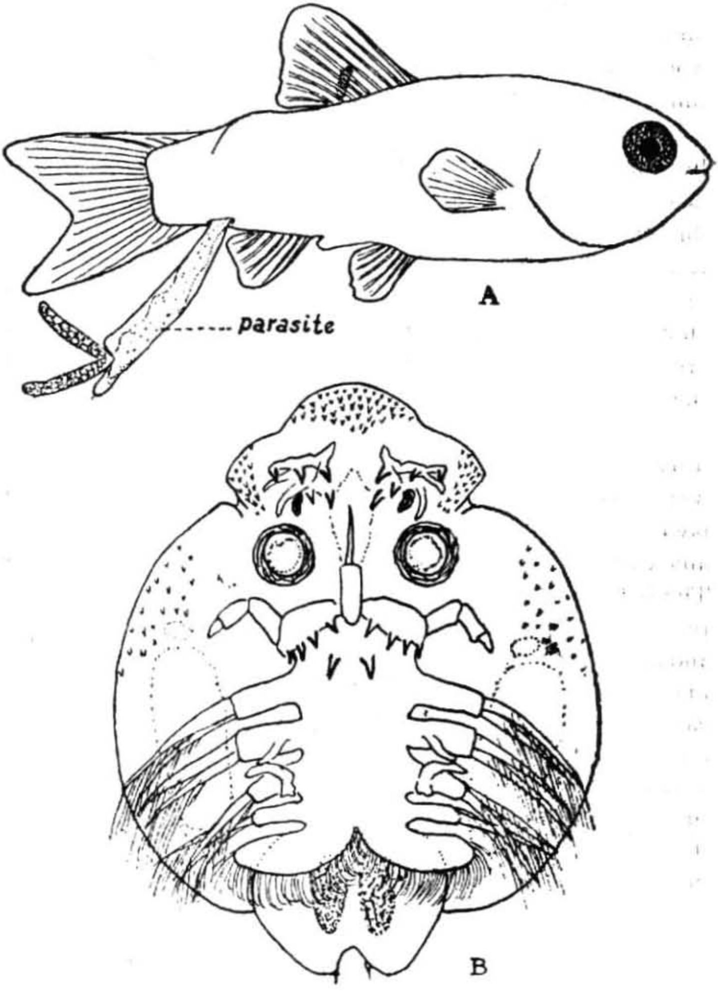
The almost invisible worm *Gyrodactylus* is a common parasite on carps in ponds, particularly *Rohu*. By attaching itself with its long hooks to the gills, the skin and other parts of the body, it causes irritation to the fish. A five-minute bath in a weak solution of acetic acid (one part of acid in 500 to 1,000 parts of water) followed by another in a three per cent salt solution is, however, sufficient to control it.

Carp lice (*Argulus*) and the allied *Lernaea* and *Ergasilus* belonging to the *Crustacea* are an important group of fish parasites. *Argulus* attaches itself to the body of the fish by means of suckers and hooks, but it can also swim freely in water. Large-scale infection of *Argulus* in ponds and rivers is not uncommon, with some acute cases of infection in ponds known in which over 2,000 specimens have been found on a single *Rohu*. The infection results in the slow sapping of vitality of the fish to the point of death.

A few wooden or bamboo poles fixed in different places in the pond are said to help the infected fish to get rid of the parasites by rubbing their body against them. In case of a large-scale infection, application of a weak alcoholic solution of 'Gammexane' (1½ to two parts of 'Gammexane' for a million parts of water) to the pond has checked the mortality of infected fishes.

Lernaea is a minute rod-like or filament-like external parasite sticking out from the angle of the shoulder-fin and body, on the tail or other fins, from the eye socket, from the corner of the mouth and other parts of the body. The head of the parasite is buried in the tissues of the fish to suck out the blood of the host. The majority of carps are subject to infection particularly during the summer months, but very heavy infection is rarely met with. When fry and fingerlings are infected, their growth slows down.

When a few fishes alone are affected, mechanical removal of the parasites by pulling them out from their anchorage by means of fine forceps would suffice, preferably followed by a weak permanganate bath for two to three minutes. Repeated application of 'Gammexane' effectively eradicates the parasite.



Common fish parasites: A. a 14 mm. long fry of the minor Barbel *Barbus stigma*, **infected by a parasite** (*Lernaea*), **seen sticking out from the distal portion of the body which is consequently swollen; B. the fish lice,** *Argulus*

Ergasilus is generally found attached to the gills in several of the fresh-water and estuarine fishes, but is not known to be very harmful.

Numerous internal parasites of fishes are known, but none of them causes large-scale mortality. Some flukes (flat-worms) pass their larval stages in the body of the fishes which thus act as intermediate hosts.

Fishes are subject to several kinds of diseases, not caused by parasites. Of these, the most important is the gas disease caused by excess of nitrogen or oxygen. Excess of the latter due to an abundance of vegetation in the water will sometimes result in accumulation of gas beneath the skin, on the fins, around the eyes, in the stomach and intestine, or in the choking of the blood capillaries. Both large and small fishes are affected, but if they are transferred in time to fresh water, they revive.

Large-scale mortality of fishes sometimes occurs in ponds usually in summer, or when there is an algal bloom in the water. Continuous sultry weather followed by sudden showers favours such mortality. Water stagnates completely without any circulation. The algae multiply, forming a dense bloom. The bottom layers are fast depleted of oxygen by quantities of decaying organic matter augmented by algae dying and settling down at the bottom. The respiratory demands during night markedly deplete dissolved oxygen in water and very early in the morning only the topmost layers of water contain some oxygen. When sudden rains fall under such circumstances, the surface and bottom waters get mixed and the dissolved oxygen content of the mixed water falls below the minimum required for the fish to live. All except air-breathing fishes soon come up gasping for breath, and die of asphyxiation.

This fatal depletion of oxygen usually takes place in the early mornings. If the distress is detected in time, the stock of fish may either be transferred to other ponds or the water in the pond aerated by beating up the surface water with poles. As the day advances, oxygen will be replenished by the algae, reviving the fishes.

Some algae may cause mortality among fishes by choking the gills or by producing toxic substances in the water.

A TYPICAL FISH FARM

DEPENDABLE sources of water supply to ponds and soil which will retain water are of fundamental importance in the selection of a site for pond construction. Low-lying, water-logged or marshy areas are suited to excavation into ponds, but the soil, if peaty, would reduce the productivity of waters. A clay-loamy soil is perhaps the best from the point of view of water retention and fertility.

When it is intended to rear carps in new ponds, the requirements for nursing, rearing, and stocking fish in different types of ponds should be remembered. A small farm, 10 acres in extent, should have the area divided as follows for different purposes :—

Nurseries	½ acre
Rearing ponds	2 acres
Stocking ponds	7½ acres

The nursery ponds should preferably be small and shallow, 40 feet $\times$ 20 feet $\times$ 5 feet (depth of water only three to four feet) being a convenient size. Rearing ponds should be slightly larger (60 —80 feet x 40 feet), but need not be proportionately deep. Stocking ponds should be deeper (six to eight feet) and longer so that the fish will have a longer run for a healthy growth. The width of the stocking pond should not exceed 100 feet, so that relatively smaller nets and a limited number of men would be sufficient to net the fish. Large ponds are not only difficult to fish but also difficult to manage, particularly in the control of overgrowth in weeds.

Shallow waters are more productive than deeper waters. If there is a regular and well assured supply of water in the nursery ponds it may be very shallow (2 feet to 2½ feet) as in a rice field. The *bundh* should, however, be properly turfed to prevent erosion. Fully protected inlets and outlets should be provided wherever necessary to regulate the inflow and outflow of water.

The sides and bottom of the ponds should be gently sloping towards the outlet in the latter case, so as to facilitate complete draining off of water when desired. If a deeper pit or trough is provided near the outlet in the pond, all the fish in it would be automatically collected there when the pond is drained.

FISH FARM IMPLEMENTS

THE fish farmer owning a small 10-acre farm, consisting of small nursery ponds and long rectangular stocking ponds should keep the following implements ready for routine use in his farm.

No.	*Item*	*Quantity*	*Used for*
1.	Drag-net, very fine mesh, 36 feet × 12 feet with floats and weights	2	Netting and collecting fish fry a week or 10 days old from nursery ponds. For use in larger ponds the two may be joined together
2.	Drag-net, $\frac{1}{4}$ inch mesh, 36 feet × 12 feet with floats and weights	2	Netting advanced fry or early fingerlings from nursery ponds for sorting and stocking
3.	Drag-net, $\frac{1}{2}$ inch mesh; 50 feet × 14 feet with float and weights	3	For periodic netting of fingerlings for transfer to stocking ponds or for giving them an occasional run and exercise
4.	Drag-net, one inch to $1\frac{1}{2}$ inches mesh, 50 feet × 16—20 feet with floats and weights	3	For catching grown up fish and examining their condition and gowth periodically or for marketing
5.	Miniature cloth tank or *hapa*, 6 × 3 × 3 to 4 feet with strong tape at all corners, top and bottom	2	For temporary storage of fish after netting from pond before sales, necessary also for sorting fingerlings of major carps from others
6.	Wide mouthed earthen pots or *hundies* about five-six gallon capacity (tins preferable, but costly).	6	For temporary storage of live fish fry, fingerlings or adults, after netting and for transport from one place to another
7.	Buckets	6	For carrying fish seed, manure etc. from place to place
8.	Baskets	1 doz.	For carrying sand, silt, manure, etc.
9.	Spades	2	For trimming embankments, desilting, etc.
10.	Jack knife	4	For trimming weeds on the embankments and in the marginal areas of ponds, etc.
11.	Bamboo poles, 8 feet to 10 feet long	1 dozen	For fixing the *hapas* in ponds and for other miscellaneous use

12.	Split bamboo screen; 10 feet ×4 feet	2	For use as a miniature conditioning tank or live pen in the pond for fish to be kept alive after catching but before marketing
13.	Weeder or bottom rake (a wooden or metal beam) 6 to 8 feet long, with strong bamboo or metal spikes fixed in all directions and with strong rope tied at either end for dragging	1	De-weeding deeper areas of ponds by repeated dragging in all directions and removing the weeds caught among the spikes every time the weeder is hauled; and disturbing the bottom mud to remove poisonous gases accumulating therein
14.	Straw rope, loose, thick, about 100 feet long	1	Dragging the surface water to remove floating weeds (*Pistia, Lemna, Azolla, Wolffia*), thick algal scums, etc., which often occur in great abundance in ponds
15.	Small boat or float	1	De-weeding purposes, particularly when the pond is deep and broad and abounds in rooted weeds like water lilies which have to be plucked out

Other miscellaneous items may also be required occasionally. An extra stock of wire-netting for protecting the inlets and outlets of ponds, if any, a balance with weights for weighing fish, a scale (in inches and centimetres) for measuring their length, etc. will be necessary. A proper maintenance of the farm will require the full-time services of at least two persons who could also profitably be engaged in vegetable farming on banks and bunds of fish ponds.

The ponds should be numbered serially, and the details regarding their dimensions, etc., entered in a maintenance register, one page for each pond. The physical characters of the water in the ponds, and the forms of life observed in the ponds including plants, insects, fishes and other animals—big, small and immature, the farming operations such as manuring, stocking, netting, marketing, size of fish caught, their number, etc.; in fact, every little operation or observation, including behaviour of fish, should be recorded in the book then and there to facilitate institution of comparisons of the different conditions at different times with a view to improving the farming methods.

APPENDIX

GLOSSARY OF TERMS

Acclimatization	Inuring to a new habitat, medium or set of conditions
Acid	Having a somewhat sour quality
Air-breather	A fish capable of directly utilizing atmospheric oxygen for respiratory purposes
Algae	Simple chlorophyll-bearing plants most of which live entirely submerged in water, fresh or salt
Algal bloom	A preponderance of algae in water which is turned completely green
Algal scum	Floating surface layer of algae in the fresh or decaying condition
Alkaline	Having an acrid taste and soapy touch
Alkalinity	A measure of the dissolved lime (calcium) content of water
Anal fin	The unpaired fin that lies along the middle line on the ventral surface of the body behind the anus or vent
Anchorage	A basis for attachment
Animalcule	A minute animal which cannot ordinarly be seen with the unaided eye
Anterior	Towards the front or head end
Aquaria	Containers with glass frontage and/or sides in which aquatic organisms could be observed and reared
Artificial food	Food not produced in the natural habitat; specially introduced food
Asphyxiation	Suffocation; death due to respiratory difficulties; i. e. inadequate exchange of oxygen and carbon dioxide
Bacteria	Extremely small, single-celled fungoid plants, reproducing rapidly, associated with decomposition of substances and regarded as germs of diseases

Barbel	A soft, slender, fleshy, whisker-like feeler near the mouth in some fishes; a fish beloning to the genus *Barbus*
Bati	A small cup-like measure, usually of 130 to 150 cubic centimetre capacity, used for measuring early carp fry
Bhasa-badha fishery	Low-lying, marshy, salt water areas under reclamation in the Sundarbans, subject to tidal-effect; embanked and provided with sluices devised to trap in fish-seed to grow
Biophysical	Pertaining to the living organisms and water conditions of the environment
Bloom	*Vide* Algal bloom. A sudden appearance of minute algae in large numbers in waters
Bottom fauna	Animal organisms usually living at the bottom of ponds and other waters
Bottom feeder	A fish that generally feeds at the lower levels of water immediately above the bottom
Brackish	Water which is intermediate in taste between salt and fresh water
Breeder	A sexually mature fish ready to breed
Breeding pond	Special pond in which fish are introduced for breeding
Brood	Group of young fish of the same age and parentage
Bundh	Irrigation tank of certain south western districts of W. Bengal in which the major Indian carps breed during the rainy months
Cannibalistic	Tendency of eating one's own kind
Carbon dioxide	A gas formed of carbon and oxygen and evolved by animal respiration and combustion
Carnivorous	Eating animal food, living or dead
Carp	A group of fresh water fishes with toothless mouth
Catfish	One of a group of scaleless fishes, often with long whisker-like feelers
Caudal fin	Tail fin

Caudal peduncle	The hind region of the body from the anal fin to the base of the tail fin
Caudal spot	Pigment spot at the base of the tail fin or at the tip of the caudal peduncle
Chironomid	An insect of the order Diptera whose young ones, blood-red and worm-like, are invariably found at the bottom of ponds living in tubes
Chlorinated	Treated with chlorine
Chromatophore	One of the pigment cells (minute spots) usually found on the skin (of fish)
Climbing perch	(*Anabas testudineus*) So called because of its occasional habit of climbing trees and seeking similar situations
Surface column feeder	A fish that generally feeds at the surface or in mid-deep water
Compatible species	Fishes which can live and grow together in a pond without preying upon one another or competing among themselves for their food
Conditioning	Process of keeping young fish in a limited space for some time, to get the gut voided of contents and also to accustom them to the limited space
Cormorant	A species of fish-eating water bird which dives in to catch fish
Crustacea	A group of animals with jointed limbs and body and hard external shell ; e.g. prawns, shrimps, and crabs
Cultivable	That which can be cultivated; that in which fish could be grown under controlled conditions
Culture	Process of cultivation of fish in all its stages
Cyst	A small bag-like structure containing quiescent or developmental stages of parasites
Derris powder	A commercial insecticide made of the powdered roots of the plant *Derris elliptica*, used as a fish poison also
Diet	A specific type or combination of prescribed food
Doctor Fish	The Tench, *Tinca tinca*, so called as its body slime is believed to have a curative effect on wounds

Dorsal	Pertaining to the back or upper part of the body
Dorsal fin	The unpaired fin along the middle line of the back
Dragon-fly	A predatory flying insect (order Odonata) which is aquatic in habit while young and immature
Dragonfly-nymph	The young aquatic crawling stage of the dragon-fly
Dry *bundh*	A *bundh* tank which dries up during summer
Duck-weeds	Group of floating plants belonging to the genera *Lemna, Azolla, Wolffia,* etc.
Ecological	Pertaining to the environment or habitat of animals and plants
Egg membrane	The thin outer envelope of the egg which swells up after fertilization to form the vitelline membrane
Embryo	The young one (fish) developing within the egg membrane
Empirical	Elementary, based on trial and error methods
Emulsion	A milky liquid prepared by mixing oil and water by means of (here) soap
Equilibrium	Balanced or normal position
Exotic species	Species of fishes not native to the country ; introduced from other countries
Fecundation	The process of impregnation or fertilization of the egg
Fecundity	Prolificness of progeny or the large production of eggs by the female (fish)
Fertilization	Same as fecundation
Filamentous	Slender or thread-like
Fimbriated	Fringed or with short fimbriae or processes
Fin	The organ by which the fish balances itself and swims
Fin rays	The segmented, usually flexible, branched or unbranched rods supporting the fin membrane
Fin rot	A disease affecting usually the fins of fishes
Fingerling	Young fish, one inch to six inches long

Fishery	The business of or place for catching fish
Fish seed	Fertilized eggs, fry or fingerlings of fish used for growing in fish culture
Forage fish	Small-sized fish generally utilized as food by larger predatory fishes
Formalin	A solution of commercial formaldehyde used as preservative of animal or plant tissues
Fry	Young fish up to one inch long
Fungus	One of the lowly groups of plants lacking the green colouring matter of higher plants (mushrooms, toadstools and moulds)
Gamcha	A piece of cloth used as tail cloth for the fry catching net, or for netting fry and fingerlings
Gas disease	A fish disease caused by excess of nitrogen or oxygen, resulting in accumulation of gas in body spaces
Gasteropod (Gastropod)	A class of usually spiral-shelled molluscs with a flat creeping foot
Genus	A group consisting of a number of closely related species
Gill	Organ by which fish and other animals breathe in water
Gill membrane	The thin layer covering the gills and permitting exchange of gases for respiratory purposes
Gill rakers	Stiff long appendages developed on the inner margin of the hoop-like gill arch
Gillrot	A disease commonly affecting the gills
Gregarious	Living together or swimming about in shoals
Gull	A fish eating bird of the sea coast and river estuaries
Gut	The alimentary canal through which food passes in digestion, assimilation and excretion
Hair weed	A genus of long and filamentous green algae, viz., *Spirogyra*
Hapa	A miniature tank-like structure made of cheap cloth and fixed to poles in water for temporary storage of fish seed

Hatching .	The process of bursting of the egg membrane and liberation of the baby fish
Hatchling	Young one just hatched out of the egg
Herbivorous	Eating or living on plants, gross or minute
Hexagonal	Six-sided
Hundi	A wide-mouthed vessel made of mud or tin used for transporting fish seed
Indigenous	Occurring naturally in a country ; native to
Inlet	Passage by which water is allowed to flow in
Inorganic	Without life; of mineral origin
Insecticide	An insect-killer made of plants or chemicals, of organic or inorganic origin
Insectivorous	Living on insects
Iris	The coloured part of the eye
Iridescence	Exhibition of colours like those of a rainbow
Larva	Young one (of fish) after hatching, till the yolk is fully absorbed
Lateral line	A longitudinal series of pores along each side of the body of the fish appearing as a dotted line
Leather Carp	A variety of the common carp (*Cyprinus carpio*) characterized by the almost complete absence of scales
Leptocephalus	Flat, transparent, ribbon-shaped young one of an eel
Lethal	Deadly
Life-cycle	The stages in the life of an organism from birth to death
Live fish	A fish that is capable of living outside water for some time by virtue of its capacity to breathe atmospheric air
Long-seasonal pond or tank	A sheet of water that is available for fish cultivation during six to eight months in a year
Macro-vegetation	Large-sized plants, as opposed to microvegetation or minute plants

Major carps	One of the larger carps attaining a length of over two feet
Microscopic	Minute, usually visible only under a microscope
Minnow	A fresh-water fish which does not generally attain a size larger than that of a fry or fingerling of larger carps
Minor carp	One of the smaller carps as opposed to the large-sized major carp
Mirror Carp	A common variety of the Common carp, *Cyprinus carpio*, having large shining mirror-like scales on the body
Mixed farming	The practice of cultivating more than one species of compatible fishes in the same pond at the same time
Molluse	A soft-bodied and shelled animal, e.g., the common pond snail, or mussel belonging to one of the divisions of Invertebrate animals
Mucilaginous	Slimy
Mulletry	A fish farm where mullets form the important crop raised
Murrel	One of the common live fishes with the head remotely resembling that of a snake and hence called snake-headed (*Ophicephalus*)
Nape	The back or upper part of the neck
Nitrate	One of the inorganic fertilizers
Nitrogen	A gas forming nearly four-fifths of the atmosphere
Non-predator	One (fish) that does not kill others for food
Nursery pond	A pond specially prepared for rearing baby carps from the early stage to advanced fry or early fingerling stage
Ocellus	A small round eye-like spot on the fin
Occipital	Pertaining to the occiput—the hindmost region on the top of the head
Omnivorous	Feeding on animal, vegetable or mineral food
Oozing	The fully ripe condition of the gonads in which the milt of the male as well as eggs of the female are ready to be shed

Ostracod	A small group of minor crustaceans
Otter	A common fish-eating carnivore of aquatic habits
Outlet	Passage for water to flow out
Ovary	The female reproductive organ in which egg cells develop
Oxygen	An essential gas forming part of the atmosphere which supports life
Parasite	An organism in or on the body of other organisms deriving its sustenance from its host
Parasitization	The process of infection by a parasite
Parental care	The practice of looking after the eggs and young ones exhibited by some fishes and other animals
Pearl Spot	The brackish water perch *Etroplus suratensis*
Pectoral fins	The front or uppermost of the paired fins, at the level of the shoulder
Pectoral spines	Modified, stronger rays of the pectoral fins
Perch	A fish of a group, with strong spines on the dorsal and anal fins which are generally long ; salt water as well as fresh water in habitat
Perennial (pond)	A pond the water in which does not dry up completly during summer
Phosphate	A common inorganic manure
Phytoplankton	Plant organisms of plankton
Pisciculture	The process of cultivation of fish
Piscivorous	That which eats fish as food
Plankton	Population of minute plants and animals with limited movement which passively float in the surface layers of fresh or salt water
Predator	That which kills other animals for food
Prolific	With high reproductive capacity
Protective food	Food which contains the essential requirements for body building

Protein	An essential food of complex composition in which the flesh of fish is rich
Rearing pond	Pond used for rearing advanced fry to fingerling stage
Rotenone	The active principle in the fish poison Derris powder
Salinity	The total salt content of water
Scale	One of the numerous, thin, plate-like structures covering the body of fish
Scale carp	A variety of the common carp *Cyprinus carpio*, having scales covering the entire body surface
Seasonal (pond)	A pond which contains water only for a part of the year, usually between four to eight months
Short-seasonal	A pond which will contain water only for three to four months in a year
Shoulder spot	A pigment spot near the pectoral or shoulder region seen in some fishes
Shrimps	A small prawn-like crustacean
Snout	The part of the head in front of the eye
Soundings	Depth records
Spawn	To lay or produce eggs, especially of fishes ; also the laid eggs of fishes and other lower animals
Spawning ground	Selected places to which fishes migrate for spawning
Species	A group of individual specimens having close resemblance but differing from others and belonging to the same genus
Sporting fish	A fish that takes bait and can be caught on a hook
Stagnating	Standing, not flowing
Stock figure	The number of fish that should be stocked in a particular pond depending on its productivity
Stocking pond	A pond for stocking fingerlings or one year old fishes
Stripping	The process of pressing out ripe roe or milt of fishes for artificial fecundation

Submerged	Sunk under water
Sucker	An adhesive organ by which a parasite attaches itself to the body of fish
Supersaturation	Over-abundance
Surface feeder	A fish that generally feeds in the surface layers of water
Table fish	Edible fish of appreciable size
Tail cloth	The open trough-like cloth at the hind end of the fry catching net in which fry accumulate
Thinning	Removing part of the fish stock from a pond
Total length	The greatest straight line distance between the tip of the snout and the tip of the tail fin
Tow-net	Conical net of fine cloth used for filtering plankton from water
Toxic	Poisonous
Toxicity	Poisonous property
Understocking	Stocking below the capacity of the pond
Unicellular	Single-celled
Ventral	Pertaining to the lower surface of the body
Ventral fins	The paired fins situated below and behind the pectrol fins ; also called the pelvic fins
Virgin water	Water not previously utilized for systematic fish culture
Viscocity	The property of being thick and not flowing quickly
Water-fleas	Micro-crustaceans largely used as food by baby fish
Weed	Unwanted plants at the bottom, sides and surface of the pond or *bundh*, or at or near the margin of water
Weed fish	Minnows and other fishes which serve as food of other selected fishes in pisciculture
Wet *bundh*	A perennial irrigation pond used for carp breeding

Wier	A platform or side usually built of stone at the outflow end of an irrigation tank or *bundh* to allow excess water to overflow after the highest level has been reached
Yearling	A fish about one year old
Yolk-sac	Sac containing the stored food of the egg on which the hatchling subsists for a few days